

# Engineering Document

Project: EHB

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## Sensitivity Analysis of an Electro-Hydraulic Valve for Use with the Electro-Hydraulic Brake (EHB) System

The automobile has become a very useful commodity in today's society. As people have to travel farther, new improvements are made to accommodate more vehicles and to allow for faster moving traffic. These changes also require that the vehicles are made safer for the driver and the passengers. One of the most important aspects of the vehicle in regards to safety is the braking system. If brakes were controlled effectively, some accidents could be prevented.

New technology is created everyday and many companies work feverishly to create revolutionary products that aim to make cars safer. One example is TRW's Electro-Hydraulic Braking System (EHB), which uses an electric signal to regulate the hydraulic fluid flow into the brake caliper. The driver will use brakes just like in any ordinary vehicle; the difference is that the driver will not be moving fluid directly into the brake caliper. The brake pedal depression will be measured and will be sent as an input to the control unit. Depending on this signal, the control unit will output two signals. One signal will be fed into an apply valve and the other one into a dump valve. The combined effect of the apply valve allowing hydraulic fluid in and the dump valve allowing the hydraulic fluid out will create a hydraulic pressure. This pressure will be applied to the brake caliper.

This system is very effective and would be a great improvement to use in today's vehicle. However, given the accuracy and robustness of control required for such a system, it is necessary to understand how the component variations might affect the overall system performance. The hydraulic valves used for apply and dump functions are small. Due to industry accepted manufacturing tolerances, some of the system parts could vary widely from their nominal value and the result is a system that does not function as expected. The main goal of this project is to identify the component attributes that have the largest impact on the variation in pressure output, which is critical for the commercialization of this product.

To aid in discovering the magnitude of variations in the EHB performance, a Simulink model of the EHB system was developed and a sensitivity analysis of parameter variation was performed. The sub-systems described in the model include coil, armature, hydraulic flow, and brake load. The model was validated against bench test results and was found to predict the steady-state value and rise time of the brake pressure accurately. The sensitivity analysis clearly shows the relative importance of individual parts, including their dimensions, stiffness, and other system parameters such as hydraulic pressure and Coulomb frictions. From analyzing the results, it is clear that special attention has to be placed in keeping the magnetic forces under control. The model and the analysis results from this project will be used to help the development of next generation TRW EHB products.