SOLAR ELECTRIC

KOSTAL

Smart connections.

Operating manual

PIKO inverter
3.0 - 20

Legal notice

Exclusion of liability

All names, trademarks, product names or other designations given in this manual may be legally protected even if this is not labelled as such (e.g.as a trademark). KOSTAL Solar Electric GmbH accepts no liability and gives no assurance that they can be freely used. The illustrations and texts have been compiled with great care. However, the possibility of errors cannot be ruled out. The compilation is made without any guarantee.

General note on gender equality

KOSTAL Solar Electric GmbH is aware of the importance of language with regard to the equality of women and men and always makes an effort to reflect this in the documentation. Nevertheless, for the sake of readability we are unable to use non-gender-specific terms throughout and use the masculine form instead.

Software version as of FW: 05.08
User Interface (UI) as of: 05.30

Contents

1. General information

Thank you for choosing a PIKO inverter from KOSTAL Solar Electric GmbH! We hope you will enjoy consistently high energy yields with the PIKO inverter and your photo-voltaic system.

If you have any technical questions, please call our service hotline:

- Germany and other countries [1]
  +49 (0)761 477 44 - 222

- France, Belgium, Luxembourg
  +33 16138 4117

- Greece
  +30 2310 477 555

- Italy
  +39 011 97 82 420

- Spain, Portugal [2]
  +34 961 824 927

- Turkey [3]
  +30 2310 477 555

[1] Language: German, English

[2] Language: Spanish, English

[3] Language: English, Turkish

1.1 Proper use

The PIKO inverter converts direct current into alternating current. This can be used as follows:

- For self-consumption

- For feeding into the public grid

The device may only be used in grid-connected photo-voltaic systems within the permissible power range and under the permissible ambient conditions. The device is not intended for mobile use.

Inappropriate use can be hazardous and lead to injury or even death to the user or third parties. Material damage to the device and other equipment can also occur. The inverter may therefore only be used for its intended purpose.

Exclusion of liability ⚠

Any use that differs from or goes beyond the stated intended purpose is considered inappropriate. The manufacturer accepts no liability for any damage resulting from this. Modifications to the inverter are prohibited. The inverter may only be used if safe to operate and in technically perfect condition. Any instance of misuse will cause the termination of the warranty, guarantee and general liability of the manufacturer.

Only a qualified electrician may open the device. The inverter must be installed by a trained electrician (according to DIN VDE 1000-10 or BGV A3 accident prevention regulations) who is responsible for observing the applicable standards and regulations.

Work that could affect the electrical power system of the relevant energy supply company at the site of the solar energy feed-in may only be carried out by qualified electricians expressly authorised (licensed) by the energy supply company. This includes changes to the factory-preset parameters. The installer must always observe the regulations of the energy supply company.

Factory settings may only be changed by qualified electrical installers or persons with at least comparable or higher technical qualifications, e.g. foremen, technicians or engineers. When doing so, all requirements are to be observed.

> **!** **IMPORTANT INFORMATION**
>
> The inverter may only be installed, maintained and repaired by a trained and qualified electrician.
>
> The electrician is responsible for ensuring that the applicable standards and regulations are observed and implemented. Work that could affect the electrical power system of the relevant energy supply company at the site of the solar energy feed-in may only be carried out by qualified electricians expressly authorised (licensed) by the energy supply company.
>
> This includes changes to the factory-preset parameters.

1.2 EU declarations of conformity

EU Declaration of Conformity PIKO 3.0 as of FW 5.0

The company

KOSTAL Solar Electric GmbH
Hanferstraße 6
79108 Freiburg i. Br., Germany

herewith declares that the inverters **PIKO 3.0 as of FW 5.0**, to which this declaration refers, are compatible with the following directives or standards.

Directive 2004/108/EC on the approximation of the laws of the Member States relating to electromagnetic compatibility

Directive 2006/95/EC on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits
Application of the CE mark in accordance with Annex III, Section B: 2012

Directive 2011/65/EU (RoHS)
to limit the use of certain hazardous substances in electrical and electronic equipment

EN 61000-3-2:2006/A1:2009/A2:2009 (Harmonic currents)

EN 61000-3-3:2013 (Patchers)

EN 61000-6-2:2005/AC:2005 (Immunity for industrial environments)

EN 61000-6-3:2007/A1:2011 (Immunity for residential environments)

EN 62109-1: 2010 (Safety of power converters for use in photovoltaic power systems – Part 1)

EN 62109-2: 2011(Safety of power converters for use in photovoltaic power systems – Part 2)

This declaration applies to all identical specimens of the product. This declaration becomes invalid if a change is made to the unit or the unit is improperly installed.

KOSTAL Solar Electric GmbH – 01/01/2015

Werner Palm   Dr. Armin von Preetzmann
(Managing Director)   (Vicepresident R&D)

This declaration certifies compatibility with the guidelines named, but does not contain any assurance of properties.

Observe the safety instructions in the enclosed product documentation!

EU Declaration of Conformity PIKO 4.2, 5.5, 7.0, 8.5 as of FW 5.0

The company

KOSTAL Solar Electric GmbH
Hanferstraße 6
79108 Freiburg i. Br., Germany

herewith declares that the inverters **PIKO 4.2, 5.5, 7.0, 8.5 as of FW 5.0**, to which this declaration refers, are compatible with the following directives or standards.

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EN 61000-3-2:2006/A1:2009/A2:2009 (Harmonic currents)

EN 61000-3-3:2013 (Patchers)

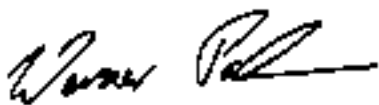EN 61000-6-2:2005/AC:2005 (Immunity for industrial environments)

EN 61000-6-3:2007/A1:2011 (Immunity for residential environments)

EN 62109-1: 2010 (Safety of power converters for use in photovoltaic power systems – Part 1)

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EU Declaration of Conformity PIKO 10, 12 as of FW 5.0

The company

KOSTAL Solar Electric GmbH
Hanferstraße 6
79108 Freiburg i. Br., Germany

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Directive 2006/95/EC on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits
Application of the CE mark in accordance with Annex III, Section B: 2013

Directive 2011/65/EU (RoHS)
to limit the use of certain hazardous substances in electrical and electronic equipment

EN 61000-3-2:2006/A1:2009/A2:2009 (Harmonic currents)

EN 61000-3-3:2013 (Patchers)

EN 61000-3-11:2000 (Patchers)

EN 61000-3-12:2011 (Harmonic currents)

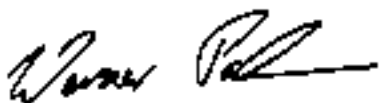EN 61000-6-2:2005/AC:2005 (Immunity for industrial environments)

EN 61000-6-3:2007/A1:2011 (Immunity for residential environments)

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Hanferstraße 6
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Directive 2004/108/EC on the approximation of the laws of the Member States relating to electromagnetic compatibility

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EN 61000-3-12:2011 (Harmonic currents)

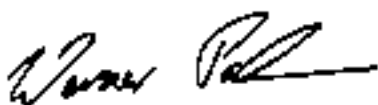EN 61000-6-2:2005/AC:2005 (Immunity for industrial environments)

EN 61000-6-3:2007/A1:2011 (Immunity for residential environments)
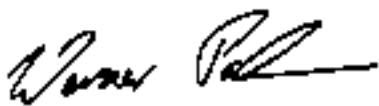
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(Safety of power converters for use in photovoltaic power systems – Part 1)

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Observe the safety instructions in the enclosed product documentation!

1.3 About this manual

Read this manual carefully in its entirety. 🅸

It contains important information about the installation and operation of the inverter. Pay particular attention to the instructions regarding safe usage. KOSTAL Solar Electric GmbH assume no liability for damages arising from failure to observe these instructions.

This manual is an integral part of the product. It applies exclusively to the PIKO inverters from the company KOSTAL Solar Electric GmbH! Keep this manual and pass it on to the new owner should you switch to a new provider.

The most recent version of the operating manual for your product is available in the download area at www.kostal-solar-electric.com.

Target group

These instructions are oriented to the trained and qualified electrical technicians who install, maintain and repair the inverters.

The inverters described in these instructions differ from one another in terms of particular technical details. Information and instructions that only apply to certain device types are to be identified accordingly.

Information concerning your safety or that of the unit is highlighted especially.

i   **TIP**

Print both sides on one sheet of paper when printing out this operating manual.

This saves paper and the document remains easy to read.

Navigation through the document

In order to enable navigation through this document, it contains clickable areas.

These are, for one, the navigation bar in the header of each page. Here you can go to the overview pages of the individual chapters with a click.

The table of contents can also be used in this way. From the index at the beginning of each chapter you can go to the indicated sub-chapter with a click.
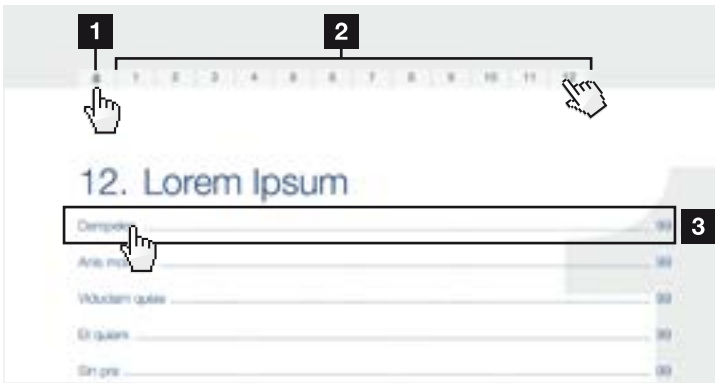

Fig. 1: Navigation through the document

1 Calling up the main table of contents
2 Navigation bar
3 Tables of contents

You can navigate to the referenced points in the document within the instruction text using the cross-references.

⬀ Ch. 1

⬀ Fig. 1, It. 2

Fig. 2: Examples of cross-references

1.4 Notes in this manual
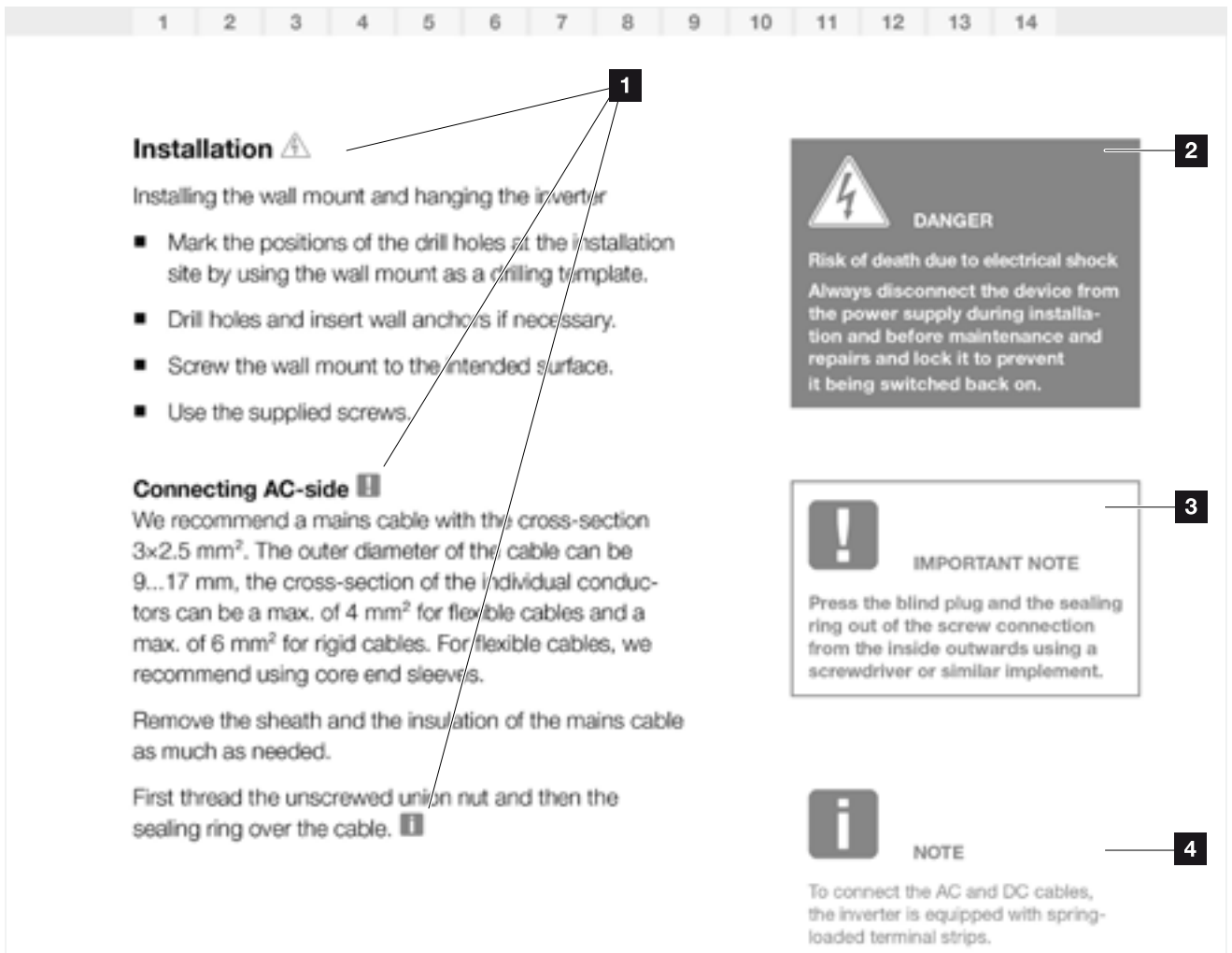

Fig. 3: Safety instructions in this manual

1   Reference icon within the instruction text
2   Warning
3   Information note
4   Other notes

Notes have been incorporated into the instruction text.
A differentiation is made in these instructions between
warnings and information notes. All notes are identified in
the text line with an icon.

Warnings

The warnings refer to life-threatening dangers. Serious injuries possibly resulting in death may occur.

Each warning consists of the following elements:

Fig. 4: Structure of the warnings

1 Warning symbol
2 Signal word
3 Type of danger
4 Corrective actions

Warning symbols

 Danger

 Danger due to electrical shock and discharge

 Danger due to electromagnetic fields

 Danger due to burns

Signal words

Signal words are used to identify the severity of the danger.

DANGER

Indicates a direct hazard with a high level of risk, which, when it is not avoided, can result in death or serious injury.

WARNING

Indicates a hazard with a moderate level of risk, which, when it is not avoided, can result in death or serious injury.

CAUTION

Indicates a hazard with a low level of risk, which, when it is not avoided, can result in minor or slight injury or property damage.

Information notes

Information notes contain important instructions for the installation and problem-free operation of the inverter. These must be followed at all times. The information notes also point out that failure to observe can result in property or financial damages.
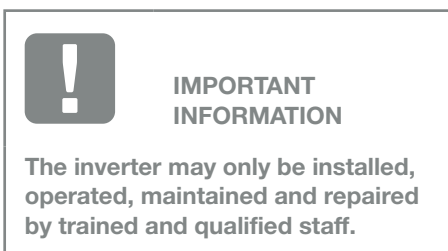
!	**IMPORTANT INFORMATION**
	The inverter may only be installed, operated, maintained and repaired by trained and qualified staff.

Fig. 5: Example of an information note

Symbols within the information notes

! Important information

⚠ Property damage possible

Other notes

They contain additional information or tips.

ℹ **INFO**

This is additional information.

Fig. 6: Example of an information note

Symbols within the additional notes

ℹ Information or tip

🔍 Enlarged representation

1.5 Symbols used

Symbol	Meaning
1), 2), 3) ...	Sequential steps in a handling instruction
→	Effect of a handling instruction
✓	Final result of a handling instruction
◪	Cross-reference to other places in the document or to other documents
■	List

Tab. 1: Symbols and icons used

Abbreviations used

Abbreviation	Explanation
Tab.	Table
Fig.	Figure
It.	Item
Ch.	Chapter

1.6 Labels on the inverter
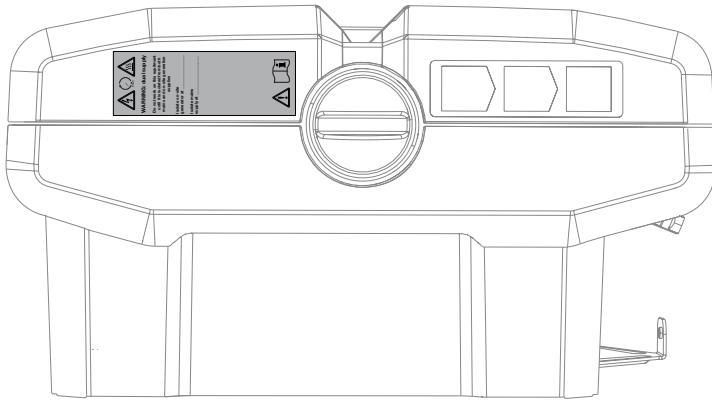
Fig. 7: Labels on the inverter – Figure example

Signs and labels are applied to the housing of the inverter. These signs and labels may not be altered or removed.

Symbol	Explanation
	Danger due to electrical shock and discharge
	Danger due to electrical shock and discharge. Wait five minutes (discharge time of the capacitors) after shut-down
	Danger due to burns
	Danger notice
	Additional earth connection
	Observe and read operating manual

2. Device and system description

2.1 The photovoltaic system
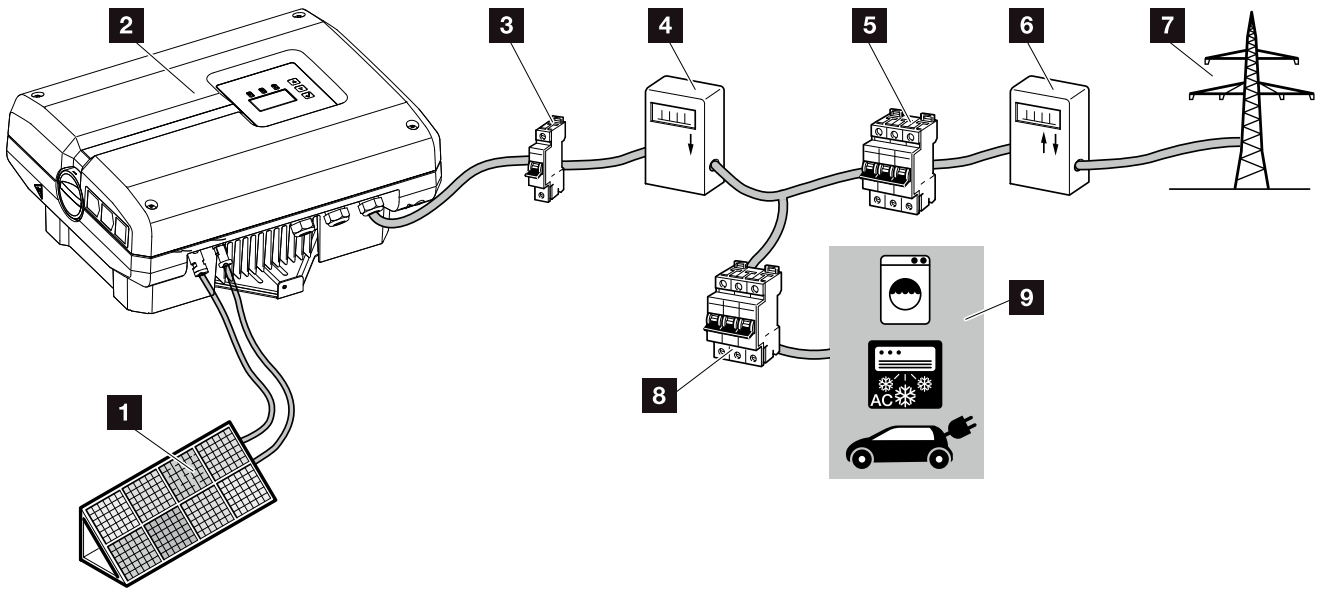
Fig. 8: Photovoltaic system 1-phase

1	PV string
2	Inverter
3	Line circuit breaker inverter
4	PV yield counter (optional)
5	Line circuit breaker for building
6	Feed-in procurement meter
7	Public grid
8	Line circuit breaker for energy consumers
9	Energy consumers
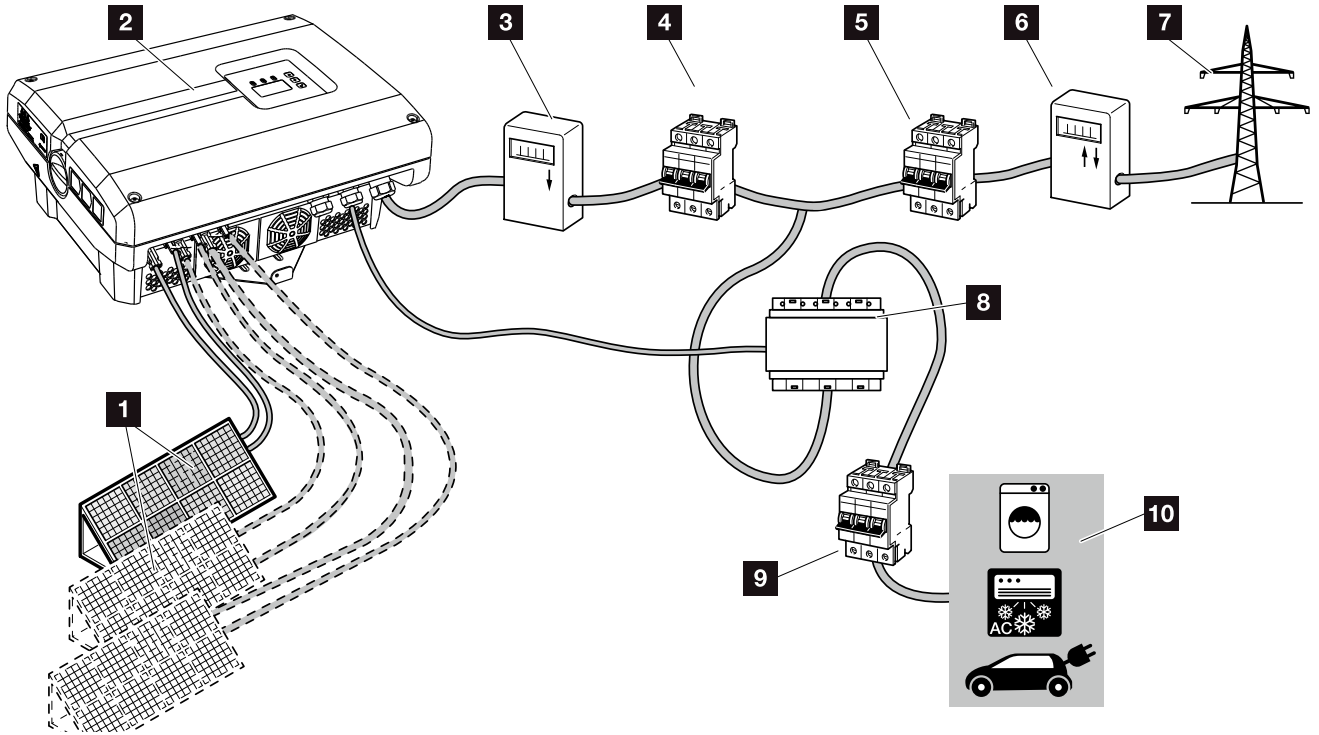
Fig. 9: Photovoltaic system 3-phase

1   PV string (2+3 optional / dependent upon type)

2   Inverter

3   PV yield counter (optional)

4   Line circuit breaker inverter

5   Line circuit breaker for building

6   Feed-in procurement meter

7   Public grid

8   PIKO BA Sensor (optional accessories)

9   Line circuit breaker consumer

10   Energy consumers

2.2 Inverter components

Exterior view of the inverter

Fig. 10: PIKO inverter 3.0 (exterior view)

1 Cover screws

2 Cover

3 Display

4 DC switch

5 Housing

6 Plug connector or cable openings to connect the solar modules

7 Wall mount

8 Cable openings for optional communication

9 Opening for the mains cable

Fig. 11: PIKO inverter 4.2 (exterior view)

1 Cover screws

2 Cover

3 Display

4 DC switch

5 Housing

6 Plug connector or cable openings to connect the solar modules

7 Fan grill (without fan)

8 Wall mount

9 Cable openings for optional communication

10 Opening for the mains cable

Fig. 12: PIKO inverters 5.5 - 8.5 (exterior view)

1 Cover screws

2 Cover

3 Display

4 DC switch

5 Housing

6 Plug connector or cable openings to connect the solar modules

7 Fan

8 Wall mount

9 Cable openings for optional communication

10 Opening for the mains cable
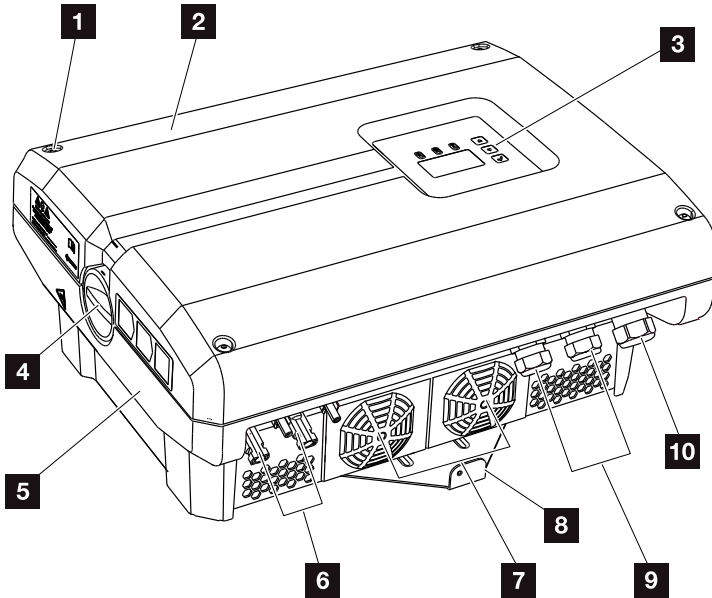
Fig. 13: PIKO inverters 10 - 12 (exterior view)

1 Cover screws
2 Cover
3 Display
4 DC switch
5 Housing
6 Plug connector or cable openings to connect the solar modules
7 Fan
8 Wall mount
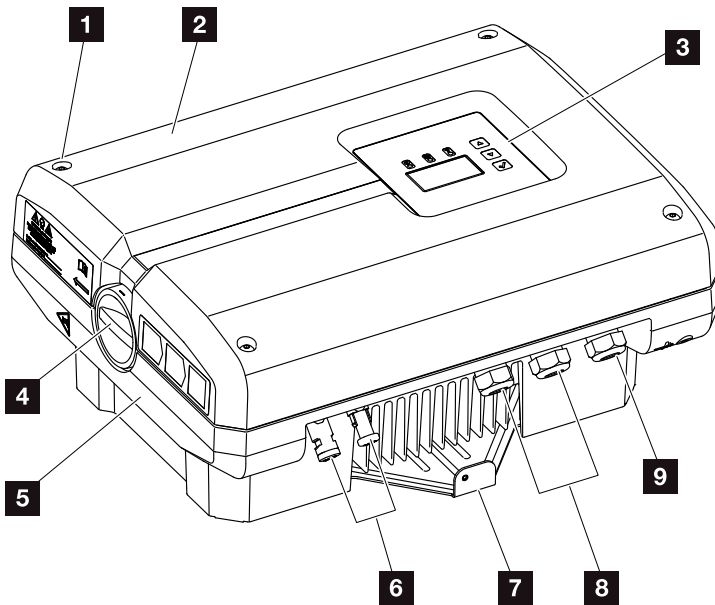9 Cable openings for optional communication
10 Opening for the mains cable
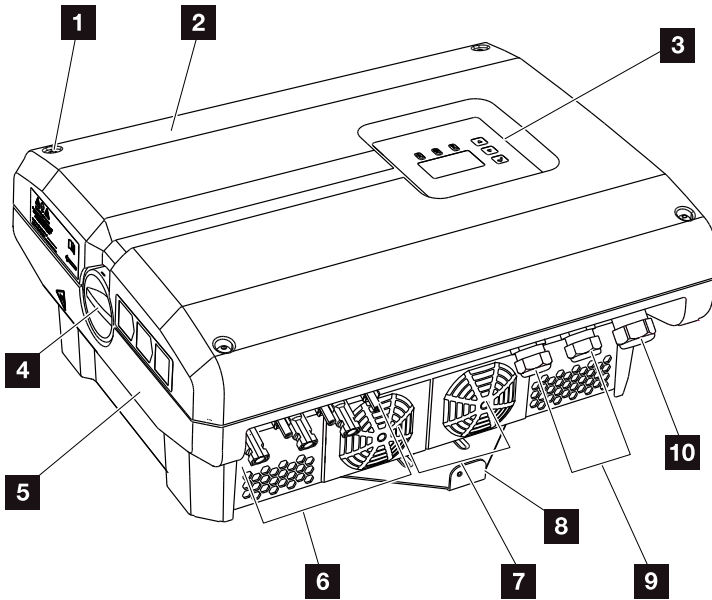
Fig. 14: PIKO inverters 15 - 20 (exterior view)

1 Cover screws
2 Cover
3 Display
4 DC switch
5 Housing
6 Plug connector or cable openings to connect the solar modules
7 Fan
8 Wall mount
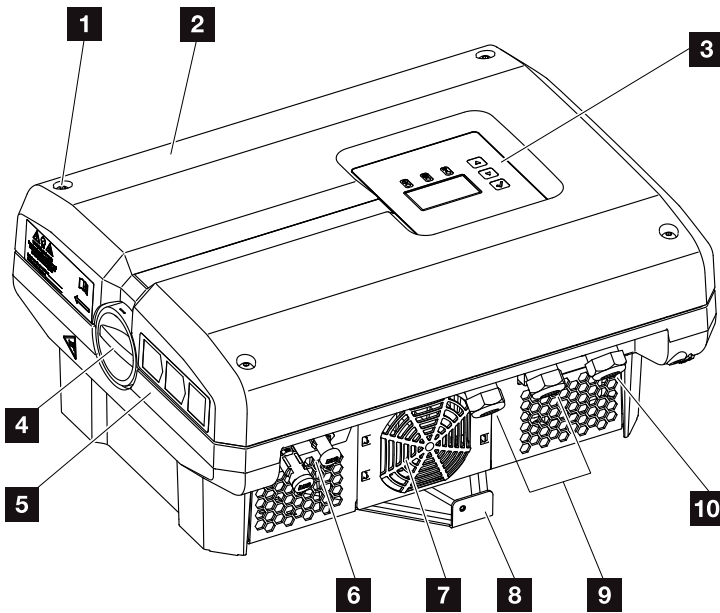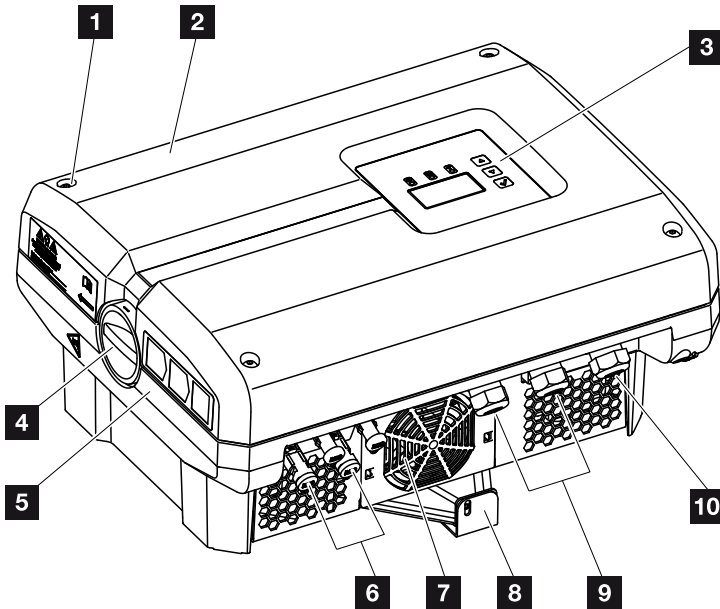9 Cable openings for optional communication
10 Opening for the mains cable

DC switch on the inverter
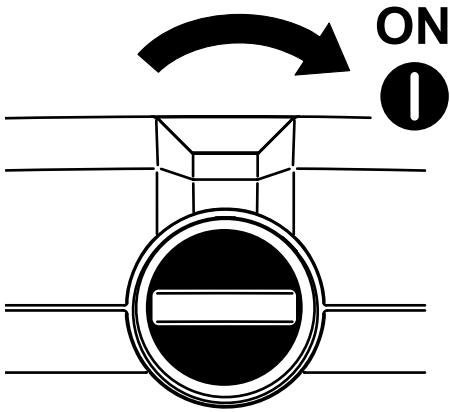
Fig. 15: DC switch ON
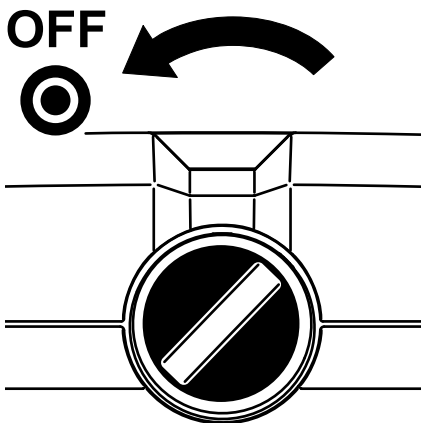
Fig. 16: DC switch OFF

Interior view of the inverter
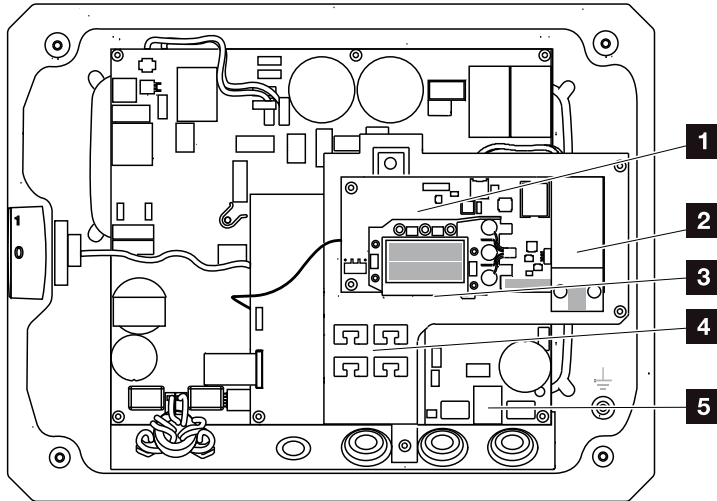
Fig. 17: PIKO inverter 3.0 (interior view)

1 Communication board
2 Expansion module (e.g. GSM modem, optional)
3 Ethernet connections (RJ45)
4 Cable tray with fastening openings
5 AC terminal
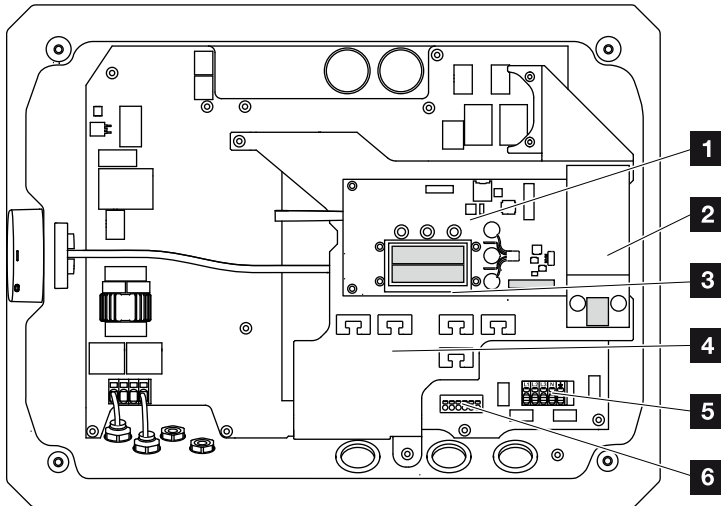
Fig. 18: PIKO inverter 4.2 (interior view)

1 Communication board
2 Expansion module (e.g. GSM modem, optional)
3 Ethernet connections (RJ45)
4 Cable tray with fastening openings
5 AC terminal
6 Terminal for sensor lines of PIKO BA Sensor
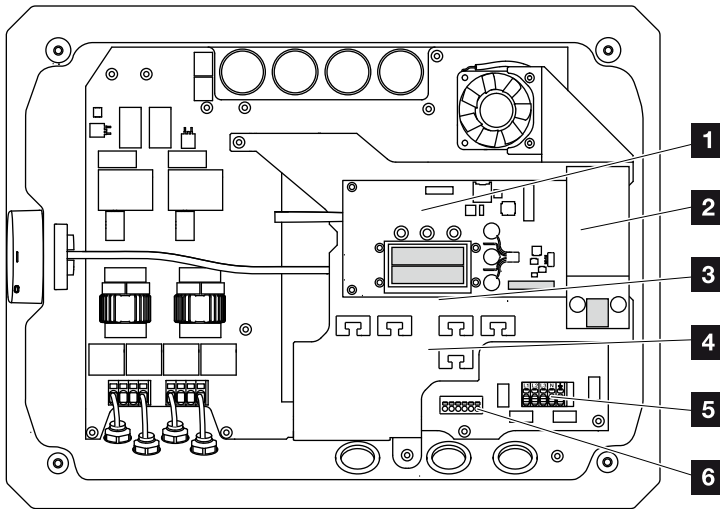
Fig. 19: PIKO inverters 5.5 - 8.5 (interior view)

1 Communication board
2 Expansion module (e.g. GSM modem, optional)
3 Ethernet connections (RJ45)
4 Cable tray with fastening openings
5 AC terminal
6 Terminal for sensor lines of PIKO BA Sensor
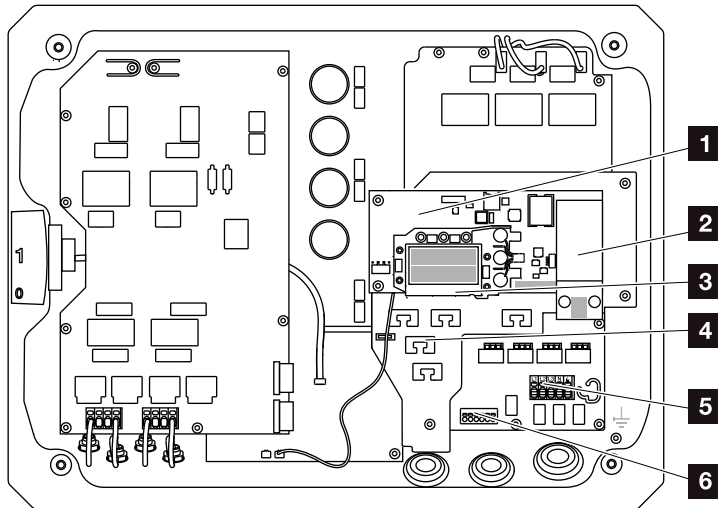
Fig. 20: PIKO inverters 10 - 12 (interior view)

1 Communication board
2 Expansion module (e.g. GSM modem, optional)
3 Ethernet connections (RJ45)
4 Cable tray with fastening openings
5 AC terminal
6 Terminal for sensor cables PIKO BA Sensor
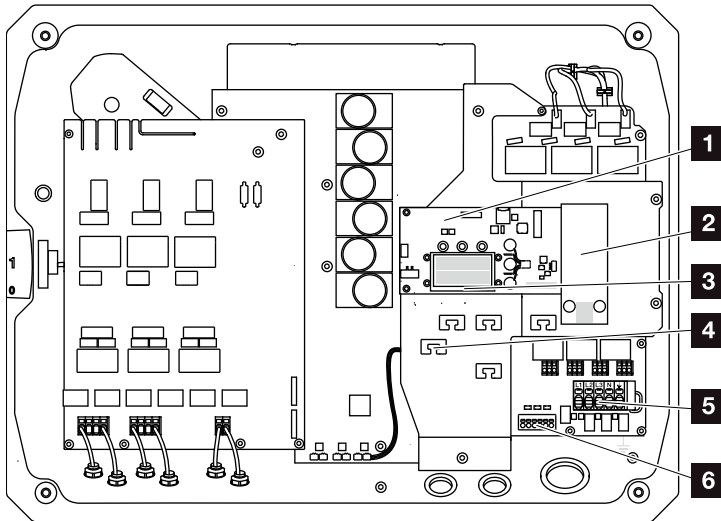
Fig. 21: PIKO inverters 15 - 20 (interior view)

1 Communication board
2 Expansion module (e.g. GSM modem, optional)
3 Ethernet connections (RJ45)
4 Cable tray with fastening openings
5 AC terminal
6 Terminal for sensor lines of PIKO BA Sensor

The communication board
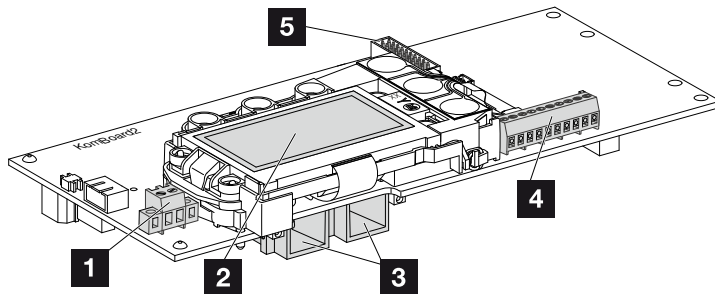
Fig. 22: Components of the communication board

1 Terminal S0/AL-Out (2-pin)
2 Display
3 2 Ethernet connections (RJ45)
4 Terminal analogue interface (10-pin)
5 Terminal expansion module
(e.g. GSM modem)

The communication board is the communications centre of the inverter. The connections for communication, the display and the control buttons are found on the communication board.

The control panel
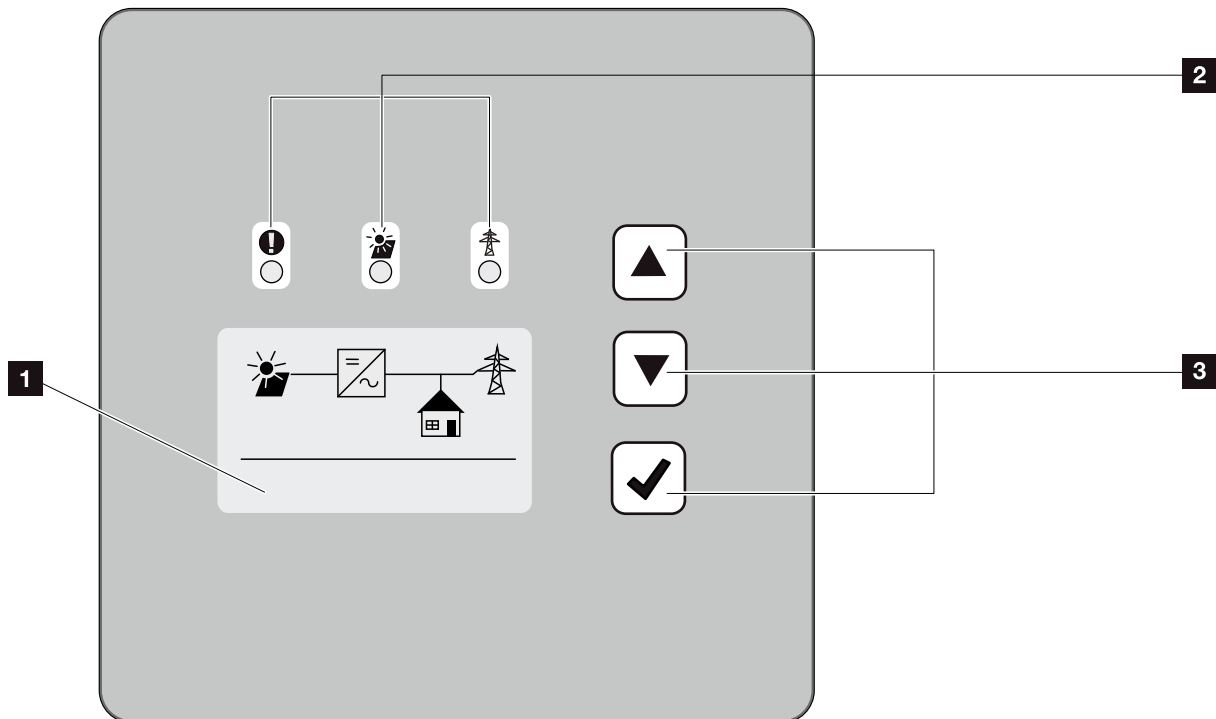
Fig. 23: Control panel

1 Display (display dependent upon the inverter type. Here it is the menu of the 3-phase inverter)
2 LEDs for displaying the operational status
3 Control buttons

Adjustments can be made and data retrieved via the control panel. Event messages are shown on the display.

The main menu
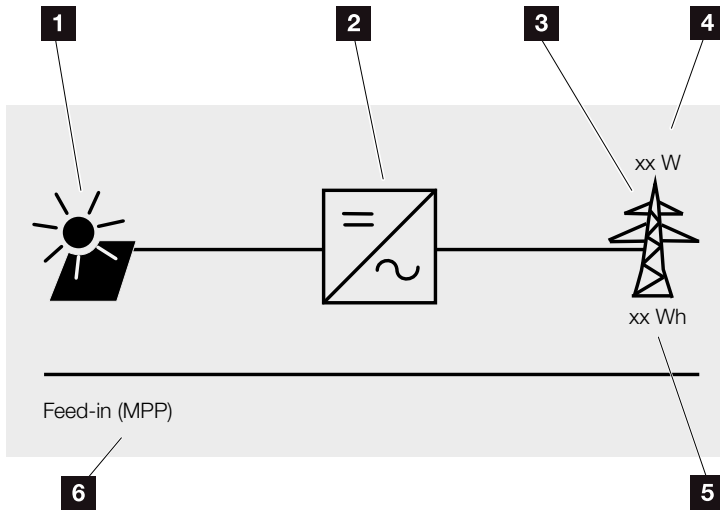
Fig. 24: Main menu: 1-phase

1 "DC" menu
2 "Settings" menu
3 "AC" menu
4 Current AC power
5 Fed-in daily yield
6 Operational status display
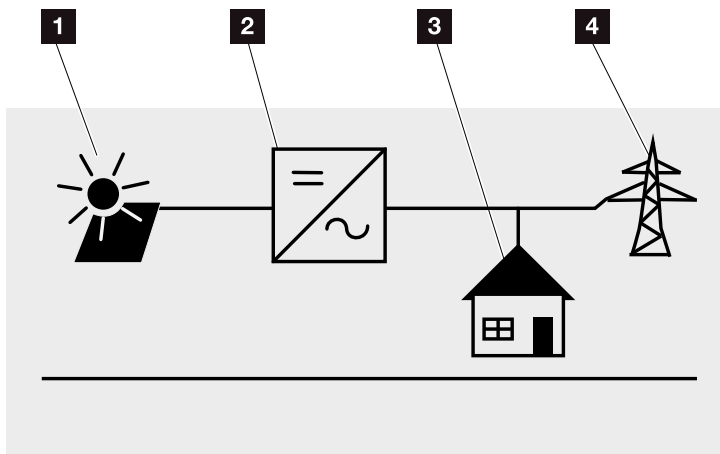
Fig. 25: Main menu: 3-phase

1 "DC" menu
2 "Settings" menu
3 "Self-consumption" menu
4 "AC" menu

The web server

The web server is a graphic interface (representation in the browser) for the configuration of the inverters. It offers the following content: ⤴ **Ch. 5.1**

Web server pages	Function
Main page	Display of yield data
History	List of the sensor data, building consumption and yield data
Info page	Status display of the analogue inputs, the modem and the last connection to the solar portal
Settings	Inverter configuration

Tab. 2: Overview of the web server pages

The data logger

A data logger is incorporated in the PIKO inverter. The data logger is a data storage system for the yield and performance data of the inverter and the storage system. Yield data (saving interval) can be saved every 5, 15 or 60 minutes. The data logger is set in the factory to a saving interval of 15 minutes. The saving interval can be changed at the "Settings" web server page. ℹ️

Saving interval	Saving time
5 minutes	Max. 130 days
15 minutes	Max. 400 days
60 minutes	Max. 1500 days

Tab. 3: Saving intervals of data logger

ℹ️ INFO

Pay attention to the saving time when selecting the saving interval!

When the internal memory is full, the oldest data will be overwritten. For long-term backup, the data must be backed up with a PC or sent to a solar portal.

3. Installation

3.1 Transport and storage

The function of the inverter has been tested, and it has been carefully packaged prior to delivery. Upon receipt, check the delivery for completeness and any transport damage.

Complaints and damage claims are to be directly addressed to the shipping company.

If stored for a longer period before installation, all components of the inverter must be kept dry and dust-free in the original packaging.

DAMAGE POSSIBLE

Risk of damage when the inverter is placed on its underside. Always place the inverter on its rear side (cooling elements) after unpacking.
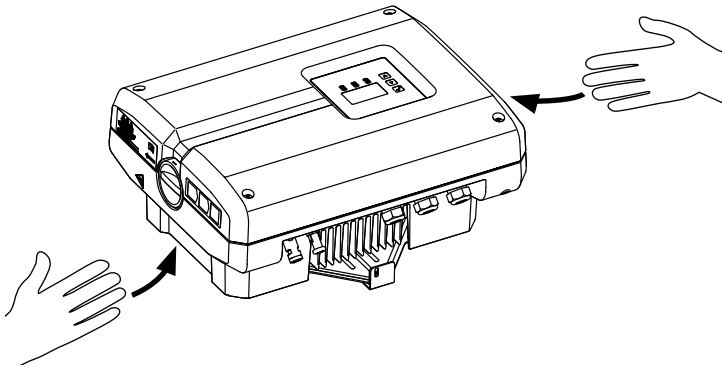
Fig. 26: Recessed grips inverter

Recessed grips have been integrated to the left and right for better transport of the inverter.

3.2 Scope of delivery
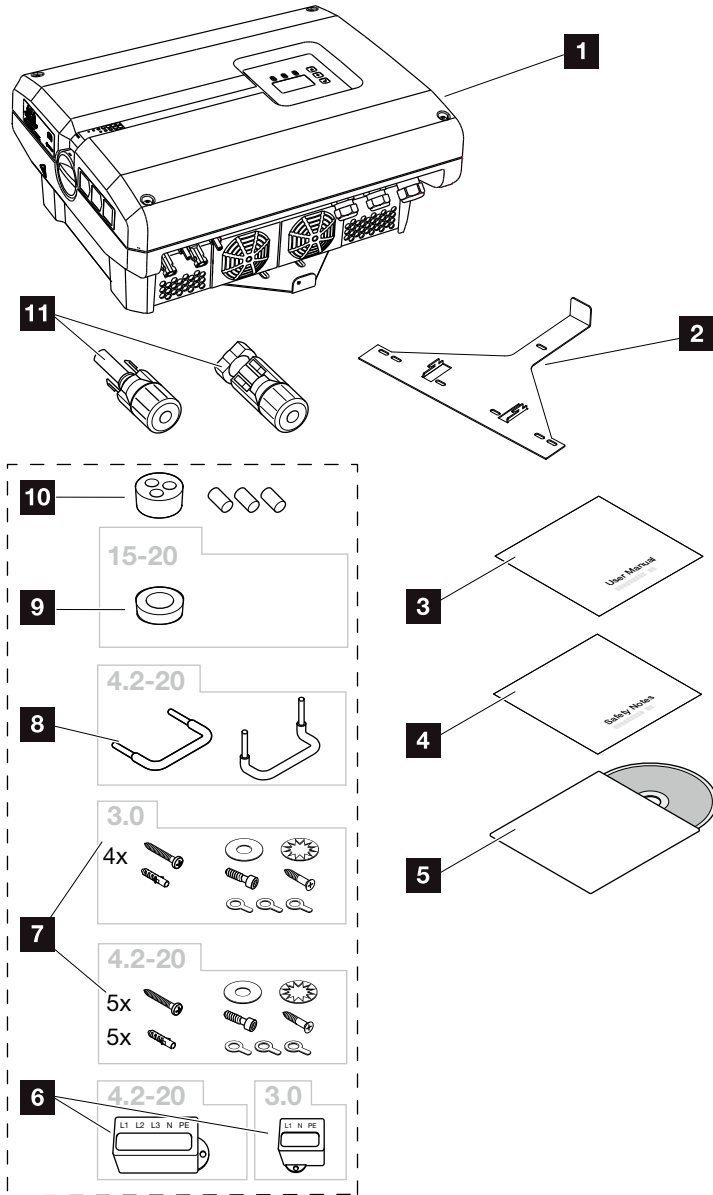
Fig. 27: Scope of delivery PIKO 3.0, 4.2 - 20

The packaging contains:

1 1 x inverter

2 1 x wall mount (not for replacement devices)

3 1 x Short Manual

4 1 x Safety Notes

5 1 x CD with operating manual

6 1 x sealing cap (3-pin or 5-pin) for sealing the AC terminal

7 **Installation accessories PIKO 3.0:**
4 x screws 6×45 A2 DIN 571,
4 x screw anchors 8 x 40,
1 x tapping screw M4×10 Form A galvanised
DIN 7516,
1 x fan washer 12x6.4 A2 DIN 6798,
1 x plain washer 12x6.4 A2 DIN 125,
1 x cylinder bolt M6x12 A2 ISO 4762
1 x ring terminal M6x16 mm^2,
1 x ring terminal M6x10 mm^2,
1 x ring terminal M6x6 mm^2

Installation accessories PIKO 4.2-20:
5 x screws 6×45 A2 DIN 571,
5 x screw anchors 8 x40 mm,
1 x tapping screw M4×10 Form A galvanised
DIN 7516,
1 x fan washer 12x6.4 A2 DIN 6798,
1 x plain washer 12x6.4 A2 DIN 125,
1 x cylinder bolt M6x12 A2 ISO 4762
1 x ring terminal M6x16 mm^2,
1 x ring terminal M6x10 mm^2,
1 x ring terminal M6x6 mm^2

8 2 x wire jumpers for parallel connection
(type-dependent)

9 **Installation accessories PIKO 15-20:**
Plug seals for screw attachment of AC cable with a
max. diameter of 14.5 mm

10 Plug seals for the screw connection of the
network cable

11 DC plug connector
(each DC input: 1× plug, 1× socket)

3.3 Installation

Selecting the installation site ⚠

Protect inverter from rain and splash water.
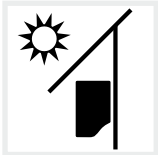
Protect inverter against exposure to direct sunlight.
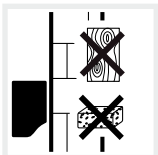
Mount inverter on a stable installation surface that can securely bear the weight. Plasterboard walls and wood planking are not permitted.
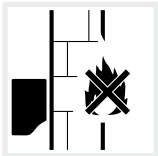
Mount inverter on a non-flammable installation surface. ⚠
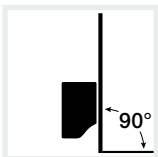
Mount inverters on vertical installation surfaces. To this purpose, use the provided wall mount.
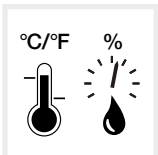
The ambient temperature must be between -20 °C and +60 °C. The air humidity must lie between 4 % and 100 % (condensing).
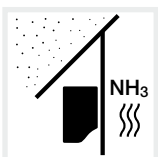
Protect the inverter against dust, contamination and ammonia gases. Rooms and areas containing livestock are not permitted as installation locations.

> ❗ **IMPORTANT INFORMATION**
>
> **Observe these instructions when selecting the installation location. Guarantee claims may be restricted or become entirely null and void in the event of failure to observe.**

> ⚠ **WARNING**
>
> **RISK OF BURNS FROM HOT PARTS IN THE INVERTER!**
>
> **Some of the inverter components can reach temperatures of over 80°C during operation. Select the installation location in accordance with the information provided in these instructions. Always keep the ventilation openings clear.**

Install inverters so that they are not accessible by children.
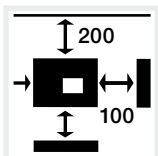
Maintain minimum distances to other inverters and the necessary clearance.
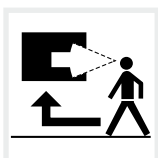
Inverters must be easily accessible and the display clearly visible.

Inverters can cause noise when in operation. Install inverters in such a way that people are not disturbed by operation noises.
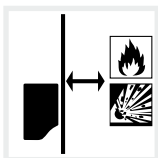
A sufficient safety distance from flammable materials and explosion hazard areas in the vicinity must be ensured.

Wall mounting ⚠ ⚠
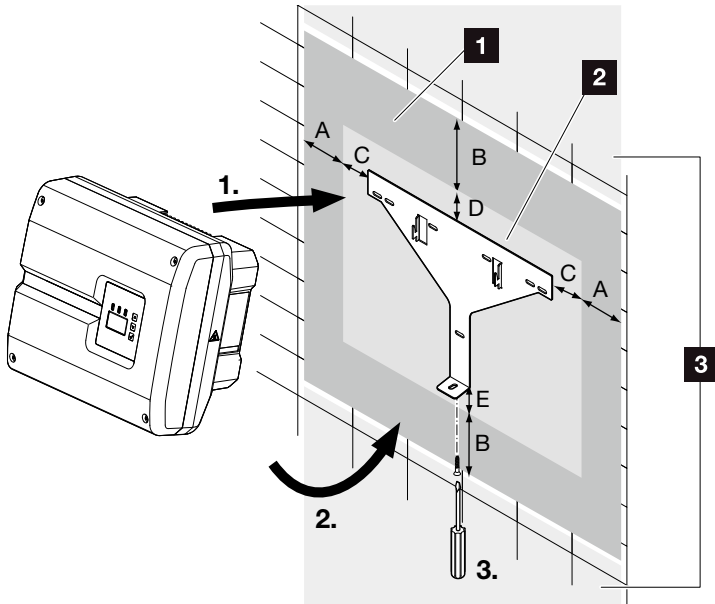
	IMPORTANT INFORMATION
❗	Be absolutely sure to maintain the clearance around the inverter in order that the inverter remains cool.

	IMPORTANT INFORMATION
❗	Only use the provided wall mount.
	When installing the wall mount, use all 5 retaining bolts.

Fig. 28: Wall installation with wall mount

1 Clearance

2 Outer dimensions of the inverter

3 Inverters may not be installed in this area

You can find the distances for wall mounting in the following table:

Frame size	Dimensions in mm (inch)				
	A	B	C	D	E
PIKO 3.0, 4.2-8.5	100 (3.9)	200 (7.9)	60 (2.4)	70 (2.8)	2 (0.1)
PIKO 10-12	100 (3.9)	200 (7.9)	66 (2.6)	35 (1.4)	2 (0.1)
PIKO 15-20	100 (3.9)	200 (7.9)	76 (2.99)	46 (1.8)	2 (0.1)

Tab. 4: Distances for wall mounting
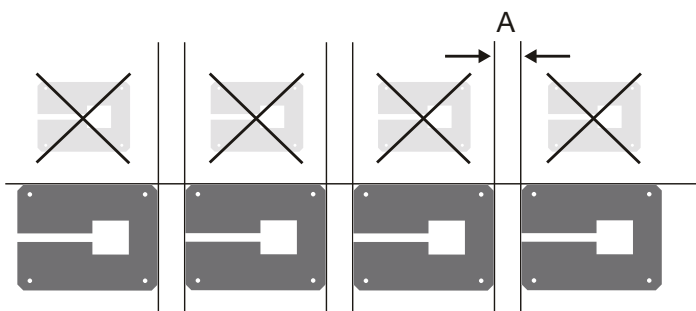
Fig. 29: Wall installation of several inverters

3.4 Electrical connection
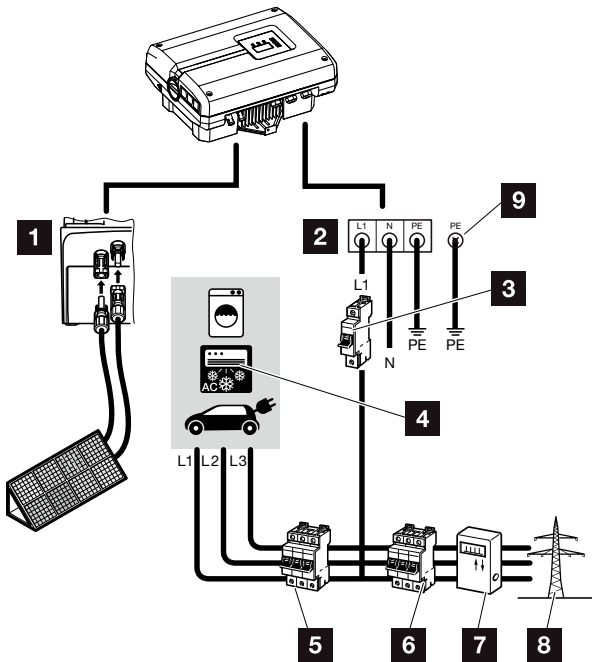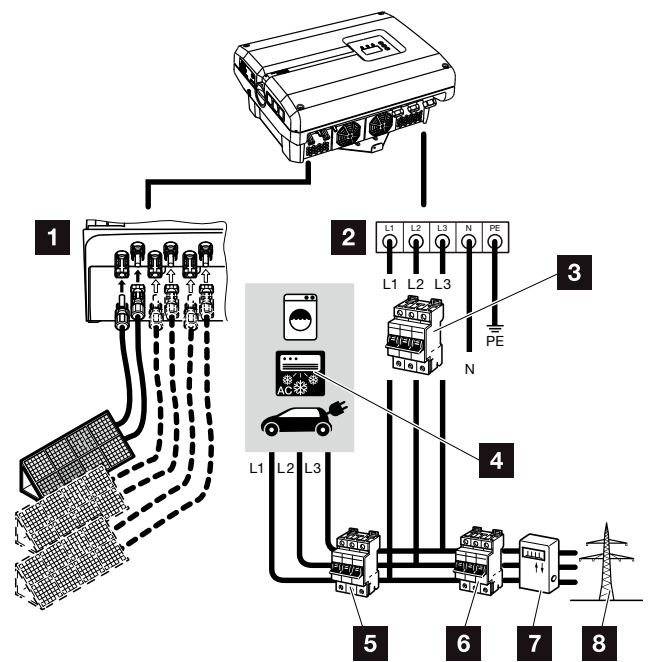
Fig. 30: Overview of the electrical connections with 1 and 3-phase inverters

Inverter connections
1 DC connections (dependent upon frame size)
2 AC terminal (1-phase or 3-phase) ⚠️

External connections ⚠️
3 Line circuit breaker for inverter (1-phase or 3-phase)
4 Energy consumers
5 Line circuit breaker for consumers
6 Line circuit breaker for building
7 Electricity meter
8 Public grid

Additional protective conductor terminal PIKO 3.0
9 Second protective conductor terminal (PE) of min. 2.5 mm² on inner or outer PE connection

> **!** **IMPORTANT INFORMATION**
>
> **It must be ensured that the phases of the AC terminal and the consumers are assigned uniformly.**

> **!** **IMPORTANT INFORMATION**
>
> **This product may generate a direct current in the outer protective earthing conductor. If protective residual current devices (RCD) or residual current monitoring devices (RCM) are used, only type B RCDs or RCMs are permitted on the AC side. Refer to the manufacturer's declaration on our website for exceptions.**

Connect mains cable

1. De-energise the inverter. ⚠️
   ↗ **Ch. 4.3**

2. Switch off DC switch on the inverter.
   ↗ **Fig. 37**

3. Secure it against reactivation.

4. Professionally lay the mains cable from the current distributor to the inverter. ❗ ❗

3.0

4.2 - 20

Fig. 31: Connect mains cable to the inverter

1 AC terminal
2 Mains cable
3 Sealing ring
4 Union nut
5 Additional protective conductor terminal for PIKO 3.0

⚠️ **DANGER**

RISK OF DEATH DUE TO ELECTRI-CAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
↗ **Ch. 4.3**
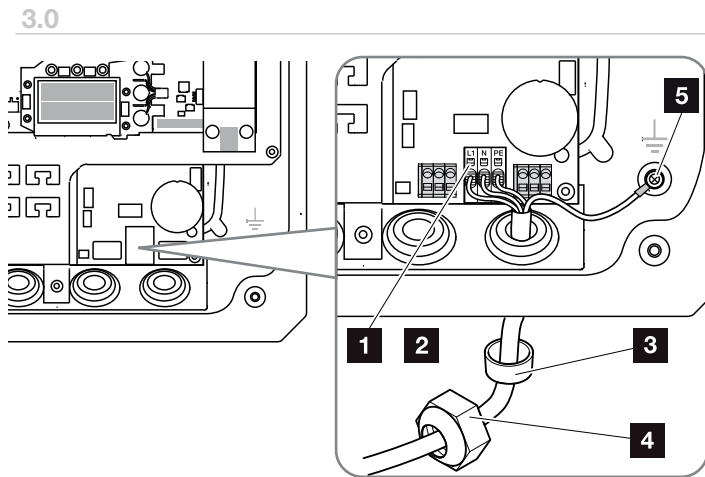
❗ **IMPORTANT INFORMATION**

See the chapter "Technical Data" for the dimensioning of the required AC line circuit breaker and the cable cross-sections to be used. ↗ **Ch. 10.1**
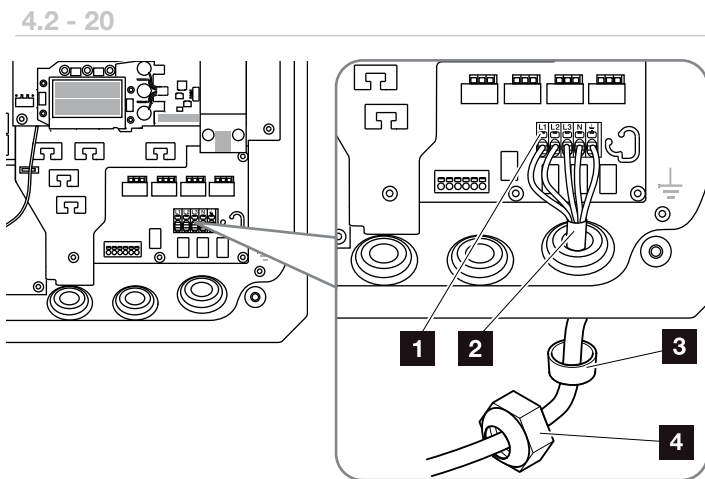
❗ **IMPORTANT INFORMATION**

For PIKO 3.0, there must always be a second protective conductor (PE) of min. 2.5 mm^2 connected on the inner or outer PE terminal with the screw provided.

---

5. Insert mains cable into the inverter and seal with sealing ring and union nut. Tighten union nut to the prescribed torque. Torques: 1.5 Nm (M12), 8 Nm (M25), 10 Nm (M32) and 13 Nm (M40). !

6. When threaded connections are not used, leave the sealing ring in the threaded connections.

7. Connect the wires of the mains cable to the AC terminal in accordance with the labelling. !
   ⬈ **Fig. 31, lt. 1**
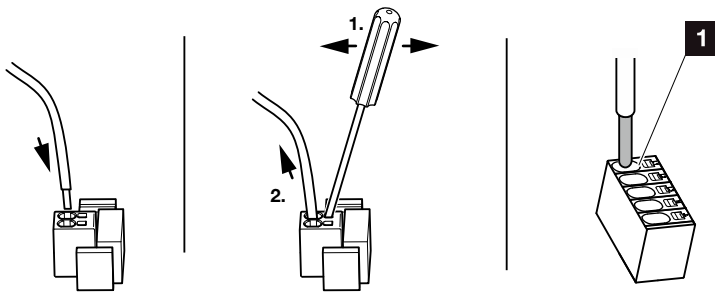
Fig. 32: Spring-loaded terminal strip

8. Install a line circuit breaker into the mains cable between the inverter and the feed meter to secure it against overcurrent. ⚠

9. In countries in which a second PE connection is prescribed, connect these at the marked place on the housing with the prescribed torque of 3 Nm (M6).
   ⬈ **Fig. 33, Pos. 1**
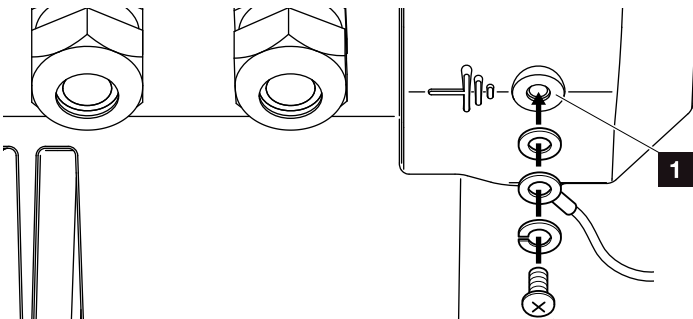
Fig. 33: Country-specific PE connection

✔ The AC connection is connected.

! IMPORTANT INFORMATION

Existing cables and their routing within the inverter must not be changed. This can otherwise result in malfunctions in the inverter.

! IMPORTANT INFORMATION

To connect the AC and DC cables, the inverter is equipped with spring-loaded terminal strips. In the process, the wires are to be inserted into the large opening (lt.1) of the terminal. The wire stripping length is 15 mm.

⚠ WARNING

RISK OF FIRE DUE TO OVER-CURRENT AND HEATING OF THE MAINS CABLE!

Install line circuit breaker to secure against overcurrent.

3.5 Connection of solar module

Solar module connections

Note the following before connecting the DC plugs:

- Check for the correct planning and wiring of the modules and then measure the DC idling voltage for plausibility.

- In order to ensure an optimal layout of the solar modules and the highest possible yields, the system should be designed within the voltage range between min. MPP and max. MPP. PIKO Plan should be used as a planning tool here.

- In the case of an elevated layout of the solar modules, it is to be ensured that the working point continues to lie within the MPP voltage range of the inverter.

- Please ensure that the maximum permitted DC idling voltage is not exceeded.
  Record and keep the measured values.

- Provide these measured values in the event of a complaint.

Failure to do so will make any manufacturer's warranty, guarantee or liability null and void unless you can prove that the damage was not due to non-compliance.

WARNING

RISK OF FIRE DUE TO IMPROPER INSTALLATION!

Improperly crimped plugs and sockets can heat up and cause a fire. When installing, be absolutely sure to follow the specifications and instructions of the manufacturer. Properly mount plugs and sockets.

WARNING

SERIOUS BURNS DUE TO ARCS ON THE DC SIDE!

DC cables must never be connected to or disconnected from the device during operation, as dangerous arcs may form. De-energise DC side, then mount or remove plug connector!

WARNING

INJURIES CAN RESULT FROM DESTRUCTION OF THE DEVICE!

When the maximum values for the permitted input voltage at the DC inputs are exceeded, this can result in serious damage, which may destroy the device and cause serious injury to any person present. Even brief exceeding of the voltage can cause damage to the device.
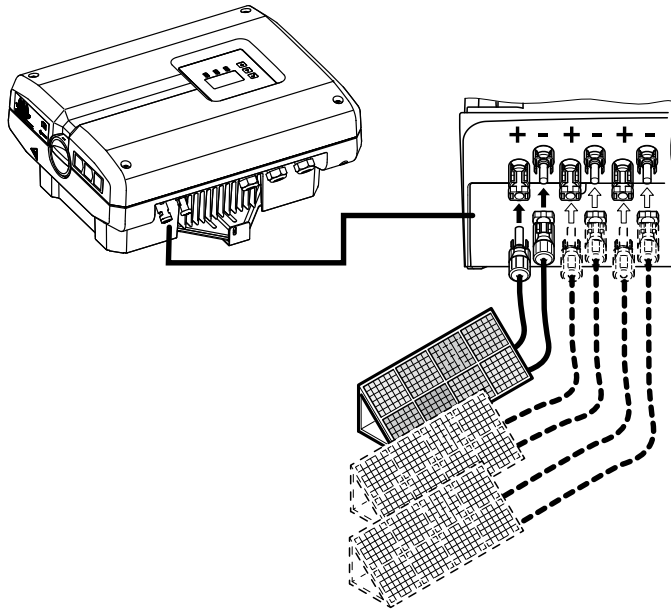
Fig. 34: Overview of DC connections

Parallel connection of solar module inputs 🏠 ❗

The function of the inverter operates based on the so-called string concept. In this system, a limited number of solar modules (depending on the desired power output while considering the maximum permissible input voltage) are connected in series as a string, which is then connected to the inverter.

The inverter is equipped with controllable inputs (DC1 and DC2) that can be connected in parallel. The device is accompanied by two bridges for this reason.

Fig. 35: Bridges for parallel connection

DAMAGE POSSIBLE

Excessive voltages on the DC side destroy the inverter.

DAMAGE POSSIBLE

One or two strings can be connected when the inputs DC1 and DC2 are connected in parallel. It must thereby be ensured that the entire input current for one or both inputs does not exceed the prescribed values. Input currents with parallel connection: ↗ Ch. 10.1

IMPORTANT INFORMATION

When more than 2 strings are connected in parallel, a string fuse may need to be installed. To this purpose, observe the information of the module manufacturer.

In the case of the PIKO 3.0 and 4.2, parallel connection of solar modules is not possible.

A string can be connected when the inputs DC1 and DC2 are connected in parallel. The maximum permissible input current for parallel connection can be derived from the technical data. ⚠️ ↗ **Ch. 10.1**

Connecting inputs in parallel:

1. De-energise the inverter. ⚠️
    ↗ **Ch. 4.3**

2. Plug the provided bridges into the terminals as shown. ⚠️
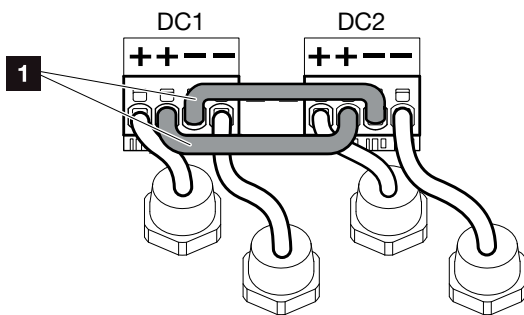
Fig. 36: Inputs 1 and 2 connected in parallel

1 DC bridges

3. Activate the parallel connection following initial commissioning in the "Settings" menu.

4. Leave the plug seals on the plug connectors not in use to protect them from moisture and dirt.

✔ Parallel connection has been set up. ⚠️

Connect solar module ⚠️ ⚠️

Only solar modules of the following category may be connected: Class A as specified in IEC 61730.

1. The PV strings may only be connected to the inverter when the housing is closed. Install the inverter cover and screw it tight (5 Nm).

2. De-energise the inverter. ⚠️
    ↗ **Ch. 4.3**

> ❗ **IMPORTANT INFORMATION**
>
> Only the inputs DC1 and DC2 can be connected in parallel.

> ⚠️ **DANGER**
>
> **RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!**
> De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
> ↗ **Ch. 4.3**

> ❗ **IMPORTANT INFORMATION**
>
> To connect the bridges, the inverter is equipped with spring-loaded terminal strips.

> ❗ **IMPORTANT INFORMATION**
>
> Parallel connection still needs to be activated in the Settings menu following initial installation.
> ↗ **Page 72**

> ⚠️ **DANGER**
>
> **RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!**
> The PV generators/cables may be live as soon as they are exposed to light.

3. Check the strings for earth faults and short circuits and correct these where appropriate.
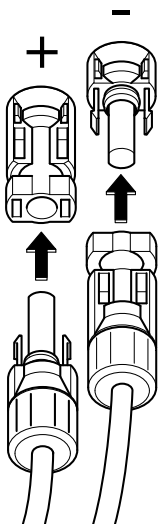
Fig. 37:   Connect the PV string

4. Crimp the plug on the plus cable and the socket on the minus cable professionally. The inverter is equipped with Multi-Contact plug connectors from (type MC4). Be absolutely sure to take note of the manufacturer's latest information (e.g. use of special tools, permitted torques, etc.)[1] when installing. Pay attention to the correct polarity when mounting the sockets and the plugs on the DC cables of the solar modules! The poles of the PV strings (PV field) must not be earthed.

5. Plug the sockets and plugs of the DC cables onto the inverter. ⤢ **Fig. 37** Keep the plug seals from the plug connectors.

✔ The DC side is connected. ▯

DANGER

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
⤢ **Ch. 4.3**

IMPORTANT INFORMATION

The cross-section of the DC cables should be as large as possible, a maximum of 4 mm² for flexible cables and 6 mm² for rigid cables. We recommend using tin-plated cables. If non-tin-plated cables are used, the copper strands may oxidise, as a result of which the transition resistance of the crimp connections will be too high.

[1] Information on the Internet at www.multi-contact.com.

3.6 Connection of communication components
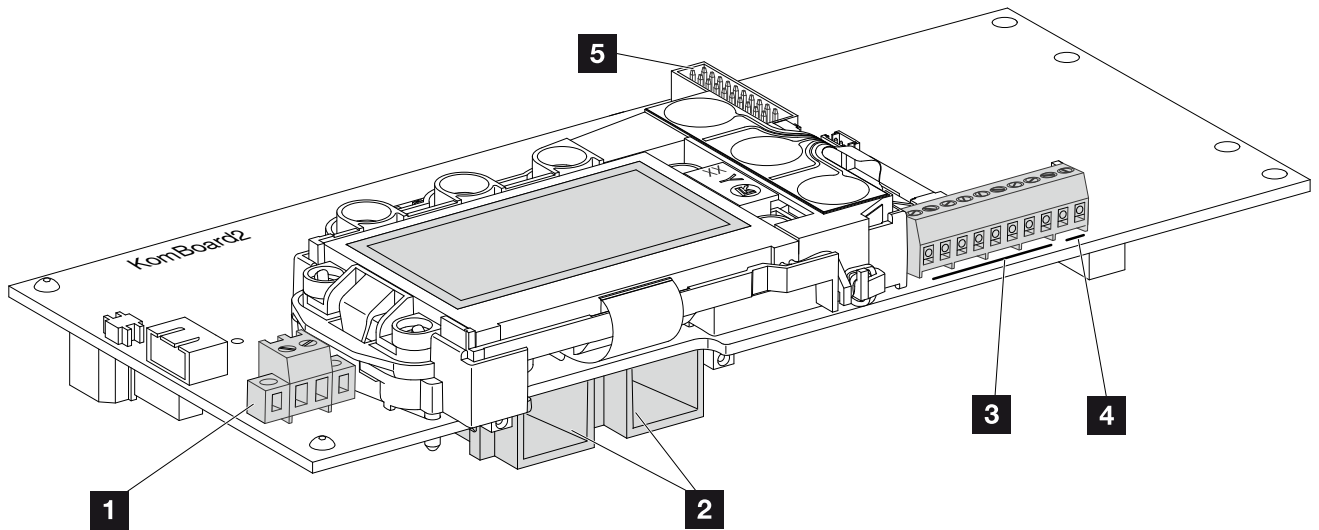
Fig. 38: Components of the communication board

1 Terminal S0/AL-Out (2-pin)
2 2 Ethernet connections (RJ45)
3 Analogue interface terminal
4 Terminal for RS485 interface
5 Expansion module terminal (e.g. GSM modem)

The communication board is the communications centre of the inverter. The connections for communication, the display and the control buttons are found on the communication board.

The communication board is covered by a protective film over the S0/AL Out terminal. This can be lifted up for installation.

Terminal S0/AL-Out ⌂

The 2-pin S0/AL-Out terminal can be assigned various functions and configured via the web server under "Settings":

Switch output function:
Pulse output (S0 interface)

The switch output functions as a pulse output as described in EN 62053-31 with a constant rate of 2,000 pulses per kilowatt hour. This function is a factory setting.

Switch output function:
Alarm output (S0 interface)

The switch output functions as a potential-free NC contact. It is opened when a fault occurs.

1. In the web server, call up the "Settings" page.
   ◪ **Fig. 54**.

2. In the "Function switch output" field, select the option "Alarm output".

3. Click "Accept".

✔ The "Alarm output" function is activated.

Switch output function: Self-consumption control or dynamic self-consumption control (switching of consumers)

The switch output functions as a potential-free NO switch. It closes when the set conditions are fulfilled.

1. In the web server, call up the "Settings" page.
   ◪ **Fig. 54**.

In the "Function switch output" field, select the option "Self-consumption control" or "Dynamic self-consumption control". ⓘ

2. Click "Accept".

✔ The "Self-consumption control" function is activated.

DAMAGE POSSIBLE

The terminal S0/AL-Out may only have a maximum load of 100 mA. The maximum permissible voltage is 250 V (AC/DC).

INFO

When selecting "Dynamic self-consumption control", the measured building consumption determined with the PIKO BA Sensor available as an option is automatically added to the set value and taken into consideration. ◪ **Ch. 8.3**

Terminal analogue interface (10-pin)

The 10-pin analogue interface terminal is structured as follows.
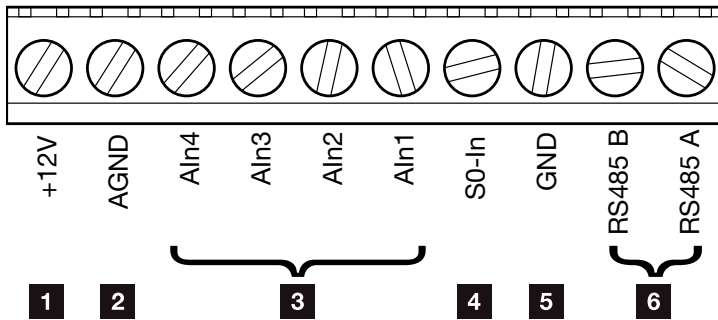
Fig. 39:   Structure of the 10-pin analogue interface terminal

Voltage output

1 **+12V:** 12 V output for external sensors or for ripple control receivers. ℹ️

Analogue inputs

2 **AGND:** Ground for analogue inputs and S0 input.

3 **Aln4-1:** Inputs for analogue sensors (0–10 V) or for ripple control receivers. ℹ️

Pulse meter input

4 **S0-In:** The S0 input registers the pulses of an energy meter. ℹ️

RS485 connections

5 **GND:** Ground for RS485.

6 **RS485 connections A & B:** Serial RS485 interfaces for the connection of external data loggers, displays and additional inverters.

ℹ️ **INFO**

The voltage output is not potential-free. It can deal with a max. load of 100 mA.

ℹ️ **INFO**

Either a PIKO sensor **or** a ripple control receiver can be connected to the analogue inputs Aln1 - Aln4.

ℹ️ **INFO**

When using the S0 input, the analogue inputs Aln3 and Aln4 are inactive.

A ripple control receiver can nonetheless be connected.

Connection options of the RJ45 sockets
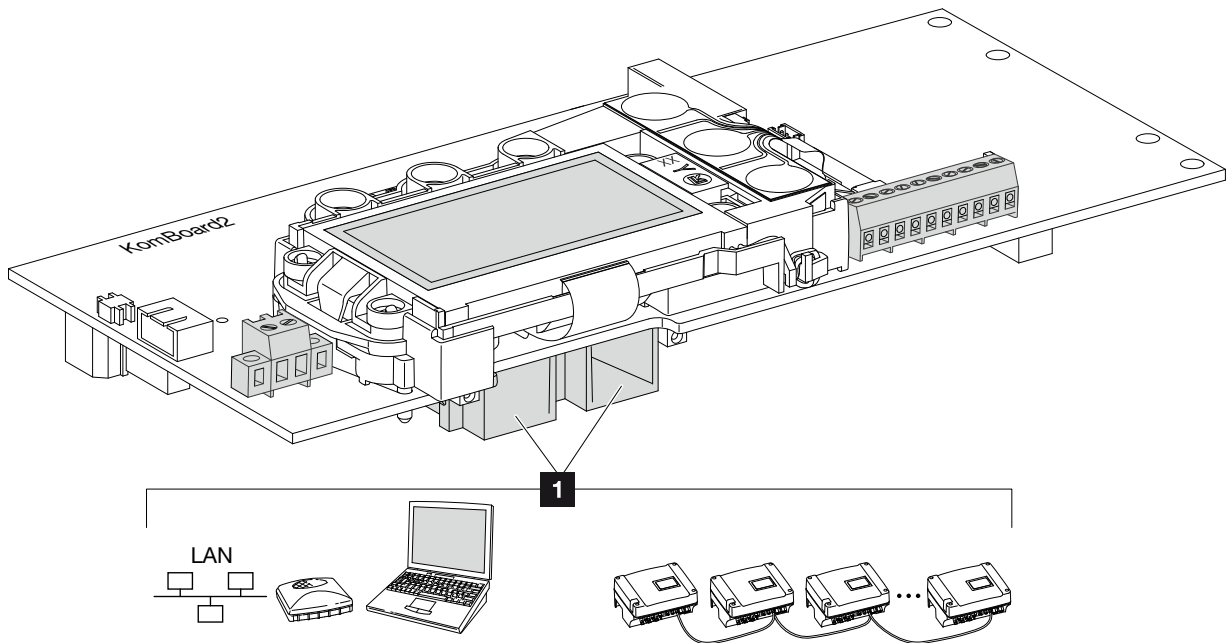
Fig. 40:   Assignment of connection sockets

1 **Socket RJ45:** Computer, LAN, router, switch, hub and/or additional inverters.
For connection with a computer or with a computer network. **ℹ** Connect several inverters to a network for data retrieval.

ℹ

INFO

For connection with a computer or computer network (Ethernet 10BaseT, 10/100 MBit/s), an Ethernet cable of category 6 (Cat 6, FTP) with a max. length of 100 m is to be used.

3.7 Initial commissioning

Procedure for initial commissioning ⚠

Fig. 41:   Fasten the cable to the cable tray

> **⚠ IMPORTANT INFORMATION**
>
> **The initial commissioning requires at least the "Min. input voltage" (U DC$_{min}$) plus the self-consumption of the inverter.**
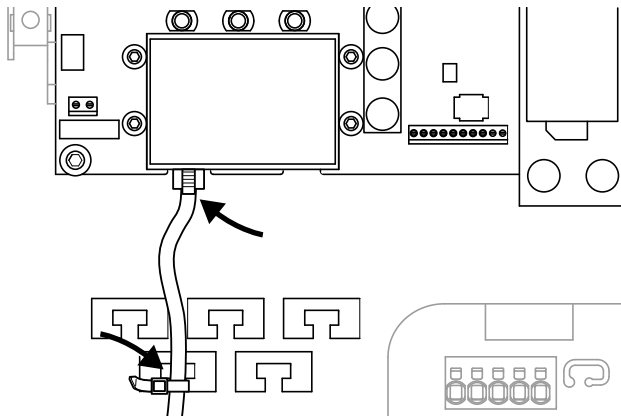
1. Properly fasten all cables to the cable tray with a cable tie. ↗ **Fig. 41**

2. Tighten all cable screw connections and check that they are properly sealed.

3. Check the fit of connected wires and braids.

4. Remove any foreign objects (tools, wire cuttings, etc.) from the inverter.

5. Install the cover and screw it tight (5 Nm).

6. Plug the sockets and plugs of the DC strings onto the inverter. ↗ **Fig. 38**

7. Activate the grid voltage via the line circuit breaker.

8. Switch the DC switch of the inverter to ON.
    ↗ **Fig. 15**
    When external DC voltage separators are present, activate the DC strings consecutively.

➜ When there is adequate DC power at the inverter, the middle LED on the control panel lights up yellow.

➜ The screensaver appears on the display and displays the device type. ℹ

> **ℹ INFO**
>
> The start-up of the inverter during initial commissioning can take up to 10 minutes.

9. The screensaver is deactivated when any key is pressed twice. ℹ️

➔ The "Language" menu appears on the display.
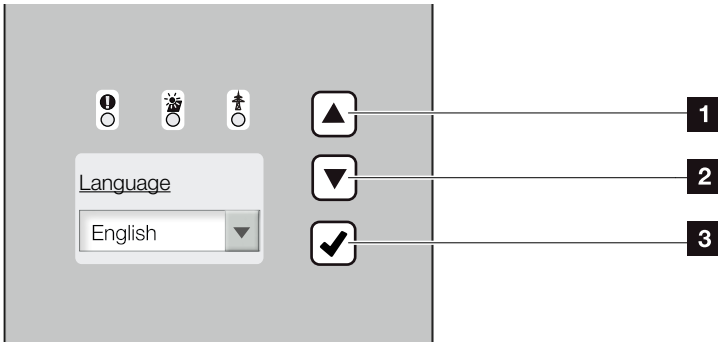
Fig. 42: Display on the inverter

1 "UP" arrow key
2 "DOWN" arrow key
3 "ENTER" key

10. Select language and confirm.

➔ The "Date/Time" menu appears on the display.

11. Set date and time and confirm. ℹ️

➔ The "String connection" menu appears on the display. ℹ️

12. Depending upon the wiring of the DC inputs, activate and confirm the parallel connection.

➔ The "Current sensor position" menu appears on the display.

13. Select and confirm the desired mode with the arrow keys. ℹ️

➔ The first "Country setting" menu appears on the display.

14. Select and confirm the desired country / standard / directive.

➔ The second "Country setting" menu appears on the display.

ℹ️ **INFO**

The installation process can vary depending upon the software version of the inverter.

Information on the handling of the menu: ↗ **Ch. 4.4**

ℹ️ **INFO**

The entry of date/time ensures that the downloaded log data has the correct time assigned to it, and the inverter goes into feed-in operation.

ℹ️ **INFO**

The string connection query only appears for inverters with at least 2 DC inputs.

ℹ️ **INFO**

Information on the various modes: ↗ **Ch. 11.2**

15. In order to secure the country setting, select and confirm the confirmation field "Yes". ℹ️

✓ The settings are assumed by the inverter.

The inverter is in operation and can now be used. Initial commissioning is completed.

ℹ️

INFO

It is no longer possible to change the country setting once it has been confirmed.

4. Operation and operating the device

4.1 Switching on the inverter

1. Activating grid voltage via the line circuit breaker.

2. Switch the DC switch on the inverter to ON.
    Z Fig. 15
    When external DC voltage separators are present,
    activate the DC strings consecutively.

➔ The inverter then starts up.

➔ During start-up, the three LEDs in the control panel
   of the inverter light up briefly. The inverter can now be
   operated.

➔ The screensaver appears in the display and displays
   the device type. The screensaver is deactivated
   when a key is pressed twice. **i**

✔ The inverter is in operation.

i **INFO**

When no key has been pressed for
several minutes, the screensaver with
the image of the inverter appears
automatically on the display.

4.2 Switching off the inverter

In order to switch off the inverter, carry out the following steps. Additional steps are necessary for maintenance or repair work on the inverter. ⤢ **Ch. 4.3**.

1. Turn the DC switch on the inverter to OFF.
    ⤢ **Fig. 16**

2. When external DC voltage separators are present, switch off the DC strings consecutively.

4.3 De-energise the inverter

When working on the inverter or the feed cables, the inverter must be completely de-energised. ⚠️

It is imperative that these steps are carried out:

1. Turn the DC switch on the inverter to OFF.
   ↗ Fig. 16

2. Switch off the AC line circuit breaker.

3. Switch off the power supply for the S0/AL-Out output (if present).

4. Secure the entire voltage supply against being switched on again.

5. Disconnect all DC connections on the inverter. To this purpose, use the disassembly tool of the plug manufacturer. Press the engaging clips together and pull the plug.
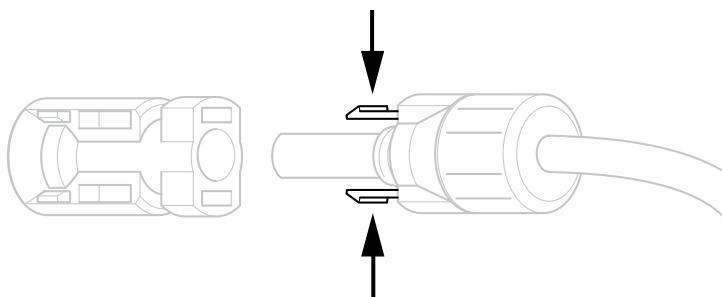
Fig. 43: Press together the engaging clips

6. Wait five minutes until the capacitors of the inverter have discharged. Allow the device to cool down.

7. Ensure that all connections are de-energised.

✔ The inverter is de-energised. Work on the inverter or on the feed cables can now be carried out.

⚡ **DANGER**

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
↗ Ch. 4.3

4.4 Control panel
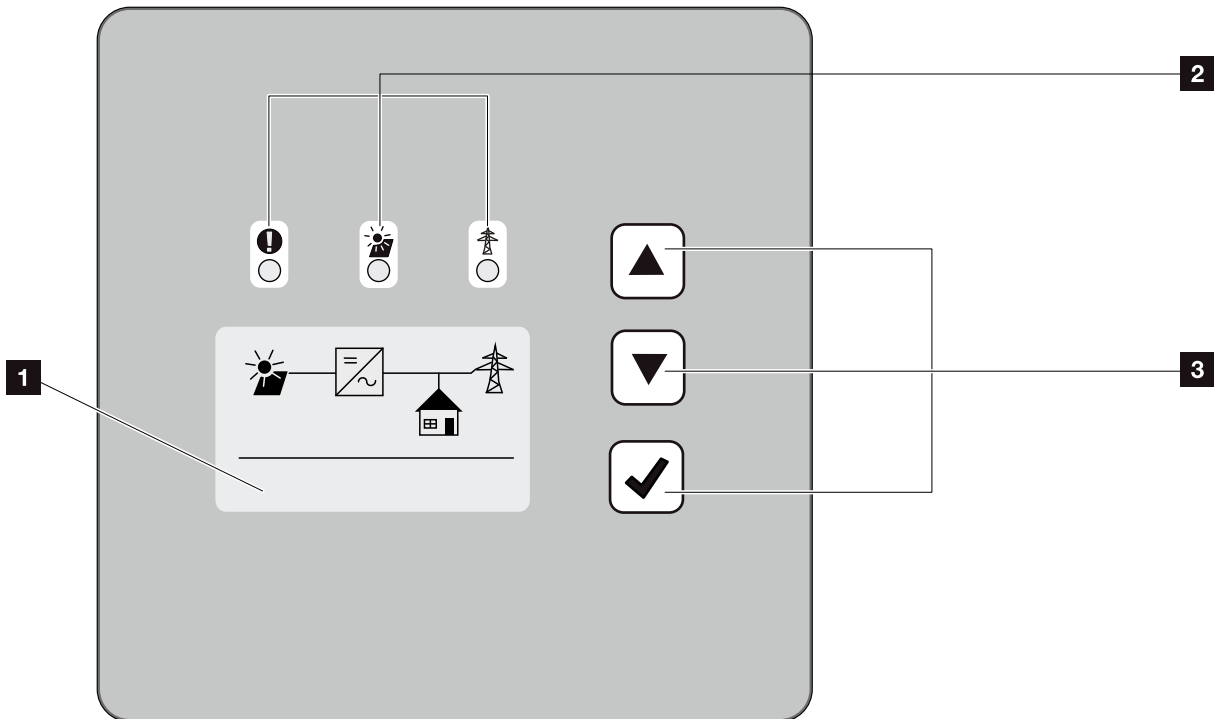
Fig. 44: Control panel

1   Display (display dependent upon the inverter type.
     Here it is the menu of the 3-phase inverter)

2   LED "Fault" (red)
     LED "DC" (yellow)
     LED "AC" (green)

3   Arrow key "UP"
     Arrow key "DOWN"
     Key "ENTER"

The inverter indicates the respective operational status through three LEDs and the display. ℹ️

The operating values can be retrieved and settings adjusted on the display.

INFO

When no key has been pressed for several minutes, the screensaver with the image of the inverter appears automatically on the display.

Operation of the display
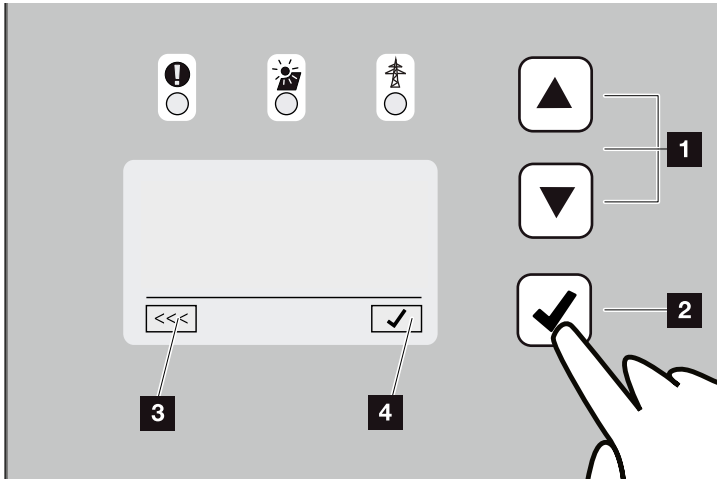
Fig. 45: Operation of the display

1 **UP / DOWN:** Characters, buttons and input fields are selected with the arrow keys.

2 **ENTER:** Briefly pressing the "ENTER" key activates the selected menu element or confirms the entry at the end. Pressing "Enter" for an extended time confirms and saves the entry.

3 **Back:** This function can be used to jump to the higher level menu. Values entered in the menu must be saved in advance, as these will not otherwise be adopted.

4 **Confirm:** Values are adopted or the selected function confirmed with this function.

Entry of text and numbers

The display can also be used to enter texts and numbers (e.g. inverter name and portal code). The table below explains the functions for the entry of text and numbers.

¦ ABC ¦	Object with a dashed line means: Object is selected and can be activated with "ENTER".
ABC	Object with black background: Object is active and can be edited.
A	Characters with a black background mean: Character is selected and can be changed with the arrow keys.
<<	Characters in text fields are deleted with this function. To this purpose, move behind the last character and press an arrow key (the character << appears in the text field). The characters can now be deleted by pressing the "ENTER" key.

4.5 Operational status (display)

The operational statuses are shown on the display of the inverter.
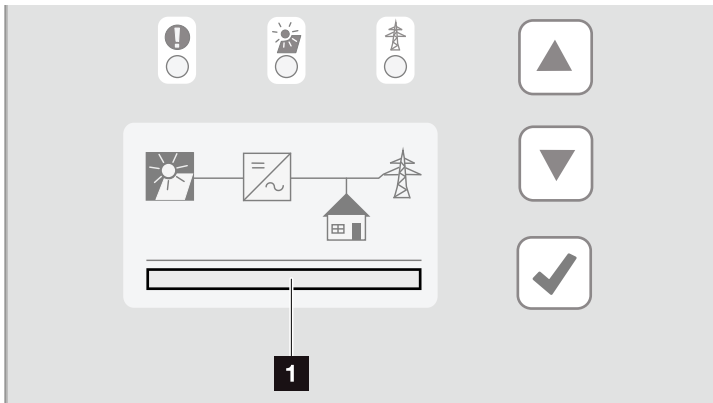
Fig. 46: "Operational status" display area

1 Display area showing the operational statuses

The following table explains the operational notifications that can appear on the display:

Display	Explanation
Off	Input voltage on the DC side (photovoltaic modules) is too low
Standby	Electronics are ready for operation, DC voltage is still too low for feed-in
Starting	Internal control measurements according to VDE 0126
Feed-in (MPP)	Measurement successful, MPP control active (MPP = maximum power point)
Feed-in regulated	Feed-in is regulated on the basis of an event (e.g. PV energy is limited ↗ **Ch. 7**, excess temperature, fault)
Event code xxxx	An event is present. Remedial measures can be found in the "Faults" chapter ↗ **Ch. 4.10**

Tab. 5: Operational notifications on the display of the inverter

4.6 Operational status (LEDs)

The LEDs on the front of the device indicate the current operational status.

LEDs on the inverter
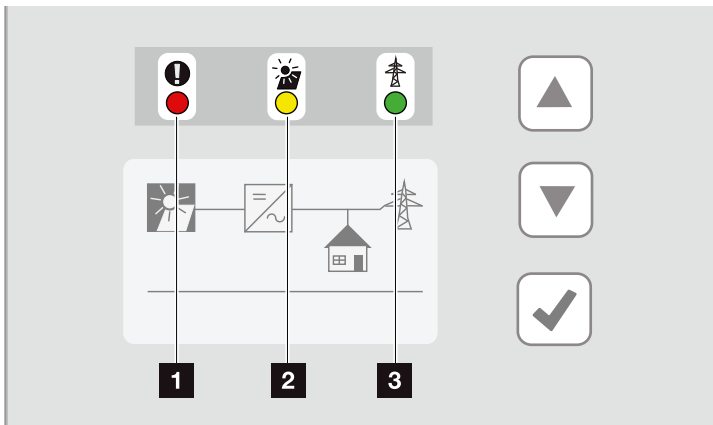
Fig. 47: LEDs on the display of the inverter

1 **"Fault" LED flashes or lights up red:**
A fault has occurred. Remedial measures can be found in the "Faults" chapter ⬈ **Ch. 4.10**

2 **"DC" LED lit yellow:** The yellow LED signals the active status of the inverter control unit. It lights up as soon as the minimum input voltage (U DCmin) is present at one of the DC inputs but the inverter is not yet feeding.
"DC" LED flashes yellow: A fault has occurred. Remedial measures can be found in the "Faults" chapter ⬈ **Ch. 4.10**

3 **"AC" LED lit green:** The green LED signalises feed-in operation of the inverter.

No LED is lit: The device is ready for operation, but the input voltage is too low ⬈ **Ch. 10.1**.
OR: The device is switched off.

4.7 The menu structure of the inverter
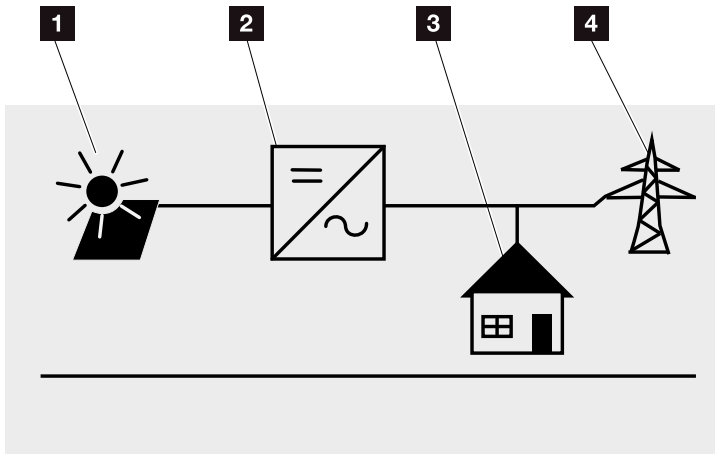
Fig. 48: Main menu structure on the display

1 DC menu
2 Settings menu
3 Self-consumption menu
4 AC menu

The menus* are listed individually on the following pages.

*Deviations due to software versions (UI status) possible.

DC menu

DC input 1 (U,I,P)

DC input 2 (U,I,P)[1]

DC input 3 (U,I,P)[1]

AC menu

Phase 1 (U,I,P)

Phase 2 (U,I,P)[2]

Phase 3 (U,I,P)[2]

Total yield —— Yield (Wh)

Operating time (h)

Grid parameter —— Reduction to (%)

Grid frequency [Hz]

cos φ

Daily yield (diagram)

Monthly yield (diagram)

Annual yield (diagram)

Total yield (diagram)

[1] DC inputs depending upon the device type

[2] Phases depending upon the device type

Self-consumption menu[1]

Daily self-consumption
- Self-consumption (Wh)[2]
- Self-consumption proportion (%)[3]
- Degree of autonomy (%)[4]

Total self-consumption
- Self-consumption (Wh)[2]
- Self-consumption proportion (%)[3]
- Degree of autonomy (%)[4]

Current building consumption
- Solar generator (W)
- Battery (W)[5]
- Grid (W)

Phase-selective building consumption
- Phase 1 (W)
- Phase 2 (W)
- Phase 3 (W)
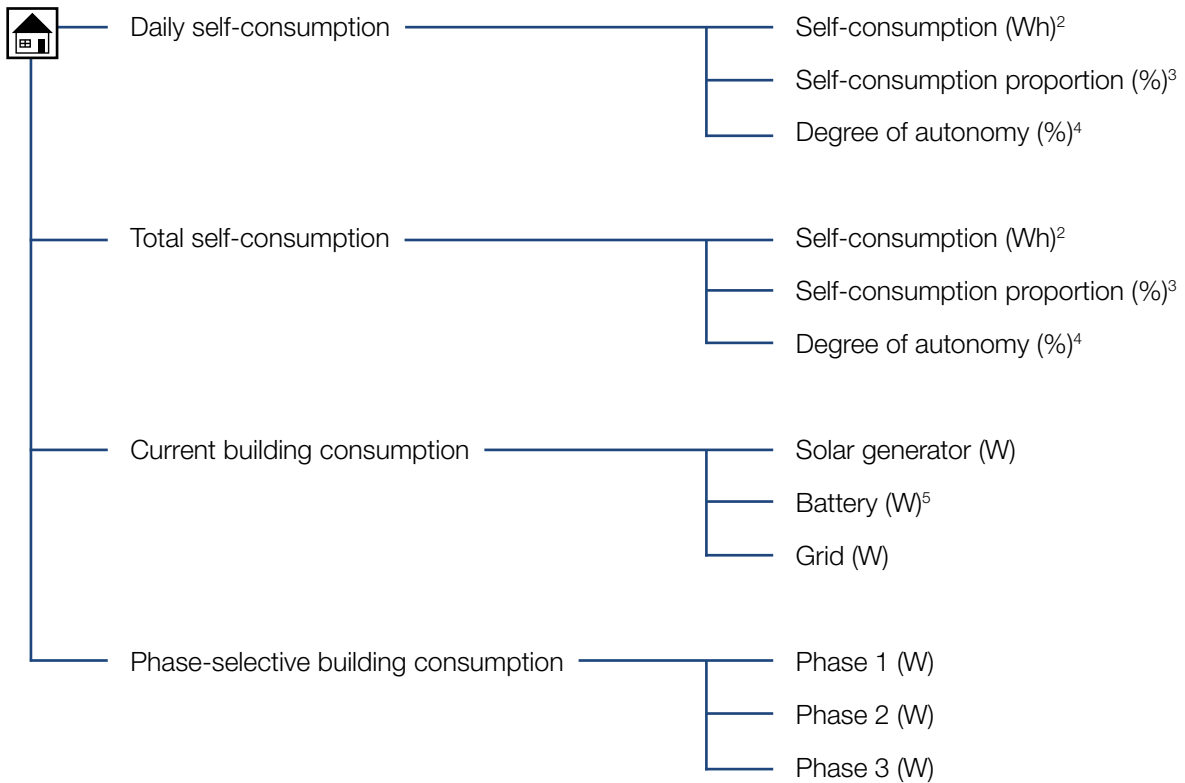
[1] The self-consumption functions can only be used/displayed in connection with a PIKO BA Sensor.

[2] Self-consumption: Shows the power generated by the inverter that has been used up to this point in time in the building itself.

[3] Self-consumption proportion: Shows the self-consumption in relation to the total of generated power of the inverter. States the percentage of generated PV power used for self-consumption.

[4] Degree of autonomy: Shows self-consumption in relation to building consumption. States the percentage of energy consumed in the building that is covered by PV energy.

[5] Values are only shown in the battery inverter.

Settings menu

Basic settings
— Language — Select language
— Inverter name — Input
— Date/time — Set date
— Set time of day

Hardware settings
— String wiring — Parallel connection[1]
— Current sensor position — Mode[2]

Communication
— Network setting 1 — Auto IP
— Network setting 2 — IP address
— Subnet mask
— Router settings — Ext. Router
— Router IP
— RS485 settings — Bus termination
— Bus bias voltage
— RS485 address
— Portal configuration — Portal code
— Data export
— Event messages[3] — Immediate distribution

Device information
— SW/HW version[4] — FW
— HW
— UI
— PAR
— Serial number
— Country setting

Functional test — Fan test

Service menu[5]
— Service code
— Factory setting
— Country settings[6]

[1] The parallel connection menu item is only visible for inverters with at least 2 DC inputs.

[2] The inverter carries out a restart when the position (mode) of the current sensor is changed in the menu.

[3] Event messages can be faults or other events. The "Immediate transmission" option sends the event message immediately following the data capture period to a selected Internet portal. When a data flat rate is not available, the data transfer with a GSM modem can result in higher costs.

[4] SW/HW version, FW: Firmware version, HW: Hardware version, UI: Software version of the communication board, PAR: Version of the parameter file.

[5] Following entry of a code, additional menu items for configuring the inverter appear. The code can be requested for installers from the Service team.

[6] Only visible once the service code has been entered.

4.8 The service menu

Using the inverter's service menu, the installer can perform settings on the inverter, which are not available to the normal user.

For the service menu to be displayed in the communication board, the installer must request a code via the service provided by the inverter manufacturer.

The code is entered by going to the following menu item: Settings > Service menu > Service code

Once the service code has been entered and confirmed, the additional service menu entries appear.

Below you will find a description of the additional functions and settings available:

INFO

The service menu entries depend on the installed inverter firmware (FW) and the communication board software (UI) and may deviate from the description provided here.

Service menu entry	Description
Service code	Input of service code and enabling of additional menu items.
Factory setting	Reset inverter to factory setting. All settings are deleted other than the country setting.
Country setting	Reset the country setting. Once the reset is complete, the inverter reports back with the country setting.

4.9 The energy management system in the inverter
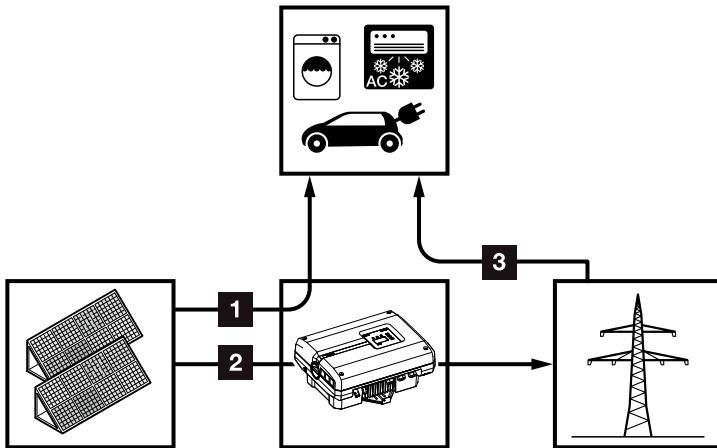
Fig. 49: Control and distribution of the energy flows

1 **PV energy:** Consumption via local consumers
2 **PV energy:** Feeding into the public grid
3 **Grid energy:** Consumption via local consumers

The energy management system (EMS) controls the distribution of the energy between the DC side (solar generator) and the AC side (building grid, public grid). To this purpose, the EMS uses the PIKO BA Sensor to check for the presence of consumption in the internal building grid. The logic of the EMS then calculates and controls the optimal usage of PV energy.

The generated PV energy is primarily used for consumers (such as light, washing machine or television). The remaining generated PV energy is fed into the grid and remunerated.

4.10 Faults

There is no need to take action when a fault occurs occasionally or only briefly and the device resumes operation. When a fault occurs over long periods or recurs frequently, the cause must be determined and rectified. ⚠

In case of an enduring malfunction, the inverter interrupts the feed-in and switches off automatically.

- Check whether the DC switch or the external DC voltage separator has been switched off.

- Check whether the fault is due to a mains power failure or whether the fuse between the feed meter and the inverter has tripped.

If the fuse has tripped, notify the installer; if there is a power failure, simply wait until the grid operator has corrected the problem.

If the fault lasts only a short time (grid fault, overheating, overload, etc.), then the inverter will automatically resume operation as soon as the fault has been resolved.

If the fault persists, notify your installer or the manufacturer's customer support team. ℹ

Provide the following information:

- Device type and serial number. You will find this information on the type plate on the exterior of the housing.

- Description of fault (LED indicator and display message).

The type of fault can be determined on the basis of the message in the display "Event code: xxxx" and the following table.

In the case of messages not listed in the table, please contact Service.

DANGER

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

Deadly voltages are present in the inverter. Only a qualified electrician may open and perform work on the device.

INFO

You can find contact details in the chapter "Warranty and service":
↗ **Ch. 12.2**

Event code xxxx	LED display	Type of fault	Description / possible cause	Measure
3000	red flashing, yellow flashing, off	System fault	Internal system fault	Support[1]
3001	red flashing, yellow flashing, off	System fault	Hardware defect in the device control	Support[1]
3003	red flashing, yellow flashing, off	Communication fault	Internal communication fault between grid monitoring and control system	Support[1] and check the generator installation where appropriate.
3005	red flashing, yellow flashing, off	System fault	Internal AC system fault	Device carries out a test several times and generally switches. Support[1]
3006	red flashing, yellow flashing, off	System fault	Internal system fault with respect to power curtailment	
3010	red flashing, yellow flashing, off	Communication fault	Internal communication fault between control system and communications PCB	Check the time setting, function of the communications PCB and other communication settings. Inverter switches despite incorrect time stamp. Support[1]
3011	red flashing, yellow flashing, off	System fault	Internal system fault	Support[1]
3012	red flashing, yellow flashing, off	System fault	DC varistor defective	Replace defective varistor[1]
3013	off, off, green flashing	Temperature fault	Excess temperature AC/DC at power level	Check installation conditions and cooling aids. Support[1]
3014	off, off, green flashing	Temperature fault	Excess temperature of processor	Check installation conditions and cooling aids. Support[1]
3017	off, yellow flashing, off	Generator fault	Overcurrent at the PV generator	Please check the generator installation/configuration[1]
3018	off, off, off	Information	Power curtailment through external specifications (grid operator)	No action, as this is only a reaction to an external signal.
3019	red, off, off	Grid fault	Power curtailment due to a grid fault (increased grid frequency)	Support[1]
3020	off, yellow flashing, off	Generator fault	Overcurrent at the PV generator	Please check the generator installation/configuration[1]
3021	red flashing, yellow flashing, off	System fault	Internal system fault	Support[1]
3022	off, yellow flashing, off	Generator fault	Overcurrent at the PV generator	Please check the generator installation/configuration[1]
3023	off, yellow flashing, off	Generator fault	Overcurrent at the PV generator	Please check the generator installation/configuration
3024	red flashing, yellow flashing, off	System fault	Internal system fault	Support[1]
3025	off, off, off	Generator fault	Overvoltage on PV generator	Please check the generator installation/configuration
3026	off, yellow flashing, off	Generator fault	Overcurrent at the PV generator	Please check the generator installation/configuration

Event code xxxx	LED display	Type of fault	Description / possible cause	Measure
3027	🔴☀️⚪	System fault	Internal system fault	Support[1]
3028	⚪⚪⚪	Generator fault	Overvoltage on PV generator	Please check the generator installation/configuration
3029	⚪☀️⚪	Generator fault	Overcurrent at the PV generator	Please check the generator installation/configuration
3030	⚪⚪🟢	Temperature fault	Excess temperature AC/DC at power level	Check installation conditions and cooling aids. Support[1]
3031	🔴🟡⚪	System fault	Internal AC system fault	Device carries out test several times and generally switches. Support[1]
3032	⚪🟡⚪	Generator fault	Overcurrent at the PV generator	Please check the generator installation/configuration
3033	⚪⚪🟢	Temperature fault	Internal system fault	Support[1]
3034	🔴☀️⚪	System fault	Internal intermediate circuit fault	Please restart the device. Support[1]
3035	🔴🟡⚪	System fault	Internal intermediate circuit fault	Please restart the device. Support[1]
3036-3039	🔴🟡⚪	System fault	Internal system fault	Support[1]
3043	🔴🟡⚪	Parameterization fault	Internal system fault	Please restart the device. Support[1]
3044-3046	🔴🟡⚪	System fault	Internal AC system fault	Device carries out test several times and generally switches. Support[1]
3047	🔴🟡⚪	System fault	Internal system fault	Support[1]
3048-3050	🔴🟡⚪	Communication fault	Internal communication error	Please check the internal communication cables between the individual PCBs. Support[1]
3051-3054	🔴☀️⚪	System fault	Internal system fault	Support[1]
3055	🔴🟡⚪	System fault	Internal system fault	Please restart the device. Support[1]
3056	🔴☀️⚪	System fault	Internal AC system fault	Contact support.
3057	🔴🟡⚪	System fault	Internal system fault	Support[1]
3058	🔴🟡⚪	Parameterization fault	Internal system fault	No action necessary. Support[1]
3059	🔴🟡⚪	System fault	Internal system fault	Country setting may be incorrect. Contact support.
3060	🔴🟡⚪	Parameterization fault	Faulty parameterization	Contact support.

Event code xxxx	LED display	Type of fault	Description / possible cause	Measure
3061	red flashing, yellow flashing, off	System fault	Internal system fault	No action necessary. Support[1]
3062	off, off, green flashing	Temperature fault	Internal system fault	No action necessary. Support[1]
3063	red flashing, yellow flashing, off	Parameterization fault	Internal system fault	Contact support.
3064	off, yellow flashing, off	DC regulator fault	Internal system fault	No action necessary. Support[1]
3065	off, yellow flashing, off	DC regulator fault	Internal system fault	No action necessary. Support[1]
3066	red flashing, yellow on, off	System fault	Internal system fault	Contact support.
3068	red flashing, yellow flashing, off	System fault	Internal system fault	Please restart the device. Support[1]
3069 - 3075	red flashing, yellow flashing, off	System fault	Internal AC system fault	Device carries out a test several times and generally switches. Support[1]
3076	red flashing, yellow flashing, off	System fault	Internal AC system fault	The AC voltage may be too low.
3077-3078	off, yellow flashing, off	System fault	Internal AC system fault	Contact support.
3079-3080	red flashing, yellow flashing, off	System fault	Internal system fault	Option of restarting the device by pressing the DC switch. Support[1]
3082	red flashing, yellow flashing, off	System fault	Internal system fault	Contact support.
3083	off, off, off	Information	Internal system fault	No action necessary. Support[1]
3084	red on, yellow on, off	System fault	Internal system fault	Contact support.
3085	off, off, green flashing	System fault	Excess temperature of processor	Check installation conditions and fan[1]
3086	red on, off, off	Grid error	Power curtailment due to a grid fault (increased AC voltage)	Support[1]
3087	red on, yellow on, off	System fault	Internal system fault	Contact support.
3088-3089	red on, yellow on, off	System fault	Contamination of or damage to the fan unit	Clean fan unit
3090	red on, yellow on, off	System fault	Internal system fault	Contact support.
3091-3092	red on, yellow on, off	System fault	Fan not correctly connected	Check fan plug connections
3093-3094	red on, yellow off, off	Parameterization fault	Incorrect parameterization	Contact support.
3095	red on, yellow on, off	Calibration fault	Incorrect calibration	Contact support.

Event code xxxx	LED display	Type of fault	Description / possible cause	Measure
3096	○ ○ ○	Generator fault	Incorrect dimensioning of PV generator	Please check the generator installation/configuration
3097	☼(red) ☼(yellow) ○	Parameterization fault	Incorrect parameterization	Contact support.
3098	○ ○ ○	Information	Grid functionality not available	No action necessary. Support[1]
3101	○ ○ ○	Information	Internal system fault	No action necessary. Support[1]
4100	○ ●(yellow) ○	System fault	Internal software fault	Support[1]
4101, 4104	☼(red) ☼(yellow) ○	System fault	Increased DC current L1	Support[1]
4102, 4105	☼(red) ☼(yellow) ○	System fault	Increased DC current L2	Support[1]
4103, 4106	☼(red) ☼(yellow) ○	System fault	Increased DC current L3	Support[1]
4110	●(red) ●(yellow) ○	System fault	Internal software fault	Support[1]
4121-4131	☼(red) ☼(yellow) ○	System fault	Internal system fault	Support[1]
4150	○ ○ ○	Information	Increased grid frequency. Frequent recurrence in the morning and the evening.	Please check the installation[1]
4151	●(red) ○ ○	Grid fault	Grid frequency too low	Please check the installation[1]
4157-4160	●(red) ○ ○	Grid fault	Increased grid frequency	Please check the installation[1]
4161	●(red) ○ ○	Grid fault	Grid frequency too low	Please check the installation[1]
4170	○ ○ ○	Information	One phase is not connected. A miniature circuit breaker was not switched on.	Please check the installation[1]
4180	●(red) ○ ○	Grid fault	PE cable not connected	Please check the installation[1]
4181	●(red) ○ ○	Grid fault	PE cable not connected	Please check the installation[1]
4185	☼(red) ☼(yellow) ○	System fault	Internal software fault	Support[1]
4200	●(red) ○ ○	Grid fault	Increased grid voltage	Please check the installation[1]
4201	●(red) ○ ○	Grid fault	Grid voltage too low	Please check the installation[1]
4210	●(red) ○ ○	Grid fault	Increased grid voltage	Please check the installation[1]
4211	●(red) ○ ○	Grid fault	Grid voltage too low	Please check the installation[1]
4220-4221	●(red) ○ ○	Grid fault	Voltage mean value of the last 10 minutes too high	Please check the installation[1]

Event code xxxx	LED display	Type of fault	Description / possible cause	Measure
4290	● ○ ○	Grid fault	The grid frequency has changed too quickly.	Please check the generator installation[1]
4300 - 4304	☀ ☀ ○	System fault	Internal system fault	Support[1]
4321	☀ ☀ ○	Parameterization fault	Residual current	Support[1]
4322	☀ ● ○	Parameterization fault	Residual current	Contact support.
4323	☀ ☀ ○	Parameterization fault	Residual current	Support[1]
4324	☀ ☀ ○	System fault	Residual current	Support[1]
4325	☀ ☀ ○	Parameterization fault	Residual current	Support[1]
4340 - 4354	☀ ○ ○	Residual current fault	Residual current	Please check the generator installation[1]
4360 - 4382	☀ ☀ ○	System fault	Internal system fault	Support[1]
4383	☀ ☀ ○	Parameterization fault	Internal system fault	Support[1]
4401 - 4404	☀ ☀ ○	System fault	Internal system fault	Support[1]
4421	☀ ☀ ○	Parameterization fault	Internal system fault	Support[1]
4422	☀ ☀ ○	Parameterization fault	Internal system fault	Contact support.
4423	☀ ☀ ○	System fault	Internal system fault	Contact support.
4424	☀ ☀ ○	Parameterization fault	Internal system fault	Support[1]
4425	☀ ☀ ○	Parameterization fault	Internal system fault	Contact support.
4450	● ● ○	Insulation fault	Insulation fault	Please check the generator installation[1]
4451	☀ ☀ ○	System fault	Internal system fault	Contact support.
4452	● ● ○	Insulation fault	Insulation fault	Please check the generator installation[1]
4475	☀ ☀ ○	System fault	Internal system fault	Support[1]
4476	○ ○ ○	Information	Weak PV supply	No action necessary. Support[1]
4800	☀ ● ○	System fault	Internal system fault	Support[1]
4801	☀ ☀ ○	System fault	Insulation fault	Support[1]

Event code xxxx	LED display	Type of fault	Description / possible cause	Measure
4802	🔴☀️ 🟡☀️ ⚪	System fault	Internal system fault	Support[1]
4803, 4804	🔴☀️ 🟡☀️ ⚪	System fault	Insulation fault	Support[1]
4805-4810	🔴☀️ 🟡☀️ ⚪	System fault	Internal system fault	Support[1]
4830	🔴☀️ 🟡☀️ ⚪	System fault	Hardware error	Support[1] or replace the defective varistor.
4850	🔴☀️ 🟡☀️ ⚪	System fault	Energy supply company	Support[1]
4870 - 4910	🔴☀️ 🟡☀️ ⚪	System fault	Internal system fault	Support[1]
4920-4922	🔴 🟡 ⚪	Measurement system	Placing of the measuring chains	Support[1]

Tab. 6: Event codes

[1] If the error occurs several times/permanently, please contact Support.

Legend for the "Event codes" table

🔴☀️ 🟡☀️ 🟢☀️   LEDs flashing

🔴 🟡 🟢   LEDs lit up

⚪ ⚪ ⚪   LEDs off

5. Web server

5.1 The web server

The web server offers a graphic interface (representation in the browser) for the configuration of the inverters.*

In order to correspond with the web server, you must connect the inverter to a computer. You can reach the web server by entering an IP address in the browser. The exact process is described as follows:

The web server offers the following content:

Web server pages	Function
Main page	Display of the yield data. **⏎ Page 88**
History	List of the sensor data, building consumption and yield data. **⏎ Page 89**
Info page	Status display of the analogue inputs, the modem and the last connection to the solar portal. **⏎ Page 90**
Self-consumption / battery	Display showing present battery data and building consumption. **⏎ Page 91**
Settings	Inverter configuration **⏎ Page 92**

Tab. 7: Overview of the web server pages

*Deviations due to software versions (UI status) possible.

5.2 Using the web server

In order to use the web server, the inverter must be connected with a computer.

Settings in the computer

- In the Internet protocol (TCP/IP) of the computer, the options "Automatically acquire IP address" and "Automatically acquire DNS server address" must be activated.

You can go to the settings for the Internet protocol (TCP/IP) via system control[1]:
System control >> Network and release centre >> Change adapter settings >> Right mouse click on "LAN connection" >> Properties >> Select "Internet protocol (TCP/IPv4)" > Properties.

- In the LAN settings of the computer, the option "Use proxy server for LAN" must be deactivated.

You can reach the "LAN settings" via the system control[1]: System control >> Internet options >> Tab: "Connections" >> LAN settings.

[1] With Windows 7

Connecting the inverter with a computer 🛈

1. De-energise the inverter. ⚠️

2. Open the inverter cover.
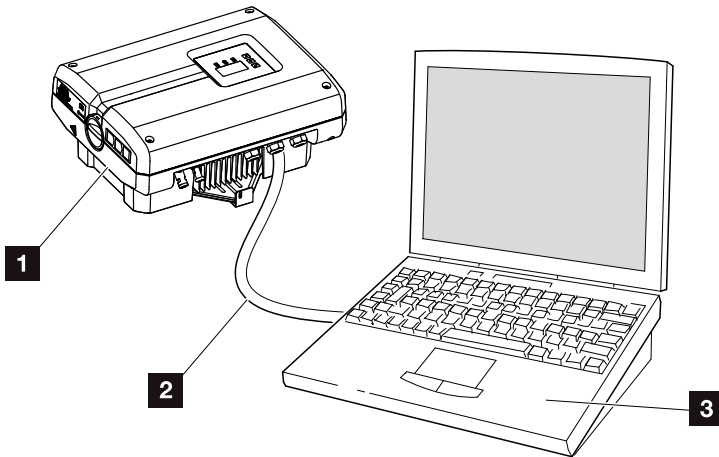
Fig. 50: Connecting inverter and computer with an Ethernet cable

1 Inverter
2 Ethernet cable
3 Computer (for configuration or data retrieval)

3. Connect the Ethernet cable to the RJ45 interface of the communication board. ❗

4. Connect the Ethernet cable to the computer.

5. Close the inverter cover.

6. Switch on the DC switch and the fuses.

✔ The inverter is connected to the computer.

ℹ️ TIP

You can find additional variants for connecting the inverter with a computer here: ↗ **Ch. 6.1**

⚡ DANGER

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
↗ **Ch. 4.3**

❗ IMPORTANT INFORMATION

If the computer and the inverter are connected directly with an Ethernet cable, the adjacent work sequence must be followed!

ℹ️ TIP

The IP address is found in the inverter menu under "Settings / Communication / Network settings 2".

Additional entry options in the address line of the browser:

- S and the serial number of the inverter on the type plate (example: http://S12345FD323456)
- Name of the inverter: The inverter can be assigned a name. This may be no longer than 15 characters and may not contain special characters like + - * /... (For example: http://SWR_5).

Call up web server

1. Launch Internet browser.

2. Enter the IP address of the inverter in the address line of the browser and confirm with "Return".

→ The input screen for the access data opens.

3. The following log in data are preset in the input screen as standard:
   User name: pvserver
   Password: pvwr
   Enter the user name and password. ℹ️

→ The main page of the inverter is displayed.

Configuring settings

Configure the necessary settings and retrievals.

Disconnect the inverter from the computer

1. De-energise the inverter.
   ↗ **Ch. 4.3** ⚠️

2. Open the inverter cover.

3. Unplug the Ethernet cable from the inverter and the PC. ℹ️

4. Close the inverter cover.

5. Switch on the DC switch and the fuses.

✔ The inverter is once again in operation.

ℹ️ **TIP**

Please change the password following initial registration.

The password may consist of no more than 15 characters and contain the following characters: a-z, A-Z, 0-9 and _

⚠️ **DANGER**

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge. ↗ **Ch. 4.3**

ℹ️ **TIP**

Leave the Ethernet cable connected to the inverter. This makes it possible to easily carry out further queries or setting configurations on the inverter.

5.3 The pages of the web server

The main page of the web server*

AC power			Energy		
Current	xxx	W	Total energy	xxx	kWh
			Daily energy	xxx	kWh
Status	Off				

PV generator			Output power		
String 1			L 1		
Voltage	xxx	V	Voltage	xxx	V
Current	xxx	A	Output	xxx	W
String 2			L 2		
Voltage	xxx	V	Voltage	xxx	V
Current	xxx	A	Output	xxx	W
String			L 3		
Voltage	xxx	V	Voltage	xxx	V
Current	xxx	A	Output	xxx	W

RS485 communication

Inverter	xxx	Display/Update

History   Info page   Self-consumption / battery   Settings

Fig. 51: Main page of a 3-phase inverter

*The representation of the web server depends upon the inverter type and the UI status.

The main page consists of three areas:

- **Performance data:** List of the voltages, currents and outputs of the AC and DC sides.

- **RS485 communication:** When networking several inverters via RS485, each inverter receives its own RS485 address. With this RS485 address, the inverter can be chosen and its yield data retrieved. One click on the "Display/Update" button updates the data or displays the data following selection of the inverter.

- **Link area:** Links to web server pages "History", "Info page", "Self-consumption / battery" and "Settings".

The web server page "History"

The link calls up the measured values (log data). The log data of the inverter can be downloaded as a DAT or a TXT file. The data are filed in a CSV file and can be represented with any spreadsheet program (e.g. Excel). ℹ️

Option **"Open"**: The data are displayed in a new or the same browser window.

Option **"Save target as..."**:
The data (LogDaten.dat) are saved on your hard drive. To this purpose, right-click on the menu item "History". After saving, these data can be displayed and further processed. ℹ️

ℹ️ **INFO**

If the inverter is not connected to a solar portal, regular backup copies of the log data should be created.

ℹ️ **INFO**

The various options depend upon the browser. The option "Save target as ..." is only available with the "Internet Explorer" browser.
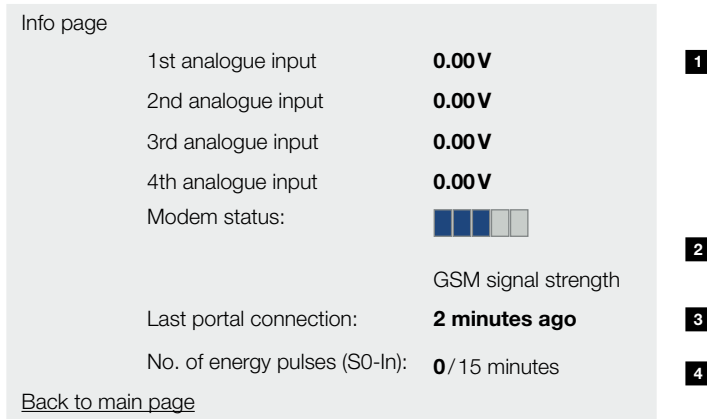
The web server page "Info page"

Info page		
1st analogue input	**0.00 V**	**1**
2nd analogue input	**0.00 V**	
3rd analogue input	**0.00 V**	
4th analogue input	**0.00 V**	
Modem status:	▮▮▮▯▯	
		2
	GSM signal strength	
Last portal connection:	**2 minutes ago**	**3**
No. of energy pulses (S0-In):	**0**/15 minutes	
Back to main page		**4**

Fig. 52: Screenshot of web server "Info page"

1 **xth analogue input:** Shows the voltage which is currently available on the analogue input x. The function of a connected sensor or ripple control receiver can be checked with the voltage entries.

2 **Modem status:** Shows the modem status: When the GSM modem is connected correctly, the GSM signal strength is displayed. When the modem is connected incorrectly or not available, "No modem available" is displayed.

3 **Last portal connection:** Displays how many minutes ago the inverter last transferred data to the solar portal (when the function is active).

4 **Number of energy pulses:** Displays the number of energy pulses per time unit occurring at the S0 interface. If, for example, an external energy meter is connected at the S0 input, its function can be checked via the displayed number of energy impulses.

The "Self-consumption/ battery" web server page

<div>

Battery

	Charging status	**0.0%**	**1**
	Voltage	**0 V**	**2**
	Charging current	**0.00 A**	**3**
	Temperature	**0.0 °C**	**4**
	Number of cycles	**0**	**5**

Building consumption

Coverage of building consumption from:

	Battery	**0.0 W**	**6**
	Solar generator	**0.0 W**	**7**
	Grid	**0.0 W**	**8**

Phase-selective consumption:

	Phase 1	**0.0 W**	**9**
	Phase 2	**0.0 W**	
	Phase 3	**0.0 W**	

</div>

Fig. 53: Screenshot of "Self-consumption/ battery" web server page

1 **Charging status:** Shows the battery's charging status.

2 **Voltage:** Shows the battery's voltage.

3 **Charging current / discharge current:** Charging current shows that the battery is being charged. Discharge current shows that the battery is being discharged.

4 **Temperature:** Shows the battery's temperature.

5 **Number of cycles:** Shows the battery's charging cycles. A cycle is considered complete when the battery has been charged to half the max. possible amount of energy. Then the next cycle starts.

6 **Battery:** Indicates energy consumption in W that is currently being covered from the battery.

7 **Solar generator:** Indicates energy consumption in W that is currently being covered from the PV modules.

8 **Grid:** Indicates energy consumption in W that is currently being covered from the grid.

9 **Phase x:** Shows the energy consumption by phase (1, 2 or 3) that is currently being consumed from the battery, PV modules and grid.

The web server page "Settings"

The configuration of the inverter and the external components (e.g. sensor, ripple control receiver, etc.) takes place on this page. ℹ️

ℹ️ INFO

The entries must be confirmed with a click on the "Accept" button. The settings are then saved.

Settings	Vers. 5.00		
Ser. no.:	90342ABC000X		**1**
Item number	200002800A		**2**
Language	German ▼		**3**
Name	No name		**4**
WR bus (RS485) address	255	(1..220)	**5**
Data capture every	15 ▼	minutes	**6**
Switch output function	S0 pulses ▼	(S0/AL-Out)	**7**
Self-consumption control:	⦿ **Function 1**		**8**

Power limit	1100	W	
Stable exceeding of the limit	45	Minutes	
Run time	60	Minutes	
Activation	99	Number/day	

⦿ **Function 2**

Activation limit	200	W
Deactivation limit	100	W
☐ Delay in the event of power loss / fault	5	Minutes

Function of analogue inputs:	Sensors ▼		**9**
Network:	⦿ Auto IP/DHCP		**10**
	◯ Manual network configuration:		

WRIP address:	192	168	1	1
Subnet mask:	255	255	255	0

☐ External router (must be located within the same subnet)

Router IP address:	192	168	1	254
DNS server address:	145	253	2	203

Fig. 54: Web server page "Settings" (Part 1)

Public line [   ] (only for analogue modem and TC system)   **11**

GSM-PIN: [****]   **12**

New log-inpassword: [   ] Repeat: [   ]   **13**

Portal code [   ]   **14**

Data export ☐ Portal   **15**

[**Accept**]   **16**

Fig. 55: Web server page "Settings" (Part 2)

1 **Ser. no.:** Inverter serial number.

2 **Item number:** Item number of the inverter.

3 **Language:** Selection of the language for the web display.

4 **Last name:** Allocation of a name to the inverter.[1]

5 **WR bus (RS485) address:** RS485 address of the inverter.[2]

6 **Data capture:** Selection of saving interval "every 15" or "every 60" minutes.[3]

7 **Function Switch output (S0/AL-Out):** Setting possibilities: S0 pulse, alarm output, self-consumption control, dynamic self-consumption control.

8 **Self-consumption control:** Setting possibilities for the self-consumption function. Detailed description in chapter Self-consumption. ⤢ **Ch. 8.1**

9 **Function of analogue inputs:** Two settings: Sensors or active power control (connection of a ripple control receiver).

10 **Network:** Configuration of the inverter network interface (Ethernet). Detailed description in System monitoring chapter. ⤢ **Ch. 6**

11 **Public line:** Only required when using an analogue modem (optional accessory) and an analogue telephone system.

12 **GSM-PIN:** PIN for the GSM modem SIM card.

13 **New log-inpassword:** Change of password.

[1] The characters a–z, A–Z and 0–9 are allowed for the name change. Spaces or special characters are not possible. The browser connection to the web server can take place with the new name following the name change. Access with the serial number remains possible.

[2] When two or more inverters are connected via RS485, each inverter must be given its own RS485 address.

[3] When 15 minutes is selected, the data can be saved for approximately 400 days. When 60 minutes is selected, the data can be saved for approximately 1500 days. When the internal memory is full, the oldest data will be overwritten.

14 **Portal code:** Input box for the portal code of a solar portal.

15 **Data export portal:** Display of the active portal. Removal of the "check" deactivates sending to the solar portal.

16 **"Accept" button:** Saves and accepts all changes.

6. System monitoring

6.1 Create connection between computer and inverter

It is possible to connect the inverter with a computer in the following cases:

- Settings and retrievals in the web server

- Retrieve log data of the inverter

Inverter and computer can be connected with the following variants:

- **Variant 1** ⬈ **Page 97**
  Connect inverter and computer directly

- **Variant 2** ⬈ **Page 97**
  Connect inverter and computer by way of a switch/ hub

- **Variant 3** ⬈ **Page 98**
  Connect inverter over DSL

Variant 1: Connect the inverter and computer directly

This variant is mainly applied for the configuration of the inverter by way of the web server on location. ⚠
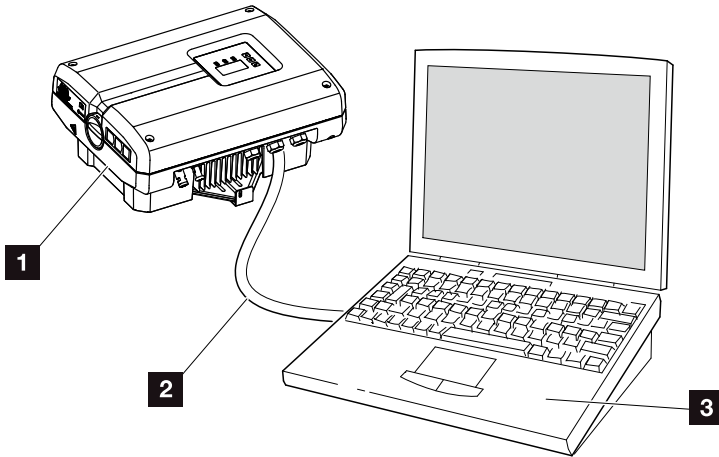
Fig. 56: Connect inverter and computer directly

1 Inverter
2 Ethernet cable
3 Computer (for configuration or data retrieval)

> **❗ IMPORTANT INFORMATION**
>
> **Use a patch cable of category 6 (Cat6e) with a maximum length of 100 m.**
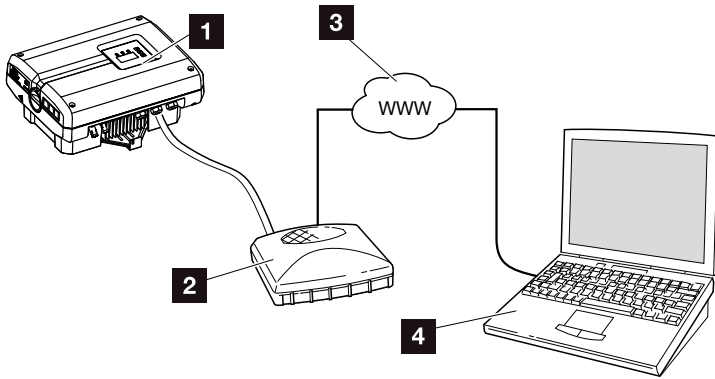
Variant 2: Connect inverter and computer by way of a switch/hub
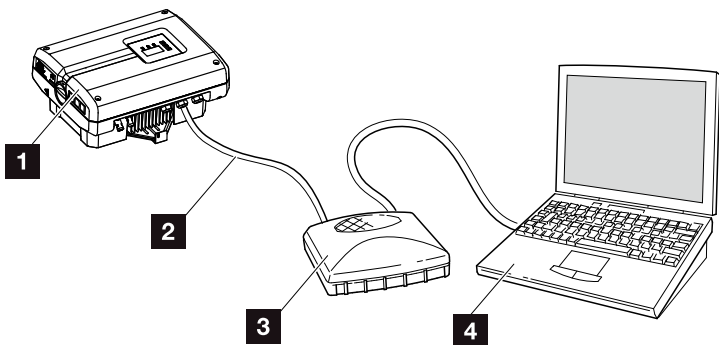
Fig. 57: Connect inverter and computer by way of a switch/hub

1 Inverter
2 Ethernet cable
3 Switch/hub
4 Computer (for configuration or data retrieval)

Variant 3: Connect inverter and computer by way of DSL ℹ️

Fig. 58: Connect inverter and computer by way of DSL

1 Inverter
2 DSL router
3 Internet
4 Computer (for configuration or data retrieval)

Manually configure network ℹ️

The option "Auto IP / DHCP" is generally activated as standard. This means that the inverter acquires its IP address from a DHCP server or automatically generates an IP address.

In the following two cases, the network setting must be entered manually:

- GSM modem does not obstruct

- Any DHCP server that generates IP addresses

A DHCP server can be, for example, a DSL router. A DHCP server (Dynamic Host Configuration Protocol) is a service that administers and distributes the IP addresses and the network configuration in a network.

ℹ️ **INFO**

Sound network knowledge is required to set up this variant.

ℹ️ **INFO**

If a GSM modem has also been installed in the inverter, but the Internet connection is to run via the DSL router, the option "external router" must be activated in the web server.

The data necessary for configuration, such as IP and DNS addresses can be found on your router.

6.2 The log data

The inverter is equipped with a data logger ↗ **Tab. 3**, which regularly records the following data from the system: ℹ

- Inverter data

- Data from external current sensors

- Grid data

- ENS data

You can find out how to retrieve, save and graphically represent log data in the following chapter ↗ **Ch. 6.3**

The log data can be used for the following purposes:

- Check operating characteristics of the system

- Determine and analyse malfunctions

- Download and graphically represent yield data

Fig. 59: Example screen "The log file"

1 File header
2 Physical variables
3 Entries in the log file

ℹ **INFO**

The log data can be downloaded as a DAT or as a TXT file.

Log file: File header

The log file contains a file header with information on the inverter:

Entry	Explanation
Inverter number	Number of the inverter
Name	Can be assigned by the user via the browser
Current time	The system time valid at the point in time of file creation in seconds. This makes allocation possible (e.g. 1372170173 = 25.06.2013 16:22:53)

Tab. 8: Log file file header

Log file: Physical variables

The file header is followed by the units of the physical variables. The following table explains the abbreviations for the physical variables:

Entry	Explanation
U	Voltage in volts [V]
I	Current strength in milliamps [mA]
P	Power in watts [W]
E	Energy in kilowatt hours [kWh]
F	Frequency in Hertz [Hz]
R	Resistance in kiloohms [kohm]
T	Counting unit in points [digits]
AIn	Counting unit in points [digits]
Time	Time in seconds [sec] since the inverter was put into operation
TE	Temperature in Celsius [°C]
H	Without function

Tab. 9: Physical variables in the log file

Log file: Entries

The units of the physical variables are followed by various entries in the log file.

The following table explains the various entries of the log file and may deviate depending upon the model:

Entry	Explanation
Time	Time in seconds since the inverter went into operation
DC x U	DC voltage: Input voltage of the respective strings (x = 1, 2 and 3) in V
DC x I	DC current: Input current of the respective strings (x = 1, 2 and 3) in mA
DC x P	DC power: Input power of the respective strings (x = 1, 2 and 3) in W
DC x T	DC temperature: Details for service. Temperature of the respective phase (1, 2 and 3) in digital values
DC x S	DC status: Entries for the service of the respective phase (1, 2 and 3)
AC x U	AC voltage: Output voltage of the respective phase (x = 1, 2 and 3) in V
AC x I	AC current: Output current of the respective phase (x = 1, 2 and 3) in mA
AC x P	AC power: Output power of the respective phase (x = 1, 2 and 3) in W
AC x T	AC temperature: Details for service. Temperature of the respective phase (1, 2 and 3) in digital values
AC F	AC frequency: Grid frequency in Hz
FC I	Residual current: Measured residual current in mA
AIn1 **AIn2** **AIn3** **AIn4**	Analogue input voltage: Display of the analogue inputs 1 to 4 of the communication board. The measured voltage value in V can be calculated with the value from the table (digits) and the following formula: Input voltage [V]=(10/1024) * digits. If the S0 input is used to count the energy pulses, both table columns AIn3 and AIn4 give the sum of the energy pulses per log interval. This total value is calculated as follows: $E_{total} = AIn3 * 2^{16} + AIn4$
AC S	AC status: Details for service of the operational status of the inverter
ERR	General malfunctions
ENS S	Status of the ENS (device for grid monitoring with assigned switching elements): Status of grid monitoring
ENS Err	Malfunctions of the ENS (device for grid monitoring with assigned switching elements)
SH x P	External current sensor power: Power of the respective phase (x = 1, 2 and 3) in W
SC x P	Self-consumption at the respective phase (x = 1, 2 and 3) in W
HC1 P	not used
HC2 P	Building consumption in W from the PV modules
HC3 P	Building consumption in W from the grid
KB S	Internal communication status when switching to AC grid
Total E	Total energy: Total fed-in energy in kWh when switching to AC grid
HOME E	Building consumption: Energy currently used in the household in kWh
Iso R	Insulation resistance in kohm when switching to AC grid
Event	POR event, "power on reset": renewed start-up of communication after a loss of AC voltage.

Tab. 10: Log data

6.3 Retrieve, save and graphically represent log data

There are three variants for retrieving and permanently saving the log data:

- **Variant 1:** Download the log data with a computer and display it

- **Variant 2:** Transfer log data to a solar portal and display it

Variant 1: Download the log data with a computer and display it ⓘ

1. Call up the main screen of the web server ⬈ **Ch. 5.2**

2. Right-click on the "History" link

3. Click "Save target at ..." in the menu window

4. Save DAT file on the computer

5. Open DAT file with EXCEL

✓ The log data are represented in table form and can be processed further.

Variant 2: Transfer log data to a solar portal and display it

With a solar portal it is possible to monitor the PV system and the performance data via the Internet.

A solar portal has the following functions, which, however, may differ depending upon the portal:

- Graphic representation of performance data

- Worldwide online access to the portal

- E-mail notification of malfunctions

- Data export (e.g. Excel file)

- Long-term storing of log data

ⓘ **INFO**

This procedure is only possible when using Internet Explorer.

Prerequisites for data transfer to a solar portal:

✓ Inverter has an Internet connection

✓ Logging into a solar portal

✓ Portal code of the solar portal

✓ Activation of data transfer in the inverter

Activate data transfer to a solar portal via the control panel ⓘ

1. Select the "Settings" menu on the control panel of the inverter.

2. Confirm with the "ENTER" key.

3. Use the "UP", "DOWN" and "ENTER" keys to select the "Communication" / "Portal configuration" menu.

4. Enter the portal code of the solar portal in the "Code:" field. The portal code can also be assigned via the web server. The portal code for the PIKO Solar Portal (www.piko-solar-portal.de) is P3421.

ⓘ **INFO**

It may take as much as 20 minutes following activation (dependent upon the portal) until the data export is visible on the solar portal.

The transfer time may increase if the connection is impaired (e.g. poor wireless connection).
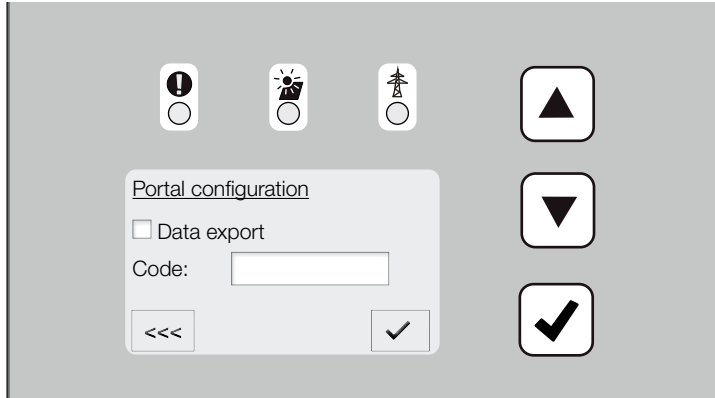
Fig. 60: Entry of the portal code

5. Press and hold down the "ENTER" key for approximately 3 seconds.

6. Select the "Accept" field and confirm with "ENTER".

✓ The data transfer to the solar portal is active (recognisable from the X in front of "Data export"). The name of the solar portal is shown. The data export to the solar portal is being executed.

7. Active power control

7.1 Why active power control?

In Germany, VDE application rule (VDE-AR-N 4105) and Renewable Energies Act (EEG) 2012 ⚠

Several energy supply companies offer the owners of PV systems the possibility to regulate their system with variable active power control, and thus to increase the feed-in to up to 100%. To this purpose, the VDE application rule (VDE-AR-N 4105) and the Renewable Energies Act are currently in effect in Germany, for example.

These application rules require active power control (reduction of the feed-in capacity) for each PV system.

The planner of a PV system can choose between two types of active power control: ℹ

- Limitation of the feed-in power to 70% of the PV power

- Active power control with a ripple control receiver

INFO

Should the PV system not fulfil the German Renewable Energies Act (EEG) 2012 requirements, the grid operator can reduce the feed-in tariff or dispense with it entirely.

INFO

When selecting active power control, check to determine which of the two possibilities offers the better energy yield.

7.2 Limitation of the PV feed-in capacity

Should the active power control not be realisable with a ripple control receiver, the feed-in capacity is then to be reduced to 70% of the PV power according to the German Renewable Energies Act 2012 (EEG 2012).

The power limitation is carried out with the parameterization software PARAKO. This software is available from Support.

The PIKO BA Sensor can be used with systems for which a permanent reduction, for example to 70%, is to be set as an affordable alternative to the ripple control receiver.

The current consumed in the building itself can be determined with the help of the PIKO BA Sensor. The intelligent self-consumption optimisation of the inverter can in this way increase the output power accordingly and maximise the yield. The power fed into the grid thereby remains limited to a maximum of 70%.

7.3 Activate the power control function with a ripple control receiver

The active power of the PIKO inverter can be controlled directly by the energy supply company with a ripple control receiver. 🛈

With this technology, the generated power can be regulated at four levels: ⚠

- 100%

- 60%

- 30%

- 0%
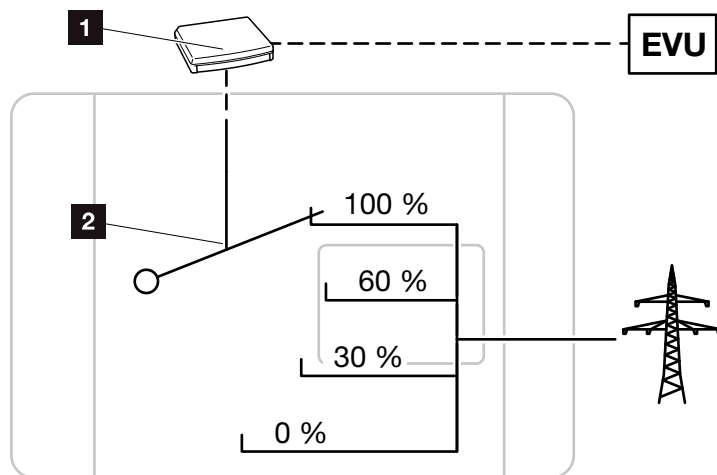
Fig. 61: Active power control with a ripple control receiver

1 Ripple control receiver
2 Control electronics of the inverter

> **🛈 INFO**
>
> In the case of all PIKO inverters, the ripple control receiver can be connected directly without any additional device.

> **🛈 INFO**
>
> Changes to the power limitation are carried out with the parameterization software PARAKO. However, the provisions of the energy supply company must be observed.

7.4 Install the ripple control receiver
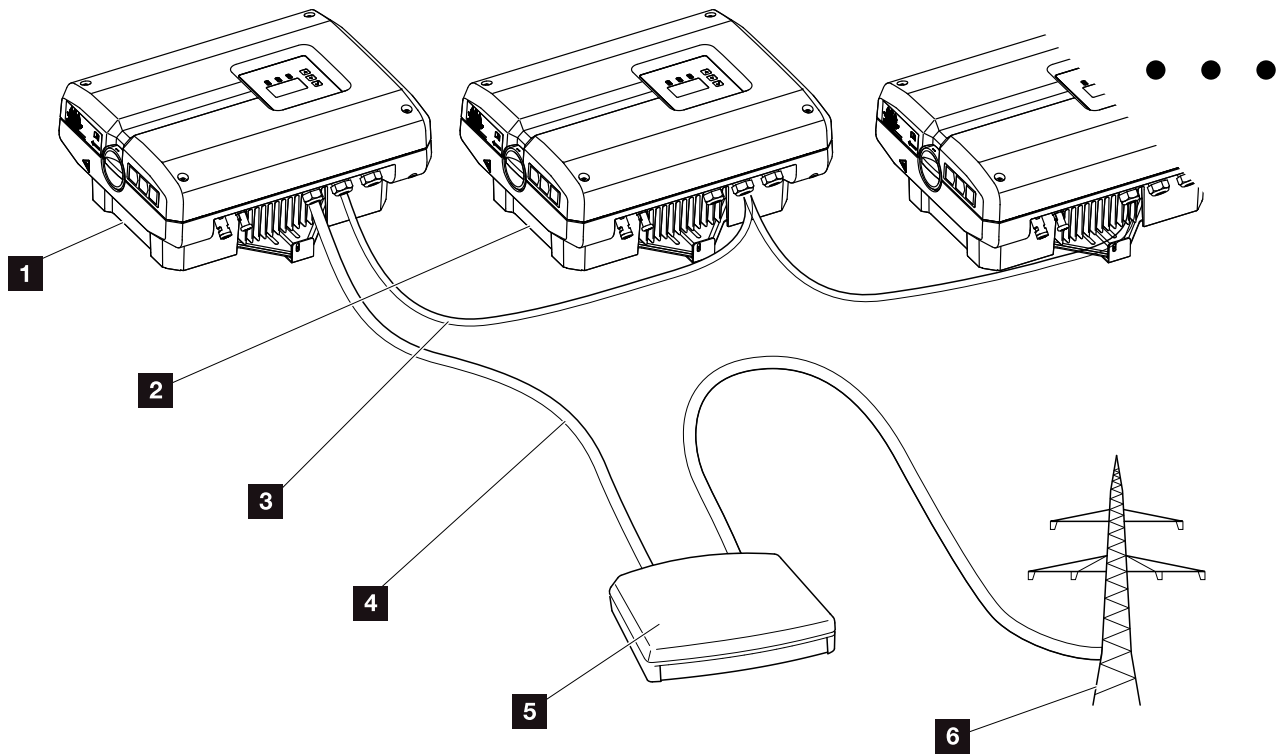
Fig. 62: Configuration of the ripple control receiver with several inverters (Ethernet networking)

1 Master inverter
2 Additional inverters (slaves)
3 Ethernet or RS485 cable
4 5-conductor connection
5 Ripple control receiver
6 Energy supply company

Connect the ripple control receiver

1. De-energise the inverter. ⬈ **Ch. 4.3** ⚠

2. Connect all inverters by way of the Ethernet connections (RJ45) with an Ethernet cable.
    ⬈ **Fig. 62**

3. Connect the ripple control receiver to the master inverter ⬈ **Fig. 62 lt. 1** on the analogue interface terminal (10-pin). ⬈ **Fig. 63** ❗
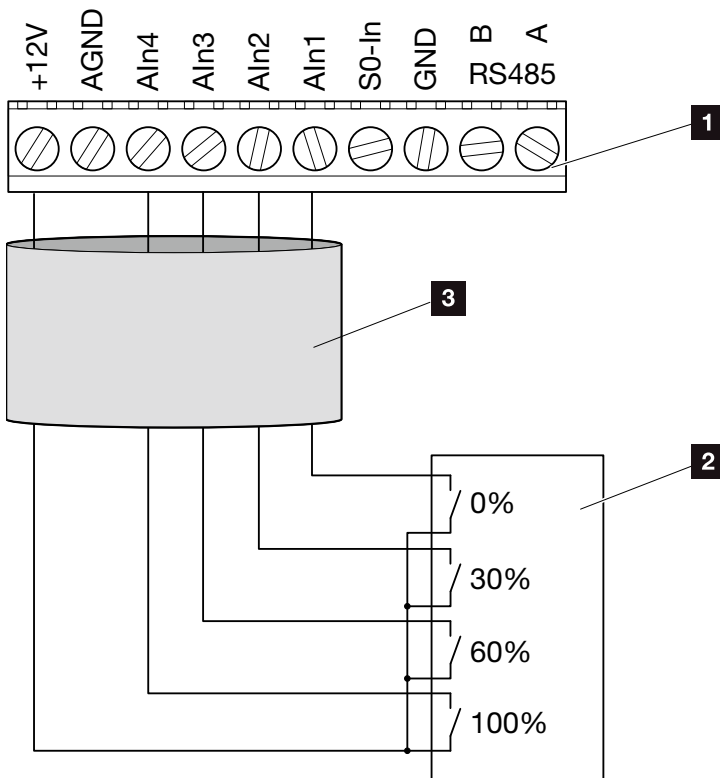
Fig. 63: Connection of ripple control receiver

1 Terminal analogue interface (10-pin)
2 Ripple control receiver
3 Cable

✓ The ripple control receiver is connected.

⚠ **DANGER**

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
⬈ **Ch. 4.3**

❗ **IMPORTANT INFORMATION**

The ripple control receiver may only be connected at the master inverter. ⬈ **Fig. 62**

Activate the active power control function in the web server

1. Connect the inverter and computer with an Ethernet cable. ⧉ **Fig. 56** ⚠

2. Launch Internet browser.

3. Enter the IP address of the master inverter in the address line of the browser and confirm with "Return". ℹ

➜ The input screen for the access data opens.

4. Enter your user name and password.

➜ The main screen of the web server opens.

5. Click on the "Settings" link.

➜ The "Settings" page opens.

6. In the menu item "Function analogue inputs", select the function "Active power control".

7. Click on the "Accept" button.

✔ The active power control for the ripple control receiver is active.

> **⚠ IMPORTANT INFORMATION**
>
> **The configuration must be carried out at the master inverter to which the ripple control receiver is connected. No further adjustments are necessary for the other inverters.**

ℹ INFO

The IP address can be queried by way of the control panel in the "Settings" menu.

The IP address is found in the inverter menu under "Settings / Communication / Network settings 2".

Additional entry options in the address line of the browser: S and the serial number of the inverter on the type plate (example: http://S12345FD323456)
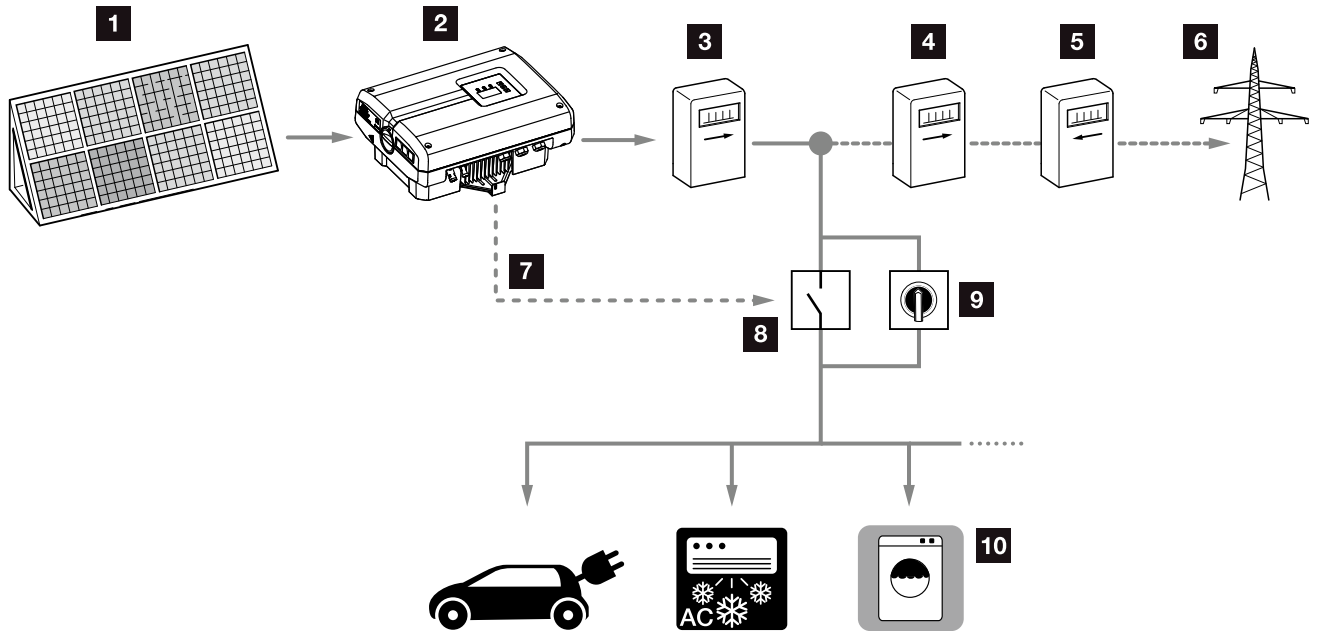
8. Self-consumption

8.1 Self-consumption overview

Fig. 64: Configuration of self-consumption

[1] Photovoltaic modules
[2] Inverter
[3] Production meter
[4] Feed meter
[5] Consumption meter
[6] Grid
[7] Control signal
[8] External load relay
[9] Jumper switch
[10] Consumer device

All inverters are designed in such a way that the gener-
ated current can be used for self-consumption.
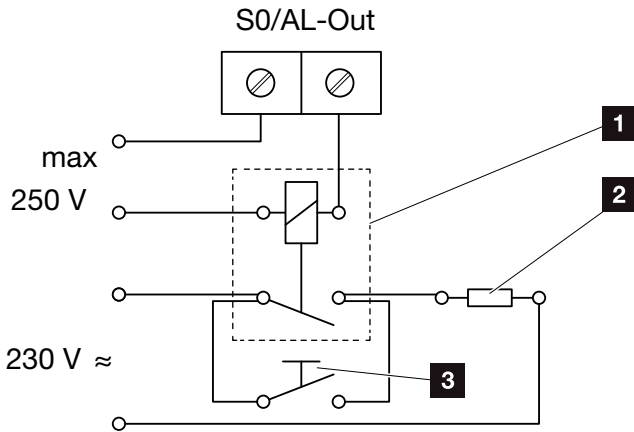
8.2 Electrical connection for self-consumption

S0/AL-Out

Fig. 65: Electrical connection for self-consumption

1 Load relay
2 Consumer device
3 Jumper switch

Proceed as follows for the electrical connection for self-consumption: ⚠

1. Properly connect the load relay to the terminal S0/AL-Out.

2. Properly install and connect the additional components for self-consumption.
   ↗ Fig. 64

✔ The electrical connection for self-consumption is complete. 🏠

Switch output S0/AI OUT	
Max. load	100 mA
Max. voltage	250 V (AC or DC)

Tab. 11: Technical data for switch output S0/AL-Out

⚠ **DANGER**

RISK OF DEATH DUE TO ELECTRI-CAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
↗ **Ch. 4.3**

🏠 **DAMAGE POSSIBLE**

An external load relay must be installed between inverters and devices. No consumers may be connected directly to the inverter!

8.3 Set up self-consumption control in the web server

Switch output function: Self-consumption control ▼   (S0/AL-Out)   **1**

Self-consumption control: ○ Function 1   **2**

    Power limit   4500   W

    Stable exceeding of the limit   1   minutes

    Run time   25   minutes

    Activation   99   number / day

    ○ Function 2   **2**

    Activation limit   1000   W

    Deactivation limit   1000   W

    ☐ Delay in drop in output / fault   **3**

    1   minutes

Fig. 66: Commands for self-consumption functions in the web server
(partial view of "Settings" page)

The following commands are required in the web server
on the "Settings" page:

1 Switch output function

2 Self-consumption function 1 or function 2

3 Delay in the event of power loss / fault

Activate self-consumption control

1. Properly connect the external load relay to the terminal S0/AL-Out. ⚡ **Fig. 65**

2. In the web server, select "Self-consumption control" or "Dynamic self-consumption control".
⚡ **Fig. 66, It. 1** 🛈

3. Choose function 1 or function 2.
⚡ **Fig. 66, It. 2** 🛈

4. Enter values for the function.

5. Activate and enter optional value for "Delay in the event of power loss/fault" with a check box.
⚡ **Fig. 66, It. 3** 🛈

6. Click "Accept".

7. Start up the inverter.

✔ The self-consumption control function is active.

Set up self-consumption control

1. Connect the inverter and computer with an Ethernet cable. ⚡ **Fig. 56**

2. Launch an Internet browser.

3. Enter the IP address of the master inverter in the address line of the browser and confirm with "Return".

➔ The input screen for the access data opens.

4. Enter your user name and password.

➔ The main screen of the web server opens.

5. Click on the "Settings" link.

➔ The "Settings" page opens.

6. In the "Function switch output" menu item, select the function "Self-consumption control" or "Dynamic self-consumption control".

7. Select function 1 ⚡ **Fig. 67** or 2 ⚡ **Fig. 68**.

8. Enter values for the function.

🛈 **INFO**

When selecting "Dynamic self-consumption control", the measured building consumption determined with the PIKO BA Sensor available as an option is automatically added to the set value and taken into consideration.

🛈 **INFO**

■ You can find more detailed explanations regarding the selection of function 1 or 2 in the course of the chapter.
■ The command "Delay in the event of power loss/fault" can be used for function 1 and 2.

9. Select function "Delay in the event of power loss / fault" and enter time.

10. Click "Accept".

11. Start up inverter.

✓ The "Self-consumption control" function is set up.

Self-consumption control function 1

Control of self-consumption by time

When a certain rating **P1** has been generated for a certain period of time **T1**, the inverter switches to self-consumption.

The inverter remains in self-consumption mode for the entire run time **T2**. Following the run time **T2**, the inverter ends self-consumption.

This is the end of the interval. This interval can be repeated several times with the "Activation" option.
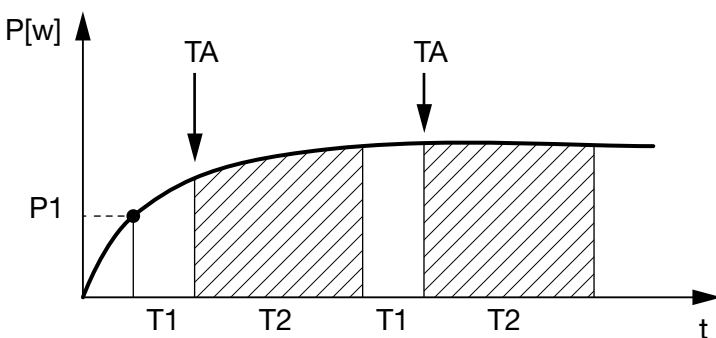

Fig. 67: Self-consumption graph (Function 1)

P1: Output limit

This is the minimum power (in watts) that must be produced before the consumer is switched on. You can enter any value from 1 watt to 999,000 watts.

T1: Period of stable exceeding of the output limit (P1)

The inverter must exceed the set "output limit" for this period of time (in minutes) before the consumer is switched on.

You can enter any value from 1 to 720 minutes (= 12 hours).

T2: Run time

The connected consumer is switched on for this period (in minutes) when both of the above conditions have been met. You can enter any value from 1 to 1,440 minutes (= 24 hours). The run time ends when the inverter shuts off. The run time ends and is not continued again if the inverter has not produced any current for three hours.

TA: Activation

Dashed area: Self-consumption active

The number **TA** (number / day) indicates how often self-consumption is activated each day.

Self-consumption control function 2

Control of self-consumption by rating

When a certain rating **P1** has been generated, the inverter switches to self-consumption.

When the rating **P2** is not achieved, the inverter ends self-consumption and resumes feeding current into the grid.
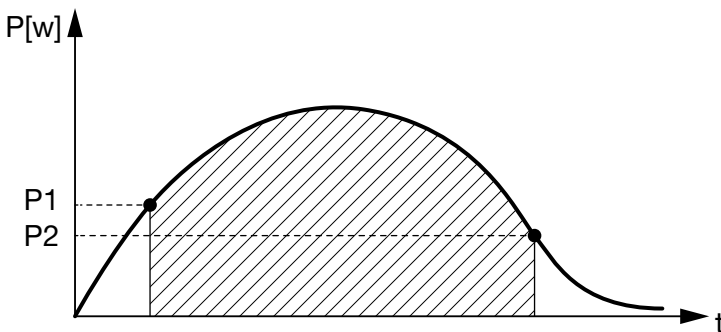

Fig. 68: Self-consumption graph (Function 2)

P1: Activation time limit
This is the minimum power (in watts) that must be produced before the consumer is activated.
You can enter any value from 1 watt to 999,000 watts.

P2: Deactivation time limit
The consumer is switched off when the power generated falls below this value.

Dashed area: Self-consumption active

Delay in the event of power loss / fault

Delay time for switching off self-consumption

With this function, self-consumption is only discontinued after the set delay time **T1**. In the event of power loss, fault **(Tx)** and the failure to achieve the shutdown limit, the consumer remains switched on for the set time **(T1)**.

If the fault period or the period of power loss is shorter than the set delay time, self-consumption remains activated.
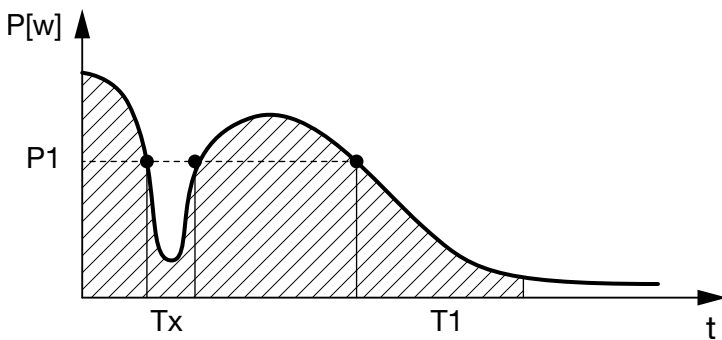

Fig. 69: Brief delay in the event of power loss / fault

P1: Power limit

T1: Delay time in the event of power loss / fault

Tx: Fault, power loss or failure of the inverter

Dashed area: Self-consumption active

9. Maintenance

9.1 Maintenance and service

Once correctly installed, the inverter runs virtually maintenance-free.

The following maintenance tasks are to be carried out for the inverter:

Activity	Interval
Carry out fan test[1] and check whether the fans function properly. Clean fans as required ⏩ **Ch. 9.2** 🏠	1x annually or after an incident
Check cable connections and plugs	1x annually
Clean fans ⏩ **Ch. 9.2** 🏠	1x annually

Tab. 12: Maintenance list

If no maintenance work is carried out, this results in an exclusion of the warranty (see 'Exclusion of warranty' in our Service and warranty conditions).

[1] The fan test can only be performed in feed-in mode (green LED lit).

DAMAGE POSSIBLE

Dirty fans mean that the inverter is not adequately cooled. Insufficient cooling of the inverter can result in a reduction in performance or the failure of the system.

9.2 Fan cleaning
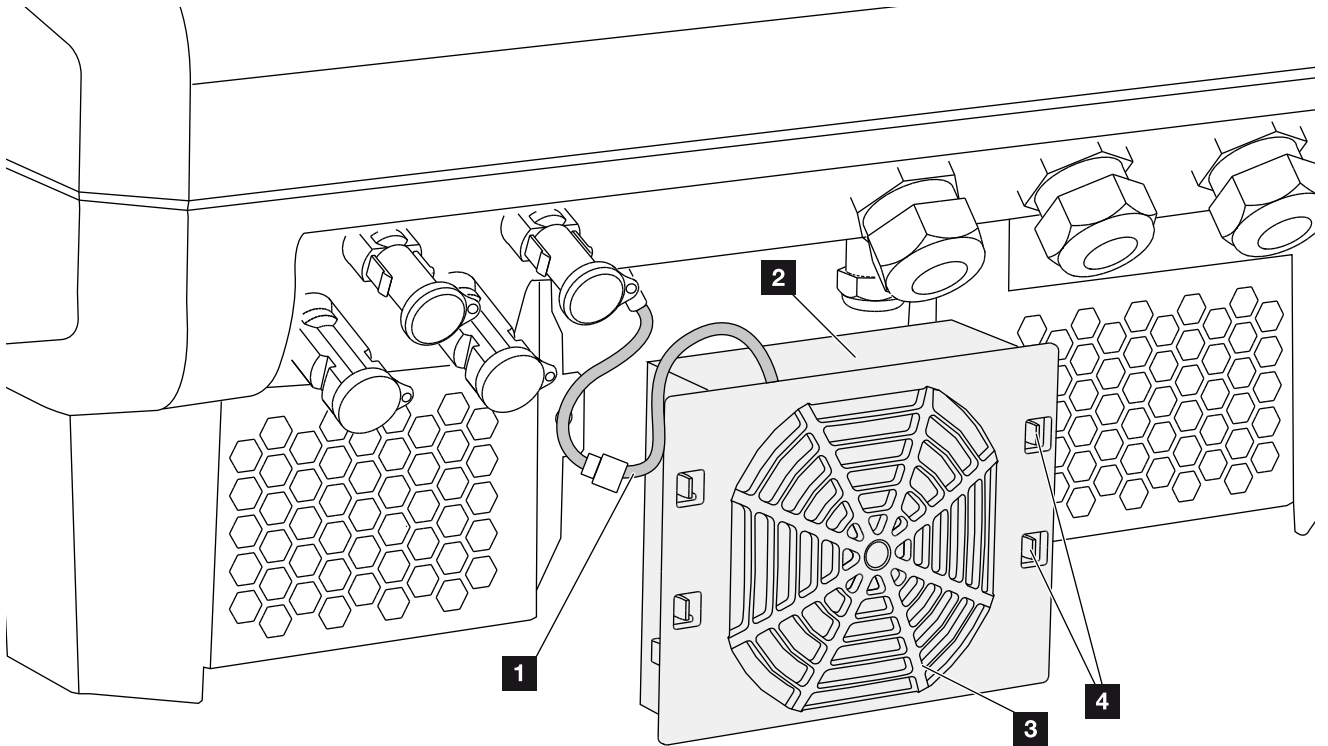
Fig. 70: Fan disassembly overview

1 Fan cable
2 Fan
3 Fan grill
4 Fastening straps

PIKO	3.0	4.2	5.5	7.0	8.5	10	12	15	17	20
DC inputs	1	1	2	2	2	2	2	3	3	3
Fan	–	–	1	1	1	2	2	2	2	2

Tab. 13: Number of fans and DC inputs according to the inverter type

Procedure

1. De-energise the inverter. ⚠️
   ↗ **Ch. 4.3**

2. Dismantle the fan. To do this, place a screwdriver at the edge of the fan grill and apply slight pressure to the fan grill. ↗ **Fig. 71**
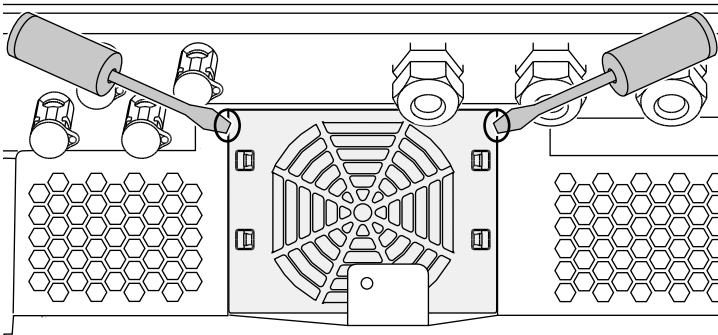

Fig. 71: Loosen fan grill

3. Press the fastening straps toward the centre of the fan with a second screwdriver.
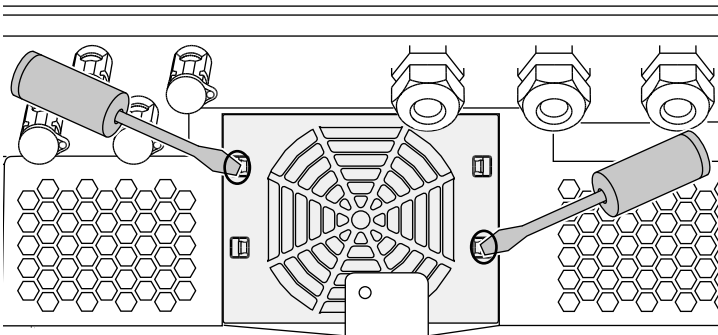   Pull the fan unit slightly forward. ↗ **Fig. 72**

Fig. 72: Loosen fastening straps

4. Completely remove the fan unit from the housing.
   To do this, disconnect the plug of the fan cable.
   ↗ **Fig. 73**

⚡ **DANGER**

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

Always de-energise the device during installation and before maintenance and repairs, and secure it against being switched back on.
↗ **Ch. 4.3 Important! After disconnecting the device from the power supply, wait five minutes for the capacitors to discharge.**
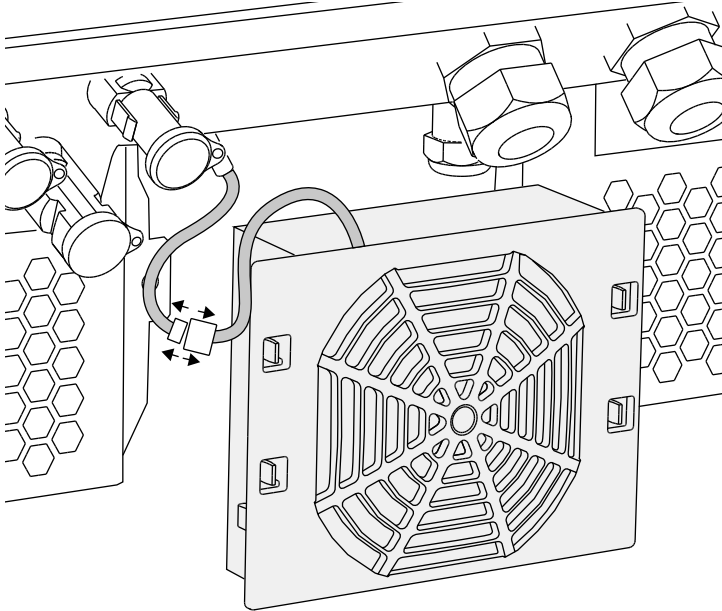
Fig. 73: Pull out fan cable

5. The fan can also be pulled off the fan grill. To do this, press the fastening straps slightly outward and pull off the fan.
↗ **Fig. 74**
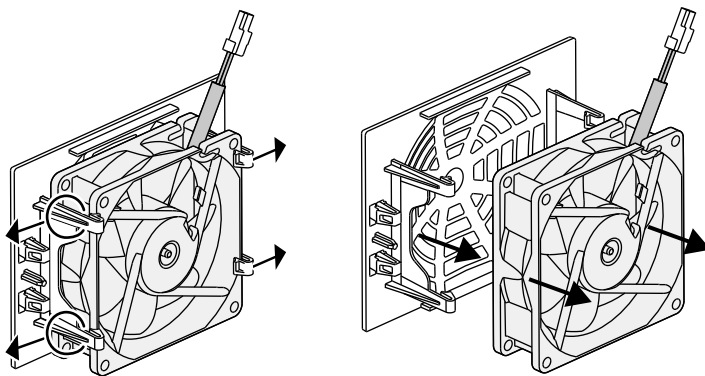
Fig. 74: Disassembly of the fan grill

6. Clean fan and housing opening with a soft brush.

7. Pay attention to the following when installing:
   The cable must point into the housing.
   The cable of the fan must not be blocked.
   The fan must be correctly installed in the fan frame
   (air flow direction). ↗ **Fig. 75**

Fig. 75: Fan installation

8. Reconnect the fan cable and insert the fan into the housing. When switching on for the first time, check whether the air from the fan is drawn inwards.

9. Start up the inverter. ↗ **Ch. 4.1**

9.3 Update software (inverter)

When the inverter firmware is updated by the manufacturer, the possibility exists to do this on site. In the process, various hardware controllers are brought entirely up to date. If an update is available, you will find this on the manufacturer's website in the download area under Service.
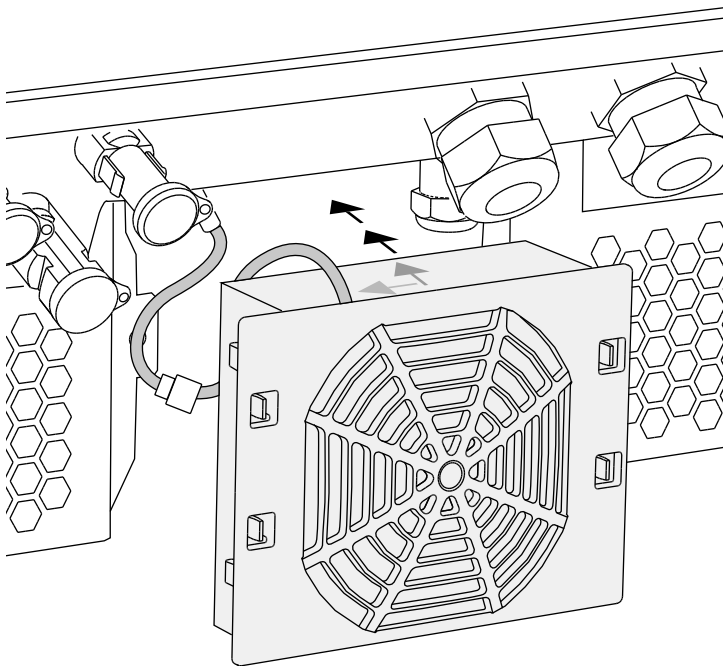
Procedure ⚠

1. Download the software update for the inverter from the manufacturer's website.

2. Go to the folder with the downloaded ZIP file.

3. Extract the ZIP file.

➔ The files are extracted into a separate folder. In this folder you will find the update and important additional information on the current firmware update.

4. If the inverter is not yet connected with a PC via LAN, connect this with the inverter now using a LAN cable. ⚠
↗ **Ch. 6.1**

5. Start the update by double-clicking on the *.exe file and follow the instructions on the PC.

➔ The update may take up to 30 minutes. This time is extended if the update is interrupted. Following the update, the message "Update successful" appears on the display of the inverter.

6. If the update was successful, confirm this on the inverter with the "ENTER" key.
If the update was unsuccessful, carry it out again or contact the Service team. ℹ

7. Following successful installation of the firmware (FW), you can retrieve the current version on the inverter. To this purpose, call up the following menu item: Settings > Device information > SW/HW version.

! **IMPORTANT INFORMATION**

In order to carry out the update, enough PV energy for approximately 30 minutes must be available. The update will otherwise be interrupted or even cancelled. For this reason, only carry out the update during the day.

⚡ **DANGER**

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

Always de-energise the device during installation and before maintenance and repairs, and secure it against being switched back on.
↗ **Ch. 4.3 Important! After disconnecting the device from the power supply, wait five minutes for the capacitors to discharge.**

---

i **INFO**

Following a successful update, the inverter automatically returns to feed-in mode.

9.4 Update software (communication board)

When the communication board is updated by the manufacturer, the possibility exists to do this on site. In the process, the software and the user interface (UI) of the communication board are brought completely up to date. If an update is available, you will find this on the manufacturer's website in the download area under Service.

Procedure [!]

1. Download the software update for the communication board from the manufacturer's website.

2. Go to the folder with the downloaded ZIP file.

3. Extract the ZIP file.

➜ The files are extracted into a separate folder. In this folder you will find the update and important additional information on the current software update.

4. If the inverter is not yet connected with a PC via LAN, connect this with the inverter now using a LAN cable. ⚠
   ↗ **Ch. 6.1**

5. Start the update by double-clicking on the *.exe file and follow the instructions of the program on the PC.

➜ The update may take up to 10 minutes. Following the update, the message "Update successful" appears on the display of the inverter.

6. If the update was successful, confirm this on the inverter with the "ENTER" key.
   If the update was unsuccessful, carry it out again or contact the Service team. [i]

7. Following successful installation of the software (UI), you can retrieve the current version on the inverter. To this purpose, call up the following menu item:
   Settings > Device information > SW/HW version.

8. Check the time on the inverter and correct this if necessary.
   To this purpose, call up the following menu item:
   Settings > Basic settings > Date/time.

! **IMPORTANT INFORMATION**

The update results in the deletion of the inverter log data. It is therefore advisable to back this up in advance.

⚡ **DANGER**

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

Always de-energise the device during installation and before maintenance and repairs, and secure it against being switched back on.
↗ **Ch. 4.3 Important! After disconnecting the device from the power supply, wait five minutes for the capacitors to discharge.**

---

i **INFO**

Following a successful update, the inverter automatically returns to feed-in mode.

9.5 Update software (country settings)

When the country setting of the inverter is updated by the manufacturer, the possibility exists to update this with the "Country Settings Tool". In the process, the country settings and parameters of the currently set country will be adjusted as appropriate.

If an update is available, you will find this on the manufacturer's website in the download area under Service. A password may be necessary in various countries in order to activate the new parameters. The password can be acquired from the Service team.

Procedure

1. Download the current "Country Settings Tool" from the manufacturer's website.

2. Go to the folder with the downloaded ZIP file.

3. Extract the ZIP file.

➔ The files are extracted into a separate folder.

4. If the inverter is not yet connected with a PC via LAN, connect this with the inverter now using a LAN cable. ⚠
   ↗ **Ch. 6.1**

5. Start the update by double-clicking on the *.exe file and follow the instructions on the PC.
   Choose the desired setting in the application and confirm with "Activate". Please note that the country settings must have been set correctly on the inverter in advance.

6. The inverter will restart when the update has been successful. If the update was unsuccessful, carry it out again or contact the Service team.

✔ The update has been carried out.

⚠ **DANGER**

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

Always de-energise the device during installation and before maintenance and repairs, and secure it against being switched back on.
↗ **Ch. 4.3 Important! After disconnecting the device from the power supply, wait five minutes for the capacitors to discharge.**

10. Technical data

10.1 Technical data

Technical changes and errors excepted. You can find current information at www.kostal-solar-electric.com.

PIKO inverter	Unit	3.0	4.2	5.5	7.0	8.5	10	12	15	17	20
Input page											
Inverter type		PIKO	PIKO	PIKO	PIKO	PIKO	PIKO	PIKO	PIKO	PIKO	PIKO
Max. PV power	kWp	4.3	4.6	6.1	7.7	9.4	10.8	12.9	16.9	19.2	22.6
Rated input voltage ($U_{DC,r}$)	V	400	680	680	680	680	680	680	680	680	680
Max. input voltage (U_{DCmax})	V	900	1000	1000	1000	1000	1000	1000	1000	1000	1000
Max. input voltage (U_{DCmax})	V	160	160	160	160	160	160	160	160	160	160
Start input voltage ($U_{DCstart}$)	V	180	180	180	180	180	180	180	180	180	180
Max. MPP voltage (U_{MPPmax})	V	730	800	800	800	800	800	800	800	800	800
Min. MPP voltage in single-tracker mode (U_{MPPmin})	V	270	400	530	660	–	527	626	–	–	–
Min. MPP voltage in two-tracker or parallel mode (U_{MPPmin})[4]	V	–	–	265	330	400	sym: 290/290 asym: 390/250	sym: 345/345 asym: 490/250	390	440	515
Min. MPP voltage in three-tracker mode (U_{MPPmin})[4]	V	–	–	–	–	–	–	–	260	290	345
Max. input current (I_{DCmax})[4]	A	12.5	11	11	11	11	sym.: 18/18 asym: 20/10	sym.: 18/18 asym: 20/10	sym.: 20/20/20 asym.: 20/20/10	sym.: 20/20/20 asym.: 20/20/10	sym.: 20/20/20 asym.: 20/20/20
Max. input current with parallel connection[6]	A	–	–	22	22	22	36 (DC1+DC2)	36 (DC1+DC2)	40 (DC1+DC2) 20 (DC 3)	40 (DC1+DC2) 20 (DC 3)	40 (DC1+DC2) 20 (DC 3)
Number of DC inputs		1	1	2	2	2	2	2	3	3	3
Number of independent MPP trackers		1	1	2	2	2	2	2	3	3	3
Max. PV short-circuit current	A	18	13.8	13.8	13.8	13.8	25	25	25	25	25
Output side											
Rated output, cos φ = 1 ($P_{AC,r}$)	kW	3	4.2	5.5	7	8.5	10	12	15	17	20
Max. output apparent power, cos $φ_{,adj}$	kVA	3	4.2	5.5	7	8.5	10	12	15	17	20
Rated output current	A	13	6.1	8	10.2	12.3	14.6	17.4	21.7	24.6	29
Max. output current (I_{ACmax})	A	13.7	6.1	8	10.2	12.5	16.2	19.3	24.2	27.4	32.2
Short-circuit current (peak / RMS)		26.4/16.9	9.5/6.7	12.5/8.8	15.8/11.2	17.7/12.5	25/16.6	27.4/16.7	42/28.5	41.3/29.0	51/36.5
Number of feed-in phases		1	3	3	3	3	3	3	3	3	3

PIKO inverter	Unit	3.0	4.2	5.5	7.0	8.5	10	12	15	17	20
Grid connection		1/N/PE, AC, 230V	3/N/PE, AC, 400V	3/N/PE, AC, 400V	3/N/PE, AC, 400V	3/N/PE, AC, 400V	3/N/PE, AC, 400V	3/N/PE, AC, 400V	3/N/PE, AC, 400V	3/N/PE, AC, 400V	3/N/PE, AC, 400V
Rated frequency (fr)	Hz	50	50	50	50	50	50	50	50	50	50
Setting range of the power factor cos $\varphi_{AC,r}$		0.9...1...0.9	0.8...1...0.8	0.8...1...0.8	0.8...1...0.8	0.8...1...0.8	0.8...1...0.8	0.8...1...0.8	0.8...1...0.8	0.8...1...0.8	0.8...1...0.8
Device properties											
Stand-by consumption	W	1.6	1.8	1.8	1.8	1.8	1.8	1.8	2.15	2.15	2.15
Efficiency											
Max. efficiency	%	96.2	97.5	97.7	97.6	97.6	97.7	97.7	98.0	98.0	98.0
European efficiency	%	95.5	96.1	96.3	96.5	96.5	97.1	97.1	97.2	97.3	97.3
Topology: Without galvanic separation - transformerless		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Internal protection according to IEC 60529		IP 55	IP 55	IP 55	IP 55	IP 55	IP 55	IP 55	IP 55	IP 55	IP 55
Protective class according to IEC 62103		I	I	I	I	I	I	I	I	I	I
Overvoltage category according to IEC 60664-1 input side (PV generator)[1]		II	II	II	II	II	II	II	II	II	II
Overvoltage category according to IEC 60664-1 output side (grid connection)[2]		III	III	III	III	III	III	III	III	III	III
Degree of contamination[3]		3	3	3	3	3	3	3	3	3	3
Environmental category (outdoor installation)		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Environmental category (indoor installation)		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
UV resistance		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Minimum cable cross-section of AC connection line	mm²	2.5	1.5	1.5	2.5	2.5	4	4	6	6	6
Maximum cable cross-section of AC connection line	mm²	6	6	6	6	6	6	6	16	16	16
Minimum cable cross-section of DC connecting line	mm²	4	4	4	4	4	4	4	4	4	4
Maximum cable cross-section of DC connection line	mm²	6	6	6	6	6	6	6	6	6	6
Max. fusing on output side		B16, C16	B16, C16	B16, C16	B16, C16	B16, C16	B25, C25	B25, C25	B32, C32	B32, C32	B40, C40
Compatibility with external residual current protection devices		RCD type B, RCM type B									
Tightening torque of PE connection, outer	Nm	3	3	3	3	3	3	3	3	3	3
Tightening torque of cover screws	Nm	5	5	5	5	5	5	5	5	5	5

PIKO inverter	Unit	3.0	4.2	5.5	7.0	8.5	10	12	15	17	20
Reverse polarity protection, DC-side, with short-circuit diodes		---	---	---	---	---	---	---	---	---	---
Operator protection according to EN62109-2		RCCB type B	RCCB type B	RCCB type B	RCCB type B	RCCB type B	RCCB type B	RCCB type B	RCCB type B	RCCB type B	RCCB type B
Electronic disconnection device integrated[5]		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Height	mm (inch)	385 (15.16)	385 (15.16)	385 (15.16)	385 (15.16)	385 (15.16)	445 (17.52)	445 (17.52)	540 (21.26)	540 (21.26)	540 (21.26)
Width	mm (inch)	500 (19.69)	500 (19.69)	500 (19.69)	500 (19.69)	500 (19.69)	580 (22.83)	580 (22.83)	700 (27.56)	700 (27.56)	700 (27.56)
Depth	mm (inch)	222 (8.74)	236 (9.29)	236 (9.29)	236 (9.29)	236 (9.29)	248 (9.76)	248 (9.76)	265 (10.43)	265 (10.43)	265 (10.43)
Weight	kg (lb)	22 (48.50)	24 (52.91)	25.5 (56.22)	26.5 (58.42)	26.5 (58.42)	37.5 (82.67)	37.5 (82.67)	48.5 (106.92)	48.5 (106.92)	48.5 (106.92)
Cooling principle - convection		✔	✔	–	–	–	–	–	–	–	–
Cooling principle - regulated fans		–	–	✔	✔	✔	✔	✔	✔	✔	✔
Max. air throughput	m³/h	–	–	84	84	84	2x48	2x48	2x84	2x84	2x84
Max. noise emission	dBA	<33	43	52	52	52	43	44	56	56	56
Ambient temperature	°C (°F)	-20 ... 60 (-4 ... 140)									
Max. installation altitude above sea level	m (ft)	2000 (6562)	2000 (6562)	2000 (6562)	2000 (6562)	2000 (6562)	2000 (6562)	2000 (6562)	2000 (6562)	2000 (6562)	2000 (6562)
Relative humidity (condensing)	%	4 … 100	4 … 100	4 … 100	4 … 100	4 … 100	4 … 100	4 … 100	4 … 100	4 … 100	4 … 100
Connection technology on input side - MC 4		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Connection technology on output side - spring-loaded terminal strip		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Interfaces											
Ethernet RJ45		2	2	2	2	2	2	2	2	2	2
RS485		1	1	1	1	1	1	1	1	1	1
S0-Bus		1	1	1	1	1	1	1	1	1	1
Analogue inputs		4	4	4	4	4	4	4	4	4	4
PIKO BA Sensor Interface		–	1	1	1	1	1	1	1	1	1
PIKO BA Sensor											
Rated current, primary	A	–	50	50	50	50	50	50	50	50	50
Rated current, secondary	A	–	1	1	1	1	1	1	1	1	1

PIKO inverter	Unit	3.0	4.2	5.5	7.0	8.5	10	12	15	17	20
Ext. current sensor transmission ratio		–	50:1	50:1	50:1	50:1	50:1	50:1	50:1	50:1	50:1
Accuracy class		–	1	1	1	1	1	1	1	1	1
Dimensions (H x W x D)	mm (inch)	–	90 x 105 x 54 (3.5 x 4.1 x 2.1)	90 x 105 x 54 (3.5 x 4.1 x 2.1)	90 x 105 x 54 (3.5 x 4.1 x 2.1)	90 x 105 x 54 (3.5 x 4.1 x 2.1)	90 x 105 x 54 (3.5 x 4.1 x 2.1)	90 x 105 x 54 (3.5 x 4.1 x 2.1)	90 x 105 x 54 (3.5 x 4.1 x 2.1)	90 x 105 x 54 (3.5 x 4.1 x 2.1)	90 x 105 x 54 (3.5 x 4.1 x 2.1)
Max. line diameter	mm (inch)	–	13.5 (0.5)	13.5 (0.5)	13.5 (0.5)	13.5 (0.5)	13.5 (0.5)	13.5 (0.5)	13.5 (0.5)	13.5 (0.5)	13.5 (0.5)
Installation on top-hat rail according to EN 60715		–	✔	✔	✔	✔	✔	✔	✔	✔	✔

[1] Overvoltage category II (DC input) The device is suitable for connection to PV strings. Long feed cables out of doors or a lightning protection system in the vicinity of the PV system may make lightning protection or surge protection equipment necessary.

[2] Overvoltage category III (AC output): The device is suitable for permanent connection in the grid distribution behind the meter and the line protection fuse. When the connection line travels outdoors over long distances, overvoltage protection devices may be necessary.

[3] Contamination degree 3: Conductive contamination is present. Dry, non-conductive contamination becomes conductive when condensation forms.

[4] In the case of symmetrical DC feed-in, two equally large strings are connected to the inverter. In the case of unsymmetrical DC feed-in, strings of varying lengths are connected to the inverter.

[5] Disconnection device to VDE V 0126-1-1, for Austria: The inverter is equipped "With automatic disconnection device in accordance with ÖVE/ÖNORM E 8001-4-712".

[6] It is essential to ensure that with parallel connection the maximum current load of the DC plugs is not exceeded (max. 30 A). This could result in damage to the device. If the DC string input current is higher than the maximum plug load (see manufacturer's information), both DC inputs should be used.

10.2 Block diagram
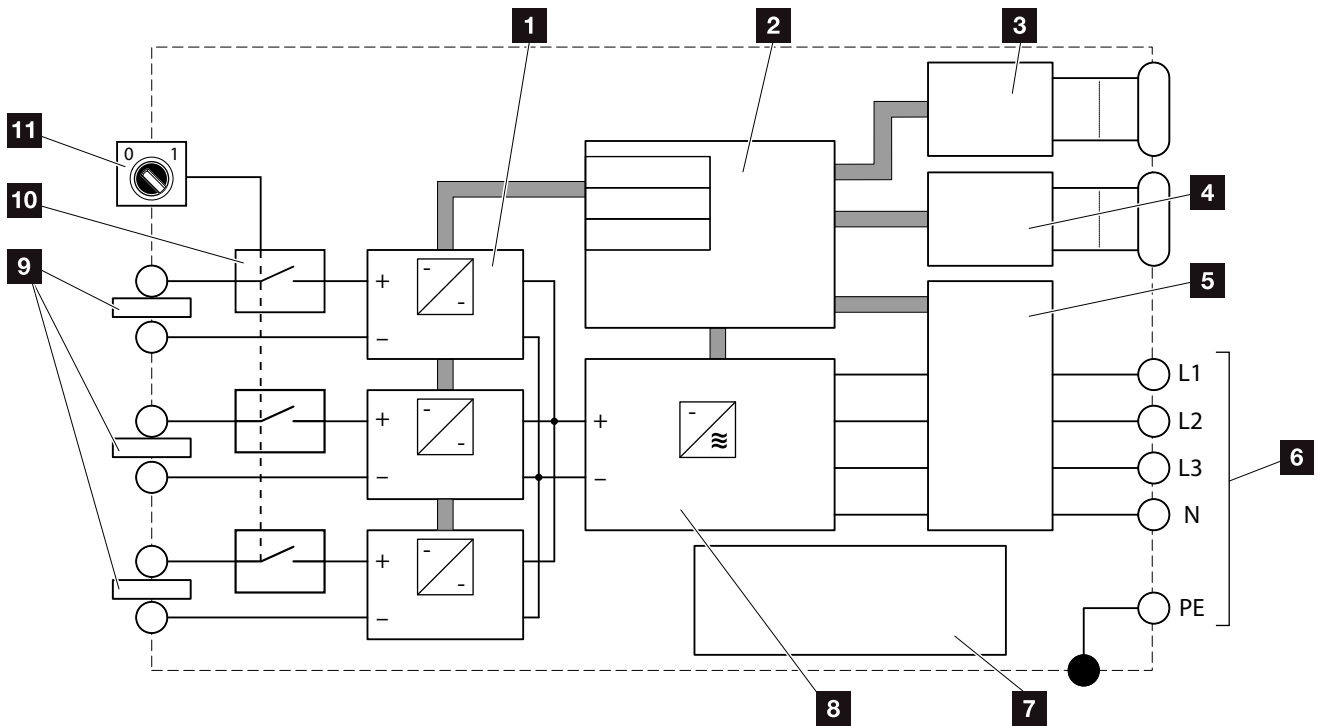
Fig. 76: Block diagram

1 DC regulator
2 System control with MPP trackers
3 Display and communication
4 PIKO BA Sensor interface (depending on type)
5 Grid monitoring and shut-down
6 1-phase or 3-phase AC output
  (phases dependent upon the type)
7 Power supply unit
8 Inverter bridge
9 PV string (number dependent upon the type)
10 Electronic DC switch
11 DC switch

11. Accessories

11.1 Installing the GSM modem

Requirements for a SIM data card

The following points must absolutely be taken into account before purchasing a SIM data card: ℹ️

- In order to use the GSM modem, you will need a SIM card with a contract with a mobile service provider.

- You should select a provider whose grid supplies the strongest GSM signal at your chosen location.

- The tariff must allow for packet data communication via GPRS.

- Prepaid cards which are charged via mobile calls are not suitable.

- Tariffs which specify particular times for data downloads cannot be used.

- The tariff must permit a data volume of at least 5 MB per month and per inverter.

- The SIM card must be activated prior to installation (e.g. via a mobile phone).

- The necessary access data are APN (Access Point Name), user name and password. ℹ️

ℹ️

INFO

Using a modem involves additional costs.
The telecommunications provider can supply details.

ℹ️

INFO

The functionality of Internet connections and networks may differ from one location to the next depending upon the environment and the installation and can thus not be guaranteed.

ℹ️

INFO

The data can be set up with the "GSM-Link" tool.

Setting up the GSM modem in the web server ℹ️

1. Connect the computer and inverter.
   ↗ **Ch. 6.1**

2. Start web server and call up the "Settings" page.
   ↗ **Fig. 53**

3. Enter the PIN number of the SIM card in the "GSM-PIN" field. ↗ **Fig. 53 It. 12**

4. Click on the "Accept" button.

5. Start the "GSM-Link" software on the provided CD-ROM.

6. Enter the IP address of the inverter in the "Host/IP address:" field.

7. Enter the data (APN, user name and password) of the SIM card in the corresponding fields of the GSM area.

8. Click on the "Write new settings!" button.

➔ The inverter is set. The modem can now be installed.

ℹ️ **INFO**

The SIM card must be activated prior to setting up the GSM modem in the web server. However, it may not yet be plugged into the GSM modem.

Installing the GSM modem
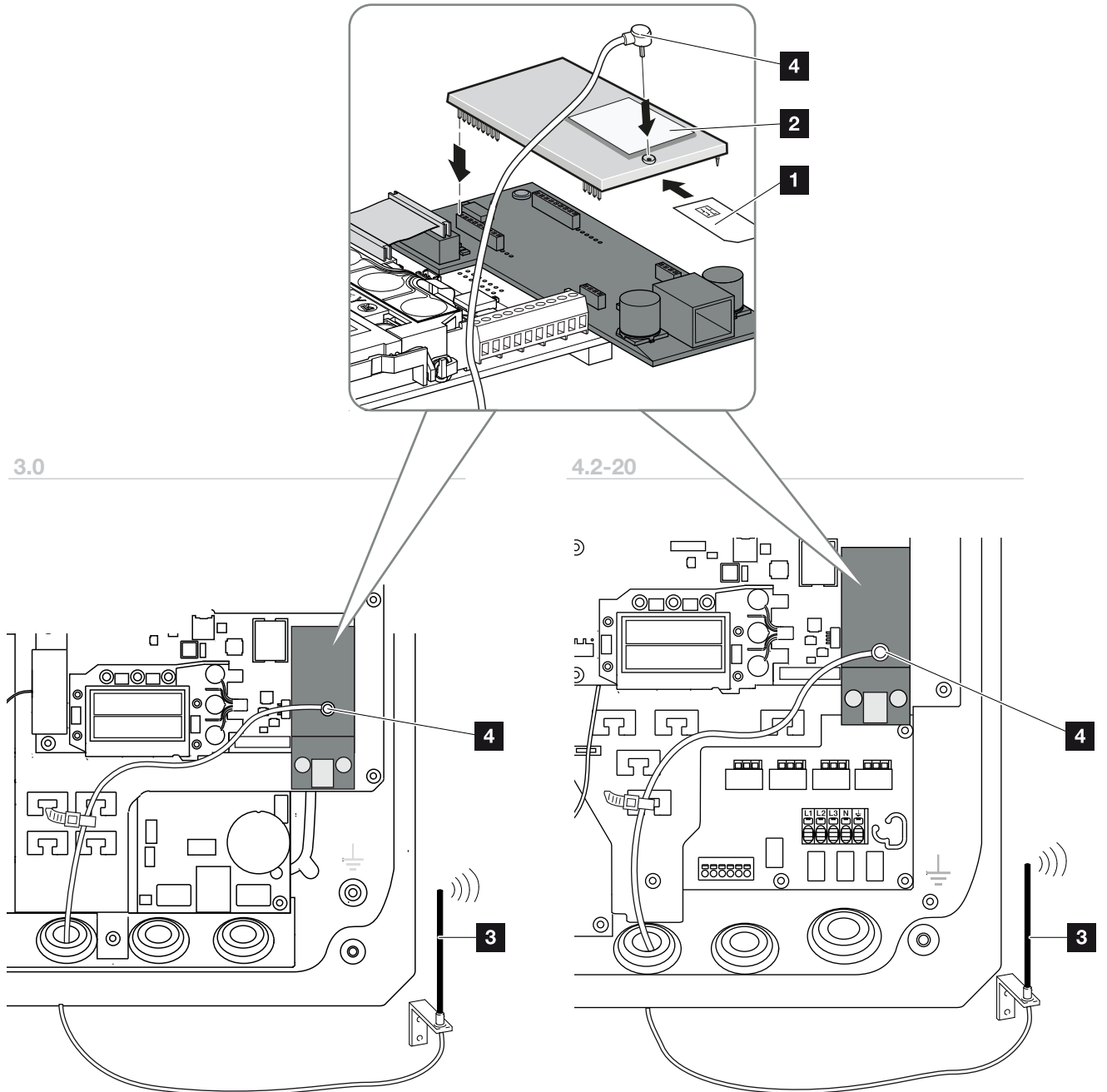
Fig. 77: Installing the GSM modem

1 SIM card
2 GSM modem
3 Radio antenna
4 Plug for radio antenna

1. De-energise the inverter. ⚠️
    ↗ **Ch. 4.3**

2. Open the inverter cover.

3. Insert the SIM card into the GSM modem:
    It. 1 ℹ️

4. Plug the GSM modem onto the PCB and install it:
    It. 2

5. Install the radio antenna: **It. 3**

6. Guide the cable into the inverter.

7. Insert the plug of the radio antenna into the GSM modem: **It. 4**

8. Fasten the cable to the cable tray.

9. Install the cover and screw it tight (5 Nm).

10. Switch on the inverter. ↗ **Ch. 4.1**

✔ The GSM modem is installed.

Check if the modem is functional

Following installation, it must be checked whether the signal strength of the GSM modem is adequate. ℹ️

Modem status:	GSM signal strength	
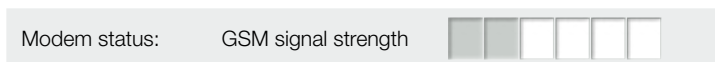
Fig. 78: Modem status on web server "Info page".

1. Start the web server and call up the "Info page" page.

2. Check modem status.

✔ The GSM modem has been checked.

⚠️ **DANGER**

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
↗ **Ch. 4.3**

ℹ️ **INFO**

The SIM card must be activated prior to setting up the GSM modem in the web server.

ℹ️ **INFO**

When the "Modem status: GSM signal strength" field is displaying at least two bars, the wireless connection is OK.

11.2 Installation of PIKO BA Sensor

The PIKO BA Sensor is used to optimally control the energy flow in the building. The control and distribution of energy between the DC side (solar generator) and the AC side (building grid, public grid) is thereby carried out by the energy management system (EMS). To this purpose, the EMS uses the PIKO BA Sensor to check for the presence of consumption in the internal building grid. The logic of the EMS then uses this to calculate and control the optimal usage of PV energy.

The generated PV energy is primarily used for consumers (such as light, washing machine or television). The energy generated beyond this is fed into the public grid.

Product features of the PIKO BA Sensor:

- Registration of building consumption with analogue current measurement

- Easy installation due to assembly on top-hat rail according to EN 60715

- Control of inverter output according to the principle of dynamic active power control.

You can find additional information about this product on our website **www.kostal-solar-electric.com** under the category Products / Monitoring.

Installation and connection of the PIKO BA Sensor !

The PIKO BA Sensor is used to record the self-consumption of the building or the power fed into the grid, and to represent it in the solar portal.

In addition to this, the sensor can also be used with smaller systems up to 30 KW for which a permanent reduction, for example, of 70% has been set as an affordable alternative to the ripple control receiver.

In combination with the inverter, the sensor can carry out dynamic self-consumption regulation, and thus optimally distribute the generated energy.
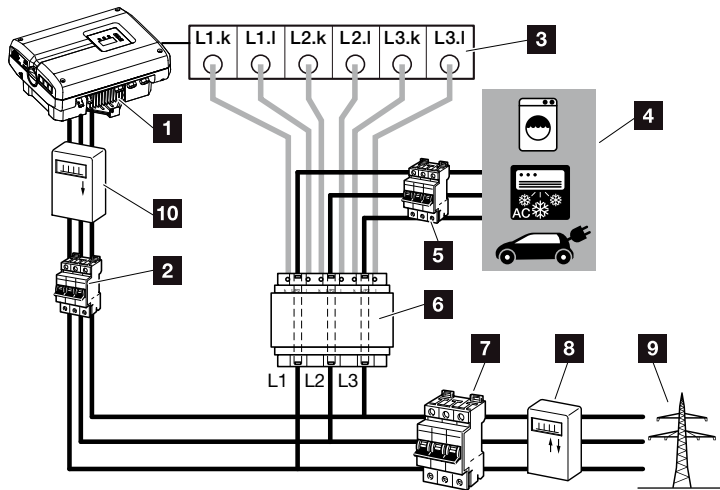
> **!** **IMPORTANT INFORMATION**
>
> **The current sensor can be used as of firmware version 05.00.**
>
> **Only one sensor can be operated per PV system. The consumption of several inverters cannot be measured using a PIKO BA Sensor.**
>
> **In the case of the PIKO 3.0 it is not possible to connect a PIKO BA Sensor.**

The sensor is installed on a top-hat rail in the meter box or the main distributor.

Fig. 79: **Mode 1** Recording building consumption data ⚠

1️⃣ PIKO inverter
2️⃣ Line circuit breaker inverter
3️⃣ Terminal for current sensor in the inverter
4️⃣ Energy consumers
5️⃣ Line circuit breaker for energy consumers
6️⃣ PIKO BA Sensor
7️⃣ Line circuit breaker for building
8️⃣ Feed-in procurement meter
9️⃣ Public grid
🔟 PV meter (as of PV systems with >10 kWp total output)

i INFO

In Mode 1 building consumption, the sensor measures the power consumption of all consumers in the building and calculates the current which is fed into the public grid.

Procedure

1. De-energise the inverter. ⚠️
   ↗ **Ch. 4.3**

2. Mount the PIKO BA Sensor on the top-hat rail of an electrical cabinet or current distributor. Only the sensor approved for the inverter may be used.

3. Open the inverter cover.

4. Depending upon the mode, properly lay the cable from the inverter into the electrical cabinet.
   ↗ **Fig. 79**

5. Direct the three phases leading from the building's line circuit breaker to the consumer through the PIKO BA Sensor. ❗

6. Connect the 6-conductor cable of the inverter according to the wiring diagram.
   The 6-conductor control cable from the inverter to the PIKO BA Sensor must have a wire cross-section of $0.75\,mm^2$ to $2.5\,mm^2$ and a maximum length of $20\,m$. The wire stripping length is 8-9 mm.

⚡	DANGER

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge. ↗ Ch. 4.3

❗	IMPORTANT INFORMATION

When carrying out the three phases through the PIKO BA Sensor, it is imperative that the following points are observed to avoid incorrect measurements:

- The phase sequence (L1, L2, L3)
- The cable from the current consumer must be guided in from above, next to the terminals for the control system cable, into the PIKO BA Sensor.

L1.k	L1.l	L2.k	L2.l	L3.k	L3.l
○	○	○	○	○	○

Fig. 80: Sensor terminal

7. Install the cover and screw it tight (5 Nm).

8. Switch on the inverter ↗ **Ch. 4.1**

9. Activate the current sensor in the menu of the inverter. ◪ **Ch. 4.7** ❗
    To this purpose, select the corresponding mode in the "Current sensor position" menu.
    Mode 0:
    No current sensor installed (standard)
    Mode 1:
    Current sensor position for measuring building consumption

❗ **IMPORTANT INFORMATION**

The position (mode) of the PIKO BA Sensor can be set via the menu in the inverter. Depending on the version of the inverter's software and hardware this may differ and not all positions may always be available.

✔ The PIKO BA Sensor is connected.

Operate system with several inverters
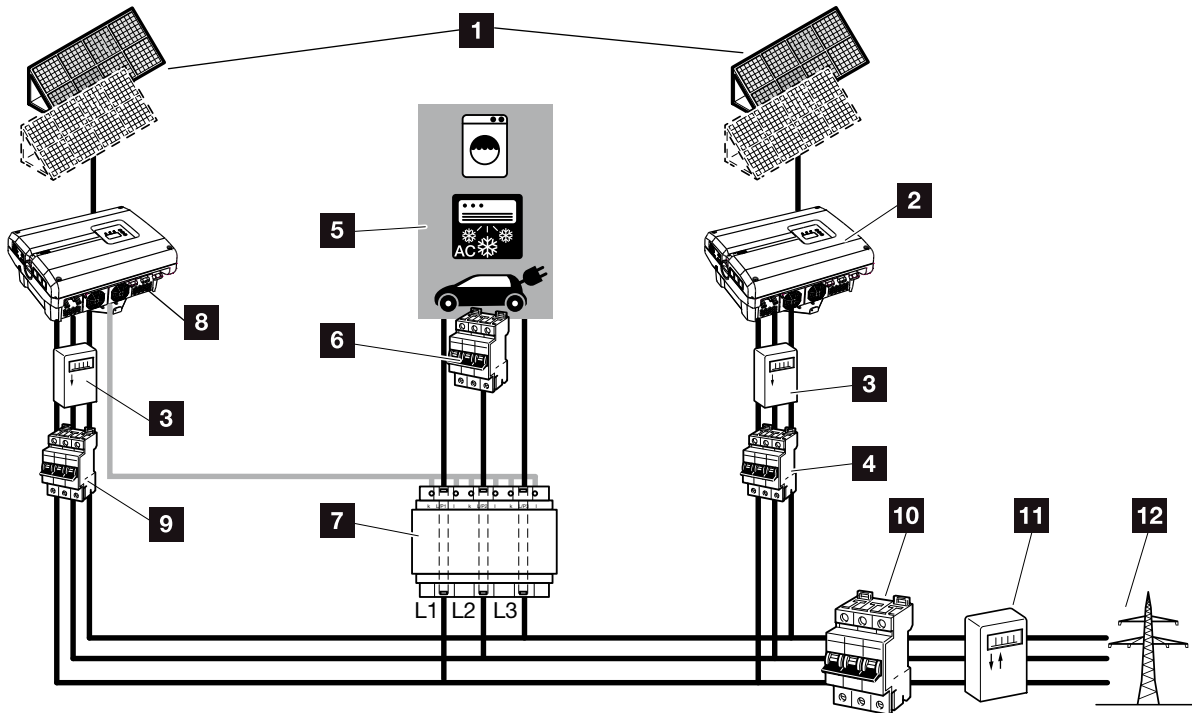
Fig. 81: Connection of several inverters - current sensor position mode 1 - building consumption data (possible as of PIKO 4.2)

1 PV generators

2 Inverters without connected sensors
(also external devices)

3 PV meter for inverter (required as of PV systems with
>10 kWp total output)

4 Line circuit breaker inverter

5 Energy consumers

6 Line circuit breaker for energy consumers

7 PIKO BA Sensor

8 PIKO inverter with sensor connection

9 Line circuit breaker for PIKO inverter

10 Line circuit breaker for building

11 Feed-in procurement meter

12 Public grid

In addition to the PIKO, other inverters can also be used in a photovoltaic system. It is to be ascertained that all inverters in the building grid fulfil the VDE-AR-N 4105 standard.

The inverters can be wired in different variants and modes.

1. De-energise the building grid and inverter.
   ↗ **Ch. 4.3** ⚠

2. Integrate inverters into the system as shown in
   ↗ **Fig. 81** and connect them properly. ❗

✔ Inverter is connected.

Only the yield of the PIKO inverter can be represented in a system with several inverters without additional measures.

⚠ **DANGER**

RISK OF DEATH DUE TO ELECTRICAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
↗ **Ch. 4.3**

❗ **IMPORTANT INFORMATION**

It must be ensured that the assignment of the phases of the AC terminal (L1, L2, L3) of the additional inverter harmonise with the phases of the PIKO BA Sensor.

11.3 Additional accessories

PIKO M2M Service

The PIKO M2M Service allows KOSTAL customers to monitor a PV system using a mobile link to the PIKO Solar Portal for continuous system monitoring.

A secure and encoded VPN connection which only allows communication between PIKO inverters and the PIKO Solar Portal protects the user against misuse and excessive costs.

The 5-year package price involves no monthly costs, reducing administration and assuring smooth monitoring for a period of at least five years. Two different packages are available depending on the size of the system.

You can find additional information about this product on our website **www.kostal-solar-electric.com** under the category Products / Monitoring.

PIKO Solar Portal

The PIKO Solar Portal makes it possible to monitor the operation of the PIKO inverters via the Internet. Registration for the PIKO Solar Portal takes place at no charge on our website.

The portal code for the PIKO Solar Portal (www.piko-solar-portal.de) is P3421.

You can find additional information about this product on our website **www.kostal-solar-electric.com** under the category Products / Monitoring.

PIKO Solar App

Using the new PIKO Solar App, customers will soon be able to monitor their systems easily via their smartphone or tablet. Important data relating to the PV system can be queried using the app. For example, you can monitor your DC yield and see how much electricity you're feeding into the public grid. If you have a PIKO inverter to which a PIKO BA Sensor is also connected, you will also be able to see the building consumption. With the PIKO BA system, you can even see how much of the electricity you are producing is being fed into the battery, or being used from the battery. In addition to this live data, which is updated via WLAN, you can also display past yields, e.g. from yesterday or last week, as a diagram.

You can find additional information about this product on our website **www.kostal-solar-electric.com** under the category Products / Monitoring - Accessories.

PIKO Sensor

The PIKO Sensor makes it possible to compare the real irradiation and temperature conditions with the performance data of the PV system.

The following values are measured with the PIKO Sensor:

- Irradiation

- Ambient temperature

- Module temperature

A special feature: The measuring values can be visualised via a solar portal (e.g. PIKO Solar Portal).

You can find additional information about this product on our website **www.kostal-solar-electric.com** under the category Products / Monitoring.

12. Appendix

12.1 Type plate

KOSTAL
Solar Electric
Hanferstraße 6 – D-79108 Freiburg
+49 (0) 761-47744-100
www.kostal-solar-electric.com
XXXXXXXXXXXXX
Art.-No.: XXXXXXXX

DCinput: U_{MPP} = XXX...XXX V,
U_{MAX} = XXX V,
I_{MAX} = XXX A
ACoutput: XXXXXXXXXXX,
XXXXX VA (cosΦ =1,adj.) max. XX.X A
(XX:YYY YW (cosΦ =1))
Protective Class 1
IP 55, -20°C...60°C, OVC DC:II / AC:III
DIN V VDE V 0126 -1-1
VDE-AR-N 4105
Art.-No.: NNNNNNNN
Ser.-No.: XXXXXABCXXXXX
HW: YYXXXX Par: XX.XX
FW: XX.XX UI: XX.XX
Serviceupdate: XXXXXXXX

CE

XXXXXABCXXXXX
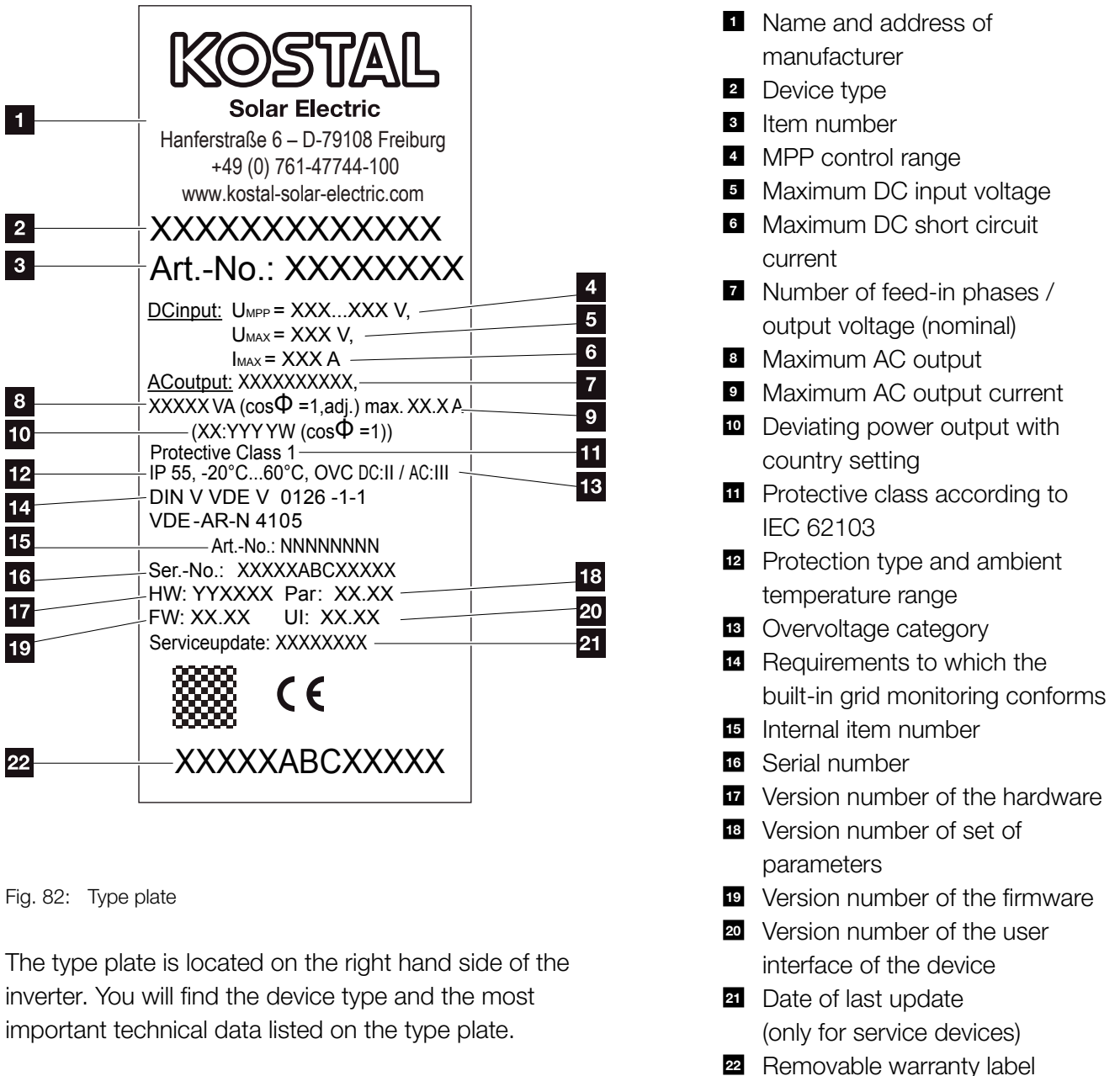
Fig. 82: Type plate

The type plate is located on the right hand side of the inverter. You will find the device type and the most important technical data listed on the type plate.

1 Name and address of manufacturer
2 Device type
3 Item number
4 MPP control range
5 Maximum DC input voltage
6 Maximum DC short circuit current
7 Number of feed-in phases / output voltage (nominal)
8 Maximum AC output
9 Maximum AC output current
10 Deviating power output with country setting
11 Protective class according to IEC 62103
12 Protection type and ambient temperature range
13 Overvoltage category
14 Requirements to which the built-in grid monitoring conforms
15 Internal item number
16 Serial number
17 Version number of the hardware
18 Version number of set of parameters
19 Version number of the firmware
20 Version number of the user interface of the device
21 Date of last update (only for service devices)
22 Removable warranty label

12.2 Warranty and service

■ Information on the warranty can be found in the warranty conditions, which are included separately.

■ For service information and a possible subsequent shipment of parts, we require your device type and the serial number. You will find this information on the type plate on the exterior of the housing.

■ If parts are required, use only original replacement parts.

If you have any technical questions, please call our service hotline:

■ Germany and other countries[1]
  +49 (0)761 477 44 - 222

■ France, Belgium, Luxembourg
  +33 16138 4117

■ Greece
  +30 2310 477 555

■ Italy
  +39 011 97 82 420

■ Spain, Portugal[2]
  +34 961 824 927

■ Turkey [3]
  +30 2310 477 555

[1] Language: German, English

[2] Language: Spanish, English

[3] Language: English, Turkish

12.3 Handover to the operator

Following successful installation and commissioning, all documents are to be handed over to the operator. The attention of the operator must be drawn to the following points:

- Position and function of the DC switch

- Position and function of the AC line circuit breaker

- Safety when handling the device

- Appropriate procedure when checking and servicing the unit

- Meaning of the LEDs and the display messages

- Contact person in the event of a fault

12.4 Disassembly and disposal

To disassemble the inverter, proceed as follows:

1. De-energise the inverter.
   ↗ **Ch. 4.3** ⚠️

2. Open the inverter cover.

3. Loosen terminals and cable screw connections.

4. Remove all DC and AC lines.

5. Close the inverter cover.

6. Loosen the screw underneath the inverter.

7. Lift the inverter from the wall mount.

8. Dismantle the wall mount.

Proper disposal

Dispose of the inverter, packaging and replacement parts in accordance with the regulations of the country in which the device has been installed. The inverter may not be disposed of with household waste.

⚠️ **DANGER**

RISK OF DEATH DUE TO ELECTRI-CAL SHOCK AND DISCHARGE!

De-energise the device, secure it against being restarted and wait five minutes so that the capacitors can discharge.
↗ **Ch. 4.3**

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