User's manual

E Ex i - controller
PR130

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1 Operation instruction explosion proofed devices

Application and Standards

This instruction manual applies to explosion protected control panels of type of protection types below. This apparatus is only to be used as defined and meets requirements of EN 60 079 particularly EN60 079-14 "electrical apparatus for potentiality explosive atmospheres". It can be used in hazardous locations which are hazardous due to gases and vapours according to the explosion group and temperature class as stipulated on the type label. When installing and operating the explosion protected device the respective nationally valid regulations and requirements are to be observed.

General Instructions

Operation of this device should only be implemented by authorised persons and in strict accordance with local safety standards. The electrical data on the type label and if applicable, the "special conditions" of the test certificate TÜV 02 ATEX 1863 are to be observed.

For outdoor installation it is recommended to protect the explosion protected device against direct climatic influence, e.g. with a protective roof. The maximum ambient temperature is 40°C, if not stipulated otherwise.

Intrinsically Safe Circuits

Erection instructions in the testing certificates of intrinsically safe apparatus are to be observed. The electrical safety values stipulated on the type label must not be exceeded in the intrinsically safe circuit. When interconnecting intrinsically safe circuits it is to be tested, whether a voltage and/or current addition occurs. The intrinsic safety of interconnected circuits is to be ensured. (EN 60079-14, section 12)

Safety Measures: to read and to comply

Work on electrical installations and apparatus in operation is generally forbidden in hazardous locations, with the exception of intrinsically safe circuits. In special cases work can be done on non-intrinsically safe circuits, on the condition that during the duration of such work no explosive atmosphere exists.

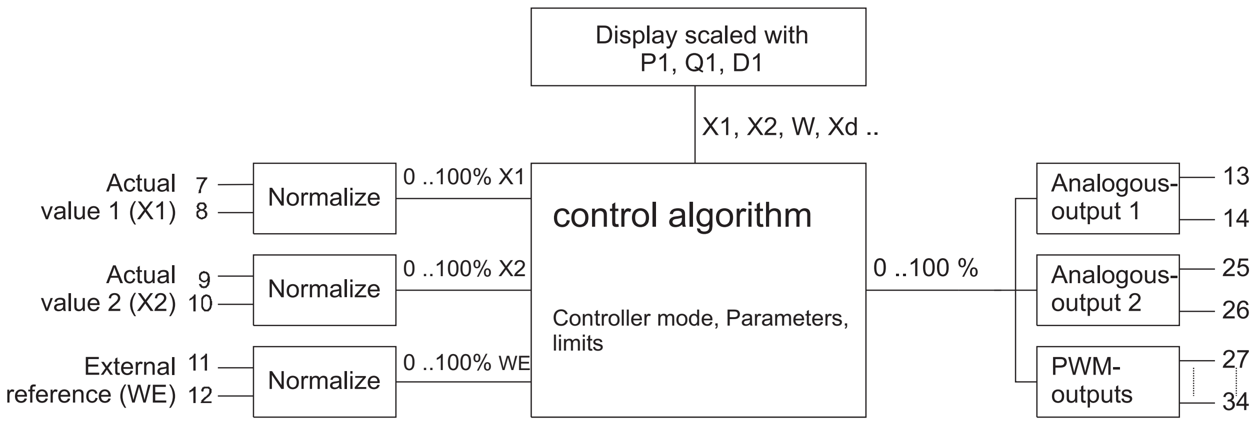
2 Introduction

The PR130 is an electronic all purpose controller for use in hazardous area. Its wide programmability offers uses in many applications.

The protection class of the PR130 is intrinsically safe, therefore any circuit connected to the controller must be intrinsically safe. The analogous output provides an active intrinsically safe signal (0/4..20 mA) to a control positioner or servo actuator.

The four digital inputs are programmable and can fulfil several functions (e.g. to toggle closed loop feed-back control and open loop control, to select the actual reference, ...). The four digital output ports can be used to monitor the actual value, the actuator signal, to alarm certain failures or as actuator signal in PWM control mode (Pulse Width Modulation).

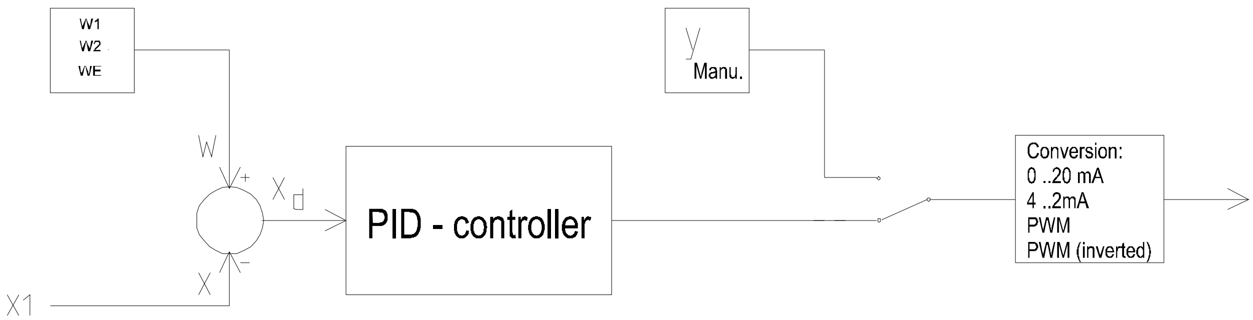
2.1 Control block diagram



2.2 Internal controller types – controller structures

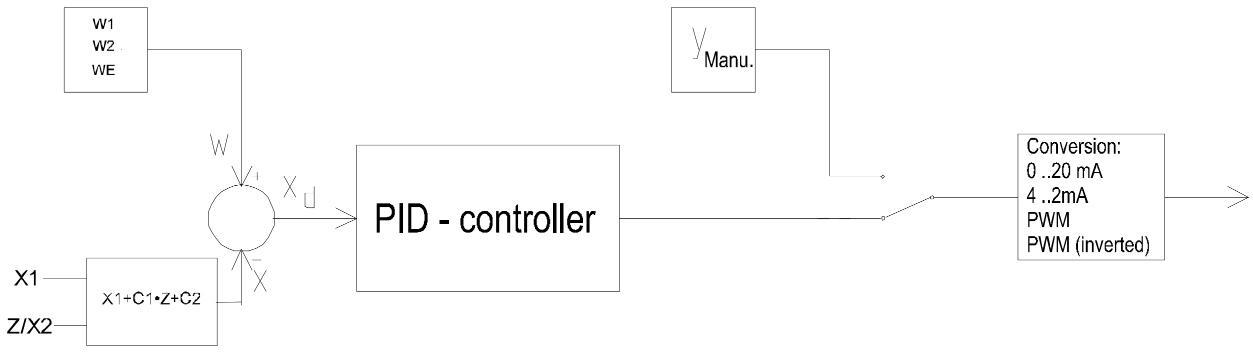
The use of the PR130 is not limited as an usual fixed reference controller. With the PR130 you can real-ise a wide area of controller types. The types are presented below:

2.2.1 Fixed reference controller

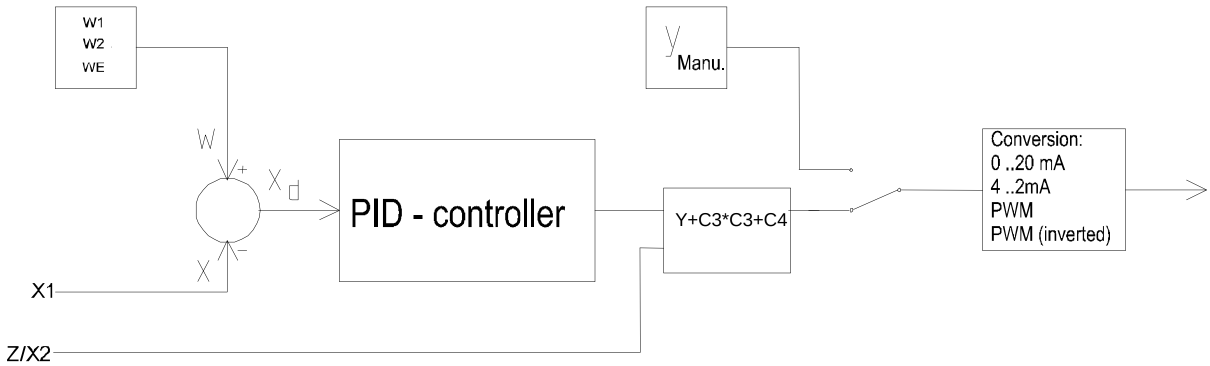


2.2.2 Fixed reference controller with disturbance rejection in error signal

In some cases the impact of a disturbance is more or less predictable: Take a heater door for example, the opening of the door leads to a certain temperature loss of 30 K. Instead of waiting until the controller reacts to the disturbance a direct reaction can be started to minimise the deviation. In this case you could locate a switch at the door and when the door is opened the heating will be increased.

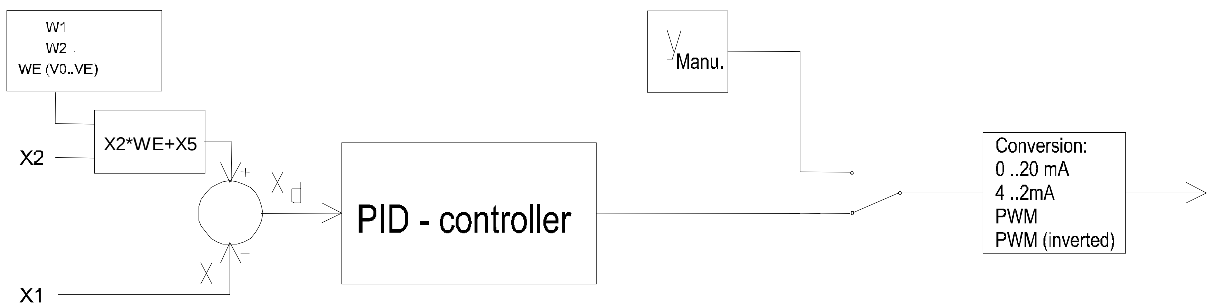


2.2.3 Fixed reference controller with disturbance rejection in actuator signal

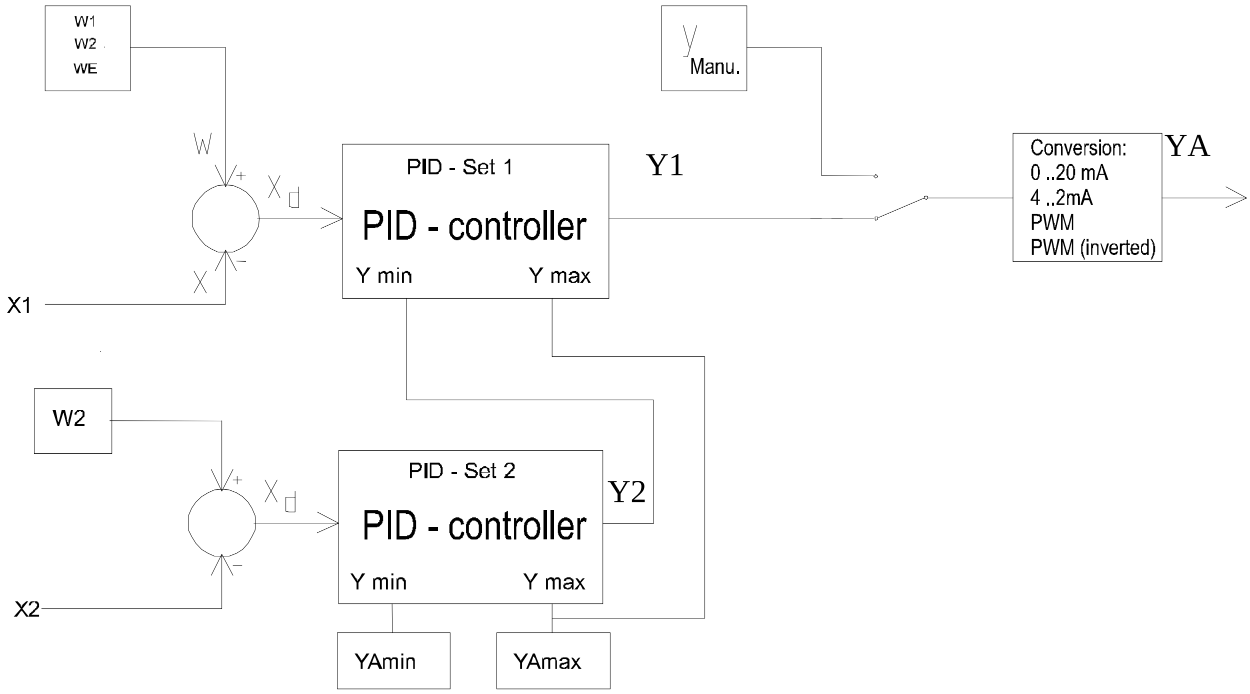


2.2.4 Ratio control

This type of controller contains two actual value inputs. The regulated value is the relationship between these actual values. The control algorithm builds the quotient of the two signals, compares to the desired value and calculates the new actuator value, according to the block diagram below:



2.2.5 Override-Min-control



Set the YAmin and YAmax in the parameter menu.

YA is always between YAmin < YA < YAmax.

Function in exception:

if W = W2 then the control algorithm is:

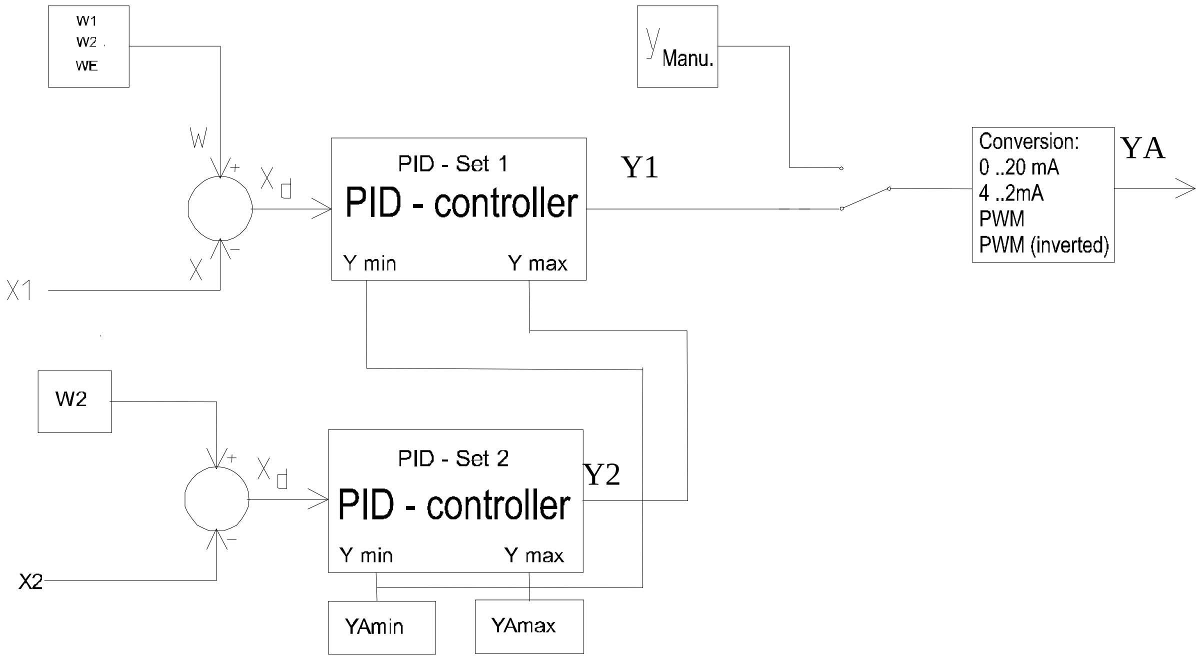
YA = [PID- algorithm] * Xd with

Xd = W2 – X1, if X2 > X1

Xd = W2 – X2, if X1 > X2

» The controller takes always the smaller actual signal as the active actual signal «

2.2.6 Override-Max-control



Set the YAmin and YAmax in the parameter menu.

YA is always between YAmin < YA < YAmax.

Function in exception:

if W = W2 then the control algorithm is:

YA = [PID- algorithm] * Xd with

Xd = W2 – X1, if X2 < X1

Xd = W2 – X2, if X1 < X2

» The controller takes always the bigger actual signal as the active actual signal «

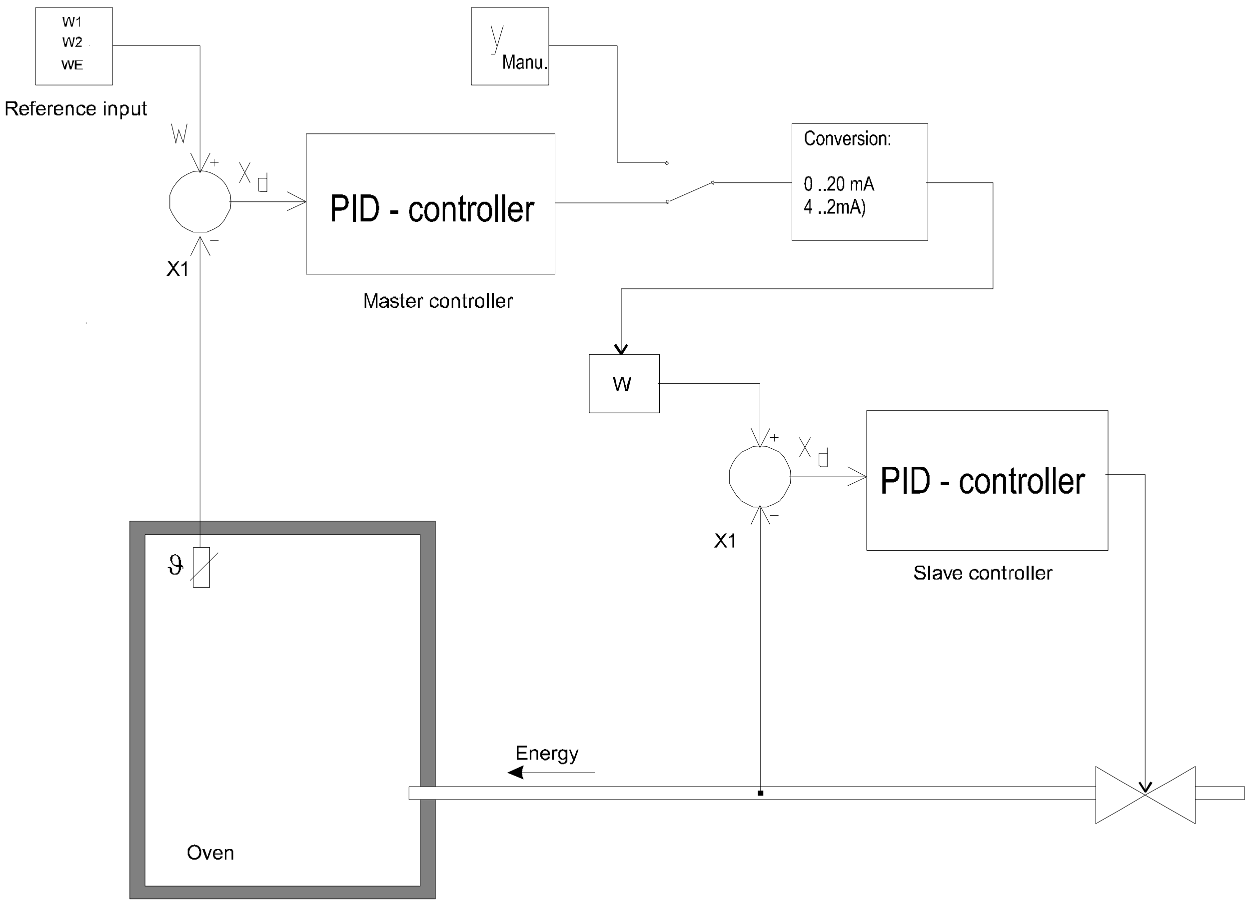
2.3 Controller structures with several controllers

2.3.1 Cascade control

Cascade control improves the control effectiveness considerably. Particularly the dynamical behaviour of the control system is improved. Control plants containing a parameter relationship Tg/Tu (see paragraph 3.3.2) less than 2..3 are hardly controllable with a single PID-controller, because of their long delay.

The solution lies in separation of the control system in (most) two partial systems, which are separately controlled. With this trick the long delays of the single system are cancelled.

To realise a cascade control **two** PR130 controllers are needed.



2.4 MODBUS- Interface (Option)

2.4.1 Registers

The PR130 uses only "Holding registers" to receive and transmit commands and measurements. The registers are defined as below:

Register (Hex)	*Access*	*Data format*	*Function*
40001	R	Floating point	Actual value 1 (X1)
40002			
40003	R	Floating point	Actual value 2 (X2)
40004			
40005	R	Floating point	External reference {desired value} (WE)
40006			
40007	R	Floating point	Manipulated variable (Y)
40008			
40009	R/W	Floating point	Internal reference (W1)
4000A			
4000B	R/W	Floating point	Internal reference (W2)
4000C			
4000D		Bit field	Info – Flags:
	R	Digital outputs	Bit 0: no function
	R		Bit 1: PWM signal 1 manipulated variable
	R		Bit 2: PWM signal 2 manipulated variable
	R		Bit 3: limit X1 underflow
	R		Bit 4: limit X1 overflow
	R		Bit 5: limit X2 underflow
	R		Bit 6: limit X2 overflow
	R		Bit 7: limit WE underflow
	R		Bit 8: limit We overflow
	R		Bit 9: limit Y underflow
	R		Bit 10: limit Y overflow
	R		Bit 11: limit X_D underflow {control error}
	R		Bit 12: limit X_D overflow {control error}
	R		Bit 13: X1 broken wire
	R		Bit 14: X1 physical current overflow
	R		Bit 15: X1 physical current overflow or broken wire
4000E	R		Bit 0: X2 broken wire
	R		Bit 1: X2 physical current overflow
	R		Bit 2: X2 physical current overflow or broken wire
	R		Bit 3: WE broken wire
	R		Bit 4: WE physical current overflow
	R		Bit 5: WE physical current overflow or broken wire
4000F		Bit field	Info – Flags:
	R	Digital inputs	Bit 0: DE1
	R		Bit 1: DE2
	R		Bit 2: DE3
	R		Bit 3: DE4
			Control
	R/W		Bit 4: DE5
	R/W		Bit 5: DE6
	R/W		Bit 6: DE7
	R/W		Bit 7: DE8

Remarks

- The bits in Registers assigned with (R) are “read only”, that means that only read access is possible
- Writing to registers with floating point content must be done with function 16 “Preset multiple register” . Write register 40009 and 4000A simultaneously otherwise the controller will ignore the value.

2.4.2 Hardware

The PR130 uses Modbus RTU, Baud rate selectable, via TTY. The parity can be set to even, odd or none.

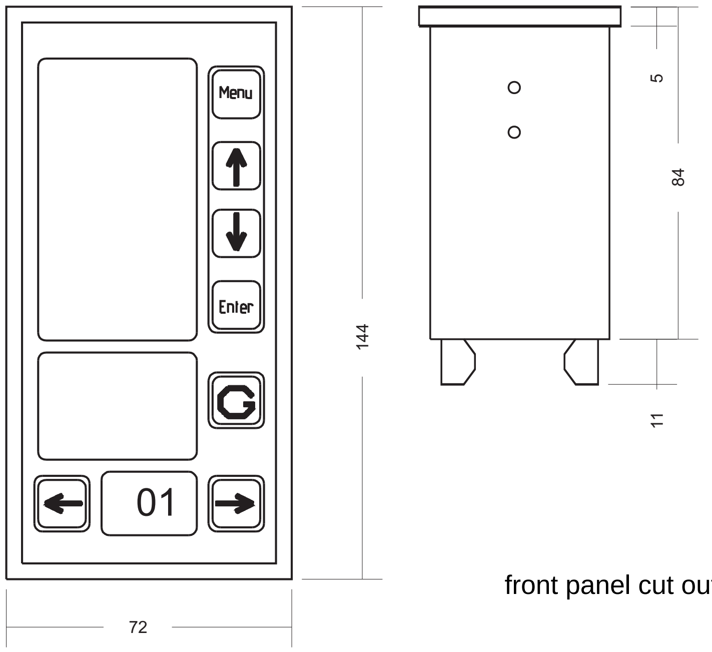
2.4.3 Functions

The PR130 supports the following functions:

Function number	*Function*
3	Read holding register
6	Preset single register
16	Preset multiple register

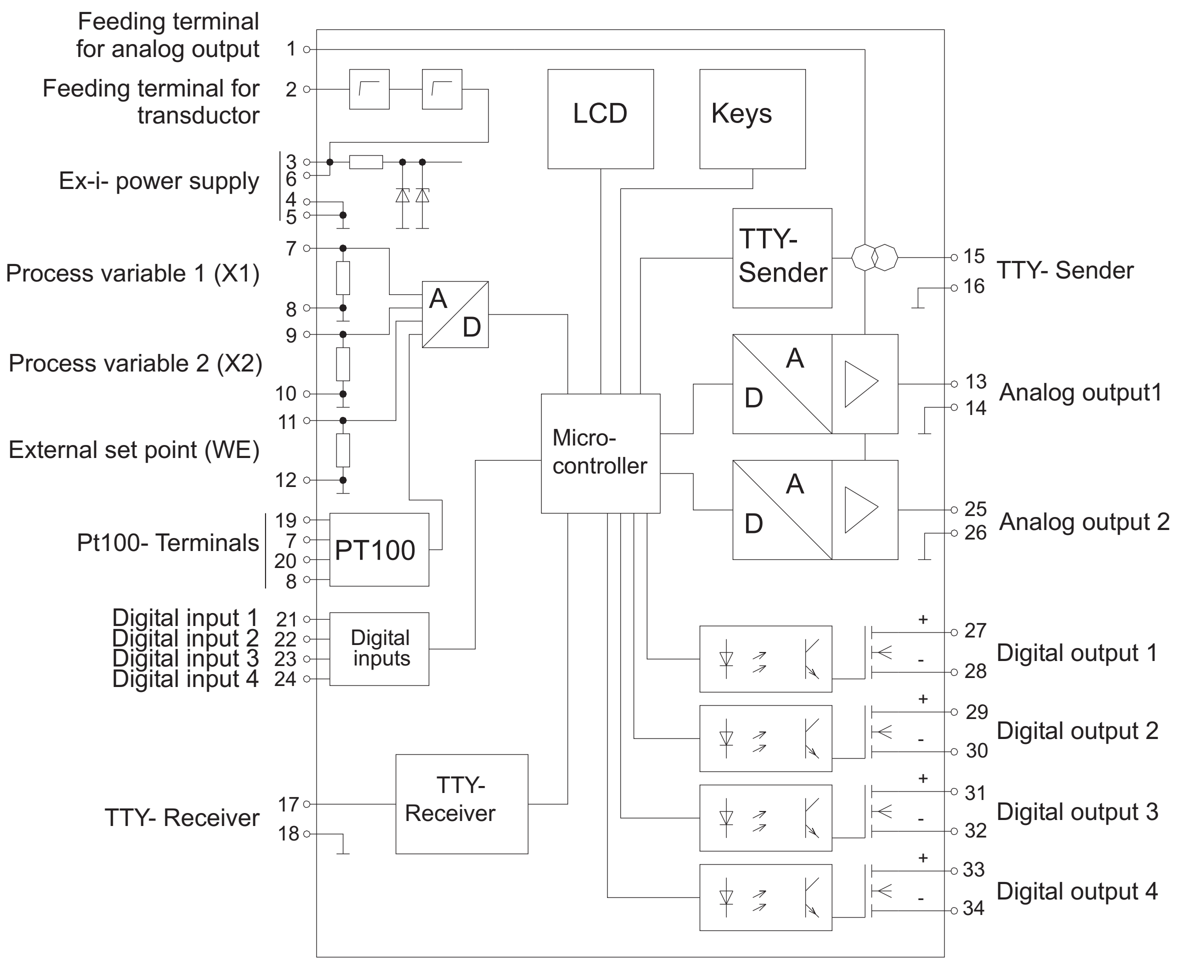
3 Mounting and Connecting

3.1 Mounting, Dimensions



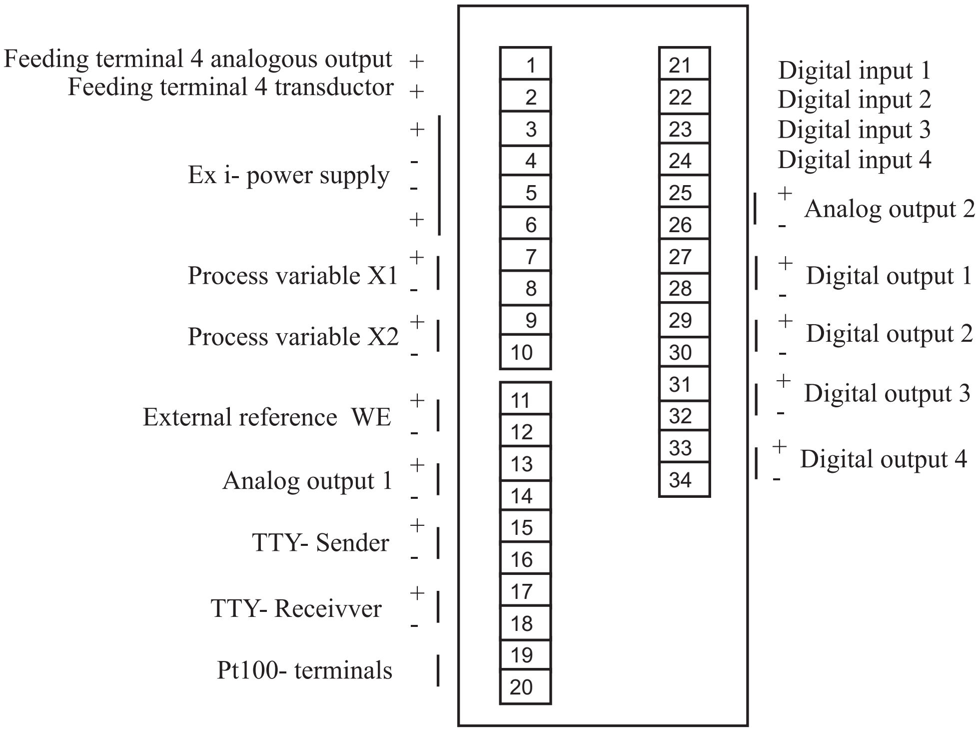
front panel cut out: 136,5 x 66 mm

3.2 Block diagram



Please use shielded cables to prevent measuring noise.

3.3 Terminal chart



3.4 Connecting

3.4.1 Power supply / Transmitter

Please connect the Ex i power supply to the terminals 3,4 .

For the controller only, it will be sufficient to use a power supply which provides 20 mA by an voltage of at least 15 V. Connect an active transducer directly to terminals 7/8.

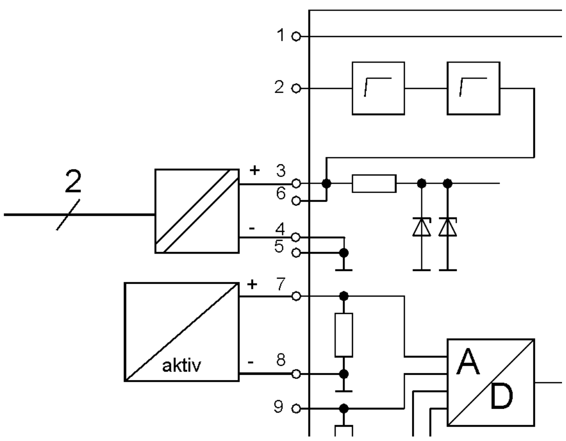


Figure 1: Power supply with active transductor

If a transmitter should be supplied too, you need a power supply providing 40 mA by an voltage of at least 15 V. Connect the power supply to the terminals 3,4 in this case and the transmitter to terminal 2 and 7.

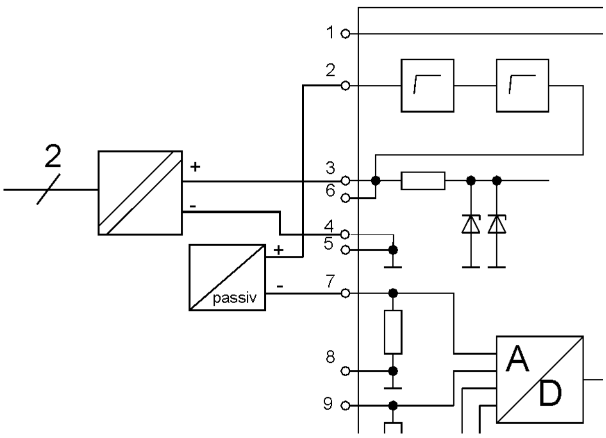
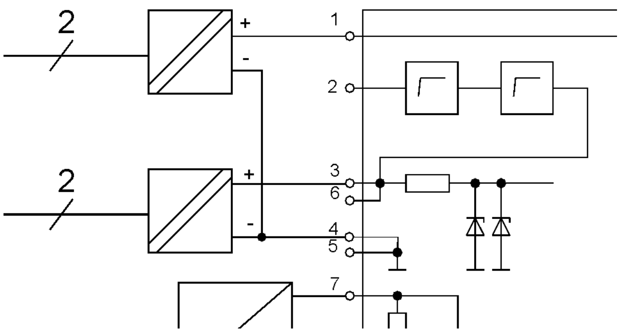


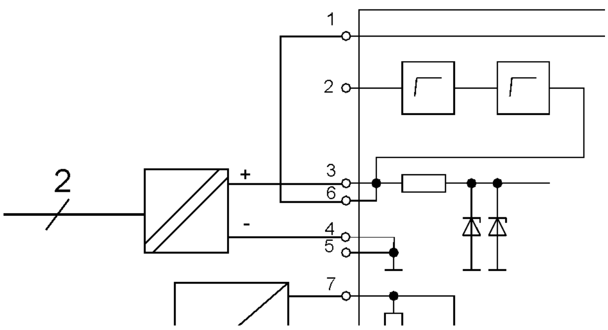
Figure 2: Terminal chart for supplying of a transmitter

3.4.2 Supply of analogous output (AO)

Supply the analogous output separately according the following chart:



otherwise you can supply the AO with the same power supply as the controller using a bridge from terminal 1 to 6. Regard in this case the power supply must deliver 20 mA **more** current at 15 V.



3.4.3 Actual value signal input (X1)

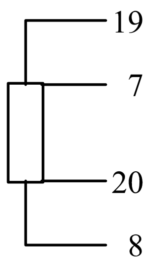
3.4.3.1 Current- Signal (0/4..20 mA)

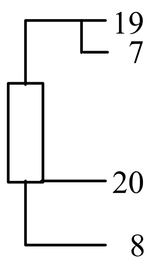
Analogous input 1 (terminals 7+, 8-), Impedance 15 Ω

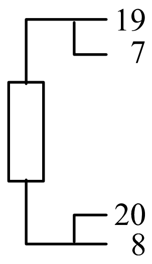
3.4.3.2 Pt100-Connection

Analogous input 1 (terminals 7, 8), and additional Pt100-Terminals (terminals 19,20)

4-wire-connection: 3- wire-connection: 2- wire-connection:







Adjust the wire impedance in 2 wire-connection by software in structure menu step 9 (KA).

3.4.4 Actual value signal 2 / disturbance input (X2)

Analogous input 2 (terminals 9+, 10-)

3.4.5 External reference input (external desired value, WE)

Analogous input 3 (terminals 11+, 12-)

3.4.6 Manipulated variable on analogous output

Analogous output 1 (terminals 13+, 14-)

Configure the analogous output of the controller in structure menu step 5 .. 6 as 0 ..20, 4 ..20, 20 ..0 or as 20 ..4 mA output. The maximum impedance depends on the used power supply.

3.4.7 Digital inputs

The four digital input terminals (terminal 21 ..24) are programmable for different functions and different working modes (normally open connection or normally closed connection). See also structure menu steps 16 up to 18.

The PR130 with MODBUS option has four additional virtual digital inputs. These inputs are only available via MODBUS. (See also chapter 2.4)

3.4.8 Digital outputs

The four digital outputs are programmable for different functions (limit monitoring min or max, external signal exceeding and PWM manipulated variable signal).

3.4.9 MODBUS

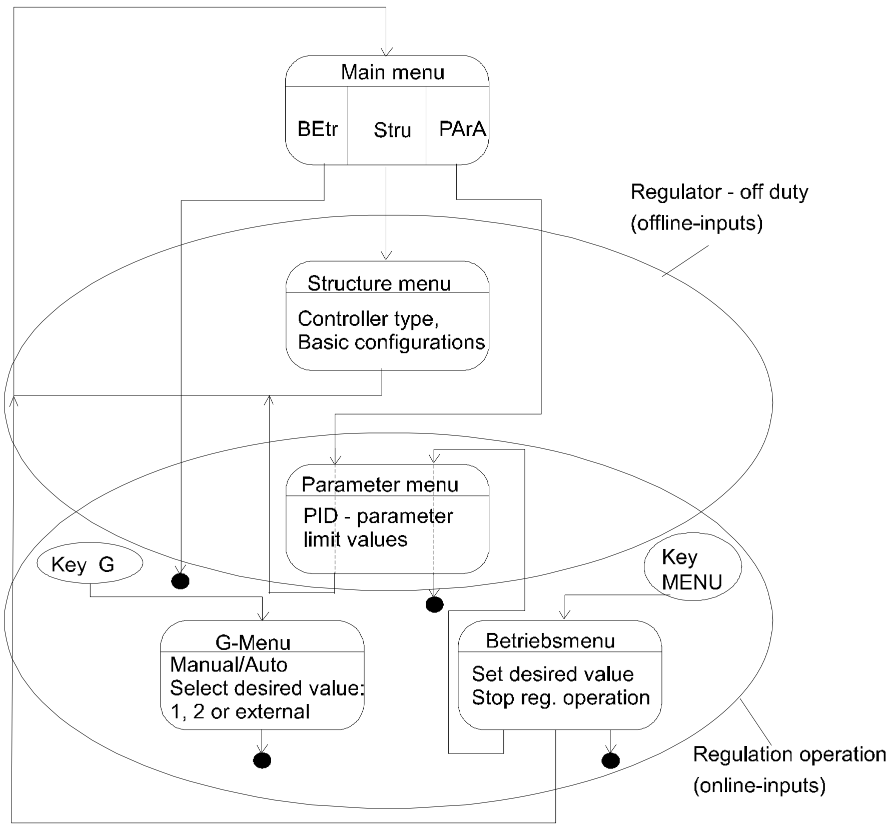
The Modbus interface works via TTY terminals 15 –18.

4 Configuration and operation

The PR130 starts always in operation mode. Press the menu- button several times to reach the *main menu* entering the right EC- Code. In this state you can enter into the structure (Stru) or parameter (PArA) menu or begin regulation operation (Betr). Enter all structure data and parameters before starting regulation operation.

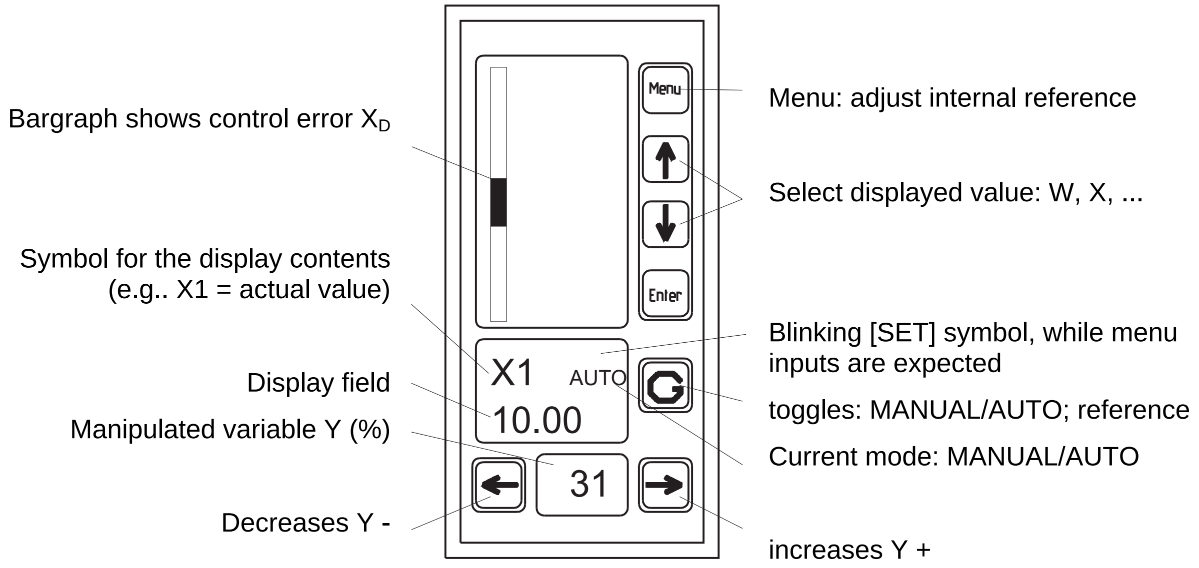
Consider that the parameter menu also can be entered while regulation operation (on-line) is active in contrast to the structure menu, this can only be entered off-line.

Controller status survey:



4.1 Controller in operation

Before starting, all structure data and parameters should be entered. The controller starts operation with Ys (safety actuator value) and in manual mode.



REMARK: The priority of the digital inputs is higher than the priority of the front keys; i.e. you are not able to manipulate certain settings with the front keys, if functions like “TOGGLE MANU/AUTO” or “SELECT EXTERNAL REFERENCE SIGNAL” are active via a digital input.

G- Menu (Call with **G**- Key, possibly protected with G- Code)

Identity	selected:	
M		Operation mode
	Choices: MANU	Manual control of the actuator output signal
	AUTO	Automatic control of the actuator output signal with PID- algorithm
W		Select Reference
	Choices: Int1	Internal reference value 1
	Int2	Internal reference value 2
	Etrn	External reference signal
	SAVE	Internal safety reference value

Reference- Menu (Call with **MENU**- key, possibly protected with B- Code)

Identity	selected:	
W1		Internal Reference 1
	Choices: Set the internal reference value 1	
W2		Internal Reference 2
	Choices: Set the internal reference value 2. Applying *override control* W2 is used as reference of the limit controller. By all other controller types W1 and W2 are valid as internal reference sources (selectable via G-menu or digital inputs)	

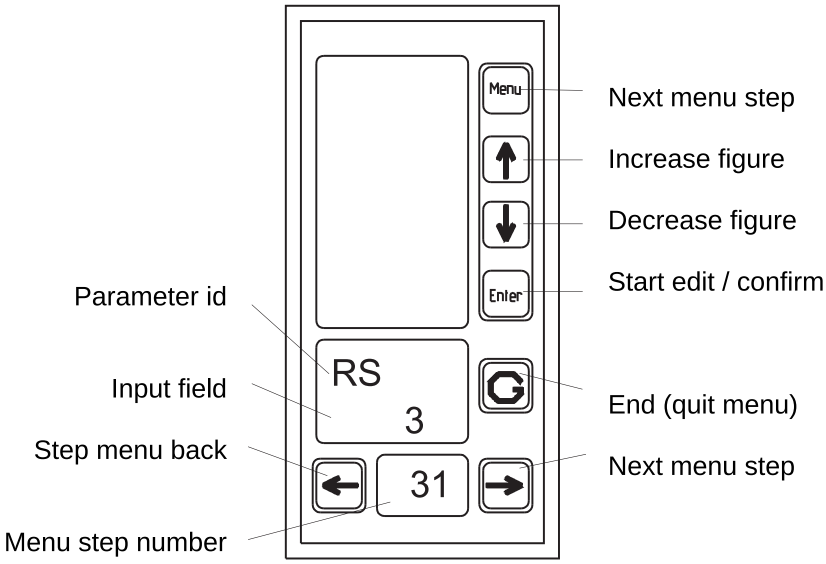
Identity	selected:	
PC		Parameter menu online call (controller is still working)
	Choices: To call the parameter menu in auto operation mode the P-code must be entered. Passing this code allows to view and set each parameter in this menu. In the meantime the controller is still working. Manipulated parameters will be confirmed with MENU, ENTER or left/right key. The ENTER - key terminates the menu.	
Identity EC	selected:	Terminate online operation (e.g. to call structure menu)
	Choices: Passing through the E-code terminates the online operation immediately. Additionally all digital outputs are getting inactive. In this state you are able to structure and to configure the device in a new way.	

4.2 Controller configuration: structure menu

The following table describes the structure menu in detail. In this table is space left for you to record your selections, or you can use the structure and parameter summary in the annex.

Stepping through the structure menu is only possible in offline mode (all digital outputs are low, the automatic regulation is inactive).

4.2.1 Key - function chart



4.2.2 Structure menu - table

Identity	Step	selected:	Parameter	Choices:
RS	1		Controller type	a) fixed reference controller (internal / external reference, 2 PID parameter sets) 1 fixed reference controller with disturbance rejection in error signal 2 fixed reference controller with disturbance rejection in actuator 3 Ratio control with internal or external ratio reference 4 Override-Min-control 5 Override-Max-control *See also the function charts of the controller types in paragraph 2.*
RE	2		Actual signal input (terminal 7,8)	0 Pt100 2-wire connection (calibration of the measure system in step 7) 1 Pt100 3- wire connection 2 Pt100 4- wire connection *A PR130 without Pt100 option doesn't show this step*
Pt	3		PT 100 temperature range	250 -250 ..250 °C 850 -250 ..850 °C
RA	4		Controller output	0 Analogous signal 0/4..20 mA (terminal 13,14) 1 2 x analogous signal 0/4..20 mA (terminal 13,14 + 25,26) [split range] 2 2-Point PWM control 3 3- Point PWM control
S1	5		Configure Analogous output 1	0 0 ..20 mA 4 4 ..20 mA (live Zero)
S2	6		Configure Analogous output 2	0 0 ..20 mA 4 4 ..20 mA (live Zero)
I1	7		Configure Analogous output 1	0 normal 1 invert
I2	8		Configure Analogous output 2	0 normal 1 invert

Identity **KA**	selected:	Call calibration menu (Pt100- 2 wire connection)
Step **9**	Choices: 0 pass calibration menu 1 call calibration menu *terminate your wire at the end of the wire with a 100 Ω resistor, then press "Enter", the calibration is done in one second*	
Identity **B1**	selected:	Configure Analogous input 1
Step **10**	Choices: 0 normal 4 4 ..20 mA (live Zero)	
Identity **B2**	selected:	Configure Analogous input 2
Step **11**	Choices: 0 normal 4 4 ..20 mA (live Zero)	
Identity **B3**	selected:	Configure Analogous input 3
Step **12**	Choices: 0 normal 4 4 ..20 mA (live Zero)	
Identity **D1**	selected:	Set global decimal point
Step **13**	Choices: 0 no decimal point 0000 1 decimal point on position 1 000,0 2 decimal point on position 2 00,00 3 decimal point on position 3 0,000	
Identity **P1**	selected:	Displayed value at 0% input current
Step **14**	Choices: -9999..9999 ***Caution**: |Q-P| must be less than 4000*	
Identity **Q1**	selected:	Displayed value at 100% input current
Step **15**	Choices: -9999..9999	

Identity	selected:	
E1		Function of Digital Input 1 (te. 21)
Step 16	Choices:	0 no function 1 select AUTO- operation 2 select MANU- operation 3 toggle MANU/AUTO 4 select internal reference 1 6 select internal reference 2 7 select internal safety reference 8 toggle internal reference 1 / internal reference 2 9 toggle internal reference / external reference 10 toggle PID parameter set 1 / PID parameter set 2 11 set manipulated value to safety set point 12 disable front keys The input with the lowest number has the highest priority, if an input conflict occurs.
E2		Function of Digital Input 2
Step 17	Choices:	like step 16
E3		Function of Digital Input 3
Step 18	Choices:	like step 16
E4		Function of Digital Input 4
Step 19	Choices:	like step 16
E5		Function of Digital Input 5 (only modbus option)
Step 20	Choices:	like step 16
E6		Function of Digital Input 6 (only modbus option)
Step 21	Choices:	like step 16
E7		Function of Digital Input 7 (only modbus option)
Step 22	Choices:	like step 16
E8		Function of Digital Input 8 (only modbus option)
Step 23	Choices:	like step 16

Identity	selected:	
C1		Working mode of Digital Input 1
Step 24	Choices:	no: normal open nc: normal closed
C2		Working mode of Digital Input 2
Step 25	Choices:	no: normal open nc: normal closed
C3		Working mode of Digital Input 3
Step 26	Choices:	no: normal open nc: normal closed
C4		Working mode of Digital Input 4
Step 27	Choices:	no: normal open nc: normal closed
C5		Working mode of Digital Input 5 (only modbus option)
Step 28	Choices:	no: normal open nc: normal closed
C6		Working mode of Digital Input 6 (only modbus option)
Step 29	Choices:	no: normal open nc: normal closed
C7		Working mode of Digital Input 7 (only modbus option)
Step 30	Choices:	no: normal open nc: normal closed
C8		Working mode of Digital Input 8 (only modbus option)
Step 31	Choices:	no: normal open nc: normal closed

Identity / Step	selected:	
A1 / 32		Function of Digital output 1
	Choices: 0: no function; 1: PWM - control 1; 2: PWM – control 2; 3: X1 min underflow; 4: X1 max overflow; 5: X2min underflow; 6 X2 max overflow; 7 WE underflow; 8: WE max overflow; 9: Y min under run; 10: Y max overflow; 11: XD min under run; 12: XD max overflow; 13: X1 broken wire (bw.); 14: X1 physical current overflow (pco.); 15: X1 pco. or bw.; 16: X2 broken wire (bw.); 17: X2 physical current overflow; 18: X2 pco. or bw.; 19: WE broken wire; 20: WE physical current overflow; 21: pco. or bw.; 22: Manual / Auto Indicator (0 = Manual, 1 = Auto)	
A2 / 33		Function of Digital output 1
	Choices: like step 24	
A3 / 34		Function of Digital output 3
	Choices: like step 24	
A4 / 35		Function of Digital output 4
	Choices: like step 24	
O1 / 36		Working mode of Digital output 1
	Choices: no: normal open; nc: normal closed	
O2 / 37		Working mode of Digital output 2
	Choices: no: normal open; nc: normal closed	
O3 / 38		Working mode of Digital output 3
	Choices: no: normal open; nc: normal closed	
O4 / 39		Working mode of Digital output 4
	Choices: no: normal open; nc: normal closed	

Identity	selected:	Description / Choices
X1Min		Limiting of actual signal X1 minimum
Step 40	Choices:	0 ignore 1 fit signal to internal limit
X1Max		Limiting of actual signal X1 maximum
Step 41	Choices:	0 ignore 1 fit signal to internal limit
X2Min		Limit monitoring / limiting of actual signal X2 minimum
Step 42	Choices:	0 ignore 1 fit signal to internal limit
X2Max		Limiting of actual signal X2 maximum
Step 43	Choices:	0 ignore 1 fit signal to internal limit
WEMin		Limiting of external reference signal minimum
Step 44	Choices:	0 ignore 1 fit signal to internal limit
WEMax		Limiting of external reference signal maximum
Step 45	Choices:	0 ignore 1 fit signal to internal limit
YAMin		Limiting of actuator signal minimum (only enabled in automatic controller mode)
Step 46	Choices:	0 ignore 1 fit signal to internal limit
YAMax		Limiting of actuator signal maximum (only enabled in automatic controller mode)
Step 47	Choices:	0 ignore 1 fit signal to internal limit
XdMin		Limiting of error signal minimum
Step 48	Choices:	0 ignore 1 fit signal to internal limit
XdMax		Limiting of error signal maximum
Step 49	Choices:	0 ignore 1 fit signal to internal limit

Identity	selected:	
Tr		**Enable tracking function for internal reference values** (W will be set to X, when controller mode is switching to automatic mode)
Step **50**	Choices:	0 disable tracking function 1 enable tracking function

Identity	selected:	
X1		**Validation of actual signal X1 (detecting physical disturbances)**
Step **51**	Choices:	0 ignore (no validation) 1 signal is too less (< 0,5 mA resp. Pt100-Min-Malfunction) 2 signal is too big (> 22,5 mA resp. Pt100-Max-Malfunction) 3 both

Identity	selected:	
X2		**Validation of actual signal X2 (detecting physical disturbances)**
Step **52**	Choices:	see step 44

Identity	selected:	
WE		**Validation of external reference signal WE (detecting physical disturbances)**
Step **53**	Choices:	see step 44

Identity	selected:	
Er		**Reaction by physical disturbances (related to step 44, 45 or 46)**
Step **54**	Choices:	0 ignore 1 sets controller to manual operation mode; actuator value is constant 2 sets controller to manual operation mode; actuator value is set to safety actuator value

Identity	selected:	
Pr		**Start up settings, after sudden power supply failure**
Step **55**	Choices:	

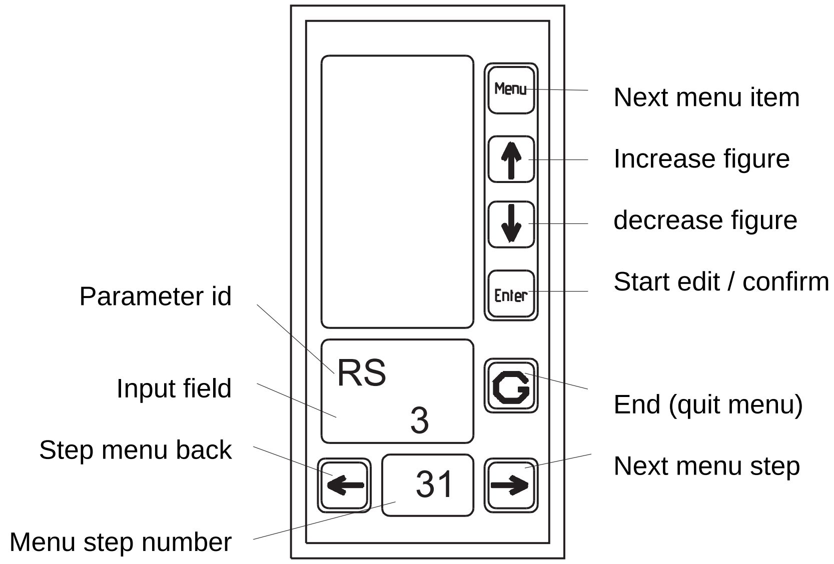
Choice	previous setting: manual control	previous setting: Automatic control
0	Set to manual control, Y = Ysafety	continues previous operation,
1	continues previous operation, Ystart = Ysafety	continues previous operation, W = Wsafety
2	continues previous operation Ystart = Ysafety	switches to manual control Y = Ysafety

Identity	selected:	
Mb		**Set Baud rate of MODBUS interface**
Step **56**	Choices:	0 600 1 1200 2 2400 3 4800 4 9600

Identity / Step	selected:	Description / Choices
MP / 57		Set parity of MODBUS interface
	Choices:	0 none 1 even 2 odd
MA / 58		Set slave address of MODBUS interface
	Choices:	1 .. 247
MF / 59		Set swap float setting of MODBUS interface
	Choices:	0 normal 1 swap float
EC / 60		Set E-Code (to leave operation mode)
	Choices:	-9999..9999
PC / 61		Set P-Code (to enter parameter menu in operation mode)
	Choices:	-9999..9999
BC / 62		Set B-Code (to enter operation menu e.g. to set internal reference values)
	Choices:	-9999..9999 Remark: “0000” disables B-code
GC / 63		Set G-Code (to enter G-menu e.g. to set auto/manual operation mode, select reference)
	Choices:	-9999..9999 Remark: “0000” disables G-code

4.3 Parameter menu

4.3.1 Key function chart



4.3.2 Parameter menu - table

Identity	Step	selected:	Description	Choices:
P1	1		PID - parameter Kp of PID parameter set 1	00,01..99,99
N1	2		Integral action time T_N of PID parameter set 1	0001..4999 sec. (Remark: 5000: I- component disabled, P- or PD- controller)
V1	3		Derivative-action time T_V of PID parameter set 1	000,0..999,9 sec. (Remark: 000,0: D- component disabled, P- or PI controller)
A1	4		Operating point for P- or PD- controller of PID parameter set 1 Actuator signal YA = P1* Xd + V1*P1*ΔXd + A1	000,0..100,0 %
P2	5		PID - parameter Kp of PID parameter set 2	00,01..99,99

Identity / Step	selected:	Description / Choices
N2		Integral action time T_N of PID parameter set 2
Step 6	Choices:	0001..4999 sec. (Remark: 5000: I- component disabled, P- or PD- controller)
V2		Derivative-action time T_V of PID parameter set 2
Step 7	Choices:	000,0..999,9 sec. (Remark: 000,0: D- component disabled, P- or PI controller)
A2		Operating point for P- or PD- controller of PID parameter set 2 Actuator signal YA = P2* Xd + V2*P2*ΔXd + A2
Step 8	Choices:	000,0..100,0 %
Identity		Set signal limits (if enabled in structure menu)
	Choices:	
X1Min	______________	Minimum of actual signal 1 (X1)
X1Max	______________	Maximum of actual signal 1 (X1)
X2Min	______________	Minimum of actual signal 2 (X2)
X2Max	______________	Maximum of actual signal 2 (X2)
WEMin	______________	Minimum of external reference signal (WE)
WEMax	______________	Maximum of external reference signal (WE)
YAMin	______________	Minimum of actuator value YA (only in auto mode active)
YAMax	______________	Maximum of actuator value YA (only in auto mode active)
XdMin	______________	Minimum of error signal Xd (unit %)
XdMax	______________	Maximum of error signal Xd (unit %)
Hy		Hysteresis of signal limits
Step 19	Choices:	Unit % (concerned to |P-Q| step 18,19 structure menu)
Wr		Slew rate limit of reference signals / values
Step 20	Choices:	Enter the approximate rising (0 to 100%) time of any reference. Unit is seconds. The value 000,0 disables the slew rate limiting.
WS		Internal safety reference value
Step 21	Choices:	Value in range of P1 – Q1
YS		Safety actuator value
Step 22	Choices:	0..100,0 %

Identity	selected:	Description / Choices
Mb (Step 23)		Adjust cut-off-frequency of low-pass filter for signal X1, X2, WE
	Choices:	0,1 .. 15 Hz
C1 (Step 24)		Coefficient C1 (related to disturbance cancellation on input)
	Choices:	-9,999 .. 9,999
C2 (Step 25)		Additive Constant C2 (related to disturbance cancellation on input)
	Choices:	-200,0..200,0
C3 (Step 26)		Coefficient C3 (related to disturbance cancellation on output)
	Choices:	-9,999 .. 9,999
C4 (Step 27)		Additive Constant C4 (related to disturbance cancellation on output)
	Choices:	-100,0..100,0
C5 (Step 28)		Additive Constant C5 (related to ratio control)
	Choices:	-100,0..100,0
V0 (Step 29)		Lowest ratio of external ratio reference (only by using ratio control, see block diagram in paragraph 2.2.4)
	Choices:	0,000..9,999 (at 0/4 mA input current)
VE (Step 30)		Highest ratio of external ratio reference (only by using ratio control, see block diagram in paragraph 2.2.4)
	Choices:	0,000..9,999 (at 20 mA input current)
Y1 (Step 31)		Actuator threshold for “heat up” (3- Point PWM and split range control only) Controller pulses only on PWM output 1, while actuator value is above Y1
	Choices:	000,0..100,0 %
Y2 (Step 32)		Actuator threshold for “cool down” (only using 3- Point PWM and split range control) Controller pulses only on PWM output 2, while actuator value is below Y2
	Choices:	000,0..100,0 %

Identity / Step	selected:	
MI 33		Minimum pulse time using PWM control
	Choices: 000,0..MI + MP < T1 t_{pulse} = T1* YA%, if T1 * YA% ≥ MI MI , else	
MP 34		Minimum pause time using PWM control
	Choices: 000,0..MI + MP < T1 t_{Pause} = T1* (100-YA%), if T1 * (100*YA%) ≥ MP MP , else	
T1 35		Periodic time using 2- Point PWM control respectively Periodic time for “heat up” using 3- Point PWM control
	Choices: 000,1..999,9 sec. (T1 = t_{pulse} + t_{pause}) Duty cycle (using 3- point PWM control) $TV_{heat\ up}$ = (YA [%] – Y1 [%]) / (100 – Y1 [%])	
T2 36		Periodic time for “cool down” using 3- Point PWM control
	Choices: 000,1..999,9 sec. Duty cycle: $TV_{cool\ down}$ = YA [%] / Y2 [%]	

4.3.3 How to determinate the PID- parameters

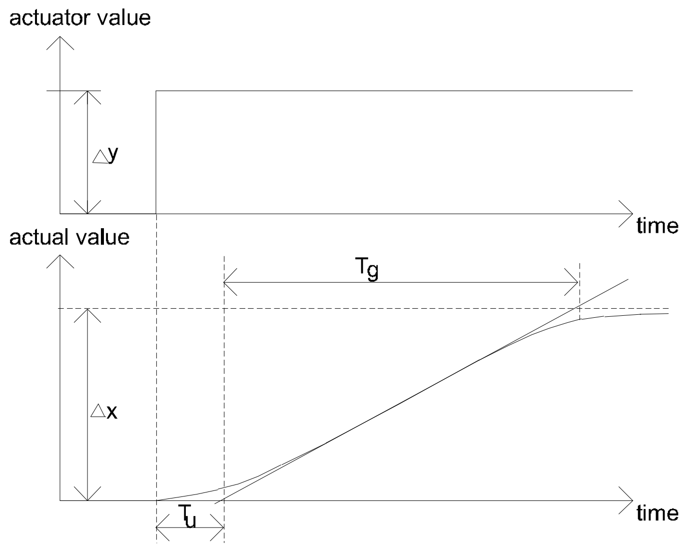
The dynamic behaviour of a PID- controller can be characterised by some general rules: integer P- controllers have a remaining control deviation, this can be cancelled by introducing an integral contribution. But this integral part increases controller oscillation tendency and the control loses speed. Plants containing a dead time are only adjustable with an integral contribution, because a pure P- controller leads to permanent oscillations. A pure I- controller is unsuitable for plants without compensation.

A D- component gives the controller a fast response, but pulsating signals, e.g. in pressure control, leads to instabilities. Controllers containing a D- component are suitable for slow plants, e.g. in temperature control. To achieve zero error conversation a PID- controller must be used.

Some further relationships between plant order and controller structure: a PI- controller is sufficient for 1st order plants. 2nd order plants requires a PID- controller, for very high claims a cascade control is required. Plants in 3rd and higher order are often only controllable with a cascade control.

Parameter determination according to the step response

To utilise the step response of the plant the controller must be off line. Points of interest are the delay time Tu, recovery time Tg and the plant amplification Ks.



Ks = Δx/Δy

Next determinate the PID parameters according the following table:

Controller		dead-beat control disturbance	dead-beat control tracking	regulation with 20% overshoot disturbance	regulation with 20% overshoot tracking
P	K_P	$0{,}3\ \frac{T_g}{T_u \cdot K_s}$	$0{,}3\ \frac{T_g}{T_u \cdot K_s}$	$0{,}7\ \frac{T_g}{T_u \cdot K_s}$	$0{,}7\ \frac{T_g}{T_u \cdot K_s}$
PI	K_P	$0{,}6\ \frac{T_g}{T_u \cdot K_s}$	$0{,}3\ \frac{T_g}{T_u \cdot K_s}$	$0{,}7\ \frac{T_g}{T_u \cdot K_s}$	$0{,}6\ \frac{T_g}{T_u \cdot K_s}$
	T_n	$4\ T_u$	$1{,}2\ T_g$	$2{,}3\ T_u$	$1\ T_g$
PID	K_P	$0{,}95\ \frac{T_g}{T_u \cdot K_s}$	$0{,}6\ \frac{T_g}{T_u \cdot K_s}$	$1{,}2\ \frac{T_g}{T_u \cdot K_s}$	$0{,}95\ \frac{T_g}{T_u \cdot K_s}$
	T_n	$2{,}4\ T_u$	$1\ T_g$	$2\ T_u$	$1{,}35\ T_g$
	T_v	$0{,}42\ T_u$	$0{,}5\ T_u$	$0{,}42\ T_u$	$0{,}47\ T_u$

Example: We are looking for Tn, Tv, and Kp in a temperature control system. The working range of the system is about 200°C. The heating power is continuos adjustable; the total power is 4 kW. First, the heat will be adjusted to achieve 180°C by 60 % power. Now increase abrupt the heating power to 80 %. The temperature course will be recorded. Next, determinate Tu and Tg by applying the turning tangent: Tu is 60 sec. and Tg is 600 sec.

The plant amplification is given by:

$$Ks = \frac{\Delta x}{\Delta y} = \frac{210°C - 180°C}{80\% - 60\%} = \frac{30K}{20\%} = 1{,}5K/\%$$

with Tu and Tg die PID- parameters are:

$$Tn = 1 \cdot Tg = 600s$$

$$Tv = 0{,}5 \cdot Tu = 0{,}5 \cdot 1 \cdot 60s = 30s$$

$$Kp = 0{,}6 \frac{Tg}{Tu \cdot Ks} = 0{,}6 \cdot \frac{10\,\text{min}}{1\,\text{min} \cdot 1{,}5K/\%} = 4\ \%/K$$

5 Annex

5.1 Technical details

		Prozess controller PR130
General	Ex- Protection	E Ex ib IIC T6
	Device group	II 2 G
	EC- Certificate	TÜV 02 ATEX 1863
Indication	LCD	LC-Display with Bargraph; figure height 10 mm
	Display Range	-9999 bis + 9999
	Displayed variables	Control error X_D (Bargraph), actual value (X1) or desired value (W) selectable and manipulated variable Y
Keyboard	Keys	on Foil with 7 keys
Montage	Zone	Hazardous area, Zone1
	Ambient temperature	-20°C ...+65°C T4, -20°C ...+40°C T6
Housing		Acc. DIN 43700
	Dimensions W x H x D	72 mm x 144 mm x 85 mm
	Material	Noryl
	Weight	ca. 500 g
	Front Protection	Standard: IP40, Option front window door: IP54 Option pasted Foil: IP65
Electrical Spec-ifications	Supply controller: te. 3,4	U ≥ 15 V, I = 20 mA
	Supply analogous output te. 1,5	U ≥ 15 V, 20 mA per each output e.g. 2 Analogous outputs + TTY output: 20 mA + 20 mA + 20 mA = 60 mA
	Sample time:	Cycle time of the controller: 33 ms
	Analogous inputs: A1..3	0/4 ..20 mA, load: 15 Ohm The power supply circuit and the three measurement circuits are gavanically connected (common ground = 4, 8, 10, 12 are internal connected).
	Error in measurement	0,2%
	Temperature error	0,01 % / K
	Digital inputs	0-Signal < 1,5 Volt 1-Signal > 3,5 Volt input resistance: min. 6 kΩ
	Analogous output	Current signal 0/4 ..20 mA, error max. 0,2% range TK < 0,01 % /K
	Digital outputs	Inquiry through intrinsically safe control circuit, Galvanically separated up to a voltage of 60 volts. Residual voltage driven: 1..2 volts
	TTY- interface (Modbus)	600 .. 9600 Baud, 8 Data bits, 1 Stop bit,

See certificate TÜV 02 ATEX 1863 for more information

5.2 Problems and solutions

Code forgotten

- turn the device off (e.g. disconnect from power supply)
- press G- key, turn the device on
- hold the key, until "REST" appears
- all data is set to ex work defaults

Display remains dark

Check, the supply circuit for a minimum current of 20 mA

Appliance runs, however no measurement value or false measurements:

- check wiring and polarity of each signal
- check parameter B1, B2, B2, P1, Q1

Appliance turns sometimes off / behaves chaotic:

- Power supply is too weak

5.3 Type code

PR130	.X	.X	.X
Inputs:			
3 x 0/4-20mA	.0		
2 x 0/4-20mA + x actuator feedback	.5		
2 x 0/4-20mA + 1 x PT100	.8		
Serial interface:			
Without TTY............		.0	
TTY-Sender and Receiver		.4	
Analogous output:			
Without analogous output 0/4-20mA			.0
One analogous output 0/4-20mA			.4
Two analogous outputs 0/4-20mA			.5

5.4 Structure- and parameter menu table

PR130 structure			Plant:	
Step	ID	Menu Point	Choices	Choosen
1	RS	Structure of controller	0: Fixed set point controller 1: Fixed set point controller with disturbance at input 2: Fixed set point controller with disturbance at output 3: Ratio controller with internal or external ratio 4: Override-Minimum-Controller 5: Override-Maximum-Controller	
2	RE	Actual value input (Con. 7, 8) *(only by PT100 option)*	0: Pt100 2-wires 1: Pt100 3-wires 2: Pt100 4-wires	
3	Pt	Measure range of Pt100	250: -250 ..+250°C 850: -250 .. + 850°C	
4	RA	Controller output	0: Analogous 0/4..20mA 2: 2-point- PWM controller 1: 2 x Analogous 0/4..20mA 3: 3 point PWM controller	
5	S1	Configure analogous outp. 1 (13/14)	0: 0 .. 20 mA 4: 4 .. 20 mA	
6	S2	Configure analogous outp. 2 (25/26)	0: 0 .. 20 mA 4: 4 .. 20 mA	
7	I1	Configure analogous outp. 1 (13/14)	0: normal 1: invert	
8	I2	Configure analogous outp. 2 (25/26)	0: normal 1: invert	
9	KA	Calibration menu	Calibration for measuring resistors e.g. Pt100 2-wire	
10	B1	Configure Analogous input 1 (X1)	0: 0 .. 20 mA 4: 4 .. 20 mA	
11	B2	Configure Analogous input 1 (X2)	0: 0 .. 20 mA 4: 4 .. 20 mA	
12	B3	Configure Analogous input 2 (WE)	0: 0 .. 20 mA 4: 4 .. 20 mA	
13	D1	Decimal point for measured value	Position of fixed decimal point for set point and actual value display	
14	P1	0% of physical value	e.g. 0..100%: 0000 -20..200°C: -020.0	
15	Q1	100% of physical value	e.g. 0..100%: 1000 -20..200°C: 200.0	
16 17 18 19	E1 E2 E3 E4	Function digital input 1 Function digital input 2 Function digital input 3 Function digital input 4	0: No function 7: Select safety set point 1: Switch to automatic 8: Toggle int. reference 1/2 2: Switch to manual 9: Toggle int./ext. reference 3: Toggle automatic/manual 10: Toggle PID-parameter set1/2 4: Select external reference 11: Select safety output value 5: Select internal set point 1 12: Lock keyboard 6: Select internal set point 2 *If a conflict between two inputs arises (due to the programming of the inputs) the input with the lowest number has priority*	
24	C1	Working mode of Digital Input 1	no: normal open nc: normal closed	
22	C2	Working mode of Digital Input 2	no: normal open nc: normal closed	
23	C3	Working mode of Digital Input 3	no: normal open nc: normal closed	
24	C4	Working mode of Digital Input 4	no: normal open nc: normal closed	
32 33 34 35	A1 A2 A3 A4	Function digital output 1 Function digital output 2 Function digital output 3 Function digital output 4	0: no function 1: PWM - control 1 2: PWM – control 2 3: X1 min under run 4: X1 max overflow 5: X2min under run 6 X2 max overflow 7 WE under run 8: WE max overflow 9: Y min under run 10: Y max overflow 11: XD min under run 12: XD max overflow 13: X1 broken wire (bw.) 14: X1 physical current overflow (pco.) 15: X1 pco. or bw. 16: X2 broken wire 17: X2 physical current overflow 18: X2 pco. or bw. 19: WE broken wire 20: WE physical current overflow 21: pco. or bw. 22: Manual / Auto Indicator	
36	O1	Working mode of Digital output 1	no: normal open nc: normal closed	
37	O2	Working mode of Digital output 2	no: normal open nc: normal closed	
38	O3	Working mode of Digital output 3	no: normal open nc: normal closed	
39	O4	Working mode of Digital output 4	no: normal open nc: normal closed	
40 41 42 43 44 45 46 47 48 49	X1 Min X1 Max X2 Min X2 Max WE Min WE Max YA Min YA Max Xd Min Xd Max	Limits for actual value (X1) Limits for actual value 2 (X2) Limits for external reference (WE) Limits for manipulated variable Limits for control error X_D	0: Ingnore 1: Fit signal to internal limit	
50	Tr	Use W-tracking-function ?	0: Don´t use 1: Use W-tracking-function	
51 52 53	X1 X2 WE	Circuit break and short circuit detection	0: No detection 1: Circuit break detection (I < 0.5mA) 2: Short circuit detection (I > 22.5mA) 3: Both (0.5mA < I < 22.5mA)	
54	Er	Reaction by malfunction	0: No reaction 1: Manual operation mode (hold last actuator value) 2: Manual operation mode (switch to safety manipulated value, Y_{Safety})	
55	Pr	Power up status	0: Continue with last settings, $Y_{Start}=Y_{Safety}$ 1: Continue with last settings, $Y_{Start}= Y_{Safety}$ res. $W_{Start}= W_{Safety}$ 2: Switch to manual operation mode, $Y_{Start}=Y_{Safety}$	
60	EC	Operation mode code	Code number to leave operation mode	
61	PC	Parameter code	Code number to change parameters	
62	BC	Operation menu code	Code number to change internal reference values	
63s	GC	G-Menu code	Code number to change auto/manual, reference 1/2/ external	

PR130-Parameters				
Step	ID	Menu Point	Choices	Choosen
1	P1	Controller constant K_P for set 1	00.01..99.99	
2	N1	Integral action time TN for set 1	0001..4999 Seconds 5000: Integrator disabled	
3	V1	Derivative-action time for set 1	000.0..999.9 Seconds 000.0: Differentiator disabled	
4	A1	Working point for P- or PD-controller set 1	000.0..100.0% only active if integra-tor is disabled	
5	P2	Controller constant K_P for set 2	00.01..99.99	
6	N2	Integral action time TN for set 2	0001..4999 Seconds 5000: Integrator disabled	
7	V2	Derivative-action time for set 2	000.0..999.9 Seconds 000.0: Differentiator disabled	
8	A2	Working point for P- or PD-controller set 2	000.0..100.0% only active if integra-tor is disabled	
9	X1 Min	Limit (if enabled)	Range of X1	
10	X1 Max	Limit (if enabled)	Range of X1	
11	X2 Min	Limit (if enabled)	Range of X1	
12	X2 Max	Limit (if enabled)	Range of X1	
13	WE Min	Limit (if enabled)	Range of X1	
14	WE Max	Limit (if enabled)	Range of X1	
15	Y Min	Limit (if enabled)	000,0 ..100,0 %	
16	Y Max	Limit (if enabled)	000,0 ..100,0 %	
17	X_D Min	Limit (if enabled)	Range of X1	
18	X_D Max	Limit (if enabled)	Range of X1	
19	Hy	Hysteresis for limit actions	000.0..100.0%	
20	Wr	Reference value ramp, minimum time to change set-point from 0 to 100% (ratio controller: 0 to 16.384)	000.0..999.9 Seconds	
21	WS	Internal safety reference value	P1..Q1	
22	YS	Safety actuator value	000.0..100.0%	
23	Mb	Adjust cut-off-frequency of low-pass filter for signal X1	0,1 .. 15 Hz	
24	C1	Coefficient C1 (related to disturbance cancellation on input)	-9.999 ..9.999	
25	C2	Additive Constant C2 (related to disturbance cancellation on input)	-200.0..200.0	
26	C3	Coefficient C3 (related to disturbance cancellation on output)	-9.999 ..9.999	
27	C4	Additive Constant C3 (rel. to disturbance cancellation on output)	-100.0..100.0	
28	C5	Additive Constant C5 (related to ratio control)	-100.0..100.0	
29	V0	Ratio-controller only Start-ratio (0%-Value)	0.000..9.999	
30	VE	Ratio-controller only End-ratio (100%-Value)	0.000..9.999	
31	Y1	3- point PWD control only On value	000.0..100.0%	
32	Y2	3- point PWD control only Off value	000.0..100%	
33	MI	Minimum pulse time using PWD control	000.1..100.0 Seconds	
34	MP	Minimum pause time using PWD control	000.1..100.0 Seconds	
35	T1	Periodic time using PWD control Periodic time for “heat” using 3- point PWD control	000.1..500.0 Seconds	
36	T2	Periodic time for “cool down” using 3- point PWD control	000.1..500.0 Seconds	

How to use the PID-Controller PR130

Buttom	Display	Description
G	Auto	**To toggle closed loop feedback control to open loop control**
↓		
Enter		Done.
↔		Press the right- or left- arrow button to increase or decrease the regulator quantity, in open loop control
G	Auto	**To choose the reference source** PR130 has 4 different reference sources:
G	Int1	Int1 = W1: internal reference 1 Int2 = W2: internal reference 2
↓	Save	Etrn = WE: external reference source (on channel 3) Save = WS: internal safety reference
Enter		Done.
↓		**To toggle the indication while operating: actual signal or chosen reference**
Menu	W1	**To enter the references W1 and W2** E.g. : W1 = 50 [°C], W2 = 100 [°C]
	0000	Press ‘menu button’, W1 for setting is chosen.
↑	0050	Press ‘arrow up button’ until 0050 is adjusted.
Menu	W2	Press ‘menu button’ a second time to select W2 for setting.
	0000	
↑	0100	Press ‘arrow up button’ until 0100 is adjusted.
Enter		Done.

(1) EG-Baumusterprüfbescheinigung

(2) Geräte und Schutzsysteme zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen **- Richtlinie 94/9/EG**

(3) EG Baumusterprüfbescheinigungsnummer

TÜV 02 ATEX 1863

(4) Gerät: PID-Regler Typ PR130

(5) Hersteller: Gönnheimer Elektronic GmbH

(6) Anschrift: D-67433 Neustadt/Weinstraße, Dr.-Julius Leber-Str.2

(7) Die Bauart dieses Gerätes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage zu dieser Baumusterprüfbescheinigung festgelegt.

(8) Die TÜV NORD CERT GmbH & Co. KG, TÜV CERT-Zertifizierungsstelle, bescheinigt als benannte Stelle Nr. 0032 nach Artikel 9 der Richtlinie des Rates der Europäischen Gemeinschaften vom 23. März 1994 (94/9/EG) die Erfüllung der grundlegenden Sicherheits- und Gesundheitsanforderungen für die Konzeption und den Bau von Geräten und Schutzsystemen zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen gemäß Anhang II der Richtlinie.

Die Ergebnisse der Prüfung sind in dem vertraulichen Prüfbericht Nr. 02 YEX 180416 festgelegt.

(9) Die grundlegenden Sicherheits- und Gesundheitsanforderungen werden erfüllt durch Übereinstimmung mit

EN 50014:1997 **EN 50020:1994**

(10) Falls das Zeichen "X" hinter der Bescheinigungsnummer steht, wird auf besondere Bedingungen für die sichere Anwendung des Gerätes in der Anlage zu dieser Bescheinigung hingewiesen.

(11) Diese EG-Baumusterprüfbescheinigung bezieht sich nur auf Konzeption und Prüfung des festgelegten Gerätes gemäß Richtlinie 94/9/EG. Weitere Anforderungen dieser Richtlinie gelten für die Herstellung und das Inverkehrbringen dieses Gerätes. Diese Anforderungen werden nicht durch diese Bescheinigung abgedeckt.

(12) Die Kennzeichnung des Gerätes muss die folgenden Angaben enthalten:

Ex II 2 G EEx ib IIC T6 bzw. T4

TÜV NORD CERT GmbH & Co. KG
TÜV CERT-Zertifizierungsstelle
Am TÜV 1
D-30519 Hannover
Tel.: 0511 986-1470
Fax: 0511 986-2555

Hannover, 15.07.2002

Der Leiter

TÜV NORD CERT

TÜV CERT A4 07.01 10.000 Lö

(13) **A N L A G E**

(14) EG-Baumusterprüfbescheinigung Nr. TÜV 02 ATEX 1863

(15) Beschreibung des Gerätes

Der PID-Regler Typ PR130 ist ein elektronischer Universalregler zur direkten Montage in explosionsgefährdeten Bereichen. Die Folientastatur darf nur feucht gereinigt werden.

Die höchstzulässige Umgebungstemperatur für die Temperaturklasse T6 beträgt 40°C und für T4 65°C.

Elektrische Daten

Speisestromkreis 1 (Klemmen 1; 4)	in Zündschutzart Eigensicherheit EEx ib IIC nur zum Anschluss an bescheinigte eigensichere Stromkreise mit folgenden Höchstwerten: U_i = 30 V I_i = 160 mA P_i = 1,5 W wirksame innere Kapazität 33 nF wirksame innere Induktivität 40 µH
Speisestromkreis 2 (Klemmen 3, 6; 4)	in Zündschutzart Eigensicherheit EEx ib IIC nur zum Anschluss an bescheinigte eigensichere Stromkreise mit folgenden Höchstwerten: U_i = 30 V I_i = 160 mA P_i = 1,5 W wirksame innere Kapazität 2 nF wirksame innere Induktivität 30 µH
Speisung Messumformer (Klemmen 2; 4)	in Zündschutzart Eigensicherheit EEx ib IIC Höchstwerte: U_o = $U_{i\ (an\ KL\ 3,\ 6)}$ I_o = 23 mA höchstzul. äußere Kapazität $C_{o\ (an\ KL\ 3,\ 6)}$ -2 nF höchstzul. äußere Induktivität $L_{o\ (an\ KL\ 3,\ 6)}$ -30 µH
Typ PR130.0.x.x Analogeingänge (Klemmen 7; 8 bzw. 9; 10 bzw. 11; 12)	in Zündschutzart Eigensicherheit EEx ib IIC nur zum Anschluss an bescheinigte eigensichere Stromkreise mit folgenden Höchstwerten je Kreis: U_i = 30 V I_i = 160 mA Die wirksame innere Kapazität und Induktivität sind vernachlässigbar klein.
PT100 Anschluss (Klemmen 7; 8; 19; 20)	beim Typ PR130.8.x.x bzw.
Poti Anschluss (Klemmen 7; 8; 19)	beim Typ PR130.5.x.x

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in Zündschutzart Eigensicherheit EEx ib IIC
Höchstwerte:
U_o = 5,4 V
I_o = 5,3 mA
P_o = 7,2 mW
höchstzul. äußere Kapazität 10 µH
höchstzul. äußere Induktivität 100 mH

Analogausgänge
(Klemmen 13; 14 bzw. 15; 16 bzw. 25; 26)

in Zündschutzart Eigensicherheit EEx ib IIC
Höchstwerte je Kreis:
$U_o = U_i$ (an KL 1)
$I_o = I_i$ (an KL 1)
$P_o = P_i$ (an KL 1)
höchstzul. äußere Kapazität $C_{o\ (an\ KL\ 1)}$ -33 nF
höchstzul. äußere Induktivität $L_{o\ (an\ KL\ 1)}$ -40 µH

TTY Empfänger
(Klemmen 17; 18)

in Zündschutzart Eigensicherheit EEx ib IIC
nur zum Anschluss an bescheinigte eigensichere Stromkreise mit folgenden Höchstwerten:
U_i = 30 V
I_i = 160 mA
P_i = 1,44 W
Die wirksame innere Kapazität ist vernachlässigbar klein.
wirksame innere Induktivität 20 µH

Digitaleingänge
(Klemmen 21 .. 24; 4)

in Zündschutzart Eigensicherheit EEx ib IIC
nur zum Anschluss an bescheinigte eigensichere Stromkreise mit folgenden Höchstwerten:
U_i = 30 V
I_i = 160 mA
R_i ≐ 6 kΩ
Die wirksame innere Kapazität ist vernachlässigbar klein.
wirksame innere Induktivität 20 µH

Digitalausgänge
(Klemmen 27; 28 bzw. 29; 30 bzw. 31; 32 bzw. 33; 34)

in Zündschutzart Eigensicherheit EEx ib IIC
nur zum Anschluss an bescheinigte eigensichere Stromkreise mit folgenden Höchstwerten je Kreis:
U_i = 30 V
I_i = 160 mA
P_i = 1,5 W
Die wirksame innere Kapazität ist vernachlässigbar klein.
wirksame innere Induktivität 20 µH

(16) Prüfungsunterlagen sind im Prüfbericht Nr. 02 YEX 180416 aufgelistet.

(17) Besondere Bedingung

keine

(18) Grundlegende Sicherheits- und Gesundheitsanforderungen

keine zusätzlichen