Controls Overview for Microstaq Silicon Expansion Valve (SEV)

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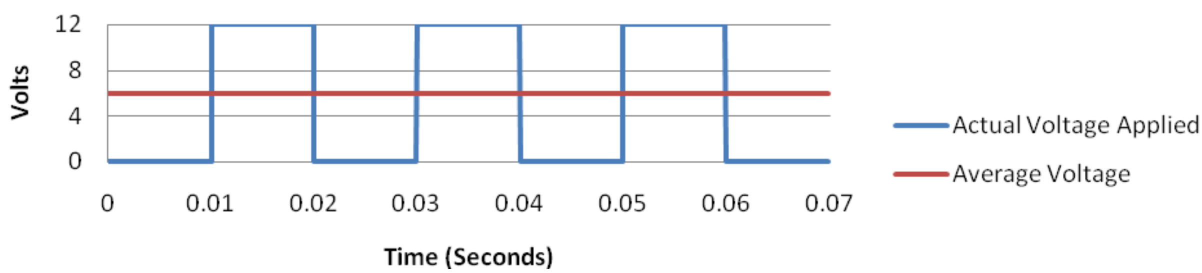
PWM Command Signal

The SEV is controlled using Pulse Width Modulation (PWM) of the supply power to the valve. Pulse Width Modulation of the supply power involves the modulation of the duty cycle to control the amount of power sent to the valve. PWM uses a square wave whose width (or duration of on state vs. off state) is modulated, resulting in the variation of the average value of the power supplied. The number of modulated impulses per cycle (one second) is referred to as the frequency and is expressed in Hertz (Hz). For example, with a 12 VDC supply power and a 50% command signal to the valve (valve 50% open) at a frequency of 50 Hz, then 12 VDC would be applied to the valve for .01 second and 0 VDC for .01 second. This wave would repeat 49 more times to complete the entire cycle (one second). The average voltage applied would be 6 VDC, thus yielding 50% opening in a valve rated for 12 VDC.



Specific frequencies of PWM signal to the valve can be used to create desirable performance characteristics. The SEV has a response time of around 100 milliseconds, full open to full close. Therefore, applying a PWM command signal of 50% and a frequency of 10 Hz will stroke the entire valve full open to closed to full open again approximately 10 times a second. This is beneficial in that it dislodges any particulate that may have accumulated if the valve had been operated at a constant position for long periods of time. The silicon pilot of the SEV (the Ventilum™) has a response time of around 5 milliseconds, so frequencies less than 200 Hz create subtle vibrations in the pilot. This motion is known as a dither, and is beneficial in that it reduces valve hysteresis and improves the overall performance of the valve. The SEV operates best with a frequency between 45 and 60 Hz.

Control Architecture

The logic used to control the SEV can be very similar to that employed to control a PMV. After all, both valves are used to control refrigerant expansion in the evaporator coil, or more specifically, superheat at the exit of the evaporator. There are many interrelated system variables that the control logic must take into account, and valve characteristics are a relatively minor subset of those variables. System variables such as evaporator circuit length and corresponding time constants, evaporator and condenser loads and corresponding refrigerant pressures are two examples that have much greater impact on control logic.

However, there are three main differences in performance between a PMV and an SEV that affect control strategy. The first and most significant is speed of response. The SEV can respond in 100-200 milliseconds, full close to full open, versus 6-10 seconds for a PMV. This can be used to advantage during startup, shutdown and prescriptive control logic for efficiency testing. The second difference is linearity, specifically in the partial load range (<25% valve opening). The SEV exhibits good linearity across its operating range, and across the system operating temperatures. The flow curve for a typical PMV can show a steep gain in the first 25% of its operating range. Therefore, the SEV should show more superheat stability under light load conditions. The third difference is that the SEV does not require periodic zeroing of the valve to ensure positional accuracy. The SEV is commanded by a continuous analog signal that defines the valve's position, and when command goes to zero or the power is removed, the valve returns to the closed state (fails closed).

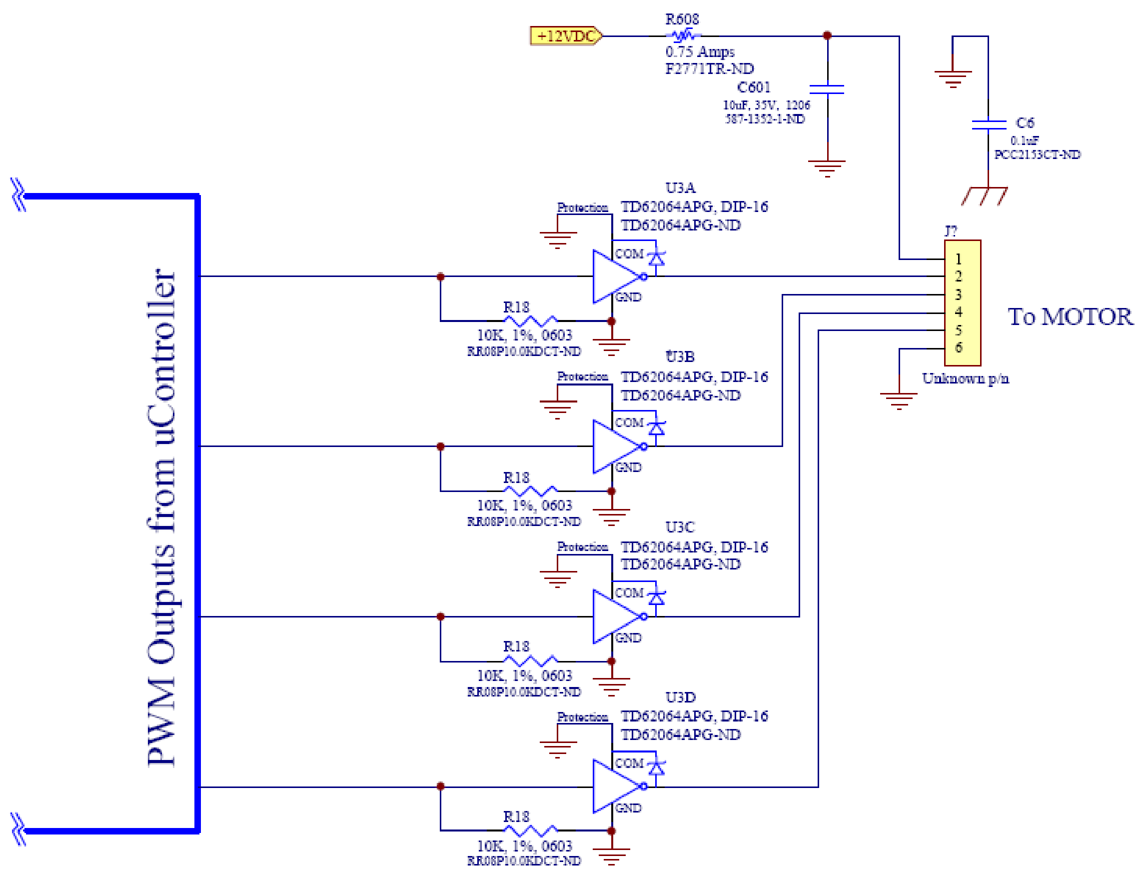
Control Hardware

As depicted in the drawing on the following page, the electrical circuit and its components that drive the SEV are simpler and less costly than the corresponding circuit used to drive the PMV. For the purpose of this comparison, we will consider the control circuit to begin at the microprocessor outputs and end at the board level connector (where the external wiring to the valve begins). The PMV control circuit consists of four processor outputs that pulse the four PMV coil drivers. These four components are typically located on the same IC package (Darlington sync driver). Capacitors and resistors are used to smooth the pulse, and a resettable PTC fuse protects the circuit. Finally, a six pin connector mates with the six-conductor cable that runs out to the valve. Of these six conductors, one supplies 12 VDC to the valve, four switch the valve state (on/off), and one functions as a ground.

The SEV circuit is much simpler by comparison. Only one microprocessor output is needed to send a PWM command to the valve driver (MOSFET). One resistor, a resettable PTC fuse and a two pin connector complete the circuit (12 VDC to the valve on one pin and the other switches the valve state).

Representative Valve Drive Circuits

Typical PMV Control Circuit



Microstaq SEV Control Circuit