SERVO VALVES PILOT OPERATED

FLOW CONTROL VALVE WITH ANALOG INTERFACE

78 SERIES

Rev. P, March 2024

HIGH PERFORMANCE, TWO-STAGE DESIGN PROVIDING FLOW CONTROL IN A SIMPLE, RUGGED, DEPENDABLE, LONGLIFE DESIGN

WHAT MOVES YOUR WORLD

MOOG

Whenever the highest levels of motion control performance and design flexibility are required, you'll find Moog expertise at work. Through collaboration, creativity and world-class technological solutions, we help you overcome your toughest engineering obstacles, enhance your machine's performance, and help take your thinking further than you ever thought possible.

PRODUCT OVERVIEW

The 78 series is part of the Moog family of Mechanical Feedback (MFB) Servo Valves. They are throttle valves for 3 and 4 way applications. This series has a high performance, two-stage design that covers a range of rated flows from 75 to 150 l/min (20 to 40 gpm) at 35 bar (500 psi) valve drop per spool land. These valves are intended for position, speed, pressure or force control applications that require high dynamic response. The 78 series MFB offers high dynamics, high resolution and low hysteresis due to its low friction double nozzle pilot stage.

The design is simple and rugged for dependable, long life operation. The output stage is a closed center, 4 way sliding spool. The pilot stage is comprised of a symmetrical, double nozzle dry torque motor. The 2nd stage spool position is controlled by a carbide tipped feedback wire. The carbide ball on the end of the feedback wire is a mandatory design requirement that ensures high accuracy, reliable operation and long service life. All of our servo valves are known for high accuracy and reliable operation even in the harshest industrial applications.

This family of valves is considered a flow control servo valve with an analog interface, but does not contain integrated electronics. The options in this series include standard and high response, special null (spool) cuts, seal materials and connectors. Intrinsically safe and flameproof designs for use in hazardous environments are also available with specific models certified to FM, ATEX, CSA and TIIS (Asian) standards.

All of our valves are backed by Moog Global Support, our promise to provide world-class repair and maintenance services delivered by our trained technicians. Each valve possesses a long life design, controlled by proven servo valve technology that has an outstanding history of 60 years of meeting the motion control needs of our customers. All of this makes Moog servo valves the best choice for your hydraulic motion control requirements.

	Standard response valves with Ø 0.625 spool			**High response valves with Ø 0.406 spool**	
Valve design	2-stage, with spool and bushing and dry torque motor				
Mounting pattern	Unique to 78 Series				
Maximum operating pressure to ports P, T, A, B	210 bar (3000 psi)				
Maximum flow	208 l/min (54.9 gpm)			156 l/min (41.2 gpm)	
Pilot stage	Nozzle Flapper				
Rated flow at Δp_N 35 bar/spool land (500 psi/spool land)	75 l/min (20 gpm)	115 l/min (30 gpm)	150 l/min (40 gpm)	75 l/min (20 gpm)	115 l/min (30 gpm)
Step response time for 0 to 100 % stroke	30 ms		40 ms	15 ms	20 ms

Intrinsically safe and explosion proof valve versions are available for use in potentially hazardous environments. Specific models are certified to FM, ATEX, CSA, TIIS and IECEx standards. Contact Moog for details.

PRODUCT OVERVIEW

Documents

Name	Description	Remark	Number
Catalog	78 series	To download document click here or scan below:	CDL6272
Manual	78 standard series		CDS6569
	78 intrinsically safe (K) series		CDS6752
	78 explosion proof (N) series		CDS6857
Installation drawing	78 standard series		CC44555
	78 instrinsically safe (K) series		
	78 explosion proof (N) series		CC42165

FEATURES AND BENEFITS

The 78 Series is proven technology that performs reliably in machines where high performance, stability and accuracy are required. Moog's Mechanical Feedback Valves are designed to provide high reliability and long service life. The current technology reflects over 60 years of experience of servo control in some of the world's most demanding environments.

Features	Benefits
100% factory tested to ensure critical specification performance	Ensures smooth and easy startup, reduces downtime and insures long life in critical industrial applications
2 Stage Design	Enables high machine performance, faster cycle times and greater accuracy - all resulting in higher productivity
Dual Coil torque motor	Redundancy for high reliability
Dual Precision Nozzles in Torque Motor	Precision flow control and predictability
Dry torque motor design	Eliminates potential contamination issues in the air gaps of the torque motor that could cause machine downtime
Hardened 440C Bushing and Spool	Provides for high life, wear resistance when used in the harsh environments; provides for low sliding friction during use
Emergency failsafe positioning	Most valves are set up to return to a failsafe position when the command signal is interrupted or eliminated
Field replaceable pilot stage filter	Enables preventive maintenance in the field, saving precious machine downtime and service costs
External null bias adjustment	Enables technicians to manually adjust the null bias of the valve to adapt to the conditions of the machine. This feature provides a simple adjustment to machine performance without the need to adjust a controller.

DESCRIPTION OF OPERATION

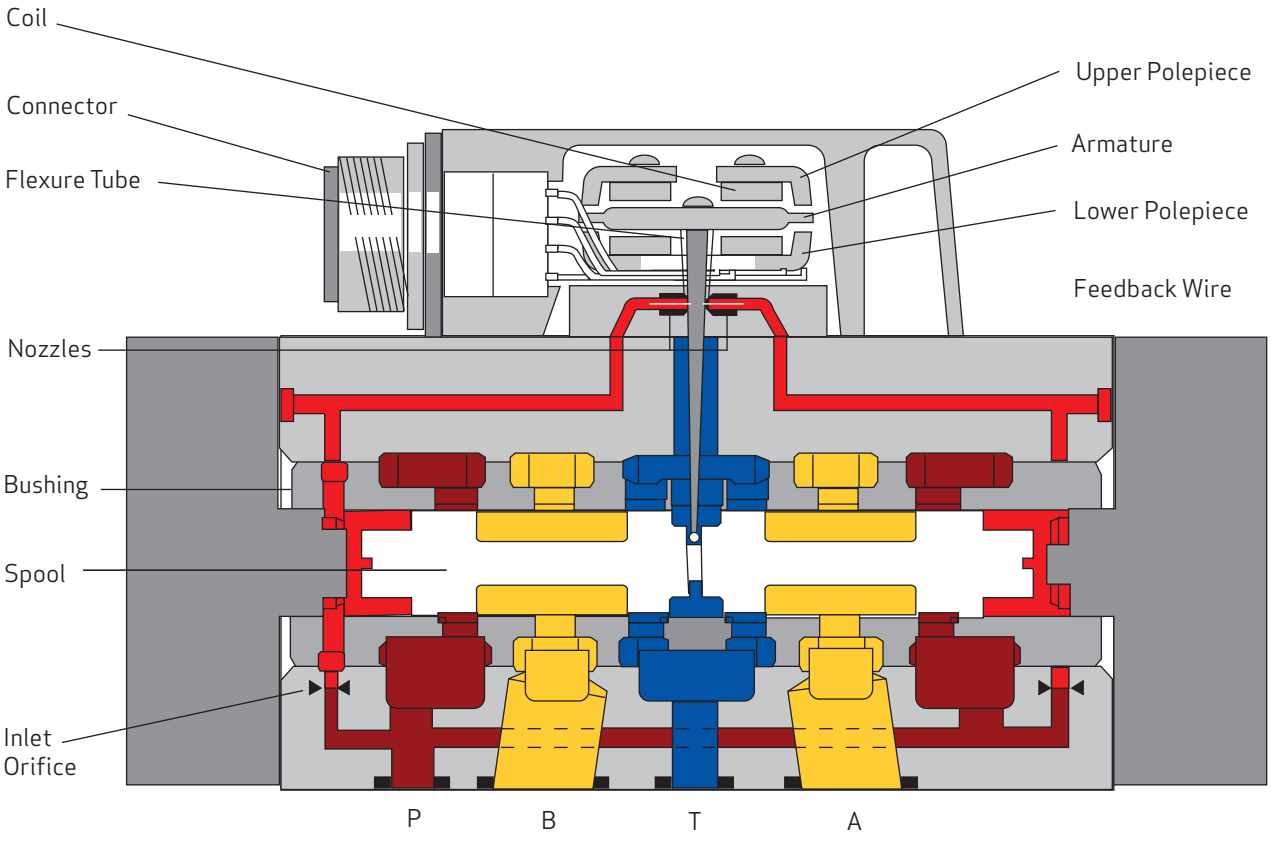
The 78 Series Flow Control Servo Valve consists of a polarized electrical torque motor and two stages of hydraulic power amplification. The torque motor armature extends into the air gaps of the magnetic flux circuit and is supported in this position by a flexure tube. The flexure tube acts as a seal between the electromagnetic and hydraulic sections of the valve. The 2 torque motor coils surround the armature, one on each side of the flexure tube.

The flapper of the first stage hydraulic amplifier is rigidly attached to the midpoint of the armature. The flapper extends through the flexure tube and passes between 2 nozzles, creating two variable orifices between the nozzle tips and the flapper. The pilot pressure is controlled by the flapper/nozzle variable orifice and is in turn fed to the end areas of the second stage spool. This action creates a differential pressure from one end of the spool to the other and results in spool displacement. The spool displacement causes a force in the feedback wire which opposes the original input signal torque. Spool movement continues until the feedback wire force equals the input signal force.

The second stage is a conventional four-way spool design in which output flow from the valve, at a fixed valve pressure drop, is proportional to spool displacement from the null position. A cantilever feedback spring is fixed to the flapper and engages a slot at the center of the spool. Displacement of the spool deflects the feedback spring which creates a force on the armature/flapper assembly.

Input signal induces a magnetic charge in the armature and causes a deflection of the armature and flapper. This assembly pivots about the flexure tube and increases the size of one nozzle orifice and decreases the size of the other.

Electro-hydraulic Servo Valve Cut-away



78 SERIES - STANDARD RESPONSE VERSION

General Technical Data

Valve design	2-stage, with spool and bushing and dry torque motor
Pilot stage	Nozzle Flapper
Mounting pattern	Unique to 78 Series
Installation position	Any orientation, fixed or movable
Weight	2.86 kg (6.3 lb)
Storage temperature range	-40 to +60 °C (-40 to +140 °F)
Ambient temperature range	-40 to +135 °C (-40 to +275 °F)
Vibration resistance	30 g, 3 axis, 10 Hz to 2 kHz
Shock resistance	30 g, 3 axis
Seal material	Fluorocarbon (FKM) 85 Shore D Others upon request

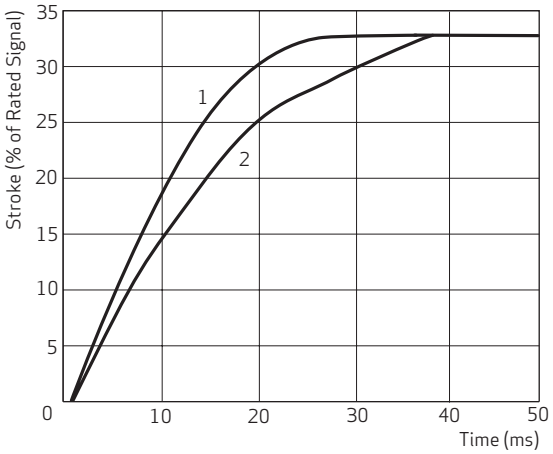
Hydraulic Data

Maximum operating pressure to ports P, T, A, B	210 bar (3,000 psi)		
Rated flow at Δp_N 35 bar/spool land (500 psi/spool land)	75 l/min (20 gpm)	115 l/min (30 gpm)	150 l/min (40 gpm)
Maximum flow	208 l/min (54.9 gpm)		
Null adjust authority	Greater than 10 % of rated flow		
Hydraulic fluid	Hydraulic oil as per DIN 51524 parts 1 to 3 and ISO 11158. Other fluids on request.		
Temperature range	-40 to +60 °C (-40 to +140 °F)		
Recommended viscosity range	10 to 85 mm^2/s (cSt)		
Maximum permissible viscosity range	5 to 1250 mm^2/s (cSt)		
Recommended cleanliness class as per ISO 4406			
For functional safety	17/14/11		
For longer service life	15/13/10		
Recommended filter rating			
For functional safety	β_{10} = 75 (10 µm absolute)		
For longer life	β_5 = 75 (5 µm absolute)		

Static and Dynamic Data

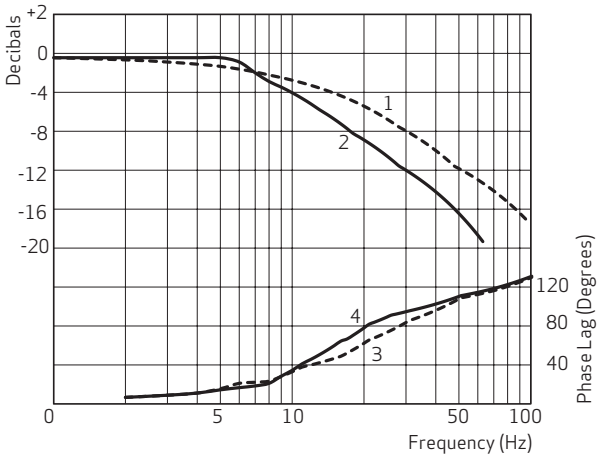
Sample deviation of rated flow	±10 %		
Step response time for 0 to 100 % stroke	30 ms	30 ms	40 ms
Threshold	0.5 %		
Hysteresis	< 3.0 %		
Null shift at ΔT = 38 °C (100 °F)	< 2.0 %		

78 SERIES - STANDARD RESPONSE VERSION



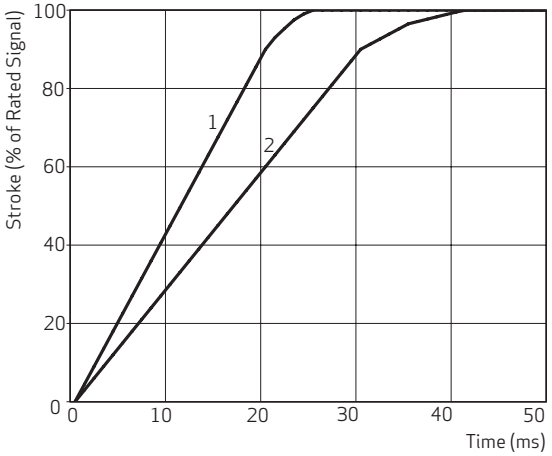
Reduced Amplitude Step Response

33 % step
Plot 1 = 75/115 l/min (20/30 gpm)
Plot 2 = 150 l/min (40 gpm)



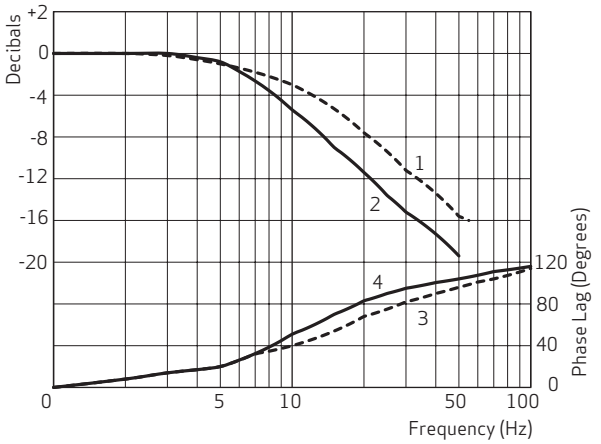
Standard Frequency Response

75/115 l/min (20/30 gpm)
Plot 1 & 3 = ±40 % rated signal
Plot 2 & 4 = ±100 % rated signal



Full Amplitude Step Response

100 % step
Plot 1 = 75/115 l/min (20/30 gpm)
Plot 2 = 150 l/min (40 gpm)



Standard Frequency Response

154 l/min (40 gpm)
Plot 1 & 3 = ±40 % rated signal
Plot 2 & 4 = ±100 % rated signal

Note: Measured with 210 bar (3,000 psi), DTE®-24 fluid at +38 °C (+100 °F)

78 SERIES - HIGH RESPONSE VERSION

General Technical Data

Valve design	2-stage, with spool and bushing and dry torque motor
Pilot stage	Nozzle Flapper
Mounting pattern	Unique to 78 Series
Installation position	Any orientation, fixed or movable
Weight	2.86 kg (6.3 lb)
Storage temperature range	-40 to +60 °C (-40 to +140 °F)
Ambient temperature range	-40 to +135 °C (-40 to +275 °F)
Vibration resistance	30 g, 3 axis, 10 Hz to 2 kHz
Shock resistance	30 g, 3 axis
Seal material	Fluorocarbon (FKM) 85 Shore D Others upon request

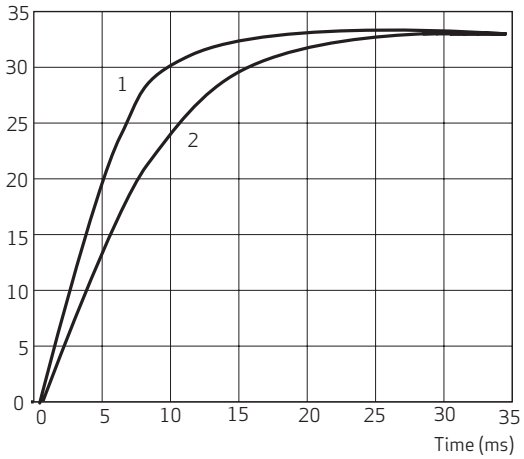
Hydraulic Data

Maximum operating pressure to ports P, T, A, B	210 bar (3,000 psi)	
Rated flow at Δp_N 35 bar/spool land (500 psi/spool land)	75 l/min (20 gpm)	115 l/min (30 gpm)
Maximum flow	156 l/min (41.2 gpm)	
Null adjust authority	Greater than 10 % of rated flow	
Hydraulic fluid	Hydraulic oil as per DIN 51524 parts 1 to 3 and ISO 11158. Other fluids on request.	
Temperature range	-40 to +60 °C (-40 to +140 °F)	
Recommended viscosity range	10 to 85 mm^2/s (cSt)	
Maximum permissible viscosity range	5 to 1250 mm^2/s (cSt)	
Recommended cleanliness class as per ISO 4406		
For functional safety	17/14/11	
For longer service life	15/13/10	
Recommended filter rating		
For functional safety	β_{10} = 75 (10 µm absolute)	
For longer life	β_5 = 75 (5 µm absolute)	

Static and Dynamic Data

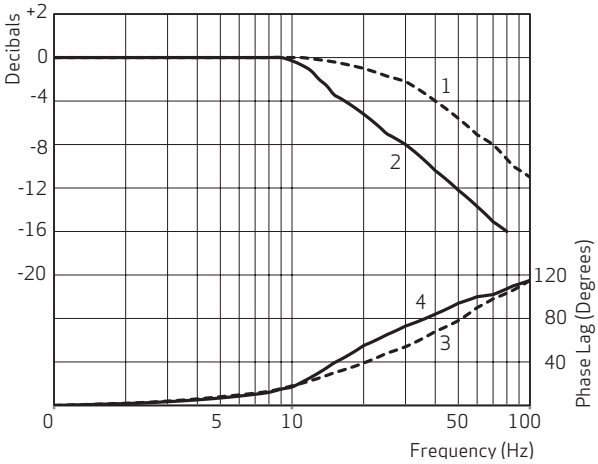
Sample deviation of rated flow	±10 %	
Step response time for 0 to 100 % stroke	15 ms	20 ms
Threshold	0.5 %	
Hysteresis	< 3.0 %	
Null shift at ΔT = 38 °C (100 °F)	< 2.0 %	

78 SERIES - HIGH RESPONSE VERSION



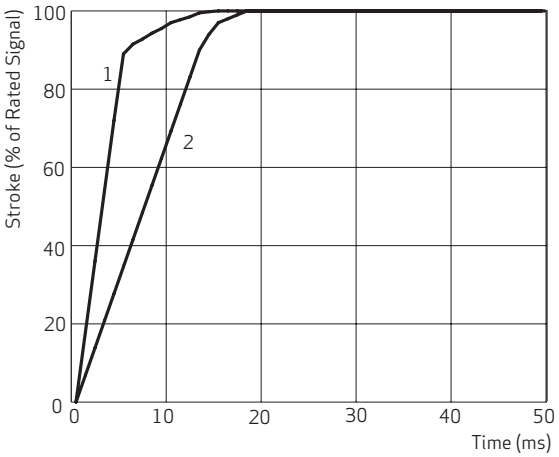
Reduced Amplitude Step Response

33 % step
Plot 1 = 75 l/min (20 gpm)
Plot 2 = 115 l/min (30 gpm)



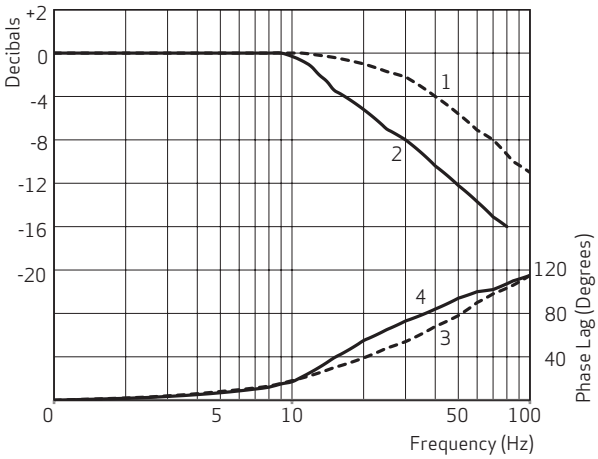
High Frequency Response

75 l/min (20 gpm)
Plot 1 & 3 = ±40 % rated signal
Plot 2 & 4 = ±100 % rated signal



Full Amplitude Step Response

100 % step
Plot 1 = 75 l/min (20 gpm)
Plot 2 = 115 l/min (30 gpm)

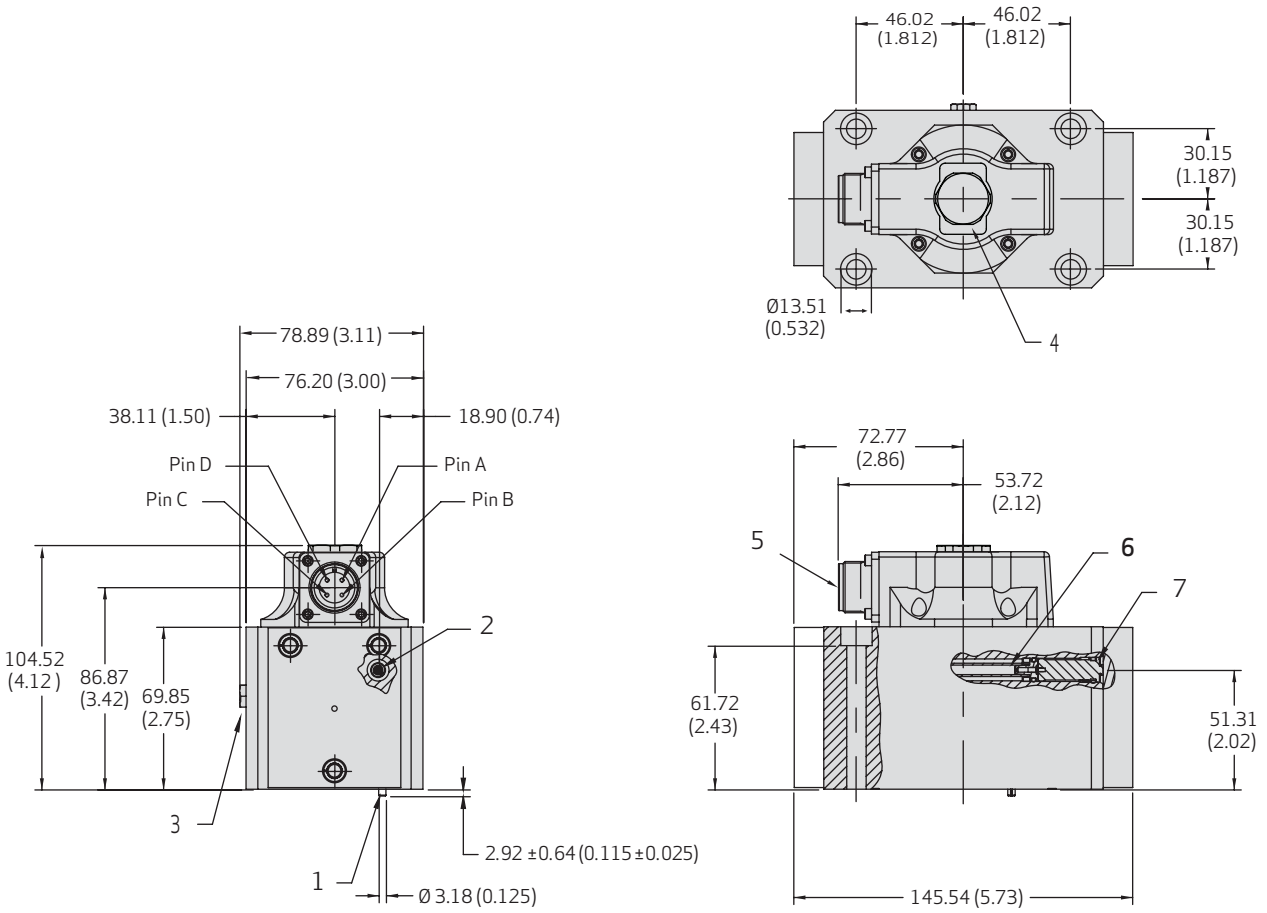


High Frequency Response

115 l/min (30 gpm)
Plot 1 & 3 = ±40 % rated signal
Plot 2 & 4 = ±100 % rated signal

Note: Measured with 210 bar (3,000 psi), DTE®-24 fluid at +38 °C (+100 °F)

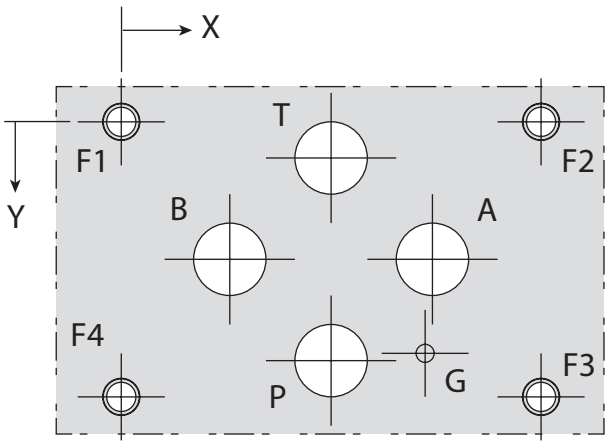
INSTALLATION DRAWING



Note: Dimensions in mm (in)

1 Locating pin
2 Filter and plug location
3 Mechanical null adjust
4 Optional magnetic null adjust
5 Electrical connector (as shown, mates with MS3106F14S-2S)
6 Filter
7 Filter plug

MOUNTING REQUIREMENTS



Designation		Ports				Locating Pin	Mounting Holes			
		P	A	B	T	G	F1	F2	F3	F4
Size Ø	**mm**	15.88	15.88	15.88	15.88	3.96	M8	M8	M8	M8
	in	0.625	0.625	0.625	0.625	0.156	5/16-18	5/16-18	5/16-18	5/16-18
Position X	**mm**	46.02	68.25	23.80	46.02	66.65	0	92.08	92.08	0
	in	1.812	2.687	0.937	1.812	2.624	0	3.625	3.625	0
Position Y	**mm**	52.37	30.15	30.15	7.92	50.77	0	0	60.33	60.33
	in	2.062	1.187	1.187	0.312	1.999	0	0	2.375	2.375

Surface

Surface to which the valve is mounted requires:
- Flatness of 0.01 mm (0.004 in) over 100 mm (3.94 in)
- Average finish R_a better than 0.8 µm (0.000032 in)

Ports

For maximum flow the ports must be designed as follows:
- P, T, A, and B must be designed with diameters of 16 mm (0.625 in)

Recommended Mounting Seals

- Material dependent on application
- 1.78 mm (0.070 in) cross section x 18.77 mm (0.739 in) inside diameter. 90 durometer
- Equivalent AS83248/2 size -018

Recommended Mounting Screws

- Material dependent on application
- SHCS 5/16 x 3.0 long. Grade 8 minimum
- SHCS M8 x 75 long. Grade 10.9 minimum

ELECTRICAL CONNECTION

Rated Current and Coil Resistance

A variety of coils are available for 78 Series Servo Valves, which offer a wide choice of rated currents.

Coil Impedance

The resistance and inductance of standard coils are given below. The 2 coils in each Servo Valve are wound with equal turns giving a normal production tolerance on coil resistance of ±12 %. Copper magnet wire is used, so the coil resistance will vary significantly with temperature. The effects of coil resistance changes can be essentially eliminated through use of a current feedback servoamplifier having high output impedance.

Inductance is determined under pressurized operating conditions and is greatly influenced by back electromagnetic forces of the torque motor. These effects vary with most operating conditions, and vary greatly with signal frequencies above 100 Hz. The apparent coil inductance values given are determined at 50 Hz.

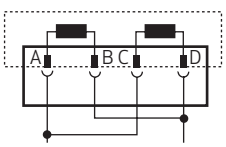
Ordering code	Command signal [mA]			Coil resistance [Ohms/coil at 25 °C (77 °F)]	Power consumption [W]			Coil inductance [H] measured at 50 Hz		
	Single coil	Series coil	Parallel coil		Single coil	Series coil	Parallel coil	Single coil	Series coil	Parallel coil
L	±40	±20	±40	80	0.128	0.064		0.22	0.66	0.18
M	±50	±25	±50	80	0.20	0.10		0.22	0.66	0.18
Z	±200	±100	±200	22	0.88	0.44		0.07	0.21	0.06

Coil Connections

A 4-pin electrical connector that mates with an MS3106F14S-2S is standard. All 4 torque motor leads are available at the connector so that external connections can be made for series, parallel, or differential operation.

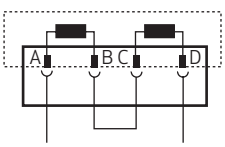
Connection for valve opening P ⟶ B, A ⟶ T

Single



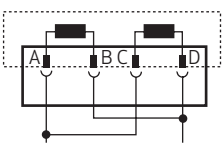
A (+), B (-) or C (+), D (-)

Series



A (+), D (-), B and C connected

Parallel



A and C (+), B and D (-)

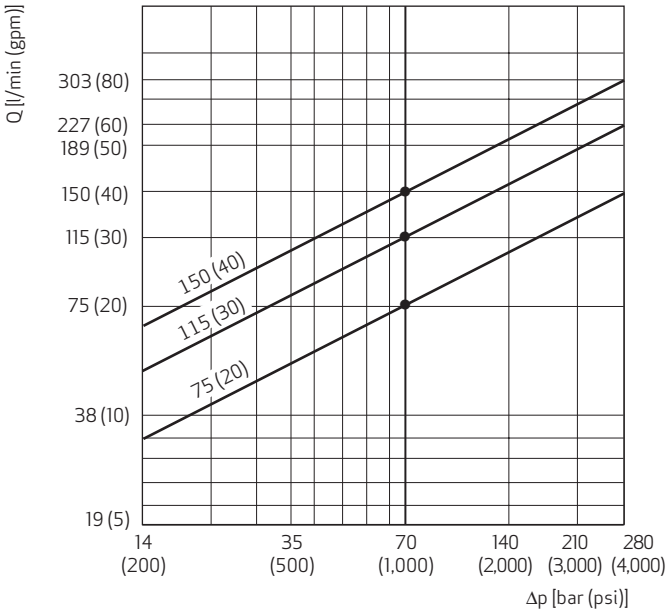
FLOW CALCULATION

The actual flow is dependent upon electrical command signal and valve pressure drop.The flow for a given valve pressure drop can be calculated using the square root function for sharp edge orifices.

$$Q = Q_N \cdot \sqrt{\frac{\Delta p}{\Delta p_N}}$$

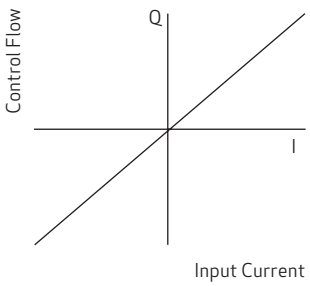
Q [l/min (gpm)]	actual flow
Q_N [l/min (gpm)]	rated flow
Δp [bar(psi)]	actual pressure drop per spool land
Δp_N [bar(psi)]	rated pressure drop per spool land

Flow diagram



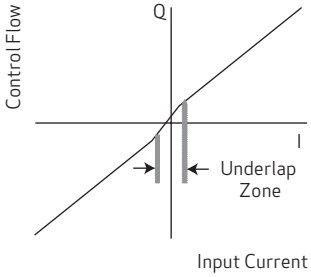
NULL CUT OPTIONS

Standard Axis Cut



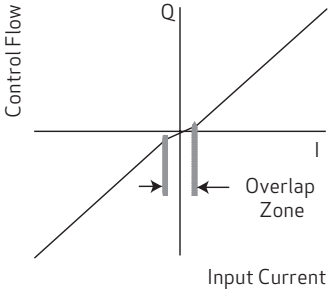
Minimal change in gain through null region. Best overall preformance for most closed loop systems.

Underlapped



Null region flow gain is higher than normal. Always allows some small amount of flow past the spool.

Overlapped

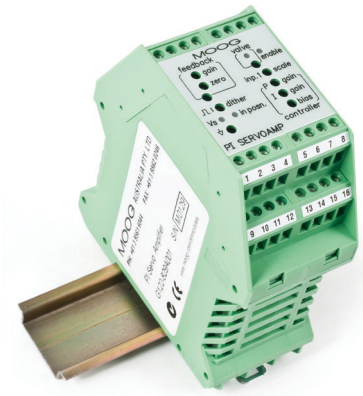


Null region flow gain is lower than normal. Spool types can range from minimal overlap to completely blocked flow.

RELATED PRODUCTS

DIN Rail Modules - Analog Control Cards

Moog's DIN rail mounted module analog control cards are ideal for use in enclosures where space is limited. Modules include servoamplifers, transducer conditioning electronics, command and auxilliary function modules, valve drive amplifiers, and power supplies. All of these modules are CE marked and require a 24 V_{DC} supply. The modules mount to standard 35 mm DIN rail mount for easy installation and removal.



DIN Rail Module

Portable Valve Testers - Evaluates Valves in the Field

Valve testers are a cost effective method for evaluating valves in the field. They provide a quick and easy means of differentiating between hydraulic and electronic problems.

There are five models to choose from, each with different levels of capability and flexibility to meet your specific requirements. All valve testers have a compact, easily portable design.

Valve Tester

Mounting Manifolds - Easier Installation and Maintenance

Various mountings manifolds are available for standard industrial valves, including base and adapter types for mounting and flushing requirements. Other hardware such as bolts and connectors are also available.

The specific accessories you may need for a particular model are listed in the relevant product catalogs and can be ordered through your local office.

Mounting Manifolds

Filtration - Oil Filtration Requirements for Industrial Servo Systems

The most effective way to reduce life cycle costs of an oil hydraulic system is through close attention to contamination control.

For industrial servo systems the ideal system filter arrangement is summarized as follows:

- Use a 15 micron (Beta 15 ≥ 75) high pressure filter without by-pass just before the valve or critical parts of the valve (e.g. pilot)
- Use a 3 micron (Beta 3 ≥ 75) low pressure filter in the return or bypass line.
- Use a filter in the tank breather that is at least the same filtration level as the finest filter in the system.

This recommendation is based on the fact that most servo and proportional valves can accept the odd particle up to 25 microns so the pressure filter will protect the valve from catastrophic failure. The real work is done by the low pressure filter reducing small particle contamination which is the prime contributor to component wear and silting.

Assuming that the filters are properly dimensioned and care is taken during initial installation and maintenance, the aim should be to limit oil contamination to 16/13 (under the old ISO 4406) or 19/16/13 (under the new ISO 4406).

For long life, the maximum levels per the old and new ISO are 15/12 and 18/15/12, respectively. It is important to note that these are maximum contamination levels and with proper care and regular filter change, significantly lower levels can and should be achieved. Attention must also be paid to a number of other factors that contribute to oil condition problems such as elevated temperatures, high tank humidity, "dirty" new oil.

ABOUT MOOG

Moog Inc. is a worldwide designer, manufacturer and integrator of precision control components and systems. Moog's Industrial Group designs and manufactures high performance motion control solutions combining electric, hydraulic, and hybrid technologies with expert consultative support in a range of applications including energy production and generation machinery, industrial production machinery and simulation and test equipment. We help performance-driven companies design and develop their next-generation machines. Moog Industrial Group, with fiscal year 2011 sales of USD 629 million and over 40 locations worldwide, is part of Moog Inc. (NYSE:MOG.A and MOG.B) which has sales of USD 2.3 billion.

Moog maintains facilities in 26 countries around the globe. This vast scope ensures that our engineers remain close to the needs of machine builders and provide flexible design solutions and technical expertise tailored to our customers' toughest challenges.

Moog experts work in close collaboration with machine builders and application engineers to design motion control systems for greater productivity, higher reliability, superior connectivity, less costly maintenance and more effective operations. Our regional presence, industry knowledge and design flexibility ensures Moog motion control solutions are tailored to their environment—from meeting operating regulations and performance standards, to taking machine performance to a higher level.

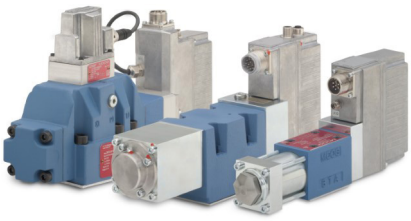
Products

At the heart of every Moog solution is an array of products engineered for precision, high performance and reliability. For more than six decades, Moog products have been specified for critical machine applications.

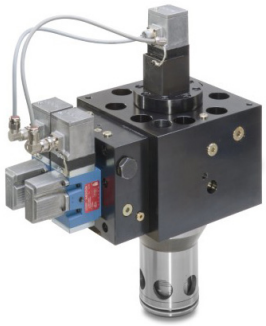
Some are developed specifically for unique operating environments. Others are standard equipment on machines across many industries. All are continuously improved to take advantage of the latest technology breakthroughs and advancements.

Moog products include:

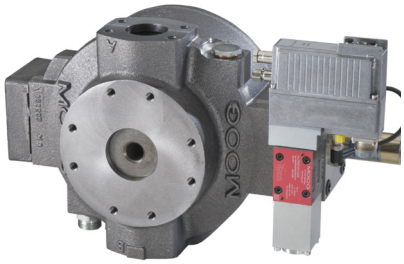
- Servo Valves and Proportional Valves
- Servo Motors and Servo Drives
- Servo Controllers and Software
- Radial Piston Pumps
- Actuators
- Integrated Hydraulic Manifold Systems and Cartridge Valves
- Slip Rings
- Motion Bases



Servo Valves



Active Cartridge Valves



Radial Piston Pumps

Servo Drives

ABOUT MOOG
Solutions

Hydraulic solutions

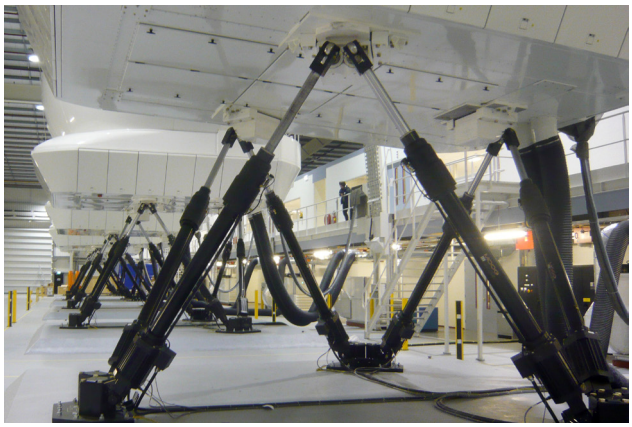
Since Bill Moog invented the first commercially viable servo valve in 1951, Moog has set the standard for world-class hydraulic technology. Today, Moog products are used in a variety of applications - providing high power, enhanced productivity and ever better performance for some of the worlds most demanding applications.

Electric solutions

Clean operation, low noise generation, less maintenance and reduced power consumption make Moog electric solutions ideal for applications worldwide. Moog is the ideal partner for applications where transitioning technologies requires special expertise.

Hybrid solutions

By incorporating the advantages of existing hydraulic and electric technologies - including modular flexibility, increased efficiency and cleanliness - into innovative hybrid solutions, Moog offers new performance potential in specialized applications.



Flight Simulation

Formula One Simulation Table

Moog Global Support

Moog Global Support is our promise to offer world-class Repair and Maintenance Services delivered expertly by our trained technicians. With the reliability only available from a leading manufacturer with facilities around the world, Moog offers you service and expertise you can count on to keep your equipment operating as it should.

This promise offers many benefits to our customers including:

- Reduce your downtime by keeping critical machines running in peak performance
- Protect your investment by ensuring reliability, versatility and long-life of products
- Better plan your maintenance activities and make systematic upgrades
- Leverage our flexible programs to meet the unique service requirements of your facility

Look to Moog for global support including:

- Repair services using OEM parts are performed by trained technicians to the latest specifications
- Stock management of spare parts and products to prevent unplanned downtime
- Flexible programs, tailored to your needs such as upgrades, preventative maintenance and annual/multi-year contracts
- On-site services bring the expertise to you, providing quicker commissioning, set-up and diagnostics
- Access to reliable services that are guaranteed to offer consistent quality anywhere in the world

For more information on Moog Global Support visit www.moog.com/industrial/service.

ACCESSORIES AND SPARE PARTS

Part designation	Description	Material	Part number
Maintenance kit	Base o-rings	FKM per AMS7259 Note that o-ring material is dependent on application.	B52555RK052K001
	Additional o-rings required for filter access		
	Filter tube		

ORDERING CODE

Model number (assigned at the factory)

Type designation

1 2 3 4 5 6 7 8 9 10

- 078 [ ] [ ] [ ] [ ] [ ]

-	Standard
K	Intrinsically Safe (I.S.)
N	Explosion Proof (E.P.)

Ascension number

Model revision

10	Signals for 100 % spool stroke (single or parallel coil value)
L	± 40 mA
M	± 50 mA
Z	± 200 mA

1	Valve version
S	Standard response
H	High response

9	Valve connector
B	4 pin MS threaded connector over B-side
A	4 pin MS threaded connector over A-side
2	4 lead pigtail connector over A-side

2	Rated flow For Δp_N = 35 bar (500 psi) per spool land	
	l/min	(gpm)
07	75	(20)
09	95	(25)
11	115	(30)
15	150	(40)

8	Seal material
V	Fluorocarbon (FKM)

7	Pilot connections
4	Internal supply

3	Maximum operating pressure in bar (psi)	
F	210	(3,000)

6	Spool position without electrical signal
M	Center position
A	Port A open to return
B	Port B open to return

4	Bushing/spool design
O	4-way: axis cut, zero lap
D	4-way: 10 % overlap
N	4-way: 2 % underlap, no overlap

5	Pilot stage design
G	High dynamics

All combinations may not be available.

Preferred Models

Model number	Type designation	Rated flow		Rated current
		l/min	gpm	mA
-078-120D	S07FOGM4VBL	75	20	± 40
-078-121D	H07FOGM4VBL	75	20	± 40
-078-130D	S11FOGM4VBL	115	30	± 40
-078-131D	H11FOGM4VBL	115	30	± 40
-078-140D	S15FOGM4VBL	150	40	± 40

TAKE A CLOSER LOOK.

Moog designs a range of motion control products that complement the performance of those featured in this catalog. Visit our website for more information and contact the Moog facility nearest you.

Australia
+61 3 9561 6044
Service + 61 3 8545 2140
info.australia@moog.com
service.australia@moog.com

Brazil
+55 11 3572 0400
info.brazil@moog.com
service.brazil@moog.com

Canada
+1 716 652 2000
info.canada@moog.com

China
+86 21 2893 1600
Service +86 21 2893 1626
info.china@moog.com
service.china@moog.com

France
+33 1 4560 7000
Service +33 1 4560 7015
info.france@moog.com
service.france@moog.com

Germany
+49 7031 622 0
Service +49 7031 622 197
info.germany@moog.com
service.germany@moog.com

Hong Kong
+852 2 635 3200
info.hongkong@moog.com

India
+91 80 4057 6666
Service +91 80 4057 6604
info.india@moog.com
service.india@moog.com

Ireland
+353 21 451 9000
info.ireland@moog.com

Italy
+39 0332 421 111
Service 800 815 692
info.italy@moog.com
service.italy@moog.com

Japan
+81 46 355 3767
info.japan@moog.com
service.japan@moog.com

Korea
+82 31 764 6711
info.korea@moog.com
service.korea@moog.com

Luxembourg
+352 40 46 401
info.luxembourg@moog.com

The Netherlands
+31 252 462 000
info.thenetherlands@moog.com
service.netherlands@moog.com

Russia
+7 8 31 713 1811
Service +7 8 31 764 5540
info.russia@moog.com
service.russia@moog.com

Singapore
+65 677 36238
Service +65 651 37889
info.singapore@moog.com
service.singapore@moog.com

South Africa
+27 12 653 6768
info.southafrica@moog.com

Spain
+34 902 133 240
info.spain@moog.com

Sweden
+46 31 680 060
info.sweden@moog.com

Turkey
+90 216 663 6020
info.turkey@moog.com

United Kingdom
+44 (0) 1684 858000
Service +44 (0) 1684 278369
info.uk@moog.com
service.uk@moog.com

USA
+1 716 652 2000
info.usa@moog.com
service.usa@moog.com

For product information, visit **www.moog.com/industrial**
For service information, visit **www.moogglobalsupport.com**

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