

MODBUS Application Manual

based on EC-Control V3.30
Version V3.01

ebmpapst

the engineer's choice



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Contents of the application manual

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Revision history

Date	Version	Change
3/31/2011	1.0	First version of the application manual, German
6/28/2011	1.01	Minor corrections
9/9/2011	1.02	Detailed improvement
9/27/2012	2.00	Revision for MODBUS 5 and EC-Control 2.10
12/13/2012	2.01	Minor error corrections (references and formatting)
8/1/2013	2.02	Formula (3) corrected on page 11
4/25/2014	2.30	Title page converted to new layout
9/28/2020	3.00	Chapter 1 Introduction added, chapter 3 content revised, chapters 1, 2, 3 layout revised, Appendix A added
7/22/2021	3.01	Fixed protocol version availability of parameter Energy consumption (kWh-meter) in appendix A – List of data points:

1 Introduction

The EC-Control application manual is used to provide numerous application-related examples and detailed descriptions, as a support for configuration and parameterization, and as supplementary documentation for the EC-Control manual (Art. no. 25717-2-0199).

All the parameters listed in section 3.7 Overview of parameters can also be configured with the FanSetApp (Android) for devices with RFID technology from MODBUS 6.0 onwards.

1.1 Using this manual

- Before you start to configure a connected MODBUS device, read chapters 1, 2 and 3 completely.
- Chapter 4 describes basic functions and should be fully read before the first use in order to be able to perform the necessary program configurations and to understand relationships
- Chapter 5 deals with the number of configuration options based on various application examples and can be used as required.

1.2 Text conventions

Italics are used in this manual for user entries or predefined values in selection lists.

[Text in square brackets] indicates menus, commands, registers, buttons and all other texts within the software.

2 Safety information

Read the EC-Control manual (Art. No.: 25717-2-0199) and this application manual carefully before starting work on EC-Control. Malfunctions may occur if warnings and this documentation are not observed. Please also pay attention to the operating instructions of the MODBUS devices, where you may find further relevant safety instructions and information.



Handling is to be carried out in accordance with national and country-specific health and safety regulations.



Prevent inadvertent switching on of a MODBUS device! This could result in serious or even fatal injury! Always operate fans with guard grills and take appropriate safety precautions!



This software has not been designed for use in safety-critical systems or to perform safety-relevant functions. This software has no real-time capability!

3 Basic principles and explanations of EC-Control

EC-Control enables visualization and parameterization of ebmBUS and MODBUS networks.

In particular, EC-Control permits the following activities:

- Setting parameters such as mode of operation, set value and control parameters
- Changing the address
- Readout of parameters such as actual speed, serial number and date of manufacture
- Readout of error status and error memory
- Monitoring of systems, including the facility to report errors by e-mail
- Management of several systems within one program installation, useful for service technicians
- Support of RS232/RS485, USB/RS485, Bluetooth/RS485 and Ethernet/RS485 interface converters
- Simultaneous monitoring of ebmBUS- and MODBUS-based plant component (requires a minimum of interface converters)

This application manual is a supplementary document for the EC-Control manual (Art. No.: 25717-2-0199). It is intended to help make full use of the scope of EC-Control V3.30 through examples of applications.

Attention: The application manual contains screenshots from EC-Control V3.30. Images of the EC-Control software may therefore differ from your version. MODBUS devices with the MODBUS protocol, version V5.00 or later, were used. Devices with older firmware do not offer all functions.

The parameter setting mask is divided into the following categories:

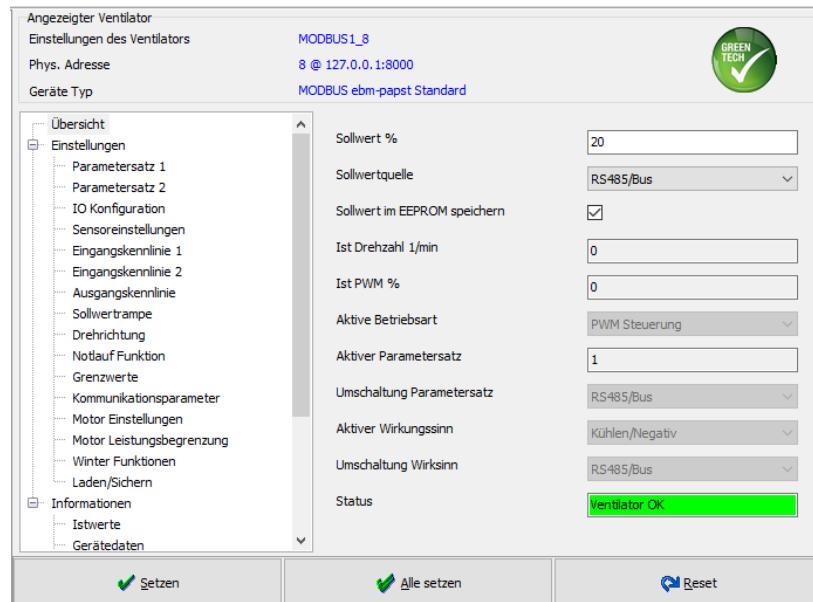


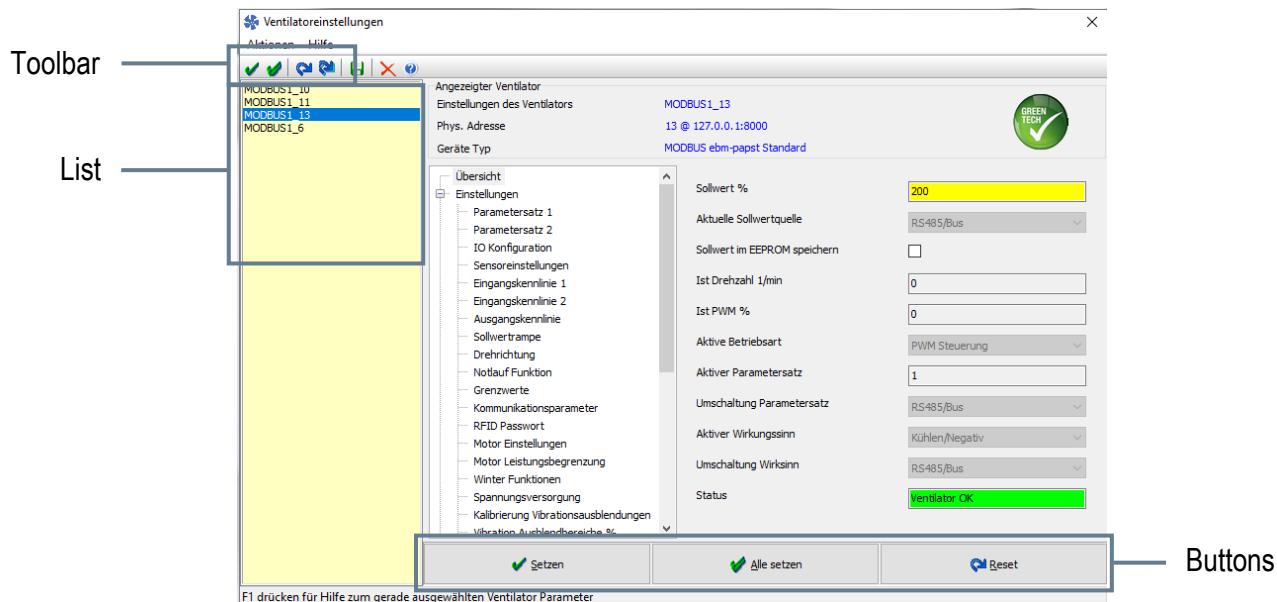
Fig. 1: EC-Control overview

Categories

- Overview
- Settings
- Information

This manual describes the Overview and Settings menus.

3.1 Set parameters and reset errors



Toolbar/button	Description
Setzen	Changed parameters are transferred to an individual MODBUS device (which is selected in the left-hand list).
Alle setzen	Changed parameters are transferred to all MODBUS devices in the left-hand list. Other MODBUS devices can be added to the list using drag & drop from the structure tree.
Reset	Certain errors (such as motor overheated) must be reset after remedying the problem with this button for an individual MODBUS device (which is selected in the left-hand list). Alternatively, the power supply can be interrupted and then restored or the Enable/Disable signal removed and reset.
	Errors (such as motor overheating) must be reset after remedying the problem with this icon for all MODBUS devices listed in the left-hand list . Alternatively, the power supply can be interrupted and then restored or the Enable/Disable signal removed and reset.

3.2 Operating modes

EC-Control works with three possible operating modes. The mode in EC-Control V3.30 can be selected under [Settings] > [Parameter set 1 or 2] > [Operating mode (P1) or (P2)].

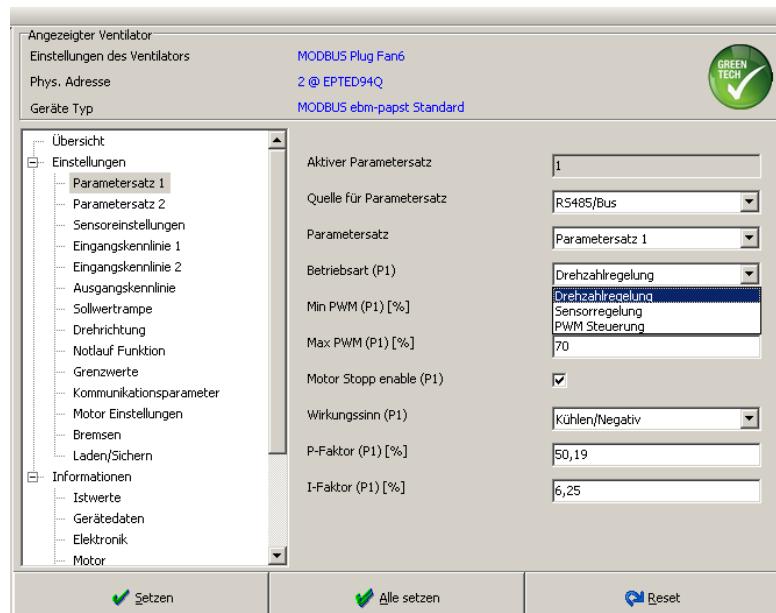


Fig. 2: Operating modes

Operating modes

- The selection of the mode is crucial for many other functions
- Operating modes can be assigned independently of each other to the two parameter sets P1 and P2

■ Speed control (closed-loop speed control)

Set values and actual values are specified directly as speed in revolutions per minute (rpm).

The current speed is determined by the electronics and adjusted according to the set value by the controller. The MODBUS device attempts to compensate for any faults or load changes that occur and so keep its speed constant.

■ Sensor control (closed-loop sensor control)

The sensor records the actual value, e.g. as a temperature, pressure or air flow. The set value is specified in the same unit. If there is a control difference between the set value and actual value, the MODBUS device attempts to minimize this, despite any disturbance variable influences.

■ PWM control (open-loop control)

Pure control. This mode has no feedback, which would be necessary to compensate for disturbance variables that occur for example. P and I factor are omitted here.

3.3 PWM control/Open-loop control

The control system is an open-loop control system in which the set value influences the output variable, but not vice versa (see Fig. 3). The aim of this is to switch the output variable x (actual value) to the desired reference variable w (set value) by choosing the correct manipulated variable y . There is no comparison between the set value and actual value and correction of the manipulated variable derived from it. Any interference is not compensated.

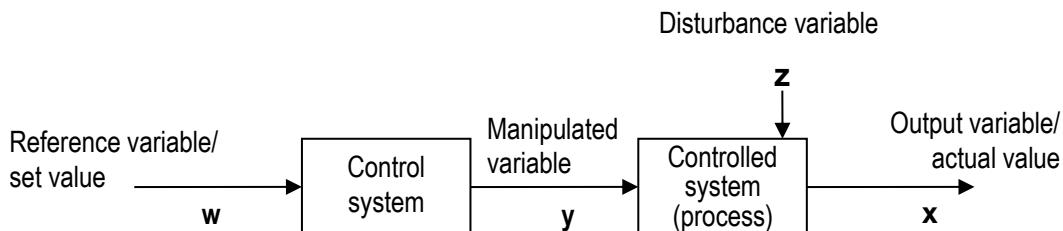


Fig. 3: Block diagram of an open-loop control system

Open control loop with 0-10 V / PWM controlled MODBUS device (Fig. 4):

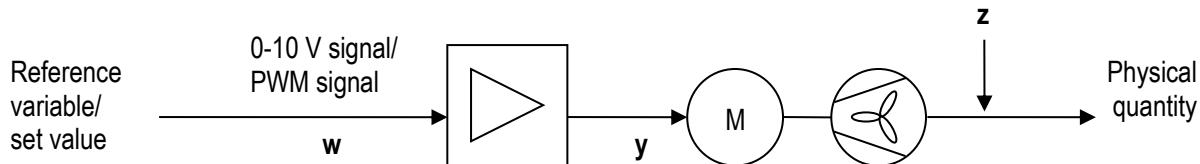


Fig. 4: ebm-papst open-loop control (fan)

3.4 Speed control/sensor control/closed-loop control

In a closed-loop control system, the actual value x is recorded and compared with the set value w as the feedback variable r via a measuring device (see Fig. 5). In the comparison element, these values are used to calculate the control difference e . It is also referred to as the control deviation. This is the difference between the set value and the feedback variable, which is constantly recalculated, as the control loop is permanently influenced by any disturbance variables z . In contrast to the open-loop control described above, this feedback enables the closed-loop control to compensate for disturbance variables that occur, so enabling the control variable x to approach the set value progression.

The following definitions apply to Fig. 5 and Fig. 6:

w	Reference variable (set value)
e	Control difference
u	Controller output variable
y	Manipulated variable
z	Disturbance variable
x	Control variable (actual value)

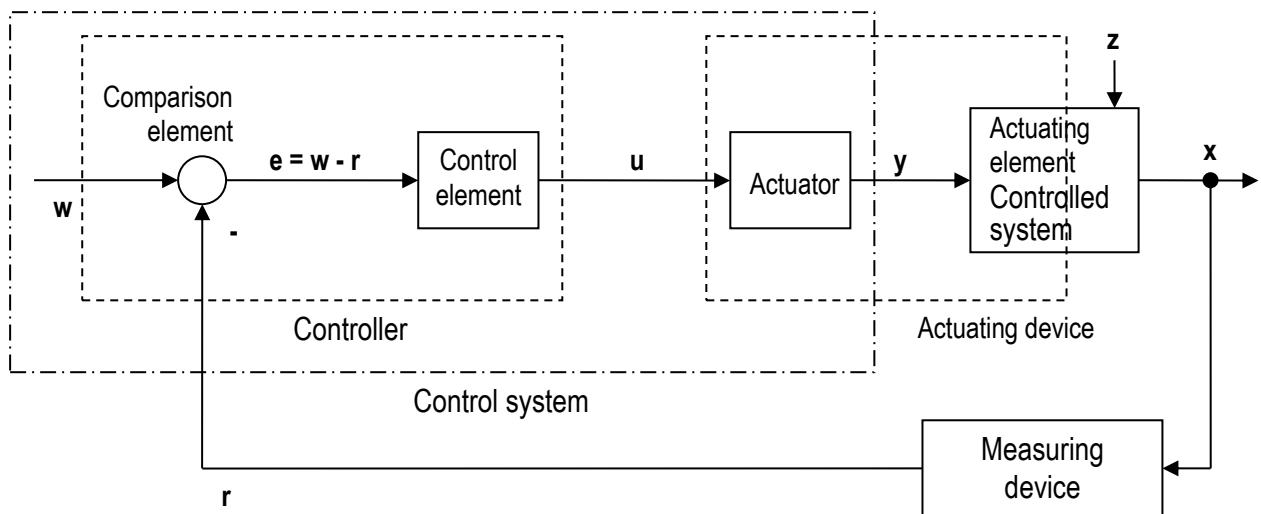


Fig. 5: Block diagram of a closed-loop control system

In general, no distinction is made between the controller output variable u and the manipulated variable y ; instead, both are referred to collectively as the manipulated variable y . The influence of the measuring device is often ignored, which means that the feedback variable r is frequently referred to as the control variable (actual value) x .

The following simplified control loop results:

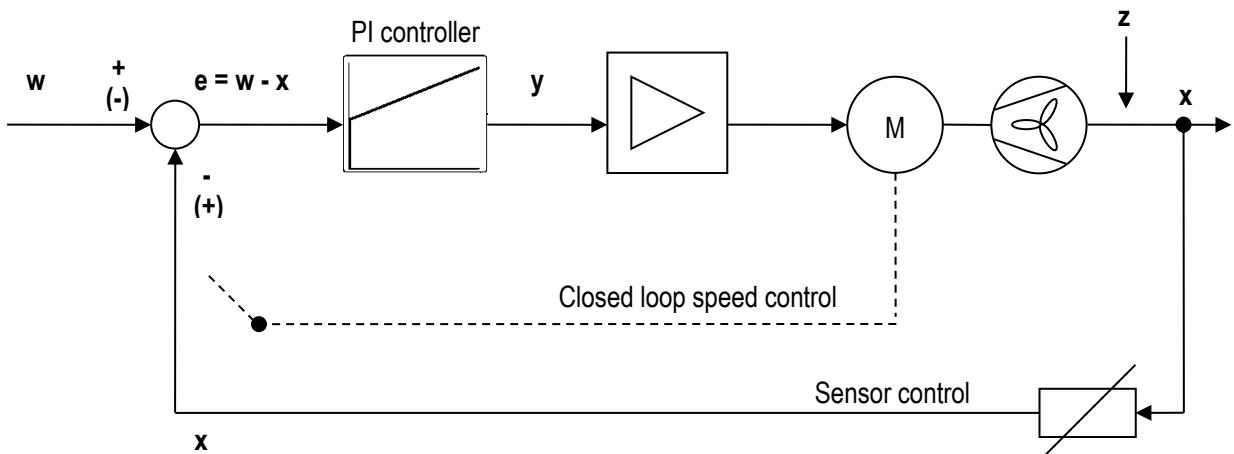


Fig. 6: ebm-papst closed control loop

Typical measuring devices for fans are pressure, air flow and temperature sensors.

The set value w can be set by analog means or preset digitally using the EC-Control software. A PI controller has the task of balancing the control difference and so attaining set value = actual value.

3.5 Direction of action of a control loop (only for “Sensor control” operating mode)

Sensor control (closed-loop sensor control) mode enables the user to reverse the direction of action. This function is not relevant for the other two modes. As shown in Fig. 7, on changing the direction of action the control difference of the set value and the actual value is reversed (cooling/Negative) and so the resulting control difference is changed. No distinction is made below between feedback variable r and set value x .

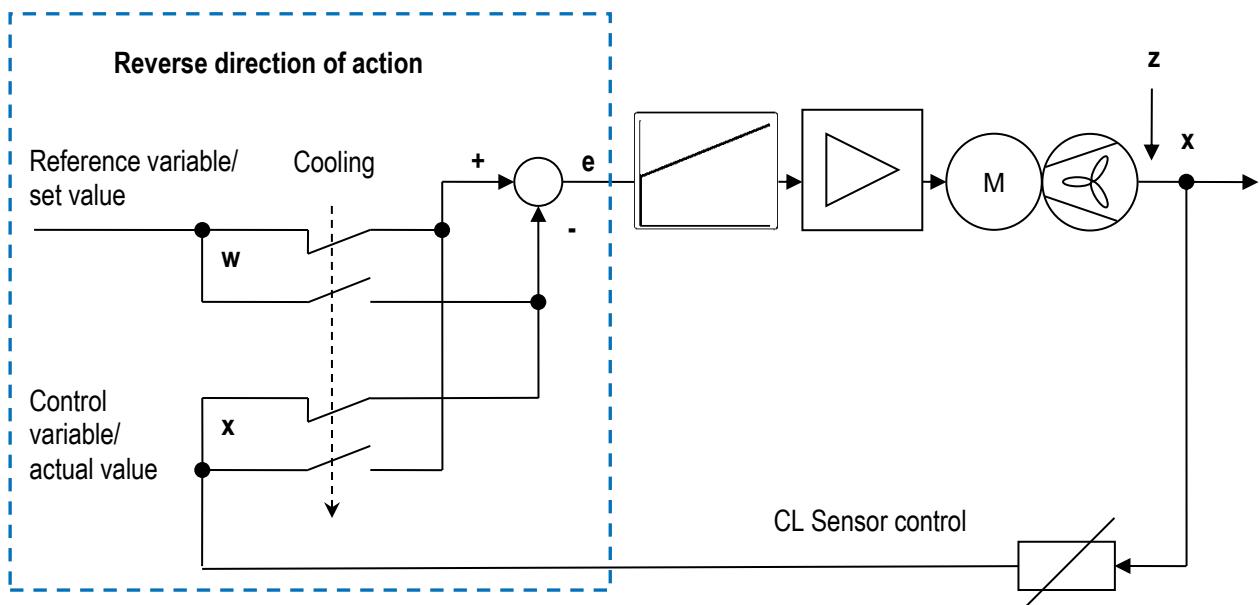
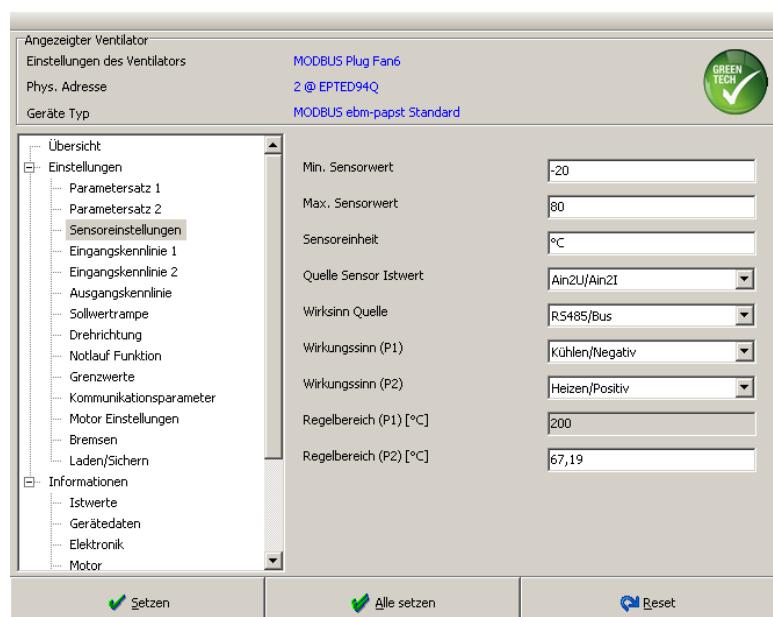


Fig. 7: Reversing the direction of action

In EC-Control, the terms Heating and Cooling are used for the direction of action. The following applies:

In case of positive direction of action ("Heating"):
In case of negative direction of action ("Cooling"):

Control difference = set value - actual value
Control difference = actual value - set value



Controller function Heating/Positive or Cooling/Negative

- Controller function determines sign for calculating control difference
- Controller function only relevant for sensor control mode
- Adjustable for both parameter sets
- Terms Heating and Cooling are also used for pressure and air flow control systems

Fig. 8: Controller function

However, the direction of action has no influence whatsoever on the direction of rotation of the motor, only on the calculation of the control difference.

Changing the direction of action can be understood by observing the x-axis in Fig. 9. Usually, *Cooling/Negative* means actual value > set value. Conversely *Heating/Positive* commonly means set value > actual value.

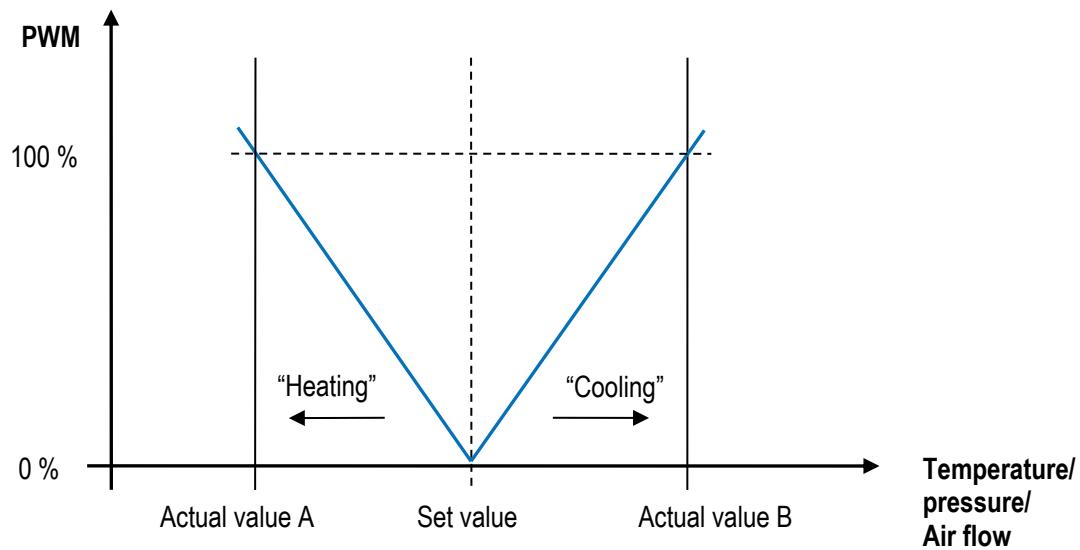


Fig. 9: Heating/Cooling

3.6 P and I factor

Ideally, the deviation between the set value and actual value in a closed-loop control system is zero (permanent control difference $e(t)=0$ for $t \rightarrow \infty$). If there is a difference in the closed-loop control shown above, the actual value is corrected. The precision and speed of response is dictated by the proportional component (P component) and the integral component (I component) of the controller.

3.6.1 P control

If the I component of a PI controller is zero, we refer to purely proportional control. A P controller functions like an amplifier for the control difference e . To understand how the P factor in EC-Control is calculated, see Fig. 10.

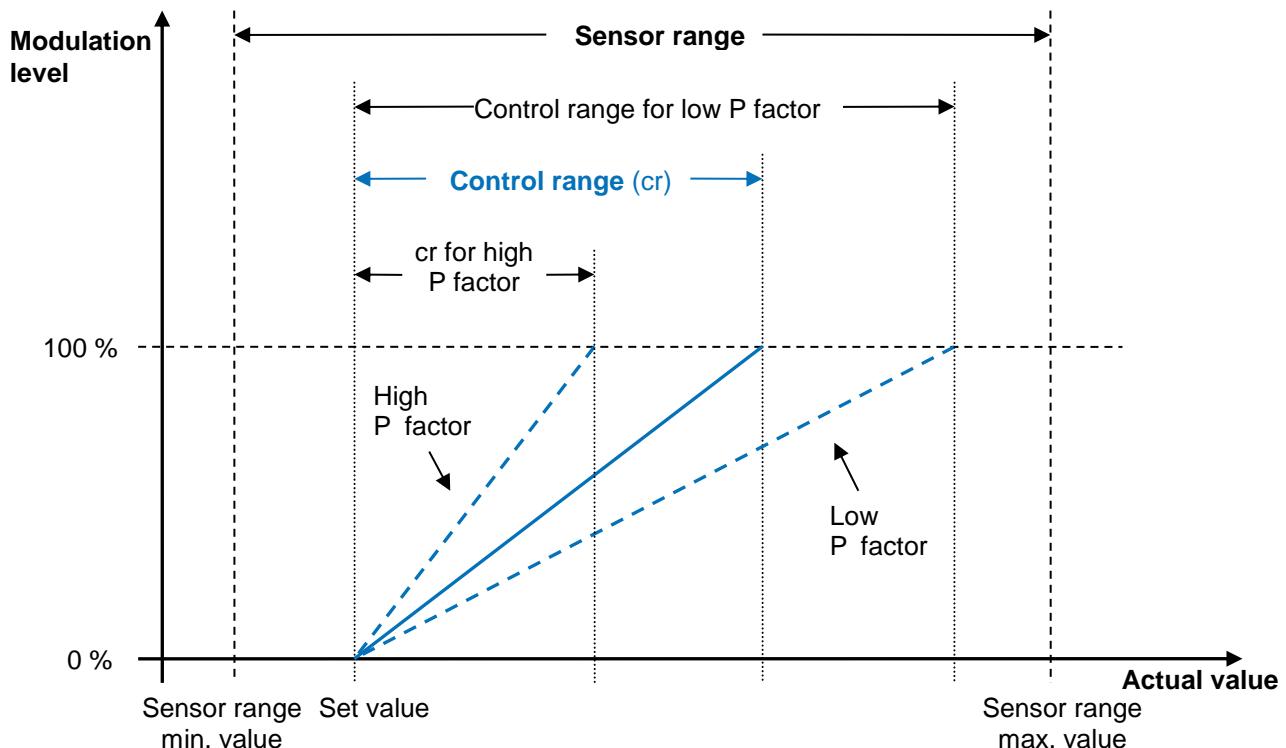


Fig. 10: P factor

The actual value is determined by a sensor. The sensor itself is limited by its minimum and maximum value, also termed the sensor range. The range is specified by the sensor itself, and must be entered in EC-Control.

The desired set value is defined by analog means (terminal Ain1 U or Ain1 I) or digitally using EC-Control. The difference between the actual value and the desired set value for which a full modulation of the motor results is termed the control range. The control range and P factor are interdependent. They are different representations of the same value. The P factor can be calculated from the sensor range and control range.

$$P \text{ Factor} = \frac{(sensor_{max} - sensor_{min})}{Control \text{ range}} \times 100\% = \frac{Sensor \text{ range}}{Control \text{ range}} \times 100\% \quad (1)$$

The P factor can be entered using EC-Control. The following applies:

- Too high a P factor can lead to sustained oscillation of the control loop.
- Too low a P factor results in permanent control deviation; the set value is never reached exactly.

The P factor can be used to calculate the P component (proportion of absolute deviation). The control difference e is the difference between the set value and the current actual value, which is continuously outputted by the sensor.

$$P \text{ Share} = P \text{ Factor} \times \frac{\text{Control difference } e(t)}{\text{Sensor range}} \quad (2)$$

Inserting equation (1) in (2) gives:

$$P \text{ Component} = \frac{\text{Sensor range}}{\text{Control range}} \times 100\% \times \frac{\text{Control difference } e(t)}{\text{Sensor range}} = \frac{\text{Control difference } e(t)}{\text{Control range}} \times 100 \quad (3)$$

If $\text{Control difference}(t) \geq \text{Control range}$ the motor runs at a maximum modulation level of 100%. If the control difference falls below the set control range, the modulation level drops.

3.6.2 PI control

Instead of the P controller with a purely proportional component, a PI controller with an additional integral component (percentage of the sum all deviations) is now considered.

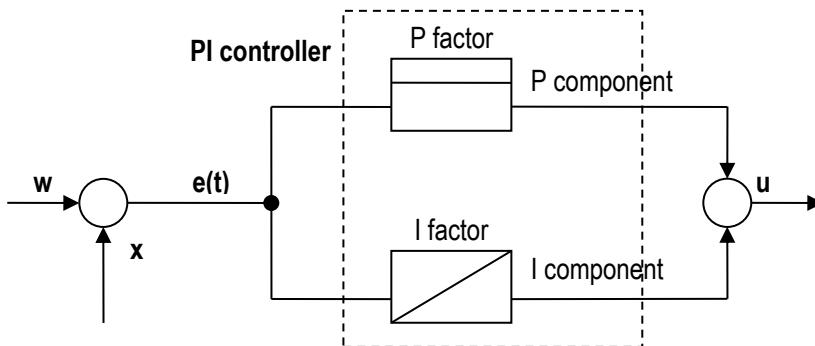


Fig. 11: PI controller

This is referred to as a proportionally integrated controller. The controller output variable u is made up of the sum of the P component and the I component, whereby the I component attempts to keep the control deviation at zero over time.

$$\text{Controller output} = P \text{ Component} + I \text{ Component} \quad (4)$$

The calculation of the P component is already known. The I component is calculated as follows.

$$\Delta I \text{ Component} = I \text{ Factor} \times \frac{\text{Control difference } e(t)}{\text{Sensor range}} \quad (5)$$

The I factor is the value that is entered in EC-Control by the user. If we now add up the difference of the I component per sampling point over a certain time, we obtain the following equation to calculate the controller output.

$$\text{Controller output}(t) = P \text{ component}(t) + \sum_{i=0}^t \Delta I \text{ component}(i) \quad (6)$$

The above equations (2) and (5) for the P and I component thus give:

$$\text{Controller output}(t) = P - \text{factor} \times \frac{e(t)}{\text{Sensor range}} + \sum_{i=0}^t I \text{ factor} \times \frac{e(t)}{\text{Sensor range}} \quad (7)$$

In order to obtain the standard control engineering representation, a reformulation is necessary.

$$\boxed{\text{Controller output}(t) = \frac{P \text{ factor}}{\text{Sensor range}} \times e(t) + \frac{I \text{ factor}}{\text{Sensor range}} \sum_{i=0}^t e(t)} \quad (8)$$

Equation (8) can be converted into the common equation of a PI controller by the following reformulations:

$$\text{Controller output}(t) = \frac{P \text{ factor}}{\text{Sensor range}} \left(e(t) + \frac{I \text{ factor}}{P \text{ factor}} \sum_{i=0}^t e(t) \right) \quad (9)$$

With proportional coefficient:

$$\boxed{cs_p = \frac{P \text{ factor}}{\text{Sensor range}}} \quad (10)$$

and the ratio of the sampling time T_a to the integral time T_n :

$$\boxed{\frac{T_a}{T_n} = \frac{I \text{ factor}}{P \text{ factor}}} \quad (11)$$

from equations (10) and (11) the commonly used equation (12) of a PI controller results:

$$\boxed{\text{Controller output}(t) = cs_p \left(e(t) + \frac{T_a}{T_n} \sum_{i=0}^t e(t) \right)} \quad (12)$$

At ebm-papst, the sampling time T_a is 50 ms, which for the I factor results in equation (13):

$$\boxed{I \text{ Factor} = \frac{50\text{ms}}{T_n} \times P \text{ factor}} \quad (13)$$

Generally familiar representation format:

$$\boxed{\text{Controller output}(t) = cs_p \left(e(t) + \frac{1}{T_n} \int_0^t e(t) dt \right)} \quad (14)$$

3.7 Overview of parameters

All the parameters listed below can also be configured in the de-energized state in the same configuration in devices with RFID technology as from MODBUS 6.0 using the FanSetApp (Android).

i The MODBUS version **ACE** designates size 55 and 74 motors with a power output of up to 170 W.

3.7.1 Device status category

Device status	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	•	•	•	•	•			
Set value %	•	•	•	•	•	D001	H	0 % to 100 %
Current set value source	-	-	-	•	•	D028	I	0 = Analog input Ain1 1 = RS485/bus 2 = Analog input Ain2) ² 3 = PWM input PWMin3) ²
Set value source	•	•	-	-	•	D101	H	0 = Analog input Ain1 1 = RS485/bus
Save set value to EEPROM	•	•	•	•	•	D103	H	0 = Set value is not saved 1 = Set value is saved
Current speed rpm	•	•	•	•	•	D010	I	0 to nMax
Current PWM %	•	-	•	•	•	D019	I	0 % to 100 %
Active operating mode	•	•	•	•	•	-	-	-
Current parameter set	•	•	-	•	-	D01D	I	0 = Parameter set 1 1 = Parameter set 2
Source of parameter set switch	•	-	-	•	-	D104	H	0 = Digital input Din2 1 = RS485/bus 2 = Digital input Din3 3 = Digital input Din1) ¹
Current controller function	•	-	-	•	•	D01E	I	0 = Heating/Positive 1 = Cooling/Negative
Source for controller function	•	-	-	•	-	D12E	H	0 = Digital input Din3 1 = RS485/bus 2 = Digital input Din2 3 = Digital input Din1) ¹
Status	•	•	•	•	•	D011/D012	I	-

)¹ = Not available in MODBUS version V5.0x

)² Not available in MODBUS version ACE

i When the value of [Set value] is continually changing, the parameter [Save set value to EEPROM] must be set to **0 = set value is not saved**. This applies to all MODBUS devices, except MODBUS version 6.x and ACE.

3.7.2 Settings category

Parameter set 1	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●	●	●	●			
Current parameter set	●	●	-	●	●	D01D	I	0 = Parameter set 1 1 = Parameter set 2
Source of parameter set switch	●	-	-	●	-	D104	H	0 = Digital input Din2 1 = RS485/bus 2 = Digital input Din3 3 = Digital input Din1) ¹
Internal parameter set	●	●	-	●	-	D105	H	0 = Parameter set 1 1 = Parameter set 2
Control mode (P1)	●	●	●	●	●	D106	H	0 = Closed loop speed control 1 = Closed loop sensor control) ² 2 = PWM control
Min PWM P1 %	●	●	●	●	●	D110	H	0 % to 100 %
Max PWM P1 %	●	●	●	●	●	D10E	H	0 % to 100 %
Motor stop enable (P1)	●	●	●	●	●	D112	H	0 = Activated (motor runs at set value = 0) 1 = deactivated (motor stops at set value = 0)
Controller function (P1)	●	-	-	●	●	D108	H	0 = Heating/Positive 1 = Cooling/Negative
P factor (P1) %	●	●	●	●	●	D10A	H	0 % to 25600 %
I factor (P1) %	●	●	●	●	●	D10C	H	0 % to 100 %

¹= Not available in MODBUS version V5.0x²= Not available in MODBUS version V5.00 Lite & DCI Gen. 1

Parameter set 2	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●	-	●	●			
Current parameter set	●	●	-	●	●	D01D	I	0 = Parameter set 1 1 = Parameter set 2
Source of parameter set	●	-	-	●	-	D104	H	0 = Digital input Din2 1 = RS485/bus 2 = Digital input Din3 3 = Digital input Din1) ¹
Internal parameter set	●	●	-	●	-	D01D	H	0 = Parameter set 1 1 = Parameter set 2
Operating mode (P2)	●	●	-	●	●	D107	H	0 = Closed loop speed control 1 = Closed loop sensor control) ² 2 = PWM control
Min PWM P2 %	●	●	-	●	●	D111	H	0 % to 100 %
Max PWM P2 %	●	●	-	●	●	D10F	H	0 % to 100 %
Motor stop enable (P2)	●	●	-	●	●	D113	H	0 = Activated (motor runs at set value = 0) 1 = deactivated (motor stops at set value = 0)
Direction of action (P2)	●	-	-	●	●	D109	H	0 = Heating/Positive 1 = Cooling/Negative
P factor (P2) %	●	●	-	●	●	D10B	H	0 % to 25600 %
I-Factor (P2) %	●	●	-	●	●	D10D	H	0 % to 100 %

¹= Not available in MODBUS version V5.0x²= Not available in MODBUS version V5.00 Lite

IO configuration	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●	-	●	●			
Mode IO 1	-	-	-	●	-	D158	H	0 = Digital input Din1 (high) 2 = Analog input Ain1 0-10V 5 = Tacho output TachOut 6 = Diagnostic output DiagOut
Mode IO 2	-	-	-	●	-	D159	H	0 = Digital input Din2 (high) 2 = Analog input Ain2 0-10V 3 = Analog input Ain2 4-20mA
Mode IO 3	-	-	-	●	-	D15A	H	0 = Digital input Din3 (high) 1 = Digital input Din3 (low) 4 = Analog output 0-10V 5 = Tacho output TachOut 6 = Diagnostic output DiagOut 7 = PWM input PWMin3
Set value source switch	-	-	-	●	-	D16C	H	0 = RS485/bus 1 = Digital input Din1 2 = Digital input Din2 3 = Digital input Din3
Set value source	●	●	-	●	●	D101	H	0 = Analog input Ain 1 = RS485/bus 2 = Analog input Ain2) ¹ 3 = PWM input PWMin3) ¹
Source of parameter set switch	●	-	-	●	-	D104	H	0 = Digital input Din2 1 = RS485/bus 2 = Digital input Din3 3 = Digital input Din1) ¹
Source sensor value	●	-	-	●	●	D147	H	0 = Analog input Ain1 1 = Analog input Ain2) ² 2 = Maximum (Ain1: Ain2)) ² 3 = Minimum (Ain1: Ain2)) ² 4 = Average (Ain1: Ain2)) ² 5 = Air flow sensor) ³ 6 = Mass flow sensor) ³
Source for controller function	●	-	-	●	-	D12E	H	0 = Digital input Din3 1 = RS485/bus 2 = Digital input Din2 3 = Digital input Din1) ¹
Source of rotating direction	●	-	-	●	-	D148	H	0 = Digital input Din3 1 = RS485/bus 2 = Digital input Din2 3 = Digital input Din1) ¹
Source disable input	-	-	-	●	●	D16A	H	0 = Inactive 1 = RS485/bus 2 = Digital input Din1) ¹ 3 = Digital input Din2) ¹ 4 = Digital input Din3) ¹ 5 = Digital input Din1 (enable)) ¹ 6 = Digital input Din2 (enable)) ¹
Disable fan	-	-	-	●	●	D00F	H	0 = Fan disabled 1 = Fan enabled

¹ = Only available in MODBUS version V6.x³ = Only available in MODBUS version ACE² = Not available in MODBUS version ACE

Sensor settings	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●) ¹	●	●	●			
Min. sensor value	●	●	●	●	●	D160/161	H	- 1.000.000 to + 1.000.000) ⁵
Max. sensor value	●	●	●	●	●	D162/163	H	- 1.000.000 to + 1.000.000) ⁵
Sensor unit	●	●	●	●	●	D164 to D169	H	
Source sensor value	●	-	-	●	●	D147	H	0 = Analog input Ain1 1 = Analog input Ain2) ³ 2 = Maximum (Ain1: Ain2) ³ 3 = Minimum (Ain1: Ain2) ³ 4 = Average (Ain1: Ain2) ³ 5 = Volume flow sensor) ⁴ 6 = Mass flow sensor) ⁴
Source for controller function	●	-	-	●	-	D12E	H	0 = Digital input Din3 1 = RS485/bus 2 = Digital input Din2 3 = Digital input Din1) ²
Controller function(P1)	●	-	-	●	●	D108	H	0 = Heating/Positive 1 = Cooling/Negative
Controller function (P2)	●	-	-	●	-	D109	H	0 = Heating/Positive 1 = Cooling/Negative
P-Band (P1)	●	-	-	●	●	-	-	- Influences P factor
P-Band (P2)	●	-	-	●	-	-	-	- Only active if I factor = 0

¹ = Only available in MODBUS version V5.01 Lite³ = Only available in MODBUS version V5.0x and V6.x² = Only available in MODBUS version V6.x⁴ = Only available in MODBUS version ACE⁵ = Unit depends on set sensor unit

Volume/mass flow	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	-	-	-	-	●			
Source sensor value	-	-	-	-	●	D147	H	0 = Analog input Ain1 1 = Volume flow sensor 2 = Mass flow sensor
Reference value for volume flow m ³ /h	-	-	-	-	●	D1ED	H	
Reference value for mass flow kg/h	-	-	-	-	●	D1EE	H	
Altitude above sea level for mass flow m	-	-	-	-	●	D602	H	0 to 15000 m

Input curve 1	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●	●	●	●			
Input curve X1 (P1) V	●	●	●	●	●	D12A	H	0 V to 10 V
Input curve Y1 (P1)	●	●	●	●	●	D12B	H) ¹
Input curve X2 (P1) V	●	●	●	●	●	D12C	H	0 V to 10 V
Input curve Y2 (P1)	●	●	●	●	●	D12D	H) ¹

¹ = Unit depends on the selected operating mode

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
Input curve 2	●	●	-	●	-			
Input curve X1 (P2) V	●	●	-	●	-	D13C	H	0 V to 10 V
Input curve Y1 (P2)	●	●	-	●	-	D13D	H) ¹
Input curve X2 (P2) V	●	●	-	●	-	D13E	H	0 V to 10 V
Input curve Y2 (P2)	●	●	-	●	-	D13F	H) ¹

)¹ = Unit depends on the selected operating mode

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
Output curve	●	-	-	●	-			
Function of analog output	●	-	-	●	-	D130	H	0 = Duty cycle % 1 = Speed rpm 2 = Installation modulation level % 3 = Pulses per revolution) ¹ 4 = Pulses/auto-addressing) ² 5 = Remote control) ²
Output curve X1	●	-	-	●	-	D140	H) ³
Output curve Y1 V	●	-	-	●	-	D141	H	0 V to 10 V
Output curve X2	●	-	-	●	-	D142	H) ³
Output curve Y2 V	●	-	-	●	-	D143	H	0 V to 10 V

)¹ = Only available in MODBUS version V5.x with specific hardware module))³ = Unit depends on the selected mode of the output curve

)² = Only available in MODBUS version V6.x

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
Set value ramp	●	●	●	●	●			
Ramp-up time s	●	●	●	●	●	D11F	H	0 s to 637.5 s
Ramp-down time s	●	●	●	●	●	D120	H	0 s to 637.5 s

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
Direction of rotation	●	●	●	●	●			
Source of rotating direction	●	-	-	●	-	D148	H	0 = Digital input Din2 1 = RS485/bus 2 = Digital input Din3 3 = Digital input Din1) ¹
Direction of rotation	●	●	●	●	●	D102	H	0 = Counter clockwise 1 = Clockwise
Direction of rotation (factory setting)	●	●	-	●	●	D282	H	0 = Counter clockwise 1 = Clockwise

)¹ = Only available in MODBUS version V6.x

Fail-safe function	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	•	•	•	•	•			
Fail-safe mode	•	•	•	•	•	D15C	H	0 = Off 1 = On or RS485/bus) ² 2 = Analog input Ain1) ² 3 = Analog input Ain2) ¹ 4 = PWM input PWMIn3) ¹
Set value fail-safe speed	•	•	•	•	•	D15D	H) ³
Time lag fail safe speed s	•	•	-	•	•	D15E	H	0 s to 25.5 s or 0 s to 6553.5 s) ²
Cable break detection voltage V	•	•	-	•	•	D15F	H	0 V to 10 V
Rotating direction fail-safe mode	•	•	-	•	•	D15B	H	0 = Counter clockwise 1 = Clockwise 2 = Keep direction

¹ = Only available in MODBUS version V6.x² = Only available in MODBUS version V6.x and ACE³ = Unit depends on the active operating mode

Limits	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	•	•	•	•	•			
Maximum speed rpm	•	•	•	•	•	D119	H	Maximum speed in rpm Info: This value must always be less than or equal to the value Maximum permitted speed rpm (D11A).
Maximum permitted speed rpm	•	•	•	•	•	D11A	H	
Minimum permitted PWM	•	•	•	•	•	D118	H	
Maximum permitted PWM %	•	•	•	•	•	D117	H	
Max. speed rotation monitoring rpm	•	•	•	•	•	D145	H	0 – Maximum speed Info: If this is not reached, the relay signals an error and the status register indicates a warning.

Communication parameters	Available in MODBUS version					Register	Input/Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●	●	●	●			
Device address	●	●	●	●	●	-	-	1 to 247
Communication speed	●	●	●	●	●	D149	H	0 = 1200 bit/sec 1 = 2400 bit/sec 2 = 4800 bit/sec 3 = 9600 bit/sec 4 = 19200 bit/sec 5 = 38400 bit/sec 6 = 57600 bit/sec) ¹ 7 = 115200 bit/sec) ¹
Communication parity	●	●	●	●	●	D14A	H	0 = 8E1 1 = 8O1 2 = 8N2 3 = 8N1
Max. packet size in bytes	●	●	●	●	●	D001	I	
Autoaddressing	-	-		●	●	D00C	H	0 = Addressing function inactive 1 = Addressing function active
RFID interface	-	-		●	-	D16F	H	0 = RFID interface inactive 1 = RFID interface active
RFID app password hash part 1	-	-		●	-	-	-	
RFID app password hash part 2	-	-		●	-	-	-	

¹⁾ = Not available in MODBUS version DCI Gen.1

RFID password	Available in MODBUS version					Register	Input/Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	-	-	-	●	-			
Password	-	-	-	●	-	-	-	Info: Default password: 491625
Confirm password	-	-	-	●	-	-	-	

Motor derating	Available in MODBUS version					Register	Input/Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●	●	●	●			
Power limitation	●	●	-	●	-	D12F	H	
Maximum allowed rating W	●	●	●	●	●	D135	H	Value dependent on reference values for DC-link voltage (D1A0) and DC-link current (D1A1)
Maximum rating W	●	●	●	●	●	D155	H	
Max. power at derating end W	●	●	-	●	-	D136	H	Value dependent on reference values for DC-link voltage (D1A0) and DC-link current (D1A1)
Moduletemperature derating start	●	●	-	●	-	D137	H	
Moduletemperature derating end	●	●	-	●	-	D138	H	
Motor temperature derating start	●	●	-	●	-	D14D	H	
Motor temperature derating end	●	●	-	●	-	D14E	H	
Ramp for power derating W/s	-	-	-	●	-	D16D	H	

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●	-	●	-			
Winter functions	●	●	-	●	-			Info: This parameter is only relevant for certain EX-protected fans in very cold climate zones
Threshold heating function on °C	●	-	-	-	-			
Threshold heating function off °C	●	-	-	-	-			
Probe motor temperature	●	-	-	-	-	D016	I	
Shedding function	●	●	-	●	-	D150	H	
Max. start PWM shake off %	●	●	-	●	-	D151	H	
Max. number of start attempts	●	●	-	●	-	D152	H	

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	-	-	-	●	-			
Power supply	-	-	-	●	-			3.3 V to 24 V
Auxiliary DC supply voltage V	-	-	-	●	-	D16E	H	

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	-	-	-	-	●			
Fan position	-	-	-	-	●			0 to 15000 m
Altitude above sea level for mass flow m	-	-	-	-	●	D602	H	

<u>Vibration mask-out backup</u>	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	-	-	-	●) ¹	-			
Select action Restore calibration values	-	-	-	●) ¹	-	D012	H	0 = Off 1 = Restore 2 = Error when restoring

¹ = Not available in MODBUS version V6.0

<u>Failure handling</u>	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●	-	●	-			
Delay relay s	●	●	-	●	-	D153	H	0 s to 255 s

3.7.3 Information category

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
Actual values	●	●	●	●	●			
Current parameter set	●	●	-	●	-	D01D	I	0 = Parameter set 1 1 = Parameter set 2
Current PWM %	●	●	●	●	●	D019	I	0 % to 100 %
Current speed rpm Reference value for maximum speed rpm	●	●	●	●	●	D010 & D119*	I H	0 to 64000 *Formula: D010 / 64000 x D119 rpm
Direction of rotation (on rotor)	●	●	●	●	●	D018	I	0 = Counter clockwise 1 = Clockwise
Current set value	●	●	●	●	●	D01A	I) ²
Current sensor value	●	●	●	●	●	D01B	H) ²
Control mode (P1)	●	●	●	●	●	D106	H	0 = Closed loop speed control 1 = Closed loop sensor control) ¹ 2 = PWM control
Set value P1 (EEPROM)	●	●	-	●	●	D114	H	
Control mode (P2)	●	●	-	●	-	D107	H	0 = Closed loop speed control 1 = Closed loop sensor control) ¹ 2 = PWM control
Set value P2 (EEPROM)	●	●	-	●	-	D115	H	

¹ = Not available in MODBUS version V5.0x Lite)

² = Unit is specified in sensor settings

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
Device data	●	●	●	●	●			
Device address	●	●	●	●	●	D100	H	
Identification	●	●	●	●	●	D000	I	
Protocol version	●	●	●	●	●	D000	I	
Serial number	●	●	●	●	●	D1A2 - D1A4	H	
Fan type	●	●	●	●	●	D1A5 - D1AA	H	
Operating hours	●	●	●	●	●	D009	H	
Production week	●	●	●	●	●	D1A4	H	
Production year	●	●	●	●	●	D1A4	H	
Software version bus controller	●	●	●	●	●	D002/ D003	I	
Software version motor controller	●	●	●	●	●	D004/ D005	I	

Electronics	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen.1	V6.x	ACE			
	●	●	●	●	●			
Direct link voltage Reference value for max. Direct-link voltage.	●	●	●	●	●	D013 & D1A0*	I H	0 to 65535 *Formula: D013 / 256 x D1A0 x 20 mV
Direct link current Reference value for max. Direct link current	●	●	●	●	●	D014 & D1A1*	I H	0 to 65535 *Formula: D014 / 256 x D1A1 x 2 mA
Power W Reference value for max. DC-link voltage Reference value for max. DC-link current	●	●	●	● ¹⁾	● ¹⁾	D021 & D1A0 & D1A1*	I H H	0 to 65535 *Formula: D021 / 65536 x D1A0 x D1A1 x 0.04 mW
Electronics temperature °C	●	●	●	●	●	D017	I	
Power module temperature °C	●	●	-	●	●	D015	I	
Power consumption kWh	-	-	-	●	●	D029	I	

¹⁾ = Alternatively register D027 with absolute power in W

Motor	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	●	●	●	●			
Motor temperature °C	● ¹⁾	● ¹⁾	-	●	● ¹⁾	D016	I	
Torque (approx.) Nm	●	●	●	●	●	-	-	Formula: Power / speed x 9.55 (M = P/n x 9.55)
Current speed rpm Reference value for maximum speed	●	●	●	●	●	D010 D119	I H	0 to 64000 D010 / 64000 x D119 rpm
Power W	-	-	-	●	●	D027	I	

¹⁾ = Available depending on motor size

Input values	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	●	● ¹⁾	●	●	●			
Current state of enable input	●	-	-	●	●	D01C		0 = Fan disabled 1 = Fan enabled
Current value Sensor 1	●	● ¹⁾	●	●	●	D023	I	0 to 65535
Current value Sensor 2	●	● ¹⁾	-	●	-	D024	I	0 to 65535
Source disable input	-	-	-	●	●	D16A	H	
Saved enable state	-	-	-	●	●	D16B	H	
Current set value source	-	-	-	●	●	D028	I	0 = Analog input Ain1 1 = RS485/bus 2 = Analog input Ain2) ² 3 = PWM input PWMin3) ²

¹⁾ = Not available in MODBUS version V5.00 Lite

²⁾ = Not available in MODBUS version ACE

	Available in MODBUS version					Register	Input/ Holding	Value
	V5.xx	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
	•	•	•	•	•			
Failure list	•	•	•	•	•	D186- D19F	H	
Contents of failure memory	•	•	•	•	•			

3.8 Electrical connection Gen. 2 (full interface)

The terminal strip (KL) has the following structure. Differences may occur depending on size and date of manufacture:

Connection		Designation	Description
1	RSA	Bus connection	RS485-RSA; MODBUS RTU-D1
2	RSB	Bus connection	RS485-RSB; MODBUS RTU-D0
3	GND	Ground	Reference ground for control interface/common cable for RS485/MODBUS
4	Ain1 U	Analog input 1 (set value)	Analog set value requirement for 0-10 V set value generator, e.g. potentiometer, see also 4.9
5	+10 V	Auxiliary voltage +10 VDC	Power supply for additional external devices, e.g. potentiometers
6	Ain1 I	Analog input 1 (set value)	Analog set value requirement for 4-20 mA set value generator, see also 4.9
KL3			Enable electronics Enable: Pin open or applied voltage 5-50 VDC Disable: Bridge to GND or applied voltage < 1 VDC
			Switching parameter set (P), see also 4.3 P1: Pin open or applied voltage 5-50 VDC P2: Bridge to GND or applied voltage < 1 VDC
			Select controller function; see also 3.7 Positive/Heating: Pin open or applied voltage 5-50 VDC Negative/Cooling: Bridge to GND or applied voltage < 1 VDC
			Reference ground for control interface/common cable for RS485/MODBUS
			Analog actual value requirement, for 0-10 V sensors; see also 4.7
			Power supply for additional external devices, max. 40 mA, e.g. sensor
			Analog actual value requirement, for 4-20 mA sensors; see also 4.7
			Output of the current modulation level or current speed; see also 3.10.3 and 3.10.4.

Connection		Designation	Description
KL2	1	NC	Status relay
	2	COM	Status relay
	3	NO	Status relay
Connection		Designation	Description
KL1	1	L1	Supply connection
	2	L2	
	3	L3	
Connection		Designation	Description
PE	PE	Protective earth	PE connection

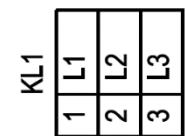
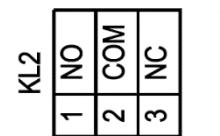
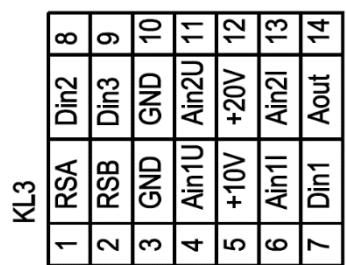


Fig. 12: Terminal strip Gen. 2 BG150

3.9 Electrical connection Gen. 3

Connection	Designation	Description
CON1	L1, L2, L3	Power supply, phase, see nameplate for voltage range
PE	PE	Protective earth
CON2	RSA	RS485 interface for MODBUS, RSA; SELV
CON2	RSB	RS485 interface for MODBUS, RSB; SELV
CON2	GND	Reference ground for control interface, SELV
CON2	IO1	Function parameterizable
CON2	IO2	Function parameterizable
CON2	IO3	Function parameterizable
CON2	Vout	Voltage output 3.3-24 VDC +/-5%, Pmax=800 mW, voltage parameterizable Short-circuit-proof, supply for external devices, SELV
CON2	COM	Status relay, floating status contact, common connection, contact rating 250 VAC / 2 A (AC1) / min. 10 mA, reinforced insulation on supply side and on control interface side
CON2	NC	Status relay, floating status contact, break for failure
	LED	Green = status good, ready for operation Orange = status warning Red = status error
	P1-IN	Input curve
	P3-OUT	Output curve

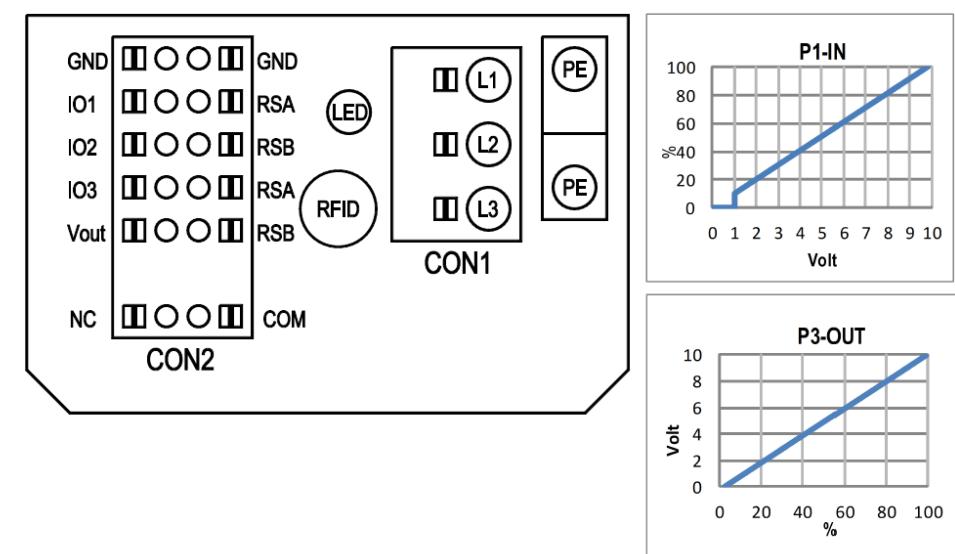
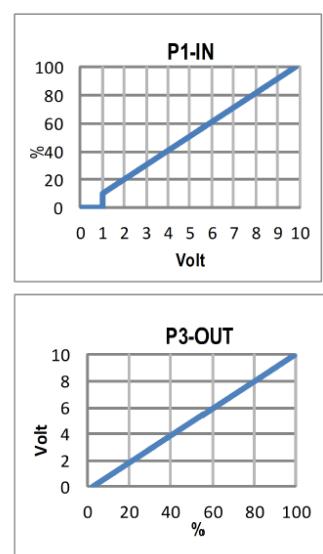


Fig. 13: Terminal strip Gen. 3 BG150



				MODBUS registers for IO function configuration			
				Configurable IO mode		MODBUS registers for IO mode configuration	
						Configurable IO function: normal /inverted	
Customer connection side	IO1	Din1 (high active): Digital input	D158 [0]	<input type="radio"/>	<input type="radio"/>	D101 [...]	
		Ain1 0-10 V/PWM: Analog input	D158 [2]	<input type="radio"/>	<input type="radio"/>	D147 [...]	
	IO2	Tach output (open collector)	D158 [5]	<input type="radio"/>	<input type="radio"/>	D104 [...]	
		Diagnostic output (open collector)	D158 [6]	<input type="radio"/>	<input type="radio"/>	D12E [...]	
	IO3	Din2 (high active): Digital input	D159 [0]	<input type="radio"/>	<input type="radio"/>	Switching: Direction of action: Heating (pos.) / Cooling (neg.)	
		Ain2 0-10 V/PWM: Analog input	D159 [2]	<input type="radio"/>	<input type="radio"/>	Switching: Direction of rotation	
		Ain2 4-20 mA: Analog input	D159 [3]	<input type="radio"/>	<input type="radio"/>	Switching: Set value source	
	RSA	Din3 (high active): Digital input	D15A [0]	<input type="radio"/>	<input type="radio"/>	Switching: Enable/disable input	
	RSB	Din3 (low active): Digital input	D15A[1]	<input type="radio"/>	<input type="radio"/>	Signal: Tach output	(•)
	Vout	PWMIn3: Digital PWM input	D15A[7]	<input type="radio"/>	<input type="radio"/>	Signal: Diagnostic output	(•)
		Aout3 0-10 V: Analog output	D15A[4]	<input type="radio"/>	<input type="radio"/>	Signal: Duty cycle %	
		Tach output (pulses)	D15A[5]	<input type="radio"/>	<input type="radio"/>	Signal: Speed rpm	
		Diagnostic output (pulses)	D15A[6]	<input type="radio"/>	<input type="radio"/>	Signal: Installation modulation level %	
		RS485 bus interface		<input type="radio"/>	<input type="radio"/>	Signal: Remote control 0-10 V	
		Power supply	D16E [...]	<input type="radio"/>	<input type="radio"/>	Autoaddressing input pulses	
		Alternatively: Auxiliary voltage input for parameterization via RS485/MODBUS RTU interface if no line voltage applied		<input type="radio"/>	<input type="radio"/>	Autoaddressing output pulses	

Basic principles and explanations of EC-Control

4 Setting options and basic functions via MODBUS

4.1 Networking and assigning addresses to MODBUS nodes

The requirement for a problem-free network operation for the fans is the correct address setup of the devices. In doing so, there are some basic things to note:

- Address setup within a MODBUSsegment must be unique
- An address may only be used once. In other words, no double assignments may be made.
- The fans have the address 1 by factory settings
- As a first step during installation, this address is to be set (automatically or manually).

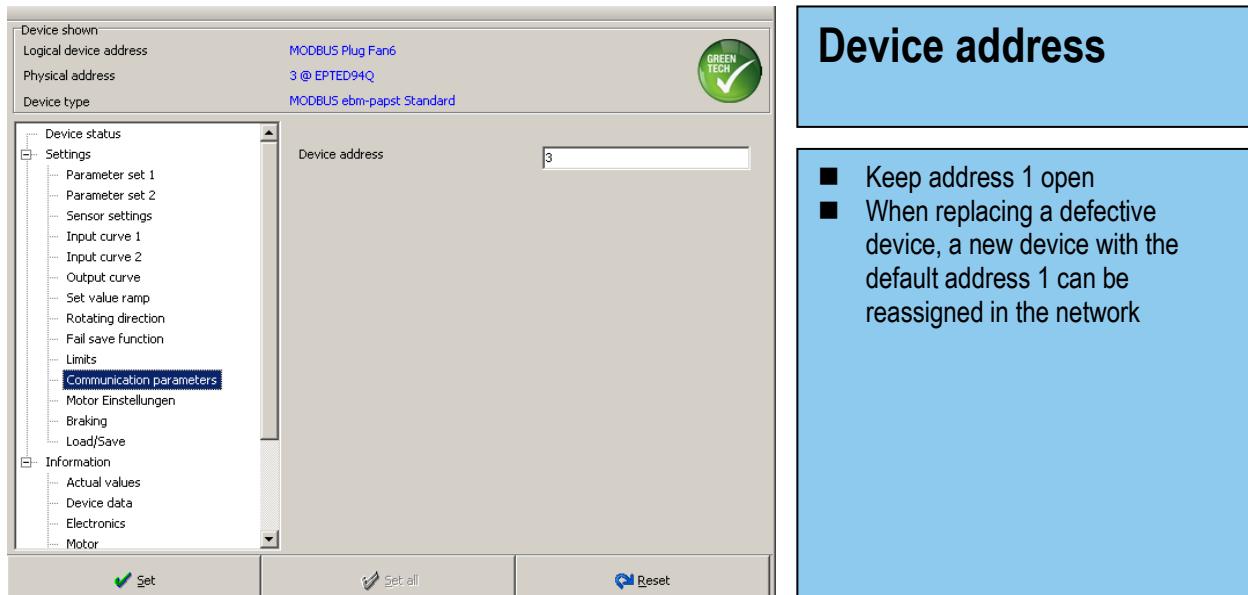


Fig. 14: Changing device address manually

With MODBUS RTU, an address range of 1 to 247 is provided. However, if you are working in a network, by definition it is possible to handle four communications paths or subnets at the same time. The address space of a subnet can in this way be multiplied. The subnets can be defined via the interface converter, and are designated correspondingly. The example below shows that the communications path is a part of the address.

Subnets and communication paths:

- | | |
|---------------------|----------|
| • RS232 / RS 485 | 1 to 247 |
| • Ethernet / RS485 | 1 to 247 |
| • Bluetooth / RS485 | 1 to 247 |

would lead to the following physical addresses:

- 1...247@RS232_Converter_1
- 1...247@Ethernet_Converter_2
- 1...247@Bluetooth_Converter_3

Networking the MODBUS node is shown in Fig. 15 and in Fig. 16 (see pages 36/37).

The connection diagram Fig. 15 includes the following features:

■ *simple twisted pair wire*

ebm-papst recommends using a simple twisted pair wire. A twisted pair wire is a cable with which the leads of a pair of leads are twisted to one another. Through the twisting, such cables provide protection from symmetrical faults.

■ *Common wire*

The configuration of a joint data line (so-called common lines) is recommended in the MODBUS specification expressly in order to work against transmission problems. In doing so, the GND potentials of the interface components are connected. All systems thus have a common reference potential.

■ *Line termination*)

In the circuit diagram below, in addition to common lines, line terminations in the form of resistors are also used, in order to minimize reflections on the ends of the line and thus obtain a better signal quality. Line termination resistors are at the beginning and the end of the bus, between D0 (RSB) and D1 (RSA). However, more than two resistors – 1xLT at the beginning and 1x LT at the end of the line - may not be installed. 120Ω LT resistors with an output of 0.5W are recommended.

The connection diagram Fig. 16 includes the following features:

■ *shielded twisted pair line*

For operation in areas prone to failure, MODBUS.org recommends using shielded twisted pair cables. The shielding consists of aluminium foil or braided copper and prevents interference from electromagnetic fields.

■ *Common wire*

See above

■ *Line termination*

See above

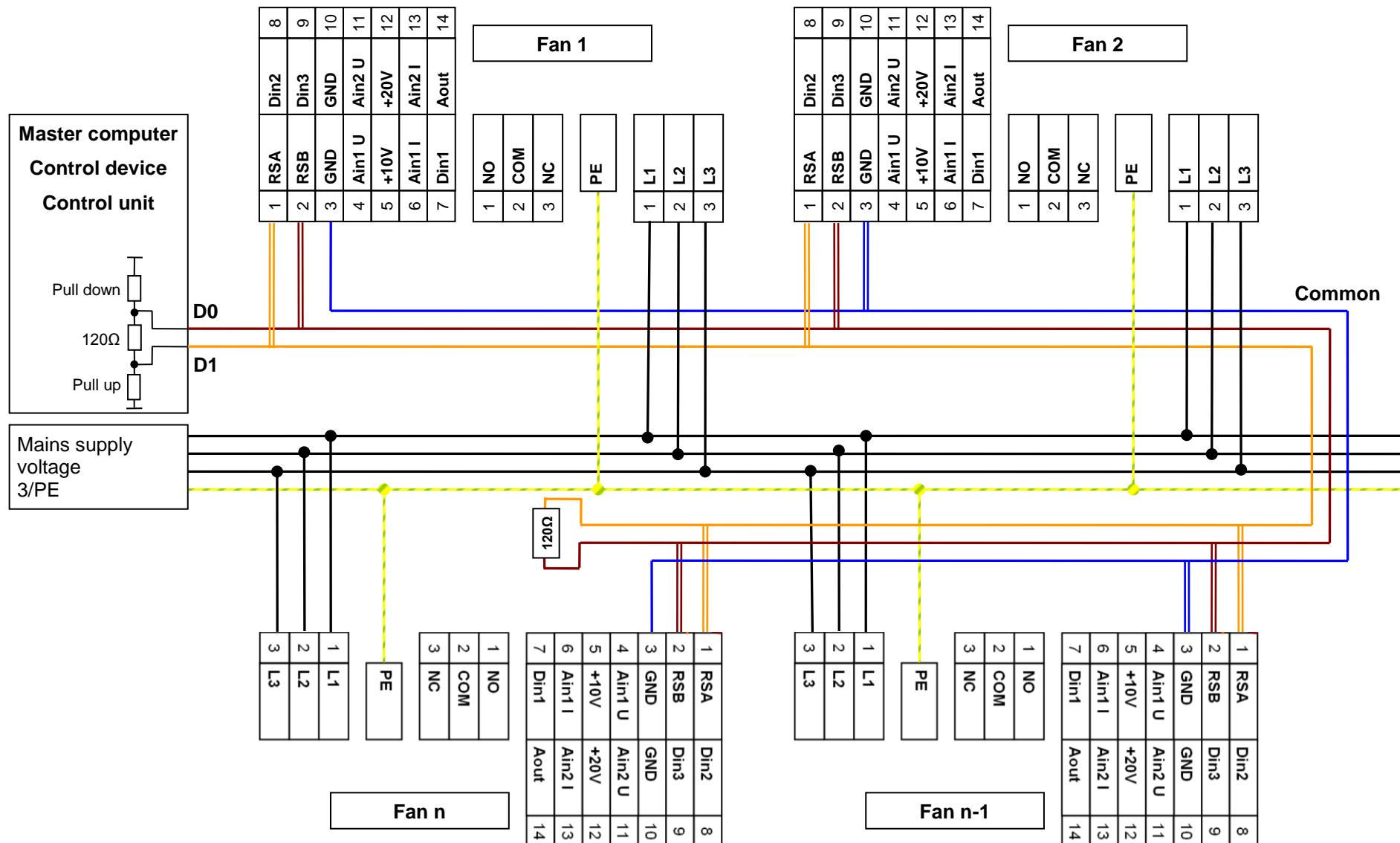


Fig. 15: Connection of multiple devices to the MODBUS via twisted pair line with 2 pairs of wire

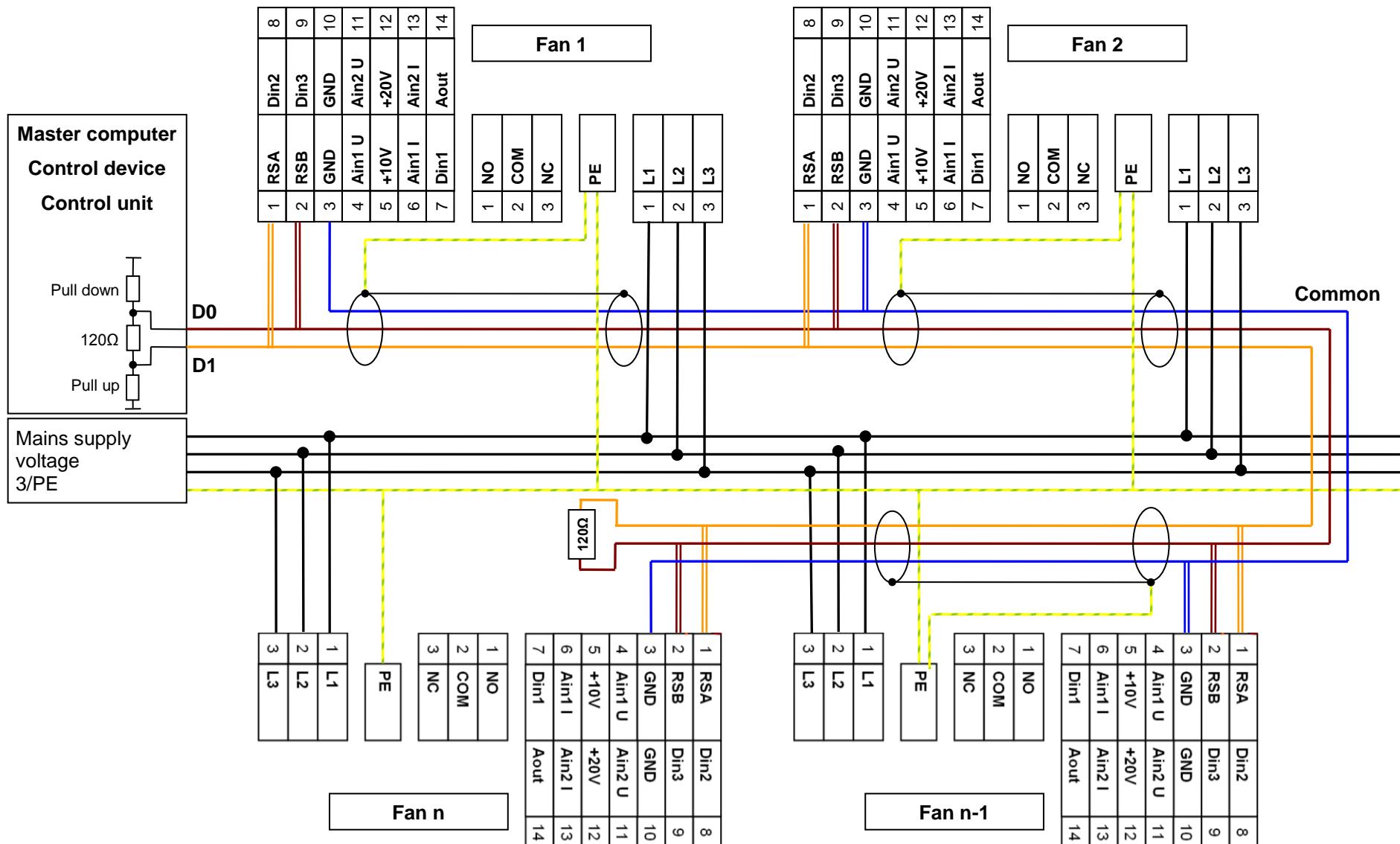


Fig. 16: Connection of multiple devices to the MODBUS via shielded twisted pair wire with 2 adapters

4.1.1 Automatic address assignment

With fans new from the factory, there is the option to use an automatic address assignment.

This option exists since ebm-papst **MODBUS protocol version 5.00**.

The function of the automatic address assignment is explained in **EC-Control user manual (Chapter 3.3.4)**.

What do I have to pay attention to in order to use this function?

- All fans for a system should be factory-new.
If in a system a subnet with factory-new fans is also wired with an ebm-papst MODBUS protocol version older than 5.00, then the automatic address assignment will automatically switch it to the semi-automatic method. You can read about how this functions in **EC-Control user manual (Chapter 3.3.5)**.
- The fans are to be sorted by serial number in increasing order during installation in a system, because during automatic address assignment, the fan addresses are sorted based on the serial number. This eases identification of individual fans in the system. The serial number is structured as follows: JJWW00XXXX, where JJ is the year of production, WW is the production week and XXXX is a sequential alphanumeric character combination.
- Aside from your ebm-papst fans, no other MODBUS devices should be connected to the subnet used.

4.2 Soft On/Off and Motor stop enable

Continuously switching EC motors on and off on the mains side places stress on electronic components and shortens their service life. To prevent this, EC motors from ebm-papst have an on-off function (Soft On/Off) for bringing the motor gently to a standstill. This occurs by applying a low signal at digital input 1 (Din1), which leads to a locking of the electronics. There is also the option of activating Motor stop enable, but this is a different approach than switching from Din1 (Soft On/Off).

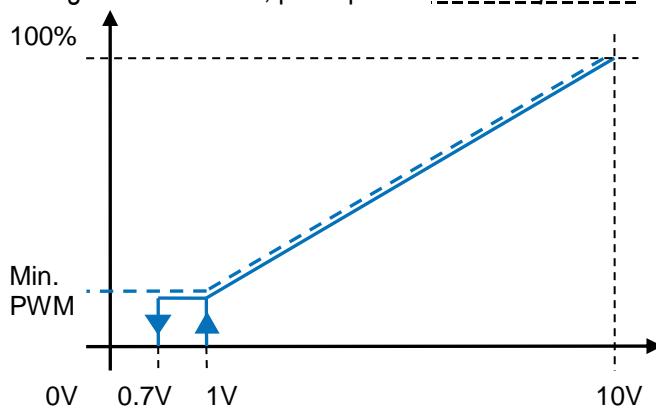
This function is primarily helpful for maintenance purposes, since by doing so you can bypass a configured basic ventilation (Min_PWM). Thus the motor can be brought to a standstill with the set value input 0 rpm or 0% PWM, without having to change the value for Min_PWM. If Motor_stop_enable is activated, the motor is also brought to a standstill in normal operation if no air flow is required at the moment (= internal 0% PWM).

Motor stop enable

- Motor_stop_enable has to be enabled in order to switch off any basic ventilation that is set
- If the function is disabled, the motor always runs at least with the preset Min_PWM value
- The motor can also be stopped with a low signal on digital input 1 (Din1) (→ disabling the electronics)

Fig. 17: Motor stop enable

- Closed loop speed control or PWM control mode
If Motor_stop_enable is activated, the motor speed can be set to zero by entering the set value 0 (speed = 0 rpm or PWM signal = 0%, depending on control mode)
- Sensor control control mode
If the actual value undershoots or exceeds the set value (depending on control function), the motor is brought to a standstill; prerequisite: Motor_stop_enable is active



- Motor_stop_enable is activated (solid line):
Motor stops at signal < 0.7 V
- Motor_stop_enable is deactivated (dashed line):
Motor runs with min. PWM signal
- Hysteresis: Motor starts with a voltage of 1 V, but does not stop until 0.7 V (if Motor_stop_enable is activated)

Fig. 18: Motor stop enable

4.3 Changing the parameter set

MODBUS gives you the ability to save two parameter sets. By selecting a parameter set you can make different pre-adjustments. Each of the two screens for the parameter sets include the following configuration options:

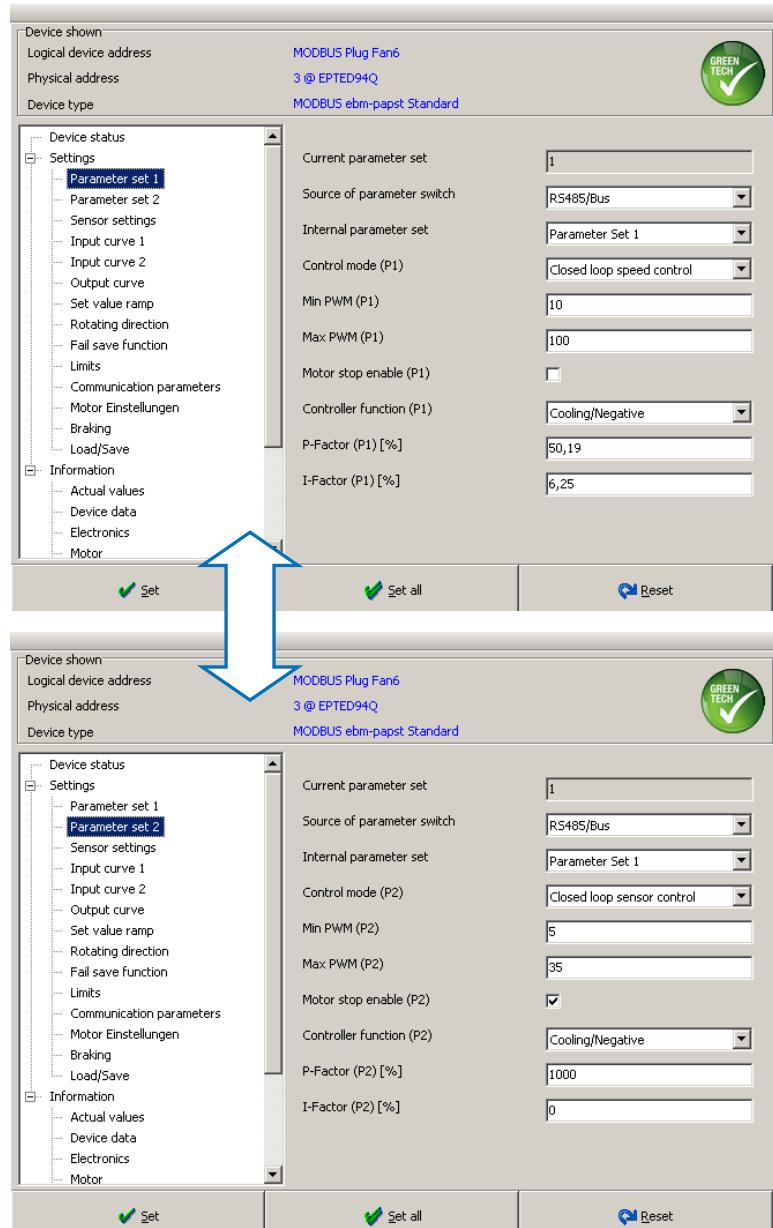


Fig. 19: Parameter set 1 and parameter set 2

If terminal Din2 or terminal Din3 is selected as Source for parameter set, consequently it will no longer be possible to change the parameter sets via EC-Control.

- Parameter set 1 is selected if Din2 (or Din3) is open or a voltage of >5 V is present.
- Parameter set 2 can be selected by bridging from Din2 (or Din3) to GND.

While the above-mentioned configuration options can be found under the Parameter set subitem, the set value can be entered only under Overview!

Parameter sets P1/P2 Explanation of the parameters

■ Source for parameter set

RS485/bus corresponds to the switching through EC-Control, terminal Din2 to the switching via Digital input Din2 of the terminal strip

■ Parameter set

If the parameter set RS485/bus is selected as the source, you can change between parameter set 1 and parameter set 2 with EC-Control

■ Operating mode

Control mode can be selected for the respective parameter set, independently of each other (see 3.2)

■ Min PWM or Max PWM

Limits of the modulation level with which the motor works (see Fehler! Verweisquelle konnte nicht gefunden werden.).

■ Motor stop enable

If this function is active, the motor can be stopped (see 4.1.1).

■ Control function (see 3.7)

■ P-factor / I-factor

Here, the control parameters P-factor and I-factor can be entered. The values influence the control behaviour in the control modes sensor control and closed_loop_speed_control (see 3.6).

4.3.1 Configuring separate set values for day/night operation

To store one set value for each of the two parameter sets, the following settings have to be configured in sequence. It is important here to activate the item after each step by clicking Set.

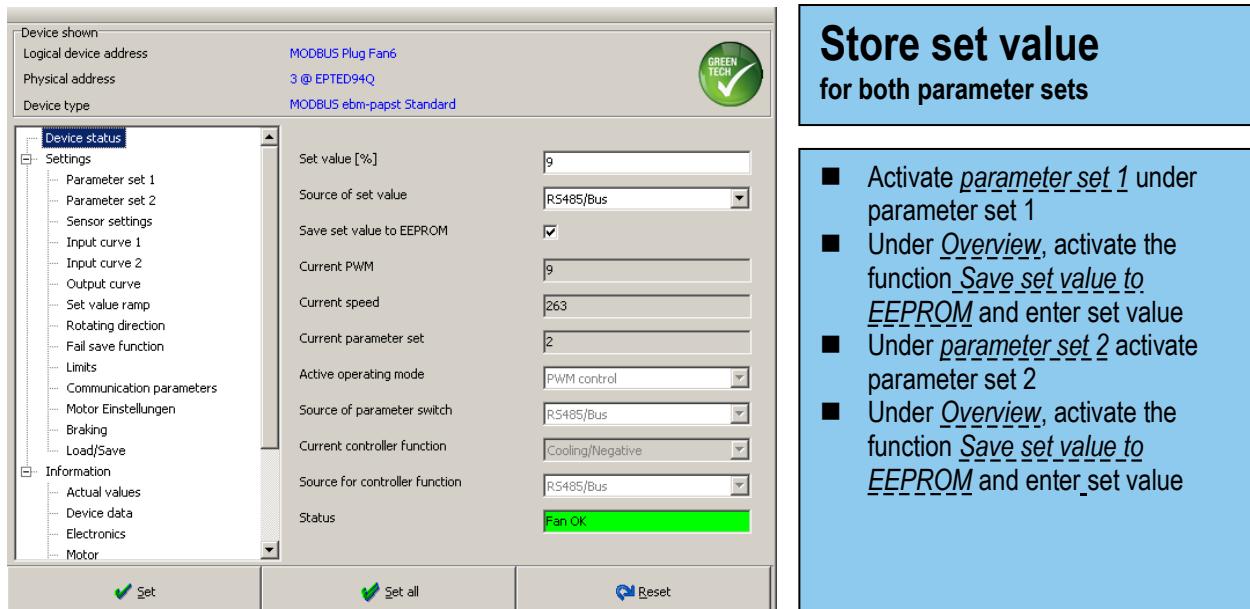


Fig. 20: Save set value to EEPROM

The Save set value to EEPROM function has to be enabled in order not to lose the set value when changing the parameter set

4.4 Fail safe function

- The fail_safe_function offers protection against unexpected cable break or malfunctions.
- If the connection (RS485/bus) to the interface is lost, this function makes it possible for the fan to assume a desired fail safe speed.
Information: The fan detects the "bus traffic" and switches to fail safe mode if no "bus traffic" is detected via the RS485 interface.
- Moreover, a threshold value can be set for the analogue input. If the analogue signal falls below this threshold value, for example at analogue_Ain1, the configured fail safe speed is applied.
- For MODBUS 5.00 and higher, the direction of rotation can also be configured during fail safe operation. These options are available: Clockwise, Counter-clockwise, Retain direction of rotation.
- This function can be used to be able to guarantee the configured air performance, even if there is a fault in the source of set values.
- As soon as the fan detects an analogue set value above the threshold value or a BUS signal again, it continues its "normal" operation with the correct direction of rotation and the last set value or assumes the detected set value.

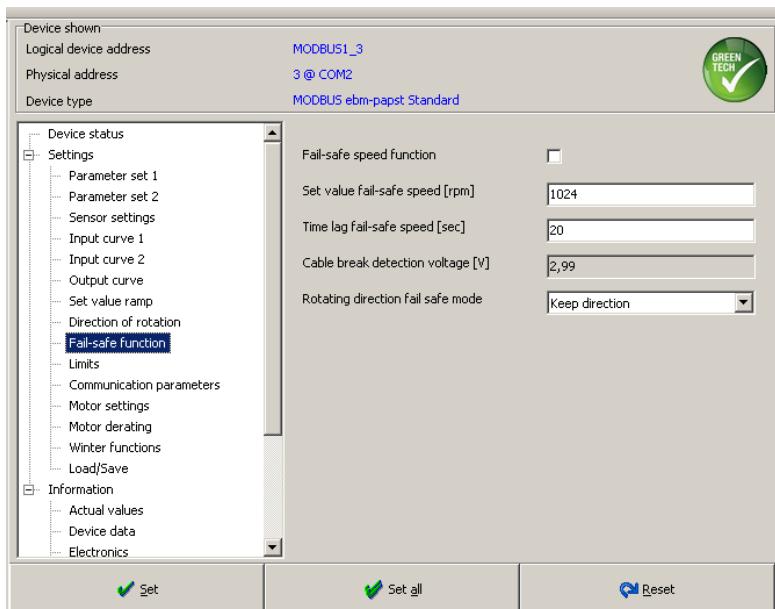


Fig. 21: Emergency operation function

Fail save function

- Activate the [fail_safe_speed_function](#) by setting the tick mark
- Enter desired [set_value_fail_save_speed](#)
- Enter the time lag after which the fail safe speed function is to be begun
- Cable break detection voltage
- Select the direction of rotation that is to be begun in the fail save mode (from MODBUS 5.00)
- Note special cases

Special cases:

■ Time lag of 0 seconds

Here you must observe that the motor immediately applies the fail safe speed – even without a cable break. If that kind of a short delay is desired, we recommend setting a time of 0.1 s.

■ Cable break at MODBUS interface and the fail safe function is not enabled

Motor does not stop, but continues running constantly. The connection to the MODBUS interface is broken and the motor can no longer be controlled. Speed changes can no longer be carried out; also, it is no longer possible to stop the motor.

■ The motor should stop completely in the event of a cable break (fail safe speed = 0 rpm).

Prerequisite: [Motor_stop_enable](#) has to be enabled. If the function is not enabled, the motor keeps running with a minimum PWM signal.

■ Cable break detection voltage

Prerequisite: Source of set values is set to [analogue Ain1](#). If the voltage at the analogue input selected as the source of set values falls below the voltage specified here, a cable break of the analogue set value device is diagnosed and the fan is switched to the fail safe speed function.

■ Exiting EC-Control, fail safe speed activated

If [Fail_safe_speed](#) is activated, the motor applies this also when ending EC-Control.

4.5 Winter functions

Winter functions

- Activate / deactivate the shake-loose function
- Max. start PWM shake-loose function establishes with how much % PWM fan level the shake-loose function should be operated at maximum
- Max. number of startup attempts: With each startup attempt, the PWM level control coefficient is increased
- In very cold areas, a motor pre-heater can be enabled. (depending on fan, see the following text)

Fig. 22: Winter functions

The winter functions, which are available only for MODBUS 5.00 and higher, involve the following two options for ensuring the fan's function in winter:

■ *Sheding function:*

Problem: If ice forms on the impeller, it can block the impeller. The fan detects a block, but still tries to start up. In doing so, however, the impeller can get damaged.

If the shake-loose function is enabled, the fan attempts to resume its operation using a duty cycle configured by ebm-papst. If this does not work, the fan tries to turn free in the opposite direction.

The number of these attempts can be set with Max.number of start attempts. After each failed attempt, the duty cycle for the startup is increased. With Max.start PWM shake off you can specify the maximum % PWM fan level with which the fan will keep trying to shake loose. If the shake-loose function succeeds, the fan rotates in the correct running direction with the originally desired set value. If the impeller remains locked even after the sheding function, the fan switches to normal locked behaviour. While trying to shake loose, a "W: sheding active" warning is displayed.

■ *Motor pre-heating:*

This function is possible only for specific fans and currently can be enabled only by ebm-papst.

Problem: If the fan is directly started at a very low operating temperature (for example -60°C), this can lead to damage of the bearings, since their lubricant is designed for temperatures no colder than -40°C.

Past a lower temperature limit (for example -60°C) set by ebm-papst, the motor pre-heating is activated and heats the motor and the bearings of the fan. The fan is disabled until the upper temperature limit has been reached. Then the motor pre-heating switches off and releases the fan again for "normal" operation. While the heating is enabled, a "W: preheating function" warning is displayed.

4.6 Motor settings (alarm relay)



Fig. 23: Motor settings

Example "Phase failure":

A system includes at least one ebm-papst fan (3-phase device). All outputs of the alarm relay are connected to the control system of this system. There will be a very brief voltage dip at one of the 3 phases. The function of the fans would not be impaired by this, but these detect the voltage dip and switch their alarm relays. This error is detected by the control system and then, possibly, the entire system comes to a standstill.

- Such briefly occurring errors (as described in the example) can be ignored by setting a drop-out delay of the alarm relay. The time of this drop-out delay should not be too long, however, since otherwise serious failures may be overlooked which in the long run could lead to damage of the fan.
- The respectively occurring error is signalled, as before, without a time delay via the MODBUS interface.

4.7 Specification of actual value by sensor via the inputs Ain2 U and Ain2 I

If the EC motor operates in *Closed loop sensor control* mode, the actual value is measured by sensors. The sensors can specify pressure, temperature and air flows.

To connect the sensor, the terminal strip (KL) is provided with the two analogue ports Ain2 U and Ain2 I (see Fig. 24). Alternatively, terminals Ain1 U and Ain1 I can also be selected. Terminal 12 serves as a power supply with a voltage of +20 VDC.

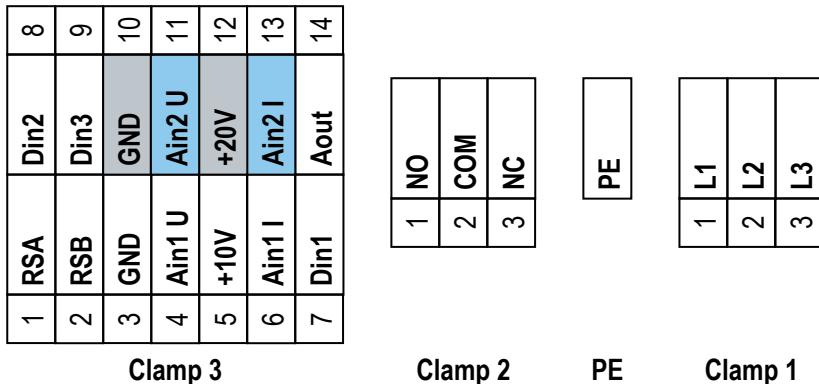


Fig. 24: Terminal strip, ports for specification of actual value with sensor control

Depending on the sensor output, you can choose between two inputs for the specification of actual value:

- Ain2 U or Ain1 U analogue port 11 or 4 (for sensors with 0 to 10V output)
- Ain2 I or Ain1 I analogue port 13 or 6 (for sensors with 4 to 20mA output)

In principle there are two different connection types, 3-wire and 2-wire (see Fig. 25).

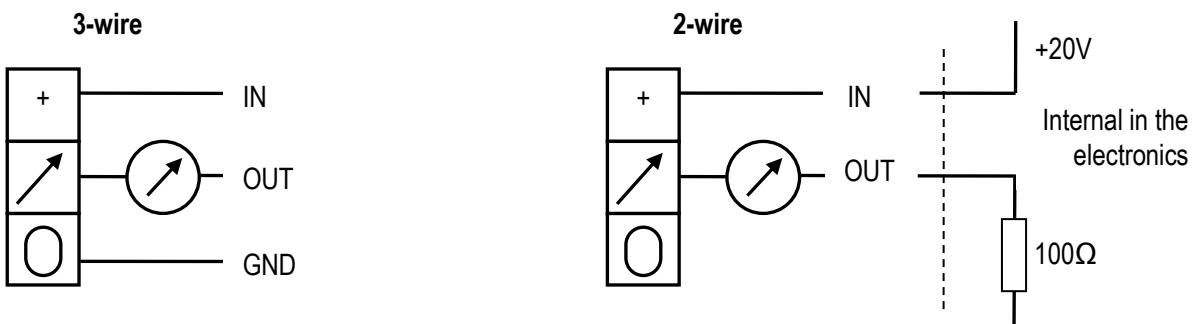
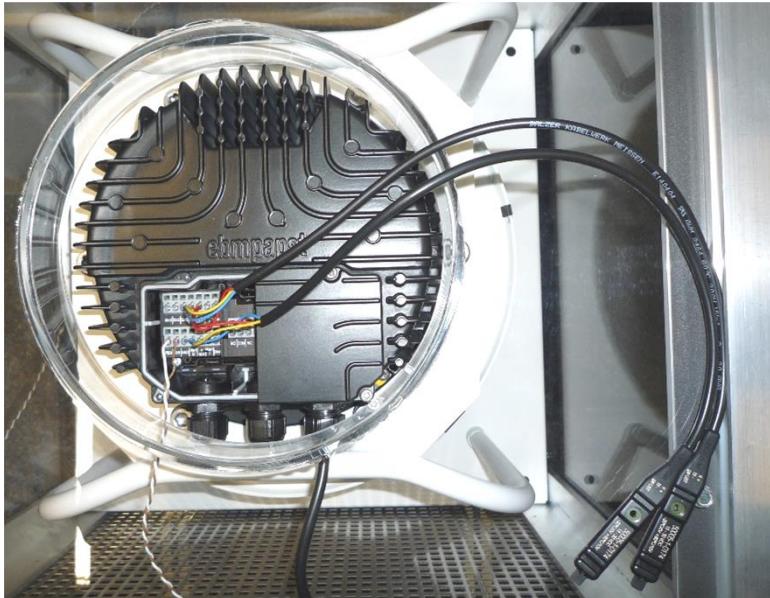


Fig. 25: 3-wire and 2-wire connection types

- **2-wire sensors**
are directly connected to the voltage source and deliver a 4 to 20mA signal. The GND connection is established via an internal 100Ω resistor (load) in the fan. On the terminal strip shown in Fig. 24 such a sensor would be connected to Ain2 I and +20V.
- **3-wire sensors**
on the other hand, are available with both output signals: current signal (4 to 20mA) and voltage signal (0 to 10V). Depending on the type, use the inputs Ain2 I (terminal 13) or Ain2 U (terminal 11).
On the terminal strip shown in Fig. 24 such a sensor would be connected to Ain2 I and Ain2 U, +20V and GND.

4.8 Specification of actual value by two sensors

An additional option for specifying the actual value is to use two sensors simultaneously. In the design photographed below (Fig. 26) two temperature sensors with ebm-papst Art. No. 50005-1-0174 are being used.



Two sensors
Example photo

- Two temperature sensors with Art. No. 50005-1-0174
- **Sensor 1:**
Ain1 U
+20V
GND
- **Sensor 2:**
Ain2 U
+20V
GND

Fig. 26: Connection of two sensors

Their sensor range extends from -20°C to +80°C. The Ain1 U and Ain2 U connections are both used here for specifying the actual value. For sensors with a 4 to 20mA output, accordingly, the Ain1 I and Ain2 I terminals have to be used.

The following options exist for calculating the actual value from the two measured values:

- | | |
|-----------------------|---|
| ■ Maximum (Ain1:Ain2) | Higher value of the two sensors serves as actual value |
| ■ Minimum (Ain1:Ain2) | Lower value of the two sensors serves as actual value |
| ■ Average (Ain1:Ain2) | Average of the two sensor values serves as actual value |

Important for determining actual values using two sensors:

The set value has to be digitally input via EC-Control (source of set values: RS485/bus), since both analogue ports are assigned!

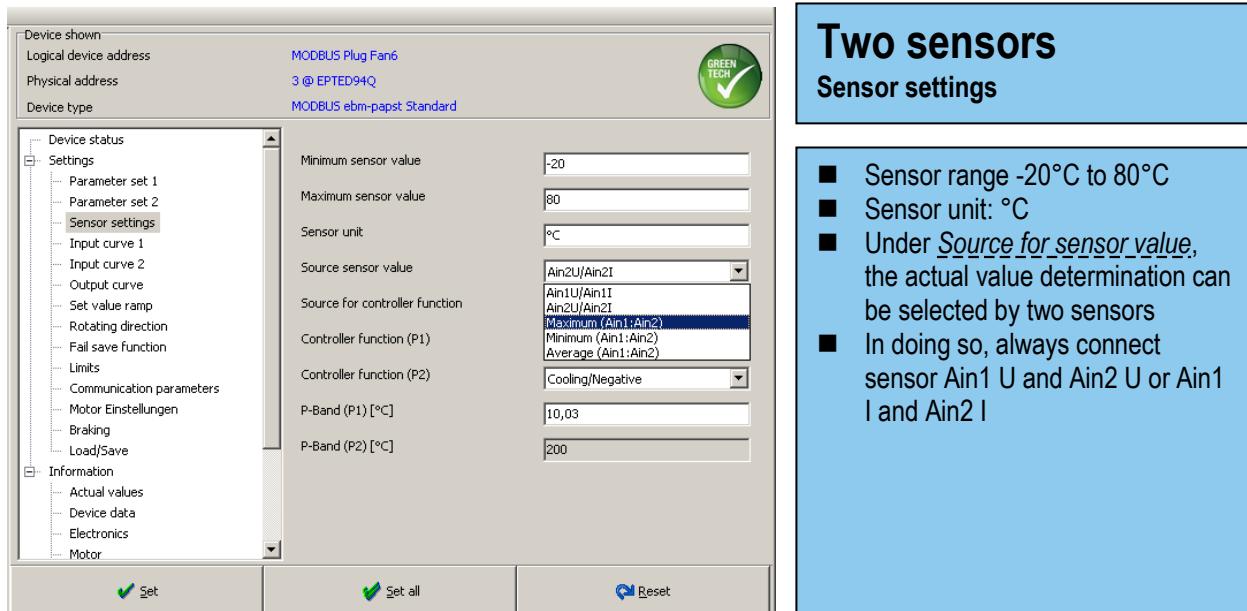


Fig. 27: Determining actual values using two sensors

4.9 Set value input via the inputs Ain1 U and Ain1 I or via EC-Control

The set value can be input via analogue Ain1 or RS485/bus, regardless of the control mode. The source can be adjusted under Overview (see Fig. 28).

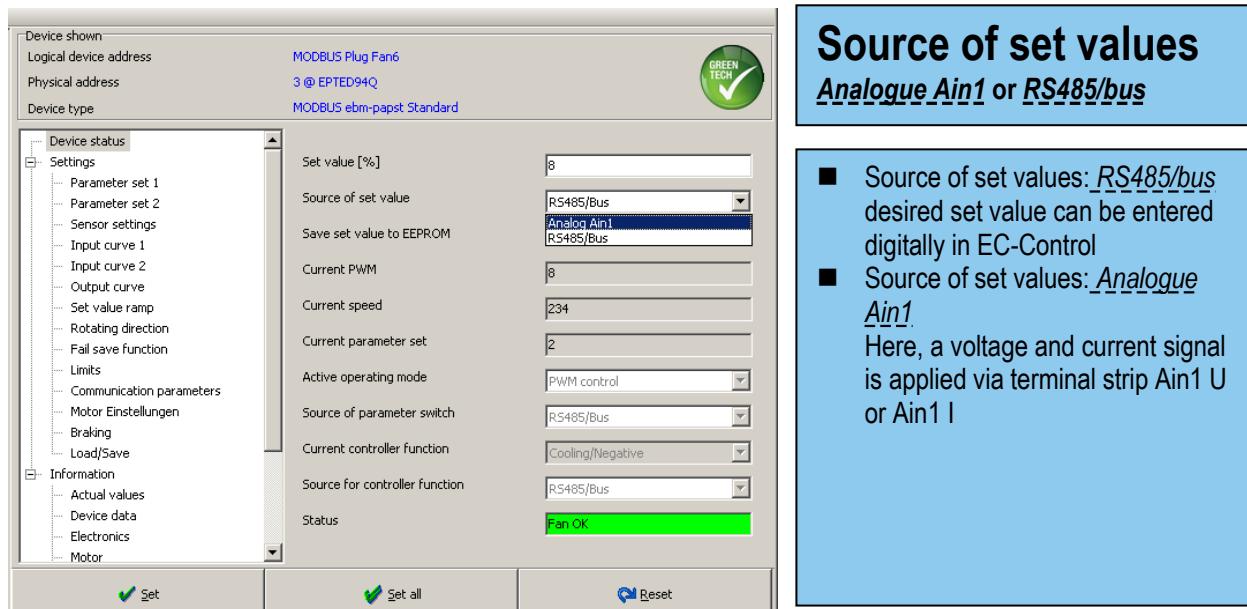


Fig. 28: Source of set values analogue or RS485

Two sensors Sensor settings

- Sensor range -20°C to 80°C
- Sensor unit: °C
- Under Source for sensor value, the actual value determination can be selected by two sensors
- In doing so, always connect sensor Ain1 U and Ain2 U or Ain1 I and Ain2 I

Source of set values Analogue Ain1 or RS485/bus

- Source of set values: RS485/bus desired set value can be entered digitally in EC-Control
- Source of set values: Analogue Ain1. Here, a voltage and current signal is applied via terminal strip Ain1 U or Ain1 I

External source of set values has to be connected to KL (for example, potentiometer). In doing so, terminal 5 can be used as an auxiliary voltage source with 10 VDC.

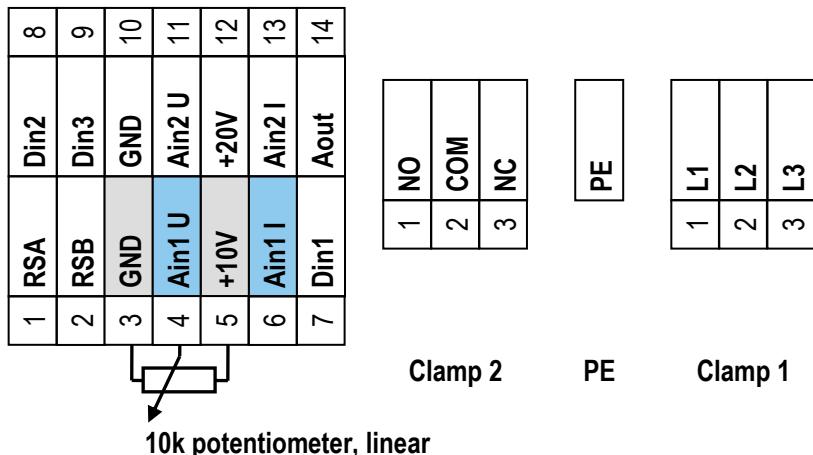


Fig. 29: Terminal strip, ports for set value input

Connections 4 and 6 in Fig. 29 are the analogue ports for the set value input. Here, as with the actual value specification, there are two different inputs:

- Ain1 U analogue port 1, terminal 4 for 0 to 10V set value device, for example, potentiometer)
- Ain1 I analogue port 1, terminal 6 for 4 to 20mA set value device

4.10 Curves

4.10.1 Input curve

The input characteristic is relevant only for analogue set value input (source of set values: *analogue Ain1*). If the set value is input via EC-Control (source of set values: *RS485/bus*), this item has no function.

- It is possible to define the input curve for source of set values *analogue Ain1* via the analogue ports Ain1 U and Ain1 I.
- The subitems *Input curve 1* and *Input curve 2* are under *Settings*
- For both input curves from Fig. 31, it would be possible to bring the motor to a standstill for 0 V signal only if the *Motor stop enable* function is enabled.

Input curve

Parameter set 1

- Ex. parameter set 1:
Control mode: closed loop speed control
- Ex. left: linear gradient of 100 to 700 rpm
- Input characteristic can be set for both parameter sets, independently of each other.
- For curve, see Fig. 31

Input curve

Parameter set 2

- Ex. parameter set 2:
Control mode: PWM control
- Ex. left: only from a 5V input voltage is modulation level > 20% possible
- Input characteristic can be set for both parameter sets, independently of each other.
- For curve, see Fig. 31

Fig. 30: Input curve

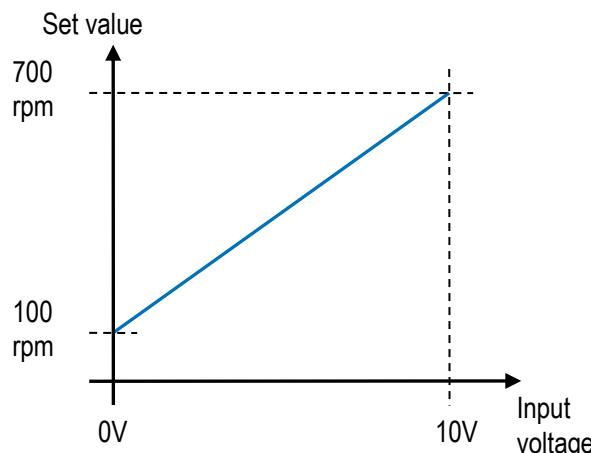
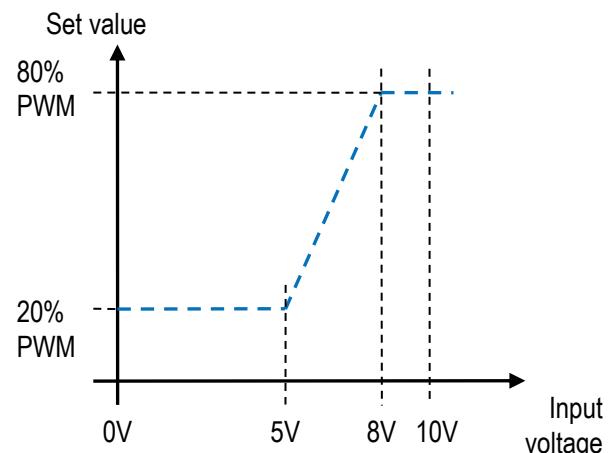
Input characteristic parameter set 1**Input characteristic parameter set 2**

Fig. 31: Examples for input curves from P1 and P2

4.10.2 Inverse curve

With analogue set value input, the input curve also offers the option of generating an inverse curve. This means that the set value increases as the input signal decreases.

Inverse curve

- Curve from Fig. 31 was inverted
- Ex. input voltage:
0V → 700 rpm
10V → 100 rpm
- Increasing the signal reduces the modulation level

Fig. 32: Inverse curve

The inverse curve becomes clear if you compare the above Fig. 31 with Fig. 33 below.

Inverse input characteristic parameter set 1

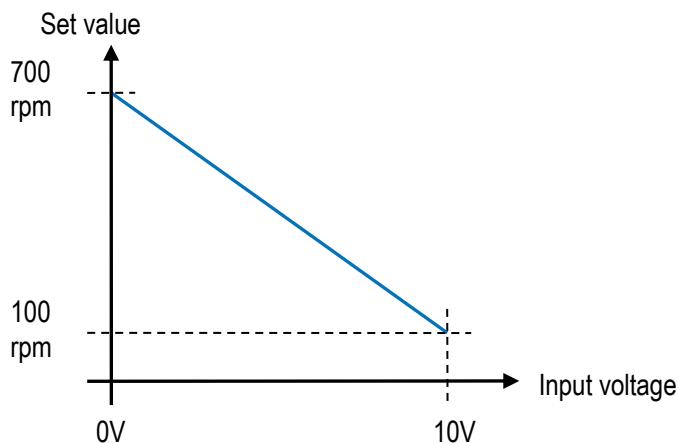


Fig. 33: Example of inverse curve

In practice, applications are known with which you can use an inverse curve to guarantee that the fan operates at maximum level when there is a cable break from the analogue set value (→ input signal 0 V). For more information, see Fail safe function (Chapter 3.4).

4.10.3 Output curve

To connect additional slaves to a master fan, the MODBUS terminal strip has an output Aout. Depending on the speed or the PWM signal, the output supplies a voltage signal, which is always output. The source of set values plays no role here.

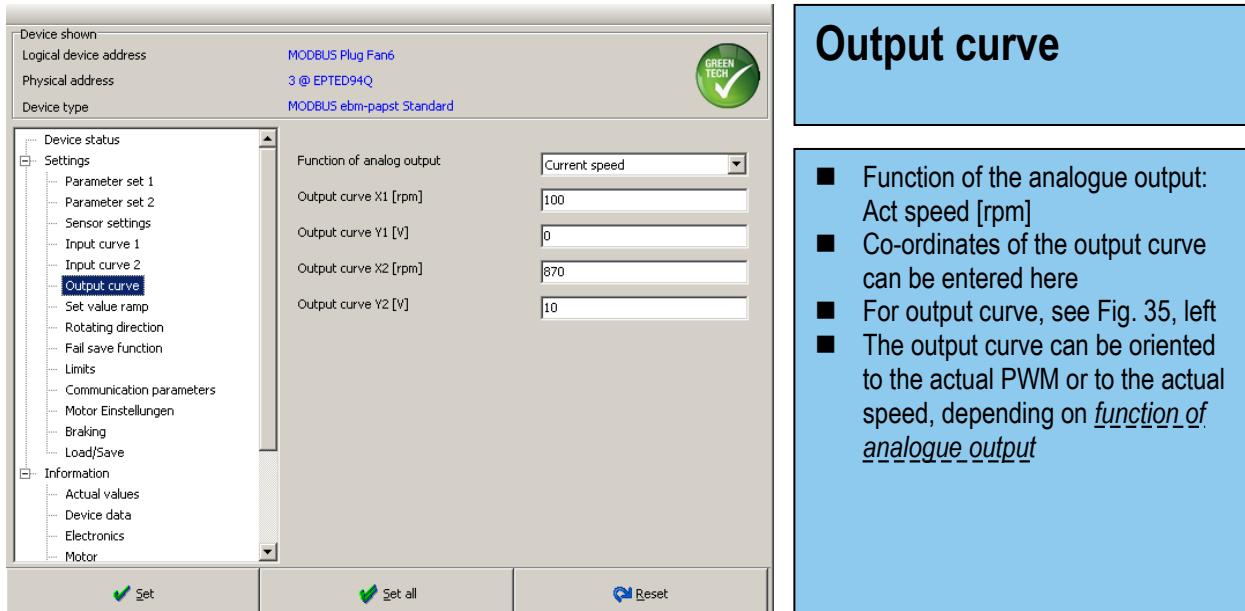


Fig. 34: Output curve

The output curve arising from this can be adapted individually to the requirements. The *Output curve* subitem is in the *Settings* menu item (see Fig. 34). Here, the analogue output function indicates whether the x-axis represents the speed or the PWM signal. The output curve would appear as follows.

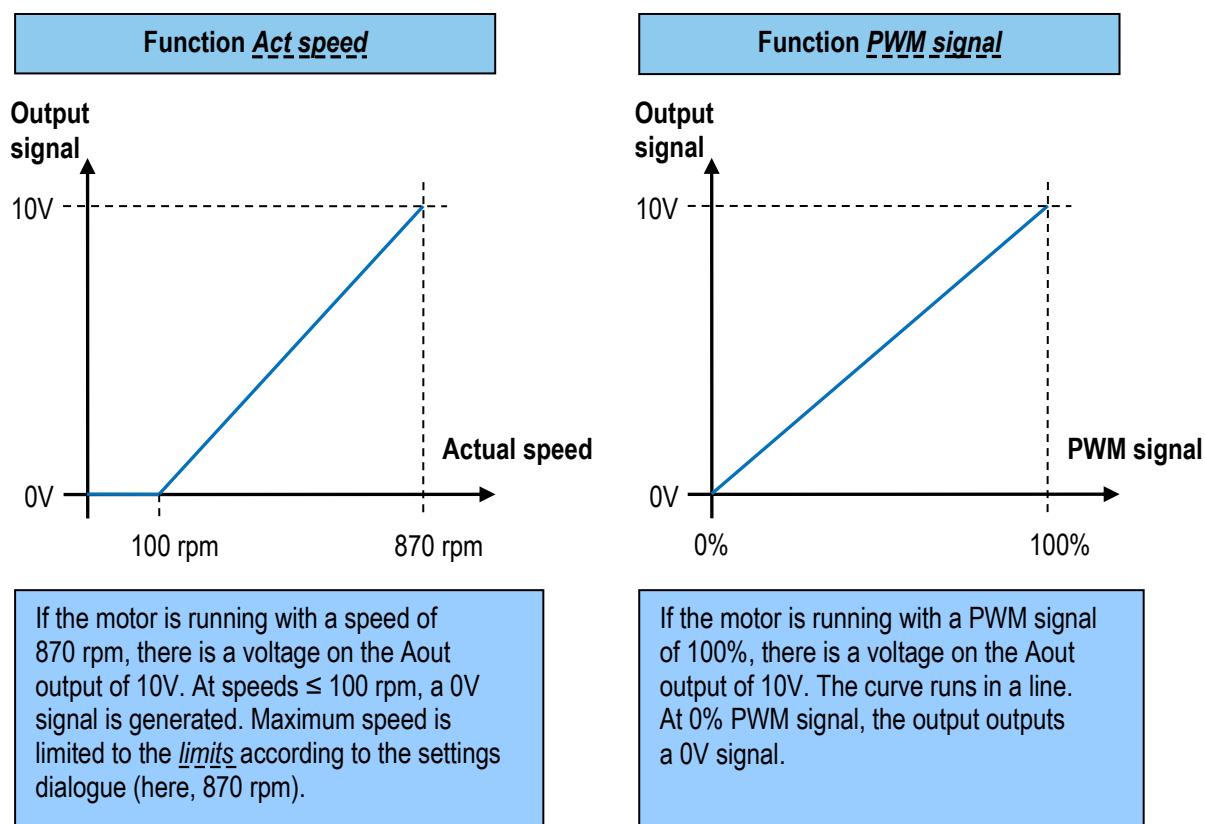


Fig. 35: Output curve

4.10.4 Analogue output: Impulses per revolution

Output curve

- Function of the analogue output: Speed monitoring (impulse)
- Impulses per revolution: Indicates how many pulses per revolution are to be output to Aout

Fig. 36: Output curve (impulses per revolution)

For MODBUS 5.00 and higher it is possible to output up to 255 impulses per revolution at the analogue output Aout. Use of this function requires a fan whose hardware supports this. However, attention should be given to choosing a reasonable number of pulses. For a very slowly rotating fan, 255 pulses may be required. The faster the fan rotates, the fewer pulses are required. Since the output frequency of the impulses per revolution is limited by hardware, with 255 pulses set and a high fan speed it could happen that the output puts out fewer pulses than anticipated.

This function is possible only for specific fans.

4.10.5 Motor derating

Motor derating

- Max. allowed power Is set by ebm-papst
- Max. power The power requirement can be limited
- For limitation of module temperature and limitation of motor temperature, see the following diagram:
Fig. 38: Derating diagram

Fig. 37: Motor power limit

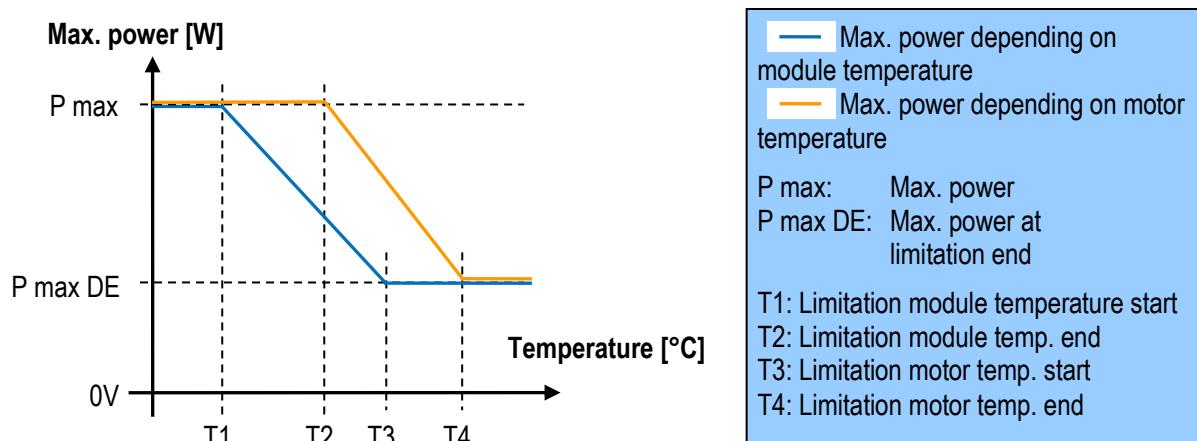


Fig. 38: Derating diagram

This parameter does not necessarily have to be configured.

If you have no information about the fan's output limit depending on the temperature, simply ignore this parameter.

As can be seen in the diagram in Fig. 38, the maximum power input depending on the module temperature and/or motor temperature can be configured.

The process depending on the motor temperature is now described by way of example:

- T2 was set to 100°C and T4 to 130°C
- Fan is running with maximum output (P max) e.g. 1191W
- Motor temperature increases to 100°C (T2)
- Power input is reduced
- Motor temperature increases further to 110°C
- Power input is further reduced
- Motor temperature reaches 130°C (T4)
- Power input is limited to maximum output with limitation end (P max DE), e.g. 1006W
- upon reaching 130°C (T4), the power input stays constant at e.g. 1006W (P max DE).

4.11 Run monitoring

MODBUS 4.00 or higher has the option of an alarm relay allow to release if a minimum rotational speed is not reached. This situation is also shown as a warning on the MODBUS (warning bit) at the same time it is signalled using the relay.

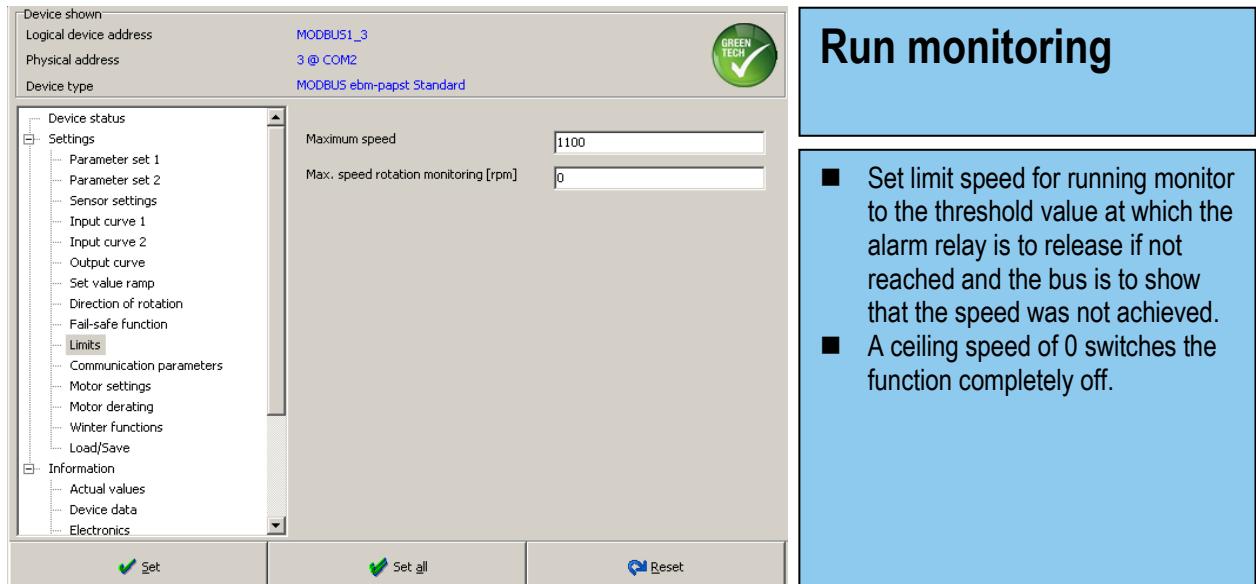


Fig. 39: Parameter set settings for run monitoring

5 Use of EC-Control in customer applications

The following points provide exemplary configuration notes and electrical connections for typical customer applications. They are recommendations and not required specifications for the specific application. Settings which are applicable to the **master** are marked by a **green** background. Settings which are applicable to the **slaves** are marked in **orange**. Settings which are applicable to all nodes are **green** and **orange**.

5.1 Refrigeration plants

5.1.1 Master-slave Configuration (star-shaped)

Usually, in a refrigeration plant, one fan works as a master and the remaining devices as slaves.

In order to be able to set the pressure in such operation, ebm-papst recommends carrying out the following system settings for the master and the corresponding slaves in EC-Control. The objective is to keep the condensing pressure constant.

Step 1:
Set parameter set

Master fan

- Set control mode: Sensor control
- Control function: cooling/negative
- P-factor: 2000%
- I-factor: 0%
- Source parameter set selection: usually RS485/bus; terminal Din2 and Din3 also adjustable.

Fig. 40: Parameter set settings for master of a refrigeration plant

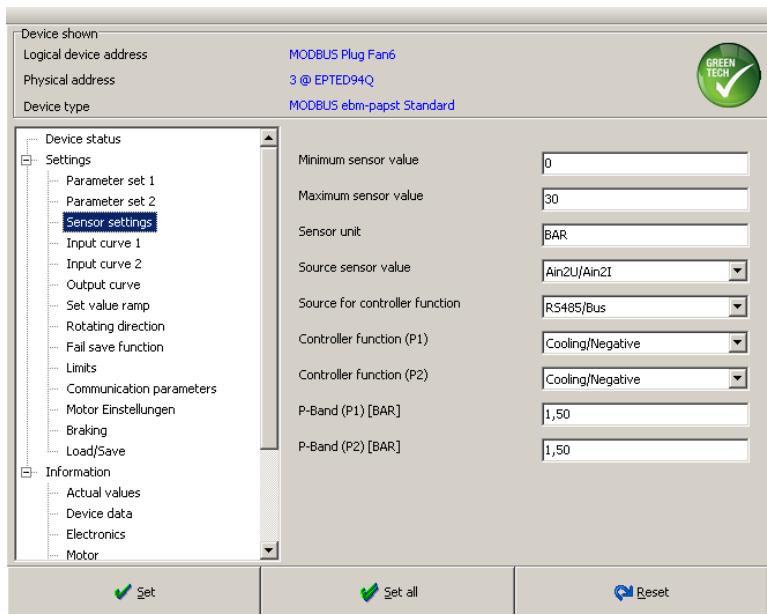


Fig. 41: Sensor settings for temperature sensor of the master

Step 2: Make sensor settings

Master fan

- Select sensor range (Max, Min), here: (30, 0) bar, can be taken from the sensor's manufacturing details
- Sensor unit: bar
- Connect sensor and select the Actual value source accordingly; Ain2U/Ain2I is provided
- Source for control function: RS485/bus
- Control function cooling/negative
- Control range: 1.5 bar

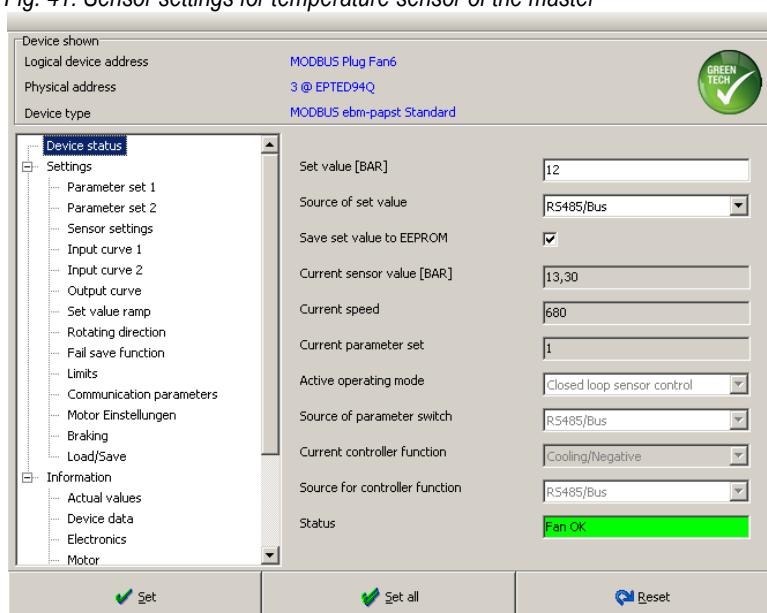


Fig. 42: Setting input of the master

Step 3: Set value input of the master

Master fan

- Activate Save set value to EEPROM
- Source of set values: RS485/bus
- Enter set value
- Set values can only be stored in the active parameter set

The slaves obtain their set value as a 0 to 10V signal through port Aout of the master via their terminals Ain1 U and GND. The output curve of the master is set as in Fig. 43. The characteristic curve is linear and selected as a function of the analogue output Act_PWM.

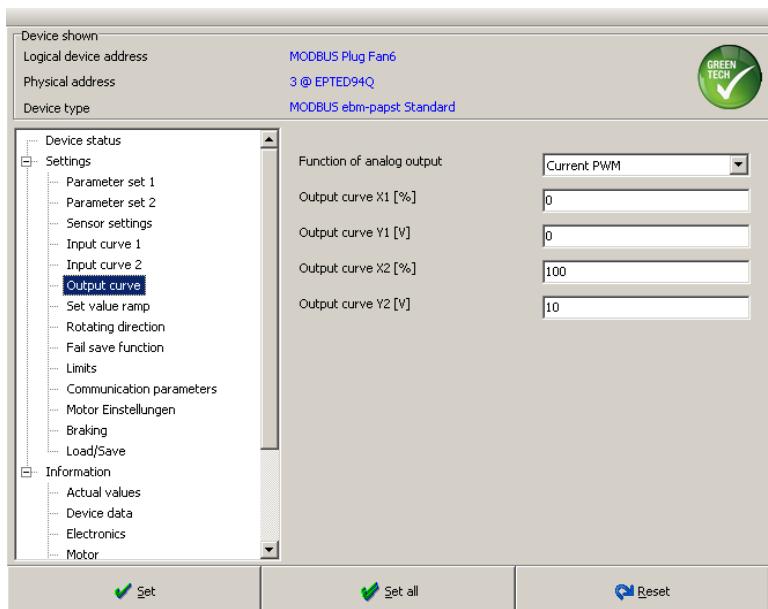


Fig. 43: Output curve for master in refrigeration plants

Step 4: Output curve of the master

Master fan

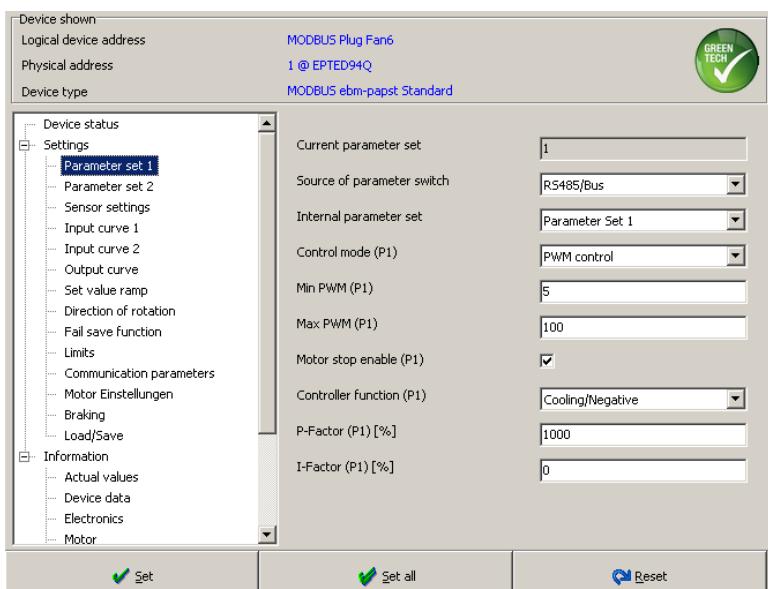
- Function of the analogue output: [Current PWM \[%\]](#)
- Output curve, linear
0% corresponds to 0V
100% corresponds to 10V

Settings for the slaves (see below):

Because no sensor and no two parameter sets are required for the slaves, their system settings are comparatively simple (see Fig. 44).

Important for slave settings:

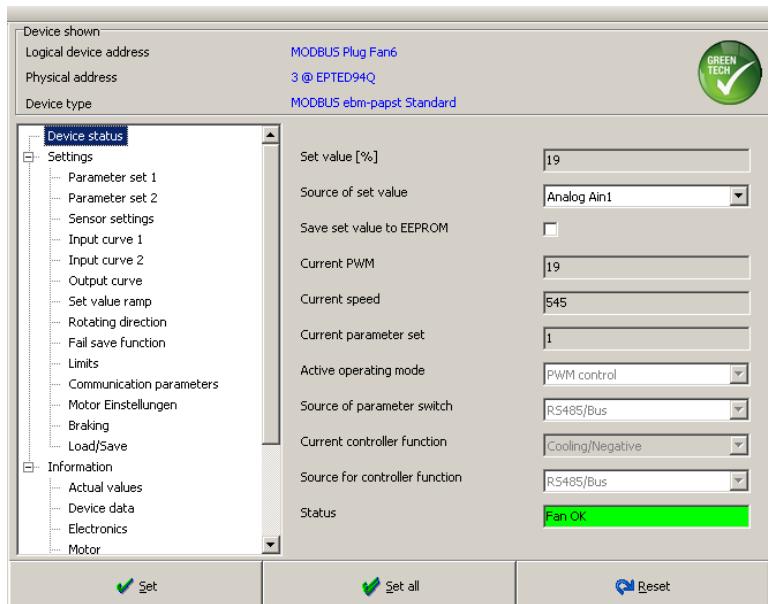
The steps 5, 6 and 7 have to be set for **ALL** slaves.



Step 5: Control mode of slaves: PWM control

Slave fans

- [Control mode: PWM control](#)
- For slaves, only one parameter set has to be configured, here P1
- [Control function](#) and [P- and I-factor](#) in [control mode PWM control](#) without significance
- Activate [Motor stop enable](#)

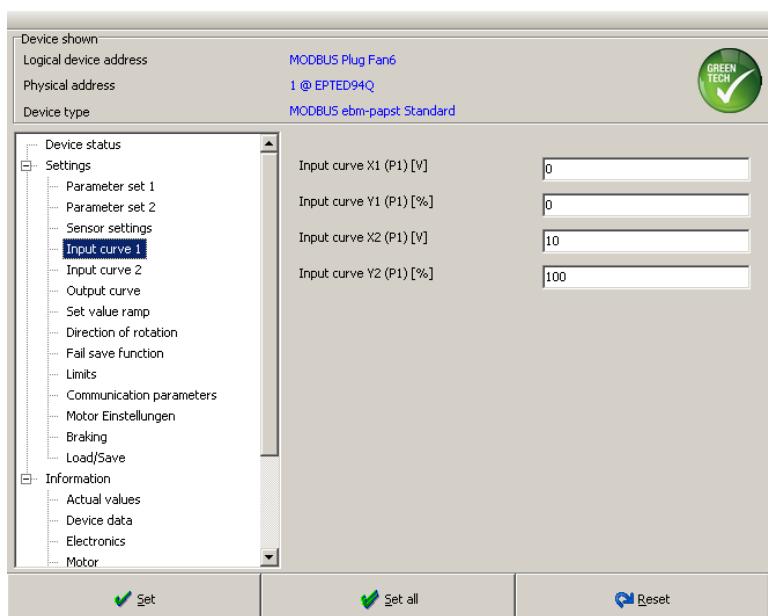


Step 6:

Overview, source of set values analogue

Slave fans

- Source of set values: Analogue Ain1
- Deactivate Save set value to EEPROM
- Slaves obtain 0 to 10V signal from the output of the master



Step 7:

Input characteristic

Slave fans

- Linear input characteristics for slaves

Fig. 44: Settings for slave fans

Fig. 45 on the next page shows the connection diagram from the master and its slaves in a refrigeration plant.

- Fans are arranged in the shape of a star
- The set value is given from the master via the output Aout as a 0 to 10V signal on a patch panel. To this distributor, the source of set values Ain1 U of the corresponding slaves is connected.
- Control mode master: Closed loop sensor control
Control mode slaves: PWM control and source of set values analogue Ain1

Advantage of this star arrangement compared to serial wiring (Series connection)

- In case of defects, just the corresponding device can be replaced very quickly and without complications, without having to break apart the system. It is, however, problematic at great distances, because significantly more lines have to be used.

Alternatively to the pressure sensor used in the example, there are also the 2-wire sensors which do not require a GND connection. Their output signal can be a current signal with 4 to 20mA. In this case, the sensor on the actual value input is Ain2 I and terminal +20V are connected (see also Chapter 4.7)

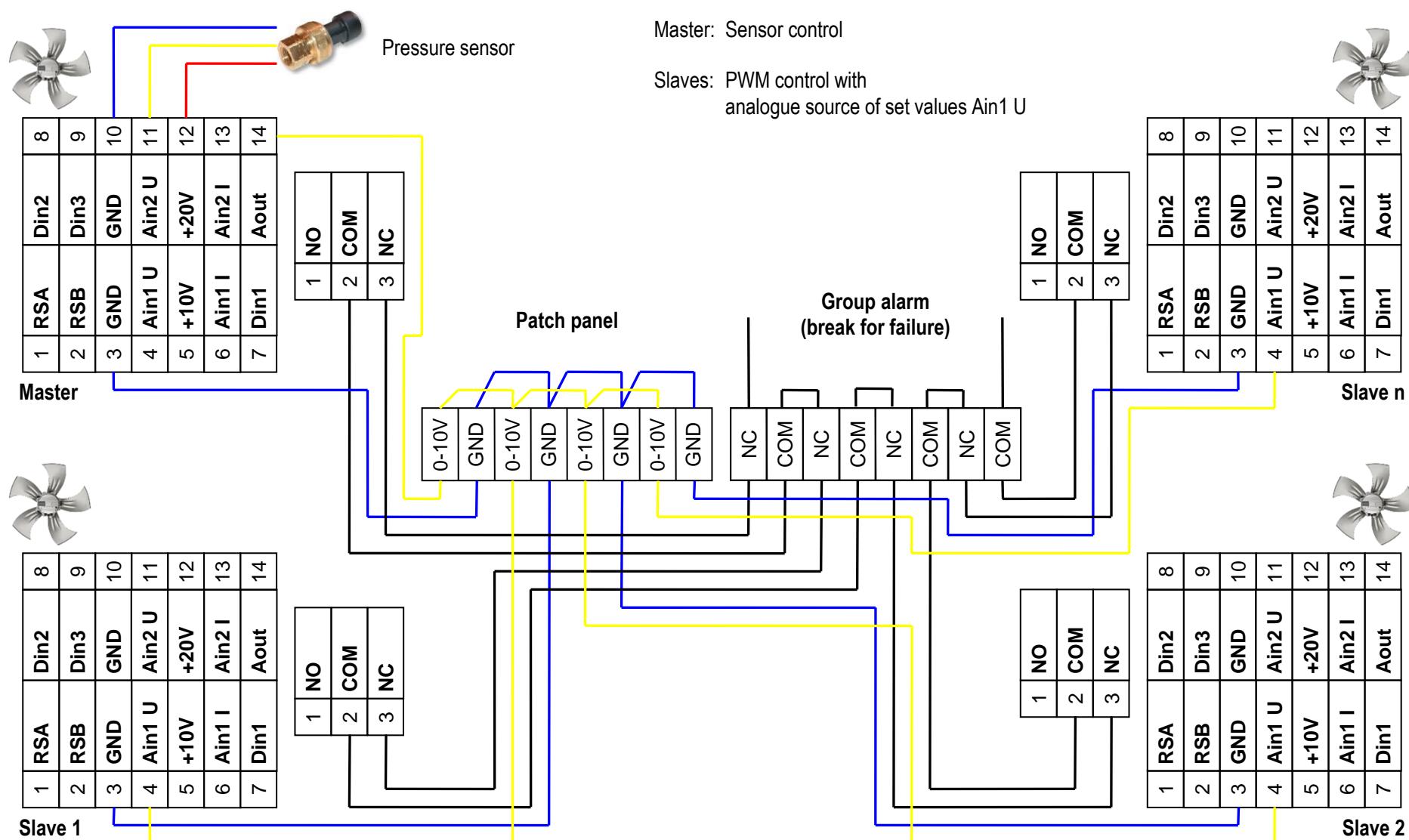


Fig. 45: Connection diagram, star-shaped master-slave Arrangement for refrigeration plants

5.1.2 Master-slave Configuration with cascade operation

Another option for the master-slave configuration is cascade operation. Via the analogue output Aout, the master forwards its set value in the form of a 0 to 10V signal to the first slave. In contrast to star-shaped arrangement from Fig. 45, the slaves here are not parallel, but rather connected in series, and the output curve of all nodes is adapted.

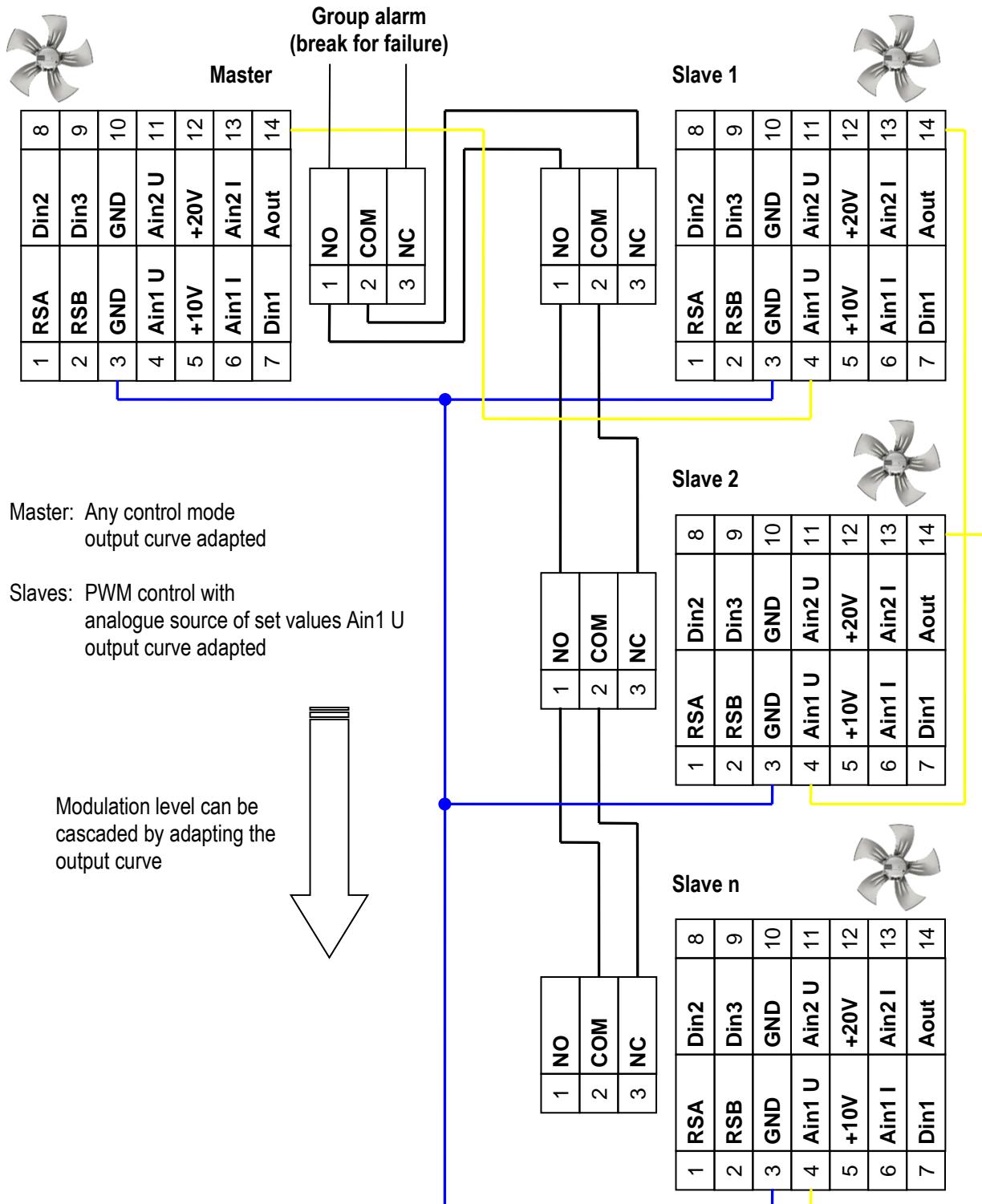


Fig. 46: Connection diagram, cascade operation, master-slave arrangement for refrigeration plants

Prerequisites for cascade operation:

- Control mode master: any
- Control mode slaves: PWM control
- Source of set values slaves: Analogue Ain1 and deactivate save set value to EEPROM
- Input characteristics of all nodes unchanged (0V/0% and 10V/100%)
- Adapted output curve for master and all slaves, ex. Fig. 47

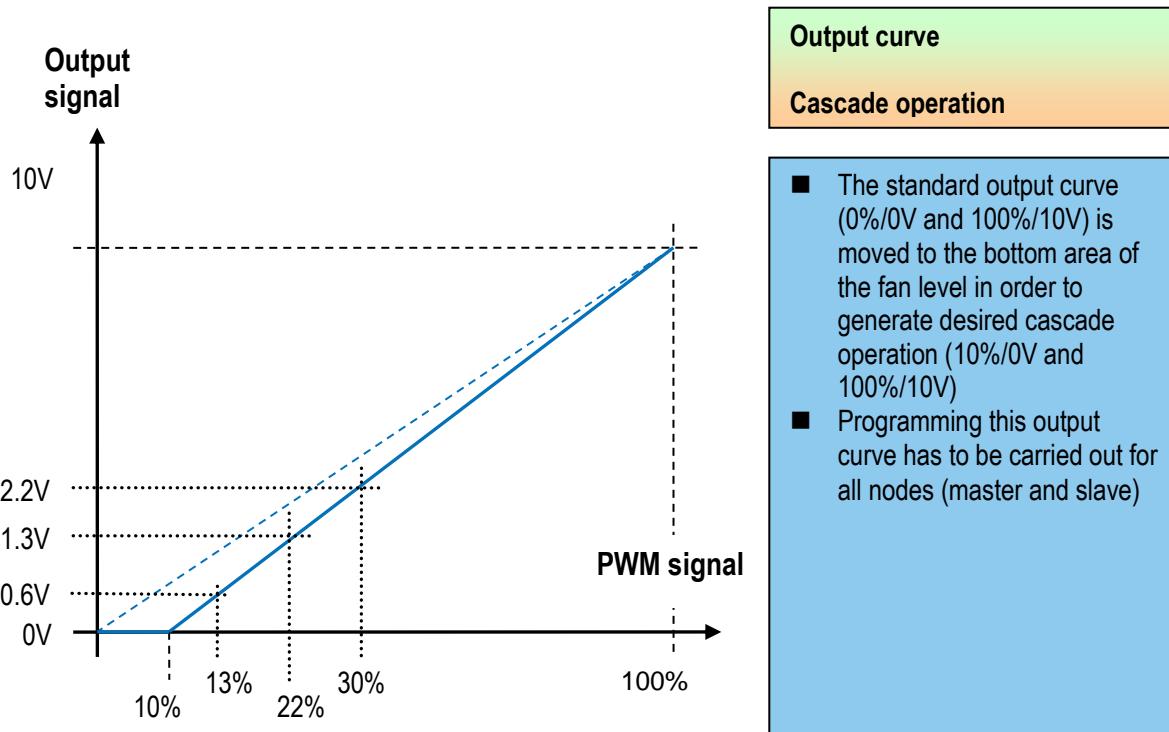


Fig. 47: Output curve for cascade operation

Fig. 47 shows an example of curve for which, at a low speed of the master, the slaves themselves take on an even lower speed in sequence. This should also lead to the last slaves in the chain being switched off.

For the above output curve, this applies:

The higher the speed of the master, the lower the difference of the speed to the other nodes becomes.
With full modulation level of the master, the slaves likewise run at 100%.

First example: **Master = 30%**. The modulation level of the master is at 30%.

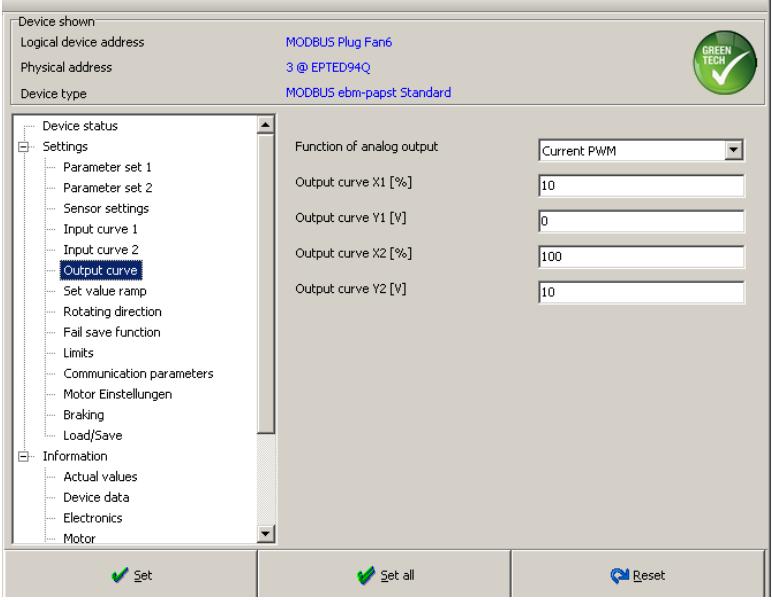
- With output curve Fig. 47, on slave 1, a signal of approx. 2.2V is output
→ Consequently, the modulation level of **slave 1 = 22%**
- Slave 1 has the same output curve as the master, and outputs a signal of approx. 1.3V to slave 2
→ Modulation level **for slave 2 = 13%**
- Slave 2 has the same output curve as the master, and outputs a signal < Switch-on threshold (0.6V) to slave 3
→ Modulation level **for slave 3 = 0%**, and thus stands still

Second example: **Master = 100%** modulation level

- With output curve Fig. 47, it outputs a signal of approx. 10V to slave 1
→ Modulation level **for slave 1 = 100%**
- Slave 1 itself has the same output curve as the master, and thus outputs a signal of approx. 10V to slave 2
→ Modulation level **for slave 2 = 100%**
- Slave 2 itself has the same output curve as the master, and thus outputs a signal of approx. 10V to slave 3
→ Modulation level **for slave 3 = 100%**

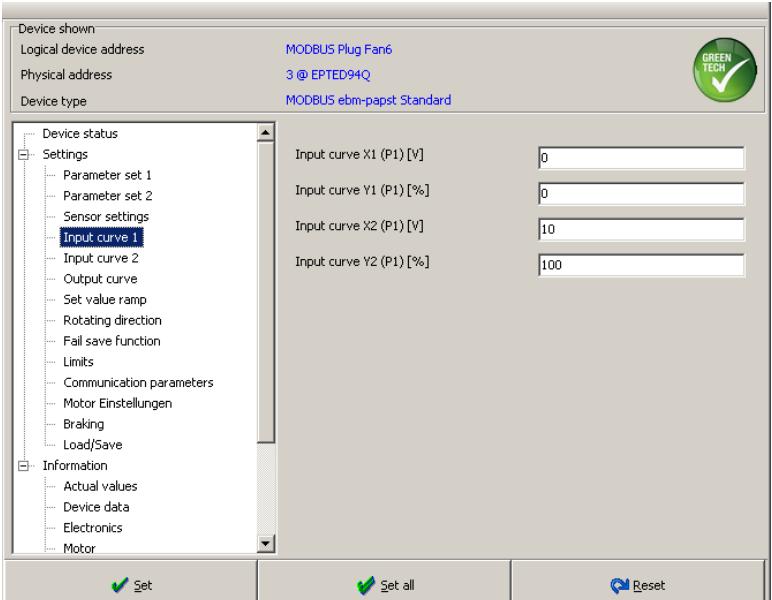
Cascade operation should only be implemented with a maximum number of nodes of 3 to 4 slaves.

Fig. 48 shows the settings which must be carried out for the input and output curve in a cascade operation according to Fig. 47 in EC-Control. Here, it is important that the input characteristics are not changed and are set to the default settings. In addition to Fig. 48, the control mode *PWM control* with source of set values *analogue Ain1* has to be selected for the slaves. The function *Save set value to EEPROM* has to be deactivated for the slaves while doing so.



Output curve

- Output curve has to be adapted by the master and all slaves
- Co-ordinate X1 shifted by 10% in comparison to standard curve



Input curve

Slave fans

- Only relevant for slaves
- Linear input characteristic
- Input characteristic has to be set to the default by all slaves (0V/0% and 10V/100%)

Fig. 48: Output and input characteristic for cascade operation

5.1.3 Reverse operation for cleaning and de-icing the exchanger

Reverse operation permits the direction of rotation of a fan to be changed. With devices which are equipped with a MODBUS interface and with a firmware protocol version later than V3.02, it is possible that the user can change the direction of rotation themselves, either via digital input or via bus.

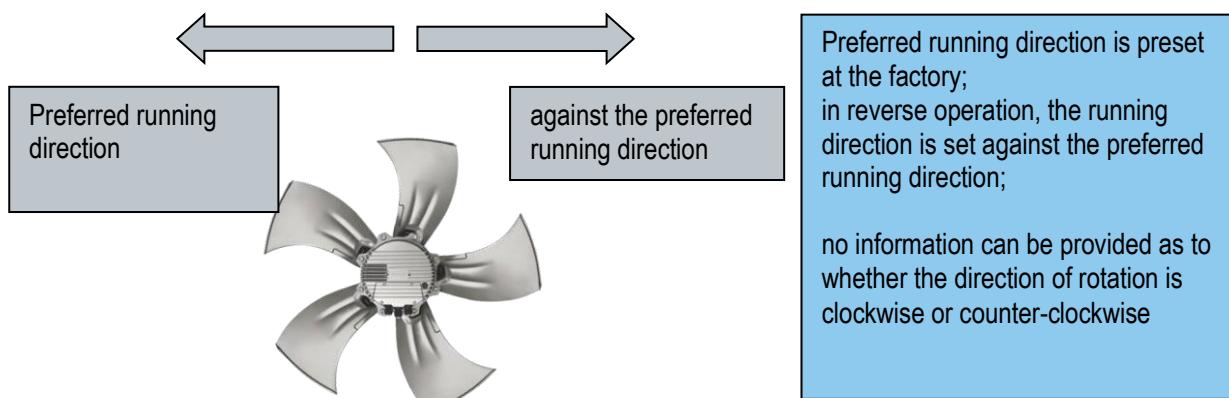


Fig. 49: Direction of rotation of an axial fan

Example: Change between two parameter sets, including reverse operation

- P1 control mode *PWM control*, direction of rotation preset according to factory settings
- P2 control mode *closed_loop_speed_control*, direction of rotation against the preferred running direction

In order to implement this mode, the following steps have to be configured one after another:

Device shown: MODBUS Plug Fan6
Logical device address: 3 @ EPTE094Q
Physical address: MODBUS ebm-past Standard

Step 1:
Configure parameter set 1

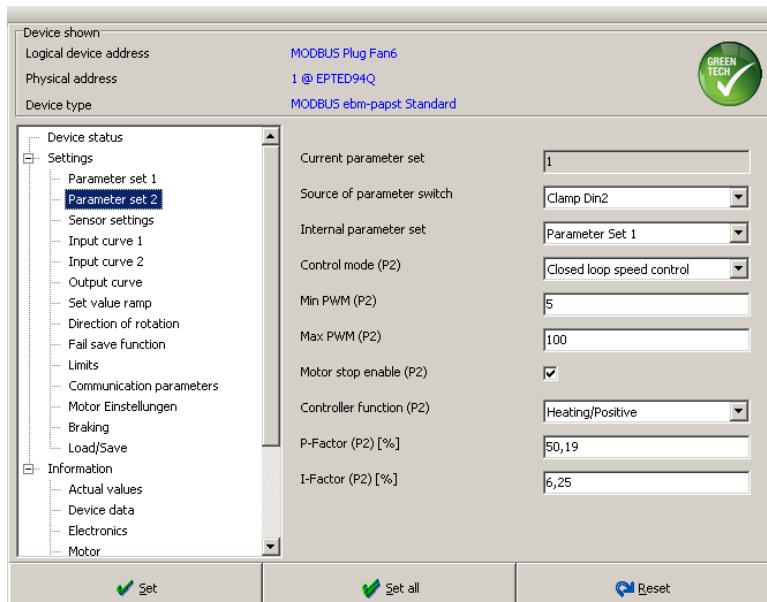
- Source for parameter set: switch terminal Din2 to the direction of rotation and at the same time change parameter set (through bridging Din2 according to GND)
- Control mode: PWM control
- P- and I-factor and control function for PWM control are irrelevant

Device shown: MODBUS Plug Fan6
Logical device address: 1 @ EPTE094Q
Physical address: MODBUS ebm-past Standard

Step 2:
Select source of set values
RS485/Bus

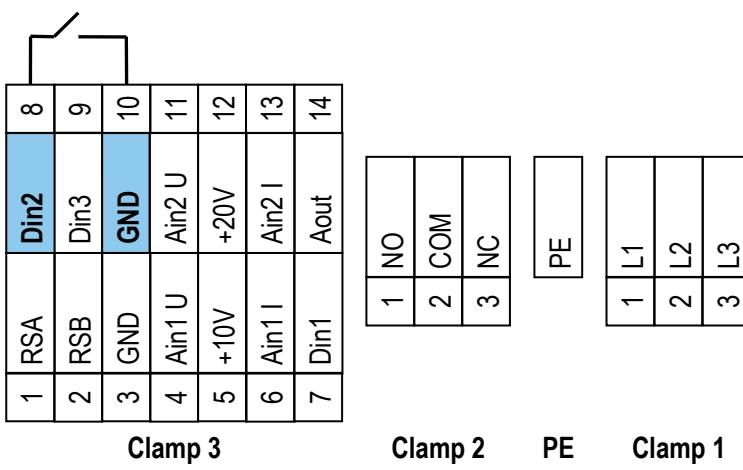
- Parameter set 1 has to be enabled
- Source of set values: RS485/bus
- Activate Save set value to EEPROM
- Enter set value [%]

Fig. 50: Parameter set 1



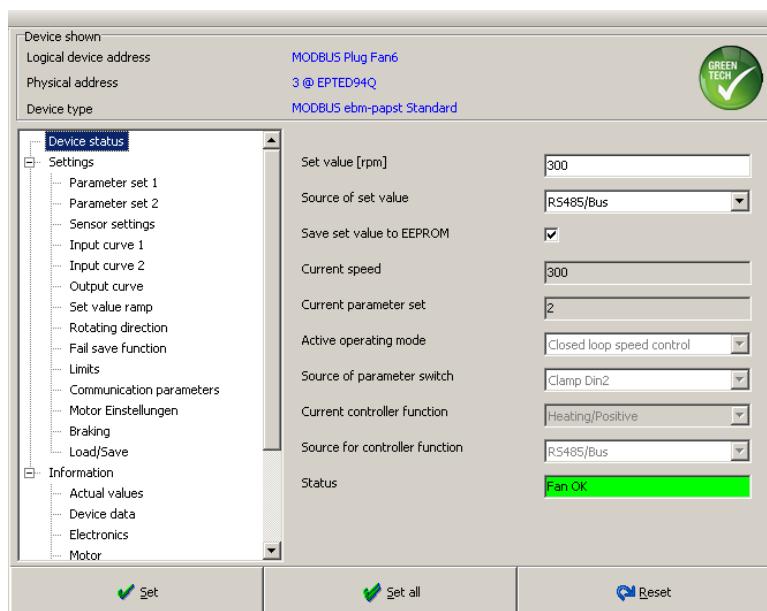
Step 3: set parameter set 2

- Source for parameter set:** Is already set to digital input terminal Din2
- Control mode:** Closed loop speed control
- P-factor:** 50%
- I-factor:** 6.25%
- Control function** for PWM control irrelevant



Step 4: activate parameter set 2

- Activate parameter set 2 by bridging from GND to Din2
- Step 5 can only be run if P2 in step 4 is enabled



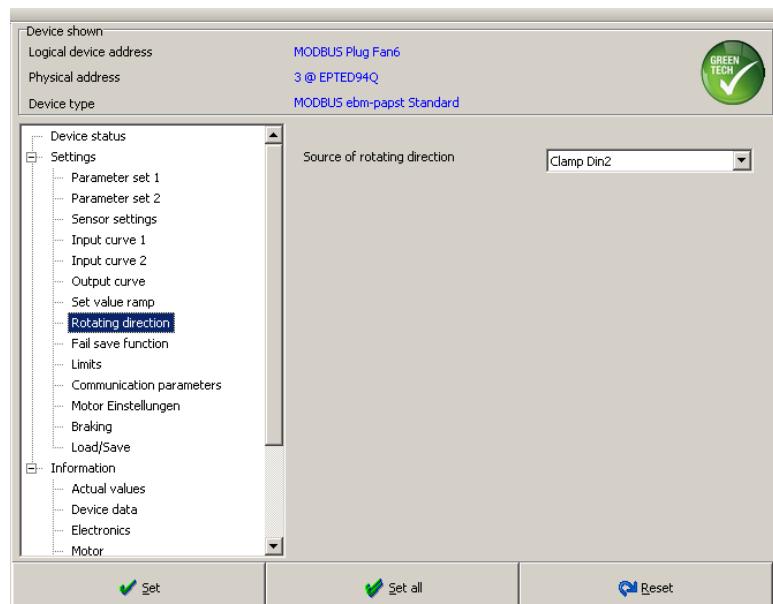
Step 5: Enter and save set value

- Parameter set 2 has to be activated beforehand (see step 4)
- Source of set values: RS485/bus
- Activate Save set value to EEPROM
- Enter set value [rpm]

Fig. 51: Parameter set 2

Parameter set 1 and preferred running direction:	Din2 open or applied voltage 5 to 50V
Parameter set 2 and reverse operation:	Bridge according to GND or applied voltage < 1V

In order to simultaneously change the direction of rotation and the parameter set, the source of rotating direction has to be the same as the source for parameter set (either terminal Din2 or terminal Din3).



Step 6: Source of rotating direction

- Source of rotating direction terminal Din2
- The source of the direction of rotation has to be the same terminal as the parameter set source

Fig. 52: Reverse operation source of rotating direction

Changing the two parameter sets and, at the same time, the direction of rotation is only done by creating a bridge from Din2 to GND.

5.2 Configuration notes for air flow control in air-conditioning units

The differential pressure approach compares the static pressure before the inlet nozzle with the static pressure inside the inlet nozzle of an EC radial fan. The air flow [m^3/h] can be calculated from the differential pressure (differential pressure of the static pressure in [Pa]) according to the following equation:

$$\dot{V} = k \times \sqrt{\Delta p_w} \quad \text{or} \quad \Delta p_w = \frac{\dot{V}^2}{k^2}$$

In the product catalogue "Plug fans with EC motor" from ebm-papst, you can find the following table for the k-factor, depending on size of the fan. The table refers to backward-curved centrifugal fans.

Inlet nozzles with measuring device to determine air flow for backward curved centrifugal fans

Part no.	Part no.	Size	k-value	For dimensions, see
25075-2-4013 ⁽¹⁾ / 25080-2-4013 ⁽²⁾		250	70	page 7
28075-2-4013 ⁽¹⁾ / 28080-2-4013 ⁽²⁾		280	93	page 9
31575-2-4013 ⁽¹⁾ / 31580-2-4013 ⁽²⁾		310	116	page 11
35675-2-4013 ⁽¹⁾ / 35680-2-4013 ⁽²⁾		355	148	page 13 / 15
40075-2-4013 ⁽¹⁾ / 40080-2-4013 ⁽²⁾		400	188	page 17
45075-2-4013 ⁽¹⁾ / 45080-2-4013 ⁽²⁾		450	240	page 19
64025-2-4013 ⁽¹⁾ / 64002-2-4013 ⁽²⁾		500	281	page 21
64030-2-4013 ⁽¹⁾ / 64001-2-4013 ⁽²⁾		560	348	page 23

subject to alterations

⁽¹⁾ with one pressure tap⁽²⁾ with piezometer ring (4 pressure taps connected by tubing)

At constant nozzle pressure, constant control of the air flow is likewise possible. The pressure-measuring point to measure Δp_w is one or four locations at the circumference of the inlet nozzle.

Example for clarification:

- Hall with footprint of 600m², height of 3m
- Air volume of the space is thus 1,800m³.
- Volume is to be replaced completely every 30 minutes by fans
→ Air flow is thus 3600 m³/h
- Product used: R3G450-AY86-01, k-factor = 240
→ Differential pressure is $(3600/240)^2 = 225$ Pa

The differential pressure in the nozzle has to be held constant at 225 Pa. The fan supplies constant volume, independent of the pressure conditions in the system. Its speed is automatically adapted along the vertical curve.

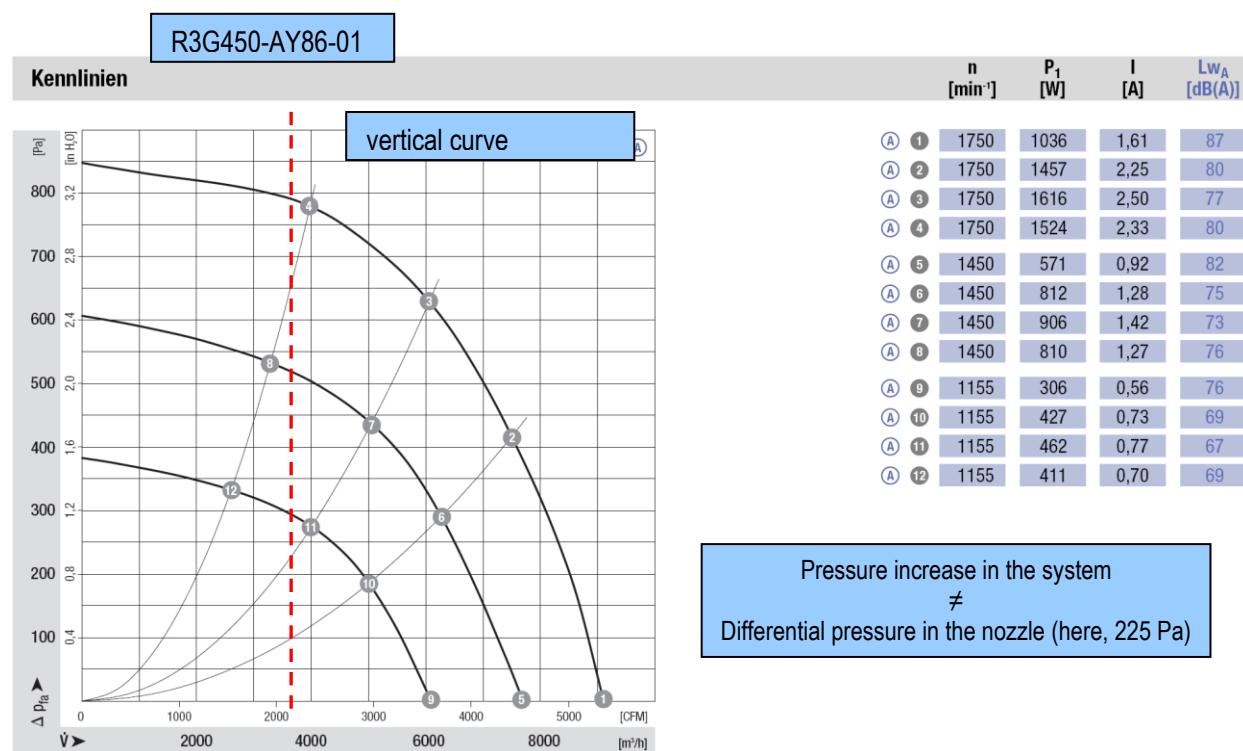


Fig. 53: Curve diagram R3G450-AY86-01

The configuration notes for EC-Control now result from the anticipated differential pressure in the nozzle.

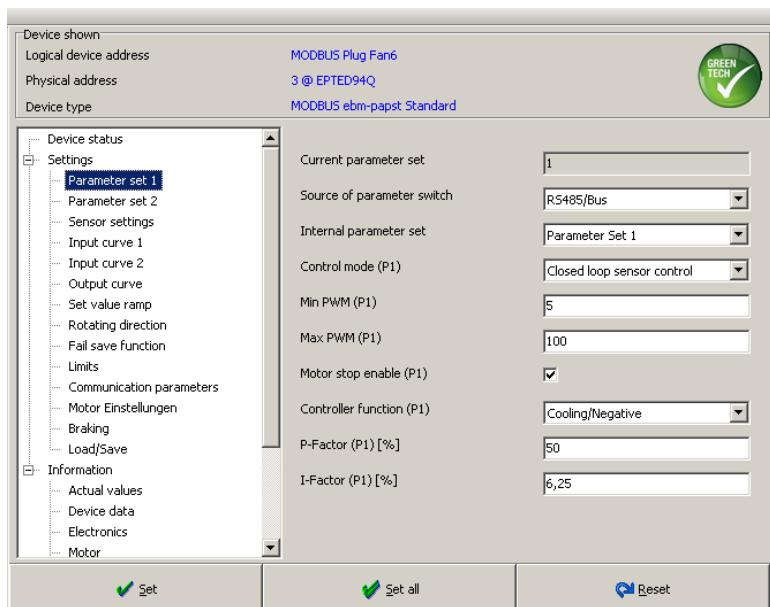


Fig. 54: Parameter set 1

Step 1: Configure parameter set 1

- Control mode: Sensor control
- Source for parameter set:
RS485/bus
- P-factor: 50%
I-factor: 6.25%
- Activate parameter set 1

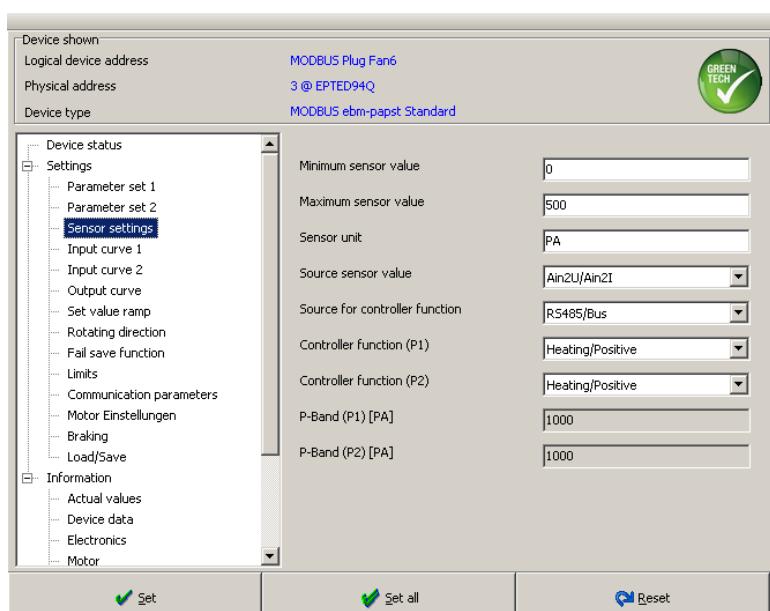


Fig. 55: Sensor settings, pressure sensor

Step 2: Sensor settings, 0 to 500 Pa

- With 0 to 500 Pa sensor
Min. sensor value: 0 Pa
Max. sensor value: 500 Pa
- Sensor unit: Pa
- Select Source for sensor value correspondingly
- Alternative sensor type:
0 to 1000 Pa
- Set controller function to Heating/Positive for both parameter sets

5.2.1 Digital setting of values for air flow control, such as day/night switchover

By changing the differential pressure in the nozzle, the air flow can also be changed in accordance with the equation in Chapter 5.2. For the above example with the plug fan R3G450-AY86-01, a k-factor of 240 and a 0 to 500 Pa pressure sensor results from the curve in Fig. 56. For the ratio of differential pressure to sensor voltage, this applies:

- a differential pressure of 500 Pa corresponds to a sensor voltage of 10V.
- a differential pressure of 225 Pa corresponds to a sensor voltage of 4.5V
(see Fig. 56, dotted line)
- A differential pressure of 0 Pa corresponds to a sensor voltage of 0 V

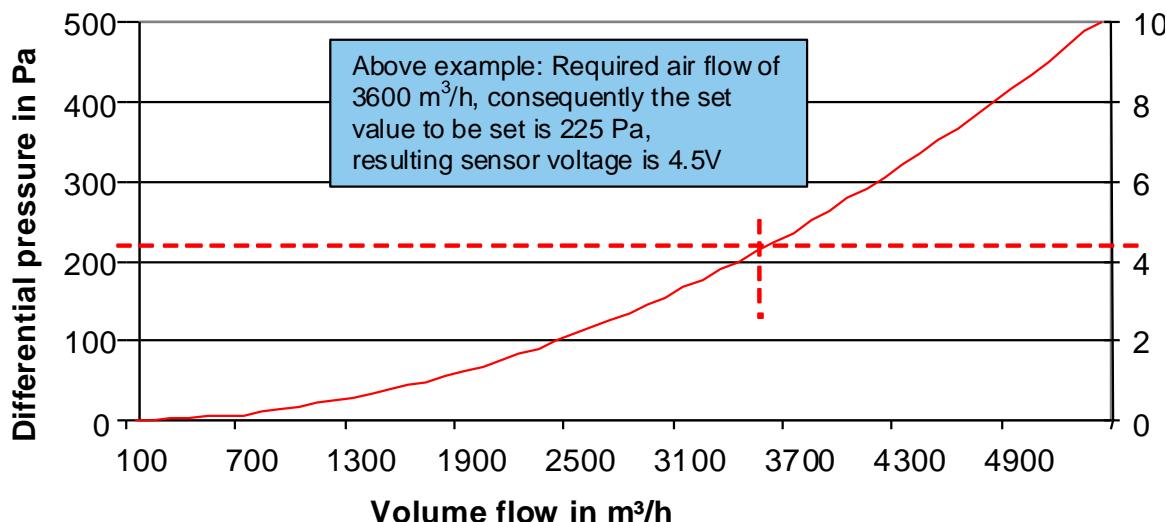


Fig. 56: Pressure, volume flow rate curve

After all settings from Chapter 5.2 have been made, you can now enter the set value of the differential pressure (225 Pa) under Overview to finish (see Fig. 57). The digital set value input is done via EC-Control. Through maintaining a constant pressure of 225 Pa in the nozzle, a constant volume is guaranteed – here, 3,600m³/h.

Step 3a: Set value via RS485/bus

- Set value here: **225 Pa**
- Day switchover
- Source of set values: **RS485/bus**
- Activate Save set value to EEPROM
- Enter required differential pressure under Set value in order to control constant air flow
- Set value ≈ Actual value

Fig. 57: Digital setting of values parameter set 1, differential pressure 225 Pa, enter set value for day switchover

Optionally, a **second parameter set** can be defined, for example, for a so-called **day/night switchover**:

After the sensor settings were made, you must proceed as follows to store set values for P1 and P2 (clicking Set is necessary after each step):

- Under parameter set 1, activate parameter set 1 and make settings (see Fig. 54)
- Under Overview, save the function Save set value to EEPROM (see Fig. 57)
- Under Overview, enter the set value (see Fig. 57)
- Under parameter set 2, activate parameter set 2 and make settings (see Fig. 58)
- Under Overview, activate the function Save set value to EEPROM (see Fig. 59)
- Under Overview, enter the set value (see Fig. 59)

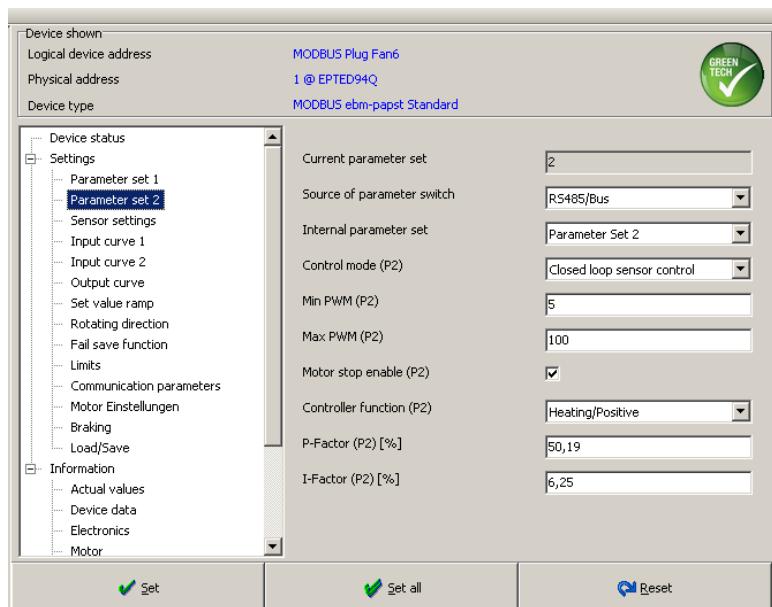


Fig. 58: Parameter set 2

Step 4: Set parameter set 2

- Control mode: Closed loop sensor control
- P-factor: 50%
- I-factor: 6,25%
- Activate parameter set 2

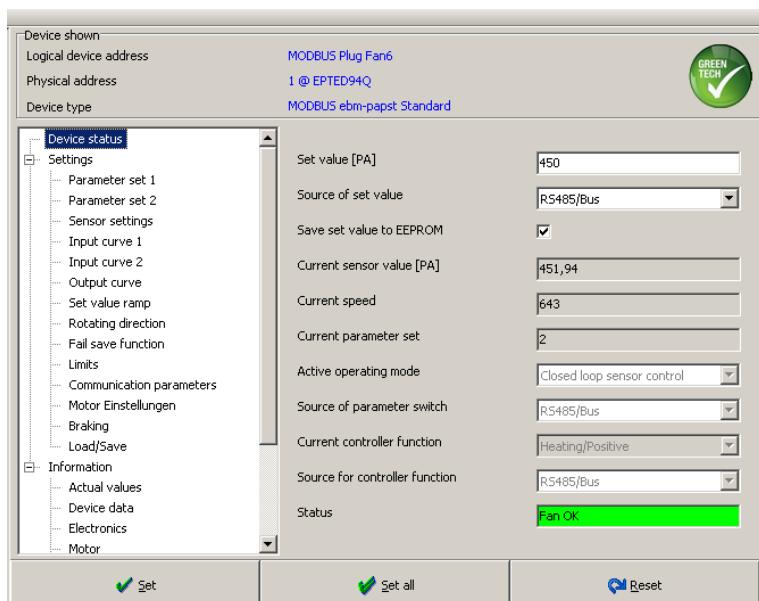


Fig. 59: digital setting of values for parameter set 2, differential pressure 450 Pa, enter set value for night switching

Step 5: Set value via RS485/bus

- Set value here: 450 Pa
- Night switching
- Source of set values: RS485/bus
- Activate Save set value to EEPROM
- Enter required differential pressure under Set value in order to control constant air flow
- Set value ≈ Actual value

5.2.2 Analogue setpoint input during air flow control

Optionally, for digital setting of values from Chapter 5.2.1, it is possible to prescribe the set value in a similar way via the inputs Ain1 U or Ain1 I. Fig. 60 shows, for example, the connection of a potentiometer for setting of values for the air flow control.

Day / night switchover with two different set values is not possible with an analogue source of set values. Steps 4 and 5 in the above example thus are omitted from this chapter.

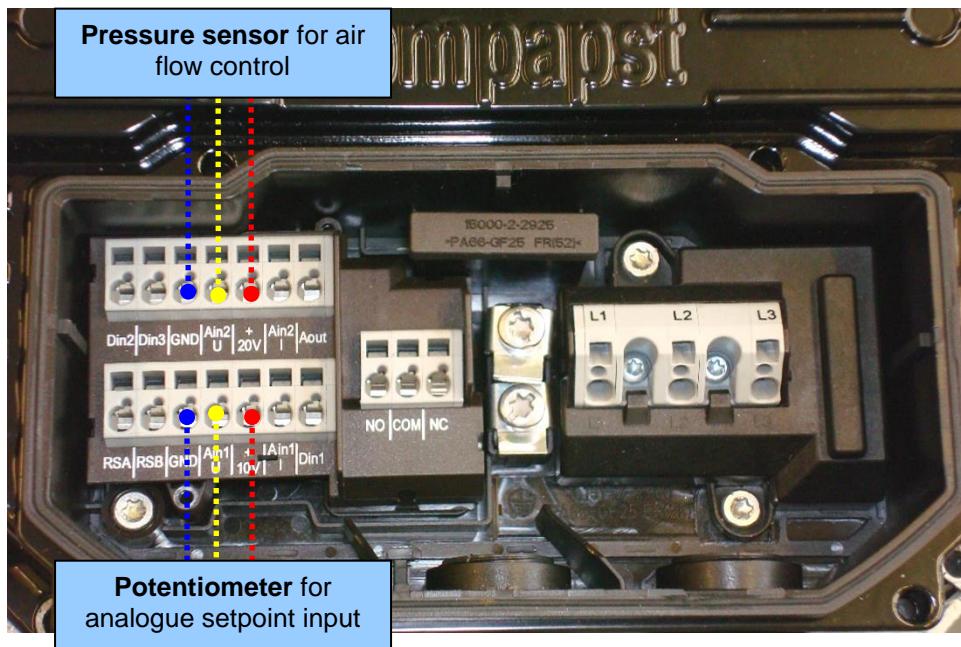


Fig. 60: Analogue setpoint input via potentiometer during air flow control

In EC-Control, additional settings have to be carried out (in addition to the configuration already discussed in Chapter 5.2). The Source of set values has to be changed to Analogue Ain1 in this, and the function Save set value to EEPROM must be disabled.

Step 3b:
Set value input analogue via Ain1

- Source of set values: Analogue Ain1
- Deactivate Save set value to EEPROM
- Set required differential pressure with external source of set values in order to regulate constant air flow
- Set value \approx Actual value

Fig. 61: Analogue setpoint input, differential pressure 225 Pa, configure set point via potentiometer

5.3 Temperature control – any control characteristic with temperature sensor

Temperature-controlled systems are found in many applications. In order to enable the initial operation of such control for the customer, the following subchapters explain setting a control characteristic.

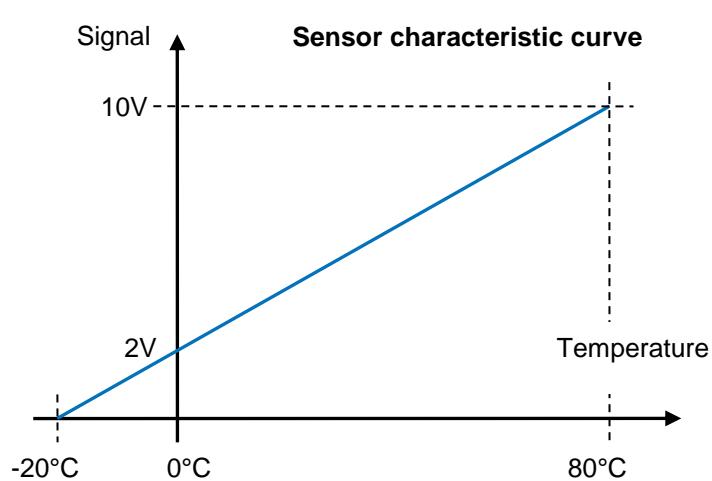
In order to measure the actual value with a temperature sensor and, from it, form an individual control characteristic, some settings are to be carried out. The following sensor is used for the example.



- Temperature sensor ebm-papst
- Art. No. 50005-1-0174
- Measuring range -20°C to 80°C
- connect to:
+20V
Ain2 U
GND

Fig. 62: Standardised temperature sensor Art. No. 50005-1-0174

For the temperature sensor, you obtain the sensor characteristic curve from Fig. 63.



- 0-10V signal from the sensor output runs linear to the measuring range (-20°C to 80°C)

Fig. 63: Sensor characteristic curve for temperature sensors

In order to simplify the configuration of the control range for the user, the following formula

$$\text{Control range} = \frac{\text{sensor range}}{\text{P factor}} \times 100\%$$

is already contained in EC-Control, as the comparison in Fig. 64 shows. It is valid as soon as the I-factor is 0%.

Step 1: pure P-control

- Control mode: Closed loop sensor control
- P-factor 1000%
- I-Factor 0%
- for temperature regulation pure P-control
- Control function: cooling/negative

Step 2: Temperature sensor settings

- Sensor range: -20°C to 80°C
- Source for sensor value: Ain2U/Ain2I
- Source for control function: RS485/bus
- Control range P1: 10°C

$$\text{Control range} = \frac{80^\circ\text{C} - (-20^\circ\text{C})}{1000\%} \times 100\% = 10^\circ\text{C}$$

Fig. 64: Control range and P-factor

You can change the control range and the P-factor via two selection windows. Because the two values are dependent on each other, when entering the P-factor, the control range changes automatically and vice-versa. If the I-factor is greater than 0%, the input window is greyed out (see Fig. 64, control range parameter set 2).

The significance of the control range of temperature regulation can be explained through the following example settings from Fig. 65.

Device status
Logical device address: MODBUS Plug Fan6
Physical address: 3 @ EPTE094Q
Device type: MODBUS ebm-past Standard

Set value [°C] 20
Source of set value RS485/Bus
Save set value to EEPROM
Current sensor value [°C] 22,06
Current speed 582
Current parameter set 1
Active operating mode Closed loop sensor control
Source of parameter switch RS485/Bus
Current controller function Cooling/Negative
Source for controller function RS485/Bus
Status Fan OK

Set Set all Reset

Step 3 (two ex.): Enter temperature set value

Example 1:

- in [°C]
Set value: 20
Actual value: 21.99
Control deviation: 1.99
Control range: 10
- with modulation level 20% and speed 574 rpm

Upper control deviation:
 $21.99^{\circ}\text{C} - 20.0^{\circ}\text{C} = 1.99^{\circ}\text{C}$

Lower control deviation:
 $25.02^{\circ}\text{C} - 20.0^{\circ}\text{C} = 5.02^{\circ}\text{C}$

Example 2:

- in [°C]
Set value: 20
Actual value: 25.02
Control deviation: 5.02
Control range: 10
- with modulation level 50% and speed 1,561 rpm

Fig. 65: Temperature regulation with control deviation of 2°C and a difference of 5°C

By enlarging the control deviation, the modulation level increases.
In the above example, the full speed of the motor would be reached if the actual value - in other words, the current temperature measured by the sensor - reached 30°C and the set value would continue to be 20°C.

Depending on the control range, the corresponding control characteristics can be generated, as in Fig. 66. The control range of the above example corresponds to control characteristic 2. The two control deviations of 2°C and 5°C are additionally plotted in the illustration. If we would select too large a control range for the above control deviation, for example, control characteristic 4, then the motor would run at the same temperature actual value with a very low speed.

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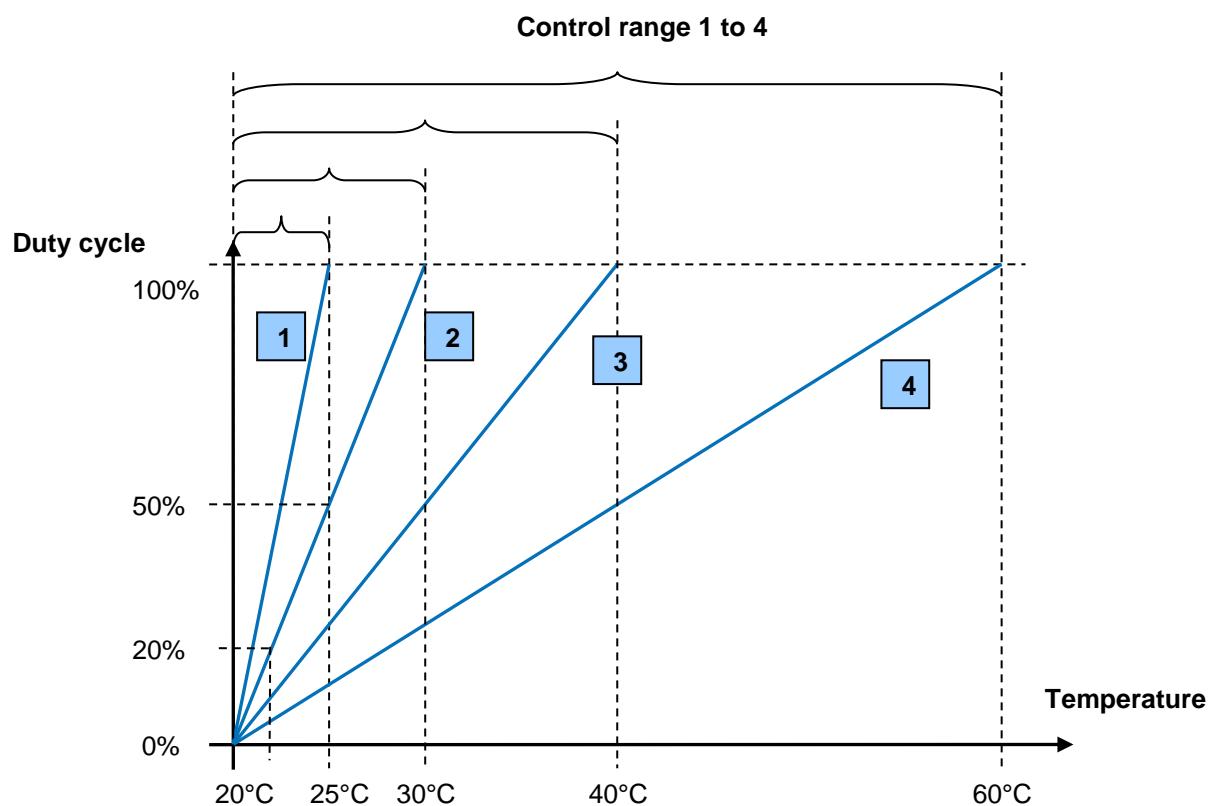


Fig. 66: Four example control characteristics for different control ranges

List of datapoints

A. List of data points

Holding Register

Parameters	available in MODBUS version					Register	Type: value	Data point/ Controller variables
	V5.0x	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
Reset	●	●	●	●	●	D000	uint16: 0-64000 2=Parameter-Reset	Reset_hxD000
Set-value	●	●	●	●	●	D001	uint16: 0-65535 at OL-PWM / CL sensor Ctrl uint16: 0-64000 at Operating mode CL-speed Ctrl.	SetValue_hxD001
Operating hours h	●	●	●	●	●	D009	uint16: 0-65535	OpHours_hxD009
Serial number mask for software DCI	-	-	●	-	-	D013 -D014 D015	char: 4 Character ASCII-coded: uint16: MSB(D015)=CY; LSB(D015) = CW	SoftDCI_hxD013
Device address / MODBUS Slave ID	●	●	●	●	●	D100	uint16: 1-247	SlaveID_hxD100
Reference value maximum speed 1/min	●	●	●	●	●	D119	uint16: 0 -65535	MaxSpeed_hxD119
Reference value max. DC link voltage	●	●	●	●	●	D1A0	uint16: 0 -65535	MaxUz_hxD1A0
Reference value max. DC link current	●	●	●	●	●	D1A1	uint16: 0 -65535	MaxIz_hxD1A1
Serial number	●	●	●	●	●	D1A2 - D1A3	char: 4 Character ASCII-coded: MSB(D1A2), LSB(D1A2), MSB(D1A3), LSB(D1A3)	SerialNumber_hxD1A2
Date of production	●	●	●	●	●	D1A4	uint16: 0-65535 Production week = LSB(D1A4) Production year = MSB(D1A4)	ProdDate_hxD1A4
Fan type	●	●	●	●	●	D1A5 - D1AA	char: 12 Character ASCII-coded: continuously MSB(D1A5), LSB(A1A5), MSB(D1A6) etc.	PartNumber_hxD1A5
DCI-Relay	-	-	●	-	-	D61B	boolean: 0=Relay open, 1 Relay closed	ForwardDCI_hxD61B
Remote Output / Impulse output for auto addressing or analogue output				●		D010	uint16: 0-65535 0xFFFF (0x0000) corresponds 100% (0%), usually translated into 10V (0V) depending on the output function; Note on pulse duration: ON-time (100%) must be > 333ms for auto addressing funtion	RemoteOutput_hxD010

List of data points

Holding Register (configuration):

Parameters	available in MODBUS version					Register	Type: value	Data point/ Controller variables
	V5.0x	V5.0x Lite	DCI	V6.x	ACE			
Set value priority	●	●	●	●	●	D101	uint16: 0-65535 1= Set value source RS485/Bus	SetValuePrio_hxD101
Save set value in EEPROM	●	●	●	●	●	D103	uint16: 0-65535 0=Do not save set value. PLC starts motor	SetValueSave_hxD103
Source parameter set	●	●	●	●	●	D104	uint16: 0-65535 0=internal (Bus)	ParamSetPrio_hxD104
Select active parameter set internal	●	●	●	●	●	D105	uint16: 0-65535 0=P1	ParamSetSelect_hxD105
Select operating mode	●	●	●	●	●	D106	uint16: 0=CL Speed Ctrl. 1=CL Sensor Ctrl. 2=OL PWM Ctrl.	OpModeSelect_hxD106
Select Sensor				●) ²	D147		uint16: 0-65535 5= Volume-Flow Control	SensorSelect_hxD147
Set auto addressing function				●	●	D00C	uint16: 0-65535 0=disable 1=enable	SetAutoAddr_hxD00C
Set auto-addressing mode: clock or analogue output				●	D130		uint16: 0-65535 4=clock output (fixed at MODBUS-ACE) 5=remote control	SetAutoAddrMode_hxD130
Enable Mask-out control				●	D603		uint16: binary coded Bit0 enable Mask-out control 1=enabled, 0=disabled Bit1=step control mode 1=pre-step, 0=post-step	MaskOutControl_hxD603
Reset	●	●	●	●	●	D000	uint16: 0-65535 2=Parameter-Reset	Reset_hxD000

List of datapoints

Input Register

Parameters	available in MODBUS version					Register	Type: value	Data point/ Controller variables
	V5.0x	V5.0x Lite	DCI Gen. 1	V6.x	ACE			
Identification	●	●	●	●	●	D000	uint16: 0-65535	DevID_ixD000
Actual Speed 1/min	●	●	●	●	●	D010	uint16: 0-64000 *Formula: D010 / 64000 x D119 1/min	ActSpeed_ixD010
Actual PWM modulation level	●	●	●	●	●	D019	uint16: 0-65535	ActPWM_ixD019
Motor status: errors	●	●	●	●	●	D011	uint16: binary coded: MSB 0 0 0 UzLow 0 0 0 0 LSB BLK HLL TFM FB SKF TFE 0 PHA	Alarm_ixD011
Motor Status: warnings	●	●	●	●	●	D012	uint16: binary coded: MSB LRF UeHigh 0 UzHigh Heizung Kabelbr. n_Low reserviert LSB Brems UzLow TEI_high TM_high TE_high P_Limit L_high I_Limit	Warning_ixD012
DC link voltage	●	●	●	●	●	D013	uint16: 0-255 *Formula: D013 / 256 x D1A0 x 20 mV	Uz_ixD013
DC link current	●	●	●	●	●	D014	uint16: 0-255 *Formula: D014 / 256 x D1A1 x 2 mA	Iz_ixD014
Power Module temperature °C	●	●	●	●	●	D015	uint16: 0-65535	ModuleTemp_ixD015
Motor temperature	●	●	●	●	●	D016	signed int16: -32768 - +32767	MotorTemp_ixD016
Electronics temperature °C	●	●	●	●	●	D017	uint16: 0-65535	ElectonicTemp_ixD017
Power (relative)	●	●	●	●	●	D021	uint16: 0-65535 Formel: D021 / 65536 x D1A0 x D1A1 x 0,04 mW	Power_ixD021
Actual value sensor 1	●	●	-	●	●	D023	uint16: 0-65535	Ain1_ixD023
Actual value sensor 2	●	● ¹⁾	-	●	●	D024	uint16: 0-65535	Ain2_ixD024
Energy consumption (kWh-meter)				●	●	D029-D02A	uint16: 2 Register MSB x 2 ¹⁶ + LSB kWh D029 x 2 ¹⁶ + D02A kWh	EnergyCounter_ixD029
Status Enable Input	●	-	-	●	-	D10C	uint16: 0=disabled; 1=enabled	StatusEnable_ixD10C

List of data points

MEMS Status				●) ³		D04B	unit16: binary coded: MSB 0 0 0 0 0 0 0 0 0 LSB 0 0 0 Bereiche XE_Err Testlauf Limit Ausbl.	StatusMEMS_ixD04B
Volume flow rate m ³ /h				●) ²	D033		uint16: 0-65535 m ³ /h	VolumeFlow_ixD033
Mass flow rate kg/h					D034		uint16: 0-65535 kg/h	MassFlow_ixD034
Temperature I ² C Sensor 1				●) ²	D02E		uint16: 0-65535 T=D02E / 10 °C	TempSensor1_ixD02E
Humidity I ² C Sensor 1				●) ²	D02F		uint16: 0-65535 Rth=D02F / 65535 x 100%	HumiditySensor1_ixD02F
Temperature I ² C Sensor 2				●) ²	D030		uint16: 0-65535 T=D030 / 10 °C	TempSensor2_ixD030
Humidity I ² C Sensor 2				●) ²	D031		uint16: 0-65535 Rth=D031 / 65535 x 100%	HumiditySensor2_ixD031
Power in W				●	D027		uint16: 0-65535 W	PowerW_ixD027
Temperature PT1000 Sensor1				●) ²	D038		uint16: 0-65535 °C	PT1000_1_ixD038
Temperature PT1000 Sensor2				●) ²	D039		uint16: 0-65535 °C	PT1000_2_ixD039

)¹ = not available if only one analog port present

)² = for system solution only, only relevant for RadiCal in spiral housing

)³ = only for MODBUS 6.2

)⁴ = not available for MODBUS Lite 5.00

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