Series 6495
TROVIS 6495-2 Industrial Controller

SAMSON

Configuration Manual

KH 6495-2 EN

Firmware version 1.11 to 1.21

Edition October 2015

TROVIS®
Electronics from SAMSON

Notes concerning this Configuration Manual

Documentation

The documentation for the TROVIS 6495-2 Industrial Controller is divided into two parts:

- Mounting and Operating Instructions EB 6495-2
- Configuration Manual KH 6495-2

This Configuration Manual KH 6495-2 is intended for qualified staff with experience in the field of control engineering. Control options determined by selecting configuration items and parameters are described in detail.
This Manual requires users to be familiar with the operation the controller, i.e. users must already know how to select and change configuration items and parameters. If necessary, refer to B 6495-2. This describes the mechanical installation, electrical wiring and operation of the controller.

Configuration

The controller is configured using configuration items and parameters required for configuration in the configuration level.

The configuration level consists of the following menus:

- Control mode M
- Input I
- Controller C
- Output O
- Communication D
- General settings A

The menus contain submenus in which the configuration items and parameters can be found. Each configuration item has several settings available for selection to adapt the configuration to user requirements.

Configuration items are marked at the top right of the display with CO and parameters with PA.

Specifications in the configuration tables

- Some functions and parameters can only be selected after certain initial settings have been made beforehand. The initial setting required is specified in angle brackets in the configuration tables. A comma represents "and" and a slash represents "or" in the following list.
  Example `<M.1-5/-6, I.3.5≠0>`:
  Either the configuration `M.1-5` and `I.3.5≠0` or the configuration `M.1-6` and `I.3.5≠0` must initially be set.
- The default setting of configuration items and parameters are written in **bold** in the configuration tables.

Abbreviations used

AI	Analog input
AO	Analog output
DI	Digital input
DO	Digital output
DV	Auxiliary variable, disturbance variable or leading process variable in ratio control
e	Error signal
FB	Position feedback
KP	Proportional-action coefficient
PV	Process variable (controlled variable)
PV0	Process variable at comparator
PVR	Process variable ratio
PWM	Pulse width modulation
SO	Switch output
SP	Set point
SP1...4	Set point 1...4
SPI	Internal set point
SP0	Set point at comparator
SPC	Set point via interface
SPE	External set point, auxiliary variable, disturbance variable
SPM	Set point of slave (follower) controller (cascade control)
SPR	Set point ratio
TN	Reset time
TR	Input variable for output tracking, auxiliary variable, disturbance variable
TV	Derivative-action time
TV.K	Derivative-action gain
Y	Manipulated variable
Y0	Operating point
YM	Output variable of master controller (cascade control)

Contents

M Control mode

The selection of the control mode determines the basic structure, e.g. fixed set point/follow-up control, in the controller.

NOTICE
The control mode must always be set right at the beginning since all configuration items and parameters are reset to their default settings after changing the control mode.

The TROVIS 6495-2 Industrial Controller supports the following control modes:

- M.1-1 1x fixed set point/follow-up control
- M.1-2 Ratio control
- M.1-3 Cascade control
- M.1-4 Override control
- M.1-5 2x fixed set point/follow-up control
- M.1-6 Ratio control and fixed set point/follow-up control

The control modes are described in following. In all control modes, the disturbance and auxiliary variables can be processed, see menu item C.3.2.

M.1	Control mode
-1	1x fixed set point/follow-up control
-2	Ratio control
-3	Cascade control
-4	Override control
-5	2x fixed set point/follow-up control
-6	Ratio control + Controller

Set point adjustment

The controller works using the **internal set point SP1** by default. Alternatively, three other internal set points (SP2, SP3, SP4) can be used for the control loop. Switchover between internal set points can be performed either in the operating menu or over the digital inputs.

- Switchover between internal set points in operating menu, refer to EB 6495-2
- Switchover between internal set points over a digital input, see menu item C.2.2.1

Operation with an **external set point** can be performed using an analog input, using an analog input assigned to one of the optional interfaces or over the optional interface as a digital value, see menu item C.2.1.2.

The switchover between an internal set point and an external set point can be performed in the operating menu or using a digital input.

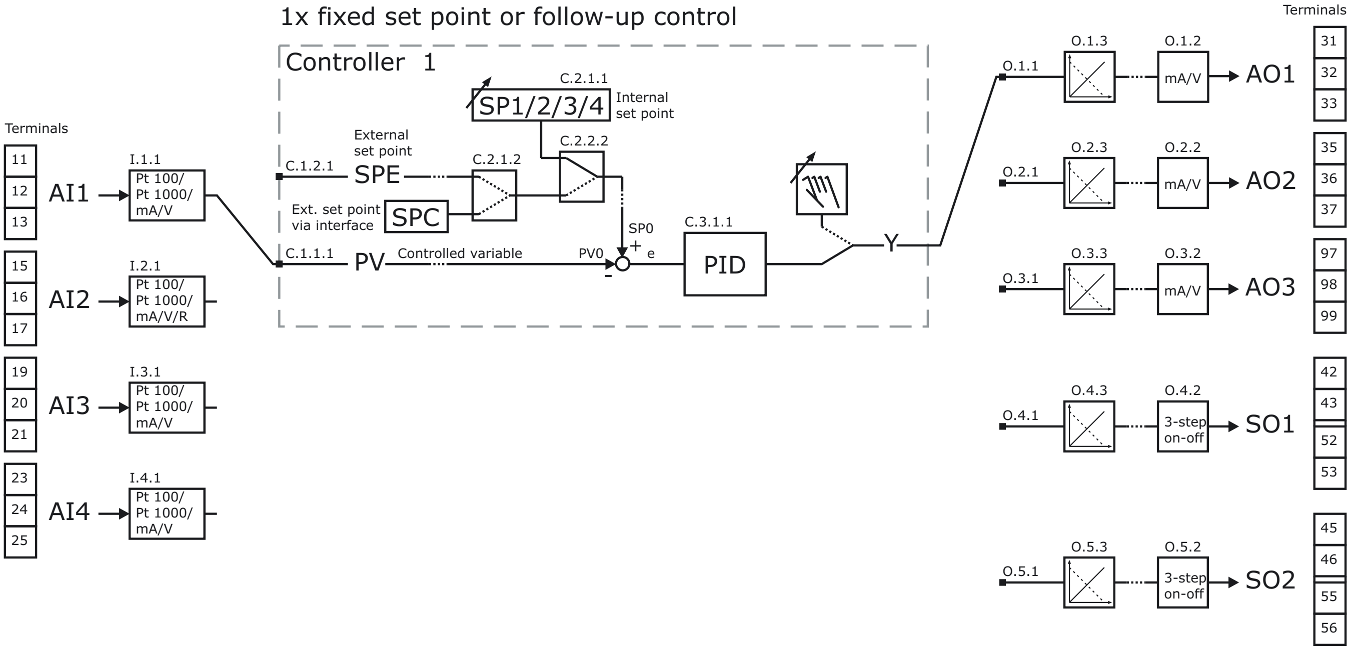
- Switchover between internal/external set point in operating menu, refer to EB 6495-2
- Switchover between internal/external set point over a digital input, see menu item C.2.2.2

Manual/automatic switchover

The controller can be switched over to manual mode by pressing the manual/automatic key, or by a digital input or due to a signal error at the analog input.

- Switchover to manual mode in the operating level (manual/automatic key), refer to EB 6495-2
- Switchover to manual mode using a digital input, see menu item C.3.3.1
- Switchover to manual mode due to a signal error at the analog input AI1/AI2/AI3/AI4, see menu item I.1.6...I.4.6
- Switchover to manual mode due to signal error SPC, see menu item C.2.1.7

M.1-1
1x fixed set point or follow-up control



M.1-1 1x fixed set point/follow-up control

- Simplified block diagram (page 10)
- Detailed block diagram (page 17)

Mode of operation

The controller [1] works as a fixed set point or slave (follower) controller. The operating keys and display on the left-hand side are used.

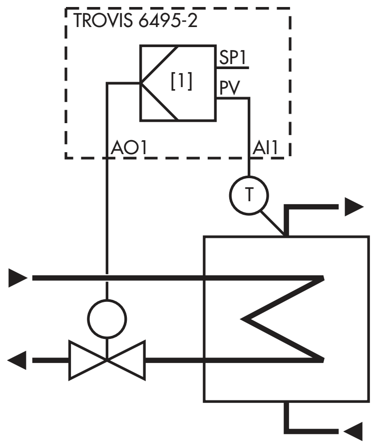
For fixed set point control, the internal set point (reference variable) is adjusted using the keys. For the follow-up control, the external set point is provided over an input or over the interface.

The block diagram on page 10 shows the control mode in the default setting as fixed set point control.

Controller [1] logs the process variable PV at input AI1 and issues the manipulated variable at output AO1.

Example 1: Flow temperature control of a heat exchanger

The temperature controller [1] receives the flow temperature T in the secondary circuit at input AI1 from a resistance thermometer Pt 100 and positions the control valve in the primary circuit by issuing a 4-20 mA signal at the output AO1 to keep the flow temperature constant at 50 °C.



For this fixed set point control, the following configuration procedure needs to be performed (configuration settings marked with an asterisk * are the same as the standard configuration for fixed set point/follow-up control and the default settings):

1.	Position both DIP switches for analog input AI1 to Pt 100 (left).		
2.	Switch on power supply.		
3.	Set control mode (1x fixed set point/follow-up control).	M.1-1	*

Set input:

4.	Set input signal (Pt 100) and measuring range (0 to 100 °C) at analog input AI1.	I.1.1-6 AI1.MIN = 0 °C AI1.MAX = 100 °C	* * *

Set controller [1]:

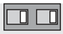
5.	Assign analog input AI1 as the source for input variable PV (process variable).	1C.1.1.1-1	*
6.	Set internal set point SP1 (number of internal set points = 1, SP1 = 50 °C).	1C.2.1.1-1 SP1 = 50 °C	*
7.	Set control algorithm (PI) and control parameter (KP = 1.00 and TN = 120 s).	1C.3.1.1-1 KP = 1.00 TN = 120 s	* * *
8.	Determine restart condition (operation mode after restart = Auto).	1C.4.1-0	*

Set output:

9.	Assign Controller [1] output Y as the source for analog output AO1.	O.1.1-1	*
10.	Set output signal (4 to 20 mA) for analog output AO1.	O.1.2-1	*
11.	Determine operating direction (increasing) for analog output AO1.	O.1.3-1	*

Examples of varying settings

- **Specify external set point SPE over analog input AI2**

After step 1: Position both DIP switches for analog input AI2 to mA (right).	
After step 4: Set input signal (4 to 20 mA) and measuring range (0 to 100 °C) for the external set point at analog input AI2.	I.2.1-1 AI2.MIN = 0 °C * AI2.MAX = 100 °C *
Determine physical unit (°C) at analog input AI2.	I.2.3-1
After step 5: Assign analog input AI2 as the source for input variable SPE (external set point).	1C.1.2.1-2
After step 6: Assign input variable SPE as the source for external set point.	1C.2.1.2-1

- **Determine three-point stepping output**

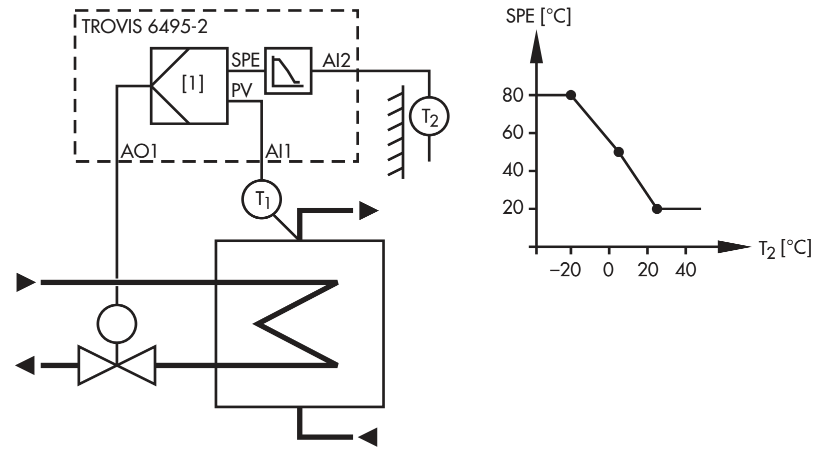
Instead of steps 9 to 11: Assign Controller [1] output Y as the source for switch output SO1.	O.4.1-1
Set three-point stepping signal as output signal for switch output SO1.	O.4.2-1
Determine transit time (time to move through rated range, SO1.TY = 60 s), dead zone (SO1.TZ = 2.0 %) and increment (SO1.SW = 1).	SO1.TY = 60 s * SO1.TZ = 2.0 % * SO1.SW = 1 *
Determine operating direction (increasing) for switch output SO1.	O.4.3-1

Example 2: Outdoor-temperature-compensated temperature control of a heat exchanger

The temperature controller [1] receives the flow temperature T_1 in the secondary circuit at input AI1 from a resistance thermometer Pt 100 and positions the control valve in the primary circuit by issuing a 4-20 mA signal at the output AO1 to keep the flow temperature constant.

For the outdoor-temperature-compensated control, the set point is specified by the outdoor temperature. For this purpose, a resistance thermometer Pt 100 at input AI2 measures the outdoor temperature T_2 and is assigned to the input variable SPE. The function generation of the input variable SPE is used to calculate the set point for the flow temperature based on the outdoor temperature.

Correlation between the outdoor temperature T_2 and the set point for flow temperature T_1								
Outdoor temperature T_2	°C	–20.0	5.0	25.0	25.0	25.0	25.0	25.0
Set point for T_1	°C	80.0	50.0	20.0	20.0	20.0	20.0	20.0



For this follow-up control, the following configuration procedure needs to be performed (configuration settings marked with an asterisk * are the same as the standard configuration for fixed set point/follow-up control and the default settings):

1.	Position both DIP switches for analog input AI1 and analog input AI2 to Pt 100 (left).	
2.	Switch on power supply.	
3.	Set control mode (1x fixed set point/follow-up control).	M.1-1 *

Set input:

4.	Set input signal (Pt 100) and measuring range (0 to 100 °C) at analog input AI1.	I.1.1-6 * AI1.MIN = 0 °C * AI1.MAX = 100 °C *
5.	Set input signal (Pt 100) and measuring range (–20 to 50 °C) at analog input AI2.	I.2.1-6 AI2.MIN = –20 °C AI2.MAX = 50 °C *

Set Controller [1]:

6.	Assign analog input AI1 as the source for input variable PV (process variable).	1C.1.1.1-1 *
7.	Assign analog input AI2 as the source for input variable SPE (external set point).	1C.1.2.1-2
8.	Perform function generation on input variable SPE: Lower range value output function generation: SPE.MIN = 0.0 °C Upper range value output function generation: SPE.MAX = 100.0 °C Input values SPE.I1 to SPE.I7 and output values SPE.O1 to SPE.O7 (see table below)	1C.1.2.4-1 SPE.MIN = 0.0 °C * SPE.MAX = 100.0 °C * SPE.I1 = –20.0 °C SPE.O1= 80.0 °C SPE.I2 = 5.0 °C SPE.O2= 50.0 °C SPE.I3 = 25.0 °C SPE.O3= 20.0 °C SPE.I4 = 25.0 °C SPE.O4= 20.0 °C SPE.I5 = 25.0 °C SPE.O5= 20.0 °C SPE.I6 = 25.0 °C SPE.O6= 20.0 °C SPE.I7 = 25.0 °C SPE.O7= 20.0 °C
9.	Assign input variable SPE as the source for external set point.	1C.2.1.2-1

		1	2	3	4	5	6	7
SPE.I	°C	–20.0	5.0	25.0	25.0	25.0	25.0	25.0
SPE.O	°C	80.0	50.0	20.0	20.0	20.0	20.0	20.0

10.	Set control algorithm (PI) and control parameter (KP = 1.00 and TN = 120 s).	1C.3.1.1-1 KP = 1.00 TN = 120 s	* * *
11.	Determine restart condition (operation mode after restart = Auto).	1C.4.1-0	*

Set output:

12.	Assign Controller [1] output Y as the source for analog output AO1.	O.1.1-1	*
13.	Set output signal (4 to 20 mA) for analog output AO1.	O.1.2-1	*
14.	Determine operating direction (increasing) for analog output AO1.	O.1.3-1	*

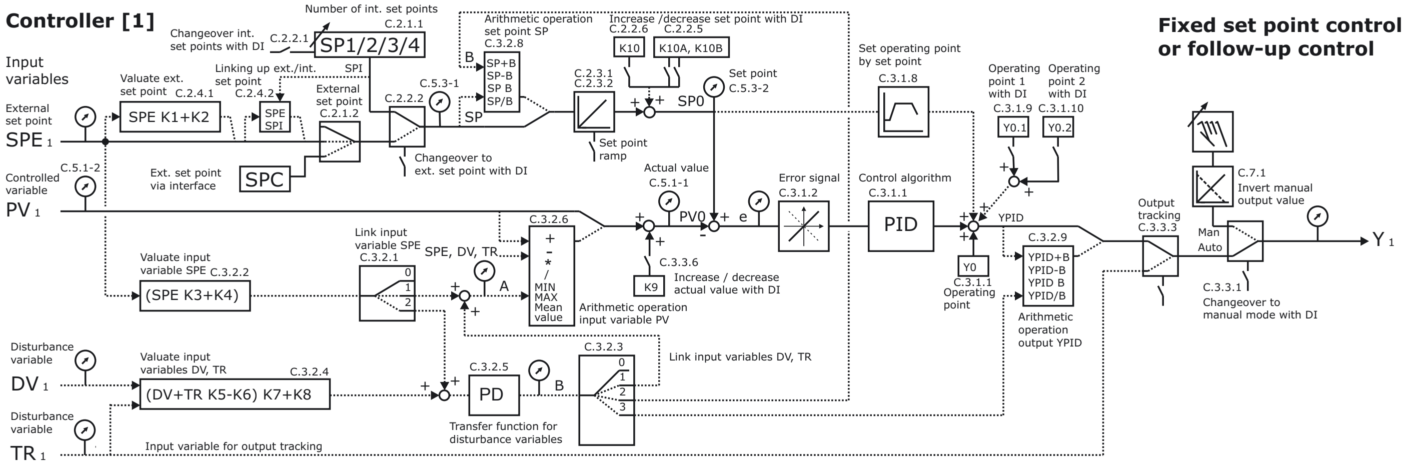
Feedforward control

Block diagram (page 17)

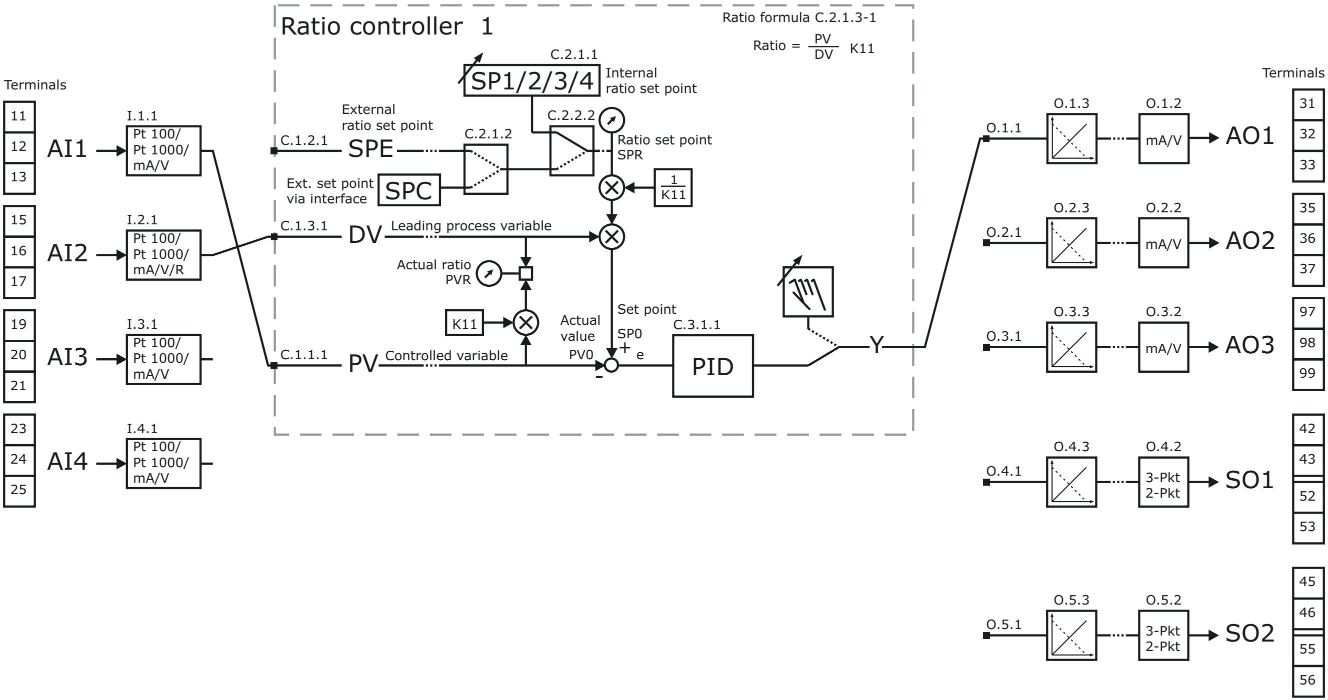
Multi-component control or feedforward control can be implemented by linking the input variables SPE, DV and TR to the input PV, to the set point SP and to the output YPID. Possible interconnections are described in menu item C.3.2.

Controller [1]

Fixed set point control or follow-up control



M.1-2
Ratio control



M.1-2 Ratio control

- Simplified block diagram (page 18)
- Detailed block diagram (pages 22 and 24)

Mode of operation

Ratio control is used when two or more components are to be mixed at a fixed ratio. Typical applications include the carbonation of beverages, the setting of the fat percentage in dairy products by filtration and the combustion ratio of a fuel/air mixture.

The controller [1] works as a ratio controller. The operating keys and display on the left-hand side are used.

The block diagram on page 18 shows the control mode in the default setting.

Controller [1] logs the process variable PV [1] at input AI1 and the leading process variable DV [1] at the input AI2 and issues the manipulated variable at output AO1.

Ratio formula

The ratio controller controls the ratio between the input variables PV, DV and TR. A ratio formula can be selected from the various ratio formulas available in C.2.1.3.

The following ratio formula is set for this control mode by default (C.2.1.3-1):

$$\text{Ratio} = \frac{\text{Flow 1}}{\text{Flow 2}} \quad \Rightarrow \quad \text{PVR} = \frac{\text{PV}}{\text{DV}} * \text{K11}$$

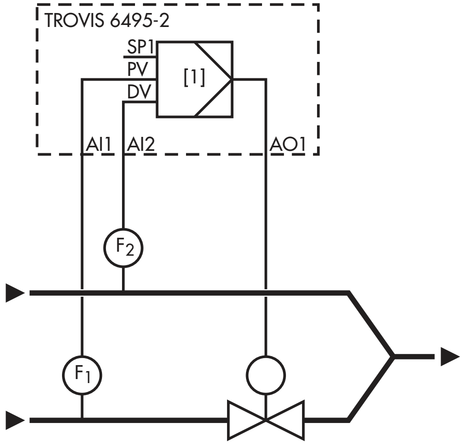
- Select ratio formula, see menu item C.2.1.3

Example: Control of the mixing ratio of two components

The ratio controller [1] receives the flows F_1 und F_2 as 4 to 20 mA signals from two transmitters (Media 6) and positions the control valve for flow F_1 by issuing a 4 to 20 mA signal at output AO1 to maintain flow rate F_1 at a ratio of 5 % to flow F_2.
Each time flow F_2 (leading process variable DV) changes, the flow F_1 (process variable PV) is adapted to meet the fixed target ratio. The target ratio F_1/F_2 is set with SP1 to 5 %.

Flow transmitter F_1: Measuring range 0 to 10 m^3/h

Flow transmitter F_2: Measuring range 0 to 200 m^3/h



For this ratio control of the mixer, the following configuration needs to be performed (configuration settings marked with an asterisk * are the same as the standard configuration for ratio control):

1.	Position both DIP switches for analog input AI1 and analog input AI2 to mA (right).	
2.	Switch on power supply.	
3.	Set control mode (ratio control).	M.1-2

Set input:

4.	Set input signal (4 to 20 mA) and measuring range (0 to 10 m³/h) at analog input AI1.	I.1.1-1 AI1.MIN = 0 m³/h * AI1.MAX = 10 m³/h
5.	Determine physical unit (m³/h) at analog input AI1.	I.1.3-8
6.	Set input signal (4 to 20 mA) and measuring range (0 to 200 m³/h) at analog input AI2.	I.2.1-1 * AI1.MIN = 0 m³/h * AI1.MAX = 200 m³/h
7.	Determine physical unit (m³/h) at analog input AI2.	I.2.3-8

Set ratio controller [1]:

8.	Assign analog input AI1 as the source for input variable PV (process variable).	1C.1.1.1-1	*
9.	Assign analog input AI2 as the source for input variable DV (leading process variable).	1C.1.3.1-2	*
10.	Set ratio set point (number of internal set points = 1, SP1 = 5.0 %).	1C.2.1.1-1 SP1 = 5.0 %	*
11.	Enter the ratio formula ($\frac{PV}{DV}$ ∗K11 and K11 = 100.0).	1C.2.1.3-1 K11 = 100.0	* *
12.	Set control algorithm (PI) and control parameters (KP = 2.00 and TN = 10 s).	1C.3.1.1-1 KP = 2.00 TN = 10 s	* * *
13.	Determine restart condition (operation mode after restart = Auto).	1C.4.1-0	*

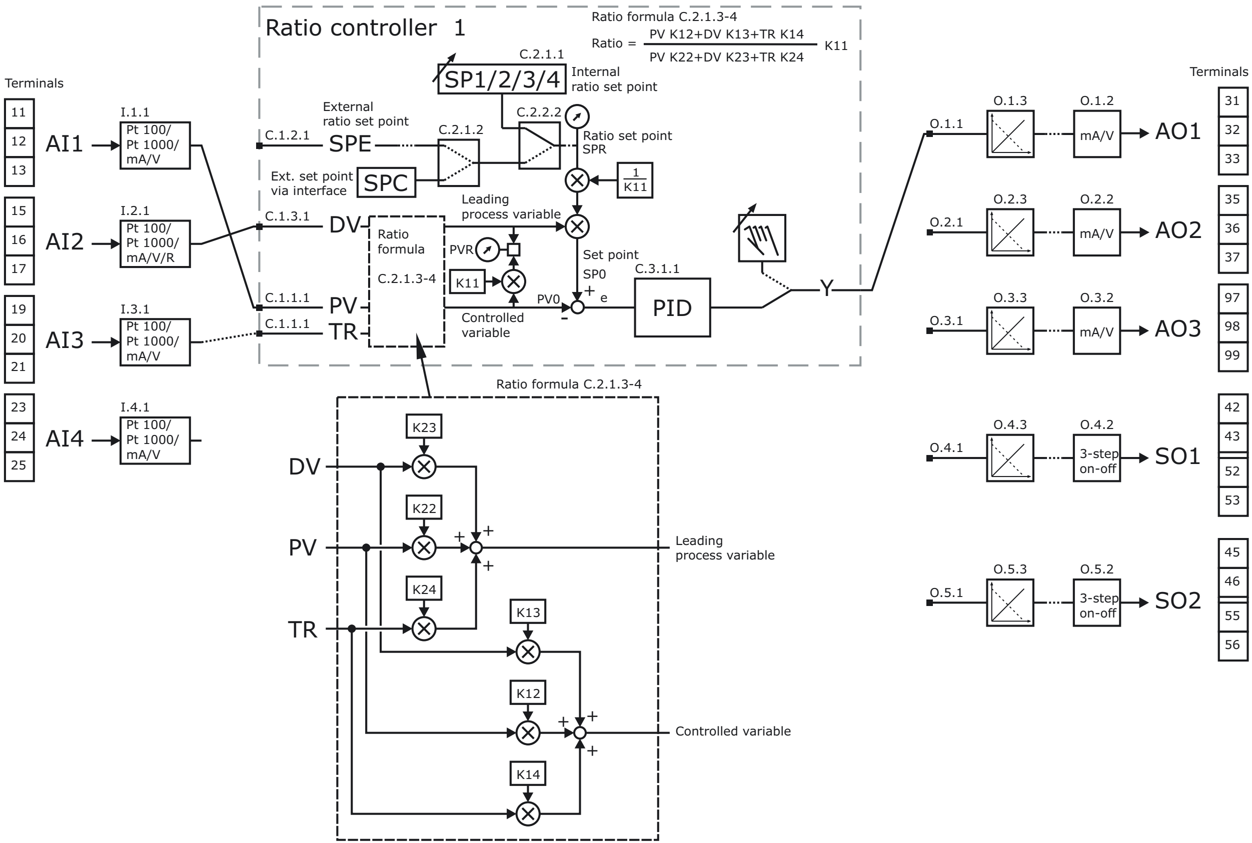
Set output:

14.	Assign Controller [1] output Y as the source for analog output AO1.	O.1.1-1	*
15.	Set output signal (4 to 20 mA) for analog output AO1.	O.1.2-1	*
16.	Determine operating direction (increasing) for analog output AO1.	O.1.3-1	*

Set additional display:

17.	Right operation display: Controller [1] add. reading	A.2.2-2
18.	Additional display, row 1: Input PV after function generation	1C.6.1-12
19.	Additional display, row 2: Input DV after function generation	1C.6.3-18

M.1-2
Ratio control



Feedforward control

Block diagrams (pages 24 and 25)

Multi-component control or feedforward control can be implemented by linking the input variable TR to the input PV or DV or to the set point SP and to the output YPID. Possible interconnections are described in menu item C.3.2.

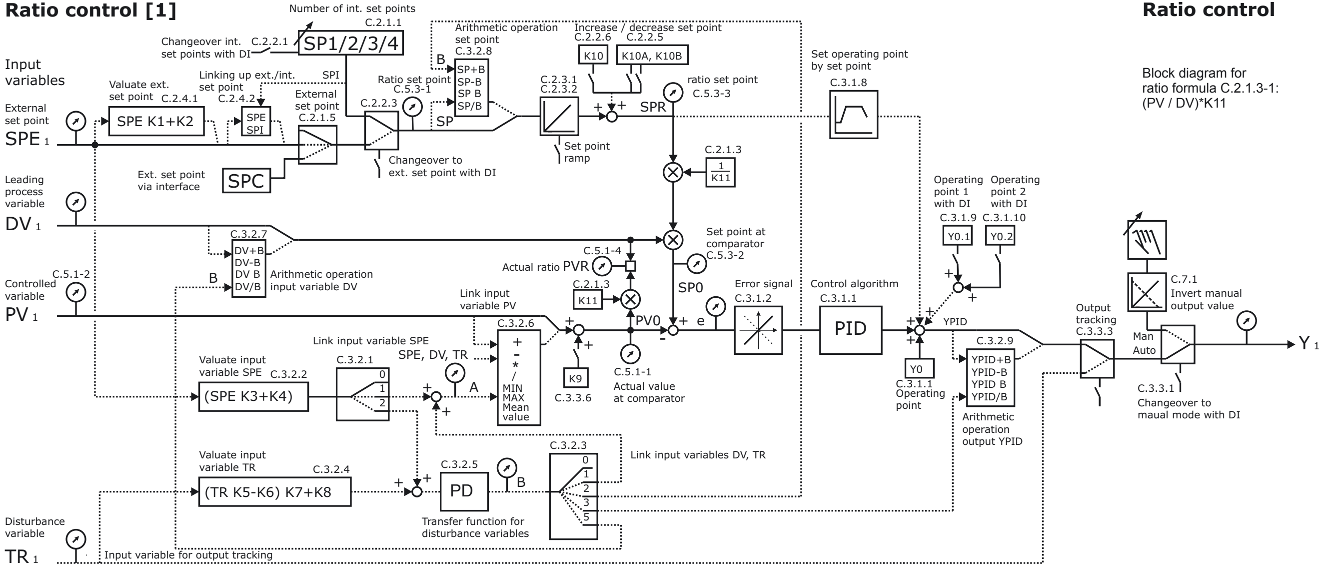
The detailed block diagram for the ratio controller with the ratio formula PV/DV * K11 (setting C.2.1.3-1) is shown on page 24.

The detailed block diagram for the ratio controller with the ratio formula ((PV * K12 + DV * K13 + TR * K14)/(PV * K22 + DV * K23 + TR * K24)) * K11 (setting C.2.1.3-4) is shown on page 25.

Ratio control [1]

Ratio control

Block diagram for ratio formula C.2.1.3-1: (PV / DV)*K11

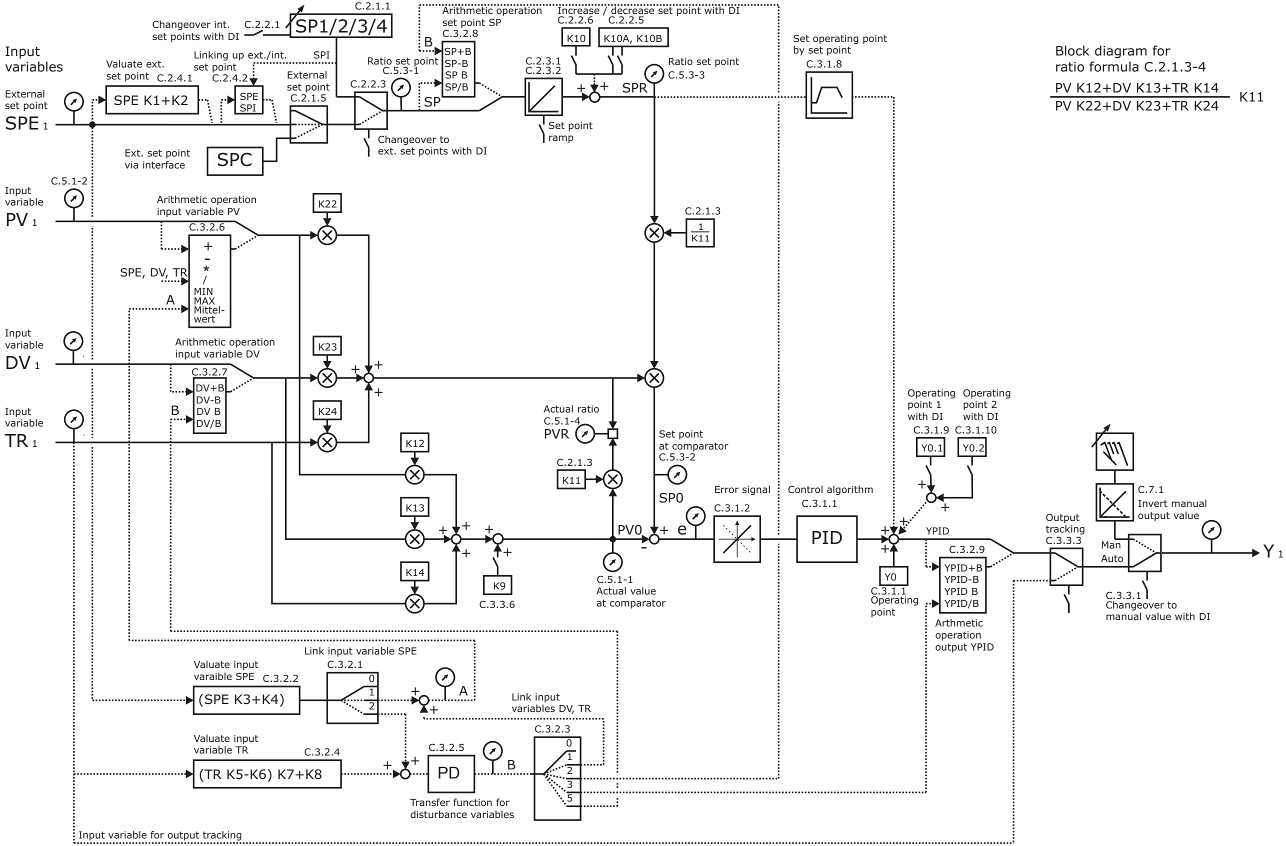


Ratio controller [1]

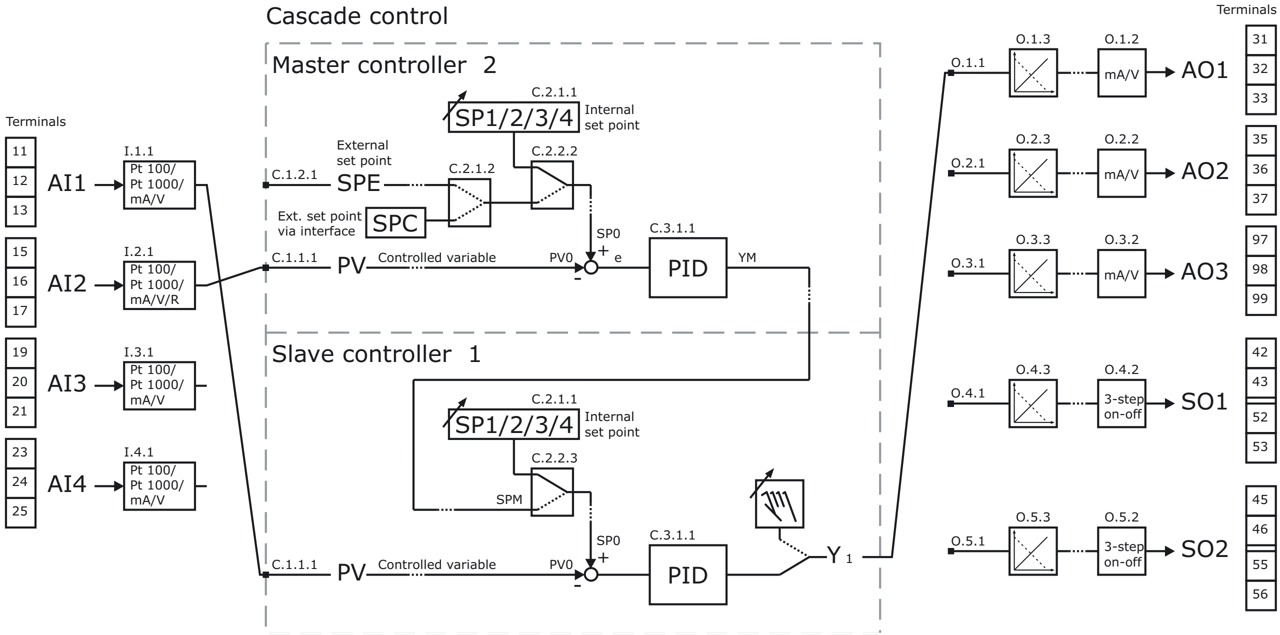
Ratio control

Block diagram for ratio formula C.2.1.3-4

$$\frac{PV\ K12 + DV\ K13 + TR\ K14}{PV\ K22 + DV\ K23 + TR\ K24}\ K11$$



M.1-3
Cascade control



M.1-3 Cascade control

- Simplified block diagram (page 25)
- Detailed block diagram (page 33)

Mode of operation

The output variable of the master controller is the set point of the slave (follower) controller in the cascade control.

After selecting the control mode, master controller [2] and slave (follower) controller [1] are configured separately from one another. The operating keys and display are arranged on the left-hand side for the slave (follower) controller [1] and on the right-hand side for the master controller [2].

The block diagram on page 25 shows the cascade control with the default settings of the inputs and outputs.

The slave (follower) controller [1] receives the auxiliary process variable PV [1] at input AI1 and issues the manipulated variable at output AO1.
The master controller [2] receives the main process variable PV [2] at input AI2 and specifies the set point SPM for the slave (follower) controller by issuing the output variable YM .

Open/close cascade

The controller cascade can either be opened by pressing the manual/automatic key of the master controller [2], in the operating menu or over a digital input.

- Open/close cascade in the operating level/operating menu, refer to EB 6495-2 EN
- Open/close cascade using digital input, see menu item C.2.2.3
- Open/close cascade using manual/automatic dialog, see menu item A.3.2

When a cascade is open, the slave (follower) controller [1] works with the internal set point (SP1 to SP4). On the display of the master controller [2], the cascade icon () appears next to the set point.

When a cascade is closed, the slave (follower) controller [1] works with the set point SPM. The cascade icon is not visible.

To ensure bumpless transfer while opening and closing the cascade, the internal set point SP1 of the slave (follower) controller [1] and the output variable YM of the master controller [2] track each other.

Special features for the set points SP2 and SP4:

When the cascade is open, the output variable YM tracks the set points SP2 to SP4 of the slave (follower) controller [1] .

When a cascade is closed, SP2 to SP4 do not track the output variable YM of master controller [2], i.e. are not overwritten. As a result, SP2 to SP4 can be used as start values to start up the operating point.

Manual/automatic switchover

The manual/automatic switchover only acts on the slave (follower) controller [1]. In manual mode, the output variable YM of the master controller [2] is stopped.

Further functions

- Limit master controller output YM, see menu item C.3.3.8
  The limits can be fixed or can be variable by entering a definable band either side of the set point SP0 of the master controller [2].
- Function generation of set point SPM at the slave (follower) controller [1], see menu item C.2.4.3
- For cascade control, it is often advisable to configure the master controller as a P controller or a PI controller with limited I-component (see menu item C.3.1.2). In both case, it makes sense to allow the set point determine the operating point, see menu item C.3.1.8.
- Switch Controller [1] and Controller [2] displays, see menu item A.2.1 and A.2.2 or refer to EB 6495-2 EN

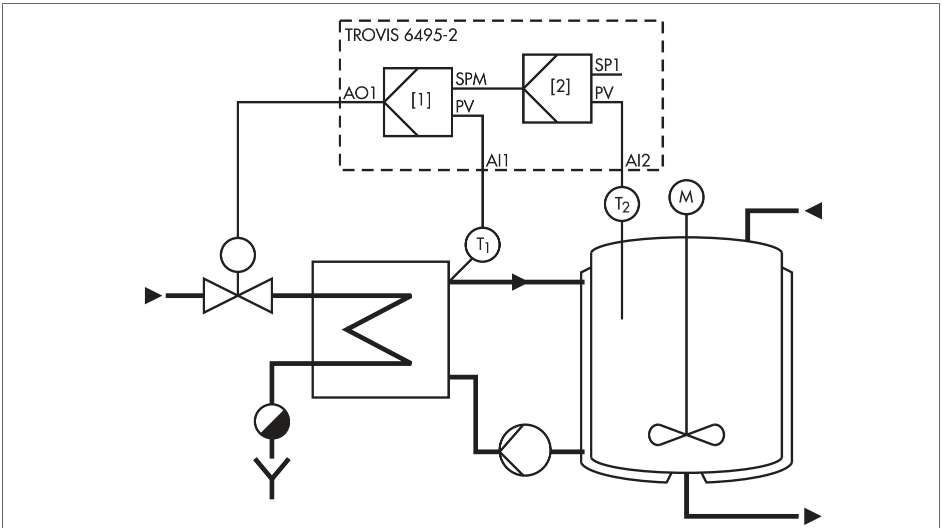
Example: Temperature cascade control

The product temperature in a reaction vessel is to be controlled. The temperature in the reaction vessel is generated by steam, which is produced by a heat exchanger and a fluid circulation system. By connecting several storage elements in series between the valve and temperature sensor in the vessel, the step response of the product temperature is delayed by changing the steam flow. Due to the fluctuations in steam temperature and pressure, the use of a fixed set point control would cause excessive fluctuations in the product temperature and, as a result, the product might be destroyed due to overheating. By using cascade control, the total controlled system is divided into two easily controlled partial systems. The slave (follower) controller reacts to fluctuations in the steam network before they can affect the product temperature. This improves the control quality. Additionally, the flow temperature can be limited by the slave (follower) controller.

The master controller [2] receives the product temperature T_2 (main process variable) from a resistance thermometer Pt 100 at input AI2 and provides the set point SPM (flow temperature set point) for the slave (follower) controller [1] by issuing the output variable YM. By limiting the output variable YM, the flow temperature set point SPM is limited to 160 °C. The set point for the product temperature is set at the master controller [2] to 125 °C.

The slave (follower) controller [1] receives the flow temperature T_1 (auxiliary process variable) from a resistance thermometer Pt 100 at input AI1 and positions the control valve by issuing a 4 to 20 mA signal at output AO1.

In the following configuration, the master controller functions as a P controller with set-point-dependent operating point. This is not absolutely necessary for cascade control, but proves to be useful in many cases. A further improvement can be achieved when the master controller is configured as a PI controller with restricted integral-action component and with set-point-dependent operating point. Refer to further settings.



For this cascade control, the following configuration needs to be performed (configuration settings marked with an asterisk * are the same as the standard configuration for cascade control):

1.	Position both DIP switches for analog input AI1 and analog input AI2 to Pt 100 (left).		
2.	Switch on power supply.		
3.	Set control mode (cascade control).	M.1-3	

Set inputs:

4.	Set input signal (Pt 100) and measuring range (0 to 200 °C) at analog input AI1.	I.1.1-6 AI1.MIN = 0 °C AI1.MAX = 200 °C	* *
5.	Set input signal (Pt 100) and measuring range (0 to 200 °C) at analog input AI2.	I.2.1-6 AI2.MIN = 0 °C AI2.MAX = 200 °C	* *

Set slave (follower) controller [1]:

6.	Assign analog input AI1 as the source for input variable PV (auxiliary process variable).	1C.1.1.1-1	*
7.	Set control algorithm (PI) and control parameters (KP = 1.00 and TN = 120 s).	1C.3.1.1-1 KP = 1.00 TN = 120 s	* * *
8.	Determine restart condition (operation mode after restart = Auto).	1C.4.1-0	*

Set master controller [2]:

9.	Assign analog input AI2 as the source for input variable PV (main process variable).	2C.1.1.1-2	
10.	Set internal set point (number of internal set points = 1, SP1 = 125 °C).	2C.2.1.1-1 SP1 = 125.0 °C	
11.	Set control algorithm (P) and control parameter (KP = 1.00).	2C.3.1.1-2 KP = 1.00	 *

12.	Define that set point determines the operating point. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | OP.I °C: 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 200.0 OP.O %: 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 100.0	2C.3.1.8-1 OP.I1 = 0.0 °C * OP.O1 = 0.0 % * OP.I2 = 0.0 °C * OP.O2 = 0.0 % * OP.I3 = 0.0 °C * OP.O3 = 0.0 % * OP.I4 = 0.0 °C * OP.O4 = 0.0 % * OP.I5 = 0.0 °C * OP.O5 = 0.0 % * OP.I6 = 0.0 °C * OP.O6 = 0.0 % * OP.I7 = 200.0 °C OP.O7 = 100.0 %
13.	Limit master controller output YM to 80 %. This causes the set point SPM for the flow temperature to be limited to max. 160 °C.	2C.3.3.8-1 YM.MIN = 0.0 % YM.MAX = 80.0 %
14.	Determine restart condition (operation mode after restart = Auto).	2C.4.1-0

	1	2	3	4	5	6	7
OP.I °C	0.0	0.0	0.0	0.0	0.0	0.0	200.0
OP.O %	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Further settings

15.	Set control algorithm (PI) and control parameters (KP = 1.00 and TN = 120 s).	2C.3.1.1-1 * KP = 1.00 * TN = 120 s *
16.	Limit integral-action component. Min. I-component (–5 K set point shift within 0 to 200 °C range) Max. I-component (+5 K set point shift within 0 to 200 °C range)	2C.3.1.2-1 I.MIN = −2.5 % I.MAX = 2.5 %

Set output:

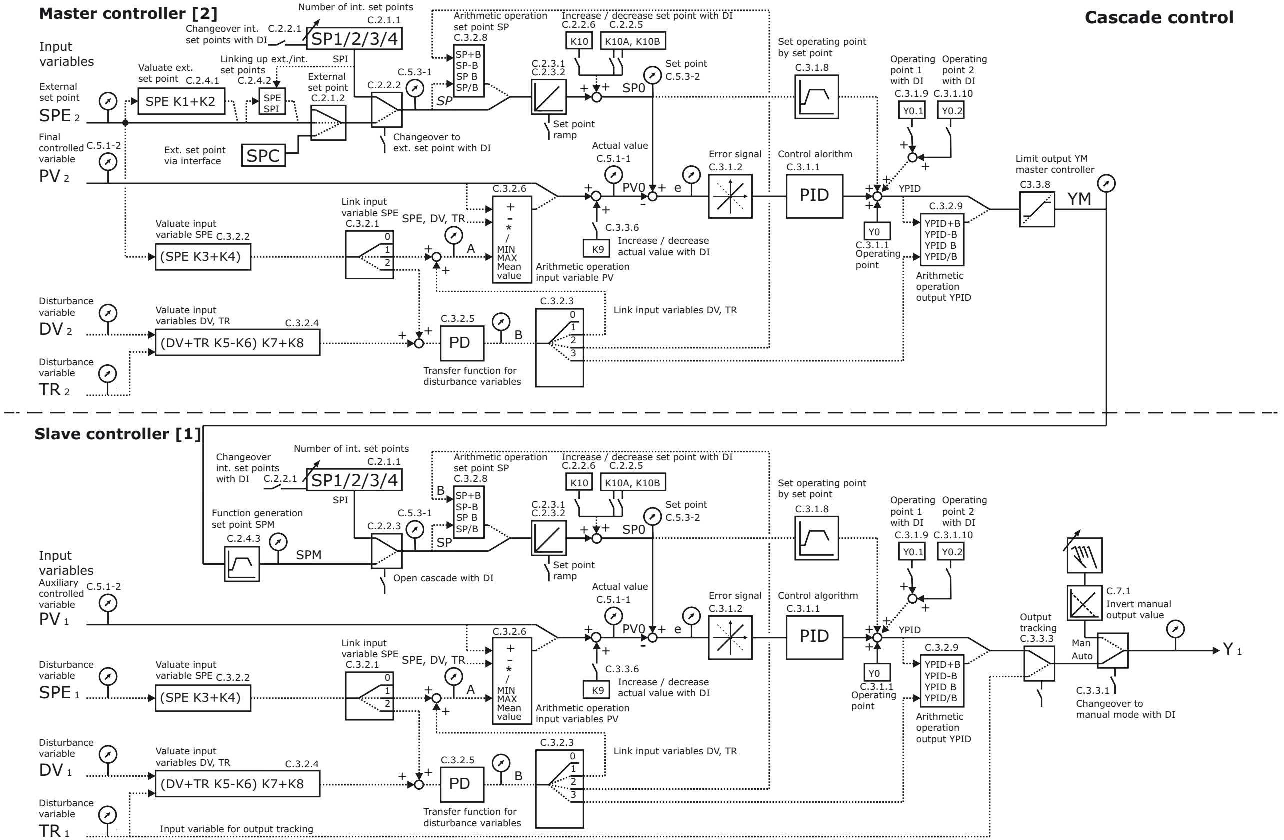
17.	Assign Controller [1] output Y as the source for analog output AO1.	O.1.1-1 *
18.	Set output signal (4 to 20 mA) for analog output AO1.	O.1.2-1 *
19.	Determine operating direction (increasing) for analog output AO1.	O.1.3-1 *

Feedforward control

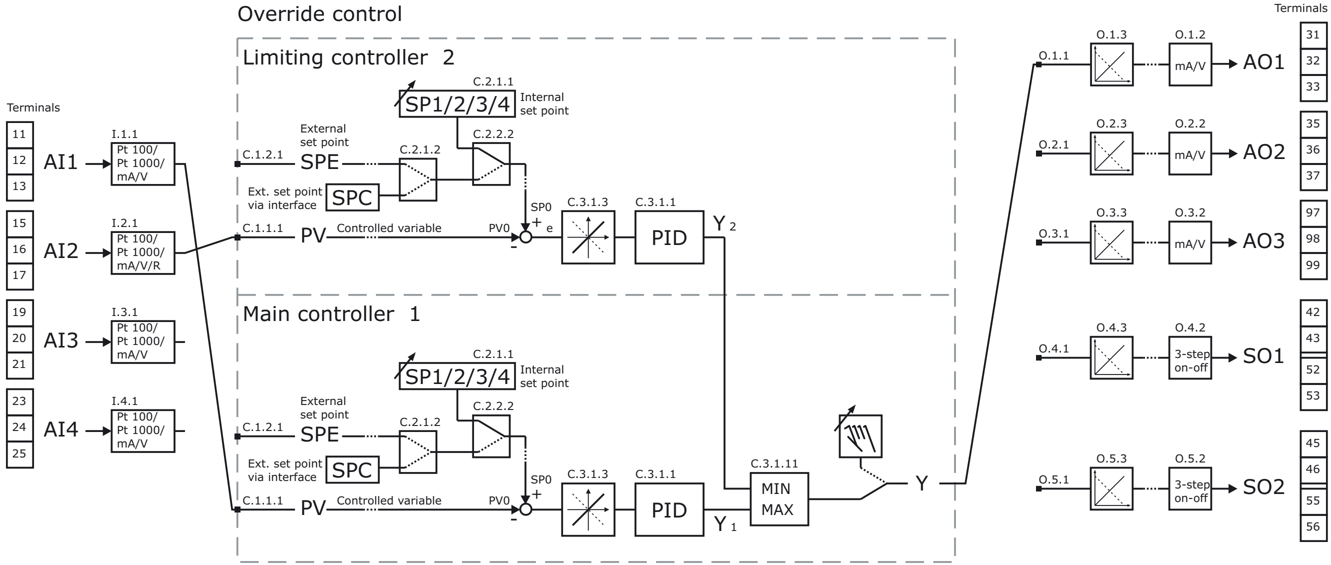
Block diagram (page 33)

The input variables SPE, DV and TR of the master controller and slave (follower) controller can be linked to the set point, process variable and output. Possible interconnections are described in menu item C.3.2.

Cascade control



M.1-4
Override control



M.1-4 Override control

- Simplified block diagram (page 34)
- Detailed block diagram (page 40)

Override control is used to control a process variable without a second process variable exceeding or falling below predefined limits. Both process variables are changed by the same valve and are therefore physically dependent on each other.

For override control, two controllers (main controller [1] and override (limiting) controller [2]) influence the same valve by selection of a minimum and maximum value of the internal control signals Y[1] and Y[2]. Depending on the control task, the largest or smallest control signal is applied to the valve. The minimum value of the control signal is selected whenever a process variable is to be controlled and the other process variable is to be limited to a maximum value. The maximum value of the control signal is selected whenever a process variable is to be controlled and the other process variable is to be limited to a minimum value. One of the controller is always takes command and controls the process. This controller is identified in the bottom display row by the ▲ icon.

To achieve a fast transfer, the selection of a minimum and maximum value of the internal control signals is performed with both controllers taking on the role as the master controller to control the control limits. For this, the control signal of the controller not in command can be limited in such a way that it can only be larger/smaller than the control signal of the controller in command by an adjustable limiting band at the maximum. The limiting band for control signal Y[1] of the main controller [1] can be adjusted at the OC.K1 parameter. The limiting band for control signal Y[2] of the override controller [2] can be adjusted at the OC.K2 parameter. The minimum value (1 C.3.1.11-1), the maximum value (1 C.3.1.11-2) and limiting bands are set in the main controller [1] in the menu item C.3.1.11 (internally controlled output limitation).

After selecting the control mode, the main controller [1] and override (limiting) controller [2] are configured separately from one another. The operating keys and display are arranged on the left-hand side for the main controller [1] and on the right-hand side for the override (limiting) controller [2].
The display arrangement for the controllers can be switched.

- Switch Controller [1] and Controller [2] displays, refer to EB 6495-2

The ▲ icon in the lower display row indicates which controller is in command of the control signal at that point in time.

By default, the analog output AO1 is displayed in row 4 of the operation display in the main controller [1] and the internal control signal Y[2] is displayed in row 4 in the override controller [2].

To check both internal control signals Y[1] and Y[2], we recommend to change the settings of the display so that the internal control signal Y[1] is displayed in row 4 in the main controller [1] and the required analog output (e.g. AO1) or switching output (e.g. SO1) in row 5. To proceed, peform the following settings:

- 1 C.5.4-7 Controller display row 4: Controller [1] output Y
- 1 C.5.6-2 Controller display row 5: Output AO1

The block diagram on page 34 shows the override control with the default settings of inputs and outputs.

The main controller [1] receives the process variable PV [1] at input AI1.
The override (limiting) controller [2] receives the process variable PV [2] at input AI2.
The internal output variables Y [1] and Y [2] are issued in the main controller [1] at output AO1 by selecting a minimum or maximum value.

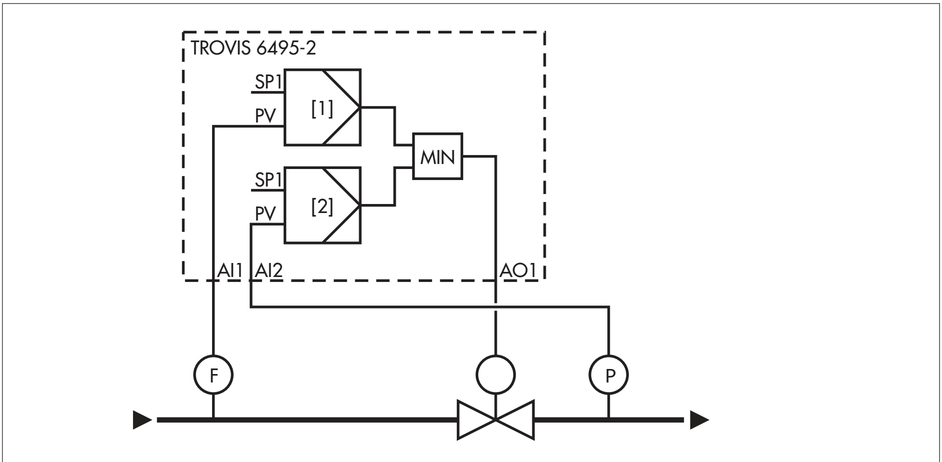
Manual/automatic switchover

The manual/automatic switchover only works on the main controller [1] during override control. In manual mode, the output Y of the override (limiting) controller [2] is set to the manual output value Y of the main controller [1] and tracks it.

Example: Flow rate control with pressure limitation

The flow rate is to be controlled without allowing the pressure to exceed a certain limit. In this application example, the flow rate F is controlled by the main controller [1] and the pressure P is limited to a maximum pressure by the override (limiting) controller [2]. The internal control signals of both controllers influence the control valve by selection of a minimum value (MIN) with both controllers taking on the role as master controller to control the maximum control limits. The main controller [1] receives the flow rate F as a 4 to 20 mA signal from a transmitter (e.g. Media 6) at input AI1. The measuring range is 0 to 10 m^3/h. The override (limiting) controller [2] receives the pressure P as a 4 to 20 mA signal from a transmitter at input AI2. The measuring range is 0 to 10 bar. A 4 to 20 mA signal at output AO1 is used to position the valve.

Under normal circumstances, the flow rate matches the adjusted set point and the pressure is lower than the adjusted set point. In this case, the flow controller [1] controls the valve since its internal output variable is smaller than that of the pressure controller [2]. Due to the internally controlled control signal limitation, the output variable of the pressure controller can be 5 % (limiting band OC.K2) greater at the maximum than the output variable of the flow controller. If the flow capacity drops, the flow controller [1] raises its output variable and tries to keep the adjusted flow rate constant in this way. This causes the pressure in the system to increase. If the pressure logged at the pressure controller [2] exceeds the adjusted set point, the pressure controller [2] reduces its output variable until it is smaller than the output variable of the flow con-



troller [1]. The pressure controller [2] then takes on the task of controlling the valve and reduces the pressure. Due to the internally controlled control signal limitation, the output variable of the flow controller [1] can be 5 % (limiting band OC.K2) greater at the maximum than the output variable of the pressure controller [2]. The interacting limitation by the adjustable limiting band speeds up the transfer of the master controller function between controllers.

For this override control, the following configuration needs to be performed (configuration settings marked with an asterisk * are the same as the standard configuration for override control):

1.	Position both DIP switches for analog input AI1 and analog input AI2 to mA (right).		
2.	Switch on power supply.		
3.	Set control mode (override control).	M.1-4	

Set inputs:

4.	Set input signal (4 to 20 mA) and measuring range (0 to 10 m^3/h) at analog input AI1.	I.1.1-1 AI1.MIN = 0 m^3/h AI1.MAX = 10 m^3/h	*
5.	Determine physical unit (m^3/h) at analog input AI1.	I.1.3-8	
6.	Set input signal (mA) and measuring range (0 to 10 bar) at analog input AI2.	I.2.1-1 AI2.MIN = 0 bar AI2.MAX = 10 bar	*

7.	Determine physical unit (bar) at analog input AI2.	I.2.3-4	

Set main controller [1]:

8.	Assign analog input AI1 as the source for input variable PV (process variable 1).	1C.1.1.1-1	*
9.	Set internal set point SP1 (number of internal set points = 1, SP1 = 40 m³/h).	1C.2.1.1-1 SP1 = 40 m³/h	*
10.	Set control algorithm (PI) and control parameters (KP = 1.00 and TN = 15 s).	1C.3.1.1-1 KP = 1.00 TN = 15 s	* *
11.	Determine internally controlled output limitation (minimum selection) as well as the limiting band of main controller and the limiting band of the override (limiting) controller.	1C.3.1.11-1 OC.K1 = 5.0 % OC.K2 = 5.0 %	* * *
12.	Determine restart condition (operation mode after restart = Auto).	1C.4.1-0	*

Set override (limiting) controller [2]:

13.	Assign analog input AI2 as the source for input variable PV (process variable 2).	2C.1.1.1-2	
14.	Set internal set point SP1 (number of internal set points = 1, SP1 = 6 bar).	2C.2.1.1-1 SP1 = 6 bar	*
15.	Set control algorithm (PI) and control parameters (KP = 1.00 and TN = 15 s).	2C.3.1.1-1 KP = 1.00 TN = 15 s	* * *

Set output:

16.	Assign Controller [1] output Y as the source for analog output AO1.	O.1.1-1	*
17.	Set output signal (4 to 20 mA) for analog output AO1.	O.1.2-1	*
18.	Determine operating direction (increasing) for analog output AO1.	O.1.3-1	*

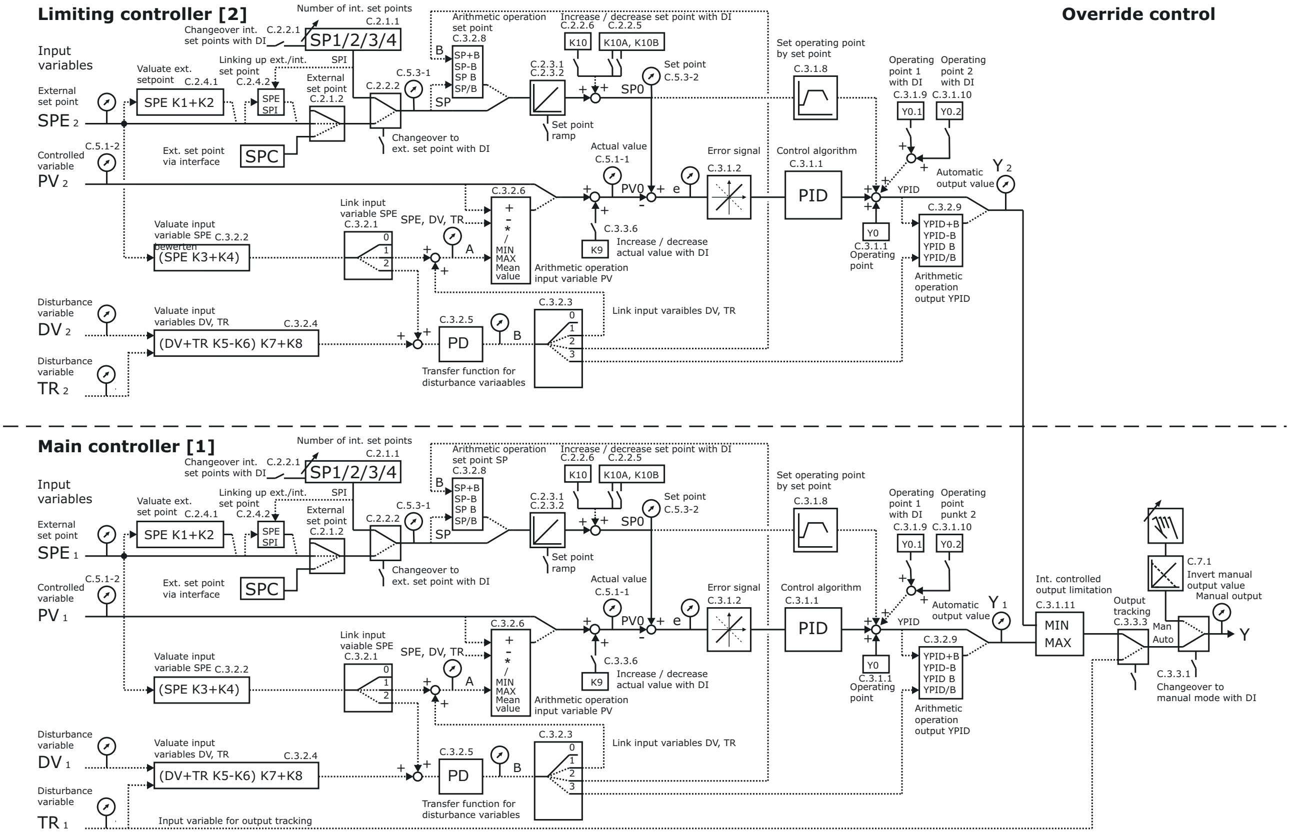
Further settings

19.	Assign row 4 of the main controller [1] display to the output variable Y.	1C.5.4-7
20.	Assign row 5 of the main controller [1] display to the analog output AO1.	1C.5.6-2

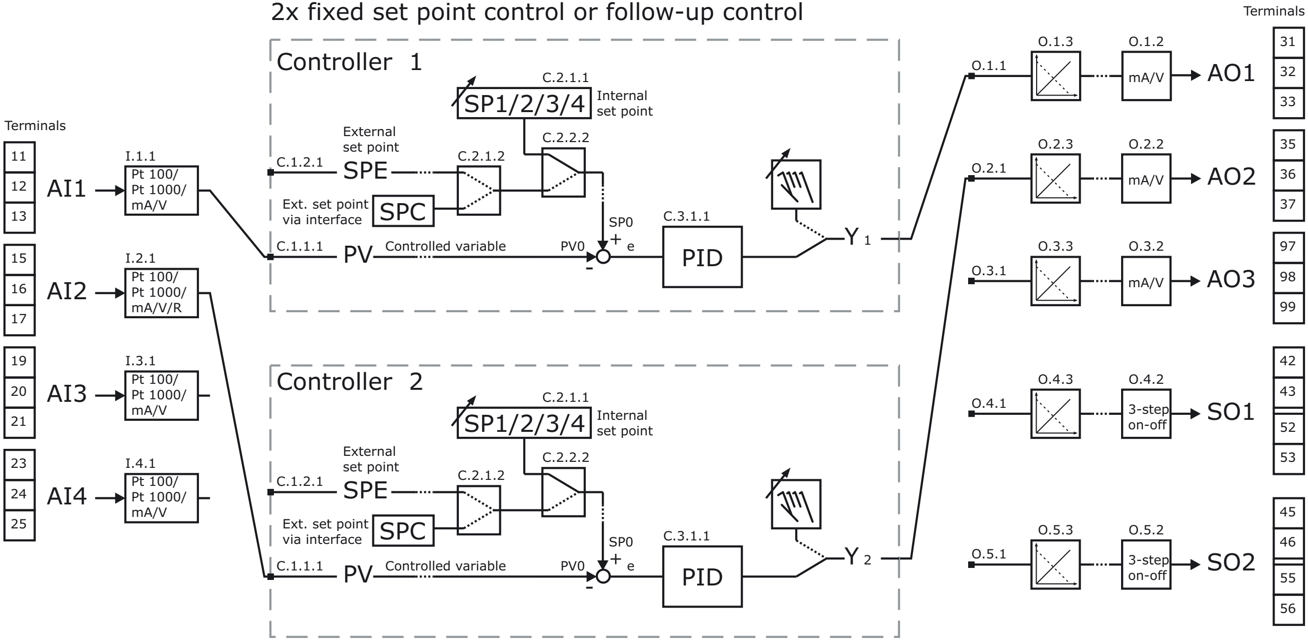
Feedforward control

Block diagram (page 40)

The input variables SPE, DV and TR of the main controller and override (limiting) controller can be linked to the set point, process variable and output. Possible interconnections are described in menu item C.3.2.


Limiting controller [2]
Override control
Number of int. set points
C.2.1.1
Changeover int. set points with DI
C.2.2.1
SP1/2/3/4
Input variables
Valuate ext. setpoint
C.2.4.1
Linking up ext./int. set point
C.2.4.2
SPI
External set point
SPE 2
SPE K1+K2
SPE
SPI
External set point
C.2.1.2
C.2.2.2
C.5.3-1
SP
Arithmetic operation set point
C.3.2.8
B
SP+B
SP-B
SP B
SP/B
Increase / decrease set point with DI
C.2.2.6
C.2.2.5
K10
K10A, K10B
C.2.3.1
C.2.3.2
Set point
C.5.3-2
SP0
Set point ramp
Set operating point by set point
C.3.1.8
Operating point 1 with DI
Operating point 2 with DI
C.3.1.9
C.3.1.10
Y0.1
Y0.2
Changeover to ext. set point with DI
Ext. set point via interface
SPC
Controlled variable
C.5.1-2
PV 2
Actual value
C.5.1-1
PV0
e
Error signal
C.3.1.2
Control algorithm
C.3.1.1
PID
Automatic output value
Y 2
YPID
C.3.2.6
Link input variable SPE
C.3.2.1
SPE, DV, TR
A
MIN
MAX
Mean value
C.3.3.6
K9
Increase / decrease actual value with DI
Arithmetic operation input variable PV
Valuate input variable SPE bewerten
C.3.2.2
(SPE K3+K4)
Y0
C.3.1.1
Operating point
C.3.2.9
YPID+B
YPID-B
YPID B
YPID/B
Arithmetic operation output YPID
Disturbance variable
DV 2
Valuate input variables DV, TR
C.3.2.4
(DV+TR K5-K6) K7+K8
C.3.2.5
PD
B
C.3.2.3
Link input varaibles DV, TR
Transfer function for disturbance variaables
Disturbance variable
TR 2
Main controller [1]
Number of int. set points
C.2.1.1
Changeover int. set points with DI
C.2.2.1
SP1/2/3/4
Input variables
Valuate ext. set point
C.2.4.1
Linking up ext./int. set point
C.2.4.2
SPI
External set point
SPE 1
SPE K1+K2
External set point
C.2.1.2
C.2.2.2
C.5.3-1
Arithmetic operation set point SP
C.3.2.8
Increase / decrease set point with DI
C.2.2.6
C.2.2.5
K10
K10A, K10B
C.2.3.1
C.2.3.2
Set point
C.5.3-2
SP0
Set point ramp
Set operating point by set point
C.3.1.8
Operating point 1 with DI
Operating point punkt 2
C.3.1.9
C.3.1.10
Y0.1
Y0.2
Changeover to ext. set point with DI
Ext. set point via interface
SPC
Controlled variable
C.5.1-2
PV 1
Actual value
C.5.1-1
PV0
e
Error signal
C.3.1.2
Control algorithm
C.3.1.1
PID
Automatic output value
Y 1
YPID
Int. controlled output limitation
C.3.1.11
MIN
MAX
Output tracking
C.3.3.3
Man
Auto
C.7.1
Invert manual output value
Manual output
Y
C.3.3.1
Changeover to manual mode with DI
C.3.2.6
Link input vaiable SPE
C.3.2.1
SPE, DV, TR
A
C.3.3.6
K9
Increase / decrease actual value with DI
Arithmetic operation input variable PV
Valuate input variable SPE
C.3.2.2
(SPE K3+K4)
Y0
C.3.1.1
Operating point
C.3.2.9
YPID+B
YPID-B
YPID B
YPID/B
Arithmetic operation output YPID
Disturbance variable
DV 1
Valuate input variables DV, TR
C.3.2.4
(DV+TR K5-K6) K7+K8
C.3.2.5
PD
B
C.3.2.3
Link input variables DV, TR
Transfer function for disturbance variables
Disturbance variable
TR 1
Input variable for output tracking

M.1-5
2x fixed set point control or follow-up control



M.1-5 2x fixed set point/follow-up control

- Simplified block diagram (page 42)
- Detailed block diagram (page 55)

Mode of operation (see menu item M.1-1)

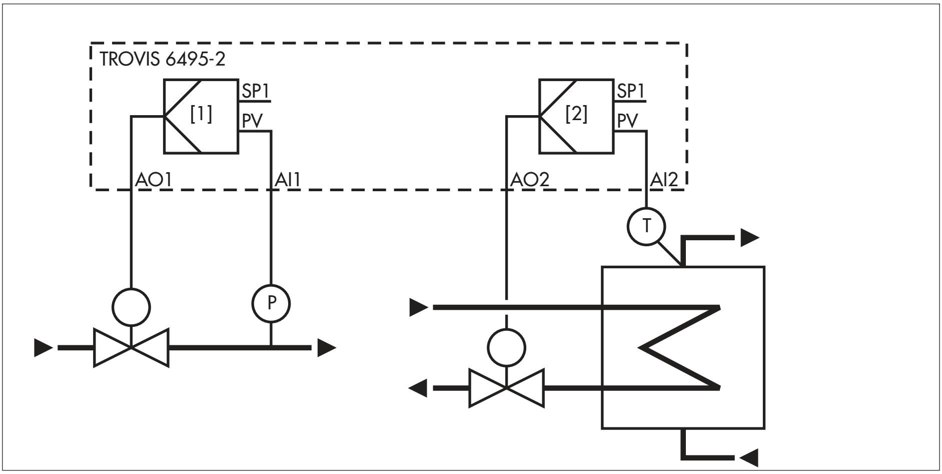
Both controllers [1] and [2] work as fixed set point or slave controllers. After selecting the control mode, both controllers are configured separately from one another. The operating keys and display are arranged on the left-hand side for controller [1] and on the right-hand side for controller [2].

The block diagram on page 42 shows the control mode with the default settings of the inputs and outputs.

Controller [1] logs the process variable PV [1] at input AI1 and issues the manipulated variable at output AO1.
Controller [2] logs the process variable PV [2] at input AI2 and issues the manipulated variable at output AO2.

Example 1: Pressure and flow temperature control

The pressure controller [1] receives the pressure downstream of the control valve as a 4 to 20 mA signal from a transmitter at input AI1 and issues a 4 to 20 mA signal at output AO1 to position the valve to keep the pressure constant at 6 bar.



The measuring range of the transmitter is 0 to 10 bar.

The temperature controller [2] receives the flow temperature T in the secondary circuit from a resistance thermometer Pt 100 at input AI2 and issues a 4 to 20 mA signal at output AO2 to position the valve in the primary circuit to keep the flow temperature constant at 50 °C.

For this double fixed set point control, the following configuration procedure needs to be performed (configuration settings marked with an asterisk * are the same as the standard configuration for double fixed set point/follow-up control):

1.	Position both DIP switches for analog input AI1 to mA/V (right).		
2.	Position both DIP switches for analog input AI2 to Pt 100 (left).		
3.	Switch on power supply.		
4.	Set control mode (2x fixed set point/follow-up control).	M.1-5	

Set inputs:

4.	Set input signal (4 to 20 mA) and measuring range (0 to 10 bar) at analog input AI1.	I.1.1-1 AI1.MIN = 0 bar AI1.MAX = 10 bar	* *
5.	Determine physical unit (bar) at analog input AI1.	I.1.3-4	
6.	Set input signal (Pt 100) and measuring range (0 to 100 °C) at analog input AI2.	I.2.1.1-6 AI2.MIN = 0 °C AI2.MAX = 100 °C	* * *
7.	Determine physical unit (°C) at analog input AI2.	I.2.3-1	*

Set controller [1]:

8.	Assign analog input AI1 as the source for input variable PV (process variable 1).	1C.1.1.1-1	*
9.	Set internal set point SP1 (number of internal set points = 1, SP1 = 6 bar).	1C.2.1.1-1 SP1 = 6 bar	*
10.	Set control algorithm (PI) and control parameters (KP = 1.00 and TN = 20 s).	1C.3.1.1-1 KP = 1.00 TN = 20 s	* *
11.	Determine restart condition (operation mode after restart = Auto).	1C.4.1-0	*

Set controller [2]:

12.	Assign analog input AI2 as the source for input variable PV (process variable 2).	2C.1.1.1-2	
13.	Set internal set point SP1 (number of internal set points = 1, SP1 = 50 °C).	2C.2.1.1-1 SP1 = 50 °C	*
14.	Set control algorithm (PI) and control parameters (KP = 1.00 and TN = 120 s).	2C.3.1.1-1 KP = 1.00 TN = 120 s	* * *
15.	Determine restart condition (operation mode after restart = Auto).	2C.4.1-0	*

Set output for controller [1]:

16.	Assign controller [1] output Y as the source for analog output AO1.	O.1.1-1	*
17.	Set output signal (4 to 20 mA) for analog output AO1.	O.1.2-1	*
18.	Determine operating direction (increasing) for analog output AO1.	O.1.3-1	*

Set output for controller [2]:

19.	Assign controller [2] output Y as the source for analog output AO2.	O.2.1-2	
20.	Set output signal (4 to 20 mA) for analog output AO2.	O.2.2-1	*
21.	Determine operating direction (increasing) for analog output AO2.	O.2.3-1	*

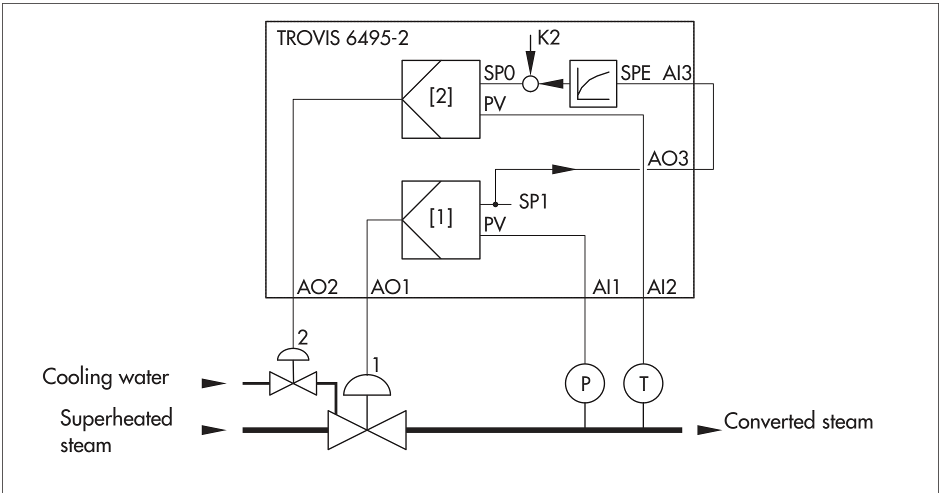
Example 2: Steam pressure and temperature control using a steam-converting valve

The pressure controller [1] receives the steam pressure as a 4 to 20 mA signal from an absolute pressure transmitter at input AI1 and issues a 4 to 20 mA signal at output AO1 to position the steam-converting valve 1 (Series 280). The transmitter has a measuring range between 0 and 10 bar.

The temperature controller [2] receives the steam temperature from a resistance thermometer Pt 100 at input AI2 and issues a 4 to 20 mA signal at output AO2 to position the spray water valve 2.

The particularity in this example is that only the required pressure set point SP1 must be provided. The associated temperature set point is set automatically by the controller. To achieve this, the set point of the pressure controller [1] is issued at output AO3 and fed by a link to input AI3 of the input variable SPE (external set point) of the temperature controller [2]. The saved saturated steam characteristic resulting from the function generation of the input variable SPE allows the associated saturated steam temperature to be calculated for every pressure set point. The cooled steam temperature must be at least 10 °C above the saturated steam temperature to allow the injected spray water to fully vaporize. Therefore, the effective temperature set point arises from raising the saturated steam temperature (resulting from the function generation) by 10 °C using K2 parameter.

Constructive measures to limit the temperature and pressure are not dealt with in this application example.



Correlation between pressure and saturated steam temperature								
Pressure	bar	1.0	2.0	3.0	4.0	5.0	6.0	7.0
Saturated steam temperature	°C	99.6	120.2	133.5	143.6	151.8	158.8	165.0

For this example, the following configuration needs to be performed (configuration settings marked with an asterisk * are the same as the standard configuration for double fixed set point/follow-up control):

1.	Position both DIP switches for analog input AI1 to mA/V (right).		
2.	Position both DIP switches for analog input AI2 to Pt 100 (left).		
3.	Position both DIP switches for analog input AI3 to mA/V (right).		
4.	Switch on power supply.		
5.	Set control mode (2x fixed set point/follow-up control).	M.1-5	

Set inputs:

6.	Set input signal (4 to 20 mA) and measuring range (0 to 10 bar) at analog input AI1.	I.1.1-1 AI1.MIN = 0 bar AI1.MAX = 10 bar	* *
7.	Determine physical unit (bar) at analog input AI1.	I.1.3-4	
8.	Set input signal (Pt 100) and measuring range (0 to 200 °C) at analog input AI2.	I.2.1.1-6 AI2.MIN = 0 °C AI2.MAX = 200 °C	* *
9.	Determine physical unit (°C) at analog input AI2.	I.2.3-1	*
10.	Set input signal (4 to 20 mA) and measuring range (0 to 10 bar) at analog input AI3.	I.3.1-6 AI3.MIN = 0 bar AI3.MAX = 10 bar	* *
11.	Determine physical unit (bar) at analog input AI3.	I.3.3-4	

Set controller [1]:

12.	Assign analog input AI1 as the source for input variable PV (process variable 1).	1C.1.1.1-1	*

13.	Set internal set point SP1 (number of internal set points = 1, SP1 = 4 bar).	1C.2.1.1-1 SP1 = 4 bar	*
14.	Set control algorithm (PI) and control parameters (KP = 0.50 and TN = 20 s).	1C.3.1.1-1 KP = 0.50 TN = 20 s	*
15.	Determine restart condition (operation mode after restart = Auto).	1C.4.1-0	*

Set controller [2]:

16.	Assign analog input AI3 as the source for input variable PV (process variable 2).	2C.1.1.1-2	
17.	Assign analog input AI3 as the source for input variable SPE (external set point).	2C.1.2.1-3	
18.	Valuate external set point SPE (SPE´= SPE ∗ K1 + K2)	2C.2.4.1-1 K1 = 1.00 K2 = 10.0 °C	*
19.	Assign input variable SPE as the source for external set point.	2C.2.1.2-1	
20.	Perform function generation of input variable SPE: Lower range value output function generation: SPE.MIN = 0.0 °C Upper range value output function generation: SPE.MAX = 200.0°C Input values SPE.I1 to SPE.I7 and output values SPE.O1 to SPE.O7	2C.1.2.4-1 SPE.MIN = 0.0 °C SPE.MAX = 200.0 °C SPE.I1 = 1.0 bar SPE.O1 = 99.6 °C SPE.I2 = 2.0 bar SPE.O2 = 120.2 °C SPE.I3 = 3.0 bar SPE.O3 = 133.5 °C SPE.I4 = 4.0 bar SPE.O4 = 143.6 °C SPE.I5 = 5.0 bar SPE.O5 = 151.8 °C SPE.I6 = 6.0 bar SPE.O6 = 158.8 °C SPE.I7 = 7.0 bar SPE.O7 = 165.0 °C	*

	1	2	3	4	5	6	7
SPE.I bar	1.0	2.0	3.0	4.0	5.0	6.0	7.0
SPE.O °C	99.6	120.2	133.5	143.6	151.8	158.8	165.0

21.	Determine physical unit (°C) after function generation.	2C.1.2.5-1	
22.	Set control algorithm (PI) and control parameters (KP = 2.00 and TN = 200 s).	2C.3.1.1-1 KP = 2.00 TN = 200 s	*

23.	Set row 3 of controller display (set point SP0 at comparator).	2C.5.3-2	
24.	Determine restart condition (operation mode after restart = Auto).	2C.4.1-0	*

Set output for controller [2]:

25.	Assign controller [1] output Y as the source for analog output AO1.	O.1.1-1	*
26.	Set output signal (4 to 20 mA) for analog output AO1.	O.1.2-1	*
27.	Determine operating direction (increasing) for analog output AO1.	O.1.3-1	*

Set output for controller [2]:

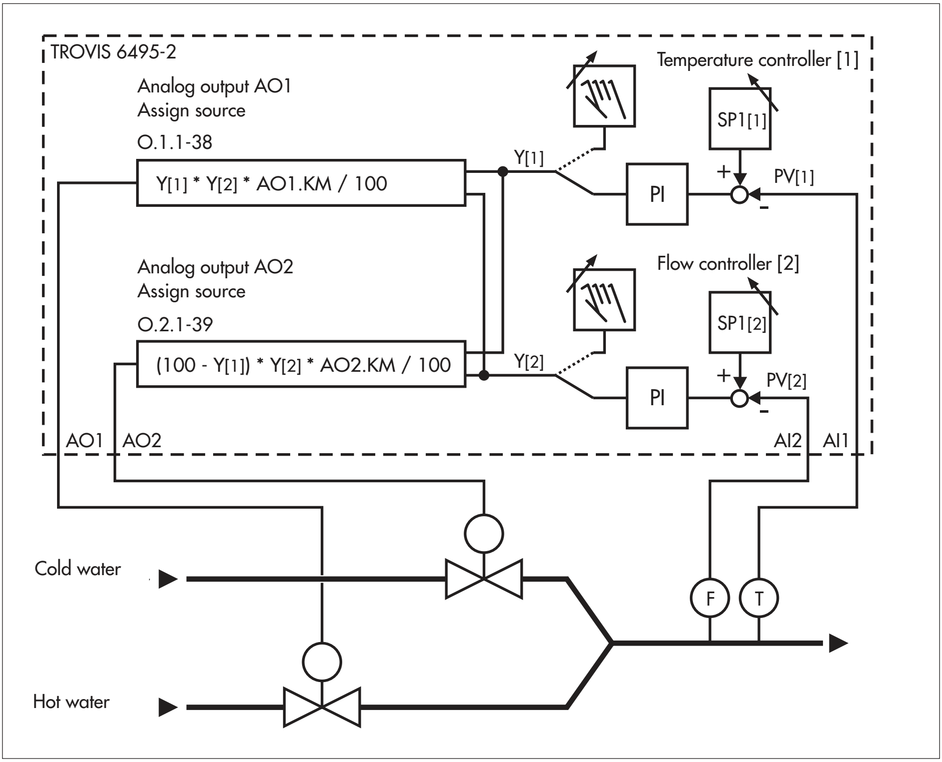
28.	Assign controller [2] output Y as the source for analog output AO2.	O.2.1-2	
29.	Set output signal (4 to 20 mA) for analog output AO2.	O.2.2-1	*
30.	Determine operating direction (decreasing) for analog output AO2.	O.2.3-2	

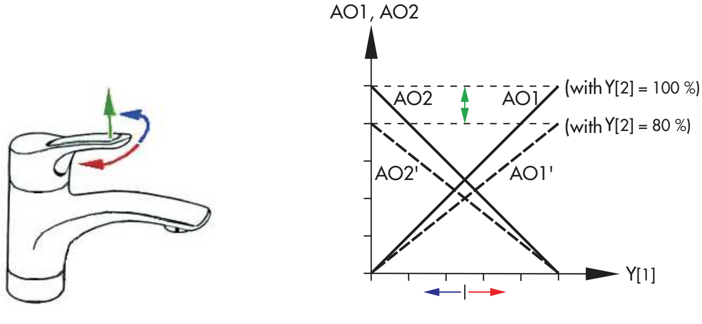
Issue set point SP0:

31.	Assign set point controller [1] SP0 as source for analog output AO3.	O.3.1-17	
32.	Set output signal (4 to 20 mA) for analog output AO3.	O.3.2-1	*

Example 3: Mixing control for temperature and flow rate (single-lever faucet principle)

The temperature controller [1] receives the mixing temperature T from a resistance thermometer Pt 100 and positions both control valves to keep the mixing temperature constant at 50 °C. The flow controller [2] receives the total flow rate F from a transmitter and positions both control valves to keep the flow rate constant at 5 m^3/h. 4 to 20 mA signals are issued at outputs AO1 and AO2 to position the control valves. The output variable Y[1] controls the mixing ratio and the output variable Y[2] the total flow rate. Mixing ratio and flow rate are in direct proportion to one another. Not all operating points can be implemented due to reasons of physics. The AO1.KM and AO2.KM parameters allow the individual flow rates to adapted to the different upstream pressures in the cold water and hot water supply pipes.





Note concerning the measurement

As there is no constant pressure downstream of the mixing point, an orifice plate (differential pressure method) should not be applied at this point to measure the total flow rate F. In this case, for example, a magnetic-inductive measurement must be used. Alternatively, if orifice plates are to be used, both partial flow rates upstream of the valves could be measured by the orifice plates and added in the controller.

Other applications

As an alternative to the total flow rate, it is also possible to control the pressure downstream of the mixing point.
Besides mixing cold and hot water, the mixing control can also be used to mix two liquefied gases (O_2 and N_2) to cool a grain silo. In this case, the mixing ratio (O_2 to N_2) and the amount of cold air are controlled. Similar to the single-lever faucet principle, the mixture O_2 to N_2 is the same as the mixed water temperature and the amount of cold air the same as the amount of water.

1.	Position both DIP switches for analog input AI1 to Pt 100 (left).	
2.	Position both DIP switches for analog input AI2 to mA/V (right).	
3.	Switch on power supply.	
4.	Set control mode (2x fixed set point/follow-up control).	M.1-5

Set inputs:

4.	Set input signal (Pt 100) and measuring range (0 to 100 °C) at analog input AI1.	I.1.1-1 AI1.MIN = 0 °C AI1.MAX = 100 °C	* * *
5.	Determine physical unit (°C) at analog input AI1.	I.1.3-1	*
6.	Set input signal (4 to 20 mA) and measuring range (0 to 10 m^3/h) at analog input AI2.	I.2.1.1-6 AI2.MIN = 0 m^3/h AI2.MAX = 10 m^3/h	* *
7.	Determine physical unit (m^3/h) at analog input AI2.	I.2.3-8	

Set controller [1]:

8.	Assign analog input AI1 as the source for input variable PV (process variable 1).	1C.1.1.1-1	*
9.	Set internal set point SP1 (number of internal set points = 1, SP1 = 50 °C).	1C.2.1.1-1 SP1 = 50 °C	*
10.	Set control algorithm (PI) and control parameters (KP = 1.00 and TN = 120 s).	1C.3.1.1-1 KP = 1.00 TN = 120 s	* * *
11.	Determine restart condition (operation mode after restart = Auto).	1C.4.1-0	*
12.	Assign row 4 of controller display to controller [1] output Y.	1C.5.4-7	
13.	Assign row 5 of controller display to analog output AO1.	1C.5.6-2	

Set controller [2]:

14.	Assign analog input AI2 as the source for input variable PV (process variable 2).	2C.1.1.1-2	
15.	Set internal set point SP1 (number of internal set points = 1, SP1 = 5 m^3/h).	2C.2.1.1-1 SP1 = 5 m^3/h	*
16.	Set control algorithm (PI) and control parameters (KP = 1.00 and TN = 20 s).	2C.3.1.1-1 KP = 1.00 TN = 20 s	* *
17.	Determine restart condition (operation mode after restart = Auto).	2C.4.1-0	*
18.	Assign row 4 of controller display to controller [2] output Y.	2C.5.4-7	
19.	Assign row 5 of controller display to analog output AO2.	2C.5.6-2	

Set output for controller [1]:

20.	Assign formula Y1 ∗ Y2 ∗ AO1.KM/100 with AO1.KM = 1 as source for analog output AO1.	O.1.1-38 AO1.KM = 1.0 *
21.	Set output signal (4 to 20 mA) for analog output AO1.	O.1.2-1 *
22.	Determine operating direction (increasing) for analog output AO1.	O.1.3-1 *

Set output for controller [2]:

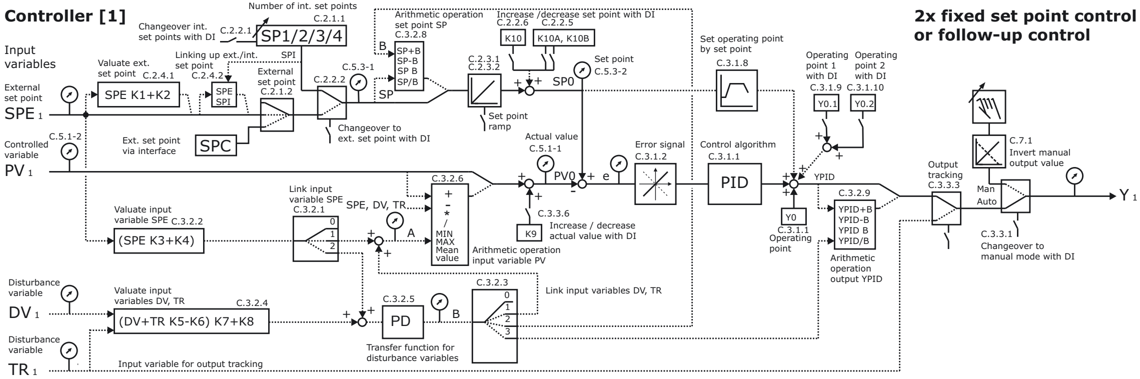
23.	Assign formula (100 – Y1) ∗ Y2 ∗ AO2.KM/100 with AO2.KM = 1 as source for analog output AO2.	O.2.1-39 AO2.KM = 1.0 *
24.	Set output signal (4 to 20 mA) for analog output AO2.	O.2.2-1 *
25.	Determine operating direction (increasing) for analog output AO2.	O.2.3-1 *

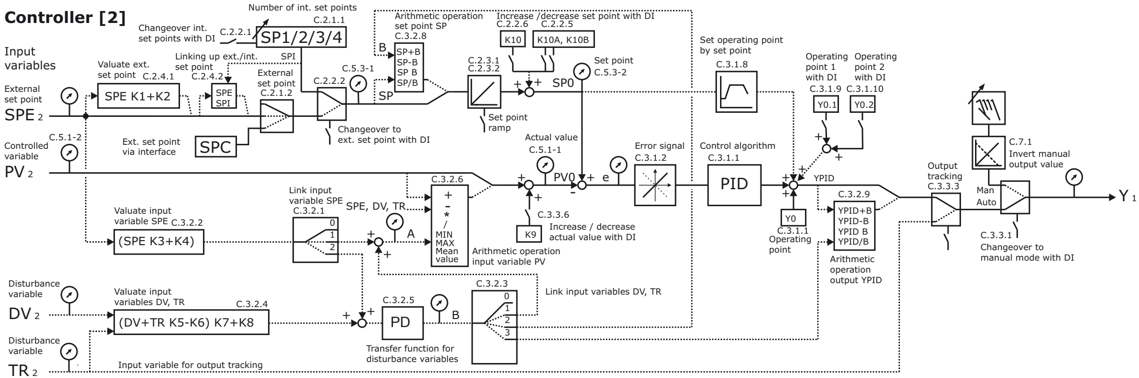
Feedforward control

Block diagram (page 55)

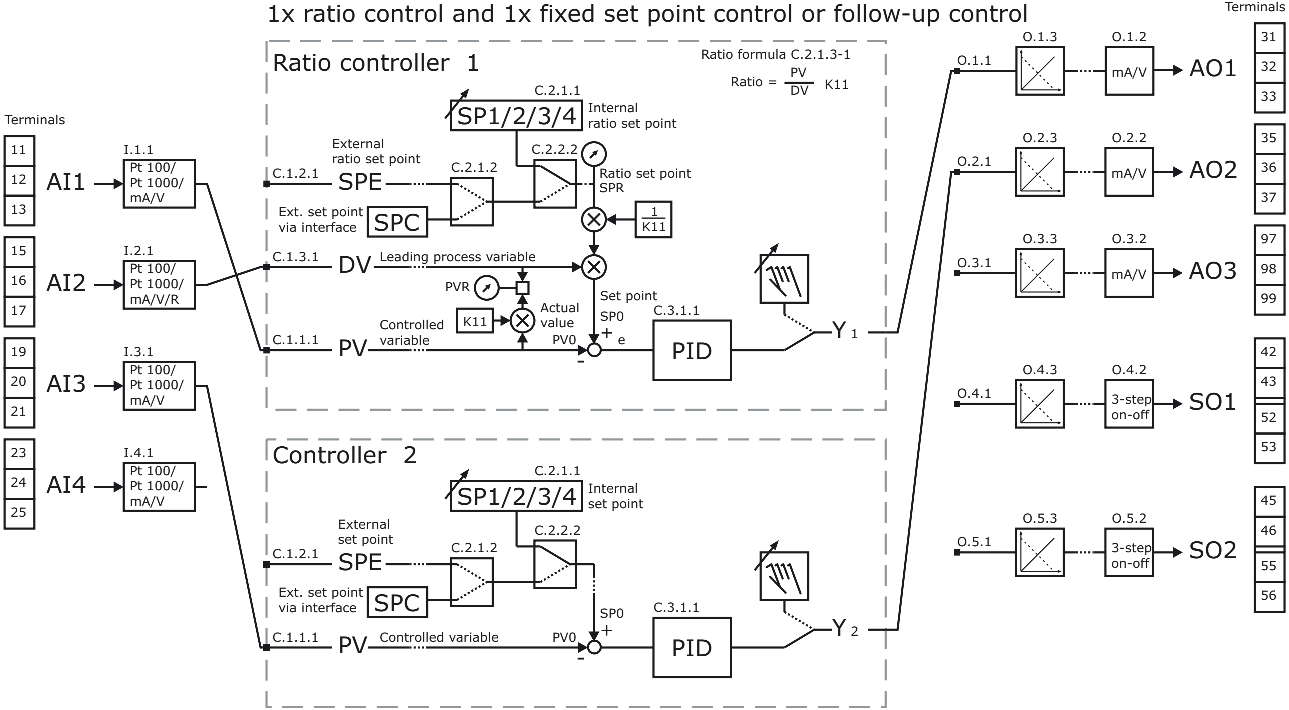
Multi-component control or feedforward control can be implemented by linking the input variables SPE, DV and TR to the input PV, to the set point SP and to the output YPID. Possible interconnections are described in menu item C.3.2.

2x fixed set point control or follow-up control





M.1-6
1x ratio control and 1x fixed set point control or follow-up control



M.1-6 Ratio control and fixed set point/follow-up control

- Simplified block diagram (page 56)
- Detailed block diagram (page 61)

Mode of operation (see menu items M.1-1 and M.1-2)

Controller [1] works as a ratio controller and controller [2] works as a fixed set point or slave controller. After selecting the control mode, both controllers are configured separately from one another. The operating keys and display for controller [1] are arranged on the left-hand side and on the right-side for controller [2].

The block diagram on page 56 shows the control mode with the default settings of the inputs and outputs.

Controller [1] receives the process variable PV [1] at input AI1 and the leading process variable DV [1] at input AI2 and issues the manipulated variable at output AO1.
Controller [2] receives the process variable PV [2] at input AI3 and issues the manipulated variable at output AO2.

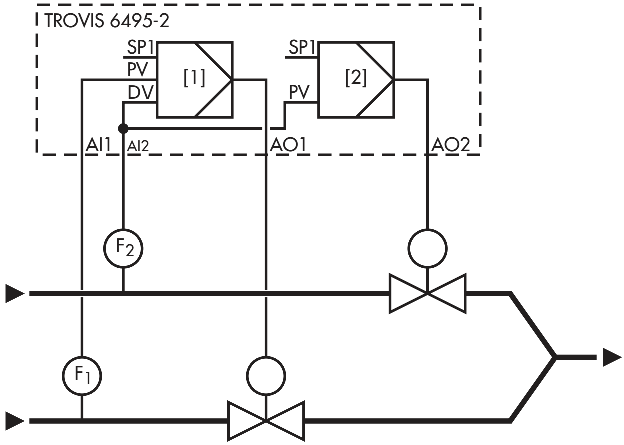
Example: Control of the mixing ratio of two components with control of the leading process variable

The ratio controller [1] receives the flows F_1 and F_2 as 4 to 20 mA signals from two transmitters (Media 6) and positions the control valve for flow F_1 by issuing a 4 to 20 mA signal at output AO1 to maintain flow rate F_1 at ratio of 5 % to flow F_2.
Each time flow F_2 (leading process variable DV) changes, the flow F_1 (process variable PV) is adapted to meet the fixed target ratio. The target ratio F_1/F_2 is set with SP1 to 5 %.

The controller [2] receives the flow F_2 and issues a 4 to 20 mA signal at AO2 to position the control valve for flow F_2 to maintain flow F_2 constant at 100 m^3/h or to limit it. The set point is adjusted with SP1 [2].

Flow transmitter F_1: Measuring range 0 to 10 m^3/h

Flow transmitter F_2: Measuring range 0 to 200 m^3/h



For this ratio control and fixed set point/follow-up control, the following configuration procedure needs to be performed (configuration settings marked with an asterisk * are the same as the standard configuration for ratio control and fixed set point/follow-up control):

1.	Position both DIP switches for analog input AI1 and analog input AI2 to 4 to 20 mA (right).	
2.	Switch on power supply.	
3.	Set control mode (ratio control and fixed set point/follow-up control).	M.1-6

Set inputs:

4.	Set input signal (4 to 20 mA) and measuring range (0 to 10 m³/h) at analog input AI1.	I.1.1-1 AI1.MIN = 0 m³/h * AI1.MAX = 10 m³/h
5.	Determine physical unit (m³/h) at analog input AI1.	I.1.3-8
6.	Set input signal (4 to 20 mA) and measuring range (0 to 200 m³/h) at analog input AI2.	I.2.1.1-1 AI2.MIN = 0 m³/h * AI2.MAX = 200 m³/h
7.	Determine physical unit (m³/h) at analog input AI2.	I.2.3-8

Set ratio controller [1]:

8.	Assign analog input AI1 as the source for input variable PV (process variable).	1C.1.1.1-1	*
9.	Assign analog input AI2 as the source for input variable DV (leading process variable).	1C.1.3.1-2	*
10.	Set ratio set point (number of internal set points = 1, SP1 = 5.0 %).	1C.2.1.1-1 SP1 = 5 %	*
11.	Enter the ratio formula ($\frac{DV}{PV}$∗K11 and K11 = 100.0).	1C.2.1.3-1 K11 = 100.0	*
12.	Set control algorithm (PI) and control parameters (KP = 2.00 and TN = 10 s).	1C.3.1.1-1 KP = 2.00 TN = 10 s	*
13.	Determine restart condition (operation mode after restart = Auto).	1C.4.1-0	*

Set controller [2]:

14.	Assign analog input AI2 as the source for input variable PV (process variable).	2C.1.1.1-2	
15.	Set internal set point SP1 (number of internal set points = 1, SP1 = 150 m^3/h).	2C.2.1.1-1 SP1 = 150 m^3/h	*
16.	Set control algorithm (PI) and control parameters (KP = 2.00 and TN = 10 s).	2C.3.1.1-1 KP = 2.00 TN = 10 s	*
17.	Determine restart condition (operation mode after restart = Auto).	2C.4.1-0	*

Set output for ratio controller [1]:

18.	Assign Controller [1] output Y as the source for analog output AO1.	O.1.1-1	*
19.	Set output signal (4 to 20 mA) for analog output AO1.	O.1.2-1	*
20.	Determine operating direction (increasing) for analog output AO1.	O.1.3-1	*

Set output for controller [2]:

21.	Assign Controller [2] output Y as the source for analog output AO2.	O.2.1-2	*
22.	Set output signal (4 to 20 mA) for analog output AO2.	O.2.2-1	*
23.	Determine operating direction (increasing) for analog output AO2.	O.2.3-1	*

Feedforward control

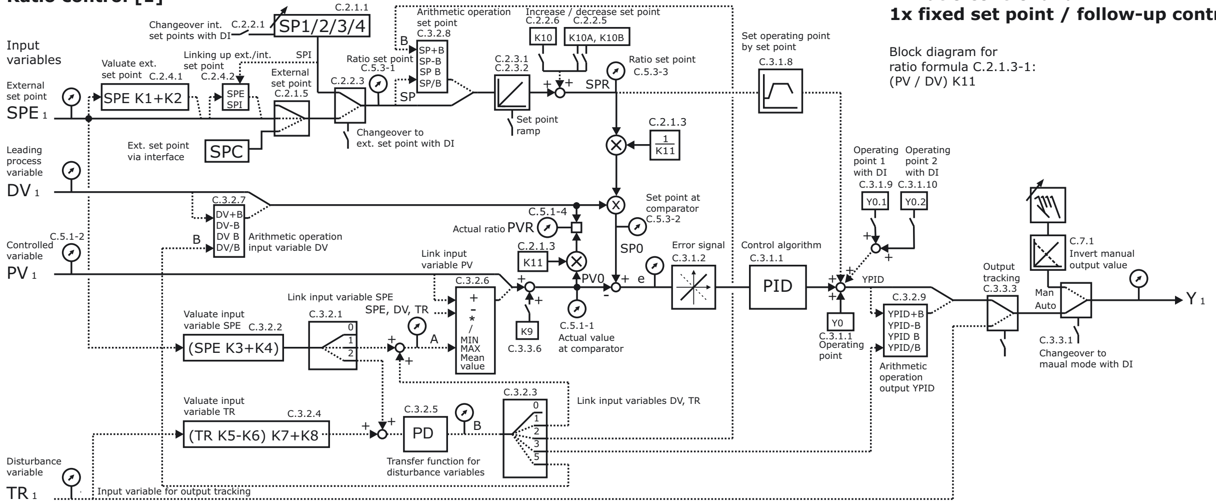
Block diagram (page 61)

Multi-component control or feedforward control can be implemented by linking the input variables SPE, DV and TR to the input PV, to the set point SP and to the output YPID. Possible interconnections are described in menu item C.3.2.

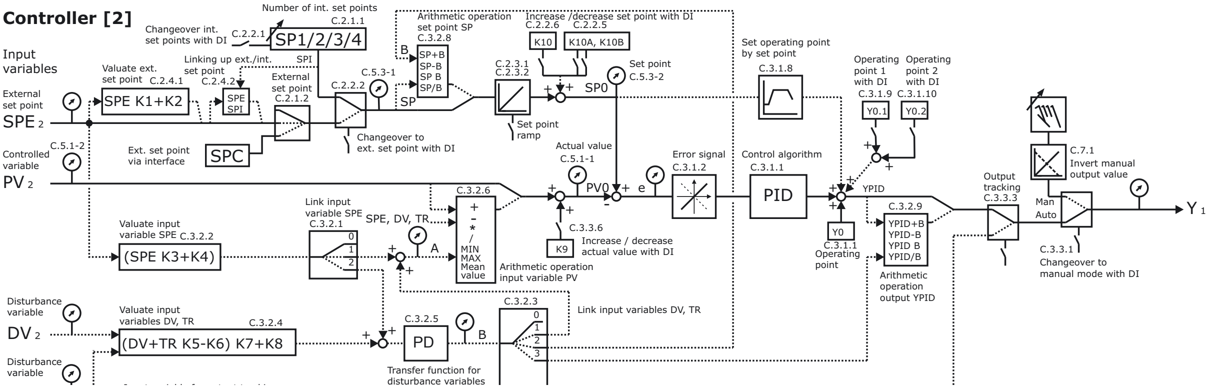
Ratio control [1]

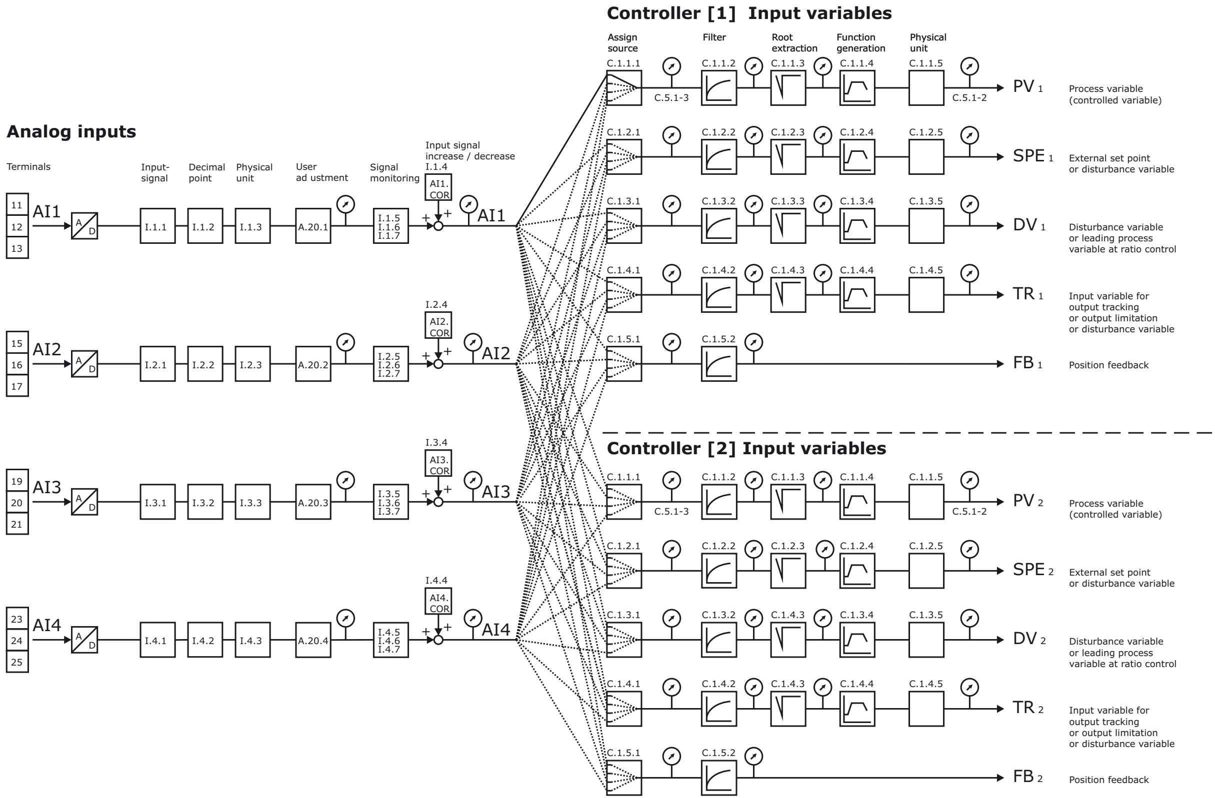
1x ratio control and 1x fixed set point / follow-up control

Block diagram for ratio formula C.2.1.3-1: (PV / DV) K11



Controller [2]





Analog inputs
Terminals
Input-signal
Decimal point
Physical unit
User ad ustment
Signal monitoring
Input signal increase / decrease
I.1.4
AI1.COR
11
12
13
AI1
A D
I.1.1
I.1.2
I.1.3
A.20.1
I.1.5 I.1.6 I.1.7
AI1
I.2.4
AI2.COR
15
16
17
AI2
I.2.1
I.2.2
I.2.3
A.20.2
I.2.5 I.2.6 I.2.7
AI2
I.3.4
AI3.COR
19
20
21
AI3
I.3.1
I.3.2
I.3.3
A.20.3
I.3.5 I.3.6 I.3.7
AI3
I.4.4
AI4.COR
23
24
25
AI4
I.4.1
I.4.2
I.4.3
A.20.4
I.4.5 I.4.6 I.4.7
AI4
Controller [1] Input variables
Assign source
Filter
Root extraction
Function generation
Physical unit
C.1.1.1
C.1.1.2
C.1.1.3
C.1.1.4
C.1.1.5
C.5.1-3
C.5.1-2
PV 1
Process variable (controlled variable)
C.1.2.1
C.1.2.2
C.1.2.3
C.1.2.4
C.1.2.5
SPE 1
External set point or disturbance variable
C.1.3.1
C.1.3.2
C.1.3.3
C.1.3.4
C.1.3.5
DV 1
Disturbance variable or leading process variable at ratio control
C.1.4.1
C.1.4.2
C.1.4.3
C.1.4.4
C.1.4.5
TR 1
Input variable for output tracking or output limitation or disturbance variable
C.1.5.1
C.1.5.2
FB 1
Position feedback
Controller [2] Input variables
C.1.1.1
C.1.1.2
C.1.1.3
C.1.1.4
C.1.1.5
C.5.1-3
C.5.1-2
PV 2
Process variable (controlled variable)
C.1.2.1
C.1.2.2
C.1.2.3
C.1.2.4
C.1.2.5
SPE 2
External set point or disturbance variable
C.1.3.1
C.1.3.2
C.1.4.3
C.1.3.4
C.1.3.5
DV 2
Disturbance variable or leading process variable at ratio control
C.1.4.1
C.1.4.2
C.1.4.3
C.1.4.4
C.1.4.5
TR 2
Input variable for output tracking or output limitation or disturbance variable
C.1.5.1
C.1.5.2
FB 2
Position feedback

I Input

The I Input menu allows the user to configure the analog inputs (AI1 to AI4) and how the digital inputs (DI1 to DI4) are to act.

I.1...I.4 AI1...AI4: Analog input 1 to 4

The following section refers to all analog inputs AI1 to AI4 (see overview on page 62). The following applies:

- Configuration items **I.1.x** apply to analog input **AI1**.
- Configuration items **I.2.x** apply to analog input **AI2**.
- Configuration items **I.3.x** apply to analog input **AI3**.
- Configuration items **I.4.x** apply to analog input **AI4**.

Sections that only apply to one specific analog input are marked accordingly.

I.1.1...I.4.1 AI1...AI4: Input signal

This configuration item is used to configure the input signal and the measuring range of the analog input. The configuration is performed step-by-step.

1. Setting the DIP switches

Before an analog input can be configured, the DIP switches must be set correspondingly. These switches are used to initially select whether an input is to accept a current/voltage signal (mA, V) or a resistance signal (Pt 100, Pt 1000, potentiometer). Two DIP switches are used to make the initial setting for each analog input. Their position must always be identical.

The initial setting only takes effect when both DIP switches of an analog input have the same position. If the position of just one DIP switch is changed, the last valid configuration of the input remains active. The digital output for error messages DO7 is activated and the fault alarm icon is displayed. The controller does not switch to manual mode. The *Error message* menu item in the info menu indicates which input is affected.

Two DIP switches are assigned to each analog input AI1 to AI4.

- Both DIP switches on right: Current signal (mA or V)
- Both DIP switches on left: Resistance signal (Pt 100 or Pt 1000)
  or potentiometer (only with analog input AI2)

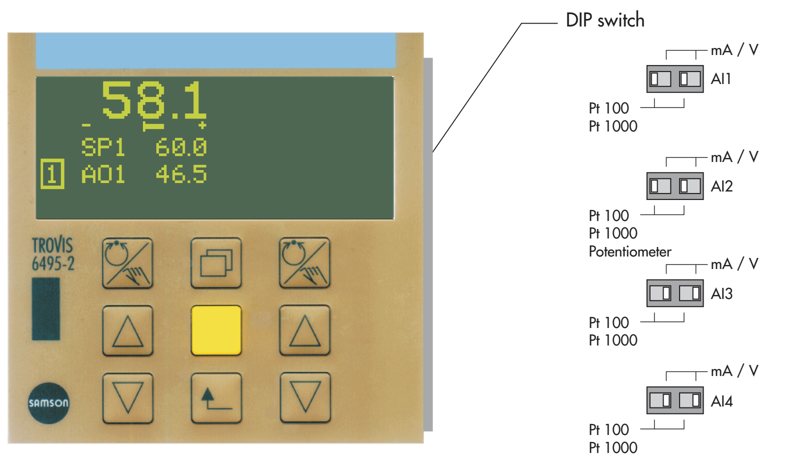


Fig. 1 · DIP switches (at the side of the housing)

2. Configuring the input signal

Depending the position of the DIP switches, the analog input can be configured as follows:

I.1.1 (AI1) **I.2.2** (AI2) **I.3.1** (AI3) **I.4.1** (AI4)	**Input signal**	
-1 1)	4–20 mA	Both DIP switches on right: mA/V
-2	0–20 mA	Both DIP switches on right: mA/V
-3	0–10 V	Both DIP switches on right: mA/V
-4	2–10 V	Both DIP switches on right: mA/V
-5	Via interface	
-6 1)	Pt 100	Both DIP switches on left: Pt 100/Pt 1000
-7	Pt 1000	Both DIP switches on left: Pt 100/Pt 1000
Additional settings of analog input AI2:		
-8	Potentiometer 100 ohm	Both DIP switches on left: Pt 100/Pt 1000/potentiometer
-9	Potentiometer 200 ohm	Both DIP switches on left: Pt 100/Pt 1000/potentiometer
-10	Potentiometer 500 ohm	Both DIP switches on left: Pt 100/Pt 1000/potentiometer
-11	Potentiometer 1000 ohm	Both DIP switches on left: Pt 100/Pt 1000/potentiometer

1) AI1 and AI2: default setting -6 · AI3 and AI4: default setting -1

By assigning the input to the interface (setting -5) the value for the input signal can be transferred over the optional interface. For example, an external set point or an external output value can be specified over the interface.

3. Defining the measuring range

The measuring range limits assign the numerical display value to the input signal. The range limits must be set to the actual measuring range of the connected transmitter.
When connecting a resistance thermometer, the range limits can be selected within a range of –50 to 300 °C (–58 to 572 °F) as required. The measurable range may be wider depending on the factory or user calibration. Controllers with firmware V1.11 and higher have an adjustable measuring range –999 to 9999. The signal monitoring (I.1.5...I.4.5) takes effect when the input signal is 5 % outside the rated signal range.
The default setting of all input ranges is 0 to 100.

AI1.MIN (AI1) AI2.MIN (AI2) AI3.MIN (AI3) AI4.MIN (AI4)	Lower range value [–999.0 …**0.0**… 9999.0]	
AI1.MAX (AI1) AI2.MAX (AI2) AI3.MAX (AI3) AI4.MAX (AI4)	Upper range value [–999.0 …**100.0**… 9999.0]	
AI1.K1 (AI1) AI2.K1 (AI2) AI3.K1 (AI3) AI4.K1 (AI4)	Initial value [–999.0 …**0.0**… 9999.0]	<I.1.1-5> <I.2.1-5> <I.3.1-5> <I.4.1-5>

Resistance thermometers

The analog inputs AI1 to AI4 are designed for the connection of resistance thermometers Pt 100 and Pt 1000 in three-wire circuits (refer to EB 6495-2 EN). Lead calibration is not necessary. Resistance thermometers can also be connected in two-wire circuits. In this case, connect a jumper between the controller terminals. Take into account that the lead resistance may reach several ohms over long distances, causing the measured value to be considerably distorted. This measured value can be compensated for by using a correction value.

- Input signal increase/decrease, see menu items I.1.5...I.4.5

The physical unit (unit of measurement) setting (°C and °F) influences the input characteristic of Pt 100/Pt 1000 sensors.

- Physical unit, see menu item I.1.3...I.4.3

Potentiometers

The analog input AI2 is designed for the connection of a potentiometer with the rated values of 100, 200, 500 or 1000 Ω.

A potentiometer is used, for instance, for position feedback of an electrical actuator or for input of the external set point.

For potentiometer measurements, calibration is performed by setting zero and the final value. See menu item A.20.

Refer also to EB 6495-2 EN for more details.

Initial value

If the interface is assigned to the analog input as the signal source, an initial value must be set in the AI1.K1...AI4.K1 parameter. The initial value is directly active after configuration or after a restart due to a power failure. It remains valid until the the control station writes a value.

The initial value can also be used for testing an input.

The AI1.K1...AI4.K1 parameter is also the default value during signal monitoring I.1.5...I.4.5.

I.1.2...I.4.2 AI1...AI4: Decimal point

This configuration item allows the number of decimal places for an analog input to be determined.

The default setting is one decimal place.

I.1.2 (AI1) **I.2.2** (AI2) **I.3.2** (AI3) **I.4.2** (AI4)	**Decimal point**	
-0	XXXX	No decimal place
-1	XXX.X	1 decimal place
-2	XX.XX	2 decimal places
-3	X.XXX	3 decimal places

I.1.3...I.4.3 AI1...AI4: Physical unit

This configuration item allows the physical unit (unit of measurement) to be assigned to an analog input.

The physical unit is displayed next to the signals and in the info menu together with the inputs and outputs. In addition, the physical unit is used for documentation purposes in the TROVIS-VIEW interface (see Fig. 2).

No unit (Off) is set by default for mA/V inputs. The °C unit is the default setting for Pt 100/Pt 1000 inputs. Only the units °C und °F can be set as the physical unit for Pt 100 and Pt 1000 input signals.

If the input is set to Pt 100 or Pt 1000, the input characteristic is automatically set to °C or °F. The physical units for all other input signals do not have any influence on the characteristic.

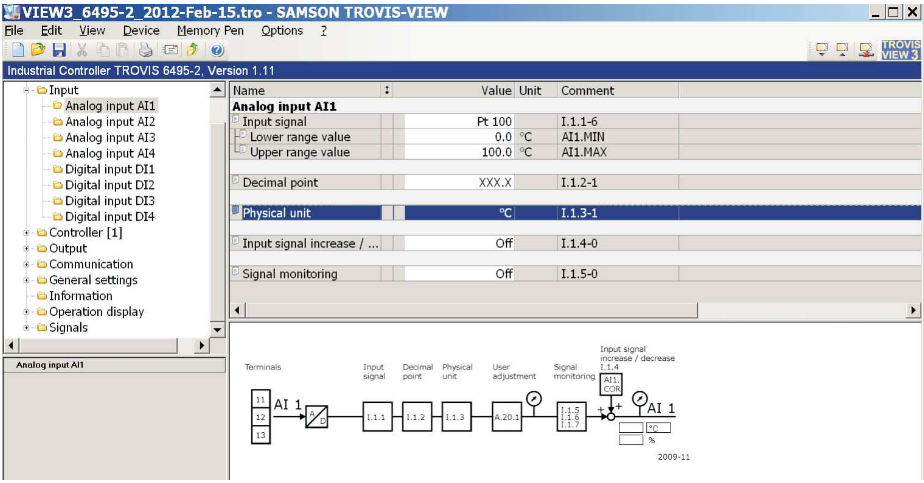


Fig. 2 · Physical unit in TROVIS-VIEW

I.1.3 (AI1) I.2.3 (AI2) I.3.3 (AI3) I.4.3 (AI4)	**Physical unit**		
-0 [1]	Off		<not with I.x.1-6/-7>
-1 [1]	°C	Temperature	
-2	°F	Temperature	
-3	K	Temperature	<not with I.x.1-6/-7>
-4	bar	Pressure	<not with I.x.1-6/-7>
-5	mbar	Pressure	<not with I.x.1-6/-7>
-6	psi	Pressure	<not with I.x.1-6/-7>
-7	kPa	Pressure	<not with I.x.1-6/-7>
-8	m^3/h	Flow rate	<not with I.x.1-6/-7>
-9	l/h	Flow rate	<not with I.x.1-6/-7>
-10	ft^3/h	Flow rate	<not with I.x.1-6/-7>
-11	kg/h	Mass flow	<not with I.x.1-6/-7>
-12	t/h	Mass flow	<not with I.x.1-6/-7>
-13	lb/h	Mass flow	<not with I.x.1-6/-7>
-14	%		<not with I.x.1-6/-7>
-15	mFS	Filling level (meter)	<not with I.x.1-6/-7>
-16	mmFS	Filling level (millimeter)	<not with I.x.1-6/-7>
-17	inH_2O	Filling level (inch w. column)	<not with I.x.1-6/-7>
-18	%rF	Relative humidity (%)	<not with I.x.1-6/-7>
-19	kg/m^3	Density	<not with I.x.1-6/-7>
-20	pH	pH value	<not with I.x.1-6/-7>

[1] AI1 and AI2: default setting -1 · AI3 and AI4: default setting -0

I.1.4...I.4.4 AI1...AI4: Input signal increase/decrease

This configuration item is used to raise or decrease the input signal by a constant amount.

This function is deactivated by default (setting -0).

The setting -1 causes an increase or decrease by the adjusted correction value to be performed. The correction value is adjusted as a numerical value.

This function is used, for instance, when a Pt 100 sensor is connected in a two-wire circuit and a higher temperature is displayed due to the lead resistance. The displayed error can be compensated for by a negative correction value.

Example: The temperature at analog input AI1 is displayed 2 °C higher than actually measured. The displayed error is compensated for by configuring I.1.4-1 and AI1.COR = –2

I.1.4 **I.2.4** **I.3.4** **I.4.4**	(AI1) (AI2) (AI3) (AI4)	**Input signal increase/decrease**	
-0		Off	
-1		On	
AI1.COR AI2.COR AI3.COR AI4.COR	(AI1) (AI2) (AI3) (AI4)	Correction value	<I.1.4-1> <I.2.4-1> <I.3.4-1> <I.4.4-1>
		[–999.0 ...**0.0**... 9999.0]	

I.1.5...I.4.5 AI1...AI4: Signal monitoring

The signal monitoring recognizes a sensor or wire breakage or a short circuit.

- **Setting -0:** Off
  The signal disturbance is not indicated.
  If the measured value lies outside the AD converter range, a range violation is indicated.
- **Setting -1:** On
  The signal disturbance is indicated.
  If the measured value is more than 5 % below the initial value or more than 5 % above the upper range value of the rated signal range, the signal disturbance is reported.
- **Setting -2:** On (with default value)
  The signal disturbance is indicated.
  If the measured value is more than 5 % below the initial value or more than 5 % above the upper range value of the rated signal range, the signal disturbance is reported and the defined default value AI1.K1...AI4.K1 is activated.

Signal monitoring for input signal over interface

If the interface was assigned to the input as the source, the cyclic write access of the control system is monitored. A signal disturbance (communication failure) is recognized whenever there is no write access of the control system within the adjusted timeout period.

Note: *The default value AI1.K1...AI4.K1 is also the initial value which is set in I.1.1... I.4.1.*

I.1.5 **I.2.5** **I.3.5** **I.4.5**	(AI1) (AI2) (AI3) (AI4)	**Signal monitoring**	
-0 -1 -2		Off On On (with default value)	
AI1.K1 AI1.K2 AI1.K3 AI1.K4	(AI1) (AI2) (AI3) (AI4)	Default value [–999.0 ...**0.0**... 9999.0]	<I.1.5-2> <I.2.5-2> <I.3.5-2> <I.4.5-2>
AI1.TOUT AI2.TOUT AI3.TOUT AI4.TOUT	(AI1) (AI2) (AI3) (AI4)	Timeout interface [1 ...**60**... 9999 s]	<I.1.1-5, I.1.5≠0> <I.2.1-5, I.2.5≠0> <I.3.1-5, I.3.5≠0> <I.4.1-5, I.4.5≠0>

Reporting the signal disturbance

When a signal disturbance occurs, the fault alarm icon is displayed in the operating level and the digitial output DO7 is activated. In the info menu, after selecting the *Error message* submenu, it is possible to read at which analog input the range violation exists or the cyclic write access failed to take place. In addition, the *Last events* submenu contains a list of time-stamped incoming and outgoing range violations.

If required, the digital outputs DO5 and DO6 can also report signal disturbances.

- Assign function for digital output DO5/6, see menu items O.10.1...O.11.1

It is also possible to automatically transfer the controller assigned to the analog input to manual mode when a signal disturbance occurs.

- Manual mode Controller [1]/[2] at signal error, see menu items I.1.6...I.4.6

I.1.6...I.4.6 AI1…AI4: Manual mode Controller [1] at signal error

This configuration item allows the controller to be configured so that it switches to manual mode when there is a signal disturbance.

This function can only be selected when the signal monitoring (see menu items I.1.5...I.4.5) of the input concerned has been configured and the input has been assigned to a controller input variable (see menu items C.1.1.1...C.1.5.1).

- **Settings -1/-2/-3/-4/-5:** Constant output value at AO1/AO2/AO3/SO1/SO2
  This determines to which output a constant output value is to be issued in manual mode. For this purpose, a parameter AO1.K1…AO3.K1 or SO1.K1…SO2.K1 is assigned to each output (AO1 to AO3 or SO1 to SO2). The constant output value is only active when the controller was in automatic mode beforehand. In manual mode, the output value can then be changed using the cursor keys (△ and ▽). The controller can first be switched back to automatic mode when there is no longer any signal disturbance.

- **Setting -6:** with last output value
  The controller switches to manual mode and the last output value is issued. In manual mode, the output value can then be changed using the cursor keys (△ and ▽).
  The controller can first be switched back to automatic mode when there is no longer any signal disturbance.

Note: *The AO1.K1…AO3.K1 and SO1.K1…SO2.K1 parameters are used for several different functions:*

– Manual mode controller at signal error SPC, see menu item C.2.1.7
– Operation mode after restart, see menu item C.4.1
– Constant output value with DI, see menu items O.1.6...O.3.6 and O.4.6...O.5.6

I.1.6	(AI1)		<I.1.5≠0>
I.2.6	(AI2)	**Manual mode Controller [1]**	<I.2.5≠0>
I.3.6	(AI3)	**at signal error**	<I.3.5≠0>
I.4.6	(AI4)		<I.4.5≠0>
	-0	Off	
	-1	Constant output value at AO1	<O.1.1-1>
	-2	Constant output value at AO2	<O.2.1-1>
	-3	Constant output value at AO3	<O.3.1-1>
	-4	Constant output value at SO1	<O.4.1-1>
	-5	Constant output value at SO2	<O.5.1-1>
	-6	With last output value	<O.1.1-1...O.5.1-1>

AO1.K1	Constant output value at AO1 [–10.0 …**0.0**… 110.0 %]	<I.1.6-1...I.4.6-1>
AO2.K1	Constant output value at AO2 [–10.0 …**0.0**… 110.0 %]	<I.1.6-2...I.4.6-2>
AO3.K1	Constant output value at AO3 [–10.0 …**0.0**… 110.0 %]	<I.1.6-3...I.4.6-3>
SO1.K1	Constant output value at SO1 [–10.0 …**0.0**… 110.0 %]	<I.1.6-4...I.4.6-4>
SO2.K1	Constant output value at SO2 [–10.0 …**0.0**… 110.0 %]	<I.1.6-5...I.4.6-5>

I.1.7...I.4.7 AI1…AI4: Manual mode Controller [2] at signal error

This configuration item can only be selected in conjunction with the control modes 2x fixed set point/follow-up control (M.1-5) and ratio control + controller (M.1-6).

In **cascade control** (M.1-3) only the slave controller [1] and in **override control** (M.1-4) only the main controller [1] can be switched over to manual mode. Therefore, in this case, only the *Manual mode Controller [1] at signal error* function can be configured.

Function description, see menu items I.1.6...I.4.6.

I.1.7 **I.2.7** **I.3.7** **I.4.7**	(AI1) (AI2) (AI3) (AI4)	**Manual mode Controller [2] at signal error**	<M.1-5/-6, I.1.5≠0> <M.1-5/-6, I.2.5≠0> <M.1-5/-6, I.3.5≠0> <M.1-5/-6, I.4.5≠0>
	-0	Off	
	-1	Constant output value at AO1	<O.1.1-2>
	-2	Constant output value at AO2	<O.2.1-2>
	-3	Constant output value at AO3	<O.3.1-2>
	-4	Constant output value at SO1	<O.4.1-2>
	-5	Constant output value at SO2	<O.5.1-2>
	-6	With last output value	<O.1.1-2...O.5.1-2>

AO1.K1	Constant output value at AO1 [–10.0 …**0.0**… 110.0 %]	<I.1.7-1...I.4.7-1>
AO2.K1	Constant output value at AO2 [–10.0 …**0.0**… 110.0 %]	<I.1.7-2...I.4.7-2>

AO3.K1	Constant output value at AO3 [–10.0 ...**0.0**... 110.0 %]	<I.1.7-3...I.4.7-3>
SO1.K1	Constant output value at SO1 [–10.0 ...**0.0**... 110.0 %]	<I.1.7-4...I.4.7-4>
SO2.K1	Constant output value at SO2 [–10.0 ...**0.0**... 110.0 %]	<I.1.7-5...I.4.7-5>

I.5...I.8 DI1...DI4: Digital input 1 to 4

The controller has four digital inputs (DI1 to DI4). A power supply of 24 V DC is used to energize these inputs. In combination with the transmitter supply of the controller, the digital input can also be energized over a floating contact.

Note: *The digital inputs DI1 and DI2 share the same ground reference, where as the digital inputs DI3 and DI4 have the same ground reference. Therefore, a mixed operation of these inputs can only be performed in groups. For example, digital inputs DI1 and DI2 are supplied by an internal power supply, while digital inputs DI3 and DI4 are supplied by an external power supply.*

Several functions can be assigned to a digital input defined in the menus C Controller, O Output and A General Settings:

- Reversing digital input, see menu item I.1.5...I.1.8
- Changeover internal set points, see menu item C.2.2.1
- Changeover to external set point, see menu item C.2.2.2
- Open/close cascade, see menu item C.2.2.3
- Incremental/decremental set point change, see menu item C.2.2.5
- Set point increase/decrease by constant, see menu item C.2.2.6
- Set point ramp, see menu item C.2.3.1
- Hold set point ramp, see menu item C.2.3.2
- Invert error signal, see menu item C.3.1.3
- Control mode changeover P(D)/PI(D), see menu item C.3.1.5
- Activate operating point for P/PD controller, see menu items C.3.1.9 and C.3.1.10
- Changeover to manual/automatic mode, see menu item C.3.3.1

- Hold output, see menu item C.3.3.2
- Active output tracking, see menu item C.3.3.3
- Increase/decrease actual value, see menu item C.3.3.6
- Activate constant output value, see menu items O.1.6...O.3.6, O.1.7...O.3.7, O.4.6...O.5.6 and O.4.7...O.5.7
- Start output ramp, see menu items O.1.4...O.3.4 and O.4.4...O.5.4
- Limit output rate, see menu item O.1.5...O.3.5
- Lock all keys, see menu item A.3.1

The following section refers to all digital inputs DI1 to DI4 (see overview on page 62). The following applies:

- Configuration item **I.5.1** applies to digital input **DI1**.
- Configuration item **I.6.1** applies to digital input **DI2**.
- Configuration item **1.7.1** applies to digital input **DI3**.
- Configuration item **1.8.1** applies to digital input **DI4**.

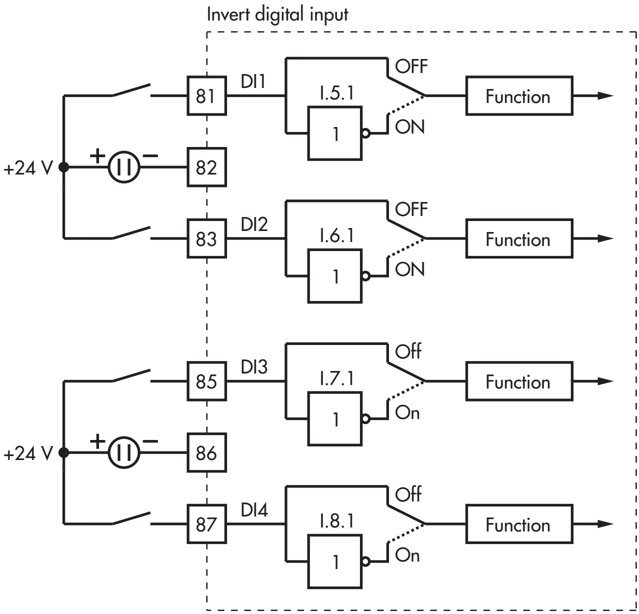
I.5.1...I.8.1 DI1...DI4: Invert

This function is used to invert the digital inputs DI1 to DI4.

Taking into account the operating direction, both NC and NC contacts can be used.

	I.5.1...I.8.1	
Voltage at DI1…DI4	**Setting -0**	**Setting -1**
0 … 10 V	Function inactive (0)	Function active (1)
17 … 31 V	Function active (1)	Function inactive (0)

I.5.1 (DI1) **I.6.1** (DI2) **I.7.1** (DI3) **I.8.1** (DI4)	**Invert**	
-0	Off	
-1	On	


Invert digital input
OFF
DI1
81
I.5.1
Function
1
ON
+24 V
82
OFF
DI2
83
I.6.1
Function
1
ON
Off
DI3
85
I.7.1
Function
1
On
+24 V
86
Off
DI4
87
I.8.1
Function
1
On

C Controller

C.1 Input variables

In contrast to the analog inputs, the input variables are assigned directly to the controller. Depending on the controller settings, the input variables take on various functions.

Submenu	Input variable	Function
C.1.1	PV	Controlled variable, process variable
C.1.2	SPE	External set point (SPE), disturbance variable, auxiliary variable
C.1.3	DV	Disturbance variable (DV), leading process variable for ratio control, auxiliary variable
C.1.4	TR	Input variable for output tracking, disturbance variable, auxiliary variable
C.1.5	FB	Input for position feedback with three-point stepping output

C.1.1...C.1.5 Input variables PV/SPE/DV/TR/FB

C.1.1.1...C.1.5.1 Assign source

This configuration item is used to assign input variables to an analog input.

C.1.1.1 (PV) **C.1.2.1** (SPE) **C.1.3.1** (DV) **C.1.4.1** (TR) **C.1.5.1** (FB)		**Assign source**
	-0 [1]	Off
	-1 [1]	Analog input AI1
	-2	Analog input AI2
	-3	Analog input AI3
	-4	Analog input AI4

[1] PV: default setting -1 · SPE, DV, TR, FB: default setting: -0

C.1.1.2...C.1.5.2 Filter

Each input variable contains a digital filter (first-order low-pass filter) which can be activated. It reduces the amplitude of the selected signal and attenuates high-frequency disturbances. The time constant is specified in seconds.

A large time constant causes

- a high attenuation of interference signals
- a slow reaction time of the input variable
- a low cutoff frequency.

C.1.1.2	(PV)		<C.1.1.1≠0>
C.1.2.2	(SPE)		<C.1.2.1≠0>
C.1.3.2	(DV)	**Filter**	<C.1.3.1≠0>
C.1.4.2	(TR)		<C.1.4.1≠0>
C.1.5.2	(FB)		<C.1.5.1≠0>
	-0	Off	
	-1	On	

PV.T		<C.1.1.2-1>
SPE.T		<C.1.2.2-1>
DV.T	Time constant	<C.1.3.2-1>
TR.T		<C.1.4.2-1>
FB.T		<C.1.5.2-1>
	[0.1 ...**1.0**... 100.0 s]	

C.1.1.3...C.1.4.3 Root extraction

This function is used to form the square root from the input variable.

The root extraction is used for flow rate measurement performed by differential pressure transmitters to calculate the corresponding flow rate from the measured differential pressure.

C.1.1.3	(PV)		<C.1.1.1≠0>
C.1.2.3	(SPE)	**Root extraction**	<C.1.2.1≠0>
C.1.3.3	(DV)		<C.1.3.1≠0>
C.1.4.3	(TR)		<C.1.4.1≠0>
	-0	Off	
	-1	On	

C.1.1.4...C.1.4.4 Function generation

The function generation is used to revaluate an input signal to allow further processing. This function makes it possible to adapt auxiliary, reference or equivalence variables, inherent in measurement or industrial processes, for the control circuit or to perform a linearization. This can be performed when the correlation between the input signal and the required new output signal is known (i.e. due to scientific laws, empirical data or measured data). Examples include the correlation between steam pressure and temperature.

Seven coordinates exist for function generation. Each coordinate is defined by an input value and an output value. Numerical values (e.g. in °C or bar) are entered. *Lower range value* and *Upper range value* define the output range of the function generation. The output values can be adjusted within these range limits. The range limits PV.MIN and PV.MAX of the input variable PV influence the control behavior.

Note:

- *We recommend creating a table or to plot the curve in a Cartesian coordinate system. The seven points for function generation must be selected to be able to plot the curve properly. The controller calculates a straight line between points. Seven points must be defined even if the signal course can be plotted sufficiently with less than seven points. If necessary, enter the first points or the last points to be the same.*
- *The polygonal chain of the curve is not restricted. Polygonal curves with more than one maximum or minimum are possible.*
  However, make sure that only one output value is assigned to an input value. Otherwise, the input signal cannot be clearly assigned to a value.

C.1.1.4 **C.1.2.4** **C.1.3.4** **C.1.4.4**	(PV) (SPE) (DV) (TR)	**Function generation**	<C.1.1.1≠0> <C.1.2.1≠0> <C.1.3.1≠0> <C.1.4.1≠0>
	-0	Off	
	-1	On	

PV.MIN SPE.MIN DV.MIN TR.MIN	(PV) (SPE) (DV) (TR)	Lower range value output function generation	<C.1.1.4-1> <C.1.2.4-1> <C.1.3.4-1> <C.1.4.4-1>
		[–999.0 ...**0.0**... 9999.0]	

PV.MAX SPE.MAX DV.MAX TR.MAX	(PV) (SPE) (DV) (TR)	Upper range value output function generation [–999.0 …**100.0**… 9999.0]	<C.1.1.4-1> <C.1.2.4-1> <C.1.3.4-1> <C.1.4.4-1>
PV.I1...PV.I7 SPE.I1...SPE.I7 DV.I1...DV.I7 TR.I1...TR.I7	(PV) (SPE) (DV) (TR)	Input value 1 to 7 [–999.0 …**1)**… 9999.0] 1) Input value 1 to 6: **0.0** Input value 7: **100.0**	<C.1.1.4-1> <C.1.2.4-1> <C.1.3.4-1> <C.1.4.4-1>
PV.O1...PV.O7 SPE.O1...SPE.O7 DV.O1...DV.O7 TR.O1...TR.O7	(PV) (SPE) (DV) (TR)	Output value 1 to 7 [–999.0 …**1)**… 9999.0] 1) Output value 1 to 6: **0.0** Output value 7: **100.0**	<C.1.1.4-1> <C.1.2.4-1> <C.1.3.4-1> <C.1.4.4-1>

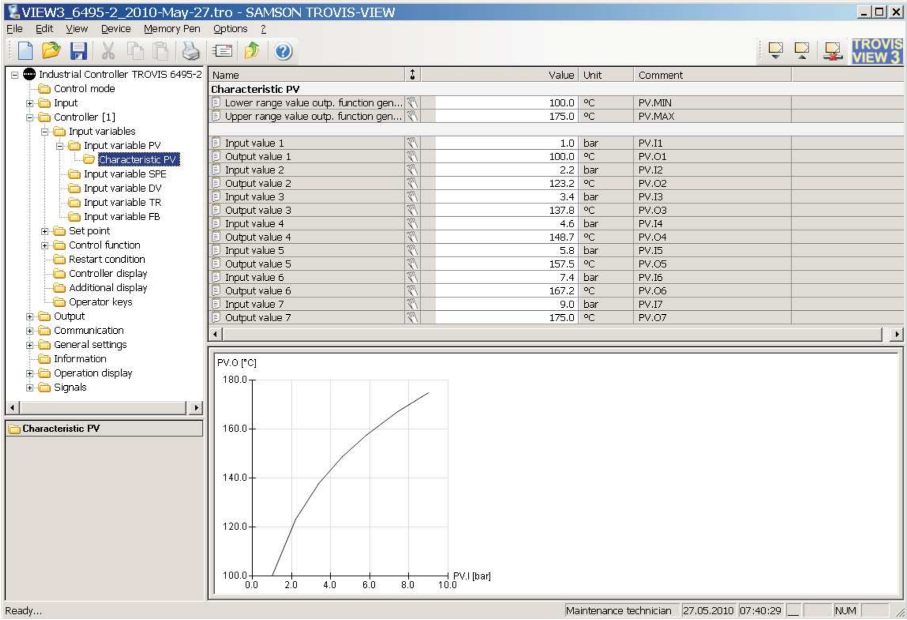
Example: Temperature control of a calender roll (Fig. 3)

The temperature of a steam-heated calender roll is to be controlled using function generation.

Installing a temperature sensor would lead to excessive costs due to the rotational movement of the roll. Therefore, another solution had to be found. As an alternative, steam pressure measurement with a pressure transmitter was installed. The steam pressure arriving on the calender roll can be assigned to a certain temperature value which can be read off at a steam table. Special constructional measures ensure the respective saturated steam temperature is not exceeded.

The pressure transmitter has a measuring range from 0 to 9 bar (absolute). This range corresponds approximately to a temperature range from 100 to 175 °C. The range limits are fixed at 100 °C and 175 °C.

The seven coordinates are obtained from the pressure-temperature curve in the measuring range from 0 to 9 bar.



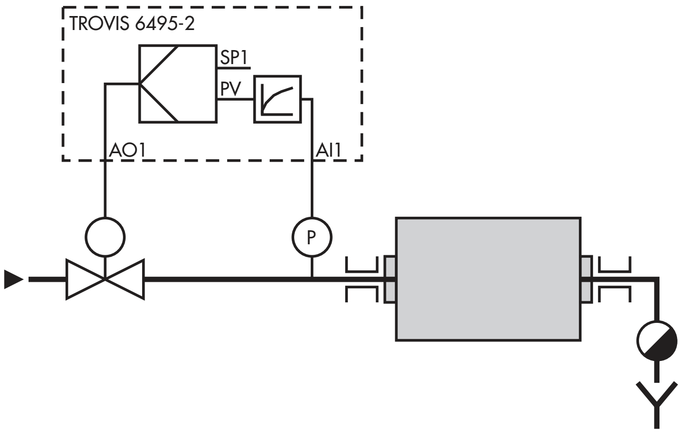


Fig. 3 · Temperature control of a calender roll

C.1.1.5...C.1.4.5 Physical unit after function generation

This configuraiton item is used to assign a physical unit (unit of measurement) to the output signal after function generation. It can only be selected if the associated function generation is activated.
The physical unit is displayed after "Fct" next to the parameter and in the info menu (Controller > Input variable). In addition, the physical unit is used for documentation purposes in the TROVIS-VIEW interface (see Fig. 3).

Note: *Activating the function generation (C.1.1.4-1...C.1.5.4-1) initially leads to the unit used for the assigned analog input (I.1.6...I.4.6) being adopted.*

C.1.1.5 **C.1.2.5** **C.1.3.5** **C.1.4.5**	(PV) (SPE) (DV) (TR)	**Physical unit after function generation**		<C.1.1.4-0> <C.1.2.4-0> <C.1.3.4-0> <C.1.4.4-0>
	-0	Off		
	-1	°C	Temperature	
	-2	°F	Temperature	
	-3	K	Temperature	
	-4	bar	Pressure	
	-5	mbar	Pressure	
	-6	psi	Pressure	
	-7	kPa	Pressure	
	-8	m^3/h	Flow rate	
	-9	l/h	Flow rate	
	-10	ft^3/h	Flow rate	
	-11	kg/h	Mass flow	
	-12	lb/h	Mass flow	
	-13	t/h	Mass flow	
	-14	%		
	-15	mFS	Filling level	
	-16	mmFS	Filling level	
	-17	inH_2O	Filling level (inch water column)	
	-18	%rF	Relative humidity	
	-19	kg/m^3	Density	
	-20	pH	pH value	

C.2 Set point

The set points (reference variable) are configured and their parameters are assigned in this submenu.

C.2.1 Set point adjustment

C.2.1.1 Number of internal set points

This configuration item determines the number of internal set points and their adjustment limits.

The set point SP1 is enabled and active by default for all control modes. Enabled set points can be adjusted in this configuration item or in the operating menu.

- Adjust set points in the operating menu, refer to EB 6495-2 EN

Adjustment limits

An internal set point can be adjusted within the adjustment limits. These limits can be entered separately for the set points SP1 to SP4. For set point SP1, the limits are entered in SP1.MIN and SP1.MAX.

By default, the adjustment limits are automatically set to the range limits of the analog input assigned to the input variable PV. As a result, the set point can be adjusted in the entire measuring range. When the function generation of the input variable PV is activated, the adjustment limits are set automatically to the range limits PV.MIN and PV.MAX.
The limitation of the external set point SPE is performed using the function generation of the input variable SPE.

C.2.1.1	**Number of internal set points**	
-1	1	
-2	2	
-3	3	
-4	4	
SP1		
SP2	Set point	<C.2.1-2/-3/-4>
SP3		<C.2.1-3/-4>
SP4		<C.2.1-4>
	[–999.0 …**0.0**… 9999.0]	

SP1.MIN SP2.MIN SP3.MIN SP4.MIN	Set point lower limit [–999.0 ...**0.0**... 9999.0] 1)	<C.2.1-2/-3/-4> <C.2.1-3/-4> <C.2.1-4>
SP1.MAX SP2.MAX SP3.MAX SP4.MAX	Set point upper limit [–999.0 ...**100.0**... 9999.0] 2)	<C.2.1-2/-3/-4> <C.2.1-3/-4> <C.2.1-4>
	with <M.1-2/-6> to controller [1]: 1) [0.0 ...**100.0**... 9999.0] 2) [0.0 ... **9999.0**]	

C.2.1.2 External set point

This configuration item determines the source for the external set point.

The external set point can be specified either over the input variable SPE or, in combination with an installed interface board, as a digital value SPC directly by a higher level communication network.

- **Setting -1:** Via input variable SPE

  Operation with the external set point SPE is possible over one of four analog inputs (AI1, AI2, AI3 or AI4).

Example: Specify external set point SPE at analog input AI2 using a 4–20 mA signal

Analog input AI2: input signal 4–20 mA Lower range value Upper range value	I.2.1-1 AI2.MIN = 0.0 AI2.MAX = 100.0
Input variable SPE: Source of analog input AI2	C.1.2.1-2
External set point: Via input variable SPE	C.2.1.2-1

The external set point SPE can also be specified over the interface. In this case, an analog input must be assigned to the interface and this analog input must be assigned as the source for the input variable SPE.

Example: Specify external set point SPE at analog input AI2 over RS-485 interface

Analog input AI2: Input signal via interface Lower range value Upper range value Start value	I.2.1-5 AI2.MIN = 0.0 AI2.MAX = 100.0 AI2.K1 = 0.0
Input variable SPE: Source of analog input AI2	C.1.2.1-2
External set point: Via input variable SPE	C.2.1.2-1
RS-485 interface: Modbus RTU protocol Station number Baud rate Parity Stop bit Response timeout	D.3.1-2 STN = 1 BITRATE = 9600 bit/s PARITY = none STOPBIT = 1 RSP.TOUT = 10.0 s

Setting -2: Via interface SPC
Operation with external set point SPC over the optional interface has the advantage that an analog input is not occupied.

Example: Specify external set point SPC over RS-485 interface

External set point: Via interface SPC	C.2.1.2-2
RS-485 interface: Modbus RTU protocol Station number Baud rate Parity Stop bit Response timeout	D.3.1-2 STN = 1 BITRATE = 9600 bit/s PARITY = none STOPBIT = 1 RSP.TOUT = 10.0 s

In SPC control (set point via interface), a control station, for example, takes over the command of the set point.
By selecting *Tracking SPI to SPE/SPC* (C.2.2.4) and *Changeover to external set point with DI* (C.2.2.2), the transfer to set point control is bumpless when the control station fails.

If *Via interface* is assigned as the source for the external set point, Initial value SPC.K1 can be adjusted. The initial value is directly active after configuration or after restarting due to power failure. It remains active until the control station writes a value. SPC.K1 also functions as the default value during signal monitoring SPC, see menu item C.2.1.6-2.

C.2.1.2	External set point	
-0	Off	
-1	Via input variable SPE	<C.1.2.1≠0>
-2	Via interface SPC	only with M.1-3 controller [2]
SPC.K1	Initial value [–999.0 ...**0.0**... 9999.0]	<C.2.1.2-2>

C.2.1.3 Ratio formula

Various ratio formulas can be adjusted to form the ratio (M.1-2 and M.1-6 in controller [1]).

- **Setting -1:** (PV / DV)∗K11
  Mixing ratio of two components (example: neutralization)

$$\text{Ratio} = \frac{\text{Flow 1}}{\text{Flow 2}} \Rightarrow \text{PVR} = \frac{\text{PV}}{\text{DV}} * \text{K11}$$

See block diagram for menu item M.1-2 on pages 18 and 22.

K11 = 1.00 by default, i.e. it does not have any effect on the ratio.
K11 = 100.00 causes the ratio to be displayed and adjusted in %.
K11 = 1000.00 causes the ratio be displayed and adjusted in ‰.

- **Setting -2:** (PV / (PV + DV∗K13))∗K11
  Fixed ratio of one component in a finished product (example: fat percentage in dairy products)

$$\text{Ratio} = \frac{\text{Flow 1}}{\text{Flow 1} + \text{Flow 2}} \Rightarrow \text{PVR} = \frac{\text{PV}}{\text{PV} + \text{DV} * \text{K13}} * \text{K11}$$

- **Setting -3:** ((PV + DV∗K13) / PV)∗K11
  Total flow in relation to the ratio of one of the components

$$\text{Ratio} = \frac{\text{Flow 1} + \text{Flow 2}}{\text{Flow 2}} \Rightarrow \text{PVR} = \frac{\text{PV} + \text{DV} * \text{K13}}{\text{PV}} * \text{K11}$$

- **Setting -4:** Universal formula

$$\text{PVR} = \frac{\text{PV} * \text{K12} + \text{DV} * \text{K13} + \text{TR} * \text{K14}}{\text{PV} * \text{K22} + \text{DV} * \text{K23} + \text{TR} * \text{K24}} * \text{K11}$$

See block diagram for menu item M.1-2 on page 24.

C.2.1.3		**Ratio formula**	<M.1-2/M.1-6 controller [1]>
	-1	(PV / DV)∗ K11	
	-2	(PV / (PV + DV∗ K13))∗ K11	
	-3	((PV + DV∗ K13) / PV)∗ K11	
	-4	Universal formula: $\frac{(PV*K12+ DV*K13+ TR*K14)}{(PV*K22+ DV*K23+ TR*K24)} * K11$	

K11	Factor [0.00 …**1.00**… 9999.00]	
K12	Factor for PV [–999.00 …**1.00**… 9999.00]	<C.2.1.3-4>
K13	Factor for DV [–999.00 …**1.00**… 9999.00]	<C.2.1.3≠1>
K14	Factor for TR [–999.00 …**1.00**… 9999.00]	<C.2.1.3-4>
K22	Factor for PV [–999.00 …**1.00**… 9999.00]	<C.2.1.3-4>
K23	Factor for DV [–999.00 …**0.00**… 9999.00]	<C.2.1.3-4>
K24	Factor for TR [–999.00 …**0.00**… 9999.00]	<C.2.1.3-4>

C.2.1.4 Decimal point for set points

The set point can be displayed with up to three decimal places after it.

One decimal place is used by default.

C.2.1.4		**Decimal point for set points**	
	-1	XXXX	No decimal place
	-2	XXX.X	1 decimal place
	-3	XX.XX	2 decimal places
	-4	X.XXX	3 decimal places

C.2.1.5 Physical unit for set points

Various physical units (units of measurement) can be assigned to the set point which are used for documentation purposes in the TROVIS-VIEW interface.

***Note:** If the unit of the assigned analog input is edited (I.1.6…I.4.6) or a function generation of the input variable is performed (C.1.1.4…C.1.5.4), the physical unit for set points is adapted accordingly.*

C.2.1.5	Physical unit SP	
-0 [1]	Off	
-1 [1]	°C	Temperature
-2	°F	Temperature
-3	K	Temperature
-4	bar	Pressure
-5	mbar	Pressure
-6	psi	Pressure
-7	kPa	Pressure
-8	m^3/h	Flow rate
-9	l/h	Flow rate
-10	ft^3/h	Flow rate
-11	kg/h	Mass flow
-12	lb/h	Mass flow
-13	t/h	Mass flow
-14	%	
-15	mFS	Filling level (meter)
-16	mmFS	Filling level (millimeter)
-17	inH_2O	Filling level (inch water column)
-18	%rF	Relative humidity
-19	kg/m^3	Density
-20	pH	pH value

[1] The unit is already set depending on PV · Ratio controller: default setting -0

C.2.1.6 Signal monitoring SPC

When the external set point is specified over interface (C.2.1.2-2), the cyclic write access of the control system is monitored and communication failure is recognized. If there is no write access over the control system within the adjustable timeout period, this is regarded as a signal disturbance and is reported by an error message. The error message is active until the external set point SPC is written.

- **Setting -1:** On
  The last value is kept when a signal disturbance exists.
- **Setting -2: On** (with default value)
  The default value SPC.K1 is active when a signal disturbance exists. The default value also functions as the initial value which becomes active after a power failure, see menu item C.2.1.2.

C.2.1.6	**Signal monitoring SPC**	<C.2.1.2-2>
-0	Off	
-1	On	
-2	On (with default value)	
SPC.K1	Default value [–999.0 ...**0.0**... 9999.0]	<C.2.1.6≠0>
SPC.TOUT	Timeout interface [1 ...**60**... 99999 s]	<C.2.1.6≠0>

Reporting the signal disturbance

When a signal disturbance occurs, the fault alarm icon is displayed in the operating level. In the info menu, after selecting the *Error message* submenu, *Signal error SPC* (as plain text) appears. In addition, the *Last events* submenu contains a list of time-stamped incoming and outgoing range violations. The digital output DO7 for error messages is activated.
If required, the digital outputs DO5 and DO6 can also report signal disturbances.

- Assign function for digital output DO5/6, see menu items O.10.1...O.11.1

It is also possible to automatically transfer the controller automatically to manual mode when a signal disturbance occurs.

- Manual mode controller at signal error SPC, see menu item C.2.1.7

C.2.1.7 Manual mode controller at signal error SPC

This function switches the controller to manual mode when there is a signal disturbance. In manual mode, the output value can then be changed using the cursor keys (△ and ▽). The controller can first be switched back to automatic mode when there is no longer any signal disturbance. The configuration item can only be selected when the signal monitoring SPC has been activated (settings C.2.1.6-1/-2). The function can be adjusted for controller [1] in cascade control (M.1-3) and override control (M.1-4).

- **Settings -1/-2/-3/-4/-5:** Constant output value at AO1/AO2/AO3/SO1/SO2
  The controller switches to manual mode and a defined output value is issued at an output which can be selected. For this purpose, a AO1.K1...SO2.K1 parameter is assigned to each output (AO1 to SO2). The constant output value is only active when the controller was in automatic mode beforehand.
- **Setting -6:** with last output value
  The controller switches to manual mode and the last output value is issued.

Note: *The AO1.K1…AO3.K1 and SO1.K1…SO2.K1 parameters are used for several different functions:*

– *Manual mode controller [1] at signal error AI, see menu items I.1.6...I.4.6*
– *Manual mode controller [2] at signal error AI, see menu items I.1.7...I.4.7*
– *Operation mode after restart, see menu item C.4.1*
– *Constant output value with DI, see menu items O.1.6...O.3.6 and O.4.6...O.5.6*

C.2.1.7	**Manual mode controller at signal error SPC**		<C.2.1.6≠0>
-0	Off	Controller [1]	Controller [2]
-1	Constant output value at AO1	<O.1.1-1/-38/-39>	<O.1.1-2/-38/-39>
-2	Constant output value at AO2	<O.2.1-1/-38/-39>	<O.2.1-2/-38/-39>
-3	Constant output value at AO3	<O.3.1-1/-38/-39>	<O.3.1-2/-38/-39>
-4	Constant output value at SO1	<O.4.1-1/-38/-39>	<O.4.1-2/-38/-39>
-5	Constant output value at SO2	<O.5.1-1/-38/-39>	<O.5.1-2/-38/-39>
-6	With last output value	<O.1.1-1/-38/-39... O.5.1-1/-38/-39>	<O.1.1-2/-38/-39... O.5.1-2/-38/-39>

AO1.K1	Constant output value at AO1 [–10.0 ...**0.0**... 110.0 %]	<C.2.1.7-1>

AO2.K1	Constant output value at AO2 [–10.0 ...**0.0**... 110.0 %]	<C.2.1.7-2>
AO3.K1	Constant output value at AO3 [–10.0 ...**0.0**... 110.0 %]	<C.2.1.7-3>
SO1.K1	Constant output value at SO1 [–10.0 ...**0.0**... 110.0 %]	<C.2.1.7-4>
SO2.K1	Constant output value at SO2 [–10.0 ...**0.0**... 110.0 %]	<C.2.1.7-5>

C.2.2 Changeover set points

This submenu contains functions to change between set points.

C.2.2.1 Changeover internal set points with DI

This configuration item causes the changeover of internal set points SP1 to SP4 initiated by digital inputs.

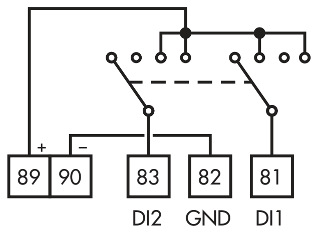
- **Settings -1/-2/-3/-4:** SP1/SP2 with DI1/DI2/DI3/DI4
  Changeover between two set points: One of the digital inputs DI1 to DI4 is used to change over between the set points SP1 and SP2. A '1' signal at the digital input (energized) causes a changeover to set point SP2. To be able to use this function, two internal set points must be configured (C.2.1.1-2).

Signal states fur set point changeover				
C.2.2.1-	**1**	**2**	**3**	**4**
Active set point	**DI1**	**DI2**	**DI3**	**DI4**
SP1	0	0	0	0
SP2	1	1	1	1

Setting -5: SP1…SP4 with DI1, DI2
Binary-coded changeover between four set points: The digital inputs DI1 and DI2 are used to perform a binary-coded changeover. To be able to use this function, four internal set points must be configured (C.2.1.1-4).

Signal states for set point changeover		
Active set point	**DI2**	**DI1**
SP1	0	0
SP2	0	1
SP3	1	0
SP4	1	1

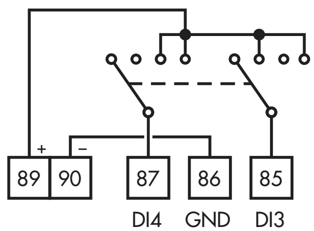
Circuit example: Double-pole four-way switch



Setting -6: SP1…SP4 with DI3, DI4
Binary-coded changeover between four set points: The digital inputs DI3 and DI4 are used to perform a binary-coded changeover. To be able to use this function, four internal set points must be configured (C.2.1.1-4).

Signal states for set point changeover		
Active set point	**DI4**	**DI3**
SP1	0	0
SP2	0	1
SP3	1	0
SP4	1	1

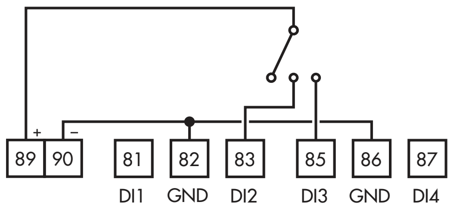
Circuit example: Double-pole four-way switch



Setting -7: SP1…SP3 with DI2, DI3
Changeover between three set points: The digital inputs DI2 and DI3 are assigned directly to the set points SP2 and SP3. To be able to use this function, three internal set points must be configured (C.2.1.1-3).

Signal states for set point changeover		
Active set point	**DI3**	**DI2**
SP1	0	0
SP2	0	1
SP3	1	0/1

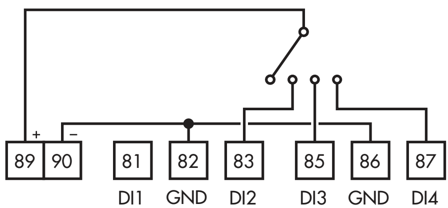
Circuit example: Three-way switch



Setting -8: SP1…SP4 with DI2, 3, 4
Changeover between four set points: The digital inputs DI2, DI3 and DI4 are assigned directly to the set points SP2, SP3 and SP4. To be able to use this function, four internal set points must be configured (C.2.1.1-4).

Signal states for set point changeover			
Active set point	**DI4**	**DI3**	**DI2**
SP1	0	0	0
SP2	0	0	1
SP3	0	1	0/1
SP4	1	0/1	0/1

Circuit example: Four-way switch



Note:
- *The operating direction of the digital inputs can be reversed, see menu items I.5.1...I.8.1.*
- *Several functions can be assigned to the digital inputs, see menu items I.5...I.8.*
- *The internal set point can also be changed in the operating level independently of the digital inputs, refer to EB 6495-2 EN.*

– *The internal set points in firmware version 1.21 and higher can be changed over using Modbus by the holding register HR 55 (Controller [1]) and HR 115 (Controller [2]). See section D.*

C.2.2.1	Changeover internal set points with DI	
-0	Off	
-1	SP1/SP2 with DI1	<C.2.1.1-2>
-2	SP1/SP2 with DI2	<C.2.1.1-2>
-3	SP1/SP2 with DI3	<C.2.1.1-2>
-4	SP1/SP2 with DI4	<C.2.1.1-2>
-5	SP1…SP4 with DI1, DI2	<C.2.1.1-4>
-6	SP1…SP4 with DI3, DI4	<C.2.1.1-4>
-7	SP1…SP3 with DI2, DI3	<C.2.1.1-3>
-8	SP1…SP4 with DI2, DI3, DI4	<C.2.1.1-4>

C.2.2.2 Changeover to external set point with DI

An internal set point can be changed to the external set point SPE (SPC) initiated by a digital input. To be able to use this function, an external set point must be configured (C.2.1.2-1/-2).

Signal states fur set point changeover	
Active set point	**DI1/DI2/DI3/DI4**
SP1, SP2, SP3, SP4	0
SPE (SPC)	1

Note:
- *The operating direction of the digital inputs can be reversed, see menu items I.5.1...I.8.1.*
- *Several functions can be assigned to the digital inputs, see menu items I.5...I.8.*
- *The internal set point can also be changed over in the operating level independently of the digital inputs, refer to EB 6495-2 EN, or over the manual/auto dialog, see menu item A.3.2.*

C.2.2.2	**Changeover to external set point with DI**	<C.2.1.2≠0, M.1-3: Controller [2] only>
-0	Off	
-1	With digital input DI1	
-2	With digital input DI2	
-3	With digital input DI3	
-4	With digital input DI4	

C.2.2.3 Open cascade with DI

The controller cascade in cascade control can be opened by a '1' signal at the digital input (energized). In an open cascade, the slave (follower) controller operates with the internal set point.

Note:
- *The operating direction of the digital inputs can be reversed, see menu items I.5.1...I.8.1.*
- *Several functions can be assigned to the digital inputs, see menu items I.5...I.8.*

C.2.2.3	**Open cascade with DI**	<M.1-3>
-0	Off	
-1	With digital input DI1	
-2	With digital input DI2	
-3	With digital input DI3	
-4	With digital input DI4	

C.2.2.4 Tracking SPI to SPE/SPC

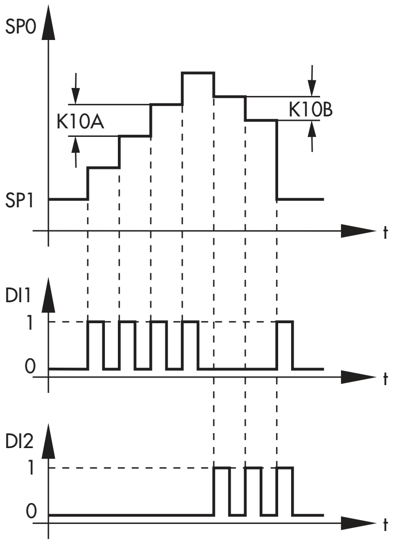
The setting C.2.2.4-1 causes the tracking of the selected internal set point to the external set point active for control. Tracking allows the bumpless changeover from the external to the internal set point.

Note: *Tracking SPI to SPE/SPC (C.2.2.4) and Incremental/decremental set point change (C.2.2.5) cannot be configured at the same time.*

C.2.2.4	**Tracking SPI to SPE/SPC**	<C.2.1.2≠0>
-0	Off	
-1	On	

C.2.2.5 Incremental/decremental set point change

The active internal or external set point can be increased or decreased in stages by a defined value using two edge-triggered digital inputs. The incremental and decremental change is performed in groups either with digital inputs DI1 and DI2 or with digital inputs DI3 and DI4. The incremental value and the decremental value are adjusted as numerical values. An incremental change is made by DI1 or DI3. A decremental change is made by DI2 or DI4.



SP0	Set point at comparator
SP1	Target set point
K10A	Incremental value
K10B	Decremental value

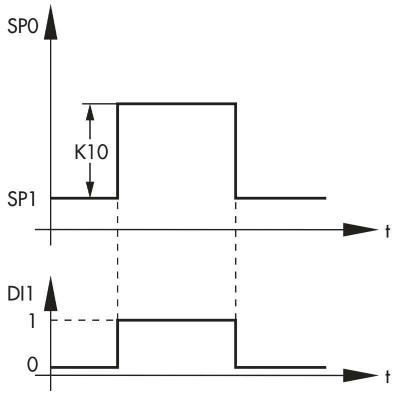
The initial set point is reset by activating both digital inputs simultaneously.
After a restart due to a power failure, incremental and decremental changes initiated by the digital inputs are ignored and the set point at comparator SP0 is valid as the active set point (initial set point).

After enabling the configuration item (C.2.2.5≠0), the set point at comparator SP0 is automatically displayed in row 3. By pressing one of the cursor keys (△ or ▽), the currently active initial set point is displayed and can be changed. The display returns to the set point at comparator SP0 when the pressed down key is released.

Note: *Tracking SPI to SPE/SPC (C.2.2.4) and Incremental/decremental set point change (C.2.2.5) cannot be configured at the same time.*

C.2.2.5		**Incremental/decremental set point change**	<C.2.2.5-0>
	-0	Off	
	-1	With digital input DI1, 2	
	-2	With digital input DI3, 4	
K10.A		Incremental value [–999.0 ...**0.0**... 9999.0]	<C.2.2.5≠0>
K10.B		Decremental value [–999.0 ...**0.0**... 9999.0]	<C.2.2.5≠0>

C.2.2.6 Set point increase/decrease by constant



SP0 Set point at comparator
SP1 Target set point
K10 Incremental/ decremental value

In this function, the current set point is reduced or increased when there is a '1' signal at the digital input. The incremental/decremental value is adjusted as a numerical value.

After enabling the configuration item (C.2.2.6≠0) , the set point at comparator SP0 is automatically displayed in row 3. By pressing down one of the cursor keys (△ or ▽) the currently active initial set point is displayed and can be changed. The display returns to the set point at comparator SP0 when the pressed down key is released.

C.2.2.6	Set point increase/decrease by constant
-0	Off
-1	With digital input DI1
-2	With digital input DI2
-3	With digital input DI3
-4	With digital input DI4

K10	Incremental/decremental value [–999.0 ...**0.0**... 9999.0]	<C.2.2.6≠0>

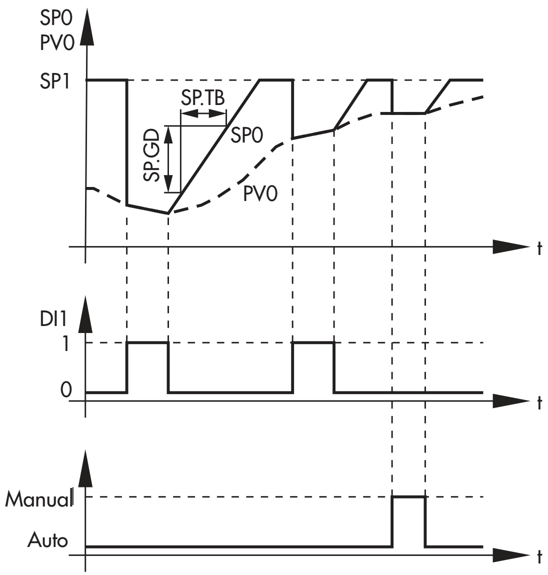
C.2.3 Set point ramp function

C.2.3.1 Set point ramp

A set point ramp is particularly suited for closed-loop controlled systems which do not tolerate rapidly changing set points. The ramped transition from one set point to another helps to avoid hunting. In the set point ramp, the set point at the comparator SP0 runs according to the gradient SP.GD and according to the time base SP.TB at a constant rate from the initial set point to the target set point. Depending on how the configuration item C.2.3.1 is configured, the ramp starts either using the process variable at the comparator PV0, the initial value SP.ST or another set point.
The gradient SP.GD is adjusted in units of time. The time base SP.TB can be adjusted in seconds, minutes or hours.

After enabling the configuration item (C.2.3.1≠0), the set point at comparator SP0 (C.5.3-2) is automatically displayed in row 3. If the target set point is the internal set point (e.g. SP1) on pressing one of the cursor keys (△ or ▽), the internal set point is displayed for two seconds. If, during these two seconds, the key is pressed again, the internal set point is changed. The display returns to the set point at comparator SP0 when the pressed down key is released. If the target set point is the external set point (e.g. SPE) on pressing one of the cursor keys (△ or ▽), the external set point is displayed for two seconds. If, during these two seconds, the key is pressed again, the currently active internal set point is displayed and can be changed. The display returns to the set point at comparator SP0 when the pressed down key is released.

Settings -1/-2/-3/-4: Start with DI1/DI2/DI3/DI4, SP=PV
Starts the set point ramp using the process variable at comparator:

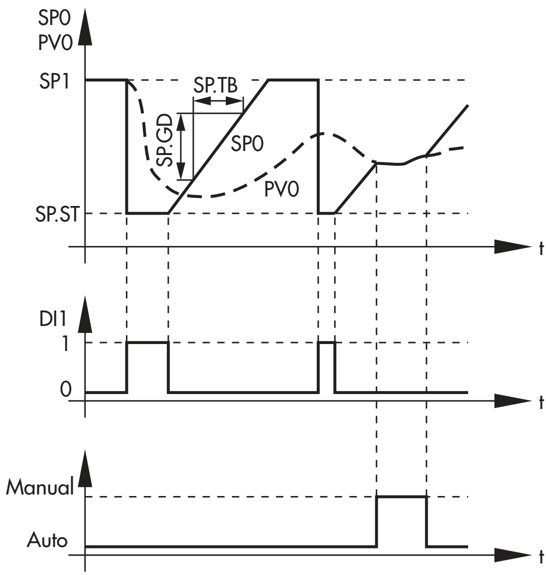


SP0	Set point at comparator
PV0	Process variable at comparator
SP1	Target set point
SP.GD	Gradient
SP.TB	Time base

This ramp function is started by a digital signal. A '1' signal at the digital input causes the set point at comparator SP0 to adopt the same value as the process variable at comparator PV0. A signal change at the digital input from '1' to '0' starts the ramp and the set point runs until it reaches the target set point (internal or external set point). After reaching the target set point, the ramp stops. The set point ramp is also stops if the target set point crosses the ramp in the opposite direction, e.g. due to changing the target set point. After the set point ramp stops, the set point at comparator SP0 instantaneously follows the target set point (e.g. SP1).

If the controller is switched to manual mode while the ramp is running, the ramp is stopped and the set point adopts the same value as the process variable PV0. After switching back to automatic mode, the ramp continues to run again until reaching the target set point. A '1' signal at the digital input while the ramp is running causes the set point at comparator SP0 to return to the same value as the process variable at comparator PV0 (retriggering).
If the controller starts after the power supply has been interrupted for more than one second in automatic mode, the set point at comparator SP0 adopts the same value as the target set point.

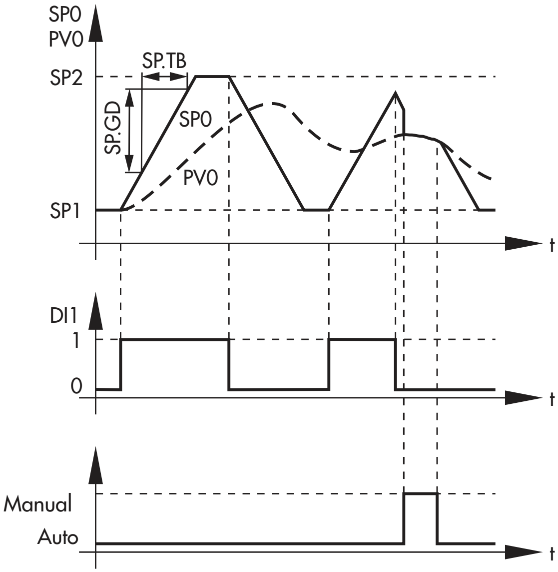
Settings -5/-6/-7/-8: Start with DI1/DI2/DI3/DI4, SP=SP.ST
Starts the set point ramp using the initial set point:



SP0	Set point at comparator
PV0	Process variable at comparator
SP1	Target set point
SP.ST	Initial set point
SP.GD	Gradient
SP.TB	Time base

This ramp function is started by a digital signal. A '1' signal at the digital input causes the set point at comparator SP0 to be set to the predetermined initial set point SP.ST. A signal change at the digital input from '1' to '0' starts the ramp and the set point runs until it reaches the target set point (internal or external set point). After reaching the target set point, the ramp stops. The set point ramp is also stops if the target set point crosses the ramp in the opposite direction, e.g. due to changing the target set point. After the set point ramp stops, the set point at comparator SP0 instantaneously follows the target set point (e.g. SP1).
If the controller is switched to manual mode while the ramp is running, the ramp is stopped and the set point at comparator SP0 adopts the same value as the process variable at comparator PV0. After switching back to automatic mode, the ramp continues to run again until reaching the target set point. If a '1' signal reappears again at the digital input while the ramp is running, this causes the set point at comparator SP0 to return to the initial set point SP.ST (retriggering).
If the controller starts after the power supply has been interrupted for more than one second in automatic mode, the set point at comparator SP0 adopts the initial set point SP.ST when there is a '1' signal at the digital input or it adopts the target set point when there is a '0' signal. The ramp is started again by the signal change from '1' to '0'.

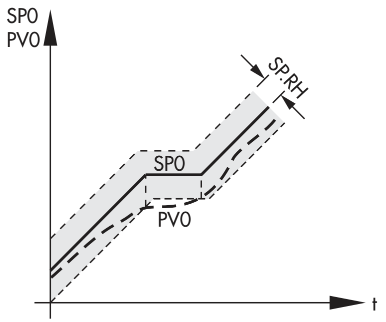
Setting -9: Continuously active
Set point ramp continuously active (without start condition):



SP0	Set point at comparator
PV0	Process variable
SP1,SP2	Target set point
SP.GD	Gradient
SP.TB	Time base

The ramp function in this setting is continuously active. Every change of the set point causes a ramped change of the set point at comparator SP0 even after changeover between set points. The diagram shows the set point ramp (SP0) during a changeover between set points SP1 and SP2 initiated by a digital input (additional settings: C.2.1.1-2, C.2.2.1-1, SP1, SP2).
If the controller is switched to manual mode while the ramp is running, the ramp is stopped and the set point at comparator SP0 adopts the same value as the process variable at comparator PV0. After switching back to automatic mode, the ramp continues to run again until reaching the target set point.
If the controller starts after the power supply has been interrupted for more than one second in automatic mode, the ramp starts with the set point 0 and runs until reaching the adjusted target set point.

Set point ramp with waiting condition



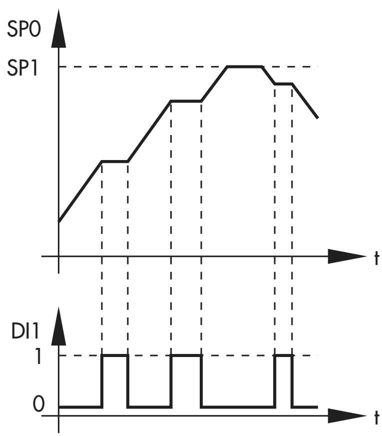
SP0	Set point at comparator
PV0	Process variable
SP.RH	Hold set point ramp [%]

While the set point ramp is running, the process variable PV0 is constantly monitored for any range violation that goes beyond the value of the set point SP0 (error signal). If the process variable violates this range, the set point ramp is stopped. It continues when the process variable re-enters the adjusted range. This ensures that the set point does not rise or drop too quickly and that the process variable can follow it. The deviation band is defined by the SP.RH parameter in percent, based on the measuring range. In firmware version 1.21 and higher, the monitoring only works on one side: the rising (falling) ramp is stopped whenever the process variable PV0 is smaller (greater) than the current ramp set point by the deviation band SP.RH.

C.2.3.1	**Set point ramp**	
-0	Off	
-1	Start with DI1, SP=PV	
-2	Start with DI2, SP=PV	
-3	Start with DI3, SP=PV	
-4	Start with DI4, SP=PV	
-5	Start with DI1, SP=SP.ST	
-6	Start with DI2, SP=SP.ST	
-7	Start with DI3, SP=SP.ST	
-8	Start with DI4, SP=SP.ST	
-9	Continuously active	
SP.GD	Gradient [0.0 …**1.0**… 9999.0]	<C.2.3.1≠0>
SP.TB	Time base [**s**, min, h]	<C.2.3.1≠0>
SP.ST	Initial set point [–999.0 …**0.0**… 9999.0]	<C.2.3.1-5/-6/-7/-8>

SP.RH	Hold set point ramp at deviation band [0.1 … **1000.0** %] from firmware version 1.21 [0.1 … **100.0** %] up to firmware version 1.11	<C.2.3.1≠0>

C.2.3.2 Hold set point ramp with DI



SP0 Set point at comparator
SP1 Target set point

A running set point ramp is stopped by a '1' signal at the digital input, i.e. the set point is halted (soak). A '0' signal at the digital input causes the ramp to continue. This function can only be selected when the set point ramp (C.2.3.1) has already been configured.

Note: *If Hold set point ramp with DI (C.2.3.2≠0) and Start set point ramp with DI (C.2.3.1≠0) are both activated, activation of the start condition has priority.*

C.2.3.2	**Hold set point ramp with DI**	<C.2.3.1≠0>
-0	Off	
-1	With digital input DI1	
-2	With digital input DI2	
-3	With digital input DI3	
-4	With digital input DI4	

C.2.4 Additional set point functions

C.2.4.1 Valuate external set point SPE

The external set point SPE can be valuated with the following arithmetic operation:

SPE' = SPE∗K1+ K2

The arithmetic operation is identical for both internal controllers. It can be used, for example, for automatic synchronization in which different controlled systems receive the same external reference variable. The arithmetic operation causes the controlled systems to be adapted to each other.

To be able to use this function, the external set point SPE must be configured (C.2.1.2≠0)

C.2.4.1		**Valuate external set point SPE**	<C.2.1.2≠0>
	-0	Off	
	-1	On	
K1		Valuation SPE' = SPE∗K1+K2 [–100.00 ...**1.00**... 100.00]	<C.2.4.1-1>
K2		Valuation SPE' = SPE∗K1+K2 [–9999.0 ...**0.0**... 9999.0]	<C.2.4.1-1>

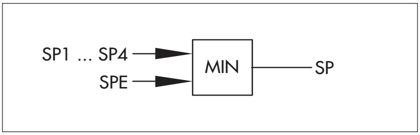
C.2.4.2 Linking up external/internal set point

This function links the external set point SPE to the currently active internal set point. While the external set point is active, the effective set point SP is made up from the link between the internal and external set point. If the internal set point (SP1 to SP4) is active, it is the effective set point.

To link the external set point SPE to the internal set point, the input variable SPE must be assigned to an input (C.1.2.1≠0) and the external set point must be assigned to the input variable SPE (C.2.1.2-1).

After enabling the configuration item (C.2.4.2≠0), the set point at the comparator SP0 is automatically displayed in row 3 in the operating level (C.5.3-2). By pressing one of the cursor keys (△ or ▽), the external set point is displayed for two seconds. If, during these two seconds, the key is pressed again, the currently active internal set point is displayed and can be changed. The display returns to the set point at the comparator SP0 when the pressed down key is released. The setting C.5.3-1 causes just the active set point, e.g. SPE, to be displayed.

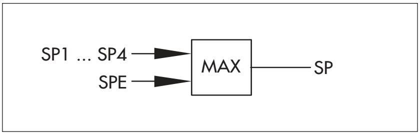
Setting -1: Min. selection (SPI, SPE)
Minimum range between internal and external set point



The effective set point SP is always the smaller set point resulting from the comparison between the external and internal set point.

Example: The internal set point can be used to limit the external set point to a maximum value.

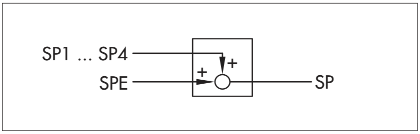
Setting -2: Max. selection (SPI, SPE)
Maximum range between internal and external set point



The effective set point SP is always the larger set point resulting from the comparison between the external and internal set point.

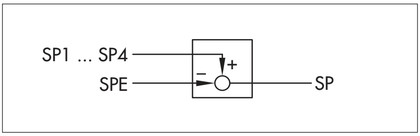
Example: The internal set point can be used to limit the external set point to a minimum value.

Setting -3: SPI + SPE
Addition of the internal and external set point



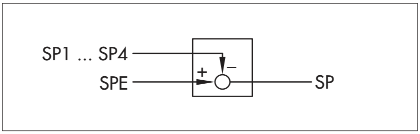
Effective set point SP = SPI + SPE

Setting -4: SPI – SPE
Subtraction of the external set point from the internal set point



Effective set point SP = SPI – SPE

Setting -5: SPE – SPI
Subtraction of the internal set point from the external set point



Effective set point SP = SPE – SPI

C.2.4.2	Linking up external/internal set point	<C.2.1.2≠0>
-0	Off	
-1	Min. selection (SPI, SPE)	
-2	Max. selection (SPI, SPE)	
-3	SPI + SPE	
-4	SPI – SPE	
-5	SPE – SPI	

C.2.4.3 Function generation of set point SPM in the slave controller

In cascade control (M.1-3), a function generation can be performed on the set point SPM of the slave (follower) controller [1], i.e. revaluated.

The function generation is used, for example, for temperature/pressure cascade control of an autoclave. The master controller [2] receives the product temperature. Its internal output value YM is fed to the slave controller [1] as the set point SPM where a function generation is performed on it. The slave controller records the steam pressure. Its control output is used to position the steam valve. A saturated steam curve can be plotted using the known correlation between steam pressure and steam temperature by the function generation. This is used to create the pressure set point for the slave controller. Seven points are available to create the steam curve. The associated input values SPM.I1...SPM.I7 are adjusted in %, based on the measuring range of the master controller [2]. The output values SPM.O1...SPM.O7 are adjusted as numerical values with the physical unit used by the slave controller [1].

Setting -0: Off
Without function generation, YM is converted to the measuring range of the process variable PV by the slave controller [2].

Example:
A PV measuring range from 0 to 200 °C and YM = 40 % results in SPM = 80 °C.

Setting -1: On
The function generation causes YM to be converted into a numerical unit for SPM using the characteristic points.

Example: Saturated steam curve
Measuring range of the master controller [2]: 0 to 200 °C
Measuring range of the slave controller [1]: 0 to 10 bar

		1	2	3	4	5	6	7
SPM.I	% (°C)	49.8 (99.6)	60.1 (120.2)	66.8 (133.5)	71.8 (143.6)	75.9 (151.8)	79.4 (158.8)	82.5 (165.0)
SPM.O	bar	1.0	2.0	3.0	4.0	5.0	6.0	7.0

The output value YM = 71.8 % represents a steam pressure of 143.6 °C. The function generation creates the associated steam pressure set point SPM = 4.0 bar.

Note: *The setting is made at the slave controller [1].*

C.2.4.3	**Function generation at slave controller**	<M.1-3>
-0 -1	Off On	
SPM.I1... SPM.I7 1)	Input value 1 to 7 [0.0 ...[1)]... 100.0 %] Input value 1 to 6: **0.0** Input value 7: **100.0**	<C.2.4.3-1>
SPM.O1... SPM.O7 1)	Output value 1 to 7 [–999.0 ...[1)]... 9999.0] Output value 1 to 6: **0.0** Output value 7: **100.0**	<C.2.4.3-1>

C.3 Control function

The control behavior is determined in this submenu. In particular, the user determines whether the controller is to work as a P, PI, PD or PID controller. In addition, feedforward control and additional control functions are configured in this submenu.

C.3.1 Control behavior

C.3.1.1 Control algorithm

This configuration item is used to configure the control algorithm and the control parameters. The controllers are set by default to be PI controllers.

The control parameters can also be configured directly in the operating menu.

- Changing control parameters in the operating menu, refer to EB 6495-2 EN

Assignment between control parameters and control behavior					
	PI	**P**	**PD**	**PID**	**I**
C.3.1.1	-1	-2	-3	-4	-5
KP	•	•	•	•	•
TN	•	–	–	•	•
TV	–	–	•	•	–
Y0	•	•	•	•	•
TV.K	–	–	•	•	–

- **Proportional-action coefficient**
  The proportional-action coefficient KP acts as gain on the P, I and D terms. It is a measure in the P term on how intense the momentary error signal affects the control loop.
  Increasing the proportional-action coefficient makes the output amplitude increase in a P controller.

- **Reset time**
  The reset (integral) time TN is the parameter of the I term. It is a measure on how intense the duration of the error signal affects the control loop. TN is the time it takes for the integral term during a step response in a PI controller to produce the same change in output as the P term.
  Increasing the reset time TN causes a reduction in the rate of change in the output when the error is constant.

- **Derivative-action time**
  The derivative-action time TV is the parameter of the D term. It is a measure on how intense the rate of change in the error signal affects the control loop. The derivative-action time TV is the time it takes the rise response of a PD controller to reach a certain output earlier than it would with just its P term.
  Increasing the derivative-action time TV causes an increase in output amplitude when the

rate of change in the error signal is constant. After ramped error changes, a larger derivative-action time TV causes the D term to continue to have a longer effect.

- **Derivative-action gain**
  The derivative-action gain TV.K is a gain factor for the derivative term.

- **Operating point**
  The operating point Y0 of the P or PD controller determines the output value which is fed to the controlled system when the process value is the same as the set point. The operating point is normally only important for P and PD controllers, but it can also be set for control strategies PI, PID and I due to the possible limitation of the integral-action component (C.3.1.2). For control strategies with integral-action component, the operating point can also be used as the initial value for a restart.

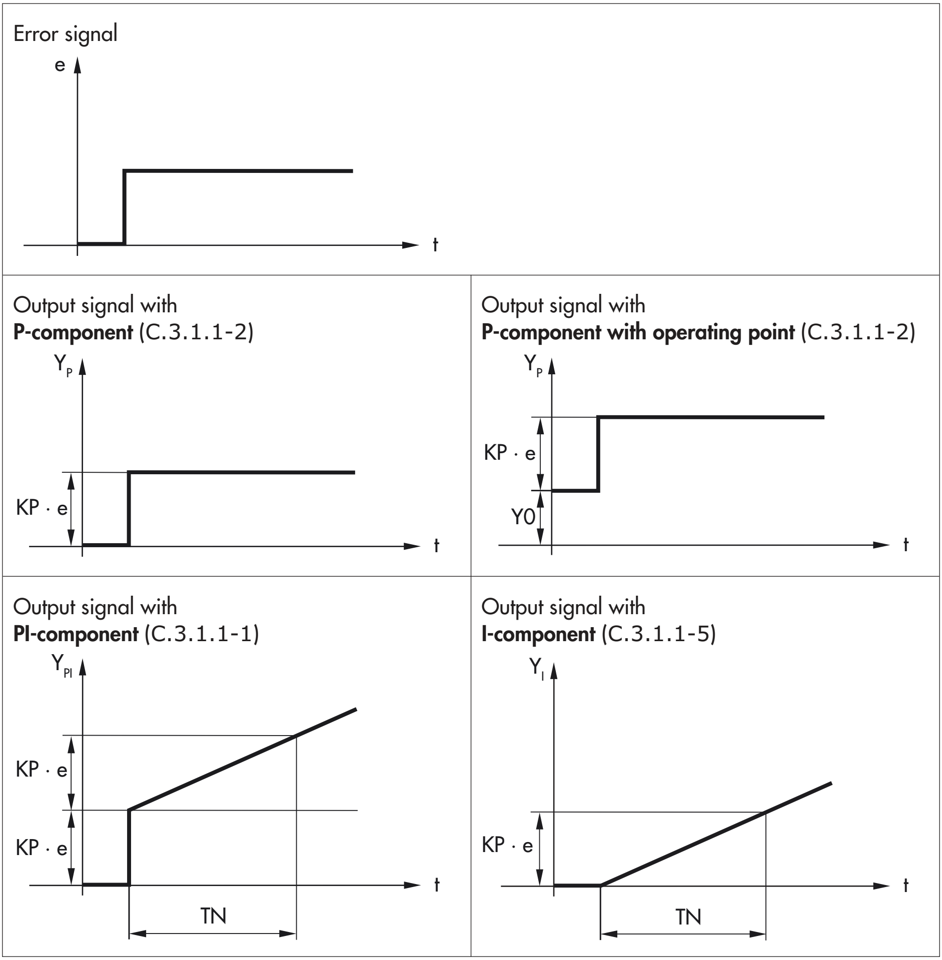
  Additionally, the effective operating point can be determined by the set point SP0 or by a digital signal. The effective operating point is calculated by simultaneously using the addition of the operating point Y0 and the set point SP0 on which function generation has been performed as well as the operating points Y0.1 and Y0.2.

  - Set operating point by set point, see menu item C.3.1.8
  - Set operating point with digital input, see menu item C.3.1.9 and C.3.1.10

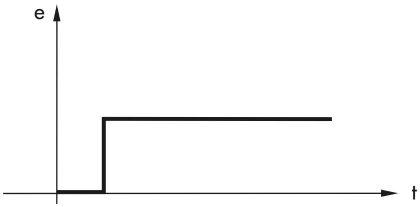
C.3.1.1	**Control algorithm**	
-1	PI	
-2	P	
-3	PD	
-4	PID	
-5	I	
KP	Proportional-action coefficient [0.01 …**1.00**… 100.00]	
TN	Reset time [1 …**120**… 9999 s]	<C.3.1.1-1/-4/-5>
TV	Derivative-action time [1 …**10**… 9999 s]	<C.3.1.1-3/-4>
Y0	Operating point [–10.0 …**0.0**… 110.0 %]	
TV.K	Derivative-action gain [0.00 …**1.00**… 10.00]	<C.3.1.1-3/-4>

Step responses

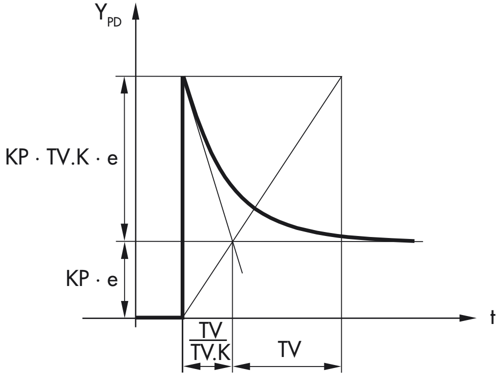
The step response is the time taken by the output when there is a step change in the error signal. The following diagrams show the effect of the control parameters on the behavior of the manipulated variable Y in the form of a step response.



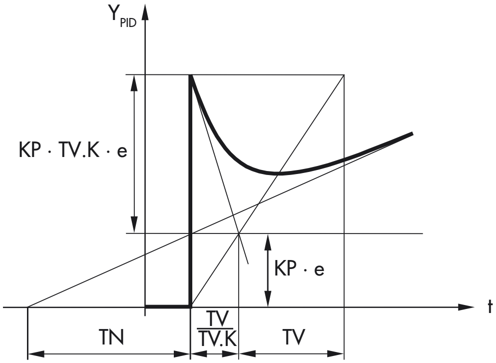
Error signal



Output signal with **PD-component** (C.3.1.1-3)



Output signal with **PID-component** (C.3.1.1-4)

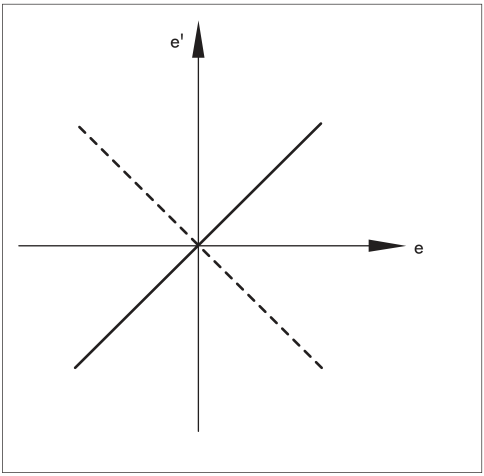


C.3.1.2 Limit integral-action component

By configuring C.3.1.2-1, the I term of PI, PID or I behavior is limited to the range determined by the I.MIN and I.MAX parameters.

C.3.1.2	**Limit I-component**	<C.3.1.1-1/-4/-5>
-0	Off	
-1	On	
I.MIN	Minimum I-component [–120.0 ...**–100.0**... 0.0 %]	<C.3.1.2-1>
I.MAX	Maximum I-component [0.0 ...**100.0**... 120.0 %]	<C.3.1.2-1>

C.3.1.3 Error signal



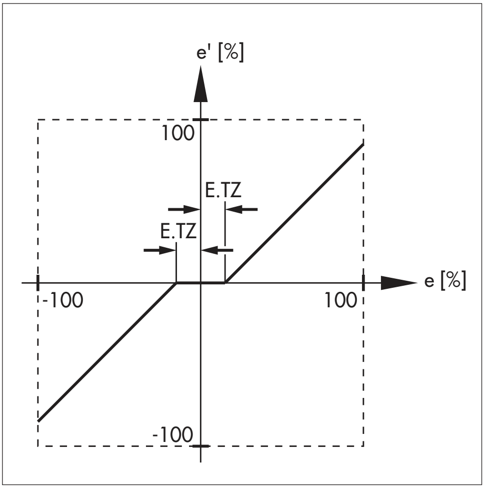
The direction of the error signal can be inverted (reversed), either permanently by configuring C.3.1.3-1 or by a '1' signal at the digital input (C.3.1.3-2/-3/-4/-5).

In addition, the operating direction of the control output can be changed in the *Output* menu.

- Change operating direction at the analog output, see menu item O.1.3...O.3.3
- Change operating direction at the switch output, see menu item O.4.3...O.5.3

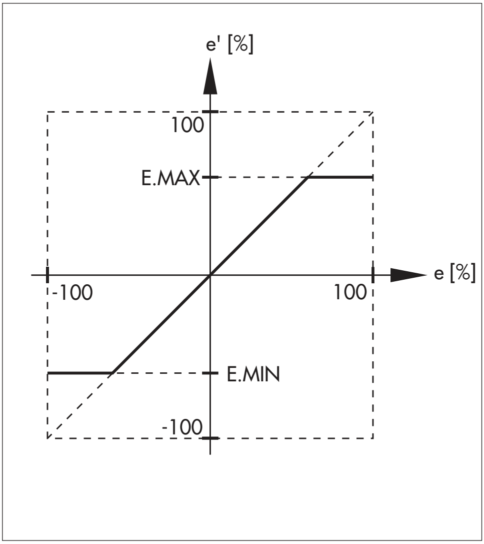
Additionally, an operating threshold and an effective range can be determined for the error signal. The error signal is not inverted by default.

Operating threshold of the error signal



The operating threshold (E.TZ) is adjusted in percent. It is used to determine a band within which the effective error signal e' for the control algorith is 0 %. This helps prevent the output from constantly altering in the settled state. The operating threshold is set to 0 % by default, i.e. the effect of the error signal is not restricted.

Limiting the error signal



The effective error signal e' for the control algorithm is limited to a predefined range. The error signal only has any effect within this range, i.e. the real error signal (e = SP0 – PV0) can lie outside this range.

Application: Feedback loops in which large error signals occur due to the mode of operation, but overshooting of the process variable is to be avoided.

The error signal limitation can be used, for example, to slowly start up a feedback loop despite a large deviation between the set point and the process variable as well as large gain KP.

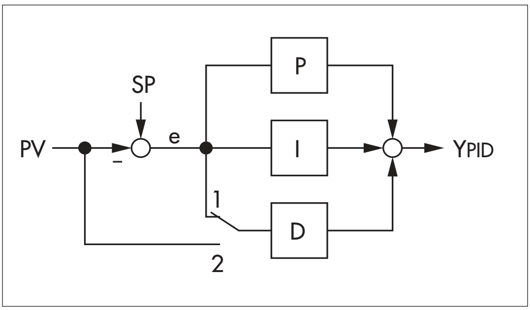
Slow start-up behavior can also be achieved by an output ramp or set point ramp.

- Set point ramp, see menu item C.2.3.1
- Output ramp, see menu item O.1.4...O.5.4

Note: *The real error signal e is displayed in the info menu (Controller -> Set point display).*

C.3.1.3	Error signal
-1	Not inverted
-2	Inverted
-3	Inverted via D1
-4	Inverted via D2
-5	Inverted via D3
-6	Inverted via D4
E.TZ	Operating threshold [**0.00** … 110.00 %] in firmware version 1.21 and higher [**0.0** … 110.0 %] in firmware version 1.11 and lower
E.MIN	Min. effective error signal [**–110.0** … 110.0 %]
E.MAX	Max. effective error signal [–110.0 … **110.0** %]

C.3.1.4 Assign derivative-action component



For PD and PID controllers, either the error signal e or the process variable PV can be assigned as the source for the derivative term. When assigning it to the process variable PV, the change in the set point SP does not have any effect on the derivative term.
The error signal e has an effect on the derivative term by default.

C.3.1.4	Assign D-component	<C.3.1.1-3/-4>
-1	To error signal	
-2	To process variable	

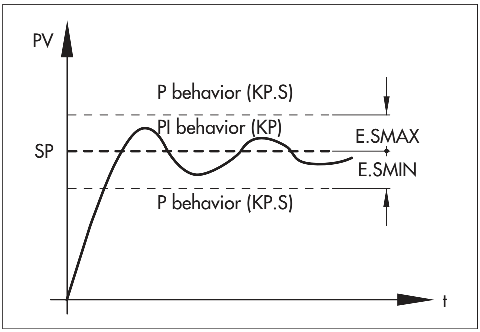
C.3.1.5 Control mode changeover P(D)/PI(D)

For PI and PID controllers, the control mode changeover enables the controller to be operated in various operating states with or without the integral term. This function allows the integral term to be automatically activated by the error signal or by a signal at the digital input. It can only be selected when a PI or PID behavior has been configured.

The P(D)/PI(D) control mode changover is preferably to be used when the set point is to start up as quickly as possible and without overshooting, while no offset is to exist. This is required especially for control of discontinuous processes, such as during batch operation of an autoclave, an open-steam vulcanizer or a hearth furnace.
With control mode changeover, the controller works as a P or PD controller with a fixed operating point Y0 during start-up. In a definable range, the integral term is activated and the controller works as a PI or PID controller.

- **Settings -1/-2/-3/-4:** With digital input DI1/DI2/DI3/DI4
  The controller works with the integral term when there is a ‘1’ signal at the digital input. A ‘0’ signal causes the integral term to be left out (P or PD behavior), meaning the operating point Y0 must be taken into account.
  A ‘1’ signal at the digital input causes the controller to work with the proportional-action coefficient KP (gain).
  A ‘0’ signal at the digital input causes the controller to work with the proportional-action coefficient KP.S.

- **Setting -5:** By error signal



The integral term is activated depending on the error signal. The controller works with the integral term within an adjustable range of the error signal and without the integral term outside this range. The range is adjusted using the E.SMIN and E.SMAX parameters in percent based on the measuring range.

The range lies between –10 % and 10 % by default, i.e. the integral term is activated within +/–10 % of the set point.

The controller works with the P or PD behavior outside the range (E.SMIN to E.SMAX), meaning the operating point Y0 must be taken into account. Within the range, the controller works with the proportional-action coefficient KP (gain). Outside the range, the controller works with the proportional-action coefficient KP.S.

C.3.1.5	**Control mode changeover P(D)/PI(D)**	<C.3.1.1-1/-4>
-0	Off	
-1	With digital input DI1	
-2	With digital input DI2	
-3	With digital input DI3	
-4	With digital input DI4	
-5	By error signal	
E.SMIN	Min. limit for PI(D) behavior [–999.0 ...**–10.0**... 999.0 %]	<C.3.1.5-5>
E.SMAX	Max. limit for PI(D) behavior [–999.0 ...**10.0**... 999.0 %]	<C.3.1.5-5>
KP.S	Prop.-action coefficient for P(D) behavior [0.01 ...**1.00**... 100.00]	<C.3.1.5≠0>

C.3.1.6 Function generation KP

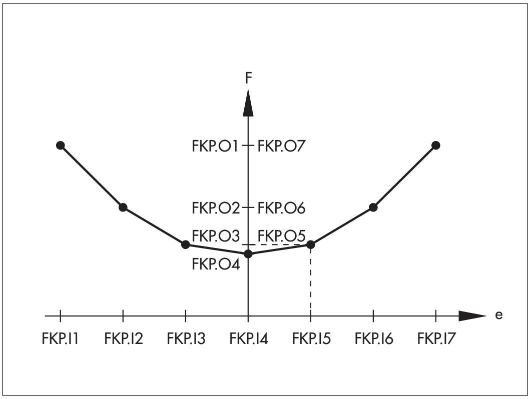
The proportional-action coefficient KP can be adapted to non-linear processes dependent on a reference value.

The reference value can either be the set point at the comparator SP0 (the ratio set point SPR with ratio control), the process variable at the comparator PV0 (the ratio set point PVR with ratio control), the error signal ±e or one of the outputs AO1 to AO3 or SO1 and SO2. By performing a function generation of the reference value, an output value can be specified for each of the seven input values.

This output value supplies the effective proportional-action coefficient KP' when it is multiplied by KP. The characteristic is defined by seven points. A line is drawn by the controller between neighboring points. The same physical units are entered for the input values as for the reference value. Numerical values are entered for the output values (factors).

Example: Adaption of the proportional-action coefficient KP dependent on the error signal e.

	1	2	3	4	5	6	7
FKP.I %	–100.0	–66.6	–33.3	0.0	33.3	66.6	100.0
FKP.O	2.75	1.75	1.25	1.00	1.25	1.75	2.75



The following applies to the proportional-action coefficient KP' in Point 5 (FKP.I5):
KP' = KP∗FKP.O5
KP = 1.00 results in KP' = 1.25

***Note:** The KP' effective for control can be displayed in the controller display (C.5.4-40) or in the additional display (C.6).*

C.3.1.6	**Function generation KP**	
-0	Off	
-1	With set point SP0	
-2	With process variable PV0	
-3	With error signal +/–e	
-4	With output AO1	
-5	With output AO2	
-6	With output AO3	
-7	With output SO1	
-8	With output SO2	
FKP.I1... FKP.I7	Input value 1 to 7 [–999.0 ...**0.0**... 9999.0]	<C.3.1.6≠0>
FKP.O1... FKP.O7	Output value 1 to 7 [0.01 ...**1.00**... 100.00]	<C.3.1.6≠0>

C.3.1.7 Function generation TN

For PI and PID controllers, the reset (integral) time can be adapted to non-linear processes dependent on a reference value.
The reference value can either be the set point at the comparator SP0 (the ratio set point SPR with ratio control), the process variable at the comparator PV0 (the process variable ratio PVR with ratio control), the error signal ±e or one of the outputs AO1 to AO3 or SO1 and SO2.

By performing a function generation of the reference value, an output value can be specified for each of the seven input values. This output value supplies the effective reset time TN' when it is multiplied by TN.

The characteristic is defined by seven points. A line is drawn by the controller between neighboring points. The same physical units are entered for the input values as for the reference value. Numerical values are entered for the output values (factors).

Example: The following applies to the reset time TN' in Point 4 (FTN.I4): TN' = TN∗FTN.O4
The effective reset time TN' can be displayed in the controller display (C.5.4-41) or in the additional display (C.6).

C.3.1.7	**Function generation TN**	<C.3.1.1-1/-4/-5>
-0	Off	
-1	With set point SP0	
-2	With process variable PV0	
-3	With error signal +/–e	
-4	With output AO1	
-5	With output AO2	
-6	With output AO3	
-7	With output SO1	
-8	With output SO2	
FTN.I1... FTN.I7	Input value 1 to 7 [–999.0 ...**0.0**... 9999.0]	<C.3.1.7≠0>
FTN.O1... FTN.O7	Output value 1 to 7 [0.01 ...**1.00**... 100.00 %]	<C.3.1.7≠0>

C.3.1.8 Set operating point by set point

The operating point of the manipulated variable can be specified dependent on the set point. The operating point is normally only important for P and PD controllers, but can also be of interest for PI, PID and I controllers (automatic operating point), see menu item C.3.1.1.

The function generation causes the set point at the comparator to be converted into a value, which is added as the operating point to the manipulated variable calculated by the control algorithm.

The characteristic is defined by seven points. A line is drawn by the controller between neighboring points. The same physical units are entered for the input values as for the set point. The output values (operating points) are entered in percent.

The manipulated variable may jump due to the various operating points if the controller must change over between various set points in automatic mode.

The operating point can also be set to a fixed value or be set by a digital signal. The effective operating point results from the addition of the values.

- Set operating point Y0, see menu item C.3.1.1
- Set operating point with digital input, see menu items C.3.1.9 and C.3.1.10

C.3.1.8	**Set operating point by set point**	
-0	Off	
-1	On	
OP.I1… OP.I7	Input value 1 to 7 [–999.0 …**0.0**… 9999.0]	<C.3.1.8-1>
OP.O1… OP.O7	Output value 1 to 7 [–10.0 …**0.0**… 110.0 %]	<C.3.1.8-1>

C.3.1.9 Operating point 1 with DI

For P and PD controllers, the operating point of the manipulated variable can be activated by a '1' signal at the digital input. The value for the operating point is specified in percent.

A second operating point can be activated in configuration item C.3.1.10.

The operating point can also be set to a fixed value or be set by a digital signal. The effective operating point results from the addition of the values.

- Set operating point Y0, see menu item C.3.1.1
- Set operating point by set point, see menu item C.3.1.8

C.3.1.9	Operating point 1 with DI	
-0	Off	
-1	With digital input DI1	
-2	With digital input DI2	
-3	With digital input DI3	
-4	With digital input DI4	
Y0.1	Operating point 1 [–110.0 ...**0.0**... 110.0 %]	<C.3.1.9≠0>

C.3.1.10 Operating point 2 with DI

See menu item C.3.1.9.

C.3.1.10	Operating point 2 with DI	
-0	Off	
-1	With digital input DI1	
-2	With digital input DI2	
-3	With digital input DI3	
-4	With digital input DI4	
Y0.2	Operating point 2 [–110.0 ...**0.0**... 110.0 %]	<C.3.1.10≠0>

C.3.1.11 Internally controlled output limitation

This configuration item can be selected in combination with override control (M.1-4) and set at the main controller [1] . This function determines the minimum and maximum selection of the internal output signals Y of the main and override controllers. The minimum and maximum selection is performed with both controllers taking on the role as master controller to control the maximum control limits. For this purpose, a band for the internally controlled output limit can be set for both the main controller [1] and the override controller [2]. Both bands are set to 5 % by default. The smaller the limiting band is, the faster the transfer from one controller to the other takes place. The role as the master controller is not transferred if both limiting bands are set to 110 %.

- **Setting -1**: Minimum selection
  The smallest signal of the two internal output signals Y is issued at the output. Minimum selection is performed with both controllers taking on the role as master controller to control the maximum control limits. The output signal Y[1] of the main controller [1] is larger than the output signal of the override controller [2] by the limiting band OC.K1 at the

maximum. The output signal Y[2] of the override controller [2] is larger than the output signal Y[1] of the main controller [1] by the limiting band OC.K2 at the maximum.

Example: The main controller [1] controls the process variable A while the override controller [2] limits the second process variable B to a maximum value. The limit value is specified by the set point at the override controller.

- **Setting -2:** Maximum selection
  The largest signal of the two internal output signals Y is issued at the output. Maximum selection is performed with both controllers taking on the role as master controller to control the maximum control limits. The output signal Y[1] of the main controller [1] is smaller than the output signal Y[2] of the override controller [2] by the limiting band OC.K1 at the maximum. The output signal Y[2] of the override controller [2] is smaller than the output signal Y[1] of the main controller [1] by the limiting band OC.K2 at the maximum.

  Example: The main controller [1] controls the process variable A while the override controller [2] limits the second process variable B to a minimum value. The limit value is specified by the set point at the override controller.

C.3.1.11	**Internally controlled output limitation**	<M.1-4>
-1	Minimum selection	
-2	Maximum selection	
OC.K1	Limiting band master controller [0.1 …**5.0**… 110.0 %]	
OC.K2	Limiting band override controller [0.1 …**5.0**… 110.0 %]	

C.3.2 Feedforward control

The following configuration items C.3.2.1 to C.3.2.9 allow inputs to be valuated, linked to each other and are fed to the process variable, set point and manipulated variable. Section M contains a detailed block diagram to each control mode which show possible links.

For example, the following functions can be implemented:

- Disturbance variable feedforward
- Differential pressure or differential temperature control by subtracting two input variables
- Mean value, minimum/maximum selection from max. four input variables
- Set point raised/reduced or limited by the input variable

- Three-component control: Level control of a steam boiler including the mass balance between the steam flow from the boiler (disturbance variable) and feedwater flow to the boiler

C.3.2.1 Link input variable SPE

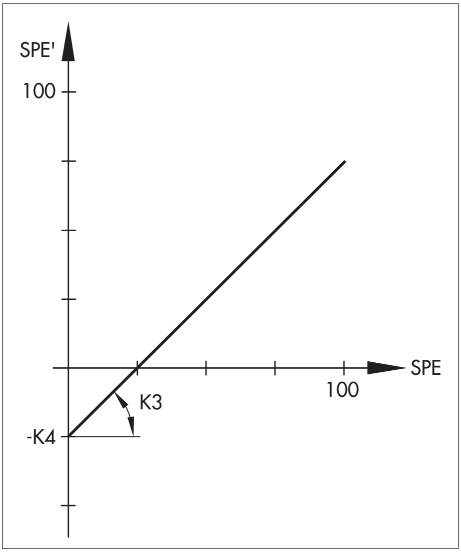
The input variable SPE can be linked either to the input variable PV or to inputs DV and TR. Possible interconnections are shown in the detailed block diagrams of the control modes, see menu items M.1-1...1-6.

C.3.2.1	**Link input variable SPE**	
-0	Off	
-1	To input variable PV	
-2	To inputs DV, TR	With M.1-2/-6 Controller [1]: To input TR

C.3.2.2 Valuate input variable SPE

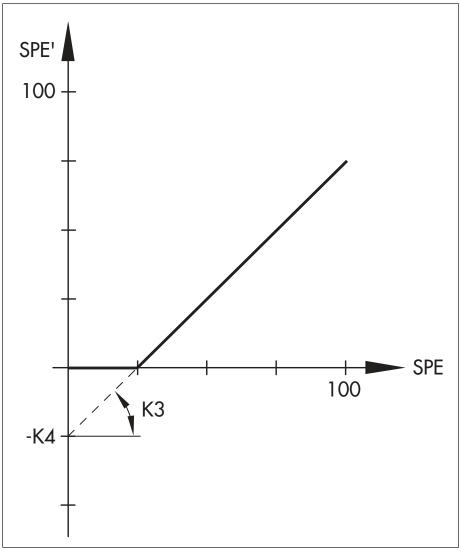
The input variable SPE linked to another input variable is valuated for feedforwarding of a disturbance variable/auxiliary variable.
The valuation is performed according to the following formula **SPE' = SPE∗K3** + **K4**.
The parameters are adjusted by entering numerical values.

Setting C.3.2.2-1:



The result can lie in the first or fourth quadrant, i.e. the sign can be '+' or '–'.

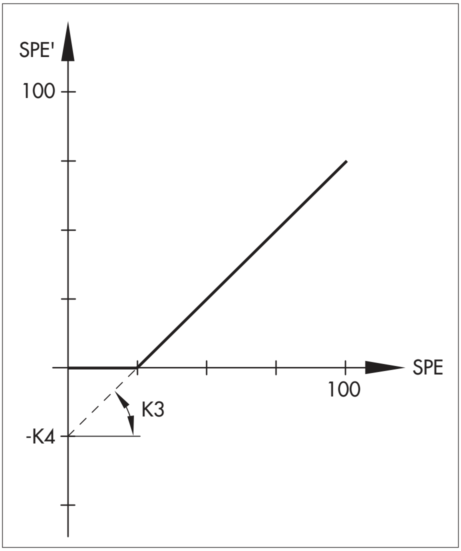
Setting C.3.2.2-2:



The result lies in the first quadrant, i.e. the sign is '+'.

The limit to suppress the input signal SPE is determined by a negative value of K4 together with a positive gain K3.

Setting C.3.2.2-3:



The result lies in the fourth quadrant, i.e. the sign is '–'.

The limit to suppress the input signal SPE is determined by a positive value of K4 together with a negative gain K3.

C.3.2.2	Valuate input variable SPE	<C.3.2.1≠0>
-1	Result pos./neg.	
-2	Result >= 0	
-3	Result <= 0	
K3	Constant, formula: SPE∗K3 + K4 [–100.00 …**1.00**… 100.00]	
K4	Constant, formula: SPE∗K3 + K4 [–9999.0 …**0.0**… 9999.0]	

C.3.2.3 Link input variables DV, TR

The input variables DV and TR can be linked either to the input variable PV, to the set point SP or to the internal output YPID. For ratio controllers (control modes M.1-2/-6), the input variable DV can also be linked to input variable TR (C.3.2.3-5).

C.3.2.3	Link input variables DV, TR	M.1-2/-6 Controller [1]: Link input variable TR
-0	Off	
-1	To input variable PV	
-2	To set point SP	
-3	To output YPID	
-5	To input variable DV	<M.1-2/-6>

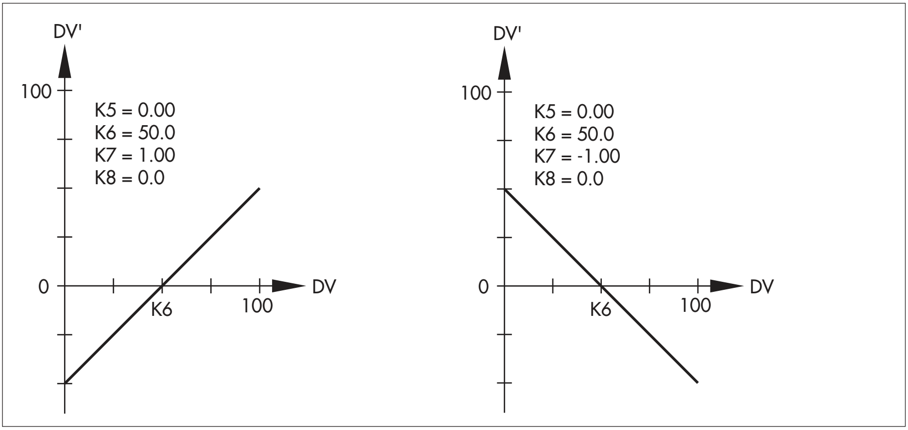
C.3.2.4 Valuate input variables DV, TR

The input variables DV and TR linked to another variable are valuated for feedforwarding of a disturbance variable/auxiliary variable.

The valuation is performed according to the following formula
DV' = (DV+ TR∗K5 − K6)∗K7+ K8 and for the ratio formula according to the formula
TR'= (TR∗K5 − K6)∗K7+ K8.

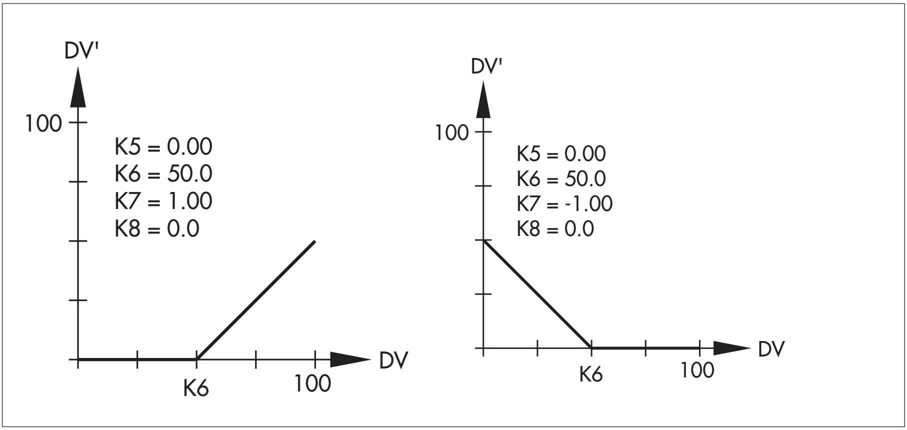
The K6 and K8 parameters are set by entering numerical values.

- **Setting -1:** Result pos./neg.



The result can lie in the first or fourth quadrant, i.e. the sign can be either '+' or '–'.

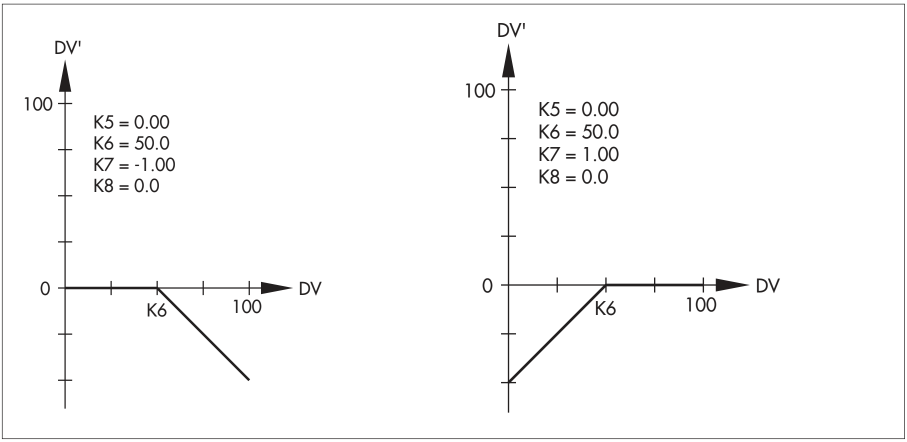
Setting -2: Result >= 0



The result lies in the first quadrant, i.e. the sign is '+'.

The limit to suppress the input signal is determined by K6. The disturbance variable takes effect in this way first when the input signal exceeds this value.

Setting -3: Result <= 0



The result lies in the fourth quadrant, i.e. the sign is '–'.

The limit to suppress the input signal is determined by K6. The disturbance variable takes effect in this way first when the input signal exceeds this value.

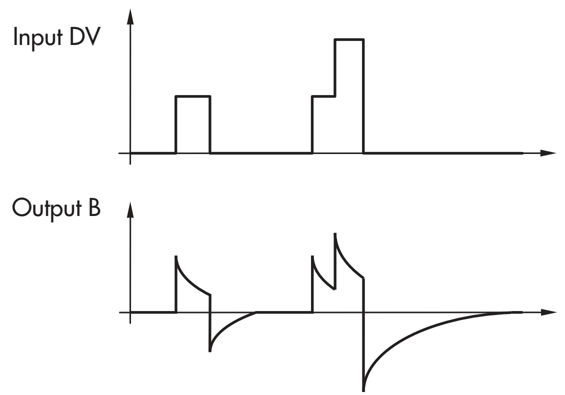
C.3.2.4	**Valuate input variables DV, TR**	<C.3.2.3≠0> M.1-2: Link input variable TR
-1	Result pos./neg.	
-2	Result >= 0	
-3	Result <= 0	
K5	Constant, formula: (DV + TR * K5 – K6) * K7 + K8 [–100.00 …**0.00**… 100.00]	With M.1-2/-6 Controller [1]: without DV
K6	Constant, formula: (DV + TR * K5 – K6) * K7 + K8 [–9999.0 …**0.0**… 9999.0]	With M.1-2/-6 Controller [1]: without DV
K7	Constant, formula: (DV + TR * K5 – K6) * K7 + K8 [–100.00 …**1.00**… 100.00]	With M.1-2/-6 Controller [1]: without DV
K8	Constant, formula: (DV + TR * K5 – K6) * K7 + K8 [–9999.0 …**0.0**… 9999.0]	With M.1-2/-6 Controller [1]: without DV

C.3.2.5 Transfer function for disturbance variables

The transfer element is used to change, adapt or compensate for the temporal behavior of the disturbance variables which have been fed forward. The transfer element is set by default to proportional term with the gain 1, i.e. the input signal is left unchanged. To be able to use the transfer function, the *Link input variables DV, TR* function must be configured (C.3.2.3≠0).

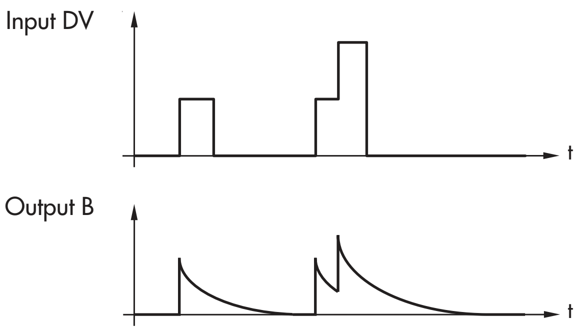
- **Setting -1:** P behavior
  The transfer element works with proportional term. The gain (proportional-action coefficient) is set with the KP.PD parameter.
- **Setting -2:** D behavior 1
  The transfer element works with derivative term 1. The proportional-action coefficient is set with the KP.PD parameter and the derivative-action time with TV.PD parameter.

Function: $\text{Output B} = KP.PD * TV.PD * \frac{d(\text{input DV})}{dt} - TV.PD * \frac{dB}{dt}$



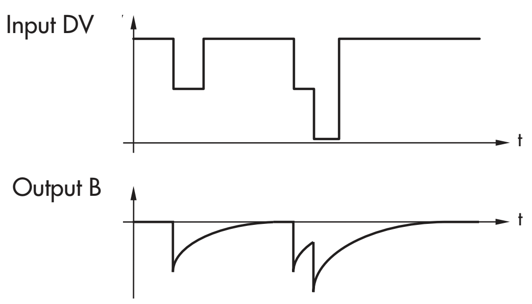
Example: Signal B is calculated from the differentiation of the input variable DV.

- **Setting -3:** D behavior 2
  The transfer element works with derivative term 2. The signal B is calculated from the differentiation of the rising input. Differentiation of the falling input is not performed.



Example: Signal B is calculated from the differentiation of the input variable DV.

- **Setting -4:** D behavior 3
  The transfer element works with derivative term 3. The signal B is calculated from the differentiation of the falling input. Differentiation of the rising input is not performed.



Example: The signal B is calculated from the differentiation of the falling input variable DV.

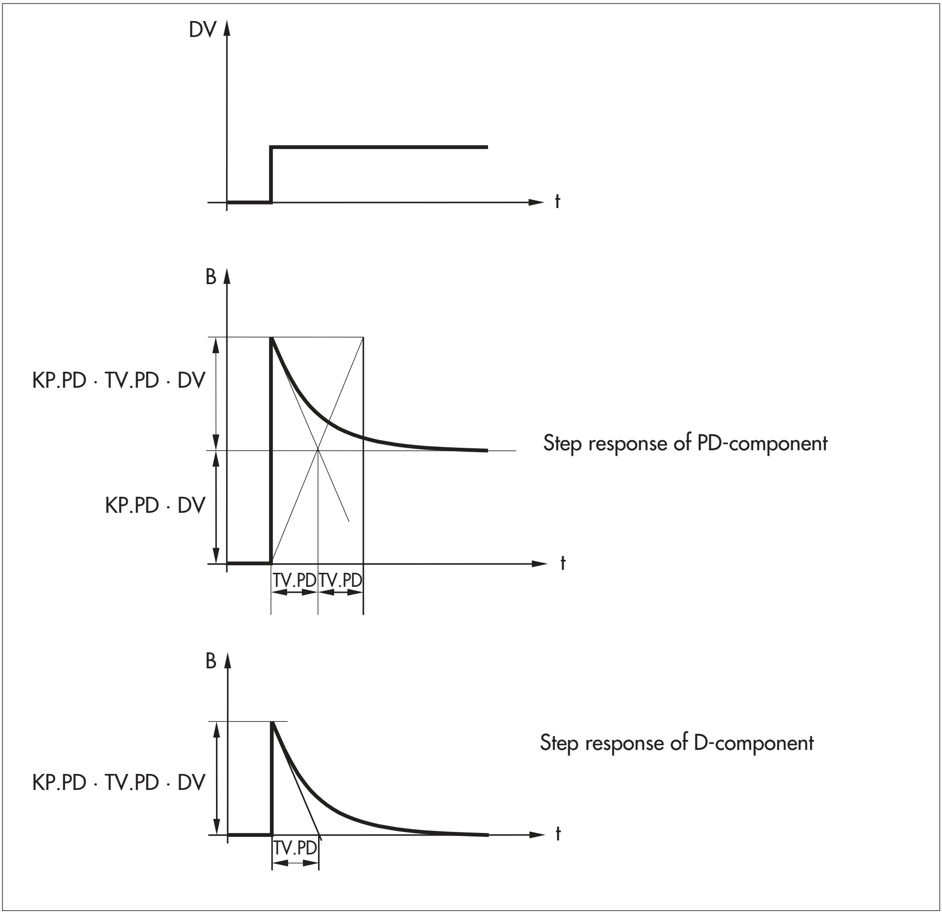
- **Setting -5:** PD behavior
  The transfer element works with proportional and derivative terms. The proportional-action coefficient is set with the KP.PD parameter and the derivative-action time with TV.PD parameter.

  Function: $\text{Output B} = \text{KP.PD} * \text{TV.PD} * \frac{d(\text{input DV})}{dt} - \text{TV.PD} * \frac{dB}{dt}$

Signal limitation

The output range of the transfer element (signal B) is limited by the B.MIN and B.MAX parameters.

The parameters are configured by entering numerical values.


DV
t
B
KP.PD · TV.PD · DV
KP.PD · DV
Step response of PD-component
t
TV.PD
TV.PD
B
KP.PD · TV.PD · DV
Step response of D-component
t
TV.PD

C.3.2.5	**Transfer function for disturbance variables**	<C.3.2.3≠0>
-1 -2 -3 -4 -5	P behavior D behavior 1 D behavior 2 D behavior 3 PD behavior	
KP.PD	Proportional-action coefficient [0.1 ...**1.0**... 100.0]	
TV.PD	Derivative-action time [**0.1** ... 9999 s]	<C.3.2.5≠1>
B.MIN	Minimum output value [**–9999.0** ... 9999.0]	
B.MAX	Maximum output value [–9999.0 ... **9999.0**]	

C.3.2.6 Arithmetic operation input variable PV

This configuration item determines the arithmetic operation to link the input variable PV to the input variables SPE, DV, TR or to the linked signal A. The linked signal A is calculated from the linking of the input variable SPE (C.3.2.1, C.3.2.2) and DV, TR (C.3.2.3, C.3.2.4).

In addition to the basic arithmetic operations (addition, subtraction, multiplication, division), the minumum and maximum selection as well as averaging are available for linking. In the minimum selection (C.3.2.6-6/-10/-14/-17/-20), the function output adopts the lowest value of the input signals. In the maximum selection (C.2.6-7/-11/-15/ -18/-21), the function output adopts the highest value of the input signals. The input variables (operands) are written in brackets. The settings C.3.2.6-5/-9/-13/-16/-19 cause the function output to be the arithmetic mean calculated from the input signals.

C.3.2.6	Arithmetic operation input variable PV	
-0	Off	
-1	PV + A	<C.1.1.1-1/-2/-3/-4, C.3.2.1-1/C.3.2.3-1>
-2	PV – A	<C.1.1.1-1/-2/-3/-4, C.3.2.1-1/C.3.2.3-1>
-3	PV∗A	<C.1.1.1-1/-2/-3/-4, C.3.2.1-1/C.3.2.3-1>
-4	PV/A	<C.1.1.1-1/-2/-3/-4, C.3.2.1-1/C.3.2.3-1>
-5	(PV+A)/2	<C.1.1.1-1/-2/-3/-4, C.3.2.1-1/C.3.2.3-1>
-6	Min (PV, A)	<C.1.1.1-1/-2/-3/-4, C.3.2.1-1/C.3.2.3-1>
-7	Max (PV, A)	<C.1.1.1-1/-2/-3/-4, C.3.2.1-1/C.3.2.3-1>
-8	PV – SPE	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4>
-9	(PV+SPE)/2	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4>
-10	Min (PV, SPE)	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4>
-11	Max (PV, SPE)	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4>
-12	PV – DV	<C.1.1.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4>
-13	(PV+DV)/2	<C.1.1.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4>
-14	Min (PV, DV)	<C.1.1.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4>
-15	Max (PV, DV)	<C.1.1.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4>
-16	(PV+ SPE+ DV)/3	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4>
-17	Min (PV, SPE, DV)	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4>
-18	Max (PV, SPE, DV)	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4>
-19	(PV+ SPE+ DV +TR)/4	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4, C.1.4.1-1/-2/-3/-4>
-20	Min (PV, SPE, DV, TR)	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4, C.1.4.1-1/-2/-3/-4>
-21	Max (PV, SPE, DV, TR)	<C.1.1.1-1/-2/-3/-4, C.1.2.1-1/-2/-3/-4, C.1.3.1-1/-2/-3/-4, C.1.4.1-1/-2/-3/-4>

C.3.2.7 Arithmetic operation input variable DV

This configuration item determines the arithmetic operation to link the input variable DV to the signal B (C.3.2.3-5) for ratio control (M.1-2/-6). The linked signal B is calculated from the linking of the input variables SPE and TR. The basic arithmetic operations (addition, subtraction, multiplication, division) are available for linking.

C.3.2.7	**Arithmetic operation input variable DV**	<M.1-2/-6, C.3.2.3-5>
-0	Off	
-1	DV + B	
-2	DV – B	
-3	DV∗B	
-4	DV/B	

C.3.2.8 Arithmetic operation set point SP

This configuration item determines the arithmetic operation to link the set point SP to the linked signal B (C.3.2.3-2). The signal B is calculated from the linking of input variables SPE, DV and TR. The basic arithmetic operations (addition, subtraction, multiplication, division) are available for linking.

Note: *For ratio controllers (M.1-2 and M.1-6 Controller [1]), the input variable DV is not included in the linked signal B. In this case, the set point ratio is linked instead of the set point at the comparator.*

C.3.2.8	**Arithmetic operation set point SP**	<C.3.2.3-2>
-0	Off	
-1	SP + B	
-2	SP – B	
-3	SP∗B	
-4	SP/B	

C.3.2.9 Arithmetic operation output YPID

This configuration item determines the arithmetic operation to link the output YPID to signal B (C.3.2.3-3). The linked signal B is calculated from the linking of input variables SPE, DV and TR. The basic arithmetic operations (addition, subtraction, multiplication, division) are available for linking.

Note:

- *For ratio controllers (M.1-2 and M.1-6 Controller [1]), the input variable DV is not included in the linked signal B.*

– *In controllers with firmware version 1.11 and lower, the disturbance variable B, scaled according to the measuring range of PV, is linked to the output signal YPID of the control algorithm over C.3.2.9.*
In controllers with firmware version 1.21 and higher, the disturbance variable B is linked over C.3.2.9 to YPID as an unscaled value.

C.3.2.9	**Arithmetic operation output YPID**	<C.3.2.3-3>
-0	Off	
-1	YPID + B	
-2	YPID – B	
-3	YPID*B	
-4	YPID/ B	

C.3.3 Additional control functions

C.3.3.1 Change over to manual mode with DI

The controller changes to manual mode when there is a '1' signal at the digital input.
A '0' signal at the digital input causes the controller to change to automatic mode.
The manual/automatic key has priority for the changeover to manual mode.
If required, the manual/automatic key can be locked (C.7.2-2).

For cascade control (M.1-3) and override control (M.1-4), the configuration item C.3.3.1 can only be configured at Controller [1]. Controller [2] cannot be changed to manual mode.

C.3.3.1	**Change over to manual mode DI**	M.1-3/-4: Controller [1] only
-0	Off	
-1	With digital input DI1	
-2	With digital input DI2	
-3	With digital input DI3	
-4	With digital input DI4	

C.3.3.2 Hold output YPID with DI

The internal output YPID is held in automatic mode when there is a '1' signal at the digital input. The last output value is saved. Control continues from the saved output value as soon as there is a '0' signal at the digital input.

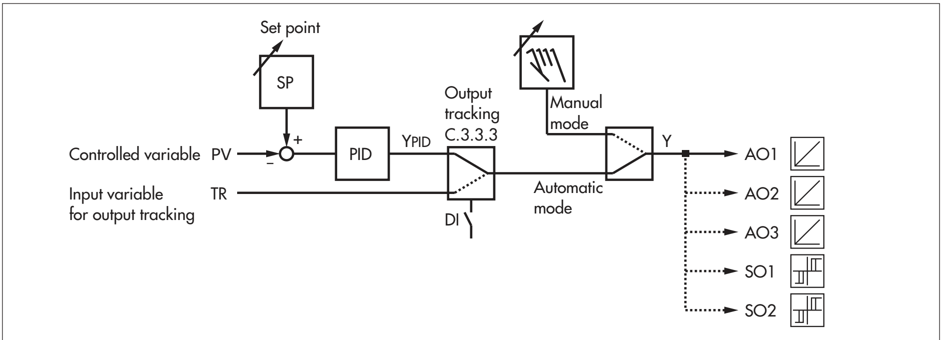
C.3.3.2	Hold output YPID with DI
-0	Off
-1	With digital input DI1
-2	With digital input DI2
-3	With digital input DI3
-4	With digital input DI4

C.3.3.3 Output tracking

The function can be selected when the input variable TR has been assigned to an analog input (C.1.4.1). During output tracking, the input variable TR (external output) is issued at the output of the controller when there is a '1' signal at the digital input. Output tracking only takes effect in automatic mode.

In output tracking mode, the internal output YPID tracks the input variable TR. The switchover to the output tracking mode is not bumpless as the input variable TR cannot track the manipulated variable Y calculated by the position algorithm. Output tracking is indicated on the display by the ■ icon on the left at the output.

A '0' signal at the digital input causes control in automatic mode to be continued with the last output value. The external output TR does not directly affect the output, but it starts to run through the entire output process to allow it to be revaluated. The switchover to automatic mode is bumpless as the integral-action component is calculated by the controller during output tracking to ensure that the manipulated variable Y is the same as the input variable TR.



Note:

– *If the output tracking function is used together with limit integral-action component function (C.3.1.2), the switchover from output tracking to automatic mode is no longer bumpless if* *the controller can no longer compensate for the adjusted operating point Y0 by limiting the integral-action component (I.MIN and I.MAX).*

– *Output tracking is not started if the constant outputs AO1.K1…AO3.K1, SO1.K1…SO2.K1 (see menu items O.1.6...O.3.6, O.4.6...O.5.6) or* Hold output YPID *(C.3.3.2≠0) are active.*

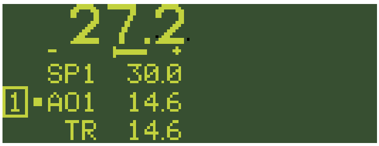
Scope of use

This function is used, for example, together with a control station. While the control station (PLC) controls the process, the industrial controller is on standby and its internal output YPID tracks the output signal of the control station TR (output tracking). In the event the control station fails, the digital input at the controller is energized to allow it to continue control with the last output value. It is also possible to set up a redundancy between two controllers in which the output signal of one of the controller tracks the output signal of the other controller and vice versa in alternating sequence.

Example: The external output variable at analog input AI2 is issued at analog output AO1 when there is a '1' signal at digital input DI1. Additionally, the external output variable (input variable TR) is indicated on the display in row 5.

Input variable TR: Analog input AI2	C.1.4.1-2
Output tracking: With input TR, DI1	C.3.3.3-1
Controller display Row 5: Input TR after function generation	C.5.6-20

When the output tracking is active, the ▣ icon appears on the display on the left next to the output.



C.3.3.3	**Output tracking**	<C.1.4.1-1/-2/-3/-4>
-0	Off	<M.1-1/-2/-3/-5/-6>
-1	With input TR, DI1	<M.1-4: Controller [1] only]
-2	With input TR, DI2	
-3	With input TR, DI3	
-4	With input TR, DI4	

C.3.3.6 Increase/decrease actual value with DI

This function increases/decreases the process variable PV by the value of the constant K9 when there is a '1' signal at the digital input. The feedforward involves addition: Process variable at the comparator PV0 = PV + K9,
For ratio controller (M.1-2/-6 Controller [1]): Process variable at the comparator PV0 = (PV + K9) ∗ K11

C.3.3.6	Increase/decrease actual value with DI	
-0	Off	
-1	With digital input DI1	
-2	With digital input DI2	
-3	With digital input DI3	
-4	With digital input DI4	
K9	Constant for process variable increase/decrease [–9999.0 ...**0.0**... 9999.0]	<C.3.3.6≠0>

C.3.3.7 Limit output in manual mode

With the setting C.3.3.7-0, the output is not limited in manual mode and can be adjusted in the whole range (–10.0 to 110.0 %).

With the setting C.3.3.7-1, the output is limited in manual mode. It is the same limitation as in automatic mode:

- Output limitation (O.1.2...O.5.2), e.g. AO1.MIN, AO1.MAX parameters
- Limit output by input TR (O.1.8...O.5.8)
- Function generation of the output (O.1.9...O.5.9)

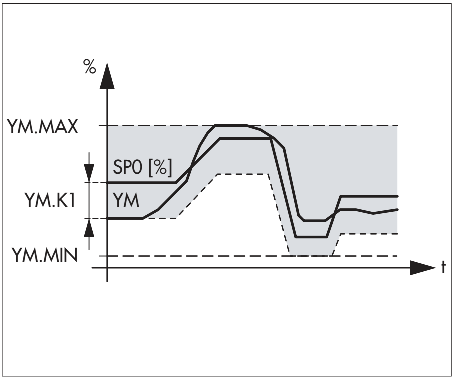
Note: *The function cannot be configured for Controller [2] when cascade control (M.1-3) or override control (M.1-4) is selected.*

C.3.3.7	Limit output in manual mode
-0	Off
-1	On

C.3.3.8 Limit master controller output YM

The internal output YM of the master controller [1] can be limited for cascade control (M.1-3). The output limits can be adjusted either as fixed limits or variable limits dependent on the set point SP0 of the master controller.

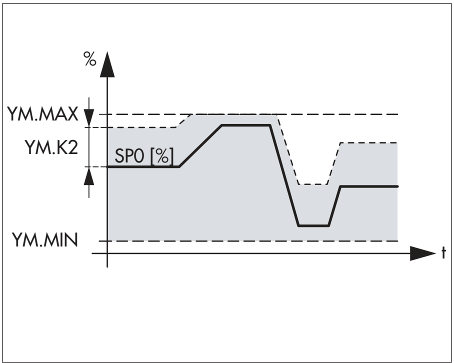
- **Setting -0:** OFF
  The output range is 0 to 100 %.
- **Setting -1:** Min/Max value = constant
  The effective range is determined by the minimum value YM.MIN and the maximum value YM.MAX.



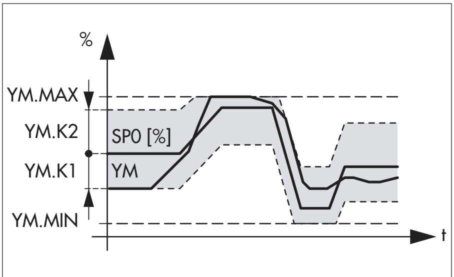
- **Setting -2:** Minimum value = f(SP0)
  The minimum value is dependent on the set point. It is smaller than the set point SP0 [%] at the comparator by the constant YM.K1. The constant YM.K1 is adjusted in percent in relation to the measuring range of the analog input assigned to the input variable PV. If the set-point-dependent minimum value is smaller than the minimum value YM.MIN, YM.MIN acts as the minimum value. If the set-point-dependent minimum value is greater than the maximum value YM.MAX, YM.MAX takes effect.

Example

Given:	Measuring range 0 to 200 °C, SP0 = 50 °C = 25 %
To be found:	YM.K1, to ensure that the internal output YM is not lower than the assigned temperature 20 °C = 10 %.
Solution:	YM.K1 = 25 % - 10 % = 15 %



- **Setting -3**: Maximum value = f(SP0)
The maximum value is dependent on the set point. It is larger than the set point SP0 [%] at the comparator by the constant YM.K2. The constant YM.K2 is adjusted in percent in relation to the measuring range of the analog input assigned to the input variable PV. If the set-point-dependent maximum value is smaller than the minimum value YM.MIN, YM.MIN acts as the minimum value. If the set-point-dependent maximum value is greater than the maximum value YM.MAX, YM.MAX takes effect.



- **Setting -4:** Min/Max value = f(SP0)
The limits are dependent on the set point. The range matches a band around the set point SP0.
The minimum value is smaller than the set point SP0 [%] at the comparator by the constant YM.K1. The constant YM.K1 is adjusted in percent in relation to the measuring range of the analog input assigned to the input variable PV. If the set-point-dependent minimum value is smaller than the minimum value YM.MIN, YM.MIN acts as the minimum value. If the set-point-dependent maximum value is greater than the maximum value YM.MAX, YM.MAX acts as the maximum value.
The maximum value is larger than the set point SP0 by the constant YM.K2. The constant YM.K2 is adjusted in percent in relation to the measuring range of the analog input assigned to the input variable PV. If the set-point-dependent maximum value is smaller than the minimum value YM.MIN, YM.MIN takes effect. If the set-point-dependent maximum value is greater than the maximum value YM.MAX, YM.MAX acts as the maximum value.

This configuration is used for control of autoclaves. The limitation allows the capacity to be limited during start-up.

C.3.3.8	Limit master controller output YM	<M.1-3>
-0	Off	
-1	Min/Max value constant	

C.3.3.8	**Limit master controller output YM**	<M.1-3>
-2	Minimum value = f(SP0)	
-3	Maximum value = f(SP0)	
-4	Min/Max value = f(SP0)	
YM.MIN	Minimum value output master [–10.0 ...**0.0**... 110.0 %]	<C.3.3.8≠0>
YM.MAX	Maximum value output master [–10.0 ...**100.0**... 110.0 %]	<C.3.3.8≠0>
YM.K1	Constant minimum value = SP0 – YM.K1 [0.1 ... **100.0** %]	<C.3.3.8-2/-4>
YM.K2	Constant maximum value = SP0 + YM.K2 [0.1 ... **100.0** %]	<C.3.3.8-3/-4>

C.4 Restart conditions

C.4.1 Operation mode after restart

After the power supply has been interrupted for more than one second, the controller starts according to the adjusted restart condition. The controller restarts in automatic mode by default.

- **Setting -0:** Auto
  The controller restarts in automatic mode.
- **Settings -1/-2/-3/-4/-5:** Auto, start AO1 = AO1.K1/AO2 = AO2.K1/AO3 = AO3.K1/SO1 = SO1.K1/SO2 = SO2.K1
  The controller restarts in automatic mode using an adjustable start value (constant output value AO1.K1...AO3.K1 or SO1.K1...SO2.K1) at the selected output.
- **Settings -6/-7/-8/-9/-10:** Manual, start AO1 = AO1.K1/AO2 = AO2.K1/AO3 = AO3.K1/SO1 = SO1.K1/SO2 = SO2.K1
  The controller restarts in manual mode using an adjustable start value (constant output value AO1.K1...AO3.K1 or SO1.K1...SO2.K1) at the selected output.
- **Settings -11/-12/-13/-14/-15:** Auto, confirmation, start AO1 = AO1.K1/AO2 = AO2.K1/AO3 = AO3.K1/SO1 = SO1.K1/SO2 = SO2.K1
  The controller restarts in automatic mode using an adjustable start value (constant output value AO1.K1...AO3.K1 or SO1.K1...SO2.K1) at the selected output. After restarting, the display blinks. The power failure is confirmed by pressing the escape key.

Note: *The AO1.K1…AO3.K1 and SO1.K1…SO2.K1 parameters are used for several different functions:*

- *Manual mode Controller [1] at signal error AI, see menu item I.1.6...I.4.6*
- *Manual mode Controller [2] at signal error AI, see menu item I.1.7...I.4.7*
- *Manual mode controller at signal error SPC, see menu item C.2.1.7*
- *Operating mode after restart, see menu item C.4.1*
- *Constant output value with DI, see menu items O.1.6...O.3.6 and O.4.6...O.5.6*

C.4.1		**Operation mode after restart**	
	-0	Auto	
	-1	Auto, start AO1 = AO1.K1	<O.1.1-1/-2/-38/-39>
	-2	Auto, start AO2 = AO2.K1	<O.2.1-1/-2/-38/-39>
	-3	Auto, start AO3 = AO3.K1	<O.3.1-1/-2/-38/-39>
	-4	Auto, start SO1 = SO1.K1	<O.4.1-1/-2/-38/-39>
	-5	Auto, start SO2 = SO2.K1	<O.5.1-1/-2/-38/-39>
	-6	Manual, start AO1 = AO1.K1	<O.1.1-1/-2/-38/-39>
	-7	Manual, start AO2 = AO2.K1	<O.2.1-1/-2/-38/-39>
	-8	Manual, start AO3 = AO3.K1	<O.3.1-1/-2/-38/-39>
	-9	Manual, start SO1 = SO1.K1	<O.4.1-1/-2/-38/-39>
	-10	Manual, start SO2 = SO2.K1	<O.5.1-1/-2/-38/-39>
	-11	Auto, confirm. AO1 = AO1.K1	<O.1.1-1/-2/-38/-39>
	-12	Auto, confirm. AO2 = AO2.K1	<O.2.1-1/-2/-38/-39>
	-13	Auto, confirm. AO3 = AO3.K1	<O.3.1-1/-2/-38/-39>
	-14	Auto, confirm. SO1 = SO1.K1	<O.4.1-1/-2/-38/-39>
	-15	Auto, confirm. SO2 = SO2.K1	<O.5.1-1/-2/-38/-39>
AO1.K1		Constant output value at AO1 [–10.0 …**0.0**… 110.0 %]	<C.4.1-1/-6/-11>
AO2.K1		Constant output value at AO2 [–10.0 …**0.0**… 110.0 %]	<C.4.1-2/-7/-12>
AO3.K1		Constant output value at AO3 [–10.0 …**0.0**… 110.0 %]	<C.4.1-3/-8/-13>
SO1.K1		Constant output value at SO1 [–10.0 …**0.0**… 110.0 %]	<C.4.1-4/-9/-14>
SO2.K1		Constant output value at SO2 [–10.0 …**0.0**… 110.0 %]	<C.4.1-5/-10/-15>

C.5 Controller display

C.5.1 Controller display row 1

The configuration item C.5.1 determines which variable is to be displayed in row 1. The process variable PV0 is displayed by default. In ratio controllers, the process variable ratio PVR is displayed by default.

C.5.1	Row 1	
-1	Off	
-2	Input PV after function generation	
-3	Input PV before filter	
-4 [1)]	Process variable ratio PVR	<M.1-2/-6>
1) Ratio controller [1]: default setting -4		

C.5.2 Controller display row 2

The configuration item C.5.2 determines how the error signal e in row 2 is to be displayed. The default setting -1 causes the error signal to be displayed as a bar graph in the range –5 to 5 % in relation to the measuring range of the analog input assigned to the input variable. The setting -2 causes the amount of the error signal to be displayed as a bar graph in the range 0 to 5 % (one graduation mark = 1 %).

Note: *The error signal is shown in the info menu (Controller -> Set point display).*

C.5.2	Row 2
-0	Off
-1	Error signal +/– e
-2	Error signal |e|

C.5.3 Controller display row 3

The configuration item C.5.3 determines which variable is to be displayed in row 3. By default, the effective set point SP (SP1…SP4, SPE, SPC or SPM with M.1-3 Controller [2]) is displayed.

C.5.3	Row 3
-0	Off

C.5.3	Row 3	
-1	Set point SP	
-2	Set point SP0 at comparator	
-3 1)	Set point ratio SPR	<M.1-2/-6>

1) Ratio controller [1]: default setting -3

C.5.4 Controller display row 4

The configuration item C.5.4 determines which variable is to be displayed in row 4. The default setting (Output according to priority) causes the first output to be displayed according to the selected sequence AO1, AO2, AO3, SO1, SO2. This is analog output AO1 in the default setting.

C.5.4	Row 4	
-0	Off	
-1	Output according to priorty	
-2	Output AO1	<O.1.1≠0>
-3	Output AO2	<O.2.1≠0>
-4	Output AO3	<O.3.1≠0>
-5	Output SO1	<O.4.1≠0>
-6	Output SO2	<O.5.1≠0>
-7	Controller [1] output Y	Controller [1] only
-8	Controller [2] output Y	<M.1-3/-4/-5/-6> Contr. [2] only
-10	Output master controller YM	<M.1-3> Controller [2] only
-11	Input PV before filter	<C.1.1.1≠0>
-12	Input PV after function generation	<C.1.1.1≠0>
-13	Process variable PV0 at comparator	<C.1.1.1≠0>
-14	Process variable ratio PVR	<M.1-2/-6> Controller [1] only
-15	Input SPE before filter	<C.1.2.1≠0>
-16	Input SPE after function generation	<C.1.2.1≠0>
-17	Input DV before filter	<C.1.3.1≠0>
-18	Input DV after function generation	<C.1.3.1≠0>
-19	Input TR before filter	<C.1.4.1≠0>
-20	Input TR after function generation	<C.1.4.1≠0>
-22	Input FB before filter	<C.1.5.1≠0>
-23	Input FB after filter	<C.1.5.1≠0>
-24	Signal A	<C.3.2.1≠0/C.3.2.3≠0>
-25	Signal B	<C.3.2.3≠0>

C.5.4	Row 4	
-26	Set point SP1	
-27	Set point SP2	<C.2.1.1-2/-3/-4>
-28	Set point SP3	<C.2.1.1-3/-4>
-29	Set point SP4	<C.2.1.1-4>
-30	Set point SPI	
-31	Set point SPM	<M.1-3> Controller [1] only
-32	Set point SPC	<C.2.1.2-2>
-33	Set point SP	
-34	Set point SP0 at comparator	
-35	Ratio set point SPR	<M.1-2/-6> Controller [1] only
-36	Error signal +/− e	
-37	Digital outputs DO1…DO4	<O.6.1≠0...O.9.1≠0>
-38	Digital outputs DO5…DO7	
-39	Digital outputs DI1…DI4	
-40	Effective KP	
-41	Effective TN	

C.5.5 Controller display row 4 representation

The configuration item C.5.5 determines how the variable is to be displayed in row 4.

If an analog variable is selected for row 4, the representation is automatically set to *Numerical*. The representation can be changed subsequently. For outputs AO1 to AO3, the representation can be adjusted to *Numerical; Numerical, inverted; Bar graph* or *Bar graph, inverted*. The inverted representation is used to adapt the display to the control direction of the controlled system or controlling element. In addition to this, the settings for the operating direction of outputs (O.1.3...O.5.3), for inverting the manual output value (C.7.1) and for inverting the error signal (C.3.1.3) need to be taken into account.
If an on/off or three-point stepping output (SO1, SO2) has been selected for row 4, the representation is automatically set to *Switch signal* and the symbols '+' and '–' are displayed. If required, the set point of the switch outputs SO1, SO2 can be displayed in the range 0 to 100 % by setting the representation to to *Numerical; Numerical, inverted; Bar graph* or *Bar graph, inverted*.
If a digital input (DI1 to DI4) or a digital output (DO1 to DO7) is selected for row 4, the representation is automatically set to *Digital signal*. In this configuration, the number of the active digital input (digital output) is displayed next to DI (DO).

C.5.5	Row 4 representation	
-1	Numerical	
-2	Numerical, inverted	
-3	Bar graph	<M.1-2/-6>
-4	Bar graph, inverted	
-5 [1)]	Switch signal	
-6 [1)]	Digital signal	

1) C.5.4-5/-6: default setting -5 · C.5.4-37/-38/-39: default setting -6

C.5.6 Controller display row 5

The configuration item C.5.6 determines which variable is to be displayed in row 5. This row is deactivated by default and a digital output DO1 to DO4 is set as a limit relay if the digital outputs DO1 to DO4 are displayed.

C.5.6	Row 5	
-0	Off	
-1	Output according to priority	
-2	Output AO1	<O.1.1≠0>
-3	Output AO2	<O.2.1≠0>
-4	Output AO3	<O.3.1≠0>
-5	Output SO1	<O.4.1≠0>
-6	Output SO2	<O.5.1≠0>
-7	Controller [1] output Y	Controller [1] only
-8	Controller [2] output Y	<M.1-3/-4/-5/-6> Contr. [2] only
-10	Output master controller YM	<M.1-3>
-11	Input PV before filter	<C.1.1.1≠0>
-12	Input PV after function generation	<C.1.1.1≠0>
-13	Process variable PV0 at comparator	<C.1.1.1≠0>
-14	Process variable ratio PVR	<M.1-2/-6> Controller [1] only
-15	Input SPE before filter	<C.1.2.1≠0>
-16	Input SPE after function generation	<C.1.2.1≠0>
-17	Input DV before filter	<C.1.3.1≠0>
-18	Input DV after function generation	<C.1.3.1≠0>
-19	Input TR before filter	<C.1.4.1≠0>
-20	Input TR after function generation	<C.1.4.1≠0>
-22	Input FB before filter	<C.1.5.1≠0>

C.5.6	Row 5	
-23	Input FB after filter	<C.1.5.1≠0>
-24	Signal A	<C.3.2.1≠0/C.3.2.3≠0>
-25	Signal B	<C.3.2.3≠0>
-26	Set point SP1	
-27	Set point SP2	<C.2.1.1-2/-3/-4>
-28	Set point SP3	<C.2.1.1-3/-4>
-29	Set point SP4	<C.2.1.1-4>
-30	Set point SPI	
-31	Set point SPM	<M.1-3> Controller [1] only
-32	Set point SPC	<C.2.1.2-2>
-33	Set point SP	
-34	Set point SP0 at comparator	
-35	Set point ratio SPR	<M.1-2/-6> Controller [1] only
-36	Error signal +/– e	
-37	Digital outputs DO1…DO4	<O.6.1≠0...O.9.1≠0>
-38	Digital outputs DO5…DO7	
-39	Digital inputs DI1…DI4	
-40	Effective KP	
-41	Effective TN	

C.5.7 Controller display row 5 representation

The configuration item C.5.7 determines how the variable is to be displayed in row 5 of the controller display. The default settings depending on the signal are the same as for row 4, see menu item C.5.5.

C.5.7	Row 5 representation
-1	Numerical
-2	Numerical, inverted
-3	Bar graph
-4	Bar graph, inverted
-5 [1)]	Switch signal
-6 [1)]	Digital signal

1) C.5.6-5/-6: default setting -5 · C.5.6-37/-38/-39: default setting -6

C.6 Additional display

Note: *The settings made under C.6.1 to C.6.10 only take effect when the additional display has been enabled by configuring A.2.1-2/-4 or A.2.2-2/-4.*

The configuration items C.6.1, C.6.3, C.6.5, C.6.7 and C.6.9 determine which variables are to be displayed in rows 1 to 5 of the additional display. These rows are deactivated by default.

C.6.1	**Row 1**	
C.6.3	**Row 2**	
C.6.5	**Row 3**	
C.6.7	**Row 4**	
C.6.9	**Row 5**	
-0	Off	
-1	Output according to priority	
-2	Output AO1	<O.1.1≠0>
-3	Output AO2	<O.2.1≠0>
-4	Output AO3	<O.3.1≠0>
-5	Output SO1	<O.4.1≠0>
-6	Output SO2	<O.5.1≠0>
-7	Controller [1] output Y	Controller [1] only
-8	Controller [2] output Y	<M.1-3/-4/-5/-6> Contr. [2] only
-10	Output master controller YM	<M.1-3>
-11	Input PV before filter	<C.1.1.1≠0>
-12	Input PV after function generation	<C.1.1.1≠0>
-13	Process variable PV0 at comparator	<C.1.1.1≠0>
-14	Process variable ratio PVR	<M.1-2/-6> Controller [1] only
-15	Input SPE before filter	<C.1.2.1≠0>
-16	Input SPE after function generation	<C.1.2.1≠0>
-17	Input DV before filter	<C.1.3.1≠0>
-18	Input DV after function generation	<C.1.3.1≠0>
-19	Input TR before filter	<C.1.4.1≠0>
-20	Input TR after function generation	<C.1.4.1≠0>
-22	Input FB before filter	<C.1.5.1≠0>
-23	Input FB after filter	<C.1.5.1≠0>
-24	Signal A	<C.3.2.1≠0/C.3.2.3≠0>
-25	Signal B	<C.3.2.3≠0>
-26	Set point SP1	

C.6.1	**Row 1**	
C.6.3	**Row 2**	
C.6.5	**Row 3**	
C.6.7	**Row 4**	
C.6.9	**Row 5**	
-27	Set point SP2	<C.2.1.1-2/-3/-4>
-28	Set point SP3	<C.2.1.1-3/-4>
-29	Set point SP4	<C.2.1.1-4>
-30	Set point SPI	
-31	Set point SPM	<M.1-3> Controller [1] only
-32	Set point SPC	<C.2.1.2-2>
-33	Set point SP	
-34	Set point SP0 at comparator	
-35	Set point ratio SPR	<M.1-2/-6> Controller [1] only
-36	Error signal +/− e	
-37	Digital outputs DO1…DO4	<O.6.1≠0...O.9.1≠0>
-38	Digital outputs DO5…DO7	
-39	Digital inputs DI1…DI4	
-40	Effective KP	
-41	Effective TN	

The configuration items C.6.2, C.6.4, C.6.6, C.6.8 and C.6.10 determine how the variables in rows 1 to 5 of the additional display are to be displayed. The default setting depending on the signal are the same as for row 4, see menu item C.5.5.

C.6.2	**Row 1 representation**
C.6.4	**Row 2 representation**
C.6.6	**Row 3 representation**
C.6.8	**Row 4 representation**
C.6.10	**Row 5 representation**
-1	Numerical
-2	Numerical, inverted
-3	Bar graph
-4	Bar graph, inverted
-5 [1)]	Switch signal
-6 [1)]	Digital signal

1) C.6.1-5/-6, C.6.3-5/-6, C.6.5-5/-6, C.6.7-5/-6, C.6.9-5/-6: default setting -5
C.6.1-37/-38/-39, C.6.3-37/-38/-39, C.6.5-37/-38/-39, C.6.7-37/-38/-39, C.6.9-37/-38/-39: default setting -6

C.7 Operator keys

This menu contains global settings for the key panel. Controller-wide settings are configured using menu A.2, see menu item A.2.

C.7.1 Invert manual output value

The control direction of the manual output value can be adapted to the control direction of the controlled system or controlling element. The inversion is deactivated in the default setting, i.e. the manual output value is not inverted.

Note that only the source for the output (AO1…AO3, SO1, SO2) is adjusted with the manual output value Y, i.e. the output still runs through the output process and its control direction can still be inverted again by configuring the menu items *Operating direction* (O.1.3...O.5.3) and *Function generation* (O.1.9...O.5.9).

***Note:** By changing the operating direction of an output, the control direction of the manual output value is automatically changed in the same direction as well. It may be necessary to adapt the control direction of the manual output value afterwards. The menu items O.1.3...O.3.3 list various examples of this.*

The output value Y can be displayed in the operating level by configuring menu items C.5.4, C.5.6. C.6.1, C.6.3, C.6.5, C.6.7 and C.6.9.

C.7.1		**Invert manual output value**
	-0	Off
	-1	On

C.7.2 Lock manual/automatic key

The setting C.7.2-1 causes the manual/automatic key to be locked. After configuration the controller remains in the mode last adjusted.

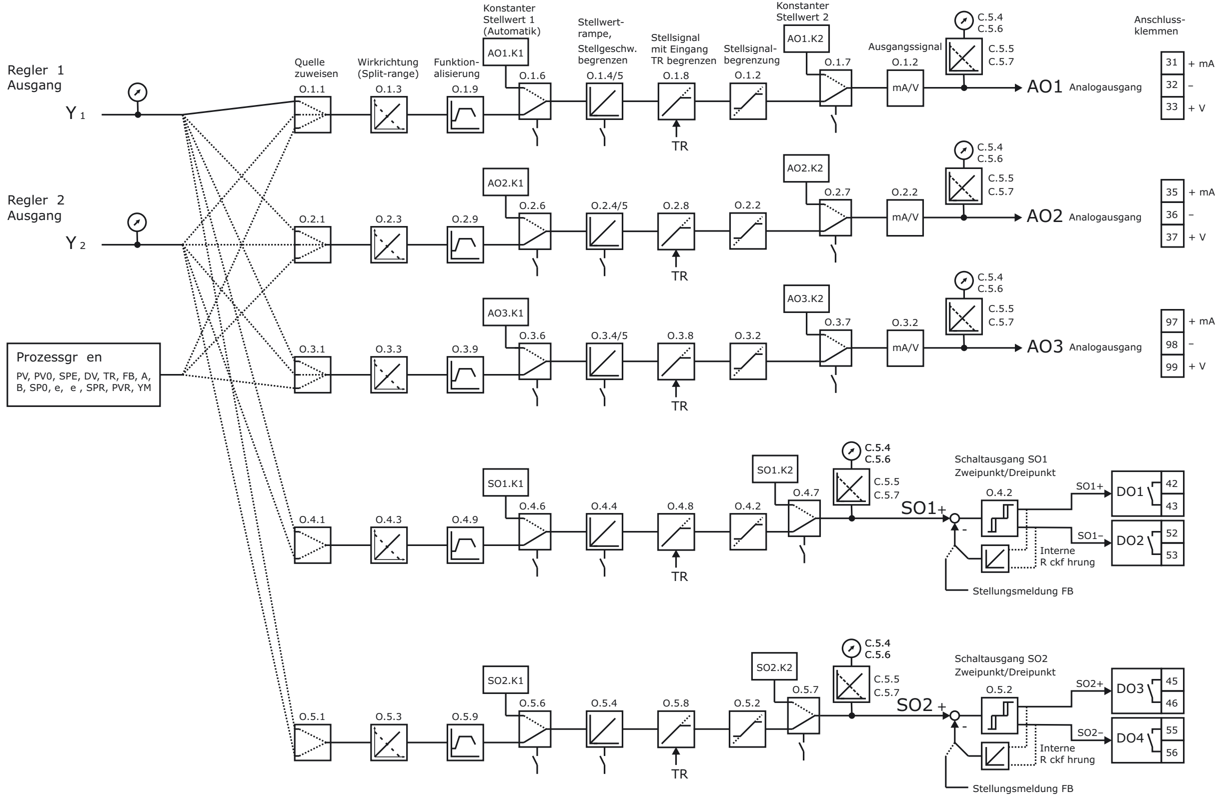
C.7.2		**Lock manual/auto key**
	-0	Off
	-1	On

C.7.3 Lock set point keys

This setting C.7.3-1 locks the keys to adjust the interna set point (SP1…SP4) in the operating level. The set point can still be adjusted in the operating menu and in the configuration menu using the keys.

C.7.3		Lock set point keys
	-0	Off
	-1	On

Ausgang


Regler 1
Ausgang
Y 1
Regler 2
Ausgang
Y 2
Prozessgr en
PV, PV0, SPE, DV, TR, FB, A, B, SP0, e, e , SPR, PVR, YM
Quelle
zuweisen
Wirkrichtung
(Split-range)
Funktion-
alisierung
Konstanter
Stellwert 1
(Automatik)
Stellwert-
rampe,
Stellgeschw.
begrenzen
Stellsignal
mit Eingang
TR begrenzen
Stellsignal-
begrenzung
Konstanter
Stellwert 2
Ausgangssignal
Anschluss-
klemmen
O.1.1
O.1.3
O.1.9
AO1.K1
O.1.6
O.1.4/5
O.1.8
O.1.2
AO1.K2
O.1.7
O.1.2
mA/V
C.5.4
C.5.6
C.5.5
C.5.7
AO1 Analogausgang
31 + mA
32 –
33 + V
TR
O.2.1
O.2.3
O.2.9
AO2.K1
O.2.6
O.2.4/5
O.2.8
O.2.2
AO2.K2
O.2.7
O.2.2
AO2 Analogausgang
35 + mA
36 –
37 + V
O.3.1
O.3.3
O.3.9
AO3.K1
O.3.6
O.3.4/5
O.3.8
O.3.2
AO3.K2
O.3.7
O.3.2
AO3 Analogausgang
97 + mA
98 –
99 + V
O.4.1
O.4.3
O.4.9
SO1.K1
O.4.6
O.4.4
O.4.8
O.4.2
SO1.K2
O.4.7
SO1+
Schaltausgang SO1
Zweipunkt/Dreipunkt
O.4.2
SO1+
SO1–
DO1 42 43
DO2 52 53
Interne
R ckf hrung
Stellungsmeldung FB
O.5.1
O.5.3
O.5.9
SO2.K1
O.5.6
O.5.4
O.5.8
O.5.2
SO2.K2
O.5.7
SO2 +
Schaltausgang SO2
Zweipunkt/Dreipunkt
O.5.2
SO2+
SO2–
DO3 45 46
DO4 55 56
Interne
R ckf hrung
Stellungsmeldung FB

O Output

The analog outputs AO1 to AO3, the switch outputs SO1 and SO2 as well as the digital outputs DO1 to DO6 are configured in this menu.

Each analog output and switch output is assigned to a group. Within the group, the output is assigned to the corresponding internal controller as well as the type of signal (signal range) and the operating direction are determined. Additionally, further functions for split-range operation, output ramps, activation of a constant output value, externally controlled output limitation and function generation can be selected.

O.1...O.3 AO1...AO3: Analog output AO1 to AO3

O.1.1...O.3.1 AO1...AO3: Assign source

This configuration item assigns the source for the output (AO1 to AO3). The output functions can only be adjusted after the source has been assigned. When the control modes M.1-1, M.1-2, M.1-3 and M.1-4 are configured, the output AO1 is automatically assigned to Controller [1]. When the control modes M.1-5 and M.1-6 are configured, the output AO1 is automatically assigned to Controller [1] and the output AO2 to Controller [2]. If need be, these assignments can be changed afterwards.

The input variables PV, SPE, DV, TR, and FB are issued in relation to the measuring range (AIx.MIN ... AIx.MAX) of the analog input assigned to the input variable. The process variable PV0 and the set point SP0 are issued in relation to the measuring range (AIx.MIN ... AIx.MAX) of the analog input assigned to the input variable PV. If the function generation of the input variable (C.1.x.4) is activated, the variable is issued in relation to the output range of the function generation.
The linked signals A and B are issued as unscaled values.

The setting -4 causes a constant output value to be assigned to the output. This constant output value is entered by configuring the associated parameter AO1.FX...AO3.FX.

The settings -18 and -35 causes the error signal (–110.0 to 110.0 %) to be issued to the output range (–10.0 to 110.0 %), i.e. 50 % is issued at the output when the error signal is 0 %.

The settings -19 and -36 causes the amount of the error signal to be issued, i.e. 10.0 % is issued at the output when the signal error is –10.0 %.

The setting -20 causes the set point ratio SPR to be issued not as numerical values while the setting -21 causes the process variable ratio PVR to be issued as unscaled values. The output range can be adapted by performing a function generation on the output.

The settings -38 and -39 are used for mixing control according to the single-lever faucet principle. Mixing control is illustrated in example 3 of menu item M.1-5.

O.1.1 (AO1)
O.2.1 (AO2) **Assign source**
O.3.1 (AO3)

-1	Controller [1] output Y	
-2	Controller [2] output Y	<M.1-3/-4/-5/-6>
-4	Constant output value	
-5	[1] Input PV before filter	<1C.1.1.1≠0>
-6	[1] Input PV after function generation	<1C.1.1.1≠0>
-7	[1] Process variable PV0	<1C.1.1.1≠0>
-8	[1] Input SPE before filter	<1C.1.2.1≠0>
-9	[1] Input SPE after function generation	<1C.1.2.1≠0>
-10	[1] Input DV before filter	<1C.1.3.1≠0>
-11	[1] Input DV after function generation	<1C.1.3.1≠0>
-12	[1] Input TR before filter	<1C.1.4.1≠0>
-13	[1] Input TR after function generation	<1C.1.4.1≠0>
-14	[1] Input FB before filter	<1C.1.5.1≠0>
-15	[1] Signal A	<1C.3.2.1-1, 1C.3.2.3-1>
-16	[1] Signal B	<1C.3.2.3≠0>
-17	[1] Set point SP0	
-18	[1] Error signal +/–e	
-19	[1] Error signal |e|	
-20	[1] Ratio set point SPR	<M.1-2/-6>
-21	[1] Process variable ratio PVR	<M.1-2/-6>
-22	[2] Input PV before filter	<M.1-3/-4/-5/-6, 2C.1.1.1≠0>
-23	[2] Input PV after function generation	<M.1-3/-4/-5/-6, 2C.1.1.1≠0>
-24	[2] Process variable PV0	<M.1-3/-4/-5/-6, 2C.1.1.1≠0>
-25	[2] Input SPE before filter	<M.1-3/-4/-5/-6, 2C.1.2.1≠0>
-26	[2] Input SPE after function generation	<M.1-3/-4/-5/-6, 2C.1.2.1≠0>
-27	[2] Input DV before filter	<M.1-3/-4/-5/-6, 2C.1.3.1≠0>
-28	[2] Input DV after function generation	<M.1-3/-4/-5/-6, 2C.1.3.1≠0>
-29	[2] Input TR before filter	<M.1-3/-4/-5/-6, 2C.1.4.1≠0>
-30	[2] Input TR after function generation	<M.1-3/-4/-5/-6, 2C.1.4.1≠0>
-31	[2] Input FB before filter	<M.1-3/-4/-5/-6, 2C.1.5.1≠0>
-32	[2] Signal A	<2C.3.2.1-1, 2C.3.2.3-1>
-33	[2] Signal B	<2C.3.2.3≠0>
-34	[2] Set point SP0	<M.1-3/-4/-5/-6>
-35	[2] Error signal +/–e	<M.1-3/-4/-5/-6>

O.1.1 **O.2.1** **O.3.1**	(AO1) (AO2) (AO3)	**Assign source**	
	-36	[2] Error signal |e|	<M.1-3/-4/-5/-6>
	-37	Output master controller YM	<M.1-3>
	-38	Y1 ∗ Y2 ∗ AO1.KM/100 (for AO1) Y1 ∗ Y2 ∗ AO2.KM/100 (for AO2) Y1 ∗ Y2 ∗ AO3.KM/100 (for AO3)	<M.1-5/-6>
	-39	(100 – Y1) ∗ Y2 ∗ AO1.KM/100 (for AO1) (100 – Y1) ∗ Y2 ∗ AO2.KM/100 (for AO2) (100 – Y1) ∗ Y2 ∗ AO3.KM/100 (for AO3)	<M.1-5/-6>

AO1.FX AO2.FX AO3.FX	(AO1) (AO2) (AO3)	Constant output value	<O.1.1-4> <O.2.1-4> <O.3.1-4>
		[–10 ...**0.0**... 110 %]	
AO1.KM AO2.KM AO3.KM	(AO1) (AO2) (AO3)	Constant, mixing operation	<O.1.1-38/-39> <O.2.1-28/-39> <O.3.1-38/-39>
		[0.0 ...**1.0**... 100.0]	

O.1.2...O.3.2 AO1...AO3: Output signal

The analog outputs AO1 to AO3 can be configured to operate with a 0 to 20 mA, 4 to 20 mA, 0 to 10 V or 2 to 10 V signal. Two parameters (MIN, MAX) are assigned to each output to determine the output range.

The maximum output range is –10 to 110 %. The default setting of the output range is 0 to 100 %.

O.1.2 **O.2.2** **O.3.2**	(AO1) (AO2) (AO3)	**Output signal**	<O.1.1≠0> <O.1.2≠0> <O.1.3≠0>
	-1	4–20 mA	
	-2	0–20 mA	
	-3	0–10 V	
	-4	2–10 V	

AO1.MIN AO2.MIN AO3.MIN	(AO1) (AO2) (AO3)	Minimum output value	
		[–10.0 ...**0.0**... 110 %]	
AO1.MAX AO2.MAX AO3.MAX	(AO1) (AO2) (AO3)	Maximum output value	
		[0.0 ...**100.0**... 110 %]	

O.1.3...O.3.3 AO1...AO3: Operating direction

The operating direction of the output can be adapted to the operating direction of the controlled system or valve. The operating direction can be adjusted to be increasing or decreasing in relation to the internal output Y.

Note: *In addition to the operating direction of the output, the control direction of the operator keys for manual output value (C.7.1) and the control direction of the output value reading (C.5.5/ C.5.7) can be adapted as required to the operating direction of the valve.*
When the operating direction of an output is changed, the control direction of the manual output value is automatically changed in the same way as well. It may be necessary to adapt the control direction of the manual output value (C.7.1) afterwards.
On page 166, four possible ways to control heating and cooling valves are illustrated.

Note: *The adjusted operating direction of the error signal must be taken into account. It can be changed again in the configuration item C.3.1.2.*

Dividing up the output range (split-range operation)

By dividing up the output range, an internal controller can be used to control a maximum of five valves in sequence over the outputs. The characteristic of an output is determined by the operating direction, the starting point (AO1.P1...AO3.P1) and the final point (AO1.P2...AO3.P2).

In the configuration **Operating direction increasing**, the starting point (AO1.P1...AO3.P1) sets the output value Y at which the output is to take on the minimum output value (AO1.MIN...AO3.MIN). The final point (AO1.P2...AO3.P2) sets the output value Y at which the output is to take on the maximum output value (AO1.MAX...AO3.MAX).

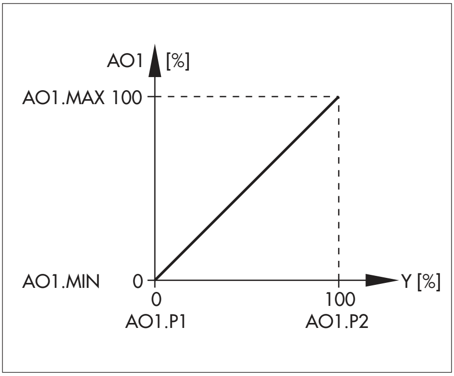
In the configuration **Operating direction decreasing**, the starting point (AO1.P1...AO3.P1) sets the output value Y at which the output is to take on the maximum output value

(AO1.MAX...AO3.MAX). The final point (AO1.P2...AO3.P2) sets the output value Y at which the output is to take on the minimum output value (AO1.MIN...AO3.MIN).

When the operating direction is changed, the characteristic is mirrored at the vertical axis.

Operating direction	Increasing	Decreasing
Parameter AO1.P1...AO3.P1	Y value for AO1.MIN...AO3.MIN	Y value f. AO1.MAX...AO3.MAX
Parameter AO1.P2...AO3.P2	Y value f. AO1.MAX...AO3.MAX	Y value for AO1.MIN...AO3.MIN

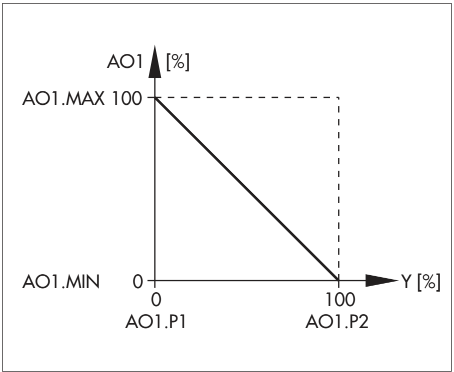
Note: *The value for the starting point AO1.P1...AO3.P1 must be smaller than the value for the final point AO1.P2... AO3.P2.*



Example 1: AO1 operating direction increasing

Setting

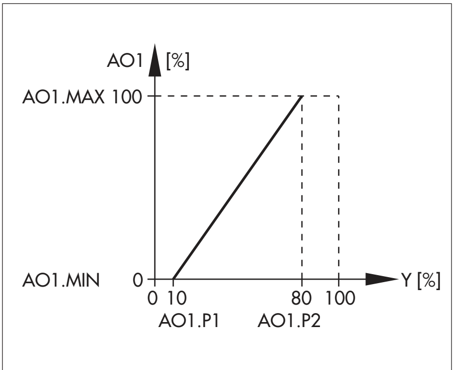
- O.1.2-1 Output signal: 4 to 20 mA
- AO1.MIN = 0.0 %
- AO1.MAX = 100.0 %
- O.1.3-1 Operating direction: increasing
- AO1.P1 = 0.0 %
- AO1.P2 = 100.0 %



Example 2: AO1 operating direction decreasing

Setting

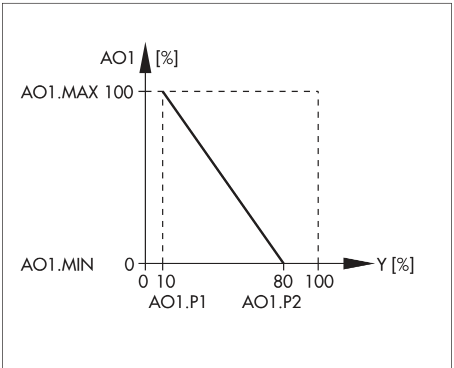
- O.1.2-1 Output signal: 4 to 20 mA
- AO1.MIN = 0.0 %
- AO1.MAX = 100.0 %
- O.1.3-2 Operating direction: decreasing
- AO1.P1 = 0.0 %
- AO1.P2 = 100.0 %



Example 3: AO1 operating direction increasing

Setting

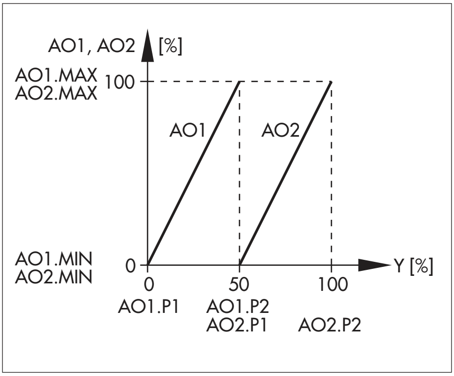
- O.1.2-1 Output signal: 4 to 20 mA
- AO1.MIN = 0.0 %
- AO1.MAX = 100.0 %
- O.1.3-1 Operating direction: increasing
- AO1.P1 = 10.0 %
- AO1.P2 = 80.0 %



Example 4: AO1 operating direction decreasing

Setting

- O.1.2-1 Output signal: 4 to 20 mA
- AO1.MIN = 0.0 %
- AO1.MAX = 100.0 %
- O.1.3-2 Operating direction: decreasing
- AO1.P1 = 10.0 %
- AO1.P2 = 80.0 %



Example 5:

Two control valves in a parallel arrangement are positioned over two outputs. The second valve first opens when the first valve is open.

Setting for output AO1

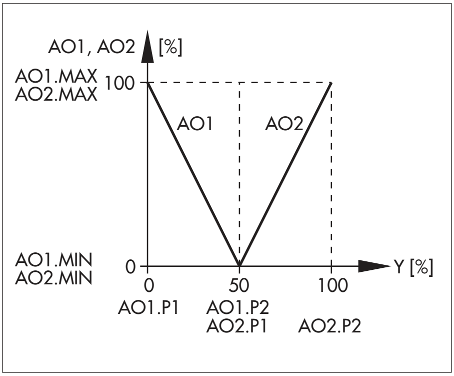
- O.1.1-1 Source: Controller [1] output Y
- O.1.2-1 Output signal: 4 to 20 mA
- AO1.MIN = 0.0 %
- AO1.MAX = 100.0 %
- O.1.3-1 Operating direction: increasing
- AO1.P1 = 0.0 %
- AO1.P2 = 50.0 %

Setting for output AO2

- O.2.1-1 Source: Controller [1] output Y
- O.2.2-1 Output signal: 4 to 20 mA
- AO2.MIN = 0.0 %
- AO2.MAX = 100.0 %
- O.2.3-1 Operating direction: increasing
- AO2.P1 = 50.0 %
- AO2.P2 = 100.0 %

Setting for controller display:

- C.5.6-3 Row 5: AO2



Example 6:

A heating valve and a cooling valve are positioned over two outputs. The heating valve first opens when the cooling valve is closed.

Setting for output AO1:

- O.1.1-1 Source: Controller [1] output Y
- O.1.2-1 Output signal: 4 to 20 mA
- AO1.MIN = 0.0 %
- AO1.MAX = 100.0 %
- O.1.3-2 Operating direction: decreasing
- AO1.P1 = 0.0 %
- AO1.P2 = 50.0 %

Setting for output AO2:

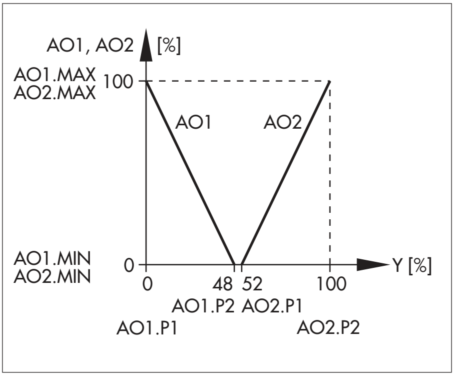
- O.2.1-1 Source: Controller [1] output Y
- O.2.2-1 Output signal: 4 to 20 mA
- AO2.MIN = 0.0 %
- AO2.MAX = 100.0 %
- O.2.3-1 Operating direction: increasing
- AO2.P1 = 50.0 %
- AO2.P2 = 100.0 %

Setting for controller display:

- C.5.6-3 Row 5: AO2

Setting for operator keys for manual output value:

- C.7.1-0 Invert manual output value: Off



Example 7: Same as example 6, but with 4 % dead zone between the heating and cooling valves

Setting for output AO1:

- O.1.1-1 Source: Controller [1] output Y
- O.1.2-1 Output signal: 4 to 20 mA
- AO1.MIN = 0.0 %
- AO1.MAX = 100.0 %
- O.1.3-2 Operating direction: decreasing
- AO1.P1 = 0.0 %
- AO1.P2 = 48.0 %

Setting for output AO2:

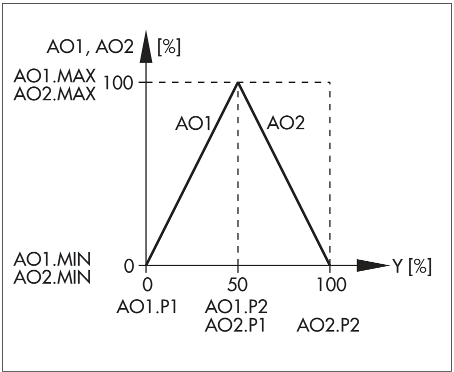
- O.2.1-1 Source: Controller [1] output Y
- O.2.2-1 Output signal: 4 to 20 mA
- AO2.MIN = 0.0 %
- AO2.MAX = 100.0 %
- O.2.3-1 Operating direction: increasing
- AO2.P1 = 52.0 %
- AO2.P2 = 100.0 %

Setting for controller display:

- C.5.6-3 Row 5: AO2

Setting for operator keys for manual output value:

- C.7.1-0 Invert manual output value: Off



Example 8

Setting for output AO1:

- O.1.1-1 Source: Controller [1] output Y
- O.1.2-1 Output signal: 4 to 20 mA
- AO1.MIN = 0.0 %
- AO1.MAX = 100.0 %
- O.1.3-1 Operating direction: increasing
- AO1.P1 = 0.0 %
- AO1.P2 = 50.0 %

Setting for output AO2:

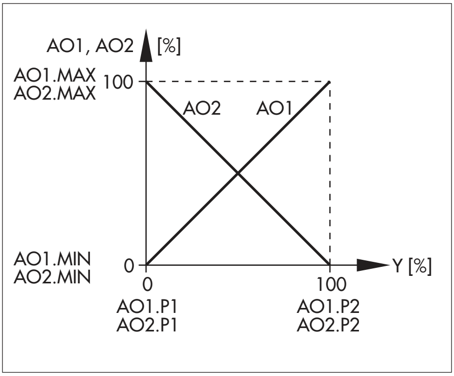
- O.2.1-1 Source: Controller [1] output Y
- O.2.2-1 Output signal: 4 to 20 mA
- AO2.MIN = 0.0 %
- AO2.MAX = 100.0 %
- O.2.3-2 Operating direction: decreasing
- AO2.P1 = 50.0 %
- AO2.P2 = 100.0 %

Setting for controller display:

- C.5.6-3 Row 5: AO2

Setting for operator keys for manual output value:

- C.7.1-0 Invert manual output value: Off



Example 9

Setting for output AO1:

- O.1.1-1 Source: Controller [1] output Y
- O.1.2-1 Output signal: 4 to 20 mA
- AO1.MIN = 0.0 %
- AO1.MAX = 100.0 %
- O.1.3-1 Operating direction: increasing
- AO1.P1 = 0.0 %
- AO1.P2 = 100.0 %

Setting for output AO2:

- O.2.1-1 Source: Controller [1] output Y
- O.2.2-1 Output signal: 4 to 20 mA
- AO2.MIN = 0.0 %
- AO2.MAX = 100.0 %
- O.2.3-2 Operating direction: decreasing
- AO2.P1 = 0.0 %
- AO2.P2 = 100.0 %

Setting for controller display:

- C.5.6-3 Row 5: AO2

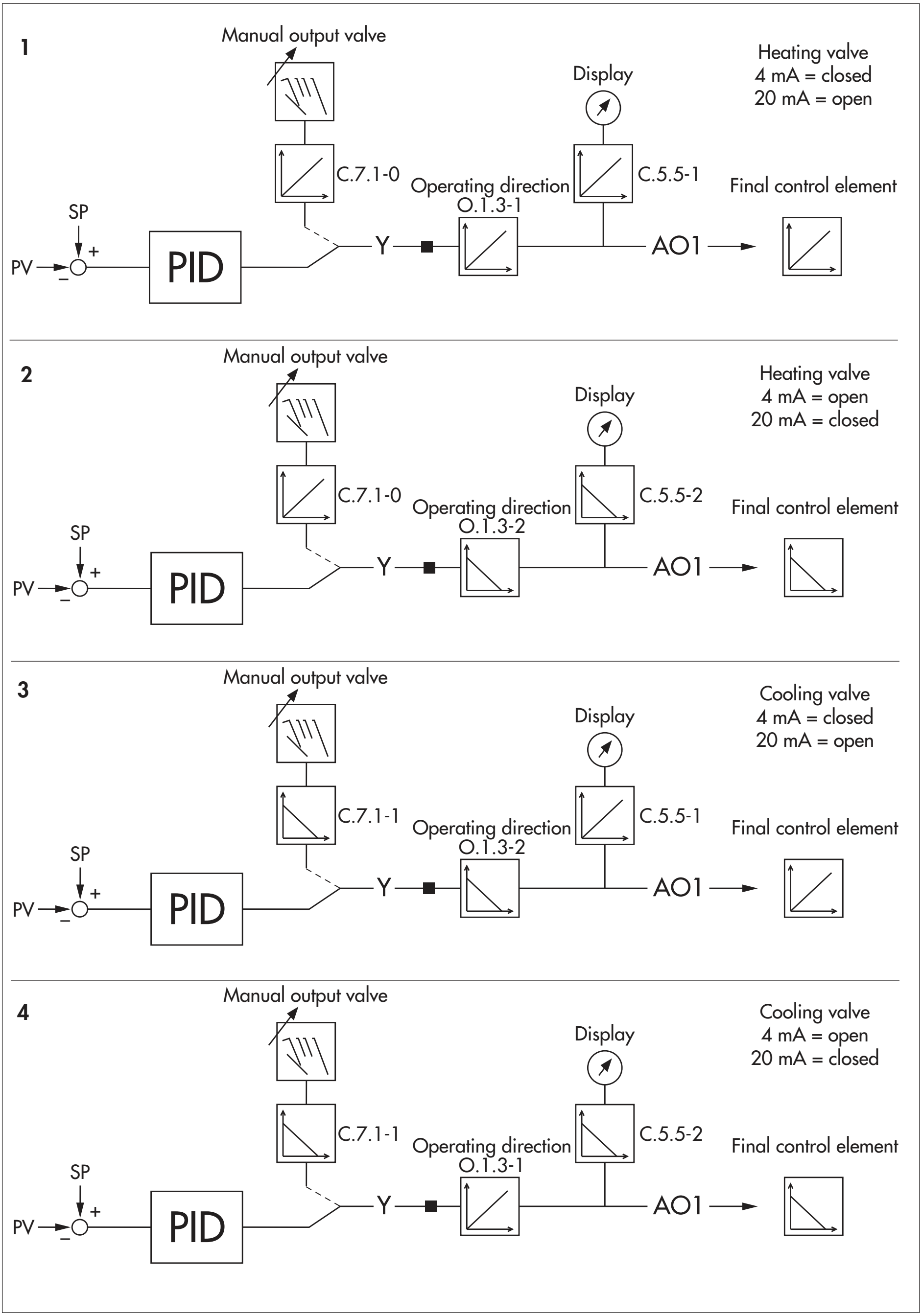
Setting for operator keys for manual output value:

- C.7.1-0 Invert manual output value: Off

O.1.3 **O.2.3** **O.3.3**	(AO1) (AO2) (AO3)	**Operating direction**	<O.1.1≠0> <O.1.2≠0> <O.1.3≠0>
	-1 -2	Increasing Decreasing	
AO1.P1 AO2.P1 AO3.P1	(AO1) (AO2) (AO3)	Y value for AO1 = AO1.MIN [1] / AO1 = AO1.MAX [2] Y value for AO2 = AO2.MIN [1] / AO2 = AO2.MAX [2] Y value for AO3 = AO3.MIN [1] / AO3 = AO3.MAX [2] [–10.0 ...**0.0**... 110.0 %]	
AO1.P2 AO2.P2 AO3.P2	(AO1) (AO2) (AO3)	Y value for AO1=AO1.MAX [1] / AO1 = AO1.MIN [2] Y value for AO2=AO2.MAX [1] / AO2 = AO2.MIN [2] Y value for AO3=AO3.MAX [1] / AO3 = AO3.MIN [2] [–10.0 ...**0.0**... 110.0 %]	

1) Operating direction increasing
2) Operating direction decreasing

The schematics opposite show the adaption of the operating direction for output, manual operator keys and manipulated variable reading.


1
Manual output valve
Display
Heating valve
4 mA = closed
20 mA = open
C.7.1-0
Operating direction
O.1.3-1
C.5.5-1
Final control element
SP
PV
PID
Y
AO1
2
Manual output valve
Display
Heating valve
4 mA = open
20 mA = closed
C.7.1-0
Operating direction
O.1.3-2
C.5.5-2
Final control element
SP
PV
PID
Y
AO1
3
Manual output valve
Display
Cooling valve
4 mA = closed
20 mA = open
C.7.1-1
Operating direction
O.1.3-2
C.5.5-1
Final control element
SP
PV
PID
Y
AO1
4
Manual output valve
Display
Cooling valve
4 mA = open
20 mA = closed
C.7.1-1
Operating direction
O.1.3-1
C.5.5-2
Final control element
SP
PV
PID
Y
AO1

O.1.4...O.3.4 AO1...AO3: Output ramp

The output ramp can be used for start-up procedures.

This configuration item implements an output ramp for analog outputs AO1 to AO3 in automatic mode. The output ramp is the change of the output at a constant rate.

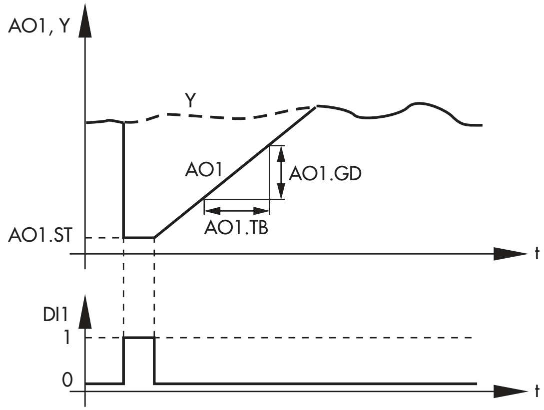
If the digital input is energized ('1' signal), the output is set to the initial value (e.g. AO1.ST). If the digital input is de-energized ('0' signal), the output runs from the initial value in a ramp form at the rate defined by the gradient (e.g. AO1.GD) and the time base (e.g. AO1.TB) to the value Y calculated by the position algorithm. If the ramp output value is the same as the output value Y, the ramp is cancelled and the output follows instantaneously the output Y. The ramp is ended at the latest when the maximum (e.g. AO1.MAX) or the minimum output value (e.g. AO1.MIN) is reached. The ramp is stopped if the controller is switched to manual mode while the output ramp is running. After switching back to automatic mode, the ramp continues running until it reaches the target output value.

If only one output with output ramp is assigned to a controller and it is switched to manual mode while the output ramp is running, the ramp is stopped and the output value Y takes on the value calculated in reverse (current output value) to ensure bumpless changeover.

If several outputs are assigned to a controller, a bumpless changeover to manual mode is not provided for outputs with output ramp. When the controller is switched to manual mode while the output ramp is running, the output concerned instantaneously takes on the target output value.

After a power supply failure lasting more than one second, the controller restarts using the restart condition (C.4.1). For a restart in automatic mode when the digital input is de-energized ('0' signal) the ramp is started at a constant output value according to the restart condition and runs until the ramp output value reaches the internal output value Y calculated by the position algorithm. For power supply failures lasting less than one second, the ramp continues when the digital input is de-engerized.

The rate of the output ramp is determined by the gradient (AO1.GD...AO3.GD) and the time base (AO1.TB...AO3.TB). The time base can be entered in seconds, minutes and hours. The initial value of the output ramp AO1.ST...AO3.ST is adjustable between –10 and 110 %.



Y	Internal manipulated variable
A01	Analog output
AO1.GD	Gradient
AO1.TB	Time base
AO1.ST	Initial value

O.1.4 **O.2.4** **O.3.4**	(AO1) (AO2) (AO3)	**Output ramp**	<O.1.1≠0> <O.2.1≠0> <O.3.1≠0>
	-0 -1 -2 -3 -4	Off Start with DI1 Start with DI2 Start with DI3 Start with DI4	
AO1.GD AO2.GD AO3.GD	(AO1) (AO2) (AO3)	Gradient [0.1 ...**1.0**... 100 %/Time base]	<O.1.4≠0> <O.2.4≠0> <O.3.4≠0>
AO1.TB AO2.TB AO3.TB	(AO1) (AO2) (AO3)	Time base [**s**, min, h]	<O.1.4≠0> <O.2.4-0> <O.3.4≠0>
AO1.ST AO2.ST AO3.ST	(AO1) (AO2) (AO3)	Initial value [–10 ...**0.0**... 110 %]	<O.1.4≠0> <O.2.4-0> <O.3.4≠0>

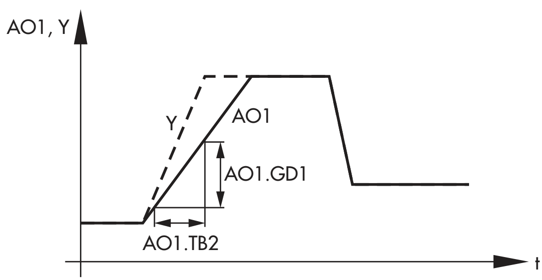
O.1.5...O.3.5 AO1...AO3: Limit output rate

For the analog outputs AO1 to AO3, the maximum output rate can be limited in automatic mode. The limitation has no effect in manual mode. The limitation can act on an increasing and/or decreasing output signal. The output changes in the restricted direction only at the rate permitted by the gradient and time base setting. If the output rate is faster than the output rate defined by the gradient, the output is ramped with the adjusted gradient. The limitation has no effect if the output rate is lower than the defined rate of change.
If only one output with output rate limitation is assigned to a controller and the controller switches to manual mode while the ramp is running, the ramp is stopped and the output value Y takes on the value calculated in reverse (current output value) to ensure bumpless changeover.
If several outputs are assigned to a controller, a bumpless changeover to manual mode is not provided for outputs with output ramp. When the controller is switched to manual mode while the output ramp is running, the output concerned instantaneously takes on the target output value.

For the increasing output signal, the maximum output rate is adjusted with the gradients AO1.GD1...AO3.GD1, while for the decreasing output signal the maximum output rate is adjusted with the gradients AO1.GD2...AO3.GD2. The time base is adjusted with the parameters AO1.TB2...AO3.TB2 in seconds, minutes or hours.

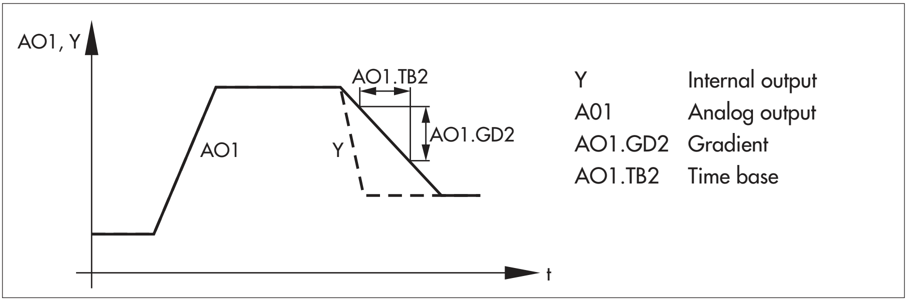
Example
The increasing output signal changes by 1 %/s at the maximum with the **gradient** AO1.GD1 = 1 and the time basis AO1.TB2 = s.

- **Setting -1:** Increasing, continuously active
  Limitation for increasing output signal
  The output rate is limited for the increasing output signal only.

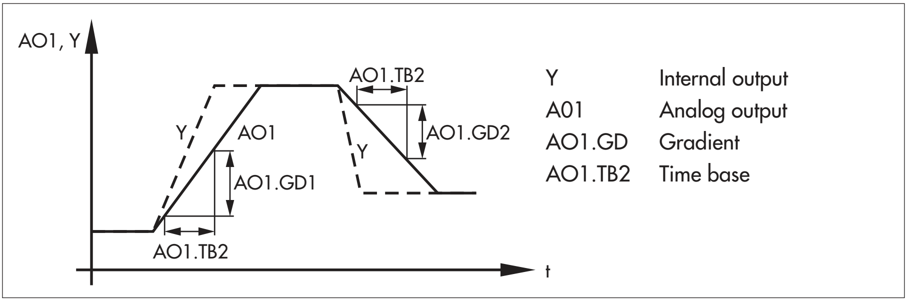


Y	Internal manipulated variable
A01	Analog output
AO1.GD1	Gradient
AO1.TB2	Time base

Setting -2: Decreasing, continuously active
Limitation for decreasing output signal
The output rate is limited for the decreasing output signal only.



Setting -3: Increasing and decreasing
Limitation for increasing output signal and decreasing output signal
The output rate is limited for the increasing and decreasing output signal.



Setting -4/-5/-6/-7: Increasing, start with DI
Limitation for increasing output signal ('1' signal at the digital input)
The output rate is limited for the increasing output signal when there is a '1' signal at the digital input.

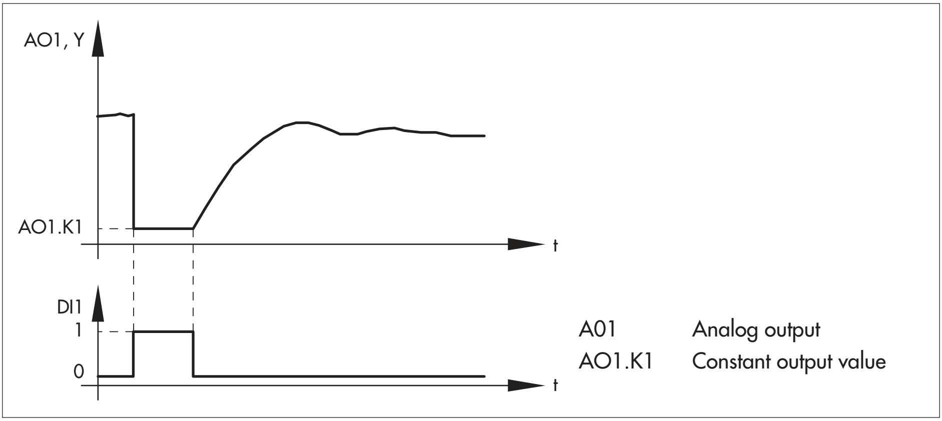
Setting -8/-9/-10/-11: Decreasing, start with DI
Limitation for decreasing output signal ('1' signal at the digital input)
The output rate is limited for the decreasing output signal when there is a '1' signal at the digital input.

O.1.5 **O.2.5** **O.3.5**	(AO1) (AO2) (AO3)	**Limit output rate**	<O.1.1≠0> <O.1.2≠0> <O.1.3≠0>
	-0	Off	
	-1	Increasing, continuously active	
	-2	Decreasing, continuously active	
	-3	Increasing and decreasing	
	-4	Increasing, start with DI1	
	-5	Increasing, start with DI2	
	-6	Increasing, start with DI3	
	-7	Increasing, start with DI4	
	-8	Decreasing, start with DI1	
	-9	Decreasing, start with DI2	
	-10	Decreasing, start with DI3	
	-11	Decreasing, start with DI4	

AO1.GD1 AO2.GD1 AO3.GD1	(AO1) (AO2) (AO3)	Gradient for increasing output signal [0.1 ...**1.0**... 100.0 %]	<O.1.5-1/-3/-4/-5/-6/-7> <O.2.5-1/-3/-4/-5/-6/-7> <O.3.5-1/-3/-4/-5/-6/-7>
AO1.GD2 AO2.GD2 AO3.GD2	(AO1) (AO2) (AO3)	Gradient for decreasing output signal [0.1 ...**1.0**... 100.0 %]	<O.1.5-2/-3/-8/-9/-10/-11> <O.2.5-2/-3/-8/-9/-10/-11> <O.3.5-2/-3/-8/-9/-10/-11>
AO1.TB2 AO2.TB2 AO3.TB2	(AO1) (AO2) (AO3)	Time basis [**s**, min, h]	<O.1.5≠0> <O.2.5≠0> <O.3.5≠0>

O.1.6...O.3.6 AO1...AO3: Constant output value 1 with DI (auto mode)

At analog output AO1 to AO3, a defined constant output value can be issued in automatic mode initiated by a digital input. The constant output value is active when there is a '1' signal at the digital input. The function can be used, for example, to enable the output. For this purpose, a parameter (AO1.K1...AO3.K1) is assigned to each output. The parameter can be adjusted in the range –10.0 to 110.0 %. The default setting is 0 %.



Controller operation with one output: While the constant output value is active, the internal output Y tracks this value. After deactivating the constant output value, control continues starting from this output value.

Controller operation with several outputs (split-range operation): If several outputs are controlled in sequence by a controller, the constant output value should be activated for only one output. As a result, the other outputs are active according to the tracked internal output Y. If constant output values are active for several outputs, the internal output Y tracks only the first constant value (according to priority AO1, AO2, AO3, SO1, SO2). For example, if AO1.K1 and AO1.K2 are set, Y tracks AO1.K1.

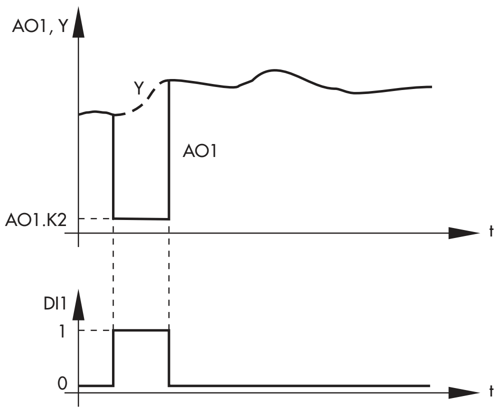
Note:
- *An activated constant output value has no effect in manual mode.*
- *The constant output value 1 is limited by the output range (e.g. AO1.MIN, AO1.MAX).*
- *The constant output value has priority over output tracking (C.3.3.3) and the internally controlled output limitation (C.3.1.11).*
- *The following functions have priority over the output value 1:*
  – Limit output by input TR, see menu item O.1.8...O.5.8
  – Hold output YPID with DI, see menu item C.3.3.2
  – Constant output value 2, see menu item O.1.7...O.5.7
- *The parameters AO1.K1...AO3.K1 and SO1.K1...SO2.K1 are used for several different functions:*
  – Manual mode Controller [1] at signal error AI, see menu item I.1.6...I.4.6
  – Manual mode Controller [2] at signal error AI, see menu item I.1.7...I.4.7
  – Manual mode controller at signal error SPC, see menu item C.2.1.7
  – Operating mode after restart, see menu item C.4.1

O.1.6 **O.2.6** **O.3.6**	(AO1) (AO2) (AO3)	**Constant output value 1 with DI (auto mode)**	<O.1.1≠0> <O.1.2≠0> <O.1.3≠0>
	-0	Off	
	-1	With digital input DI1	
	-2	With digital input DI2	
	-3	With digital input DI3	
	-4	With digital input DI4	

AO1.K1 AO2.K1 AO3.K1	(AO1) (AO2) (AO3)	Constant output value 1 (AO1...AO3)	<O.1.6≠0> <O.2.6≠0> <O.3.6≠0>
		[–10.0 ...**0.0**... 110.0 %]	

O.1.7...O.3.7 AO1...AO3: Constant output value 2 with DI (manual/automatic)

At analog output AO1 to AO3, a defined constant output value 2 can be issued in automatic mode initiated by a digital input. The difference to constant output value 1 is that the internal output Y does not track it. As a result, the constant output value 2 takes effect in both automatic and manual mode. The constant output value is active when there is a ’1’ signal at the digital input. The function can be used, for example, to enable the output. For this purpose, a parameter (AO1.K2...AO3.K2) is assigned to each output. The parameter can be adjusted in the range –10.0 to 110.0 %. The default setting is 0 %.



A01	Analog output
AO1.K2	Constant output value

Note:

- *The output variable Y cannot be changed in manual mode when the constant output value 2 is active.*
- *The constant output value is also active even when it is outside the output range (e.g. AO1.MIN...AO1.MAX).*
- *The constant output value 2 has priority over the following functions:*
  - *Hold output YPID with DI, see menu item C.3.3.2*
  - *Output tracking, see menu item C.3.3.3*
  - *Internally controlled output limitation, see menu item C.1.1.11*
  - *Constant output value 1 with DI (auto mode), see menu item O.1.6...O.5.6*
  - *Limit output by input TR, see menu item O.1.8...O.5.8*

O.1.7 **O.2.7** **O.3.7**	(AO1) (AO2) (AO3)	**Constant output value 2 with DI (man/auto)**	<O.1.1≠0> <O.1.2≠0> <O.1.3≠0>
	-0	Off	
	-1	With digital input DI1	
	-2	With digital input DI2	
	-3	With digital input DI3	
	-4	With digital input DI4	

AO1.K2 AO2.K2 AO3.K2	(AO1) (AO2) (AO3)	Constant output value 2 (AO1...AO3)	<O.1.7≠0> <O.2.7≠0> <O.3.7≠0>
		[–10.0 ...**0.0**... 110.0 %]	

O.1.8...O.3.8 AO1...AO3: Limit output by input TR

This function allows the analog output (AO1, AO2, AO3) to be limited by the input variable TR to a minimum or maximum value. The input variable TR in percent of its measuring range determines the lower or upper limit of the output in percent. For this purpose, the input variable TR of the internal controller concerned must be assigned to an analog input (C.1.4.1≠0). This externally controlled output limitation is active within the fixed output limits, which are determined for output AO1, for example, by selecting O.1.2 and configuring the parameters AO1.MIN and AO1.MAX.

The setting -1 determines the minimum limit by the input variable TR and the setting -2 the maximum limit.

The output limitation by TR also takes effect in manual mode when the output limitation in manual mode (C.3.3.7-1) is activated. If this is deactivated (C.3.3.7-0), limitation only takes effect in automatic mode.

O.1.8	(AO1)		<O.1.1≠0>
O.2.8	(AO2)	**Limit output by input TR**	<O.2.1≠0>
O.3.8	(AO3)		<O.3.1≠0>
	-0	Off	
	-1	To minimum value	
	-2	To maximum value	

O.1.9...O.3.9 AO1...AO3: Function generation

The characteristic of outputs AO1 to AO3 can be changed.
Seven coordinates are used to define the characteristic.

- **Setting -0**: Off
  The output characteristic is linear.
- **Setting -1:** Free adjustment
  Die characteristic is freely adjustable.

  The correlation between the input signal and output signal is made by seven points. The input values are entered as numerical values between –999.0 and 9999.0 with the parameters AO1.I1 to AO1.I7. The associated output values are entered with the parameters AO1.O1 to AO1.O7. Values are entered within the range –10.0 to 110.0 %. The characteristc coodinates must be selected to allow a curve to be plotted properly. The controller draws a line between the points. Seven points must be defined even if the signal course can be plotted sufficiently with less than seven points. If necessary, enter the first points or the last points to be the same.

Note: *The curve of the function generation characteristic is not restricted. It is possible to enter a non-montonic curve (more than one minimum or maximum), but this leads to problems in the top range while calculating back the manual output value to the automatic output value.*

- **Setting -2:** Equal percentage
  The characteristic is equal percentage.

  The user cannot enter any coordinates. They are fixed as follows:

	Input values	Output values
1	0.0000	0.0000
2	35.5781	8.0444
3	56.4453	18.1978
4	71.2266	32.4450
5	82.7031	50.8313
6	92.0703	73.3292
7	100.0000	100.0000

Example: An equal percentage characteristic is created together with a control valve with a linear characteristic.

Setting -3: Equal percentage inverse
The characteristic is equal percentage inverse (reversed).

The user cannot enter any coordinates. They are fixed as follows:

	Input values	Output values
1	0.0000	0.0000
2	1.8750	16.6582
3	5.4922	33.3828
4	12.4141	50.0427
5	25.7031	66.7089
6	51.1563	83.3495
7	100.0000	100.0000

Example: A linear characteristic is created together with a control valve with an equal percentage characteristic.

O.1.9 **O.2.9** **O.3.9**	(AO1) (AO2) (AO3)	**Function generation**	<O.1.1≠0> <O.2.1≠0> <O.3.1≠0>
	-0 -1 -2 -3	Off Free adjustment Equal percentage Equal percentage inverse	
AO1.I1...AO1.I7 AO2.I1...AO2.I7 AO3.I1...AO3.I7	(AO1) (AO2) (AO3)	Input value 1 to 7	<O.1.9-1> <O.2.9-1> <O.3.9-1>
		[–9999 ... 1) ... 9999] 1) Input value 1 to 6: **0.0** Input value 7: **100.0**	
AO1.O1...AO1.O7 AO2.O1...AO2.O7 AO3.O1...AO3.O7	(AO1) (AO2) (AO3)	Output value 1 to 7	<O.1.9-1> <O.2.9-1> <O.3.9-1>
		[–10 ... 1) ... 110 %] 1) Output value 1 to 6: **0.0** Output value 7: **100.0**	

O.4...O.5 SO1...SO2: Switch output 1 and 2

O.4.1...O.5.1 SO1...SO2: Assign source

This configuration item assigns the output to one of the internal controller.
The switch outputs are not assigned to a source by default (setting -0). After assigning the source, the output functions can be configured.

O.4.1 **O.5.1**	(SO1) (SO2)	**Assign source**	
	-0	Off	
	-1	Controller [1] output Y	
	-2	Controller [2] output Y	<M.1-3/-4/-5/-6>
	-38	Y1 ∗ Y2 ∗ SO1.KM/100 (for SO1) Y1 ∗ Y2 ∗ SO2.KM/100 (for SO2)	<M.1-5/-6>
	-39	(100 – Y1) ∗ Y2 ∗ SO1.KM/100 (for SO1) (100 – Y1) ∗ Y2 ∗ SO2.KM/100 (for SO2)	<M.1-5/-6>

SO1.KM SO2.KM	(SO1) (SO2)	Constant, mixing operation (SO1...SO2)	<O.4.1-38/-39> <O.5.1-38/-39>
		[0.0 …**1.0**… 100.0]	

O.4.2...O.5.2 SO1...SO2: Output signal DO1/DO2

The switch outputs SO1 and SO2 are internal output channels to produce on-off or three-step switching signals. By default, the switch output SO1 acts on the relays DO1 and DO2 while the switch output SO2 acts on relays DO3 and DO4.

Alternatively, the switching signals can be issued at the transistor outputs DO5 and DO6, see O.10.1-16/-17/-18 and O.11.1-16/-17/-18. In this case, the maximum permissible voltages and currents must be observed. The corresponding relays are then available for limit monitoring.

Assignment between type of signal and digital outputs

			Relay				Transistor	
	Setting	Type of signal	DO1	DO2	DO3	DO4	DO5	DO6
SO1	O.4.2-1	3-step	+	–			+	–
	O.4.2-2	3-step with external feedback	+	–			+	–
	O.4.2-3	On-off PWM "+" display	+				+	
	O.4.2-4	On-off PWM "–" display	–				–	
	O.4.2-5	3-step PWM with internal feedback	+	–			+	–
	O.4.2-6	3-step PWM with external feedback	+	–			+	–

			Relay				Transistor	
	Setting	Type of signal	DO1	DO2	DO3	DO4	DO5	DO6
SO2	O.5.2-1	3-step			+	–	+	–
	O.5.2-2	3-step with external feedback			+	–	+	–
	O.5.2-3	On-off PWM "+" display			+		+	
	O.5.2-4	On-off PWM "–" display			–		–	
	O.5.2-5	3-step PWM with internal feedback			+	–	+	–
	O.5.2-6	3-step PWM with external feedback			+	–	+	–

- **Setting -1:** Three-step

The three-step output with internal feedback allows control of a valve proportional to the position using an electric actuator which is controlled by two output relays. One relay sets the electric actuator towards OPEN and the other relay towards CLOSED. If both relays are switched off, the actuator stops. The three-point stepping output works with internal feedback. The travel position of the electric actuator is calculated internally using the transit time and used as position feedback. A feedback potentiometer is not required on the actuator shaft. This prevents any control problems which may be caused by a feedback potentiometer (wear, dirt).

***Note:** In manual mode, the cursor keys act directly on the relays if the three-step output SO1 or SO2 is assigned to row 4 of the controller display. The cursor key △ acts on SO1+…SO2+ and the cursor key ▽ acts on SO1–…SO2–.*

- **Transit time SO1.TY…SO2.TY**
  The transit time is the actuator transit time between the positions 0 and 100 %. The controller determines the actuator's actual position using the transit time.
  If the transit times for clockwise and counterclockwise directions deviate strongly from one another, the average transit time must be adjusted. The transit time is set to 120 s by default.
- **Dead zone SO1.TZ…SO2.TZ**
  The dead zone between the clockwise and counterclockwise direction is set in % of the transit time.
  The larger the dead zone is set, the longer the switchover from counterclockwise to clockwise and vice versa takes. The dead zone is set to 2 % by default.

- **Increments SO1.SW…SO2.SW**
  The increments are used to set the ratio between dead zone and hysteresis. The increment is set to 1 by default.

  The **effective dead zone TZ** is calculated from:
  TZ = SO1.TZ ∗ SO1.SW for output SO1
  TZ = SO2.TZ ∗ SO2.SW for output SO2

  The **hysteresis Xsd** is calculated from:
  Xsd = SO1.TZ ∗ 0.25 (SO1.SW∗2 – 1) for output SO1
  Xsd = SO2.TZ ∗ 0.25 (SO2.SW∗2 – 1) for output SO2

  The hysteresis determines the switching frequency. The smaller the hysteresis, the higher the switching frequency.

- **Minimum and maximum output value SO1.MIN…SO2.MIN/SO1.MAX…SO2.MAX**
  The output value SO1…SO2 is the reference variable for on-off or three-step outputs. This output value can be limited to a minimum and a maximum output value.
  The parameters are set to 0 and 100 % by default.

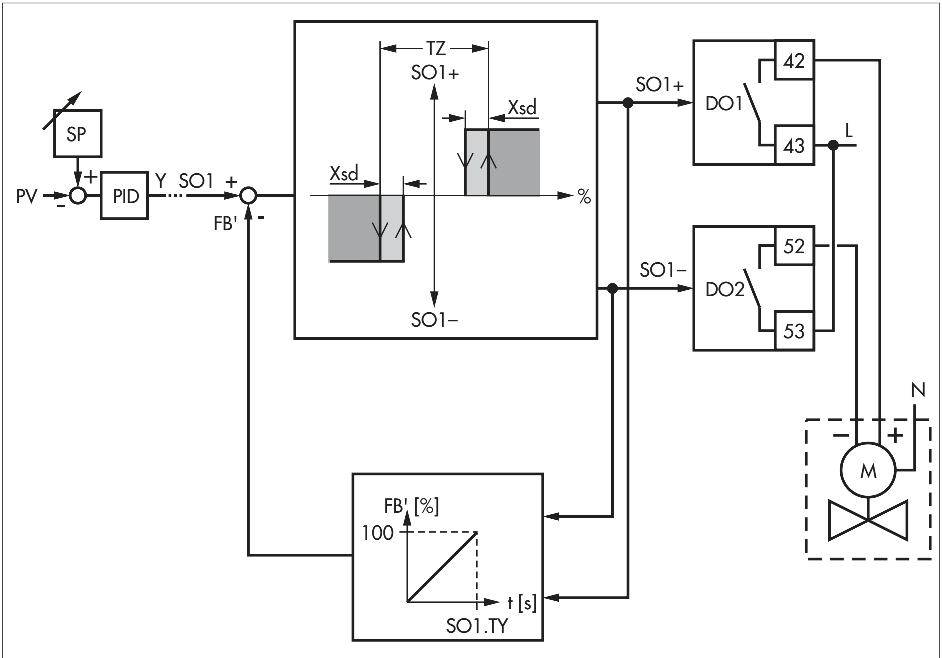
Operating principle of the three-step output

The '+' output SO1+ is activated whenever the difference between the target and actual position is greater than TZ/2.

The '–' output SO1– is activated whenever the difference between the target and actual position is lower than –TZ/2.

SO1+ and SO1– are deactivated whenever the difference between the target and actual position is greater than (TZ/2 + Xsd) or lower than (TZ/2 – Xsd).

At the three-point stepping output, a continuous signal is issued at the '–' output when the output value is 0 % and a continuous signal is issued at '+' output when the output value is 100 % to ensure that the control valve moves to its end position (fail-safe position).



Other settings:
The reference variable SO1 or SO2 can be displayed on the output value display to indicate the electric actuator position (C.5.4-5/-6 together with C.5.5-1 or C.5.6-5/-6 together with C.5.7-1).
In settled state, it corresponds with the approximate actuator position. The reading is corrected when the actuator moves to one of the end positions (0 % or 100 %).

In the event that a precise and repeatable reading of the actuator travel position is required, a potentiometer connected to the actuator shaft can be connected at analog input AI2 to display the travel position at the output variable display using the input variable FB (C.1.5.1-2, C.5.6-22).

Setting -2: 3-step with external feedback

The three-step output with external feedback allows control of a valve proportional to the position using an electric actuator which is controlled by two output relays. One relay sets the electric actuator towards OPEN and the other relay towards CLOSED. If both relays are switched off, the actuator stops. The travel position of the electric actuator is fed back externally over an input (for example, using a potentiometer). For this purpose, the input must be assigned to the input variable FB (C.1.5.1≠0). The signal for position feedback should be calibrated at the controller, see menu item A.20 and EB 6495-2 EN.

***Note:** In manual mode, the cursor keys act directly on the relays if the three-step output SO1 or SO2 is assigned to row 4 of the controller display. The cursor key △ acts on SO1+ and the cursor key ▽ acts on SO1–.*

- **Dead zone SO1.TZ...SO2.TZ**
  The dead zone between the clockwise and counterclockwise direction is set in % of the transit time.
  The larger the dead zone is set, the longer the switchover from counterclockwise to clockwise and vice versa takes. The dead zone is set to 2 % by default.

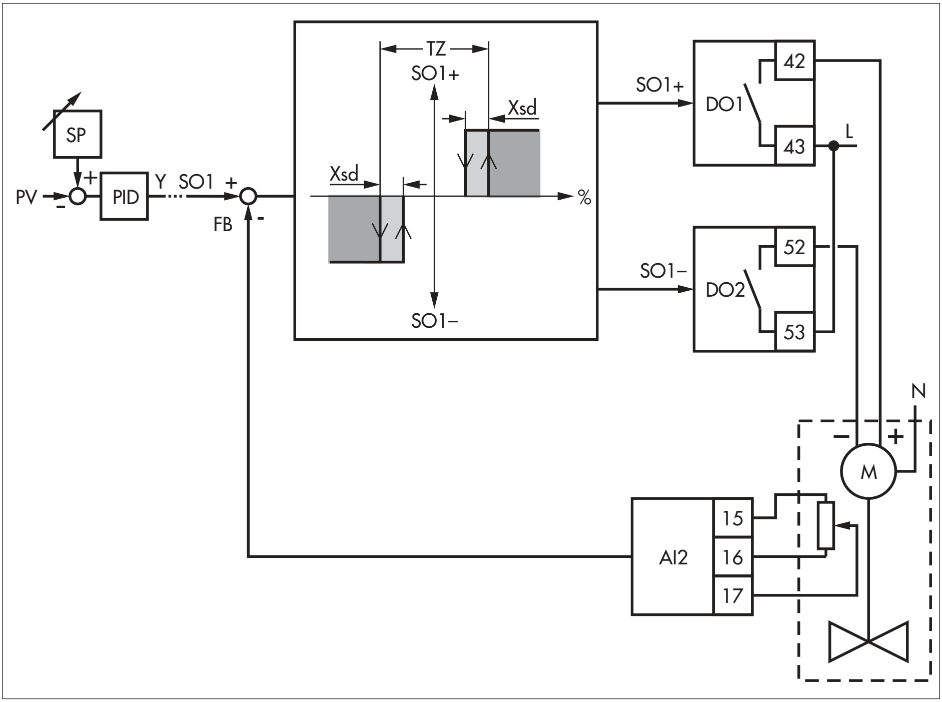
- **Increments SO1.SW...SO2.SW**
  The increments are used to set the ratio between dead zone and hysteresis. The increment is set to 1 by default.

  The effective dead zone TZ is calculated from:
  TZ = SO1.TZ ∗ SO1.SW for output SO1
  TZ = SO2.TZ ∗ SO2.SW for output SO2

  The hysteresis Xsd is calculated from:
  Xsd = SO1.TZ ∗ 0.25 (SO1.SW∗2 – 1) for output SO1
  Xsd = SO2.TZ ∗ 0.25 (SO2.SW∗2 – 1) for output SO2

The hysteresis determines the switching frequency. The smaller the hysteresis, the higher the switching frequency.

- **Minimum and maximum output value**
  SO1.MIN...SO2.MIN/SO1.MAX...SO2/MAX
  The output value SO1…SO2 is the reference variable for on-off or three-step outputs. This output value can be limited to a minimum and a maximum output value.
  The parameters are set to 0 and 100 % by default.



Operating principle of the three-step output with external feedback

The '+' output SO1+ is activated whenever the difference between the target and actual position is greater than TZ/2.

The '–' output SO1– is activated whenever the difference between the target and actual position is lower than –TZ/2.

SO1+ and SO1– are deactivated whenever the difference between the target and actual position is greater than (TZ/2 + Xsd) or lower than (TZ/2 – Xsd).

Other settings:
The reference variable SO1 or SO2 can be displayed on the output value display to indicate the electric actuator position (C.5.4-5/-6 together with C.5.5-1 or C.5.6-5/-6 together with C.5.7-1).
The travel position of the electric actuator can be displayed at the controller display using the input variable FB (e.g. C.5.6-22).

- **Settings -3/-4:** On-off PWM "+/–" display

For the on-off output with pulse width modulation (PWM), the internal output SO1…SO2 is converted into a pulse sequence whose pulse/interval ratio is proportional to the output value.

The setting O.4.2-3...O.5.2-3 is used to display the activated digital output with the '+' symbol.
If a cooling valve is controlled, the setting O.4.2-4...O.5.2-4 causes the '–' symbol to appear on the display instead of '+'.

- **Dead zone SO1.TZ...SO2.TZ**
  The dead zone is set in %. If the output SO1 or SO2 is lower than the dead zone, a switching pulse is not issued.

- **Duty cycle SO1.P+...SO2.P+**
  The duty cycle is set in seconds. Within the duty cycle, a switching pulse is issued. The larger the output value is, the longer the pulse is.

  The on-time is calculated from:
  $T_{E\ SO1}$ = SO1 ∗ (SO1.P+)/100 %
  $T_{E\ SO2}$ = SO2 ∗ (SO2.P+)/100 %

- **Minimum on-time SO1.TMIN+...SO2.TMIN+**
  The minimum on-time is set in % of the duty cycle.

  The minimum on-time in seconds is calculated from:
  $T_{Emin\ SO1}$ = (SO1.TMIN+) ∗ (SO1.P+)/100 %
  $T_{Emin\ SO2}$ = (SO2.TMIN+) ∗ (SO2.P+)/100 %

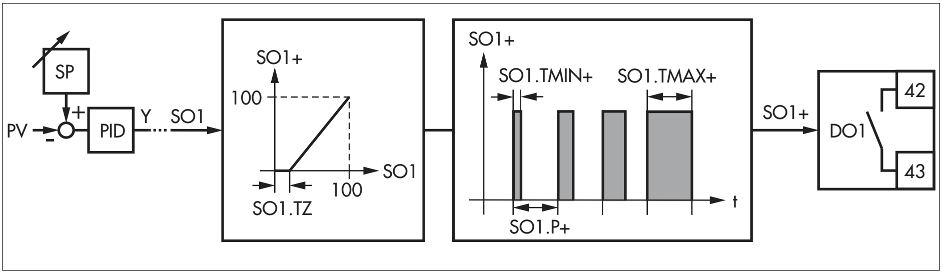
If the switching signal is issued at the relay DO1 or DO2, the minimum on-time is at least 0.3 s.

By selecting the appropriate duty cycle and minimum on-time, a compromise between the low deviation width of the controlled variable (high switching frequency) and a high life cycle of the valve (low switching frequency) can be achieved.

- **Maximum on-time SO1.TMAX+...SO2.TMAX+**
  The maximum on-time is set in % of the duty cycle.

  The maximum on-time in seconds is calculated from:
  $T_{Emax\ SO1}$ = (SO1.TMAX+) ∗ (SO1.P+)/100 %
  $T_{Emax\ SO2}$ = (SO2.TMAX+) ∗ (SO2.P+)/100 %

- **Output limitation SO1.MIN...SO2.MIN/SO1.MAX...SO2.MAX**
  The output SO1…SO2 can be limited to a minimum value and a maximum value.



***Note:** An on-off output with hysteresis can be implemented with the digital outputs DO1 to DO4 functioning as limit relays. For this, the process variable PV, the error signal e or the manipulated variable SO1, SO2 is monitored to make sure it does not violate a minimum or maximum limit, see menu item O.6.3...O.9.3, examples 1, 2 and 5.*

- **Setting -5**: 3-step PWM with internal feedback

  For the three-step output with pulse width modulation (PWM) and internal feedback, the difference between the internal output SO1…SO2 and the feedback signal FB' is converted into a pulse sequence whose pulse/interval ratio is proportional to the differential signal. The travel position of the electric actuator is calculated internally using the transit time and fed back.

  - **Transit time SO1.TY...SO2.TY**
    The transit time is the actuator transit time between the positions 0 and 100 %. The controller determines the actuator's actual position using the transit time.

If the transit times for clockwise and counterclockwise directions deviate strongly from one another, the average transit time must be adjusted. The transit time is set to 120 s by default.

- **Dead zone SO1.TZ...SO2.TZ**
  The dead zone between the clockwise and counterclockwise direction is set in % of the transit time.
  The larger the dead zone is set, the longer the switchover from counterclockwise to clockwise and vice versa takes. If the output SO1…SO2 is smaller than the dead zone, a switching pulse is not issued. The dead zone is set to 2 % by default.

- **Duty cycle SO1.P+...SO2.P+/SO1.P–...SO2.P–**
  The duty cycle is set in seconds for the (+) signal and for the (–) signal. Within the duty cycle, a switching pulse is issued. The larger the output value is, the longer the pulse is.

  The on-time is calculated from:
  $T_{E\ SO1}$ = SO1 ∗ (SO1.P+)/100 %
  $T_{E\ SO2}$ = SO2 ∗ (SO2.P+)/100 %

- **Minimum on-time**
  SO1.TMIN+...SO2.TMIN+/SO1.TMIN–...SO2.TMIN–
  The minimum on-time for the (+) signal und for the (–) signal is set in % of the duty cycle.

  The minimum on-time in seconds is calculated for the (+) signal from:
  $T_{Emin\ SO1+}$ = (SO1.TMIN+) ∗ (SO1.P+)/100 %
  $T_{Emin\ SO2+}$ = (SO2.TMIN+) ∗ (SO2.P+)/100 %

  The minimum on-time in seconds is calculated for the (–) signal from:
  $T_{Emin\ SO1-}$ = (SO1.TMIN–) ∗ (SO1.P-)/100 %
  $T_{Emin\ SO2-}$ = (SO2.TMIN–) ∗ (SO2.P-)/100 %

  If the switching signal is issued at the relay DO1 or DO2, the minimum on-time is at least 0.3 s

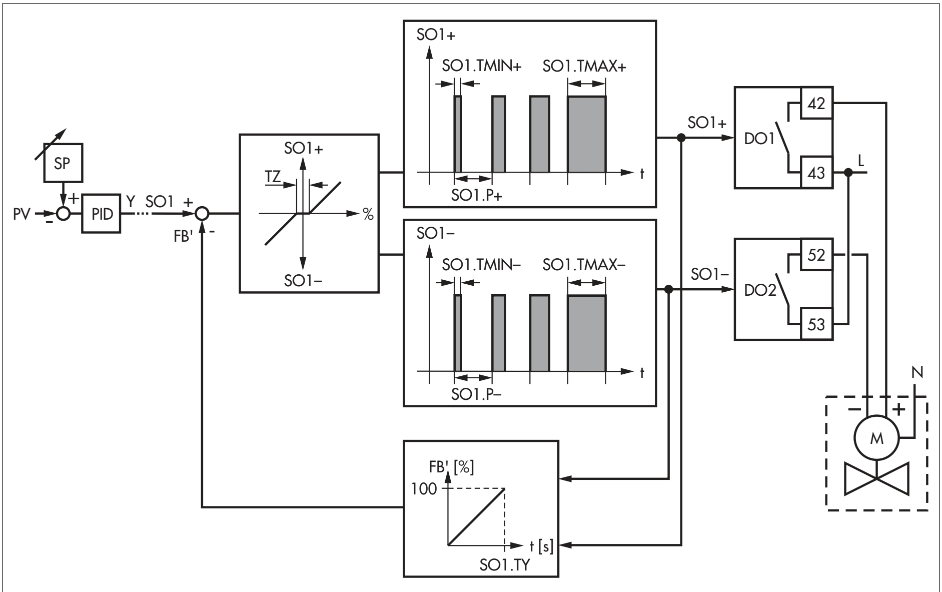
  By selecting the appropriate duty cycle and minimum on-time, a compromise between the low deviation width of the controlled variable (high switching frequency) and a high life cycle of the valve (low switching frequency) can be achieved.

- **Maximum on-time SO1.TMAX+...SO2.TMAX+/SO1.TMAX–...SO2.TMAX–**
  The maximum on-time for the (+) signal und for the (–) signal is set in % of the duty cycle.

  The maximum on-time in seconds is calculated for the (+) signal from:
  $T_{Emax\ SO1+}$ = (SO1.TMAX+) ∗ (SO1.P+)/100 %
  $T_{Emax\ SO2+}$ = (SO2.TMAX+) ∗ (SO2.P+)/100 %

The maximum on-time in seconds is calculated for the (–) signal from:
$T_{Emax\ SO1-}$ = (SO1.TMAX–) ∗ (SO1.P+)/100 %
$T_{Emax\ SO2-}$ = (SO2.TMAX–) ∗ (SO2.P+)/100 %

- **Output limitation SO1.MIN...SO2.MIN/SO1.MAX...SO2.MAX**
  The output SO1…SO2 can be limited to a minimum value and a maximum value.



- **Setting -6:** 3-step PWM with external feedback

For the three-step output with pulse width modulation (PWM) and external feedback, the difference between the internal output SO1…SO2 and the feedback signal FB is converted into a pulse sequence whose pulse/interval ratio is proportional to the difference signal.
The travel position of the electric actuator is fed back externally over an input (for example, a potentiometer). For this purpose, the input must be assigned to the input variable FB (C.1.5.1≠0). The signal for position feedback should be calibrated at the controller, see menu item A.20 and EB 6495-2 EN.

- **Dead zone SO1.TZ...SO2.TZ**
  The dead zone between the clockwise and counterclockwise direction is set in % of the transit time.
  The larger the dead zone is set, the longer the switchover from counterclockwise to

clockwise and vice versa takes. If the output SO1…SO2 is smaller than the dead zone, a switching pulse is not issued. The dead zone is set to 2 % by default.

- **Duty cycle SO1.P+...SO2.P+/SO1.P–...SO2.P–**
  The duty cycle is set in seconds for the (+) signal and for the (–) signal. Within the duty cycle, a switching pulse is issued. The larger the output value is, the longer the pulse is.

  The on-time is calculated from:
  $T_{E\ SO1} = SO1 * (SO1.P+)/100\ \%$
  $T_{E\ SO2} = SO2 * (SO2.P+)/100\ \%$

- **Minimum on-time**
  SO1.TMIN+...SO2.TMIN+/SO1.TMIN–...SO2.TMIN–
  The minimum on-time for the (+) signal und for the (–) signal is set in % of the duty cycle.

  The minimum on-time in seconds is calculated for the (+) signal from:
  $T_{Emin\ SO1+} = (SO1.TMIN+) * (SO1.P+)/100\ \%$
  $T_{Emin\ SO2+} = (SO2.TMIN+) * (SO2.P+)/100\ \%$

  The minimum on-time in seconds is calculated for the (–) signal from:
  $T_{Emin\ SO1-} = (SO1.TMIN-) * (SO1.P-)/100\ \%$
  $T_{Emin\ SO2-} = (SO2.TMIN-) * (SO2.P-)/100\ \%$

  If the switching signal is issued at the relay DO1 or DO2, the minimum on-time amounts to 0.3 s at least.

  By selecting the appropriate duty cycle and minimum on-time, a compromise between the low deviation width of the controlled variable (high switching frequency) and a high life cycle of the valve (low switching frequency) can be achieved.

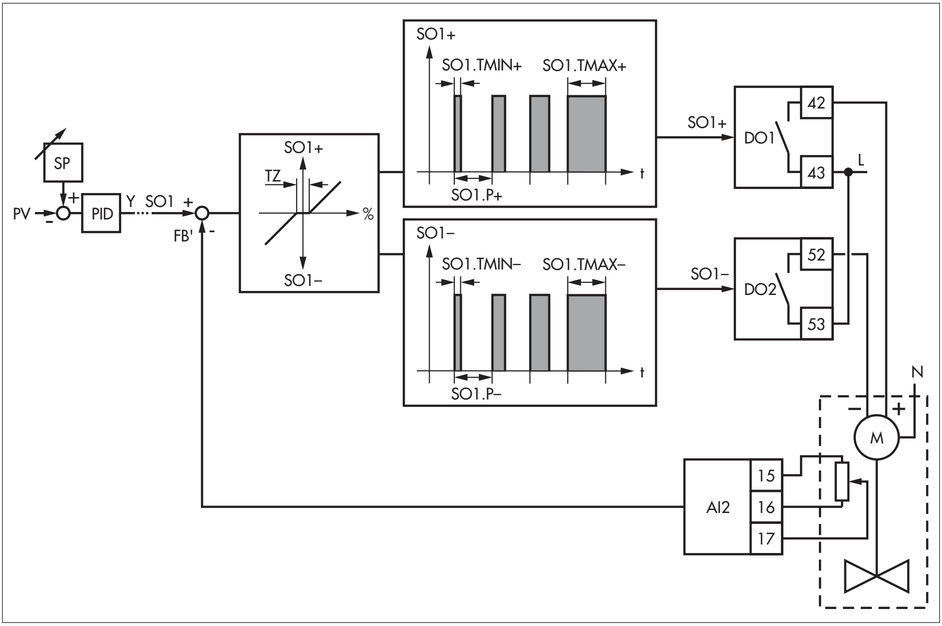
- **Maximum on-time**
  SO1.MAX+...SO2.MAX+/SO1.MAX–...SO2.MAX–
  The maximum on-time for the (+) signal und for the (–) signal is set in % of the duty cycle.

  The maximum on-time in seconds is calculated for the (+) signal from:
  $T_{Emax\ SO1+} = (SO1.TMAX+) * (SO1.P+)/100\ \%$
  $T_{Emax\ SO2+} = (SO2.TMAX+) * (SO2.P+)/100\ \%$

  The maximum on-time in seconds is calculated for the (–) signal from:
  $T_{Emax\ SO1-} = (SO1.TMAX+) * (SO1.P+)/100\ \%$
  $T_{Emax\ SO2-} = (SO2.TMAX+) * (SO2.P+)/100\ \%$

Output limitation SO1.MIN...SO2.MIN/SO1.MAX...SO2.MAX

The output SO1…SO2 can be limited to a minimum value and a maximum value



O.4.2 **O.5.2**	(SO1) (SO2)	**Output signal DO1/DO2**	<O.4.1≠0> <O.5.1≠0>
	-0	Off	
	-1	3-step with internal feedback	
	-2	3-step with external feedback	
	-3	On-off PWM "+" display	
	-4	On-off PWM "–" display	
	-5	3-step PWM with internal feedback	
	-6	3-step PWM with external feedback	

SO1.TY SO2.TY	(SO1) (SO2)	Transit time (SO1...SO2)	<O.4.2-1/-5> <O.5.2-1/-5>
		[10 …**60**… 1000 s]	

SO1.TZ SO2.TZ	(SO1) (SO2)	Dead zone [0.1 ...**2.0**... 100.0 %]	<O.4.2≠0> <O.5.2≠0>
SO1.SW SO2.SW	(SO1) (SO2)	Increment [**1** ... 4]	<O.4.2-1/-2> <O.5.2-1/-2>
SO1.P+ SO2.P+	(SO1) (SO2)	Duty cycle (+) signal [1.0 ...**10.0**... 1000.0 s]	<O.4.2-3/-4/-5/-6> <O.5.2-3/-4/-5/-6>
SO1.P– SO2.P–	(SO1) (SO2)	Duty cycle (–) signal [1.0 ...**10.0**... 1000.0 s]	<O.4.2-5/-6> <O.5.2-5/-6>
SO1.TMIN+ SO2.TMIN+	(SO1) (SO2)	Minimum on-time (+) signal [0.1 ...**1.0**... 100.0 %]	<O.4.2-3/-4/-5/-6> <O.5.2-3/-4/-5/-6>
SO1.TMIN– SO2.TMIN–	(SO1) (SO2)	Minimum on-time (–) signal [0.1 ...**1.0**... 100.0 %]	<O.4.2-5/-6> <O.5.2-5/-6>
SO1.TMAX+ SO2.TMAX+	(SO1) (SO2)	Maximum on-time (+) signal [0.1 ... **100.0** %]	<O.4.2-3/-4/-5/-6> <O.5.2-3/-4/-5/-6>
SO1.TMAX– SO2.TMAX–	(SO1) (SO2)	Maximum on-time (–) signal [0.1 ... **100.0** %]	<O.4.2-5/-6> <O.5.2-5/-6>
SO1.MIN SO2.MIN	(SO1) (SO2)	Minimum output value [**0.0** ... 100.0 %]	<O.4.2≠0> <O.5.2≠0>
SO1.MAX SO2.MAX	(SO1) (SO2)	Maximum output value [0.0 ... **100.0** %]	<O.4.2≠0> <O.5.2≠0>

O.4.3...O.5.3 SO1...SO2: Operating direction

The operating direction of the switch outputs SO1 and SO2 is assigned in the same way as for the operating direction of the analog outputs AO1 to AO3, see menu items O.1.3...O.3.3.

O.4.3 **O.5.3**	(SO1) (SO2)	**Operating direction**	<O.4.1≠0> <O.5.2≠0>
	-1	Increasing	
	-2	Decreasing	
SO1.P1 SO2.P1	(SO1) (SO2)	Y value for SO1 = SO1.MIN / SO1 = SO1.MAX Y value for SO2 = SO2.MIN / SO2 = SO2.MAX	<O.4.3-1 / O.4.3-2> <O.5.3-1 / O.5.3-2>
		[**0.0** … 100.0 %]	
SO1.P2 SO2.P2	(SO1) (SO2)	Y value for SO1 = SO1.MAX / SO1 = SO1.MIN Y value for SO2 = SO2.MAX / SO2 = SO2.MIN	<O.4.3-1 / O.4.3-2> <O.5.3-1 / O.5.3-2>
		[0.0 … **100.0** %]	

O.4.4...O.5.4 SO1...SO2: Output ramp

The output ramp of the switch outputs SO1 and SO2 is activated in the same way as for the output ramp of the analog outputs AO1 to AO3, see menu items O.1.4...O.3.4.

O.4.4 **O.5.4**	(SO1) (SO2)	**Output ramp**	<O.4.1≠0> <O.5.1≠0>
	-0	Off	
	-1	Start with DI1	
	-2	Start with DI2	
	-3	Start with DI3	
	-4	Start with DI4	
SO1.GD SO2.GD	(SO1) (SO2)	Gradient	<O.4.4≠0> <O.5.4≠0>
		[0.1 …**1.0**… 100 %]	
SO1.TB SO2.TB	(SO1) (SO2)	Time base	<O.4.4≠0> <O.5.4≠0>
		[**s**, min, h]	
SO1.ST SO2.ST	(SO1) (SO2)	Initial value	<O.4.4≠0> <O.5.4≠0>
		[–10.0 …**0.0**… 110.0 %]	

O.4.6...O.5.6 SO1...SO2: Constant output value 1 with DI (auto mode)

The constant output value 1 is issued at the switch outputs SO1 and SO2 in the same way as at the analog outputs AO1 to AO3, see menu items O.1.5...O.3.5.

O.4.6 **O.5.6**	(SO1) (SO2)	**Constant output value 1 with DI (auto mode)**	<O.4.1≠0> <O.5.2≠0>
	-0	Off	
	-1	With digital input DI1	
	-2	With digital input DI2	
	-3	With digital input DI3	
	-4	With digital input DI4	
SO1.K1 SO2.K1	(SO1) (SO2)	Constant output value 1	<O.4.6≠0> <O.5.6≠0>
		[–10.0 ...**0.0**... 110.0 %]	

O.4.7...O.5.7 SO1...SO2: Constant output value 2 with DI (manual/automatic)

The constant output value 2 is issued at the switch outputs SO1 and SO2 in the same way as at the analog outputs AO1 to AO3, see menu items O.1.6...O.3.6.

O.4.7 **O.5.7**	(SO1) (SO2)	**Constant output value 2 with DI (man/auto)**	<O.4.1≠0> <O.5.2≠0>
	-0	Off	
	-1	With digital input DI1	
	-2	With digital input DI2	
	-3	With digital input DI3	
	-4	With digital input DI4	
SO1.K2 SO2.K2	(SO1) (SO2)	Constant output value 2	<O.4.7≠0> <O.5.7≠0>
		[–10.0 ...**0.0**... 110.0 %]	

O.4.8...O.5.8 SO1...SO2: Limit output by input TR

The limitation of the switch outputs SO1 and SO2 by the input variable TR to a minimum and a maximum value is performed in the same way as for the limitation of analog outputs AO1 to AO3, see menu items O.1.7...O.3.7.

O.4.8 **O.5.8**	(SO1) (SO2)	**Limit output by input TR**	<O.4.1≠0, C.1.4.1≠0> <O.5.1≠0, C.1.4.1≠0>
	-0	Off	
	-1	To minimum value	
	-2	To maximum value	

O.4.9...O.5.9 SO1...SO2: Function generation

The function generation of the output characteristic at the switch outputs SO1 and SO2 is performed in the same way as for the function generation of the analog outputs AO1 to AO3.

However, the input values and the associated output values are set in the range –10.0 to 110.0 % for the switch outputs.

O.4.9 **O.5.9**	(SO1) (SO2)	**Function generation**	<O.4.1≠0> <O.5.1≠0>
	-0	Off	
	-1	Free adjusment	
	-2	Equal percentage	
	-3	Equal percentage inverse	

SO1.I1...SO1.I7 SO2.I1...SO2.I7	(SO1) (SO2)	Input value 1 to 7 [–10.0 ...[1]... 110.0 %] [1] Input value 1 to 6: **0.0** Input value 7: **100.0**	<O.4.9-1> <O.5.9-1>
SO1.O1...SO1.O7 SO2.O1...SO2.O7	(SO1) (SO2)	Output value 1 to 7 [–10.0 ...[1]... 110.0 %] [1] Output value 1 to 6: **0.0** Output value 7: **100.0**	<O.4.9-1> <O.5.9-1>

O.6…O.9 DO1…DO4: Digital output 1 to 4

The digital outputs DO1 to DO4 are relays with NO contacts. If the power supply is disconnected, the relay contacts are open.

O.6.1…O.9.1 DO1…DO4: Assign function

The digital outputs DO1 to DO4 can work as limit relays (settings -1 and -2) or they can be activated over a digital input DI1 to DI4 (settings -3 to -6) or digital output DO5, DO6 (settings -7 and -8).

O.6.1 **O.7.1** **O.8.1** **O.9.1**	(DO1) (DO2) (DO3) (DO4)	**Assign function**	
	-0	Off	
	-1	Limit relay Controller [1]	
	-2	Limit relay Controller [2]	<M.1-3/-4/-5/-6>
	-3	With digital input DI1	
	-4	With digital input DI2	
	-5	With digital input DI3	
	-6	With digital input DI4	
	-7	With digital output DO5	<O.10.1≥5>
	-8	With digital output DO6	<O.11.1≥5>

O.6.2…O.9.2 DO1…DO4: Assign signal

This configuration determines the signal which is monitored for range violation.

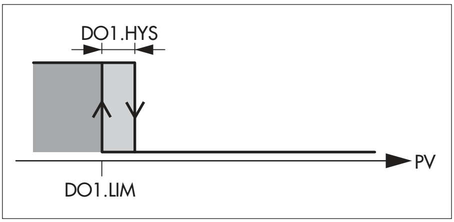
O.6.2 **O.7.2** **O.8.2** **O.9.2**	(DO1) (DO2) (DO3) (DO4)	**Assign signal**	<O.6.1≠0> <O.7.1≠0> <O.8.1≠0> <O.9.1≠0>
	-0	Off	
	-1	Input PV	<C.1.1.1≠0>
	-2	Input SPE	<C.1.2.1≠0>
	-3	Input DV	<C.1.3.1≠0>
	-4	Input TR	<C.1.4.1≠0>
	-5	Input FB	<C.1.5.1≠0>

O.6.2 **O.7.2** **O.8.2** **O.9.2**	(DO1) (DO2) (DO3) (DO4)	**Assign signal**	<O.6.1≠0> <O.7.1≠0> <O.8.1≠0> <O.9.1≠0>
	-6	Process variable PV0	<C.1.1.1≠0>
	-7	Difference PV – SPE	<C.1.1.1≠0, C.1.2.1≠0>
	-8	Difference PV – DV	<C.1.1.1≠0, C.1.3.1≠0>
	-9	Difference SPE – DV	<C.1.2.1≠0, C.1.3.1≠0>
	-10	Error signal e	
	-11	Abs. error signal |e|	
	-12	Output AO1	<O.1.1≠0>
	-13	Output AO2	<O.2.1≠0>
	-14	Output AO3	<O.3.1≠0>
	-15	Output SO1	<O.4.1≠0>
	-16	Output SO2	<O.5.1≠0>
	-17	Process variable ratio PVR	<M.1-2/-6 Regler [1], O.6.1-1>
	-18	Difference PV[1] – PV[2]	<M.1-3/-4/-5/-6, C.1.1.1≠0, O.6.1-1/-2>

O.6.3...O.9.3 DO1...DO4: Switch function

This configuration determines whether the limit relay is activated when the value falls below or exceeds the limit value.

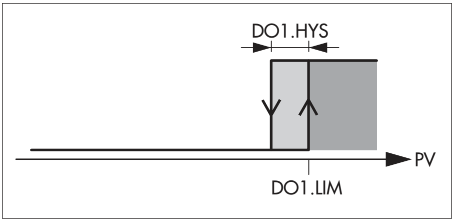
For input-related limit monitoring, the limit value and the hysteresis are entered in numerical values. For limit monitoring relating to an output or the signal error, the limit value and the hysteresis are entered in % values.



Example 1:
Input PV smaller than limit DO1.LIM

- O.6.1-1 DO1 function:
  Limit relay Controller [1]
- O.6.2-1 DO1 signal:
  Input variable PV
- O.6.3-1 DO1 switch function:
  Signal below limit

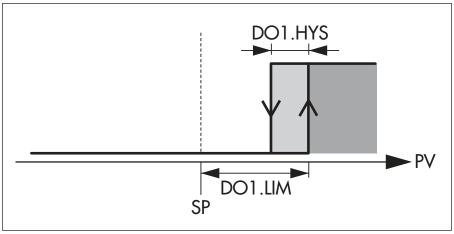
  DO1.LIM = 10.0 °C
  DO1.HYS = 0.5 °C



Example 2:
Input PV greater than limit DO1.LIM

- O.6.1-1 DO1 function:
  Limit relay Controller [1]
- O.6.2-1 DO1 signal:
  Input variable PV
- O.6.3-2 DO1 switch function:
  Signal above limit

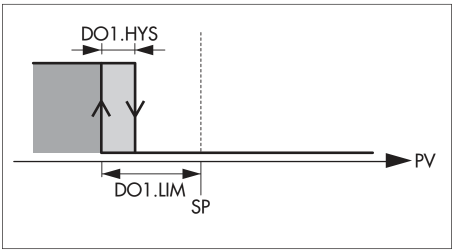
DO1.LIM = 90.0 °C
DO1.HYS = 0.5 °C



Example 3:
Error signal e smaller than limit DO1.LIM (e = SP – PV)

- O.6.1-1 DO1 function:
  Limit relay Controller [1]
- O.6.2-10 DO1 signal:
  Error signal e
- O.6.3-1 DO1 switch function:
  Signal below limit

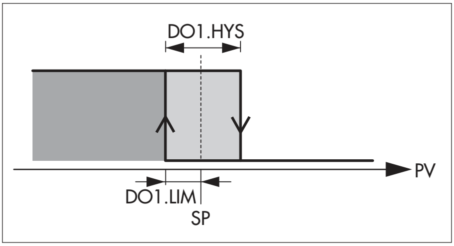
DO1.LIM = –1.5 °C
DO1.HYS = 0.5 °C



Example 4:
Error signal e greater than limit DO1.LIM (e = SP – PV)

- O.6.1-1 DO1 function:
  Limit relay Controller [1]
- O.6.2-10 DO1 signal:
  Error signal e
- O.6.3-2 DO1 switch function:
  Signal above limit

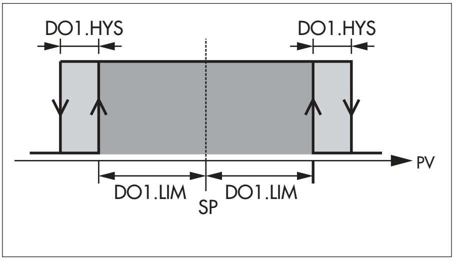
DO1.LIM = 1.5 %
DO1.HYS = 0.5 %



Example 5: On-off output
Error signal e greater than limit

- O.6.1-1 DO1 function: Limit relay Controller [1]
- O.6.2-10 DO1 signal: Error signal e
- O.6.3-2 DO1 switch function: Signal above limit

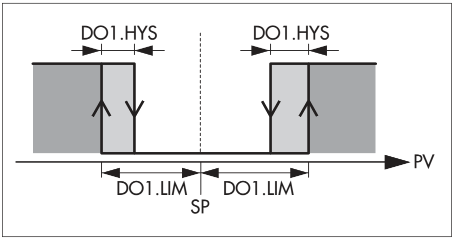
DO1.LIM = 0.5 %
DO1.HYS = 1.0 %



Example 6:
Abs. error signal | e | smaller than limit DO1.LIM (| e | = | SP – PV |)

- O.6.1-1 DO1 function: Limit relay Controller [1]
- O.6.2-11 DO1 signal: Abs. error signal | e |
- O.6.3-1 DO1 switch function: Signal below limit

DO1.LIM = 1.5 %
DO1.HYS = 0.5 %



Example 7:
Abs. error signal | e | greater than limit DO1.LIM (| e | = | SP – PV |)

- O.6.1-1 DO1 function: Limit relay Controller [1]
- O.6.2-11 DO1 signal: Abs. error signal | e |
- O.6.3-2 DO1 switch function: Signal above limit

DO1.LIM = 1.5 %
DO1.HYS = 0.5 %

Note:

- *With settings O.6.2-7...O.9.2-7 to O.6.2-9...O.9.2-9 and O.6.2-18...O.9.2-18 the input variables are subtracted in numerical values. The limit and hysteresis are entered as numerical values.*
- *For setting O.6.2-18...O.8.2-18, the limit relay is assigned to Controller [1] or to Controller [2].*

O.6.3 **O.7.3** **O.8.3** **O.9.3**	(DO1) (DO2) (DO3) (DO4)	**Switch function**	<O.6.2≠0> <O.7.2≠0> <O.8.2≠0> <O.9.2≠0>
	-0 -1 -2	Off Signal under limit Signal over limit	
DO1.LIM DO2.LIM DO3.LIM DO4.LIM	(DO1) (DO2) (DO3) (DO4)	Limit	<O.6.3≠0> <O.7.3≠0> <O.8.3≠0> <O.9.3≠0>
		[–999.00 …**0.0**… 9999.00]	<O.6.2-1/-2/-3/-4/-5/-6/-17... O.9.2-1/-2/-3/-4/-5/-6/-17>
		[–9999.00 …**0.00**… 9999.00]	<O.6.2-7/-8/-9/-18...O.9.2-7/-8/-9/-18>
		[–110.00 …**0.00**…110.00 %]	<O.6.2-10...O.9.2-10>
		[**0.00** … 110.00 %]	<O.6.2-11...O.9.2-11>
		[–10.00 …**0.00**… 110.00 %]	<O.6.2-12/-13/-14/-15/-16... O.9.2-12/-13/-14/-15/-16>
DO1.HYS DO2.HYS DO3.HYS DO4.HYS	(DO1) (DO2) (DO3) (DO4)	Hysteresis	<O.6.3≠0> <O.7.3≠0> <O.8.3≠0> <O.9.3≠0>
		[0.00 …**0.50**… 9999.00]	
		[0.00 …**0.50**… 110.00 %]	<O.6.2-10/-11/-12/-13/-14/-15/-16... O.9.2-10/-11/-12/-13/-14/-15/-16>

O.6.4...O.9.4 DO1...DO4: Inverting

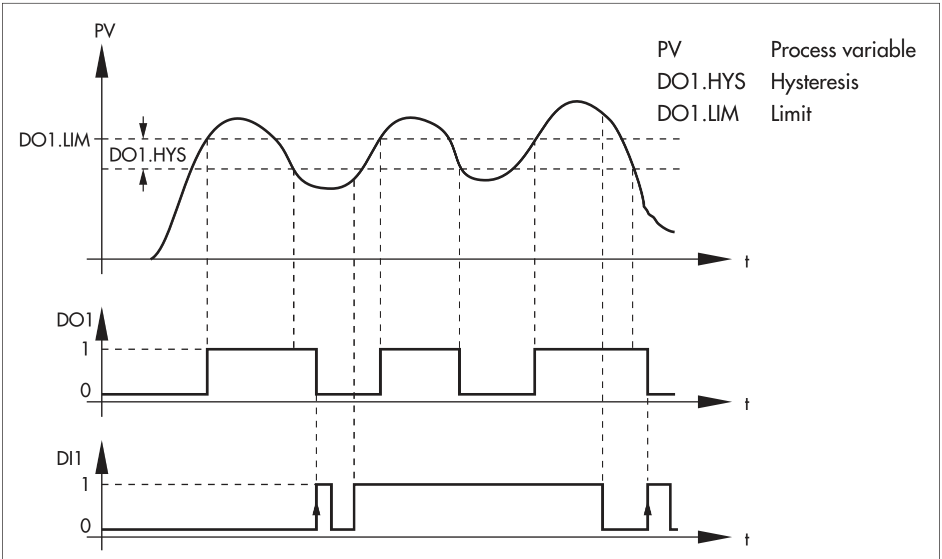
The control action of digital outputs DO1 to DO4 can be reversed (inverted). Inversion (setting -1) causes the contact **to open** when the reporting condition (e.g. limit value) is met. The setting -0 causes the contact **to close** when the reporting condition is met.

O.6.4	(DO1)	**Inverting**	<O.6.1≠0>
O.7.4	(DO2)		<O.7.1≠0>
O.8.4	(DO3)		<O.8.1≠0>
O.9.4	(DO4)		<O.9.1≠0>
	-0	Off	
	-1	On	

O.6.5...O.9.5 DO1...DO4: Storage

This function saves the active state of the digital output (DO1…DO4). If the reporting condition is not met, the digital output remains active. The digital output is reset (confirmed) with the selected digital input (DI1…DI4).

Example: Storage of a limit alarm with reset by digital input



The process variable is monitored for range violation. If the process variable PV exceeds the limit DO1.LIM, the digital output DO1 becomes active. If it was not saved, the digital output would become inactive as soon as the process variable became smaller than the limit (minus hysteresis DO1.HYS). By saving it, the digital output remains active. The digital output first becomes inactive when the digital input DI1 is set. The digital input confirms the range violation by resetting the alarm.

***Note:** The active status of the digital output is also saved whenever the digital output has been activated by a digital input DI1 to DI4 or digital output DO5, DO6.*

O.6.5	(DO1)	**Storage**	<O.6.1≠0>
O.7.5	(DO2)		<O.7.1≠0>
O.8.5	(DO3)		<O.8.1≠0>
O.9.5	(DO4)		<O.9.1≠0>
	-0	Off	
	-1	Reset with DI1	
	-2	Reset with DI2	
	-3	Reset with DI3	
	-4	Reset with DI4	

O.10...O.11 DO5...DO6: Digital output 5 and 6

The digital outputs DO5 and DO6 are designed as galvanically isolated transistor outputs.

O.10.1...O.11.1 DO5...DO6: Assign function

The digital outputs DO5 and DO6 can be assigned to various alarms.

Setting		Description	Reporting condition
O.10.1	O.11.1		The digital output becomes active when ...
-0	-0	Off	–
-1	-1	Digital input DI1 active	The digital input is active
-2	-2	Digital input DI2 active	
-3	-3	Digital input DI3 active	
-4	-4	Digital input DI4 active	

Setting		Description	Reporting condition
O.10.1	O.11.1		The digital output becomes active when …
-5	-5	Sensor/signal error	The signal monitoring of an analog input (I.1.5...I.4.5) responds or the signal monitoring of an analog input over interface (I.1.5...I.4.5) responds upon communication failure or the signal monitoring of a set point via interface SPC (C.2.1.6) responds. This alarm is also issued at digital output DO7 for collective fault alarm.
-6	-6	Communication failure	The communication monitoring of the control station (D.1.1) responds or the signal monitoring of an analog input over interface (I.1.5...I.4.5) responds upon communication failure or the signal monitoring of a set point via interface SPC (C.2.1.6) responds. This alarm is also issued at digital output DO7 for collective fault alarm.
-7	-7	Cascade open	The cascade is open during cascade control (M.1-3), i.e. the set point of the slave controller SPM switches over to one of the internal set points (SP1...SP4).
-8	-8	[1] Automatic mode	Controller [1] is in automatic mode.
-9	-9	[1] Manual mode	Controller [1] is in manual mode.
-10	-10	[1] External set point active	Controller [1] external set point SPE/SPC is active.
-11	-11	[1] External output value active	Controller [1] external output value TR is active.
-12	-12	[2] Automatic mode	Controller [2] is in automatic mode.
-13	-13	[2] Manual mode	Controller [2] is in manual mode.
-14	-14	[2] External set point active	Controller [2] external set point SPE/SPC is active.
-15	-15	[2] External output value active	Controller [2] external output value TR is active.

Setting		Description	Reporting condition
O.10.1	O.11.1		The digital output becomes active when …
-16		3-step SO1+ instead of DO1	The three-step signal SO1+ is active.
-17		3-step SO2+ instead of DO3	The three-step signal SO2+ is active.
-18		On-off SO1+ instead of DO1	The on-off signal SO1+ is active.
	-16	3-step SO1– instead of DO2	The three-step signal SO1– is active.
	-17	3-step SO2– instead of DO4	The three-step signal SO2– is active.
	-18	On-off SO2+ instead of DO3	The on-off signal SO2+ is active.

Note:

- *Settings -16 to -18 cause the three-step and on-off signals of the switch outputs SO1 and SO2 not to be issued at the relay outputs DO1 to DO4, but at the transistor outputs DO5 and DO6. As a result, the relays can be used, for example, as limit relays.*
- *The settings -16 to -18 can only be configured when the corresponding switch output SO1 or SO2 has been configured.*

O.10.1 **O.11.1**	(DO5) (DO6)	**Assign function**	
	-0	Off	
	-1	Digital input DI1 active	
	-2	Digital input DI2 active	
	-3	Digital input DI3 active	
	-4	Digital input DI4 active	
	-5	Sensor/signal error	<I.1.5≠0...I.4.5≠0>
	-6	Communication failure	<D.1.1-1>
	-7	Cascade opened	<M.1-3>
	-8	[1] Automatic mode	
	-9	[1] Manual mode	
	-10	[1] External set point active	<1C.2.1.2≠0>
	-11	[1] External output value active	<1C.3.3.3≠0>
	-12	[2] Automatic mode	<M.1-3/-4/-5/-6>
	-13	[2] Manual mode	<M.1-3/-4/-5/-6>
	-14	[2] External set point active	<M.1-3/-4/-5/-6, 2C.2.1.2≠0>
	-15	[2] External output value active	<M.1-3/-4/-5/-6, 2C.3.3.3≠0>
	-16	O.10: 3-step SO1+ instead of DO1 O.11: 3-step SO1– instead of DO2	<O.4.2-1/-2/-5/-6> <O.4.2-1/-2/-5/-6>
	-17	O.10: 3-step SO2+ instead of of DO O.11: 3-step SO2– instead of DO4	<O.5.2-1/-2/-5/-6> <O.5.2-1/-2/-5/-6>
	-18	O.10: On-off SO1+ instead of DO1 O.11: On-off SO2+ instead of DO3	<O.4.2-3/-4> <O.5.2-3/-4>

O.10.2...O.11.2 DO5...DO6: Inverting

The control action of the digital outputs DO5 and DO6 can be reversed (inversed). Without inversion (setting -0), the transistor is energized when the alarm is active. Inversion (setting -1) causes the transistor to be energized when the alarm is inactive.

O.10.2 **O.11.2**	(DO5) (DO6)	**Inverting**
	-0	Off
	-1	On

O.12.2 DO7: Inverting

The digital output DO7 is designed as a galvanically isolated transistor output and issues the collective fault alarm. Without inversion (setting -0), the transistor is energized when the alarm is active. Inversion (setting -1) causes the transistor to be energized when the alarm is inactive.

The digital output DO7 becomes active during the following events:

- Internal error: The power supply and the programs are monitored electronically by watchdogs. If the controller fails, a periodic signal with approx. 1.3 Hz (0.8-2.2 Hz) is issued at digital output DO7 and the display blinks red. The watchdog alarm is linked to the software alarm (see events below) by an exclusive-OR. Inversion of DO7 does not have any effect in this case.
- Slide switches for analog input are set to different positions, i.e. one switch is in the left position while the other switch is in the right position.
- The temperature inside the controller is lower than –5 °C or higher than 65 °C: this alarm can occur due to a temperature violation.
- Signal monitoring for analog input responds (I.1.5...I.4.5), e.g. sensor fault
- Signal monitoring for set point SPC via interface responds (C.2.1.6)
- Communication failure: The controller is not addressed by the control station within the defined time (Timeout) (D.1.1).

The response of signal monitoring of the analog inputs and the set point SPC via interface as well as the communication failure can be reported at digital outputs DO5 and DO6. The internal malfunction and the alarm caused by the incorrectly set slide switches are only issued at digital output DO7.

O.12.2	(DO7)	**Inverting**
	-0	Off
	-1	On

D Communication

All settings required for operation with one of the optional RS-232/USB or RS-485/USB interface boards are made in the *Communication* menu.
The infrared interface is used for data transmission using TROVIS-VIEW. This interface is always active and cannot be configured at the controller.

Modbus communication

Communication works with the Modbus RTU protocol. It is a master/slave protocol (where a control station is the master and the industrial controller the slave).

The following Modbus functions are supported:

Function code		
Dec	Hex	Function
1	01	Read coils
3	03	Read multiple holding registers
6	06	Write single holding register
15	0F	Write multiple coils
16	10	Write multiple holding registers

The industrial controller can give the following Modbus error responses:

Error code		
Dec	Hex	Error
2	02	Invalid address or block length
3	03	Invalid value

Modbus register list

The table below contains some of the major data points from the Modbus register list. The complete register list is available on request. Note that the addresss of the following register list starts with address 1. However, within the Modbus telegram, the address is always one number less. If the counting at the communication partner starts with address 0, the address number of this register list must be counted one number less.

Holding register no.	Designation	Access	Transmission range		Reading range	
			Start	End	Start	End
Device information						
1	Device number (6495)	R	6495	6495	6495	6495
2	Varianten version	R	2	2	2	2
Input and output signal						
30	Analog input AI1 3)	R/W	–32768	32767	–3276.8	3276.7
31	Analog input AI2 3)	R/W	–32768	32767	–3276.8	3276.7
32	Analog input AI3 3)	R/W	–32768	32767	–3276.8	3276.7
33	Analog input AI4 3)	R/W	–32768	32767	–3276.8	3276.7
34	Analog output AO1	R	–100	1100	–10.0	110.0
35	Analog output AO2	R	–100	1100	–10.0	110.0
36	Analog output AO3	R	–100	1100	–10.0	110.0
37	Switch output SO1	R	–100	1100	–10.0	110.0
38	Switch output SO2	R	–100	1100	–10.0	110.0
Controller [1]						
41	[1] Input PV after function generation 3)	R	–32768	32767	–3276.8	3276.7
42	[1] Process variable PV0 at comparator 3)	R	–32768	32767	–3276.8	3276.7
43	[1] Process variable ratio PVR	R	–32768	32767	–327.68	327.67
45	[1] Input SPE after function generation 3)	R	–32768	32767	–3276.8	3276.7
47	[1] Input DV after function generation 3)	R	–32768	32767	–3276.8	3276.7
49	[1] Input TR after function generation 3)	R	–32768	32767	–3276.8	3276.7
52	[1] Input FB after filter 3)	R	–32768	32767	–3276.8	3276.7
53	[1] Signal A	R	–32768	32767	–3276.8	3276.7
54	[1] Signal B	R	–32768	32767	–3276.8	3276.7
55	Firmware version 1.21 and higher 2) [1] Current internal set point 1 = SP1, 2 = SP2, 3 = SP3, 4 = SP4	R/W	1	4	1	4
57	[1] Set point SPM	R	–32768	32767	–3276.8	3276.7

Holding register no.	Designation	Access	Transmission range		Reading range	
			Start	End	Start	End
58	[1] Set point SPC	R/W	–32768	32767	–3276.8	3276.7
60	[1] Set point SP0 at comparator	R	–32768	32767	–3276.8	3276.7
61	[1] Ratio set point SPR	R	–32768	32767	–327.68	327.67
62	[1] Error signal e	R	–32768	32767	–3276.8	3276.7
63	[1] Output Y	R/W 4)	–100	1100	–10.0	110.0
551	[1] Set point SP1	R/W 1)	–9990	32767	–999.0	3276.7
554	[1] Set point SP2	R/W 1)	–9990	32767	–999.0	3276.7
557	[1] Set point SP3	R/W 1)	–9990	32767	–999.0	3276.7
560	[1] Set point SP4	R/W 1)	–9990	32767	–999.0	3276.7
Controller [2]						
101	[2] Input PV after function generation 3)	R	–32768	32767	–3276.8	3276.7
102	[2] Process variable PV0 at comparator	R	–32768	32767	–3276.8	3276.7
105	[2] Input SPE after function generation 3)	R	–32768	32767	–3276.8	3276.7
107	[2] Input DV after function generation 3)	R	–32768	32767	–3276.8	3276.7
109	[2] Input TR after function generation 3)	R	–32768	32767	–3276.8	3276.7
112	[2] Input FB after filter 3)	R	–32768	32767	–3276.8	3276.7
113	[2] Signal A	R	–32768	32767	–3276.8	3276.7
114	[2] Signal B	R	–32768	32767	–3276.8	3276.7
118	[2] Set point SPC	R/W	–32768	32767	–3276.8	3276.7
120	[2] Set point SP0 at comparator	R	–32768	32767	–3276.8	3276.7
122	[2] Error signal e	R	–32768	32767	–3276.8	3276.7
123	[2] Output Y	R/W 4)	–100	1100	–10.0	110.0
124	[2] Output master controller YM	R	–100	1100	–10.0	110.0
1351	[2] Set point SP1	R/W 1)	–9990	32767	–999.0	3276.7
1354	[2] Set point SP2	R/W 1)	–9990	32767	–999.0	3276.7
1357	[2] Set point SP3	R/W 1)	–9990	32767	–999.0	3276.7
1360	[2] Set point SP4	R/W 1)	–9990	32767	–999.0	3276.7

Coil no.	Designation	Access	Status	
Fault message				
1	Collective alarm	R	OK (0)	Alarm (1)
2	AI1 Min. measuring range violation	R	OK (0)	Alarm (1)
3	AI1 Max. measuring range violation	R	OK (0)	Alarm (1)
4	AI2 Min. measuring range violation	R	OK (0)	Alarm (1)
5	AI2 Max. measuring range violation	R	OK (0)	Alarm (1)
6	AI3 Min. measuring range violation	R	OK (0)	Alarm (1)
7	AI3 Max. measuring range violation	R	OK (0)	Alarm (1)
8	AI4 Min. measuring range violation	R	OK (0)	Alarm (1)
9	AI4 Max. measuring range violation	R	OK (0)	Alarm (1)
Digital inputs/digital outputs				
40	Digital input DI1	R	inactive (0)	active (1)
41	Digital input DI2	R	inactive (0)	active (1)
42	Digital input DI3	R	inactive (0)	active (1)
43	Digital input DI4	R	inactive (0)	active (1)
44	Digital output DO1	R	inactive (0)	active (1)
45	Digital output DO2	R	inactive (0)	active (1)
46	Digital output DO3	R	inactive (0)	active (1)
47	Digital output DO4	R	inactive (0)	active (1)
48	Digital output DO5	R	inactive (0)	active (1)
49	Digital output DO6	R	inactive (0)	active (1)
50	Digital output DO7	R	inactive (0)	active (1)
Status alarms for Controller [1]				
60	[1]: Manual/automatic mode	R/W 5)	automatic (0)	manual (1)
61	[1]: Internal/external set point	R/W 5,6,7)	external (0)	internal (1)
62	[1]: Open/close cascade	R/W 5, 7)	closed (0)	opened (1)
63	[1]: Output tracking	R	inactive (0)	active (1)
560	[1]: Signal error SPC (timeout)	R	inactive (0)	active (1)
Status alarms for Controller [2]				
100	[2]: Manual/automatic mode	R/W 5)	automatic (0)	manual (1)

Coil no.	Designation	Access	Status	
101	[2]: Internal/external set point	R/W [5,6,7]	external (0)	internal (1)
103	[2]: Output tracking	R	inactive (0)	active (1)
104	[2]: Signal error SPC (timeout)	R	inactive (0)	active (1)

1) The data are saved in a non-volatile memory (EEPROM). This type of memory has a limited life of approx. one million write cycles per memory address. If configurations and parameters are only changed manually at the keys on the controller or over TROVIS-VIEW, it can be ruled out that the maximum number of write cycles will be reached. However, the maximum number of write cycles must be taken into account for automatic parameter changes (e.g. over Modbus communication) and measures must be taken to prevent the parameters being written to the device too frequently.

2) The holding registers 55 and 115 supply the number of the current internal set point. The internal set points can be changed over by writing a value between 1 and 4, provided the set points are enabled over the configuration C.2.1.1. This changeover has the same priority as the changeover over the keys. If the set point changeover over the digital inputs is configured (C.2.1.1), Modbus cannot be used to change over the set points.

3) Up to firmware version 1.11, it is transferred as a percentage in relation to the measuring range. In firmware version 1.21 and higher, it is transferred as a physical value (unscaled).

4) Can only be read up to firmware version 1.11. In firmware version 1.21 and higher, it can be written in manual mode and only read in automatic mode.

5) Can only be read up to firmware version 1.11.

6) Up to firmware version 1.11, the control direction is reversed: internal (1), external (0).

7) In firmware version 1.21 and higher, it can be written when the function is not activated by a digital input.

R: Read · W: Write

D.1 General settings

D.1.1 Communication monitoring

This function monitors the cyclic read and write access of the control station (Modbus protocol) or TROVIS-VIEW (SSP protocol) to the controller. If the controller (slave) does not receive any telegram (Modbus RTU or SSP) addressed to it within the adjusted time period (Query timeout QRY.TOUT), the controller reports it as a communication failure and the digital output DO7 is activated. In firmware version 1.21 and higher, there is an entry in the error list and event list in the event of timeout. In addition, the fault alarm icon is displayed.

This communication failure can also be reported at digital outputs DO5 (O.10.1-6) and DO6 (O.11.1-6).

D.1.1	Communication monitoring	
-**0**	Off	
-1	On	
QRY.TOUT	Query timeout [1 ...**60**... 9999 s]	<D.1.1-1>

D.2 RS-232 interface

Data can be transferred over the RS-232 interface either using the SAMSON protocol SSP or using the Modbus RTU protocol. The protocol SSP is used to communicate with TROVIS-VIEW software and the memory pen. The Modbus RTU protocol supports communication with a Modbus master (e.g. control station). Modbus RTU is a communication protocol based on a master-slave architecture. In combination with the RS-232 interface, a Modbus master can only communicate with one Modbus slave (e.g. controller) (point-to-point connection). Furthermore, the line length is limited to just a few meters when a RS-232 interface is used. The line length also depends on the capacitance of the cable used. Because a bus termination cannot be connected to the end of the line when a RS-232 interface is used, the data transmission disturbance increases, the longer the line length is due to reflection.

- Optional interface boards, refer to EB 6495-2 EN

D.2.1 Protocol

RS-232 data transmission is automatically performed using either SSP or Modbus RTU protocol.

Data are exchanged over the infrared interface and memory pen regardless of the configured protocol.

- **Setting -1:** Automatic
  The SSP and Modbus protocols are automatically recognized: The interface parameters are internally set to Baud rate 9600 bit/s, 8 data bits, no parity, 1 stop bit. The controller can exchange data with TROVIS-VIEW or with control station without having to switchover. Station number STN and response timeout RSP.TOUT can be adjusted.
- **Setting -2**: SSP
  Communication is performed using the SAMSON SSP protocol with fixed interface parameters (Baud rate 9600 bit/s, 8 data bits, no parity, 1 stop bit). The controller can exchange data with TROVIS-VIEW.
- **Setting -3:** Modbus RTU
  Communication is performed using the Modbus RTU protocol. All interface parameters

listed below can be adjusted. The controller cannot exchange data with TROVIS-VIEW over RS-232 interface nor over the USB port.

Station number: The station number STN is used for the Modbus-RTU protocol to identify the controller.

Baud rate: The Baud rate is adjusted using the BITRATE parameter. It is the transfer rate between the controller and control station/PC. The Baud rate adjusted at the controller must match the Baud rate of the control station, otherwise communication cannot be established.

Parity: The parity is adjusted using the PARITY parameter. The selection of parity (none = 0, even = 1 and uneven = 2) helps detect data transmission errors. This is done by adding the parity bit to the data bit after transmission.
PARITY = 1 (even parity) detects a transmission error when the set of bits is odd.
PARITY = 2 (odd parity) detects a transmission error when the set of bits is even.

Stop bit: The number of stop bits is adjusted using the STOPBIT parameter. To synchronize the data transmission, a start bit is sent in front of the data bits and either one or two stop bit(s) afterwards.

Response timeout: The controller must respond within the time adjusted in RSP.TOUT.

D.2.1	**Protocol**	
-0	Off	
-**1**	Automatic (9600, 8, N, 1)	
-2	SSP (9600, 8, N, 1)	
-3	Modbus RTU	
STN	Station number [**1** ... 255]	<D.2.1-3>
BITRATE	Baud rate [300, 600, 1200, 2400, 4800, **9600**, 19200, 38400, 57600, 115200 bit/s]	<D.2.1-3>
PARITY	Parity [**0** = none, 1 = even, 2 = uneven]	<D.2.1-3>
STOPBIT	Stop bit [**1**, 2]	<D.2.1-3>

RSP.TOUT	Response timeout [0.1 …**10.0**… 100.0 s]	<D.2.1-3>

D.3 RS-485 interface

Data can be transferred over the RS-485 interface either using the SAMSON protocol SSP or using the Modbus RTU protocol. The protocol SSP is used to communicate with TROVIS-VIEW software. The Modbus RTU protocol supports communication with a Modbus master (e.g. control station). Modbus RTU is a communication protocol based on a master-slave architecture. In combination with the RS-485 interface, a Modbus master can communicate with one or more Modbus slaves (e.g. controller).

- Optional interface boards, refer to EB 6495-2 EN

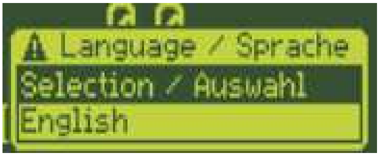
D.3.1 Protocol

See menu item D.2.1 for description.

D.3.1	**Protocol**	
-0	Off	
-**1**	Automatic (9600, 8, N, 1)	
-2	SSP (9600, 8, N, 1)	
-3	Modbus RTU	
STN	Station number [**1** … 255]	<D.2.1-3>
BITRATE	Baud rate [300, 600, 1200, 2400, 4800, **9600**, 19200, 38400, 57600, 115200 bit/s]	<D.2.1-3>
PARITY	Parity [**0** = none, 1 = even, 2 = uneven]	<D.2.1-3>
STOPBIT	Stop bit [**1**, 2]	<D.2.1-3>
RSP.TOUT	Response timeout [0.1 …**10.0**… 100.0 s]	<D.2.1-3>

A General settings

A.1 Sprache/Language



After the controller has been connected to the power supply for the first time or after the controller has been reset to its default settings, the user is prompted to select a language.

The controller menus appear in the language selected here.

It is possible to change the language setting later, without having to reset the controller to its default settings, in the configuration item A.1.1 Auswahl/Selection.

A.1.1 Auswahl/Selection

The language setting can be changed at any time in this configuration item.

A.1.1	Auswahl/Selection
-1	Deutsch
-2	English
-3	Français

A.2 Operation display

In the submenu A.2 Operation display the left and right displays are assigned to the controller and additional readings. The display contrast can be adapted as well.

A.2.1...A.2.2 Left/right display

By default the left display is used for Controller [1]. For control modes with one controller (M.1-1/-2) the right display remains blank. For control modes with two controllers (M.1-3/-4/-5/-6) the right display is used for Controller [2].

The configuration items A.2.1 and A.2.2 determine whether the left or right display are used for Controller [1] or Controller [2] and whether their additional displays are to be shown. Which values are to be shown in the additional display is configured separately.

- Set up additional display, see menu item C.6 and EB 6495-2
- Switching Controller [1] and Controller [2] displays, refer to EB 6495-2 EN

Note: *It is not possible to select the same configuration in both displays, e.g. A.2.1-0 and A.2.2-0 (deactivate both displays) or A.2.1-3 and A.2.2-3 (both displays Controller [2]).*

A.2.1 **A.2.2**	**Left display** **Right display**	
-0 1)	Off	
-1 1)	Controller [1]	
-2	Controller [1] additional reading	
-3	Controller [2]	<M.1-3/-4/-5/-6>
-4	Controller [2] additional reading	<M.1-3/-4/-5/-6>

1) Left display: default setting -1 · Right display: default setting -0

A.2.3 Contrast

The contrast of the display can be adapted to the lighting conditions at the site of installation.

The contrast is set to 50 by default.
Lower values cause the display to darken, while larger values brighten the display.

A.2.3	**Contrast**
CTRST	Contrast [0 …**50**…100]

A.3 Operator keys

In this menu, the operator key settings for the entire controller can be made.

A.3.1 Lock all keys

This configuration allows all operator keys to be locked by a '1' signal at the selected digital input.

A.3.1	Lock all keys
-0	Off
-1	With digital input DI1
-2	With digital input DI2
-3	With digital input DI3
-4	With digital input DI4

A.3.2 Manual/auto dialog

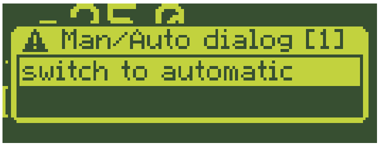
The manual/auto dialog allows the following actions to be performed from the operating menu:

- Change over manual/automatic mode
- Switchover internal/external set point (for operation with external set point)
- Open/close cascade (for cascade control)

In contrast to the direct changeover between manual/automatic mode using the manual/automatic key, the manual/auto dialog changes to manual or automatic mode after confirming it by pressing the enter key.

Pressing the manual/automatic key starts the manual/auto dialog.

Select the required action using the cursor keys △, ▽ and confirm by pressing the enter key . Activate the escape key to to exit the manual/auto dialog.



Actions possible (△, ▽) in manual/auto dialog	Description
Activate automatic mode	Switch over to automatic mode
Activate manual mode	Switch over to manual mode
With internal set point	Switch over to internal set point (SP1…SP4)
With external set point	Switch over to external set point SPE (SPC)

In cascade control (M.1-3), the cascade can also be opened and closed:

Actions possible (△, ▽) in manual/auto dialog	Description
Slave controller [1]	
Activate automatic mode	Switch over to automatic mode
Activate manual mode	Switch over to manual mode
With internal set point	Switch over to internal set point (SP1…SP4) Cascade is opened
With external set point	Switch over to external set point SPM Cascade is closed
Open cascade	Open cascade
Close cascade	Close cascade
Master controller [2]	
With internal set point	Switch over to internal set point (SP1…SP4)
With external set point	Switch over to external set point SPE (SPC)
Open cascade	Open cascade
Close cascade	Close cascade

Note: *In override control (M.1-4), switchover to the internal/external set point can only be done using the manual/auto dialog.*

A.3.2	Manual/auto dialog
-0	Off
-1	On

A.4 Key number

A.4.1 Activate key number operation

When key number operation is enabled, changes in the configuration level as well as changes to settings in the operating menu can only be made after entering the key number.

- Activate key number, refer to EB 6495-2 EN

A.4.1		Key number operation
	-0	Off
	-1	On
CODE		Key number [**0** ...9999]

A.5 Power frequency

A.5.1 Ripple filter for AI1

This function is used to filter out 50 Hz or 60 Hz ripple signals from the input signal at the analog input. Select the power frequency (50 Hz or 60 Hz) of the low-voltage installation. The power frequency must be set even when the controller is operated by DC voltage.

A.5.1		Ripple filter for AI1
	-0	50 Hz
	-1	60 Hz

A.20.1...A.20.7 User adjustment (calibration) AI1...4, AO1...3

The analog inputs and outputs (AI1 to AI4 and AO1 to AO3) are calibrated by default. Based on the factory calibration, the zero and end value of the input and output signals can be calibrated by the user. This calibration, for example, helps to compensate for inaccuracies of transducers or control elements. User calibration is described in EB 6495-2 EN.

Note:

- *After saving a new zero or end value, the difference between the new value and the factory calibration appears above the calibrated value in brackets. The assigned digit of the A/D converter is displayed on the right next to the calibrated value.*
- *The setting A.21.1-2 allows the user calibration values to be reset to factory-calibration settings.*

A.20.1		**Analog input AI1**	
A.20.2		**Analog input AI2**	
A.20.3		**Analog input AI3**	
A.20.4		**Analog input AI4**	
	.1	Current zero (4 mA)	<I.1.1-1...I..4.1-1>
	.2	Current end (20 mA)	<I.1.1-1...I..4.1-1>
	.3	Current zero (0 mA)	<I.1.1-2...I.4.1-2>
	.4	Current end (20 mA)	<I.1.1-2...I.4.1-2>
	.5	Voltage zero (0 V)	<I.1.1-3...I.4.1-3>
	.6	Voltage end (10 V)	<I.1.1-3...I.4.1-3>
	.7	Voltage zero (2 V)	<I.1.1-4...I.4.1-4>
	.8	Voltage end (10 V)	<I.1.1-4...I.4.1-4>
	.9	Pt 100 zero (0 °C)	<I.1.1-6...I.4.1-6>
	.10	Pt 100 end (300 °C)	<I.1.1-6...I.4.1-6>
	.11	Pt 1000 zero (0 °C)	<I.1.1-7...I.4.1-7>
	.12	Pt 1000 end (300 °C)	<I.1.1-7...I.4.1-7>
	.13	Potentiometer zero · A.20.2 only	<I.2.1-8/-9/-10/-11>
	.14	Potentiometer end · A.20.2 only	<I.2.1-8/-9/-10/-11>

A.20.5		**Analog output AO1**	
A.20.6		**Analog output AO2**	
A.20.7		**Analog output AO3**	
	.1	Current zero (0 mA/4 mA)	<O.1-1/-2...O.3-1/-2>
	.2	Current end (20 mA)	<O.1-1/-2...O.3-1/-2>
	.3	Current zero (0 V/2 V)	<O.1-3/-4...O.3-3/-4>
	.4	Current end (10 V)	<O.1-3/-4...O.3-3/-4>

A.21 Factory defaults

A.21.1 Reset controller

This configuration item allows the controller to be reset to its default settings by changing the configuration:

- **Setting -1:** All except calibration
  Resets configuration and parameter settings including key number to factory defaults.

  After reset, the user is prompted to select a language, see menu item A.1

- **Setting -2:** Only user calibration
  Resets just the user calibration (A.20) of the analog inputs and outputs to factory defaults.

A.21.1	**Reset controller**
-**0**	Off
-1	All except calibration
-2	Only user calibration

Index

A

B

C

D

SAMSON AG · MESS- UND REGELTECHNIK
Weismüllerstraße 3 · 60314 Frankfurt am Main, Germany
Phone: +49 69 4009-0 · Fax: +49 69 4009-1507
Internet: http://www.samson.de

KH 6495-2 EN

2020-02