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## Through the snow as if on rails

Thanks to variably distributable drive power, electric vehicles with separately powered wheels can remain stable even in critical situations— as long as the torque control reliably detects deviations from the target state and reacts immediately. Porsche Engineering has developed and tested a solution for e-SUVs that does precisely that. Without additional sensors— entirely through software.



And Porsche Engineering developed just such a torque control system for all-wheel drive SUVs. The software can be used for different constellations and motor configurations—for other electric vehicle types as well, of course. In general, development begins with the base distribution, i.e. software that controls how much power is transmitted to the front and rear axle, respectively. For straight-line driving and balanced weight scenario, for example, a 50/50 distribution would make sense. If the driver accelerates, the software switches to full rear-wheel drive—or all frontwheel drive around a sharp bend. “This makes the vehicle noticeably more stable, even for the passenger,” says function developer Rezac. As the optimization is achieved entirely electronically, theoretically it would even be possible to offer the driver various different configurations: one mode for sports car sprightliness, another for smooth cruising.

The second task of the control software is to adjust the torque to the wheel speed. The algorithms follow a simple objective: All wheels are supposed to spin at the same speed. That’s easy to accomplish on a dry freeway, but it is considerably trickier when driving on a snowy mountain pass. If the front wheels encounter an icy patch, for example, they could—without electronic intervention—start spinning. But the torque control system detects the suboptimal situation immediately and directs the torque to the wheels that are turning more slowly and still have grip within fractions of a second. There is something similar in the world of combustion engines—the speed-sensing limited-slip differential, also known by the brand name Visco Lok. In this component, gear wheels and hydraulics ensure that no wheel turns faster than the others. But mechanical solutions are slow. In an electric SUV, by contrast, software assumes the role of the differential— with much swifter reactions and naturally entirely without wear.

“The development of the vehicle observer was the biggest challenge,” says Rezac. The fact that so much development work was required here goes back to a fundamental problem: A car knows relatively little about its own state. It doesn’t know its own speed; it can only derive it from the speed of the wheels, which is difficult on ice and snow particularly. The observer therefore has to use additional information about the longitudinal and lateral acceleration in order to estimate the speed. The information regarding weight distribution

is equally vague. While the suspension does capture the load on the individual wheels, even this information provides mere clues rather than certainty. If the shock absorbers report increased weight on the rear axle, for example, it could be due to the vehicle being parked on a slope—or simply being heavily loaded.

The data situation is decidedly meager. And because the client insisted that no additional sensors could be added, the SUV project called on the creativity of the software developers. “The observer has to estimate the vehicle’s important parameters,” explains Rezac. Some unusual data sources are brought to bear: The torque control system communicates with a sensor that detects the inclination of the car, for example, which is usually used for the automatic adjustment of the headlights.

The entire software package not only had to be developed, but calibrated in real test drives. And all that in a very short period of time: There were just two winters available in which the fine-tuning could be tested on a frozen river. It emerged, among other things, that the great advantage of electric motors—their rapid reaction times—sometimes resulted in undesired side effects. “The electric motors respond so quickly that vibrations can occur,” reports Hintze, who conducted the test drives with his team. In a few situations the software transferred the torque between the axles at increasingly fast intervals, which resulted in an audible revving of the motors. Thanks to close collaboration between the calibration team and the development team around Martin Rezac, however, they quickly managed to put a stop to this build-up through a modification of the software.

This detailed work is exactly where the challenge lies in such projects. As the software is to be used in a series vehicle, it has to be tested for every imaginable situation, no matter how improbable it might seem. If the sensor reports faulty data, for example, the torque control has to decide if it is still allowed to function even without the data source or should be switched off. Another hurdle was posed by the limits of the electric drive technology. It may be the case, for example, that individual e-motors cannot transmit the available battery power. The function developers had to take such limitations into account. “The control range collapses in this case,” says Hintze. Instead of 100 percent torque on one axle, perhaps only 60 percent might be available. And the torque control has to take that into account as well. But all involved are convinced: The pioneering work was well worth the effort, as electric vehicles with up to four motors will soon shed their exotic reputation. And many drivers will be grateful that they can drive through the snow as if on rails.

In brief

Porsche Engineering developed a torque control system for an all-wheel-drive e-SUV that provides maximum stability and safety in every situation—without additional sensors on board. All four wheels are actuated with the optimal force within milliseconds and stabilize the vehicle. The software was not only developed by Porsche Engineering, but also calibrated in real test drives over a period of just two winters. The software is suitable for different constellations and motor configurations.

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