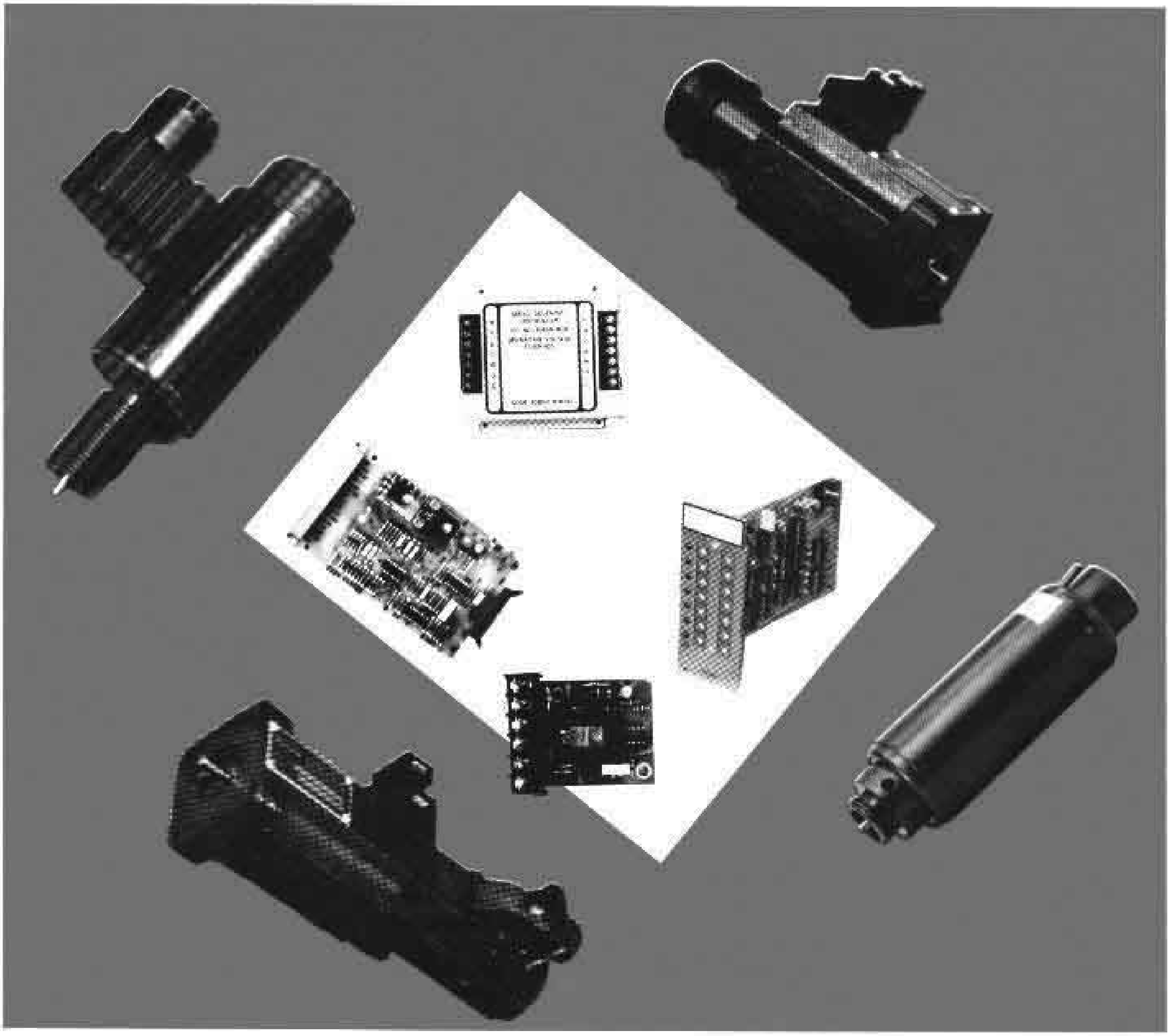
CATALOG SS-1105

Elwood Proportional Solenoids and Electronics

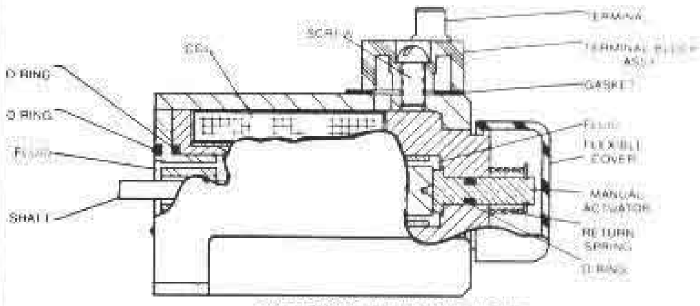


ELWOOD™

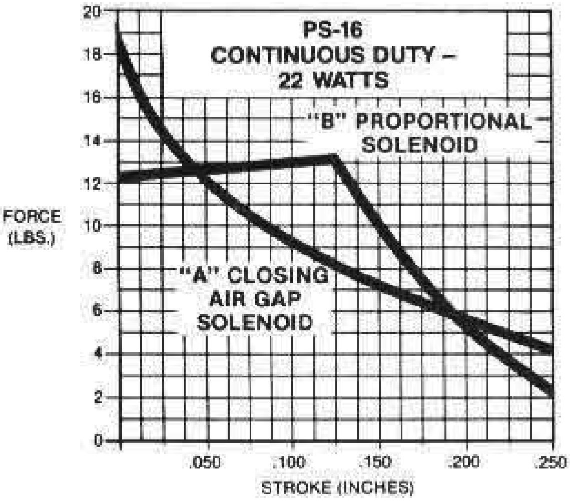
COMPLETE RANGE FROM ONE SOURCE

What is Proportional Solenoid?

Unlike the typical snapacting type, this solenoid offers a stroke which is proportional to input current. This enables the operator to position the solenoid plunger at any point along its stroke by merely increasing or decreasing the current to the coil. This unique feature is particularly the current to the coil. This unique feature is particularly useful in the relatively new field of electro-hydraulics. In recent years, it has become increasingly important to combine the precision of electronics with the brute force of hydraulics. This catalog will emphasize the use of the proportional solenoid in controlling a spool value in a hydraulic or wet system. Other fluids can be used as well as no fluids at all. You can benefit by utilizing a low cost proportional actuator capable of being controlled by an operator (open loop) or an attended system (closed loop) with extreme accuracy, using an inexpensive unregulated supply. Minimal filtration is required (100 microns) and direct replacement of servo valves is possible, with our proportional solenoid actuating the vave spool directly. Where larger valves cannot be controlled directly, proportional solenoids can be used with a smaller spool valve acting as a pilot valve.



PROPORTIONAL SOLENOID



The force versus stroke curves (shown left) are for a typical closing air gap type solenoid (Curve A) and for a proportional solenoid (Curve B). The force curve for the closing air gap solenoid shows that the force level increases as the distance between the pole pieces decreases. The force curve for the proportional solenoid increases (similar to the closing air gap solenoid), and then levels off and remains relatively flat for the remainder of the stroke. Design concepts developed by Ledex allow the manufacture of a solenoid in which the lines of flux within the solenoid control the force output from the solenoid, forming a flat force-versus-stroke relationship.

Table of Contents

	Page
What Is Proportional Solenoid	2
Explanation of Hysteresis	3
How To Use Solenoid Data	4
Technical Information	
Solenoid Specifications	5
LVDT	
Proportional Solenoid Size PS-16	6
Proportional Solenoid Size PS-20	8
Controllers	10
Amplifiers - Open Loop	11
Amplifiers - Closed Loop	12
Ramp Generator	13
Options/Applications	14
Systems	15

Explanation of Hysteresis

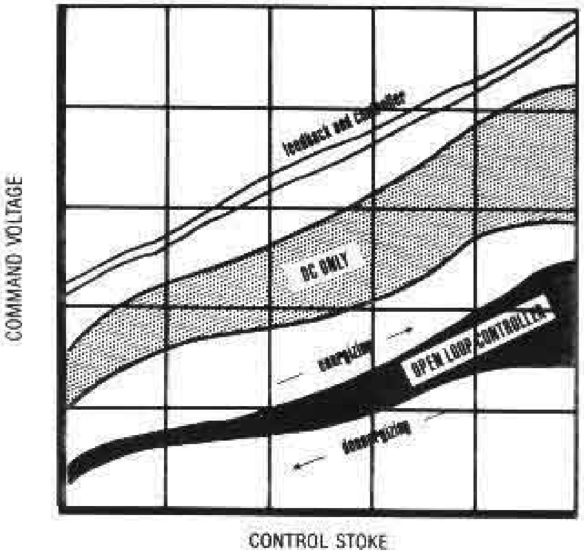
The main feature and performance characteristic of the proportional solenoid is the ability to directly control the armature position within the solenoid by the input signal to the solenoid. This control can be accomplished in a variety of ways with varying degrees of accuracy. Hysteresis in the proportional solenoid is related to the difference in current required to maintain the same position of the output shaft when the solenoid is cycled through its full control stroke. Usually, hysteresis is expressed as a percent of the rated current.

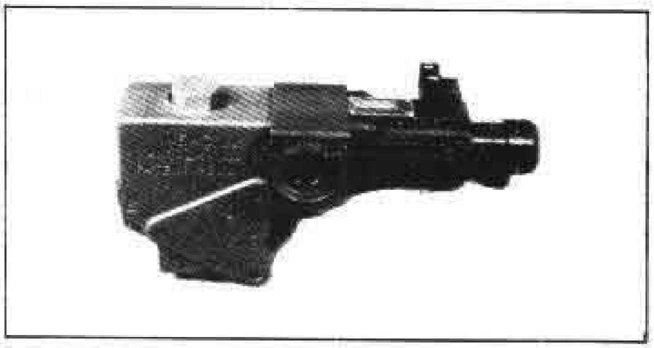
Shown here are typical hysteresis curves for three different modes of operation for a PS16 proportional solenoid at 20°C working against a spring load.

The least accurate system would be to supply a DC voltage directly to the solenoid coil. By varying the voltage, the position of the armature will change accordingly. With no method of feedback from the solenoid, the repeatability of such a system leaves much to be desired. This is due mostly to friction and loading within the solenoid.

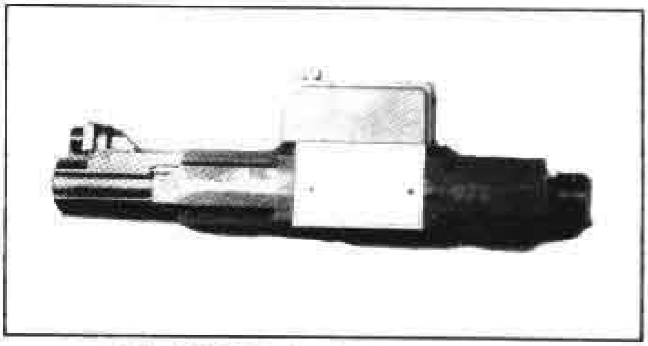
The addition of a Ledex open loop controller to this system provides increased accuracy with improved repeatability. The main difference of the basic open loop controller is the addition of a 100 Hz "dither" frequency applied to the output voltage of the controller. This, in essence, keeps the output shaft moving constantly back and forth at the rate of 100 times per second. This minimizes the effect of friction and breakaway forces of the plunger and will improve repeatability, as indicated by the graph.

When additional accuracy and repeatability is required, a Ledex feedback device should be incorporated into the system. This feedback device is a linear variable differential transformer (LVDT), which monitors the solenoid armature position and improves repeatability of the stroke to ±5 percent. This device is supplied as an integral part of the solenoid and is used with a closed inner loop controller. As indicated by the graph, the hysteresis curve is considerably better than that of the proportional solenoid operated either with DC Only and no feedback, or Open Loop and no feedback.





Typical PS 16 Solenoid on Mobile Valve



Typical PS 16 Solenoid on Industrial Valve

How To Use Solenoid Data

Proportional solenoids are available in two sizes, both with and without feedback. The PS16 is the smaller of the two units and will provide output forces ranging from 16 pounds at continuous duty to 30 pounds at 1/4 duty throughout a controlled stroke of .125 inch. Total stroke capability of the PS16 is .266 inch.

The PS20 is the larger of the two units and provides output forces ranging from 20 pounds at continuous duty to about 35 pounds at 1/4 duty throughout a controlled stroke of .312 inch. Total stroke of the PS20 is .625 inch.

The approach portion of the total stroke is required when two solenoids are operating against each other to control a spool valve. If this is not required on your system, use only the control zone. The control zone is that segment of the stroke that can be proportionally controlled. See the force versus stroke curves on adjacent pages.

Basic selection should begin with determining force and stroke requirements and selecting one of the two sizes available. Dynamic flow and spring forces in the spool valve must not exceed forces shown on the force versus stroke curves.

Once a solenoid size has been selected, the operating parameters must be determined; such as open or closed loop system, duty cycle, power source, and wet or dry application.

1. Open or Closed Loop System - First determine what type of system you will be using: either open loop with a DC power supply only or with an open loop controller, or closed loop using a feedback signal from the solenoid LVDT or some external source.

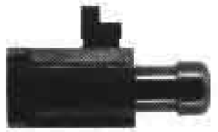
2. Duty Cycle - If your system will be run open loop, you must select a solenoid which is rated for low power with a duty cycle of continuous, which is under the "open loop" heading of the coil data section.

If your system will be run closed loop, you may select a solenoid which is rated either continuous duty or intermittent duty, depending on your load requirements. Closed loop controllers typically provide about four times (1/4 duty) continuous duty power to move a load and then revert back to a lower power level to hold the load.

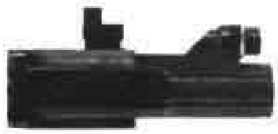
In determining your selection, it must be kept in mind that the solenoid can be powered up to obtain high force values only if it is done intermittently. The ON and OFF sequence is the time factor which determines the allowable watts input. Duty cycle is an attempt to express this time factor mathematically. f = the maximum fraction or percentage of time the solenoid is energized out of one cycle. This means that intermittently a solenoid can be powered to, for instance, the f = 1/4 voltage but the length of time it can be at that level cannot exceed 25% (1/4) without possible thermal damage to the unit.

3. Available Power Source - Once you have determined which column of the chart you will be operating in, move down the column and select a coil wire size which is suitable for your power source. Then move to the left and determine the solenoid part number for that coil. The left-most two columns contain part numbers for units with feedback for closed loop applications, and without feedback for open loop applications. Stocked units are shown in green type.

PROPORTIONAL SOLENOIDS — SIZE PS-16



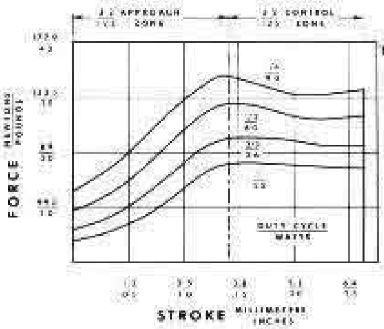
Flange Mount Size 16
P/N 160040-***



Flange Mount Size 16 With Feedback (LVDT)
P/N 160041-***

COIL DATA

STANDARD MODELS Stock Models Shaded Area PS-16 w/o LVDT 160040-***	PS-16 with LVDT 160041-***	duty cycle watts at 20°C (approx.) awg. no	resistance	OPEN LOOP Low Power f = 1 22 volts DC	CLOSED LOOP Low Power f = 2/3 36 volts DC	Med. Power f = 1/3 60 volts DC	High Power f = 1/4 90 volts DC
-002	-002	21	1.78	6.0	8.0	10.0	12.0
-003	-003	22	2.46	8.0	10.0	12.0	15.0
160040-004	160041-004	23	4.45	10.0	12.0	15.0	20.0
-005	-005	24	6.18	12.0	15.0	20.0	24.0
160040-006	160041-006	25	10.59	15.0	20.0	24.0	30.0
-007	-007	26	17.53	20.0	24.0	30.0	36.0
-008	008	27	24.28	24.0	30.0	36.0	48.0
-009	009	28	39.23	30.0	36.0	48.0	60.0
-010	-010	29	62.48	36.0	48.0	60.0	72.0
-011	-011	30	97.58	48.0	60.0	72.0	95.0
-012	-012	31	167.10	60.0	72.0	95.0	120.0
-013	013	32	253.57	72.0	95.0	120.0	150.0
-014	-014	33	414.07	95.0	120.0	150.0	200.0
-015	-015	34	614.97	120.0	150.0	200.0	230.0



TYPICAL FREQUENCY RESPONSE

Stroke	Duty Cycle	Current (Amps)	Spring Force Initial	Spring Force Ending	Time Millisec. Energ.	Time Millisec. De-energ.	Max Rate Hz
.125" Control Zone	Cont.	1.15	4#	10#	52	40	11
	1/2	1.66	4#	10#	30	43	13.5
	1/4	2.34	4#	10#	21	46	15
.250" Control & Approach Zone	Cont.	1.15	2 1/2#	7#	72	65	7
	1/2	1.66	2 1/2#	7#	38	68	9
	1/4	2.34	2 1/2#	7#	35	72	10

This table depicts typical frequency response of a size 16 proportional solenoid, with 16.4 ohm coil at 20°C ambient temperature working against a spring. A 1N4004 diode was used for arc suppression when de-energized. These speeds are in an open loop mode.

Solenoid Specifications

Parameter	PS16	PS20
Stroke	.125" controlled, .125" approach	.312" controlled, .312" approach
Pressure	2500 psi	2500 psi
Filtration	100 microns	100 microns
Mounting	sq. flange w/ 4 holes on 1.418 sq.	1.062-12UN-2A male thd., .38 lg.
Life	10 million cycles min.	10 million cycles min.
Frequency response	7 Hz at cont. duty, .250" stroke	5.5 Hz at cont. duty, .625" stroke
Hysteresis w/o LVDT @ 120 Hz with LVDT @ 1000 Hz	 ±5% ±2%	 ±5% ±2%
Insulation Class of Coil	F, 155° C	F, 155° C
Vibration	10G, 500 Hz	10G, 500 Hz
Shock	30G, 11 ms	30G, 11 ms
High Temperature	+71° C	+71° C
Low Temperature	−40° C	−40° C
Dielectric Strength	0.5mA max. @ 1000 VRMS	0.5mA max. @ 1000 VRMS

LVDT — What Is It and How Does It Work?

An LVDT is a basic linear position, electrical feedback sensor. Its function is similar to that of a common potentiometer. The device consists of three coils and a core rod of special material. The core rod is attached to the rear of the solenoid armature and slides through the inside of the three coils without contacting them.

A voltage feeds into the primary coil which induces a voltage in the two secondary coils. The intensity of the induced voltage is dependent upon the amount of core rod material inside the coil. When the core rod is centered, an equal voltage is induced in both secondaries. When the core rod is displaced unequally under the two secondary coils, an unequal voltage is induced.

Illustrated here is the LVDT displacement-versus-ouput voltage. It is this characteristic that can be utilized by an electronic controller as an electrical feedback signal to determine position.

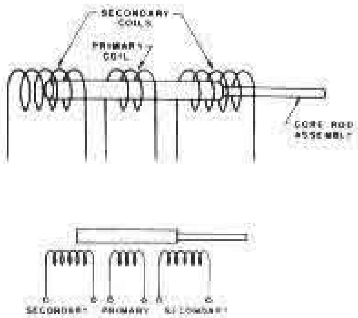


Fig. 1

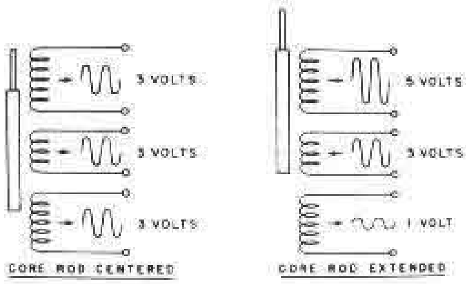


Fig. 2

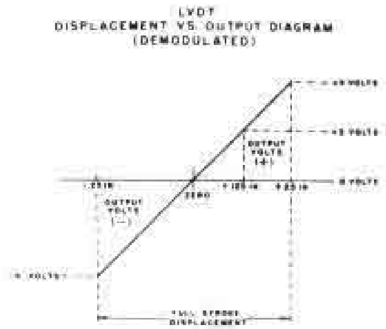
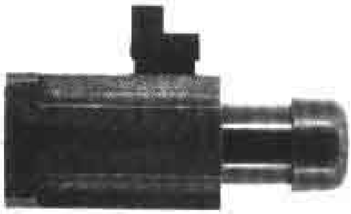
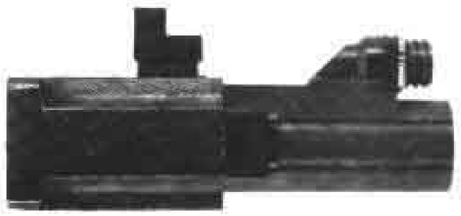


Fig. 3

Proportional Solenoids size PS-16



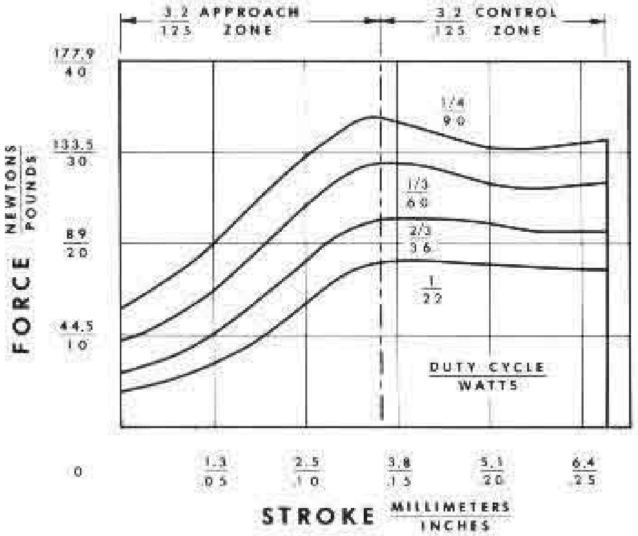
Flange Mount Size 16
P/N 160040-***



Flange Mount Size 16 With Feedback (LVDT)
P/N 160041-***

COIL DATA

STANDARD MODELS Stock Models in Shaded Areas				OPEN LOOP	CLOSED LOOP		
				Low Power	Low Power	Med. Power	High Power
PS-16 w/o LVDT 160040-***	PS-16 with LVDT 160041-***	duty cycle		f = 1	f = 2/3	f = 1/3	f = 1/4
		watts at 20°C (approx.)		22	36	60	90
		awg. no	resistance	volts DC	volts DC	volts DC	volts DC
-002	-002	21	1.78	6.0	8.0	10.0	12.0
-003	-003	22	2.46	8.0	10.0	12.0	15.0
160040-004	160041-004	23	4.45	10.0	12.0	15.0	20.0
-005	-005	24	6.18	12.0	15.0	20.0	24.0
160040-006	160041-006	25	10.59	15.0	20.0	24.0	30.0
-007	-007	26	17.53	20.0	24.0	30.0	36.0
-008	-008	27	24.28	24.0	30.0	36.0	48.0
-009	-009	28	39.23	30.0	36.0	48.0	60.0
-010	-010	29	62.48	36.0	48.0	60.0	72.0
-011	-011	30	97.58	48.0	60.0	72.0	95.0
-012	-012	31	167.10	60.0	72.0	95.0	120.0
-013	-013	32	253.57	72.0	95.0	120.0	150.0
-014	-014	33	414.07	95.0	120.0	150.0	200.0
-015	-015	34	614.97	120.0	150.0	200.0	230.0



TYPICAL FREQUENCY RESPONSE

Stroke	Duty Cycle	Current (Amps)	Spring Force Initial	Spring Force Ending	Time, Millisec. Energ.	Time, Millisec. De-energ.	Max Rate (Hz)
.125"	Cont.	1.15	4#	10#	52	40	11
Control	1/2	1.66	4#	10#	30	43	13.5
Zone	1/4	2.34	4#	10#	21	46	15
.250"							
Control &	Cont.	1.15	2 1/2#	7#	72	65	7
Approach	1/2	1.66	2 1/2#	7#	38	68	9
Zone	1/4	2.34	2 1/2#	7#	35	72	10

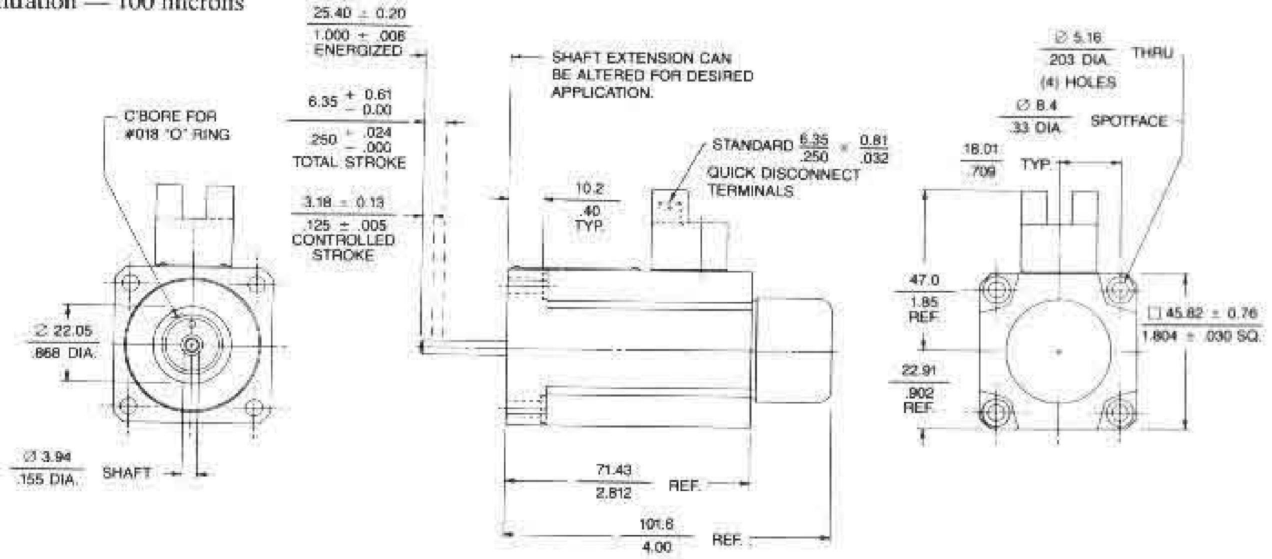
This table depicts typical frequency response of a size 16 proportional solenoid, with 16.4 ohm coil at 20°C ambient temperature working against a spring. A 1N4004 diode was used for arc suppression when de-energized. These speeds are in an open loop mode.

Electrical
Coil Temp. — Max. Rated 150°C
Case Temp. — (Nom.) 80°C
Insulation Class — F, 155°C
Dielectric Strength — 0.5 mA Max. Leakage Allowable Coil To Case at 1000 VRMS
Inductance —
- Current build-up
  - Shaft extended — 363.7 mh
  - Shaft retracted — 146.2 mh
- Current decay
  - Shaft extended — 145.2 mh
  - Shaft retracted — 150.6 mh

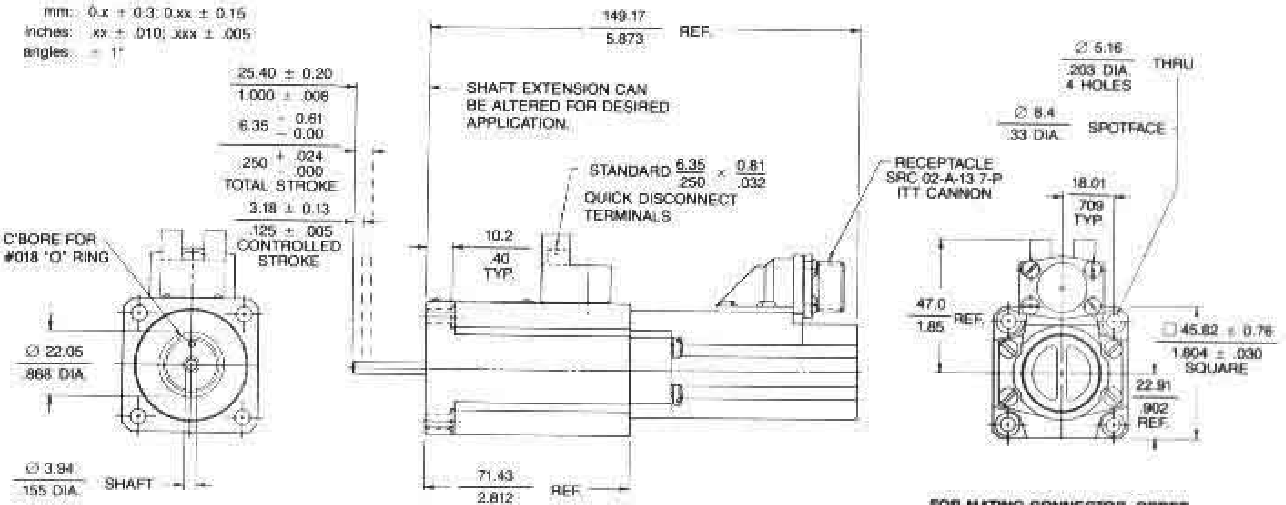
Mechanical
Weight w/o LVDT — 1 lb. 6 oz. (.62 kg)
with LVDT — 2 lb. (.9 kg)
Life (full cycles) — 10 million min.
Pressure — 2500 psi static
Filtration — 100 microns

Electrical
Coil Res. Primary — 7.8 ± 10%
Secondary 66.5 ± 10%
Insulation Class — F, 155°C
Primary Input Volts — 8 VAC Peak to Peak
Input Frequency — 8 KHz
Linearity — 2% of full stroke
Output — ± 4.25 VRMS @ 5 KHz

Mechanical
Life (full cycles) — 10 million min.
Pressure — 2500 psi static
Filtration — 100 microns
Connector — SRC-02-A-13-7-P ITT Cannon

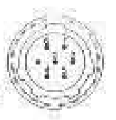


Tolerance:
mm: 0.x ± 0.3; 0.xx ± 0.15
inches: .xx ± .010; .xxx ± .005
angles: ± 1°



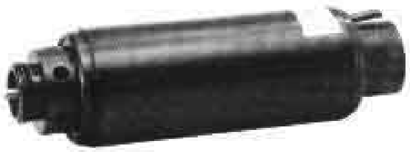
FOR MATING CONNECTOR, ORDER LUCAS LEDEX PART NO. 192000-001.

Metrics are for reference only.



PIN PATTERN

SECONDARY COIL "A" PIN 1 & 3 (66.49 ± 10% Ω AT 20°C)
PRIMARY COIL — PIN 4 & 5 (7.82 ± 10% Ω AT 20°C)
SECONDARY COIL "B" PIN 6 & 7 (66.49 ± 10% Ω AT 20°C)

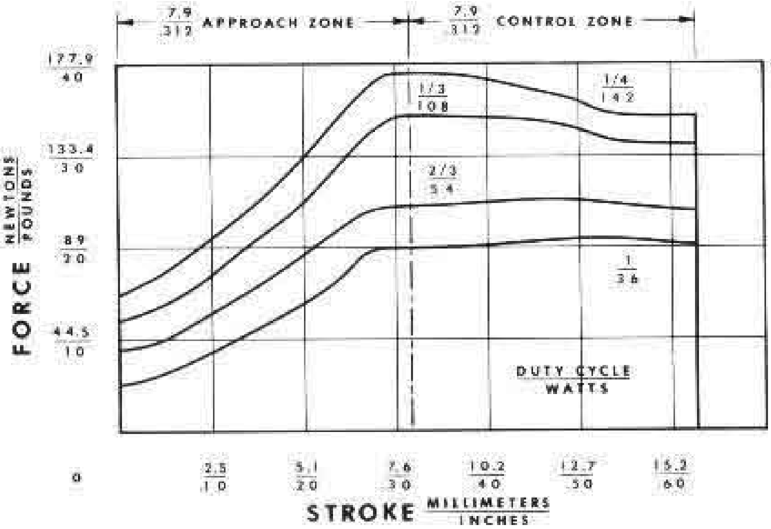


Thread Mount Size 20
P/N 162012-***

Thread Mount Size 20 With Feedback (LVDT)
P/N 162013-***

COIL DATA

STANDARD MODELS Stock Models in Shaded Areas				OPEN LOOP	CLOSED LOOP		
				Low Power	Low Power	Med. Power	High Power
PS-20 w/o LVDT 162012-***	PS-20 with LVDT 162013-***	duty cycle		f = 1	f = 2/3	f = 1/3	f = 1/4
		watts at 20°C (approx.)		36	54	108	142
		awg.no.	resistance	volts DC	volts DC	volts DC	volts DC
-003	-003	17	.46	4.0	6.0	7.0	8.0
-004	-004	18	1.03	6.0	7.0	10.0	12.0
162012-005	162013-005	19	1.43	7.0	10.0	12.0	14.0
-006	-006	20	2.79	10.0	12.0	16.0	19.0
162012-007	162013-007	21	3.85	12.0	16.0	19.0	24.0
-008	-008	22	6.95	16.0	19.0	24.0	32.0
-009	-009	23	9.62	19.0	24.0	32.0	38.0
-010	-010	24	16.52	24.0	32.0	40.0	48.0
-011	-011	25	27.31	32.0	40.0	48.0	60.0
-012	-012	26	44.23	40.0	48.0	60.0	80.0
-013	-013	27	61.18	48.0	60.0	80.0	95.0
-014	-014	28	109.91	60.0	80.0	100.0	120.0
-015	-015	29	170.15	80.0	100.0	120.0	160.0
-016	-016	30	260.26	100.0	120.0	165.0	200.0



TYPICAL FREQUENCY RESPONSE

Stroke	Duty Cycle	Current (Amps)	Spring Force Initial	Spring Force Ending	Time, Millisec. Energ.	Time, Millisec. De-energ.	Max Rate (Hz)
.312" Control Zone	Cont.	5.77	5#	25#	160	51	4.5
	1/2	8.16	5#	25#	84	56	7.0
	1/4	11.55	5#	25#	42	62	9.5
.625" Control & Approach Zone	Cont.	5.77	3#	17#	88	88	5.5
	1/2	8.16	3#	17#	59	92	6.5
	1/4	11.55	3#	17#	42	100	7.0

This table depicts typical frequency response of a size 20 proportional solenoid, with a 1.04 ohm coil at 20°C ambient temperature working against a spring. A 1N4004 diode was used for arc suppression when de-energized. These speeds are in an open loop mode.

PS-20 SOLENOID CHARACTERISTICS

Electrical

Coil Temp. — Max. Rated 150°C
Case Temp. — (Nom.) 90°C
Insulation Class — F, 155°C
Dielectric strength — 0.5 mA Max. Leakage
Allowable Coil To Case at 1000 VRMS
Inductance —
Current build-up
Shaft extended — 93.8 mh
Shaft retracted — 33.3 mh
Current decay
Shaft extended — 22.5 mh
Shaft retracted — 30.3 mh

Mechanical

Weight w/o LVDT — 3 lb. 8 oz. (1.6 kg)
with LVDT — 4 lb. 8 oz. (2.0 kg)
Life (full cycles) — 10 million min.
Pressure — 2500 psi static
Filtration — 100 microns

LVDT CHARACTERISTICS

Electrical

Coil Res. Primary — 9.4 ± 10%
Secondary 73.2 ± 10%
Insulation Class — F, 155°C
Primary Input Volts — 8 VAC Peak to Peak
Input Frequency — 8 KHz
Linearity — 2% of full stroke
Output — ± 4.25 VRMS @ 5 KHz

Mechanical

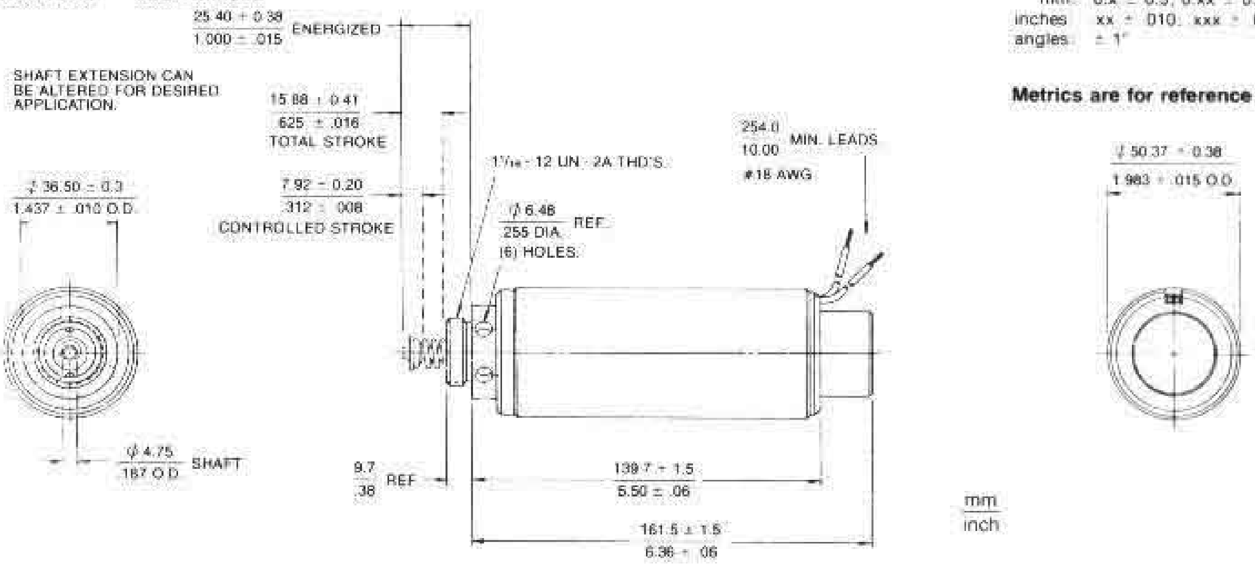
Life (full cycles) — 10 million min.
Pressure — 2500 psi static
Filtration — 100 microns
Connector — Leads

CAUTION: These solenoids not for use with water-based fluids. Please consult factory.

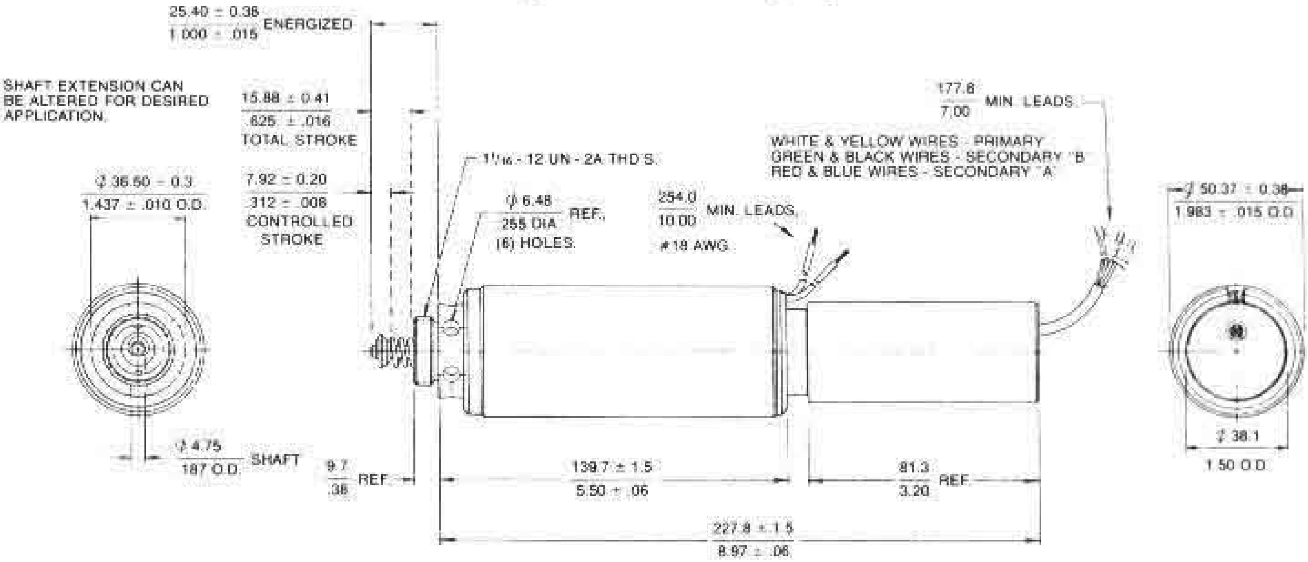
Tolerance:

mm: 0.x ± 0.3; 0.xx ± 0.15
inches: .xx ± .010; .xxx ± .005
angles: ± 1°

Metrics are for reference only.



Caged Spring Shown, Follower Spring Available.



Caged Spring Shown, Follower Spring Available.

Controllers

As control systems become more complex, electronics moves into the forefront as the leader in the control field. Nothing to date offers the flexibility required to accommodate the maze of requirements common in the design of today's control systems.

In general, there are two control areas. The first is the intelligence. This is that area which can visualize the outcome of a product or service, and monitors for control the operations involved in rendering that product or service.

The other area of control is the actual muscle necessary to insure that the system will stay within the parameters set down by the intelligence. This muscle can be an integral part of the intelligence, the strong right arm on a backhoe operator's shoulder, or it can be an amplified electrical signal from a programmable controller to a servo or a proportional device. The electrical amplification might also be the only electronics involved in the system with the backhoe operator manipulating an electrical control lever. The operator supplies the intelligence. This part of the control equation is the part the electronic controllers are designed to address; in particular, we are concerned with the proportional solenoid type system.

To best control the proportional solenoid, we selected a method of control called pulse width modulation (PWM). When comparing a proportional solenoid to a more common servo type device, some major differences are apparent. The proportional solenoid consumes watts; the servo device consumes milli-watts. Thus the controllers for proportional solenoids must be capable of handling higher current levels. Because the moving mass of the proportional solenoid is greater than that of the servo device, friction is much more significant. Another point to consider when designing a proportional controller is the magnetic hysteresis of the materials involved. In manufacturing the solenoid, this hysteresis presents itself much like mechanical friction. To minimize the problems of power loss and component heating due to high current levels, and to help reduce the frictional sticking and magnetic hysteresis of the solenoid, the signal to the solenoid is a pulsing DC voltage. A DC pulse is applied to the solenoid with a variable duration (proportional to the command), at a predetermined frequency. The more power required to position the solenoid, or higher the force required, the longer the "on" time supplied by the controller. These pulses also provide a "dither" to the solenoid plunger. While the solenoid cannot follow these pulses, it does feel the vibration these pulses introduce. The vibration minimizes the mechanical and magnetic friction.

The last major consideration for the design of the controller is closing of the feedback loop. When greater accuracy or repeatability is required, a closed loop system must be utilized. On servo devices there is normally some method of mechanical feedback. On the proportional system there is utilized, when necessary, electrical feedback in reference to the solenoid plunger position. The controllers are designed to operate in conjuction with an LVDT that is integral to the solenoid or the load being controlled. The controller can then compare the desired command to the actual solenoid position and cause the solenoid to comply with the command. Besides direct monitoring of the solenoid shaft position, the controllers also have capabilities of monitoring the final, or output, function and adjusting the solenoid to achieve the desired end result. "Closed inner loop" means monitoring and controlling the solenoid shaft extension only. "Closed outer loop" means monitoring the work output by controlling the solenoid shaft. A closed outer loop system may involve both inner and outer loop monitoring and control.

1. Amplifiers
   - A. Open Loop
     - 1. Constant voltage — controls one proportional solenoid without LVDT
       - Least expensive
       - Very simple
       - No options available
     - 2. Constant current — controls one proportional solenoid without LVDT
       - Nullifies effects of temperature variation
       - Adjustable current levels
       - Adjustable dither frequency
       - Adjustable supply voltage
   - B. Closed Loop
     - 1. Single channel — controls one proportional solenoid with LVDT
       - Adjustable centering
       - Adjustable span
       - Adjustable gain
       - Adjustable control voltage
     - 2. Dual channel — controls 2 proportional solenoids (1 with LVDT, 1 without)
       - Adjustable centering
       - Adjustable span
       - Adjustable gain
       - Adjustable control voltage

- PWM circuitry is used to minimize power loss and heating as well as to provide dither.
- Lead-lag compensation is used to stabilize the system under various load conditions.
- Low cost, wide tolerance power supply can be used, since built-in voltage regulation is provided.
- Closed loop controller provides approximately four times (1/4 duty) continuous power to move the load and then reverts to a lower power level to hold the load.

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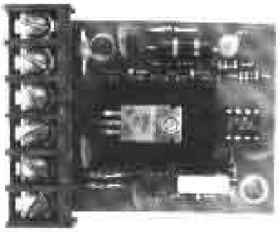
Amplifiers — Open Loop

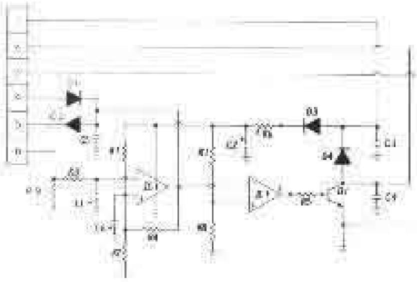
CONSTANT VOLTAGE
Single Channel
P/N 185307-001



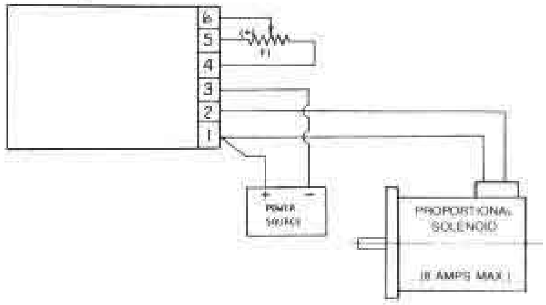
Rating	Min.	Typ.	Max.	Units
+ DC Input	11	12	14	Volts
Operating Temperature	-15°C	—	+75°C	°C
Load Current	—	—	8	Amps
CMA. POT.(P1)	—	100K	—	Ohms
PWM Freq.	80	100	120	HzC

The single channel constant voltage controller is an inexpensive method of achieving pulse width modulation control in proportional solenoid applications. This device is designed to give a proportional PWM signal in relationship to the angular displacement of a 100K potentiometer. In comparison to a rheostat type controller, the constant voltage controller offers the advantage of dither to minimize mechanical friction. Its size is small when compared to output available.

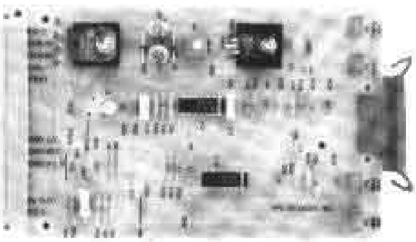
Schematic



Wire Hook-up



CONSTANT CURRENT
Single Channel
P/N 190093-001

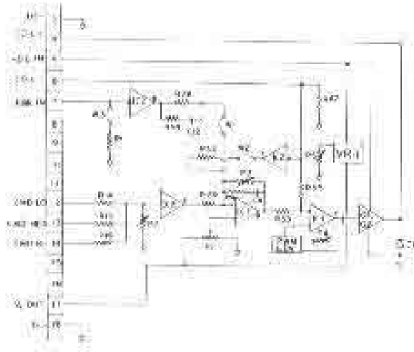


Rating	Min.	Typ.	Max.	Units
+ DC Supply input	13	15	29	Volts
Command Voltage	0		10	Volts
Coil Current Range**				
CMD Lo	192	225	258	mA
CMD Med	255	300	345	mA
CMD Hi	340	400	460	mA
Zero Current Adj.		±90		mA
Dither Freq. Adj.	100		500	Hz
*CMD & Fbk Input Impedance	25K			Ohms
Operating Temperature	-25		+70	°C

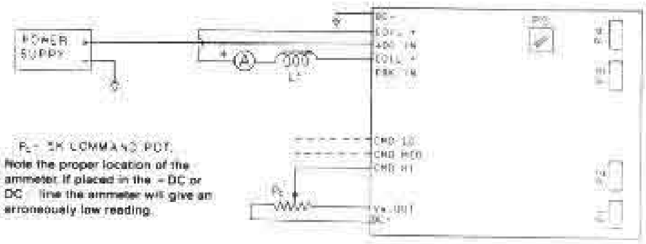
* Does Not Apply to 4-20mA Feedback
** Ranges shown are typical for minimum setting of GAIN (P3)

The single channel constant current controller converts an input analog signal to a pulse width modulated output signal that will hold a constant average current through a proportional solenoid. If the task the proportional solenoid is doing is dependent on a constant force output, regardless of solenoid stroke or coil temperature, this controller will suffice. There are three different current levels available on this controller: 0-225 mA, 0-300 mA, and 0-400 mA. The desired level is programmable by three different input selection ports. There are also provisions on board for externally generated feedback signals of 0-10 V DC or 4-20 mA.

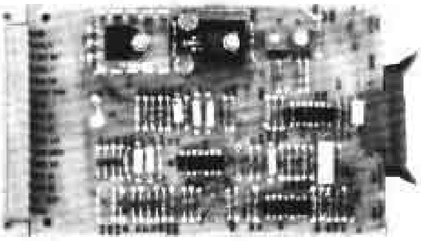
Schematic



Wire Hook-up



CONSTANT VOLTAGE
Single Channel
P/N 190094-001

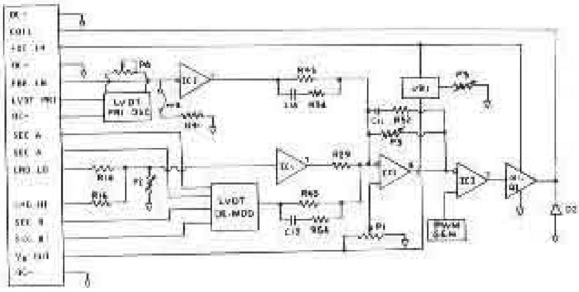


Rating	Min.	Typ.	Max.	Units
+ DC Input	13	15	29	Volts
Command Voltage	0		10	Volts
Span—CMD Hi		.0125		In./Volt
Span—CMD Lo		.0063		In./Volt
PWM Frequency		250		Hz
Command Input Impedance	50K			Ohms
*Feedback Impedance		25K		Ohms
Operating Temperature	-25		+70	°C

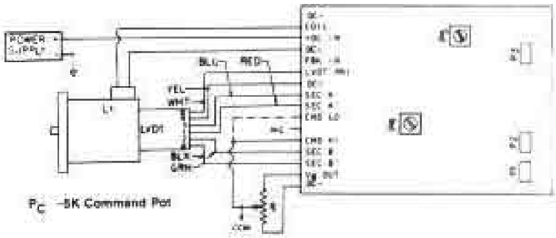
*Does Not Apply to 4-20mA Feedback

The single channel controller converts an input command voltage to a proportional output signal for controlling the position of a proportional solenoid. This device utilizes pulse width modulation for optimum performance along with positional feedback from an LVDT. In addition to the LVDT position feedback, the controller also has provisions for externally generated feedback signals of 0-10V DC or 4-20 mA.

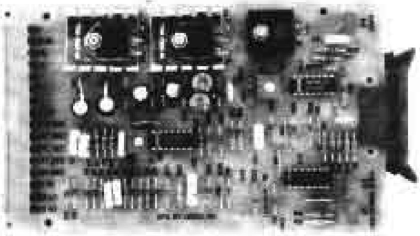
Schematic



Wire Hook-up



CONSTANT VOLTAGE
Dual Channel
P/N 190095-001

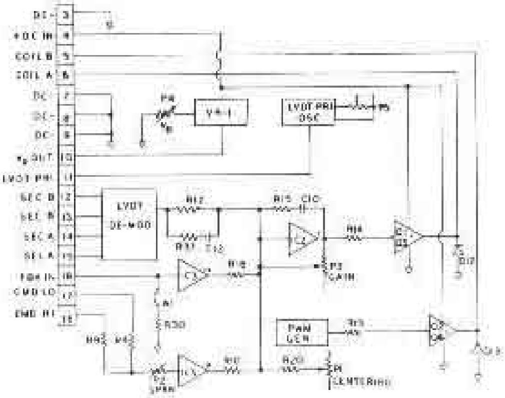


Rating	Min.	Typ.	Max.	Units
+ DC Supply Input	13	15	29	Volts
Command Voltage	0		10	Volts
Span—CMD Lo		.005		In./Volt
Span—CMD Hi		.01		In./Volt
CMD & FBK Input Impedance*	25K			Ohms
V_ROut (Adj. Range)	5.0	10.0		Volts
Center Voltage		5		Volts
Solenoid Resistance	2.2	4		Ohms
Operating Temperature	-25	+25	+70	°C

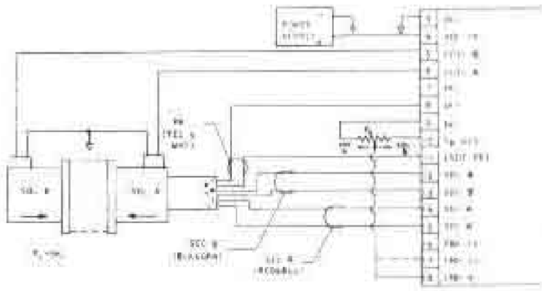
*Does Not Apply For 4-20mA Feedback

The two-channel controller converts an input command voltage to a proportional output signal for controlling the position of two proportional solenoids working in opposition to one another. The controller determines which solenoid is to energize and how much that solenoid is to energize. This device utilizes pulse width modulation for optimum performance along with positional feedback from an LVDT. In addition to the LVDT positio[n] feedback, the controller also has provisions for externally gene[r]ated feedback signals of 0-10V DC or 4-20 mA.

Schematic



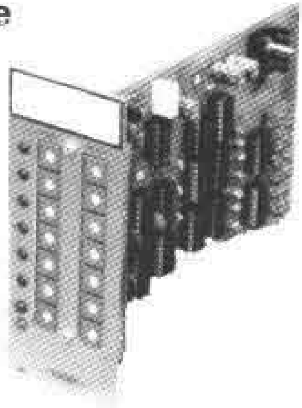
Wire Hook-up



Ramp Generator

7 Channel, 7 Rate

P/N 190096-001

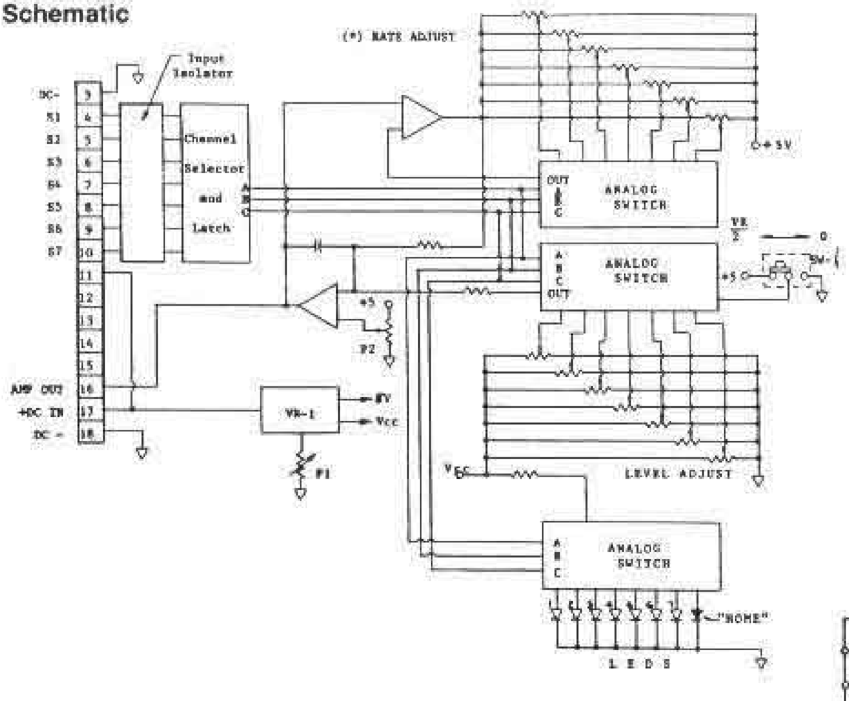


Rating	Min.	Typ.	Max.	Units
+DC Supply Input	13	15	29	Volts
Output Voltage (a)	1		9	Volts
Ramp Rate	<0.5		225	V/Sec.
Input Line Impedance		1.5K		Ohms
Input Pulse Amplitude	10	15	29	Volts
Input Pulse Length	10		Cont.	MS
Operating Temperature	−25	+25	+70	°C

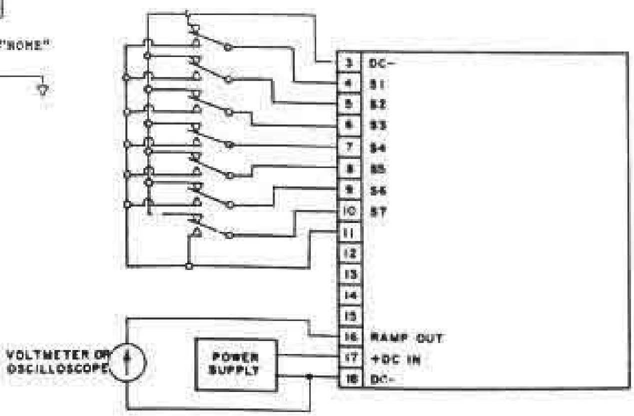
(a) Output Load Impedance ≥2K Ohms

The ramp generator is a controller which offers a DC output at any one of seven predetermined levels. The rate at which the levels shift is also independently adjustable. In addition to the seven predetermined levels, the controller also has a "home" feature. If for any reason the power to the controller is disrupted, the output goes to a safe, or home, level when power is restored. There are two home levels offered, "0"V DC or 5V DC. The level shifts are effected by a DC trigger pulse applied to the input ports. The trigger level may be a continuous voltage or a pulse of 20 ms or longer. This controller is designed to operate in conjunction with the Ledex proportional controllers, but the output of the ramp generator is such that it will interface with any equipment whose input impedance is greater than 2K ohms.

Schematic



Wire Hook-up



Options

Solenoids

Common

- Terminations — Spade
  — Flying Leads
  — Hirschman
  — Cannon
  — MS Type Connectors
  — Specials
- Shaft Length — 1.00" Standard
  — Any Desired Length
- Stroke — Standard as noted
  — Any length *shorter*
- Springs — Can be added as required
- Manual Actuators — Push Type
  — Threaded Type
  — None if desired

Special Design

- Stroke — Longer than standard
- * Mounting — Can be changed to accommodate
- * Size — Can be designed if quantity is sufficient

* Will require tooling dollars.

Electronics

Common

Mounting — Bare Boards
— Rack Mounted
— Panel Mount
— Housed
— Housed and Potted

Voltage Ranges — 11-42
— 24-60

Applications

The applications listed below are but a few of the many versatile uses found for proportional solenoids and related components. Please consult the factory for help on your specific application.

SALT SPREADER TRUCKS –
Ground oriented; application rate control

WATER PUMPS –
Swash plate control

FORK LIFT TRUCKS –
Man in the air; lift, tilt, and traverse controls

TRENCHERS –
Horsepower control

STEEL ROLLING –
Cylinder positioning

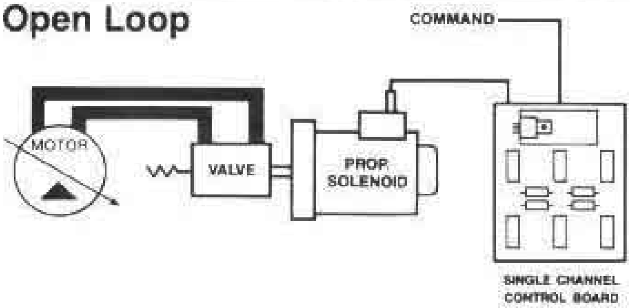
HONING MACHINES –
Quill speed control

DIE CAST MACHINES –
Application rate control

COMBINES –
Variable speed reel drives

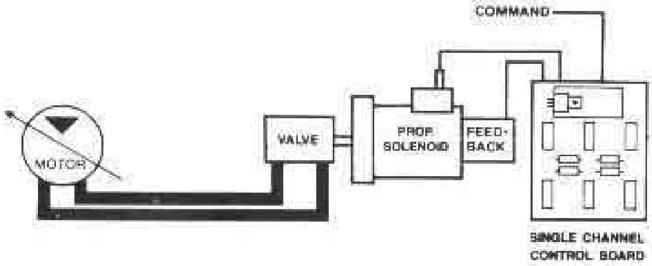
Systems

Open Loop



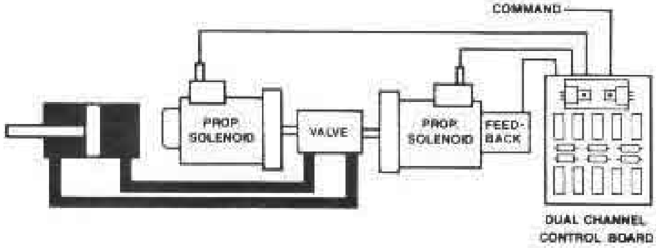
Open loop systems are the simplest form of control. They require no electrical feedback. Normally they rely on an operator, who provides this feedback, using visual, audible or tactile methods. Open loop control will not compensate by itself for the effects of temperature or force changes.

Closed Inner Loop, Single Channel



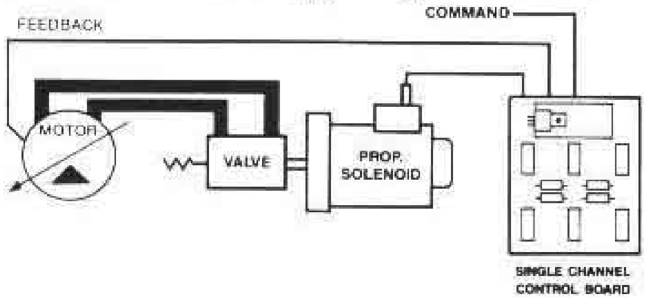
Closed inner loop, single channel systems refer to the addition of electrical feedback on a single solenoid. This method improves control over an open loop system by compensating for various parameters affecting the solenoids. Here, solenoid position can be held without question for long periods of time.

Closed Inner Loop, Dual Channel



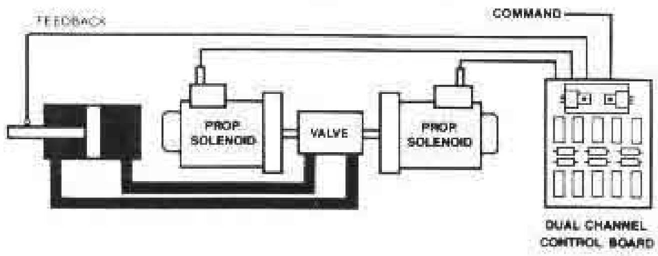
Closed inner loop, dual channel systems refer to two-solenoid operation with feedback on the solenoid. This system is similar to the one immediately above, with the addition of a second solenoid. Closed inner loop control is accurate and yet simple.

Closed Outer Loop, Single Channel

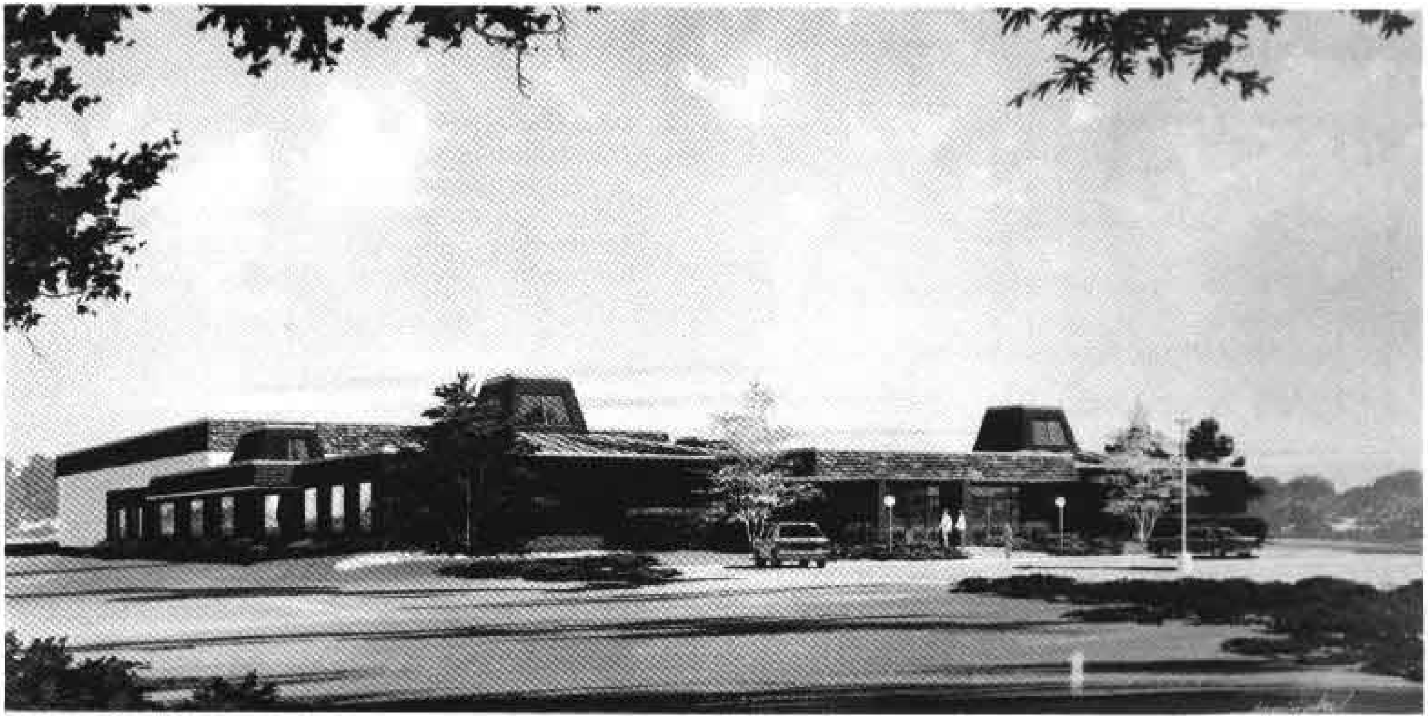


Closed outer loop, single channel systems incorporate a single solenoid without feedback. This system loop is closed by placing a feedback device on the final item being controlled; in this case, a hydraulic motor. This allows the outer loop to be controlled more precisely.

Closed Outer Loop, Dual Channel



Closed outer loop, dual channel systems utilize two solenoids without feedback. The feedback device is again located on the outer or final element; in this case, a cylinder. Outer loop control is the most precise but the most difficult to set up.



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