

Intelligent Power Management for High Tech Car

In the search for more fuel efficient cars, hybrid electric vehicles offer the promise of combining the efficiency and reduced emissions of electric vehicles with the power, performance and long range that we've come to expect from traditional internal combustion engines.

Hybrid electric vehicles (HEVs) use a combination of power sources – a small internal combustion engine and battery driven electric motor(s). With more than one power production system, a key question in any HEV is how the different power sources should be used under different running conditions to give the best possible performance and economy.

Mathematicians from CSIRO have found optimal ways to employ the power systems of the aXcessaustralia HEV.

The Car

The aXcessaustralia concept car was designed and produced by collaboration of over 80 Australian component manufactures and the CSIRO, working together through the Australian Concept Car Project Ltd.

The car's innovative power system comprises the following:

- a novel, compact internal combustion engine (developed by CMC Research)
- three novel switched-reluctance electric motors and generators (developed by CSIRO)
- a high power capability supercapacitor pack (developed by CSIRO)
- advanced lead-acid batteries (developed by CSIRO)

To get the best from these sophisticated components, an intelligent, co-ordinated strategy for the overall running of the car is needed.



CSIRO mathematicians found the best ways to employ the power system of the aXcessaustralia car by simulating how it would run in urban conditions.

Modelling for Intelligent Operation

CSIRO Mathematicians used their generic skills in optimisation and modelling to determine the best way to operate the aXcessaustralia vehicle. This involved balancing the many factors which contribute to the vehicle's performance and economy to find the optimal patterns of energy management.

To do this, they created a mathematical model of the car's power system. It included:

- the function of the motors and generators, coupled to the batteries and capacitors
- changes in engine efficiency (specific fuel consumption) depending on its use and design
- the combination and interaction of the car's power and storage systems

This model served as a test bed for designing the car's power management system. CSIRO mathematicians used it to simulate journeys

through a standard city cycle to compare different power management strategies. The model returned information about the car's efficiency and performance, allowing the best strategy to be found for the co-operative functioning of the power system's components.

The optimised strategy that they devised is now encapsulated in the car's power management software.

Optimised Power Management

The optimised power management strategy involves three separate modes, each optimised to meet a distinct goal:

- maximum fuel efficiency
- maximum performance of the car
- maximum range without using the engine, for zero-emission zones

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For example, for maximum range without the engine, the battery handles drag forces and power losses in the system, while the supercapacitor handles the inertial forces. This separation of powers is enforced by the power management algorithm.

The driver selects one of these modes at any time, making the car effectively three cars combined.

Each mode makes optimal use of regenerative braking (capturing the energy released during deceleration) and ensures that the internal combustion engine is used as efficiently as possible when it is on.

Design Specifications

Mathematics also provided design specifications in the early stages of the car's development, including:

- optimal storage capacity, in the batteries and capacitors, to achieve various goals for the vehicle's range and economy
- power and torque requirements of the motor and generator to be able to optimise both performance and economy

Further Information:

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