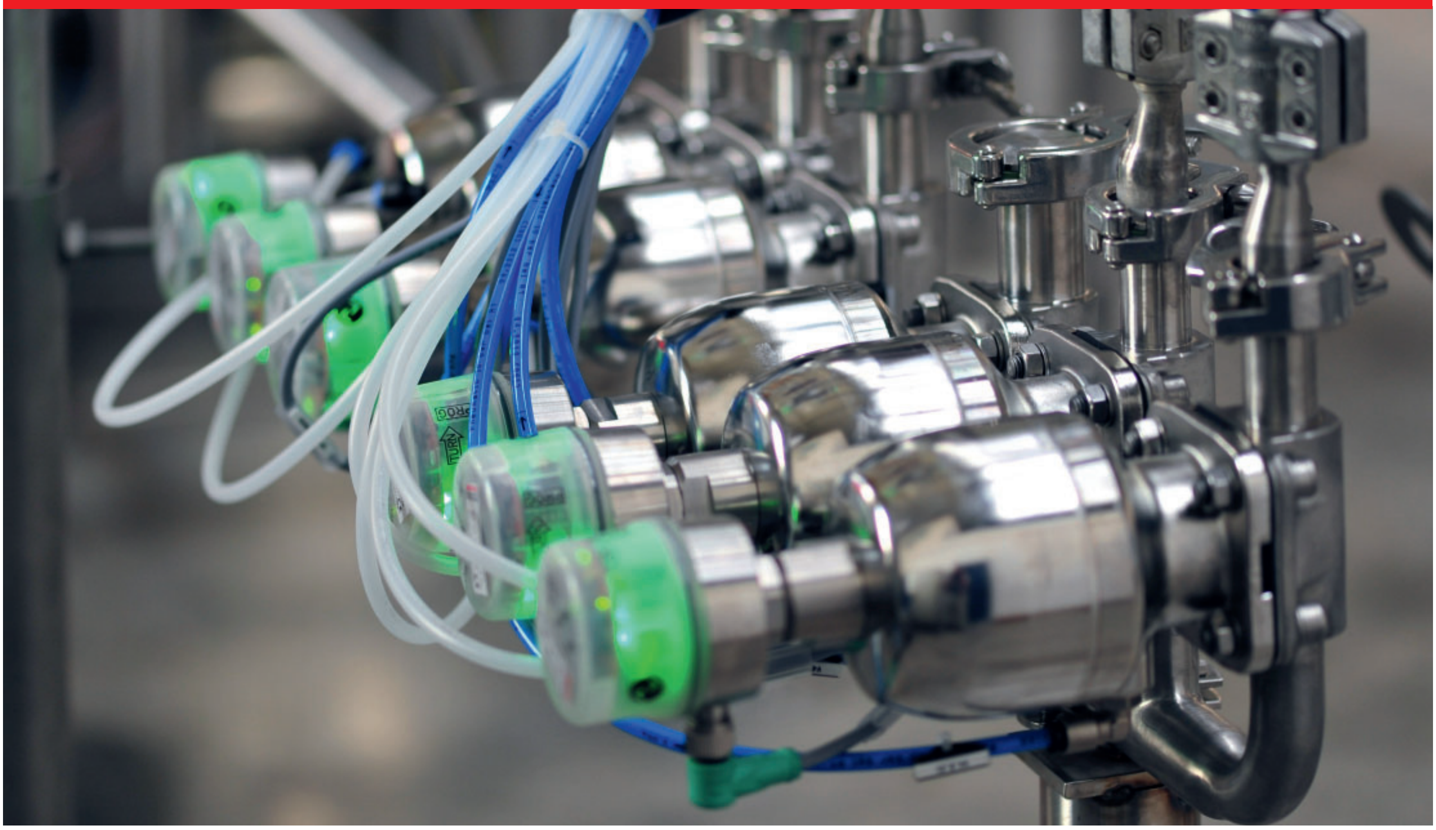
Automation components for linear and quarter turn valves

Automation components are integrated components of an intelligent process automation system

Intelligent process automation follows a comprehensive approach which comprises the control levels as well as also innovative components and valves at the field level. GEMÜ has been offering valves and precisely tuned valve instrumentation, controllers, sensor systems, valve actuators, and system solutions for process automation for some years now: It could be said that you take care of your process, we take care of the component interfaces. Moreover, we believe that the most reliable and safest monitoring of valves always take place directly at the valve itself.

Linear type valves and quarter turn valves are frequently used with automation components. GEMÜ provides the most varied designs to suit any automation concept. The product range not only comprises simple switches but also intelligent designs equipped with timesaving automated initialisation. Advanced combi switchboxes may be used in fieldbus networks such as AS-interface and DeviceNet as well as IO-Link.



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The optimal controller
for trouble-free process control

Notes for selecting positioners
The optimum function of a control system is not solely achieved by the selection of the positioner. All system components must be optimally adapted to each other.
If not achieved, poor positioning and control results will be observed. The greater the demands with regard to control accuracy, positioning ratio, cavitation and optimum operating and procurement costs, the more careful a selection must be made.

Electro-pneumatic positioners
Electro-pneumatic positioners are most frequently used as positioners or as combined position and process controllers for control functions. Because of the more favourable procurements costs in comparison with motorized actuators, electro-pneumatic positioners are used wherever control air is already available. The combination of electro-pneumatic positioners and compressed air controlled valves is basically determined by the control task.

GEMÜ has developed a complete range of positioners for performing various different control tasks.
The electro-pneumatic positioner range comprises the GEMÜ 1434 µPos, GEMÜ 1435 ePos, GEMÜ 1436 cPos and GEMÜ 1436 cPos eco.

- GEMÜ 1434 µPos - as a simple, low cost positioner without display and setting keys. Suitable for valves with single acting linear actuators and small to medium nominal sizes
- GEMÜ 1435 ePos and GEMÜ 1436 cPos are positioners for use in demanding applications.
  They can be adapted individually to the control task with the front keypad and display
- GEMÜ 1436 cPos as a positioner, optionally with integrated process controller. Wide range of connection options thanks to optional fieldbus interface and digital inputs
- GEMÜ 1436 cPos eco as a positioner without display and setting keys (comparable to the functions of type GEMÜ 1434 µPos). Thanks to the higher air output valves with small and larger nominal sizes can be controlled

In addition, the relation between the air output of the positioner, required control pressure and the size of the valve actuator still plays a role. This relation determines the valve's operating time. Depending on the control task and range of the valve, shorter operating times and therefore higher flow volumes through the control valves in the positioners are necessary. The GEMÜ 1434 µPos positioner was specially developed for small linear actuators.

Normally the pilot pressure for a globe valve is controlled in a positioner and a certain valve opening set as a result. The GEMÜ 1436 cPos additionally offers an optional process control circuit for controlling the process. It can be used as a local process controller and thus relieves the load on the central control system.

Independently of the correct valve design, the valve must be positioned with the positioner and the necessary sensors at the "right place" in the pipe system. Only then is an optimum function guaranteed. With electro-pneumatic positioners, for example, generally pressure and flow sensors should always be installed before the valve, temperature and pH value sensors after the valve.

Electrical positioners and control actuators
GEMÜ offers several valve types with a motorized actuator. These actuators are an optimum alternative in sterile environments or offer reduced "Total Costs of Ownership". The procurement costs for a motorized valve are a little higher but there may be a cost advantage in terms of total life cycle costs. The actuators are comparable with the electro-pneumatic positioners in their functionality. They are available with both integrated positioner and combined position and process controller.

GEMÜ 1436 cPos

Positioners and process controllers

for linear and quarter turn valves

Positioners and process controllers - Overview

Function / Features		 GEMÜ 1434 µPos	 GEMÜ 1435 ePos	 GEMÜ 1436 cPos	 GEMÜ 1436 cPos eco
Controller type	Positioner	●	●	●	●
	Process controller			●	
Operation	Local display / keypad		●	●	
	Status display	●	●	●	●
	Web browser user			●	
	Fieldbus option (Profibus DP, Device Net)			●	
Housing	Plastic	●		●	●
	Aluminium		●		
Functions	Automatic initialisation (speed-AP)	●	●	●	●
	Alarm / error outputs		●	●	
	Min/max positions adjustable		●	●	
Mounting	Direct mounting to linear actuators	●	●	●	●
	Remote mounting to linear actuators	●	●	●	●
	Direct mounting to quarter turn actuators		●	●	●
	Remote mounting to quarter turn actuators		●	●	●
Control function of valve actuator	Control function 1, normally closed (NC)	●	●	●	●
	Control function 2, normally open (NO)	●	●	●	●
	Control function 3, double acting (DA)		●	●	
Air output		15 Nl/min.	50 Nl/min. 90 Nl/min.	150 Nl/min. 200 Nl/min. 300 Nl/min.	150 Nl/min. 200 Nl/min.

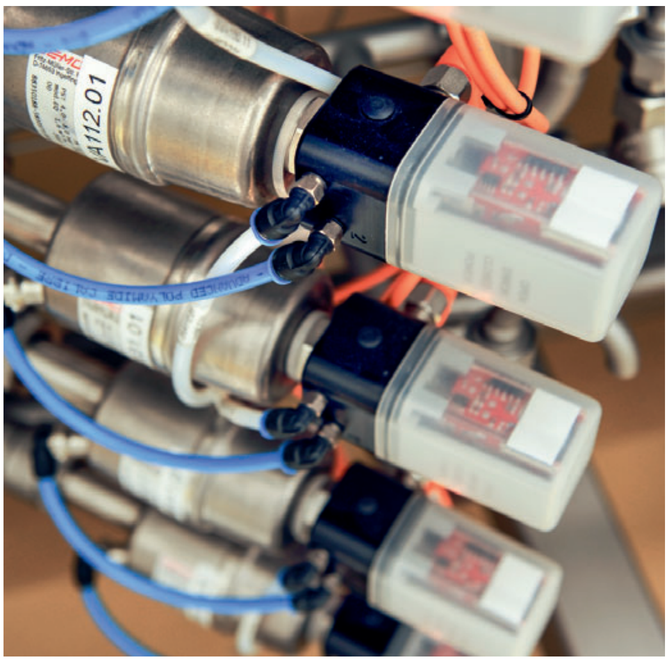
GEMÜ 1434 µPos

Electro-pneumatic positioner

The GEMÜ 1434 µPos positioner was specially developed for small globe and diaphragm valves.

The GEMÜ 1434 µPos is directly mounted on the process valve or, as an alternative, separately mounted with a separate travel sensor. The **speed**$^{\text{-AP}}$ function minimises installation and commissioning time. A control signal starts initialisation which runs automatically. The positioner then adapts itself to the valve.

With this device GEMÜ has succeeded in developing a totally digital positioner with very small dimensions.



GEMÜ 695 with
GEMÜ 1434 μPos

GEMÜ 650 with
GEMÜ 1434 μPos
remote mounting

GEMÜ 550 with
GEMÜ 1434 μPos

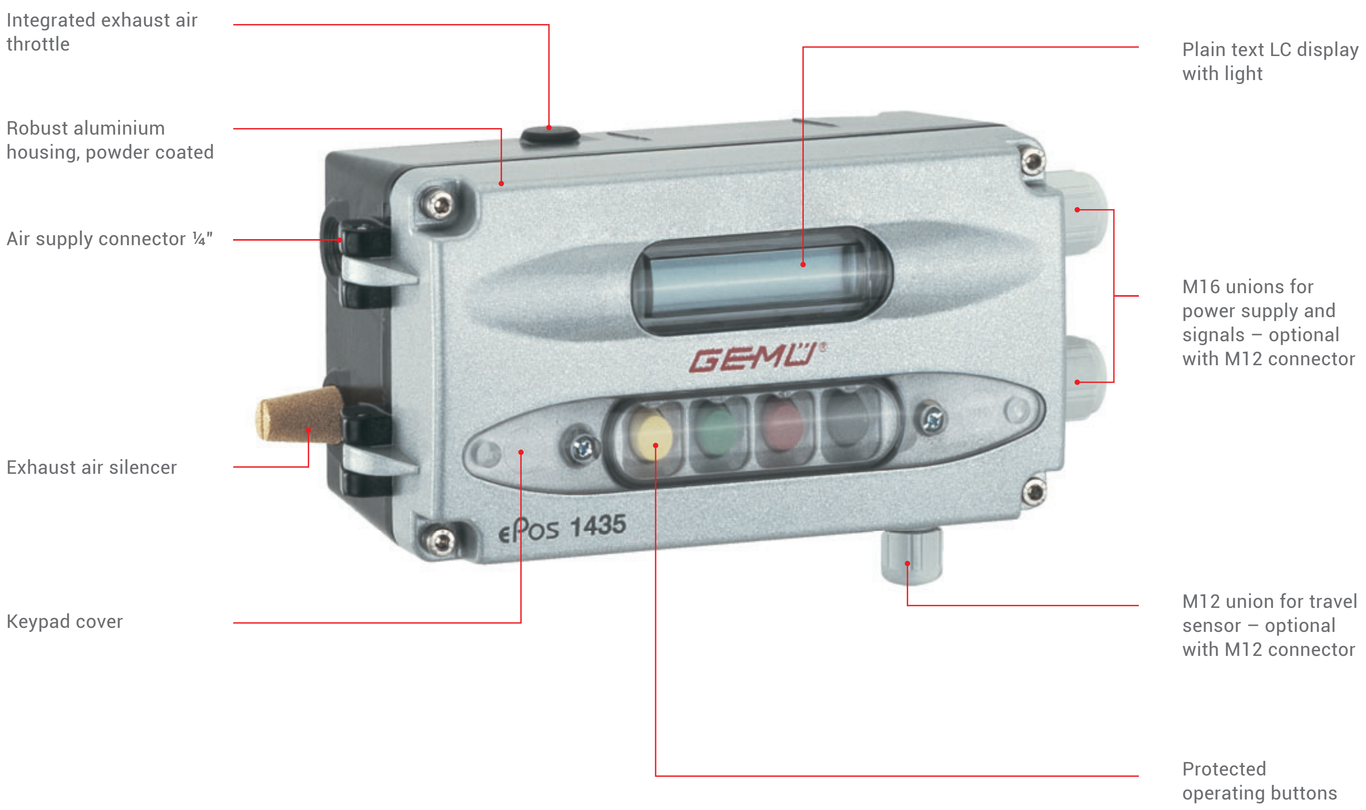
Construction
The GEMÜ 1434 μPos digital positioner detects the valve position via its longlife travel sensor. It was specially designed for small linear valve actuators and has a light, plastic and aluminium housing (optional stainless steel).

Features

- Automatic initialisation by 24 V DC signal
- Automatically optimises the valve control during initialisation
- No air consumption when idle
- Suitable for single acting linear actuators
- Push-in pneumatic air connectors
- Compact construction, small dimensions
- Remote mounting of positioner and travel sensor is possible
- Integrated potentiometer
- Low investment costs
- Low operating costs
- Fast commissioning, no need to open the housing
- Simple operation
- Easy mounting to GEMÜ valves and other makes
- Simple electrical and pneumatic connection
- ***Speed***$^{\text{-AP}}$ function

GEMÜ 1435 ePos

Electro-pneumatic positioner



The GEMÜ 1435 ePos digital electropneumatic positioner detects the valve position via its external travel sensor. It has a robust metal housing with protected operating buttons and an easy to read LC display with background light. The operating times can be set by integrated throttles.

GEMÜ 620 with
GEMÜ 1435 ePos

Quarter turn actuator
GEMÜ SC with
GEMÜ 1435 ePos

GEMÜ 650 with
GEMÜ 1435 ePos
remote mounting

Features

- Simple, self-explanatory menu
- Automatic initialisation function
- Automatically optimises the valve control during initialisation
- Safety function in case of compressed air and power supply failure
- No air consumption when idle
- Adjustable digital outputs for limit values
- Adjustable alarm functions
- Operation by fascia buttons
- Suitable for quarter turn or linear actuators
- Can be used for single or double acting actuators
- Remote mounting of positioner and travel sensor is possible
- Low operating costs, no air consumption when idle
- High air output for larger actuators
- Fast commissioning
- Simple operation
- Easy mounting to the valve
- Simple electrical connection by detachable terminals
- ***Speed***-AP function
- Integrated heating element (optional) for extended temperature range

GEMÜ 1436 cPos

Electro-pneumatic positioner with optional integrated process controller

The GEMÜ 1436 cPos digital electro-pneumatic positioner with an integrated process controller is for the control of liquids, gases and steam.

When using the optional process controller the signals from a process sensor (e.g. flow, level, pressure, temperature) are detected and the media adjusted according to the specified set value. The membrane keypad and the backlit display are arranged at the front. Pneumatic and electrical connections are at the rear. Integrated pneumatic throttles allow regulation of the control air to adapt the controller to different valve actuators and actuating speeds.

GEMÜ 761 with
GEMÜ 1436 cPos

GEMÜ 687 with
GEMÜ 1436 cPos

GEMÜ 536 with
GEMÜ 1436 cPos

Features

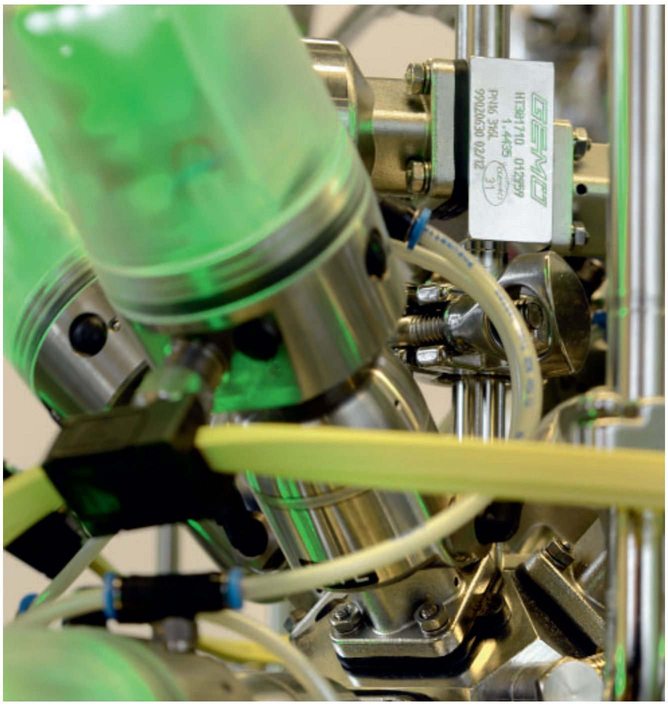
- PID process control possible
- Remote control
- Diagnostics, alarms, monitoring
- Integrated Web browser capability
- Parameter sets can be saved and reloaded
- User levels (access authorisation)
- Fieldbus: Profibus DP, Device Net
- Simple, self-explanatory menu
- Automatically optimises the valve control during automatic initialisation
- Safety function in case of compressed air and power supply failure
- Optional digital inputs
- Freely configurable relay outputs
- Parameterisation during operation
- Remote mounting of positioner and travel sensor is possible
- Low operating costs, no air consumption when idle
- High air output for larger actuators
- Fast commissioning
- Simple operation
- No air consumption when idle
- Easy mounting to the valve
- ***Speed***$^{\text{-AP}}$ function
- ***e.***$^{\text{sy}}$-com interface

Combi switchboxes and electrical position indicators

for pneumatically operated linear valves

Our devices detect the valve stroke in any installation position without play and are tension-free. The sensor base of the GEMÜ 1234, 1235 and 4242 series is positively connected to the valve spindle by means of a preloaded spring so that possible tangential forces of the valve actuator do not negatively affect the position indicator. The position indicators can be quickly and easily assembled and are safe and uncomplicated to handle.

They can be adapted to pneumatic actuators of GEMÜ globe and diaphragm valves. Due to its special design, the GEMÜ 9415 quarter turn actuator may likewise be combined with this type of position indicator.



	Combi switchbox	Electrical position indicators									
Device type	**4242**	**1215**	**1230**	**1231**	**1232**	**1201**	**1211**	**1214**	**1234**	**1235/ 1236**	**1242**
Valve stroke (in mm)	2 - 75		2 - 20	2 - 20	2 - 20	2 - 70	2 - 70	2 - 70	1 - 10	2 - 30 4 - 50 5 - 75	2 - 46
Electrical connection	M12	1)	1)	2)	1)	2)	2)	1)	M12	M12	M12
Programmable	●								●	●	●
With integrated pilot valve	●										
Ex design		● 3)		●			●				
NEC 500 version	●										●
Fieldbus interface	●								●		●
Mechanically adjustable switches			●	●	●	●	●	●			
Mechanically adjustable (microswitches)			●			●					
UL version	●		●								●
SIL version										●	
Optical position indicator (LEDs)	●		●		●			●	●	●	●
Optical position indicator (mechanical)	● 4)	●									
Feedback (OPEN and CLOSED)	●		●	●	●	●	●	●	●	●	●
Feedback (OPEN)		●									

[1] cable gland, M12 (optional)
[2] cable gland
[3] not with optional M12 plug
[4] for size 2 only

Combi switchboxes

Combi switchboxes with integrated pilot valve

In comparison to standard electrical position indicators these combi switchboxes have additional integrated pilot valves. The fully electronic version GEMÜ 4242 has an analogue travel sensor system and automatic initialisation by means of **speed**-AP function. The two Atex versions GEMÜ 4241 and GEMÜ 4216 have mechanically adjustable proximity switches. In all versions the pilot valve can be operated manually.

speed-AP - Speed Assembly and Programming
Particularly user-friendly fast assembly, adjustment and initialisation, of electrical position indicators, combi switch-boxes and positioners.

GEMÜ 4242

Features

- For linear actuators with 2 mm to 75 mm stroke
- Optical high visibility position and function indication via LEDs (colours can be inversed)
- Base aluminium anodised or stainless steel (size 1) or plastic (size 2)
- ***speed***-AP function for fast mounting and initialisation
- Adjustable switch point tolerances
- Extensive diagnostic facilities via IO-Link
- On-site or remote programming via programming input
- Fieldbus connection AS-Interface or DeviceNet
- M12 plug
- No need to open the housing for commissioning
- Compact design
- Protection class IP65, IP 67 (with piped air outlet)
- Ambient temperature 0 to 60 °C
- Integrated manual override

Size 1

Size 2

Combi switchboxes

Combi switchboxes for explosion-proof areas with integrated pilot valve

GEMÜ 4241

Features

- Can be retrofitted to GEMÜ valves or other makes
- Proximity switches individually continuously and precisely adjustable via threaded spindles
- Integrated, intrinsically safe pilot valve with 250 Nl/min. air output
- Suitable for single and double acting actuators
- ATEX zones:
  II 2G Ex ib IIB T4 Gb
  II 2D Ex ib IIIC T1
  20 °C Db, 0 °C ≤ Ta ≤ +50 °C

GEMÜ 4216

Features

- Can be retrofitted to GEMÜ valves or other makes
- Proximity switches individually continuously and precisely adjustable via threaded spindles
- Integrated, intrinsically safe pilot valve
- Suitable for single and double acting actuators
- ATEX zone:
  II 3G Ex ic IIB T4 Gc X
  -10°C ≤ Ta ≤ +50°C

GEMÜ 4241

GEMÜ 4216

Programmable electrical position indicators

Programmable electrical position indicators with automatic initialisation

This type of electrical position indicators considerably reduces commissioning times in a plant. The intelligent, microprocessor controlled ***speed***$^{\text{-AP}}$ function enables even large plants with several devices to be initialised and ready for operation in only a couple of minutes. The automated programming of switch points is either directly controlled on site or remotely controlled by means of a digital programming input.

GEMÜ 1235
IO-Link version
Version with high visibility LEDs for optical position indication, colours can be inversed

GEMÜ 1234, GEMÜ 1235/1236

Features

- Easy setting of switch points by automatic initialisation (***speed***$^{\text{-AP}}$ function)
- Adjustable switch point tolerances
- Tried and tested contactless Long-Life travel sensor
- Simple and fast mounting
- No need to open the housing cover for commissioning
- Suitable for single and double acting actuators
- Can be retrofitted to GEMÜ valves or other makes
- Optical position indication via LEDs
- Optical position indication via high visibility LEDs (GEMÜ 1235/1236)
- Communication interface IO-Link (GEMÜ 1235/1236)

GEMÜ 1234

GEMÜ 1234 with GEMÜ 605

GEMÜ 1236

GEMÜ 1236
with GEMÜ 550

Programmable electrical position indicators

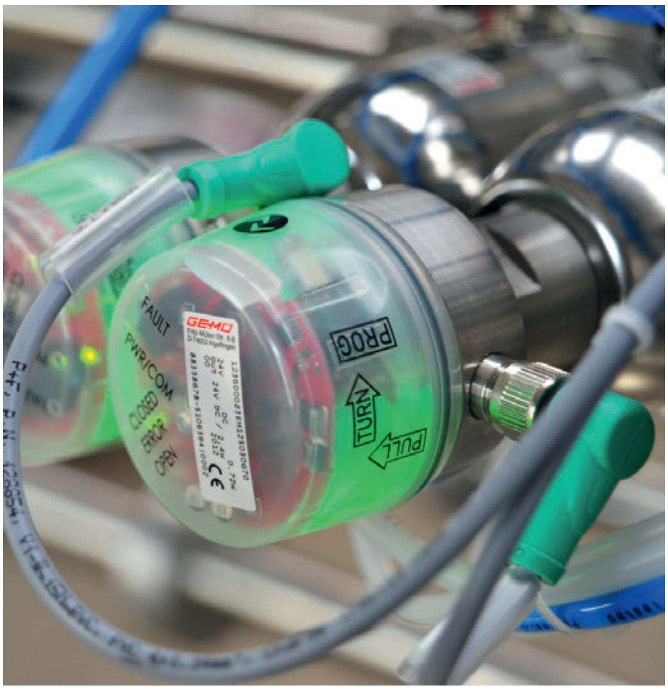
Functions of GEMÜ 1235/1236
IO-Link version

Features

- Feedback for position OPEN
- Feedback for position CLOSED
- End position programming
- Feedback for operating mode
- Setting for switch point OPEN
- Setting for switch point CLOSED
- Switching cycle counter
- Programming point OPEN
- Programming point CLOSED
- Last actual position OPEN
- Last actual position CLOSED
- Change-over of the LED signalling colour
- Change-over of the position feedback
- Deactivation of the high visibility LEDs
- Deactivation of the on-site programming
- Error feedback
  - Communication error
  - Programming error / No stroke
  - Programming error / Stroke < Minimum stroke
  - Programming error / Programming error after sensor error
  - Sensor error / OPEN position
  - Sensor error / CLOSED position

GEMÜ 1235
with GEMÜ R690

Safety Integrity Level
GEMÜ
SIL
IEC 61508 / IEC 61511



Position indicators with proximity switches

Contactless 3-wire proximity switches for end position detection

GEMÜ 1214

This electrical position indicator is suitable for linear actuators with up to 70 mm actuating travel. It has either one or two inductive proximity switches. An LED display can be integrated as an option.

Features

- Simple mounting and retrofitting to linear actuators
- Solid housing
- Protection class IP65
- Low-wear switch
- Contactless detection

GEMÜ 1232

The GEMÜ 1232 electrical position indicator is suitable for linear actuators with up to 20 mm actuating travel. It has either one or two proximity switches. An LED display can be integrated as an option.

Features

- Simple mounting and retrofitting to linear actuators
- Solid housing
- Protection class IP65
- Low-wear switch
- Contactless detection

GEMÜ 1214

GEMÜ 1232

Position indicators with microswitches

Position indicators with microswitches for end position detection, for linear valves

GEMÜ 1201

This electrical position indicator has either one or two mechanical microswitches. They are individually adjustable via a locking lever.

Features

- Simple mounting and retrofitting to linear actuators
- Solid housing
- Protection class IP65

GEMÜ 1230

The GEMÜ 1230 electrical position indicator is suitable for linear actuators with up to 20 mm actuating travel. It has either one or two microswitches. They are individually continuously adjustable via a threaded spindle. An LED display can be integrated as an option.

Features

- Simple mounting and retrofitting to linear actuators
- Solid housing
- Protection class IP65

GEMÜ 1201

GEMÜ 1230

Position indicators for explosion-proof areas

Position indicators for explosion-proof areasfor linear valves

GEMÜ 1205

The GEMÜ 1205 electrical position indicator is suitable for linear actuators with up to 70 mm actuating travel. It has electro-mechanical microswitches in a flameproof enclosure. Two valve positions, open and/or closed can be remotely indicated.

- ATEX zones:
  II 2G Ex db eb IIC T6 Gb
  II 2D Ex tb IIIC T80°C Db

GEMÜ 1205

GEMÜ 1231

Dieser elektrische Stellungsrückmelder ist für Linearantriebe bis 20 mm Betätigungsweg geeignet. Er besitzt wahlweise einen bzw. zwei induktive Näherungsschalter nach NAMUR.

- ATEX zones:
  II 2G Ex ib IIC/IIB T6 Gb
  II 2D Ex ib IIIC T 80°C Db
  -20°C ≤ Ta ≤ +60°C

GEMÜ 1231

GEMÜ 1211

The GEMÜ 1211 electrical position indicator is suitable for linear actuators with up to 70 mm actuating travel. It has either one or two inductive proximity switches to NAMUR.

- ATEX zones:
  II 2G Ex ib IIC/IIB T6 Gb
  II 2D Ex ib IIIC T 80°C Db
  -20°C ≤ Ta ≤ +60°C

GEMÜ 1211

GEMÜ 1215

The GEMÜ 1215 electrical position indicator indicates one position of the valve. It is designed so that it can be mounted to GEMÜ valves via a female thread in the actuator housing. In addition to electrical position indication an optical position indicator is also installed.

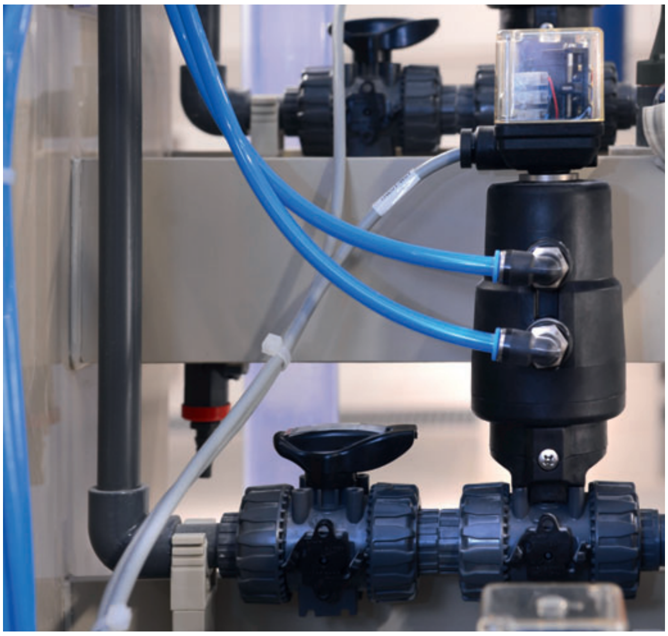
- ATEX zone:
  II 2G IIB T6 X

GEMÜ 1215

Combi switchboxes and electrical position indicators
for pneumatically operated quarter turn valves

Various electrical position indicators are available for ball valves and butterfly valves. These devices detect the valve position in any installation position without play and are tension-free. The position indicators can be quickly and easily assembled and are safe and uncomplicated to handle.

The special design of the GEMÜ 9415 quarter turn actuator enables its combination with electrical position indicators for linear actuators.



Butterfly valve GEMÜ 481 with GEMÜ 1235 electrical position indicator

Device type	4221* (end-of-series item)	LSF	LSC	1225
Travel range	0 - 90°	0° / 90°	0 - 90°	0 - 90°
Connection	M12 x 1 5-pin	M12 x 1 4-pin	M20 x 1.5	PG 13.5
Programmable	●			
With integrated pilot valve	●			
Ex design		●	●	
IEC version			●	
Fieldbus interface	●		●	
Mechanically adjustable switches			●	●
UL version			●	●
SIL version			●	
Optical position indicator (mechanical)		●	●	●
Feedback (OPEN and CLOSED)	●	●	●	●

* Combi switchbox

Combi switchboxes

GEMÜ 4242

Features

- For 0-90° quarter turn actuators
- Optical high visibility position and function indication via LEDs (colours can be inversed)
- Base aluminium anodised or stainless steel (size 1) or plastic (size 2)
- ***speed***-AP function for fast mounting and initialisation
- Adjustable switch point tolerances
- Extensive diagnostic facilities via IO-Link
- On-site or remote programming via programming input
- Fieldbus connection AS-Interface or DeviceNet
- M12 plug
- No need to open the housing for commissioning
- Compact design
- Protection class IP65, IP 67 (with piped air outlet)
- Ambient temperature 0 to 60 °C
- Integrated manual override

GEMÜ 481 butterfly valve with
4242 combi switchbox (size 1+2)

Inductive double sensor

Contactless 2-wire NAMUR and 3-wire proximity switches for end position detection, for quarter turn valves

GEMÜ 481 butterfly valve with LSF proximity switch

GEMÜ 487 butterfly valve with LSF proximity switch

GEMÜ 487 butterfly valve with LSF proximity switch

Device type	LSF switch code 206	LSF switch code 312	LSF switch code 316
Switch	P+F, NCN3-F25F-N4-V1 2-wire NAMUR	P+F, NBN3-F25F-E8-V1 3-wire, make contact, PNP	IFM, IN 5225 3-wire, make contact, PNP
Rated voltage	8.2 V DC	10 – 30 V DC	10 – 36 V DC
Output current	≥3mA undamped, ≤ damped	Max. 200 mA	Max. 250 mA
Protection class	IP 67	IP 67	IP 67
Temperature range	-25 to 100 °C	-25 to 70 °C	-25 to 80 °C
Angle of rotation	0° to 90°	0° to 90°	0° to 90°
Housing material	PBT	PBT	PBT
Connection	4-pin M12 connector	4-pin M12 connector	4-pin M12 connector

Limit switch box

Position indicators with microswitches and inductive proximity switches for end position detection, for quarter turn valves

GEMÜ LSC

The GEMÜ LSC electrical position indicator is suitable for GEMÜ DR/SC and GEMÜ ADA/ASR single or double acting pneumatic actuators and for other makes.

The GEMÜ LSC limit switch box is suitable for mounting to manually and pneumatically operated quarter turn actuators. Using the integrated mechanical system, the valve position can be reliably detected and indicated accordingly via an optical indicator.

Features

- Ambient temperature: -25 to 80 °C
- Switching range: 0 to 90°
- Protection class: IP 67
- Switch types: Microswitch / 2-wire proximity switch / 3-wire proximity switch
- Electrical connection type:M20 cable gland / M12 plug | NPT threaded connection
- ATEX zones:
  II 2G Ex ia IIB T6 Gb
  II 2D Ex ia IIIC T80 °C Db
  -25°C < Ta < +70°C

  II 2G Ex de IIC T6 Gb
  II 2D Ex t IIIC T80°C Db
  -20°C < Ta < +40°C

GEMÜ 1225

The GEMÜ 1225 electrical position indicator is suitable for GEMÜ 410 to 428 plastic or metal butterfly valves. The range of butterfly valves are manual, pneumatic or motorized depending on the type.

Features

- Easy setting of the trip cams
- Additional indication of the switch position via colour LEDs

GEMÜ 1225

Basic terms of control technology

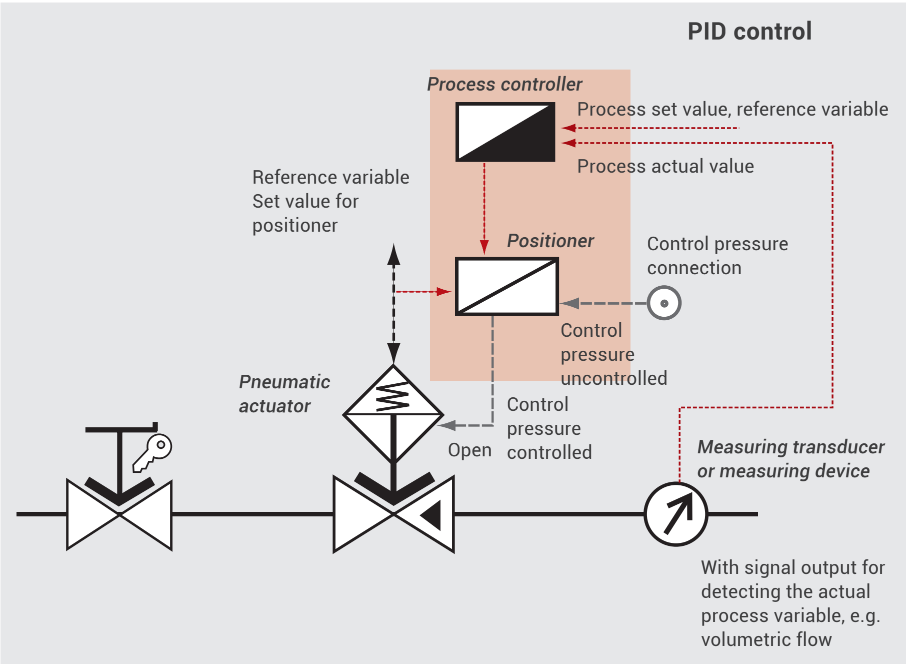
According to DIN 19226, control or controlling is a process in which the variable to be controlled is continuously measured, compared with the command variable and influenced in the sense of adjustment to the command variable. Typical for the control is the closed action circuit in which the controlled variable influences itself continuously within the control circuit.
The right design of the control circuit is necessary for good, reliable functionality. The valve and the control or regulating device must be closely adapted to each other.

The control is characterised by:

- Type of control/regulation
- Accuracy of the control
- Controlled system and its influential factors
- Controller type (2-point, 3-point, P, PI, PD, PID etc.)
- Control task (pressure, temperature, filling level, flow, pH value etc.)
- Control range of the valve (Kv value)

Electro-pneumatic process control

Positioners and process controllers exist as single and "2 in 1" devices. If the travel is measured mechanically, the positioner must be mounted directly on the valve. Using an electronic travel detector, the positioner can be positioned remotely from the actuator.



The example shows a diaphragm valve with a pneumatic membrane actuator in control function "normally closed" (single acting) and a manually operated/lockable diaphragm valve.
In the regulation of volume/mass flow, the measuring element (actual value transmitter) should be positioned before the valve.
In this way the volume flow on the measuring instrument is damped so that the control does not experience sudden measuring step jumps.
The actual value transmitter must be positioned after the valve in pressure and temperature controls.

Open loop control

Control is to be understood as a process in which one or more process variables are influenced by one or more input variables of a system. The momentary state of the system is not normally taken into account. A control is an open action circuit without an automatic set-actual comparison. Faults are not detected by the system.
Example: To fill a container with a constant drain, a valve with its actuator, is opened. The filling level and the filling speed can be influenced by the position of the valve. When the desired filling level has been reached or the filling speed is to be changed, the valve must be actuated again. By monitoring the process over a certain period of time and repeatedly readjusting the valve position, it will be possible to keep the filling level constant after a certain time. However, this example works only if the process does not change.

Closed loop control

In a closed loop the actual value and the controlled variable of a system is measured continuously and compared with the set value, the reference variable. The difference between these two variables is the control difference or the control error. Depending on the measured difference, a positioning process is initiated to adapt the control difference to the command variable. Regulation is therefore a closed loop process.

Discontinuous control

A process which takes place step by step is known as discontinuous control. The correcting variable on the controller jumps back and forth between discrete values. Depending on how many states the correcting variable can adopt, it refers to two, three or multi-point controllers. A two-point controller only has 2 switching states, "OPEN" and "CLOSED". Due to the erratic switching of the controller, the controlled variable fluctuates within a certain range around the set value. By installing energy stores and correct setting of time constants, the controlled variable can be kept constant without too great a fluctuation even in discontinuous control. However, this also strongly depends on the controlled system to be designed, any disturbance variables and the selection of the actuators and sensors. The fluctuation width of the controlled variable depends on different factors (e.g. reaction time of the control circuit, characteristic of the valve).

Continuous control

Continuous controllers intervene continuously in the process and influence the actuator accordingly. The positioning process runs permanently. The correcting variable of the controller can adopt any value within the given fluctuation width.
A sensor measures the process variable continuously and passes on the signal to the controller. This compares it with the set value and influences the valve position accordingly.

Basic terms of control technology

Position control/positioner

In position control, the positioner only influences the actuator, e.g. the position of the valve. The sensor reports the controlled variable to a PLC. This compares it with the command variable, calculates the control difference and passes on an appropriate correcting variable to the positioner. This responds accordingly and changes the position of the valve. This variant for controlling valves is selected when a master control is available.

Process control/process controller

In a process controller, the controlled variable is reported directly to the controller which is installed locally at the valve or in a local control cabinet for example. This unites the functions of PLC and positioner. It calculates the controlled variable and passes on an appropriate signal to the valve. Modern process controllers can be set both on site on the system and by a PLC.

The design of a control circuit, the corresponding system layout and the selection of all the necessary components also depends on the control accuracy being aimed at. The narrower the tolerances of the control the more precisely the components operate and the higher the reproducibility has to be. Narrow tolerances for a control mean that the valve must be selected and designed very carefully:

- Exact calculation of the necessary minimum and maximum Kv value
- Design of the valve and the control fitting to this optimum control range
- Jolt-free actuator without slipping-sticking effect
- Long stroke distance at simultaneously low cross-sectional increase at the valve seat
- The valve should only be used for controlling, a stop function (close-tight) should be covered by an additional on/off valve
- Selection of the right controller type and controller
- Exact determination of positioner and valve

The greater the accuracy of the control, the higher the costs for the components and commissioning as a rule. Under certain process conditions, high-precision controls can only be implemented after substantial effort. For this reason, you should consider very carefully in advance planning how accurate the control must be.

Controlled variable x (actual value):
The variable to be controlled in a process is referred to as x. Controlled variables in plant construction are, for example, temperature, pressure, flow, pH value, hardness.

Command variable w (set value):
The command variable indicates the value which the process variable should adopt. Its value in the form of an electrical variable (current or voltage), for example, is compared with the controlled variable x.

Control difference e = w-x
The control difference is the difference between the controlled variable and the command variable. It is the input variable for the controlled element. The control error is exactly the same size as the control difference but with the inverse sign.

Correcting variable y
The correcting variable is the output variable of the controller and has a direct influence on the actuator. It depends on the control parameters of the controller and the control error.

Disturbance variable z
Factors which have an undesirable influence on a process and therefore change the controlled variables are referred to as disturbance variables.

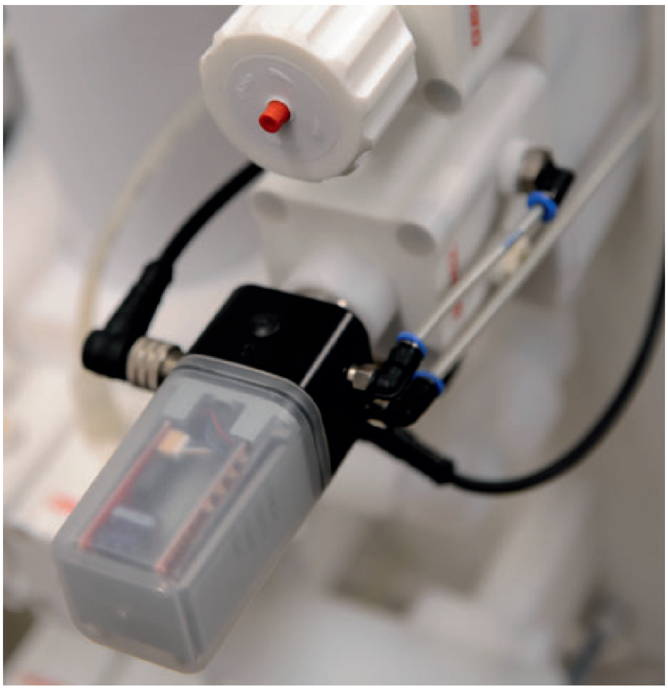
Positioning range yh
The correcting variable y of a controller is within the positioning range. This can be defined accordingly depending on the controller used.

Positioning element
The positioning element influences the process to match the controlled variable to the command variable. Positioning elements in plant construction are, for example, valves, pumps, heat transfer elements.

Controlled element
The controlled element creates the correcting variable from the control difference. The controlled element is part of the controller.

Dead zone
If a controlled variable only reacts to the changes at the actuator after a certain time, we refer to controlled systems with dead zone. Examples of such controlled systems are the pressure control of compressible media or the continuing flow of a medium from a pipe into a container after a valve has been closed.

Energy store
Control processes may run with delays due to the energy stores occurring in every controlled system. This is clearly seen in heating processes. Pipes, containers and valves have to also achieve a temperature increase. At the same time, the energy loss to the environment increases with rising Δt. Energy stores have a damping effect on the temperature rise in the system in this case.



Basic terms of control technology

Controlled systems are basically characterised by their time behaviour. This determines the effort and the accuracy with which a control task can be solved. The jump response of the controlled system is used to represent this system dynamic. The jump response shows how the controlled variable reacts to changes in the correcting variable. Controlled systems are divided into four basic types by their timing. At the same time, a distinction must be made between systems with compensation and systems without compensation. In systems with compensation a new final value is set whilst systems without compensation do not achieve a new balanced state.

P controlled systems

In P controlled systems, the controlled variable always changes proportionally to the correcting variable. Adaptation takes place without a time delay.

I controlled systems

An I controlled system exhibits an integral behaviour and has no compensation. The controlled system does not achieve a balanced state if the correcting variable is not zero. The correcting variable changes continuously so that the controlled variable rises or falls permanently.

Systems with dead zone

In controlled systems with dead zone, the controlled variable only reacts to the positioning intervention after a certain delay. This frequently leads to oscillations, especially when the controlled variable and the correcting variable change periodically in relation to each other and offset to the dead zone. Dead zones are usually caused by the process or the system design (lead times, lag times, positioning of the sensor, controller and actuator etc.). Many of these influential variables can be optimised by appropriate system planning for control-technical requirements. Everything else must be influenced by an appropriate design of the control circuit.

Systems with energy stores

Control processes may run with delays due to the use of energy stores occurring in every controlled system. This is clearly seen in heating processes. Pipes, containers and valves have to also achieve a temperature increase. At the same time, the energy loss to the environment increases with rising Δt. Energy stores have a damping effect on the temperature change in this case. Compensation vessels and air dampers in hydraulic systems, for example, have the same effect, they delay the change in pressure.
Whether and to what extent the energy stores influence the control dynamic is different in every system. It may be ignored in the design of the control circuit depending on the influence on the control circuit.
Complex controlled systems are usually a mixture of the four above basic types with and without compensation. For this reason the most common controllers are also combinations of the types described above.

Controller selection and controller design

It is important to conduct an exact analysis of the system to design the control circuit. Make sure that valves are only assigned one function in a control circuit to guarantee perfect design and operation. The selection of the controller depends on the controlled system (integral or proportional), the delays and energy stores, the desired speed of the control and whether a remaining control error is acceptable.

The following brief characteristics can be used as a rough guideline:

- P controllers are used in easy to control systems in which a remaining control difference is acceptable.
- I controllers are suitable for systems with a low control dynamic. The systems should not contain any long delays.
- PD controllers are suitable for systems with large delays in which a remaining control error is not a problem.
- PI controllers achieve a dynamic control behaviour. They can also be used for systems with delays.
- PID controllers are always used when the operating time of a PI controller is insufficient in systems with longer delays. PID controllers are the fastest and most accurate controllers for complex control tasks.

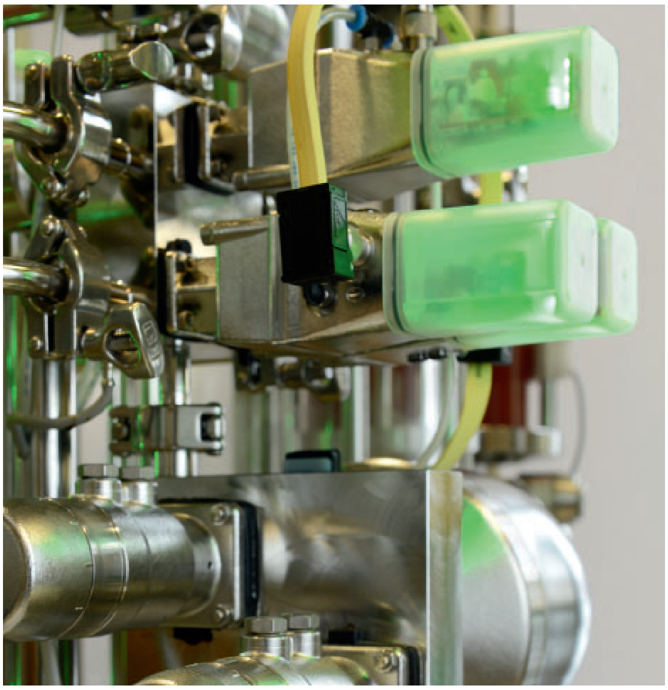
Controlled element	Control error	Actuating speed
P	permanent	fast
I	idle	slow
PD	permanent	very fast
PI	idle	fast
PID	idle	very fast

Control tasks

The following table gives you an initial idea of which controls are to be preferred for different applications. It is only a rough guide, every controlled system must be designed to meet the requirements of the actual plant.

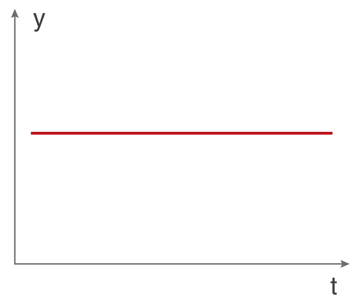
Application	Controller type		
	P	PI	PID
Pressure	●	+	+
Flow	-	+	●
Filling level	+	-	-
Temperature	●	+	+
pH value	●	+	+

- unsuitable
● only conditionally suitable
+ suitable

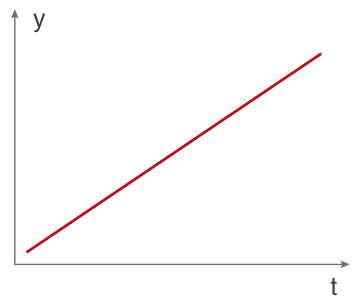


Basic terms of control technology

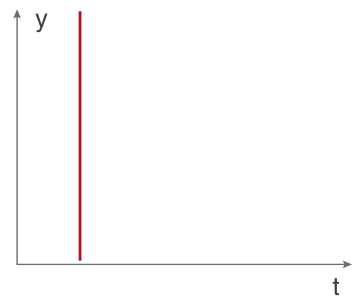
P controller
A P controller is a proportionally acting controller. The initial variable (correcting variable y) is always proportional to the control difference. P controllers respond very quickly and have an immediate positioning effect but they have a permanent control difference between the command variable and the controlled variable.
The proportional action factor Kp to be set on the controller influences the reaction of the controller to a control error. A large Kp leads to a stronger control intervention and lower control errors. Too high a proportional action factor can, however, lead to oscillations.



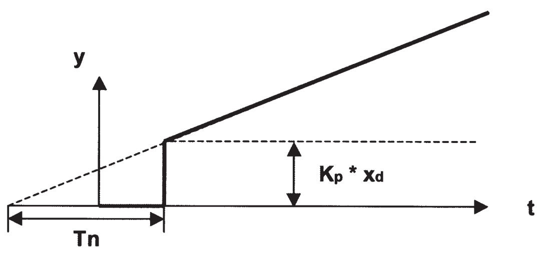
I controllers
I controllers are integrally acting controllers. A proportional relation exists between control error and actuating speed. I controllers are slower than P controllers but eliminate the control difference completely. The I component in a controller therefore leads to an increase in the accuracy. The speed of the controller depends on the integral action time Tn. The greater the integral action time, the slower the controller responds. This is because the correcting variable y only rises slowly. If too small an integral action time Tn is selected so that the controller reaches the given command variable faster, oscillations may occur.



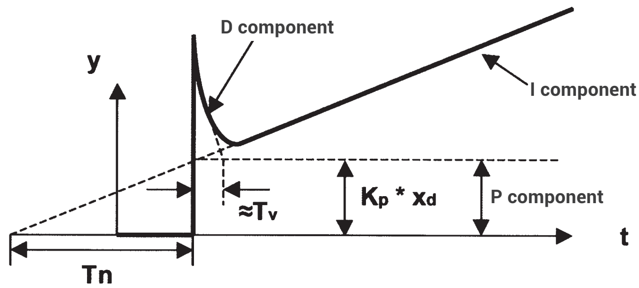
D controllers
D controllers are controllers with a differentiating action. D controllers only affect the speed with which the control difference changes. They therefore react very quickly independently of the control difference. High positioning amplitudes are achieved even at low control difference. It does not recognise a constant control error. D controllers are only used in practice in connection with P and I controllers.



PI controllers
A P and an I controller are connected in parallel in a PI controller. It reacts very quickly and leads to a full control without remaining control error. The control behaviour is influenced by the proportional action factor Kp and the integral action time Tn. PI controllers are very variable in their control.



PID controllers
In the PID controller, a D component is connected to the PI controller. This leads to a faster control transient, i.e. reaching the idle state. PID controllers are particularly suitable for controlled systems with large energy stores i.e. for higher order systems.



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