Design and Control of a Brake-by-Wire System Using a Permanent Magnet Synchronous Motor

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Abstract : The conventional hydraulic braking system operates through the activation of a master cylinder and solenoid valves that distribute and regulate brake fluid flow, adjusting the pressure at each wheel to prevent locking during sudden braking. However, in recent years, there has been a significant increase in the integration of electronic units into various vehicle control systems. In this context, one of the technologies most recently researched is the Brake-by-wire system, which combines electronic, hydraulic, and mechanical technologies to manage braking. This proposal introduces the design and control of a Brake-by-wire system, which will be part of a fully electric and teleoperated vehicle. This vehicle will have independent four-wheel drive, braking, and steering systems. The vehicle will be operated by embedded controllers programmed into a Speedgoat test system, which allows programming through Simulink and real-time capabilities. The braking system comprises all mechanical and electrical components, a vehicle control unit (VCU), and an electronic control unit (ECU). The mechanical and electrical components include a permanent magnet synchronous motor from Odrive and its inverter, the mechanical transmission system responsible for converting torque into pressure, and the hydraulic system that transmits this pressure to the brake caliper. The VCU is responsible for controlling the pressure and communicates with the other components through the CAN protocol, minimizing response times. The ECU, in turn, transmits the information obtained by a sensor installed in the caliper to the central computer, enabling the control loop to continuously regulate pressure by controlling the motor's speed and current. To achieve this, tree controllers are used, operating in a nested configuration for effective control. Since the computer allows programming in Simulink, a digital model of the braking system has been developed in Simscape, which makes it possible to reproduce different operating conditions, faithfully simulate the performance of alternative brake control systems, and compare the results with data obtained in various real tests. These tests involve evaluating the system's response to sinusoidal and square wave inputs at different frequencies, with the results compared to those obtained from conventional braking systems.

Keywords : braking, CAN protocol, permanent magnet motor, pressure control
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