Energy Management Strategies For Hybrid Electric Vehicles

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Sustainable Energy - Without the Hot Air with David MacKay Electrified Vehicle Energy Management: Solutions and Opportunities *Energy Management Strategies For Hybrid*

The energy management strategy in a hybrid electric vehicle (HEV) plays a very important role in the improvement of fuel economy and the reduction of emissions. This chapter discusses several practical and advanced energy management strategies of an HEV. A rule-based energy management strategy is one of the most commonly used strategies in light to mild HEVs, especially in the early development stage.

Energy Management Strategies for Hybrid Electric Vehicles ...

Energy management strategies in hybrid renewable energy systems: A review 1. Introduction The past few decades have shown an accelerated global effort in the development of renewable energy... 2. Energy management strategies in standalone hybrid renewable energy systems This section reviews the ...

Energy management strategies in hybrid renewable energy ...

Abstract In this paper a fuzzy logic, rule based control strategy is proposed for a parallel, hybrid electric vehicle. The energy management optimizes engine operational efficiency while...

Energy Management Strategies for a Hybrid Electric Vehicle

V. ENERGY MANAGEMENT STRATEGY The basic idea of a hybrid vehicle is to decouple the energy source (in the ICE and the BAT) from the energy utilization (in the wheels) by an intermediate stage (the IS). The energy contained in the fuel is transformed to mechanical energy (ICE) and by a generating element (the DFIG) in electric

Energy Management Strategies for Hybrid Electric Vehicles

A suitable energy management strategy is the vital technology to determine the energy saving and emission reduction performance of HCM. In the present paper, the dierence between construction machinery and automobiles is first analyzed from the perspective

Energy Management Strategies for Hybrid Construction ...

The highest control layer of a (hybrid) vehicular drive train is termed the Energy Management Strategy (EMS). In this paper an overview of different control methods is given and a new rule-based...

(PDF) A Rule-based energy management strategies for hybrid ...

Abstract: A rule-based control and energy management strategy for a series hybrid vehicle is presented. The strategy is based on splitting the power demand between the engine and the battery such that these power sources are operated at high efficiency. The power demand is estimated as the output of a high gain PI controller that controls the longitudinal acceleration of the vehicle.

A rule-based energy management strategy for a series ...

This SpringerBrief deals with the control and optimization problem in hybrid electric vehicles. Given that there are two (or more) energy sources (i.e., battery and fuel) in hybrid vehicles, it shows the reader how to implement an energy-management strategy that decides how much of the vehicle’s power is provided by each source instant by instant.

Hybrid Electric Vehicles - Energy Management Strategies ...

Abstract: The highest control layer of a (hybrid) vehicular drive train is termed the Energy Management Strategy (EMS). In this paper an overview of different control methods is given and a new rule-based EMS is introduced, based on the combination of Rule-Based – and Equivalent Consumption Minimization Strategies (RB-ECMS).

Rule-based energy management strategies for hybrid ...

Various techniques have been proposed to optimize the performance of rule-based energy management strategy, such as blending energy management strategy composed of rule-based energy management strategy and instantaneous energy management strategy , hybrid energy management strategy combining rule-based energy management strategy and ECMS , extracting efficient thresholds and rules from optimization-based energy management strategy such as DP and PMP .

A comprehensive analysis of energy management strategies ...

A Supervisory Energy Management Control Strategy in a Battery/Ultracapacitor Hybrid Energy Storage System. Abstract: One of the major challenges in a battery/ ultracapacitor hybrid energy storage system (HESS) is to design a supervisory controller for real-time implementation that can yield good power split performance.

A Supervisory Energy Management Control Strategy in a ...

Energy Management Strategies for Plug-In Hybrid Electric Vehicles 2007-01-0290 Plug-in hybrid electric vehicles (PHEVs) differ from hybrid vehicles (HEVs) with their ability to use off-board electricity generation to recharge their energy storage systems.

Energy Management Strategies for Plug-In Hybrid Electric ...

This paper comprehensively explores the Energy Management Strategy (EMS) of a Hybrid Energy Storage System (HESS) with battery, Fuel Cell (FC) and a supercapacitor (SC) for the application of Electric Vehicles (EV). Improving the efficiency and effective utilization of the battery system in safe operating conditions is the main concern of the ...

Energy Management Strategies for Hybrid Energy Storage ...

An instantaneous fuel efficiency optimization strategy was developed for parallel hybrid vehicle with the charge sustaining mode in [6]. Also, to implement the global constraint, the authors developed a nonlinear penalty function in terms of battery SOC deviation from its desired value.

Energy Management Strategy Implementation for Hybrid ...

The battery with high-energy density and ultracapacitor with high-power density combination paves a way to overcome the challenges in energy storage system. This study aims at highlighting the various hybrid energy storage system configurations such as parallel passive, active, battery–UC, and UC–battery topologies.

A comprehensive review on energy management strategies of ...

A rule-interposing deep reinforcement learning (RIDRL) based energy management strategy (EMS) of hybrid electric vehicle (HEV) is investigated.

GitHub - lryz0612/DRL-Energy-Management: Deep ...

Energy management strategies (EMS) determine the power allocation among different power sources and promote the energy efficiency and service life of the hybrid power system. In general, the energy management strategies can be classified into two categories : optimization-based strategies and rule-based strategies.

Fuzzy State Machine Energy Management Strategy for Hybrid ...

The hybrid vehicle control problem at the highest level is termed the Energy Management Strategy (EMS). This paper presents a new, and simple Rule-Based (RB) EMS, whereby maximum power level of the electric machine during pure electric driving is the control design variable.

Rule-based energy management strategies for hybrid vehicle ...

Energy Management Strategies for Modern Electric Vehicles Using MATLAB/Simulink 283 charge (SOC) of the battery is full, it directly starts to charge the battery until its SOC is reached to the maximum limit. The lithium ion battery and a proton exchange membrane (PEM) based electrolyzer is considered.

Energy Management Strategies for Modern Electric Vehicles ...

This paper presents a formalization of the energy management problem in hybrid electric vehicles and a comparison of three known methods for solving the resulting optimization problem. Dynamic programming (DP), Pontryagin’s minimum principle (PMP), and equivalent consumption minimization strategy (ECMS) are described and analyzed, showing formally their substantial equivalence.

This SpringerBrief deals with the control and optimization problem in hybrid electric vehicles. Given that there are two (or more) energy sources (i.e., battery and fuel) in hybrid vehicles, it shows the reader how to implement an energy-management strategy that decides how much of the vehicle’s power is provided by each source instant by instant. Hybrid Electric Vehicles: •introduces methods for modeling energy flow in hybrid electric vehicles; •presents a standard mathematical formulation of the optimal control problem; •discusses different optimization and control strategies for energy management, integrating the most recent research results; and •carries out an overall comparison of the different control strategies presented. Chapter by chapter, a case study is thoroughly developed, providing illustrative numerical examples that show the basic principles applied to real-world situations. The brief is intended as a straightforward tool for learning quickly about state-of-the-art energy-management strategies. It is particularly well-suited to the needs of graduate students and engineers already familiar with the basics of hybrid vehicles but who wish to learn more about their control strategies.

This book addresses the practical issues for commercialization of current and future electric and plug-in hybrid electric vehicles (EVs/PHEVs). The volume focuses on power electronics and motor drives based solutions for both current as well as future EV/PHEV technologies. Propulsion system requirements and motor sizing for EVs is also discussed, along with practical system sizing examples. PHEV power system architectures are discussed in detail. Key EV battery technologies are explained as well as corresponding battery management issues are summarized. Advanced power electronic converter topologies for current and future charging infrastructures will also be discussed in detail. EV/PHEV interface with renewable energy is discussed in detail, with practical examples.

Hybrid electric vehicles are a result of a global push towards cleaner and fuel-efficient vehicles. They use both electrical and traditional fossil-fuel based energy sources, which makes them ideal for the transition towards much cleaner electric vehicles. A key part of the hybridization effort is designing effective energy management algorithms because they are crucial in reducing fuel consumption and emission of the hybrid vehicle. In the automotive industry, energy management systems are designed, prototyped, and validated in a software simulation environment before implementation on the hybrid vehicle. The software simulation uses model-based design techniques which reduce development time and cost. Traditionally, the design of energy management systems is based on statutory drive-cycles. Drive-cycle based solutions to energy management systems improve fuel economy of the vehicle and are well suited for statutory certification of fuel economy and emissions. In recent times however, the fuel economy and emissions over real-world driving is being considered increasingly for statutory certification. In light of these developments, methodologies to simulate and design new energy management strategies for real-world driving are needed. The work presented in this dissertation systematically addresses the challenges faced in the development of such a methodology. This work identifies and solves three sub-problems which together form the methodology for model-based real-world look-ahead energy management system development. First, a simulation framework to simulate real-world driving and look-ahead sensor emulation is developed. The simulation framework includes traffic simulation and powertrain simulation capabilities. It is termed traffic integrated powertrain co-simulation.Second, a comprehensive algorithm is developed to utilize look-ahead sensor data to accurately predict the vehicle's future velocity trajectories. Finally, through the use of optimal control algorithms, a look-ahead energy management system is developed to understand the utility of different look-ahead technologies in the improvement of fuel economy.

Abstract: The dissertation offers an overview of the energy management problem in hybrid electric vehicles. Several control strategies described in literature are presented and formalized in a coherent framework. A detailed vehicle model used for energy flow analysis and vehicle performance simulation is presented. Three of the strategies (dynamic programming, Pontryagin's minimum principle, and equivalent consumption minimization strategy, also known as ECMS) are analyzed in detail and compared from a theoretical point of view, showing the underlying similarities. Simulation results are also provided to demonstrate the application of the strategies.

The dissertation offers a systematic analysis on the interdependency between fuel economy and battery capacity degradation in hybrid electric vehicles. Optimal control approaches including Dynamic Programming and Pontryagin's Minimum Principle are used to develop energy management strategies, which are able to optimally tradeoff fuel consumption and battery aging. Based on the optimal solutions, a real-time implementable battery-aging-conscious Adaptive Equivalent Consumption Management Strategy is proposed, which is able to achieve performance that is comparable to optimal results. In addition, an optimal control based charging strategy for plug-in hybrid electric vehicles and battery electric vehicles is developed, which minimizes battery capacity degradation incurred during charging by optimizing the charging current profile. Combining a generic control-oriented vehicle cabin thermal model with the battery aging model, the benefit of this strategy in terms of decreasing battery aging is significant, when compared with the existing strategies, such as the widely accepted constant current constant voltage (CC-CV) protocol. Thus this dissertation presents a complete set of optimal control solutions related to xEVs with consideration of battery aging.

Abstract : Hybrid Electric Vehicles (HEVs) are used to overcome the short-range and long charging time problems of purely electric vehicles. HEVs have at least two power sources. Therefore, the Energy Management (EM) strategy for dividing the driver requested power between the available power sources plays an important role in achieving good HEV performance. This work, proposes a novel real-time EM strategy for HEVs which is named ECMS-CESO. ECMS-CESO is based on the Equivalent Consumption Minimization Strategy (ECMS) and is designed to Catch Energy Saving Opportunities (CESO) while operating the vehicle. ECMS-CESO is an instantaneous optimal controller, i. e., it does not require prediction of the future demanded power by the driver. Therefore, ECMS-CESO is tractable for real-time operation. Under certain conditions ECMS achieves the maximum fuel economy. The main challenge in employing ECMS is the estimation of the optimal equivalence factor L*. Unfortunately, L* is drive-cycle dependent, i. e., it changes from driver to driver and/or route to route. The lack of knowledge about L* has been a motivation for studying a new class of EM strategies known as Adaptive ECMS (A-ECMS). A-ECMS yields a causal controller that calculates L(t) at each moment t as an estimate of L*. Existing A-ECMS algorithms estimate L*, by heuristic approaches. Here, instead of direct estimation of L*, analytic bounds on L* are determined which are independent of the drive-cycle. Knowledge about the range of L*, can be used to adaptively set L(t) as performed by the ECMS-CESO algorithm. ECMS-CESO also defines soft constraints on the battery state of charge (SOC) and a penalty for exceeding the soft constraints. ECMS-CESO is allowed to exceed a SOC soft constraint when an energy saving opportunity is available. ECMS-CESO is efficient since there is no need for prediction and the intensive calculations for finding the optimal control over the predicted horizon are not required. Simulation results for 3 different HEVs are used to confirm the expected performance of ECMS-CESO. This work also investigates the performance of the model predictive control with respect to the predicated horizon length.

Abstract : The equivalent consumption minimization strategy (ECMS) is a well-known energy management strategy for Hybrid Electric Vehicles (HEV). ECMS is very computationally efficient since it yields an instantaneous optimal control. ECMS has been shown to minimize fuel consumption under certain conditions. But, minimizing the fuel consumption often leads to excessive battery damage. The objective of this dissertation is to develop a real-time implementable optimal energy management strategy which improves both the fuel economy and battery aging for Hybrid Electric Vehicles by using ECMS. This work introduces a new optimal control problem where the cost function includes terms for both fuel consumption and battery aging. The Ah-throughput method is used to quantify battery aging. ECMS (with the appropriate equivalence factor) is shown to also minimize the cost function that incorporates battery aging. Finding the appropriate equivalence factor often required prior knowledge of the entire drive cycle. While using the appropriate equivalence factor might miss the opportunities for fuel savings under certain conditions. Therefore, an adaptive control law of equivalence factor called Catch Energy Saving Opportunity (CESO) has been introduced in this work to make the proposed aging ECMS real-time implementable. In order to better understand the impact of the developed optimal strategies on battery aging in HEVs, systematic analysis has been performed to find relations between fuel economy, battery aging and the optimization decisions when using ECMS. Therefore, the varies equivalence factors, state of charge constraints and battery temperatures are observed and analyzed under different Combined Drive-cycles (CDs). The CDs are formulated to test the energy management strategy and battery aging with weights on city and highway drive. In addition, rule-based control in charge-depletion mode aimed to improve battery aging has been simulated in a HEV truck. The simulation results show that, the fuel consumed and battery aging degradation during varied operation could be significantly improved by using a simple control rule in charge-depletion mode. This further indicates the benefits of implementing a battery aging term which impacts the control decision in charge-sustaining ECMS. Based on the analysis results, an aging ECMS has been developed by adding a battery aging term as a cost to the battery. The simulation results showed that this optimal energy management strategy improves battery aging significantly with little or no penalty in fuel economy. In addition, aging CESO ECMS, a real-time optimal strategy, has been developed based on the proposed aging ECMS. The simulation results show that aging CESO ECMS improvs upon the basic aging ECMS performance.