PNEUTRONICS
General Valve

Parker Hannifin Corporation
Pneutronics Division
26 Clinton Drive, Unit 103
Hollis, NH 03049 USA
Tel: 603-595-1500
800-525-2857
Fax: 603-595-8080
www: pneutronics.com
E-Mail: PNDinfo@parker.com

Understanding Pulsed Width Modulation (PWM) and Inductance

Definitions:

Newton's First Law
An object at rest or in constant motion will remain at rest or in constant motion unless an unbalanced force acts on it.

Unbalanced forces
In a valve some of the unbalanced forces are magnetic fields, (coil strength) springs and gas pressure.

PWM
Pulse Width Modulation (PWM) is essentially turning the power on and off at a high rate of speed (frequency) and varying the time that the voltage is on versus the time it is off.

Defining a 1kilohertz (1000 cycles per second), 25% duty cycle, control signal:
A control signal with a 25% duty cycle, generates 1000, 12 volt pulses every second. The maximum duration that each pulse can be on is 1 thousandth of a second (1 millisecond) (T=1/F) 25 % of that time (or 250 nanoseconds) the voltage is at 12 volts. 75% of that time (or 750 nanoseconds) the voltage is at 0 volts. This ratio is expressed as the "Duty Cycle". It is essentially the "applied power" and equals the "area under the curve"

A 100% duty cycle PWM signal can be applied to a valve for the duration that is long enough to get the valve to initially actuate. This is typically 2-50 milliseconds depending on the unbalanced forces. When the plunger has moved towards the coil, the magnetic forces on the plunger multiply and the valve becomes more efficient. At this time, the duty cycle can be reduced by approximately 50% to allow for power savings. If the frequency is too slow the valve will drop out.

For example: If a 12 volt, 25 % duty cycle signal is applied to a 12 volt, 1 Watt coil, the power consumption is now 1/4 of a watt. *Remember also that the applied power (magnetic field) acting on the plunger is now 1/2 of a watt and may not be enough to overcome the unbalanced forces (spring or gas pressure) to actuate the valve.

Low Duty Cycle --High Duty Cycle

Parker Automation

Inductance

Using a plumbing analogy for the inductance, suppose a pump is to circulate water in a closed-pipe system. A long time after the pump has been turned on, the flow rate is determined only by the strength of the pump and the resistance of the pipes. But when the pump is first switched on, there is another effect that limits the water flow: inertia. Since the water has mass, it is not possible instantly to set it in motion, so it takes a while for the water to accelerate up to its final speed. Similarly, if the pump is turned off, the inertia of the water will cause its circulation gradually to decrease, rather than to stop immediately. This is just how inductance affects the flow of current in electrical circuits, so the inductance is analogous to the mass, or inertia, of the water in the pipes.

Like Capacitors or Accumulators the inductance essentially affects how fast the magnetic field is created or collapses as the voltage turns on and off.

What this all means in a valve

Higher inductance is good for "smoothing" out the fast switching of a PWM power supply so that the valves plunger doesn't "dither", however it also means that the field will generate and collapse slower which makes the valve turn on and off slower. Inductance in coils is proportional to the number of windings, the number of layers and the size of the coil. Coils with higher resistance, more windings or larger in size will have more inductance. Depending on the frequency and duty cycle of the signal combined with the inductance of the coil, (and the unbalanced forces) the plunger may or may not predictably actuate in response to the control signal relative to response time.

Remember that most of our valves actuate quite fast and have relatively low inductance so they might respond to a 1 khz signal by turning on and off at 1khz. We typically recommend that signals greater than 5 khz are applied to prevent the plunger from "dithering".

Richard Parker
Parker Hannifin Corporation
Pneutronics Division
26 Clinton Drive, Unit 103
Hollis, NH 03049 USA
603-595-1500