**DESCRIPTION**

The why, what and how of the electric vehicle powertrain

Empowers engineering professionals and students with the knowledge and skills required to engineer electric vehicle powertrain architectures, energy storage systems, power electronics converters and electric drives.

The modern electric powertrain is relatively new for the automotive industry, and engineers are challenged with designing affordable, efficient and high-performance electric powertrains as the industry undergoes a technological evolution. Co-authored by two electric vehicle (EV) engineers with decades of experience designing and putting into production all of the powertrain technologies presented, this book provides readers with the hands-on knowledge, skills and expertise they need to rise to that challenge.

This four-part practical guide provides a comprehensive review of battery, hybrid and fuel cell EV systems and the associated energy sources, power electronics, machines, and drives. The first part of the book begins with a historical overview of electromobility and the related environmental impacts motivating the development of the electric powertrain. Vehicular requirements for electromechanical propulsion are then presented. Battery electric vehicles (BEV), fuel cell electric vehicles (FCEV), and conventional and hybrid electric vehicles (HEV) are then described, contrasted and compared for vehicle propulsion. The second part of the book features in-depth analysis of the electric powertrain traction machines, with a particular focus on the induction machine and the surface- and interior-permanent magnet ac machines. The brushed dc machine is also considered due to its ease of operation and understanding, and its historical place, especially as the traction machine on NASA’s Mars rovers. The third part of the book features the theory and
applications for the propulsion, charging, accessory, and auxiliary power electronics converters. Chapters are presented on isolated and non-isolated dc-dc converters, traction inverters, and battery charging. The fourth part presents the introductory and applied electromagnetism required as a foundation throughout the book.

• Introduces and holistically integrates the key EV powertrain technologies.

• Provides a comprehensive overview of existing and emerging automotive solutions.

• Provides experience-based expertise for vehicular and powertrain system and sub-system level study, design, and optimization.

• Presents many examples of powertrain technologies from leading manufacturers.

• Discusses the dc traction machines of the Mars rovers, the ultimate EVs from NASA.

• Investigates the environmental motivating factors and impacts of electromobility.

• Presents a structured university teaching stream from introductory undergraduate to postgraduate.

• Includes real-world problems and assignments of use to design engineers, researchers, and students alike.

• Features a companion website with numerous references, problems, solutions, and practical assignments.

• Includes introductory material throughout the book for the general scientific reader.

• Contains essential reading for government regulators and policy makers.

Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles is an important professional resource for practitioners and researchers in the battery, hybrid, and fuel cell EV transportation industry. The book is a structured holistic textbook for the teaching of the fundamental theories and applications of energy sources, power electronics, and electric machines and drives to engineering undergraduate and postgraduate students.

**Textbook Structure and Suggested Teaching Curriculum**

This is primarily an engineering textbook covering the automotive powertrain, energy storage and energy conversion, power electronics, and electrical machines. A significant additional focus is placed on the engineering design, the energy for transportation, and the related environmental impacts. This textbook is an educational tool for practicing engineers and others, such as transportation policy planners and regulators. The modern automobile is used as the vehicle upon which to base the theory and applications, which makes the book a useful educational reference for our industry colleagues, from chemists to engineers. This material is also written to be of interest to the general reader, who may have little or no interest in the power electronics and machines. Introductory science,
mathematics, and an inquiring mind suffice for some chapters. The general reader can read the introduction to each of the chapters and move to the next as soon as the material gets too advanced for him or her.

Part I Vehicles and Energy Sources

Chapter 1 Electromobility and the Environment

Chapter 2 Vehicle Dynamics

Chapter 3 Batteries

Chapter 4 Fuel Cells

Chapter 5 Conventional and Hybrid Powertrains

Part II Electrical Machines

Chapter 6 Introduction to Traction Machines

Chapter 7 The Brushed DC Machine

Chapter 8 Induction Machines

Chapter 9 Surface-permanent-magnet AC Machines

Chapter 10: Interior-permanent-magnet AC Machines

Part III Power Electronics

Chapter 11 DC-DC Converters

Chapter 12 Isolated DC-DC Converters

Chapter 13 Traction Drives and Three-phase Inverters

Chapter 14 Battery Charging

Chapter 15 Control of the Electric Drive

Part IV Basics

Chapter 16 Introduction to Electromagnetism, Ferromagnetism, and Electromechanical Energy Conversion

The first third of the book (Chapters 1 to 6), plus parts of Chapters 14 and 16, can be taught to the general science or engineering student in the second or third year. It covers the introductory automotive material using basic concepts from mechanical, electrical,
environmental, and electrochemical engineering. Chapter 14 on electrical charging and Chapter 16 on electromagnetism can also be used as a general introduction to electrical engineering.

The basics of electromagnetism, ferromagnetism and electromechanical energy conversion (Chapter 16) and dc machines (Chapter 7) can be taught to second year (sophomore) engineering students who have completed introductory electrical circuits and physics.

The third year (junior) students typically have covered ac circuit analysis, and so they can cover ac machines, such as the induction machine (Chapter 8) and the surface permanent-magnet ac machine (Chapter 9). As the students typically have studied control theory, they can investigate the control of the speed and torque loops of the motor drive (Chapter 15). Power electronics, featuring non-isolated buck and boost converters (Chapter 11), can also be introduced in the third year.

The final-year (senior) students can then go on to cover the more advanced technologies of the interior-permanent-magnet ac machine (Chapter 10). Isolated power converters (Chapter 12), such as the full-bridge and resonant converters, inverters (Chapter 13), and power-factor-corrected battery chargers (Chapter 14), are covered in the power electronics section. This material can also be covered at the introductory postgraduate level. Various homework, simulation, and research exercises are presented throughout the textbook.

The reader is encouraged to attempt these exercises as part of the learning experience. Instructors are encouraged to contact the author, John Hayes, direct to discuss course content or structure.

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ABOUT THE AUTHOR

John G. Hayes, PhD, MSEE, MBA, lectures at University College Cork, Ireland, and specialises in automotive, industrial and renewable energy systems and related power electronics, machines and electromagnetism. He previously worked in Southern California for ten years at General Motors' Hughes Aircraft subsidiary developing EV propulsion and inductive charging systems for the General Motors EV1, the first modern production EV. John's recent focus has been on the development of integrated and holistic EV teaching materials for the engineering student and the automotive professional.

G. Abas Goodarzi, PhD, P.E., is the Chief Executive Officer and President of US Hybrid Corporation, Torrance, California, which he founded in 1999. He is also the President of US FuelCell, a company formed with the acquisition by US Hybrid of the United Technologies PEM fuel cell transportation division. He served as Senior Scientist at General Motors' Hughes Aircraft subsidiary, and as Technical Director for the General Motors EV1. He has designed various EV, HEV, and FCEV powertrain systems for light, medium, and heavy-duty, on-road, off-road, and special-purpose vehicles.
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