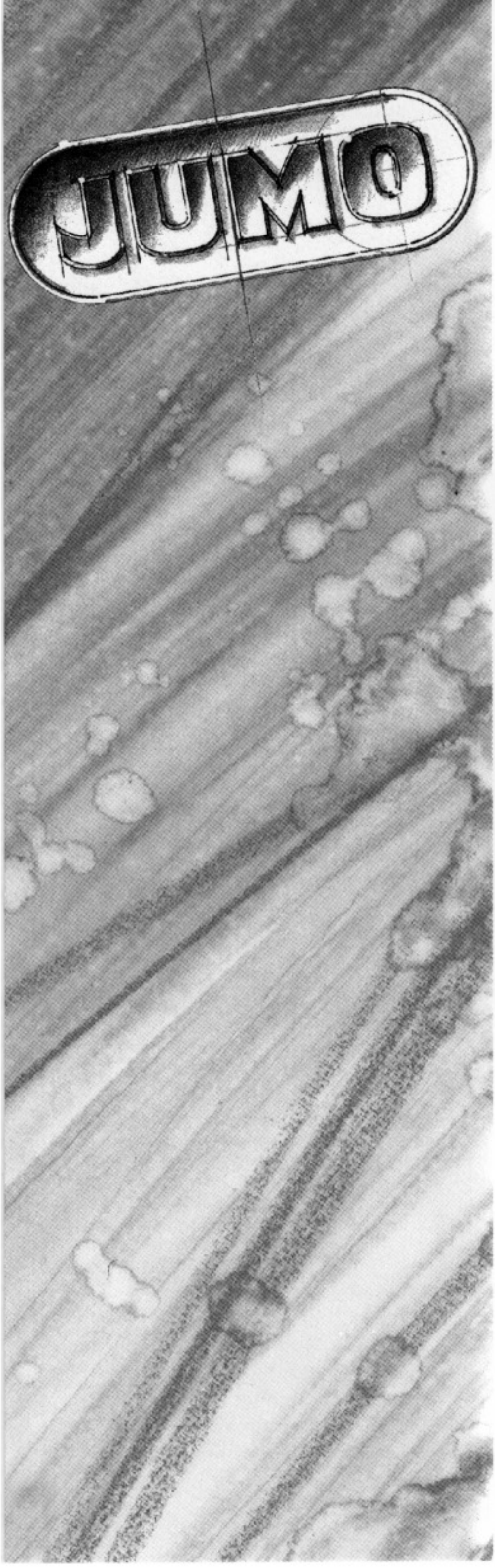


JUMO DICON 1000

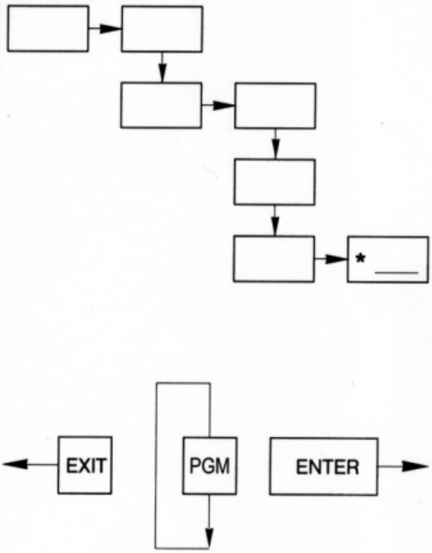
Universal Profile Controller

B 70.3560
Operating Manual

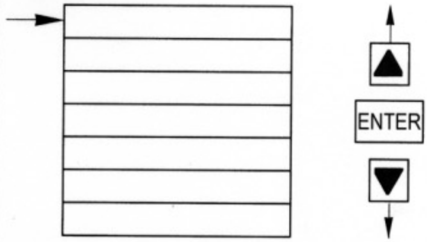
10.01/00314266

5.5 Overview of the key functions

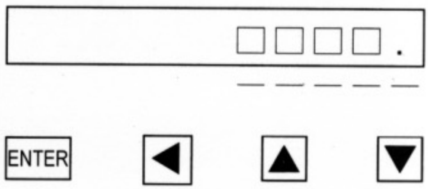
Levels and menus



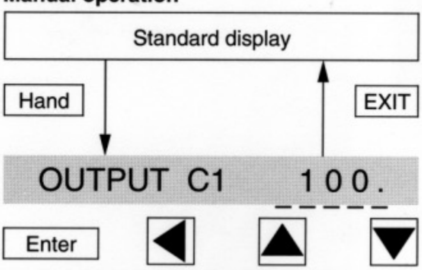
Selection



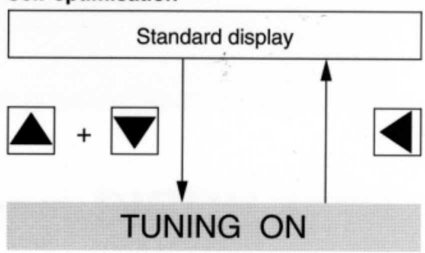
(Setpoint) value input



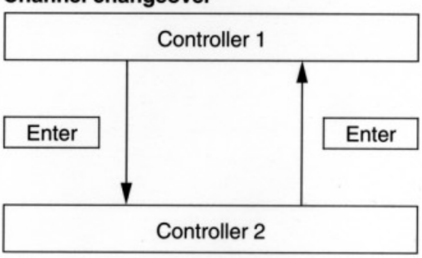
Manual operation



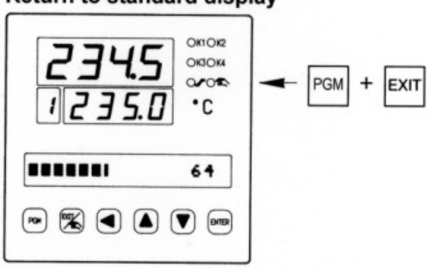
Self-optimisation



Channel changeover



Return to standard display



FOLD-OUT

Please read this Manual before starting up the instrument. Keep this Manual in a place which is at any time accessible to all users.

Please assist us to improve this Manual where necessary.

We are always grateful for your suggestions.

Phone:
Germany (0661) 6003-727
abroad (int. +49) 661 6003-0

Fax:
Germany (0661) 6003-508
abroad (int. +49) 661 6003-607

All necessary settings and, where appropriate, alterations inside the unit are described in this Operating Manual. If any problems should arise during start-up do not carry out any manipulations on the unit which are not permitted.

This endangers your rights under the warranty!

Please contact the nearest JUMO office or the main factory.

When returning chassis, modules or components the rules of EN 100 015 "Protection of electrostatically endangered components" have to be observed.

Use only the appropriate ESD packaging material for transport.

Please note that we cannot be held liable for any damage caused by ESD (electrostatic discharges)

CONTENTS

CONTENTS

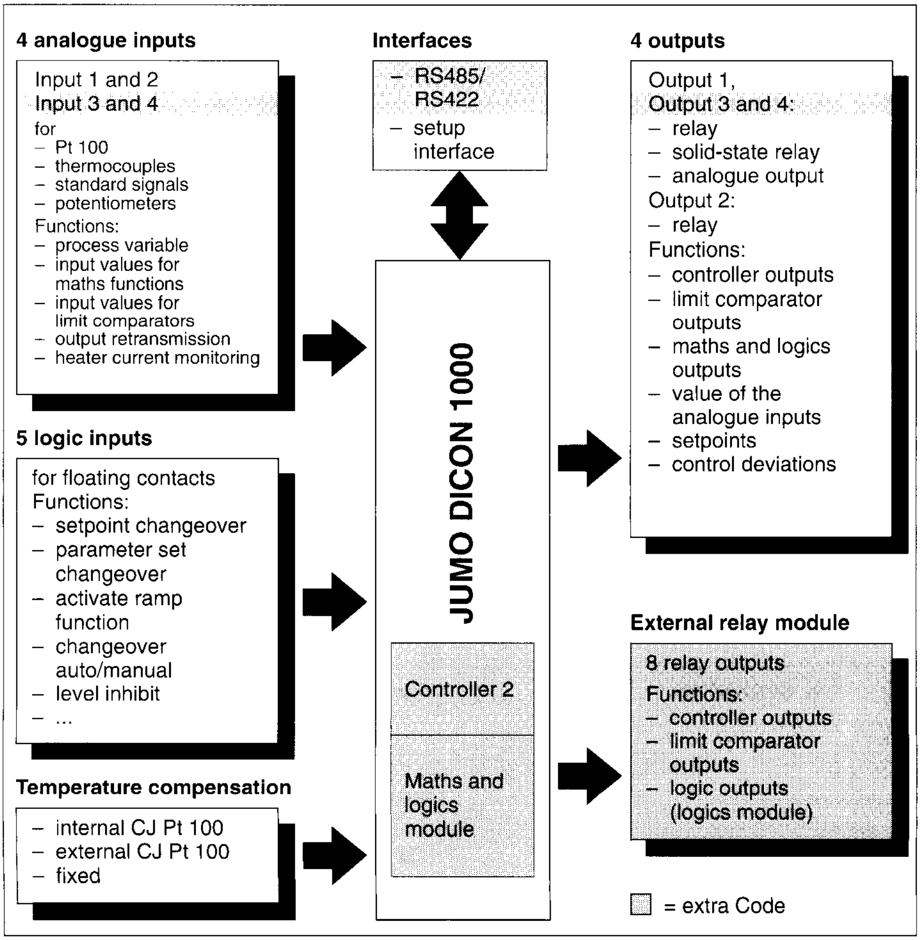
CONTENTS

1.1 Description

The JUMO DICON 1000 is a universal, freely programmable controller with one or two channels for different physical control parameters.
The instrument can be used as single and double setpoint controller, as modulating and proportional controller, and also as a proportional controller with integral actuator driver. The controller software features include a ramp function, parameter set changeover, self-optimization, a fuzzy logic module, as well as 8 limit comparators.

Linearisations for conventional transducers are held in the memory. The setup program can be used to program customized tables.
A maths and logics module is available as an extra. The controller can be integrated into a data network through its serial interface. The number of outputs can be increased through an external relay module with eight switching outputs.

1.2 Block structure



1.3 Arrangement of this Manual

The Manual is divided into individual information blocks (chapters) which are so arranged that the user can follow the individual items step by step.

Step	Chapter	Purpose
1	**1 INTRODUCTION**	❑ To find out how the documentation, in particular this Manual, is arranged! ❑ To get to know the symbols and forms of presentation!
2	**2 IDENTIFYING THE INSTRUMENT VERSION**	❑ To find out the instrument version from the details on the label!
3	**3 INSTALLATION**	❑ To install the instrument correctly in relation to the climatic conditions on site!
4	**4 ELECTRICAL CONNECTION**	❑ To make safe connections to the instrument with due regard to the "installation notes"!
5	**5 PREPARATION**	❑ To get to know the controls and indications on the front panel! ❑ To understand the principle of operation! ❑ To obtain an overview of the operating modes, states, levels and menus! **This is the most important precondition for the following chapters!**
6	**6 OPERATION**	❑ To achieve expertise in all settings and manipulations during operation! ❑ To be able to activate different operating modes!
7	**7 OPERATING LEVEL**	❑ To indicate and alter process parameters.

Step	Chapter	Purpose
8	**8 PARAMETER LEVEL**	❑ To determine parameter sets for controllers 1 and 2!
9	**9 CONFIGURATION LEVEL C1**	❑ To set controller-specific features!
	10 CONFIGURATION LEVEL C2	❑ To set system-specific features!
	11 CONFIGURATION LEVEL C3	❑ To identify the extra Codes incorporated in hardware and software!
10	**12 LOGIC INPUTS**	❑ To get to know the functions of the logic inputs!
11	**13 OPTIMISATION**	❑ To adapt the controller to the process loop using self-optimisation! ❑ To get to know the functions of the fuzzy parameters and their settings! ❑ To check the results of optimisation!
12	**14 RAMP FUNCTION**	❑ To get to know the ramp function!
13	**15 EXTRA CODES AND ACCESSORIES**	❑ To get to know extra Codes and accessories!
14	**16 EXAMPLES OF CONFIGURATION**	❑ To get to know different controller types and their configuration!
15	**17 RETROFITTING MODULES**	❑ To fit and remove modules safely!
16	**18 APPENDIX**	❑ Technical data ❑ Limit comparator functions ❑ Alarm messages, indication priorities ❑ Character set

1.4 Typographical conventions

1.4.1 Warning signs

The signs for **Danger** and **Warning** are used in this manual under the following conditions:

Danger This mark is used when there may be **danger to personnel** if the instructions are disregarded or not followed accurately.

Warning This mark is used when there may be **damage to equipment or data** if the instructions are disregarded or not followed accurately.

Warning This symbol is used when precaution have to be observed in handling components liable to be damaged by electrostatic discharges.

1.4.2 Note signs

Note This symbol is used if your **special attention** is drawn to a remark.

Reference This symbol refers to **additional information** in other handbooks, chapters or sections.

abcd[1]

Footnote Footnotes are **notes** which refer to certain points in the text. Footnotes consist of 2 parts: the text marking and the footnote text.

The text markings are arranged as continuous raised numbers.

The footnote text (in smaller typeface) is placed at the bottom of the page and starts with a number and a full stop.

*

Action This sign refers to the description of an **action to be performed**.

The **individual steps** are indicated by this asterisk, e.g.

* Press PGM key
* Enter with ENTER

1.4.3 Presentation

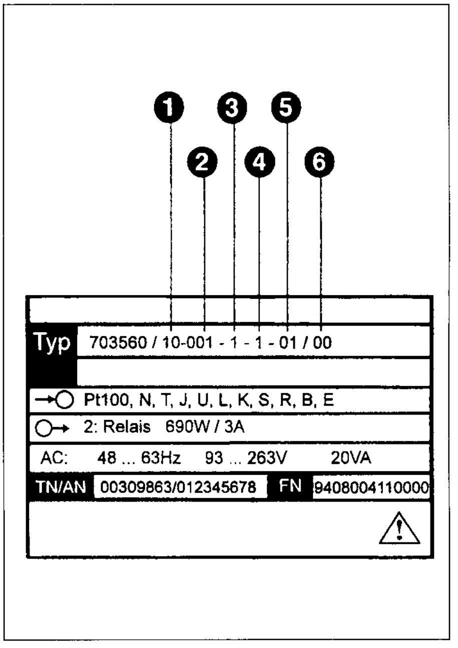
▲ ENTER	**Keys**	Keys are shown in a frame. Both symbols and texts are possible. Where a key has multiple functions (function keys) the text shown corresponds to the function which is currently active.
SETPOINT 1 0 0 .	**Matrix display**	The grey area represents the matrix display showing parameter values, text, messages and notes for operator guidance.
SETPOINT 1 0 0 . – – – – –	**Position**	The line marks the position where a value is being input.
❶	**Item**	This is followed by explanations for drawings and concepts.
↵	**Return**	Key on the PC keyboard to enter an input.

2.1 Type designation

The label is affixed to the housing. The type designation contains all factory settings such as controller function, inputs and extra Codes.

The Codes under ❻ are listed in sequence and separated by a comma.

The supply must agree with the voltage indicated on the label.



❶ Controller function

Description	■ ■
single-setpoint controller with O (break) function (relay de-energised for process above setpoint), controller structure can be configured	1 0
single-setpoint controller with S (make) function (relay de-energised for process below setpoint), controller structure can be configured	2 0
double-setpoint controller, controller structure can be configured	3 0
modulating controller, controller structure can be configured	4 0
proportional controller, controller structure and output signal can be configured	5 0
proportional controller with integral driver for motorised actuators	8 0

❷ Input 1 probe type

	■ ■ ■
resistance thermometer Pt 100 in 3-wire circuit	0 0 1
NiCr-Con E	0 3 8
Cu-Con T	0 3 9
Fe-Con J	0 4 0
Cu-Con U	0 4 1
Fe-Con L	0 4 2
NiCr-Ni K	0 4 3
Pt10Rh-Pt S	0 4 4
Pt13Rh-Pt R	0 4 5
Pt30Rh-Pt6Rh B	0 4 6
NiCrSi-NiSi N	0 4 8
linear input signals	
0 — 20 mA	0 5 2
4 — 20 mA	0 5 3
0 — 1 V	0 6 2
0 — 10 V	0 6 3
0 — 50 mV	0 6 4
0 — 2 V (for C-level controller)	0 7 3

❸ Output 1 output signal

	■
relay	1
solid state relay 1 A	2
logic 0/24 V	3
analogue output	
0 — 20 mA	4
4 — 20 mA	5
-20 / 0 / +20 mA	6
0 — 10 V	7
2 — 10 V	8
-10 / 0 / +10 V	9

Relay output is the normal version for Output 2.

❹ Operator guidance

	■
German	1
English	2
French	3

❺ Supply

93 — 263 V AC 48 — 63 Hz	0 1
20 — 53 V DC/AC 0/48 — 63 Hz	2 2

❻ Extra Codes, hardware

none	0 0
analogue inputs 3 + 4	0 1
output 3	3 .
output 4	4 .
relay	. 1
solid state relay	. 2
logic 0/24 V	. 3
analogue output	
0 — 20 mA	. 4
4 — 20 mA	. 5
−20 / 0 / +20 mA	. 6
0 — 10 V	. 7
2 — 10 V	. 8
−10 / 0 / +10 V	. 9
interface RS422, isolated	5 2
interface RS485, isolated	5 3
Controller meets requirements of Underwriter Laboratories Inc.	6 1
Carbon level controller (only factory-configured)	0 4

❻ Extra Codes, software

second controller	0 2
maths and logics module (incl. difference, ratio and psychrometric humidity)	0 3

Software extra Codes can be enabled by using "Code" in the setup program (also see Online help).

2.2 Accessories

External relay module ER8 with eight relays

Supply 93 — 263 V AC
Sales No. 70/00325805

Supply 20 — 53 V DC/AC
Sales No. 70/00325806

⇨ Chapter 15.1

PC interface with TTL/RS232 converter
Sales No. 70/00301315

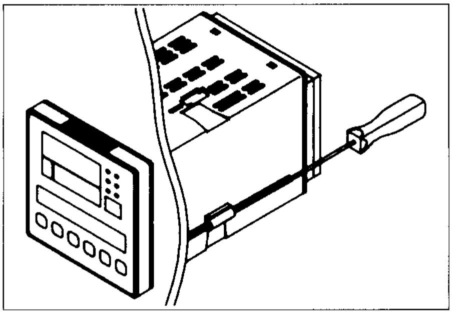
⇨ Chapter 15.4

Setup program for configuration and parameter setting

⇨ Chapter 15.4

3.1 Location and climatic conditions

The instrument location should as far as possible be free from shock and vibration. Electro-magnetic fields, e.g. from motors, transformers etc., should be avoided. The ambient temperature at the instrument location should be between 0 and 50 °C at a relative humidity of not more than 75 %. Corrosive gases and fumes reduce the life of the controller.

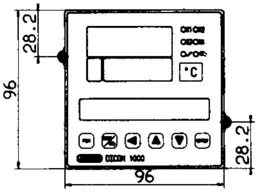


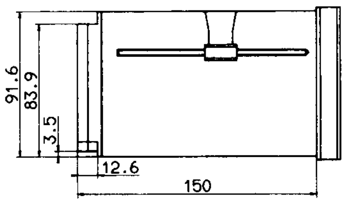
3.2 Fitting in position

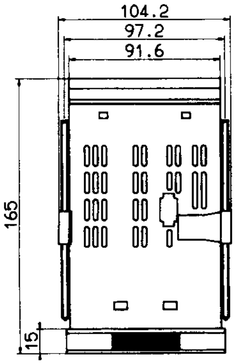
* Attach the blank label, which is provided, to the side of the controller.
* Insert the controller from the front into the panel cut-out.
* Insert the mounting brackets from behind the panel into the cut-outs at the sides of the housing; the flat sides of the brackets must be against the housing.
* Place the brackets against the rear of the panel and tighten them evenly using a screwdriver.

mm	inch	mm	inch
3.5	0.14	91.6	3.61
5	0.2	$92.0^{+0.8}$	$3.62^{+0.03}$
12.6	0.50	96	3.78
15	0.59	97.2	3.83
20	0.8	104.2	4.10
28.2	1.11	150	5.91
60	2.4	165	6.50
83.9	3.30		

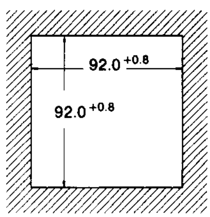
3.3 Dimensions



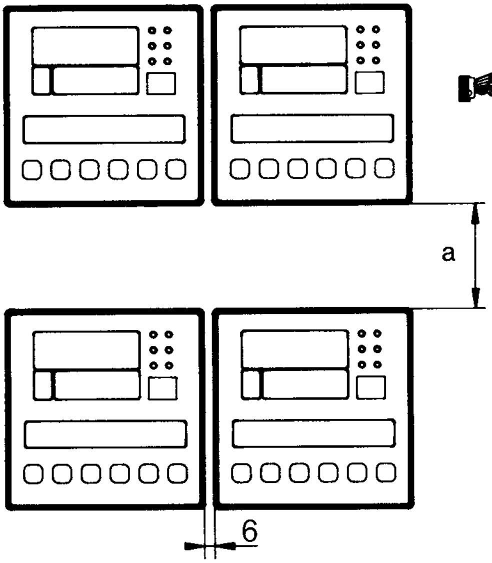




Panel cut-out to DIN 43 700



3.4 Close-up mounting



The setup interface is located at the top of the housing.

A minimum spacing " a " between two controllers is required to provide access for the PC interface plug.

Minimum spacing	a
with PC interface	60 mm
without PC interface	25 mm

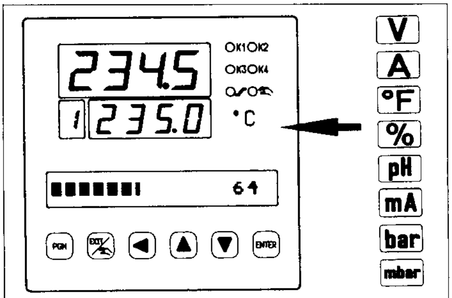
3.5 Cleaning the front panel

The front panel can be cleaned with commercially available rinsing and cleaning agents. It has limited resistance to organic solvents (e.g. alcohol, surgical spirit, P1, xylol etc.). Do not use a high-pressure cleaner!

3.6 Affixing the unit label

The controller is supplied as standard with a collection of labels with different physical units.

* Peel off the backing foil from the unit label and affix the latter over the printed °C sign.



4.1 Installation notes

The choice of cable, the installation and the electrical connection of the instrument must meet the requirements of VDE 0100 "Regulations on the Installation of Power Circuits with nominal voltages below 1000 V" or the appropriate local regulations.

- Work inside the instrument must only be carried out to the extent described and, like the electrical connection, only by suitably qualified personnel.
- Isolate the unit on line and neutral from the supply if there may be contact with live parts during work.
- A built-in current limiting resistor interrupts the supply circuit in case of a short-circuit. The external fuse of the supply should not be rated above 1 A (slow). The load circuit has to be fused for the maximum relay current in order to prevent welding of the output relay contacts in case of an external short-circuit.
- Electromagnetic compatibility conforms to the Standards and Regulations specified under Technical Data.

⇨ Chapter 18.1

- Input, output and supply lines should be run separately and not parallel to each other.
- Sensor and interface lines should be screened and twisted together. Do not run them close to live components or cables. Ground the screen only at one end at the instrument terminal TE.
- Ground the instrument at terminal TE to the protective ground conductor. This line should have the same cross-section as the supply lines. Run the ground lines in a star configuration to a common ground point connected to the ground conductor of the supply. Do not loop the ground connections, i.e. do not run them from one instrument to another.

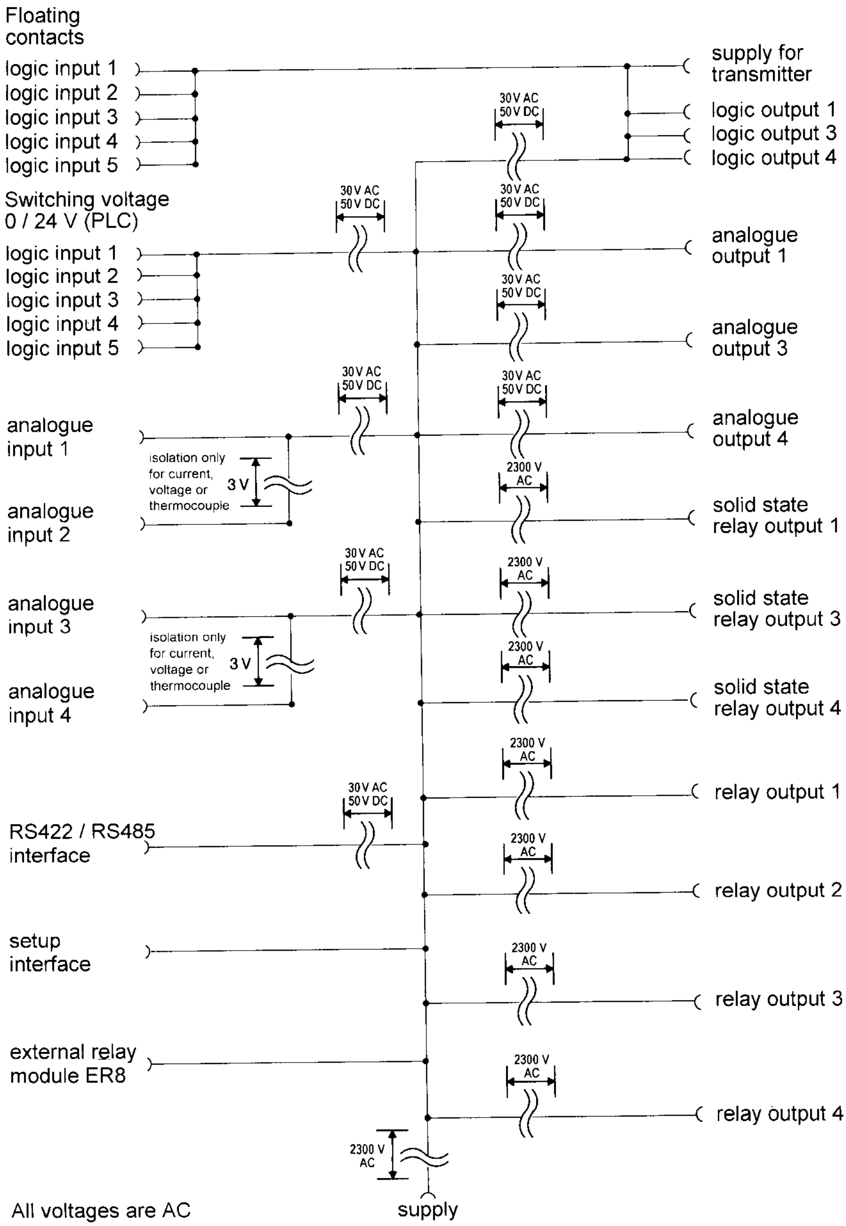
⇨ Chapter 4.4

- Do not connect any further loads to the supply terminals of the instrument.
- The instrument is not suitable for installation in hazardous areas.
- Apart from unsatisfactory installation, incorrect settings on the controller (setpoint, data at parameter and configuration level, alterations inside the instrument) may interfere with the proper operation of the controlled process or result in damage.

  Provision should therefore always be made for safety devices independent of the controller, e.g. overpressure valves or temperature limiters/monitors.

  Setting up must be restricted to qualified personnel. Please observe the appropriate safety regulations in this connection. Adaptation (self-optimisation) cannot be expected to handle all possible control loops so that there is theoretically a possibility of setting unstable parameters. The final process value should therefore be checked for its stability.
- The maximum permitted voltage difference between the inputs of the controller and TE is 30 V AC or 50 V DC.
- All input and output cables without power connection must be twisted and screened. Earth the screen at one end at the instrument side.
- Conductors for UL-approved devices
  Use copper only!
  sol/str: ø 0.5 - 1.5 mm^2 AWG No. 20-16
  str: ø 2.5 mm^2 AWG No. 14

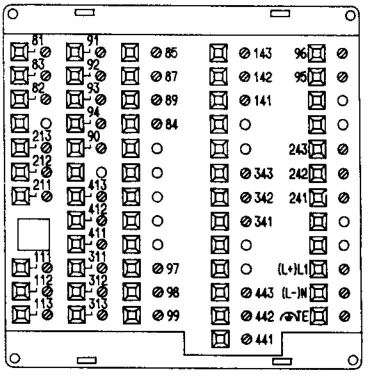
4.2 Isolation



All voltages are AC

4.3 Connection diagram

Rear view with screw terminals



⚠ The electrical connection must only be made by suitably qualified personnel.

Connect the controller connection TE with the system TE to discharge any interference potentials. If no TE connection is available, use the PE connection of the supply.

Outputs 1 to 4		Relay[1]	Solid state relay[2]	Logic outputs	Analogue outputs	Terminals
Relay, solid state relay or logic outputs analogue outputs	1	141 (O) n.c. (break) 142 (P) common 143 (S) n.o. (make)	142 143	142– 143+	142– 143+	141 142 143
	2	241 (O) n.c. (break) 242 (P) common 243 (S) n.o. (make)				241 242 243
	3	341 (O) n.c. (break) 342 (P) common 343 (S) n.o. (make)	342 343	342– 343+	342– 343+	341 342 343
	4	441 (O) n.c. (break) 442 (P) common 443 (S) n.o. (make)	442 443	442– 443+	442– 443+	441 442 443
External relay module ER8		97 RXD/TXD (+) 98 RXD/TXD (–) 99 GND	communication with external relay module			97 98 99
Interface RS 422	RXD	91 RXD (+) 92 RXD (–)	receive data			91 92 93 94 90
	TXD	93 TXD (+) 94 TXD (–)	send data			
	GND	90 GND				
Interface RS 485	RXD/TXD	93 RXD/TXD (+) 94 RXD/TXD (–)	receive/send data			93 94 90
	GND	90 GND				

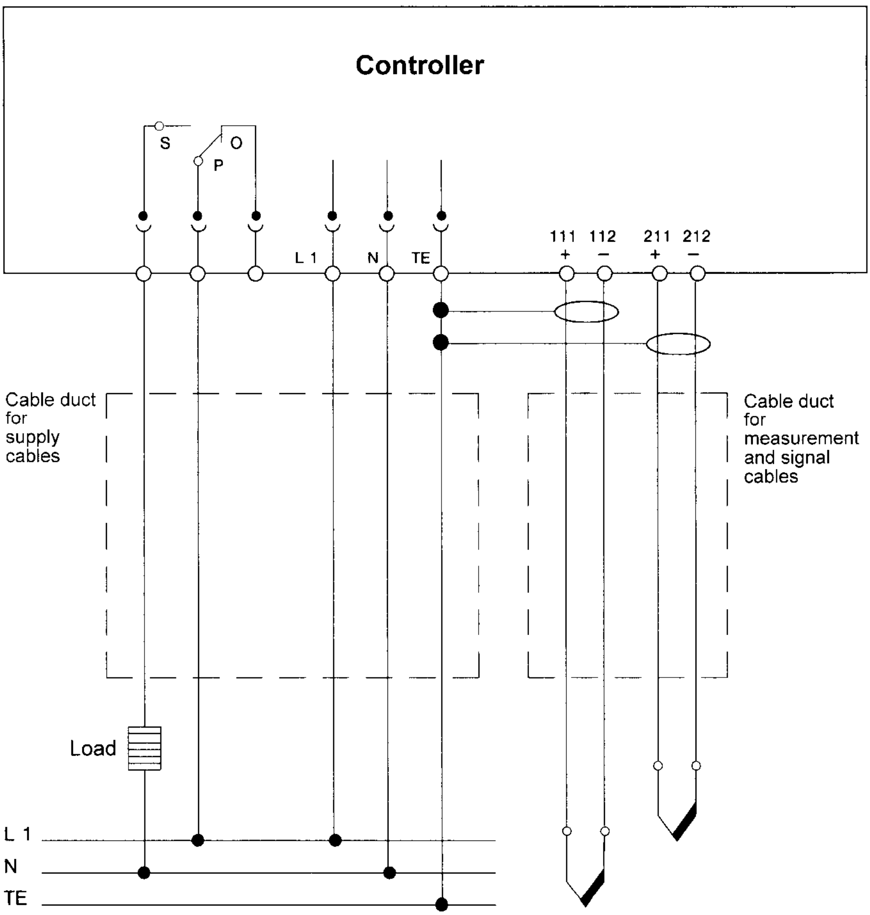
1. Contact protection circuit 22 nF / 56 Ω between common and make
2. Varistor protection circuit 300 V

4 ELECTRICAL CONNECTION

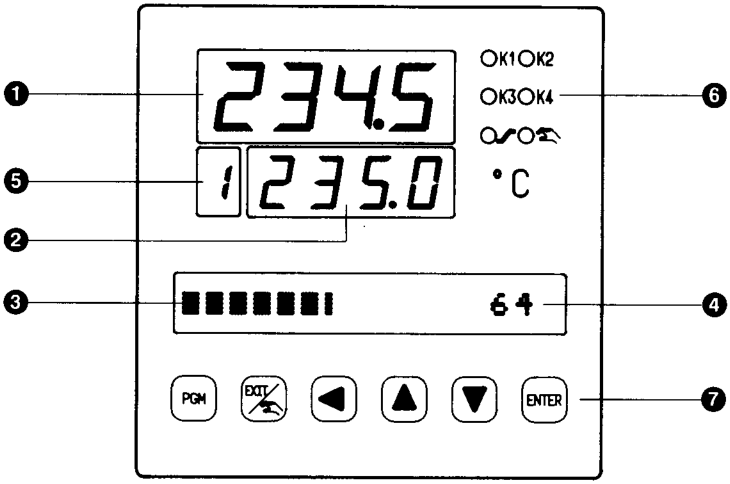
Output	Connections					Terminals
Source for 2-wire transmitters	95 + 18 V 45 mA supply 96 –					95 96 + –
Supply as on label (UC = AC/DC)	TE technical earth (ground) L1 line N neutral AC			L+ L– DC		L+ L– TE L1 N
Analogue inputs	Input 1	Input 2	Input 3	Input 4		
Thermocouple	111+ 112–	211+ 212–	311+ 312–	411+ 412–		.11 .12 + –
Resistance thermometer in 3-wire circuit	111 112 113	211 212 213	311 312 313	411 412 413		.12 .13 .11
Resistance thermometer in 2-wire circuit	111 112 113	211 212 213	311 312 313	411 412 413	$R_{comp} = R_{line}$	.12 .13 .11 R_{comp}
Current input	111+ 113–	211+ 213–	311+ 313–	411+ 413–		.11 .13 + –
Voltage input	111+ 112–	211+ 212–	311+ 312–	411+ 412–		.11 .12 + –
Resistance transmitter	111 112 113	211 212 213	311 312 313	411 412 413	.11 start (A) .12 slider (S) .13 end (E)	.11 .12 .13 A S E
Logic inputs						
Logic input 1	81 82				81 82	81 82 + –
Logic input 2	83 82				83 82	83 82 + –
Logic input 3	85 84				85 84	85 84 + –
Logic input 4	87 84	floating contacts or voltage 0 / 24 V (to special order)			87 84	87 84 + –
Logic input 5	89 84				89 84	89 84

4.4 Earth (ground) connection

Connect the controller connection TE with the system TE to discharge any interference potentials. If no TE connection is available, use the PE connection of the supply.



5.1 Displays and keys on the front panel



Displays

❶	234.5	13 mm red display, can be configured (factory-set: process value)
❷	235.0	10 mm green display, can be configured (factory-set: setpoint)
❸,❹	▪▪▪▪▪▪▪▪ 64	dot matrix display, green (factory-set: output (bargraph/decimal value))
❺	1	7 mm red channel display lights up when controller 2 is activated

Status indication

❻	○K1 . . . ○K4	lights up when switching outputs 1 to 4 are activated
	○ ramp	lights up during ramp function
	○ manual	lights up during manual operation

Keys

❼	PGM	programming	◄	digit
	EXIT	EXIT/ manual	▲	increment
	ENTER	ENTER	▼	decrement

5.2 Operating modes and states

Operating modes/states	Notes
Normal display	Initial status
Operate, set parameters, configure	The user makes settings at levels and menus
Ramp function	Status indication "O _/‾" lights up ⇨ Chapter 14
Manual operation	Status indication "O☜" lights up ⇨ Chapter 6.2, 7.5
Self-optimisation	Message: TUNING ON ⇨ Chapter 6.3, 7.4, 13.2
Initialisation	After connection to the supply all indications light up briefly. Display ❷ is flashing.
Automatic channel scrolling	⇨ Chapter 7.6
Overrange/ underrange	The outputs move to defined states. ⇨ Chapter 9.5, 18.3

5.3 Principle of operation

In order to obtain a clear picture of the many possible manipulations the parameters and functions are arranged on seven different **levels**:

Standard display
Initial status

Setpoint
The current setpoint can be selected here.

Operating level
This level can be used to indicate measurements, alter parameters and activate functions and operating modes:
- setpoints
- process parameters
- self-optimisation (start/stop)
- manual operation (on/off)
- automatic channel scrolling
- channel changeover (controller 1 / controller 2)

Parameter level[1]
The parameters at this level are used to adjust the controller to the control loop. The level contains:
- controller parameters (Xp1, Xsh ...)

A total of four parameter sets each for controller 1 and controller 2 are provided.

Configuration level C 1 (controller data)[1]
This level serves to adapt the controller to the control task. It contains:
- data specific to the controller (controller types, inputs and outputs, limit comparators ...)

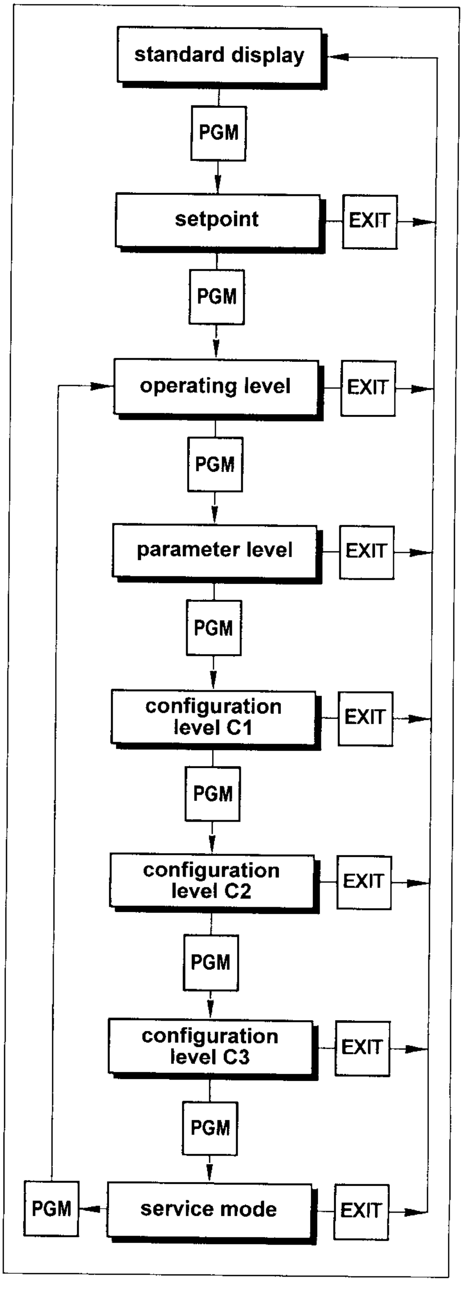
Configuration level C 2 (system data)[1]
This level also serves to adapt the controller to the control task. It contains:
- data specific to the system (displays, interface ...)

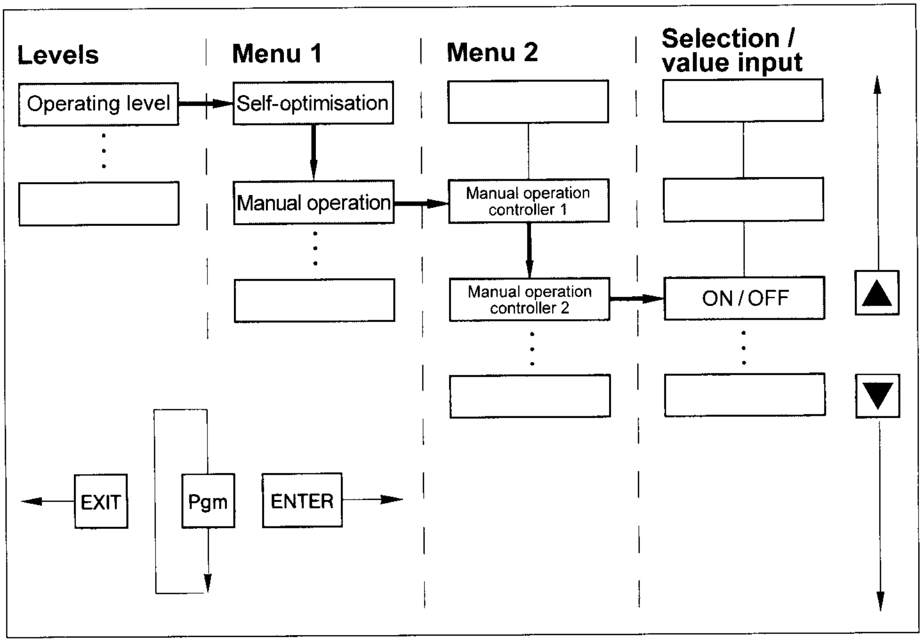
Configuration level C 3 (Codes)
The parameters at this level contain extra Codes for hardware and software in accordance with the controller specification:
- hardware and software Codes (version, maths and logics module)

No data can be input at this level. It changes automatically on alterations and retrofitting of hardware or software.

Service mode
Only accessible to service personnel.

1. protected by access code.





From the operating level onwards every level is divided into **menus** whose number varies. This results in a tree-like structure.

In order to alter a certain parameter the user runs through the levels and menus according to the menu items and finally reaches a **selection** (of functions) or a **value input**.

The controller is provided for operator guidance with a matrix display which permits displaying alphanumerical characters. In this way the operator is assisted by messages and notes in plain language.

During programming of the controllers the menu items contained in the level and menu structure appear on the matrix display in plain language.

The selection from a list of functions and the value input are also presented through messages in plain language.

⇨ The factory settings at the operating and parameter levels as well as at the configuration levels C1 and C2 are described in Chapters 7, 8, 9 and 10.

⇨ A simplified operating scheme entitled **"Overview of the key functions"** appears on the fold-out at the beginning of the Operating Manual. Exceptions in the key functions are specially mentioned.

Time-out function

The time-out function is activated when the controller is in the operating, parameter or configuration mode.

If no key is pressed for about 30 seconds the controller automatically returns to the standard display.

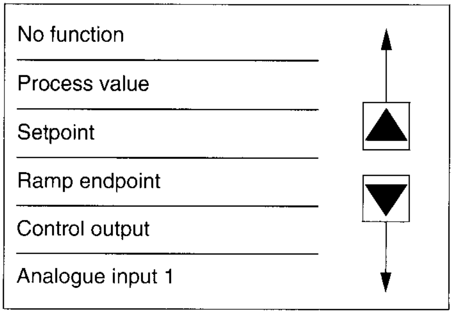
If this time is not sufficient it can be altered at configuration level C2.

⇨ Chapter 10.7

Selection

Here a function is selected from a list. The functions appear on scrolling in the matrix display, e.g.

RAMP END

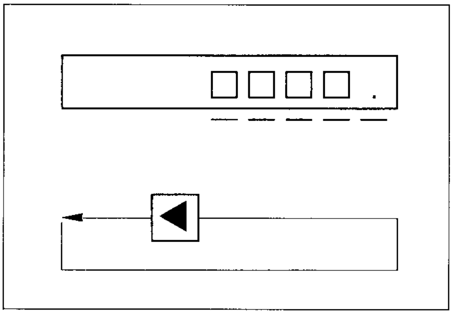


- ✱ Select function with [▲] and [▼] (matrix display is flashing!)
- ✱ Enter with [ENTER]

Value input

Here a value is assigned to a menu item in the matrix display.

SETPOINT 100.



- ✱ Select digit with [◄] (selected digit is flashing!)
- ✱ Alter value or shift decimal point with [▲] and [▼]
  The sign is altered in the fourth place from the right (– / –1).
- ✱ Enter with [ENTER]

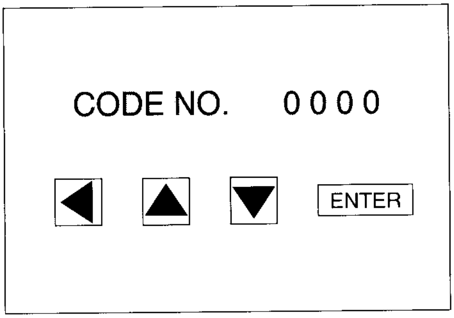
- If an illegal value is input the matrix display shows the minimum or maximum permitted value.
  The display is flashing.
  - ✱ Repeat the input
- If the value can not be represented using the selected decimal point, special characters appear instead of the numbers.

SETPOINT ✱✱.✱✱

- ✱ Shift decimal point
- A value consists of a maximum of 4 places.
  (before + after the decimal point)

5.4 Level inhibit and access code

The parameter level and the configuration levels C1 and C2 as well as the customized recalibration are protected by a 4-digit numerical access code. If one of these levels or the menu item is selected the controller requests the access code.



Factory-set codes

Parameter level	0001
Configuration level C1	0002
Configuration level C2	0003
Customized recalibration	0004

The access codes can only be changed through the setup program.

Parameter level and configuration levels C1 and C2 can be inhibited through a logic input. Access to these levels via the keys is then no longer possible.

Chapter 10.3, 12.4

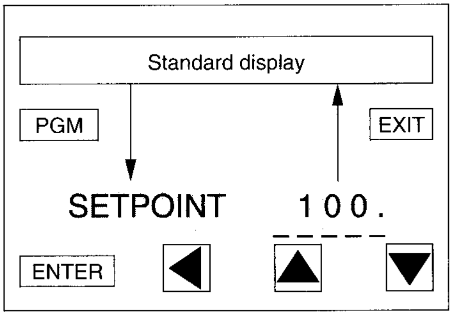
6.1 Altering the setpoint

The current setpoint can be altered at the setpoint level.

⇨ The range of the setpoint can be restricted (setpoint limits).

Chapter 9.7

- * Change to the setpoint level with PGM
- * Alter the current setpoint with ▲, ▼ and ◄
- * Enter with ENTER
- * The new setpoint is now effective.
- * Return to the standard display with EXIT



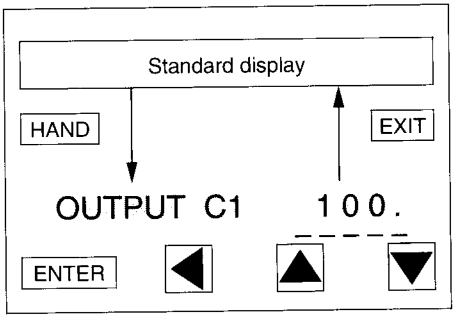
6.2 Manual operation

The control loop can be opened by changing over to manual operation; the controller output is then adjusted manually.

Operating with keys:

* Change to manual operation with HAND
* Alter the controller output with ▲, ▼ and ◄
* Enter with ENTER
  The new controller output is now effective.
* Terminate manual operation with EXIT

The control loop is closed again and the output is determined by the controller.



Operating through menu item:

⇨ OPERATING LEVEL:
manual operation, Chapter 7.5

* Selection:

  MANUAL C1 ON

* Quit operating level with EXIT
* Alter the controller output with ▲, ▼ and ◄
* Enter with ENTER
  The new controller output is now effective.
* Terminate manual operation by selecting:

  MANUAL C1 OFF

Special case: Modulating controller and proportional controller with integral driver

* Operation of the actuator motor (clockwise/anticlockwise rotation) using the keys ▲ and ▼

6.3 Self-optimisation

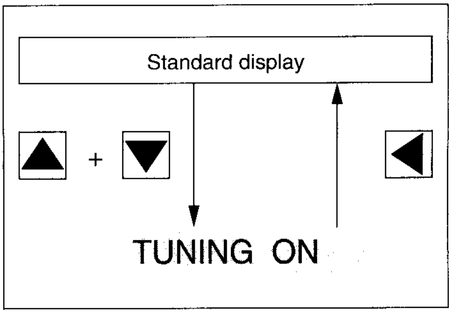
The self-optimisation function can be started to adjust the controller parameters to the control loop.

Operating with keys:

* Start with [▲] and [▼]
  (press both keys simultaneously!)

The duration of self-optimisation is approximately 10 times the delay time (Tu) of the control loop.

* Abort with [◄]



Operating through menu item:

⇨ OPERATING LEVEL: self-optimisation, Chapter 7.4

* Start self-optimisation by selecting:

  TUNE C1 ON

* Terminate self-optimisation by selecting:

  TUNE C1 OFF

⇨ Chapter 7.4, 12.1, 13.2

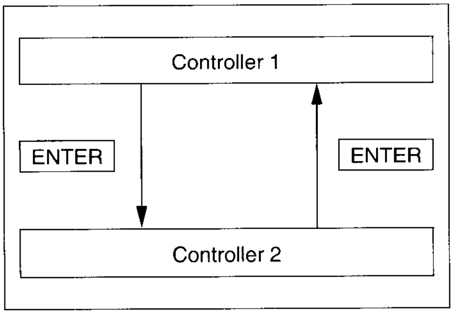
6.4 Channel changeover

Only when controller 2 is activated (channel indication is illuminated)

The process variables of the controllers are shown (depending on configuration) on the front display. It is possible to switch over between the displays of the process variables of the two controllers.

Operating with keys

* Changeover controller 1 - controller 2 with ENTER



Operating through menu item

OPERATING LEVEL: channel changeover, Chapter 7.7

Operating through the keys (setpoint alteration, start of self-optimisation, manual operation) refers to the controller whose process variables are shown on the displays.

7.1 Overview

Setpoints
- Setpoint 1 controller 1
- Setpoint 2 controller 1
- Setpoint 3 controller 1
- Setpoint 4 controller 1
- Setpoint 1 controller 2
- Setpoint 2 controller 2
- Setpoint 3 controller 2
- Setpoint 4 controller 2

Process variables
- Analogue input 1
- Analogue input 2
- Analogue input 3
- Analogue input 4
- Math 1
- Math 2
- Output controller 1
- Output controller 2

Self-optimisation
- Self-optimisation controller 1
- Self-optimisation controller 2

Manual operation
- Manual operation controller 1
- Manual operation controller 2

Automatic channel scrolling

Channel changeover
- Controller 1
- Controller 2

7.2 Setpoints

Operating level

Setpoints ❶
Process variables
Self-optimisation
Manual operation
Automatic channel scrolling
Channel changeover

Setpoint 1 controller 1
Setpoint 2 controller 1
Setpoint 3 controller 1
Setpoint 4 controller 1
Setpoint 1 controller 2
Setpoint 2 controller 2
Setpoint 3 controller 2
Setpoint 4 controller 2
❷

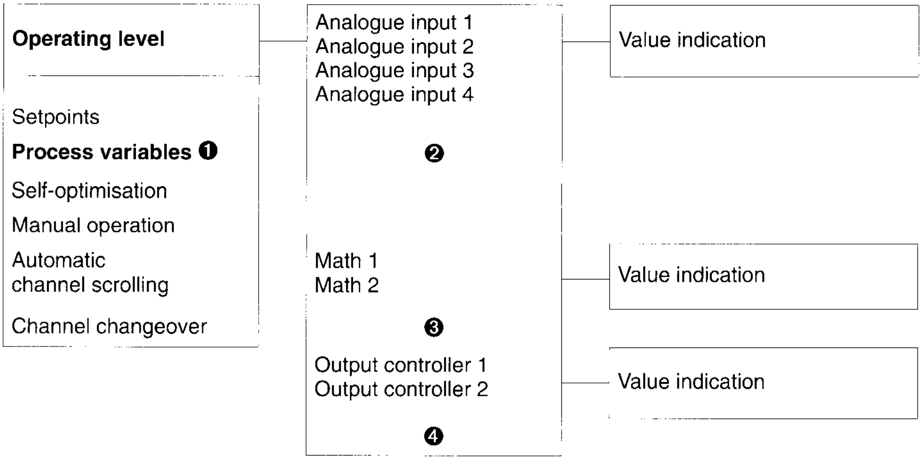
Value * _____

Value range: –1999 to +9999
factory-set: 0

Setpoints

No.	Item	Display	Notes
❶	Setpoints	SETPOINTS	Four setpoints are available for each of the two controllers. The setpoints are switched over through logic inputs. ⇨ Configuration level C2: Logic inputs → Logic input 1 — 5 → Setpoint changeover controller 1/2 Chapter 10.3 ⇨ Chapter 12.3
❷	Setpoint 1 controller 1	SPT1. CONTROLLER1	—

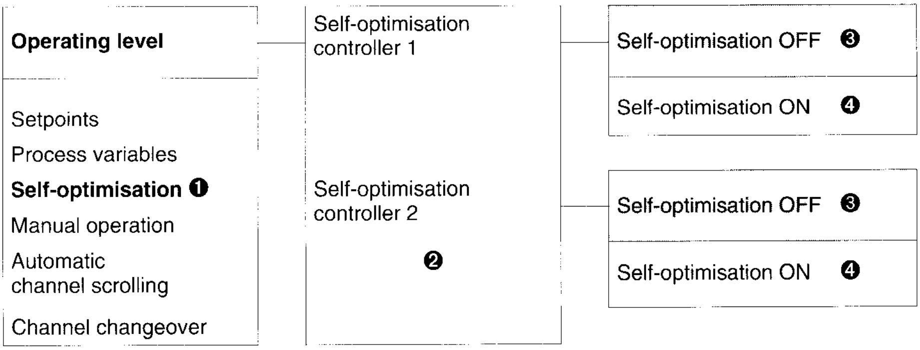
7.3 Process variables



Process variables

No.	Item	Display	Notes
❶	Process variables	PROCESS PARAMS	Here the different process variables are shown on the matrix display.
❷	Analogue input 1	ANALOG INPUT 1	Value of the selected analogue input 1 — 4.
❸	Math 1	MATH 1	Result of a mathematical operation. The formulae are entered in the setup program. ⇨ Configuration level C1 Chapter 9.7, 15.3, 16.13
❹	Output controller 1	OUTPUT C1	Output in %

7.4 Self-optimisation



Explanation:

* = input a value

☐ = factory setting

Self-optimisation

No.	Item	Display	Notes
❶	Self-optimisation	TUNE	⇨ Chapter 13.2
❷	Self-optimisation controller 1	TUNE C1	—
❸	Self-optimisation OFF	TUNE C1 OFF	—
❹	Self-optimisation ON	TUNE C1 ON	—

7.5 Manual operation

Operating level

Setpoints
Process variables
Self-optimisation
Manual operation
Automatic channel scrolling
Channel changeover

Manual operation controller 1
- Manual operation OFF ❷
- Manual operation ON ❸

Manual operation controller 2 ❶
- Manual operation OFF ❷
- Manual operation ON ❸

Explanation:
* = input a value
☐ = factory setting

Manual operation

No.	Item	Display	Notes
❶	Manual operation controller 1	MANUAL C1	—
❷	Manual operation OFF	MANUAL C1 OFF	—
❸	Manual operation ON	MANUAL C1 ON	—

7.6 Automatic channel scrolling

Operating level		Value * _____
Setpoints		Value range: 0 to +9999
Process variables		factory-set: 0
Self-optimisation		0 = switched off
Manual operation		(10 = 10 sec approx)
Automatic channel scrolling ❶		
Channel changeover		

Explanation:

* = input a value

☐ = factory setting

Automatic channel scrolling

No.	Item	Display	Notes
❶	Automatic channel scrolling	SCROLLMODE	Input of the time interval between the automatic display changeover from controller 1 to controller 2 and vice versa.

7.7 Channel changeover

Operating level		Controller 1
Setpoints		Controller 2
Process variables		
Self-optimisation		
Manual operation		
Automatic channel scrolling		
Channel changeover ❶		

Explanation:

* = input a value

☐ = factory setting

Channel changeover

No.	Item	Display	Notes
❶	Channel changeover	SWITCH CHANNEL	The process variables of the controller (depending on configuration) are shown on the front displays. It is possible to switch over between displaying the process variables of the two controllers.

8.1 Overview

- **Parameter sets controller 1**
- **Parameter sets controller 2**
  - Parameter set 1
  - Parameter set 2
  - Parameter set 3
  - Parameter set 4
    - Controller structure 1
    - Controller structure 2
    - Xp1
    - Xp2
    - Tv1
    - Tv2
    - Tn1
    - Tn2
    - Cy1
    - Cy2
    - Xsh
    - Xd1
    - Xd2
    - TT
    - Y0
    - Y1
    - Y2
    - Tk1
    - Tk2
    - Fc1
    - Fc2

Four parameter sets can be stored for each controller. The changeover is made through logic inputs.

Configuration level C2:
Logic inputs ‣
Logic input 1 — 5
Chapter 10.3

Chapter 12.3

Parameters with index " 2 " (e.g. Xp2, Tv2) are only relevant for a double-setpoint controller (second output).

8.2 Parameter set

Parameter	Display	Value range	Factory-set	Explanation
Controller structure	STRUCTURE 1	P, I, PD, PI, PID	PID	The controller structure can be switched between P, I, PD, PI and PID structure. (Structure 2 refers to the second output on a double-setpoint controller)
	STRUCTURE 2	P, I, PD, PI, PID	PID	
Proportional band	PROPBD XP1	0 — 9999 digit	0 digit	Value of the proportional band. The controller structure is ineffective when Xp1,2 = 0
	PROPBD XP2	0 — 9999 digit	0 digit	
Derivative time	DERIV TV1	0 — 9999 sec	80 sec	Influences the derivative component of the controller output signal.
	DERIV TV2	0 — 9999 sec	80 sec	
Reset time	RESET TN1	0 — 9999 sec	350 sec	Influences the integral component of the controller output signal.
	RESET TN2	0 — 9999 sec	350 sec	
Switching cycle time	CYCLE CY1	0 — 9999 sec	20 sec	In the case of a switching output the switching cycle time should be selected so that the energy supplied to the process is virtually continuous while the switching element is not stressed excessively.
	CYCLE CY2	0 — 9999 sec	20 sec	
Contact spacing	CT SEP XSH	0 — 999 digit	0 digit	Spacing between the two control contacts on double-setpoint controllers and modulating controllers.
Switching differential	DIFF XD1	0 — 999 digit	1 digit	Differential on switching controllers for Xp = 0.
	DIFF XD2	0 — 999 digit	1 digit	
Stroke time	STR TIM TT	5 — 3000 sec	60 sec	Actual stroke time range of the control valve on modulating controllers.
Working point	WORKPT Y0	−100 to +100 %	0 %	Output on P and PD controllers (y = Y0 at x = w).
Output limit	STR LIM Y1	0 — 100%	100 %	High output limit.
	STR LIM Y2	−100 to +100%	−100 %	Low output limit.
Minimum ON time	TIME REL1	0 — 60 sec	0 sec	Limit of switching frequency in the case of switching outputs.
	TIME REL2	0 — 60 sec	0 sec	
Fuzzy intensity	FZ INT FC1	0 — 100%	0 %	Intensity of the fuzzy signal added to controller output to improve control quality.
Fuzzy parameter adjustment	FZ PAR FC2	0 — 100%	30 %	Influence on the controller parameters through activated fuzzy module to improve control quality.

9.1 Overview (controller data)

- **Controllers**
  - Controller mode controller 1 + 2
  - Time constant for control loop monitoring controller 1 + 2
- **Limit comparators**
  - Limit comparator 1 — 8
    - Function
    - Action
    - Differential
    - Limit
    - Function on overrange or underrange
- **Inputs**
  - Function
    - Inputs controller 1 + 2
      - Process value
      - External setpoint
      - External setpoint with correction
      - Stroke retransmission
      - Additive disturbance
      - Multiplying disturbance
    - Inputs of limit controllers 1 — 8
      - lk process value
      - lk setpoint
  - Type
    - Analogue input 1 — 4
      - Transducer
      - Linearisation
      - Process value correction
      - Constant cold junction temperature
      - External cold junction temperature
      - Heater current monitoring
      - Display start
      - Display end
      - Range start
      - Range end
      - Filter time constant
- **Outputs**
  - Output 1 — 4
    - Function
    - Output signal
    - Zero
    - Full scale
    - Output signal on overrange/underrange
- **External relay module**
  - External output 1 — 8
    - Function
    - Function on overrange or underrange
- **Special functions**
  - Ramp
    - Ramp controller 1 + 2
      - Function
      - Slope
      - Unit
  - Manual output
    - Manual output controller 1 + 2
  - Manual operation
    - Manual operation controller 1 + 2
  - Self-optimisation
    - Self-optimisation controller 1 + 2
  - Setpoint limits
    - Setpoint limits controller 1 + 2
      - Setpoint start
      - Setpoint end
  - Maths and logics module
    - Math 1 + 2
      - Function
      - Variable a
      - Variable b
      - Range start
      - Range end
    - Logic 1 + 2

9.2 Controllers

C1

- **Controllers**
- Limit comparators
- Inputs
- Outputs
- External relay module
- Special functions

Parameter	Setting	Remarks
Controller mode controller 1 ❶ / Controller mode controller 2 ❶	No function[1]	factory-set on controller 2
	Single-setpoint controller O (break) function ❸	factory-set on controller 1
	Single-setpoint controller S (make) function ❹	
	Double-setpoint controller switching / switching ❺	
	Double-setpoint controller falling characteristic / switching ❻	
	Double-setpoint controller switching / rising characteristic ❼	
	Double-setpoint controller falling characteristic / rising characteristic ❽	
	Modulating controller ❾	
	Proportional controller with integral driver for motorised actuators ❿	
	Proportional controller falling characteristic ⓫	
	Proportional controller rising characteristic ⓬	
Time constant for control loop monitoring controller 1 ❷	Value * _____	Value range: 0 — 9999 sec factory-set: 0 sec 0 sec = switched off
Time constant for control loop monitoring controller ❷	Value * _____	Value range: 0 — 9999 sec factory-set: 0 sec 0 sec = switched off

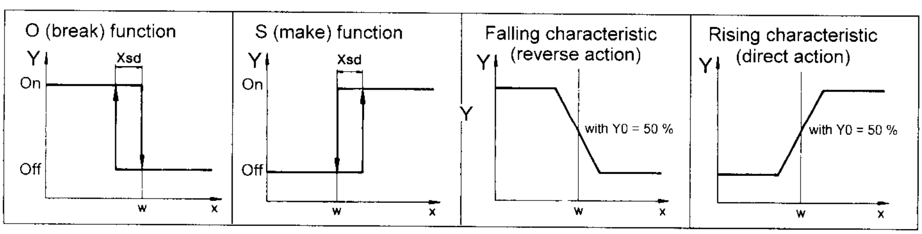
Explanation:

* = input a value

☐ = factory setting

1. "No function" not possible for controller mode controller 1

Controller functions



Y= control output, w = setpoint, x = process value, X_{Sd} = switching differential

Controller

No.	Item	Display	Notes
❶	Mode controller X	CONTROLR MODE CX	Function of controller(s)
❷	Time constant for control loop monitoring controller X	MON TIM CX	The DICON 1000 tracks the changes in the process value. If the process value does not follow the controller output signal within the programmed interval, a fault is recognised. The time constant must be matched to the control loop.
❸	Single-setpoint controller O (break) function	1-SETPT FUNCT. O	Relay de-energised for process above setpoint
❹	Single-setpoint controller S (make) function	1-SETPT FUNCT. S	Relay de-energised for process below setpoint
❺	Double-setpoint controller switching / switching	2-SETPT SWITCHG	Two relay or logic outputs
❻	Double-setpoint controller falling characteristic / switching	2-SETPT ANAL/SWG	One analogue output and one relay or logic output
❼	Double-setpoint controller switching/ rising characteristic	2-SETPT SWG/ANAL	One relay or logic output and one analogue output
❽	Double-setpoint controller falling characteristic/ rising characteristic	2-SETPT ANALOG	Two analogue outputs ⇨ ⓫ and ⓬
❾	Modulating controller	MODULATING	—
❿	Proportional controller with integral driver for motorised actuators	ACTUATOR DRIVER	⇨ Configuration level C1: Inputs → Function → Inputs controller 1 + 2 → Stroke retransmission Chapter 9.4 ⇨ Chapter 16.7
⓫	Proportional controller falling characteristic	ANAL. CONTRLR O	Output y reduces as process value x increases
⓬	Proportional controller rising characteristic	ANAL. CONTRLR S	Output y increases as process value increases

9.3 Limit comparators

C1

- Controllers
- **Limit comparators** ❶
- Inputs
- Outputs
- External relay module
- Special functions

Limit comparator 1
Limit comparator 2
Limit comparator 3
Limit comparator 4
Limit comparator 5
Limit comparator 6
Limit comparator 7
Limit comparator 8

❷

Function ❸	No function lk1 lk2 lk3 lk4 lk5 lk6 lk7 lk8
Action	Absolute ❻ Relative ❼
Switching differential ❹	Value* ____
Limit	Value* ____
Function on overrange / underrange ❺	Relay de-energised Relay energised

Explanation:

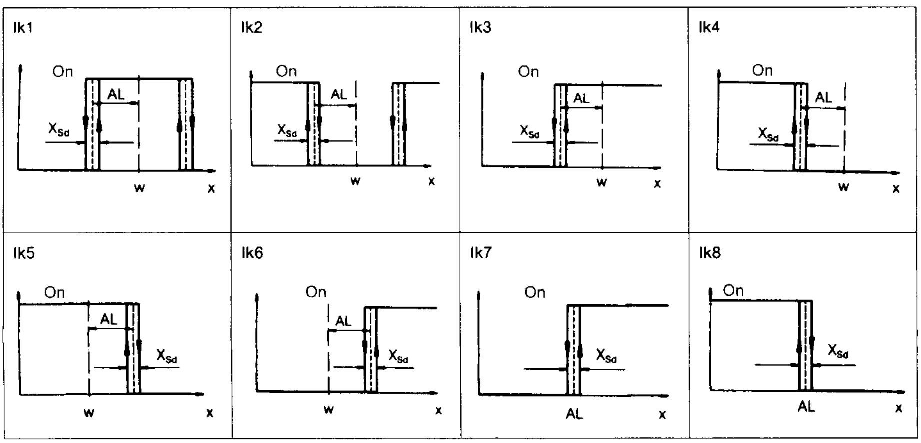
* = input a value

☐ = factory setting

Value range: 0 — 9999 sec
factory-set: 1

Value range: –1999 to +9999 digit
factory-set: 0

Limit comparator functions



AL = limit, X_{Sd} = switching differential, w = setpoint, x = process value

Limit comparators

No.	Item	Display
❶	Limit comparators	LIMIT COMPARATOR
❷	Limit comparator 1	LIM.COMPARATOR 1
❸	Function	LIMCOMP FUNCTION
❹	Switching differential	DIFFERENTIAL
❺	Function on over-range / underrange	RANGE FUNC
❻	Absolute	ABSOLUTE
❼	Relative	RELATIVE

☞ When a limit comparator is switched to an output, the output setting "Function on overrange/underrange" has priority.

⇨ Section 9.5, 9.6

Notes

⇨ Section 18.2

Limit comparator absolute / relative

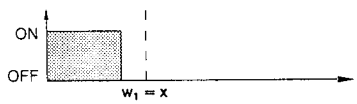
The settings determine the action of the limit comparators for an alteration of the limit (AL) or the (limit comparator) setpoint.

Absolute:
At the time of the alteration the limit comparator acts according to its function.

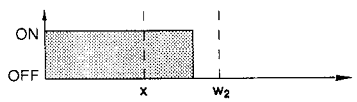
Relative:
The limit comparator is in the OFF status. If an alteration of the limit or of the (limit comparator) setpoint would cause the limit comparator to switch ON, this reaction is suppressed. This status is retained until the (limit comparator) actual value has **moved away** from the switch-on region (grey area).

Example:
Monitoring the (controller) process value x with lk4. Setpoint alteration $w_1 \rightarrow w_2$

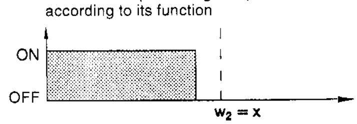
a) Initial status



b) Status at the time of the alteration. The limit comparator remains on OFF although the process value is within the switch-on region



c) Control stabilised
The limit comparator again operates according to its function



9.4 Inputs

C1	Function			
Controllers		Inputs controller 1	Process value	Analogue input 1
Limit comparators		Inputs controller 2		Analogue input 2
Inputs				Analogue input 3
Outputs				Analogue input 4
External relay module				Math 1
Special functions				Math 2
			External setpoint ❶	No function
			External setpoint with correction ❷	Analogue input 1
			Stroke retransmission ❸	Analogue input 2
			Additive disturbance ❹	Analogue input 3
			Multiplying disturbance ❺	Analogue input 4
				Math 1
				Math 2

Explanation:

* = input a value

☐ = factory setting

Inputs

No.	Item	Display	Notes
❶	External setpoint	EXT SETPOINT	An external setpoint is input via an analogue input or a maths function. The external setpoint corresponds to setpoint 1 in the operating level.
❷	External setpoint with correction	EXT. SETPT W CORR	External setpoint + setpoint 1 = effective setpoint The external setpoint is corrected up or down with the keys at the operating level (setpoint 1).
❸	Stroke retransmission	STROKE RETRANSM.	⇨ Configuration level C1: Controllers → Controller mode → Function → Controller with integral driver for motorised actuators Chapter 16.7
❹	Additive disturbance	ADD. DISTURBANCE	⇨ Chapter 16.8
❺	Multiplying disturbance	MULT.DISTURBANCE	☞ Not available on modulating controllers ⇨ Chapter 16.9

Inputs

C1
- Controllers
- Limit comparators
- **Inputs**
- Outputs
- External relay module
- Special functions

Function

- Inputs limit comparator 1
- Inputs limit comparator 2
- Inputs limit comparator 3
- Inputs limit comparator 4
- Inputs limit comparator 5
- Inputs limit comparator 6
- Inputs limit comparator 7
- Inputs limit comparator 8

(1)

Ik process value (2)
- Analogue input 1
- Analogue input 2
- Analogue input 3
- Analogue input 4
- Math 1
- Math 2
- Setpoint controller 1
- Setpoint controller 2
- Ramp end controller 1 (4)
- Ramp end controller 2 (4)

Ik setpoint (3)
- Analogue input 1
- Analogue input 2
- Analogue input 3
- Analogue input 4
- Math 1
- Math 2
- Setpoint controller 1
- Setpoint controller 2
- Ramp end controller 1 (4)
- Ramp end controller 2 (4)

Explanation:

* = input a value

☐ = factory setting

Inputs

No.	Item	Display	Notes
(1)	Inputs limit comparator 1	INPUTS LC1	—
(2)	Process value	LC ACTUAL VALUE	—
(3)	Setpoint	LC SETTING	—
(4)	Ramp end controller 1	RAMP END C1	—

Inputs

C1

- Controllers
- Limit comparators
- **Inputs**
- Outputs
- External relay module
- Special functions

Type → Analogue input 1 / Analogue input 2 / Analogue input 3 / Analogue input 4

Transducer
- No function[1]
- Resistance thermometer[2] (10)
- Thermocouple internal cold junction (11)
- Thermocouple external cold junction (12)
- Thermocouple constant cold junction (13)
- Resistance transmitter (14)
- 0 — 50 mV
- 0 — 1 V
- 0 — 10 V
- 0 — 20 mA
- 10 — 50 mV
- 0.2 — 1 V
- 2 — 10 V
- 4 — 20 mA

Linearisation
- Linear
- Pt 100
- Fe-Con J
- NiCr-Con E
- NiCr-Ni K
- NiCrSi-NiSi N
- Cu-Con T
- Pt30Rh-Pt6Rh B
- Pt13Rh-Pt R
- Pt10Rh-Pt S
- Cu-Con U
- Fe-Con L (15)
- Customized linearisation 1
- Customized linearisation 2

Explanation:

* = input a value

= factory setting

Value range	Parameter		Setting
Value range: –1999 to +9999 factory-set: 0	Process value correction	(1)	Value* ____
Value range: 0 — 100 factory-set: 50	Constant cold junction temperature	(2)	Value* ____
	External cold junction temperature	(3)	Analogue input 1 / Analogue input 2 / Analogue input 3 / Analogue input 4
	Heater current monitoring	(4)	No function / Output 1 / Output 2 / Output 3 / Output 4
Value range: –1999 to +9999 factory-set: 0	Display start	(5)	Value* ____
Value range: –1999 to +9999 factory-set: 100	Display end	(6)	Value* ____
Value range: –1999 to +9999 factory-set: -1999	Range start	(7)	Value* ____
Value range: –1999 to +9999 factory-set: 9999	Range end	(8)	Value* ____
Value range: 0 — 100 sec factory-set: 0.15 sec	Filter time constant	(9)	Value* ____

1. Factory setting on analogue input 2 - 4
2. Factory setting on analogue input 1

Inputs

No.	Item	Display	Notes
❶	Process value correction	OFFSET	Using the process value correction a measured value can be corrected upwards or downwards by a certain amount. Examples: measured value / offset / indicated value 294.7 / +0.3 / 295.0 295.3 / –0.3 / 295.0 The controller uses the corrected (= indicated) value for its calculation . This value does not correspond to the actually measured value. With inappropriate use it is possible to produce prohibited values of the controller output.
❷	Constant cold junction temperature	CJ TEMP.	Temperature of the cold junction thermostat.
❸	External cold junction temperature	EXT.CJ TEMP.	Measurement of cold junction temperature with a temperature probe.
❹	Heater current monitoring	HEATER CURNT MON	The heater current is evaluated using a current transformer with a standard output signal; it can be monitored by linking the analogue input to a limit comparator. The measurement is always made when the heating contact is closed. The measured value is retained until the next measurement.

Inputs

No.	Item	Display	Notes
❺	Display start	DISPLSTART	On transducers with standard signal and also on resistance transmitters an indicated value is assigned to the actual signal; example: 0 — 20 mA = 0 — 1500 °C. The range of the physical signal can be 20% wider or narrower without triggering an alarm.
❻	Display end	DISPL.END	
❼	Range start	RANGESTART	The measuring range of the transducers can be restricted for monitoring. Going above or below these limits (range start, range end) results in an alarm. Example: Pt 100 (measuring range: –200 to +850 °C) An alarm message is required outside the range 15 to 200 °C. range start: 15 range end: 200
❽	Range end	RANGE END	
❾	Filter time constant	FILTER TIM	To adjust the digital input filter to disturbances in the input signal.
❿	Resistance thermometer	RESISTANCE	Pt 100 resistance thermometer in 2-wire or 3-wire circuit.
⓫	Thermocouple internal cold junction	TC INTERNAL CJ	Determining the cold junction temperature using an internal Pt 100. The cold junction is at the terminals on the back panel.
⓬	Thermocouple external cold junction	TC EXTERNAL CJ	Measurement of the cold junction temperature using a temperature probe.
⓭	Thermocouple constant cold junction	TC CONSTANT CJ	Maintaining a constant cold junction temperature using an external cold junction thermostat.
⓮	Resistance transmitter	RETRANSMITTER	Potentiometer with 3-wire connection (100 Ω min, 10 kΩ max.)
⓯	Customized linearisation	CUSTOMIZED LIN.	20 calibration points max. Only available with setup program. ⇨ For a description, see online help

9.5 Outputs

C1

- Controllers
- Limit comparators
- Inputs
- **Outputs**
- External relay module
- Special functions

Output 1
Output 2[1]
Output 3
Output 4

Parameter		Selection / Value	Notes
Function	❶	No function[2] Output 1 controller 1[3] Output 2 controller 1 Output 1 controller 2 Output 2 controller 2 Output limit comparator 1 Output limit comparator 2 Output limit comparator 3 Output limit comparator 4 Output limit comparator 5 Output limit comparator 6 Output limit comparator 7 Output limit comparator 8 Logic 1 Logic 2 Math 1[4] (not on output 2) Math 2[4] (not on output 2) Analogue input 1[4] (not on output 2) Analogue input 2[4] (not on output 2) Analogue input 3[4] (not on output 2) Analogue input 4[4] (not on output 2) Setpoint controller 1[4] (not on output 2) Setpoint controller 2[4] (not on output 2) Deviation controller 1[4] (not on output 2) Deviation controller 2[4] (not on output 2)	
Output signal (not on output 2)	❷	0 — 10 V 2 — 10 V −10 / 0 / +10 V 0 — 20 mA 4 — 20 mA −20 / 0 / +20 mA	
Zero (not on output 2)	❸	Value* _____	Value range:-1999 to +9999 factory-set: 0
Full scale (not on output 2)	❹	Value* _____	Value range:-1999 to +9999 digit factory-set: 100
Output signal on overrange or underrange[5]	❺	Value* _____	Value range:0 - 100% factory-set: 0% 101: the true output signal is output. 0: relay de-energised 100: relay energised

Explanation:

* = input a value

☐ = factory setting

1. Always switching output
2. Factory-set on output 2 - 4
3. Factory-set on output 1
4. Not on output 2
5. Not on controller outputs

Outputs

No.	Item	Display	Notes
❶	Function	OUTPUT FUNCTION	—
❷	Signal	OUTPUT SIGNAL	—
❸	Zero		A range of values is assigned to a physical output signal; e.g. 0 — 20 mA = 150 — 500 °C.
❹	Full scale		☞ Controller output on proportional controllers with rising characteristic: zero: 0 full scale: –100
❺	Output signal on overrange or underrange	RANGE FUNC	The output produces a defined signal. ☞ If the output is a controller output the controller switches over to manual operation and outputs a defined controller output.

9.6 External relay module

C1			
Controllers	External output 1 (K5) ❷	Function ❸	No function
Limit comparators	External output 2 (K6)		Output 1 controller 1 ❺
Inputs	External output 3 (K7)		Output 2 controller 1 ❺
Outputs	External output 4 (K8)		Output 1 controller 2 ❺
External relay module ❶	External output 5 (K9)		Output 2 controller 2 ❺
Special functions	External output 6 (K10)		Output limit comparator 1
	External output 7 (K11)		Output limit comparator 2
	External output 8 (K12)		Output limit comparator 3
			Output limit comparator 4
			Output limit comparator 5
			Output limit comparator 6
			Output limit comparator 7
			Output limit comparator 8
			Logic 1
			Logic 2
		Function on overrange or underrange[1] ❹	Relay de-energised
			Relay energised

Explanation:

* = input a value

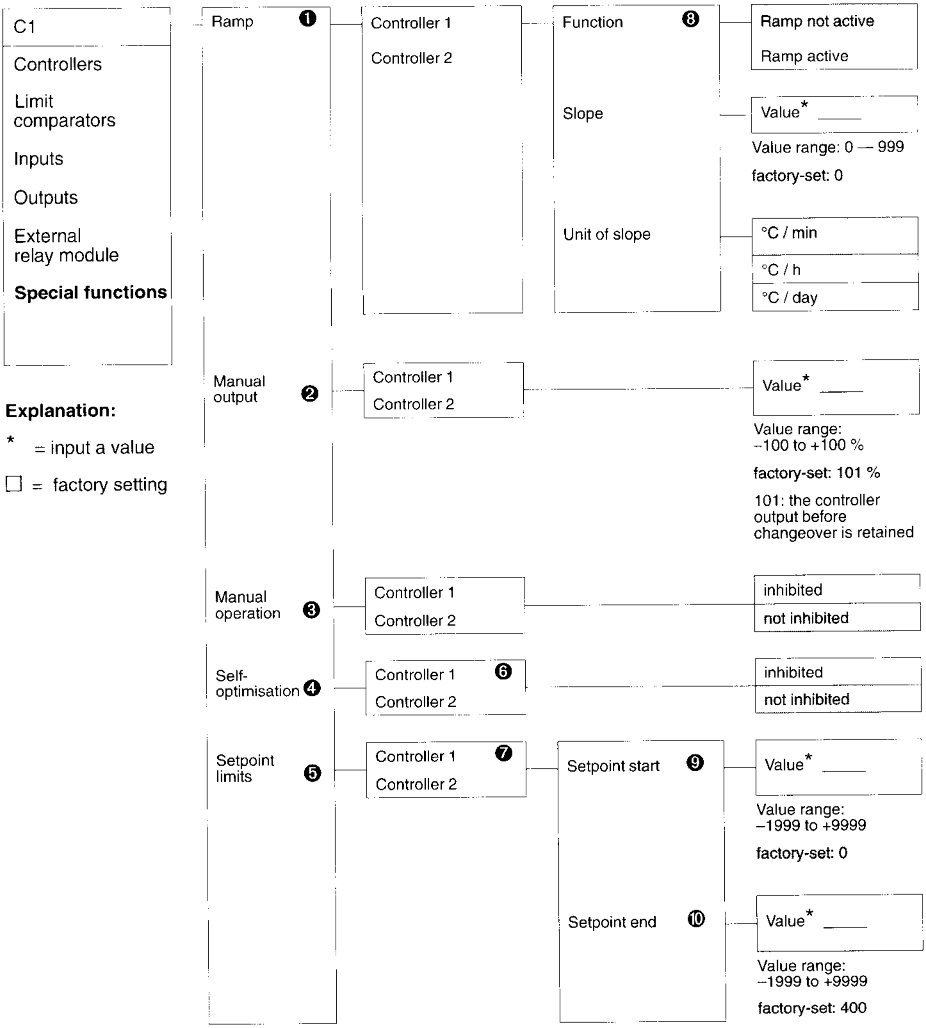
☐ = factory setting

1. not on controller outputs

External relay module

No.	Item	Display	Notes
❶	External relay module	RELAY MODULE	External relay module ER8 with eight relays. ⇨ Chapter 15.1
❷	External output 1	EXTERNAL OUT 1	—
❸	Function	OUTPUT FUNCTION	—
❹	Function on overrange or underrange	RANGE FUNC	If the external output is a controller output the controller switches over to manual operation and outputs a defined controller output (0 / 100 %)
❺	Output 1 controller 1	OUTPUT 1 C1	—

9.7 Special functions



Special functions

No.	Item	Display	Notes
❶	Ramp	RAMP	⇨ Chapter 14, 16.12
❷	Manual output	MANUAL OUTPUT	Value used as output on changeover to manual operation.
❸	Manual operation	INHIBIT MANUAL	Manual operation can be inhibited.
❹	Self-optimisation	INHIBIT TUNE	Self-optimisation can be inhibited.
❺	Setpoint limits	SETPOINT LIMITS	The range of setpoint values can be restricted here.
❻	Controller 1	TUNE C1	—
❼	Controller 1	SETPOINT LIM. C1	—
❽	Function	RAMP FUNCTION	Activation of ramp function.
❾	Setpoint start	SETPT STRT	Limits within which setpoints have to be specified.
❿	Setpoint end	SETPT END	

Special functions

- **C1**
  - Controllers
  - Limit comparators
  - Inputs
  - Outputs
  - External relay module
  - **Special functions**
    - Mathematics and logics module
      - Math 1
      - Math 2
        - Function
          - No function
          - Difference (a - b) ⓭
          - Ratio (a/b) ⓮
          - Humidity (a; b) ⓯
          - Math formula ⓰
        - Variable a
          - Analogue input 1
          - Analogue input 2
          - Analogue input 3
          - Analogue input 4
        - Variable b
          - Analogue input 1
          - Analogue input 2
          - Analogue input 3
          - Analogue input 4
        - Range start ⓫
          - Value* ____
          - Value range: –1999 to +9999
          - factory-set: –1999
        - Range end ⓬
          - Value* ____
          - Value range: –1999 to +9999
          - factory-set: +9999
      - Logic 1
      - Logic 2
        - No function
        - Logic formula ⓱

Explanation:

* = input a value

☐ = factory setting

Special functions

No.	Item	Display	Notes
11	Range start	RANGESTART	Setting a range of values for the result of a mathematical calculation. An alarm message is produced if the result is outside this range.
12	Range end	RANGE END	
13	Difference (a-b)	DIFFERENCE (A-B)	⇨ Chapter 15.3, 16.13
14	Ratio (a/b)	RATIO (A/B)	The control is always referred to variable a. The maths module forms the ratio of the values of a and b (a/b) and provides the setpoint for the controller. The ratio of the measured values a and b can be called up and displayed using the function "Math 1" or "Math 2". The required ratio a/b is programmed as setpoint (ratio setpoint) in the setpoint setting. ☞ Math 1 provides the setpoint for controller 1 Math 2 provides the setpoint for controller 2 ⇨ Chapter 16.5
15	Humidity (a;b)	HUMIDITY	a – dry bulb temperature b – wet bulb temperature ⇨ Chapter 16.6
16	Math formula	MATH FORMULA	Can only be input using the setup program. ⇨ Chapter 15.3, 15.4, 16.13
17	Logic formula	LOGICS FORMULA	

10 CONFIGURATION LEVEL C2

10.1 Overview

- **Display**
  - Display controller 1 + 2
    - Display 1 — 4
      - Display value
      - Decimal point
  - Display brightness display 3 + 4
- **Logic functions**
  - Logic input 1 — 5
  - Limit comparator output 1 — 8
  - Logic 1 + 2
- **Cascade controller**
  - Function
  - Start of output conversion
  - End of output conversion
- **Customized recalibration**
  - Analogue input 1 — 4
    - Start value
    - End value
- **Time-out**
- **Unit**
- **Supply frequency**
- **Interface**
  - Protocol
  - Data format
    - Parity
    - Stop bit
    - Baud rate
  - Instrument address
  - Minimum response time

10.2 Display

C2

- **Display**
- Logic functions
- Cascade controller
- Customized recalibration
- Time-out
- Unit
- Supply frequency
- Interface

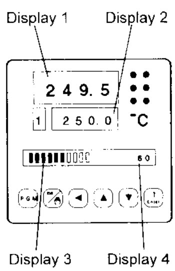
Display

- Display controller 1
- Display controller 2
  - Display 1
    - Display value
      - No function
      - Process value
      - Setpoint
      - Ramp end[1]
      - Control deviation
      - Control output
      - Analogue input 1
      - Analogue input 2
      - Analogue input 3
      - Analogue input 4
      - Math 1
      - Math 2
    - Decimal point ❶
      - XXXX.
      - XXX.X
      - XX.XX
      - X.XXX
  - Display 2
    - Display value
      - No function
      - Process value
      - Setpoint
      - Ramp end[1]
      - Control deviation
      - Control output
      - Analogue input 1
      - Analogue input 2
      - Analogue input 3
      - Analogue input 4
      - Math 1
      - Math 2
    - Decimal point ❶
      - XXXX.
      - XXX.X
      - XX.XX
      - X.XXX
  - Display 3
    - Display value
      - No function
      - Process value
      - Setpoint
      - Ramp end[1]
      - Control deviation
      - Control output
      - Analogue input 1
      - Analogue input 2
      - Analogue input 3
      - Analogue input 4
      - Math 1
      - Math 2
      - Bargraph control output ❷
      - Bargraph control deviation ❸
    - Decimal point ❶
      - XXXX.
      - XXX.X
      - XX.XX
      - X.XXX

Explanation:

* = input a value

☐ = factory setting



1. or ratio setpoint

Display

C2

- **Display**
- Logic functions
- Cascade controller
- Customized recalibration
- Time-out
- Unit
- Supply frequency
- Interface

Display → Display controller 1 / Display controller 2 → Display 4 →

- Display value:
  - No function
  - Process value
  - Setpoint
  - Ramp end[1]
  - Control deviation
  - **Control output**
  - Analogue input 1
  - Analogue input 2
  - Analogue input 3
  - Analogue input 4
  - Math 1
  - Math 2
- Decimal point ❶:
  - XXXX.
  - XXX.X
  - XX.XX
  - X.XXX

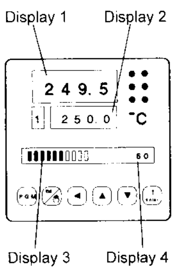
Display → Display brightness display 3 + 4 ❹ → Steps:

- 6
- 5
- 4
- 3
- 2
- 1

Explanation:

* = input a value

☐ = factory setting



1. or ratio setpoint

Displays

No.	Item	Display	Notes
❶	Decimal point	DECIMAL POINT	If the value to be displayed can no longer be shown with the programmed decimal places, the number of decimal places is automatically reduced. If the measured value later reduces again, the number of decimal places is increased up to the programmed number.
❷	Bargraph display control output	BARGRAPH OUTPUT	Single-setpoint controller: 0 % 100 % □ □ □ □ □ □ □ □ □ □ Resolution: 2 % / division Double-setpoint controller: –100 % 0 100 % □ □ □ □ □ □ □ □ □ □ Resolution: 4 % / division
❸	Bargraph display control deviation	BARGR. DEVIATION	–50 0 +50 □ □ □ □ □ □ □ □ □ □ Resolution: 2 digit/division
❹	Display brightness display 3 + 4	BRIGHTNESS	—

10.3 Logic functions

C2

- Display
- **Logic functions** ❶
- Cascade controller
- Customized recalibraton
- Time-out
- Unit
- Supply frequency
- Interface

Logic input 1
Logic input 2
Logic input 3
Logic input 4
Logic input 5

❷

Limit comparator 1 output
Limit comparator 2 output
Limit comparator 3 output
Limit comparator 4 output
Limit comparator 5 output
Limit comparator 6 output
Limit comparator 7 output
Limit comparator 8 output

Logic 1
Logic 2

No function	
Start of self-optimisation controller 1	❸
Start of self-optimisation controller 2	❸
Aborting self-optimisation controller 1	❹
Aborting self-optimisation controller 2	❹
Changeover manual/auto controller 1	❺
Changeover manual/auto controller 2	❺
Inhibit manual operation controller 1	❻
Inhibit manual operation controller 2	❻
Ramp stop controller 1	❼
Ramp stop controller 2	❼
Ramp OFF controller 1	❽
Ramp OFF controller 2	❽
Setpoint switch-over controller 1	❾
Setpoint switch-over controller 2	❾
Process value switch-over controller 1	❿
Process value switch-over controller 2	❿
Parameter set switch-over controller 1	⓫
Parameter set switch-over controller 2	⓫
Key inhibit	⓬
Parameter and configuration levels inhibit	⓭
Text display	⓮
All displays OFF [1]	⓯

Explanation:

* = input a value

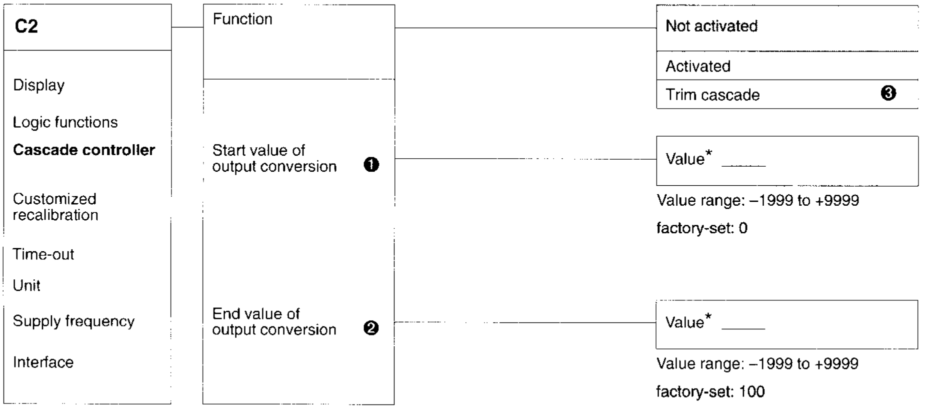
☐ = factory setting

1. incl. LEDs

Logic inputs

No.	Item	Display	Notes
1	Logic inputs	LOGIC INPUTS	—
2	Logic input 1	LOGIC INPUT 1	—
3	Start of self-optimisation controller 1	START TUNE C1	⇨ Chapter 12.1
4	Aborting self-optimisation controller 1	ABORT TUNE C1	
5	Changeover manual/auto controller 1	MANUAL C1	⇨ Chapter 12.2
6	Inhibit manual operation controller 1	INHIB. MANUAL C1	
7	Ramp stop controller 1	RAMP STOP C1	⇨ Chapter 12.4
8	Ramp ON/OFF controller 1	RAMP C1 OFF	
9	Setpoint switch-over controller 1	SETPT SWITCH C1	⇨ Chapter 12.3
10	Process value switch-over controller 1	PROCVAL.SWITCHC1	
11	Parameter set switch-over controller 1	PARSET SWITCH C1	
12	Key inhibit	KEYS INHIBIT	⇨ Chapter 12.4
13	Parameter and configuration levels inhibit	MENU INHIBIT	⇨ Chapter 12.4
14	Text display	TEXT DISPLAY	Any 16-character text can be shown on the matrix display. Text inputs only through setup program. ⇨ Chapter 12.4
15	All displays off	DISPLAYS OFF	⇨ Chapter 12.4

10.4 Cascade controller



Explanation:

* = input a value

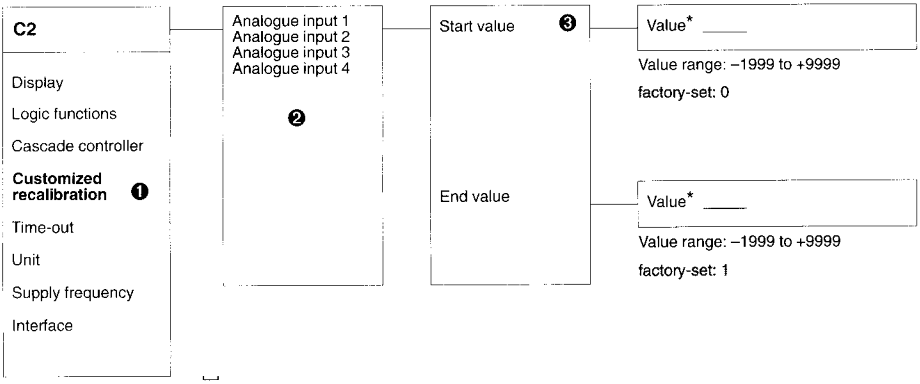
☐ = factory setting

Controller 1: master controller
Controller 2: slave controller

Cascade controller

No.	Item	Display	Notes
❶	Start value of output conversion	OUTPUT ST.	⇨ Chapter 16.2
❷	End value of output conversion	OUTPUT END	
❸	Trim cascade	TRIMCASCADE	⇨ Chapter 16.3

10.5 Customized recalibration



Explanation:

* = input a value

☐ = factory setting

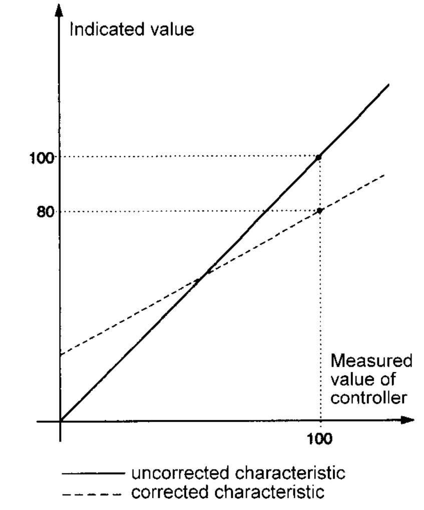
Customized recalibration

No.	Item	Display	Notes
❶	Customized recalibration	RECALIBRATION	⇨ Description on the next two pages.
❷	Analogue input X	CORRECTION INP.1	—
❸	Start value	STRT VALUE	—

Customized recalibration

Through the analogue inputs of the controller a signal is processed electronically (conversion, linearisation ...) to produce a measured value. This measured value enters into the calculations of the controller and can be shown on the display (measured value = indicated value).

This fixed relationship can be modified if required, i.e. the position and the slope of the measured value characteristic can be altered.



Procedure:

Apply two measurement points (❶ , ❸) to the controller; they should be as far apart as possible.
At these measurements input the required indication value (start value, end value) to the controller. A reference measuring instrument is most convenient for determining the measured values M1 and M2.
Measurement conditions must remain stable during programming.

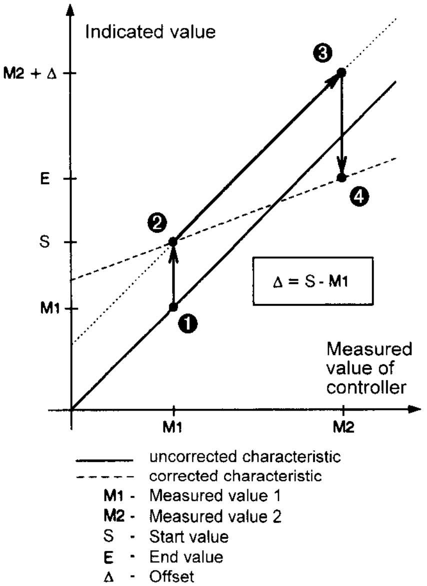
Programming:

* Move to measurement point ❶
* Input start value S ❷

⇨ Configuration level 2:
Customized recalibration ›
analogue input 1 — 4 › start value

* Move to measurement point ❸
* Input end value E ❹

⇨ Configuration level 2:
Customized recalibration →
analogue input 1 — 4 → end value



☞ If recalibration is performed using the controller alone (without measuring instrument) the offset Δ must be taken into account when moving to measuring point ❸.

The recalibration can be cancelled by programming the start value and end value to the same value. This sets the start value to 0 and the end value to 1.

Otherwise any subsequent recalibration is based on the corrected characteristic.

10.6 Time-out

C2

- Display
- Logic inputs
- Cascade controller
- Customized recalibration
- **Time-out**
- Unit
- Supply frequency
- Interface

Value* _____

Value range: 0 - 9999

factory-set: 30 (approx. 30 sec)

Explanation:

* = input a value

☐ = factory setting

10.7 Unit

C2		Degree Celsius
Display		Degree Fahrenheit
Logic inputs		
Cascade controller		
Customized recalibration		
Time-out		
Unit		
Supply frequency		
Interface		

Explanation:

* = input a value

☐ = factory setting

10.8 Supply frequency

C2		
Display		
Logic inputs		
Cascade controller		
Customized recalibration		
Time-out		
Unit		
Supply frequency	—	50 Hz
		60 Hz
Interface		

Explanation:

* = input a value

☐ = factory setting

10.9 Interface

C2

- Display
- Logic inputs
- Cascade controller
- Customized recalibration
- Time-out
- Unit
- Supply frequency
- **Interface** ❶
  - Protocol
    - SETUP ❹
    - MODBUS
    - JBUS
  - Data format
    - Parity
      - No parity
      - Odd parity
      - Even parity
      - Null parity
    - Stop bit
      - 1 Stop bit
      - 2 Stop bits
    - Baud rate
      - 9600 baud
      - 4800 baud
      - 2400 baud
      - 1200 baud
      - 600 baud
      - 300 baud
      - 150 baud
      - 19200 baud
      - 38400 baud
      - 125000 baud
      - 187500 baud
  - Instrument address ❷
    - Value* _____
    - Value range: 0 — 255
    - factory-set: 0
  - Minimum response time ❸
    - Value* _____
    - Value range: 0 — 999 msec
    - factory-set: 0 msec

Explanation:

* = input a value

☐ = factory setting

Interface

No.	Item	Display	Notes
❶	Interface	INTERFACE	⇨ Chapter 15.2 ⇨ B 70.3560.2 Interface description
❷	Instrument address	INSTR.ADDR	—
❸	Minimum response time	MIN.TIME	Minimum time interval from the interrogation of an instrument in a data network up to the controller response.
❹	SETUP	SETUP	☞ The data format for SETUP requires the “Even parity” setting

11 CONFIGURATION LEVEL C3

11.1 Overview

Version	❶
VDN Numer	❷
Inputs 3+4	❸
Output 1	❹
Output 2	❹
Output 3	❹
Output 4	❹
Setup interface	❺
Interface	❻
External relay module	❼
Number of controllers	❽
Maths and logics module	❾
Carbon level	❿

No data can be input at this level. It alters automatically when hardware or software are changed or retrofitted.

Overview

No.	Item	Display	Notes
❶	Version	VERSION	Version number of software
❷	VDN Number	VDN-NO	Number of special controller version
❸	Inputs 3+4	ADC MODULE 2	– exist – do not exist
❹	Output 1	OUTPUT 1	– does not exist – Relay – Solid-state relay – Analogue output – Logic output
❺	Setup interface	SETUP INTERFACE	– connected – not connected ⇨ Chapter 15.4
❻	Interface	INTERFACE	– does not exist – RS422/RS485 (see label) ⇨ Chapter 15.2
❼	External relay module	RELAY MODULE	– exists – does not exist ⇨ Chapter 15.1
❽	Number of controllers	NO.CONTROLLERS	– Single-channel controller – Double-channel controller
❾	Maths and logics module	MATHS-LOGICS	– exists – does not exist ⇨ Chapter 15.3
❿	Carbon level	C-LEVEL CONTR.	– exists – does not exist

The binary functions, limit comparators or logic outputs are activated through floating contacts (switches / relay contacts).

The functions are divided into two groups:

Edge-triggered functions
The logic input reacts to switch-on or switch-off edges (start and abort of self-optimisation, manual/auto changeover).

State-triggered functions
The logic input reacts to ON or OFF states (all other functions).

12.1 Self-optimisation

At the start or abort of self-optimisation the logic input reacts to the switch-on edge. External keys are used to activate the functions.

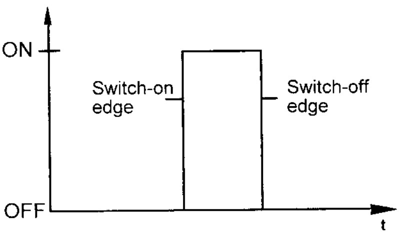
12.2 Changeover manual / auto operation

At the manual / auto changeover the logic input reacts to the switch-on and switch-off edge.

Switch-on edge → manual operation

Switch-off edge → auto operation

Floating contact or switching pulse



ON - contact closed
OFF - contact open

12.3 Changeover setpoint, process value and parameter set

A combination of two operating variables (logic inputs, limit comparators and logic outputs (logics module)) is used to realise the functions setpoint changeover, process value changeover and parameter set switching.

The selection of the operating variables is unrestricted. The assignment of the states Z1 and Z2 to the operating variables is made in descending order (see list), e.g. if Z1 is assigned to limit comparator 1, Z2 can not be assigned to logic input 1 — 5.

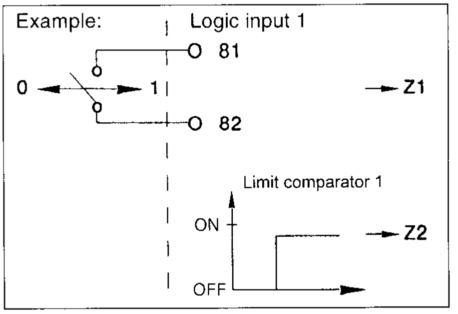
Assignment: status - operating variable
Z1 → Logic input 1
•
•
•
Logic input 5
Z2 → Limit comparator 1
•
•
•
Z2 → Limit comparator 8
Logic 1
Z4 → Logic 2

Example:

The changeover of the process value is to operate through a logic input and the status of a limit comparator.

Z1 – Logic input 1

Z2 – Limit comparator 1



Setpoint	Process value	Parameter set	Z1	Z2
Setpoint 1	Analogue input 1	Parameter set 1	0	0
Setpoint 2	Analogue input 2	Parameter set 2	1	0
Setpoint 3	Analogue input 3	Parameter set 3	0	1
Setpoint 4	Analogue input 4	Parameter set 4	1	1

0 = switch open / OFF 1 = switch closed / ON

If switching between only two setpoints (analogue inputs, parameter sets) is required, only one logic input (Z1) need be programmed and provided with a switch.

If more than two binary functions are configured for setpoint changeover (process value changeover, parameter set switiching), only the first two are significant (see list: assignment).

12.4 Other functions

Function	Contact closed / ON	Contact open / OFF
Ramp stop Controllers 1 + 2	Ramp is stopped ⇨ Chapter 16.12	Ramp is running
Ramp off Controllers 1 + 2	Ramp is switched off	Ramp is running (if it has previously been activated under menu item "Ramp")
Manual operation inhibited Controllers 1 + 2	Manual operation inhibited	Manual operation **not** inhibited
Keys inhibited	Keys inhibited	Keys **not** inhibited
Parameter and configuration levels inhibited	Levels inhibited	Levels **not** inhibited
Text display	Text is shown on matrix display. Action according to priority list. ⇨ Chapter 18.3	Display according to status and configuration
All indications off	Indications are off. Action according to priority list. ⇨ Chapter 18.3	Indications according to status and configuration

Control engineering distinguishes between two different optimisation criteria: "control" and "disturbance".

For good **control response** it is desirable to achieve rapid approach of the process value to the setpoint without overshoot.

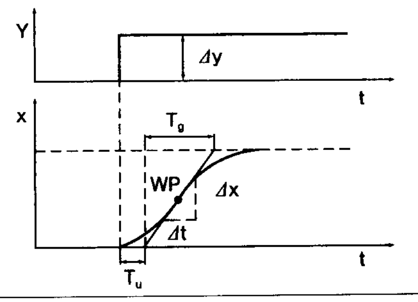
Good **disturbance response** involves extensive suppression of process value fluctuations caused through external influences on the control loop.

Where a control loop can be accurately represented in mathematical terms it is possible to calculate the appropriate controller parameters. Such a mathematical description is only rarely found in practice.

Certain procedures for control loop analysis and for determining controller parameters, as described below, are therefore employed.

The controllability of the process can be expressed through the ratio T_g/T_u.

The diagram alongside shows schematically the behaviour of a control loop with saturation in response to a step change.



T_g/T_u	more than 10:	satisfactory control
T_g/T_u	from 10 to 3:	just controllable
T_g/T_u	less than 3:	difficult to control

The following facilities for optimisation are available:

Classical optimisation method

⇨ Chapter 13.1

Self-optimisation

⇨ Chapter 13.2

Improving the control and disturbance response through fuzzy parameters

⇨ Chapter 13.3

List of symbols

Cy	switching cycle time
k	constant for output steps less than 100%
t	time
T_g	stabilisation time
T_k	oscillation period in case of oscillation
T_n	reset time
T_u	delay time
T_v	derivative time
v_{max}	max. rate of rise
w	setpoint
WP	inflection point
x	process value
X_p	proportional band
X_{pk}	setting of X_p in case of oscillation
X_{Sd}	switching differential
X_{Sh}	contact spacing
Y	control output in %
Y1	upper output limit in %
Y2	lower output limit in %
Δy	output step in %
Δt	time difference
Δx	process value difference

13.1 Optimisation method after Ziegler and Nichols

Many control loops (pressure, flow, level, humidity) can be represented as a mathematical approximation by a combination of a dead time and a first-order time constant. Ziegler and Nichols have determined empirical setting criteria for the controller parameters on such control loops. These settings are particularly suitable for good disturbance response.

Oscillation method

This method applies to control loops which can be rendered unstable for a brief period.

(a) For proportional controllers

The controller is first operated with the following settings:

* set controller to P action
* set X_{p1} (and X_{p2}) to maximum
* set contact spacing X_{Sh} to 0
* slowly reduce X_{p1} (and X_{p2}) to find the stability limit at which the process value performs oscillations of constant amplitude

X_{pk} = setting of X_p

T_k = oscillation period

The controller parameters for the different controller structures can be calculated according to the table alongside.

(b) For switching controllers

It is possible to achieve roughly similar satisfactory results through the following procedure:

* Set X_{p1} (and X_{p2}), the switching differential X_{Sd} and the contact spacing to 0.

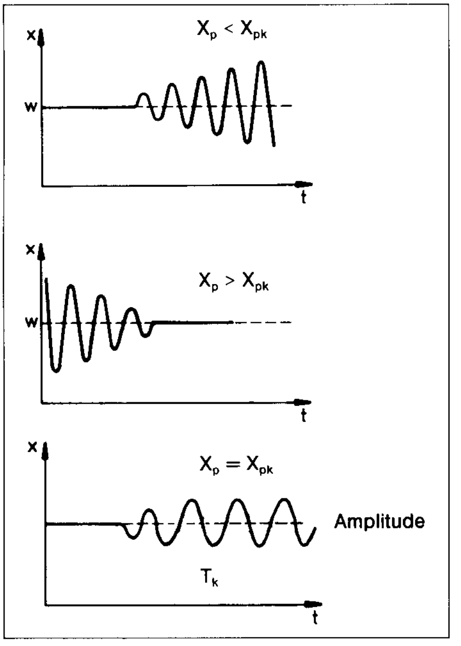
Compared with proportional controllers there is roughly twice the oscillation amplitude. By dividing the value of the oscillation amplitude by two it is possible to use the above formulae to calculate the parameters for a PID structure.

$$X_{pk} = \frac{\text{oscillation amplitude}}{2}$$

The switching cycle time Cy should then be set according to the following equation:

$Cy = T_k/12$ approx.

If after stabilisation there remain permanent process value oscillations in synchronism with the switching action it is recommended to reduce Cy further.



Controller structure	Setting
P	$X_p = \frac{X_{pk}}{0.5}$
PI	$X_p = \frac{X_{pk}}{0.45}$ $T_n = 0.85 \cdot T_k$
PID	$X_p = \frac{X_{pk}}{0.6}$ $T_n = 0.5 \cdot T_k$ $T_v = 0.12 \cdot T_k$

Recording the control loop step response

In this method the response of the control loop to a step change in control output is recorded. It is advisable to carry out this test in the neighbourhood of the intended working range; it can not be assumed that the control loop exhibits a similar behaviour in other regions.

* Record the process value using a pen recorder
* Produce an output step Δy (manual operation)
* Leave the recorder switched on at least long enough until the point of inflection is passed and the rate of rise of the process value decreases again.
* Draw the tangent through the point of inflection WP
* Calculate $v_{max} = \Delta x / \Delta t$
* Read off T_u
* Calculate the constant k:

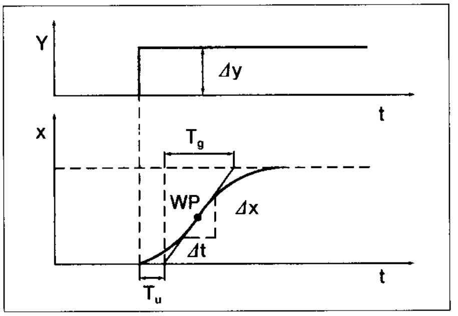
$$k = \frac{(Y1 - Y2)^2}{\Delta y \cdot 100\ \%}$$

(k is a correction factor for output steps within the output limits Y_1 and Y_2)

* Insert the value obtained from the diagram into the formulae and calculate the controller parameters.

During the optimisation procedure and in particular during alterations of the controller parameters it is possible to reach conditions which must not be allowed to appear during normal operation.

It is advisable to monitor the process continuously during optimisation in order to avoid consequential damage.

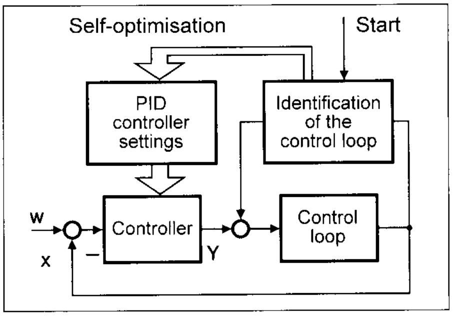


Controller structure	Setting
P	$X_p \approx v_{max} \cdot T_u \cdot k$
PI	$X_p \approx 1.2 \cdot v_{max} \cdot T_u \cdot k$ $T_n \approx 3.3 \cdot T_u$
PID	$X_p \approx 0.83 \cdot v_{max} \cdot T_u \cdot k$ $T_n \approx 2 \cdot T_u$ $T_v \approx 0.5 \cdot T_u$

13.2 Self-optimisation

The self-optimisation function (SO) is purely a software function and is incorporated in the controller.

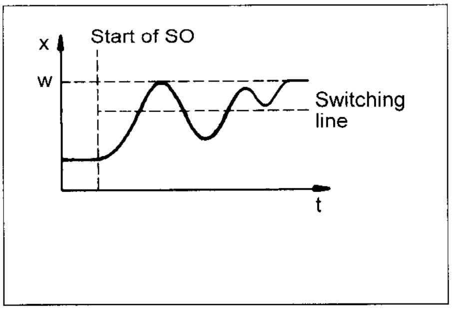
SO employs a special procedure to analyse the response of the control loop to steps in control output. Using the control loop response (process value) an extensive computing algorithm determines the controller parameters for a PID controller and stores them. If a double-setpoint controller has to be optimised the algorithm determines two separate proportional bands (X_{p1} and X_{p2}). In case of a switching double-setpoint controller the switching cycle time Cy2 is also calculated. The SO procedure can be repeated as often as desired.



SO can be activated by keys, logic inputs or menu settings. With cascade control, the inner control loop of the controller must be optimised first.

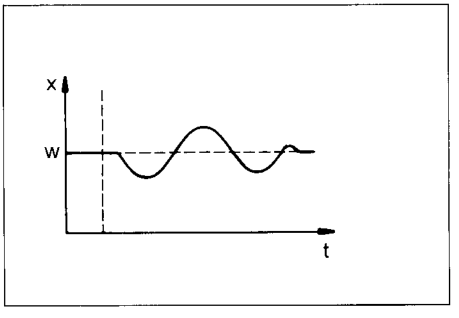
SO operates according to two different procedures which are selected automatically depending on the dynamic state of the process value and its distance from the setpoint at the start of SO. SO can be performed starting from any dynamic course of the process value.

If process value and setpoint are far apart when SO is activated, a switching line is determined and the controlled value is made to perform a forced oscillation about this line during the self-optimisation procedure.



The switching line is selected so that the process value preferably does not go beyond the setpoint. If there is only a small control deviation between setpoint and process value, e.g. when the control loop has stabilised, an enforced oscillation is produced about the setpoint.

Using the recorded process loop data the calculation determines the controller parameters T_n, T_v, X_{p1}, X_{p2}, Cy1, Cy2 and also the optimum filter time constant for this control loop for filtering the process value. The fuzzy parameters Fc1 and Fc2 are set to their base values. SO is then successfully concluded.



If after stabilisation a switching controller exhibits permanent process value oscillations in synchronism with the switching action it is recommended to reduce Cy further.

13.3 Fuzzy parameters

In addition to the algorithms for the various controller structures the controller software also includes a fuzzy module. This can be used to improve both the control and the disturbance response of the controller.

When supplied, and also after self-optimisation, the fuzzy parameters are set to Fc1 = 0 and Fc2 = 30.

The fuzzy module can be activated at any time by setting Fc1 > 0.

The setting Fc2 = 30 is suitable for many applications. The optimum setting can be determined with the aid of the table at the bottom right.

When the fuzzy module is activated the output Y is made up of the controller output and the output signal of the fuzzy module. The parameter Fc1 determines the intensity of the fuzzy signal:

Fc1 = 0 fuzzy module not activated

$0 < Fc1 \leq 100$ fuzzy module is activated

If the fuzzy module activated by Fc1 makes corrections to the control output Y the reset time T_n is influenced during the correction.

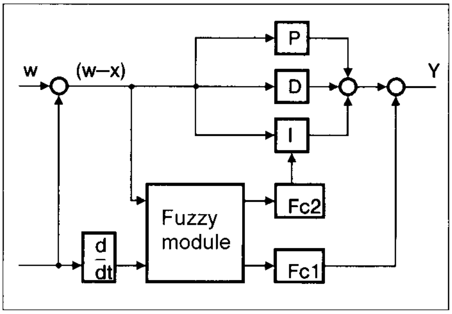
The parameter Fc2 is used to adjust the degree of influencing the reset time T_n.

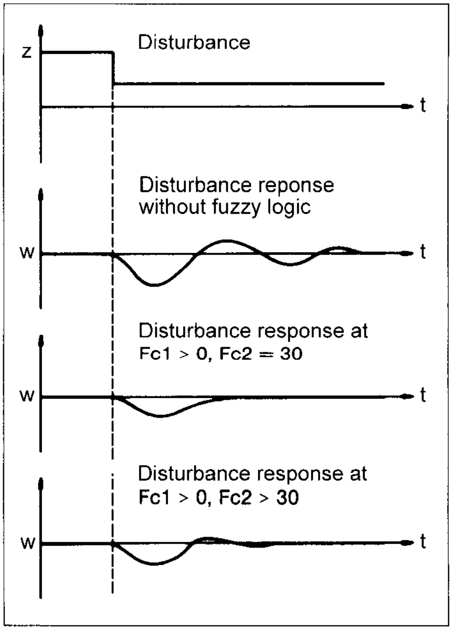
Fc2 = 0 no influence on T_n
$0 < Fc2 \leq 100$ influence on T_n

If the fuzzy module is inactivated (Fc1 = 0) there is no influence through Fc2.

The action and sensitivity of the fuzzy parameters depend very largely on the process being controlled.

The influence is greater in the case of proportional controllers than with switching controllers.



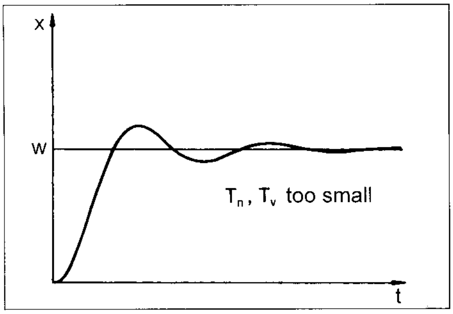


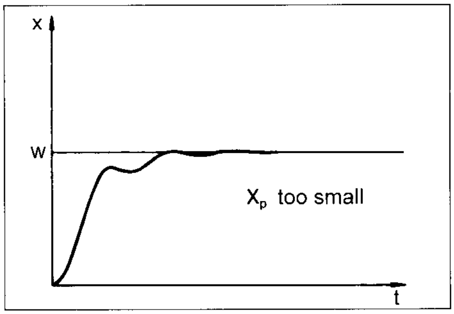
Action	Response
Fc1 ↑	disturbance amplitude reduced, stabilisation time increased
Fc1 ↓	disturbance amplitude increased, stabilisation time reduced
Fc2 ↑	stabilisation time reduced
Fc2 ↓	stabilisation time increased

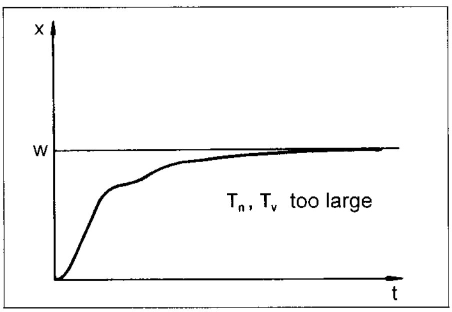
13.4 Checking the optimisation

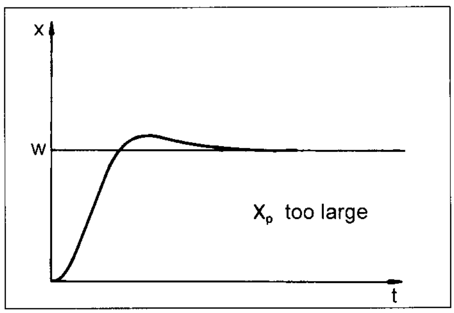
The optimum adjustment of the controller to the process can be checked by recording a start-up with the control loop closed.

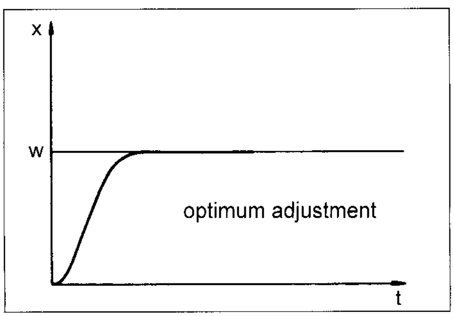
The diagrams below indicate possible incorrect adjustments and the corrections required. The control response of a third-order control loop for a PID controller is shown as example. The procedure for adjusting the controller parameters can however also be applied to other control loops.











14 RAMP FUNCTION

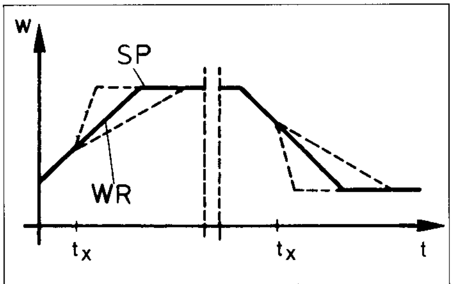
It is possible to set a rising or a falling ramp function. As soon as the supply is switched on the current process value is set equal to the ramp setpoint and the setpoint runs along the set slope until the ramp endpoint SP is reached.

The ramp endpoint is input during the setpoint input.

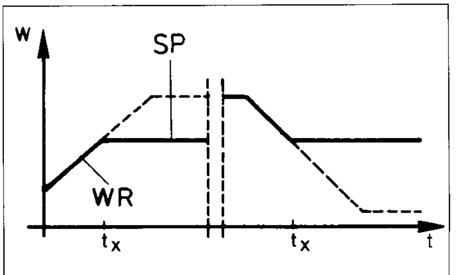
If the ramp is de-activated before the ramp endpoint is reached the controller controls at the ramp endpoint. The ramp endpoint is now the current setpoint.

WR – ramp setpoint
SP – ramp endpoint
t_x – instant of change

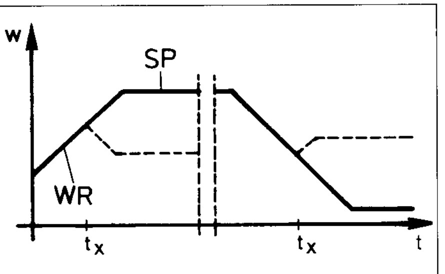
When the ramp endpoint is reached WR = SP.



Altering the ramp slope



Altering the ramp endpoint



Altering the ramp endpoint

Action on probe break

On a break in the probe the ramp function is interrupted. The action of the outputs is as for either overrange or underrange (can be configured). When the fault has been rectified the controller accepts the current process value as the ramp setpoint and continues the ramp function.

Action on supply failure

When the supply is restored the controller accepts the current process value as the ramp setpoint and continues the ramp function with the set parameters.

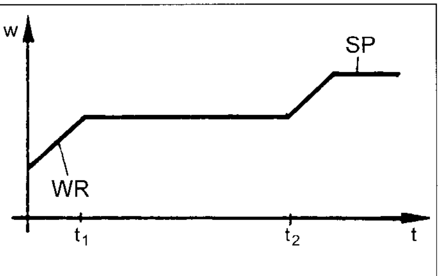
Action during manual operation

During manual operation the ramp function is interrupted. On changing to automatic operation the controller accepts the current process value as the ramp setpoint and continues the ramp function with the set parameters.

Ramp stop

On activating the ramp stop through a logic input the ramp function is held up. After de-activating the ramp stop the ramp function continues with the ramp setpoint at the instant of the ramp stop.

The ramp stop can be realised in software by programming a slope = 0 from the keys or the setup program.



Ramp stop

15.1 External relay module ER8

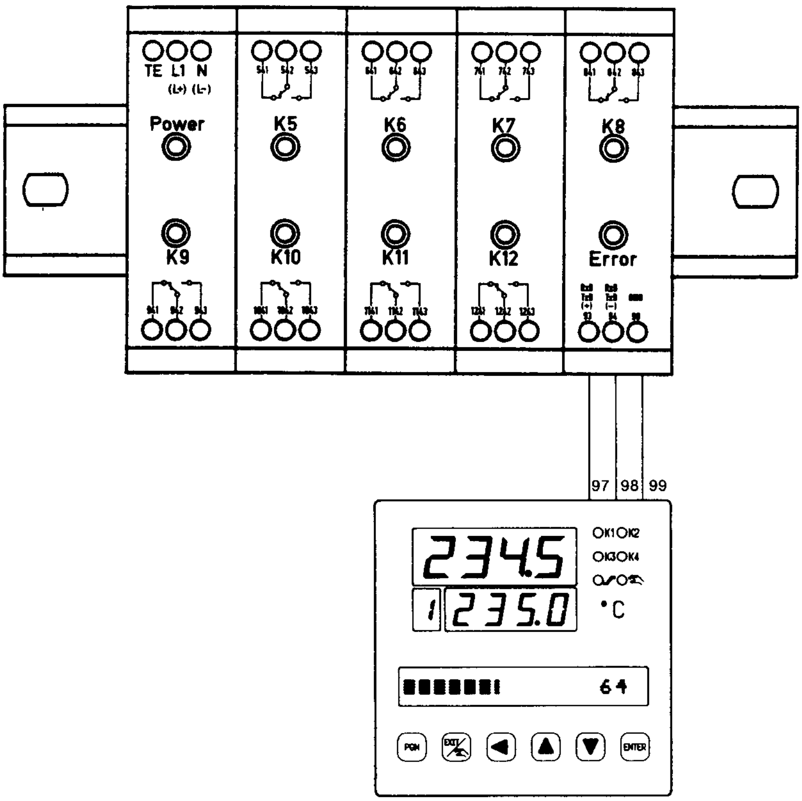
Through the use of the external relay module ER8 a further eight switched outputs can be added to the controller.

The following functions can be assigned to the outputs:

- controller outputs
- limit comparators
- logic linkages

The connection between controller and relay module is made through a serial interface (available as standard).

The external relay outputs 1 — 8 correspond to the contacts K5 — K12.



15.2 RS422/RS485 interface

Using the interface the controller can be integrated into a data network. The following applications can be realised, for example:

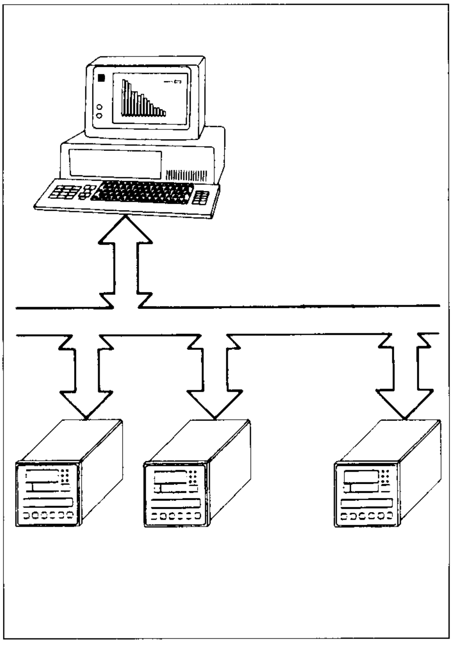
- visualise the process
- system control
- generate reports

The bus system is designed on the master-slave principle. A master computer can address up to 31 controllers and instruments (slaves). The interface is a serial interface to the RS422 or RS485 standard.

The following data protocols are available:

- MOD-Bus protocol
- J-Bus protocol
- SETUP protocol

Interface description B 70.3560.2



15.3 Maths and logics module

The maths module processes real and Boolean values. The starting points are real values.
The logics module processes Boolean values. The starting points are Boolean values.

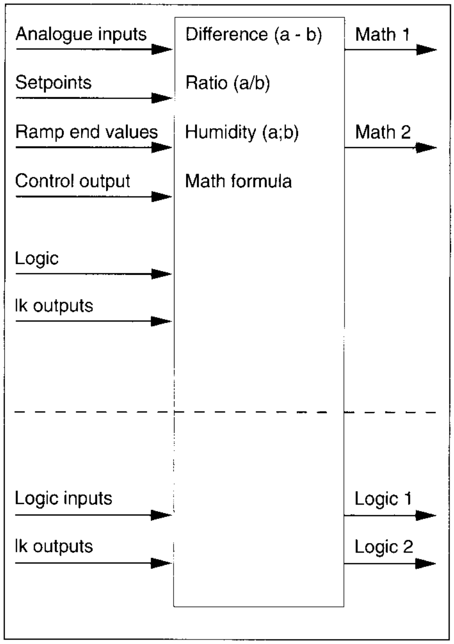
The sampling time of the controller may be extended depending on the extent of the calculations.

The settings “difference”, “ratio” and “humidity” represent the standard formulae for the corresponding controller types.

The parameters “variable a” and “variable b” provide the input values for these formulae.

Chapters 16.4, 16.5, 16.6

Software extra Codes can be enabled by using “Code” in the setup program (also see Online help).



15.3.1 Math formula

The maths module permits linking various analogue and Boolean inputs through a mathematical formula.

A formula can be specified for each of the two output values (Math 1/2).

Formula input:

- The formula chain consists of ASCII characters and has a maximum length of 70 characters.
- The formula can be input only in the setup program.
- The formulae can be input freely according to the usual mathematical rules.
- Space characters can be inserted in the formula chain without restriction.
  There must be no space character within function designations, variables names and constants.

If the formula chain contains an error, an error message is output after entering the input, and the cursor is positioned on the error.

Example:

Math formula

Formula 1:

`(AIN1+AIN2+AIN3)/3`

Formula 2:

`30*SQRT(AIN1)`

Mathematical signs and functions

Priority	Mathematical sign/function	Note
high	( )	brackets
	SQRT, MIN, MAX, LOG, LN, SIN, COS, TAN, ABS, EXP	functions
	* *	exponent (x^y)
	+, −	sign
	*, /	multiplication, division
low	+, −	addition, subtraction

Variables

Variable name	Note
AIN1 or E1	Analogue input 1
AIN2 or E2	Analogue input 2
AIN3 or E3	Analogue input 3
AIN4 or E4	Analogue input 4
WR1	Setpoint controller 1
WR2	Setpoint controller 2
WE1	Ramp end point controller 1
WE2	Ramp end point controller 2
Y1	Control output controller 1
Y2	Control output controller 2
W12	Setpoint 2 controller 1 (operating level)
W13	Setpoint 3 controller 1 (operating level)
W14	Setpoint 4 controller 1 (operating level)
W22	Setpoint 2 controller 2 (operating level)
W23	Setpoint 3 controller 2 (operating level)
W24	Setpoint 4 controller 2 (operating level)
LK1 : LK8	Output limit comparator 1 : Output limit comparator 8
L1 L2	Logic 1 Logic 2

Syntax	Function
SQRT(a)	square root of a Examples: SQRT(AIN2) SQRT(13.5 + AIN3)
MIN(a1, a2 ...)	returns the smallest value of a series of arguments Examples: MIN(3.4, 7) (returns the value 3.4) MIN(AIN1, AIN2, AIN3, 0.1)
MAX(a1, a2 ...)	returns the largest value of a series of arguments Examples: MAX(3.4, 7) (returns the value 7) MAX(AIN1, AIN3, AIN3, 0.1+AIN4)
LOG(a)	logarithm to base 10 Examples: LOG(1000) (returns the value 3) LOG(AIN1/100)
LN(a)	logarithm to base e Examples: LN(2.71828128) (returns the value 1) LN(AIN1/100)
SIN(a)	sine of a a in degrees (0 - 360°) Examples: SIN(90) (returns the value 1) SIN(AIN1*360/100)
COS(a)	cosine of a a in degrees (0 - 360°) Examples: COS(180) (returns the value -1) COS(AIN1*360/100)
TAN(a)	tangent of a a in degrees (0 - 360°) Examples: TAN(45) (returns the value 1) TAN(AIN1*45/100)
ABS(a)	absolute value of a Examples: ABS(-12) (returns the value 12) ABS(13.5+AIN3)
EXP(a)	exponential function e^a Examples: EXP(1) (returns the value 2.718) EXP(AIN1/100)

15.3.2 Logic formula

The logics module provides a facility for logically linking the logic inputs and the lk outputs. A formula can be specified for each of the two Boolean output values (Logic 1/2).

Example:

Logic formula

Formula 1:

(BIN1 OR BIN2) AND LK1

Formula 2:

LK1 OR LK2 OR LK3

Logic operators

Priority	Operator	Note
high	( )	brackets
	NOT	negation
	AND, &	AND linkage
	XOR, ^	exclusive OR linkage
low	OR, ¦	OR linkage

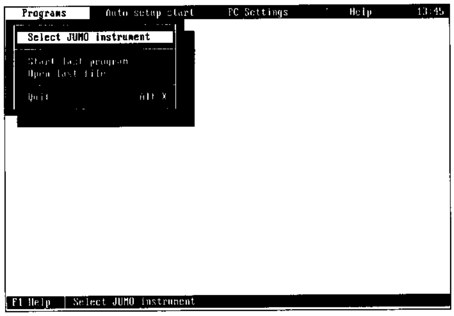
Variables

Variable name	Note
BIN1 or B1 : BIN5 or B5	Logic input 1 : Logic input 5
LK1 : LK8	Output limit comparator 1 : Output limit comparator 8

Constants

Constant name	Note
TRUE	logic 1
FALSE	logic 0

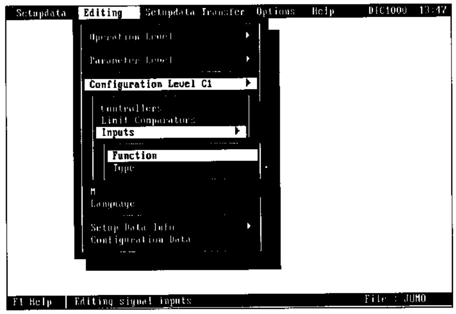
15.4 Setup program



A setup program is available to permit easy configuration of the controller.

The program runs under the JUMODESK user interface which is based on the widely-used SAA standard. This ensures simple operation.

The program can be operated from the keyboard or with the mouse.



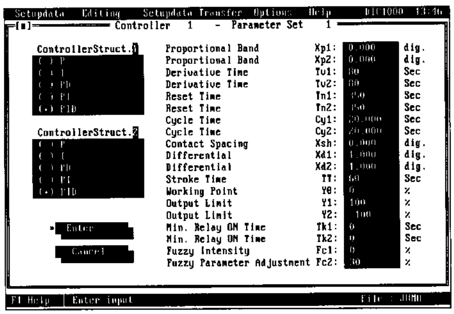
Hardware requirements:

IBM-AT or compatible computer to the following specification:

- 640 kB RAM (of this at least 480 kB free)
- 3½" disk drive
- hard disk (at least 3 MB free)
- serial interface (RS232)

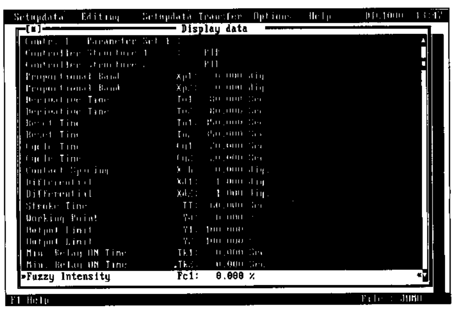
Software requirements:

- MS-DOS Version 3.3 or higher
- mouse support from driver version:
  - Microsoft Version 6.24
  - Logitech Version 4.10
  - Genius Version 9.02



Installation:

- ✱ Place diskette into the drive
- ✱ Input:
  A:INSTALL ↵ or B:INSTALL ↵
- ✱ After installation has been completed start the user interface with JUMODESK ↵



If a setup program has already been installed on the computer, additional copying is limited to the missing data.

Be certain to make a back-up copy of your setup program.

15.5 C-level control

C-level control is used to regulate the carbon activity in the atmosphere of a gas carburisation furnace. The C-level is determined by measuring the oxygen level, with a zirconium dioxide sensor, and the sensor temperature.

⇨ Chapter 16.14

15.5.1 C-level calculation

The calculations are made by the controller according to the following formula:

$$E = 0.0992 \cdot T \cdot (-\lg (P_{CO}) + 1.995 + 0.15 \cdot C_p + \lg (C_p)) \cdot mV/°C + 816.1\ mV$$

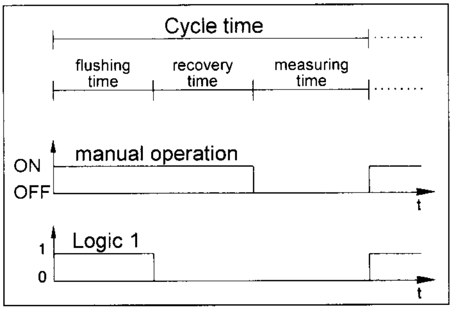
E - e.m.f. of the zirconium dioxide sensor
T - sensor temperature in °C
P_{CO} - partial pressure of CO in % by volume
C_p - carbon level

15.5.2 Control sequence

The operation of a zirconium dioxide sensor has to follow a fixed time frame. The sensor must be flushed at regular intervals (cycle time) in order to ensure error-free measurements.

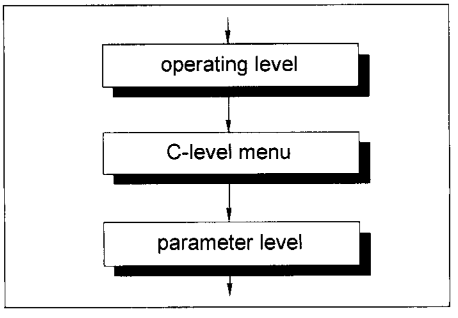
The controller is in manual operation during flushing and the following recovery time. The last measured value is stored. The output is the average of the latest actuator settings.

During flushing the logic 1 output is at “1”. The logical combination with an output enables a control of the flushing procedure.



15.5.3 C-level menu

The C-level menu, for controllers with the Extra Code “C-level control”, can be found between the operating and parameter levels.



C-level measurement

C-LEVEL MENU
- **C-level measurement**
- Sensor flushing

Menu item	Setting
Sensor voltage ❶	no C-L measurement / Analogue input 1
Sensor temperature ❷	Analogue input 2
CO measurement ❸	no CO measurement / Analogue input 3
CO content ❹	Value* ____ Value range: –1999 to +9999 factory-set: 33
Correction factor ❺	Value* ____ Value range: –1999 to +9999 factory set: 1

Explanation:

* = input a value

☐ = factory setting

Inputs

No.	Item	Display	Notes
❶	Sensor voltage	SENSOR VOLTAGE	This activates the Extra Code "C-level control". If "no C-L measurement" is set, then the controller operates in the normal manner. The sensor voltage is measured at analogue input 1. ⇨ Chapter 15.5.4
❷	Sensor temperature	SENSOR TEMP.	The sensor temperature is measured at analogue input 2.
❸	CO measurement	CO MEASUREMENT	The CO content is measured at analogue input 3
❹	CO content	CO CONTENT	If "no CO measurement" is set under ❸, then the known value for the CO content must be entered here in % by volume.
❺	Correction factor	COR. VALUE	The correction factor is a C-level determined by reference measurement.

Sensor flushing

C-LEVEL MENU
C-level measurement
Sensor flushing

Cycle time ❶
Value* ____
Value range: 0 to 600 min
factory-set: 0 min

Flushing time
Value* ____
Value range: 0 to 600 min
factory set: 0 min

Recovery time
Value* ____
Value range: 0 to 600 min
factory set: 0 min

Explanation:

* = input a value

☐ = factory setting

Inputs

No.	Item	Display	Notes
❶	Cycle time	P. TIME	—

15.5.4 Notes

Design changes

In units with the Extra Code "C-level control" the measurement ranges for analogue input 1 are changed as follows:
0 — 10 V -> 0 — 2 V
2 — 10 V -> 0.4 — 2 V

There is no probe break monitoring.

Maths module

The menu settings
"Special function – Math 1" and
"Special function – Logic 1"
are ineffective when the C-level control is switched on.

Communication via RS 422 / RS 485

It is not possible to access the configuration files in the C-level menu via the serial interface.

Oxygen measurement

An oxygen measurement is possible when the C-level control is switched off. The oxygen content can be calculated according to Nernst's equation, using the maths module.

$$P_{02} = P_{02,ref} \bullet \exp [-(46.51 \bullet E) / (\vartheta_s + 273.2\ °K] \bullet °K/mV$$

P_{02} = partial pressure of oxygen
$P_{02,\,ref}$ = reference pressure (20.9%)
E = e.m.f. of the zirconium dioxide sensor
ϑ_s = sensor temperature in °C

Formula syntax (maths module)

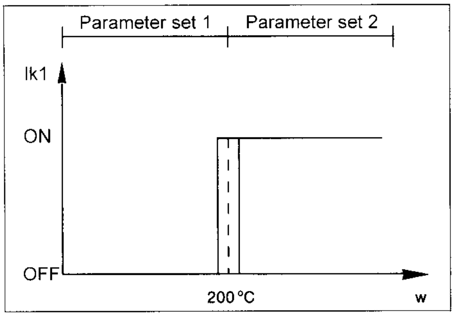
```
0.209 • EXP [–(46.51 • AIN1) / (AIN2 + 273.2)]
```

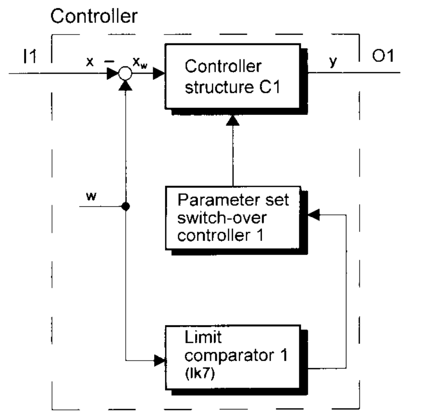
16.1 Controller with parameter set switching depending on setpoint

The controller has to operate at two different setpoints (setpoint ranges) with different controller parameters.

By linking the setpoint to a limit comparator (Ik7) it is possible to switch between two parameter sets using a logic input. The relay output O2 has to be connected to the logic input 1.

Example:
w < 200 °C → parameter set 1
w > 200 °C → parameter set 2





List of symbols

O1 – Output 1
w – Setpoint
x – Process value
x_w – Deviation
y – Control output

Configuration level C1			
Limit comparators	Limit comparator 1	Function	Ik7
		Switching differential	1
		Limit	200
Inputs	Limit comparator 1	LC actual value	Setpoint controller 1

Configuration level C2		
Logic functions	Limit comparator 1	Parameter set switch-over controller 1

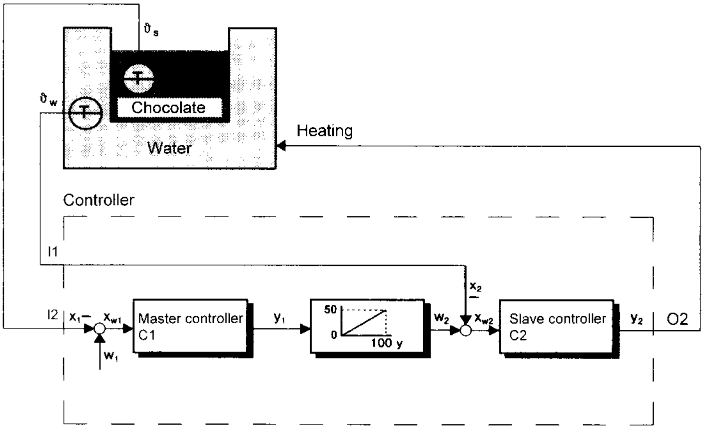
16.2 Cascade controller

Chocolate has to be heated to ϑ_S = 40 °C for processing. The chocolate temperature must nowhere exceed 50 °C (even close to the heater). It is therefore heated on a water bath.

Cascade control is used in order to achieve rapid stabilisation.

Controller 1 is always the master controller, controller 2 always the slave.

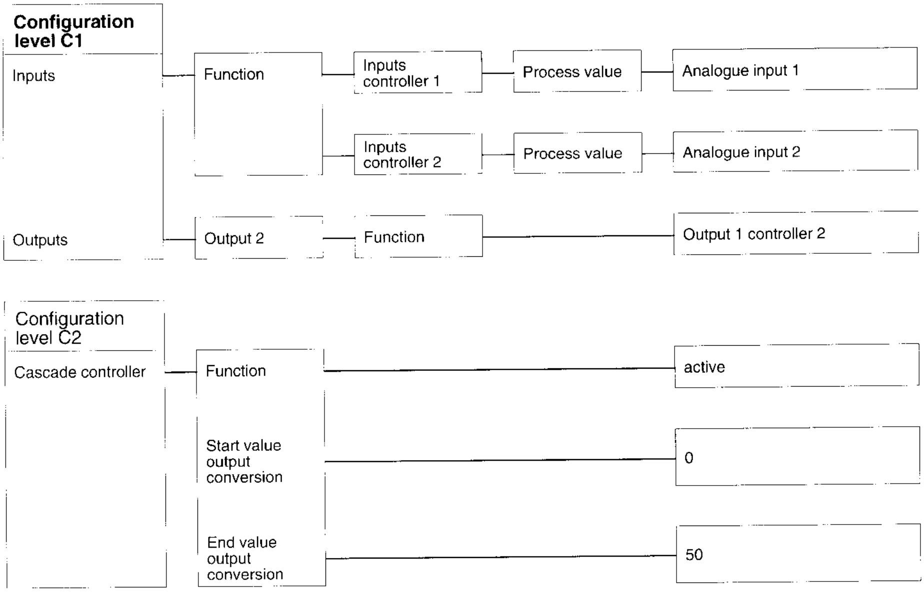
The setpoint for the slave controller is produced by output conversion. The control output y_1 is converted to a setpoint using the unit of the process value x_2 (here: 0 — 100 % = 0 — 50 °C).



List of symbols

C1 – Controller 1
C2 – Controller 2
I1 – Analogue input 1
I2 – Analogue input 2
O2 – Output 2
w_1 – Setpoint controller 1
w_2 – Setpoint controller 2
x_1 – Process value controller 1
x_2 – Process value controller 2
x_{w1} – Deviation controller 1
x_{w2} – Deviation controller 2
y_1 – Control output 1
y_2 – Control output 2; output 1 of controller 2
ϑ_S – Chocolate temperature
ϑ_W – Water bath temperature

Cascade controller



16.3 Trim cascade controller

Two charges of chocolate have to be heated to 40 °C and 50 °C. The chocolate temperature must nowhere (not even close to a heater) exceed the setpoint by more than 10 °C. It is therefore heated on a water bath.

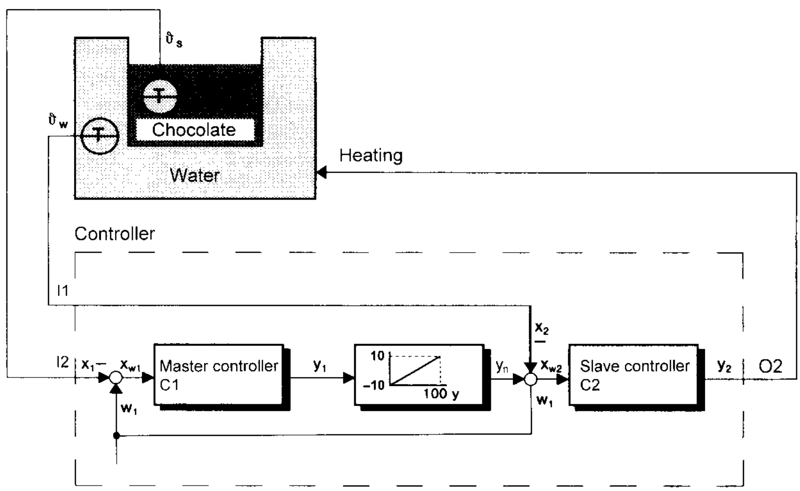
Trim cascade control is used to achieve rapid stabilisation without overshoot and without altering the controller configuration (output conversion) at a change of setpoint (batch change).

Controller 1 is always the master controller, controller 2 always the slave controller.

The setpoint for the slave controller is produced by output conversion and the addition of the master controller setpoint (w_1).

In setpoint conversion, the control output y_1 is converted to a value with the unit of the process value w_2. It corresponds to the maximum permitted temperature difference ($\pm | x_1 - w_1 |$; here: 0 — 100 % = −10 to +10 °C).

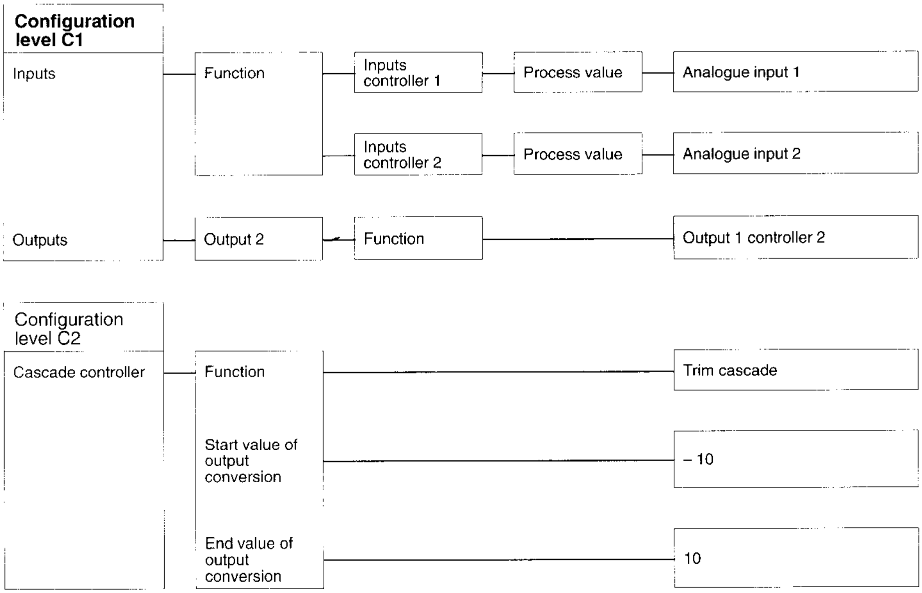
Using the maths module, the process value can be used to form the setpoint for the slave controller.



List of symbols

- C1 – Controller 1
- C2 – Controller 2
- I1 – Analogue input 1
- I2 – Analogue input 2
- O2 – Output 2
- w_1 – Setpoint controller 1
- x_1 – Process value controller 1
- x_2 – Process value controller 2
- x_{w1} – Deviation controller 1
- x_{w2} – Deviation controller 2
- y_1 – Control output 1
- y_2 – Control output 2; output 1 of controller 2
- y_n – Converted control output 1
- ϑ_s – Chocolate temperature
- ϑ_w – Water bath temperature

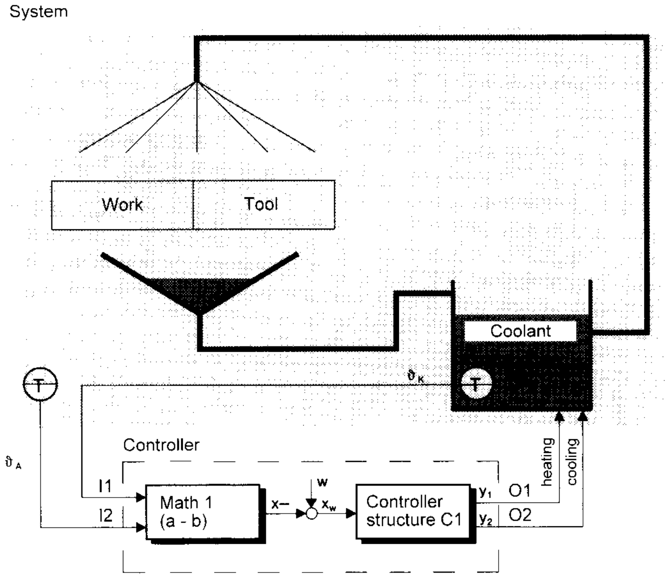
Trim cascade controller



16.4 Difference controller

On precision machine tools (e.g. lathes) it is necessary to maintain tool, work and positioning device at the same temperature in order to ensure the required tolerances. This requirement can be met by thermostating the coolant using difference control.

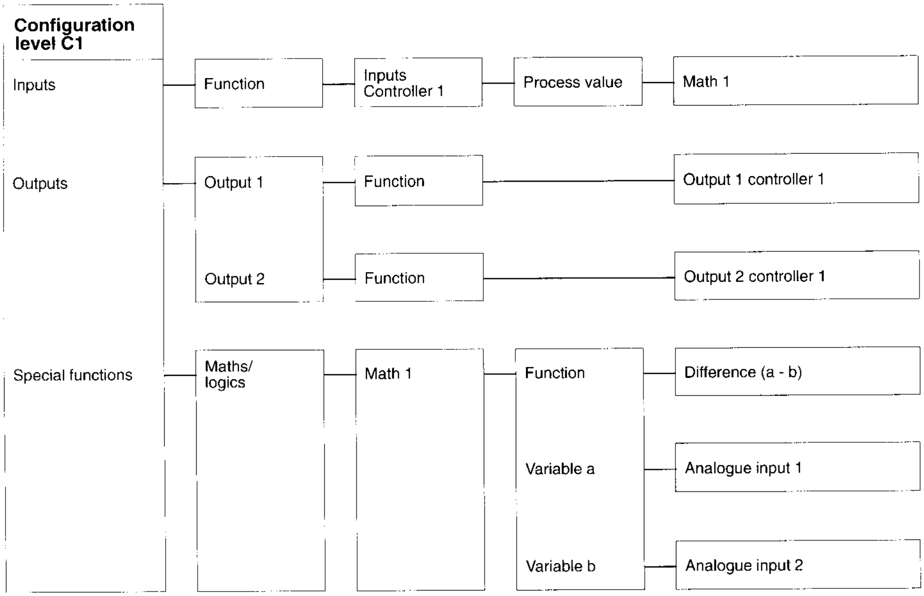
The coolant temperature and the temperature of the remaining equipment are fed to the maths module and the difference of the two values is applied to the controller structure as the controlled variable.



List of symbols

C1 – Controller 1
I1 – Analogue input 1
I2 – Analogue input 2
O1 – Output 1
O2 – Output 2
w – Setpoint (required difference)
x – Process value (controlled variable)
x_w – Deviation
y_1 – Control output 1: Controller 1 output 1
y_2 – Control output 2; Controller 1 output 2
ϑ_A – System temperature
ϑ_K – Coolant temperature

Difference controller



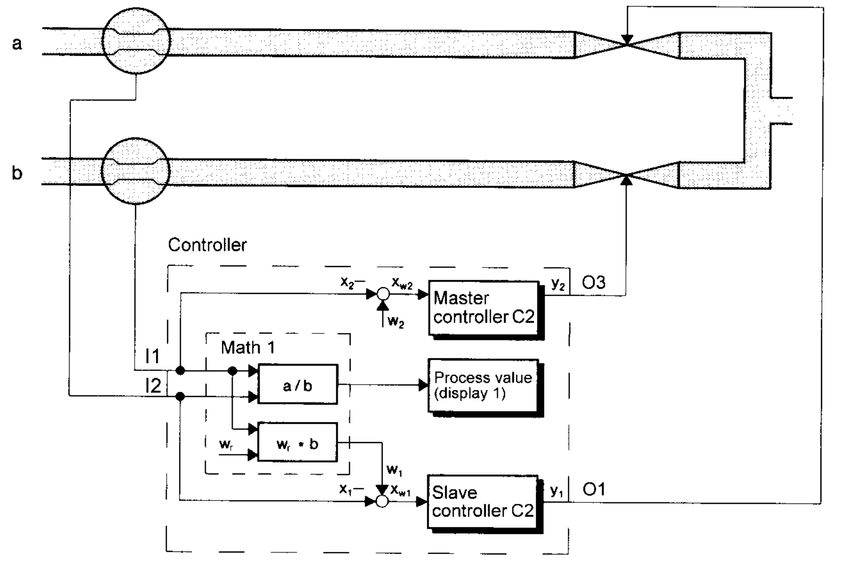
16.5 Ratio controller

Two substances have to be mixed in a fixed ratio. The quantity b (setpoint w_2) is controlled by the master controller C2. This controller determines also the total quantity (a + b). Setpoint w_2 is programmed as the setpoint input of controller 2.

The mixing ratio (a:b) is determined by the ratio setpoint w_r which is programmed in the setpoint input of controller 1.

In the case of ratio control the maths module and the controller have a fixed internal linkage.

- Maths module 1 alters the setpoint of controller 1
- Maths module 2 alters the setpoint of controller 2



List of symbols

a	– Quantity material a	w_2	– Setpoint controller 2
b	– Quantity material b	w_r	– Ratio setpoint
C1	– Controller 1	x_1	– Process value controller 1
C2	– Controller 2	x_2	– Process value controller 2
I1	– Analogue input 1	x_{w1}	– Deviation controller 1
I2	– Analogue input 2	x_{w2}	– Deviation controller 2
O1	– Output 1	y_1	– Control output 1: output controller 1
O3	– Output 3	y_2	– Control output 2: output controller 2
w_1	– Setpoint controller 1		

Ratio controller

Configuration level C1

- Inputs
  - Function
    - Inputs controller 1
      - Process value
        - Analogue input 2
    - Inputs controller 2
      - Process value
        - Analogue input 1
- Outputs
  - Output 1
    - Function
      - Output 1 controller 1
    - Signal
      - 4 — 20 mA
    - Zero
      - 0
    - Full scale
      - 100
  - Output 3
    - Function
      - Output 1 controller 2
    - Signal
      - 4 — 20 mA
    - Zero
      - 0
    - Full scale
      - 100
- Special functions
  - Maths/Logics
    - Math 1
      - Function
        - Ratio (a/b)
      - Variable a
        - Analogue input 2
      - Variable b
        - Analogue input 1

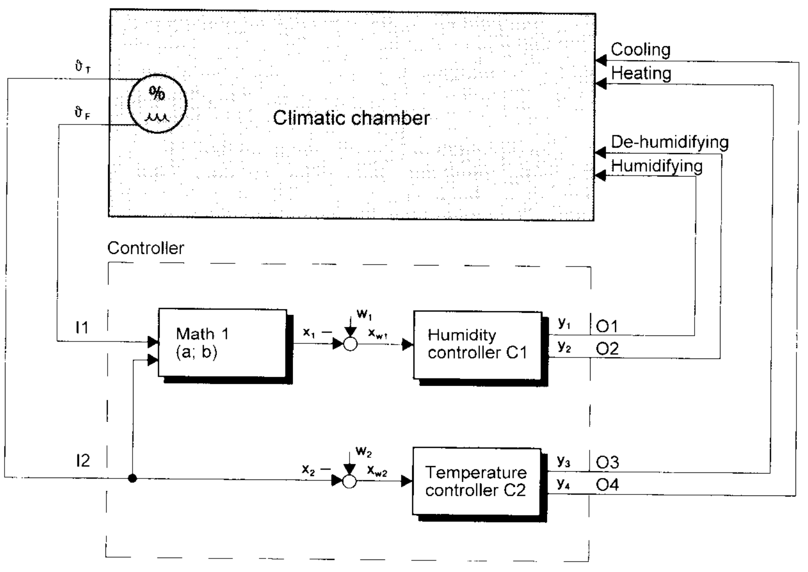
Configuration level C2

- Display
  - Display controller 1
    - Display 1
      - Display value
        - Math 1
    - Display 2
      - Display value
        - Ramp end value*

* or ratio setpoint

16.6 Humidity controller

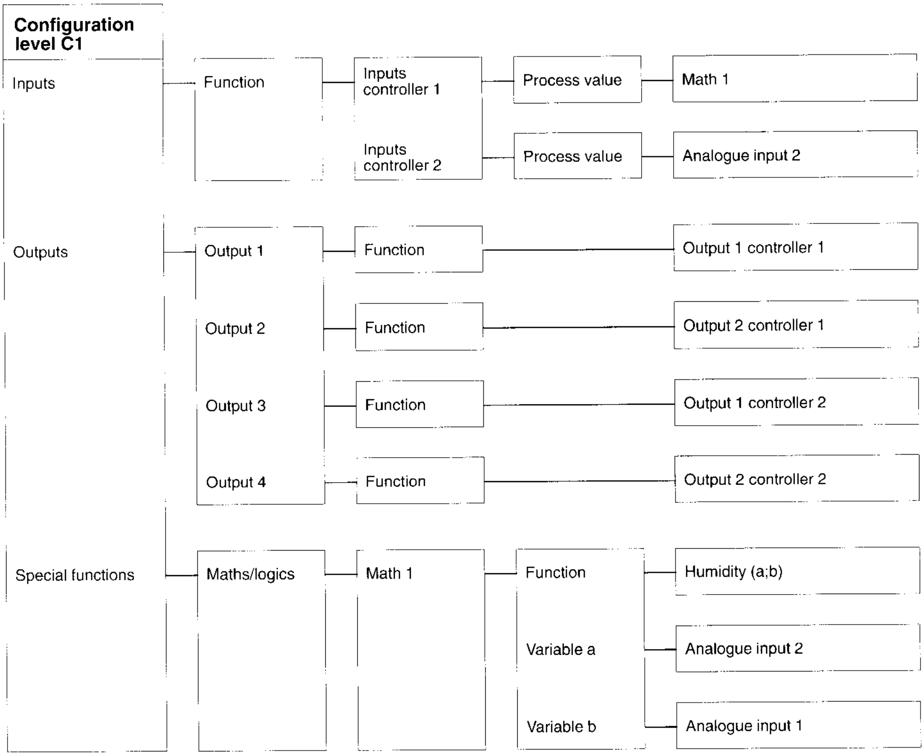
In a climatic cabinet the humidity and the temperature have to be controlled. The humidity controller receives the process value from a psychrometric humidity probe through the mathematical linkage of wet bulb and dry bulb temperatures. The calculated process value can vary between 0 and 100 (% rH). The probe also provides the process value (dry bulb temperature) for the temperature control.



List of symbols

C1	– Controller 1	x_1	– Process value controller 1
C2	– Controller 2	x_2	– Process value controller 2
I1	– Analogue input 1	x_{w1}	– Deviation controller 1
I2	– Analogue input 2	x_{w2}	– Deviation controller 2
O1	– Output 1	y_1	– Control output 1: output controller 1
O2	– Output 2	y_2	– Control output 2: output controller 1
O3	– Output 3	y_3	– Control output 3: output controller 2
O4	– Output 4	y_4	– Control output 4: output controller 2
w_1	– Setpoint controller 1 (humidity)	ϑ_F	– Wet bulb temperature
w_2	– Setpoint controller 2 (temperature)	ϑ_T	– Dry bulb temperature

Humidity controller

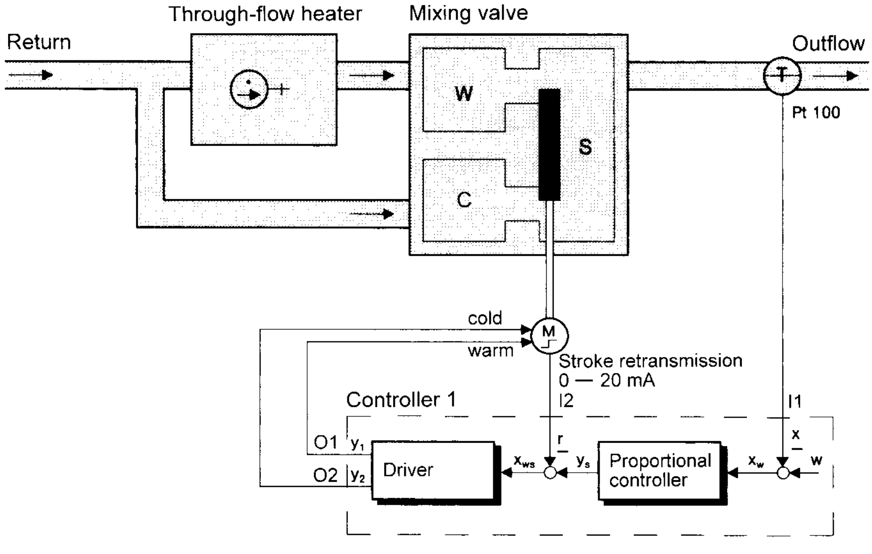


a = dry bulb temperature
b = wet bulb temperature

16.7 Proportional controller with integral driver for motorised actuators

The supply temperature in a district heating scheme has to be controlled. A mixing valve is provided whose chambers W and C for warm and cold water are connected through pipes to the return water flow.
The outflow temperature is measured with a Pt 100 resistance thermometer and should be 55 °C. The temperature is varied by moving the slider S through an actuating motor whose position is retransmitted using a standard 0 — 20 mA signal.

The input to the actuating motor consists of switching pulses from the actuator driver for opening or closing the valve ports. The proportional controller with integral driver for motorised actuators represents a cascade control system.
The characteristic parameter of the actuating motor is its stroke time from one end stop of the slider to the other (stroke time TT = 90 sec).
The subordinate circuit (driver controller) is optimised after the input of the stroke time into the controller.



List of symbols

- I1 – Analogue input 1
- I2 – Analogue input 2
- O1 – Output 1
- O2 – Output 2
- r – Stroke retransmission
- w – Setpoint
- x – Process value
- x_w – Deviation
- x_{ws} – Deviation (actuator driver)
- y_s – Control output of proportional controller
- y_1 – Control output 1: output controller 1
- y_2 – Control output 2: output controller 1

Proportional controller with integral driver for motorised actuators

Operating level

- Setpoints
  - Controller 1 Setpoint 1 — 55

Parameter level

- Parameter sets Controller 1
  - Parameter set 1
    - Stroke time TT — 90

Configuration level C1

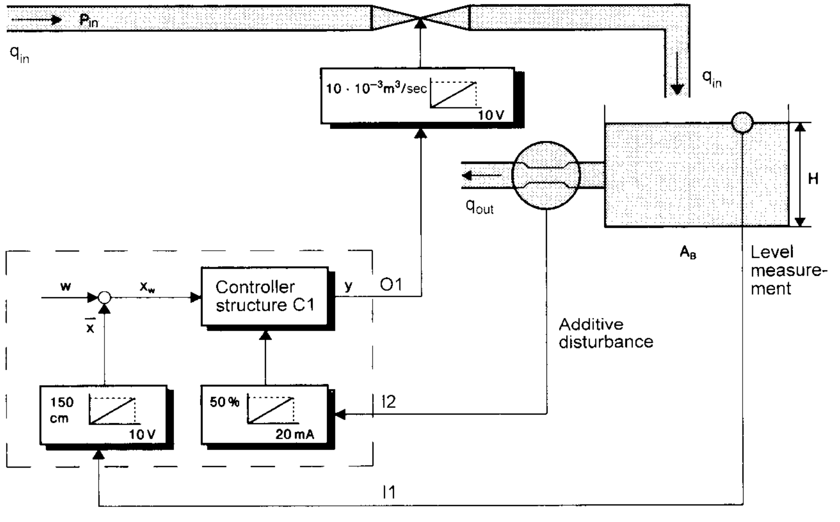
- Controller
  - Controller mode Controller 1 — Proportional controller with integral driver for motorised actuators
- Inputs
  - Function
    - Inputs controller 1
      - Process value — Analogue input 1
      - Stroke retransmission — Analogue input 2
  - Type
    - Analogue input 1
      - Transducer — Resistance thermometer
      - Linearisation — Pt 100
    - Analogue input 2
      - Transducer — 0 — 20 mA
      - Linearisation — linear
      - Display start — 0
      - Display end — 100
- Outputs
  - Output 1 — Output 1 controller 1
  - Output 2 — Output 2 controller 1

16.8 Controller with additive disturbance compensation

The liquid level in a tank with a rectangular base area A_B has to be held at 70 cm. The liquid level is disturbed by an outflow q_{out}. In order to achieve improved control action this outflow is being measured by a flowmeter whose signal is fed into the controller as an additive disturbance. As a result the controller alters its control output so that a change in the outflow is immediately compensated by a change in the inflow q_{in}. The inflow at maximum controller output is 10×10^{-3} m³/sec.

The tank has a height of 1.20 m. Since the supply pressure P_{in} is constant there is a proportional relationship between the controller output and the inflow rate.

The size of the additive disturbance is determined by a mean outflow of 2×10^{-3} m³/sec, corresponding to a current signal of 8 mA.



List of symbols

A_B – Base area of the tank
C1 – Controller 1
H – Height of tank
I1 – Analogue input 1 (0 — 10 V)
I2 – Analogue input 2 (0 — 20 mA)
O1 – Output 1 (0 — 10 V)
P_{in} – Supply pressure
q_{in} – Inflow
q_{out} – Outflow
w – Setpoint
x – Process value
x_w – Deviation
y – Control output

Controller with additive disturbance compensation

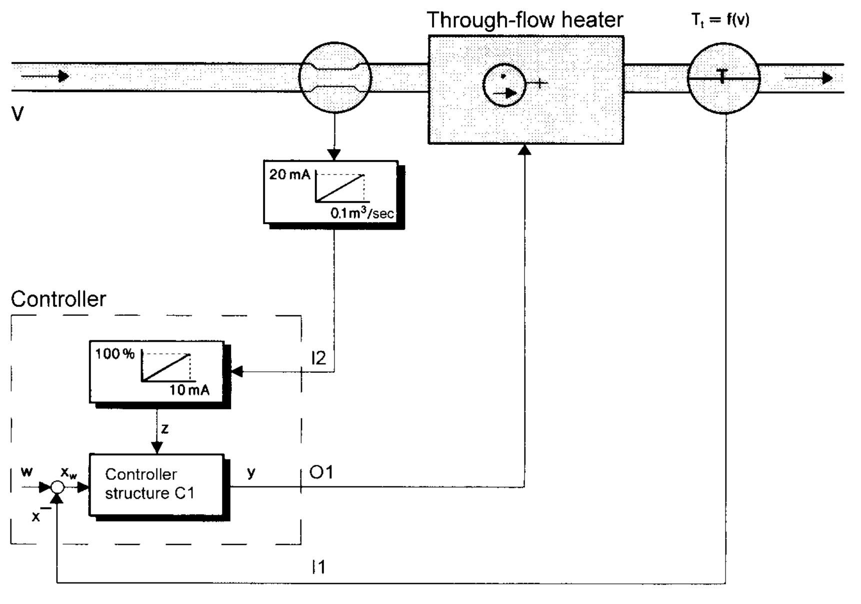
Operating level				
Setpoints	Controller 1 Setpoint 1			70

Configuration level C1				
Controllers	Controller mode controller 1			Proportional controller falling characteristic
Inputs	Function	Inputs controller 1	Process value	Analogue input 1
			Additive disturbance	Analogue input 2
	Type	Analogue input 1	Transducer	0 — 10 V
			Linearisation	linear
			Display start	0
			Display end	150
		Analogue input 2	Transducer	0 — 20 mA
			Linearisation	linear
			Display start	0
			Display end	50
Outputs	Output 1		Function	Output 1 controller 1
			Output signal	0 — 10 V
			Zero	0
			Full scale	100

16.9 Controller with multiplying disturbance compensation

A liquid is passing through a pipe at a flow rate which can vary between 0 and 0.1 m^3/sec. The liquid has to be heated to 200 °C by a heater.

The effect on the control of fluctuations in the volumetric flow rate are compensated by a multiplying disturbance correction. The controller is configured so that the disturbance z has a value of 100 % at the mid-point of operation (average volumetric flow rate 0.05 m^3/sec).



List of symbols

C1 – Controller 1
I1 – Analogue input 1 (Pt 100)
I2 – Analogue input 2 (0 — 20 mA)
O1 – Output 1 (0 — 10 V)
V – Flow rate
w – Setpoint
x – Process value
x_w – Deviation
y – Control output
z – Disturbance

Controller with multiplying disturbance compensation

Operating level

Setpoints	Controller 1 Setpoint 1			200

Configuration level C1

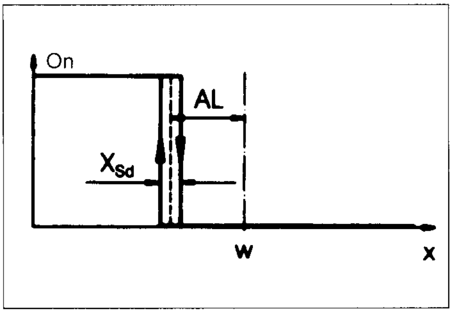
Controllers	Controller mode controller 1			Proportional controller falling characteristic
Inputs	Function	Inputs controller 1	Process value	Analogue input 1
			Multiplying disturbance	Analogue input 2
	Type	Analogue input 1	Transducer	Resistance thermometer
			Linearisation	Pt 100
		Analogue input 2	Transducer	0 — 20 mA
			Linearisation	linear
			Display start	0
			Display end	200
Outputs	Output 1		Function	Output 1 controller 1
			Output signal	0 — 10 V
			Zero	0
			Full scale	100

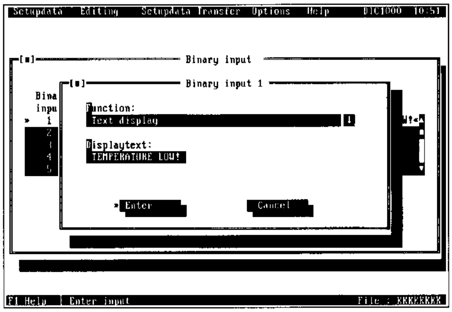
16.10 Controller with limit comparator and text display

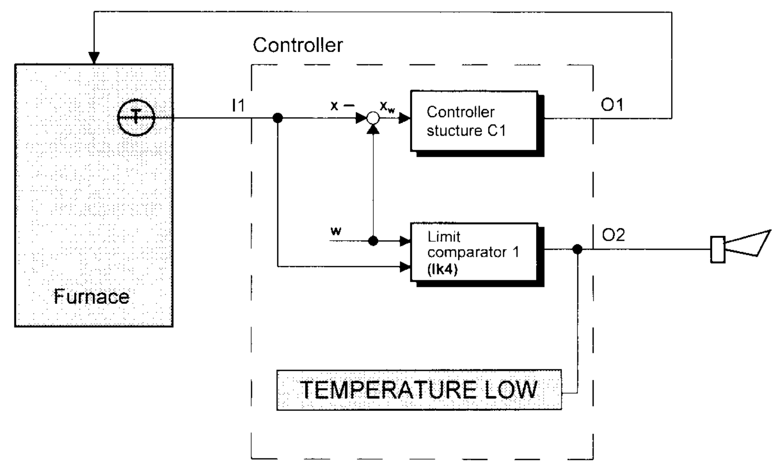
A furnace is controlled by a temperature controller. The actual temperature x must not fall below the setpoint w = 1000 °C by more than 20 °C.

If the difference between setpoint and actual temperature is larger, an alarm (hooter) has to be produced (the relay of output O2 has to pull in) and the matrix display has to show the text "TEMPERATURE LOW".

The text display can only be programmed using the setup program (accessory).



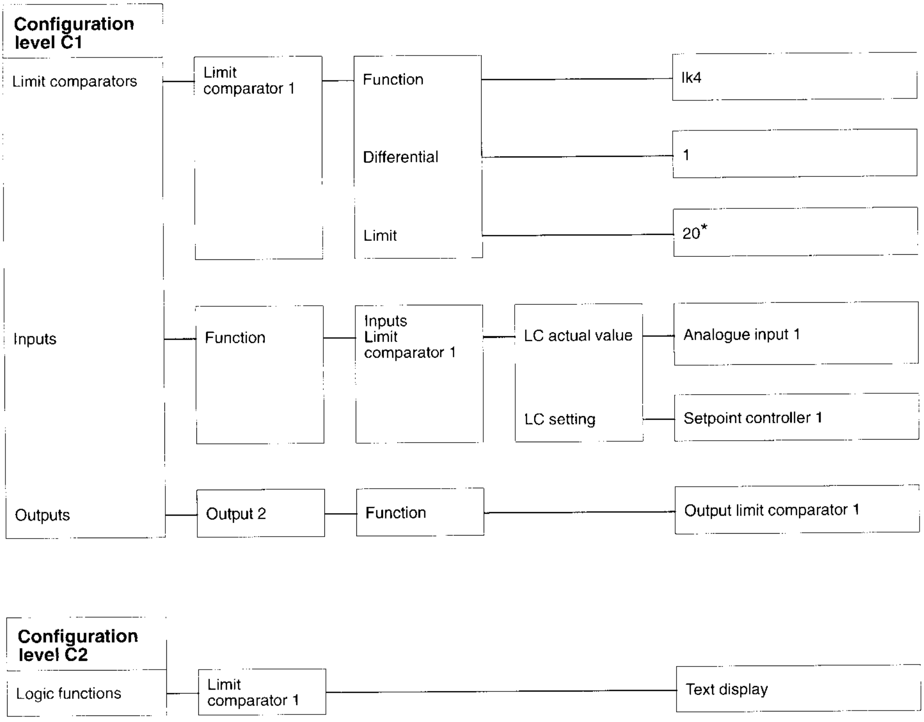




List of symbols

AL – Limit	O1 – Output 1	x – Process value
BI1 – Logic input 1	O2 – Output 2	X_{Sd} – Differential
I1 – Analogue input 1	w – Setpoint	x_w – Deviation

Controller with limit comparator and text display



* Switching differential X_{Sd} neglected

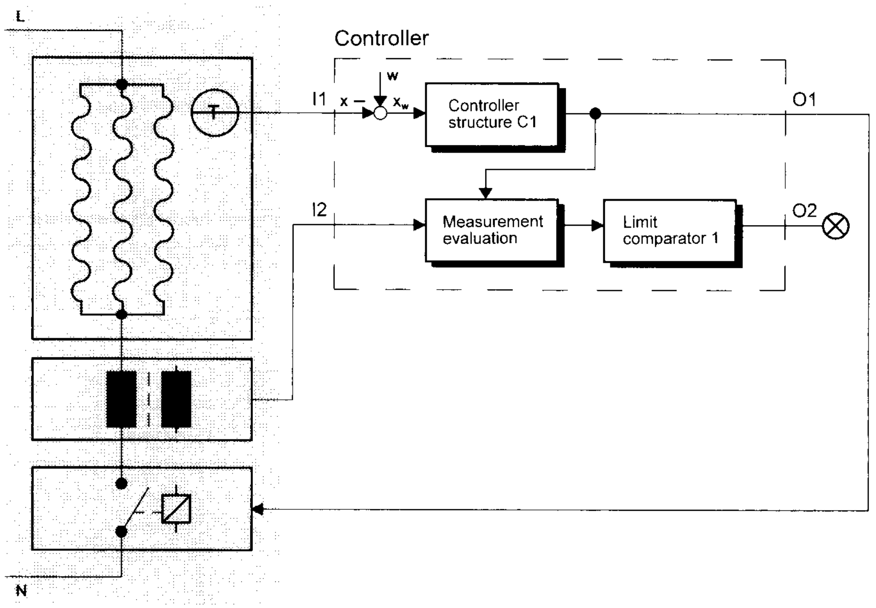
16.11 Controller with heater current monitoring

In electrically heated ovens and furnaces it may be useful in the case of several heater circuits to monitor the heating current in order to determine whether one circuit has failed.

In the example the normal heating current is 100 A. If one of the heater circuit fails, the heater current is reduced to approx. 67 A.

The heating current is evaluated by a current transformer with a standard output signal (0 — 100 A AC → 0 — 20 mA AC).

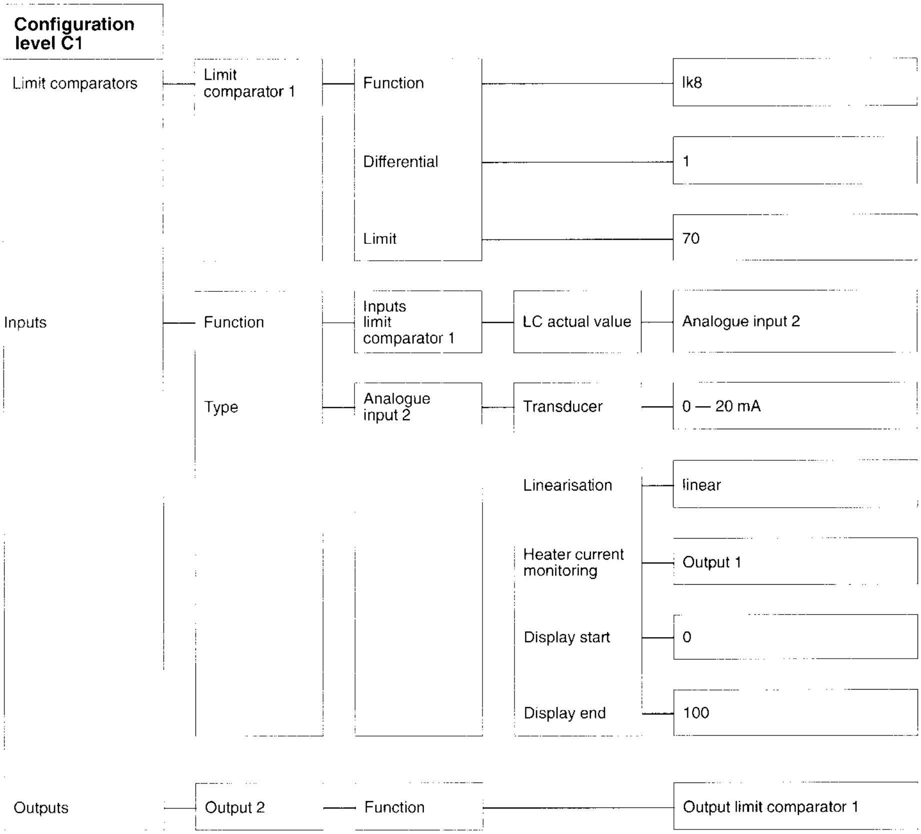
The measurement is made when the heating contact is closed. A limit comparator (lk8) can be used to signal when the current falls below a certain limit (AL = 70).



List of symbols

I1 – Analogue input 1
I2 – Analogue input 2
O1 – Output 1
O2 – Output 2
w – Setpoint
x – Process value
x_w – Deviation

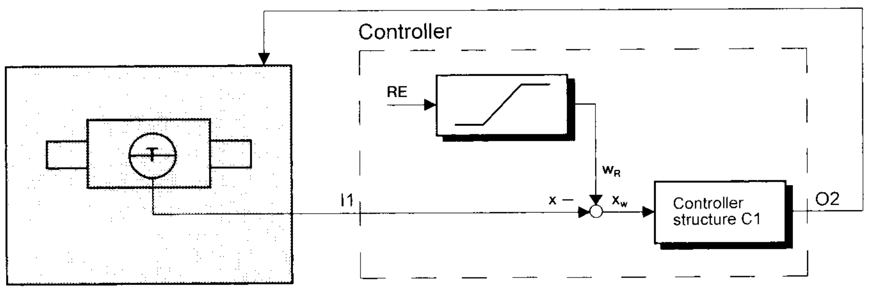
Controller with heater current monitoring



16.12 Controller with ramp function

The calender roller in a plant has to be heated up to an operating temperature of RE = 200 °C (ramp endpoint). The coating of the calender is very sensitive so that the plant has to be run up very slowly (30 °C/h). This can be controlled by a ramp function.

The ramp endpoint RE is programmed at the setpoint input.



List of symbols

I1 – Analogue input
O2 – Output 2
RE – Ramp endpoint
w_R – Ramp setpoint
x – Process value
x_w – Deviation

Configuration level C1				
Inputs	Function	Inputs controller 1	Process value	Analogue input 1
Outputs	Output 2	Function		Output 1 controller 1
Special functions	Ramp	Ramp controller 1	Function	active
			Slope	30
			Unit	°C/h

16.13 Controller with maths module

The scheme represents a flow control. A flow-meter provides a differential pressure Δp as the measured value. The flow q can be calculated from the following formula:

$$q = k \cdot \sqrt{\Delta p}$$

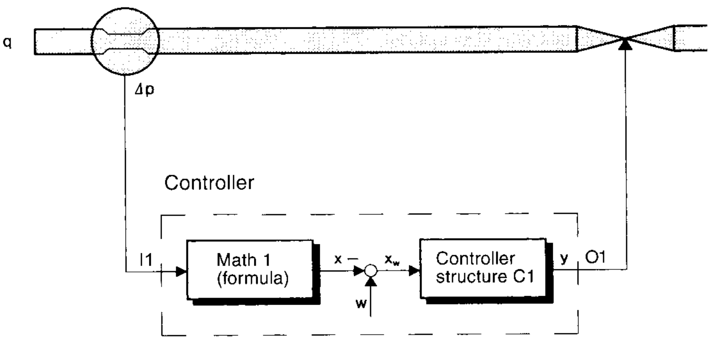
☞ The formula can only be input in the setup program.

Math formula

Formula 1:

1.5 * SQRT (AIN1)

Formula 2:



List of symbols

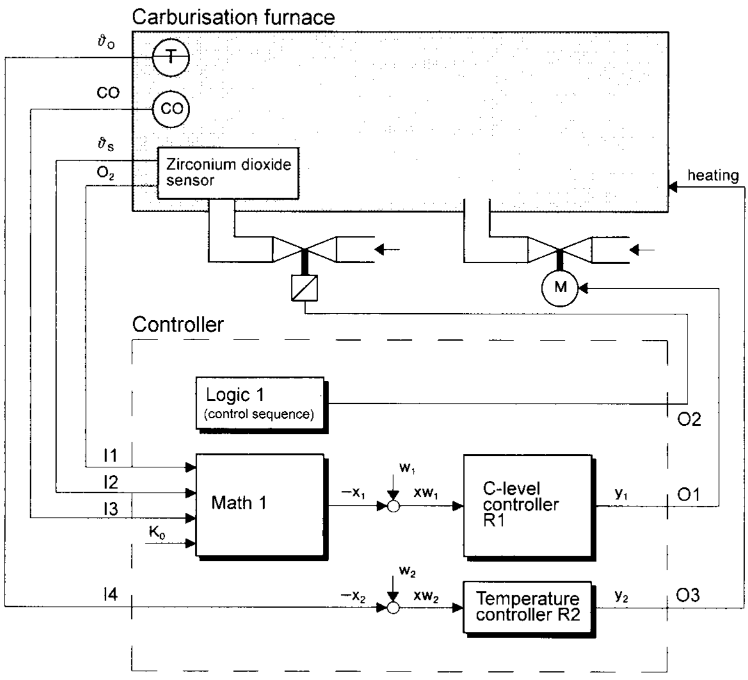
I1 – Analogue input 1
k – Constant (depending on system)
O1 – Output 1
w – Setpoint
x – Process value
x_w – Deviation
y – Control output: output 1 controller 1
Δp – Pressure difference

Configuration level C1				
Inputs	Function	Inputs controller 1	Process value	Math 1
Outputs	Output 1	Function		Output 1 controller 1
Special functions	Maths/Logics	Math 1	Function	Math formula

16.14 C-level controller

The task is to control the carbon level in the atmosphere of a carburisation furnace and the furnace temperature. The values which are required for the C-level control are measured by a zirconium dioxide sensor and a CO analyser.

The furnace temperature is measured by a thermocouple.



List of symbols

- CO – CO content
- I1 – Analogue input 1
- I2 – Analogue input 2
- I3 – Analogue input 3
- I4 – Analogue input 4
- K_0 – Furnace correction
- O1 – Output 1
- O2 – Output 2
- O3 – Output 3
- O_2 – Oxygen level
- w_1 – Setpoint controller 1
- w_2 – Setpoint controller 2
- x_1 – Process value, contr. 1
- x_2 – Process value, contr. 2
- x_{w1} – Deviation, contr. 1
- x_{w2} – Deviation, contr. 2
- y_1 – Control output, contr. 1
- y_2 – Control output, contr. 2
- ϑ_o – Furnace temperature
- ϑ_s – Sensor temperature

C-level controller

C-level menu

- C-level measurement
  - Sensor voltage — Analogue input 1
  - CO measurement — Analogue input 3
- Sensor flushing
  - Cycle time — 120
  - Flushing time — 600
  - Recovery time — 300

Configuration level C1

- Controller
  - Controller type controller 1 — Proportional controller falling characteristic
  - Controller type controller 2 — Single-setpoint controller O-function
  - Function
    - Inputs, controller 1 — Process value — Math 1
    - Inputs, controller 2 — Process value — Analogue input 4
- Inputs
  - Type
    - Analogue input 1
      - Transducer — 0 — 10 V
      - Linearisation — linear
      - Display start — 0
      - Display end — 2000
    - Analogue input 2
      - Transducer — Thermocouple
      - Linearisation — PtRh-Pt S
    - Analogue input 3
      - Transducer — 0 — 20 mA
      - Linearisation — Linear
      - Display start — 0
      - Display end — 100
    - Analogue input 4
      - Transducer — Thermocouple
      - Linearisation — PtRh-Pt S

C-level controller

Configuration level C1			
Outputs	Output 1	Function	Output 1, controller 1
		Output signal	0 — 10 V
		Zero	0
		Full scale	100
	Output 2	Function	Logic 1
	Output 3	Function	Output 1, controller 2

Configuration level C2				
Display	Display controller 1	Display 1	Display value	Math 1
			Decimal point	XX.XX
		Display 2	Display value	Analogue input 2
			Decimal point	XXXX.
		Display 3	Display value	Analogue input 1
			Decimal point	XXXX.
		Display 4	Display value	Setpoint
			Decimal point	XX.XX
	Display controller 2	Display 1	Display value	Actual value
			Decimal point	XXXX.
		Display 2	Display value	Setpoint
			Decimal point	XXXX.
		Display 3	Display value	Bargraph display control deviation
		Display 4	Display value	Controller output
			Decimal point	XXXX.

In case a controller has to be extended or modified, a variety of retrofit cards (assemblies) are available. They are summarised at the end of the chapter and can be ordered individually.

The operations for retrofitting the cards are described below.

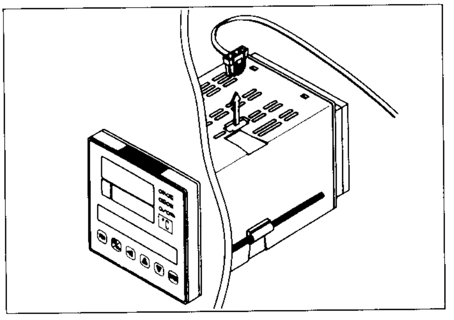
The cards to be used can be damaged by electrostatic charges. Avoid electrostatic charges during fitting and removal. Carry out the card change on a workbench which is grounded.

Only qualified personnel are permitted to retrofit cards.

Pulling off the PC interface plug

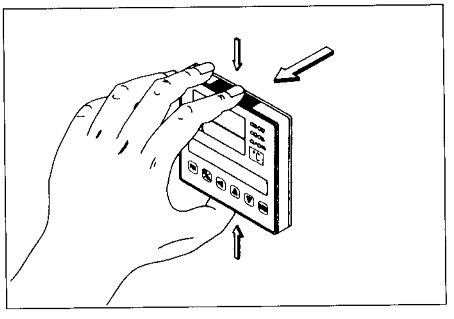
The plug is located at the top of the controller when it is linked to a PC.

* Pull off the plug upwards.



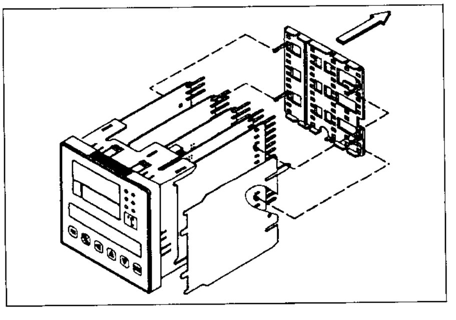
Pulling out the controller chassis

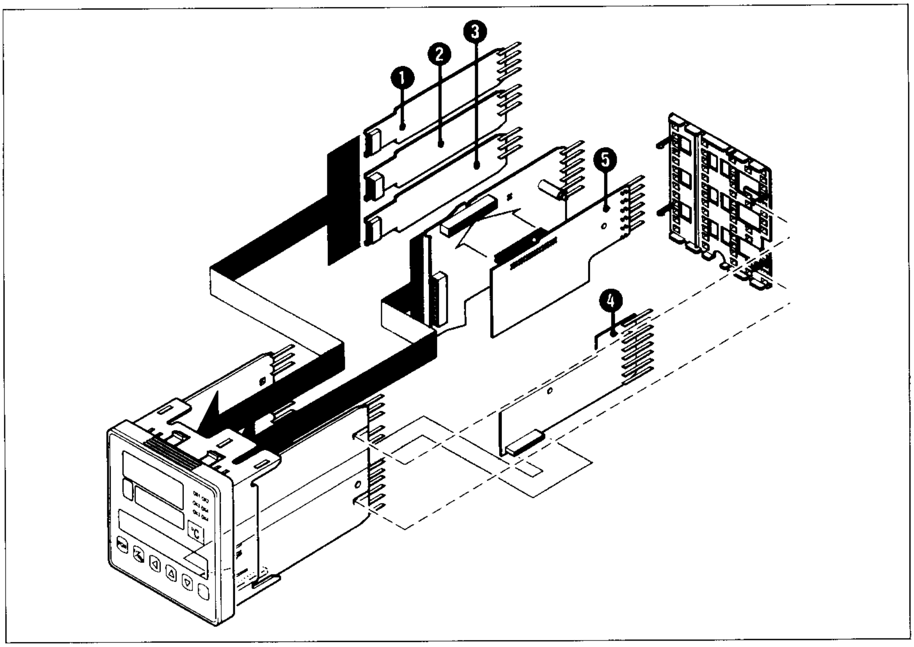
* Grasp the front panel by the corrugated areas (top and bottom), press them together and pull out the controller chassis.



Removing the insulating and guide plates

* Remove the insulating plate
* Release the four retaining clips engaging with the outer cards and pull off the guide plate.





List of cards

Item	Description		Code	Sales No.
❶	Output 1:	relay	1	70/00308449
		solid state relay 1 A	2	70/00310737
		logic 0/24 V	3	70/00308450
		Analogue output		
		0 — 20 mA	4	70/00308453
		4 — 20 mA	5	70/00308453
		−20 / 0 / +20 mA	6	70/00308453
		0 — 10 V	7	70/00308453
		2 — 10 V	8	70/00308453
		−10 / 0 / +10 V	9	70/00308453
❷	Output 3:	relay	31	70/00308449
		solid state relay 1 A	32	70/00310737
		logic 0/24 V	33	70/00308450
		Analogue output		
		0 — 20 mA	34	70/00308453
		4 — 20 mA	35	70/00308453
		−20 / 0 / +20 mA	36	70/00308453
		0 — 10 V	37	70/00308453
		2 — 10 V	38	70/00308453
		−10 / 0 / +10 V	39	70/00308453

Item	Description	Code	Sales No.
❸	Output 4: relay	41	70/00308449
	solid state relay 1 A	42	70/00310737
	logic 0/24 V	43	70/00308450
	Analogue output		
	0 — 20 mA	44	70/00308453
	4 — 20 mA	45	70/00308453
	–20 / 0 / +20 mA	46	70/00308453
	0 — 10 V	47	70/00308453
	2 — 10 V	48	70/00308453
	–10 / 0 / +10 V	49	70/00308453
❹	Analogue inputs 3 + 4 (A/D converter II)	01	70/00308448
❺	Interface RS422, isolated	52	70/00306273
	Interface RS485, isolated	53	70/00331016

18.1 Technical data

Analogue inputs

Resistance thermometer in 3-wire circuit

Type	Range
Pt 100	−200 + 850 °C

Lead resistance:
40 Ω max.

Measurement current:
150 µA

Thermocouples

Type	Range
NiCrSi-NiSi N	−100 +1300 °C
Cu-Con T	−200 + 400 °C
Fe-Con J	−200 +1200 °C
Cu-Con U	−200 + 600 °C
Fe-Con L	−200 + 900 °C
NiCr-Ni K	−200 +1372 °C
Pt10Rh-Pt S	0 +1768 °C
Pt13Rh-Pt R	0 +1768 °C
Pt30Rh-Pt6Rh B	− 55 +1820 °C
NiCr-Con E	−200 + 915 °C

Lead resistance:
300 Ω max.

Standard signals

Signal	Internal resistance Ri Voltage drop ΔUe
0 — 50 mV	Ri = 1 MΩ min.
0 — 1 V	Ri = 100 kΩ min.
0 — 10 V	Ri = 100 kΩ min.
0 — 20 mA	ΔUe = 1 V max.
10 — 50 mV	Ri = 1 MΩ min.
0.2 - 1 V	Ri = 100 kΩ min.
2 - 10 V	Ri = 100 kΩ min.
4 - 20 mA	ΔUe = 1 V max.

max. permitted input voltage: 12 V

Resistance transmitter
100 Ω min., 10 kΩ max.

Measurement current
2 mA max.

Current input for heater current indication
0 — 20 mA AC 50/60 Hz ±1 %
for connection to a current transformer

Logic inputs

Functions are normally activated by a floating contact (switching voltage 0/24 V to special order):

- start/abort self-optimisation
- auto/manual changeover
- inhibit manual operation
- ramp stop
- ramp ON/OFF
- setpoint switching
- process value switching
- parameter set switching
- inhibit parameter or configuration level
- text display
- all displays OFF

Outputs

Four outputs are available. Output 2 is always a switching output, the others can be either switching or analogue outputs.

The following **output modules** are available:

Relay output
- changeover contact, 3 A at 230 V AC resistive load
- 10^6 operations at rated current
- contact protection circuit between common and n.o. (make) contact

Logic output
- 0/24 V, Ri = 1.2 kΩ

Solid state relay (triac)
- 1 A, 230 V

Analogue output

Signal	Load
0 — 10 V	500 Ω min.
2 — 10 V	
−10 / 0 / +10 V	
0 — 20 mA	500 Ω max.
4 — 20 mA	
−20 / 0 / +20 mA	

Supply for 2-wire transmitter
−18 V 45 mA, isolated

Controller modes

Single-setpoint controller
- O (break) function (heating) (relay de-energised above setpoint)
- S (break) function (cooling) (relay de-energised below setpoint)

Double-setpoint controller
- switching (heating), switching (cooling)
- falling characteristic (heating), switching (cooling)
- switching (heating), rising characteristic (cooling)
- falling characteristic (heating), rising characteristic (cooling)

Modulating controller

Proportional controller
- falling characteristic (heating)
- rising characteristic (cooling)

Proportional controller with integral driver for motorised actuators

Controller structures

Single-setpoint, double-setpoint and proportional controllers
- P
- I
- PD
- PI
- PID

Modulating controller
- PI
- PID

Proportional controller with integral driver for motorised actuators
- P
- I
- PD
- PI
- PID

Interfaces

RS422 or RS485 interface
Transfer rate: 187.5 kbaud max.
Transfer protocol: J-Bus/MOD-Bus

Setup interface
Connection via PC interface with TTL/RS232 converter; connector at top of housing (extra hardware Code)

General data

Displays:
one red 13 mm 4-digit 7-segment display
one green 10 mm 4-digit 7-segment display
one red 7 mm 1-digit 7-segment display
one green 5 mm 16-digit 5x5 dot matrix display

Measurement accuracy	Ambient temperature error
when used with resistance thermometers and resistance transmitters	
0.05 % or better	0.025 % max. per 10 °C
when used with thermocouples within the working range	
0.25 % or better	0.05 % max. per 10 °C
when used with transducers with standard signal	
0.05 % or better	0.1 % max. per 10 °C
when used with resistance transmitters (after compensating the lead resistance)	
0.15 % or better	0.025 % max. per 10 °C

These values include linearisation tolerances.

Signal circuit monitor for transducers	probe break	short-circuit
Thermocouples:	X	—
Resistance thermometers and transmitters:	X	X
0 — 50 mV	X	—
10 — 50 mV	X	X
0.2 — 1 V	X	X
2 — 10 V	X	X
4 — 20 mA	X	X

X = is recognized — = is not recognized

The outputs move to a defined status.

Resolution A/D converter
15 bit

Resolution D/A converter
13 bit

Sampling time

single-channel controller:	50 msec at 50 Hz
	75 msec at 60 Hz
dual-channel controller:	110 msec at 50 Hz
	125 msec at 60 Hz

During mathematical calculations the sampling time increases depending on the complexity of the formula.

Data back-up
EEPROM

Supply
93 — 263 V AC 48 — 63 Hz
20 — 53 V DC/AC 0/48 — 63 Hz

Operation with zener barriers is not permitted on 93 — 263 V AC range.

Power rating
20 VA max.

Electrical connection
screw terminals up to 2.5 mm^2 cross-section and core termination sleeve

Permitted ambient temperature range
0 to 50 °C

Permitted storage temperature range
–40 to +70 °C

Climatic conditions
relative humidity 75 % max. annual mean, no condensation

Housing
flush panel mounting to DIN 43 700, conductive plastics, base material ABS, with plug-in controller chassis
bezel 96 x 96 mm
depth behind panel 150 mm

Protection
to EN 60 529
front IP 65
rear IP 20

Electrical safety
to EN 61 010
– overvoltage category II
– protection Class I (rear)
– protection Class II (front through panel mounting)

Electromagnetic compatibility
EN 61 326
Interference emission: Class B
Immunity to interference: industrial requirements

Operating position
unrestricted

Weight
850 g

Limit comparators

The controller includes eight limit comparators which can be provided with software linkages or switched to mechanical outputs.

Switching differential
X_{Sd} adjustable within the range 0 — 9999 digit

Limit setting
AL adjustable within the range –1999 to +9999 digit

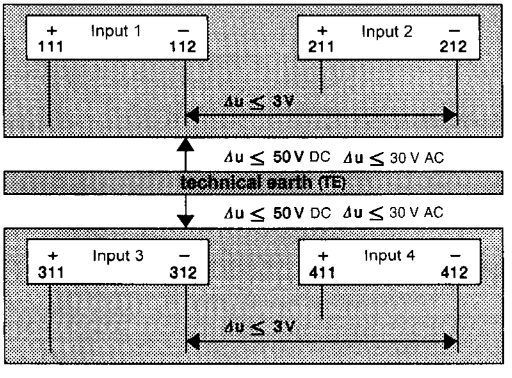
Maths and logics module

Maths module:
Linking the analogue inputs and logics signals by a mathematical formula.

Logics module:
Linking the logic inputs and the limit comparator outputs.

Difference, ratio and humidity controllers are set up through standard formulae implemented in the maths and logics module.

Isolation of inputs



18.2 Limit comparator functions

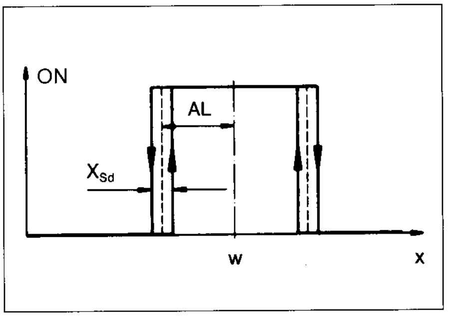
Function lk1

Window function: the relay is energised when the process value is within a window about the setpoint (w).

Example: w = 200 °C, AL = 20, X_{Sd} = 10

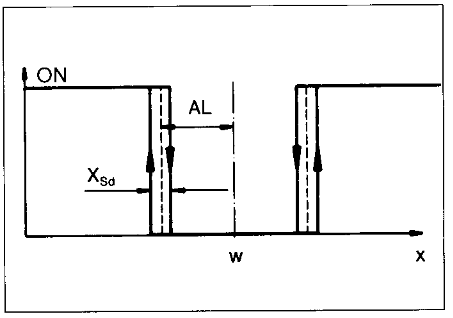
Process value rising:
relay switches on at 185 °C and off at 225 °C.

Process value falling:
relay switches on at 215 °C and off at 175 °C.



Function lk2

as lk1 but relay action reversed



Function lk3

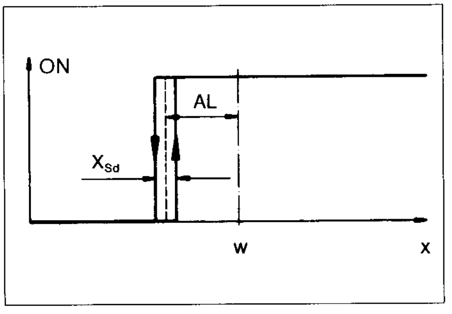
low alarm

Function: the relay is de-energised when the process value falls below (setpoint - limit value).

Example: w = 200 °C, AL = 20, X_{Sd} = 10

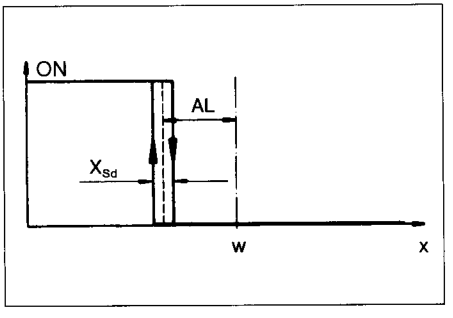
Process value rising:
relay switches on at 185 °C.

Process value falling:
relay switches off at 175 °C.



Function lk4

as lk3 but relay action reversed



w = setpoint
x = process value
X_{Sd} = differential
AL = limit

Function lk5

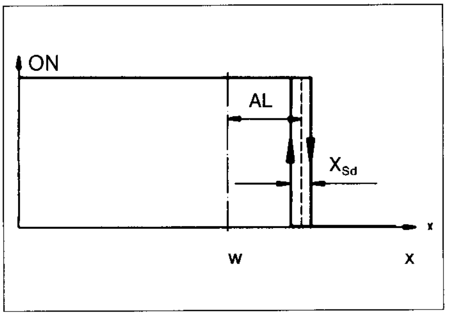
high alarm

Function: the relay is de-energised when the process value rises above (setpoint + limit value).

Example: w = 200 °C, AL = 20, X_{Sd} = 10

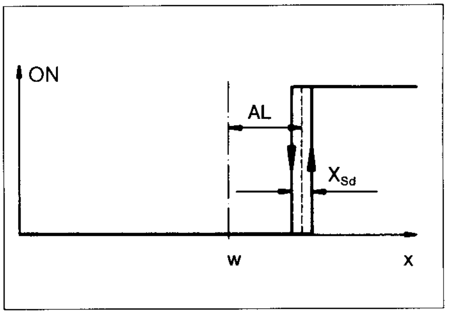
Process value rising:
relay switches off at 225 °C.

Process value falling:
relay switches on at 215 °C.



Function lk6

as lk5 but relay action reversed



Function lk7

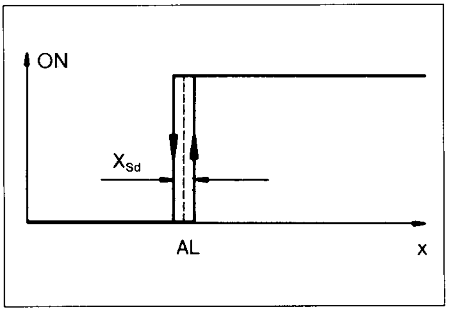
Switching point is independent of the controller setpoint and is determined only by AL.

Function: the relay is energised when the process value is above the limit AL.

Example: AL = 150, X_{Sd} = 10

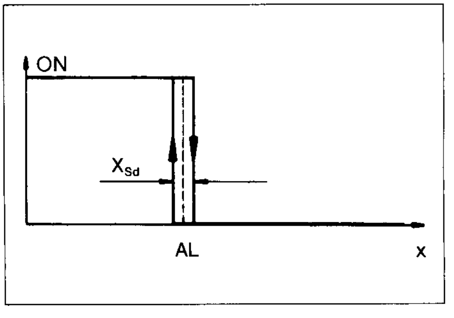
Process value rising:
relay switches on at 155 °C.

Process value falling:
relay switches off at 145 °C



Function lk8

as lk7 but relay action reversed



18.3 Alarm messages and indication priorities in the normal display

Alarm messages in plain language (matrix display)

Priority	Display	Notes
high	(no display)	Logic input “all displays off” is configured and active
	PROBE BREAK IN1	Probe break or short-circuit
	PROBE BREAK IN2	
	PROBE BREAK IN3	
	PROBE BREAK IN4	
	OVERRANGE IN1	Overrange
	OVERRANGE IN2	
	OVERRANGE IN3	
	OVERRANGE IN4	
	UNDERRANGE IN1	Underrange
	UNDERRANGE IN2	
	UNDERRANGE IN3	
	UNDERRANGE IN4	
	OVERRANGE MATH1	Overrange maths module (calculation result > range end)
	OVERRANGE MATH2	
	UNDERRANGE MATH1	Underrange maths module (calculation result < range start)
	UNDERRANGE MATH2	
	MATH 1 ERR	Mathematical error (violation of mathematical rules, illegal values)
	MATH 2 ERR	
	LOGIC 1 ERROR	Logics error (violation of mathematical rules)
	LOGIC 2 ERROR	
	LOOP ERROR C1	Load short-circuit or interruption has been recognised
	LOOP ERROR C2	
	ADC ERROR	Error A/D converter
	RELAY MODULE ERR	Error on relay module
	(TEXT) : (TEXT)	Text display (logic input 1) : Text display (logic input 5)
	(TEXT) : (TEXT)	Text display (limit comparator 1) : Text display (limit comparator 8)
	(TEXT)	Text display (logic 1)
	(TEXT)	Text display (logic 2)
	TUNE ACTIVE	Self-optimisation has been activated
low	(indication as configured)	—

IN = analogue input; M = maths

Alarm messages in numerical display

Display	Note
9999. INPUT1 9999.	– Overrange – Probe break (segment display is flashing)
-1999. INPUT1 –1999.	Underrange (segment display is flashing)
- - - - INPUT1 -----	No measurement

18.4 Character set for matrix display

0		32		64	@	96		128	Ç	160	á	192		224	α
1		33	!	65	A	97	a	129	ü	161	í	193		225	β
2		34	“	66	B	98	b	130	é	162	ó	194		226	Γ
3		35	#	67	C	99	c	131	â	163	ú	195		227	Π
4		36	$	68	D	100	d	132	ä	164	ñ	196		228	Σ
5		37	%	69	E	101	e	133	à	165	Ñ	197		229	σ
6		38	&	70	F	102	f	134	å	166		198		230	µ
7		39	‘	71	G	103	g	135	ç	167		199		231	γ
8		40	(	72	H	104	h	136	ê	168	¿	200		232	φ
9		41	)	73	I	105	i	137	ë	169		201		233	θ
10		42	*	74	J	106	j	138	è	170		202		234	Ω
11		43	+	75	K	107	k	139	ï	171		203		235	δ
12		44	,	76	L	108	l	140	î	172		204		236	∞
13		45	-	77	M	109	m	141	ì	173		205		237	∅
14		46	.	78	N	110	n	142	Ä	174		206		238	∈
15		47	/	79	O	111	o	143	Å	175		207		239	∩
16		48	0	80	P	112	p	144	É	176		208		240	
17		49	1	81	Q	113	q	145	æ	177		209		241	
18		50	2	82	R	114	r	146	Æ	178		210		242	
19		51	3	83	S	115	s	147	ô	179		211		243	
20		52	4	84	T	116	t	148	ö	180		212		244	
21		53	5	85	U	117	u	149	ò	181		213		245	
22		54	6	86	V	118	v	150	û	182		214		246	
23		55	7	87	W	119	w	151	ù	183		215		247	
24		56	8	88	X	120	x	152	ÿ	184		216		248	°
25		57	9	89	Y	121	y	153	Ö	185		217		249	·
26		58	:	90	Z	122	z	154	Ü	186		218		250	
27		59	;	91	[	123	{	155	¢	187		219		251	
28		60	<	92	\	124	|	156	£	188		220		252	
29		61	=	93	]	125	}	157	¥	189		221		253	
30		62	>	94	^	126	~	158		190		222		254	
31		63	?	95	_	127		159		191		223		255	

200 — 210 reserved for bargraph display

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