Integrated Traction and Brake Torque Control Method and Control Device for Electric Vehicles

Invention offer

The invention relates to an integrated traction and brake torque control for electric vehicles with individual wheel drive, in which each wheel is driven by an electric motor. The required torque on each wheel is calculated by the slip controller in accordance with the total torque demand produced by the driver, estimated target slip for each wheel and the mode of the vehicle motion. During a traction mode, individual wheel torques are solely controlled by the driving motors. During a braking mode, individual wheel torques are controlled both by the driving motors, operating as the generators, and friction brakes.

Solution

A system has a common structure for the traction control and anti-lock braking (ABS) functions, and consists of feedforward (predictive) and feedback (reactive) contributions (Fig. 1). The estimated values of the tyre-road friction coefficient and the vertical wheel force are used for saturating the torque demand \( T_{dem} \) thus yielding the predictive torque value for the specific wheel \( T_{pred} \). The reactive torque contribution \( T_{react} \) is activated only when specific conditions on the slip ratio are satisfied, i.e., is used to correct \( T_{pred} \) in the case of significant longitudinal slip of the individual tyre. \( T_{react} \) is the output of a feedback controller mainly based on the reference slip ratio, the estimated slip ratio, and vehicle velocity. For the ABS function the system splits the contribution for each vehicle corner into the torque shares to be generated by the electric motor and the friction brake.

Stage of development & property rights

- The method and the control device is successfully validated on the real vehicle demonstrator, Fig. 2
- Patent granted

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Advantage

- Accurate and smooth slip ratio tracking performance, Fig. 3, with special benefits for active safety and driving comfort
- Considerable stopping distance reduction at braking due fast and precise response of electric motors
- Possibility of energy regeneration in ABS mode
- Off-road capability – the system guarantee a high performance in transient and rough road surface conditions

Technical data of the demonstrator:

Sport utility vehicle; Switched-reluctance on-board motors;
Decoupled electro-hydraulic brake system

Application areas

In general, application is useful for electric vehicles with

- Individually controlled in-wheel motors
- Individually controlled on-board motors

Fig. 1: Block diagram of integrated control device

Fig. 2: Vehicle demonstrator with on-board electric motors

Fig. 3: Benchmarking of controlled braking on low-friction inhomogeneous surface - invented ABS (right) and state-of-the-art industrial ABS (right)

The research leading to these results has received funding from the European Union Seventh Framework Program FP7/2007-2013 under grant agreement no. 284708