



Through-the-Road Parallel Hybrid Demonstrator Vehicle



Three Separate Driving Modes

MAHLE Powertrain and Protean Electric have converted a standard gasoline powered C-segment car to a "through-the-road" parallel hybrid vehicle by applying in-wheel motors to the rear axle to work in combination with the standard front wheel drive configuration.



Protean in-wheel electric motors

Plug-in hybrid electric vehicles (PHEVs) overcome many of the short-comings of EVs. Retaining a standard driveline, along with the EV driveline, enables the traction battery storage capacity to be reduced, though still maintaining an acceptable vehicle driving range. The aim of this project was to improve both the performance and the fuel economy of the vehicle through the addition of the hybrid system. The hybrid configuration adopted also provides the vehicle with all-wheel drive (AWD) capability.



Parallel hybrid demonstrator vehicle

The in-wheel motors, which also incorporate the disc brake and associated power electronics, provide an innovative solution to this challenge by utilising the available space within, and around, the wheels.

In addition to the packaging benefits, the in-wheel motors also bring advantages in the areas of performance and handling. In-wheel motors offer a large flat-torque response and the delivery of tractive effort is instant and seamless. This in turn sharpens up the feel of the vehicle by improving the response to driver torque demand.



4WD high performance mode
RWD zero emission EV mode

Drive Systems

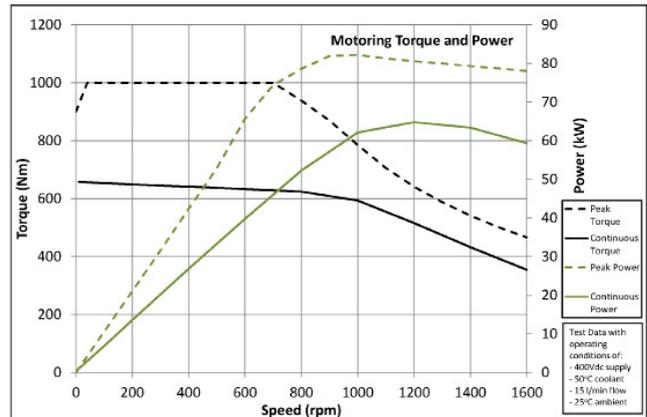
- 2 independent drive systems
- MAHLE Flexible ECU (MFE) used as main Vehicle Control Unit (VCU)
- MFE provides 4 key functions simultaneously:
 - › System control
 - › System safety
 - › Traction motor torque control
 - › Interface to the donor vehicle ECU (Includes CAN message modification)
- VCU has each subsystem set up as standalone model
- Increased model reusability

Performance Targets

- Vehicle performance targets achieved
 - › Benchmark 0-100km/h acceleration time reduced from 13.9 to <7.0 seconds
 - › Top speed increase by more than 10%
- NEDC fuel economy reduced from 6.4 to 1.7l/100km
- CO₂ emissions from 149 to <40g/km
- AWD capability enhances dynamic behaviour in high & low grip road conditions

Vehicle specifications

CO ₂ output NEDC:	< 40 g/km
Pure Electric Range:	> 50 km
Combined Range:	> 900 km
Maximum Speed:	190 km/h
Kerb Weight:	1,500 kg



Motor Performance

Advantages

- High torque inwheel motors
- Reconfigurable controller architecture
- VCU interacts with multiple separate CAN buses simultaneously
- Provides ideal development platform for demonstrator & niche volume vehicle fleets