Resolution Air

MPPV-2, 4, 6, 8
Valve Instruction Manual
Date:12/1/16

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Valve Description

Resolution Air, Ltd.'s Miniature Proportional Pinch Valves allow the benefits of pinch valve fluid separation to be combined with proportional valve control for sanitary processes requiring highly accurate, fluid metering where cleanliness and sterility is required. Furthermore, the MPPV series generates significant more pinch force than a traditional solenoid valve and does it without the expense of compressed air.

Each valve consists of a bi-polar stepper motor. The motor receives square wave pulses (PWM) from either a driver or driver/controller. For these motors, each square pulse translates into a single step or rather a 7.5 degree rotation of the motor. Attached to the motor is an integral leadscrew which converts 1 step of rotation into .0005" linear movement. A custom piston with an elastomeric seal is attached to the end of the lead screw which then accurately positions the piston. This allows tubes to be pinched with fine control for the metering of liquids and gases.

System Control Requirements and Options

- Bi-Polar Chopper Driver w/programmable logic controller
- Bi-Polar Chopper Drive/Controller
- Power Supply
- End of Stroke Sensor

The 2 primary methods for controlling a bi-polar stepper motor are the following: 1.) bi-polar chopper driver. 2.) bi-polar programmable driver/controller. A bi-polar chopper drive receives two input signals: A.) Step signal. B.) Direction signal. The step signal is the PWM signal and the direction signal is a digital binary signal. The purpose of the driver is to amplify the PWM signal sufficiently to drive the motor in the direction determined by the digital direction signal. (Resolution Air, Ltd. offers the DRV-1 driver). Because these 2 signals are only amplified by the driver, they must be generated with either A.) Programmable logic controller (plc), or B.) Lab-View control system. Besides the bi-polar chopper drive, the other control option is the programmable driver/controller. These devices both generate and amplify the required step and direction control signals. In addition, they are also programmable and therefore can be used as a control system.

Resolution Air, Ltd.'s MPPV-DK development kit utilizes a programmable driver/controller to facilitate initial evaluation of the MPPV-series of valves. This USB powered drive/controller is powered by the computer and therefore does not require an additional power supply.

Recommended Power Supply

In general, unregulated DC (or linear regulated) power supplies are best suited for stepper motor applications. Switching power supplies, which tend to be very cost efficient, are also suited for many stepper motor applications; however, their ability to provide surge currents is limited and may require additional capacitors to be added, depending on your application. The stepper linear actuators used in our valves are rated at 5 VDC; however, the motors need to be powered from 5 to 8 x the rated voltage (24 to 40 VDC).

MPPV-S: End of Stroke Sensor

Resolution Air, Ltd.'s MPPV-Series of Miniature Proportional Pinch Valves are equipped with a hall-effect sensor for indicating the full open position of the valve. The sensor is activated by a rare earth magnet embedded in the end of the internal screw. The compact profile of the sensor allows for the installation in limited space applications. The sensor has virtually unlimited cycle life. Special cabling and connectors can be provided. See below for the sensor technical data. Please note a pull up resistor is required to protect the sensor from exceeding maximum output current rating and also for proper functioning of sensor. Generally, a 10kohms resistor works well with most applications.

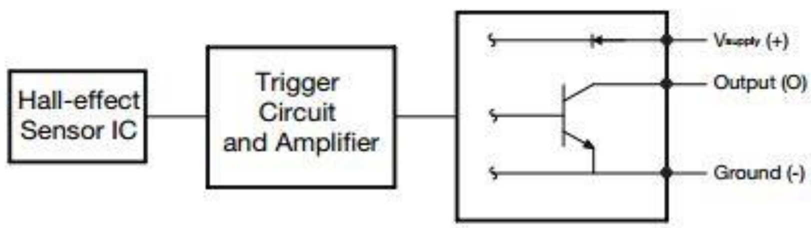
MPPV-S: Procedure for Homing the valve

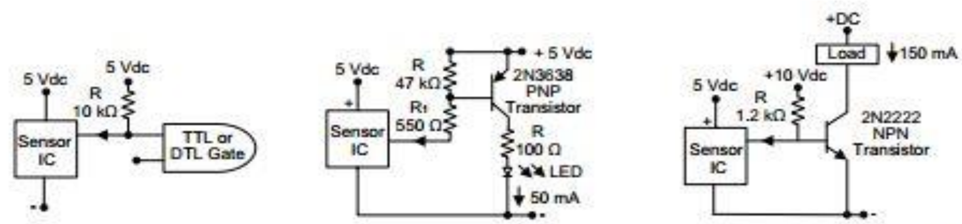
In order to optimize the positional accuracy of the end of stroke sensor and minimize hysteresis, the recommended homing procedure is as follows:

1.) Open the valve until the end of stroke sensor turns on
2.) Stop Motion
3.) Close valve until sensor turns off.(single stepping motor)
4.) Stop motion
5.) Open valve until sensor turns back on.(single stepping motor)

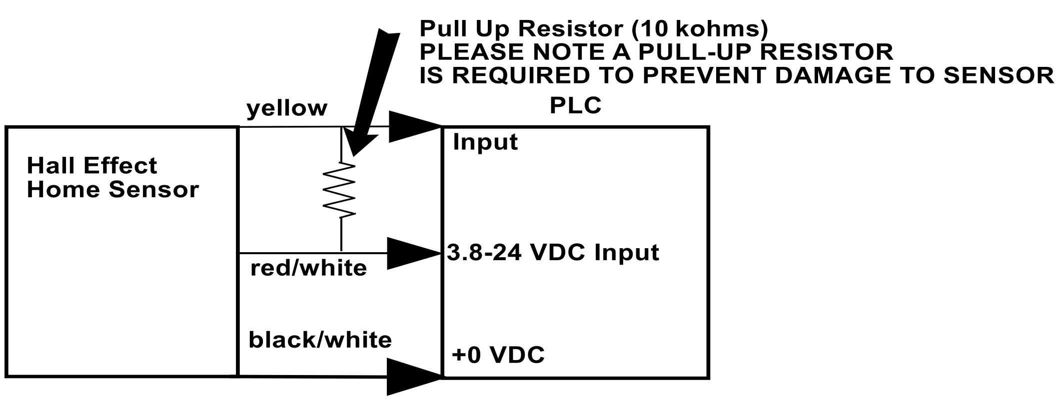
Technical Data-Home Sensor

Supply Voltage (VDC):	3.8 min. to 24 max.
Current consumption:	10 mA max.
Output voltage (operated)	0.15 typ., 0.40 max.; Sinking 20 mA max.
Output current	20 mA max.
Output leakage current (released)	10µA max. @ Vout = 24 VDC; Vcc = 24 VDC
Output switching time	
Rise, 10 to 90%: .05 µs typ., 1.5 µs max. @ Vcc = 12 V, RL = 1.6 KOhm	Fall, 90 to 10%: .15 µs typ., 1.5 µs max. @ CL = 20 pF





TYPICAL SENSOR WIRING-PLC

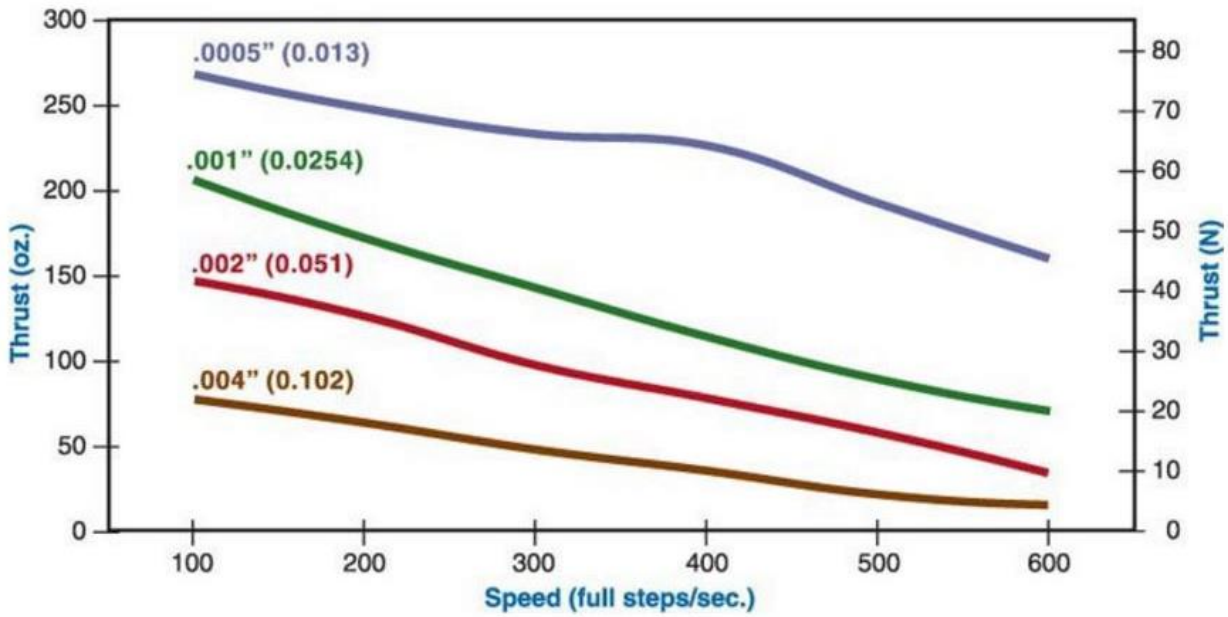


Recommended Tubing Type

Resolution Air, Ltd. recommends the use of 50-60 Shore A durometer tubing in order to optimize valve performance and life. Ideally, the force required to pinch the tube should be ½ of the available force generated by the bi-polar stepper linear actuator. The curve below shows how the force is a function of motor speed. As the speed decreases the force available increases. In addition, the ramping of the speed can used to optimize valve performance.

Thrust vs Speed Curve

Bi-Polar Chopper Drive 100% Duty Cycle (.0005” Curve)



Electrical Specifications

STEPPER MOTOR CHARACTERISTICS

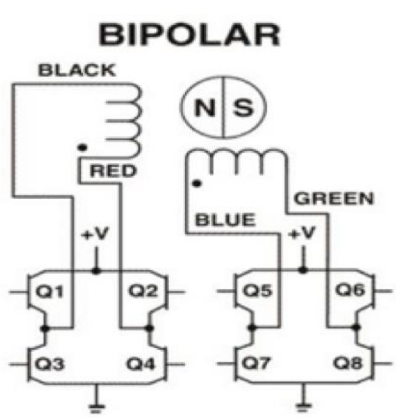
WIRING	BIPOLAR
MOTOR CONNECTION	A+ = RED, A- =BLACK, B+ = BLUE, B- = GREEN
STEP ANGLE	7.5 DEGREES
MOTOR VOLTAGE*	5 VDC
SUPPLY VOLTAGE	24VDC - 40 VDC
CURRENT/PHASE	.385 A
RESISTANCE/PHASE	13 Ω
INDUCTANCE/PHASE	10.6 mH
POWER CONSUMPTION	3.85 WATTS
ROTOR INERTIA	1.07 gcm^2
TEMEPERATURE RISE	135 F
INSULATION RESISTANCE	20 MΩ

Stepping Sequence and Wiring Diagram

ACTUATOR WIRING DIAGRAM

STEPPING SEQUENCE

Bipolar	Q2 - Q3	Q1 - Q4	Q6 - Q7	Q5 - Q8
Unipolar	Q1	Q2	Q3	Q4
Step				
1	ON	OFF	ON	OFF
2	OFF	ON	ON	OFF
3	OFF	ON	OFF	ON
4	ON	OFF	OFF	ON
5	ON	OFF	ON	OFF



Valve Operation

- Tube and Piston Clearance

When the piston is fully retracted, there is a nominal clearance of .031" between the top of the tube and the top of piston.

- Maximizing Pinch Force

Maximum pinch force is achieved with slower speeds. See the thrust vs speed curve.

- Minimizing Cycle Times

Lowest cycle times are achieved by minimizing tube durometer and fluid pressure. In addition, fluid metering does not occur until the tube is partially pinched. Initially the shape of the tube is being changed prior to a reduction in tube cross sectional area. See flow curve. Therefore, extremely low cycle times can be generated by beginning a cycle with the tube partially pinched. This reduces the distance the piston will need to travel to be fully pinched. In addition, in order to achieve both high pinch force and low cycle time, valve speed can be changed throughout its travel. For example, the valve speed can be high initially but then as the tube approached the fully pinch state, speed can be reduced.

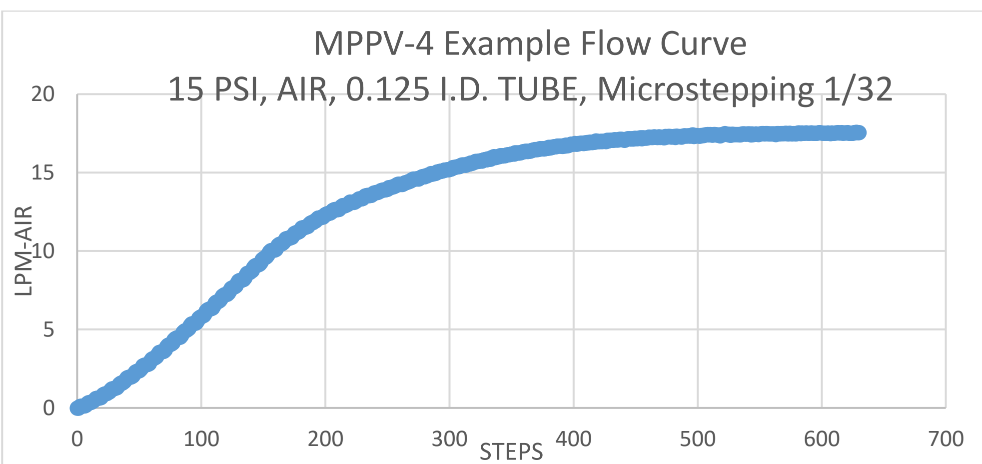
- Methods for Fully Pinching the Tube

The valve can be closed until the stepper motor stalls under full load. Besides placing an unnecessary load on the leadscrew nut of the linear actuator the step count will not be accurate.

The preferred method to completely pinch the tube is to close the valve until the tube is bubble tight and then continue an additional few steps. This maintains an accurate step count and also maximizes the life of the leadscrew nut and therefore the valve itself.

- Typical Flow Curve

The flow curve below was generated using our MPPV-4 valve with Air at 15 PSIG in a 0.125" I.D. hose (0.250" O.D.). Note the linearity from full closed to step150.



- Micro-Stepping

Previously we mentioned a single step equated to 7.5 degrees rotation of the motor (.0005" linear displacement). If an application requires finer control of fluid metering, the MPPV-series can be micro-stepped. This reduces the rotation angle associated with each step. For example, the DRV-1 has 16 switch selectable micro-stepping ranges. With ½ micro-stepping, the motor would rotate 3.75 degrees rather than the 7.5 degrees achieved whilst full stepping. This rotation would be reduced to .47 degrees with 1/16 micro-stepping.

The graph below reveals the benefit of micro-stepping the MPPV-4 utilizing the DRV-1 drive. These are average flow values measured in the linearity portion of the flow curve (first 150 steps).