Jaguar: Rear Wheel Drive More Sporty

- Jaguar Land Rover uses dSPACE Prototyper for powertrain control algorithms
- Vehicle tests with MicroAutoBox on a Jaguar S-Type
- More safety and driving fun for rear wheel driven cars

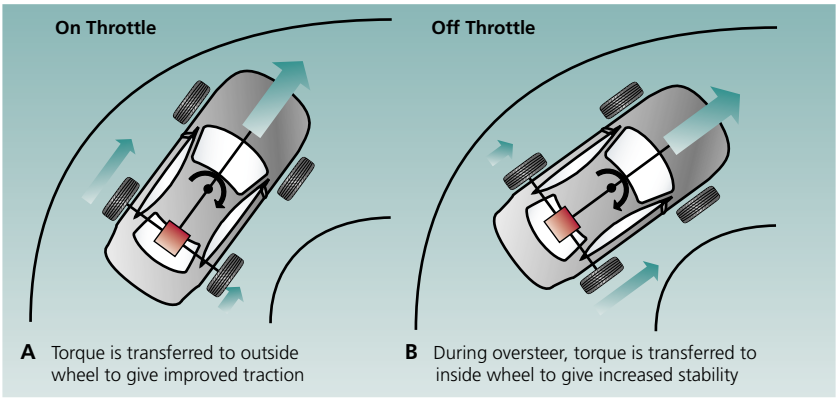
Jaguar Land Rover (JLR) in the United Kingdom is enjoying great success using dSPACE Prototyper to improve the handling and stability of the famous Jaguar S-Type with an electronically controlled limited slip differential (LSD). The approach is based on adjusting and optimizing torque transfer to the driven wheels by applying strategies which they tested in a vehicle using MicroAutoBox. The result is improved safety and a better driving experience. A key advantage was a development time of only nine months from project start to the first prototype vehicle.

Limited Slip Differential

In a rear wheel drive car, engine torque is transferred to the rear axle through a crown wheel and pinion. If the axle is rigid, cornering becomes a problem as the outside wheel wants to rotate faster than the inside wheel, causing them to slip. The problem is overcome by fitting a differential, which allows the wheels to rotate at different speeds, while the same torque is transmitted to each. However, when the car is cornering, a strong centrifugal force transfers the vertical load from the inside wheel to the outside wheel, reducing the amount of torque which the inside wheel is able to transmit to the road. Eventually a point is reached where the inside wheel begins to spin, which sets the limit for the torque which can be transmitted by the outside wheel, as the differential will only allow the same torque to be transmitted by each wheel. A similar situation occurs when one wheel is on ice and the other on a clear road surface, when the traction of both wheels is limited to that of the wheel on ice. By fitting a controlled limited slip differential, JLR engineers are able to direct torque from the slipping wheel to the nonslipping wheel and greatly improve the vehicle's traction, while maintaining control of vehicle stability, which would not be possible with a mechanical LSD.

Traction and Handling Control

The JLR traction control algorithm aims to optimize wheel speed difference. Developing a suitable controller for the LSD is critical to traction control, as the balance between improving traction and



With the right control strategy, the controlled limited slip differential can both improve safety and enhance the driving experience.

maintaining stability has to be just right – too much power transferred to one wheel will destabilize the car. An LSD can also enhance handling. On cornering, the electromechanical lockers cause torque to be transferred to the inside, or slower, wheel. This in turn leads to understeer off-throttle, which JLR realized had the potential to significantly improve handling.

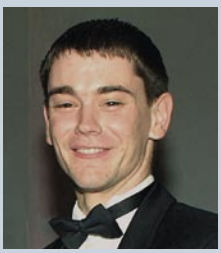
The algorithms were developed with two aspects in mind:

- Improving safety
- Making driving a more pleasurable experience

The JLR approach is to develop control strategies in computer simulation, before implementing them on a vehicle. Once they were happy with the simulation results, the next stage was to take the algorithm to real time on a test vehicle. Early results were good, as the project team was able to start vehicle tests with dSPACE Prototyper on a Jaguar S-Type only nine months after starting the project. A MicroAutoBox mounted inside the Jaguar, in combination with the ControlDesk monitoring software on a notebook, made it possible to test, and optimize, the LSD control algorithms under realistic conditions, and to change parameters dynamically while driving on the test track. The effect of the LSD control is clear, and the theory was successfully validated by a further six months of development.

Speedy Development Process

The Advanced Chassis Technology department initiated the development project. This department investigates new chassis technologies for JLR cars by applying simulation and rapid control prototyping, and developing a technology to the point where it is suitable for production. JLR are very pleased with progress made in the project because the results have demonstrated that it is possible to apply hardware formerly used only in sports utility vehicles to their road vehicles. The added value for the drivers of Jaguar and Land Rover cars – more safety, highly reduced driver intervention and a better driving experience – became apparent during vehicle tests with the Jaguar S-Type. dSPACE's MicroAutoBox made it much easier for JLR to experiment with different control strategies and quickly adapt them. A fast turnaround time helps them compete with other vehicle manufacturers.



Matthew Hancock
Advanced Chassis Technology
Jaguar Land Rover
United Kingdom

Matthew Hancock explained that MicroAutoBox was a natural choice for the application. "JLR have a number of dSPACE installations up and running successfully, and there is a lot of experience of using the tools in the company, so we knew that MicroAutoBox would be able to do what we needed."

Bob Williams
Advanced Chassis Technology
Jaguar Land Rover
United Kingdom

"The results have shown that we can use the limited slip differential control to stabilize the vehicle in difficult conditions, as well as improve the overall driving experience."