

Electric Drives
and Controls

Hydraulics

Linear Motion and
Assembly Technologies

Pneumatics

Service

Rexroth
Bosch Group

p/Q closed-loop control amplifier

RE 30058/06.12
Replaces: 03.04

1/14

Type VT-VARAP1-...-2X/...

Component series 2X

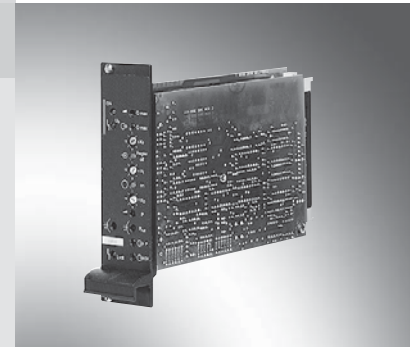


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Features

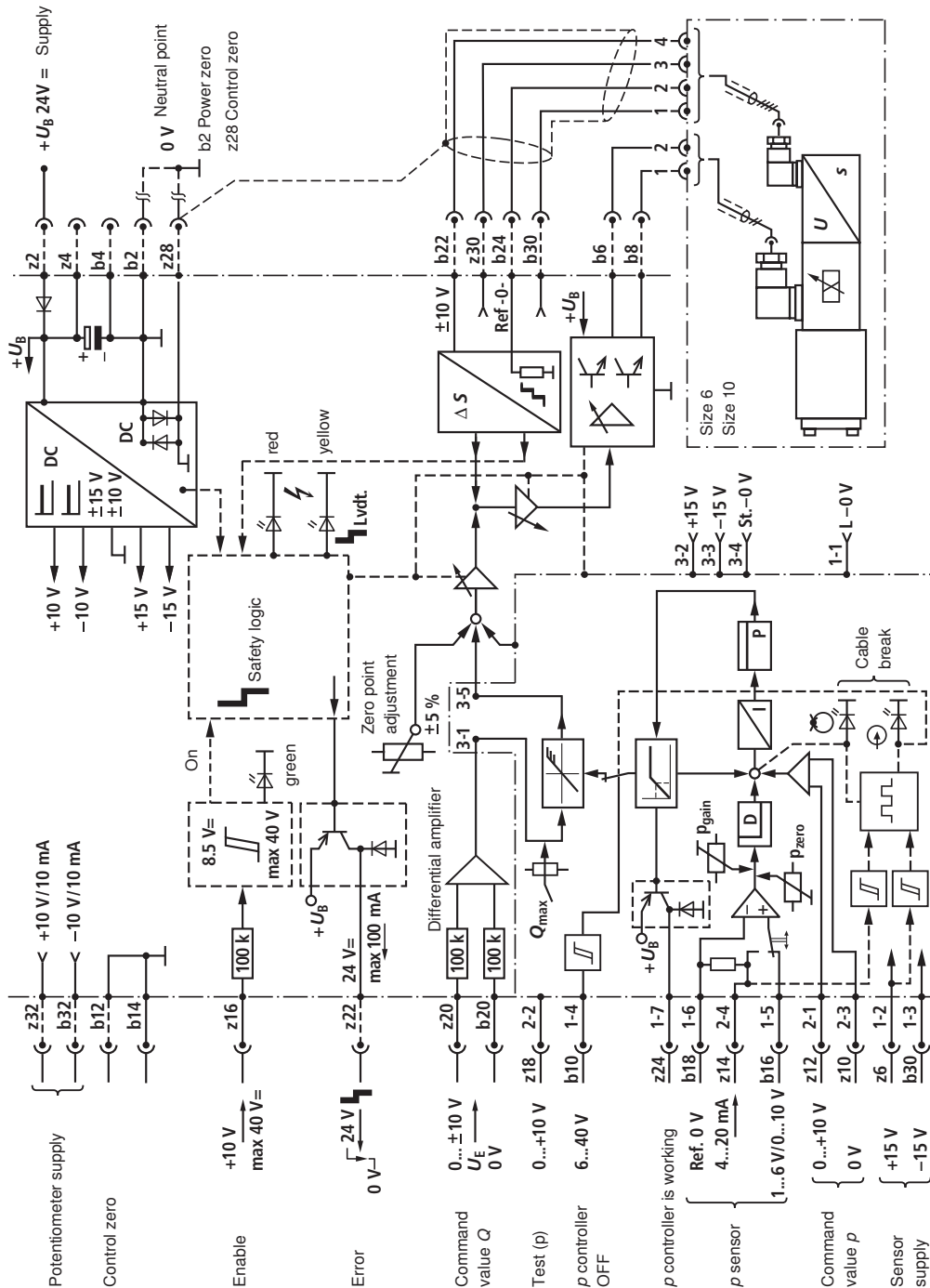
Page	– Suitable for controlling direct and pilot operated control valves
1	– Amplifier with additional electronics (daughter card)
2	– Analog amplifiers in Europe format for installation in 19" racks
2	– Valve position control with PID behavior
3, 4	– Pressure control with external pressure load cell
5, 6	– Controlled output stage
6	– Enable input
7	– Outputs short-circuit-proof
8	– Adjustment possibilities – Zero point valve
9	– Cable break detection for actual value cable and pressure sensor
10	
11	– Fast energization and fast deletion for short actuating times
12	– External controller shut-off
13	– Suitable for pressure sensors (1...6 V, 0...10 V, 4...20 mA), see data sheet 30271
14	
14	

Notice:

The photo is an example configuration.
The delivered product differs from the figure.

Block diagram with pin assignment

0811405152, 0811405153, 0811405154



Technical data (For applications outside these parameters, please consult us!)

Supply voltage U_B at z2 – b2	Nominal 24 V = Battery voltage 21...40 V, Rectified alternating voltage $U_{\text{eff}} = 21...28$ V (one-phase, full-wave rectifier)	
Smoothing capacitor, separately at z2 – b2	Recommendation: Capacitor module VT 11110 (see data sheet 30750) (only necessary if the ripple of $U_B > 10$ %)	
Valve solenoid, max.	A/VA	2.7/40 (size 6) 3.7/60 (size 10)
Current consumption, max.	A	1.7 2.7
	The current consumption may increase with min. U_B and extreme cable length to the control solenoid	
Power consumption (typical)	W	37 55
Input signal (command value)	b20: 0...±10 V } Differential amplifier z20: 0...±10 V } ($R_i = 100$ kΩ)	
Input signal (command value p)	z12: 0...10 V } Differential amplifier z10: 0 V }	
Actual value from the pressure sensor	z14: 4...20 mA – Current input b16: 0...+10 V/1...+6 V – Voltage input b18: 0 V – Reference	
Pressure controller OFF	b10: 6...40 V =	
External enquiry pressure controller active	z24: 24 V/0.1 A max.	
Limit frequency	For applications ≤ 30 Hz	
Signal source	Potentiometer 10 kΩ Supply with ±10 V from b32, z32 (10 mA) or external signal source	
Enable output stage	At z16, $U = 8.5...40$ V, $R_i = 100$ kΩ, LED (green) on front plate lights up	
Sensor supply	z6: +15 V/35 mA, $R_i \sim 25$ Ω	
Position transducer	Supply	b30: –15 V (25 mA) z30: +15 V (35 mA)
Pilot control valve	Actual value signal	b22: 0...±10 V, $R_i = 10$ kΩ/Ref. b24
Main stage	Actual value reference	b26: 0...±10 V, $R_i = 10$ kΩ/Ref. b28
Solenoid output b6 – b8	I_{max}	Clocked current controller 2.7 A 3.7 A
Cable lengths between amplifier and valve	Solenoid cable: up to 20 m 1.5 mm ² 20 to 60 m 2.5 mm ² Position transducer: 4 x 0.5 mm ² (shielded) Pressure sensor: 4 x 0.5 mm ² (shielded)	
Special features	Cable break protection for actual value cable, Position control with PID behavior, Pulsed output stage, Fast energization and fast deletion for short actuating times, Short-circuit-proof outputs, Controller shut-off	
Adjustment	Zero point via trimming potentiometer ±5% Command value attenuator Q Pressure controller K_p , K_i and K_D Sensitivity pressure load cell Zero point pressure load cell	
LED displays	green: Enable yellow: Cable break position transducer red: Supply voltage (U_B too low) yellow: Pressure controller OFF yellow: Pressure controller is working both yellow LEDs are flashing: Cable break pressure sensor	

Technical data (For applications outside these parameters, please consult us!)

Error message		
- Cable break actual value		
- U_B too low		z22: Open collector output to $+U_B$
- ± 15 V stabilization		Max. 100 mA; no error: $+U_B$
Circuit board format	mm	(100 x 160 x approx. 35) / (W x L x H) Europe format with front panel 7 TE
Plug-in connection		Connector DIN 41612 – F32
Ambient temperature	°C	0...+70
Storage temperature range	°C	-20...+70
Weight	m	0.49 kg

Notice:

Power zero b2 and control zero b12 or b14 or z28 must be separately led to the central ground (neutral point).

Additional information

Applications

The p/Q closed-loop control amplifiers consist of a basic card with front plate containing the valve amplifier with position control as well as an attached daughter card on which the actual pressure control has been realized.

These amplifiers are only supplied as complete combinations. In connection with the corresponding high-response valves (see table page 2) and pressure sensors (sensor signal 1...6 V, 0...10 V or 4...20 mA), flows can be controlled and pressures in closed control loops can be regulated.

The input variables are the pressure p and flow Q command values. Pressure and valve spool path are fed back as actual values.

The combination of valve amplifier and p/Q controller takes effect:

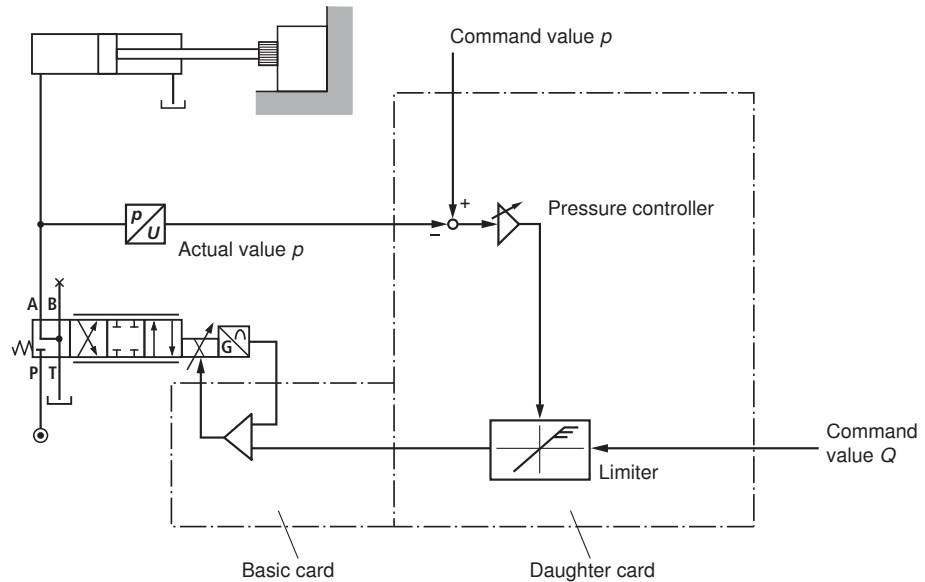
- As long as $p_{\text{command}} < p_{\text{actual}}$ as flow control, i.e. the pressure control does not take effect, yet.
- With $p_{\text{command}} \cong p_{\text{actual}}$ as pressure control, i.e. the flow is reduced until $p_{\text{actual}} = p_{\text{command}}$. The pressure control works only with a positive command value voltage at z20.

The command value Q corresponds to the spool path as long as the pressure control does not take effect, yet, i.e. $p_{\text{command}} > p_{\text{actual}}$ or if the pressure controller is switched off (DIL 4 OFF). The command value Q may range between $U_E = 0... \pm 10$ V. For the dynamic pressure control there should, however, in addition to the command value p also be a command value Q , $U_E \cong 2... +10$ V.

Examples

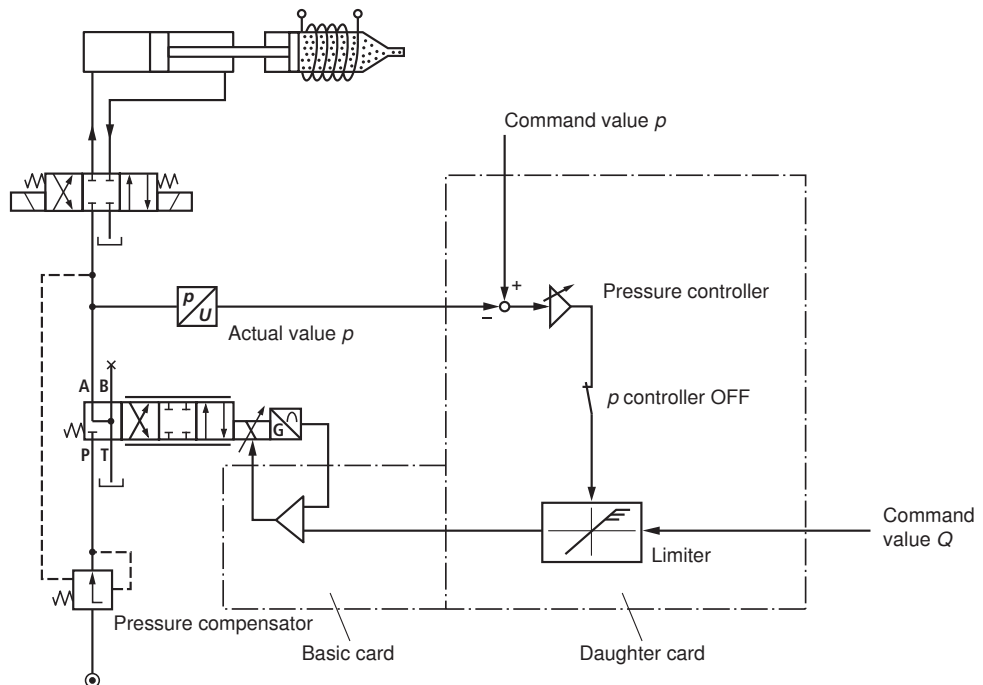
Example 1

Pressure control in a cylinder chamber for achieving a constant clamping force.



Example 2

Flow with load compensation controlled via pressure compensator and the pressure regulated in the closed control loop (pressure cut off).



Function

The combination of basic card and daughter card is shown in the block diagrams on page 3 and 4. Details of the daughter card, i.e. the pressure control, result from a detailed block diagram on page 9.

The command value p (z12) is specified by the user by a voltage $0...+10$ V, e.g. by means of a potentiometer which can be supplied from z32/b12 (z10 to 0 V).

The actual value p is supplied by a pressure sensor. Optionally, sensors with current signal interface $4...20$ mA or voltage signal interface $1...6$ V and/or $0...10$ V can be used. Zero point and sensitivity of the sensor can be set at the front plate. Cable break of the pressure sensor is signaled (LEDs flash) if the sensor is supplied at z6.

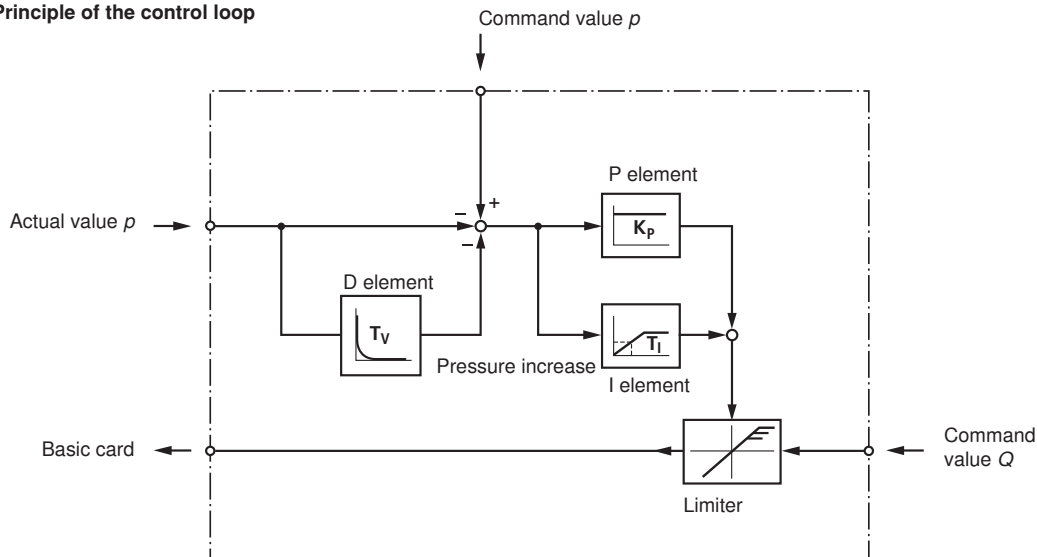
Command and actual value are compared in the summing point which is moreover affected by a differentiated actual value.

The control deviation is amplified by a PID controller and reaches a limiter superimposing the command value Q with the pressure controller signal if $p_{\text{command}} \leq p_{\text{actual}}$.

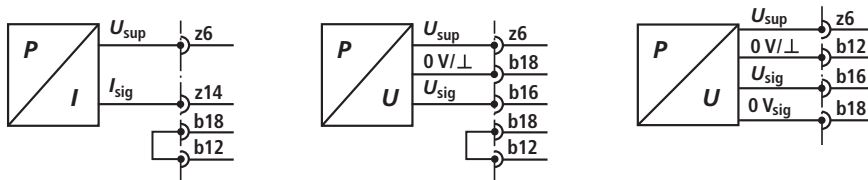
As long as $p_{\text{command}} > p_{\text{actual}}$ or if the command value Q ranges between $0...-10$ V, the limiter and thus the pressure control do not take effect and there is simple flow control.

The characteristic of the PID controller and the D element can be roughly set by means of the DIL switch on the daughter card and finely by means of the HEXCODE switch on the front plate. If the pressure is regulated, this condition is displayed on the front plate (LED) and can be used for switching purposes via an acknowledgement output (z24). However, the pressure control can also be switched off so that there is only flow control, independent of p_{actual} .

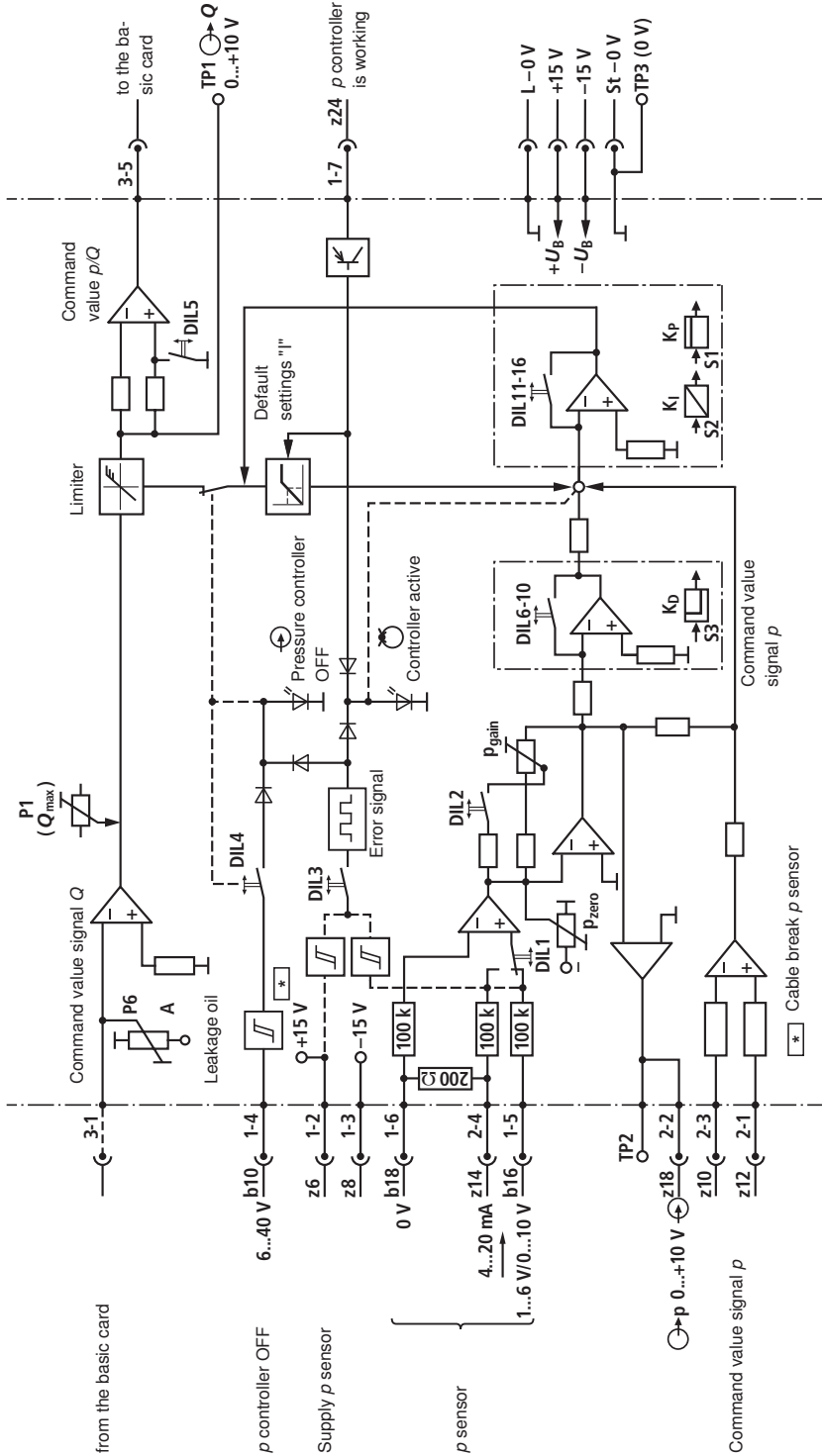
Principle of the control loop



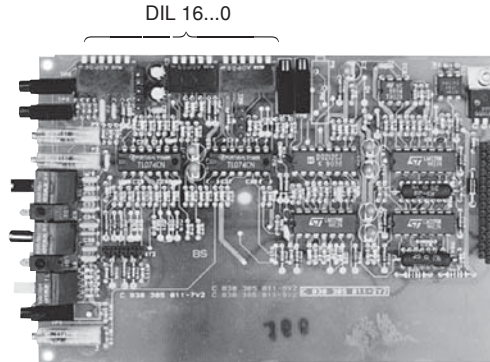
Pressure sensor connection versions



Block diagram daughter card



Mode setting (DIL switch, daughter card)



DIL no.	Status	Function
0	–	without function
1	ON	Pressure sensor signal
	OFF	1...6 V/0...10 V 4...20 mA
2	ON	Pressure sensor amplification
	OFF	$p_{SYS}^{2)} \Delta \sim p_{NOM}^{3)}$ $p_{SYS} \Delta \sim 0.5 p_{NOM}$
3	ON	Cable break monitoring
	OFF	On Off
4	ON	Pressure controller
	OFF	On Off
5	ON	Valve output signal
	OFF	not inverted inverted
6	ON	Pressure build-up
	OFF	
7	ON	D Pressure reduction
	OFF	
8	ON	Share high (9, 10 = OFF)
9	ON	Share medium (8, 10 = OFF)
10	ON	Share low (8, 9 = OFF)
11	ON	I Share = 0 (12 = OFF) Share available (11 = OFF)
12	ON	
13	ON	P Reduced pressure reduction
	OFF	
14	ON	Share low (16 = ON/15 = OFF)
15	ON	Share medium (14, 16 = OFF)
16	ON	Share high (14, 15 = OFF)

¹⁾ With DIL 6 and 7 = OFF, DIL 8...10 is ineffective

²⁾ p_{SYS} = System pressure

³⁾ p_{NOM} = Nominal sensor pressure

General notes:

Setting during the commissioning is effected using potentiometers and HEXCODE switches on the front plate as well as using DIL switches on the daughter card bottom side. Test points for voltage measurements as well as LED displays are located on the front plate. The measured values generally refer to the test point 0 V. The test points may only be loaded with measuring instruments $R_L \geq 10 \text{ k}\Omega$. Overload impairs the control function and/or the printed circuit board is damaged.

Before the commissioning, the basic settings of the as-delivered state are to be checked.

In the card comparison, proceed in the order of the points shown:

A: Adjustment of the valve zero point (basic card front plate)

- 1) DIL 4 OFF (pressure controller OFF)
- 2) Applying the voltage and pressure supply
- 3) Command value specification $Q = 0 \text{ V}$
- 4) Use the "Zero" potentiometer to bring the cylinder to a standstill

B: Pressure sensor comparison

- 1) Sensor type selection
DIL 1 ON $\triangleq U_A = 1...6 \text{ V}/0...10 \text{ V}$
OFF $\triangleq U_A = 4...20 \text{ mA}$
- 2) Sensor amplification selection
DIL 2 ON if $p_{\text{SYS}} \sim p_{\text{NOM}}$
OFF if $0.5 \cdot p_{\text{NOM}} \leq p_{\text{SYS}} \leq p_{\text{NOM}}$
- 3) Hydraulic supply OFF
- 4) Zero point calibration with potentiometer "P_{Zero}" (at TP "0" = 0 V)
- 5) Hydraulic supply ON – max. system pressure
- 6) Sensitivity adjustment with potentiometer "P" (at TP "P" = 10 V)

C: Comparison – command value Q

- 1) Specification $Q_{\text{command}} = 10 \text{ V}$
- 2) Limitation of the max. valve opening (50...100% opening) by potentiometer "Q_{max}".
Control of the voltage value at TP "Q_{max}":
10 V \triangleq 100% Valve opening (with $Q_{\text{command}} = 10 \text{ V}$)
5 V \triangleq 50% Valve opening (with $Q_{\text{command}} = 10 \text{ V}$)

D: Controller adjustment

The P, I and D shares of the closed-loop control amplifier are to be optimized according to the properties of the control distance, the disturbance variables and the static and dynamic requirements on the control result.

- 1) Pressure controller ON – DIL 4 ON
- 2) Connection of an oscilloscope at terminals z18 and b12 (0 V) $\rightarrow p_{\text{actual}}$
- 3) Usefully connection of a 2nd oscilloscope channel at z2 and z10 (0 V) $\rightarrow p_{\text{command}}$
- 4) DIL 6 and DIL 7 serve to compensate dynamic differences in the pressure build-up and reduction in the system
DIL 6 ON = Normal application
OFF = Special application
DIL 7 ON = Normal application
OFF = Special application
- 5) DIL 13 – reduces the pressure reduction by means of a valve opening < approx. 15%
ON = Special application
OFF = Normal application

6) Aim of the controller optimization

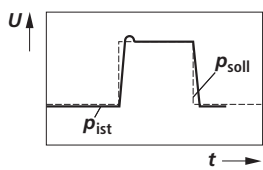
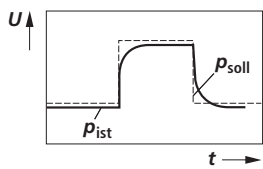
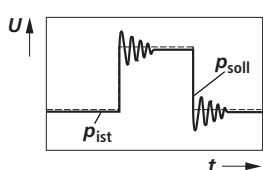
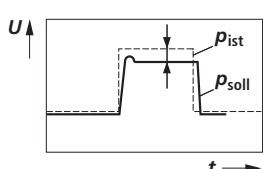
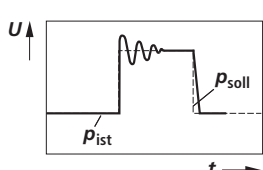
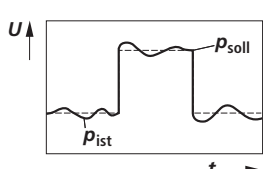
An optimum between change over characteristic (overshooting tendency with excessive static amplification) and static accuracy (control error with starting pressure cut off) is to be achieved (a).

Procedure (see table, page 12)

An increase in the P share of the controller increases the dynamic of the control behavior (b). In case of excessive gain, the tendency to oscillate increases (c). Limitation of the I share reduces the static gain. With increasing static gain, the control deviation is reduced (d).

The D share can be used to influence the transition behavior (minimization of the tendency to oscillate); thus, the command value is only reached after a longer transition time (f).

Ideal development

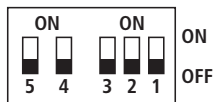
<p>a</p> 							
<p>b</p> 	<p>Problem: P share too small</p> <p>Solution:</p> <ul style="list-style-type: none"> → Rotate K_P against 13 (fine adjustment) → P gain > <table border="1" data-bbox="861 784 1013 862"> <tbody> <tr> <td>DIL 14</td> <td>ON</td> </tr> <tr> <td>DIL 15</td> <td>OFF</td> </tr> <tr> <td>DIL 16</td> <td>ON</td> </tr> </tbody> </table>	DIL 14	ON	DIL 15	OFF	DIL 16	ON
DIL 14	ON						
DIL 15	OFF						
DIL 16	ON						
<p>c</p> 	<p>Problem: P share too large</p> <p>Solution:</p> <ul style="list-style-type: none"> → Rotate K_P against 0 (fine adjustment) → use DIL 14 –16 to reduce the P gain according to the table 						
<p>d</p> 	<p>Problem: P share correct, control deviation too large</p> <p>Solution:</p> <ul style="list-style-type: none"> → Increase the I gain share → DIL 11 ON = I share = 0 → DIL 12 ON = I share connected → Rotate K_I against 13 						
<p>e</p> 	<p>Problem: Time constant of the I share too low</p> <p>Solution:</p> <ul style="list-style-type: none"> → Rotate K_I against 13 until control deviation and vibration are perfect → If $K_I = 13$ is not sufficient, the P share must also be reduced 						
<p>f</p> 	<p>Problem: D share too low</p> <p>Solution:</p> <ul style="list-style-type: none"> → Rotate K_D against 13 → D share > <table border="1" data-bbox="861 1724 1013 1803"> <tbody> <tr> <td>DIL 8</td> <td>ON</td> </tr> <tr> <td>DIL 9</td> <td>OFF</td> </tr> <tr> <td>DIL 10</td> <td>OFF</td> </tr> </tbody> </table>	DIL 8	ON	DIL 9	OFF	DIL 10	OFF
DIL 8	ON						
DIL 9	OFF						
DIL 10	OFF						

Adjustment protocol

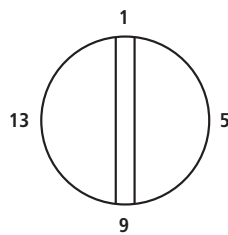
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DIL switch

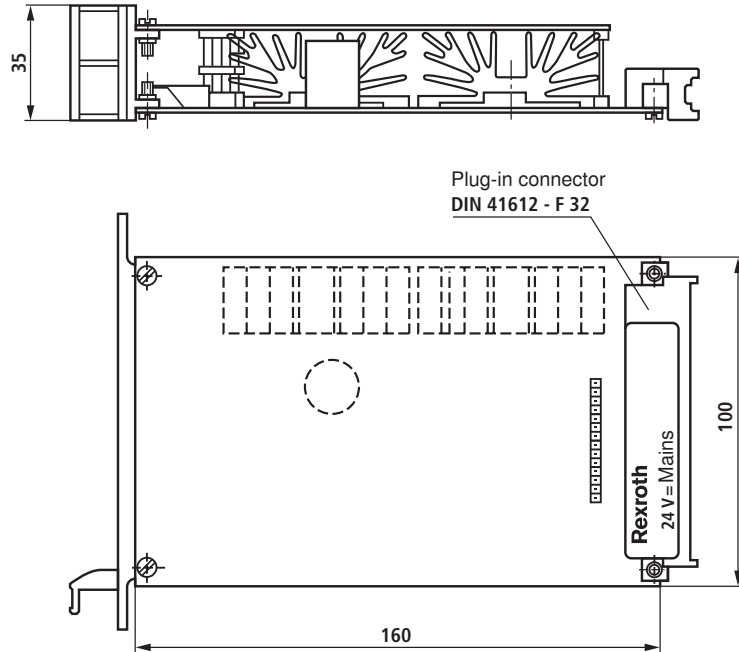


HEXCODE switch



Switches	As-delivered state		
DIL 1	OFF		
DIL 2	ON		
DIL 3	ON		
DIL 4	ON		
DIL 5	OFF		
DIL 6	OFF		
DIL 7	OFF		
DIL 8	OFF		
DIL 9	OFF		
DIL 10	OFF		
DIL 11	OFF		
DIL 12	OFF		
DIL 13	OFF		
DIL 14	OFF		
DIL 15	ON		
DIL 16	OFF		
HEX K _p	3		
HEX K _i	9		
HEX K _D	5		

Unit dimensions (dimensions in mm)



Project planning / maintenance instructions / additional information

- The amplifier card may only be unplugged and plugged when de-energized.
- The distance to aerial lines, radios and radar systems must be sufficient (> 1 m).
- Do not lay solenoid and signal lines near power cables.
- For signal lines and solenoid conductors, we recommend using shielded cables.
The cable shield must be connected to the control cabinet extensively and as short as possible.
- The valve solenoid must not be connected to free-wheeling diodes or other protective circuits.
- The cable lengths and cross-sections specified on page 5 must be complied with.

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