

# Switched Mode Power Supplies

## 10.1. INTRODUCTION

A *switched mode power supply* (SMPS) is a dc-dc converter with an unregulated input dc voltage and a regulated output voltage. The converter circuitry consists of arrangements of inductor, capacitors, diodes, and transistors. The transistors are switched between the ON state (saturation) and the OFF state (cutoff) at rates that typically range from 10 kHz to 40 kHz. Regulation of the output voltage is realized by control of the percentage of time that the transistor is in the ON state. The SMPS efficiency is significantly higher than that of the so-called linear power supplies that realize output voltage control by active region operation of the transistors.

The material of this chapter will be limited to steady-state operation covering the common case of continuous inductor current.

## 10.2. ANALYTICAL TECHNIQUES

Although numerous circuit topologies exist for SMPS, certain analysis techniques are universally applicable. Clear understanding of the results significantly simplifies analysis of the various SMPS arrangements. Notation adopted for analysis uses lowercase  $v$  and  $i$  for instantaneous values and upper case  $V$  and  $I$  for average values (dc quantities).

### Inductor Voltage and Current

Consider the current  $i$  flowing through the inductor  $L$  of Fig. 10-1(a). If  $v_C$  changes insignificantly over an interval of interest (good approximation of  $C$  is sufficiently large) so that  $v_C(t) \approx V_C$ , then

$$v_L(t) = V_B - V_C = L \frac{di}{dt} \quad (10.1)$$

Whence,

$$\int_{t_0}^{t_0+\Delta t} dt = \frac{V_B - V_C}{L} \int_0^{\Delta t} dt$$

# Switched Mode Power Supplies In Practice

**Issa Batarseh, Ahmad Harb**



## **Switched Mode Power Supplies In Practice:**

**Switched-Mode Power Supplies in Practice** Otmar Kilgenstein, 1989 A handbook on the theory and application of switched mode power supplies Presents all important established techniques and includes many detailed examples using manufacturer s actual data sheets Covers design and use of DC to DC power converter circuits non isolated DC to DC converters IC controllers for switched mode power converters and isolated power converters Also discusses the radio frequency interface and addresses electromagnetic compatibility problems A special chapter examines characteristics circuits and peculiarities of many of the integrated drive circuits currently available **Practical Computer Analysis of**

**Switch Mode Power Supplies** Johnny C. Bennett, 2018-10-03 When designing switch mode power supplies SMPSs engineers need much more than simple recipes for analysis Such plug and go instructions are not at all helpful for simulating larger and more complex circuits and systems Offering more than merely a cookbook Practical Computer Analysis of Switch Mode Power Supplies provides a thorough understanding of the essential requirements for analyzing SMPS performance characteristics It demonstrates the power of the circuit averaging technique when used with powerful computer circuit simulation programs The book begins with SMPS fundamentals and the basics of circuit averaging models reviewing most basic topologies and explaining all of their various modes of operation and control The author then discusses the general analysis requirements of power supplies and how to develop the general types of SMPS models demonstrating the use of SPICE for analysis He examines the basic first order analyses generally associated with SMPS performance along with more practical and detailed methods for developing SMPS and component models The final chapter features the circuit averaging macromodel of the integrated circuit PWM controller illustrated through analyses of three power supplies Practical Computer Analysis of Switch Mode Power Supplies builds a strong foundation on the principles of SMPS analysis enabling further development and advancement of the techniques while supplying meaningful insight into the process **Switched**

**Mode Power Supplies** H. W. Whittington, Brian W. Flynn, Donald Ewen Macpherson, 1997 Switched mode power supplies are now established as an industry standard method of providing power to many types of electronic equipment This book provides thorough up to date coverage of all aspects of switched mode power supply technology Covers the full range of topics associated with the successful design and production of a switched mode power supply Provides a sound rigorous treatment of the theory as well as practical applications to allow the reader to achieve a suitable design and functionally satisfactory switched mode power supply Considerably expanded since the first edition The second edition includes coverage of electromagnetic compatibility the main statutory regulations associated with switched mode power supply production and validated simulation programs **Switched Mode Power Supplies** H. W. Whittington, Brian W. Flynn, Donald Ewen

Macpherson, 1992 **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

### **Computer-Aided Analysis and Design of Switch-Mode Power Supplies**

Lee,2017-10-19 This comprehensive reference text explains the development and principles of operation modelling and analysis of switch mode power supplies SMPS highlighting conversion efficiency size and steady state transient regulation characteristics Covering the practical design techniques of SMPS this book reveals how to develop specific models of circuits and components for simulation and design purposes explains both the computer simulation of the switching behaviours of dc to dc converters and the modelling of linear and nonlinear circuit components deals with the modelling and simulation of the low frequency behaviours of converters including current controlled converters and converters with multiple outputs and regulators describes computer aided design CAD techniques as applied to converters and regulators introduces the principles and design of quasi resonant and resonant converters provides details on SPICE a circuit simulator package used to calculate electrical circuit behaviour Containing over 1000 helpful drawings equations and tables this is a valuable reference for circuit design electrical and electronics engineers and serves as an excellent text for upper level undergraduate and graduate students in these disciplines

### **Pulse-width Modulated DC-DC Power Converters Marian K.**

Kazimierczuk,2008-09-15 This book studies switch mode power supplies SMPS in great detail This type of converter changes an unregulated DC voltage into a high frequency pulse width modulated PWM voltage controlled by varying the duty cycle then changes the PWM AC voltage to a regulated DC voltage at a high efficiency by rectification and filtering Used to supply electronic circuits this converter saves energy and space in the overall system With concept orientated explanations this book offers state of the art SMPS technology and promotes an understanding of the principle operations of PWM converters as well as enabling the readers to evaluate their characteristics Design orientated analysis including a steady state analysis for both continuous and discontinuous conduction modes and numerous real world practical examples including circuit models of the PWM converters demonstrate how to design these from scratch The book provides an in depth presentation of topologies of PWM DC DC power converters voltage and current mode control of PWM DC DC power converters considers power losses in all components device stresses output voltage ripple converter efficiency and power factor correction PFC It also includes extensive coverage of the following topologies of high efficiency switching mode PWM and soft switching DC DC power converters DC voltage transfer functions conversion ratios component values losses efficiency and stresses small signal

averaged circuit models current mode and voltage mode feedback controls metal oxide semiconductor field effect power transistors MOSFETs silicon Si and silicon carbide SiC power semiconductor devices Before now there has been no book that covers silicon carbide devices Pulse width Modulated DC DC Power Converters is a comprehensive textbook for senior undergraduate and graduate students in the areas of electrical electronics and telecommunications engineering It includes end of chapter review questions problems and thorough summaries of the key concepts to aid learning and a Solutions Manual is available for professors Scientists and practicing design engineers working with SMPS within such applications as computers telecommunications industrial systems automobile electronics medical equipment aerospace power technology and radars amongst others will also find this text insightful Electrical Engineering Ralf Kories, Heinz Schmidt-Walter, 2011-06-28 This is a superb source of quickly accessible information on the whole area of electrical engineering and electronics It serves as a concise and quick reference with self contained chapters comprising all important expressions formulas rules and theorems as well as many examples and applications *RFID+ Study Guide and Practice Exams* Paul Sanghera, 2011-04-18 Radio Frequency Identification RFID is an automatic identification method relying on storing and remotely retrieving data using devices called RFID tags also called transponders This book is a guide to CompTIA's new RFID Security exam and includes the following study elements Exam objectives covered in a chapter are clearly explained in the beginning of the chapter Notes and Alerts highlight the crucial points Exam's Eye View emphasizes the important points from the exam's perspective Key Terms present definitions Review Questions contain questions modeled after the real exam questions Answers to these questions are presented with complete explanations in an appendix Also included is a full practice exam modeled after the real exam The answers to the exam questions are presented with full explanations The only RFID study guide that provides 100% coverage of all exam objectives for the CompTIA RFID exam Packed full of special features and material to aid and reinforce learning **The Circuit Designer's Companion** Peter Wilson, 2012-01-12 Grounding and Wiring Printed Circuits Passive Components Active Components Analog Integrated Circuits Digital Circuits Power Supplies Electromagnetic Compatibility General Product Design Appendices **DC Power Supplies** Nihal Kularatna, 2018-10-03 As we increasingly use electronic devices to direct our daily lives so grows our dependence on reliable energy sources to power them Because modern electronic systems demand steady efficient reliable DC voltage sources often at a sub 1V level commercial AC lines batteries and other common resources no longer suffice New technologies also require intricate techniques to protect against natural and manmade disasters Still despite its importance practical information on this critical subject remains hard to find Using simple accessible language to balance coverage of theoretical and practical aspects DC Power Supplies Power Management and Surge Protection details the essentials of power electronics circuits applicable to low power systems including modern portable devices A summary of underlying principles and essential design points it compares academic research and industry publications and reviews DC power supply

fundamentals including linear and low dropout regulators Content also addresses common switching regulator topologies exploring resonant conversion approaches Coverage includes other important topics such as Control aspects and control theory Digital control and control ICs used in switching regulators Power management and energy efficiency Overall power conversion stage and basic protection strategies for higher reliability Battery management and comparison of battery chemistries and charge discharge management Surge and transient protection of circuits designed with modern semiconductors based on submicron dimension transistors This specialized design resource explores applicable fundamental elements of power sources with numerous cited references and discussion of commercial components and manufacturers Regardless of their previous experience level this information will greatly aid designers researchers and academics who study design and produce the viable new power sources needed to propel our modern electronic world

**Power Supply Devices and Systems of Relay Protection** Vladimir Gurevich,2017-12-19 Power Supply Devices and Systems of Relay Protection brings relay protection and electrical power engineers a single concentrated source of information on auxiliary power supply systems and devices The book also tackles specific problems and solutions of relay protection power supply systems and devices which are often not dealt with in the literature The author an experienced engineer with more than 100 patents draws on his own experience to offer practical tested advice to readers A Guide to Relay Protection Power Supply for Engineers and Technicians The first chapter reviews the electronics and primary elements of the system including transistors thyristors optocouplers logic elements and relays and their principles of operation This background gives staff who service relay protection power supply systems the necessary electronics knowledge to help them work more effectively with the equipment The next chapters of the book then cover built in digital protection relay power supplies battery chargers accumulator batteries uninterruptible power supply and characteristic features of auxiliary DC systems at substations and power plants The final chapters discuss questions and problems that engineers and technicians may face These include insulation problems issues in auxiliary DC power supply such as voltage dips and electromagnetic disturbances such as blackouts spikes and surges The author also explains how to address them Suitable for beginners and experienced engineers alike the book is written for those who work with relay protection systems and with AC and DC auxiliary power systems in power plants and substations It combines theory and practical recommendations to provide a valuable reference on power supply devices and systems

**Power Electronics Applied to Industrial Systems and Transports, Volume 3** Nicolas Patin,2015-05-07 Some power electronic converters are specifically designed to power equipment under a smoothed DC voltage Therefore the filtering part necessarily involves the use of auxiliary passive components inductors and capacitors This book deals with technical aspects such as classical separation between isolated and non isolated power supplies and soft switching through a special converter It addresses the problem of regulating the output voltage of the switching power supplies in terms of modeling and obtaining transfer of SMPS functions Power Electronics for Industry and Transport Volume

3 offers a case study of an isolated flyback power which the complete design is presented the active and passive components are sized based on the specifications initially set Particular attention is given to the converter output capacitors and all the surrounding organs Introducing Essential notions in power electronics from both the theoretical and technological perspectives Detailed chapters with a focus on switch mode power supplies another key area in which power electronics is used is in the supply of energy to a variety of electronic equipment for signal and information processing Presented from a user s perspective to enable you to apply the theory of power electronics to practical applications

**RF Power Amplifiers** Marian K. Kazimierczuk, 2014-10-14 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

**Electric Machines** Charles A. Gross, 2006-10-20 The two major broad applications of electrical energy are information processing and energy processing Hence it is no wonder that electric machines have occupied a large and revered space in the field of electrical engineering Such an important topic requires a careful approach and Charles A Gross Electric Machines offers the most balanced a

**Design of Medical Electronic Devices** Reinaldo Perez, 2002-03-21 The design of medical electronics is unique because of the background needed by the engineers and scientists involved Often the designer is a medical or life science professional without any training in electronics or design Likewise few engineers are specifically trained in biomedical engineering and have little or no exposure to the specific medical requirements of these devices Design of Medical Electronic Devices presents all essential topics necessary for basic and advanced design All aspects of the electronics of medical devices are also covered This is an essential

book for graduate students as well as professionals involved in the design of medical equipment Covers every stage of the process from design to manufacturing to implementation Topics covered include analogue digital conversions data acquisition signal processing optics and reliability and failure      *Electrical Engineering: Know It All* Clive Maxfield, John Bird, Tim Williams, Walt Kester, Dan Bensky, 2011-04-19 The Newnes Know It All Series takes the best of what our authors have written to create hard working desk references that will be an engineer's first port of call for key information design techniques and rules of thumb Guaranteed not to gather dust on a shelf Electrical engineers need to master a wide area of topics to excel The Electrical Engineering Know It All covers every angle including Real World Signals and Systems Electromagnetics and Power systems A 360 degree view from our best selling authors Topics include digital analog and power electronics and electric circuits The ultimate hard working desk reference all the essential information techniques and tricks of the trade in one volume      Reactive Power Control in AC Power Systems Naser Mahdavi Tabatabaei, Ali Jafari Aghbolaghi, Nicu Bizon, Frede Blaabjerg, 2017-04-05 This textbook explores reactive power control and voltage stability and explains how they relate to different forms of power generation and transmission Bringing together international experts in this field it includes chapters on electric power analysis design and operational strategies The book explains fundamental concepts before moving on to report on the latest theoretical findings in reactive power control including case studies and advice on practical implementation students can use to design their own research projects Featuring numerous worked out examples problems and solutions as well as over 400 illustrations Reactive Power Control in AC Power Systems offers an essential textbook for postgraduate students in electrical power engineering It offers practical advice on implementing the methods discussed in the book using MATLAB and DlgSILENT and the relevant program files are available at extras.springer.com      **Recent Topics in Electromagnetic Compatibility** Ahmed Kishk, 2022-02-23 Recent Topics in Electromagnetic Compatibility discusses several topics in electromagnetic compatibility EMC and electromagnetic interference EMI including measurements shielding emission interference biomedical devices and numerical modeling Over five sections chapters address the electromagnetic spectrum of corona discharge life cycle assessment of flexible electromagnetic shields EMC requirements for implantable medical devices analysis and design of absorbers for EMC applications artificial surfaces and media for EMC and EMI shielding and much more      **Cathodic Protection for Reinforced Concrete Structures** Paul M. Chess, 2018-10-12 Cathodic protection of reinforced concrete structures is a technique for rescuing corrosion damaged structures and in certain instances preventing them from corroding in the first place and its use is growing This book is for specialist contractors large consultants and owners of corrosion damaged structures and looks at international experience with this technique It examines why corrosion is occurring the differences in the application of CP with the stark dichotomy in its success and failure and finally ways in which its performance can be improved on future installations Information is valuable as the success or failure of the CP system has a marked effect on the service life of the structure



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