

ESP II – The Next Generation

- **Vehicle dynamics control with active steering intervention**
- **Active driving safety and comfort with ESP II**
- **Control design with dSPACE Prototyper in bypass mode**

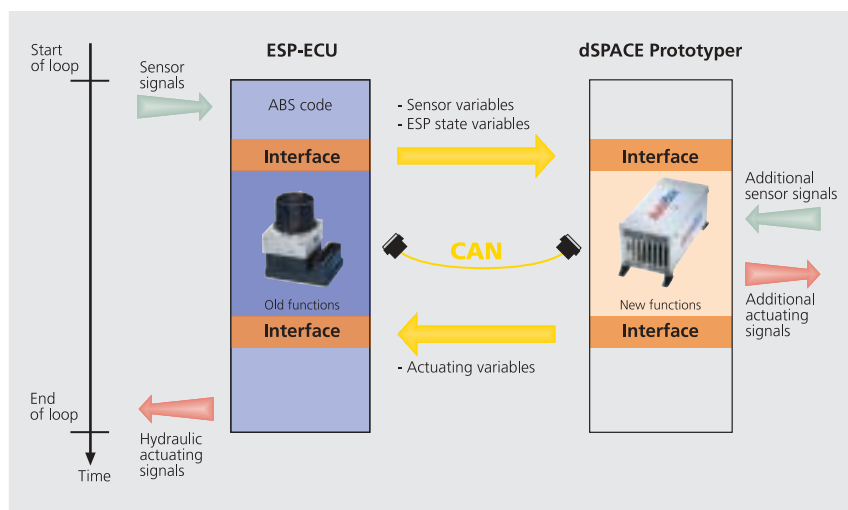
Continental Teves has taken a major step towards supplying a completely networked chassis with global control. ESP II is a milestone in the pioneering Global Chassis Control project. Active steering intervention has now been integrated into the new electronic stability program by networking the braking and steering systems. This greatly improves safety, the pleasure of driving, and ride comfort. dSPACE Prototyper is used to develop and verify the control algorithms, working alongside the Continental Teves ECU in bypass mode.

The ESP II system consists of the braking, steering and optional suspension subsystems, together with their internal and external sensors. The electronic braking system used is a further development of today's ESP equipment. It has internal pressure sensors for redundant capture of the four wheel braking pressures and driver input, which are needed for some ESP II functions. All the software functions for sensor data evaluation and control of the brake hydraulics (analog pressure valves) are already implemented in the existing production ECU.

Another ECU in the network controls the most innovative component, a superposition steering system, whose basic function is to adjust the steering ratio

to the vehicle speed, achieving a direct, sporty ratio lower than 12:1 or a more indirect ratio of up to 20:1. This makes the vehicle more agile to handle, yet at the same time, the driver feels safer.

In dynamic or critical situations, the superposition steering system allows an extra angle to be superimposed on the angle set by the driver at the steering wheel. This is done by a two-stage planetary gear driven by an electric motor and integrated into the steering column. The actual angle of the wheels, which affects the vehicle dynamics and the strength needed to steer, is therefore made up of the driver's steering wheel angle and the additional angle superimposed by the planetary gear.



In the prototype vehicle, dSPACE Prototyper (AutoBox) is used to control the braking and steering ECU, while sensor data and actuating signals are physically exchanged between the networked devices via a private CAN. The extended ESP II algorithms are added to the functions that are already on the braking ECU (ABS/ESP) via a bypass. For greater flexibility and far shorter development times, the new ESP II functionality is being developed on the prototyping system first before being transferred to the target production system later, which will ideally be done by means of automatic production code generation.

▲ Precise, loop-synchronous data exchange between the ECU and dSPACE Prototyper (AutoBox) is guaranteed in every control cycle.

Loop-Synchronous CAN Bypassing

Bypass technology is being used to develop all the new software functions on the prototyping system under MATLAB®/Simulink®, while continuing to use the software functionality of the existing production ECU. Because the ECU is a highly optimized development, tailored-made for ABS/ESP, it was an obvious step to use CAN as a simple means of implementing the bypass. In CAN communication, it must be guaranteed that the timing of all data exchange from the ECU to dSPACE AutoBox (sensors) and back (actuators) is absolutely accurate, in other words, it must be loop-synchronous. Working together with dSPACE Engineering Services, Continental Teves produced a completely trigger-controlled and watchdog-monitored Simulink model that fulfils this vital requirement. The entire ABS/ESP algorithm of the production ECU was ported to the AutoBox to implement the bypass. The control of drivers and sensor preprocessing were left on the ECU.

Winter Tests in North Sweden

Braking maneuvers on a road surface with different skid potential on either side (μ -split braking: ice and asphalt) are a particularly vivid example of the effectiveness of ESP II. The yaw torque from the different braking forces (the braking force on the high-friction side is greater than that on the low-friction side) can be compensated by automatic fast countersteering in response to the situation. The driver can continue to steer in the direction he or she wants to go. Unlike today's ABS and ESP systems, where the driver has to countersteer, the steering wheel position in this new system is held in the desired direction. Moreover, depending on how great the difference in the friction coefficients is, and on how the conventional ABS/ESP is adjusted, braking distances can be reduced by up to 15%.

Because the steering system is integrated into the yaw control as well as the brakes, ESP II has an extra means of acting on horizontal vehicle dynamics



▲ The prototype vehicle with ESP II handles the most difficult driving maneuvers in winter tests in North Sweden.

compared with the standard ESP. The limits of critical vehicle dynamics are being pushed outwards. Critical situations are easier to handle, as ESP II automatically counteracts in oversteer situations. This intervention is not perceptible to the driver, so it can be performed earlier to avoid critical stability situations the moment they arise. If dynamic instability does arise, ESP II can intervene more effectively via the steering system, as this has more leverage than the braking system – the wheel base is greater than the track width. However, braking to reduce driving speed is still indispensable in these situations.

Summary

By integrating the steering system, and optionally also the chassis, ESP II not only boosts active driving safety and comfort, but also provides considerable savings potential in application effort compared with stand-alone systems. Using bypass technology in cooperation with dSPACE considerably speeded up control design for the basic ESP II project and customer projects. The prototyping approach that was chosen provides great development speed and flexibility.

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