FP160
User manual

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Status 08.2024

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1 General information

1.1 Features and functions

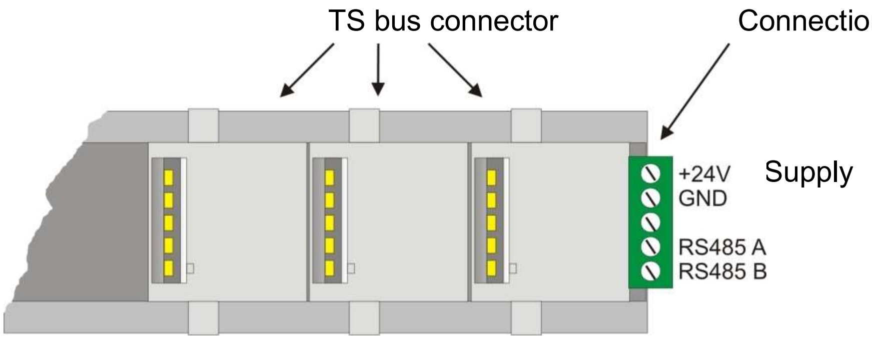
- Different methods for calculating the output power for each zone:
  * Manually adjustable, constant output
  * PID temperature control for heating / cooling
  * Takeover of the output of a neighboring zone in the event of a sensor fault
  * Comparator function (see parameter 4, Xp)
  * Permanently switching off limiter as safety function (see parameter 2, HI)
- Self-optimization of the zones on request
- FE3 bus via RS485 for parameterization / visualization (e.g. Visual Fecon or Paracon)
- Short-circuit-proof outputs for controlling solid-state relays

2 Hardware structure

The ***FP160*** temperature controller is integrated in a system module that can be snapped onto a top-hat rail.

2.1 Top-hat rail system

The controller is supplied with power and communicates via a 5-pole terminal system ("TS bus connector", article number 90-00217), which can be mounted by simply pressing it into a standard top-hat rail.



The TS bus connectors can be strung together in any length in order to supply several FP160 controllers next to each other on one rail if required.

The number of TS bus connectors required per FP160 is determined by the width of the controller housing:

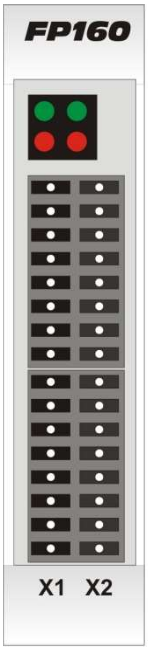
Controller type	Bus terminals
FP160Cx08, FP160CP4L4	1
FP160Cx08E, FP160Cx16, FP160CP4L4E	2
FP160Cx16E, FP160CP4L8E	3

The 24V supply voltage is fed in electrically and the RS485 interface is connected via a 5-pin connection socket (article number 90-000216), which can be plugged onto the side of the TS bus connector.

The terminal assignment is shown in the figure above.

2.2 FP160 Cx08

FRONT

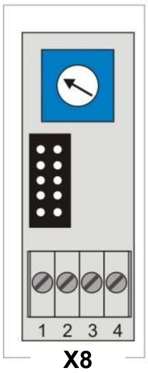


TX: Busy
H1: System Fault, Overload
Sensor inputs
Sensor 1(-) X1.1
Sensor 2(-) X1.2
Sensor 3(-) X1.3
Sensor 4(-) X1.4
Sensor 5(-) X1.5
Sensor 6(-) X1.6
Sensor 7(-) X1.7
Sensor 8(-) X1.8
24VDC outputs
Heating zone 1 X1.9
Heating zone 2 X1.10
Heating zone 3 X1.11
Heating zone 4 X1.12
Heating zone 5 X1.13
Heating zone 6 X1.14
Heating zone 7 X1.15
Heating zone 8 X1.16

V+: Power
H2: Malfunction
Sensor inputs
X2.1 Sensor 1(+)
X2.2 Sensor 2(+)
X2.3 Sensor 3(+)
X2.4 Sensor 4(+)
X2.5 Sensor 5(+)
X2.6 Sensor 6(+)
X2.7 Sensor 7(+)
X2.8 Sensor 8(+)
24VDC outputs
X2.9 LO alarm *)
X2.10 Hi-Alarm *)
X2.11 DEV alarm *)
X2.12 SYS alarm *)
X2.13 Cooling zone 5 *)
X2.14 Cooling zone 6 *)
X2.15 Cooling zone 7 *)
X2.16 Cooling zone 8 *)

*) Cooling output if parameter no. 12 < "0"

BOTTOM



Address

Service
(behind cover plate)

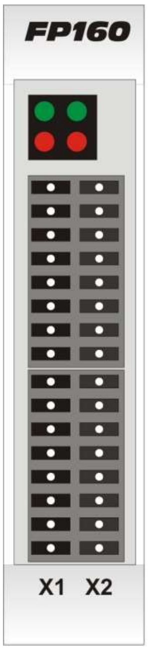
24VDC supply for the outputs
+24V input X7.1
NC X7.2

X7.3 NC
X7.4 GND input

2.3 FP160 CP4L4

FRONT

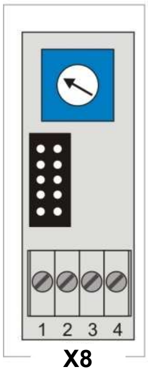
TX: Busy
H1: System Fault, Overload
Sensor inputs
Pt100 1(P+) X1.1
Pt100 1(P-) X1.2
Pt100 2(P+) X1.3
Pt100 2(P-) X1.4
Pt100 3(P+) X1.5
Pt100 3(P-) X1.6
Pt100 4(P+) X1.7
Pt100 4(P-) X1.8
24VDC outputs
Heating zone 1 X1.9
Heating zone 2 X1.10
Heating zone 3 X1.11
Heating zone 4 X1.12



V+: Power
H2: Malfunction
Sensor inputs
X2.1 1(S+)
X2.2 1(S-)
X2.3 2(S+)
X2.4 2(S-)
X2.5 3(S+)
X2.6 3(S-)
X2.7 4(S+-)
X2.8 4(S-)
24VDC outputs
X2.9 LO alarm
X2.10 Hi-Alarm
X2.11 DEV alarm
X2.12 SYS alarm

BOTTOM

24VDC supply for the outputs
+24V input X7.1
NC X7.2



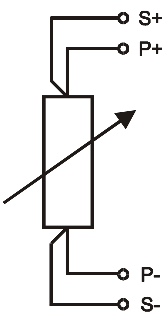
Address

Service
(behind cover plate)

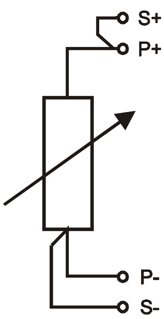
X7.3 NC
X7.4 GND input

2.3.1 Equivalent circuit diagrams Pt100/4-wire

4-wire:



3-wire:



The measurement inputs S+ and S- must be connected or bridged.

2.4 FP160 Cx08E: 8 zone controller with "Real Time Ethernet" option

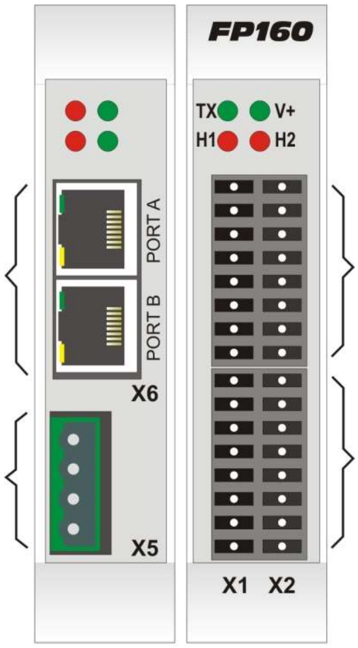
(Profinet, Sercos or EtherCAT)

FRONT

ALM: Alarm | SYS OK
CRT: Bus function | CGN

Real Time Ethernet

Contact outputs
X5.13
X5.14
X5.23
X5.24



TX: Busy | V+: Power
H1: System Fault | H2: Malfunction

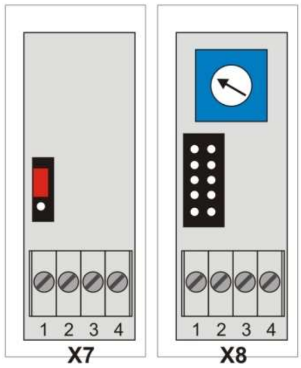
Sensor inputs	**Sensor inputs**
Sensor 1(-) X1.1	X2.1 Sensor 1(+)
Sensor 2(-) X1.2	X2.2 Sensor 2(+)
Sensor 3(-) X1.3	X2.3 Sensor 3(+)
Sensor 4(-) X1.4	X2.4 Sensor 4(+)
Sensor 5(-) X1.5	X2.5 Sensor 5(+)
Sensor 6(-) X1.6	X2.6 Sensor 6(+)
Sensor 7(-) X1.7	X2.7 Sensor 7(+)
Sensor 8(-) X1.8	X2.8 Sensor 8(+)
24VDC outputs	**24VDC outputs**
Heating zone 1 X1.9	X2.9 LO alarm *)
Heating zone 2 X1.10	X2.10 Hi-Alarm *)
Heating zone 3 X1.11	X2.11 DEV alarm *)
Heating zone 4 X1.12	X2.12 SYS alarm *)
Heating zone 5 X1.13	X2.13 Cooling zone 5 *)
Heating zone 6 X1.14	X2.14 Cooling zone 6 *)
Heating zone 7 X1.15	X2.15 Cooling zone 7 *)
Heating zone 8 X1.16	X2.16 Cooling zone 8 *)

*) Cooling output if parameter no. 12 < "0"

BOTTOM

Configuration jumper

24V control inputs
+/-24V or 24VAC input 1 X7.1
-/+24V or 24VAC input 1 X7.2
+/-24V or 24VAC input 2 X7.3
-/+24V or 24VAC input 2 X7.4



Address

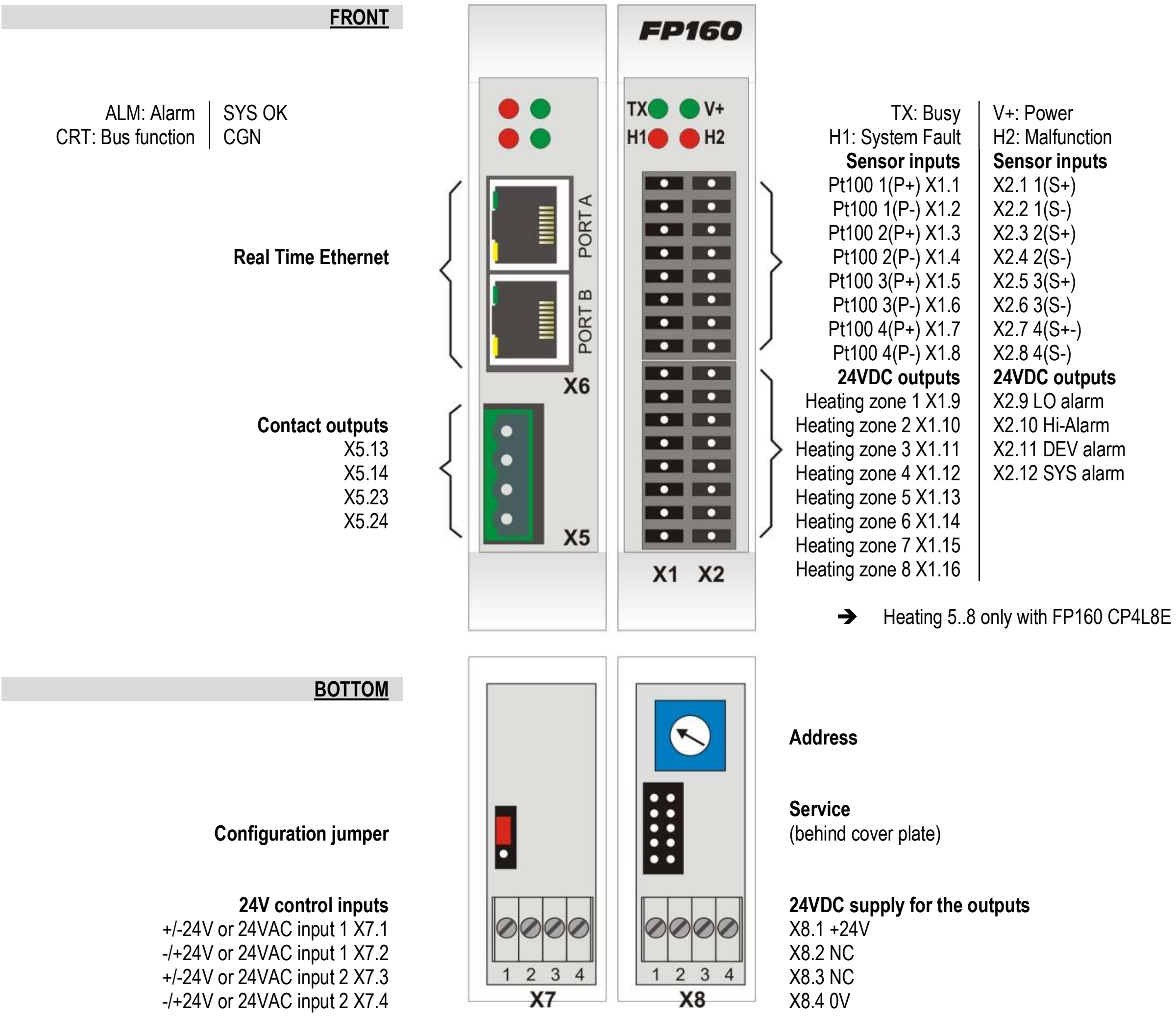
Service
(behind cover plate)

24VDC supply for the outputs
X8.1 +24V
X8.2 NC
X8.3 NC
X8.4 0V

The control inputs are suitable for both DC signals, regardless of polarity, and AC signals.

2.5 FP160 CP4L4E: 4 zone Pt100/4L controller with "Real Time Ethernet" option

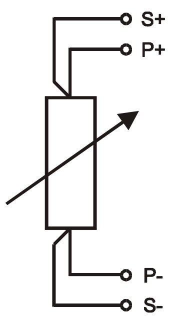
(Profinet, Sercos or EtherCat)



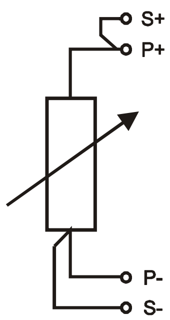
The control inputs are suitable for both DC signals, regardless of polarity, and AC signals.

2.5.1 Equivalent circuit diagrams Pt100/4-wire

4-wire:



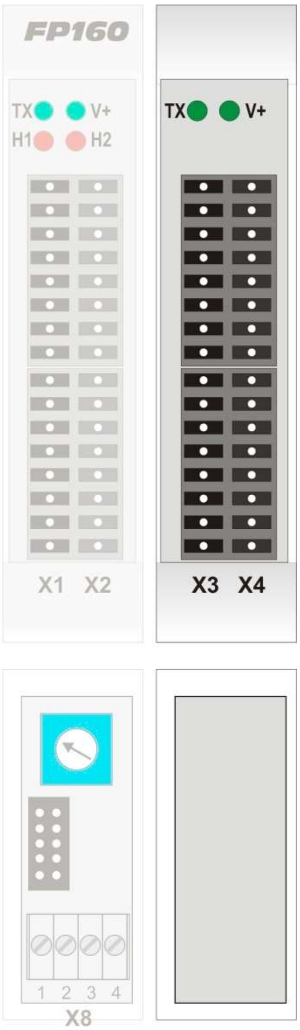
3-wire:



The measurement inputs S+ and S- must be connected or bridged.

2.6 FP160 Cx16: Zones 9-16

Zones 1 - 8 identical to FP160 x08



TX: Busy	V+: Power
Sensor inputs	**Sensor inputs**
Sensor 9(-) X3.1	X4.1 Sensor 9(+)
Sensor 10(-) X3.2	X4.2 Sensor 10(+)
Sensor 11(-) X3.3	X4.3 Sensor 11(+)
Sensor 12(-) X3.4	X4.4 Sensor 12(+)
Sensor 13(-) X3.5	X4.5 Sensor 13(+)
Sensor 14(-) X3.6	X4.6 Sensor 14(+)
Sensor 15(-) X3.7	X4.7 Sensor 15(+)
Sensor 16(-) X3.8	X4.8 Sensor 16(+)
24VDC outputs	**24VDC outputs**
Heating zone 9 X3.9	X4.9 Cooling zone 9 *)
Heating zone 10 X3.10	X4.10 Cooling zone 10 *)
Heating zone 11 X3.11	X4.11 Cooling zone 11 *)
Heating zone 12 X3.12	X4.12 Cooling zone 12 *)
Heating zone 13 X3.13	X4.13 Cooling zone 13 *)
Heating zone 14 X3.14	X4.14 Cooling zone 14 *)
Heating zone 15 X3.15	X4.15 Cooling zone 15 *)
Heating zone 16 X3.16	X4.16 Cooling zone 16 *)

*) Cooling output if parameter no. 12 < "0"

2.7 Functions of the processor module

2.7.1 LEDs

LED	Function
V+	Lights up permanently in normal operation and indicates that supply voltage is present.
Tx	Flashes at 500ms intervals
H1	The H1 LED lights up in the event of a serious error (internal hardware problem) or flashes if one of the outputs is short-circuited. In the event of such a short circuit, the affected output switches off permanently. This alarm is acknowledged when the controller is switched on again.
H2	

Additional LEDs for the FP160 Cxxx**E** processor variant (with real-time Ethernet)

LED	Function
ALM	When the "ALM" LED lights up, the controller detects a temperature alarm (HI exceeded). At the same time, contact 5.13 - 5.14 is opened.
SYS OK	If the green SYS OK goes out, there is a hardware fault in the controller. At the same time, contact 5.23 - 5.24 is opened.
CRT	Status of the Ethernet connection: LED off: No communication to the bus master LED flashes: Communication to the bus master is being established LED on: existing communication to the bus master
CGN	Currently without function

2.7.2 Alarm outputs

The alarm outputs LO-Alarm, HI-Alarm, DEV-Alarm and SYS-Fault normally provide 24V DC for activating external relays. If one of the zones reports an alarm, the voltage at the corresponding alarm output drops to 0V. SYS-Fault stands for the integrated hardware monitoring.

2.7.3 Alarm contacts

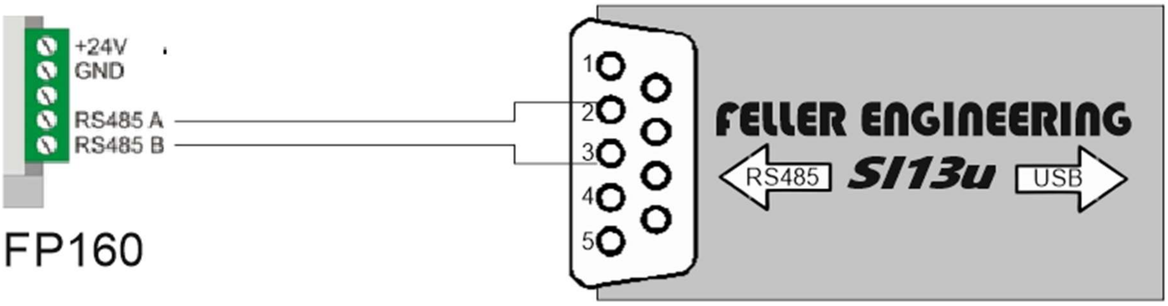
Two potential-free contacts are available for the variant with real-time Ethernet (FP160 *CxxxE*):

Contact us	Function
5.13 - 5.14	Normally closed, Contact opens at temperature HI alarm
5.23 - 5.24	Normally closed, Contact opens in the event of a serious controller hardware error.

2.7.4 RS485

An RS485 interface is led out via the connections of the bus terminal. This allows up to 30 devices to be connected to a two-wire bus. The device address can be set using the BCD rotary switch on the underside of the housing.

To parameterize the controller via RS485, the free PARACON software is available for download at www.fellereng.de/downloads. For the connection between the FP160 and PARACON, an SI13U interface converter (USB→ RS485) with galvanic isolation is also required, which must be ordered separately. As shown below, a connection between pin 2 and pin 3 of the interface converter and the RS485 connection of the bus terminal of the FP160 is established as follows:



2.7.5 Supply of the outputs

A 24V DC auxiliary voltage must be applied to the 4-pin plug-in terminal on the underside of the module (X8), which is used internally to supply the output drivers. Although the controller works without this voltage, the front outputs for controlling the solid state relays remain switched off.

2.7.6 Technical data

		FP160 Cx08	**FP160 Cx16**	**FP160 Cx08E**	**FP160 Cx16E**	
Temperature range for " Pt100" variant (*FP160CPxx*)	T_{in} max	0,0 ... 500,0				°C
Temperature range for variant "FeCuNi type J" (*FP160CTxx*)	T_{in} max	0,0 ... 700,0				°C
Temperature resolution		0,1				°K
Heating / cooling outputs	I max	80				mA
		Inductive loads (e.g. relays) must be fitted with a free-wheeling diode!				
Max. Capacity of the connected load	C max	100				nF
Power consumption (24V DC)	I b	100		200		mA
Ambient temperature	T max	50				°C
Weight		150	300	250	380	g
Load capacity of the alarm contacts		-	-	4		A
Max. Voltage at the alarm contacts		-	-	230		V AC

2.7.7 Permissible conductor cross-sections for X1..X4 (spring-cage connection)

	min	**max**	
Rigid conductor cross-section	0,2	1,5	mm^2
Flexible conductor cross-section	0,2	1,5	mm^2
Conductor cross-section flexible w. ferrule without plastic sleeve	0,25	1,5	mm^2
Conductor cross-section flexible w. ferrule w. plastic sleeve	0,25	0,75	mm^2

3 Parameterization

By default, the device is delivered with parameter settings that correspond to the general control requirements. User specifications such as setpoints, alarm limits, operating modes, etc. must be set individually. A reset to factory settings is carried out via the system parameter **STD**.

3.1 System parameters

These general parameters may be required when operating and commissioning the **FP160** device. They are not related to individual zones.

3.1.1 HI value {HIW}

Setting limits	0..900
Default value	400
Unit	-
FE3 protocol	G01**? HIW=**
Function	This parameter limits the input of set values.

3.1.2 Enable all control outputs {ENA}

Setting limits:	0..1
Default value:	0
Unit	-
FE3 protocol	G01**?ENA**

Function

This parameter is used to achieve the general release of all control outputs without operating the individual zones. This is useful to prepare the controller for self-optimization or to parameterize the individual zones "at rest" without immediate effects on the heating.

This method is preferable to a hardware switch-off via the main switch, as the controller "freezes" the zones and does not unnecessarily charge the integral component (risk of overshoot when switching on).

Start-up optimization is best started in conjunction with this parameter:

First "passive" switching with "0".
Wait until the zones are in a stable state (cold!).
During this time, the desired set values can be specified and the tuning of the zones can be started.
When the temperatures are in a stable state, switch on the heaters by setting this parameter to "active" (=1). Only now is the actual tune process triggered internally - the best way to achieve the simultaneous start-up of thermally coupled control loops.

3.1.3 Behavior in case of sensor break {APM}

Setting limits:	0..4
Default value:	0
Unit	-
FE3 protocol	G01**? APM**

Function	This global parameter can be used to define the behavior of the zones if a sensor break occurs in control mode:

Setting "0" (default)

With this setting, the power of the zone is switched off in the event of a sensor break. The zone remains in control mode. As soon as the temperature sensor is working again, the previously set setpoint is controlled.

Setting "1"

The controller switches from control mode to actuator mode and uses the previously calculated average output level of the zone as the constant output power.

Setting "2"

For reasons of compatibility, this setting is identical to the setting "1"

Setting "3"

The controller switches from control mode to actuator mode and uses the parameter number 17 entered as the output setpoint as the constant output power.

Setting "4"

The controller switches from control mode to actuator mode. The output level of the reference zone, which was specified as parameter P26, is also used as the output power for the defective zone.

3.1.4 Standby mode {SBY}

Setting limits	0..1
Default value	0
Unit	-
FE3 protocol	G01**? SBY=**

Function	This global parameter can be used to set all zones in control mode to standby mode at the same time. These zones then control to the value set as the 2nd setpoint in→ P11.

3.1.5 Alarm delay {DLY}

Setting limits	0..60
Default value	0 (off)
Unit	sec
FE3 protocol	G01**? DLY=**

Function

This parameter is used to suppress alarms that occur briefly. Only if a zone alarm (e.g. LO, HI or DEV alarm) is present for longer than the time set here in seconds is it reported via the alarm contacts and via the data interface.

3.1.6 Loading the standard parameters {STD}

Setting limits	0..60
Default value	0 (off)
Unit	sec
FE3 protocol	G01**? STD=**

Function

Writing this system parameter once to the value "1" causes the factory-set default parameters to be loaded.

This corresponds to the delivery status of the controller

3.1.7 Query the software identifier {AZ#}

Setting limits	read only
Default value	-
Unit	-
FE3 protocol	G01? **AZ#**=

Function

In order to identify the correct firmware, its identifier can be queried here.

The firmware identifier is a number from 00001 ... 99999.

For example, the standard FP160 reports with the AZ number 310

3.1.8 Query the number of control zones (channels) {KAN}

Setting limits	read only
Default value	-
Unit	-
FE3 protocol	G01? **KAN**=

Function

Depending on the expansion stage of the controller, the device has 8 or 16 zones, which can be queried via this parameter.

3.1.9 Query the software version {VER}

Setting limits	read only
Default value	-
Unit	-
FE3 protocol	G01**? VER**=
Function	The software version of the controller can be queried here for information.

3.2 Zone parameters

Each individual zone has its own parameter set

3.2.1 P01: Lo-Alarm {LO_}

Setting limits	0...9999
Default value	0
Unit	1/10 °K
FE3 protocol	G01K01**P01**=
Function	If the **temperature** falls below the value set as parameter 1, the respective zone reports **an LO alarm**. The "Low temperature" collective alarm on X2.9 is also activated. The value must be set in 1/10 ° resolution. A setting of 200 therefore corresponds to 20.0 °.

3.2.2 P02: Hi-Alarm {HI_}

Setting limits	0...9999
Default value	4000 (=400,0 °)
Unit	1/10 °K
FE3 protocol	G01K01**P02**=
Function	If the value set as parameter 2 is exceeded, the respective zone reports **a HI alarm**. The "Overtemperature" collective alarm on X2.10 is also activated. The value must be set in 1/10 ° resolution. A setting of 4000 therefore corresponds to 400.0 °. **Special case**: When HI=0 is set, the zone operates as a **limiter**. The power is fully switched on until the setpoint value (=limiter value) is reached. If the setpoint is exceeded, a HI alarm is generated and the zone switches off permanently (operating mode = OFF). Once the value falls below the setpoint, the zone can be restarted manually. This method can protect another control zone from overheating by connecting the output actuators in series. Further safety is achieved if the controller and limiter are set up as separate hardware components (each with its own processor)

3.2.3 P03: Deviation alarm {DEV}

Setting limits	1...9999

Default value	150
Unit	1/10 °K
FE3 protocol	G01K01**P03**=

Function

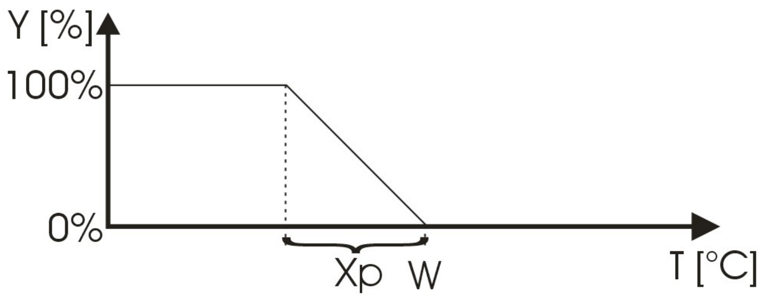
As soon as the actual value deviates from the setpoint value by more than the value set here, the zone reports a deviation alarm. The collective alarm "DEV alarm" on X2.11 is also activated. The value must be set in 1/10 ° resolution. A setting of 150 therefore corresponds to 15.0°.

3.2.4 P04: Proportional band of the heating {XPH}

Setting limits	1...100
Default value	5
Unit	% (from 500)
FE3 protocol	G01K01**P04**=

Function

The P component changes the output power of the controller in proportion to the deviation between the setpoint and actual value. The proportional band (xp) is the range of the process variable in which this linear relationship occurs before the output power reaches its minimum or maximum.



For the FP160, a fixed measuring range of 500°C is assumed (1% therefore corresponds to 5K).
If the selected proportional band is too large, the adjustment will be very sluggish. If the proportional band is too small, it will react very strongly to small deviations, so that the controller tends to oscillate.
If only P controllers are used (without I and D components), the control deviation cannot be fully eliminated.
Special case: If xP=0 is set, the controller is in comparator **mode** . The power is switched off when the setpoint is exceeded by 2° and switched on again fully when it falls below the setpoint by 2°. The hysteresis is therefore +/- 2°

3.2.5 P05: Integral part of the heating {TNH}

Setting limits	0...9999
Default value	800
Unit	1/10 s
FE3 protocol	G01K01**P05** =

Function

The integral component of the controller prevents a permanent control deviation. This is achieved by constantly changing the output power until the control deviation is regulated to zero. The speed at which this change takes place depends on the time set here. A small value means a rapid change in power with a control deviation. A long time has the opposite effect.

With the "0" setting, the effect of the I component is switched off completely.

3.2.6 P06: Differential component of the heating {TVH}

Setting limits	0...9999
Default value	200
Unit	1/10 s
FE3 protocol	G01K01**P06** =

Function

The differential component reacts to the rate of change of the control deviation. The control component 'brakes' the output level for a time that can be set here if the actual value approaches the setpoint value at too high a speed.
With the "0" setting, the effect of the D component is switched off completely.

3.2.7 P07: Proportional band of the cooling {XPK}

Setting limits	0..100
Default value	5
Unit	% (from 500)
FE3 protocol	G01K01**P07** =

Function

See→ P04
However, the parameter is effective for previously negatively calculated outputs, i.e. if cooling of the zone has been requested

3.2.8 P08: Integral part of the cooling {TNK}

Setting limits	0...9999
Default value	800
Unit	1/10 s
FE3 protocol	G01K01**P08** =
Function	See→ P05 However, the parameter is effective for previously negatively calculated outputs, i.e. when cooling of the zone has been requested.

3.2.9 P09: Differential component of cooling {TVK}

Setting limits	0...9999
Default value	200
Unit	1/10 s
FE3 protocol	G01K01**P09**=
Function	See→ P06 However, the parameter is effective for previously negatively calculated outputs, i.e. when cooling of the zone has been requested.

3.2.10 P10: Operating mode of the zone {MOD}

Setting limits	0...3
Default value	2
Unit	-
FE3 protocol	G01K01**P10**=
Function	The 3 available operating modes can be changed via this parameter. 0 = OFF (OFF) 1 = Manual mode (constant output power) (→ P17) 2 = Control mode (→ P04..P09) 3 = Setback mode (standby) (→ P11)

3.2.11 P11: Standby setpoint {SBY}

Setting limits	0...9999
Default value	0
Unit	°C
FE3 protocol	G01K01**P11**=
Function	This parameter can be used to specify a setback temperature in normal control mode. This value is used as the setpoint in setback mode (→ P10)

3.2.12 P12: Minimum output power {YMI}

Setting limits	-100...0
Default value	0
Unit	%
FE3 protocol	G01K01**P12**=

Function	To activate the cooling function of a zone, the minimum output power must be adjusted with this parameter (-100% corresponds to maximum cooling power)

3.2.13 P13: Maximum output power {YMA}

Setting limits	0...100
Default value	100
Unit	%
FE3 protocol	G01K01**P13**=

Function	This parameter limits the maximum output power of the heaters.

3.2.14 P14: Output power setpoint {YST}

Setting limits	-100...100
Default value	0
Unit	%
FE3 protocol	G01K01**P14**=

Function	a) In actuator mode (parameter P10 = 1), the value entered here is used directly as a constant output power. b) In control mode (parameter P10 = 2 or 3), the set output level can be specified in preparation for a later switchover to control mode (intermittent switchover). In control mode, changing this parameter has no effect on the control.

3.2.15 P15: Cycle time for heaters {CYH}

Setting limits	1...20
Default value	1
Unit	s
FE3 protocol	G01K01**P15**=

Function	In order to reduce the very fast switching outputs to a speed that is compatible with contactors, for example, this parameter for the switching speed of the heating outputs must be changed upwards.

Increasing this parameter causes the outputs to slow down. The cycle time is always the sum of the switch-on time + switch-off time. The shortest switching pulse results from the cycle time: 100

3.2.16 P16: Cycle time for cooling {CYC}

Setting limits	1..20
Default value	1
Unit	s
FE3 protocol	G01K01**P16**=

Function

In order to reduce the very fast switching outputs to a speed that is compatible with contactors, for example, this parameter for the switching speed of the cooling outputs must be changed upwards. Increasing this parameter causes the outputs to slow down. The cycle time is always the sum of the switch-on time + switch-off time. The shortest switching pulse results from the
Cycle time: 100!

3.2.17 P17: Average output power {YAV}

Setting limits	Read only
Default value	0
Unit	%
FE3 protocol	G01K01**P17**=

Function

This parameter is used to read the average output power of a controlled zone. This is only calculated as long as the zone is in the OK state (without temperature deviation). It is not possible to change this value manually (read-only).
In the event of a sensor break, the zone can be set to actuator mode and the value read here can be output as constant power

3.2.18 P18 Ramp up {RP+}

Setting limits	0..100
Default value	0
Unit	Sec / K
FE3 protocol	G01K01**P18**=

Function

If gentle heating of the medium is required, a heating ramp can be set via P13. This is effective if:
- the device has just been switched on
- the setpoint has been raised

The ramp causes the *INTERNAL* setpoint value to change slowly in the direction of the set setpoint value. As soon as the *INTERNAL* setpoint value has reached the set setpoint value, the ramp has no effect until the next setpoint value change.

Control is always to the *INTERNAL* setpoint!
The ramp speed in the heating ramp is set here in the unit sec/K, i.e. large values result in a slow ramp

3.2.19 P19: Ramp down {RP-}

Setting limits	0..100
Default value	0
Unit	sec / K
FE3 protocol	G01K01**P19**=

Function

In contrast to P18 (upward ramp), a downward ramp can be programmed here, i.e. this ramp only becomes effective when the setpoint is lowered.

3.2.20 P20: Diagnostic time: Heating and sensor monitoring {DIA}

Setting limits	0...9999
Default value	0
Unit	sec
FE3 protocol	G01K01**P20**=

Function

If the zone is operating at more than 97% heat output in control mode, it must experience a temperature increase of 5 K within the time set here.

If this is not the case, the zone is switched off permanently for safety reasons. This could be due to

- Short-circuited thermocouple
- Temperature sensor not connected to the heater
- Defective fuse or
- Defective heating

The zone can only be switched back on manually by setting the setpoint of the faulty zone again.

A setting of "0" means that the plausibility check for this zone is switched off.

3.2.21 P21: Reserve

Setting limits	
Default value	
Unit	
FE3 protocol	G01K01**P21**=
Function	

3.2.22 P22: Temperature offset {OFS}

Setting limits	-999...999
Default value	0
Unit	1/10 K
FE3 protocol	G01K01**P22**=
Function	The actual value recorded by the temperature sensor can be changed by the value set here in 1/10 K increments. This enables, for example, precise line balancing with PT100 sensors

3.2.23 P23: Sensor type {SEN}

Setting limits	2, 3, 7 depending on the hardware of the **FP160** (see below)
Default value	3, 7 (see below)
Unit	
FE3 protocol	G01K01**P23**=
	This parameter is available from version 1.08.
Function	2 = NiCrNi, version for thermocouple available 3 = FeCuNi available for thermocouple version 7 = Pt100 with version for Pt100 available

Maximum values 900°C for Pt100!

4 FE3 protocol

Communication between a PC (master) and a device (slave) with
FE3 bus is based on the master-slave principle in the form of data request / response. The master controls the data exchange, the slaves have a pure response function. They are identified by their device address.

The controller can be fully operated and queried via the FE3 protocol.

The protocol is a pure ASCII protocol. The telegrams begin with a fixed start character "G" and end with an {etx} character. Faulty protocols can be detected via a checksum. Data values to be transmitted are sent in 5-digit blocks.

4.1 Protocol framework:

Request from the Master:

G	0	1	xxxxx	cs	cs	*{etx}*
0x47	0x30	0x31				0x03
Initial sign	Device address (for example 1)		Data	Checksum HI-Nibble	Checksum LO-Nibble	End indicator

Response from the slave:

G	0	1	=	xxxxx	cs	cs	*{etx}*
0x47	0x30	0x31					0x03
Initial character	Device address (for example 1)			Data	Checksum HI-Nibble	Checksum LO-Nibble	End indicator

4.2 Checksum calculation:

The checksum is formed from the addition of all ASCII characters to be transmitted, starting with the "G", with the exception of the checksum itself and with the exception of the *etx character*. After addition, the checksum is rounded with 0xFF and thus shortened to a single byte. The checksum is then converted to hexadecimal and the two resulting characters are transferred in ASCII.

Example for calculating the checksum:

G	1	0	K	0	5	P	0	0	=	0	0	0	5	0	3	A	{etx}
0x47	0x31	0x030	0x4B	0x30	0x35	0x50	0x30	0x30	0x3D	0x30	0x30	0x30	0x35	0x30	0x33	0x41	0x03

a) 0x47+0x31+0x030+0x4B+0x30+0x35+0x50+0x30+0x30+0x3D+0x30+0x30+0x30+0x35+0x30 = 0x33A
b) 0x33A & 0xFF = 0x3A
c) Checksum to be transmitted = "3" and "A"

4.3 Zone-related values

Individual values are addressed via a two-digit zone number and the two-digit parameter number (see parameter description). The zone number is preceded by a "**K**" and the parameter number by a "**P**".

G 0 1 K *0 5* P *0 1* = ... therefore causes the "LO alarm" parameter (parameter *1*) of zone *5* to respond for device with address 1.

4.3.1 Set individual zone-related values

To set a value, it is transferred as a 5-digit ASCII number with leading zeros. The value must be preceded by an "**=**". If the value described above is to be set to 20, it must be transmitted:

`G01K05P01=0002038{etx}` *(The checksum in this case is 38)*

The controller then responds with

`G01{ack}` if the value has been accepted and set

or

`G01{nak}` if the value was rejected by the controller.

For negative values, a "-" must be placed first. So -47 is transmitted as **"-0047"**. Not "0-47" and not "-047" !!!

4.3.2 Query individual zone-related values

To query a value on the controller, the checksum and the *{etx}* are sent directly after the "**=**".

`G01K05P01=46{etx}` *(The checksum in this case is 46)*

The controller then responds with

`G01=00020D7{etx}` to report that the LO alarm (parameter 1) of zone 5 is set to 20

or

`G01{nak}` if the request is invalid.

4.3.3 Query a parameter value from all zones

If "**AL**" is sent instead of the two-digit zone number, the controller responds with the desired values for all zones in a single telegram.

`G01KALP01=6E{etx}` *(The checksum in this case is 6E)*

The controller then responds with

`G01=0002000020000200002000020000200002000020000200002059{etx}`

The values of the zones are to be interpreted as 5-digit ASCII numbers. The length of the telegram depends on the number of zones existing in the controller.

It is not possible to set values for several zones in one telegram.

4.3.4 Query process values (actual values, alarms...) from zones

Changing process values can only be queried on the controller, not set. The following is transferred instead of the parameter number:

PII for querying actual values

PYY to query the currently output power

PSS for querying the zone status

PIX for querying the heating current value of the zone

G01KALPII= therefore requests all actual values of the controller.

4.3.5 The zone status

The zone status contains information about various warnings, alarms and states of a zone. Like all other values, the status is queried by the controller as a decimal number and must then be interpreted bit by bit.

<table>
<tr><td>Bit 0</td><td colspan="8">0 = There is a zone alarm, 1 = Zone OK</td></tr>
<tr><td>Bit 1</td><td colspan="8">1 = LO alarm</td></tr>
<tr><td>Bit 2</td><td colspan="8">1 = HI alarm</td></tr>
<tr><td>Bit 3</td><td colspan="8">1 = Sensor break alarm</td></tr>
<tr><td>Bit 4</td><td colspan="8">1 = Sensor short-circuit alarm</td></tr>
<tr><td>Bit 5</td><td>0</td><td rowspan="2">Operating mode OFF</td><td>1</td><td rowspan="2">MAN operating mode</td><td>0</td><td rowspan="2">AUTO operating mode (PID)</td><td>1</td><td rowspan="2">STANDBY operating mode</td></tr>
<tr><td>Bit 6</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>Bit 7</td><td colspan="8">1 = Error during tuning (self-optimization)</td></tr>
<tr><td>Bit 8</td><td colspan="8">1 = Tuning active</td></tr>
<tr><td>Bit 9</td><td colspan="8">1 = Negative temperature deviation from the setpoint (-DEV)</td></tr>
<tr><td>Bit 10</td><td colspan="8">1 = Positive temperature deviation from the setpoint (+DEV)</td></tr>
<tr><td>Bit 11</td><td colspan="8">1 = Alarm due to a setpoint change</td></tr>
<tr><td>Bit 12</td><td colspan="8">1 = Heating current alarm</td></tr>
<tr><td>Bit 13</td><td colspan="8">1 = HIHI alarm exceeded</td></tr>
<tr><td>Bit 14</td><td colspan="8">-</td></tr>
<tr><td>Bit 15</td><td colspan="8">-</td></tr>
</table>

Examples:

Queried status of the zone = 00065 (dec) = 0000 0000 0100 0001 (bin)

bit 0 set→ Zone OK,

bit 5=0 and bit 6=1→ AUTO operating mode

Queried status of the zone = 0068 (dec) = 0000 0000 0100 0100 (bin)

bit 0=0→ Zone has an ALARM,

bit 2=1→ HI alarm

bit 5=0 and bit 6=1→ AUTO operating mode

4.4 System parameters

In addition to the parameters that affect individual zones, there are also "global" settings whose values affect the entire device.

The following protocol frame is used to query and set these device-related parameters:

4.4.1 Query system parameters

Request from the Master:

G	0	1	?	x	x	x	=	cs	cs	{etx}
0x47	0x30	0x31	0x3F				0x3D			0x03
Initial character	Bus address (for example 1)			Abbreviation of the Global Parameter-name				Checksum HI-Nibble	Checksum LO-Nibble	End indicator

"x x x" must be replaced by the 3-character abbreviation of the global parameter.
This abbreviation is given in the description of the parameter in the respective chapter.

Response from the slave:

G	0	1	=	w	w	w	w	w	cs	cs	{etx}
0x47	0x30	0x31	0x3D								0x03
Initial character	Bus address (for example 1)			Parameter value					Checksum HI-Nibble	Checksum LO-Nibble	End indicator

4.4.2 Setting system parameters

Request from the Master:

G	0	1	?	x	x	x	=	w	w	w	w	w	cs	cs	{etx}
0x47	0x30	0x31	0x3F				0x3D								0x03
Initial character	Bus address (for example 1)			Abbreviation of the global parameter name				Parameter value					Checksum HI-Nibble	Checksum LO-Nibble	End indicator

"x x x" must be replaced by the 3-character abbreviation of the global parameter. This abbreviation is given in the description of the parameter in the respective chapter in the manual.

The controller then responds with

`G01{ack}` if the value has been accepted and set
or

`G01{nak}` if the value was rejected by the controller.

Example: Switching on all control outputs of device with address 5: `G05?ENA=00001`

5 Realtime Ethernet (Profi Net / Sercos / EtherCAT)

5.1 Technical details

5.1.1 GSDML file (ProfiNet)

The GSDML file required for bus configuration on the master is available for download on our homepage www.fellereng.de.

5.1.2 SDDML file (Sercos)

The SDDML file required for bus configuration on the master is available on request.

5.1.3 ESI file (EtherCAT Slave Information)

The ESI file required for bus configuration on the master is available on request.

5.2 User data exchange

The device has a certain number of setting values for each individual zone, such as the setpoint, alarm limits and various control parameters. There is also information about the current status of the zones (actual values, alarm messages, output power) as well as global, cross-zone setting values.

With the Feller Engineering BusProfile, all these settings can be accessed to make the controller as transparent as possible.

However, it is impossible (and also nonsensical) to send all this user data simultaneously in a single telegram. Therefore, the desired data must be requested from the control system by the bus master.

The data exchange from and to the controller takes place via an input area and an output area of 20 bytes each.

Each area consists of 4 bytes of "header" and 16 bytes (=8 words) of "user data".

The bus master requests certain data from the controller by writing to its output area, which the controller then stores in the input area of the bus master.

This makes the configuration of a connection somewhat more complex than for "smaller" devices such as scales and valves, which can hold all available data in a single area.

When processing the transmission steps, the programmer
of the bus master must take a few important things into account:

5.3 Ensuring consistency

In the first program step, before the rest of the output data area is written, the consistency byte must be written to "0". This initially declares all telegrams transmitted to the controller as "invalid".

The consistency byte must only be written as the last action after the output data area has been completely written in order to mark the data set as "valid".

The background to this is that many bus masters operate their data transmission asynchronously to the user program and data packets are transmitted that have not yet been completely compiled (because the user program is currently executing this).

Such errors then occur rarely and sporadically and are extremely difficult to isolate. It is therefore essential to ensure that the sequence is adhered to!

5.4 Check after data request for desired data in the input area

The requested data is not immediately available in the input area after the request, as it must first be compiled by the addressed slave and then sent as a response. The user program must therefore "wait" until the requested data has arrived by checking bytes 1 and 2 of the input area.

5.5 Note the format of the user data

All user data is always saved as an integer number. The "INTEL FORMAT" is used, i.e. first the LO byte, then the HI byte.

Some Profibus masters (e.g. those from Siemens) use the "MOTOROLA FORMAT" for word representation, in which the HI byte precedes the LO byte.
The user must swap the bytes before access.

5.6 Transfer settings only when changed

To reduce the processor and bus load, the setting values should only ever be transmitted to the device when a change is made. It makes no sense to cyclically send the same, unchanged values to the controller again and again. The controller saves the values once sent permanently and independently of the mains in its EEPROM.

5.7 Definition of the Profinet/Sercos/EtherCAT input and output ranges

5.7.1 The output range in the bus master (is sent from the master to the slave)

Byte no.	Name	Function (content)	
0	*oAction*	**1** = Read values from slave **2** = Write values to the slave	HEADER
1	*oGroup*	A "group" is defined as 8 consecutive zones. **1** = Zones 1..8 **2** = Zones 9..16 Special group: **0** = Access to global setting values (see below)	
2	*oSignification*	The number of the desired parameter is transferred here. **0** = setpoint **1** = Parameter P01 (LO alarm, see chapter 3.2.1) **2** = Parameter P02 (HI alarm, see chapter 3.2.2) **3** = Parameter P03 (DEV alarm, see chapter 3.2.3) ... etc ... **252** = Heating current (not for all devices) **253** = Output level **254** = Actual value **255** = Zone status (see below for description)	
3	*oConsistency*	As described above, the consistency byte must first be set to **0** before any further changes are made to the output range. Only after all data in the output range has been written by the user program should the consistency byte be set as the last action. The consistency byte consists of 8 bits, which individually identify the validity of the following data words 1..8. A set bit indicates a valid data word (bit0 for data word 1, bit7 for data word 8). This makes it possible to apply write commands to individual or multiple zones.	
4 5	*oDataword 1*	Value to be set for the 1st zone within the group. In the case of a read command (byte 0 = 1), the content has no meaning	BENEFIT DATA
6 7	*oDataword 2*	Value to be set for the 2nd zone within the group In the case of a read command (byte 0 = 1), the content has no meaning	
8 9	*oDataword 3*	Value to be set for the 3rd zone within the group In the case of a read command (byte 0 = 1), the content has no meaning	
10 11	*oDataword 4*	Value to be set for the 4th zone within the group In the case of a read command (byte 0 = 1), the content has no meaning	
12 13	*oDataword 5*	Value to be set for the 5th zone within the group In the case of a read command (byte 0 = 1), the content has no meaning	
14 15	*oDataword 6*	Value to be set for the 6th zone within the group In the case of a read command (byte 0 = 1), the content has no meaning	
16 17	*oDataword 7*	Value to be set for the 7th zone within the group In the case of a read command (byte 0 = 1), the content has no meaning	
18 19	*oDataword 8*	Value to be set for the 8th zone within the group For a read command (byte 0 = 1), the content is meaningless	

5.7.2 The input area in the bus master (sent from the slave to the master)

Byte no.	Name	Function (content)	
0	*iAction*	**3** = Values were accepted by the slave **4** = Slave reports range exceeded, one or more values were not set.	**HEADER**
1	*iGroup*	The slave stores the number of the group here as it was requested in the output area of the master. The requested user data should only be evaluated if the group number in the input area matches the group number in the output area.	
2	*iSignification*	The slave stores the identifier here as it was requested in the output area of the master. The requested user data should only be evaluated if the identifier in the input area matches the identifier of the output area.	
3	*iConsistency*	The subsequent user data may only be evaluated when bit 0 of the consistency is set. Bit 1 toggles from 0 to 1 in the slave's data processing cycle.	
4	*iDataword 1*	Value read out for the 1st zone within the group	**BENEFIT DATA**
5			
6	*iDataword 2*	Value read out for the 2nd zone within the group	
7			
8	*iDataword 3*	Value read out for the 3rd zone within the group	
9			
10	*iDataword 4*	Value read out for the 4th zone within the group	
11			
12	*iDataword 5*	Value read out for the 5th zone within the group	
13			
14	*iDataword 6*	Value read out for the 6th zone within the group	
15			
16	*iDataword 7*	Value read out for the 7th zone within the group	
17			
18	*iDataword 8*	Value read out for the 8th zone within the group	
19			

5.8 Zone status

The read status of a zone must be viewed bit by bit.
Here, 16 bits are transmitted per zone, which have the following meaning:

BIT	Meaning			
0	1=Zone ok 0=zone faulty			
1	0=O.K. 1=LO alarm			
2	0=O.K. 1=HI alarm			
3	0=O.K. 1=Sensor break / overflow			
4	0=O.K. 1=Sensor closure			
5 6	0 Zone off 0	1 actuator operation 0	0 Regular operation 1	1 Lowering 1
7	0=O.K. 1=Error during optimization			
8	1=Self-optimization requested			
9	0=O.K. 1= negative deviation alarm			
10	0=O.K. 1= positive deviation alarm			
11	0=O.K. 1=Alarm due to setpoint change			
12	0=O.K. 1=Heating current error			
13	0=O.K. 1=Max. Setpoint (HI value) exceeded (see chapter 3.1.1)			
14 15	always 0 always 0			

Writing to bit 8 of the status (the only permissible write command) switches the self-optimization of the zone on or off. The procedural boundary conditions of the optimization process are described in more detail in the device manual

5.9 Global values

As soon as a "0" is entered by the master in byte 1 ("Group"), so-called global values are exchanged instead of zone-specific values. Some can be operated as READONLY, others as READ / WRITE parameters (see column R / RW). Byte 2 ("identifier") is used to determine which of the global values are to be transferred.

Byte 1 "Group"	Byte 2 "Identifier"	Byte 4..19 "Values"		R / RW
0	0	oDataword 1	Firmware ID number (AZ number)	R
0	0	oDataword 2	Firmware version	R
0	0	oDataword 3	Firmware date (TAG)	R
0	0	oDataword 4	Firmware date (MONTH)	R
0	0	oDataword 5	Firmware date (YEAR)	R
0	0	oDataword 6	Serial number	R
0	0	oDataword 7	reserve	R
0	0	oDataword 8	Number of zones in the controller	R
0	1	oDataword 1	*Reserve*	R
0	1	oDataword 2	Profile version	R
0	1	oDataword 3	*Reserve*	R
0	1	oDataword 4	*Reserve*	R
0	1	oDataword 5	*Reserve*	R
0	1	oDataword 6	*Reserve*	R
0	1	oDataword 7	*Reserve*	R
0	1	oDataword 8	*Reserve*	R
0	2	oDataword 1	Control outputs (0=disable, 1=enable)	RW
0	2	oDataword 2	Alarm delay in seconds (0=no delay)	RW
0	2	oDataword 3	Reserve	RW
0	2	oDataword 4	Max. Temperature setting value (HI value)	RW
0	2	oDataword 5	Lowering mode (0=normal, 1=lowering)	RW
0	2	oDataword 6	Reserve	RW
0	2	oDataword 7	Reserve	RW
0	2	oDataword 8	*Reserve*	RW
0	3	oDataword 1	*Reserve*	R
0	3	oDataword 2	*Reserve*	R
0	3	oDataword 3	*Reserve*	R
0	3	oDataword 4	*Reserve*	R
0	3	oDataword 5	*Reserve*	R
0	3	oDataword 6	*Reserve*	R
0	3	oDataword 7	*Reserve*	R
0	3	oDataword 8	*Reserve*	R
0	4	oDataword 1	0=no reaction 1=Load default parameters*) (factory settings) 2=Execute device reset*) (warm start controller)	W
0	4	oDataword 2	*Reserve*	W
0	4	oDataword 3	*Reserve*	W
0	4	oDataword 4	*Reserve*	W
0	4	oDataword 5	*Reserve*	W
0	4	oDataword 6	*Reserve*	W
0	4	oDataword 7	*Reserve*	W
0	4	oDataword 8	*Reserve*	W

*) Special routines can be executed in the device via group 0, identifier 4. When these routines are called, the system causes a transmission pause in the device, which may last several seconds.

Examples

The bus master would like to read the actual values of zones 9..16:

1. ***oConsistency*** set to 0
2. ***oAction*** to 1 (it should be read)
3. ***oGroup*** to 2 (request zones 9..16)
4. ***oSignification*** to 254 (request the actual values)
5. Set ***oConsistency*** to 255 (all 8 bits = 1)
6. Wait until i***Group*** = ***oGroup*** = 2
7. Wait until i***Signification*** = ***oSignification*** = 254
8. Wait until bit0 of ***iConsistency*** is set
9. Now the desired actual values of zones 9..16 can
   be read from ***iDataword1*** ... *i**Dataword8***

The bus master would like to set the setpoint for zone 2 to 30.0°C. All other setpoints should not be changed.

1. ***oConsistency*** set to 0
2. ***oAction*** set to 2 (it should be written)
3. ***oGroup*** set to 1 (zone 2 is within group 1)
4. ***oSignification*** set to 0 (parameter 0=setpoint)
5. ***oDataword2*** set to 300 (byte 6= 44, byte 7 = 1. Note LO byte first !)
6. ***oConsistency*** set to binary *00000010* = 2. This means that only data word 2 is valid
7. Wait until ***iGroup*** = ***oGroup*** = 1
8. Wait until ***iSignification*** = ***oSignification*** = 0
9. Wait until bit0 of ***iConsistency*** is set.
10. Is ***iAction*** = 3 ? Then the value was accepted.
    If ***iAction* = 4**, the range would have been exceeded
11. With ***iDataword2***, the new setpoint can already be read out again as a check.

6 Troubleshooting FAQ

The following chapter lists faults and their possible causes.
This information is intended to enable faults to be isolated as quickly as possible, particularly when the controller is commissioned for the first time.

6.1 The controller does not heat

Possible causes:

- **Is the global release of the outputs set to "1" via parameter "ENA"?**
  See chapter 3.1.2: Enable all control outputs
  See chapter 5.9 Group 0, identifier 2, data word 1: Control outputs
- **Are status bits 5 and/or 6 set?**
  See chapter 5.8 and 4.3.5: If both bits are set to "0", then the operating mode = OFF and the controller will not heat the zone.
- **Is the operating mode of the zone set to "Control" (parameter value = 2)?**

  See chapter 3.2.10: Operating mode of the zone
  If the value is set to 0 (=OFF), the zone is switched off and does not heat.
- **Is the read actual value higher than the setpoint?**
  If the actual value is significantly higher than the set setpoint, the heating is switched off by the controller. The output level is then 0%, which is normal in this case.
- **Is the FP160 parameterized as a limiter?**
  If the HI alarm is set to 0, the controller switches the output off permanently when the setpoint is exceeded.
  See chapter 3.2.2
- **If the output level read for the zone is > 0%**
  see chapter 5.7.1

  If the output level is read out at > 0% and the controller still does not heat, this could have various causes.
- **Has the 24V auxiliary voltage been connected to the bottom of the device (X8)?**
  The 24V for the outputs must be supplied separately again, independently of the controller supply.
  see chapter 2.7.5
- **Does the controller provide 24V at the output to control the heating?**
  To do this, disconnect the connected solid state relay and measure with a voltage tester.
  In very rare and isolated cases, certain solid state types can overload the output integrated in the controller due to pulse currents. SSRs from Siemens from the "Sirius" series are particularly well known for this. In the event of an overload, the driver switches off permanently until the controller is switched off. A series resistor of approx. 100 Ohm in the control of the SSR eliminates this effect.
- **Have programming errors occurred in the past?**

  If errors were made when the customer programmed the interface (e.g. by swapping the LO/HI bytes), the FP160 may still be set incorrectly in unexpected places. In this case, it may be helpful to load the factory settings after correcting the program error.
  See chapter 5.9: Group 0, identifier 4, write data word 1 to "1"

6.2 General assistance with commissioning

PARACON parameterization software

Free "PARACON" parameterization software is available for parameterizing the controller via RS485. This can be obtained from the Feller Engineering homepage (www.fellereng.de). See also chapter 2.7.4

7 Document history

Date		Changed
10.4.2023	OT	Document history added. Docu version 1.1 EtherCat mentioned as a new option.
9.11.2023	OT	Chapter 5: Description of the zone parameters and scope of the global parameters adapted to FP160. Fixed spelling mistake in example.
10.11.2023	OT	Chapter 5.9: Table of global parameters numbered with data words
15.11.2023	OT	Chapter 5.8: Bit 13 described in the status
31.1.2024	OT	Chapter 5.9: Correction in the specification of the identifier
23.5.2024	OT	Chapter 3.1: Typo: ~~FP1600~~
17.6.2024	OT	New: Chapter 6: Troubleshooting
12.7.2024	MH	Reference to Paracon, Div. Typo, PT100-4L extension is no longer available.
30.7.2024	OT	Chapter 2.7.4 extended by connection of an SI13u
30.7.2024	OT	Chapter 6.2 General assistance, Paracon