

## Section 5 Inductor and Flyback Transformer Design

Filter inductors, boost inductors and flyback transformers are all members of the “power inductor” family. They all function by taking energy from the electrical circuit, storing it in a magnetic field, and subsequently returning this energy (minus losses) to the circuit. A flyback transformer is actually a multi-winding coupled inductor, unlike the true transformer discussed in Section 4, wherein energy storage is undesirable.

### Application Considerations

Design considerations for this family of inductors vary widely, depending on the type of circuit application and such factors as operating frequency and ripple current.

Inductor applications in switching power supplies can be defined as follows (see Fig. 5-1):

- *Single winding inductors:*
  - Output filter inductor (buck-derived)
  - Boost inductor
  - Flyback (buck-derived) inductor
  - Input filter inductor
- *Multiple winding inductors:*
  - Coupled output filter inductor<sup>(1)</sup>
  - Flyback transformer

Inductor design also depends greatly on the inductor current operating mode (Figure 5-2):

- *Discontinuous inductor current mode*, when the instantaneous instantaneous (instant) in all windings) dwell at zero for a portion of each switching period.
- *Continuous inductor current mode*, in which the total instantaneous does not dwell at zero (although the current may pass through zero).

In the continuous current mode, the ripple current is often small enough that no winding has and no wire has any significant, but in the discontinuous mode, no losses may dominate.

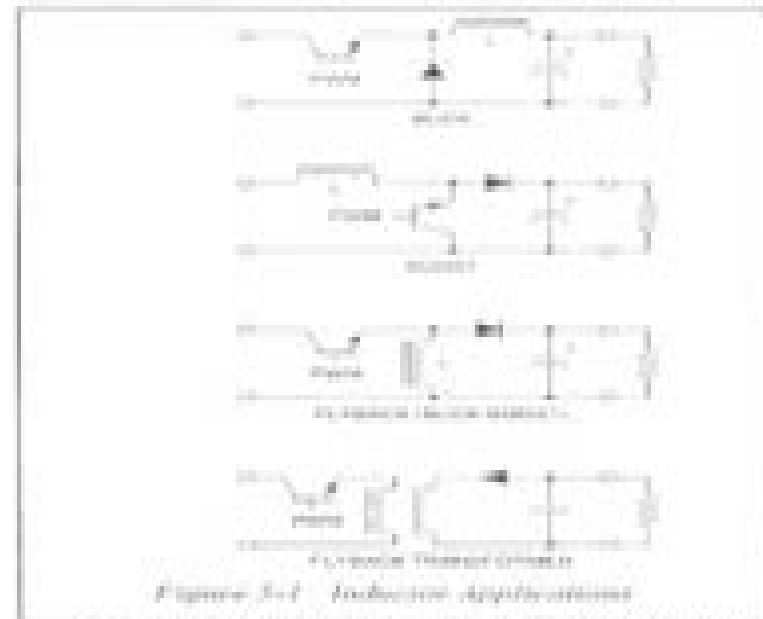


Figure 5-1 Inductor Applications

**Design limitations:** The most important limiting factors in inductor design are (a) temperature rise and efficiency considerations arising from wire losses and ac and dc winding losses, and (b) core saturation.

**Output filter inductors (buck-derived) —single and multiple windings** are seldom operated in the discontinuous current mode because of the added burden this places on the output filter capacitor, and because it results in poor cross-regulation in multiple output supplies. Typically operated in the continuous mode with peak peak ripple current much smaller than full load current, ac winding loss is usually not significant compared to dc loss.

# Magnetics Design 5 Inductor And Flyback Transformer Design

**Nihal Kularatna**



## **Magnetics Design 5 Inductor And Flyback Transformer Design:**

Transformer and Inductor Design Handbook, Third Edition Colonel Wm. T. McLyman, 2004-03-31 Extensively revised and expanded to present the state of the art in the field of magnetic design this third edition presents a practical approach to transformer and inductor design and covers extensively essential topics such as the area product  $A_p$  and core geometry  $K_g$  The book provides complete information on magnetic materials and core characteristics using step by step design examples and presents all the key components for the design of lightweight high frequency aerospace transformers or low frequency commercial transformers Written by a specialist with more than 47 years of experience in the field this volume covers magnetic design theory with all of the relevant formulas

**Transformer and Inductor Design Handbook** Colonel Wm. T. McLyman, 2017-12-19 With its practical approach to design Transformer and Inductor Design Handbook Fourth Edition distinguishes itself from other books by presenting information and guidance that is shaped primarily by the user's needs and point of view Expanded and revised to address recent industry developments the fourth edition of this classic reference is reorganized and improved again serving as a constant aid for anyone seeking to apply the state of the art in transformer and inductor design Carefully considering key factors such as overall system weight power conversion efficiency and cost the author introduces his own new equation for the power handling ability of the core intended to give engineers faster and tighter design control The book begins by providing the basic fundamentals of magnetics followed by an explanation of design using the  $K_g$  or  $A_p$  techniques It also covers subjects such as laminations tape cores powder cores and ferrites and iron alloys In addition new topics include Autotransformer design Common mode inductor design Series saturable reactor design Self saturating magnetic amplifier Designing inductors for a given resistance With the goal of making inductors that are lighter and smaller but still meet requirements this book helps users avoid many antiquated rules of thumb to achieve a better more economical design Presenting transformer design examples with step by step directions and numerous tables and graphics for comparison it remains a trusted guide for the engineers technicians and other professionals who design and evaluate transformers and inductors It also serves as an ideal primer for students illustrating the field for them from the ground up

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

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

*Modern Ferrite Technology* Alex Goldman, 2006-09-28

For the past seventy years ferrites magnetic ceramics have been prized for a range of properties that has no equivalent in the existing metal magnetic materials They have contributed to many important advances in electronics and new high performance products are appearing all the time Ferrite technology has produced greater progress in the past 15 years since the first edition was published Many of the semiconductor and IC technology responsible for the computer and Internet explosion would not have been possible without the magnetic materials technology needed for powering and otherwise exploiting those developments Modern Ferrite Technology 2nd ed offers the readers an expert overview of the latest ferrite advances as well as their applications in electronic components This volume develops the interplay among material properties component specification and device requirements using ferrites Throughout emphasis is placed on practical technological concerns as opposed to mathematical and physical aspects of the subject The book traces the origin of the magnetic effect in ferrites from the level of the simplest particle and the increases the scope to the larger and larger hierarchies From the desired magnetic properties the author

deduces the physical and chemical material parameters taking into consideration major chemistry impurity levels ceramic microstructures and grain boundary effects He then discusses the processing conditions and associated conditions required for implementation In addition to conventional ceramic techniques he describes non conventional methods such as coprecipitation co spray roasting and single crystal growth The second section of this book deals with a complete listing of the many important applications in the field including ferrites for permanent magnet telecommunications power supplies memory systems magnetic recording and microwave applications The function of ferrites in each of these applications is described The requirements of the electronic circuit and device are broken down into the individual component specifications with regard to size and configuration Design criteria for power level degree of stability and cost are then considered

*Magnetic Core Selection for Transformers and Inductors* Colonel Wm. T. McLyman, 1997-05-05 Written as a companion to Transformer and Inductor Design Handbook second ed this work compiles the specifications of over 12 000 industrially available cores and brings them in line with standard units of measurement simplifying the selection of core configurations for the design of magnetic components      Simplified Design of Switching Power Supplies John Lenk, 2013-10-22 Describes the operation of each circuit in detail Examines a wide selection of external components that modify the IC package characteristics Provides hands on essential information for designing a switching power supply Simplified Design of Switching Power Supplies is an all inclusive one stop guide to switching power supply design Step by step instructions and diagrams render this book essential for the student and the experimenter as well as the design professional Simplified Design of Switching Power Supplies concentrates on the use of IC regulators All popular forms of switching supplies including DC DC converters inverters buck boost buck boost pulse frequency modulation pulse width modulation current mode control and pulse skipping are described in detail The design examples may be put to immediate use or may be modified to meet a specific design goal As an instructional text for those unfamiliar with switching supplies or as a reference for those in need of a refresher this unique book is essential for those involved in switching power supply design      **Power Electronics Design Handbook** Nihal Kularatna, 1998-09-09 Power Electronics Design Handbook covers the basics of power electronics theory and components while emphasizing modern low power components and applications Coverage includes power semiconductors converters power supplies batteries protection systems and power ICs One of the unique features of the Power Electronics Design Handbook is the integration of component and system theory with practical applications particularly energy saving low power applications Many chapters also include a section that looks forward to future developments in that area References for further information or more in depth technical reading are also included Nihal Kularatna is a principal research engineer with the Arthur C Clarke Foundation in Sri Lanka He is also the author of Modern Electronic Test and Measuring Instruments published by the Institute of Electrical Engineers Emphasizes low and medium power components Offers a unique mix of theory and practical application Provides a useful guide to further reading

**Leistungselektronik** Franz Zach, 2015-12-10 Die Methoden der Leistungselektronik gewinnen ständig an Bedeutung insbesondere für die Entwicklung von neuen Antriebskonzepten z.B. von Hybridantrieben für Kraftfahrzeuge Stromversorgungen Schaltnetzteilen elektronischer Geräte von Computern Mobiltelefonen etc. Beleuchtungstechnik Solarkonvertern etc. In dieser bearbeiteten und erweiterten Ausgabe des Standardwerks von Professor Zach werden Aufbau Wirkungsweise und Analyse der entsprechenden Schaltungsprinzipien und der elektrischen Vorgänge anhand von Funktionsabläufen Zeitdiagrammen und Schnittzeichnungen grundlegend dargestellt

**Power Sources and Supplies: World Class Designs** Marty Brown, 2011-04-08 Newnes has worked with Marty Brown a leader in the field of power design to select the very best design specific material from the Newnes portfolio Marty selected material for its timelessness its relevance to current power supply design needs and its real world approach to design issues Special attention is given to switching power supplies and their design issues including component selection minimization of EMI toroid selection and breadboarding of designs Emphasis is also placed on design strategies for power supplies including case histories and design examples This is a book that belongs on the workbench of every power supply designer Marty Brown author and power supply design consultant has personally selected all content for its relevance and usefulness Covers best design practices for switching power supplies and power converters Emphasis is on pragmatic solutions to commonly encountered design problems and tasks

**Handbook of Modern Ferromagnetic Materials** Alex Goldman, 2012-12-06 Below is a copy of Professor Takeshi Takei's original preface that he wrote for my first book Modern Ferrite Technology I was proud to receive this preface and include it here with pride and affection We were saddened to learn of his death at 92 on March 12 1992 Preface It is now some 50 years since ferrites debuted as an important new category of magnetic materials They were prized for a range of properties that had no equivalents in existing metal magnetic materials and it was not long before full fledged research and development efforts were underway Today ferrites are employed in a truly wide range of applications and the efforts of the many men and women working in the field are yielding many highly intriguing results New high performance products are appearing one after another and it would seem we have only scratched the surface of the hidden possibilities of these fascinating materials Dr Alex Goldman is well qualified to talk about the state of the art in ferrites For many years Dr Goldman has been heavily involved in the field as director of the research and development division of Spang Co and other enterprises This book Modern Ferrite Technology based in part on his own experiences presents a valuable overview of the field It is testimony to his commitment and bountiful knowledge about one of today's most intriguing areas of technology

Advances in Electrical and Computer Technologies Thangaprakash Sengodan, M. Murugappan, Sanjay Misra, 2020-09-07 The book comprises select proceedings of the first International Conference on Advances in Electrical and Computer Technologies 2019 ICAECT 2019 The papers presented in this book are peer reviewed and cover wide range of topics in Electrical and Computer Engineering fields This book contains the papers presenting the latest developments in the areas of

Electrical Electronics Communication systems and Computer Science such as smart grids soft computing techniques in power systems smart energy management systems power electronics feedback control systems biomedical engineering geoinformative systems grid computing data mining image and signal processing video processing computer vision pattern recognition cloud computing pervasive computing intelligent systems artificial intelligence neural network and fuzzy logic broad band communication mobile and optical communication network security VLSI embedded systems optical networks and wireless communication This book will be of great use to the researchers and students in the areas of Electrical and Electronics Engineering Communication systems and Computer Science      *Analog Circuit Design* Bob Dobkin, Jim Williams, 2011-09-26 Analog circuit and system design today is more essential than ever before With the growth of digital systems wireless communications complex industrial and automotive systems designers are challenged to develop sophisticated analog solutions This comprehensive source book of circuit design solutions will aid systems designers with elegant and practical design techniques that focus on common circuit design challenges The book's in depth application examples provide insight into circuit design and application solutions that you can apply in today's demanding designs Covers the fundamentals of linear analog circuit and system design to guide engineers with their design challenges Based on the Application Notes of Linear Technology the foremost designer of high performance analog products readers will gain practical insights into design techniques and practice Broad range of topics including power management tutorials switching regulator design linear regulator design data conversion signal conditioning and high frequency RF design Contributors include the leading lights in analog design Robert Dobkin Jim Williams and Carl Nelson among others      Conference Proceedings 1988 , 1988      **Smart Small Satellites: Design, Modelling and Development** Chander Prakash, V. Sambasiva Rao, D. V. A. Raghava Murthy, 2023-01-02 This book comprises the select proceedings of the International Conference on Small Satellites and its Applications ICSS 2022 It aims to provide a comprehensive and broad spectrum picture of the state of the art research development and commercial perspective of various discoveries conducted in the real world smart small satellites applications and their services The contents of this book focuses on efficient power management system application based optimum payload designs telemetry and telecommand advanced navigation and RF systems flight and ground software's structure mechanism and materials space craft autonomy quality testing and reliability for designing the small satellites through advanced computational procedures for a variety of applications etc This book proves a valuable resource for those in academia and industry      **CMOS Analog Circuit Design** Phillip E. Allen, Douglas R. Holberg, 2011 A textbook for 4th year undergraduate first year graduate electrical engineering students      **Resonant Behaviour of Pulse Generators for the Efficient Drive of Optical Radiation Sources Based on Dielectric Barrier Discharges** Meißer, Michael, 2014-05-22 Dielectric barrier discharge DBD excimer lamps emit vacuum UV optical radiation This work presents novel methods for efficiently operating DBDs with short high voltage pulses Transformer less systems utilising SiC power

semiconductor switches are presented Pulse frequencies of up to 3.1 MHz and peak inverter efficiencies of 92 % were achieved The work encloses both mathematical backgrounds of pulsed resonant circuits and practical implementation of low inductive power stages

**Analog Design and Simulation Using OrCAD Capture and PSpice** Dennis

Fitzpatrick,2011-11-16 Anyone involved in circuit design that needs the practical know how it takes to design a successful circuit or product will find this practical guide to using Capture PSpice written by a former Cadence PSpice expert for Europe an essential book The text delivers step by step guidance on using Capture PSpice to help professionals produce reliable effective designs Readers will learn how to get up and running quickly and efficiently with industry standard software and in sufficient detail to enable building upon personal experience to avoid common errors and pit falls This book is of great benefit to professional electronics design engineers advanced amateur electronics designers electronic engineering students and academic staff looking for a book with a real world design outlook Provides both a comprehensive user guide and a detailed overview of simulation Each chapter has worked and ready to try sample designs and provides a wide range of to do exercises Core skills are developed using a running case study circuit Covers Capture and PSpice together for the first time

**Switching Power Supplies A - Z** Sanjaya Maniktala,2012-04-04

Chapter 1 The Principles of Switching Power Conversion Chapter 2 DC DC Converter Design and Magnetics Chapter 3 Off line Converter Design and Magnetics Chapter 4 The Topology FAQ Chapter 5 Optimal Core Selection Chapter 6 Component Ratings Stresses Reliability and Life Chapter 7 Optimal Power Components Selection Chapter 8 Conduction and Switching Losses Chapter 9 Discovering New Topologies Chapter 10 Printed Circuit Board Layout Chapter 11 Thermal Management Chapter 12 Feedback Loop Analysis and Stability Chapter 13 Paralleling Interleaving and Sharing Chapter 14 The Front End of AC DC Power Supplies Chapter 15 DM and CM Noise in Switching Power Supplies Chapter 16 Fixing EMI across the Board Chapter 17 Input Capacitor and Stability Chapter 18 The Math behind the Electromagnetic Puzzle Chapter 19 Solved Examples Appendix A

**Average Current-Mode Control of DC-DC Power Converters** Marian K. Kazimierczuk,Dalvir K. Saini,Agasthya

Ayachit,2022-03-14 AVERAGE CURRENT MODE CONTROL OF DC DC POWER CONVERTERS An authoritative one stop guide to the analysis design development and control of a variety of power converter systems Average Current Mode Control of DC DC Power Converters provides comprehensive and up to date information about average current mode control ACMC of pulse width modulated PWM dc dc converters This invaluable one stop resource covers both fundamental and state of the art techniques in average current mode control of power electronic converters featuring novel small signal models of non isolated and isolated converter topologies with joint and disjoint switching elements and coverage of frequency and time domain analysis of controlled circuits The authors employ a systematic theoretical framework supported by step by step derivations design procedures for measuring transfer functions challenging end of chapter problems easy to follow diagrams and illustrations numerous examples for different power supply specifications and practical tips for developing power stage



small signal models using circuit averaging techniques The text addresses all essential aspects of modeling design analysis and simulation of average current mode control of power converter topologies such as buck boost buck boost and flyback converters in operating continuous conduction mode CCM Bridging the gap between fundamental modeling methods and their application in a variety of switched mode power supplies this book Discusses the development of small signal models and transfer functions related to the inner current and outer voltage loops Analyzes inner current loops with average current mode control and describes their dynamic characteristics Presents dynamic properties of the poles and zeros time domain responses of the control circuits and comparison of relevant modeling techniques Contains a detailed chapter on the analysis and design of control circuits in time domain and frequency domain Provides techniques required to produce professional MATLAB plots and schematics for circuit simulations including example MATLAB codes for the complete design of PWM buck boost buck boost and flyback DC DC converters Includes appendices with design equations for steady state operation in CCM for power converters parameters of commonly used power MOSFETs and diodes SPICE models of selected MOSFETs and diodes simulation tools including introductions to SPICE MATLAB and SABER and MATLAB codes for transfer functions and transient responses Average Current Mode Control of DC DC Power Converters is a must have reference and guide for researchers advanced graduate students and instructors in the area of power electronics and for practicing engineers and scientists specializing in advanced circuit modeling methods for various converters at different operating conditions

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