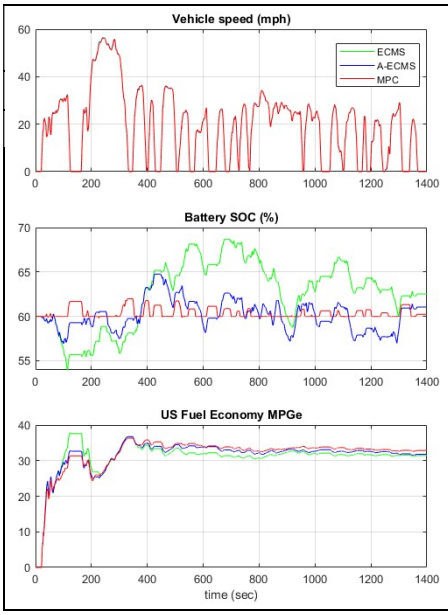
Project Note 76

Design and Evaluation of Advanced Powertrain Control for Hybrid Electrical Vehicles

ISC has worked with NXP Semiconductors to design and evaluate, in Processor-In-the-Loop tests, the performance of an advanced powertrain controller for hybrid electrical vehicles (HEV). The controller was based on model-based predictive control (MPC). It was compared with the traditional Equivalent Consumption Minimisation Strategy (ECMS) and Adaptive ECMS design solutions. The focus of the study was to demonstrate the potential performance achievable using an advanced MPC policy. The implementation in the current generation of micro processing devices was considered and ways to reduce computational loading were investigated.

MPC provided the ability to optimise the use of the electric power source (the battery) and the Internal Combustion Engine (ICE), improving the HEV fuel economy (evaluated by the MPGe index) and reducing the dynamic trade-off variations between the instantaneous battery State-Of-Charge (SOC) and the SOC reference value of 60% recommended by the battery manufacturer.



$Controller$	$\frac{m_f}{\Delta d}[L/100Km]$	$MPG_e\ [mpg]$	$SoC(t_{end})$ [%]	$D_b \times 10^5$
ECMS	7.13	32.62	53.52	10.93
A - ECMS	7.49	31.49	61.03	5.66
MPC	7.08	33.28	60.24	0.76

The numerical feasibility of the MPC was also evaluated with respect to the computational complexity of a baseline ECMS policy by considering the average and peak CPU usage. The NXP prototyping platform GreenBox II was used for testing different algorithms. Profiling PIL results revealed the ISC/NXP developed predictive controller could be implemented on the control board with an average CPU usage of 28% and a peak usage of 70%, in comparison with the A-ECMS requirements of 12% (averaged) and 20% (peak). There was an increased computational complexity, but MPC achieved an economic improvement of 4.5% over the best result given by the ECMS-based policy, and a reduction of battery degradation up to 90% over the ECMS policy.

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ISC Limited supplies control consultancy services to various areas of the automotive industry, including EV/HEV powertrain, combustion engine, autonomous vehicles, and batteries/storage. The services supplied include Model-based optimal control for engine management, engine and SCR catalyst system modelling and calibration, system identification and nonlinear parameter estimation for engine models, comparative evaluation of classical and advanced control for electronic throttle position, evaluation of control strategies for engine temperature control.

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