M4d

Proportional Pneumatic Control Valve with Integrated Driver

Product Manual

Contents

Warnings & Notices

WARNING:

Installation and operation of electric and high pressure systems (fluids and compressed gas) involves risk including property damage and personal injury or death.

Installers and users should be properly trained or certified and take safety precautions. This product may cause death, personal injury, or property damage if improperly used or installed.

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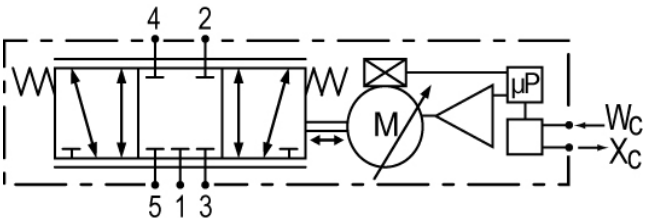
Overview

The M4d is an instrument-grade, proportional, pneumatic directional control valve with an integrated driver. The M4d utilizes a specialized linear force motor rather than a traditional proportional solenoid.

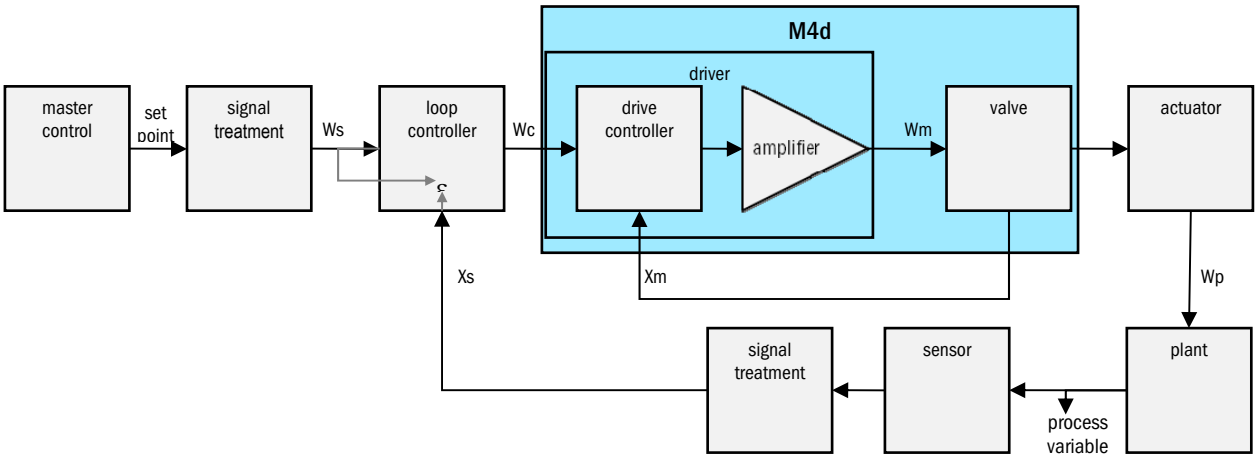
The valve includes integrated on-board driver electronics, as well as a feedback output to monitor valve activity and a drive sleep interrupt input. The highly efficient bi-directional motor driver includes factory calibrated dither and deadband elimination settings. Onboard signal conditioning accepts either voltage or current command signals.

The aperture of the M4d is controlled at very high speed, allowing the valve to respond quickly to set-point command changes. When at a given set-point, the aperture is held steady rather than pulsing to create an average flow from a duty cycle. The result is high fidelity - commands are faithfully reproduced increasing overall system performance.

Internal construction allows the valve to operate from vacuum through high pressure simultaneously. Common applications include the control of position, pressure, force or flow. The M4d is suitable for both open-loop and closed-loop systems.



M4d Valve Diagram (ISO 1219)

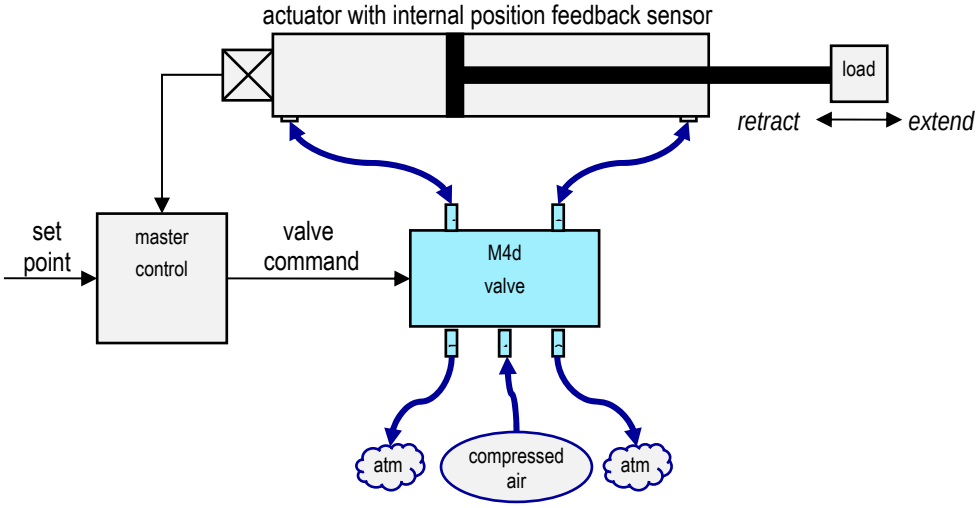


Typical Applications

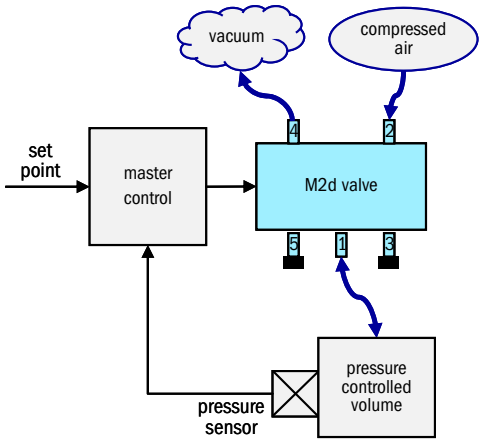
There are numerous applications and configurations for the M4d. Below are a chart of generic application descriptions and three common applications in pneumatics.

Control Objective		Technology	Control Scheme
▪ Position	▪ Mass Flow	▪ Pneumatic	▪ Open-Loop
▪ Motion	▪ Volumetric Flow		▪ Closed-Loop
▪ Pressure	▪ Velocity (speed)		
▪ Force	▪ Others		

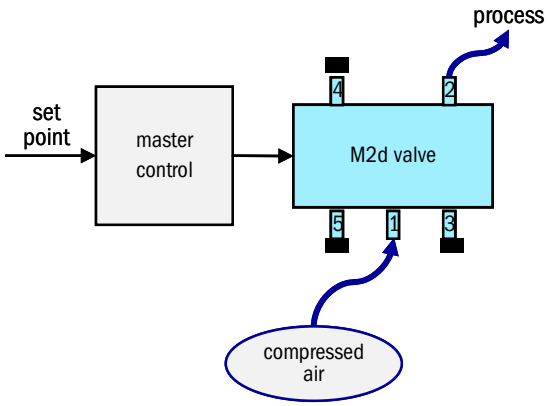
Basic Closed-Loop Proportional Pneumatic Position Control System



Basic Closed-Loop Proportional Gas Pressure Control System



Basic Open-Loop Proportional Gas Flow Control System



Product Specifications

Specification	Value	
Physical Characteristics	**SI Units**	**Imperial Units**
Mass (Weight)	0,852 kg	(30.0 oz)
Approximate Physical Dimensions (L x W x H)	171.9 mm x 55.0 mm x 45.0 mm	6.77" x 2.17" x 1.77"
Materials	Aluminum, Nitrile, 440C SS, 316 SS, Nickel Plated Steel, Glass-Filled Nylon	
Valve Function	5-Port Bi-Directional Flow Control Valve, Normally Closed Center	
Valve Type	Lapped Spool and Sleeve	
Control Mechanism	Direct-Acting, Patented Linear Force Motor	
Ports	3/8" NPTF	
Mounting Direction	Stationary: Perpendicular to gravity Moving: Perpendicular to direction of motion	
Performance Characteristics		
Shifting Time (ISO 12238)	2.8 ms	
Bandwidth	110 Hz	
Pressure (at any port)	Vacuum → 1.5 MPa (15 bar)	Vacuum → 225 psig
Maximum Effective Aperture	30 mm^2	0.047 in^2
Flow Capacity and Critical Pressure Ratio (ISO 6358)	$C = 4.5 \times 10^{-8}$ $s \cdot m^4/kg$; $b \approx 0.4$	$C_v = 1.3$
Flow Rate of Air at 20 °C (68°F) and 65% RH (refer to Mass Flow Graphs)	900 SLPM (6.0 bar → 5.0 bar)	60 SCFM (80 psig → atm)
Leakage Rate (80psig → atm)	0.6 SCFM	
Turndown Ratio	200:1	
Electrical Characteristics		
Power	20W Max	
Supply Voltage	24Vdc Nom. (12-36Vdc)	
Current	1.1A Max	
Electrical Connections	M12-8pin[1]	
Input Impedance	120 kΩ	
Input Signal Ranges	-10 Vdc to 10 Vdc -5 Vdc to 5 Vdc 0 Vdc to 5 Vdc 0 Vdc to 10 Vdc 0 mA to 20 mA 4 mA to 20 mA	
Output Signal	0 to 5 Vdc Valve Current Monitor	
Status LED's	Power On, Reverse Polarity Warning, Operating Condition	
Environmental Characteristics		
Environmental Protection Class	IP65	
Temperature	0°C – 50°C	32°F – 122°F
Humidity	5% - 95% RH	
Filtration Requirements	Clean, dry, non-lubricated air; 5 µm particulate and 0.3 µm coalescing filters recommended.	
Lubrication Requirements	Lubrication is not recommended and may void warranty.	
Operating Fluids	Inert, non-flammable pneumatic fluids only. No liquids.	

System Requirements

The following components are minimally required to implement a system. Refer to the Product Specifications and Configuration Instructions for details.

Components

Component	Notes	Recommendations & Sources
24V DC, 30W power supply	Power supply to convert AC line voltage to low voltage DC system power.	Enfield Technologies A-PWR-BS-24V-36W
Cable	--	Enfield Technologies part number: A-CBL-M12-08P-XXXX
Command signal source	Voltage/Current command (see Product Specifications) from a "master controller" such as a computer or PLC; a simple potentiometer is sufficient.	Enfield Technologies ASG-1 Signal Source if a simple potentiometer is needed (requires regulated excitation voltage; LS-Cable optional)
Pneumatic device*	If not using for flow control into the atmosphere, the system will have a "device" being controlled such as an actuator or pressure chamber (fixed or flexible)	Enfield Technologies ACT family actuators with internal position feedback sensors if a double acting air cylinder is needed (requires regulated excitation voltage and LS-Cable)

Tools

- Small flat head screw driver (preferably with a non-conductive shaft)
  - For connecting wires to terminal blocks
  - For making tuning and setting adjustments to rotary potentiometers
- Wire cutter & stripper
- Voltmeter (recommended)
  - Optional, but recommended for tuning and diagnostics
  - Multimeter recommended to also permit measurement of current and resistance
  - 2 or 3 channel oscilloscope recommended for advanced system tuning and diagnostics

Configuration

- Analog signal grounds ("DC common") for all system electronics that interrelate with each must be tied together (made common)

Implementation Instructions

The M4d can be used in many applications. Accordingly, it can be configured in many ways. These configuration instructions cover standard open-loop and closed-loop implementations as well as some advanced variations. The concepts of open-loop versus closed-loop systems, are important to implementing this or any pneumatic control system.

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Receipt Inspection & Handling

- Upon receipt, ensure the packaging is intact and the product is not damaged.
- Use care when handling the product. Avoid inadvertent contamination of the ports
- Observe common electro-static discharge (ESD) procedures when configuring the command signal DIP switches.
- Non-conductive tools are recommended, such as those with polymer or carbon-fiber type shafts.

Installation and Removal

(Do not leave the command signal floating. A command signal must be present whenever power is applied to the valve. The factory default command signal range is 0…10 Vdc. Make sure to apply a 5 Vdc command signal when power is applied to hold the valve in the closed position)

Install the M4d as follows:

- Verify the desired command signal input
  - (see following section: Configuration of Command Signal via DIP Switch Settings)
- Install the M4d using the two (2) mounting holes provided.
- Connect all signal and power connections to the appropriate connectors on the M4d.
- Connect the M4d to the target apparatus pneumatically and ensure that the apparatus and the surrounding area are safe for operation.
- Connect the M4d to the pneumatic supply (see filtration requirements in Product Specifications)
- Configure and tune the master controller as required for specific application.

Remove the M4d as follows:

- Ensure the target apparatus is in a safe state.
- Disconnect the pneumatic supply from the M4d
- Remove the pneumatic connections between the M4d and the target apparatus
- Disconnect all signal connections from the M4d
- Remove the two (2) mounting screws.
- Package the Device Controller in appropriate packaging (the original packaging is preferred).

Start-Up & Shutdown

Ensure that the electromechanical system is in a state such that the system is safe, even in the event of unexpected system operation.

- Ensure that your application will remain safe before making any change (powering down, removing valve, powering on, etc) even in the event of unexpected valve operation
- Ensure that the M4d is properly connected to the master controller on startup to ensure proper valve operation
- Ensure that the target apparatus is properly connected to the M4d on startup to ensure proper operation
- Apply or remove the command signal to the M4d (verify actual command signal)
- Apply or remove electrical power to the M4d
- Apply pneumatic supply last on start-up.
- Remove pneumatic supply first on shutdown

Wiring External Connections (using A-CBL-M12-08P-F-XXXX)

(Do not leave the command signal floating. A command signal must be present whenever power is applied to the valve. The factory default command signal range is 0…10 Vdc. Make sure to apply a 5 Vdc command signal when power is applied to hold the valve in the closed position)

1) (White) Driver Sleep - connect the drive sleep input to ground (PGND) to disable the valve driver.
2) (Brown) Power - connect the power input to a 24 Volt DC power supply (+) output (minimum 1.0A, 25W).
3) (Green) "Command –" - command signal input (-), connect to the master controller command signal output
4) (Yellow) "Command +" - command signal input (+), connect to the master controller command signal output
5) (Grey) "Aux 1+" functionality not supported by the M4d
6) (Pink) "Aux 1-" functionality not supported by the M4d
7) (Blue) Ground - connect the ground to the power supply ground (-) output.
8) (Red) I Feedback - current feedback output (0…5 Vdc)

- Common Ground: All DC powered components in the system should share a common ground to reduce the chance that power anomalies will create erroneous command or feedback signals.

- Shared Power Supply: Enfield Technologies recommends that if a common power supply is used for both the M4d and the feedback sensor, that it should have a separately regulated power supply connections for the valve and the sensor.

LED Indicators

The M4d is equipped with three LED indicators:

- Power Indicator: Upon successful powering of the device, the power indicator will light green. If the power connections are reversed, the power indicator will light red.

Power LED	Condition
Off	Power Off
Green	Normal Operation
Red	Reversed Power Connection

- Status Indicators 1 and 2: Both status indicators will light green for one second, after which they will light amber for one second. After this sequence, the states of these two LEDs describe the operation of the Device, as outlined in below.

Status LED 1	Status LED 2	Condition
Off	Off	Normal Operation
Blinking Amber (Quickly)	Any	Short Circuit Fault
Blinking Green (Slowly)	Any	Open Circuit Fault
Any	Green (Solid)	Reference Voltage Error
Any	Amber (Solid)	Symmetry Fault

Configuration of Command Signal via DIP Switch Settings

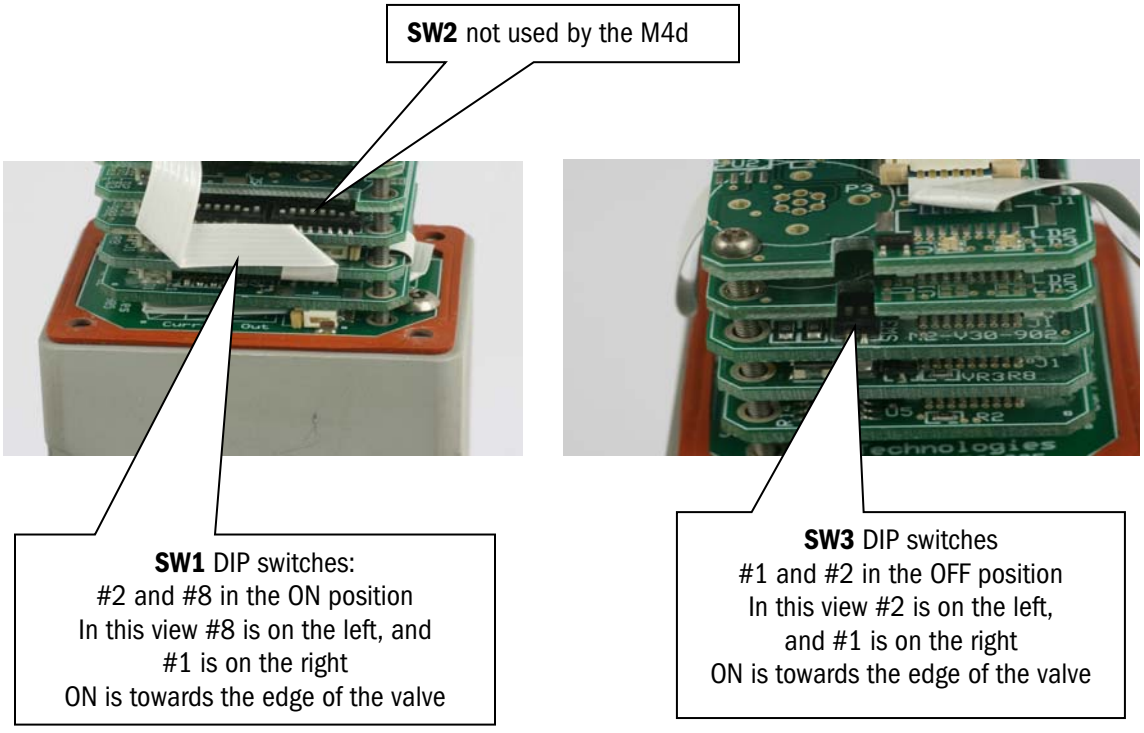
Configure the Command Signal Input as follows

- Remove the nut from the M12 Connector
- Remove the four (4) Phillips-head screws from the cap
- Remove the cap and adjust the DIP switch settings

Note: The Factory Default Command Signal Setting is (0V → +10V)

Command Signal	SW1								SW3
	1	2	3	4	5	6	7	8	1
-10V → +10 V	O				O				
-5 V → +5V		O			O				
0V → +5V			O			O			
0V → +10V		O						O	
0mA → +20mA			O			O			O
4mA → +20mA				O			O		O

Notes: (O) Indicates Dip Switch in the ON Position
SW2 functionality not supported by the M4d



Calibration & Periodic Maintenance

The M4d does not require periodic factory calibration, but periodic tuning of the control system may be required due to physical changes (friction, machine and/or parts wear, etc) in the system under control and to account for any sustained changes in the operating environment's conditions such as temperature and humidity. Keep the M4d free from dirt, debris, and excessive moisture.

Decommissioning & Corrective Maintenance

The device is not serviceable in the field. If corrective maintenance is required, contact the manufacturer for return authorization at +1 203 375 3100 (+1 800 504 3334 toll free in North America) or via email at info@enfieldtech.com.

Configuring and Tuning for Closed-Loop Control

These instructions use a proportional pneumatic positioning system adjusted for high response as an example. Tuning for a pressure, force, or closed-loop mass flow control system is similar even thought the sensors and valve plumbing may be different.

Tuning Theory

The objective of tuning is to make the system stable under its maximum expected load while seeking to achieve accuracy, minimal overshoot, minimum or maximum speed, or other performance objectives. Many system parameters influence stability including friction, command and feedback signal accuracy and quality (noise), and exogenous disturbances.

In full PID systems, there are many established tuning theories and methods, most notably the Ziegler-Nichols method. Advanced control methods are complex because changes in tuning one term often affects the other terms, and thus the process can be recursive with several possible solutions. Academic and practical information on these theories and methods are widely available.

Tuning a pneumatic system is more of an art than a science. The system probably has components from several different vendors and the components all have different dynamics characteristics such as friction, variations in signal levels, and so forth. Every application has a different set of parameters including the amount and physical orientation of the load, the speed at which the system must operate and the desired smoothness of operation, and the operating environment. Even identically configured systems have differences due to slight variations in the many parts used to make each component. Assuming that the system is required to respond rapidly, it must be tuned to operate "on the edge" of oscillation. That is, the system should be tuned to respond quickly to a command without breaking into uncontrolled oscillation or "hunting" because of signal over-saturation or target overshoot.

Product Warranty

This product is covered by Enfield Technologies' standard 1-year Limited Warranty. The terms of the Limited Warranty are subject to change. The Limited Warranty is available online at www.enfieldtech.com or by request (see contact information below).

Product Revision and Change Record

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