Rexroth
Bosch Group

p/Q closed-loop control amplifier

RE 30058/06.12
Replaces: 03.04

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

Component series 2X

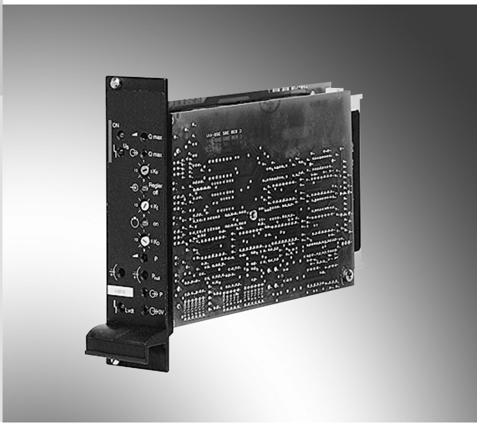


Table of contents

Contents	**Page**

Features

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

Notice:

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

Ordering code, accessories

VT-	V	A	R	A	P	1 –	–	2X /	V0 /	

Hydraulic component (control)
Axis control **= A**

Valve type
High-response valve **= R**

Control
Analog **= A**

Function
p/Q control **= P**

Output stages
1 output stage **= 1**

Serial number for types
527 = 2.7 A solenoid
537 = 3.7 A solenoid

2X = Component series 20 to 29 (20 to 29: Unchanged technical data and pin assignment)

Customer version
V0 = Catalog version

Option
no code = High-response valve size 6/10 direct operated
5/3V = *p/Q* valve size 10 direct operated
2STV = High-response valve pilot operated
3/2V = High-response valve pilot operated Control line A → X

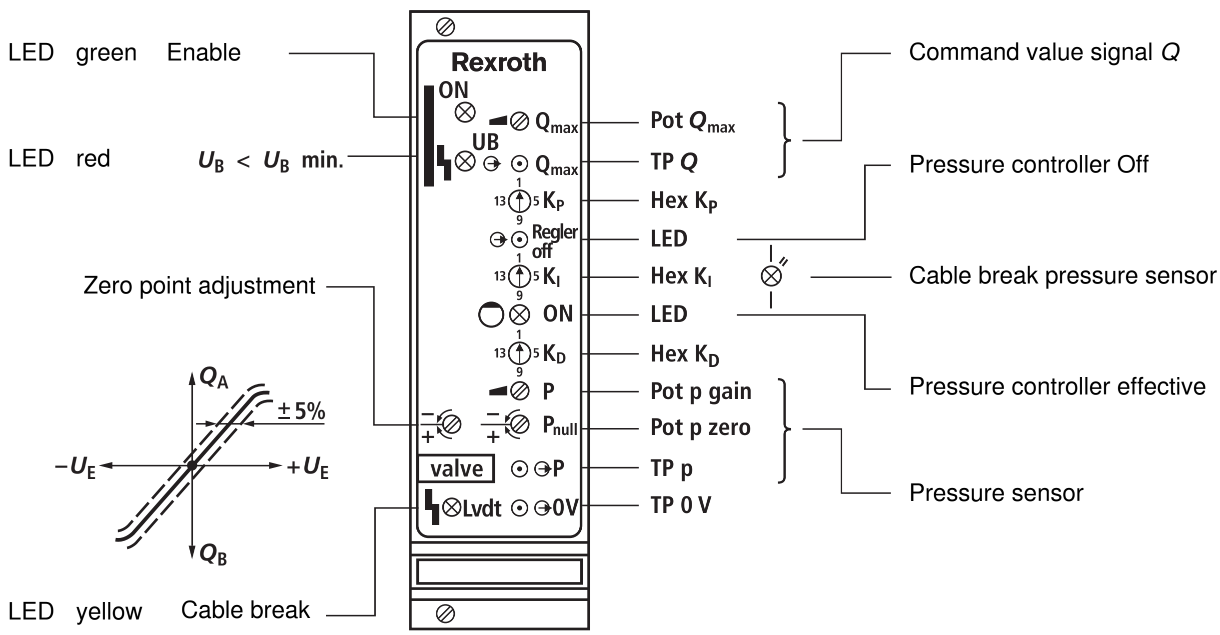
Preferred types

Amplifier type	Material number	For high-response valves with electrical position feedback
VT-VARAP1-527-20/V0	0811405152	4WRPH6...
VT-VARAP1-537-20/V0	0811405153	4WRPH10...
VT-VARAP1-537-20/V0/5/3V	0811405154	5WRP10...
VT-VARAP1-527-20/V0/2STV	0811405155	4WRL...
VT-VARAP1-527-20/V0/3/2VAX	0811405156	3WRCBH25...50...

Suitable card holder:

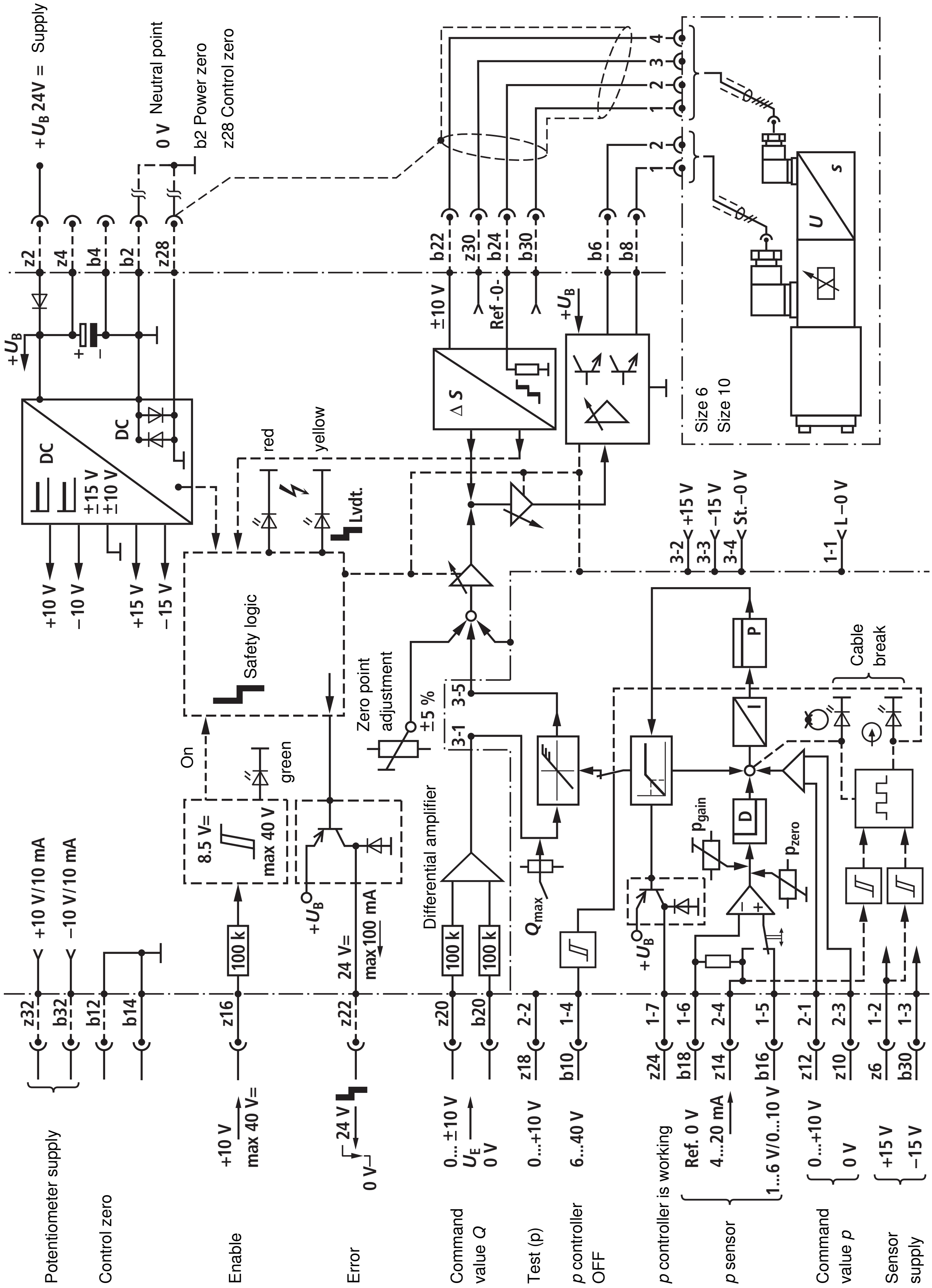
– Open card holder VT 3002-1-2X/32F
(see data sheet 29928).
Only for control cabinet installation!

Front plate



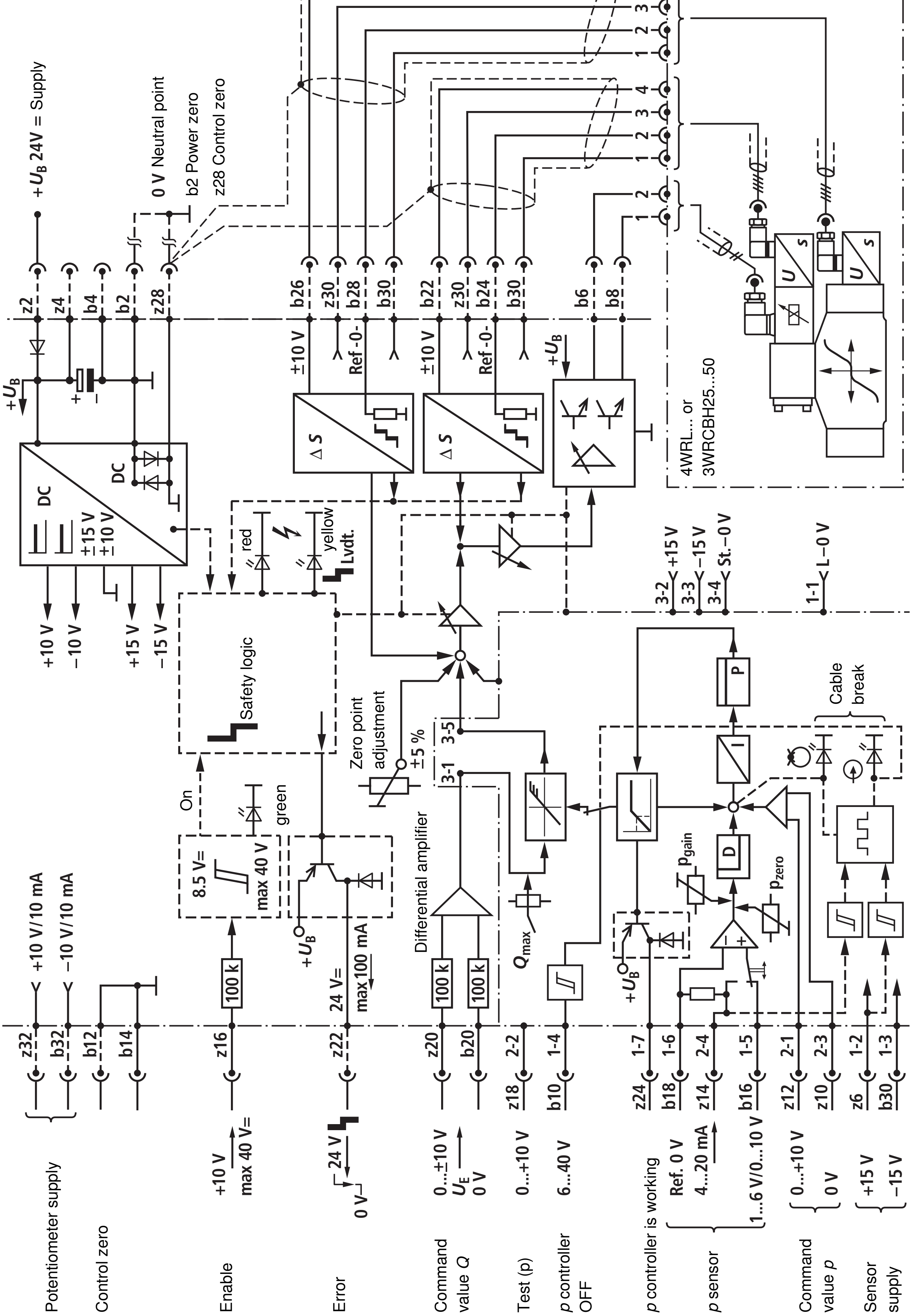
Block diagram with pin assignment

0811405152, 0811405153, 0811405154



Block diagram with pin assignment

0811405155,
0811405156



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_{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 ~ 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_L = 10 kΩ/Ref. b24	
Main stage	Actual value reference	b26: 0...±10 V, R_L = 10 kΩ/Ref. b28	
Solenoid output		Clocked current controller	
b6 – b8	I_{max}	2.7 A	3.7 A
Cable lengths between amplifier and valve		Solenoid cable: up to 20 m 1.5 mm² 20 to 60 m 2.5 mm² Position transducer: 4 x 0.5 mm² (shielded) Pressure sensor: 4 x 0.5 mm² (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 – ±15 V stabilization		z22: Open collector output to $+U_B$ 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.

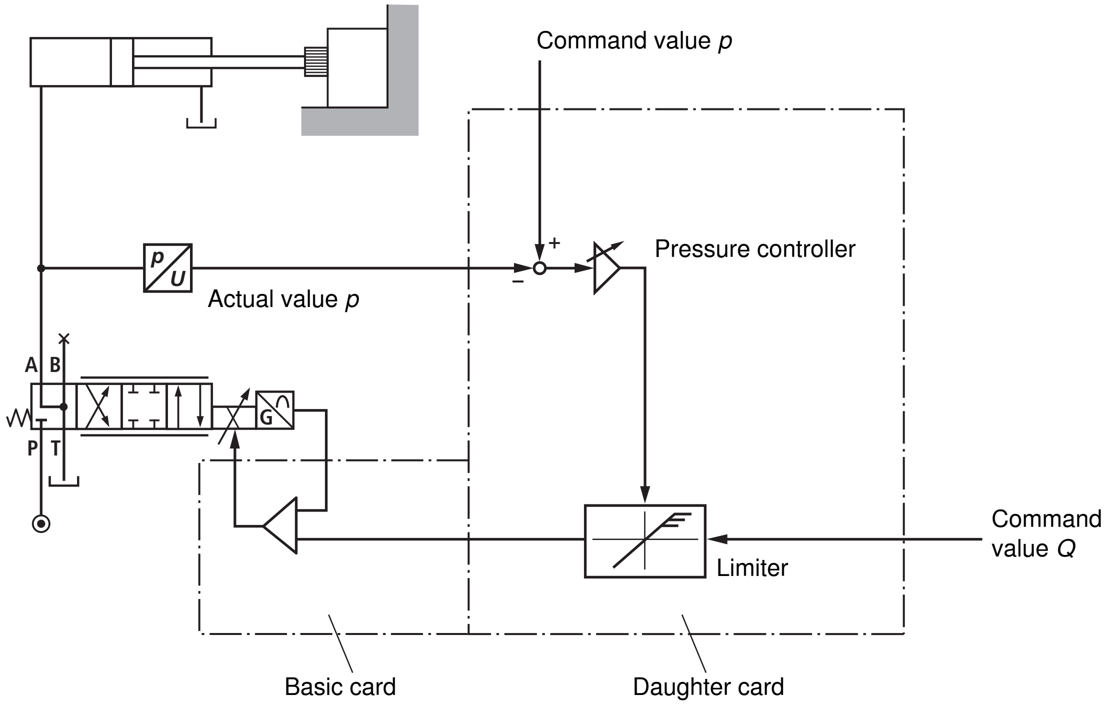
The combination of valve amplifier and *p/Q* controller takes effect:
a) As long as $p_{command} < p_{actual}$ as flow control, i.e. the pressure control does not take effect, yet.
b) With $p_{command} \geqq p_{actual}$ as pressure control, i.e. the flow is reduced until $p_{actual} = p_{command}$. The 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. $p_{command} > p_{actual}$ or if the pressure controller is switched off (DIL 4 OFF). The command value *Q* may range between U_E = 0...±10 V. For the dynamic pressure control there should, however, in addition to the command value *p* also be a command value Q_1 $U_E \geqq$ 2...+10 V.

Examples

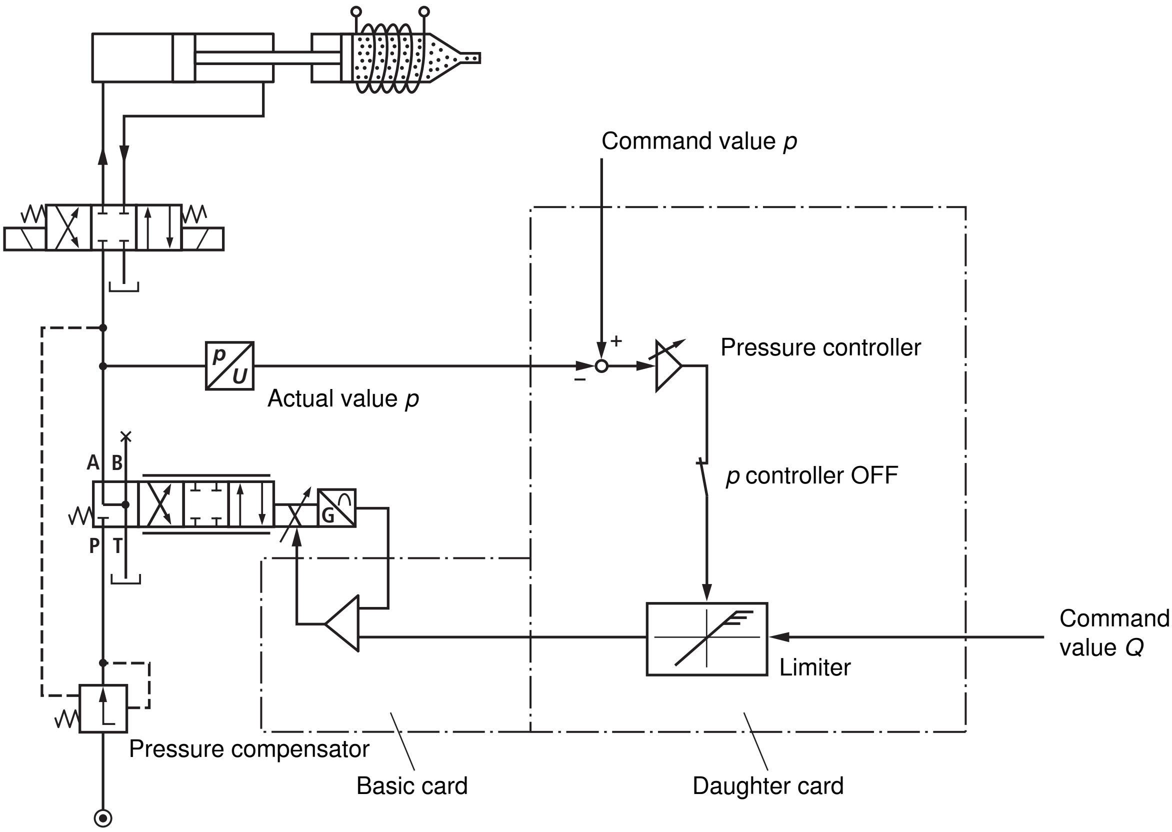
Example 1

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).

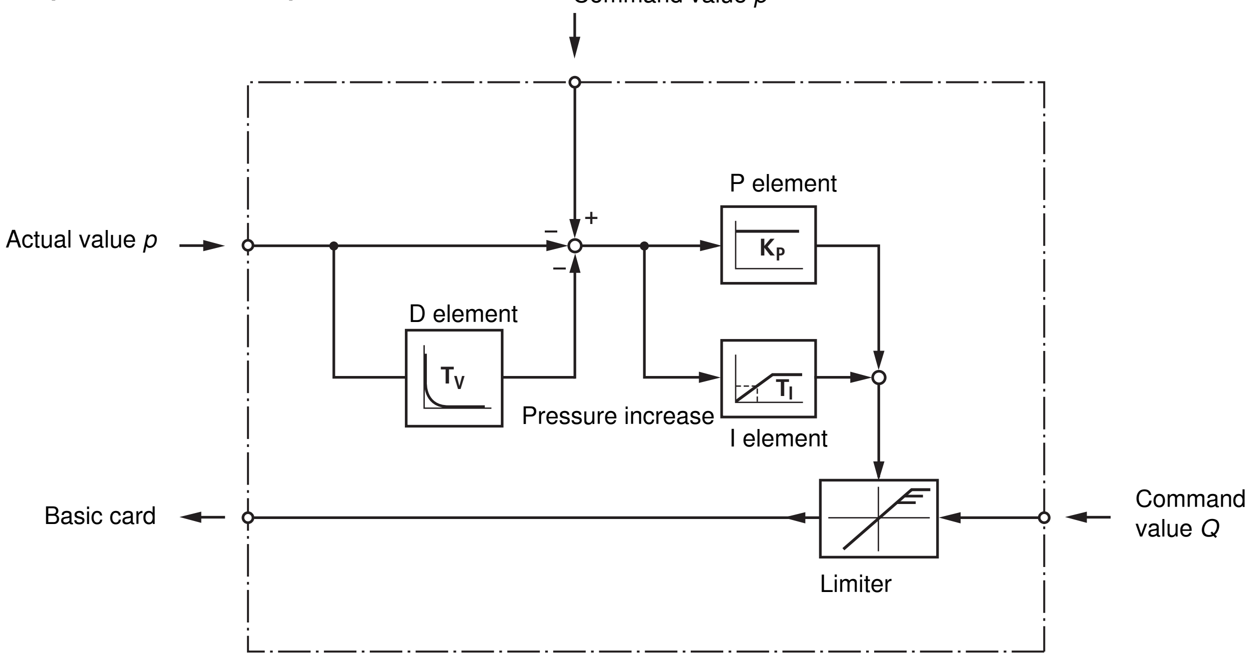


Function

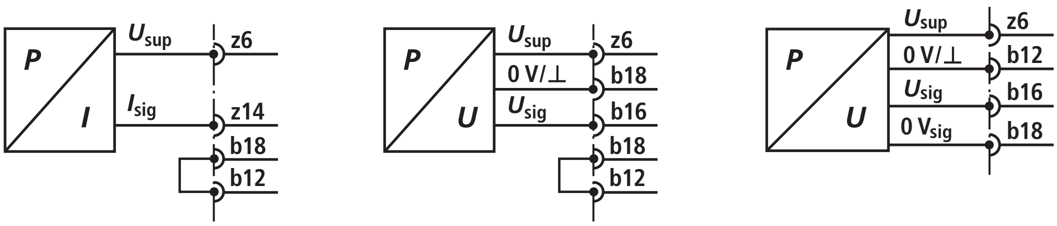
The combination of basic card and daughter card is shown in the block diagrams on page 3 and 4. Details of the daughter card, i.e. the pressure control, result from a detailed block diagram on page 9.
The command value *p* (z12) is specified by the user by a voltage 0...+10 V, e.g. by means of a potentiometer 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 signalized (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 $p_{command} \leqq p_{actual}$.
As long as $p_{command} > p_{actual}$ 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}.

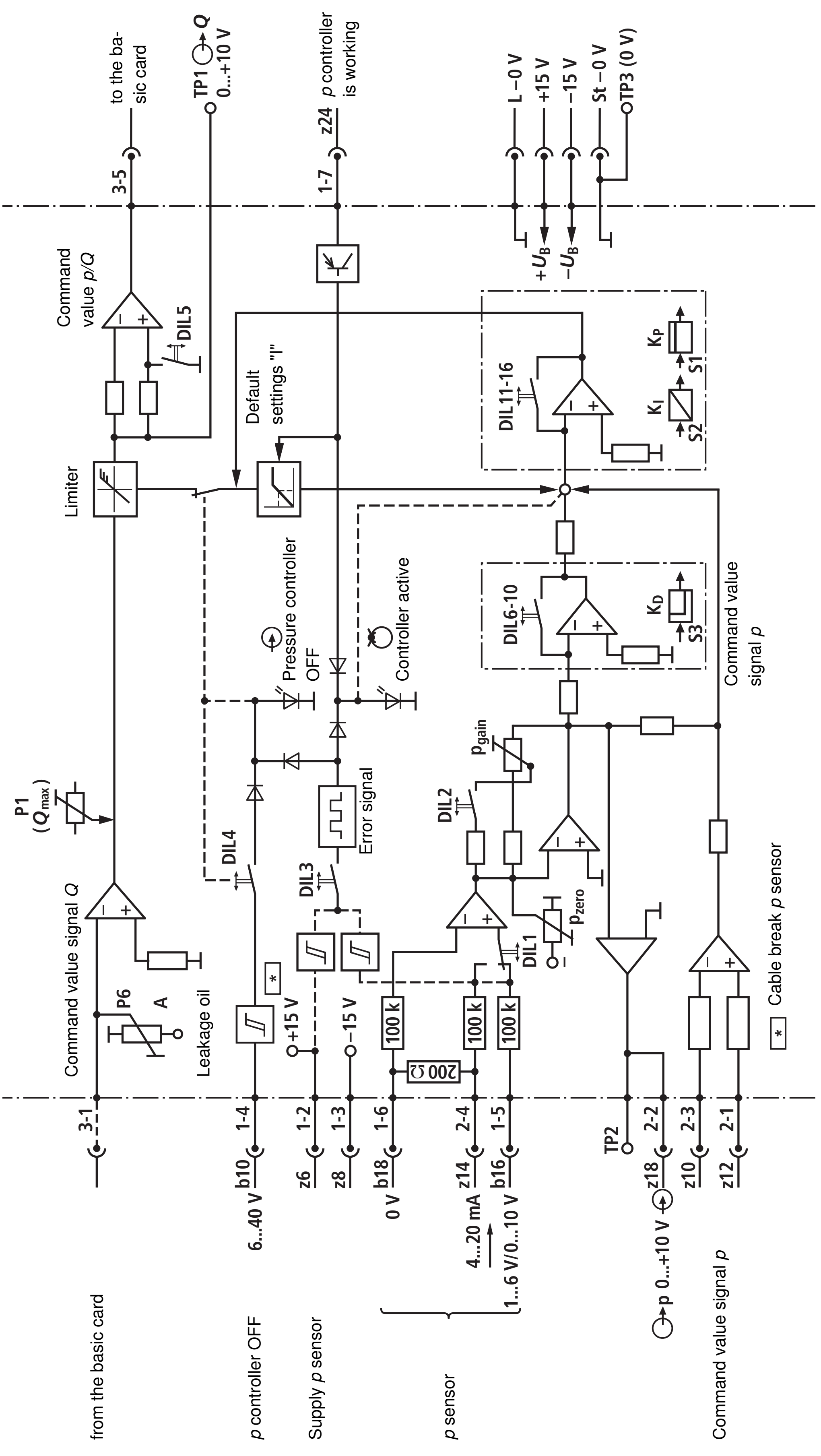
Principle of the control loop



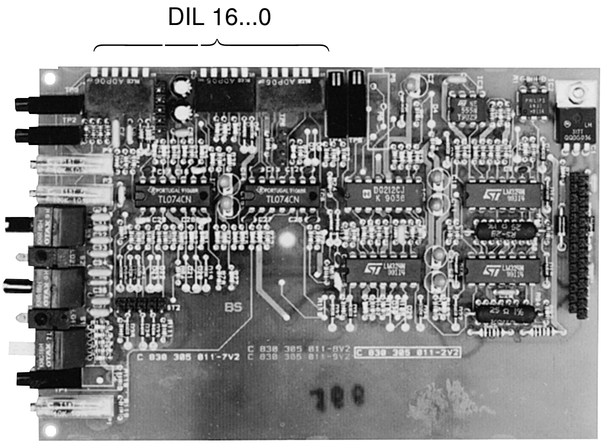
Pressure sensor connection versions



Block diagram daughter card



Mode setting (DIL switch, daughter card)



DIL no.	Status	Function		
0	–	without function		
1	ON	Pressure sensor signal		1...6 V/0...10 V
	OFF			4...20 mA
2	ON	Pressure sensor amplification		p_{SYS}[2] ≙ ~ p_{NOM}[3]
	OFF			p_{SYS} ≙ ~ 0.5 p_{NOM}
3	ON	Cable break monitoring pressure sensor		On
	OFF			Off
4	ON	Pressure controller		On
	OFF			Off
5	ON	Valve output signal		not inverted
	OFF			inverted
6	ON	D	Pressure build-up	normal
	OFF	D		reduced [1]
7	ON	D	Pressure reduction	normal
	OFF	D		reduced [1]
8	ON	D	Share high	(9, 10 = OFF)
9	ON	D	Share medium	(8, 10 = OFF)
10	ON	D	Share low	(8, 9 = OFF)
11	ON	I	Share = 0	(12 = OFF)
12	ON	I	Share available	(11 = OFF)
13	ON	P	Reduced pressure reduction	Valve opening in case of pressure reduction < approx. 15%
	OFF	P		ineffective
14	ON	P	Share low	(16 = ON/15 = OFF)
15	ON	P	Share medium	(14, 16 = OFF)
16	ON	P	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 $R_L \geqq 10\ k\Omega$. 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 V
4) Use the "Zero" potentiometer to bring the cylinder to a standstill

↓

B: Pressure sensor comparison

1) Sensor type selection
   DIL 1 ON ≙ U_A = 1...6 V/0...10 V
   OFF ≙ U_A = 4...20 mA
2) Sensor amplification selection
   DIL 2 ON if $p_{SYS} \sim p_{NOM}$
   OFF if $0.5 \cdot p_{NOM} \leqq p_{SYS} \leqq p_{NOM}$
3) Hydraulic supply OFF
4) Zero point calibration with potentiometer "P_{Zero}" (at TP "○→" = 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 $Q_{command}$ = 10 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 ≙ 100 % Valve opening (with $Q_{command}$ = 10 V)
   5 V ≙ 50 % Valve opening (with $Q_{command}$ = 10 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.

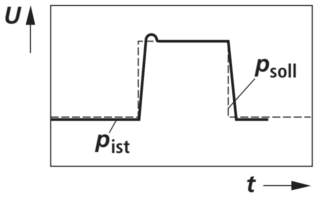
1) Pressure controller ON – DIL 4 ON
2) Connection of an oscilloscope at terminals z18 and b12 (0 V) → p_{actual}
3) Usefully connection of a 2nd oscilloscope channel at z2 and z10 (0 V) → $p_{command}$
4) DIL 6 and DIL 7 serve to compensate dynamic differences in the pressure build-up and reduction 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)

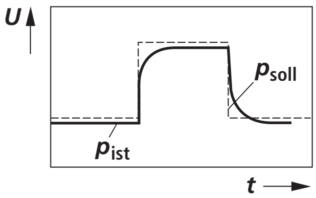
An increase in the P share of the controller increases the dynamic of the control behavior (b). In case of excessive gain, the tendency to oscillate increases (c). Limitation of the I share reduces the static gain. With increasing static gain, the control deviation is reduced (d).
The D share can be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

a



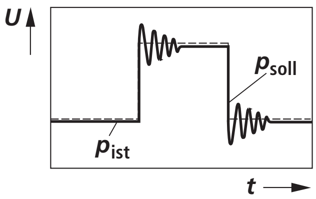
b



Problem:
P share too small
Solution:
→ Rotate K_P against 13 (fine adjustment)
→ P gain >

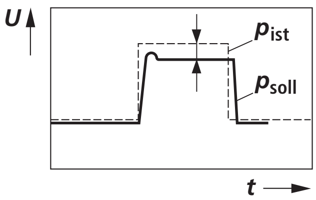
DIL 14	ON
DIL 15	OFF
DIL 16	ON

c



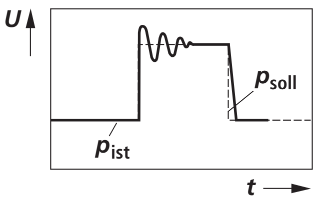
Problem:
P share too large
Solution:
→ Rotate K_P against 0 (fine adjustment)
→ use DIL 14 –16 to reduce the P gain according to the table

d



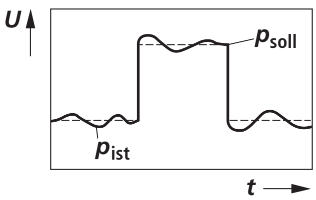
Problem:
P share correct, control deviation too large
Solution:
→ Increase the I gain share
→ DIL 11 ON = I share = 0
DIL 12 ON = I share connected
→ Rotate K_I against 13

e



Problem:
Time constant of the I share too low
Solution:
→ 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

f



Problem:
D share too low
Solution:
→ Rotate K_D against 13
→ D share >

DIL 8	ON
DIL 9	OFF
DIL 10	OFF

Adjustment protocol

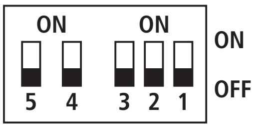
Created by:

____

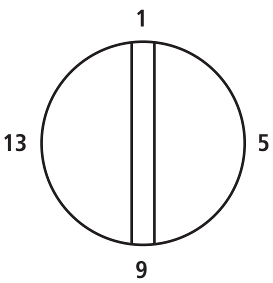
Date:

____

DIL switch

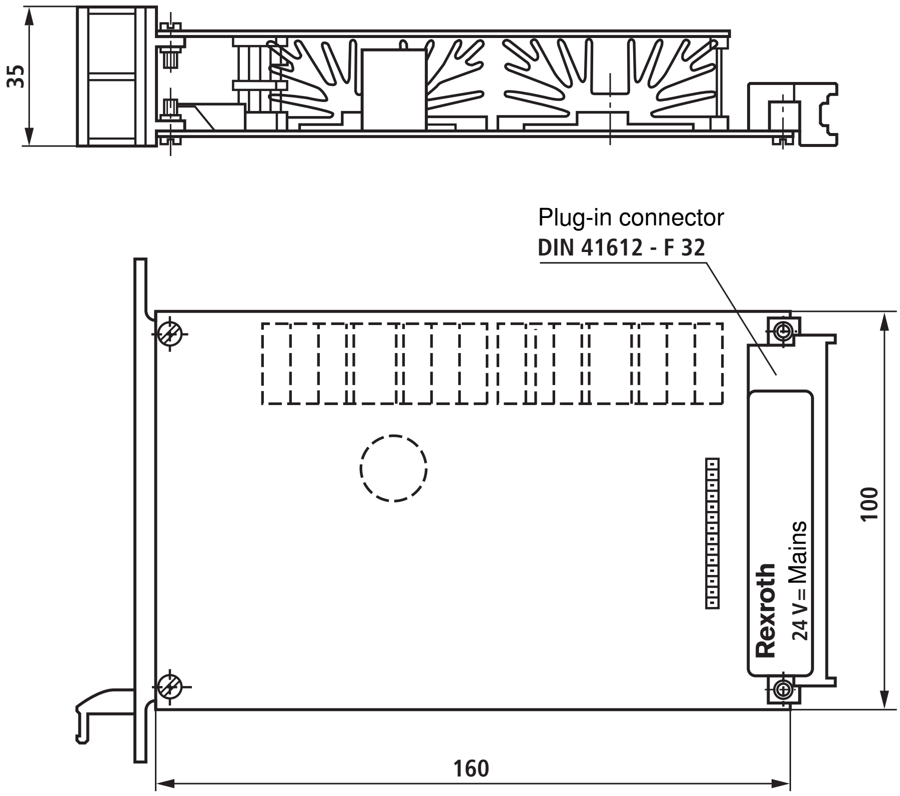


HEXCODE switch



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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Notes

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Notes

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