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Electro Hydraulic Brake System

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ABSTRACT:

A base brake event can be described as a normal or typical stop in which the driver maintains the vehicle in its intended direction at a controlled deceleration level that does not closely approach wheel lock. All other braking events where additional intervention may be necessary, such as wheel brake pressure control to prevent lock-up, application of a wheel brake to transfer torque across an open differential, or application of an induced torque to one or two selected wheels to correct an under- or over steering condition, may be classified as controlled brake performance. Statistics from the field indicate the majority of braking events stem from base brake applications and as such can be classified as the single most important function. From this perspective, it can be of interest to compare modern-day Electro-Hydraulic Brake (EHB) hydraulic systems with a conventional vacuum-boosted brake apply system and note the various design options used to achieve performance and reliability objectives.

I. Introduction

This system is a system which senses the driver's will of braking through the pedal simulator and controls the braking pressures to each wheels. The system is also a hydraulic Brake by Wire system. Many of the vehicle sub-systems in today's modern vehicles are being converted into "by-wire" type systems. This normally implies a function, which in the past was activated directly through a purely mechanical device, is now implemented through electro-mechanical means by way of signal transfer to and from an Electronic Control Unit. Optionally, the ECU may apply additional "intelligence" based upon input from other sensors outside of the driver's influence. Electro-Hydraulic Brake is not a true "by-wire" system with the thought process that the physical wires do not extend all the way to the wheel brakes. However, in the true sense of the definition, any EHB vehicle may be braked with an electrical "joystick" completely independent of the traditional brake pedal. It just so happens that hydraulic fluid is used to transmit energy from the actuator to the wheel brakes. This configuration

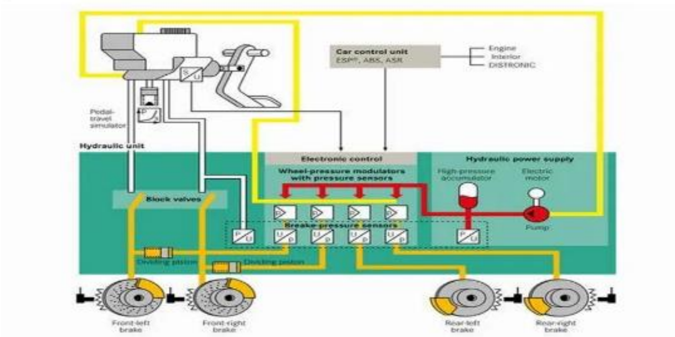

Fig 1: Electronic control unit

II. Technology

EHB has made significant investment in its technologies like:

- Electro hydraulic composite braking system structure
- Brake circuit
- Braking coordination process
- The structure of the EHB

Electro Hydraulic Composite Braking System Structure:

The configuration of the considered vehicle is shown in Figure 1.0. This configuration adds a rear permanent magnet synchronous motor to the traditional P2 configuration. Its main purpose was to achieve better acceleration performance in the pure electric drive mode and recover more energy when braking. The upper controller, vehicle control unit (VCU), collects signals such as the vehicle velocity, gear position, brake pedal status, and brake master-cylinder pressure. When the driver depresses the brake pedal, the VCU quickly determines the driving state of the vehicle based on the signal of the brake pedal sensor and sends a control signal to the lower controller, the ABS/RBS integrated controller, through the controller area network (CAN) bus. Based on whether the control signal is an emergency brake signal, regenerative brake signal, or synergistic signal of the two conditions, the lower controller sends control signals to the hydraulic system control unit and the front and rear motors in accordance with the commands of the established algorithms.

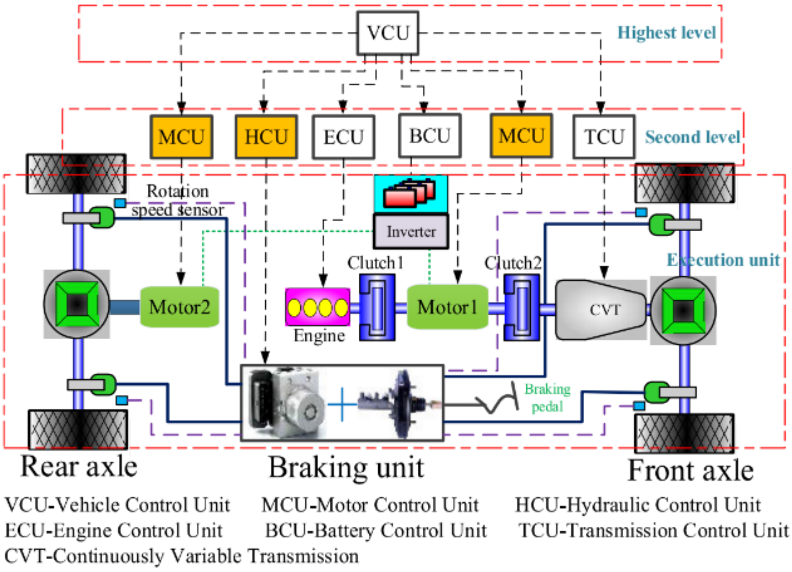

Fig 2: Electro-hydraulic composite braking system structure

Brake Circuit:

The friction plates are connected with the rotating axle shaft or hub by spline, while the steel plates are fixed in the groove of the axle housing along the half axis direction. When braking is required, the operator steps on the brake valve pedal, and the high-pressure oil in the two accumulators flows into the brakes of the front and rear axles, respectively. The high-pressure oil in the brake pushes the piston ring to press the dual steel discs and friction discs against each other to generate a braking torque.

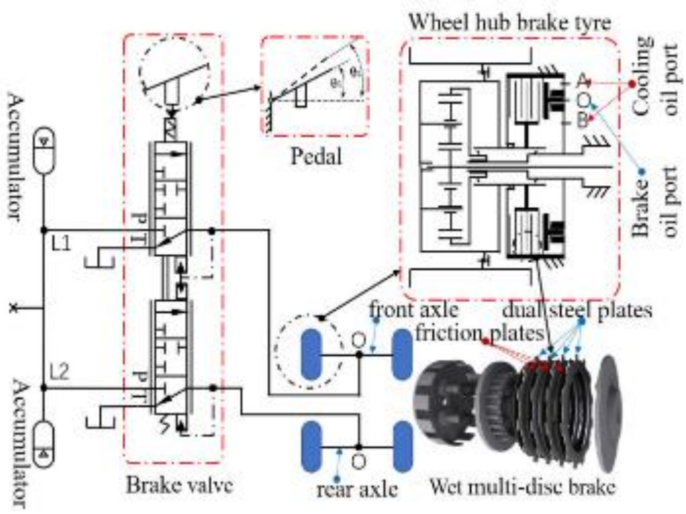

Fig3: Break circuit

Braking Coordination Process

When the braking mode is judged as small-intensity braking, the front and rear motors can provide the required braking torque. Hence, the demand for the braking torque is distributed by the RBS algorithm. During emergency braking, the brake controller switches from RBS to ABS module according to the signals of the slip rate (s) and wheel deceleration (a). The ABS control module calculates s and a in real time and distributes the braking torque according to the braking coordination control algorithm; then it sends a control signal to the motor and the hydraulic braking system.

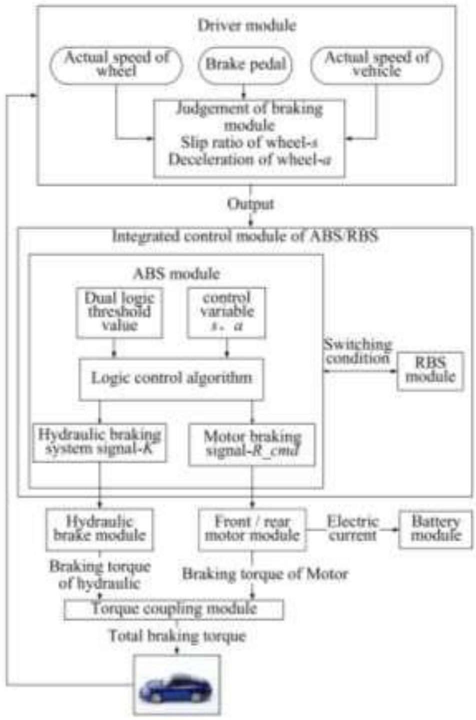

Fig 4: Braking coordination process

Structure of EHB:

The structure of the EHB is an HCU (Hydraulic Control Unit) and a pedal feel simulator are consisted in this system. Normally, the master cylinder is decoupled from the wheel cylinders, and the simulator is used to provide the driver with comfortable feedback of brake pedal sensation. When the brake pedal is pressed, the brake fluid discharged from the master cylinder by the driver will flow into the simulator but not the wheel cylinders. At the same time, a motor and a high pressure accumulator is used as the high pressure source, and the motor will drive brake fluid from the reservoir into the wheel cylinders to generate hydraulic brake pressure. The HCU uses ten solenoid valves: two normally-open solenoid valves are used as isolation valves (FLCV, FRCV) to decouple the master cylinder from the wheel cylinders when the EHB works normally.

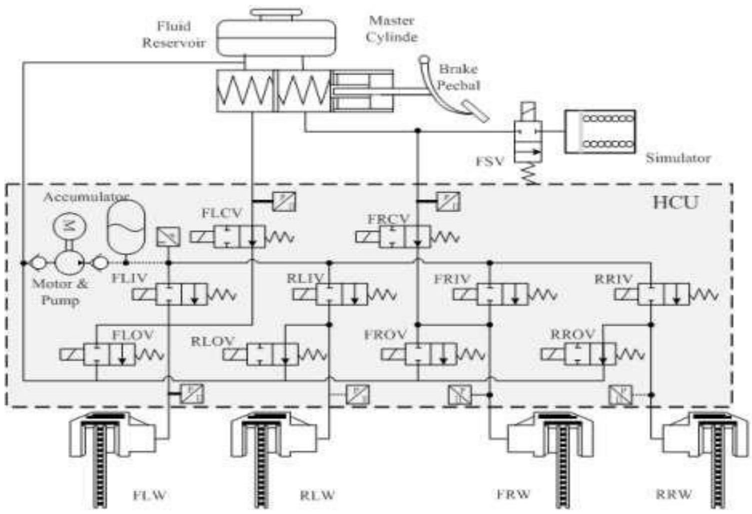

Fig 5: The structure of the EHB

III. Advantages

Compact structure, improved braking efficiency
The control is convenient and reliable, and the braking noise is significantly reduced
No vacuum device is required, which effectively reduces the kick of the brake pedal and provides a better pedal feel;
Due to the improvement of the degree of modularization, the flexibility of the design is improved in the vehicle design process, the number of parts of the brake system is reduced, and the layout of the brake system in the vehicle is saved.

IV. Applications

- Cranes
- Transfer Cars
- Rotating Machines
- N.C. Machines
- C.N.C Machines

V. Conclusion

This paper introduces a novel nonlinear backstepping control algorithm for an EHB based on the bond graph model. Using the bond graph method, a mechanical-electric-hydraulic combination model for the single-wheel brake system is constructed, which considers the capacitive effect of the hydraulic fluid and the damping and inertia effects of the caliper. Based on this nonlinear model, a backstepping controller is designed and the control signals of the inlet and outlet valves are described by a unified expression. Step by step, it realizes the stability of the nonlinear brake system by virtual-state variable feedback-stability control based on the Lyapunov function and asymptotic stability theorem.

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