Whitepaper

Pulse and Hold Power Management

Reduce energy consumption and waste heat

Introduction

Acro Associates' solenoid pinch valves employ a spring-loaded linear actuator to control motion of the pinching surfaces. Most linear solenoid actuators are closing-the-air-gap devices, where the force characteristics vary substantially throughout the stroke. Generally, actuators are designed so that the force to power ratio increases by a factor of 3–4 as the unit moves towards the fully energized position. Utilizing these characteristics of solenoid actuators, the "Pulse and Hold" technique can hold a pinch valve in the energized state at reduced power with respect to applied power required for initial activation. Power consumption is optimized, heat generation minimized and the result is increased performance: higher actuation forces, longer strokes, extended duty cycles and longer on times.

Model 900R Modular Solenoid Controller

Acro's Model 900R is a rugged, cost effective control module designed for interfacing high performance solenoid actuators (such as Acro's Model 904, 955. 958 and 960 solenoid pinch valves) to computer systems and digital logic. Its primary purpose is to provide "Pulse & Hold" actuation, which improves valve efficiency and performance. This allows Acro to solve difficult pinch valve applications.

The Circuit Model of a Solenoid

A solenoid actuator can be modeled as a fixed resistance in series with a variable inductance (an RL circuit). Resistivity of the wire used to wind the solenoid's coil determines the DC resistance of the solenoid. The arrangement of the windings and materials used to construct the actuator, in addition to the position of the ferrite plunger (or core), determine inductance of the solenoid. Because the solenoid is resistive, any current passing through the windings produces heat. Excessive heat may damage the actuator and consume unnecessary power. In general, power management devices, such as Acro's Model 900R, modulate output current to the device, so that desired mechanical performance is achieved, while significantly reducing energy consumption and waste-heat production.

Adaptive Pulse and Hold

"Pulse and Hold" (also known as "Spike and Hold", "Pick and Hold", and "Hit and Hold") is a technique whereby a strong, short duration DC pulse is passed through the solenoid actuator to close the air gap; then current is lowered to an appropriate hold level. In the hold state, Acro's Model 900R controller operates the power switch in PWM mode and the reduced current maintains the solenoid's energized state. When the control signal is removed, the power switch shut offs and the cycle ends.

1990 Olivera Road, Suite A
Concord, CA 94520-5455

E-mail: support@acroassociates.com
www.acroassociates.com

Phone: 925) 676-8828
Fax: (925)-680-8113

As an enhancement to standard “Pulse and Hold” techniques, Acro utilizes an integrated microprocessor, which analyzes load current for additional power savings and for over current protection. This exclusive adaptive technology makes our products 3 to 10 times more power efficient than other solenoid control products on the market.

Pulse Width Modulation

PWM is used to vary the total amount of power delivered to a load without resistive waste and is a method commonly used in DC motor speed control. It is also useful in varying current through a solenoid because it keeps the power switch either in cut-off or saturation mode most of the time, which minimizes heat generated by the switch. Acro’s Model 900R contains a low-side Field-Effect Transistor (FET) power switch employing a PWM output.

A PWM power signal consists of a fixed frequency square wave with a varying duty cycle, which is fed to the gate of the power switch. If the frequency of the signal is much higher than response time of the core in the actuator (usually out of the audio range), then effective current through the solenoid is proportional to the duty cycle of the square wave at the gate or the power switch. The low-side MOSFET power switch employed in Acro’s Model 900R Modular Solenoid Controller, operates at a fixed PWM frequency of 25.0kHz.

Conclusion

Power savings realized by making use of the “Pulse and Hold” technique is dependent upon the pinch valve’s intended application (see Table 1). Generally, if the actuator is energized for long periods, standard “Pulse and Hold” will reduce waste energy significantly. Acro’s “Adaptive Pulse and Hold”, as utilized in the Model 900R, provides for additional power savings, which is highly recommended for applications where pinch valve cycles at a high rate.

“Pulse and Hold” power management increases capacity of the user’s power system and the life of solenoid actuators by reducing required energy consumption and emitted waste heat. The resulting benefits allow Acro pinch valves to provide higher actuation forces, longer strokes, extended duty cycles and longer on times.

About Acro Associates

Acro Associates, Inc. is the leading innovator of high performance fluid control systems. Our designs maximize reliability and repeatability of fluid control in medical devices and bioprocessing equipment. Our dedication to meeting customers' needs is unsurpassed. We offer products and services that can utilize any selected portion or the full range of our capabilities— from engineering design, prototyping and pilot production to full-scale production manufacturing and quality control. In addition, we also offer fully customized solutions tailored to individual customer requirements.

Table 1: Typical Power Consumption by Application

Manufacturing Parameters					Application		Power Management		
Volts	**Coil**	**Std. Pulse**	**Act. Pulse**	**Hold Volts**	**On Time**	**Off Time**	**None**	**Std.**	**Adapt.**
24 V	8.5 Ω	200 ms	45 ms	4.5 V	1 s	1 s	33.9 W	7.7 W	2.7 W
24 V	8.5 Ω	200 ms	45 ms	4.5 V	∞ s	0 s	67.8 W	2.4 W	2.4 W
24 V	8.5 Ω	200 ms	45 ms	4.5 V	1 s	3 s	16.9 W	3.9 W	1.3 W
24 V	8.5 Ω	200 ms	45 ms	4.5 V	250 ms	250 ms	33.9 W	27.3 W	7.1 W
12 V	6 Ω	200 ms	-	6 V	1 s	1 s	12W	4.8 W	-
12 V	6 Ω	200 ms	-	6 V	1 s	3 s	6 W	2.4 W	-
24 V	47 Ω	200 ms	50 ms	8 V	1 s	1 s	6.1 W	1.8 W	1.0 W
24 V	47 Ω	200 ms	50 ms	8 V	1 s	3 s	3.1 W	0.9 W	0.5 W
24 V	8.5 Ω	100 ms	26 ms	6 V	1 s	1 s	33.9 W	5.3 W	2.9
24 V	8.5 Ω	100 ms	26 ms	6 V	1 s	3 s	16.9 W	2.6W	1.5 W

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Example: An application for a solenoid pinch valve using a 24V, 8.5Ω coil with the typical manufacturing parameters shown above, where the user desires to energize the valve for 1 second(on time = 1s), then de-energize it for 3 seconds (off time = 3s) in cyclical fashion would consume an average power of 16.9 Watts. If the user utilized Acro's Model 900R Modular Solenoid Controller in this same application, the average power of 1.3 Watts would be consumed. In this case, power consumption was reduced by a factor of more than 10.