

## **Phase-Shift High-Speed PWM Hydraulic Valve**

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### **Abstract**

Control of hydraulic actuators has historically required some form of throttling valve or a variable displacement pump or motor. An alternative method is switch-mode control, which uses a high speed valve to rapidly switch between efficient on and off states, allowing any hydraulic source or actuator to have virtually variable displacement. A technical barrier to switch-mode control is a high frequency on-off valve with high efficiency. A novel high speed valve concept is presented that uses a phase shift between two continuously switching segments, operating at the same frequency, to achieve a pulse-width modulated flow with any desired duty ratio. Switching within the three-way valve is performed by a continuously rotating valve plate that moves past fixed port plates, with flow in the axial direction. A mathematical model of the valve was constructed that simulates the flow and pressure, while quantifying the sources of energy loss. The model was used to optimize the geometric parameters for the design of a prototype valve. Experimental work demonstrated the concept and validated the model.