

Implementation of Lock-in-Last Strategy

Supplement to Fisher™ FIELDVUE™ Digital Valve Controller Instruction Manuals

Many applications require a valve assembly to remain in the position it was prior to a specific control system failure (lock-in-last position). Functionality and safety can be designed into valve assemblies with FIELDVUE digital valve controllers by utilizing an array of accessories. The following paragraphs describe standard solutions for a number of generic lock-in-last applications with DVC7K, DVC6200, DVC6200f, or DVC6000 digital valve controllers.

Note

Refer to the appropriate quick start guide or instruction manual listed below for additional instrument information. All documents are available from your Emerson sales office or at Fisher.com.

- DVC7K Digital Valve Controller Quick Start Guide ([D104766X012](#))
- DVC7K Digital Valve Controller Instruction Manual ([D104767X012](#))
- DVC6200 Series Digital Valve Controller Quick Start Guide ([D103556X012](#))
- DVC6200 HW2 Digital Valve Controller Instruction Manual ([D103605X012](#))
- DVC6200f Digital Valve Controller Instruction Manual ([D103412X012](#))
- DVC6200 HW1 Digital Valve Controller Instruction Manual ([D103409X012](#))
- DVC6000 Digital Valve Controllers Instruction Manual ([D102794X012](#))

Other related documents include:

- Fisher 377 Trip Valve Instruction Manual ([D200319X012](#))
 - 167D, 167DA, 167DS and 167DAS Switching Valves Installation Guide ([D103234X014](#))
 - 167D, 167DA, 167DS and 167DAS Switching Valves Instruction Manual ([D103234X012](#))
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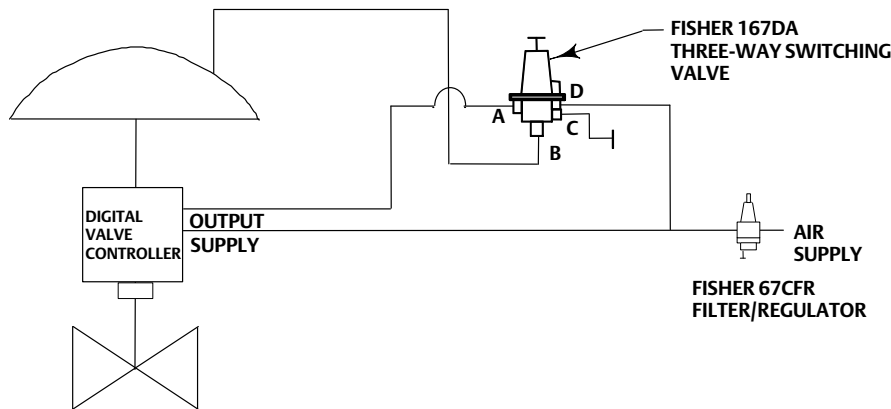
Lock-in-Last on Loss of Supply Pressure

Once the supply pressure falls below a minimum value, the digital valve controller can no longer position a valve assembly; the valve will start to go to the actuator “at rest” position. The locking device senses this change and activates, preventing the remaining air from venting. The valve is “locked-in” this new position.

Note

The locked-in valve position depends on the exhausting speed of the actuator.

Figure 1. Lock-in-Last on Loss of Supply Pressure for an Assembly with a Single-Acting Actuator



Assemblies with Single-Acting Actuators

A Fisher 167DA three-way switching valve should be used for locking a single-acting actuator in place on loss of supply pressure. Figure 1 is a schematic representing proper assembly layout. In normal operation, the digital valve controller output passes through the switching valve from port A to port B and on to the actuator.

In a fail condition, the pressure at port D is below the switching valve's set point, causing the switching valve to trip. This closes port B, which locks the pressure in the actuator. Port C is plugged so the digital valve controller output will not exhaust to the atmosphere.

Assemblies with Double-Acting Actuators

Similar to the locking strategy used with single-acting actuators, the locking strategy with double-acting actuators also uses a valve for locking supply pressure in the actuator. For assemblies with double-acting actuators, a Fisher 377L trip valve is used as the locking device. The 377L trip valve has two output ports for locking pressure on both sides of a double-acting actuator. Figure 2 is a schematic representing proper assembly layout.

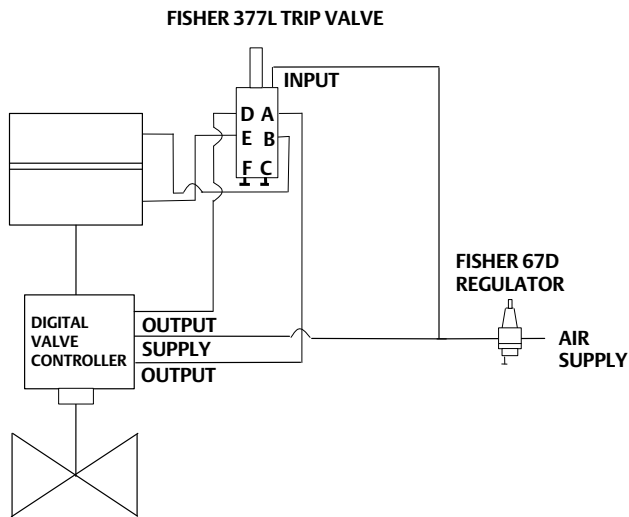
Connection of the digital valve controller output to a double-acting actuator determines the action of the actuator. Figure 2 shows the digital valve controller providing lower cylinder pressure through ports D and E, and upper cylinder pressure through ports A and B. When the supply pressure falls below the set point of the trip valve, the trip valve closes ports D and A and connects port B to C and port E to F. Because C and F are plugged, the control valve is locked in place by locking pressure on both sides of the actuator piston. The assembly returns to normal operation once supply pressure is restored at the trip valve INPUT port.

Note

Double-acting actuators with a 377L trip valve require a Fisher 67D or MR95H regulator. Regulators with smaller flow capacities may cause the trip valve to cycle (lock and unlock repeatedly) due to air flow demand as the assembly attempts to reset. Use a Fisher 252 or 262C pilot filter to filter supply air.

Both the 167DA switching valve and the 377L trip valve have a deadband that must be overcome. The switching valve must be calibrated to reset upon restoration of adequate supply pressure to the regulator. The 377L trip valve has only one spring selection. However, for minimal deadband, the lightest appropriate spring should be selected for the 167DA switching valve.

Figure 2. Lock-in-Last on Loss of Supply Pressure for an Assembly with a Double-Acting Actuator



Lock-in-Last Using Solenoid Valves

Note

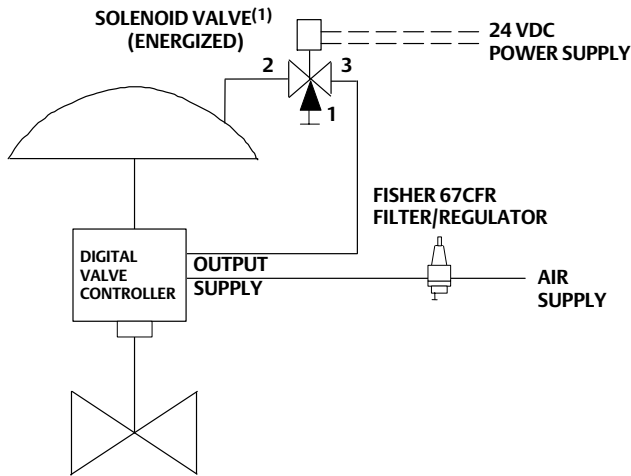
Applications for Lock-in-Last Using Solenoid Valves are applicable for HART communicating digital valve controllers. They are also applicable for FOUNDATION fieldbus digital valve controllers when a current switch, such as the Phoenix Mini MCR-SL-UI-REL, is used. Applications appropriate for both HART and FOUNDATION fieldbus digital valve controllers start on page 8.

Solenoid valves are used with valve assemblies in many ways. Their electrical control can be utilized in combination with switches and controller logic to perform a number of functions.

Note

Solenoid valves placed between the output of a FIELDVUE digital valve controller and the input to an actuator require a minimum C_v of 0.49. Greater restrictions can affect the response of the assembly. An example of an appropriate three-way solenoid valve for use with the digital valve controller is the ASCO™ 8327 Series solenoid valve from ASCO Valve, Inc.

Figure 3. Lock-in-Last Strategy for an Assembly with a Single-Acting Actuator Using a Solenoid Valve



NOTE:

1. A SOLENOID VALVE WITH A MINIMUM C_v OF 0.49, SUCH AS THE ASCO 8327 SERIES OR EQUIVALENT, IS REQUIRED FOR THIS ASSEMBLY

Assemblies with Single-Acting Actuators

A three-way universal solenoid valve can be placed between the digital valve controller output and the actuator input. Switching the valve assembly from an unlocked state to a locked state is controlled by switching power on and off to the solenoid valve. Figure 3 depicts proper assembly layout.

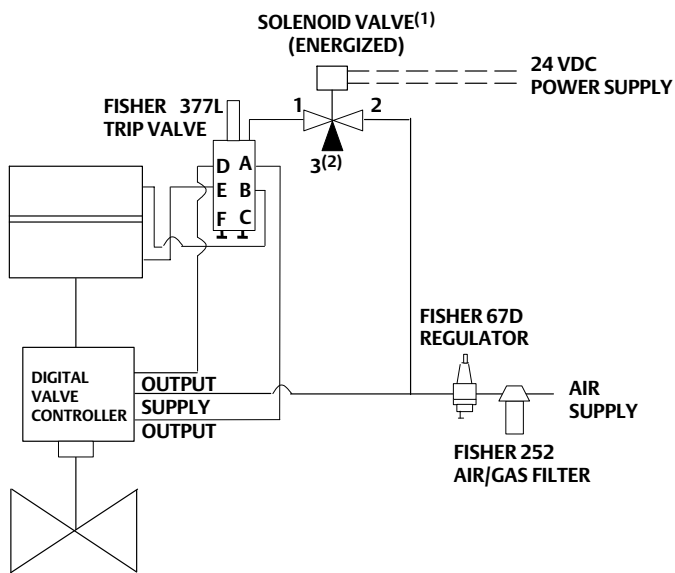
Under normal operating conditions the solenoid is energized and supply air flows from the digital valve controller output to the actuator input. In the fail state, power is removed from the solenoid causing the solenoid valve to close, locking air pressure in the actuator. Port 1 of the solenoid valve is plugged, preventing actuator air pressure from exhausting to the atmosphere.

Assemblies with Double-Acting Actuators

Assemblies with double-acting actuators require a 377L trip valve to lock pressures on both sides of the actuator piston. Figure 4 is a schematic of a double-acting actuator with lock-in-last capability shown in its normal operating mode. The solenoid valve is placed in series with the supply pressure port of the trip valve. When tripped, the solenoid valve exhausts the supply pressure to the trip valve to atmosphere. This simulates a loss in supply pressure, causing the trip valve to lock pressure in the actuator.

The solenoid valve in this solution does not require a C_v greater than 0.49. Flow capacity of this valve can be much smaller. An example of a proper solenoid valve for this assembly is the 8320 Series three-way solenoid valve. As with all solenoid valves, ensure that the solenoid valve operating pressure differential rating is adequate for the supply pressure.

Figure 4. Lock-in-Last for an Assembly with a Double-Acting Actuator Using a Solenoid Valve



NOTE:

1. THE ASCO 8320 SERIES SOLENOID VALVE OR EQUIVALENT IS APPROPRIATE FOR THIS ASSEMBLY.
2. THIS PORT NEEDS TO EXHAUST TO THE ATMOSPHERE.

Lock-in-Last on Loss of Supply Pressure and/or Loss of Loop Current

Most applications require a valve assembly to be in a lock-in-last fail state not only on loss of adequate supply pressure but also on loss of loop power. Lock-in-last on loss of supply pressure is quite straight forward. Lock-in-last on loss of loop power can be more complex.

Most control loops operate on a 4-20 mA control signal (HART) or on 9 to 32 Volt fieldbus segment (FOUNDATION fieldbus). A solenoid valve, adequately sized for the application, requires more than 4 mA to energize. Therefore, the control loop cannot be used to energize the solenoid. Instead the solenoid must be powered by a separate 24 volt power source.

Using a Digital Valve Controller with the Output Terminals Configured as a Switch

Note

DVC7K HART instruments require the I/O Options Package. Refer to the DVC7K instruction manual ([D104767X012](#)) for switch configuration.

DVC6200 HW2 HART instruments require the I/O Package. Refer to the DVC6200 HW2 instruction manual ([D103605X012](#)) for switch configuration.

The solenoid is wired through the output terminals of the digital valve controller and the output terminal is configured as a switch. When the digital valve controller reaches a point where minimum power is lost the switch state will go open.

Note

This application requires the Output Terminal function be configured as a switch.

The DVC7K with the I/O Options Package has output circuits for two solid state dry contact switches. Switch 1 is a normally open circuit and Switch 2 is a normally closed circuit. This application uses Switch 1.

Configure the Output Terminal on the DVC6200 as a switch.

Note

The digital output (DO) card will provide power through the switch and to the solenoid valve. Power will be maintained to the solenoid as long as the input terminals of the digital valve controller are sufficiently powered.

Note

Configuration of the switch trip point may trigger the solenoid, consequently the alert switch or position switch point could trigger the solenoid fail/trip state.

Note

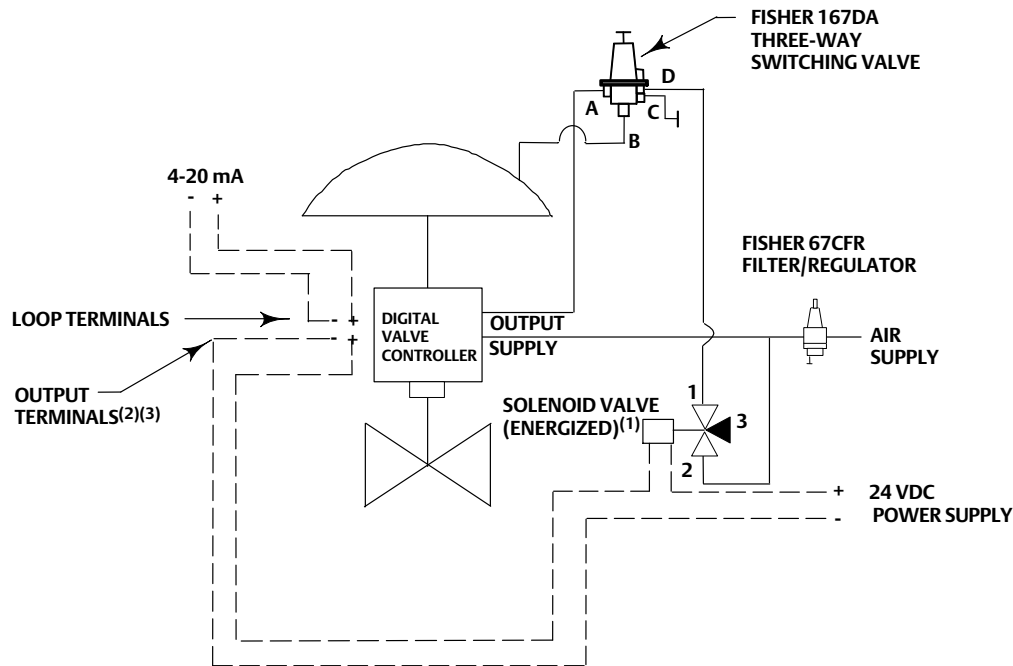
There will be a slight delay between the switch state going to open and the valve being locked-in to the new position.

Assemblies with Single-Acting Actuators

Assemblies with a single-acting actuator use a 167DA three-way switching valve in conjunction with a solenoid valve. Figure 5 is a schematic of a single-acting actuator assembly with lock-in-last capability on loss of supply pressure or loop current. Under normal operating conditions power is supplied to the solenoid valve and adequate supply pressure is available to the switching valve. Upon loss of supply pressure, the set point of the switching valve is exceeded and the switching valve trips.

Upon loss of loop current, the switch state goes to open, and trips the solenoid valve by cutting the power to the solenoid. When the solenoid valve trips, the supply pressure that was holding the switching valve open is exhausted to atmosphere. This simulates a loss of supply pressure, causing the switching valve to trip.

Figure 5. Lock-in-Last on Loss of Loop Current and/or Supply Pressure for an Assembly with a Single-Acting Actuator



NOTE:

1. THE ASCO 8320 SERIES SOLENOID VALVE OR EQUIVALENT IS APPROPRIATE FOR THIS ASSEMBLY.
2. CONFIGURE SWITCH 1 (NORMALLY OPEN) ON THE DVC7K DIGITAL VALVE CONTROLLER.
3. CONFIGURE THE OUTPUT TERMINAL ON THE DVC6200 AS A SWITCH.

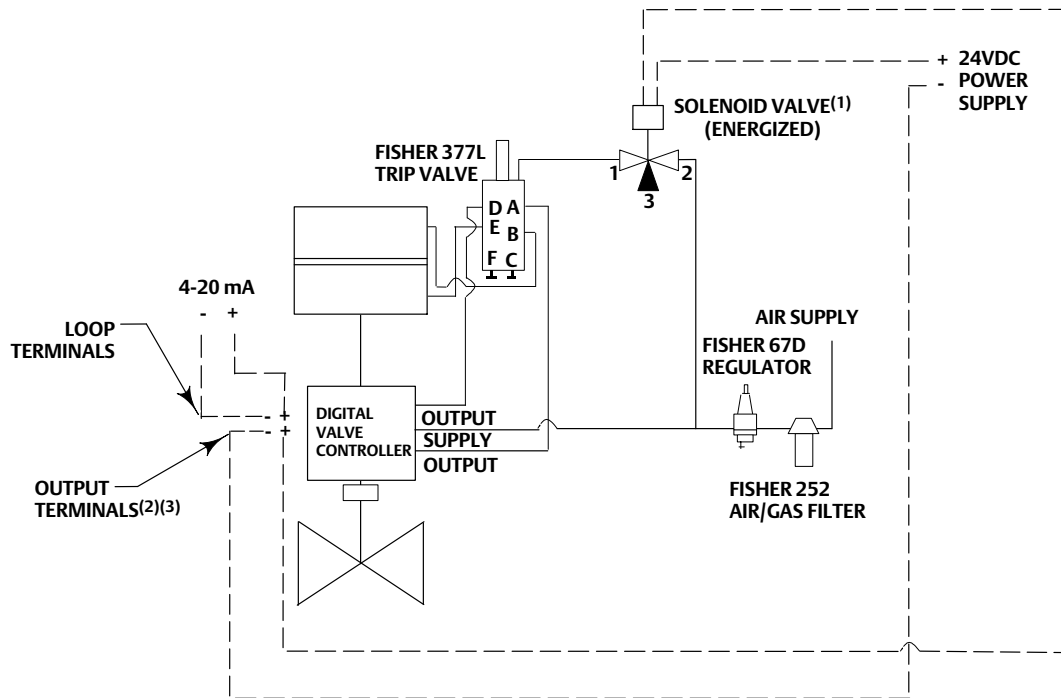
Assemblies with Double-Acting Actuators

The same principle used for assemblies with single-acting actuators is used for assemblies with double-acting actuators. Figure 6 is a schematic of the double-acting assembly with lock-in-last capability shown under normal operating conditions.

Note

FIELDVUE digital valve controllers require approximately 0.5 seconds to initialize upon power up. During this time, the digital valve controller cannot provide control. In the case where control of a previously locked valve is restored to a digital valve controller prior to the completion of initialization, the valve will travel toward its fail-safe position.

Figure 6. Lock-in-Last on Loss of Loop Current and/or Supply Pressure for an Assembly with a Double-Acting Actuator



NOTE:

1. THE ASCO 8320 SERIES SOLENOID VALVE OR EQUIVALENT IS APPROPRIATE FOR THIS ASSEMBLY.
2. CONFIGURE SWITCH 1 (NORMALLY OPEN) ON THE DVC7K DIGITAL VALVE CONTROLLER.
3. CONFIGURE THE OUTPUT TERMINAL ON THE DVC6200 AS A SWITCH.

Using a Current Switch

Note

These applications are appropriate for both HART and FOUNDATION fieldbus digital valve controllers.

A current threshold switch can be used to monitor the 4-20 mA signal (HART) or current on a fieldbus segment to the digital valve controller. Upon loss of this signal, or when the signal falls below the threshold, the threshold switch will open an internal relay. This relay, if placed between a solenoid valve and its power supply, will essentially open and close the solenoid valve. The solenoid valve can be placed in line with the tubing to the actuator to provide the lock-in-last function.

To ensure adequate response time of a locking system to a loss of loop current, a threshold switch with a maximum deadtime of 0.025 seconds should be used. The locking system will be faster than the response of the positioning system to the failure.

One switch that meets the maximum deadtime requirements is the Phoenix Contact Dual Setpoint Module, Mini MCR-SL-UI-REL.

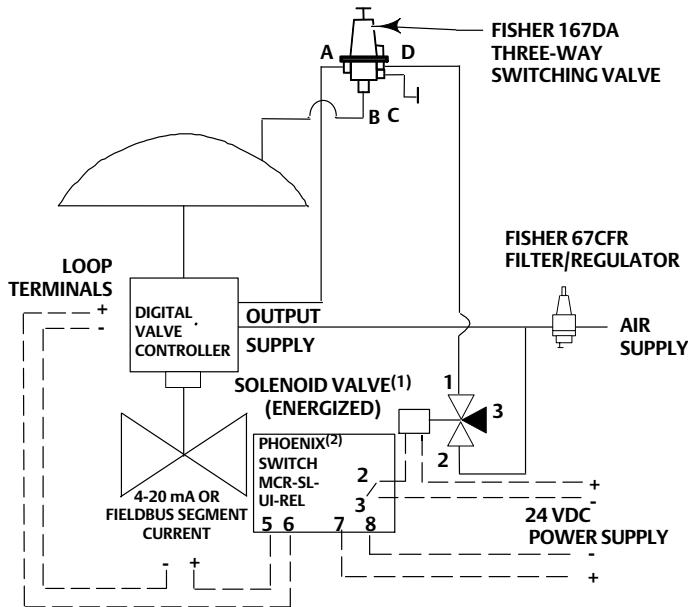
Note

The Mini MCR-SL-UI-REL switch is not provided by Emerson. Order this switch from Phoenix Contact.

Assemblies with Single-Acting Actuators

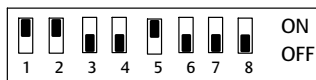
Assemblies with a single-acting actuator use a 167DA three-way switching valve in conjunction with a solenoid valve. Figure 7 is a schematic of a single-acting actuator assembly with lock-in-last capability on loss of supply pressure or loop current. Under normal operating conditions power is supplied to the solenoid valve and adequate supply pressure is available to the switching valve. Upon loss of supply pressure, the set point of the switching valve is exceeded and the switching valve trips.

Figure 7. Lock-in-Last on Loss of Loop Current and/or Supply Pressure for an Assembly with a Single-Acting Actuator



NOTES:

1. THE ASCO 8320 SERIES SOLENOID VALVE OR EQUIVALENT IS APPROPRIATE FOR THIS ASSEMBLY.
2. MINI MCR-SL-UI-REL DIP SWITCH SETTINGS:



Note

After the threshold switch is connected, as shown in figure 7, use a single set point source to apply 4 mA for HART applications or the minimum required for the fieldbus segment, to power both the switch and the digital valve controller.

The threshold switch low trip point is established using the potentiometer, which is located under the switch cover along with a Yellow LED indicator. If the LED is on, adjust the potentiometer just to the point that the light goes off. Then adjust the

potentiometer back until the light just comes back on. If the light was off when power was first applied adjust the potentiometer as described previously until the light just comes on. This sets the the low trip point for the switch.

For HART applications, if the switch is connected and calibrated correctly, the LED indicator should stay lit as long as the digital valve controller and switch are sufficiently powered from the control system AO and have a control signal of 4 mA or higher.

For FOUNDATION fieldbus applications, if the switch is connected and calibrated correctly, the LED indicator should stay lit as long as the digital valve controller and switch are sufficiently powered from the control system H1 card segment power supply and have the minimum required control signal of the fieldbus segment .

If the LED is not on it indicates that a fault state exists and the threshold switch relay will open to disconnect power to the solenoid and the valve should be in the lock-in-last state.

Upon loss of loop current, the threshold switch relay opens, and trips the solenoid valve by cutting the power to the solenoid. When the solenoid valve trips, the supply pressure that was holding the switching valve open is exhausted to atmosphere. This simulates a loss of supply pressure, causing the switching valve to trip.

Note

For HART applications, use a single 24 V power source for both the analog output (AO) card providing loop current to the digital valve controller and the solenoid valve. This ensures power is maintained to the solenoid valve as long as the AO card is sufficiently powered.

For FOUNDATION fieldbus applications, use a single 24 V power source for both the H1 card and segment power providing loop current to the digital valve controller and the solenoid valve. This ensures power is maintained to the solenoid valve as long as the H1 card and the fieldbus segment are sufficiently powered.

Assemblies with Double-Acting Actuators

The same principle used for assemblies with single-acting actuators is used for assemblies with double-acting actuators. Figure 8 is a schematic of the double-acting assembly with lock-in-last capability shown under normal operating conditions.

Note

After the threshold switch is connected, as shown in figure 8, use a single set point source to apply 4 mA or the minimum required for the fieldbus segment to power both the switch and the digital valve controller.

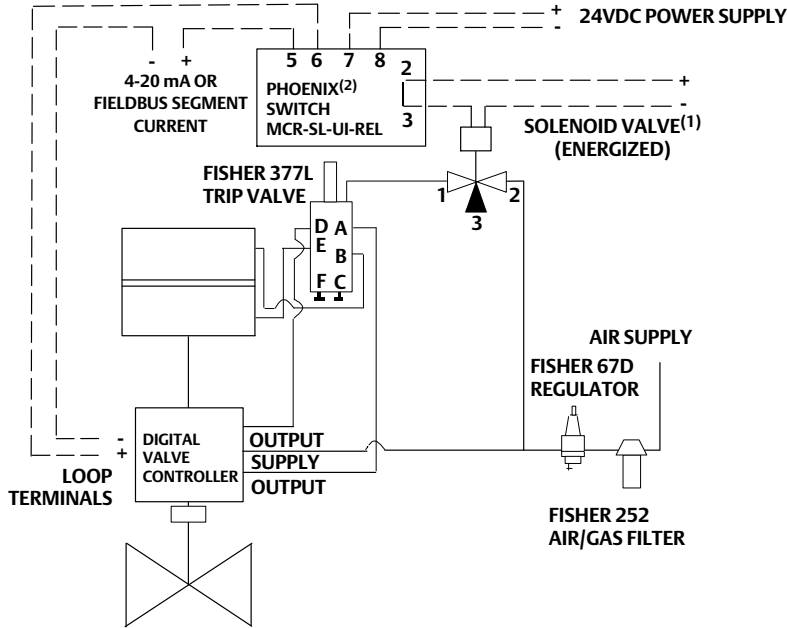
The threshold switch low trip point is established using the potentiometer, which is located under the switch cover along with a Yellow LED indicator. If the LED is on, adjust the potentiometer just to the point that the light goes off. Then adjust the potentiometer back until the light just comes back on. If the light was off when power was first applied adjust the potentiometer as described previously until the light just comes on. This sets the the low Trip point for the switch.

For HART applications, if the switch is connected and calibrated correctly, the LED indicator should stay lit as long as the digital valve controller and switch are sufficiently powered from the control system AO and have a control signal of 4 mA or higher.

For FOUNDATION fieldbus applications, if the switch is connected and calibrated correctly, the LED indicator should stay lit as long as the digital valve controller and switch are sufficiently powered from the control system H1 card segment power supply and have the minimum required control signal of the fieldbus segment.

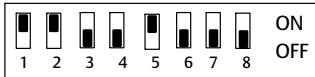
If the LED is not on it indicates that a fault state exists and the threshold switch relay will open to disconnect power to the solenoid and the valve should be in the lock-in-last state.

Figure 8. Lock-in-Last on Loss of Loop Current and/or Supply Pressure for an Assembly with a Double-Acting Actuator



NOTES:

1. THE ASCO 8320 SERIES SOLENOID VALVE OR EQUIVALENT IS APPROPRIATE FOR THIS ASSEMBLY.
2. MINI MCR-SL-UI-REL DIP SWITCH SETTINGS:



Note

FIELDVUE digital valve controllers require approximately 0.5 seconds to initialize upon power up. During this time, the digital valve controller cannot provide control. In the case where control of a previously locked valve is restored to a digital valve controller prior to the completion of initialization, the valve will travel toward its fail-safe position. A relay with an engagement deadtime, such as the MCR-SL-UI-REL from Phoenix Contact, can be used to delay the release of the locking system until the digital valve controller has completely initialized. An engagement delay of 1.0 seconds will adequately minimize the dip in travel.

Note

While the valve is in a locked state, the set point from the digital valve controller may change in response to changes in process conditions. This change in set point may result in a process bump when control is restored to the digital valve controller.

Phoenix Threshold Switch Specifications⁽¹⁾

<p>Switch Model Number Mini MCR-SL-UI-REL</p> <p>Size 6.2 x 93.1 x 101.2 mm (0.24 x 3.67 x 3.98 inches)</p> <p>Mounting Mounts in control room (DIN rail mount)</p> <p>Wiring Connect switch in series between control loop and field device Control Loop + to switch terminal 5 Digital Valve Controller + to switch terminal 6 24 VDC Power Supply to switch connections Power Supply + to switch terminal 7 Power Supply - to switch terminal 8</p>	<p>Connect switch in series between the solenoid valve and 24 VDC power supply</p> <p>Power Supply + to switch terminal 2 Solenoid wire to switch terminal 3</p> <p>Configuration <i>Engagement Deadtime: 1 second</i></p> <p>Switch Settings</p> <table border="1"> <thead> <tr> <th>Switch</th> <th>Setting</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>On</td> <td>In</td> </tr> <tr> <td>2</td> <td>On</td> <td>In</td> </tr> <tr> <td>3</td> <td>Off</td> <td>Hysteresis</td> </tr> <tr> <td>4</td> <td>Off</td> <td>Hysteresis</td> </tr> <tr> <td>5</td> <td>On</td> <td>Delay</td> </tr> <tr> <td>6</td> <td>Off</td> <td>Delay</td> </tr> <tr> <td>7</td> <td>Off</td> <td>Delay</td> </tr> <tr> <td>8</td> <td>Off</td> <td>Operating Current</td> </tr> </tbody> </table>	Switch	Setting	Description	1	On	In	2	On	In	3	Off	Hysteresis	4	Off	Hysteresis	5	On	Delay	6	Off	Delay	7	Off	Delay	8	Off	Operating Current
Switch	Setting	Description																										
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6	Off	Delay																										
7	Off	Delay																										
8	Off	Operating Current																										

1. The Phoenix threshold switch is not supplied by Emerson. Order the switch from the manufacturer, Phoenix Contact (www.phoenixcontact.com). For complete installation details, see the instruction manual provided by the switch manufacturer.

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