Application Note

FESTO

Pressure Bypassing for Increased Robustness of Double-Acting Actuators with CMSH

In some applications with double-acting actuators, low actuator pressure levels lead to susceptibility with respect to external disturbances. This document presents an approach to increase system stiffness by a throttled connection between supply pressure line and one actuator port.

CMSH

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1 Components

Name	Type Codes
Double-Acting Positioner	CMSH-*-D-*, CMSH-*-SD-*
One-way flow control valve / adjustable throttle	GR-QS-*
Push-in T-connector or Y-connector	QST, QSY
Push-in sleeve	QSH
Push-in L-connector	QSL

Table 1.1: Components applicable

2 Introduction – Background and Motivation

In applications with specific motion patterns of a double-acting actuator operated by a positioner, low average pressure levels in the actuator chambers can be observed. Typically, such a motion pattern involves frequent rather slow ramp-type actuator movements that rarely reach end positions.

Information

The positioner actuates its integrated pneumatic valves for both actuator chambers symmetrically, i.e. when pressurizing working port (2), de-pressurizing simultaneously occurs at working port (4). When the average airflow for de-pressurizing is slightly higher than the average pressurizing airflow, the overall pressure level in the chambers will decrease.

A typical time course of actuator position and pressures for such a scenario is depicted in Fig. 2.1. Here, actuator position periodically changes between 30% and 50% of the stroke. While pressure p2 is always slightly higher than p4, the average pressure decreases to about 1.5 bar within around 8 minutes.

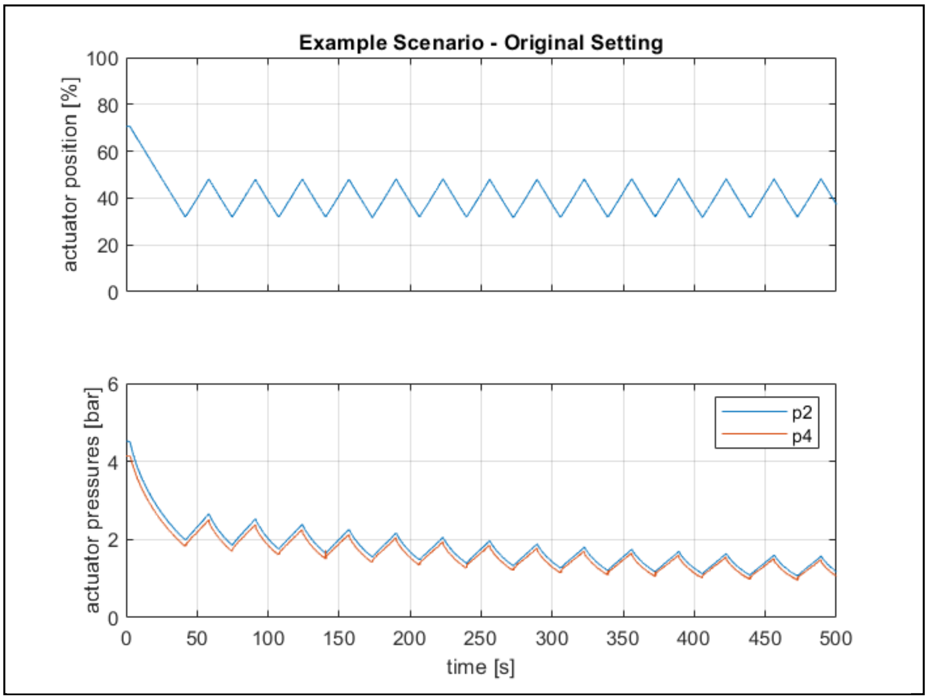

Fig. 2.1: Time course of measurement signals in setting with decreasing pressures

A low average pressure level can reduce system stiffness to the point that the actuator becomes sensitive to external disturbances. For applications where high stiffness is required, a solution approach is presented here. It mainly involves a throttled bypass between pressure supply port and one working port of the positioner and can be realized entirely with Festo components.

3 Solution Approach

3.1 Principle

The central element for increasing the average pressure level in the actuator chambers is a throttled bypass connection between the supply pressure line and one actuator port. A circuit diagram for such a setup is shown in Fig. 3.1. Here, two T- or Y-connectors are used to place an adjustable throttle or one-way flow control valve between the supply pressure line and the line connecting working port (2) of the CMSH with the corresponding actuator port.

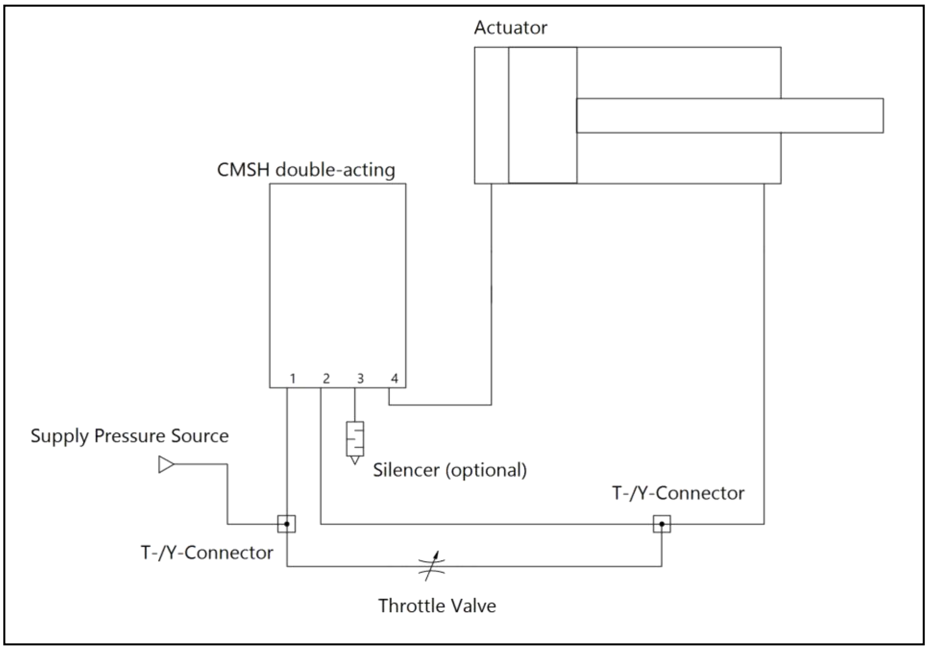

Fig. 3.1: Pneumatic circuit diagram for pressure bypassing to working port (2)

Information

The throttled bypass leads to a slow pressure increase in the actuator chamber connected to CMSH working port (2). This modifies the pressure difference between the actuator chambers and the force created by the piston changes. The CMSH will react to these changes by gently de-pressurizing working port (2) and simultaneously pressurizing port (4) to keep the actuator at the current target position. Thereby, the average pressure level in the actuator chambers is increased and the application-induced actuator pressure decrease can be compensated for.

Generally, the approach works in the same manner when creating a bypass between the supply pressure line and working port (4).

3.2 Implementation

The solution approach can be implemented with Festo products as listed in Table 1.1:

- Bifurcations and junctions for the bypass connection can be realized with push-in T-connectors QST or Y-connectors QSY.
- A one-way flow control valve GR-QS can be used as an adjustable throttle.
- Connections between the above elements and the lines linking either supply pressure and CMSH port (1) or CMSH working ports and actuator ports can be realized with standard pneumatic tubes, push-in sleeves QSH, L-connectors QSL or others, according to the application-specific conditions.

An example assembly is shown in Fig. 3.2.

1	pressure supply	4	junction with T-connector
2	bifurcation with Y-connector	5	from working port (2) to actuator
3	adjustable throttle valve	6	from working port (4) to actuator

Fig. 3.2: Assembly example for pressure bypassing to Working Port (2)

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Information

In the assembly shown in Fig. 3.2, 8 mm tubing and fittings are used for the regular pneumatic connections and 6 mm for the bypass. Therefore, some of the depicted components have 6 mm connections: Push-in sleeve QSH-8-6, L-connector QSL-6H, T-connector QST-8-6 and the one-way flow control valve GR-QS-6 as adjustable throttle. While any size of GR-QS is suitable, it might be easier to select an appropriate opening degree of the screw element with GR-QS-6 or GR-QS-4 compared to GR-QS-8. See Fig. A.1 and Fig. A.2 in the Appendix for details.

In an experimental setting, the time course of actuator position and pressures shown in Fig. 3.3 was achieved. In contrast to the original setting without pressure bypass as depicted in Fig. 2.1, actuator pressures are stabilized at a level of about 3 bar.

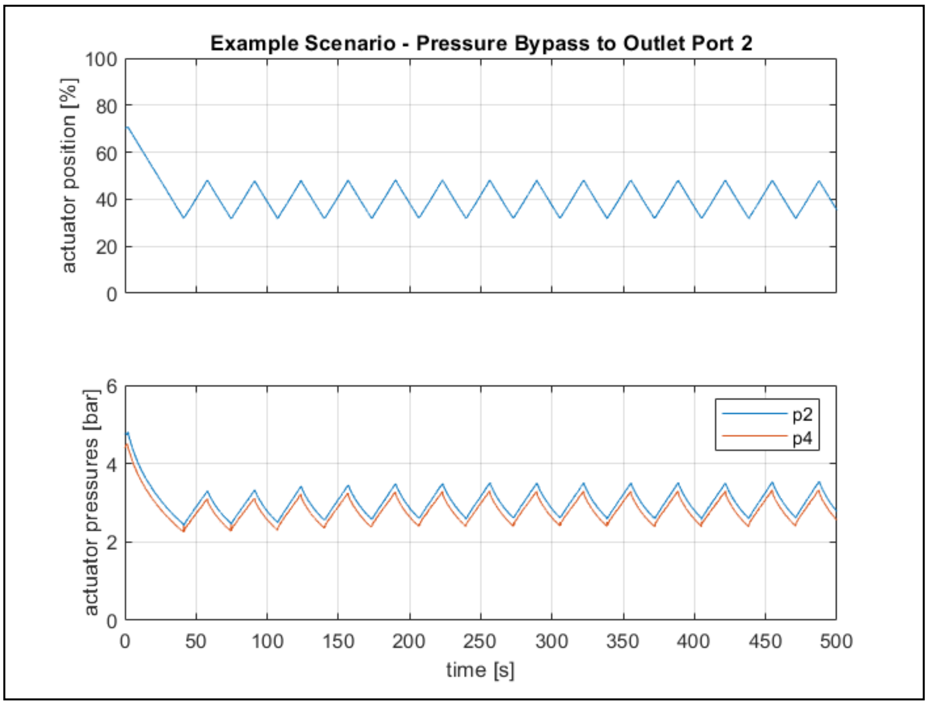
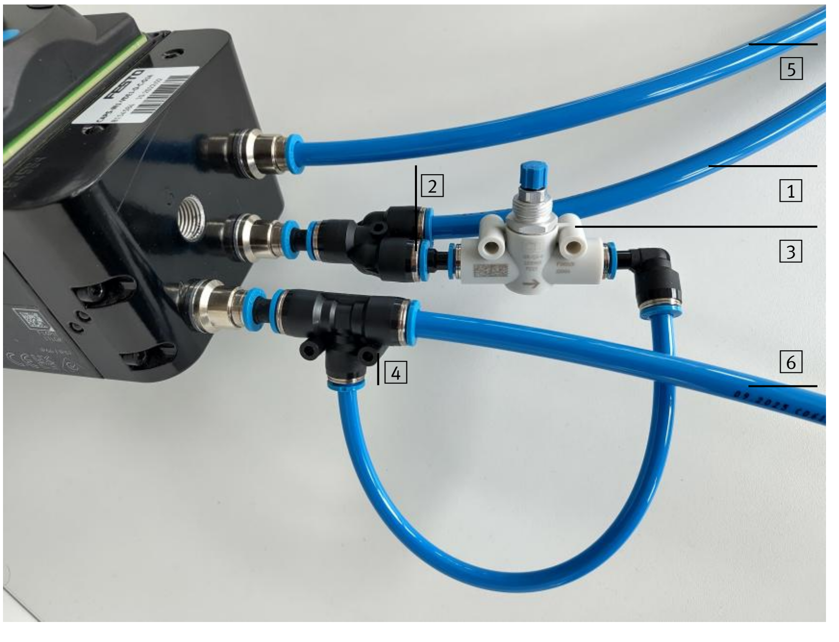


Fig. 3.3: Time course of measurement signals with pressure bypass to Working Port 2

For the sake of completeness, an alternative assembly example for pressure bypassing to Working Port 4 is shown in Fig. 3.4.



1 pressure supply
2 bifurcation with Y-connector
3 adjustable throttle valve
4 junction with T-connector
5 from working port (2) to actuator
6 from working port (4) to actuator

Fig. 3.4: Assembly example for pressure bypassing to Working Port (4)

3.3 Step by Step Procedure

1. **Evaluate average actuator pressure levels.**
   a. There are two options to view actuator pressures p2 and p4 as measured by CMSH:
      i. In the Local User Interface of CMSH, starting from the default view with target and actual position, press the left button until you arrive at the menu showing current actuator pressures p2 and p4:

      ii. Connect to CMSH via HART and use Device Type Manager or FDI Package to view current chamber pressures at the bottom of the Process Variables View:

   b. Observe p2 and p4 while carrying out typical movement scenarios. Note average pressure levels as a starting point.
   c. Define an approximate target pressure level above the starting point as desired minimum average actuator pressure.

2. **Choose a small value for the static deadband parameter of CMSH.** This will help the positioner to quickly react on changes of actuator pressures induced by pressure bypassing.
   a. In the Local User Interface of CMSH, navigate to Settings --> Control --> Deadband.
   b. If "Deadband Type" can be selected, choose "Static".
   c. For "Static Deadband", choose the smallest possible value.

3. **De-energize the system.**

Warning

Compressed air can cause serious injury.

Risk of penetrating injury and hearing damage.

- Lockout/tagout and depressurize pneumatic lines before performing maintenance.
- Verify zero pressure before disassembly.

   a. Turn off supply pressure and depressurize the pressure supply line to CMSH.
   b. Remove electrical energy supply from CMSH.
   c. Depressurize the actuator.

4. **Assemble pressure bypass**
   a. Establish a throttled connection between the supply pressure line and working port (2) or (4), analogous to the illustration in Fig. 3.2 or Fig. 3.4.
   b. For the beginning, turn the adjusting screw of the throttle valve clockwise until the “closed” limit is reached.

5. **Re-energize the system**
   a. Re-establish electrical energy supply to CMSH.
   b. Re-pressurize the pressure supply line to CMSH.

6. **Establish appropriate setting of the adjustment screw.**
   a. Initiate several actuator movements that are typical for your application and observe pressures p2 and p4 until low average pressure levels are manifest.

Information

After startup, pressure levels may seem appropriate without further modifications. Typically, it takes several movement cycles until low pressure levels are reached (see example in Fig. 3.1).

   b. Open the adjustable throttle by turning the adjustment screw counterclockwise while observing actuator pressures p2 and p4. Proceed slowly and continuously until you observe a pronounced pressure level increase. Then, turn back the adjustment screw clockwise by about 45 to 90 degrees until the pronounced pressure increase is stopped again.
   The effect “pressure level change by turn” depends on actuator size, typical movement speed, supply pressure and on the size of the adjustable throttle (see section A.1 in the Appendix).
   c. Observe pressures p2 and p4 during several actuator movement cycles.
      i. If pressure averages converge to a value above the previously defined target pressure level that is appropriate for your application, keep the setting.
      ii. If pressure averages are not increased sufficiently, open the screw a little more and go back to c.
      iii. If pressure averages increase too fast, close the screw a little more and go back to c.

Information

- At some point, in particular when actuator movements are rare, pressures may rise almost up to supply pressure level eventually.
- If you observe frequent control actions by the positioner without satisfactory increase of pressure levels, try a bypass from the supply pressure to the other working port instead, starting at 3.

4 Safety Considerations

Caution

Limited Capability for Safety Position Option „Fail in Place“.

For double-acting CMSH with Safety Position configuration “Fail in Place”, working ports (2) and (4) are automatically closed in the event of electrical power failure. Without a bypass between supply pressure line and one of the working ports and in the absence of air leakage, the consequence of this behavior is that the position in the moment of power interruption is kept constant until electrical supply is re-established. However, a pressure bypass will lead to a (however slow) pressure increase at the connected working port in the absence of electrical power and, at some point, to an actuator movement towards the limit position that is related to higher pressure at the connected port.

- Don’t use the presented pressure bypass if Safety Position „Fail in Place“ is crucial for your application.

Caution

Limitation for Safety Position Option „Fail Safe“ with Pressure Bypass to Working Port (2).

For double-acting CMSH with Safety Position configuration “Fail Safe”, working port (2) is automatically de-pressurized and working port (4) pressurized in the event of electrical power failure. Without a bypass between supply pressure line and one of the working ports and in the absence of air leakage, the consequence of this behavior is that the actuator moves immediately with maximum speed towards the limit position that is related to higher pressure at working port (4). However, a pressure bypass to working port (2) will lead to a (however little) airflow from the supply pressure line to port (2) in the absence of electrical power, which might slow down actuator speed in that case.

- If Safety Position „Fail Safe“ is crucial for your applicaton and you choose a pressure bypass to working port (2), assure that actuator speed is sufficient in the event of electrical power failure. In case of doubts, try a pressure bypass to working port (4) instead.

A Appendix

A.1 Technical data - Flow Characteristics of GR-QS

The following figures extracted from the GR-QS data sheet of the one-way flow control valve GR-QS may be helpful to select the diameter appropriate for the respective application.

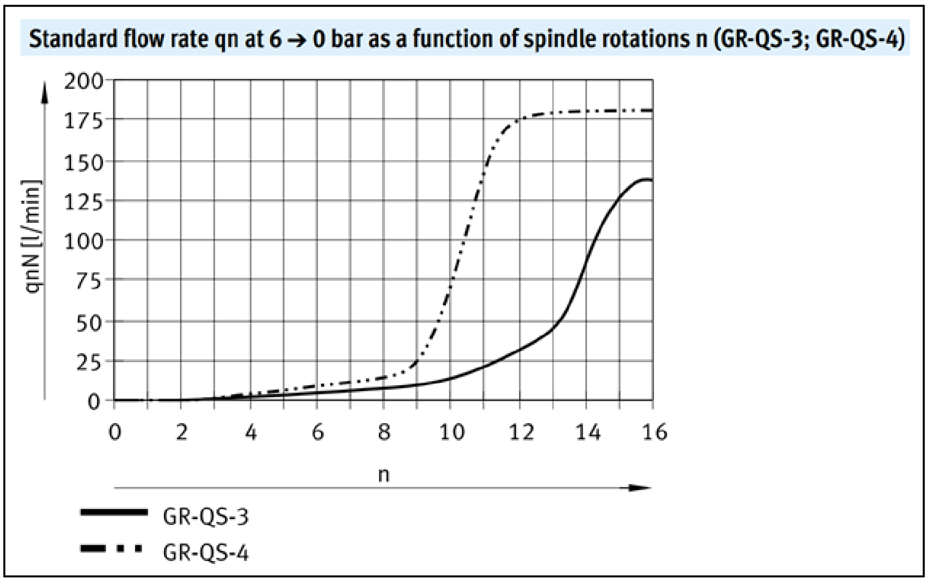


Fig. A.1: Flow Characteristics of GR-QS-3 and GR-QS-4

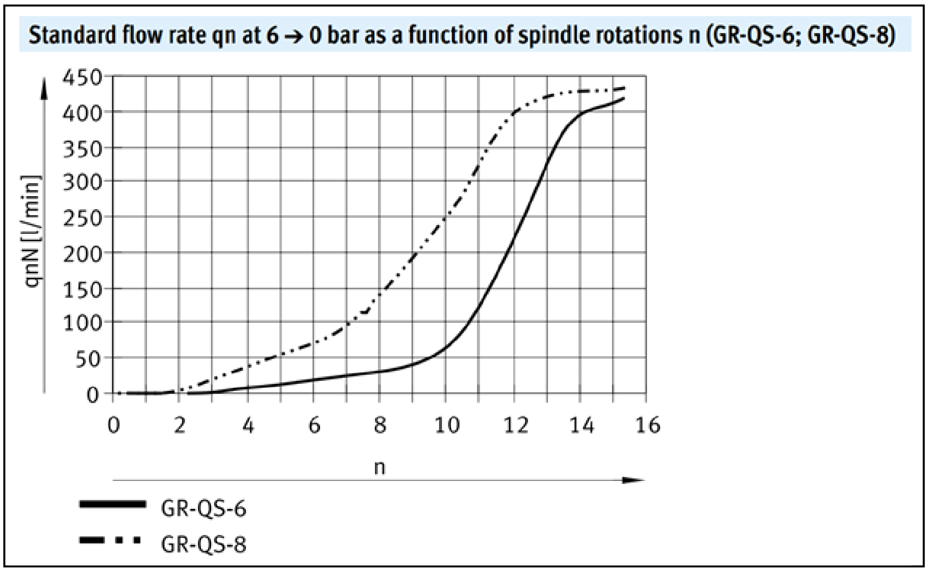


Fig. A.2: Flow Characteristics of GR-QS-6 and GR-QS-8