New Concepts for Electric Vehicle Development, from Optimization to Controls and System Architecture

Prof. Francis Assadian, Ehsan Arasteh, GSR, Dr. Andrew Burke

Mechanical and Aerospace Engineering and Institute of Transportation Studies, University of California, Davis - *12/2015*

Introduction

In this study, we investigate the impact of battery aging, efficiency and performance of EV/HEVs by considering all possible combinations of hardware components, such as energy/power storage devices, ultra-capacitors and PV (Photovoltaic Panels), and control software, and functional architectures.

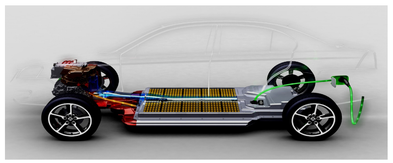

Fig 1. Battery and powertrain of an EV

Fig 2. Ultra-capacitors

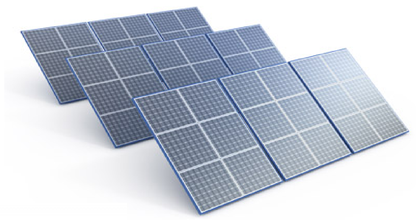

Fig 3. Solar Panels

Fig 4. Batteries of an EV

1st Phase: Lit. review, Physical system modelling

Detailed physical system modelling of different EV/HEVs will be performed. Bond graph method will be utilized to model the physical components, such as battery and supercapacitor, and the overall EV/HEV powertrain architecture. These models will be used as forward facing in the final phase of this project.

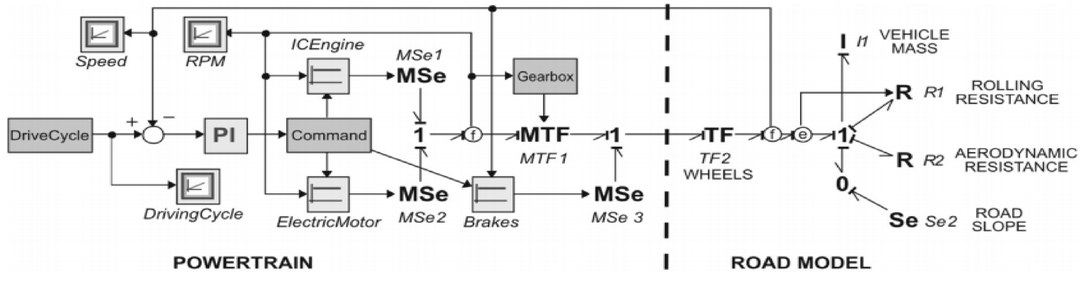

Fig 5. Example of a Bond Graph of powertrain

2nd Phase: Backward models and optimization

An investigation of new modeling techniques, such as inverse bond graph approach, will be considered. These models will be employed as backward facing models to be used in the optimization phase of this project. This modeling approach will be extended for powertrain optimization of ultra-capacitor and battery HEV/EVs. The outcome of this optimization should result in an increase in battery life (and therefore lower maintenance cost), and overall powertrain efficiency.

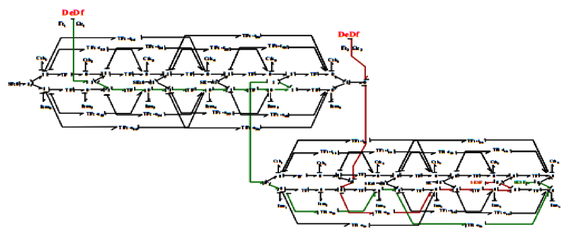

Fig 6. An example of inverse bond graph method

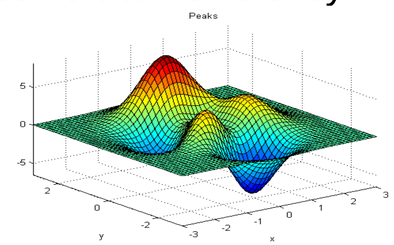

Fig 7. Example of optimization in MATLAB ®

3rd Phase: Applying advanced controls

The impact of advanced control algorithms and control functional architecture on further optimizing the EV powertrain using our previously developed models will be researched.

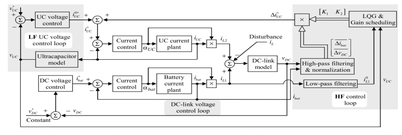

Fig 8. Advanced control concepts used in EV powertrain optimization

Final Phase: Test and Validating

Our plan is to test and validate our findings on an EV powertrain test rig, which will be developed as a part of this research.

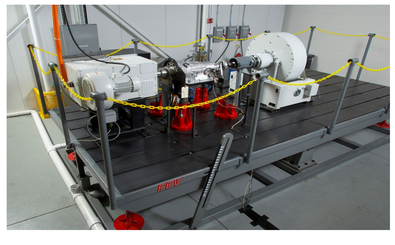

Fig 9. Powertrain test rig FEV Inc.

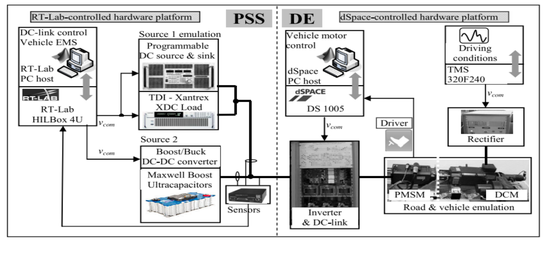

Fig 10. Hardware configuration of the real-time simulation test bench used for EV EMS validation

References:

Fig 1. http://etap.com/renewable-energy/photovoltaic-array-solar-panel.htm?lang=en-US

Fig 2. http://www.icd-sales.com/Products/Super-Capacitors-and-Modules.aspx

Fig 3. http://www.businesskorea.co.kr/english/news/industry/8555-patent-powers-three-local-companies-occupy-345-patents-electric-car-batteries

Fig 4. http://www.greencarreports.com/news/1084687_electric-car-battery-breakthroughs-ultimate-guide

Fig 5. Filippa et al (2005),"Modeling of a Hybrid Electric Vehicle Powertrain Test Cell Using Bond Graphs.", IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 54, NO. 3

Fig 6. Ref: Derkaoui et al (2006), "Design of an actuating system using Inverse bond graph methodology: Application of FEM to a tow-links flexible manipulator.", IEEE Industrial Electronics, IECON 2006 - 32nd Annual Conference

Fig 7. -

Fig 8. Florescu et al (2015), "LQG Optimal Control Applied to On-Board Energy Management System of All-Electric Vehicles.", IEEE Transactions on control systems Tech. VOL. 23, NO. 4

Fig 9. http://articles.sae.org/6397/

Fig 10. Same as Fig 8.

SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

An Institute of Transportation Studies Program

Contacting the Authors:

Francis Assadian (*f.assadian@ucdavis.edu),* Ehsan Arasteh (*earasteh@ucdavis.edu)*