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Vehicle Power Management

Modeling, Control and Optimization

Springer

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Preface

The world faces two important challenges nowadays: increased energy demand and serious environmental concerns. Global climate change due to green house gas emissions has brought worries about sea-level increase and severe climate damages that are afflicting people. However, the fact is that the vexations are brought about by the human-beings ourselves. The blind deforestation, large-scaled urbanization, and exponentially expanded consumption of fossil-fuel are key contributors to these social and environmental problems. Fortunately, we are more and more aware of these challenges and in the process of developing effective measures to tackle and mitigate these problems. The Kyoto Protocol, Copenhagen Accord, and Cancun Agreements are good proofs.

Automobiles as a major contributor for air pollution and greenhouse gases emissions are under deep innovation and brand-new definitions. Meanwhile the global energy shortage also offers new demands on alternative fuel applications to the automobile industry. Under such a background, development of electric vehicles, hybrid electric vehicles, plugin hybrid electric vehicles, and fuel cell vehicles has been the hottest topic across the automobile industry. New energy sources and energy storage systems (ESS) such as lithium-ion batteries, hydrogen fuel cell and ultra-capacitors are introduced to the design and production of electric and hybrid electric vehicles. Besides, high-performance alternators, electric motors and mechanical transmissions are incorporated in various hybrid architectures (e.g. parallel, series, series-parallel, complex, etc.).

Historically, studies have been concentrated on modeling, control and optimization of vehicle powertrain structure and components with the aim of fuel economy improvement, pollutant emission reduction, lifetime extension of ESS, vehicle drivability and reliability enhancement for various types of electric and hybrid electric vehicles. In the past two decades, new ideas about vehicle power management have been emerging exponentially, including dynamic programming (DP), analytical approaches and intelligent system approaches. Additionally, satisfactory test results when applied to real vehicles are considerable.

Unfortunately, although reasonable amount of literature exists in the area of vehicle power management, there always exists a feeling that the research results

are dispersive and not systematic. With such a consideration, the authors decide to write a book to systematically define, analyze and summarize the vehicle power management technology. Thus, this book is born.

The material of the book composition is mainly derived from many years of research experience of the authors and several colleagues and students. Some ideas from published references are introduced and quoted with their permissions. Three aspects for vehicle power management with modeling, control and optimization involved are focused on. Definitions, objectives, mathematical models, development tools, cases studies, and prospects related to vehicle power management are covered by the book. In addition, the system-level and component-level methodologies are both discussed. The book consists of 11 chapters, and reasonable configurations and stratified descriptions will bring in fresh and comprehensive understanding to the vehicle power management technology.

Similar to most publications, the book starts with an introduction in Chap. 1. An overview of application fields and necessity of vehicle power management is provided in this chapter.

Chapter 2 focuses on fundamentals and basic concepts of vehicle power management, including effects on vehicle performance, drive cycles and power demands, major applied software tools and so on.

In Chap. 3, uniform model representations for vehicular components (i.e., energy sources, ESS, electric machines and mechanical devices) existing in the vehicle powertrain are described in detail.

Chapters 4–7 describe the theoretical fundamentals and applications of state-of-the-art vehicle power management strategies. The analytical approach, dynamic and quadratic programming, and intelligent system approach employed for vehicle power management have already existed in various publications. However, the authors extend some new thoughts to their applications. These three strategies are introduced in Chaps. 4, 6 and 7, respectively. The wavelet-based power management approach for multiple on-board energy sources and ESS is depicted in Chap. 5. The theoretical system for applications of the wavelet technology on various types of vehicles is established, and the real-time analysis for employment in real vehicles is also given.

The battery is an essential factor for development of alternative fuel vehicles. At some point of view, the cost, volume, charging convenience and lifetime of the battery determines the marketization process of hybrid electric and all-electric vehicles. Consequently, the book specially gives one chapter's space to the management of energy storage systems with main focus on batteries. Chapter 8 focuses on the energy management strategies for the purpose of battery lifetime extension and precise estimation of the battery status for powertrain controls.

Type selection, configuration, and design optimization of powertrain components in the early development stage for hybrid vehicles will represent significant impacts to running vehicles on dynamic performance, fuel economy and emissions. Therefore, Chap. 9 discusses the component optimization issues for avoiding unnecessary losses on these aspects.

Hardware-in-the-loop (HIL) and software-in-the-loop (SIL) are delineated in Chap. 10 since they can substantially lower the cost and the time for delivery of a vehicular product to market.

Chapter 11 paints magnificent application prospects of vehicle power management for readers, and points out potential problems to be faced. Also, some advanced technologies of alternative fuel vehicles and accordingly powertrain components are introduced in this chapter.

The book can be used as a textbook to educate undergraduate and graduate students majoring in automotive engineering. Students majoring in mechanical engineering, electric engineering, and computer science and engineering may find this book useful when dealing with vehicle related design, optimization and control development. Besides, the book can be used as a reference for designers and engineers working in the automobile industry. Abundant case studies are beneficial for development of alternative fuel vehicular systems.

The authors wish to extend sincere thanks to several colleagues who made signification contributions for the successful publication of this book. In particular, Mr. Mengyang Zhang, a specialist in HEV, lent his idea to the authors to form the basis of Chap. 4, Analytical Approaches for Vehicle Power Management. Students in the research group of Professor Chris Mi provided the original material and helped draft the manuscript of a few chapters: Dr. Zheng Chen for Sects. 6.1 to 6.2, and Sect. 7.5, Zhiguang Zhou for Sect. 6.3 and Sect. 7.6, Bingzhang Zhang for Sects. 4.1 and 9.1, Yan Yang for Sect. 4.2, Dr. Wenzhong Gao for Sect. 9.2. Without their great efforts, the book would not have been possible.

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