KACO new energy.

Powador 2500xi 3600xi | 4000xi 4500xi | 5000xi

Operating instructions

- Operator
- Skilled and authorised electrician

product design award 2006

The next generation of transformerless inverters with an integrated DC disconnector.

The installation instructions for authorised electricians begin after the operating instructions

Intended for use by the operator

Operating Instructions

Powador 2500xi / 3600xi / 4000xi / 4500xi / 5000xi

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General Notes

By purchasing an inverter from KACO new energy GmbH, you have opted for a reliable, high-performance technology and will profit from KACO new energy GmbH's many years of experience in the field of current inverter technology and power electronics.
The Powador 2500xi, 3600xi, 4000xi, 4500xi and 5000xi inverters are transformerless, fanless, robust, high-efficiency inverters. Using the illuminated display and intuitive menu navigation, you can display the most important information pertaining to the inverter's grid feed. The mounting plate that is included provides for optimal and simple installation on a wall. The inverter's data can be transmitted over the serial interface to a PC, where it can then be visualised.
With protection class IP54, the units are ready for operation in all ambient conditions. The inverters can also be used without hesitation in agriculture and industry.

1 About This Documentation

The following notes guide you through all of the documentation. Additional documents are applicable in conjunction with these operating and installation instructions.
We assume no liability for any damage caused by failure to observe these instructions.

Other applicable documents

When installing the inverters, be sure to observe all assembly and installation instructions for components and other parts of the system. These instructions are delivered together with the respective components and additional parts of the system.

1.1 Retention of documents

Please pass these operating and installation instructions on to the plant operator. These documents must be stored next to the system and must be available at all times.

1.2 Symbols used in this document

When installing the inverter, observe the safety instructions provided in these installation instructions.

DANGER

Failure to observe a warning indicated in this manner will directly lead to serious bodily injury or death.

WARNING

Failure to observe a warning indicated in this manner may directly lead to serious bodily injury or death.

CAUTION

Failure to observe a warning indicated in this manner may lead to minor or moderate bodily injury or to serious damage to property.

ATTENTION

Failure to observe a warning indicated in this manner may lead to damage to property.

NOTE

Useful information and notes.

ACTION

This symbol indicates that a certain action is required.

IMPORTANT

Failure to observe this information may result in reduced convenience or impaired functionality.

Danger due to lethal voltages.

1.3 CE marking

The CE marking is used to document that the Powador inverter shown on the name plate fulfills the fundamental requirements of the following relevant directives:
Directive concerning electromagnetic compatibility
(Council Directive 2004/108/EC)
Low Voltage Directive
(Council Directive 2006/95/EC).

1.4 Name plate

The name plate showing the exact designation of the unit is located on the support plate on the underside of the housing.

2 Safety Instructions and Regulations

DANGER

Danger due to lethal voltages.

Lethal voltages are present within the unit and on the power supply lines. Therefore, only skilled and authorised electricians may install and open the unit.

Even when the unit is switched off, high contact voltages may still be present inside the unit.

Accident prevention regulations

The inverter must be installed by an authorised electrician, who is responsible for observing existing standards and regulations.

The proper and safe operation of this unit requires proper transportation, storage, assembly and installation, as well as careful operation and maintenance.

The inverter may only be operated by persons who have read and understood the operating instructions.

Modifications

Modifications to the inverter are generally prohibited. Always consult an authorised electrician for modifications to the surroundings of the inverter, as they are qualified to undertake such work.

CAUTION

Risk of damage due to improper modifications. Never modify or manipulate the inverter or other components of the system.

Transportation

The inverter is subjected to extensive testing and inspections in our test field. This is how we ensure the high quality of our products. Our inverters leave our factory in proper electrical and mechanical condition. Special packaging provides for a safe and careful transportation. However, transport damage may still occur. The shipping company is responsible in such cases.

Thoroughly inspect the inverter upon delivery. If you discover any damage to the packaging which indicates that the inverter may have been damaged, or if you discover any visible damage to the inverter, notify the responsible shipping company immediately.

If necessary, your solar installer or KACO new energy GmbH will assist you. Damage reports must be received by the shipping company in writing within six days of receipt of the goods.

When transporting the inverter, the original or equivalent packaging is to be used, as this ensures safe transport.

3 Notes on Installation and Operation

3.1 Intended use

The unit converts the DC voltage generated by the photovoltaic (PV) modules into AC voltage and feeds this into the power grid.
Powador inverters are built according to the state of the art and recognised safety rules. However, improper use may cause lethal hazards for the operator or third parties, or may result in damage to the units and other property.
The inverter may only be operated with a permanent connection to the public power grid.
The inverter is not intended for mobile use.

Any other or additional use is not considered the intended use. The manufacturer/supplier is not liable for damage caused by such unintended use. Damage caused by such unintended use is at the sole risk of the operator.

Intended use also includes adherence to the operating and installation instructions. Your authorised electrician undertakes the registration with your power supply company and obtains approval for your photovoltaic installation from the supply grid operator on your behalf. Some of the documents that you require in order to register your photovoltaic installation and have it approved are included in the installation instructions.

3.2 Factory warranty and liability

KACO new energy GmbH issues a warranty of seven years on the Powador inverter starting from the date of installation, but at most 90 months after shipment by KACO new energy GmbH.

During this time, KACO new energy GmbH guarantees the proper operation of the units and to undertake repairs at the factory free of charge in the event of a defect for which we are responsible.

Contact your specialty dealer or installer if your unit exhibits a defect or fault during the warranty period.

Warranty claims are excluded in the following cases:

- Use of the units in ways not intended
- Improper installation and installation that does not comply with standards
- Improper operation
- Operation of units with defective protective equipment
- Unauthorised modifications to the units or repair attempts
- Influence of foreign objects and force majeure (lightning, overvoltage, severe weather, fire)
- Insufficient ventilation of the unit
- Failure to observe the relevant safety regulations
- Transport damage.

All warranty claims must be handled at the premises of KACO new energy GmbH. The unit must, where possible, be returned in its original or equivalent packaging. The costs for these services cannot be borne by KACO new energy GmbH.

KACO new energy GmbH will only perform warranty services if the defective unit is returned to KACO new energy GmbH together with a copy of the invoice which was issued to the user by the dealer. The name plate on the unit must be fully legible. If these requirements are not fulfilled, KACO new energy GmbH reserves the right to deny warranty services.

The warranty period for repairs or replacement deliveries is six months after delivery. However, it continues at least until the end of the original warranty period for the delivery item.

3.3 Service

We place special emphasis on the quality and longevity of our inverters, starting with the product development phase. More than 60 years of experience in the field of current inverters support us in this philosophy.

However, despite all quality assurance measures, faults may occur in exceptional cases. In such cases, KACO new energy GmbH will provide you with the maximum possible support. KACO new energy GmbH will make every effort to remedy such faults in an expeditious manner and without a great deal of bureaucracy. In such cases, contact our service department directly by telephone at

+49 (0)7132-3818-660

4 Operation

CAUTION

Incorrect use is prohibited.

The grid feed process begins in the morning when sufficient light is available, and, therefore, when a certain minimum voltage is present at the inverter. The inverter enables grid feed after a country-specific start-up time (see Installation Manual, section 4, "Technical Data").
If, as nightfall approaches, the voltage drops below the minimum voltage, the grid feed mode ends and the inverter switches off.

4.1 Overview of controls and displays

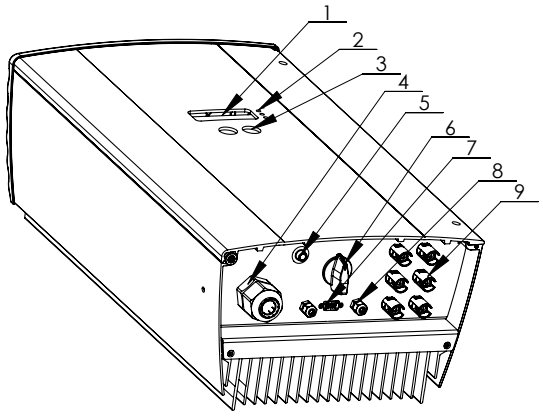

Figure 4.1: **Overview of the Powador**

Legend

1 Display
Displays measured values and configuration parameters

2 LED displays
Display the operating status

3 Control keys
Switch between the display and configuration of parameters

4 Cable fitting for AC connection

5 Night start-up button
For activating the display after nightfall

6 DC disconnector

7 RS232 interface

8 Cable feedthrough for RS485 interface cable

9 Cable feedthrough for DC connection

4.2 LED displays

During normal operation, the photovoltaic modules generate voltage as soon as the insolation is sufficient. If this voltage is present in the inverter at a certain level for a certain time, the inverter begins to feed into the grid.
The inverter is equipped with three LEDs, which give information about the various operating statuses as follows.

Figure 4.2: **LED displays**

LED (1) (green):

The LED begins to light up beginning with a photovoltaic module voltage of approx. 300 V and goes out again if the module voltage is lower than 250 V.
The "OK" LED indicates that the inverter and the inverter control are active. If this LED is not lit, the inverter cannot feed into the grid.
In normal mode, the LED begins to light up in the morning (if there is enough sunlight) and goes out as nightfall approaches.

LED (2) (green):

The LED lights up every time the inverter feeds into the grid. For this to happen, the photovoltaic module voltage must exceed 400 V (factory setting) and sufficient power must be provided by the PV generator. If the grid feed is interrupted because the power is too low, the inverter waits for a country-specific length of time before it begins feeding into the grid once again. LED (2) can, therefore, light up only when LED (1) is already lit.
In a normal state, the inverter begins feeding into the grid in the morning and stops feeding into the grid as it becomes increasingly darker. On cloudy days and in the winter months, the grid feed can - depending on the PV generator and the current grid feed power - be temporarily interrupted and subsequently re-started. This process can repeat itself several times, especially in the morning and evening. This is in no way an indication of defective operation, but instead constitutes normal operating behaviour.

LED (3) (red):

The LED indicates that the grid feed was stopped due to a fault.
The following faults activate the LED (3):

- Grid overvoltage or undervoltage on one of the three phases
- Failure of one of the phases L2 or L3
- Generator power is too high
- Shutdown due to the temperature being too high
- Fault in the unit
- Leakage current is too high (RCD type B)
- Overfrequency or underfrequency
- Insulation fault
- Communication error
- Fault in the DC grid feed
- Fault in the voltage transformer
- Selftest fault
- Fault in the RCD type B module.

Wait approx. 10 minutes to see if the fault is only temporary in nature. If this is not the case, notify your authorised electrician.
If the fault is cleared, the grid feed begins once again after a country-specific waiting period (see Installation Instructions, Section 4, "Technical Data").

IMPORTANT

If the grid feed phase fails (power failure on the public grid), LED (3) does not light up. If this happens, all LEDs and the display go out. The inverter is shut down completely.
The inverter can only resume its normal operation when the grid feed phase is available once again.

Check whether the fault in question relates to a general power failure or whether the fuse between the meter and the inverter has failed. If the fuse has failed, notify your authorised technician. If there was a power failure, simply wait until the fault has been cleared. The system automatically re-starts.

4.3 Keys "1" and "2"

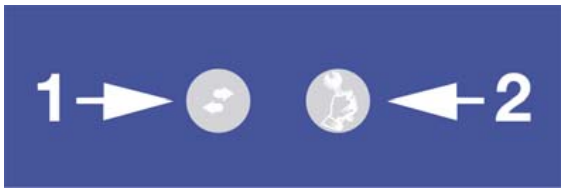

Figure 4.3: **Powador control keys**

Key "1" is used to switch between the various displays for measured values and data. With key "2", settings such as those relating to the shutdown value can be configured. Here, menu navigation is divided into two levels. In level 1 (display mode), measured values such as the solar generator voltage and yields can be read. Here, only key "1" is activated. In configuration mode, key "1" is also used to navigate through the individual displays, and settings are configured with key "2".

ACTION

By pressing key "1" for approx. 1 second, you can choose which measured value is to be displayed.
The menus are continuous, which means that when you arrive at the last entry in a menu, the first entry is displayed once again the next time key "1" is pressed (see Figure 4.4).

4.4 Level 1 menu - Display menu

The display menu is displayed once the Powador inverter has started up. Measured values and all of the meters are displayed here. Key "1" is used to navigate through the individual menu items.

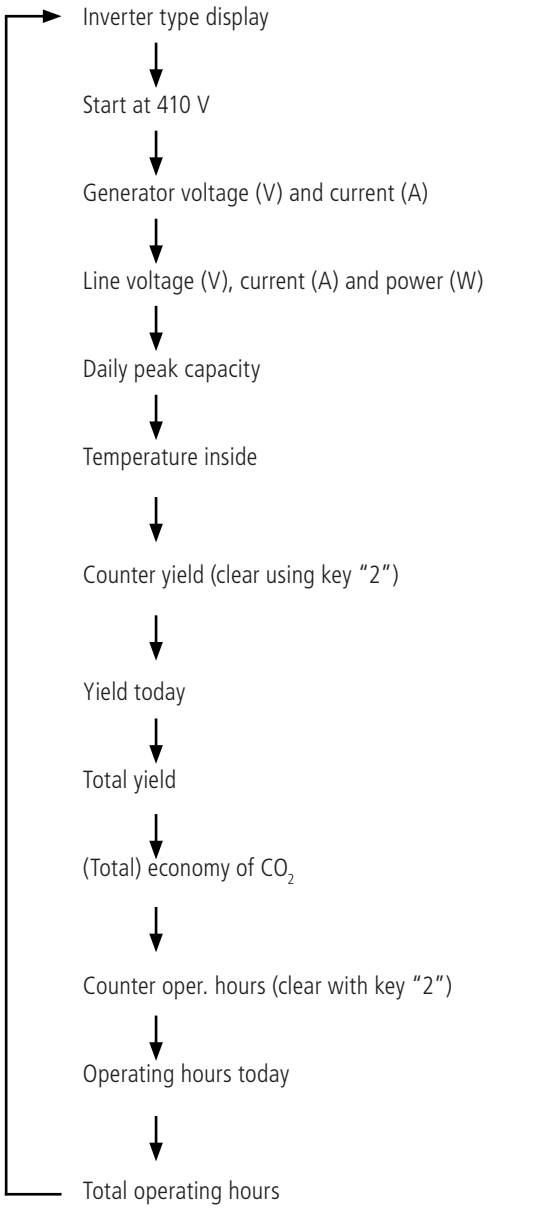

Figure 4.4: **Display mode menu**

Explanation of the menu items in display mode

Powador 2500xi / 3600xi / 4000xi / 4500xi / 5000xi

The inverter waits until the voltage exceeds 410 V. One minute later, the grid feed begins.

The current voltage and current of the solar generator connected to the inverter.

The current line voltage, line current and the power that is currently being fed into the grid.

The current day's peak power (in watts) that was fed into the grid over a short time.

A display of the current temperature inside the unit, in °C. The inverter limits the grid feed power depending on the temperature of the semiconductors.

This meter totals all yields until it is reset again. The customer can configure the time periods for this meter, e.g. as a monthly meter.

The power that has been fed into the grid on the current day in watt-hours (Wh).

The power that has been fed into the grid since start-up of the inverter.

Shows the CO_2 savings of this PV installation compared to the German electricity mix. The CO_2 savings are calculated from the total yield meter and can also be cleared with this meter.

The customer can configure the time periods for this meter, e.g. as a monthly meter. The procedure for resetting meters is explained at the bottom of the page.

Today's hours of operation. As soon as the inverter is in standby mode (i.e. when LED (1) lights up), the running time is added up.

Hours of operation since start-up of the inverter. As soon as the inverter is in standby mode (i.e. when LED (1) lights up), the running time is added up.

"Counter yield" and **"Counter oper. hours"** can be cleared separately from the other meters. When "Counter yield" or "Counter oper. hours" is displayed, you can reach the "Clear counter?" display by pressing key "2". Key "2" must now be used to select "yes". Press key "1" to confirm the clearing. The display jumps back to the meter that was cleared. "Counter yield" and the "Counter oper. hours" are always cleared together. Therefore, clearing one meter suffices to clear both.

4.5 Level 2 menu - Configuration mode

ACTION

To switch to configuration mode, keep key "1" pressed down while at the same time pressing key "2", until the software version is displayed in the configuration mode. Pressing key "1" now switches to the next menu item, and changes can be made in the respective menu item by pressing key "2". The set value increases each time key "2" is pressed. If the maximum value has been reached, the value jumps to the minimum setting choice. The various settings are highlighted in figure 4.5.

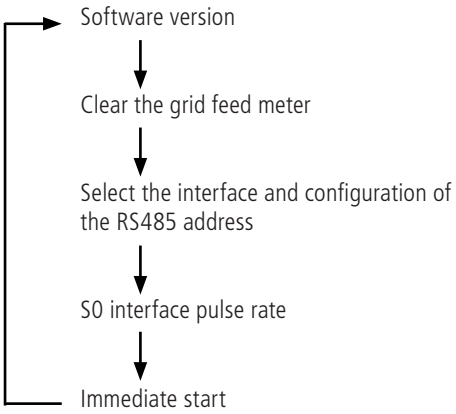

Figure 4.5: **Configuration mode menu**

Clearing the grid feed meter

When the grid feed meter is cleared, all meters ("Counter yield", "Yield today", "Total yield", "Economy of CO_2", "Daily peak capacity", "Counter oper. hours", "Operating hours today", "Total operating hours") are reset to zero.
To clear the meters, select "Yes" with key "2", and confirm your selection by pressing key "1". The required code is "2" and is entered using key "2". By means of an additional confirmation with key "1", all meters are cleared. A display indicating that the grid feed counters have been cleared confirms this action.

NOTE

Meters can only be cleared.It is not possible to set the meters.

Choice of interface and address setting

Using the menu item "Interface", you can use key "2" to switch between the RS232 and RS485 interfaces.
If the RS485 interface is activated, you can reach the address setting by pressing key "1". By pressing key "2", the address can be set in a consecutive manner from 1 to 32.
The address then jumps back to 1. The RS485 interface is used to communicate with the Powador-proLOG. When several inverters are connected to a Powador-proLOG, each address may only be used once. It is, therefore, possible to monitor 32 Powador inverters with one Powador-proLOG.

S0 interface pulse rate

The S0 interface is designed as a galvanically isolated transistor output. This interface is designed according to "DIN 43864 - Current interface for transmitting pulses from a pulsing meter to a tariff metering device".
The S0 interface pulse rate can be chosen in three unit intervals: 500, 1000 and 2000 pulses/kWh. Due to these tolerances, the emitted pulse yield may deviate from the values on your supply grid operator's grid feed meter by up to 15 %.

ACTION

Settings are saved only upon exiting configuration mode. If 2 minutes elapse without a key being pressed, the configuration mode is automatically exited. The configuration mode can also be immediately exited by pressing both keys. As a confirmation, "Settings saved" appears on the display for 4 seconds. The settings are now permanently saved in the Powador inverter.

Immediate start

The inverter can also be started up without any waiting period for the purpose of testing or for the purpose of acceptance by your power supply company.
If the inverter is already feeding into the grid, this menu item is not available.

ACTION

Keep key "2" pressed down for a short time until the inverter switches on (relays switch audibly) and the green grid feed LED (2) lights up. If there is insufficient solar generator power, the inverter stops feeding into the grid after a short period of time.

4.6 DC disconnector

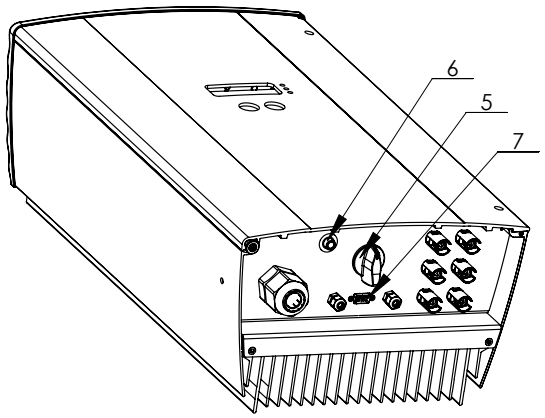

Figure 4.6: **Underside of the Powador**

The inverters include an internal DC disconnector, which allows for the inverter to be disconnected from the photovoltaic generator in case of repair or fault.

To disconnect the inverter from the photovoltaic generator, turn the internal DC disconnector on the underside of the inverter from the ON (1) position to the OFF (0) position (see figure 4.6).

When delivered, the inverter's internal DC disconnector is in the OFF (0) position.

4.7 Night start-up key

The unit switches off in the evening as nightfall approaches. The display is no longer shown. In order to retrieve the values from the current day, (daily yield, daily hours of operation and max. grid feed power) after the display switches off, the unit can also be activated during the night by pressing the night start-up key on the underside of the inverter.

ACTION

To do this, press the "night start-up" key (see figure 4.6 - (6)) on the underside of the unit for approx. 5 seconds until a display appears.

You can now scroll through the menu and retrieve the saved values. If over one minute elapses without a key being pressed, the unit switches off automatically once again.
The "Counter oper. hours ", "Total operating hours", "Counter yield", and "Total yield" data are permanently saved and totaled. This data remains in memory even if the inverter is switched off for a long time.
The daily yield, daily hours of operation and the max. daily grid feed power are available until the following morning and are cleared when PV generator voltage is present again.

4.8 The serial RS232 interface

Operating data can be transmitted to a computer (e.g. notebook) over a galvanically isolated serial interface (see figure 4.6 - (7)) from where it can then be individually processed further using standard spreadsheet software.

A standard serial 1:1 interface cable is all that is required for connecting the inverter to the computer. The cable length should not exceed 20 metres.

The data from the inverter is sent unidirectionally as pure ASCII text over the serial interface. The data is not checked for errors.

Powador Sub-D male 9-pole	Signification	PC Sub-D female 9-pole
2	TXD	2
3	RXD	3
4	RTS	4
5	GND	5

Table 4.1: **RS232 interface pin assignment**

The RS232 interface has the following parameters:

Baud rate	Data bits	Parity	Stop bits	Protocol
9600 baud	8	none	1	none

Figure 4.7 shows, as an example, a few of lines of transmission via the RS232 interface.
Data can be received with any terminal emulator, which comes with every operating system, or with the KACO-viso visualisation tool.

NOTE

The KACO-viso visualisation software can be downloaded from
http://www.kaco-newenergy.de

Together with the Powador inverter, KACO-viso takes over the role of a data logger. It saves the data from the inverter and displays it in various diagram types as a daily or monthly representation.
The PC, however, must also run continuously. Because of the amount of energy used, this type of monitoring only makes sense over limited periods, such as during a fault analysis. For permanent monitoring, we recommend the optional accessories (see section 5).

NOTE

With the optional accessories (see section 5), you can also implement wireless data transmission over long distances between the inverter and your PC.

The interface of the PC or laptop that is connected must comply with the standard for RS232 interfaces. Some computer manufacturers do not fully adhere to the standard. In such cases, problems may occur during data transmissions.

NOTE

The measured data for current and voltage istainted with the specified tolerances (see Installation Instructions).This data is not suitable for measuring efficiency or compiling yield data.Its sole purpose is to monitor the basic operation of the system.

4.9 The RS485 interface

Powador inverters are also equipped with an RS485 interface (see Installation Instructions, figure 6.7) in order to enable remote monitoring of your photovoltaic installation. Several inverters can be monitored over this interface at the same time. Using the Powador-proLOG series, you can receive yield and operating data as well as error messages by SMS (text message) or e-mail. This monitoring option is especially recommended for situations where you are unable to check the functionality of the installation on-site at regular intervals, e.g. if you live far away from the installation site.

In addition, you can use the Powador link within your installation to bridge long distances between several inverters or between an inverter and the Powador-proLOG by means of a wireless radio transmission. Contact your installer if you wish to integrate remote monitoring into your system.

4.10 Display

Inverters in the Powador xi series are equipped with a backlit LCD (see figure 4.1 - (1)) which displays measured values and data.
In normal mode, the backlighting is switched off. As soon as you press one of the keys, the backlighting is activated. If approx. 1 minute elapses without a key being pressed, it switches off once again.

IMPORTANT

Due to measuring tolerances, the measured values may not always correspond to the actual values. The inverter's measuring elements have been selected to ensure maximum solar yields.

Due to these tolerances, the daily yields displayed on the inverter may deviate from the values on your supply grid operator's grid feed meter by up to 15 %.

Column 1	2	3	4	5	6	7	8	9	10
00.00.0000	00:05:30	4	363.8	0.37	134	226.1	0.53	103	23
00.00.0000	00:05:40	4	366.0	0.39	142	226.1	0.53	112	23
00.00.0000	00:05:50	4	359.5	0.41	147	226.1	0.53	116	23
00.00.0000	00:06:00	4	369.8	0.42	155	226.1	0.58	118	23
00.00.0000	00:06:10	4	377.0	0.43	162	226.1	0.63	131	23
00.00.0000	00:06:20	4	373.6	0.45	168	226.1	0.63	133	23
00.00.0000	00:06:30	4	364.0	0.48	174	226.1	0.68	146	23
00.00.0000	00:06:40	4	364.3	0.49	178	226.1	0.68	146	23

Figure 4.7: **Excerpt from the protocol of a transmission via the RS232 interface**

Column	Explanation	Column	Explanation
1	Not in use	6	Generator power in W
2	Daily operating time	7	Grid voltage in V
3	Operating mode (see table 4.3)	8	Grid current, delivered current in A
4	Generator voltage in V	9	Grid-feeding power in W
5	Generator current in A	10	Device temperature in °C

Table 4.2: **Explanation of the individual columns**

Operating statuses

Status	Explanation	Comment
0	Inverter has just switched on	Only for a brief time after the inverter first switches on in the morning.
1	Waiting to start	Selftest is complete, the Powador will switch to grid feed mode in a few seconds.
2	Waiting to switch off	Generator voltage and power is too low. The status before it changes over to night shutdown mode.
3	Constant voltage regulator	When the grid feed begins, a constant generator voltage is fed in (80 % of the measured no-load voltage) for a short period.
4	MPP regulator, constant search movement	In cases of low insolation, the grid is fed into while the MPP regulator is searching.
5	MPP regulator, without search movement	In cases of high insolation, the grid is fed into while the MPP regulator is stationary so as to maximise yields.
6	Wait mode before grid feed, testing the grid and solar voltage	The inverter has stopped the grid feed because the power of the PV modules is too low (e.g. twilight). If the generator voltage is higher than the switch-on threshold (410 V), the inverter begins the grid feed once again after a country-specific waiting period (see Installation Instructions, section 4, Technical Data).
7	Wait mode before selftest, testing the line and solar voltage	The inverter waits until the generator voltage exceeds the switch-on threshold and begins the selftest of the relays after a country-specificwaiting period (see Installation Instructions, section 4, Technical Data).
8	Selftest of the relays	Testing line relays prior to beginning grid feed.
10	Overtemperature shutdown	If the inverter overheats (heat sink temperature >85 °C) due to the ambient temperature being too high and inadequate air circulation, the inverter switches off.
11	Power limitation	Protective function of the inverter when too much generator power is supplied or the heat sink of the unit exceeds 75 °C.
12	Overload shutdown	Protective function of the inverter when too much generator power is supplied.
13	Overvoltage shutdown	Protective function of the inverter when the line voltage L1 is too high.
14	Line failure (3-phase monitoring)	Protective function of the inverter when the measured values of one of the three grid phases are beyond the permitted tolerance. Reasons for line failures are: undervoltage, overvoltage, underfrequency, overfrequency, a fault in the phase conductor.
15	Changing over to night shutdown mode	Inverter switches from stand-by to night shutdown mode.
18	RCD type B shutdown	Residual current is too high, the integrated AC/DC-sensitive residual current circuit breaker has registered an unduly high leakage current to the PE.
19	Insulation resistance too low	Insulation resistance from PV-/PV+ to PE <1.2 MOhm.
30	Fault in the voltage transformer	The current and voltage measurements in the inverter are not plausible.
31	Fault in the RCD type B module	A fault has occurred in the AC/DC-sensitive residual current circuit breaker.
32	Selftest error	An error has occurred during the line relay test, a line relay is not functioning correctly.
33	Fault in the DC grid feed	The DC feed into the grid was too large.
34	Communication error	An error has occurred in the internal data transmission.

Table 4.3: **Explanation of the operating states**

Fault signals

Display	Explanation
Line failure Undervoltage Lx	The voltage of a grid phase is too low, the grid cannot be fed into. The phase in which the fault occurs (undervoltage) is displayed in each case.
Line failure Overvoltage Lx	The voltage of a grid phase is too high, the grid cannot be fed into. The phase in which the fault occurs (overvoltage) is displayed in each case.
Line failure Phase conductor	The phase shifts of the phase voltages are incorrect. A proper three-phase supply network is not present.
Line error overvoltage L1	Overvoltage shutdown due to a voltage boost caused by increased line impedance of the grid connection L1.
Line failure Underfrequency	The line frequency is too low.
Line failure Overfrequency	The line frequency is too high.
Error DC grid feeding	The DC feed into the grid has exceeded the permitted limit value. This grid feed can be impressed from the grid on the Powador inverter so that no inverter fault exists.
Error current switch-off	The current and voltage measurements in the inverter are not plausible. This can be caused by very dynamic weather conditions, if there are quick changes between low grid feed power (e.g. 200 W) and high grid feed power (e.g. the inverter's maximum grid feed power).
Error RCD module	An operational fault has occurred in the AC/DC-sensitive residual current circuit breaker.
Error Selftest	The internal grid separation relay test has failed.
Error Measurement	The current and voltage measurements in the inverter are not plausible. This can be caused by very dynamic weather conditions if there are quick changes between low grid feed power (e.g. 200 W) and high grid feed power (e.g. the maximum grid feed power).
Error isolation generator	The insulation resistance on the DC side is <1.2 MOhm. The grid cannot be fed into. The insulation resistance of the PV modules must be tested.
Temperature too high inside	The temperature in the unit has become too high (>85 °C). Starting from an internal temperature of 75 °C, the inverter limits the power and levels off between 75 °C and 80 °C.An internal temperature of 85 °C is only achieved if convection cooling is impeded by external factors, e.g. by covering the cooling fins.
Failure PV overvoltage	The power of the modules was too high for a short time. This can occur during times of very dynamic weather conditions. The power limiter usually prevents too much power at the input of the inverter so that the inverter does not shut down.
Line failure Average voltage	The average line voltage measurement over a 10 minute period according to EN 50160 has exceeded the maximum permitted limit value.

Table 4.4: **Fault signals**

Fault signals

When these error messages are displayed, the grid feed is interrupted, the red LED (3) lights up, and the fault signal relay has switched. This error correction takes a country-specific length of time (see Installation Instructions, section 4, Technical Data). Afterwards the red fault LED (3) goes out, the fault signal relay drops out again, and the display signals that it is ready to feed into the grid once again. If the fault is no longer present, the Powador inverter begins feeding into the grid once again after a preset waiting period (see Installation Instructions, section 4, Technical Data).
Many of these fault signals point to a fault in the grid, and are, therefore, not an operational fault on the part of the Powador inverter. The minimum triggering levels are determined by applicable standards (e.g. VDE0126-1-1), and the inverter must switch off if the permitted values are exceeded.

Automatic display during operation

Display	Explanation
Selftest in progress	The grid separation relays are tested for proper operation.

Table 4.5: **Display**

5 Troubleshooting

In line with our ever-growing quality assurance system, we endeavour to eliminate all errors and faults. You have purchased a product which left our factory in proper condition. Endurance tests as well as extensive tests for the purpose of assessing the operating performance and the protective equipment have been successfully undertaken with each individual unit.
If your photovoltaic installation does not function properly, we suggest the following troubleshooting procedures:
The first step is to check that the solar generator and grid connections are properly connected to the Powador. In doing so, observe all the safety instructions specified in this manual. Monitor the inverter closely and, where applicable, make a note of display indications and LED displays.
The following faults may occur and should be remedied as described.

Fault	Cause of fault	Troubleshooting / explanation
Inverter displays an impossible daily peak value	Faults in the line voltage.	Inverter continues to operate as normal without losses to the yield, even when an erroneous daily peak value is displayed. The value is reset overnight. To immediately reset the value, the inverter must be switched off, disconnected, reconnected and switched on again.
Daily energy yields do not correspond with the yields on the grid operator's grid feed meter	Measuring elements' tolerances in the inverter	A measurement error occurs due to the measuring elements' tolerances. The daily energy yield may deviate from the yield on the grid feed meter by up to 15 %, and even more in cases of low insolation.
The line fuse trips	– The line fuse capacity is too low – Damage to the inverter's hardware	In cases of high insolation, the inverter can, depending on the solar generator, exceed its rated current for a short period. For this reason, the capacity of the inverter's pre-fuse should be somewhat higher than the maximum grid feed current. The line fuse immediately trips if the inverter switches to grid feed mode (after the start-up period is complete). In such a case, there is damage to the inverter's hardware. Should this be the case, the unit must be repaired by KACO new energy GmbH.
The display is blank	– The unit is in night shutdown mode – There is no line voltage – The solar generator voltage is lower than 300 V – DC switch is at "0"	The inverter switches off overnight. If the display does not light up during the daytime, check the grid feed meter to see if the grid is nevertheless being fed into. If the grid is being fed into, the display module is faulty. The inverter must be repaired by KACO new energy GmbH. If the grid is not being fed into, check to see if there is any line voltage and if the solar generator voltage is greater than 300 V. If both are the case and the display is still blank, the unit must be repaired by KACO new energy GmbH.
The inverter does not start up, LED (1) is off	– The unit is in night shutdown mode – There is no line voltage – The solar generator voltage is lower than 410 V – DC switch is at "0"	The inverter switches off overnight. The display and all three LEDs are off. If the inverter does not start up during the daytime, check to see if there is any line voltage and if the solar generator voltage is greater than 410 V. If both are the case and the inverter still does not start up, the unit must be repaired by KACO new energy GmbH.

The inverter is active but does not feed to the grid. Display shows: Start at 410 V meas.: xxx V	Not enough generator voltage available. The measured voltage is lower than 410 V	After sunrise, at sunset and when there is not enough solar insolation due to bad weather conditions, the generator voltage or the generator power that comes from the roof may be too low to be able to feed in. If the inverter has switched off because the power is too low, it waits a country-specific length of time (see Installation Instructions, section 4, Technical Data) before attempting to feed in once again.
The inverter is active but does not feed in – the display shows: Start at 410 V meas.: xxx V (measured voltage is greater than 410 V	The inverter has interrupted the grid feed due to a fault.	After an interruption to the grid feed due to a fault (line fault, overtemperature, overload, etc.), the inverter waits a country-specific length of time (see Installation Instructions, section 4, Technical Data) before switching over to grid feed mode. With faulty grids, the inverters may even shut down during the day. Notify your solar installer if the inverter shuts down regularly over a period of several weeks (more than 10 times per day with error messages).
The inverter stops the grid feed mode shortly after being switched on, although there is sufficient sunlight.	Faulty grid separation relay in the inverter	Although there is sufficient sunlight, the inverter feeds into the grid only for a few seconds before switching off again. During the short grid feed period, the inverter shows a fed power of between 0 and 5 W. If the inverter is definitely receiving sufficient generator power, the grid separation relay is presumably faulty, thus preventing the inverter from connecting.
Noise emission from the inverter.	Unusual ambient conditions	When there are unusual ambient conditions, the units may emit audible noises. The following reasons may be determining factors: – Line interference or a line failure caused by particular loads (motors, machines, etc.) that are either connected to the same point on the grid or may be spatially situated nearby. – In cases of dynamic weather conditions (frequent switching between sunny and cloudy conditions) or strong insolation, a light hum may be audible due to the increased power. – With particular grid conditions, resonances may form between the unit's input filter and the grid which may even be audible when the inverter is switched off. – For people with very sensitive hearing (particularly children), it is possible that the high-frequency hum caused by the inverter's operating frequency of approx. 18 kHz is audible. Such noise emissions do not affect the operation of the inverter. They also cannot lead to reduced efficiency, failure, deterioration or a shortening of the unit's service life.

Table 5.1: **Troubleshooting**

If the measures described in this guide do not assist in clearing the fault, please notify your installer.
In order to enable our factory customer support team to respond in an appropriate and expeditious manner, some details are imperative:

Details pertaining to the inverter

– The unit's serial number
– Model
– A short description of the fault
– Is the error or fault reproducible? If yes, how?
– Does the error or fault occur sporadically?
– What type of insolation conditions existed?
– Time of day

Details pertaining to the photovoltaic module

– Module type, manufacturer (if available, also send the data sheet)
– The number of modules in series
– The number of strings
– Generator power

6 Recycling and Disposal

For the most part, both the inverter and the corresponding transport packaging are made from recyclable raw materials.

Device

Do not dispose of faulty inverters or accessories in the household waste. Ensure that the old unit and, where applicable, any accessories are disposed of in a proper manner.

Packaging

Ensure that the transport packaging is disposed of in a proper manner.

Intended for use by authorised electricians

Installation Instructions

Powador 2500xi / 3600xi / 4000xi / 4500xi / 5000xi

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1 About This Documentation

The following notes guide you through all of the documentation. Additional documents are applicable in conjunction with these operating and installation instructions.

We assume no liability for any damage caused by failure to observe these instructions.

Other applicable documents

When installing the inverters, be sure to observe all assembly and installation instructions for components and other parts of the system. These instructions are delivered together with the respective components and additional parts of the system.

1.1 Retention of documents

Please pass these operating and installation instructions on to the plant operator. The plant operator retains the documents. The instructions must be available whenever they are needed.

1.2 Symbols used in this document

When installing the inverter, observe the safety instructions provided in these installation instructions.

DANGER

Failure to observe a warning indicated in this manner will directly lead to serious bodily injury or death.

WARNING

Failure to observe a warning indicated in this manner may directly lead to serious bodily injury or death.

CAUTION

Failure to observe a warning indicated in this manner may lead to minor or moderate bodily injury or to serious damage to property.

ATTENTION

Failure to observe a warning indicated in this manner may lead to damage to property.

NOTE

Useful information and notes.

ACTION

This symbol indicates that a certain action is required.

IMPORTANT

Failure to observe this information may result in reduced convenience or impaired functionality.

Danger due to lethal voltages.

Risk of fatal injury from fire or explosions.

Risk of burns from hot housing components.

Disconnect the inverter from all power sources

1.3 CE marking

The CE marking is used to document that the Powador inverter shown on the name plate fulfills the fundamental requirements of the following relevant directives:

– Directive concerning electromagnetic compatibility (Council Directive 2004/108/EC)
– Low Voltage Directive (Council Directive 2006/95/EC).

1.4 Name plate

The name plate showing the exact designation of the unit is located on the support plate on the underside of the housing.

2 Safety Instructions and Regulations

DANGER

Danger due to lethal voltages.

Lethal voltages are present within the unit and on the power supply lines. Therefore, only skilled and authorised electricians may install and open the unit.

Even when the unit is switched off, high contact voltages may still be present inside the unit.

Standards and regulations

IEC 60364-7-712:2002:
Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems.

Technical rules

The installation must be suited to the on-site conditions and comply with local regulations and technical rules.

Accident prevention regulations

The inverter must be installed by an authorised, skilled electrician who is approved by the supply grid operator. The electrician is responsible for observing existing standards and regulations.

The proper and safe operation of this unit requires proper transportation, storage, assembly and installation, as well as careful operation and maintenance.

Only skilled electricians who have read and fully understood all safety instructions contained in these operating and installation instructions, as well as other instructions concerning assembly, operation and maintenance, may work on this unit.

When the unit is operating, certain parts of the unit unavoidably carry hazardous voltages, which can lead to death or serious bodily injury. The precautions listed below must be followed in order to minimise the risk of death or injury.

– The unit must be installed in compliance with safety regulations as well as all other relevant national or local regulations. To ensure operational safety, proper earthing, conductor dimensioning and appropriate protection against short circuiting must be provided.

– All covers on the unit must remain closed during operation.

– Prior to performing any visual inspections or maintenance, ensure that the power supply has been switched off and is prevented from being inadvertently switched back on. If measurements must be taken while the power supply is switched on, never touch the electrical connections. Remove all jewellery from your wrists and fingers. Ensure that the testing equipment is in good and safe operating condition.

– When working on the unit while it is switched on, stand on an insulated surface, thus ensuring that there is no earthed connection.

– Follow the instructions contained in these operating and installation instructions exactly, and observe all danger, warning and caution information.

– This list does not constitute a complete listing of all measures required for the safe operation of the unit. Contact your specialty dealer if any specific problems arise which are not sufficiently covered for the purposes of the buyer.

Modifications

Modifications to the inverter are generally prohibited. Changes to the surroundings of the inverter are only permitted if they comply with national standards.

CAUTION

Risk of damage due to improper modifications. Never modify or manipulate the inverter or other components of the system.

Transportation

The inverter is subjected to extensive testing and inspections in our test field. This is how we ensure the high quality of our products. Our inverters leave our factory in proper electrical and mechanical condition. Special packaging provides for a safe and careful transportation. However, transport damage may still occur. The shipping company is responsible in such cases.

Thoroughly inspect the inverter upon delivery. If you discover any damage to the packaging which indicates that the inverter may have been damaged, or if you discover any visible damage to the inverter, notify the responsible shipping company immediately.

If necessary, KACO new energy GmbH will assist you. Damage reports must be received by the shipping company in writing within six days of receipt of the goods.

When transporting the inverter, only the original packaging is to be used, as this provides for a safe transportation.

3 Notes on Installation and Operation

3.1 Intended use

The Powador inverter converts the DC power generated by the photovoltaic (PV) modules into AC power and feeds this into the power grid.
Powador inverters are built according to the state of the art and recognised safety rules. However, improper use may cause lethal hazards for the operator or third parties, or may result in damage to the units and other property.
The inverter may only be operated with a permanent connection to the public power grid. The inverter is not intended for mobile use.

Any other or additional use is not considered the intended use. The manufacturer/supplier is not liable for damage caused by such unintended use. Damage caused by such unintended use is at the sole risk of the operator.
Intended use also includes adherence to the operating and installation instructions. Some of the documents that you require in order to register your photovoltaic installation and have it approved are included in the installation instructions (see section 9).

3.2 Factory warranty and liability

KACO new energy GmbH issues a warranty of seven years on the Powador inverter starting from the date of installation, but at most 90 months after shipment by KACO new energy GmbH.

During this time, KACO new energy GmbH guarantees the proper operation of the units and to undertake repairs at the factory free of charge in the event of a defect for which we are responsible.

Contact your specialty dealer if your unit exhibits a defect or fault during the warranty period.

Warranty claims are excluded in the following cases:
- Use of the units in ways not intended
- Improper installation and installation that does not comply with standards
- Improper operation
- Operation of units with defective protective equipment
- Unauthorised modifications to the units or repair attempts
- Influence of foreign objects and force majeure (lightning, overvoltage, severe weather, fire)
- Insufficient ventilation of the unit
- Failure to observe the relevant safety regulations
- Transport damage.

All warranty claims must be handled at the premises of KACO new energy GmbH. The unit must, where possible, be returned in its original or equivalent packaging. The costs for these services cannot be borne by KACO new energy GmbH.

KACO new energy GmbH will only perform warranty services if the defective unit is returned to KACO new energy GmbH together with a copy of the invoice which was issued to the user by the dealer. The name plate on the unit must be fully legible. If these requirements are not fulfilled, KACO new energy GmbH reserves the right to deny warranty services.

The warranty period for repairs or replacement deliveries is six months after delivery. However, it continues at least until the end of the original warranty period for the delivery item.

3.3 Service

We place special emphasis on the quality and longevity of our inverters, starting with the product development phase.. More than 60 years of experience in the field of current inverters support us in this philosophy.

However, despite all quality assurance measures, faults may occur in exceptional cases. In such cases, KACO new energy GmbH will provide you with the maximum possible support. KACO new energy GmbH will make every effort to remedy such faults in an expeditious manner and without a great deal of bureaucracy. In such cases, contact our service department directly.

Telephone +49 (0)7132-3818-660

4 Technical Data

Input - Electrical data

Model	2500xi	3600xi	4000xi	4500xi	5000xi
DC rated power	2710 W	3600 W	4600 W	4800 W	5730 W
Max. PV generator power	3200 W	4400 W	5250 W	6000 W	6800 W
MPP range	350 ... 600 V				
No-load voltage	Max. 800 V				
Monitoring input voltage	Stand-by from Ue > 300 V Night shutdown from Ue < 250 V				
DC voltage ripple	< 3 % eff				
Max. DC input current	8.6 A	12.0 A	14.5 A	15.2 A	18.0 A
Polarity safeguard	Short-circuit diode				

Output - Electrical data

Model	2500xi	3600xi	4000xi	4500xi	5000xi
AC rated power	2600 W	3600 W	4400 W	4600 W	5500 W
Maximum power AC	2850 W	4000 W	4800 W	5060 W	6000 W
Line voltage	See section 4 - Technical Data - Country-specific parameters - page 9				
Rated current	11.3 A	15.6 A	19.1 A	20.0 A	23.9 A
Max. current	12.4 A	17.5 A	20.9 A	22.0 A	26.0 A
Power factor	≈1				
Frequency	See section 4 - Technical Data - Country-specific parameters - page 9				
Distortion factoraccording to EN 61000-3-2	<3 % at rated power <5 % over the entire range				
Fault signal relay	Potential-free NO contact (make contact), max. 30 V/1 A				
S0 output	Open collector – output max. 30 V/50 mA				

Inverter – Electrical data

Model	2500xi	3600xi	4000xi	4500xi	5000xi
Max. degree of efficiency	96.4 %	96.4 %	96.4 %	96.3 %	96.3 %
Euro. deg. of efficiency	95.8 %	95.8 %	95.8 %	95.3 %	95.3 %
Internal consumption	Night shutdown: 0 W Operation: 11 W				
Minimum grid feed power	ca. 35 W				
Circuit design	Self-inverted, transformerless				
Clock frequency	18 kHz				
Principle	Single-phase full bridge with IGBT technology				
Grid monitoring	Redundant 3-phase monitoring according to VDE0126-1-1				

Inverter - Mechanical and technical data

Model	2500xi	3600xi	4000xi	4500xi	5000xi
Visual displays	LED: PV generator (green) LCD (2 x 16 characters)		Grid feed (green)		Fault (red)
Controls	2 keys for operating display				
DC disconnector	Integrated DC disconnector with continuous function				
Connections	PCB terminals inside the unit Cable supply through cable fittings				
Ambient temperature	-20 ... +60 °C (> 40 °C power derating at high ambient temperature)				
Temperature monitoring	>75 °C temperature-dependent impedance matching >85 °C Disconnection from the grid				
Cooling	Free convection (no fan)				
Protection class	IP54 according to EN 60529				
Noise emission	< 35 dB (noiseless)				
Housing	Aluminium wall-mounting housing				
Dimensions W x D x H	340 x 200 x 500 mm	340 x 220 x 550 mm	340 x 220 x 550 mm	340 x 220 x 600 mm	340 x 220 x 600 mm
Weight	19 kg	21 kg	26 kg	28 kg	30 kg

Country-specific setting of parameters

Parameter → / Country ↓	Line voltage range [V]	Line voltage according to EN 50160 [V]	Standard frequency range [Hz]	Start-up value after a re-start [s]	Reset time after insufficientgrid feed power [s]	Reset time after a fault [s]
Germany	190 ... 264	253 V	47.5 ... 50.2	> 60	> 180	> 30
Spain	196 ... 254	-	49.0 ... 51.0	> 180	> 180	> 180
Italy	190 ... 264	-	49.7 ... 50.3	> 180	> 180	> 30
France	190 ... 264	253 V	49.5 ... 50.5	> 60	> 180	> 30
Cyprus (GR)	208 ... 252	-	49.5 ... 50.5	> 180	> 180	> 180
Greece	190 ... 264	-	49.5 ... 50.5	> 180	> 180	> 180
South Korea	194 ... 242	-	59.3 ... 60.5	> 360	> 360	> 360
Czech Republic	196 ... 252	253 V	49.5 ... 50.5	> 60	> 180	> 30
Portugal	196 ... 264	-	47.0 ... 51.0	> 60	> 180	> 30
Bulgaria	196 ... 264	-	47.0 ... 51.0	> 60	> 180	> 30

The switch-on times after a re-start, a fault or after insufficient grid feed power are approximate values.

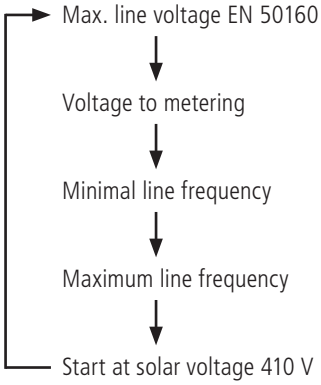
Country-specific grid connection table

Parameter → / Country ↓	L 1	L 2	L 3	N	PE	Comment
Germany	X	X	X	X	X	With phase conductor monitoring
Spain	X			X	X	
Italy	X			X	X	
France	X	X	X	X	X	
Cyprus (GR)	X			X	X	
Greece	X			X	X	
South Korea	X			X	X	
Czech Republic	X	X	X	X	X	With phase conductor monitoring
Portugal	X			X	X	
Bulgaria	X			X	X	

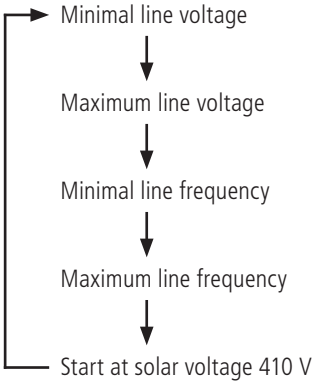
Country-specific parameter menu

Parameter menu → / Country ↓	A	B
Germany	X	
Spain		X
Italy		X
France	X	
Cyprus (GR)		X
Greece		X
South Korea		X
Czech Republic	X	
Portugal		X
Bulgaria		X

Parameter menu A



Parameter menu B



5 Device Description

CAUTION

Incorrect use is prohibited.

The transformerless Powador xi units are currently available for five different power ratings. The appropriate inverter type is selected according to the maximum output of the photovoltaic modules that have been installed. The maximum output values can be found in the data sheet (see Technical Data, section 4).
Your inverter's designation is located on the front side, above the display and on the name plate.

5.1 Scope of delivery

– Powador
– Wall bracket
– Installation kit
– Documentation

5.2 Dimensioning the PV generator

The selection of the PV generator is of central importance when dimensioning a PV installation. When doing so, you must be sure that the solar generator is also compatible with the inverter.
Observe the data provided in the data sheet (see Technical Data, section 4) when dimensioning the solar generator.

NOTE

KACOCALC Pro, a dimensioning program for the easy selection of PV modules, can be downloaded at no cost at the following address:
http://www.kaco-newenergy.de

Dimensioning the PV generator

The number of PV modules connected in series must be selected in such a way that the output voltage of the PV generator stays within the permitted input voltage range of the inverter - even during extreme outside temperatures. In Central Europe, module temperatures between -10 °C and +70 °C should be assumed. Depending on the way in which the modules are installed and the geographic location, +60 °C or +70 °C should be used when calculating the voltage. The temperature coefficients of the solar modules should be taken into account. The following criteria must be met for calculating the voltage of the PV generator:

– U_0 (-10 °C) < max. input voltage (800 V). Even at very low outside temperatures (-10 °C), the no-load voltage of the connected string must lie within the permitted input voltage range. If the temperature falls from 25 °C to -10 °C, the no-load voltage in 12 V modules increases by approx. 2.8 V per module (5.6 V for a 24 V module). The no-load voltage of the entire string must be less than 800 V .

– U_{Mpp} (+60 °C) > min. input voltage (350 V). Even at very high outside temperatures (+60 °C), the MPP voltage of the connected string should lie within the permitted input voltage range. If the temperature increases from 25 °C to 60 °C, the MPP voltage in 12 V modules decreases by approx. 3.6 V per module (7.2 V for a 24 V module). The MPP voltage of the entire string should be at least 350 V.

If the MPP voltage moves outside of the permitted input range, the installation still functions properly. In this situation, the maximum possible amount of power is not fed into the grid; instead, a small amount less is fed.

Provided that the input voltage is within the permitted input voltage range, the inverter will not be damaged if a connected PC generator provides current that is above the max. usable input current.
If the PV generator briefly provides more than the inverter's max. PV generator power, especially with changing cloud cover and relatively low module temperatures, the inverter may switch off due to safety reasons and automatically switch on again after a country-specific waiting period (see section 4, Technical Data). The overload status is shown by a red LED and as plain text on the display. Under normal circumstances, the dynamic control of the inverter ensures that the inverter continues to operate without interruption.

The solar generator still represents the largest factor in the cost of a solar installation. For this reason, it is extremely important to obtain maximum energy yields from the solar generator. To achieve this, solar generators in Central Europe should be oriented to the south at an angle of inclination of 30°. They should never be shaded.

This orientation is quite often not possible due to structural reasons. In order to achieve the same energy yield as an optimally oriented solar generator (south, 30° angle of inclination), the solar generator power can be increased.
For roofs with an east-west orientation, we recommend a two-string PV installation. To achieve an optimum yield from the installation, the first string must be installed on the east side of the roof; the second string on the west side.
For exposed locations in mountains or in southern regions, we recommend that the power generator be reduced appropriately. Please consult with us or your specialty dealer about this matter.

5.3 Protection concepts

The following monitoring and protective functions are integrated into Powador inverters:
– Redundant 3-phase grid monitoring in order to protect the operator and to avoid islanding.
– Overvoltage conductors/varistors to protect the power semiconductors from high-energy transients on the grid side.
– Temperature monitoring of the heat sink.
– EMC filters to protect the inverter against high-frequency line interference.
– AC/DC-sensitive residual current circuit breaker **RCD** type B switch (**R**esidual **C**urrent protective **D**evice), which monitors the leakage current from the Powador's grid connection to the PV generator and interrupts the feed to the grid when the residual current exceeds 30 mA. The RCD type B switch triggers when a cable has a fault in the insulation, a frame fault or an earth fault.

6 Installation and Start-up

WARNING

Risk of fatal injury from fire or explosions. The Powador's housing may become hot during operation.

Do not mount the Powador on flammable materials.

Do not install the Powador in areas which contain highly flammable materials.

Do not install the Powador in areas where there is a risk of explosion.

CAUTION

Risk of burns from hot housing components. Install the Powador so that unintentional contact with it is not possible.

6.1 Selecting an appropriate place for installation

NOTE

Powador inverters meet the requirements of protection class IP54 if all cable feedthroughs are used or suitably closed off.

The units should be installed in areas that are as dry as possible in order to extend their service life. In addition, be sure that the units are installed in climate-controlled areas in order to protect them from overheating. This extends their service life.

When selecting the inverter's place of installation, attention should be paid to the following items:
– Ensure good access to the unit for installation or any service work that may later be required.
– Maintain the following minimum clearances around the unit:
  200 mm side clearance to other units,
  700 mm clearance to other stacked units,
  500 mm to cabinets, ceilings, etc.

– The unit has been designed for vertical wall installation.
– Air must be allowed to circulate freely around the housing and through the heat sink on the rear side.

– If the inverter is built into a switching cabinet or similar, provide forced ventilation to insure that heat is sufficiently dissipated.
– The heat sink may reach a max. temperature of 90 °C. Therefore, mount the inverter only on walls made from heat-resistant material.
– Ensure that the wall has adequate load-bearing capacity and use appropriate installation material.
– In areas prone to flooding, be sure to install the inverter in a sufficiently elevated place.
– Installation at eye level makes it easier to read the display.

IMPORTANT

Due to the high system voltage, the current that flows on the DC side is lower than that flowing on the AC side. If the cable cross-sections are the same, losses on the AC-side lead are, therefore, higher than those on the DC side. For this reason and due to thermal factors, it makes sense to position the inverter near the meter.

6.2 Installing the inverter

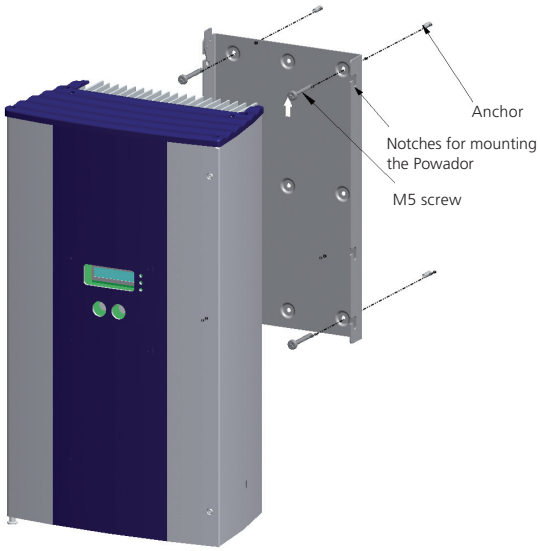


Figure 6.1: **Powador wall bracket**

An installation kit consisting of four anchors and four 70 mm screws is shipped with the inverters. Check the composition and condition of the wall before installation. If necessary, use an installation kit other than the one shipped with the inverter.

ACTION

– Drill the holes for the anchors at the selected installation position to match the cut-outs in the mounting plate.
– Place the anchors into the holes.
– Use the screws to mount the mounting plate onto the wall at the selected location. When doing so, be sure that the arrow cut into the mounting plate points upwards.
– Mount the inverter on the mounting fixture so that the pegs in the heat sink rest in the notches.
– Lock the safety catch. To do this, slide the upper end of the safety catch towards the wall until the groove runs parallel to the wall (see figure 6.2).

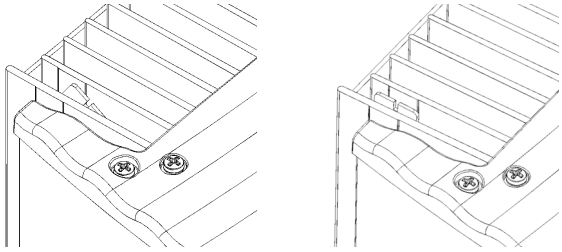


Figure 6.2: **Safety catch** open (left) and closed (right)

6.3 Electrical connection

General information

After the inverter has been installed in its fixed location, the electrical connection to the unit can be established.

DANGER

The Powador may be installed only by trained and authorised specialists.

All mandatory safety regulations, the currently required technical connection specifications of the responsible electrical supply company, as well as other generally applicable local regulations are to be adhered to.

When connecting the inverter, the AC and DC sides must be disconnected from all power sources and secured against being inadvertently switched back on.
The connection of the PV generator and the grid connection are established via PCB terminals in the connection box of the inverter (see figure 6.3).

ACTION

The door of the housing must be opened to do this. The door is held shut with two Phillips recessed-head screws on the front of the housing.

NOTE

At the AC and DC connection terminals, the maximum conductor cross-section that can be connected is 10 mm² for flexible conductors and 16 mm² for rigid conductors. Strip off 10 mm of insulation. Tighten the terminal with a torque of 1.2 to 1.5 Nm.

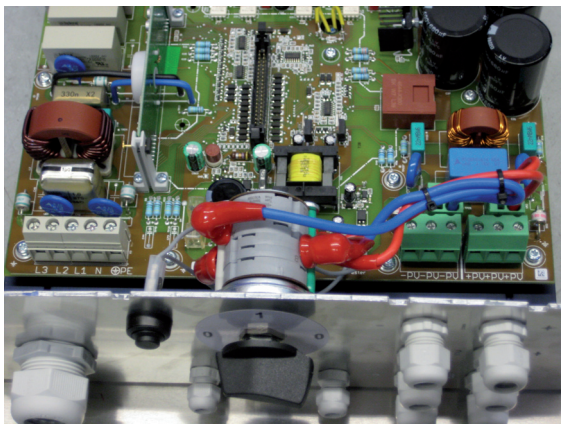


Figure 6.3: **Powador connection box**

AC/DC-sensitive residual current circuit breaker RCD type B

The inverter is equipped with an AC/DC-sensitive residual current circuit breaker. If there is an impermissible residual current, the inverter is disconnected from the grid. An external residual current circuit breaker is, in compliance with the applicable directives in the respective country, not required if a corresponding low-resistance earthing of the unit is possible.

Grid connection

The inverter feeds in single-phased at terminal L1. However, the grid connection is established in various ways, depending on the country (see section 4, Technical Data). There is an appropriate cable fitting on the underside of the housing for inserting the leads.

We recommend the following conductor cross-sections for cable lengths up to 20 m:
– Powador 2500xi / 3600xi: 2.5 mm²
– Powador 4000xi: 4.0 mm²
– Powador 4500xi / 5000xi: 6.0 mm²

Larger cross sections should be used for longer leads.

In accordance with VDE 0100 part 430 "Protection of cables and cords against overcurrent", when NYM cables are permanently laid, with an ambient temperature in the B2 laying system (multi-conductor lead in the pipe or duct, either on or in walls or flush-mounted) of 25 °C, the cables should be secured as follows:
– 2.5 mm² 20 A
– 4 mm² 25 A
– 6 mm² 35 A

NEOZED fuses (gL) should be used.

NOTE

Be sure to use cables with a sufficiently large cross-section to avoid excessive line impedance between the building's distribution box and the respective Powador unit.

When the line impedance is high, i.e. long AC-side leads, the voltage at the line terminals of the inverter will increase as power is being fed in to the grid. The inverter measures this voltage. If the voltage at the line terminals exceeds the line overvoltage limit, the inverter will switch off due to line overvoltage. This must be taken into consideration when wiring the AC and dimensioning the AC lead.

DANGER

Risk of electric shock at live connections.
Check that the power lead is voltage-free before inserting it into the unit.

ACTION

Guide the lead, which has been stripped of its jacket and insulation, through the cable fitting.
Connect the lead, which has been stripped of its jacket and insulation, as is shown on the label on the left side of the PCB terminal.

CAUTION

Check that the leads are properly connected. Exchanging L and N will destroy the inverter.

ACTION

Once again, check that all connected leads are firmly connected.
Tighten the cable seal of the cable fitting.

PV generator connection

The PV generator leads are connected in the connection box on the right side.

DANGER

To ensure maximum protection against hazardous contact voltages while assembling photovoltaic installations, both the positive and the negative leads must be strictly isolated electrically from the earth potential (PE).

ATTENTION

Risk of damage.
Ensure that the polarity is correct when connecting the unit.

ACTION

Before connecting the PV generator to the Powador, check that the PV generator is not earthed.

- Measure the DC voltage between the protective earth (PE) and the positive lead and between the protective earth (PE) and the negative lead of the PV generator.If stable voltages can be measured, there is an earth fault in the PV generator or its wiring. The ratio between the measured voltages gives an indication as to the location of this fault. This fault must be remedied before taking any further measurements.
- Measure the electrical resistance using a tester according to DIN VDE0100 (a megohmmeter) between the protective earth (PE) and the positive lead and the protective earth (PE) and the negative lead of the PV generator.

Low resistance (< 2 MΩ) indicates a high-ohm earth fault of the PV generator, which must be remedied before further installation.

CAUTION

The voltage of the solar generator must be measured before connecting the DC leads to the inverter terminals. The DC voltage must not exceed 800 V. Connecting to a higher voltage will destroy the unit.

The PV generator can be connected in the following ways:

- Cable fittings
- Tyco plug connectors
- MC plug connectors

When delivered, the cable fittings are already installed. As an option, Tyco and MC plug connectors can be delivered with the inverter.

Connecting the PV generator using cable fittings

ATTENTION

To achieve protection class IP54, unused cable fittings must be closed off by using the included blind caps.

ACTION

To do this, unscrew the cable fittings until you can insert the cables through the fitting, and screw the ends of the cables into place in the connection terminals labelled "PV+" and "PV-". When doing this, ensure that the polarity is correct. Tighten the cap of the cable fitting.

Connecting the PV generator using MC or Tyco plug connectors

As an option, MC and Tyco plug connectors can be delivered with the inverter. These can be used instead of the cable fittings that were already installed upon delivery. These pre-installed cable fittings must first be removed before installing the appropriate plug connectors.

WARNING

Always disconnect the inverter from the PV generator by operating the integrated DC disconnector before pulling apart the plug connector. Failure to observe this may cause arcing, which can result in a hazard to health and to the unit.

ACTION

Unscrew the cable fittings from the cut-outs in the base plate of the inverter.
Insert the Tyco or MC sockets from the outside through the cut-outs, and secure them from the inside using the black plastic nut.

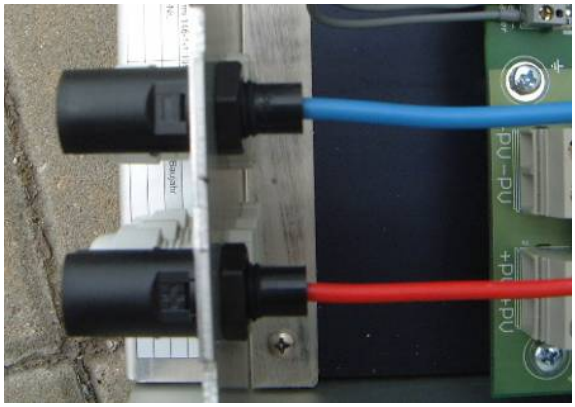


Figure 6.4: **Installing Tyco sockets**

The assembly of the Tyco and MC plug connectors is shown in figure 6.5 and figure 6.6 respectively.

Figure 6.5: **Assembly of the Tyco plug connectors**

Figure 6.6: **Assembly of the MC plug connectors**

6.4 Connecting the fault signal relay

The solar inverter is equipped with a potential-free relay contact in order to signal faults. This contact closes if a fault occurs.

Maximum contact load: 30 V / 1 A.

IMPORTANT

In the event of failure of the grid feed phase (power failure on the public grid), the relay will not trigger. If this happens, all LEDs and the display go out. The inverter is shut down completely.
A failure signal cannot be sent.

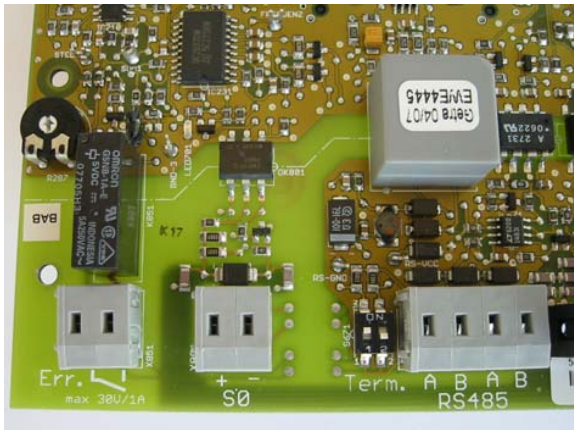


Figure 6.7: **Connections**

6.5 The S0 output connection

The inverter is equipped with an S0 pulse output. Items such as a large display can be connected to it. The pulse rate is adjustable (see section 6.8, Parameter programming).

6.6 The RS485 interface connection

On the inverter's control card (rear panel of the door), there are four terminals labelled RS485 A and B (see figure 6.7). To connect several Powadors, terminal A of one Powador is connected to terminal A of the other Powador. Terminal B is connected in the same manner. A twisted, shielded data cable is required for this. The connection to the Powador-proLOG is established similarly to the interconnection of inverters. A connection diagram is displayed in figure 6.8. The length of the RS485 wiring should not exceed a total of 250 m.

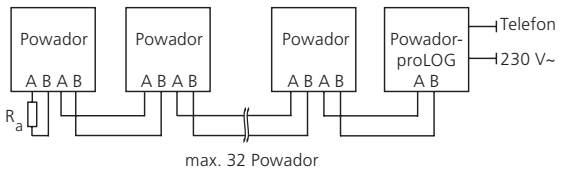


Figure 6.8: **Connection diagram for the RS485 interface**

Figure 6.8 shows a terminating resistor (Ra) with 330 Ω on the left inverter. For proper signal transmission, the last inverter in a chain must have a terminating resistor.
The terminating resistors (switch "1") in the other inverters in the chain must be deactivated.
Switch "1" is located on the control card to the left of the RS485 terminals and is labelled "Term." (figure 6.7).
Figure 6.7 shows the factory setting with an activated terminating resistor (switch "1" is "on" and switch "2" is deactivated).
The control card is installed on the rear of the door of the inverter. Switch "2" must always be off, as is shown in figure 6.7 (Term.).

With a bus system such as RS485, each device sharing this bus must possess a unique address, regardless of whether it is an inverter or a current sensing device (Powador-go). Inverters may have an address range from 1 to 32. The address for each inverter can be specified using the configuration menu (see Operating Instructions, section 4.5, Choice of interface and address setting).

IMPORTANT

Ensure that the A and B wires are properly connected. Communication is not possible if the wires are exchanged.

6.7 Starting up the inverter

After completing the mechanical and electrical installation, the inverter is put into operation as follows:

NOTE

The inverter can only be put into operation under daylight conditions (i.e. at a solar generator voltage of > 300 V). If no daylight or solar generator voltage is present, the inverter can be activated by pressing the night start-up key on the underside of the inverter (see Operating Instructions). However, normal operation is not possible in this condition. The values can only be read off the display.

ACTION

– Switch on the line voltage (via the external circuit breakers).
– Switch on the solar generator using the DC disconnector (0 ⟶ 1).

The uppermost green LED (1) lights up if the generator voltage is greater than 300 V. The display now shows the inverter type for 4 seconds, followed by the current generator voltage: "Start at 410 V meas.: xxx V". If the measured voltage is greater than 410 V, the unit begins feeding into the grid after a country-specific time period (see section 4, Technical Data). This country-specific start-up period is required in order to ensure that the generator voltage is continuously above the power delivery limit of 410 V. An quick start routine is provided for start-up and test purposes. This routine circumvents the start-up period. This quick start routine is found in the configuration mode menu (see Operating Instructions).

During the start-up procedure, the line power relay audibly switches on and power delivery starts. This is signalled by the green LED (2). The display now shows the power being fed to the grid. Key "1" can now be used to display the various measured values (see Operating Instructions).

If the inverter stops feeding into the grid because the power is too low, it waits a country-specific length of time before resuming power delivery (see section 4,Technical Data).

Quick start

The inverter can also be started up without any waiting period for the purpose of testing or for the purpose of acceptance by your power supply company.

ACTION

To do this, switch to the configuration mode menu by pressing both keys at the same time. Press key "1" to move through the menu until you have reached the "Quick start with key 2" menu item.
When you have reached this menu item, keep key "2" pressed down for a short time until the inverter switches on (relays switch audibly) and the green grid-feed LED (2) lights up. If the solar generator voltage is too low, the inverter switches off again.

6.8 Programming - Configuration mode menu

Various operating mode parameters can be set in the configuration mode menu of Powador xi units.

WARNING

Incorrect parameter settings will lead to a loss of function, render your Safety Certificate invalid, and result in the loss of the safety functions.

Modifications may only be made in exceptional cases and only after having consulted with the manufacturer and the power supply company.

In order to switch to the configuration mode menu, hold key "2" pressed down for 15 seconds until the display changes and displays the first parameter.

Use key "1" to scroll through the various menu items. The menu is continuous. When you reach the end, the display automatically jumps back to the first item.

The parameter menu is country-specific.
Details can be found in:
– **Section 4**
– **Technical Data**
– **Country-specific parameters.**

Figure 6.9: **Configuration mode menu**

ACTION

Use key "2" to change the parameter that is shown. When doing so, the value increases or decreases, depending on the parameter. The values here are also continuous, i.e. after you reach the maximum value, they jump back to the minimum value.

Explanation of individual parameters:

– Max line voltage EN 50160: The line voltage is averaged over 10 minutes. If the set value is exceeded, the inverter is disconnected from the grid. The voltage threshold can be set at 244 V or 253 V under "MAX LINE VOLTAGE EN 50160".

– Under "VOLTAGE TO METERING", the limit value can be set between 0 V and 11 V in 1 V increments. This voltage drop between the inverter and the grid feed meter is added to the limit value of "Max line voltage EN50160". With a line voltage of 253 V and a voltage drop of 5 V, the Powador switches off if the average line voltage over a ten-minute period is greater than 258 V.

– Minimum and maximum line frequency: The line frequency is also monitored. If the frequency drops below the value set in "MINIMAL LINE FREQUENCY" or exceeds the value set in "MAXIMUM LINE FREQUENCY", the inverter switches off. Both limit values can be set in 0.1 Hz increments. (Section 4, Technical Data, Country-specific setting of parameters).

– Start at solar voltage: After sunrise, the inverter begins to feed into the grid once the voltage has reached 410 V (display: "Start at 410 V") This setting enables safe operation in any solar generator configuration. In exceptional cases, it may be necessary to adjust this starting voltage threshold. At a low generator voltage (few modules connected in series), the starting voltage may be reduced to ensure a safe start-up, even during unfavourable weather conditions. At a high generator voltage, the starting voltage may be increased to ensure that the inverter does not switch itself on and off too often with low power. The starting voltage may be set within a range from 370 V to 500 V, in increments of 10 V (factory setting: 410 V).

ACTION

After the parameters have been changed, the configuration mode must be exited so that the settings are permanently saved in the inverter.
To exit, press both keys at the same time until the display shows "Settings saved". This display changes back to the "normal" display after 4 seconds.
The parameter settings are now saved. If 2 minutes elapse without either key "1" or "2" being pressed, configuration mode is automatically exited and the parameters are automatically saved.

7 Switching the Inverter Off

The inverter must be switched off to adjust settings and for maintenance and repair work. This is done as follows:

DANGER

– **Risk of fatal injury by electric shock at live connections.**
– **Lethal voltages are still present in the inverter even after the electrical connections have been disconnected.**
– **Wait 30 minutes before reaching into the inverter.**
– **When working on the photovoltaic modules, you must always disconnect the DC disconnector at all poles in addition to disconnecting from the grid.**
– **Disconnecting the line voltage is not enough.**

ACTION

Disconnect the line voltage (switch off the external circuit breakers).
Disconnect the photovoltaic module using the DC disconnector (1 → 0).
Check and ensure that the grid connection terminals and the DC connection terminals of the inverter are voltage-free.

8 Powador as Part of a PV Installation

8.1 Design of installation

A sample design of a grid-connected PV installation using a Powador is shown in the following overview circuit diagrams.

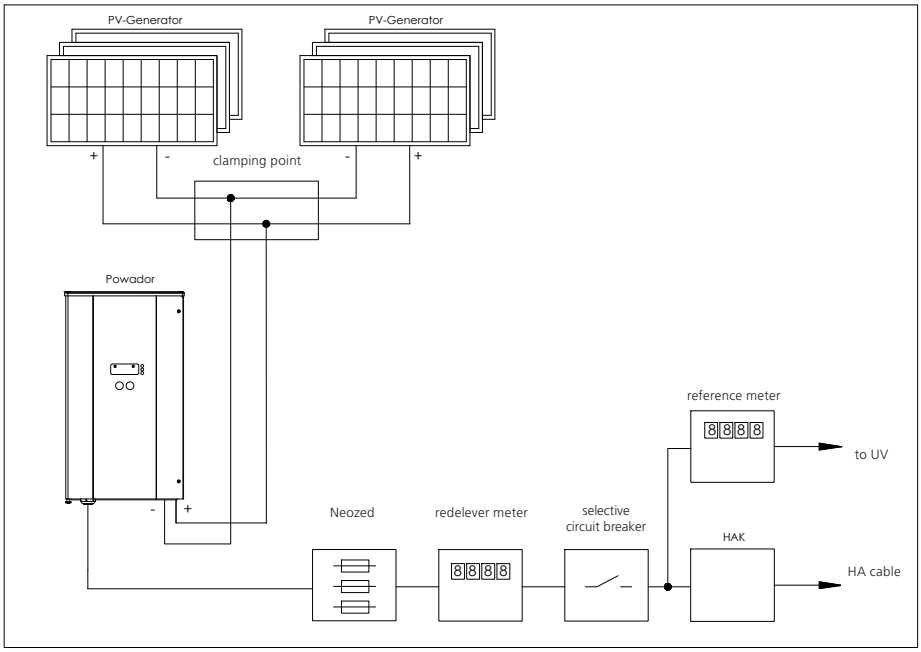


Figure 8.1 **Single-pole overview circuit diagram for an installation with one inverter**

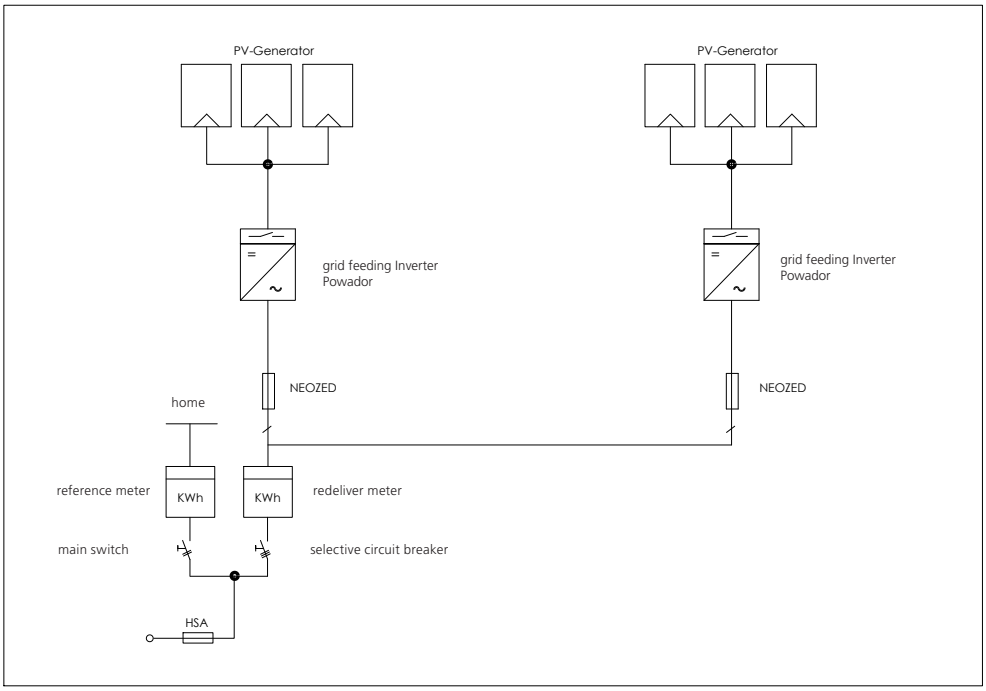


Figure 8.2 **Single-pole overview circuit diagram for an installation with two inverters**

A summary of the components:

DC terminal point:

Two generator strings are connected in parallel either at a DC terminal point between the solar generator and the inverter or directly on the inverter (terminals for three strings are provided on the inverter). Of course, you can also connect the strings directly to the solar generator and then run just one negative and one positive lead to the inverter.

DC disconnector:

In order to be able to disconnect the inverter on the generator side from sources of voltage, the inverter comes equipped with an integrated DC disconnector. As a result, the installation of an external DC disconnector is not required.

Line fuses:

In order to protect the lead, the inverter's power supply lead should be secured with NEOZED fuses. The fuses that are used should be appropriate to the length and cross-section of the leads and fulfil applicable standards and directives.

Grid feed meter:

The required grid feed meter is specified and installed by the responsible power supply company. Some power supply companies also allow the installation of your own calibrated meters. In this case, you do not need to pay rent for the meter, but the power supply company may require that the meter be periodically calibrated.

Selective main switch:

Contact your power supply company if you have questions concerning the required main switch.

8.2 Installation with multiple inverters

Observe the following regarding installations with multiple inverters:

Asymmetric grid feed:
The power should be distributed as equally as possible over the three phases. In Germany, the asymmetry between the phases may be a maximum of 4.6 kW (according to the VDEW guidelines concerning the connection and parallel operation of independent power generating plants on the low-voltage grid, 4th edition, 2001).

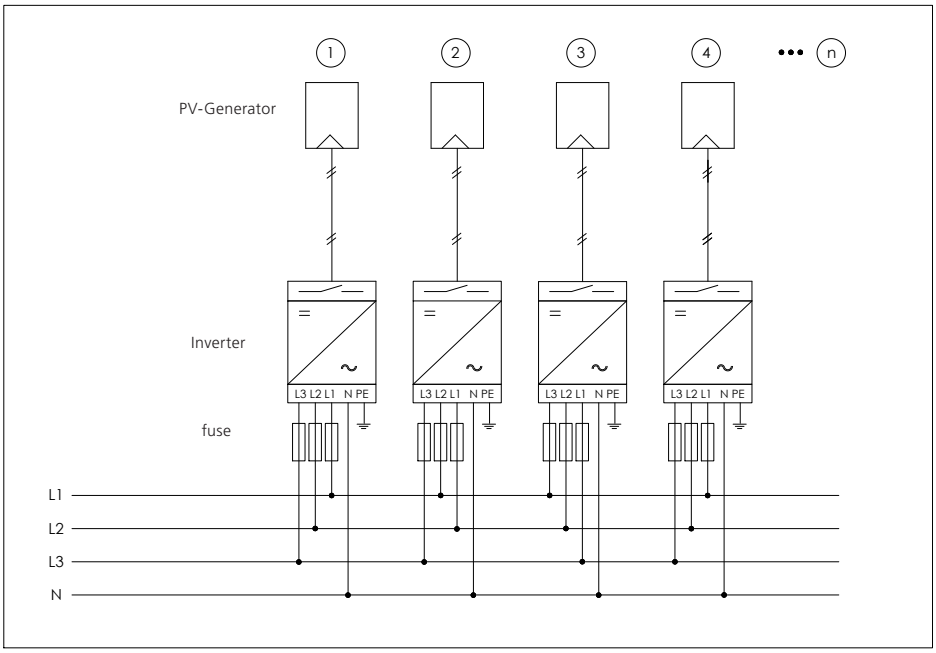


Figure 8.3: **Grid-side connection for installations with multiple inverters**

Electrical connection:

The Powador is equipped with 3-phase monitoring, but it only feeds in on one phase. In order to avoid asymmetries in the grid, installations with multiple inverters should be designed so that the inverters feed into the grid in differing phases. The inverter feeds into the phase that is labelled L1 on the inverter's terminals

If you have multiple inverters, connect the actual phase L1 to terminal L1 on the first unit. On the second unit, connect phase L2 to terminal L1. On the third unit, connect phase L3 to terminal L1. Continue as above. This distributes the power optimally.

Figure 8.4: **Electrical connection**

Connection L1 feeds into the grid.
Connections L2 and L3 are just monitored.

8.3 Notes specific to the Powador 5000xi

NOTE

The Powador 5000xi is designed for installations with several inverters, and, at 5.5 kW, is above the limit for single-phase feed into the grid. It, therefore, may be operated only together with at least two additional inverters in order to ensure that the asymmetry is not greater than 4.6 kW (in Germany). For this, the inverters are distributed over all three phases (according to VDEW).

Sample configurations:

L1: Powador 5000xi	L2: Powador 5000xi	L3: Powador 1501xi Asymmetry: 3.7 kW
L1: Powador 5000xi	L2: Powador 5000xi	L3: Powador 2500xi Asymmetry: 2.7 kW
L1: Powador 5000xi	L2: Powador 5000xi	L3: Powador 3600xi Asymmetry: 1.9 kW
L1: Powador 5000xi	L2: Powador 4000xi	L3: Powador 4000xi Asymmetry: 0.8 kW
L1: Powador 5000xi	L2: Powador 4000xi	L3: Powador 4500xi Asymmetry: 0.6 kW

9 Documents

9.1 EU Declaration of Conformity

Name and address of the manufacturer:	**KACO new energy GmbH** Carl-Zeiss-Str. 1 74172 Neckarsulm, Germany
Product description:	**Photovoltaic grid-tied inverter Powador**
Type description:	**Powador 2500xi / 3600xi / 4000xi / 4500xi / 5000xi**

This is to confirm that the devices stated above are compliant with the protection requirements set forth in the EU Council Directive as of 15 December 2004 for the Harmonization of Legal Stipulations of the Member States concerning Electromagnetic Compatibility (2004/108/EC) and the Low Voltage Directives (2006/95/EC).

The devices are compliant with the following standards:

2006/95/EC "Directive concerning electrical equipment designed for use within certain voltage limits"	**Safety of the device** EN 60950-1:2006 EN 50178:1997* * regarding clearance and creepage distances
2004/108/EC "Directive concerning electromagnetic compatibility"	**Interference immunity:** EN 61000-6-1:2007 EN 61000-6-2:2005 **Emitted interference:** EN 61000-6-3:2007 EN 61000-6-4:2007** ** regarding radiated emission **Secondary effects on the grid:** EN 61000-3-12:2005 EN 61000-3-11:2000

Therefore, the types stated above are labelled with the CE marking.

Any unauthorised modifications to the supplied devices and/or any use for other than for the intended purposes shall render this Declaration of Conformity null and void.

Neckarsulm, 01st February 2009
KACO new energy GmbH

ppa. Matthias Haag
Head of Grid-Coupled Systems Division

9.2 Declaration of Conformity

Bureau Veritas Consumer Product Services GmbH
Businesspark A96
86842 Türkheim
Germany
+ 49 (0) 8245 96810-0
cps-tuerkheim@de.bureauveritas.com

Certificate of compliance

Applicant: **Kaco new energy GmbH**
Carl-Zeiss-Str. 1
74172 Neckarsulm
Germany

Product: **Automatic disconnection device between a generator and the public low-voltage grid**

Model: **Powador 2500xi, Powador 3600xi, Powador 4000xi, Powador 4500xi und Powador 5000xi**

Use in accordance with regulations:

Automatic disconnection device with three-phase mains surveillance in accordance with DIN V VDE V 0126-1-1:2006-02 for photovoltaic systems with a single-phase parallel coupling via an inverter in the public mains supply. The automatic disconnection device is an integral part of the aforementioned inverter. This serves as a replacement for the disconnection device with insulating function which the distribution network provider can access at any time.

Applied rules and standards :

DIN V VDE V 0126-1-1 (VDE V 0126-1-1):2006-02 and „Generator at the public low-voltage grid, 4th edition 2001, guideline for connection and parallel operation of generators in the public low-voltage grid" with VDN additions (2005) from the German Electricity Association (VDEW) and Association of network operator (VDN).

The safety concept of an aforementioned representative product corresponds at the time of issue of this certificate to the valid safety specifications for the specified use in accordance with regulations.

Report number: **05KFS087-VDE0126**
Certificate nummer: **U09-189**
Date of issue: **2009-09-04** **Valid until:** **2012-09-04**

Andreas Aufmuth

Notice

31000569-02-100517

KACO new energy.

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