Preface

The origin of hybrid electric vehicles dates back to 1899, when Dr. Ferdinand Porsche, then a young engineer at Jacob Lohner & Co, built the first hybrid vehicle [1], the Lohner-Porsche gasoline-electric *Mixte*. After Porsche, other inventors proposed hybrid vehicles in the early twentieth century, but then the internal combustion engine technology improved significantly and hybrid vehicles, much like battery-electric vehicles, disappeared from the market for a long time.

Nearly a century later, hybrid powertrain concepts returned strongly, in the form of many research prototypes but also as successful commercial products: Toyota launched the Prius—the first purpose-designed and -built hybrid electric vehicle—in 1998, and Honda launched the Insight in 1999. What made the new generation of hybrid vehicles more successful than their ancestors was the completely new technology now available, especially in terms of electronics and control systems to coordinate and exploit at best the complex subsystems interacting in a hybrid vehicle. Substantial support to research in this field was provided by government initiatives, such as the US *Partnership for a New Generation of Vehicles* (PNGV) [2], which involved DaimlerChrysler, Ford Motor Company, and General Motors Corporation. PNGV provided the opportunity for many research projects to be carried out in collaborations among the automotive companies, their suppliers, national laboratories, and universities. The material assembled in this book is an outgrowth of the experience that the authors gained while working together at the Ohio State University Center for Automotive Research, one of the PNGV academic labs, which has been engaged in programs focused on the development of vehicle prototypes and on the development of energy management strategies and algorithms since 1995.

Energy management strategies are necessary to achieve the full potential of hybrid electric vehicles, which can reduce fuel consumption and emissions in comparison to conventional vehicles, thanks to the presence of a reversible energy storage device and one or more electric machines. The presence of an additional energy storage device gives rise to new degrees of freedom, which in turn translate into the need of finding the most efficient way of splitting the power demand

between the engine and the battery. The energy management strategy is the control layer to which this task is demanded.

Despite many articles on hybrid electric vehicles system, control, and optimization, there has not been a book that systematically discusses deeper aspects of the model-based design of energy management strategies. Thus, the aim of this book is to present a systematic model-based approach and propose a formal framework to cast the energy management problem using optimal control theory tools and language.

The text focuses on the development of model-based supervisory controller when the fuel consumption is being minimized. It does not consider other cost functions, such as pollutant emissions or battery aging. Drivability issues such as noise, harshness, and vibrations are neglected as well as heuristic supervisory controllers design.

The aim is to provide an adequate presentation to meet the ever-increasing demand for engineers to look for rigorous methods for hybrid electric vehicles analysis and design.

We hope that this book will be suitable to educate mechanical and electrical engineering graduate students, professional engineers, and practitioners on the topic of hybrid electric vehicle control and optimization.

Acknowledgments

We are extremely grateful to all our colleagues for the fruitful discussions on the topics discussed in this book. We are also grateful to Springer editorial staff for their support and patience.

August 2015

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http://www.springer.com/978-1-4471-6779-2

Hybrid Electric Vehicles
Energy Management Strategies
Onori, S.; Serrao, L.; Rizzoni, G.
2016, XV, 112 p. 71 illus., 3 illus. in color. With online files/update., Softcover
ISBN: 978-1-4471-6779-2