mmannesmann *engineering*
Rexroth

2-way proportional throttle valve (cartridge valve) Type FE(E)

Nominal size 16

Series 2X

Maximum operating pressure 315 bar

Maximum flow 190 L/min at a $\Delta p = 10$ bar

H/A 4541/94

Type FEE 16 C-2X/…K0…
with plug-in connector (separate order)

Overview of contents

Contents	Page

Features

– Pilot operated 2-way proportional throttle valve

– Installation dimensions to DIN ISO 7368-BA-06-2-A

– Orifice spool is electrically closed loop position controlled

– Flow direction A to B

– If the power fails, there is a cable break (or if the enable is withdrawn [1]) the orifice spool automatically moves into its closed position and isolates the flow from A to B

– Can be used in conjunction with a pressure compensator for pressure compensated flow control

– Type FE also with external amplifiers (separate order), see page 5

– Type FEE: completely matched unit with integrated control electronics, can be optionally supplied with a voltage or current interface

[1] Only for type FEE

Rexroth
Hydraulics

Ordering details

| FE | | 16 | C | – 2X / | | | | * |

For external control electronics = **No code**
With integrated control electronics = **E**

Nominal size 16 = **16**

Cartridge = **C**

Series 20 to 29 = **2X**
(20 to 29: unchanged installation and connection dimensions)

Flow characteristics „linear" [1]

100 L/min = **100L**
190 L/min = **190L**

Further details in clear text

M = [2] NBR seals
V = FKM seals

Interface (also see page 7)
B1 = Command value input 0 to 10 V/
Actual value output 0 to – 10 V
G1 = Command value input 4 to 20 mA/
Actual value output 4 to 20 mA
No code = Version FE
for external control electronics

Electrical connections
for external control electronics
K4 = With component plug to DIN 43 650-AM2
for proportional solenoid and GSA20
manufacturer Hirschmann for the position transducer
Without plug-in connectors
Plug-in connectors – separate order, see page 6
With integrated control electronics
K0 = With component plug to DIN 43 651
Without plug-in connector
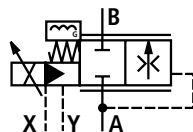Plug-in connector – separate order, see page 7

[1] Nominal flow in L/min at a $\Delta p = 10$ bar between ports A and B
(also see the hydraulic technical data on page 4)

[2] Suitable for mineral oil (HL, HLP) to DIN 51 524

Preferred types

Material no.	Type
00954413	FEE 16 C-2X/190LK0B1M

Symbols
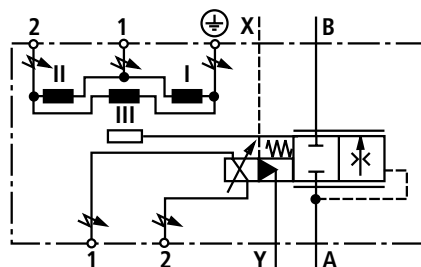
Simplified

FE 16 C-2X/… [1]

FEE 16 C-2X/… [1]
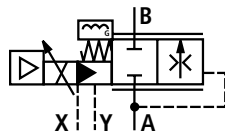
Detailed

FE 16 C-2X/…

Direction of flow: A to B (X connected with A)

☞ **Note:** Connect pilot oil connection X with A or externally

⚠ **Attention!** With external pilot oil supply at X the pressure at X **must** ≥ than the pressure at A!

[1] **A** Actuator connection
B Actuator connection
X Pilot oil supply
Y Pilot oil drain

Function, section

The valve types FE(E) are pilot operated 2-way proportional throttle valves (cartridge valves) for the stepless closed loop control of a flow.

Technical design

The valve comprises of four main groups:

– Cover (1) with connection surface for the pilot oil connections.
– Main valve (2) with orifice spool (3).
– Pilot control valve (4) with proportional solenoid (5).
– Integrated control electronics (6) (not with type FE) with position transducer (7).

Functional description

General function:

– Command value related closed loop position control of the orifice spool (3) and thereby a defined opening of the orifice (8).
– The flow through the orifice is dependent on the Δp over the orifice (8) and the position of the orifice spool (3).
– Actual value acquisition of the position of the orifice spool (3) is via the position transducer (7); command/actual value comparison is in the electronics (6); deviations are processed and passed on to the proportional solenoids (5) as an adjustment variable and the pilot valve (4) for the correcting the position of the orifice spool (3).
– The area relationship of the area (15) to area (12) = 1 : 1.
– Flow direction A $\rightarrow$ B; connect X to A or externally.
– **Attention!** With an external pilot oil supply, for correct valve function, the pressure at X has to be $\geq$ than the pressure in A.
– Pilot oil bypass via the orifice (16) increases the oscillation damping.
– When the enable is withdrawn the orifice spool (3) moves within the valve bush until the end stop (17) is reached (closed position) and so isolates the flow from A $\rightarrow$ B.
– The orifice spool position is closed loop controlled with a command value of 0 V or 4 mA, the orifice (8) is however stilll in the positive overlap position A $\rightarrow$ B.
– For details regarding the drain oil, via the orifice spool (3) and the pilot control valve (4) with a 0 V or 4 mA command value as well as an inactive enable, see technical data on page 4.

Function open orifice spool:

Flow is from A $\rightarrow$ B and A is connected to X

• The proportional solenoid (5) pushes the pilot control spool (4.1) against the spring (13) and opens the connection from the control chamber (12) to Y; a reduction in pressure in the control chamber (12) and the movement of the orifice spool (3) in the opening direction due to the pressure in A on the area (15).

Function close orifice spool:

Flow is from A $\rightarrow$ B and A is connected to X

• With a reduction in the current at the proportional solenoid (5); the spring (13) pushes the pilot control spool (4.1) against the proportional solenoid and opens the connection from X to the control chamber (12); an increase of pressure in control chamber (12); pressure on the orifice spool area in control chamber (12) plus the spring force (10) moves the orifice (3) in the closed direction.

Flow control function:

• In conjunction with a pressure compensator the unit can be used for load compensated closed loop flow control.

Loss of power supply:

• The integrated electronics de-energises the solenoid if the power supply fails or if there is a cable break in the position transducer (7).
• The spool is moved into the closed position by the pressure acting on pilot oil connection X plus the spring force (10) and so isolates the flow from A $\rightarrow$ B.

⚠ **Attention:** Loss of the power supply causes the axis to abruptly stop. The resulting accelerations could cause damage to the machine!

Type FEE 16 C-2X/…

Type FE 16 C-2X/…
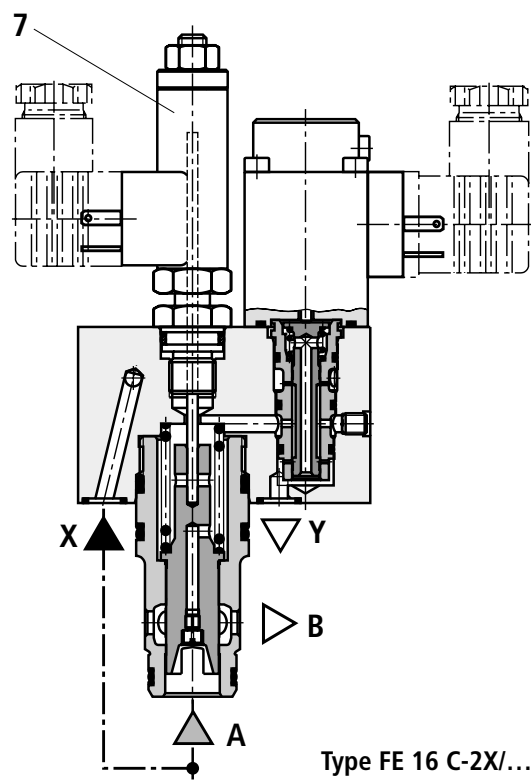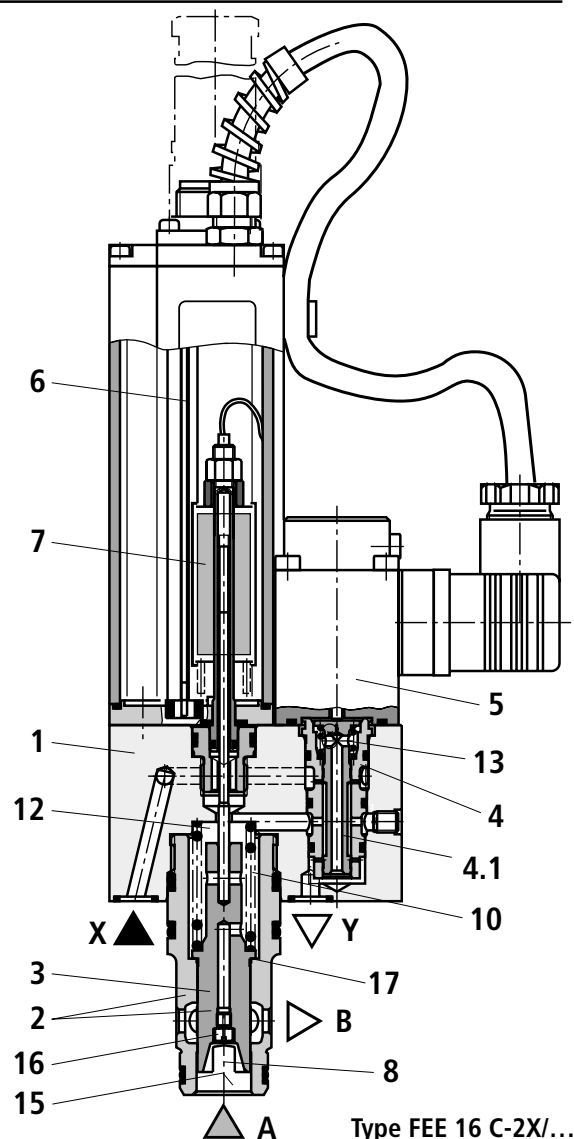
Technical data (for applications outside these parameters, please consult us!)

General

Installation			Optional
Storage temperature range		°C	− 20 to + 80
Ambient temperature range	FE	°C	− 20 to + 70
	FEE	°C	− 20 to + 50
Weight	FE	kg	2.7
	FEE	kg	2.9

Hydraulic (measured at $v = 41$ mm^2/s and $\vartheta = 50$ °C)

Operating pressure	Ports A, B	bar	Up to 315
Pilot pressure	Port X	bar	Up to 315
Return pressure	Port Y		Zero pressure to tank
Min. inlet pressure	In A (flow direction A → B)	bar	7
Max. flow q_{Vmax} of the main valve at a $\Delta p = 10$ bar			
	Flow direction A → B	L/min	190
Pilot oil volume for switching into the seat position			
	0 → 100%	cm^3	0.9
Pilot oil flow at port Y:			
	With a stepped form of input signal	L/min	Up to 2.5
Flow direction			A → B
Pilot oil connection			Connect X with A or externally. ⚠ **Attention!** With an external pilot oil supply the pressure at X must be ≥ than the pressure at A.
Drain flow	Condition: Command value 0 V or 4 mA		From A → B see characteristic curve on page 9 Max. 0.4 L/min from A → X and via the orifice in the main spool to Y at a Δp of 315 bar
	Condition: Enable inactive (solenoid de-energised)		Max. 1.5 L/min from A → B at a Δp of 315 bar; Max. 0.2 L/min from A → X and via the orifice in the main spool to Y at a Δp of 315 bar
Pressure fluid			Mineral oil (HL, HLP) to DIN 51 524; Further pressure fluids on request!
Pressure fluid temperature range		°C	− 20 to + 80
Viscosity range		mm^2/s	15 to 380

Degree of contamination		Maximum permissible degree of contamination of the pressure fluid is to NAS 1638	A filter with a minimum retention rate of $\beta_x \geq 75$ is recommended
	Pilot valve	Class 7	x = 10
	Main valve	Class 7	x = 10

Hysteresis	%	< 0.2
Response sensitivity	%	< 0.1
Reversal error	%	< 0.15

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

Type FE (external control electronics)

Electrical, solenoid (pilot control valve for type FE)

Voltage type			24 V DC
Nominal current		mA	1000
Coil resistance	Cold value at 20 °C	Ω	12.7
	Max. warm value	Ω	19.3
Duty		%	100
Electrical connection			With component plug to DIN 43 650-AM2
			Plug-in connector to DIN 43 650-AF2/Pg11 [1]
Protection to DIN 40 050			IP 65

Electrical, inductive position transducer (main stage)

Coil resistance	Total spool resistance between		1 and 2	2 and ⏚	⏚ and 1
at 20 °C (see symbols on page 2)		Ω	31.5	45.5	31.5
Inductivity		mH	6 to 8		
Oscillator frequency		kHz	2.5		
Electrical connections			With component plug GSA20, manufacturer Hirschmann		
			Plug-in connector GM209N (Pg9), manufacturer Hirschmann [1]		
Protection to DIN 40 050			IP 65		
Electrical position measuring system			Differential throttle		

Control electronics (only for type FE, separate order)

Amplifier in Eurocard format	analogue	VT-VRPA1-50-1X to RE 30 117

Type FEE (integrated control electronics)

Electrical

Duty		%	100
Current consumption	I_{max}	A	1.3
	Impulse load	A	1.5
Electrical connections			With component plug to DIN 43 651
			Plug-in connector to DIN 43 651 11-pin + PE/Pg16 [2]
Protection			IP 65
Control electronics			Integrated into the valve (see page 8)

[1] Separate order, see page 6
[2] Separate order, see page 7

☞ **Note:** For details regarding the **environmental simulation test** covering EMC (electro-magnetic compatibility), climate and mechanical loading see RE 29 202-U (declaration regarding environmental compatibility).

Electrical connections for valves with external control electronics type FE

Connections at component plug
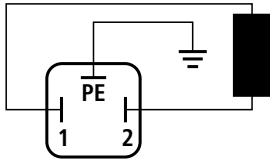
Connections at plug-in connector

PE

1   2

PE

1   2
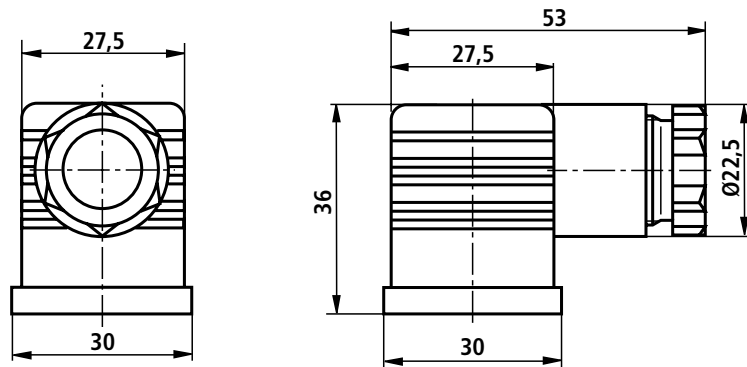
To amplifier
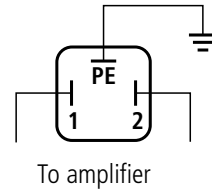
Plug-in connector to DIN 43 650-AF2/Pg11
Separate order under material no. **00074684** (plastic version)

27,5

53

27,5

36

Ø22,5

30

30

Inductive position transducer

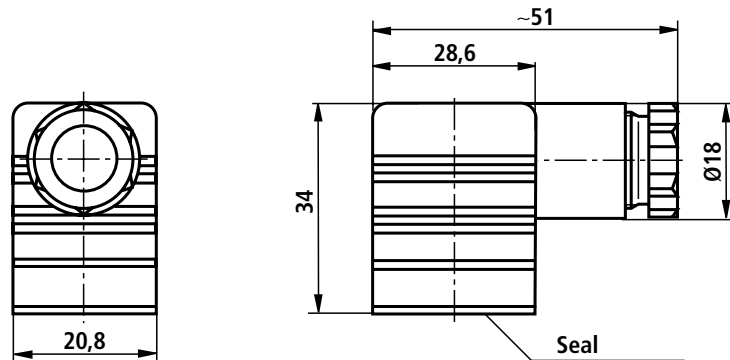I   III   II

Screen

2 1
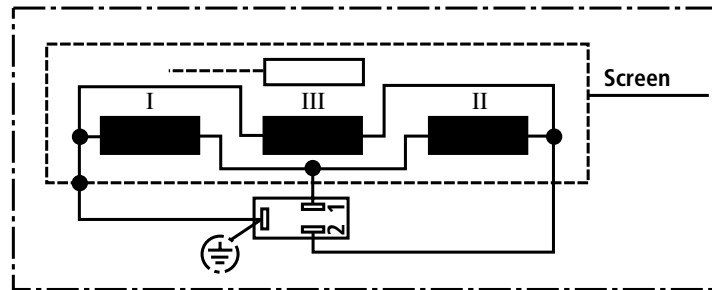
Plug-in connector GM209N (Pg9), manufacturer Hirschmann
Separate order under material no. **00013674** (plastic version)

~51

28,6

34

Ø18

20,8

Seal

Electrical connections for valves with integrated control electronics type FEE
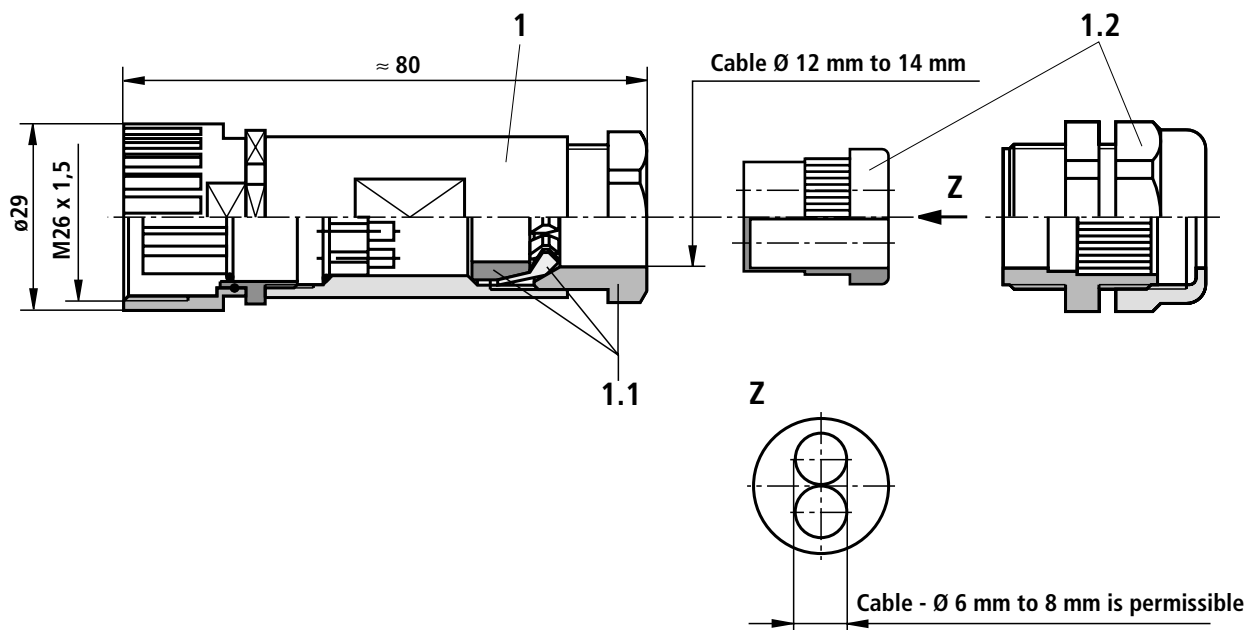
Plug-in connector to DIN 43 651/11-pin + PE/Pg16
Separate order under material no. **00855978**
(plastic version)
Assembly comprises of Pos. 1 and 1.1 or Pos. 1 and 1.2,
protection IP65

Note:
– When using **one** cable combine Pos. 1 with Pos. 1.1
– When using **two** cables combine Pos. 1 with Pos. 1.2

Cable Ø 12 mm to 14 mm

Cable - Ø 6 mm to 8 mm is permissible

Pin	Function	Conditions	
1	Operating voltage +UL	U_B = 24 VDC; $u_B(t)_{max}$ = 36 V; $u_B(t)_{min}$ = 21.6 V	
2	Mass L0		
3	Enable input / reference for Pin 2	log 1 = 10 V to 36 V; log 0 = U < 8 V	
		Type **FEE…/…B1…**	Type **FEE…/…G1…**
		Voltage interface	Current interface
4	Command value input	0 V to + 10 V (R_e > 50 kΩ)	+ 4 mA to + 20 mA / impedance = 100 Ω
5	Command value input, reference		
6	Actual value output	0 V to − 10 V (I_{max} = 5 mA)	+ 4 mA to + 20 mA / impedance ≤ 500 Ω
7	Actual value output, reference		
8	Free		
9	Free		
10	Free		
11	Operational (output)	Valve not operational:	U_{Pin11} < 8 V;
		Valve operational:	$U_{Pin11} = U_B − 3$ V
		Reference – Pin 2:	(I_{max} against 0 V; 50 mA);
PE	Earth ⏚		

Recommended connection cable: – Up to 25 m → min. 0.75 mm^2 per core

– Up to 50 m → min. 1.5 mm^2 per core

– Connect the screen only to PE on the supply side

Functional description of the integrated control electronics

1. Switching sequence/fault characteristics:

After the 24 V power supply has been applied the electronics are operational when the following conditions are fulfilled.

– The operating voltage U_B > 18 V DC

– The internal supply voltage ± 7.5 V is symmetrical

– The connection to the position transducer is not interrupted.

– The command value line is not interrupted (only for the 4 mA to 20 mA interface)

If one of these conditions is not met then the controller and output stage are locked and operational signal is set to < 8 V.

2. Normal operation

With an inactive enable (< 8 V) and a command value is applied (0 to 10 V or 4 to 20 mA) the orifice spool is at its end stop and so isolates the flow from A to B.

By applying a voltage of > 10 V at the enable, the position controller for the orifice spool and the output stage of the pilot control valve are switched on. At the same time the actual value from the orifice spool position is compared with the applied command value in the position controller (PID) and is applied to the output stage as an adjustment variable, the solenoid current is changed until the orifice spool position relates to the command value.

The actual value of the orifice spool position is acquired via an inductive position transducer. This signal is rectified by a demodulator and then fed back to the PID controller.

The following are available as an output signal at the plug:

– Position actual value FEE.../...B1 (Pin 6)
  • 0 V to −10 V relates to a 0 % to 100 % valve opening
  • Orifice spool is on its endstop → actual value > 0.2 V

– Position actual value FEE.../...G1 (Pin 6)
  • 4 mA to 20 mA relates to a 0 % to 100 % valve opening
  • Orifice spool is on its endstop → actual value < 3.65 mA

– Operational signal (Pin 11)
  • All of the above stated conditions have been fulfilled → > 10 V
  • One condition has not been fulfilled → < 8 V

Block circuit diagram for the integrated control electronics
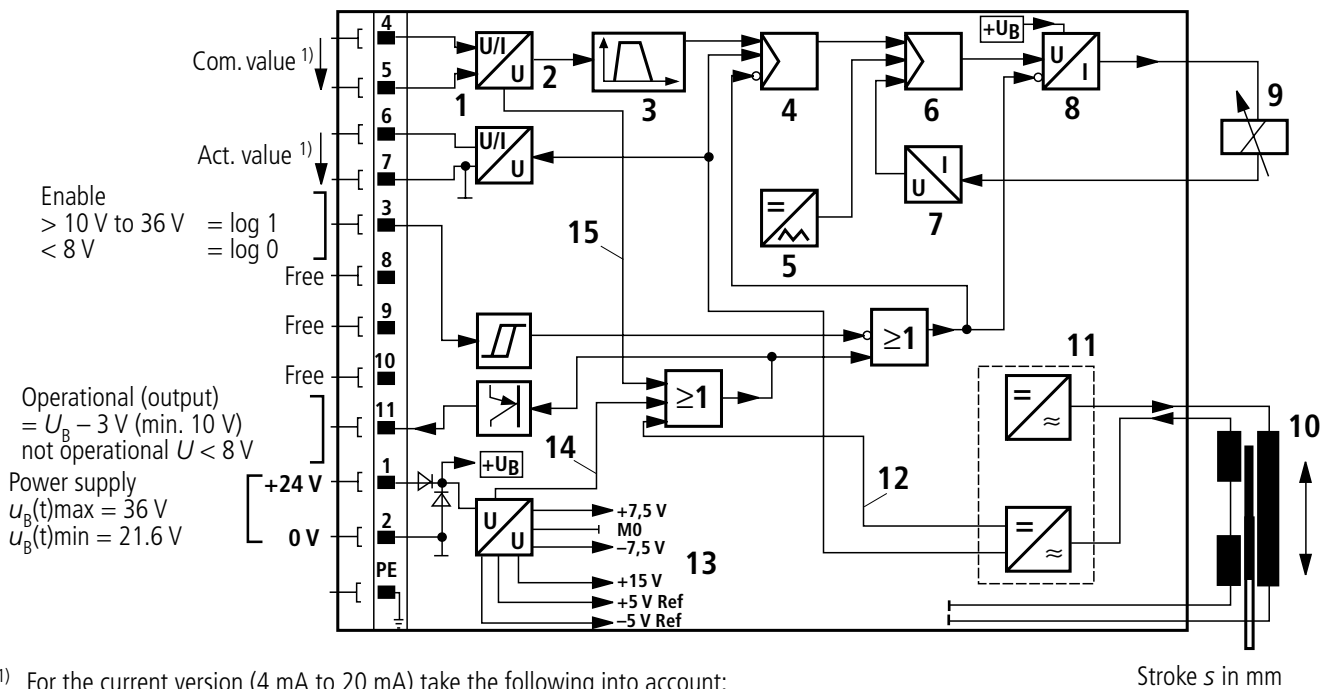
1) For the current version (4 mA to 20 mA) take the following into account:
Between connections 5 and 4 the impedence = 100 Ω
Between connections 6 and 7 the impedence ≤ 500 Ω

Stroke s in mm

1	Input	**9**	Proportional solenoid
2	Output	**10**	Position transducer
3	Fixed ramp	**11**	Oscillator / Demodulator
4	Position controller	**12**	Fault signal, position transducer
5	Clock	**13**	Power supply
6	Current controller	**14**	Fault signal at $+U_B$ under voltage and unsymmetry in the power supply
7	I/U convertor		
8	Output stage	**15**	Cable break signal with a current command value

Characteristic curves (measured at HLP 46 and $\vartheta_{oil} = 40\ °C \pm 5\ °C$)

Linear flow characteristics

FE(E) 16 C…

1 $\Delta p =$	10 bar
2 $\Delta p =$	20 bar
3 $\Delta p =$	30 bar
4 $\Delta p =$	50 bar
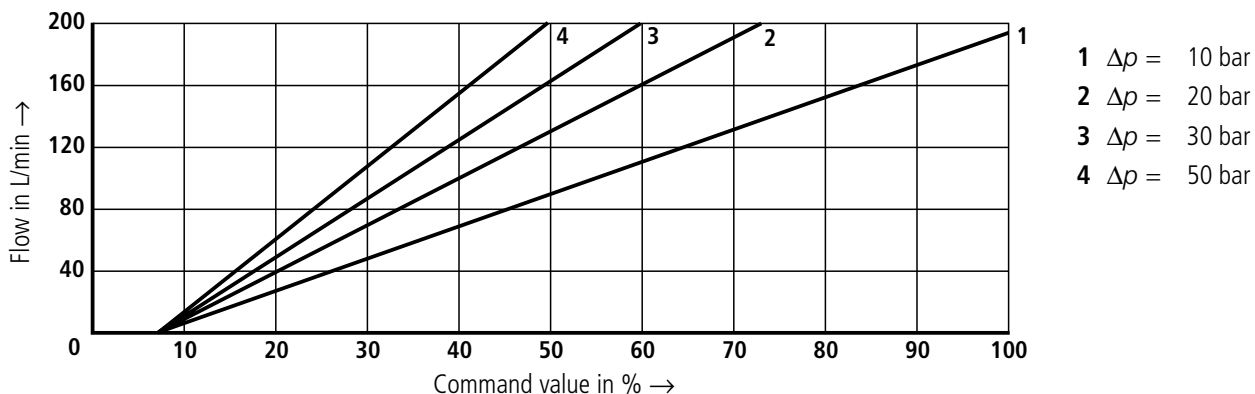
Transient function with a stepped form of command value change[1]

FE(E) 16 C…

Step response

0 – 100 – 0 %	———
10 – 90 – 10 %	—·—·—
25 – 75 – 25 %	– – – –

[1] Measurement conditions
Pressure in A = 50 bar

Command value change 0 → 100 %
Pressure in A < 50 bar → adjustment time increases
Pressure in A > 50 bar → adjustment time decreases
Command value change 100 → 0 %
No change to the adjustment time when the pressure at
X = A
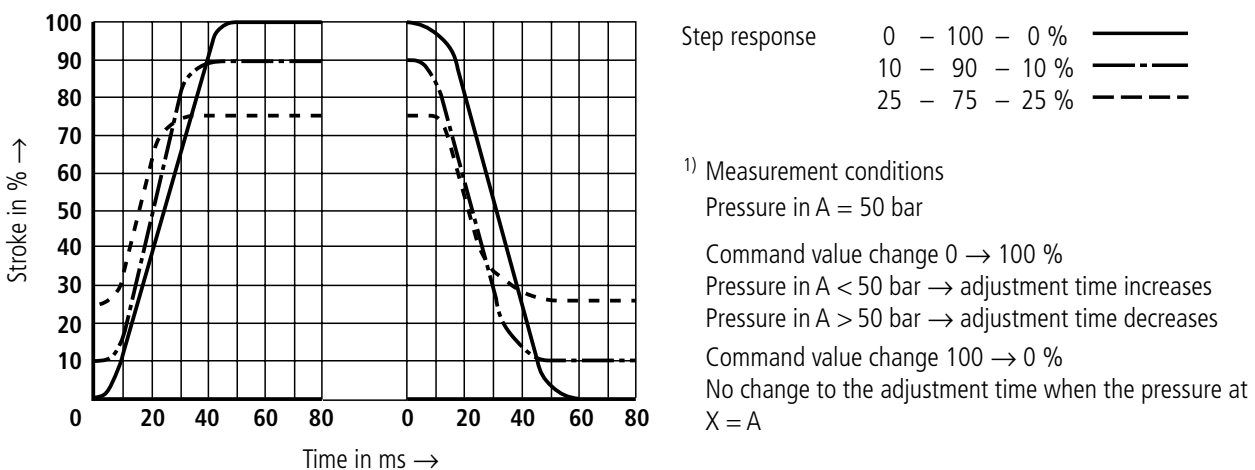
Leakage from A → B in relation to the pressure differential Δp (command value 0 V or 4 mA)

FE(E) 16 ../..190L..

RE 29 202/03.00
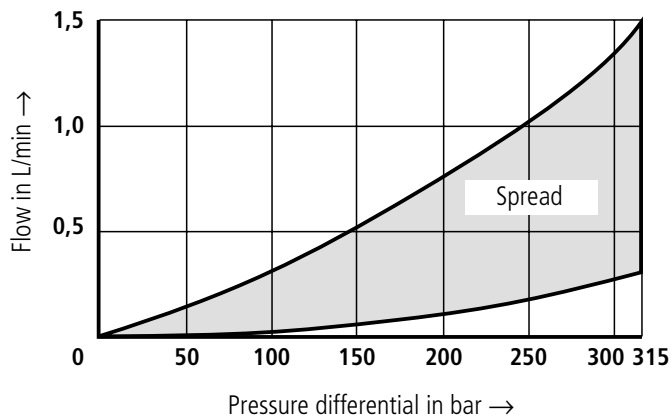
Unit dimensions: type FE   (Dimensions in mm)
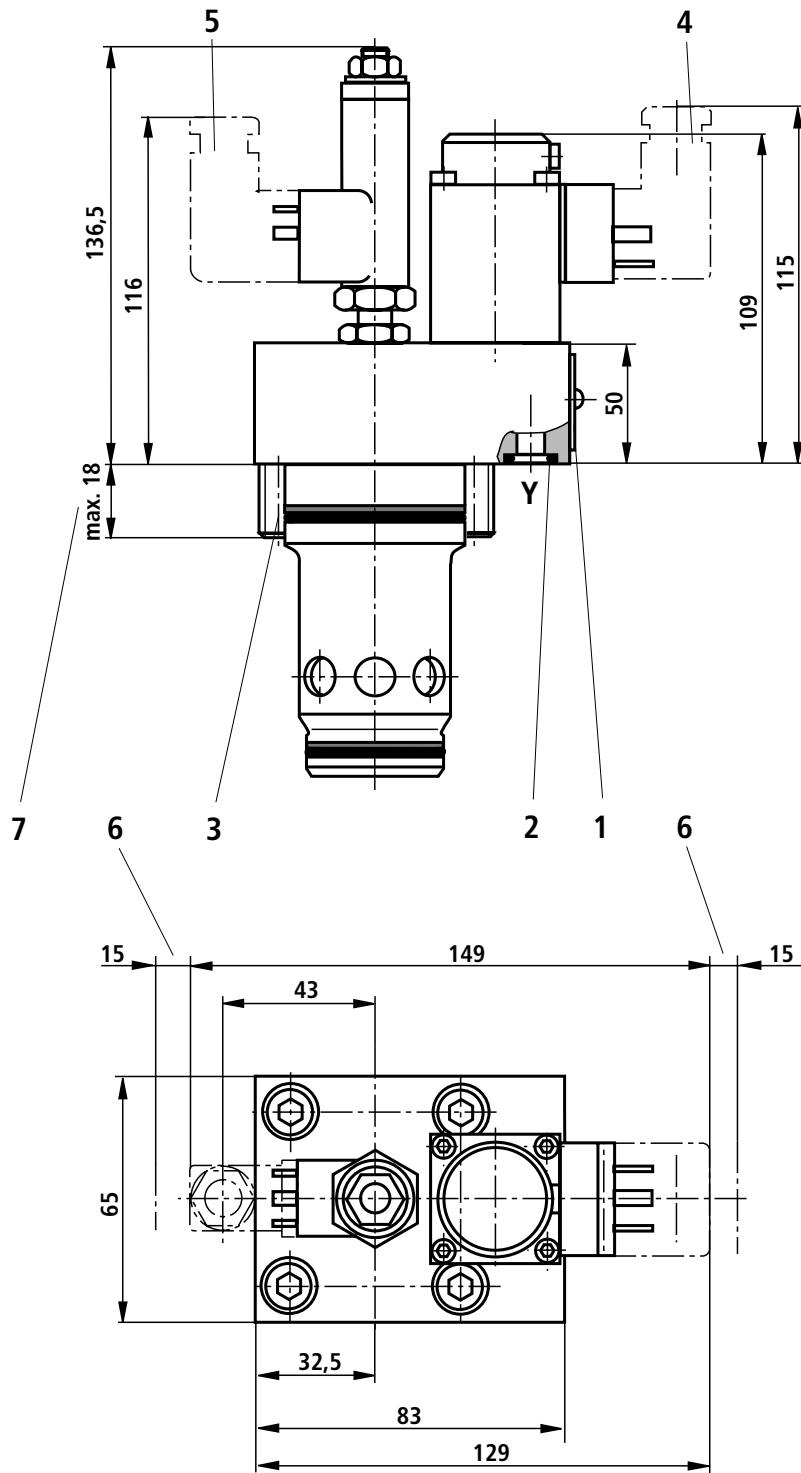
1 Name plate

2 R-ring 9.81 x 1.5 x 1.78 (X, Y)

3 4 off valve fixing screws
M8 x 35 to DIN 912-10.9 (are included within the scope of
supply) tightening torque $M_A = 25$ Nm

4 Plug-in connector to DIN 43 650-AF2/Pg11
separate order, see page 6

5 Plug-in connector GM209N (Pg9), manufacturer Hirschmann
separate order, see page 6

6 Space required to remove the plug-in connector

7 Screw in length of the valve fixing screws

Unit dimensions: type FEE
(Dimensions in mm)

1 Name plate

2 R-ring: 9.81 x 1.5 x 1.78 (X, Y)

3 4 off valve fixing screws
to DIN 912-10.9:
M8 x 35, tightening torque M_A = 25 Nm
(are included within the scope of supply)

4 Plug-in connector to DIN 43 651 11-pin +
PE/Pg16,
separate order, see page 7

5 Space required to remove the plug-in
connector

6 Screw in length of the valve fixing screws

Unit dimensions

(Dimensions in mm)

Installation dimensions to DIN ISO 7368-BA-06-2-A

6   Port X

7   Port Y

8   Locating pin hole

9   Depth of fit

10   Control dimensions

11   Connection B can be arranged at random about the middle axis of connection A. Care has, however to be taken that the fixing holes and control bores are not damaged.

12   If the diameter for connection B is different from that stated then the distance from the control cover, mounting surface to the hole centre line has to be calculated.

[1]   Min. distance (29.5 mm) at max. diameter (Ø 25 mm)

$$\frac{x}{} = \sqrt{R_{max}4}$$

$$\frac{y}{} = \sqrt{R_{max}8}$$

$$\frac{z}{} = \sqrt{R_z 10}$$

a – a

The specified data is for product description purposes only and may not be deemed to be guaranteed unless expressly confirmed in the contract.

          FE(E)