The Continuing Evolution & Design of Hydraulic Valves

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Bethlehem, PA
Agenda

Shock vs speed of shift

Basic „on-off“ solenoid valves

„Soft shift“- using spools and/or throttles

Proportional Technology

Field buses and related directional products
Agenda

Shock vs speed of shift

Basic „on-off“ solenoid valves

„Soft shift“- using spools and/or throttles

Proportional Technology

Field buses and related directional products
Directional Valve Evolution

Standard Blocked Center Valve

"Soft" Shift Directional Valve

"Affordable" Proportional Valve

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Agenda

Shock vs speed of shift

Basic „on-off“ solenoid valves

„Soft shift“- using spools and/or throttles

Proportional Technology

Field buses and related directional products
Standard Directional Valves

Pressure drop vs. flow (above)

DC solenoid forces vs. flow (left)
# Poppet Valves

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## Features

- Direct operated directional poppet valve with solenoid actuation
- Position of ports to DIN 24340 form A
- Closed port is leak tested installed
- Safe operation even after longer periods of standstill under pressure
- Watertight DC solenoid with solenoid coil (AC-voltage possible by means of rectifier)
- Solenoid coil can be rotated through 90°
- Pressuretight chamber means not to be enabled for a change of the coil
- Electrical connection as individual connection
- With concentrated manual override, optional
- Inductive position switch (contact-free and housing), optional, see page 12.

Additional Information on available spare parts:

www.boschrexroth.com/epc
Standard Products (Poppet Valves)

Poppet Valves; SED, SEW

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Poppet Valves Characteristics

Shifting time [on/off] related to system pressure

<table>
<thead>
<tr>
<th>Pressure $p$ in PSI (bar)</th>
<th>Flow $q$, in GPM (L/min)</th>
<th>$t$ in ms</th>
<th>DC solenoid Symbols UK, CK, D, Y</th>
<th>AC solenoid + rectifier Symbols UK, CK, D, Y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without tank pressure</td>
<td>£</td>
<td>£</td>
<td>£</td>
</tr>
<tr>
<td></td>
<td></td>
<td>£</td>
<td>£</td>
<td>£</td>
</tr>
<tr>
<td>1000 (70)</td>
<td>6.60 (25)</td>
<td>45</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>2000 (140)</td>
<td>6.60 (25)</td>
<td>50</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>3000 (210)</td>
<td>6.60 (25)</td>
<td>50</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>4000 (280)</td>
<td>6.60 (25)</td>
<td>50</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>4600 (315)</td>
<td></td>
<td>65</td>
<td>45</td>
<td>65</td>
</tr>
<tr>
<td>5000 (350)</td>
<td></td>
<td>65</td>
<td>65</td>
<td>65</td>
</tr>
</tbody>
</table>

Pressure drop vs. flow, D03 poppet valve

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Moisture ingress resistant

- AC connections
M12 & “Mobile” oriented

- DC connections
Agenda

- Shock vs speed of shift
- Basic „on-off“ solenoid valves
- „Soft shift“- using spools and/or throttles
- Proportional Technology
- Field buses and related directional products
4WE6...Soft-Shift / Slow-Shift

4WE6...6X/EG...N9Z45/A12

Solenoid Operated with metering spools/ tubes

4WE6...6X/EG...N9DK35L/A12
“5th” Chamber Valves

“5th” chamber valve, with shift time control

Model 5-WX 10, 10,000...
Ideal pressure with symbols A, B and C)

This version is a directional valve with 2 switched positions and 2
wipers which means that 3 different working positions in the
preselected condition.

Model 5-WX 10, 31, 100...
Ideal pressure with symbols A, B and C)

This version is a directional valve with 3 different working positions
and 2 wipers. This implies that the unit will only be held in the last
switched position, permanent energization of the coil is not required.

RE 23 351/02.03

4/3-, 4/2- and 3/2-way directional valves
with switching time adjustment,
Type 5-WX 10
(5-chamber version)

Nominal size 10
Series 3X
Maximum operating pressure 315 bar
Maximum flow 120 L/min
“5” Chamber Operation

Cross sectional view of “5th” chamber valve, [with mechanical adjustment option]

Model S-4WE 10 E3X/CG24N9K4/C...

With the installation of orifices, spool switching time may be lengthened by more than 100 ms. The actual time is dependent upon individual system parameters (e.g. pressure, flow and viscosity).

When re-taping or modifying a throttling system, care must be taken that the fluid volume in the spring chambers and the connecting bore (5) is retained, as this is a prerequisite for the smooth operation of the switching time adjustment.
“Soft-Shift” Directional Valves

D03 and D05 type “soft-shift” direct operated directional valves, “metering spools” also possible

Soft switching
4/2 and 4/3 directional valves
with DC solenoids
Model WE...73 -.. /A12..

Nominal sizes 6 and 10
Series 6X (size 6)/3X (size 10)
Maximum operating pressure 5076/4569 PSI
(350/315 bar)
Maximum flow 15.85/26.42 GPM (60/100 L/min)

Orifice
Alternate spool lands

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Soft-Shift Characteristics

Impact of “soft-shift”

vs.

[Load Acceleration]

Impact of “metering spools”;
spool pressure drop vs. flow
### Directional: Family photo

#### Directional spool valves, direct operated

<table>
<thead>
<tr>
<th>Type</th>
<th>Solenoid actuation</th>
<th>Subplate mounting</th>
<th>Sandwich plate design</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS</td>
<td>WS</td>
<td>WS_TL_A12</td>
<td>WS_C</td>
</tr>
<tr>
<td>MS</td>
<td>MS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LWS</td>
<td>LWS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWS</td>
<td>NWS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Directional spool valves, pilot operated

<table>
<thead>
<tr>
<th>Fluid, mechanical, manual operation</th>
<th>Solenoid actuation</th>
<th>Subplate mounting</th>
<th>Sandwich plate design</th>
</tr>
</thead>
</table>

#### Directional seat valves, direct operated

<table>
<thead>
<tr>
<th>Fluid, mechanical, manual operation</th>
<th>Solenoid actuation</th>
<th>Subplate mounting</th>
<th>Sandwich plate design</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3W, M4W</td>
<td>M3W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M4W, M5W</td>
<td>M4W</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Agenda

- Shock vs speed of shift
- Basic „on-off“ solenoid valves
- „Soft shift“- using spools and/or throttles
- Proportional Technology
- Field buses and related directional products
PROPORTIONAL CONTROL: 4WREE6*.2X/
Proportional Valves Characteristics

4WRAB6E12-1X

Basic proportional technology
Spool Comparison: Conventional / Proportional

Spool position solenoid B
Center position
Symbol E
Spool overlap of conventional 3-position, closed-center directional valves

Spool position solenoid B
Center position
Symbol E
Spool overlap of proportional directional valve (closed-center position)
Within the technology of proportional hydraulic controls, proportional solenoids represent the link between electronics and hydraulics. Proportional solenoids are a form of DC linear solenoids. When a proportional solenoid receives a variable input signal, it produces force or travel as an output variable that is proportional to the electrical current received.

Only DC linear solenoids can be used for the current-proportional change in output variables force or stroke. AC solenoids cannot be used because of their in-rush/holding current characteristics which are stroke-dependent. Depending on the application, it is necessary to distinguish between two Types of DC solenoids. Force-controlled solenoids are solenoids with a clearly defined force/current relationship that operate over a very short stroke.

force-controlled proportional solenoid

Characteristic force-stroke curves

<table>
<thead>
<tr>
<th>Force F in lbf. (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>850 mA</td>
</tr>
<tr>
<td>600 mA</td>
</tr>
<tr>
<td>400 mA</td>
</tr>
<tr>
<td>250 mA</td>
</tr>
</tbody>
</table>

approx. 0.06 in. (1.5 mm)

Stroke s in in. (mm)
Proportional Amplifiers

Flow vs rated current curve for a nominal flow rate of 17 GPM (L/min) at valve pressure drop of 145 PSI (10 bar).

Transition function with stepped electrical input signal; signal change 25–75%

Transition function with stepped electrical input signal; signal change 0–100%
Force Controlled Proportional Valves

4WRA6/10...-2X/

4WRZE16...-7X/...
Stroke Controlled Proportional Valves

- 4WREE10-2X
- 4WRE6-2X
- 4WRE(E)6-2X
High Performance, Stroke Controlled Proportional Valves

- 4WRP(E)H6-2X
- 4WRP(E)H10-2X
Pilot Operated Proportional Valves
Force/Stroke Controlled

4WRZE10...-7X/

4WRLE-3X
Spool Operating Characteristics

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“Flapper-jet” servo pilot

4WRDE/ 4WRDU
Proportional: Family photo

### Proportional directional valves, direct operated

<table>
<thead>
<tr>
<th>Type</th>
<th>Component name</th>
<th>Series</th>
<th>Series 5</th>
<th>Series 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-way</td>
<td>4-way valve</td>
<td>4-way</td>
<td>4-way</td>
<td>4-way</td>
</tr>
</tbody>
</table>

### Proportional directional valves, pilot operated

<table>
<thead>
<tr>
<th>Type</th>
<th>Component name</th>
<th>Series 5</th>
<th>Series 6</th>
<th>Series 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-way</td>
<td>3-way valve</td>
<td>3-way</td>
<td>3-way</td>
<td>3-way</td>
</tr>
</tbody>
</table>

### Proportional throttle valves, pilot operated

<table>
<thead>
<tr>
<th>Type</th>
<th>Component name</th>
<th>Series 5</th>
<th>Series 6</th>
<th>Series 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-way</td>
<td>2-way valve</td>
<td>2-way</td>
<td>2-way</td>
<td>2-way</td>
</tr>
</tbody>
</table>

### High-response directional valves, pilot operated

<table>
<thead>
<tr>
<th>Type</th>
<th>Component name</th>
<th>Series 5</th>
<th>Series 6</th>
<th>Series 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-way</td>
<td>4-way valve</td>
<td>4-way</td>
<td>4-way</td>
<td>4-way</td>
</tr>
</tbody>
</table>

### Servo directional valves

<table>
<thead>
<tr>
<th>Type</th>
<th>Component name</th>
<th>Series 5</th>
<th>Series 6</th>
<th>Series 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-way</td>
<td>2-way valve</td>
<td>2-way</td>
<td>2-way</td>
<td>2-way</td>
</tr>
</tbody>
</table>
# Proportional Matrix

<table>
<thead>
<tr>
<th>Valve Model</th>
<th>Nominal Flow (Lpm)</th>
<th>Nom Ap (bar)</th>
<th>Data Sheet</th>
<th>With Jump Comp (OBE + E, W)</th>
<th>Valve Dynamic</th>
<th>Typical Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>4WRA(E)</td>
<td>Size-6: 7, 15, 30</td>
<td>10</td>
<td>RE 29055</td>
<td>Yes</td>
<td>Low</td>
<td><img src="green" alt="Open Loop" /> <img src="red" alt="Position Low Precision" /> <img src="red" alt="Position High Precision" /> <img src="red" alt="Force Closed Loop" /></td>
</tr>
<tr>
<td></td>
<td>Size-10: 30, 60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4WRP(E)</td>
<td>Size-6: 8, 18, 32</td>
<td>10</td>
<td>RE 29022</td>
<td>Yes</td>
<td>Medium</td>
<td><img src="green" alt="Open Loop" /> <img src="green" alt="Position Low Precision" /> <img src="red" alt="Position High Precision" /> <img src="red" alt="Force Closed Loop" /></td>
</tr>
<tr>
<td></td>
<td>Size-10: 50, 80</td>
<td></td>
<td>RE 29025</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4WRE(E)</td>
<td>Size-6: 4, 8, 16, 32</td>
<td>10</td>
<td>RE 29061</td>
<td>No</td>
<td>Medium 40 Hz</td>
<td><img src="green" alt="Open Loop" /> <img src="green" alt="Position Low Precision" /> <img src="green" alt="Position High Precision" /> <img src="green" alt="Force Closed Loop" /></td>
</tr>
<tr>
<td></td>
<td>Size-10: 25, 50, 75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4WRSE</td>
<td>Size-6: 4, 10, 20, 35</td>
<td>10</td>
<td>RE 29067</td>
<td>No</td>
<td>High 70-100 Hz</td>
<td><img src="red" alt="Open Loop" /> <img src="red" alt="Position Low Precision" /> <img src="green" alt="Position High Precision" /> <img src="green" alt="Force Closed Loop" /></td>
</tr>
<tr>
<td></td>
<td>Size-10: 25, 50, 75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4WRP(E)H</td>
<td>Size-6: 2, 4, 12, 24, 40</td>
<td>70</td>
<td>RE 29035</td>
<td>No</td>
<td>High 60-125 Hz</td>
<td><img src="red" alt="Open Loop" /> <img src="red" alt="Position Low Precision" /> <img src="red" alt="Position High Precision" /> <img src="red" alt="Force Closed Loop" /></td>
</tr>
<tr>
<td></td>
<td>Size-10: 50, 100</td>
<td></td>
<td>RE 29037</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4WRREH</td>
<td>Size-6: 4, 8, 12, 24, 40</td>
<td>70</td>
<td>RE 29041</td>
<td>No</td>
<td>Very High 200 Hz</td>
<td><img src="red" alt="Open Loop" /> <img src="red" alt="Position Low Precision" /> <img src="red" alt="Position High Precision" /> <img src="red" alt="Force Closed Loop" /></td>
</tr>
<tr>
<td>4WS(E)2E</td>
<td>Size-6: 2, 5, 10, 15, 20</td>
<td>70</td>
<td>RE 29564</td>
<td>No</td>
<td>Very High 100-250 Hz</td>
<td><img src="red" alt="Open Loop" /> <img src="red" alt="Position Low Precision" /> <img src="red" alt="Position High Precision" /> <img src="red" alt="Force Closed Loop" /></td>
</tr>
<tr>
<td></td>
<td>Size-10: 10, 20, 30, 45, 60, 75, 90</td>
<td></td>
<td>RE 29583</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Prop & Control Matrix

Electrohydraulic Position Control

Start

No

Accuracy < 0.1% of Stroke? Yes

1 Axis? No

No

No

No

Yes

Programmed Motion? No

No

No

Yes

Yes

Yes

Yes

Yes

Yes

Yes

Yes

No

VT-MACAS? No

VT-HACD-1? No

VT-HNC100-1? No

VT-HNC100-2? No

Consult Bosch Rexroth

Control: VT-MACAS
- RE 30050
- Analog Position Control Module (AVPC)

Control: VT-HACD-1
- RE 30143
- Digital Axis Control Card

Control: VT-HNC100-1
- RE 30131
- 1 Drive NC Programmable

Control: VT-HNC100-2
- RE 30131
- 2 Drives NC Programmable

Control: VT-MACAS
- RE 30156
- Up to 32 Drives

* Guideline only. Not a guarantee of performance
“Axis controllers”

- STW-0196
- WREQ6-1X
- 4WRPNH6-1X

- Integral Controller & Pressure Transducer
- NC Programmable
- \( \Delta pQ \): Closed Loop Pressure or Force, with Electronic Flow Control

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NC Control in IAC-R

G01  G01  G04  G01

PLC  CANopen  PROFIBUS  24 V  4WRPNH

;NC-Programm
;24.05.2001
G01  X400  F10000  5000
G01  X450  F5000
G04   F2.5
G01  X100  F10000
M30
Programmed Motion

- VT-HNC100-1
  User can access and modify the NC Program

- Optional Bus interfaces

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Shock vs speed of shift

Basic „on-off“ solenoid valves

„Soft shift“- using spools and/or throttles

Proportional Technology

Field buses and related directional products
Conventional Wiring Using Standard Components
Connection of Intelligent Actuators/Sensors
Directional Valve with Integrated Bus Interface
Standard Products (New Developments)

„M12 connectivity“

DESINA® requests

automation customers

plug and play functionality, internal protection circuitry

„added value“ (indicator light and protection circuitry)
Standard Products (Bus Systems)

integrated solution
“Bus” Option

PLC, Device Net, converter, and standard solenoid valves