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# **Digital Control in Power Electronics**

*Second Edition*

**Simone Buso**  
**Paolo Mattavelli**

*SYNTHESIS LECTURES ON  
POWER ELECTRONICS*

*Jerry Hudgins, Series Editor*

# Digital Control In Power Electronics Synthesis Lectures On Power Electronics

**Fang Lin Luo, Hong Ye, Muhammad H.  
Rashid**



## **Digital Control In Power Electronics Synthesis Lectures On Power Electronics:**

Digital Control in Power Electronics Simone Buso, Paolo Mattavelli, 2015-05-01 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

*Digital Control in Power Electronics* Simone Buso, Paolo Mattavelli, 2006 Digital Control in Power Electronics presents students of electrical engineering a basic introduction to typical power converter control problems their digital solutions and the most widespread digital control techniques Although the presentation has been limited to a single converter topology the half bridge voltage source inverter the control topics represent a significant spectrum of the more frequently encountered digital control applications in power electronics Authors Paolo Mattavelli and Simone Buso introduce the reader to basic control problems in power electronic circuits in order to illustrate widely applied digital solutions to these problems They also aim to raise students awareness of discrete time control theory stimulating new developments in its application to power converters

*Digital Control In Power Electronics* S. Morgan Buso, 2006      **Digital Control in Power Electronics, 2nd Edition** Simone Buso, Paolo Mattavelli, 2015-05-08 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

*Digital Control in Power Electronics* Simone Buso, Paolo Mattavelli, 2022-12-06 This book presents the reader

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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

*Power Electronics in Smart Electrical Energy Networks* Ryszard Michal Strzelecki, 2008-08-29 Power Electronics in Smart Electrical Energy Networks introduces a new viewpoint on power electronics re thinking the basic philosophy governing electricity distribution systems The proposed concept fully exploits the potential advantages of renewable energy sources and distributed generation DG which should not only be connected but also fully integrated into the distribution system in order to increase the efficiency flexibility safety reliability and quality of the electricity and the networks The transformation of current electricity grids into smart resilient and interactive networks necessitates the development propagation and demonstration of key enabling cost competitive technologies A must read for professionals in power engineering and utility industries and researchers and postgraduates in distributed electrical power systems the book presents the features solutions and applications of the power electronics arrangements useful for future smart electrical energy networks

*Power Electronics for Photovoltaic Power Systems* Mahinda Vilathgamuwa, Dulika Nayanasinghe, Shantha Gamini, 2022-06-01 The world energy demand has been increasing in a rapid manner with the increase of population and

rising standard of living The world population has nearly doubled in the last 40 years from 3.7 billion people to the present 7 billion people It is anticipated that world population will grow towards 8 billion around 2030 Furthermore the conventional fossil fuel supplies become unsustainable as the energy demand in emerging big economies such as China and India would rise tremendously where the China will increase its energy demand by 75% and India by 100% in the next 25 years With dwindling natural resources many countries throughout the world have increasingly invested in renewable resources such as photovoltaics PV and wind The world has seen immense growth in global photovoltaic power generation over the last few decades For example in Australia renewable resources represented nearly 15% of total power generation in 2013 Among renewable resources solar and wind account for 38% of generation In near future energy in the domestic and industrial sector will become ubiquitous where consumers would have multiple sources to get their energy Another such prediction is that co location of solar and electrical storage will see a rapid growth in global domestic and industrial sectors conventional power companies which dominate the electricity market will face increasing challenges in maintaining their incumbent business models The efficiency reliability and cost effectiveness of the power converters used to interface PV panels to the mains grid and other types of off grid loads are of major concern in the process of system design This book describes state of the art power electronic converter topologies used in various PV power conversion schemes This book aims to provide a reader with a wide variety of topologies applied in different circumstances so that the reader would be able to make an educated choice for a given application

### **Dynamics and Control of DC-DC Converters** Farzin Asadi, Kei

Eguchi, 2022-05-31 DC DC converters have many applications in the modern world They provide the required power to the communication backbones they are used in digital devices like laptops and cell phones and they have widespread applications in electric cars to just name a few DC DC converters require negative feedback to provide a suitable output voltage or current for the load Obtaining a stable output voltage or current in presence of disturbances such as input voltage changes and or output load changes seems impossible without some form of control This book tries to train the art of controller design for DC DC converters Chapter 1 introduces the DC DC converters briefly It is assumed that the reader has the basic knowledge of DC DC converter i.e. a basic course in power electronics The reader learns the disadvantages of open loop control in Chapter 2 Simulation of DC DC converters with the aid of Simulink is discussed in this chapter as well Extracting the dynamic models of DC DC converters is studied in Chapter 3 We show how MATLAB and a software named KUCA can be used to do the cumbersome and error prone process of modeling automatically Obtaining the transfer functions using PSIM is studied as well These days softwares are an integral part of engineering sciences Control engineering is not an exception by any means Keeping this in mind we design the controllers using MATLAB in Chapter 4 Finally references are provided at the end of each chapter to suggest more information for an interested reader The intended audiences for this book are practice engineers and academicians

*Computer Techniques for Dynamic Modeling of DC-DC Power Converters*

Farzin Asadi,2022-06-01 Computers play an important role in the analyzing and designing of modern DC DC power converters This book shows how the widely used analysis techniques of averaging and linearization can be applied to DC DC converters with the aid of computers Obtained dynamical equations may then be used for control design The book is composed of two chapters Chapter 1 focuses on the extraction of control to output transfer function A second order converter a buck converter and a fourth order converter a Zeta converter are studied as illustrative examples in this chapter Both ready to use software packages such as PLECS and MATLAB programming are used throughout this chapter The input output characteristics of DC DC converters are the object of considerations in Chapter 2 Calculation of input output impedance is done with the aid of MATLAB programming in this chapter The buck buck boost and boost converter are the most popular types of DC DC converters and used as illustrative examples in this chapter This book can be a good reference for researchers involved in DC DC converters dynamics and control

**Electronic Instrumentation for Distributed Generation and Power Processes** Felix Alberto Farret, Marcelo Godoy Simões, Danilo Iglesias Brandão,2017-08-16 The goal of the book is to provide basic and advanced knowledge of design analysis and circuit implementation for electronic instrumentation and clarify how to get the best out of the analog digital and computer circuitry design steps The reader will learn the physical fundamentals guiding the electrical and mechanical devices that allow for a modern automation and control system which are widely comprised of computers electronic instrumentation communication loops smart grids and digital circuitry It includes practical and technical data on electronic instrumentation with respect to efficiency maximum power and applications Additionally the text discusses fuzzy logic and neural networks and how they can be used in practice for electronic instrumentation of distributed generation smart grids and power systems

*Robust Control of DC-DC Converters* Farzin Asadi,2022-05-31 DC DC converters require negative feedback to provide a suitable output voltage or current for the load Obtaining a stable output voltage or current in the presence of disturbances like input voltage changes and or output load changes seems impossible without some form of control This book shows how simple controllers such as Proportional Integral PI can turn into a robust controller by correct selection of its parameters Kharitonov's theorem is an important tool toward this end This book consists of two parts The first part shows how one can obtain the interval plant model of a DC DC converter The second part introduces the Kharitonov's theorem Kharitonov's theorem is an analysis tool rather than a design tool Some case studies show how it can be used as a design tool The prerequisite for reading this book is a first course on feedback control theory and power electronics

**The Smart Grid** Math Bollen,2022-06-01 This book links the challenges to which the electricity network is exposed with the range of new technology methodologies and market mechanisms known under the name smart grid The main challenges will be described by the way in which they impact the electricity network the introduction of renewable electricity production energy efficiency the introduction and further opening of the electricity market increasing demands for reliability and voltage quality and the growing need for more

transport capacity in the grid Three fundamentally different types of solutions are distinguished in this book solutions only involving the electricity network like HVDC and active distribution networks solutions including the network users but under the control of the network operator like requirements on production units and curtailment and fully market driven solutions like demand response An overview is given of the various solutions to the challenges that are possible with new technology this includes some that are actively discussed elsewhere and others that are somewhat forgotten Linking the different solutions with the needs of the electricity network in the light of the various challenges is a recurring theme in this book Table of Contents Introduction The Challenges Solutions in the Grid Participation of Network Users Market Incentives Discussion Conclusions

**Transient Electro-Thermal Modeling on Power Semiconductor Devices** Tanya Kirilova Gachovska, Jerry Hudgins, Bin Du, Enrico Santi, 2022-06-01 This book presents physics based electro thermal models of bipolar power semiconductor devices including their packages and describes their implementation in MATLAB and Simulink It is a continuation of our first book Modeling of Bipolar Power Semiconductor Devices The device electrical models are developed by subdividing the devices into different regions and the operations in each region along with the interactions at the interfaces are analyzed using the basic semiconductor physics equations that govern device behavior The Fourier series solution is used to solve the ambipolar diffusion equation in the lightly doped drift region of the devices In addition to the external electrical characteristics internal physical and electrical information such as junction voltages and carrier distribution in different regions of the device can be obtained using the models The instantaneous dissipated power calculated using the electrical device models serves as input to the thermal model RC network with constant and nonconstant thermal resistance and thermal heat capacity or Fourier thermal model of the entire module or package which computes the junction temperature of the device Once an updated junction temperature is calculated the temperature dependent semiconductor material parameters are re calculated and used with the device electrical model in the next time step of the simulation The physics based electro thermal models can be used for optimizing device and package design and also for validating extracted parameters of the devices The thermal model can be used alone for monitoring the junction temperature of a power semiconductor device and the resulting simulation results used as an indicator of the health and reliability of the semiconductor power device

Modeling Bipolar Power Semiconductor Devices Tanya K. Gachovska, Jerry L. Hudgins, Enrico Santi, Angus Bryant, 2022-05-31 This book presents physics based models of bipolar power semiconductor devices and their implementation in MATLAB and Simulink The devices are subdivided into different regions and the operation in each region along with the interactions at the interfaces which are analyzed using basic semiconductor physics equations that govern their behavior The Fourier series solution is used to solve the ambipolar diffusion equation in the lightly doped drift region of the devices In addition to the external electrical characteristics internal physical and electrical information such as the junction voltages and the carrier distribution in different regions of the device can be obtained using

the models      **Automotive, Mechanical and Electrical Engineering** Lin Liu, 2017-06-26 The 2016 International Conference on Automotive Engineering Mechanical and Electrical Engineering AEMEE 2016 was held December 9 11 2016 in Hong Kong China AEMEE 2016 was a platform for presenting excellent results and new challenges facing the fields of automotive mechanical and electrical engineering Automotive Mechanical and Electrical Engineering brings together a wide range of contributions from industry and governmental experts and academics experienced in engineering design and research Papers have been categorized under the following headings Automotive Engineering and Rail Transit Engineering Mechanical Manufacturing Process Engineering Network Communications and Applied Information Technologies Technologies in Energy and Power Cell Engines Generators Electric Vehicles System Test and Diagnosis Monitoring and Identification Video and Image Processing Applied and Computational Mathematics Methods Algorithms and Optimization Technologies in Electrical and Electronic Control and Automation Industrial Production Manufacturing Management and Logistics      *Engineered Nanomaterials and Phytonanotechnology: Challenges for Plant Sustainability*, 2019-11-20 Engineered Nanomaterials and Phytonanotechnology Challenges for Plant Sustainability Volume 87 in the Comprehensive Analytical Chemistry series highlights new advances in the field with this new volume presenting interesting chapters on the Environmental application of nanomaterials A promise to sustainable future Plant nanoparticle interactions Mechanisms effects and approaches A general overview on application of nanoparticles in agriculture and plant science Engineered nanomaterials uptake bioaccumulation and toxicity mechanisms in plants Engineered nanomaterials in plants Sensors carriers and bio imaging Antioxidant role of nanoparticles for enhancing ecological performance of plant system Toxicity assessment of metal oxide nanoparticles on terrestrial plants and much more      *Signal Processing for Solar Array Monitoring, Fault Detection, and Optimization* Henry Braun, Mahesh Banavar, Andreas Spanias, Venkatachalam Krishnan, CIHAN TEPEDELENLIOGLU, Tohru Takemasa, Shinichi Takeda, 2022-06-01 Although the solar energy industry has experienced rapid growth recently high level management of photovoltaic PV arrays has remained an open problem As sensing and monitoring technology continues to improve there is an opportunity to deploy sensors in PV arrays in order to improve their management In this book we examine the potential role of sensing and monitoring technology in a PV context focusing on the areas of fault detection topology optimization and performance evaluation data visualization First several types of commonly occurring PV array faults are considered and detection algorithms are described Next the potential for dynamic optimization of an array s topology is discussed with a focus on mitigation of fault conditions and optimization of power output under non fault conditions Finally monitoring system design considerations such as type and accuracy of measurements sampling rate and communication protocols are considered It is our hope that the benefits of monitoring presented here will be sufficient to offset the small additional cost of a sensing system and that such systems will become common in the near future Table of Contents Introduction Overview of Photovoltaics Causes Performance Degradation and



Outage Fault Detection Methods Array Topology Optimization Monitoring of PV Systems Summary      Analysis of Sub-synchronous Resonance (SSR) in Doubly-fed Induction Generator (DFIG)-Based Wind Farms Hossein Ali

Mohammadpour, Enrico Santi, 2022-05-31 Wind power penetration is rapidly increasing in today's energy generation industry. In particular, the doubly fed induction generator (DFIG) has become a very popular option in wind farms due to its cost advantage compared with fully rated converter based systems. Wind farms are frequently located in remote areas far from the bulk of electric power users and require long transmission lines to connect to the grid. Series capacitive compensation of DFIG based wind farm is an economical way to increase the power transfer capability of the transmission line connecting the wind farm to the grid. For example, a study performed by ABB reveals that increasing the power transfer capability of an existing transmission line from 1300 MW to 2000 MW using series compensation is 90% less expensive than building a new transmission line. However, a factor hindering the extensive use of series capacitive compensation is the potential risk of subsynchronous resonance (SSR). The SSR is a condition where the wind farm exchanges energy with the electric network to which it is connected at one or more natural frequencies of the electric or mechanical part of the combined system comprising the wind farm and the network and the frequency of the exchanged energy is below the fundamental frequency of the system. This oscillatory phenomenon may cause severe damage in the wind farm if not prevented. Therefore, this book studies the SSR phenomenon in a capacitive series compensated wind farm. A DFIG based wind farm which is connected to a series compensated transmission line is considered as a case study. The book consists of two main parts. Small signal modeling of DFIG for SSR analysis. This part presents a step by step tutorial on modal analysis of a DFIG based series compensated wind farm using Matlab Simulink. The model of the system includes wind turbine aerodynamics, a 6th order induction generator, a 2nd order two mass shaft system, a 4th order series compensated transmission line, a 4th order rotor side converter (RSC) controller and a 4th order grid side converter (GSC) controller and a 1st order DC link model. The relevant modes are identified using participation factor analysis. Definition of the SSR in DFIG based wind farms. This part mainly focuses on the identification and definition of the main types of SSR that occur in DFIG wind farms, namely 1) induction generator effect (SSIGE), 2) torsional interactions (SSTI) and 3) control interactions (SSCI).      Digital Power Electronics and Applications Fang Lin Luo, Hong Ye, Muhammad H. Rashid, 2010-07-20 The purpose of this book is to describe the theory of Digital Power Electronics and its applications. The authors apply digital control theory to power electronics in a manner thoroughly different from the traditional analog control scheme. In order to apply digital control theory to power electronics, the authors define a number of new parameters including the energy factor, pumping energy, stored energy, time constant and damping time constant. These parameters differ from traditional parameters such as the power factor, power transfer efficiency, ripple factor and total harmonic distortion. These new parameters result in the definition of new mathematical modeling. A zero order hold (ZOH) is used to simulate all AC/DC rectifiers. A first order hold (FOH) is used to simulate all DC/AC

inverters A second order hold SOH is used to simulate all DC DC converters A first order hold FOH is used to simulate all AC AC AC DC AC converters Presents most up to date methods of analysis and control algorithms for developing power electronic converters and power switching circuits Provides an invaluable reference for engineers designing power converters commercial power supplies control systems for motor drives active filters etc Presents methods of analysis not available in other books

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