

# Preface

Switched electronic systems are used in a huge number of everyday domestic and industrial utilities: liquid crystal displays, home appliances, lighting, personal computers, power plants, transportation vehicles and so on. Efficient operations of all such applications depend on the essential “hidden work” done by switched electronic systems, whose behaviour is determined by a suitable interconnection and control of analogue and digital devices.

From the engineering point of view, most switched electronic systems can be classified as power converters. These systems can be viewed as networks composed of semiconductor switches, e.g., thyristors, transistors and diodes, along with passive elements, e.g., inductors, capacitors and resistors, and current–voltage sources. Such systems play a fundamental role in all those environments where regulation, control and conversion of the electrical energy is a key issue. In recent years, continuously more demanding efficiency and quality constraints are imposed on the electrical energy in applications such as electrical drives, power systems and transportation vehicles. This has determined a renewed research interest in the study of formal approaches for the analysis and control of power converters. In this context the analysis, design and control of switched electronic systems is a key issue, and the use of advanced mathematical tools can be an effective approach for tackling increasing requirements in performance and efficiency.

From the mathematical point of view, switched systems represent a useful framework for modelling power converters. A typical approach for the analysis of power electronics converters consists of assuming idealised characteristics of the electronic switches. This approach yields to an important advantage: neglecting some details of the device behaviour does not eclipse the basic operation of the circuit, making easier the analysis and, sometimes, reducing the computational load for numerical simulations. Ideal characteristics of the switching devices allow one to model power electronic converters as switched systems. The network evolves through multiple topologies (or modes) depending on the discrete states of the switching devices (conducting or blocking). Unfortunately, the commutation conditions of the electronic switches, also in open-loop operating conditions, can depend on the state variables, and the switched model eventually becomes rather complex also for sim-

ple converter topologies. Then, idealisation of power converters introduces problems not commonly encountered when analysing generic switched models or non-switched electrical networks. In this sense the analysis of switched electronic systems can represent a source for new ideas and benchmarks also for the more general class of switched and hybrid systems.

This book presents an overview of the recent research advances on modelling, simulation and control of switched electronic systems. Contents organisation, illustration of realistic examples and numerical simulations provide the reader with specific quick references and a mathematically based state-of-the-art on the analysis and control design techniques for switched power converters. The book is organised in four parts. Part I provides some inspiring preliminaries coming from the power electronics community. Non-conventional converters topologies, advanced modulation techniques, commercial solutions for power converter controllers and applications to electrical energy grid guide the reader throughout the comprehension and exploration of most promising techniques used in power electronics which could inspire some practically-based directions for theoretical investigations on switched systems. Part II is dedicated to the most promising mathematical modelling frameworks suitable for switched electronic systems: continuous-time averaging, differential algebraic equations, linear complementarity models, energy- and power-based approaches. In Part III some modern control strategies for power converters are presented dealing with averaging, sliding modes, model predictive control, Hamiltonian systems. Challenges in numerical simulations of switched electronic systems are proposed in Part IV by presenting an overview of most common commercial simulation tools, numerical integrations of complementarity models and real-time techniques.

The book will be readily appreciated by engineers, mathematicians and physicists working on system and circuit theory, control systems development, electronic and energy conversion systems design:

- Several practical examples originating from power electronics stimulate control engineers and mathematicians to look at open issues in modelling, simulation and control of switched systems.
- A good balance between rigorous analysis and intuitive illustrations easily allows electronic engineers to become familiar with advanced mathematical techniques suitable for electronic systems.
- Examples on the modelling, simulation and control of power converters can inspire industrial engineers to the solution of related analysis and design problems in complex energy conversion systems.

We wish the reader an interesting and insightful journey throughout the book!

Benevento, Italy

Francesco Vasca  
Luigi Iannelli

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Vasca, F.; Iannelli, L. (Eds.)

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