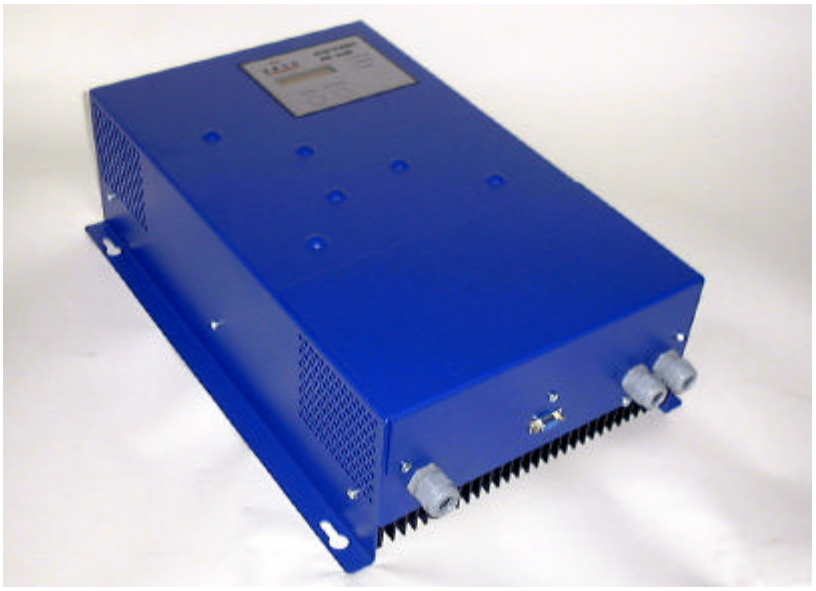
PV-Line Input Inverters

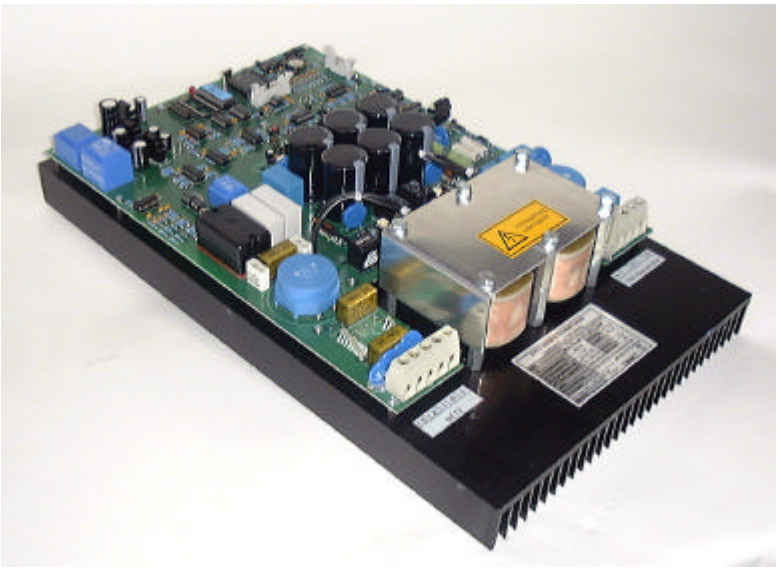
Blue Planet PVI 2600

KACO GERÄTETECHNIK



Manual

PVI 2600 - 2.0kW
PVI 2600 - 2.6kW



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Safety Information

Installation and maintenance of these inverters must be performed by skilled personnel only. Lethal voltages are present inside the device - therefore, the device must be opened by skilled electricians or your responsible dealer only.

Hazardous live voltages may be present even if the instrument has been disconnected. This manual describes how to operate and handle the instrument properly. Therefore, please read this manual carefully before putting it into operation.

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1. Introducing KACO GERÄTETECHNIK

Device Technology is a powerful partner for system solutions in the field of current inverters and power electronics.

Our location at Heilbronn has been developing, designing and manufacturing current inverters and power electronics for more than 60 years.

Our capable and efficient development and projecting team will meet all special customers' requirements while ensuring fast response times.

History:

- Founded in 1914 under the name of "Kupfer-Asbest-Company Gustav Bach" (KACO), our company was Germany's first special factory that produced ring gaskets used in the automotive industry.

- In 1927, the product range was extended by electrotechnical products, and it has permanently been enhanced and expanded since that date.

- By 1970 the electrotechnical division had grown significantly and was transferred to a separate company - Bach & Co. KACO Elektrowerk.

- In 1991, the company name was changed to KACO ELEKTROTECHNIK Bach GmbH + Co.

- In 1996, the company, whose name had meanwhile been changed to KACO ELEKTROTECHNIK GmbH, joined the American Danaher Corporation of Washington, DC.

- On January 1st, 1999, the strongly expanding Gerätetechnik Profit Center focussed on inverter technology and power electronics, was re-established as an independent company under the name of KACO GERÄTETECHNIK GmbH.

2. Short Description of Blue Planet PVI 2600

Blue Planet PVI 2600 is a new milestone in the field of photovoltaics. Its technology meets state-of-the-art requirements and sets new standards concerning price/performance ratio, reliability, efficiency and power density.
Its essential features are summarized below:

- Continuous AC output 2.0 kW or 2.6 kW
- AC peak power 2.5 kW and 3.0 kW
- Working without transformer
- Degree of efficiency > 95%
- Lightweight: only 12 kg
- Small dimensions
- Input voltage range up to 750VDC
- MPP range: 350-600VDC
- Extremely easy to install
- RS232 interface as standard
- VDEW conformance
- LCD display showing the following operational data (permanent access):

Solar generator voltage	Date and hour
Solar generator current	Daily yield
Mains voltage	Annual yield
Delivered current	Total yield
Delivered power	Daily operating time
Daily peak output	Annual operating time
Temperature inside instrument	Total operating time
Operating status	

Our name obliges. For more than 60 years, KACO Gerätetechnik has been developing and manufacturing a variety of different current inverter types and techniques at its location in Heilbronn/Germany. High product quality and longevity are our essential hallmark. Our competent team of experts ensures innovative developments in the field of power electronics.

3. Functional Principle of Blue Planet PVI 2600

The functional principle of the inverter is depicted in Figure 1.

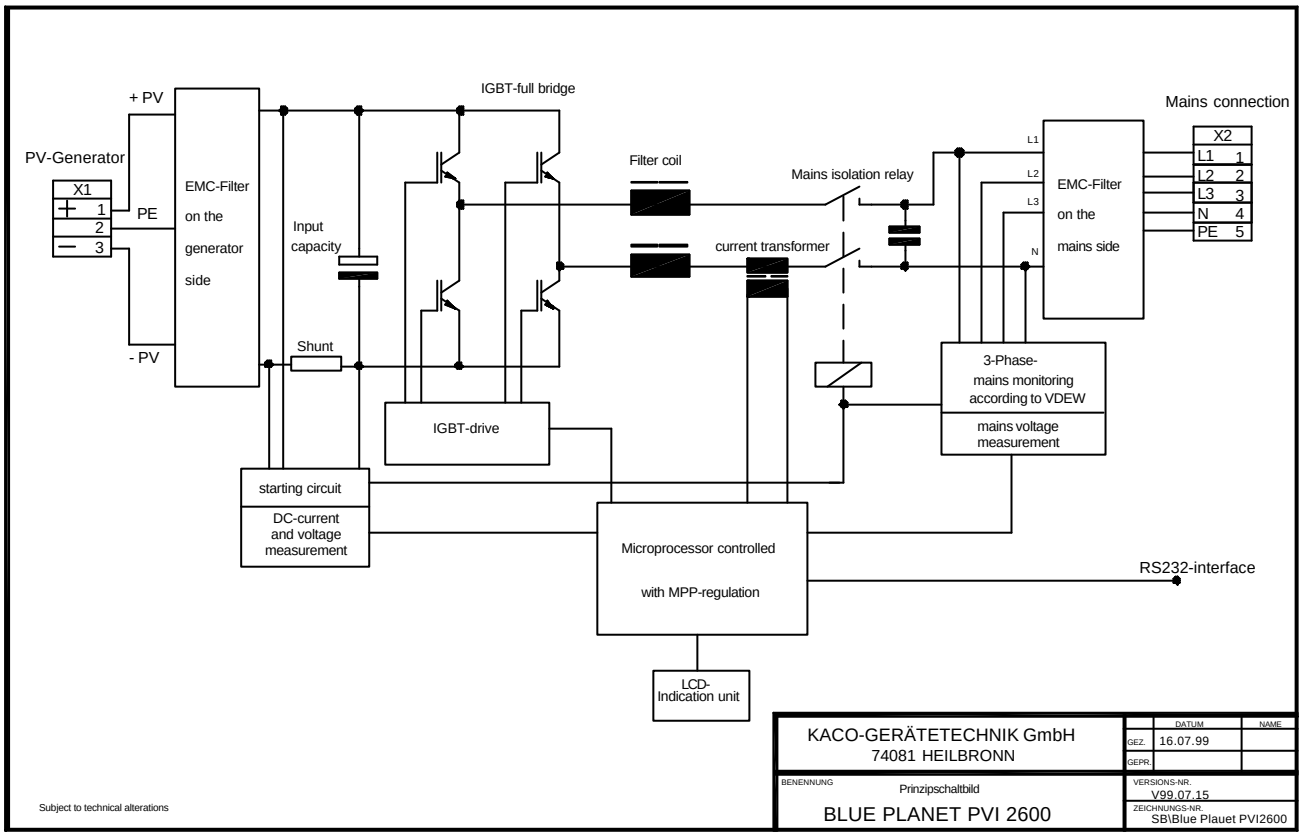


Figure 1. Functional Principle of Blue Planet PVI 2600

3.1. Description of Components

EMC Filters

Specially adapted discrete EMC filters are integrated on the generator and mains side. These filters ensure compliance with EMC standard threshold values. Due to their high performance there is no need to use ready-made standard line filters. An excerpt of EMC measurements is shown on page 39, Chapter 10.3 - EMC Measurements.

Input Capacities

The inverter works under high insolation conditions and according to a patented MPP algorithm, which ensures highest adaptive degrees of efficiency. This MPP algorithm is based on the voltage and current ripple on the DC side. This high-performance MPP tracker requires an appropriately dimensioned input capacity on the generator side, which has been implemented with special snap-in electrolytic capacitors for Blue Planet.

IGBT Full Bridge

The IGBT full bridge is composed of individual discrete IGBT semiconductors, which are triggered via optocouplers. A special protective circuit ensures that the IGBT components are not damaged even under extreme operating conditions. High-quality semiconductors ensure fast switching times and minimized loss in throughput.

Line Power Inductors

Line power inductors ensure that the delivered current is sinusoidal. These inductors are manufactured in a special process, and their special design guarantees an excellent efficiency degree of the inverter.

Line Power Disconnection

A VDE-approved relay ensures safe disconnection from line power during night shutdown and in the event of failures. The relay meets the requirements for line power disconnection, i.e. a contact spacing of 3 mm.

Start-up Circuit

The start-up circuit monitors the DC voltage of the solar generator and ensures that the inverter “goes to sleep“ at night and “wakes up“ again when the sun rises. In this way, the inverter does not use any mains power during the night shutdown period. Starting at a generator voltage of approx. 300V, the start-up circuit enables the inverter controls and changes over to a self-holding mode, which avoids any additional load on the generator. Power delivery starts at a generator voltage of approx. 410V.

DC-Voltage and Current Measurement

The generator current and voltage are recorded by a precise measurement circuit. These values are the input values for controlling the delivered current. The generator voltage and generator current values can be read off the integrated display.

Line Power Monitoring
A VDEW-compliant (VDEW = German Association of Power Generating Plants) line power monitoring system is integrated in the inverter. This system monitors the voltage of all three phases and disconnects all inverter poles in the event of a line power failure, overvoltage or low voltage condition. As soon as line power has recovered and is within the permissible tolerances again the inverter automatically resumes its operation after completing the start-up routine.

Microprocessor-controlled Guided Operation
The inverter offers a variety of different functions.
The analog current regulator provides very fast response to line fluctuations and harmonics of the line voltage. It obtains its nominal values from the MPP tracker (amplitude) and the current line voltage (curve shape). The cos ϕ value of 0.985 is far better than required by law.

The MPP tracker, which is designed in digital technology, uses the line-induced ripple of the generator voltage and, therefore, works without a continuous search movement, thus ensuring a very high degree of adaptability.

This guided operation is based on a high-performance 8-bit micro-controller. C-language and an advanced real-time operating system have been used for programming the controls. Therefore, the program can be expanded and the inverter can be adapted to new tasks very easily. The possibility of assigning a variety of priority levels allows safe simultaneous operation of the user interface, serial interface, and power delivery operation.

LCD Display
By means of 2 keys and a dual-line display, users can retrieve information about the actual operating status or stored data (yield and operating times). The only entry that is required is the date and hour (if the system is installed for the first time or has not been used for an extended period of time – please refer to page 19, Chapter 6.3, Display Operation/Settings).

Serial Interface
An electrically isolated serial interface transfers operating data to a computer (e.g. notebook) and allows further individual processing with conventional spreadsheet programs. More details about the data format, connections and data processing are given on page 24, “Operation of the RS 232 Interface“.

3.2. Protective Functions

The following monitoring and protective functions are integrated in the inverter:

1. Generator-side overvoltage dischargers/varistors as lightning protection.
2. 3-phase line power monitoring to protect against the risk of personal injuries and the development of an “island effect“ (isolated mains).
3. Overvoltage dischargers/varistors to protect the power semiconductors against high-energy line transients.
4. Heat sink temperature monitoring.
5. EMC filters to protect the inverter against RF line interference.
6. Line input varistors to ground – to protect the inverter against burst and surge pulses.

4. Inverter Assembly

4.1. General Information about the Place of Assembly

The overall planning of a PV installation should include a favorable inverter location.
Below is a summary of the most important criteria to be observed for an optimal installation site:

Criteria for an optimum inverter location:

- Wall assembly in indoor areas
- Do not directly expose the inverter to wetness or humidity
- Note that less current flows on the generator side than on the mains side.
- Installation at eye-level makes it easier to read the display and LCD.
- Ensure accessibility for assembly or service work
- Provide a minimum clearance of 200 mm above the case, i.e. to other devices, cabinets, ceiling, or similar.
- Ensure free air circulation around the case/enclosure and through the heat sink.
- If Blue Planet PVI 2600 is installed in a switch cabinet or similar, ensure that heat is carried-off sufficiently, e.g. by means of forced ventilation.
- The heat sink can reach a temperature of more than 80°C.

Important:
Depending on the type of wall you should use the appropriate screws and dowel pins for fastening Blue Planet PVI 2600. Conventional dowel pins and screws are usually appropriate for safe fastening of the inverter.

Data referring to the place of installation:

Admissible relative air humidity	:	less than 95%
Admissible ambient temperature	:	-25 ... +50°C
Protection	:	IP21
Case/enclosure material	:	Aluminum

The case/enclosure is solely made of lightweight aluminum. Therefore, there is no risk of corrosion.

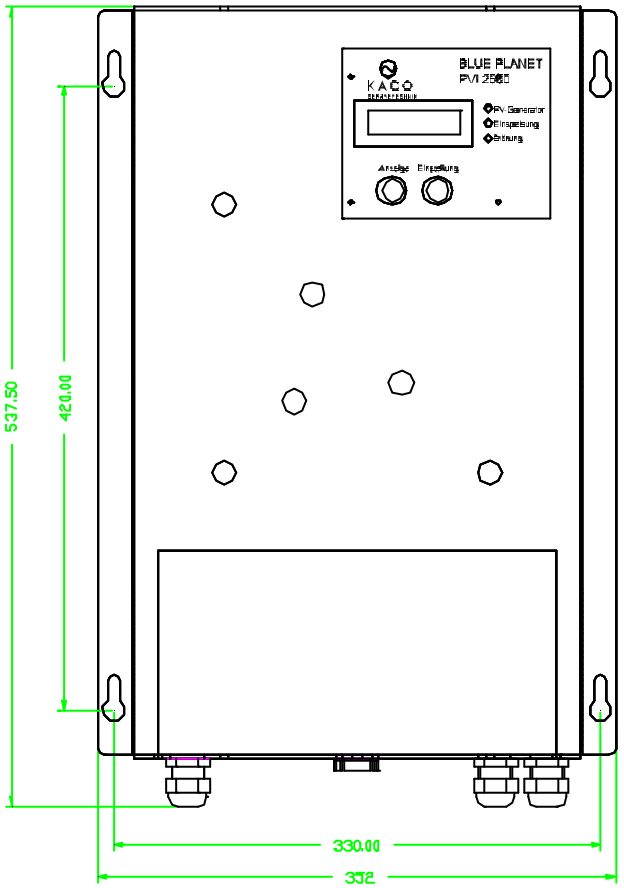
An IP 65 version of this inverter has not been provided for the following three reasons:

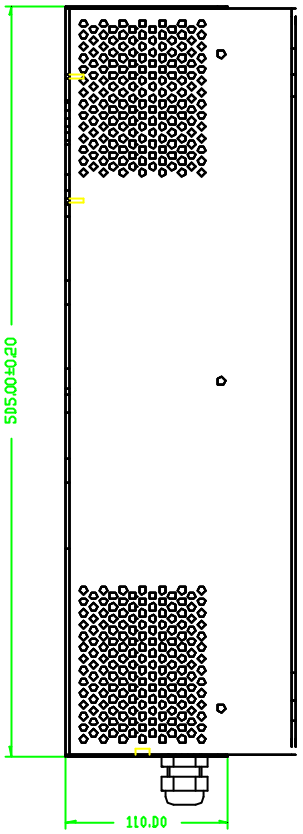
1.) Good air circulation ensures low operating temperatures of the inverter and, consequently, a longer useful life of its electronic components. IP65-type enclosures are hermetically sealed, which results in higher interior temperatures as compared to IP20 enclosures, and which would reduce the mean useful life of these components.

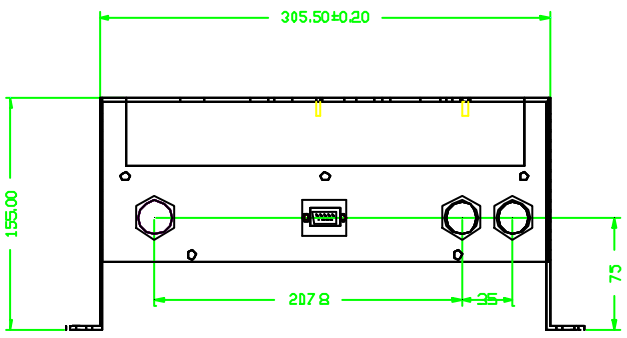
2.) The condensation water problems stated with IP65 enclosures are not found with IP20 enclosures. Due to the fact that they are hermetically sealed, IP65 inverters must be “drained“ regularly, i.e. a water drain/outlet must be provided.

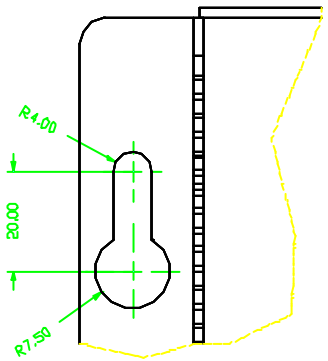
3.) 99% of all inverters are installed indoors. IP65 enclosures involve significantly higher manufacturing and production costs. Summarizing all these aspects and bearing in mind our customers‘ benefit and maximum device usability, we have decided not to include IP65 devices in our product range.

4.2. Mechanical Dimensions









5. Electrical Connections

5.1. General Information

The electrical connections can be established as soon as Blue Planet PVI 2600 has been installed in its fixed location.

The electrical installation of Blue Planet PVI 2600 must only be performed by skilled personnel and by an electrician who is approved by the responsible Electrical Supply Company.

All applicable safety instructions, technical connections stipulated by the responsible Electrical Supply Company, and the relevant VDE regulations must be adhered to.

The PV generator connections and line power connections are implemented by means of PCB terminals in the connection box of the inverter. Remove the cover of this box, which is fastened with three recessed-head screws at the underside of the enclosure.

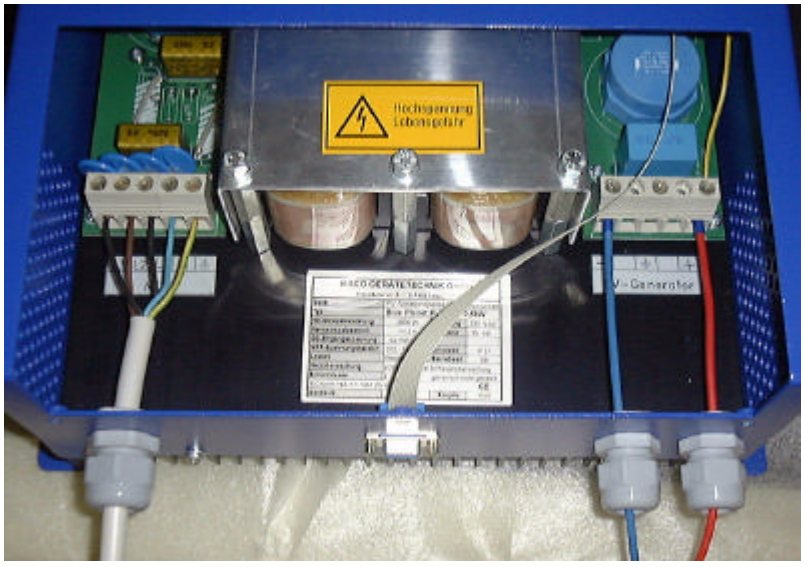


Figure 4 : Connection Box of Blue Planet PVI 2600

The electrical connections of Blue Planet, and the connection of DC and AC voltages must be performed in the sequence described here.

5.2. Line Power Connection

5-lead connections are used (L3, L2, L1, N, PE), with wire cross-sections up to 6 mm^2.
PG fittings (PG16) are provided at the underside of the enclosure for inserting the wires.

We recommend the use of automatic 16 A safety fuses for circuit protection.
All further components required for line power connection are described on page 29, Chapter 8: Blue Planet as Part of a PV Installation.

Please make sure to use sufficiently wide wire cross-sections to avoid excessive line impedance (internal resistance of the electrical grid) between the domestic distribution and the respective Blue Planet installation (we recommend a value of $Z_L \leq 0{,}5\ \Omega$).

The impedance value is calculated by adding the line impedance value of the domestic connection to all resistance values of the remaining leads and terminals.

Important for dimensioning:
The resistance values of a single lead alone, e.g. a 20-m lead having a cross-section of 1.5 mm^2, correspond to approx. 0.48 Ω, which, at a rated current of approx. 12 A, effects an increase in the inverter voltage of approx. 6 V as compared to the domestic connection. Similarly, a 35-m lead having a cross-section of 2.5 mm^2 corresponds to approx. 0.50 Ω.

At a high mains impedance, i.e. long AC-side leads, the voltage at the line terminals will increase during power delivery. This voltage is measured by the inverter. If the voltage at the line terminals exceeds the limit of 264V, the inverter switches off due to mains overvoltage. This condition must by all means be taken into consideration for dimensioning the AC lead.

Before inserting the line power lead into the device, please check that it does not carry voltage.

Insert the unshielded and stripped lead through the PG16 fitting. Connect the stripped lead according to the marking on the left PCB terminal.
Check that all connected leads are firmly seated.
Tighten the seal of the PG16 fitting.

5.3. PV Generator Connections

The PV generator leads are connected on the right side of the connection box.
Important: Ensure correct polarity.

To obtain maximum safety and protection against hazardous live voltages during the assembly of PV systems, the positive and negative leads must be strictly isolated from earth potential (PE). Prior to installing the PV generator to the Blue Planet unit, please check that the PV generator installation is free from possible ground faults:

1.) Determine the DC voltage between protective earth (PE) and the positive lead or, respectively, between the protective earth (PE) and the negative lead of the PV generator. If stabilized voltages values can be measured, this indicates a ground fault in the PV generator or generator wiring. The ratio between the measured voltages indicates the location of this fault. Make sure to remedy this fault prior to performing any further measurements!

2.) Determine the electrical resistance between the protective earth (PE) and the positive (plus) lead or, respectively, between the protective earth (PE) and the negative (minus) lead of the PV generator.

    A low resistance value (< 2 MΩ) indicates a high-resistance ground fault of the PV generator, which must by all means be remedied prior to further installation!

    After completing these checks for ground faults you may now start to establish the electrical connections to the Blue Planet.

Safety Information concerning the use of Multi-Contact Connectors:

Disconnecting the PV generator from the Blue Planet PVI 2600 (i.e. pulling the connector cord) must NEVER be performed under load, i.e. NEVER during the inverter's power delivery operation. Always make sure to disconnect the system from mains supply by de-activating the mains fuses.

(Otherwise the connectors might be damaged due to the formation of an arc,
and both parts of the respective damaged connector must be exchanged).

6. Inverter Operation

6.1. Starting-Up the Inverter

After completing the mechanical and electrical installation of the inverter (see Chapter 4, Inverter Assembly, and Chapter 5, Electrical Connection of the Inverter), you may now put the inverter into operation as follows:

1. Switch on the line voltage (via the external automatic safety breakers).

2. Switch-on the solar generator via the DC circuit breaker (or multi-contact connector). Response: the green LED “PV generator“ is illuminated (if the generator voltage is greater than 300V). The display shows the start message: “PV 2600 or, respectively, “PVI 2600-2.0“. After approx. 2 seconds, the display changes and the current generator voltage is measured: “Start from 410 V; measurement xxx V.“ If the measured voltage is greater than 410V, the instrument starts its power delivery after approx. 2 – 3 minutes. This starting-up period of 2-3 minutes is necessary to ensure that the generator voltage is permanently above the power delivery limit of 410V.
   A quick-start routine is provided for test purposes – this routine circumvents the start-up period. This quick-start is menu-controlled and obtained from the set-up mode (see page 18, Chapter 6.3, Display Operation and Settings).

3. During the normal start-up procedure the line power relay is switched on after approx. 2-3 minutes (audible acoustic noise) and the power delivery is started. This is also signaled by the green “Power Delivery“ LED. The display now shows the delivered power. The “Display“ key can be used to indicate the various measurement values
   (see page 18, Chapter 6.3, Display Operation and Settings).

4. It may be necessary to reset the date and hour (please refer to page 18, Chapter 6.3, Display Operation and Settings).

5. The inverter is now fully in operation.

6.2. Switching-off the Inverter

1.) Switch off line voltage (de-activate the external automatic safety breakers).

2.) Check that the line power terminals of the inverter do no longer carry voltage.

3.) Switch-off the solar generator by means of the DC circuit breaker (or, respectively, multi-contact connector).

Attention! Especially when using multi-contact connectors, the sequence described above must be followed very carefully, as otherwise there is a risk of arcing, which may destroy the connectors.

Attention – Lethal Hazard! Hazardous Live Voltage can be present in the inverter even if the electrical connections have been switched off.

Please wait for three minutes before accessing the inverter.
If you have to carry out any work on the solar generator, you must additionally de-activate all connections of the DC main switch (or, respectively, the multi-contact connector) – it is not sufficient to switch off the line voltage in this case!

6.3. Display Operation and Settings

General Information:

In the normal operating mode you will only need the '**Display**" key to toggle between the individual measuring values and data. The "Set" key is required for setting the date and hour and to select the quick-start routine and clear the internal power meter of the inverter.

Display Screen and Operation:

After starting-up the inverter (see Page 16, Chapter 6.1, Starting-Up the Inverter), various measuring values and data are shown on the display. Use the "Display" key to toggle between the different values and data. Keep the "Display" key pressed until the next value is shown. If the Display key on the inverter has not been in use for an extended period of time, the display automatically indicates the currently delivered power. The following values and data may appear on the display:

No.	Display Message	Explanation
1	Blue Planet PVI 2600 or Blue Planet PVI 2600-2.0	Start message, which appears after starting-up the device. Shows the type of inverter and the inverter capacity (PVI 2600 for 2.6 kW device; PVI 2600-2.0 for 2.0 kW device)
2	Start measurement from 410V xxx V	Display shown during the starting-up period (in the morning), after a malfunction or prior to night shutdown. **No power delivery** in this mode of operation. The inverter waits until the voltage has exceeded a value of 410 V. If this value has been exceeded for more than 3-4 minutes the power delivery is started. An audible sound is generated when the mains isolation relay is enabled.
3	Solar generator voltage xxx V	Actual voltage of the solar generator connected to the inverter. Shown in volts; tolerance ± 3%
4	Solar generator current xxx A	Actual current supplied to the solar generator by the inverter. Shown in amps; tolerance ± 7% at rated power. Greater tolerances are possible when smaller generator currents are displayed.

No.	Display Message	Explanation
5	Line voltage xxx V	Actual line voltage (measurement of the phase into which power is delivered); displayed in volts; tolerance: ± 2%
6	Line current xxx A	Actual current that is fed into the mains. Displayed in amps; tolerance: ± 5%
7	Delivered power xxxx W	Power that is currently fed into the mains. Displayed in Watts.
8	Daily peak capacity xxxx W	Short-term peak delivery capacity of the day, displayed in W.
9	Temperature inside the device	Display of the actual heat sink temperature, in °C. The inverter limits the power delivery if the temperature exceeds 65°C. If the device temperature exceeds 80°C it is switched off automatically.
10	Status: 1.) Power delivery operation 2.) Waiting for start-up 3.) Waiting for shut-down 4.) Power limitation 5.) Overload 6.) Overvoltage 7.) Line voltage failure	Display of the various operating statuses: 1.) Normal delivery operation. Power is fed into the mains. 2.) Waiting for sufficient solar generator power. The generator voltage is not sufficiently high to feed power, or the power delivery process was stopped and the system is re-started after a failure. 3.) Waiting for night shutdown. The generator capacity is no longer sufficient for power delivery, and the device waits for the night shutdown. 4.) Device has heated up excessively during operation and limits the delivered power until it has cooled down again. 5.) The connected solar generator supplies excessive power. 6.) The connected solar generator supplies excessive voltage. 7.) Line voltage failure prevents proper power delivery operation. The display shows which phase is disturbed (overvoltage or low voltage).

	8.) Device switches off	8.) Device changes to night shutdown.

No.	Display Message	Explanation
11	Date: xx.xx.2000 Hour: xx.xx.xx	Display of date and hour
12	Yield today: xxxx Wh	Power delivered since sunrise. Display in watt hours (not kWh!!)
13	Annual yield: xxxx kWh	Power delivered during the current calendar year (since January 1st to-date).
14	Total yield: xxxx kWh	Power delivered since the time of inverter start-up.
15	Operating hours today: xx:xx	Today's operating hours since sunrise. Displayed in hours and minutes.
16	Annual operating hours: xx:xx	Operating hours during the past calendar year (since January 1st to-date).
17	Total operating hours: xx:xx	Operating hours since the time of inverter start-up.

Important Information:
The inverter only saves the actual values of the day. After switching-off the inverter these daily values are no longer retrievable. The annual operating hours, total operating hours, annual power delivery, total power delivery, etc. are saved and accumulated. These data will not be lost – even if the device has not been in operation for an extended period of time. However, if the device has not been in use for several days it may be necessary to reset the date and hour.

Please note:
The displayed measuring values, i.e. generator current, generator voltage, mains current, mains voltage, etc. all have a certain tolerance. This will of course affect the values derived therefrom; i.e. delivered power, daily peak capacity and yield data.

The inverter display is designed to monitor the general operation of your system and to provide data about its functionality. However, the actual yield of your PV installation should be determined on the basis of a calibrated power meter, which is provided by your Electrical Supply Company (admissible tolerance of your electric meter: ± 2%).

Attention!
In disturbed mains or installations that have to be disconnected from the grid occasionally due to disturbances, yield data and operating hours may not be displayed properly. This is not an inverter error. Even if such incorrect values are shown the inverter continues to work properly and without any yield loss.

Similarly, disturbed mains may cause inverter shutdowns during the day, although no obvious error has occurred. In this case, the inverter display returns the message “Line Voltage Failure“, and incorrect measurements may be caused as described above. After such shutdown conditions the inverter continues to operate properly.

Accuracy of Measuring Data Acquisition
Each measurement and, consequently, each display of measured values is subject to tolerances, i.e. measured values do not correspond exactly to actual values. Depending on the specific requirements the appropriate measuring elements and circuits are selected.

The measuring elements and measuring circuits of PVI were selected in a way allowing optimum operation and maximum solar yield. Measuring errors that are within tolerance limits do not reduce the solar yield.

Note: The power meters provided by the Electrical Power Company have an admissible tolerance of ± 2%.

Based on the tolerance values shown in our table above the daily yield displayed on the inverter can deviate from the values of your electrical meter by up to 15- 20 %.

Description of LED´s :

PV Generator LED (green):
This LED is illuminated from a generator voltage of approx. 300 V onward and extinguishes as soon as the generator voltage falls below 250 V. The PV generator LED signals that the inverter is in its active state and the inverter controls are enabled. If this LED is not lit up the inverter fails to supply energy. Under normal operating conditions the LED is illuminated in the morning when there is enough daylight, and extinguishes again when it gets dark.

Power Delivery LED (green):
This LED is illuminated when the inverter feeds energy into the mains. To this effect, the generator voltage must first exceed a value of 410 V for 3-4 minutes, ensuring that the PV generator provides enough power. This means that the “Power Delivery“ LED is not lit up unless the PV generator LED is illuminated.

Under normal operating conditions the inverter starts delivering power in the morning and terminates this process as it becomes dark. On dull days or during the winter months the power delivery process can be interrupted at certain times, depending on the PV generator and the actual power delivery capacity, and can be resumed again later on. This process can be repeated for several times, especially in the morning and evening.

Disturbance LED (red):
This LED is enabled in the event of the following disturbances:
- Mains overvoltage or low voltage on one of the three phases
- Failure of one of the phases L2 or L3
- Excessive generator voltage
- Excessive generator power
- Shutdown due to excessive temperature
- Device defect.

In general, any one of these disturbances will lead to a termination of the power delivery operation. If the cause of the disturbance has been remedied, power delivery is resumed after a starting-up period of approx. 3-4 minutes.

Exception: Failure of phase L1 (Line phase to which electrical power is fed).
In the event of a failure of the power delivery phase the Disturbance LED is not lit up. In this case, all LED’s and the display are extinguished and the inverter is shut-down completely. Only after the power delivery phase is available again can the inverter resume its normal operation.

Setting Date and Hour:
To change over to the Set Mode, keep the “Display“ key pressed while simultaneously pressing the “Set“ key.
You have now selected the Setting Mode in which you can set the actual date and hour.
First press the “Set“ key for several times to adjust the correct hour. Use the “Display“ key to select the minutes and press the “Set“ key until the correct minute is displayed. Press “Display“ again to enter the date, using the same procedure as described above.

If, after setting the date hour, you wish to return to the normal operating mode, keep the “Display“ key pressed while simultaneously pressing the “Set“ key. You have now returned to the starting menu where you can select the various measuring values by means of the “Display“ key.

The Setting mode can also be used for selecting the following parameters:

1.) Output of EPROM data (Key 2): Unique output of internal inverter data for diagnostic purposes via serial interface.

2.) Output of operating data:
Output of operating data via serial interface. Standard setting: Active.

3.) Clear the power meter: Resets the values shown on the display, i.e. annual operating hours, total operating hours, delivery power per year, total power delivery, etc. (Use the “Set“ key to enter the required code 2).

4.) Quick-start: Start immediately, using key 2 (“Settings“).

Quick Start:
The quick-start routine can be used for test purposes or acceptance tests conducted by your local Electrical Supply Company (EVU). In this case, the inverter is started without any delay within 3-4 minutes.

As described for setting the date and hour, change to the Setting Mode first.
Keep the “Display“ key pressed while simultaneously pressing the “Set“ key.
Using the “Display“ key, scroll through the menu and select the menu item “Start immediately with key 2“. Now press the “Set“ key – the inverter is activated after a short time (with an audible click of the relay), and the green Power Delivery LED is lit up.
If there should not be enough solar generator power the inverter is shut-down again after a short period of time.

6.4. Operation of the RS232 Interface

A common serial interface cable is suitable for connecting the inverter to a PC. However, the cable length should not exceed 20 m.

Inverter data is transmitted via the serial interface (unidirectionally, text only; no error checks).

Below are a few example rows of data transmission:

04.10.1999 16:55:30 S 4 U 363.8 I 0.37 P 134 UN 226.1 IN 0.53 PN 103 T 23
04.10.1999 16:55:40 S 4 U 366.0 I 0.39 P 142 UN 226.1 IN 0.53 PN 112 T 23
04.10.1999 16:55:50 S 4 U 359.5 I 0.41 P 147 UN 226.1 IN 0.53 PN 116 T 23
04.10.1999 16:56:00 S 4 U 369.8 I 0.42 P 155 UN 226.1 IN 0.58 PN 118 T 23
04.10.1999 16:56:10 S 4 U 377.0 I 0.43 P 162 UN 226.1 IN 0.63 PN 131 T 23
04.10.1999 16:56:20 S 4 U 373.6 I 0.45 P 168 UN 226.1 IN 0.63 PN 133 T 23
04.10.1999 16:56:30 S 4 U 364.0 I 0.48 P 174 UN 226.1 IN 0.68 PN 146 T 23
04.10.1999 16:56:40 S 4 U 364.3 I 0.49 P 178 UN 226.1 IN 0.68 PN 146 T 23
04.10.1999 16:56:50 S 4 U 365.9 I 0.49 P 179 UN 226.1 IN 0.68 PN 144 T 23

Explanation of abbreviations:

Abb.	**Explanation**	**Abb.**	**Explanation**
S	Operating mode / Status	UN	Mains voltage
U	Generator voltage	IN	Mains current, delivered current
I	Generator current	PN	Delivered power
P	Generator power	T	Device temperature

Explanation of Operating Mode Symbols:

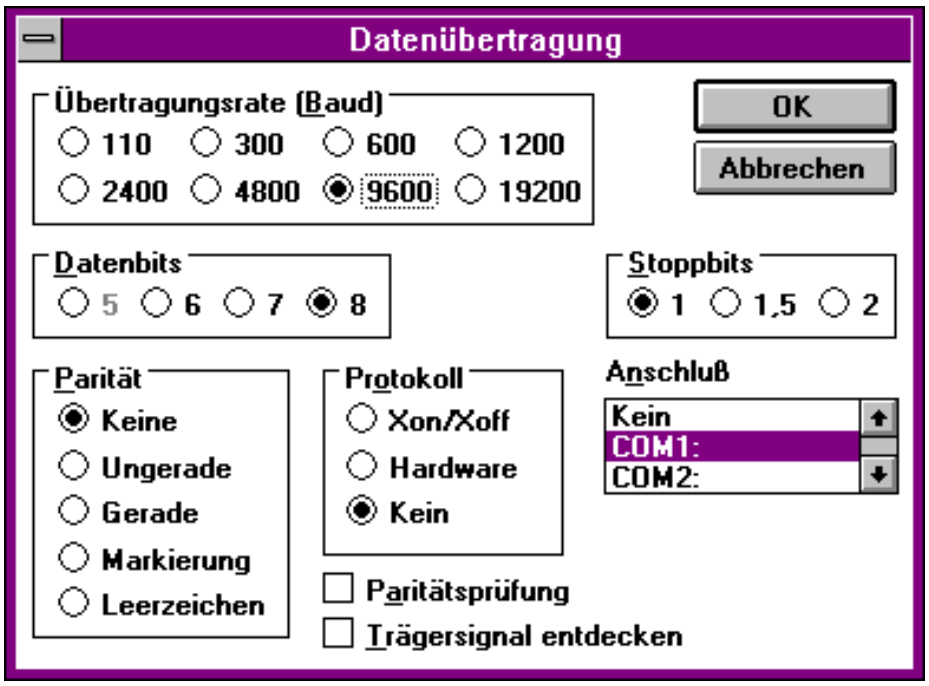
Mode	**Explanation**	**Remarks:**
0	Inverter has just switched on	Only after the first start-up in the morning.
1	Waiting mode. Testing the mains and solar voltage	The inverter waits until voltages have stabilized and power delivery can be started.
2	Waiting for shut-down	Insufficient generator voltage and generator power. Condition that precedes the night shutdown.
3	Constant voltage regulator	At the start of the power delivery, constant generator voltage is fed-in for a short time (80% of the measured no-load voltage)
4	MPP tracker; continuous search movement	At times of low insolation, power delivery is effected via the searching movements of the MPP tracker.

Mod	Explanation	Remarks
5	MPP tracker, 100 Hz ripple without searching movement	At times of high insolation, maximum yield is ensured by means of a patented MPP tracker.
9	Troubleshooting operation	Initiated whenever an internal error occurs.
10	High-temperature cut-off	The inverter is automatically cut-off in the event of excessive temperatures (heat sink temperature >80°C) due to continuous overload or a lack of air circulation. Possible causes of overheating are an over-dimensioned solar generator, excessive ambient temperature, or a defective inverter.
11	Power limitation	Protective inverter function – protects against excessive generator power.
12	Overload cut-off	Protective inverter function – protects against excessive generator power.
13	Overvoltage cut-off	Protective inverter function – protects against excessive mains voltage
14	Line power failure (3-phase monitoring)	Protective inverter function. Becomes effective if one of the three line phases have failed, or if the voltage is out of tolerance.
15	Transition to night shut-down	The inverter “goes to sleep“.

Note: Codes that are not listed above are not assigned.

Please note that the current and voltage measuring data are subject to the tolerances stated. These data are not suitable for measurements of the degree of efficiency or yield data, and should only be used to monitor the general functions and operation of an installation.

Data can be transmitted by any available terminal emulation supplied with all types of operating systems. Below is an example showing a setting of the Windows 3.11 terminal program:



The terminal setting of the MS Windows 95/98/200 terminal programs is similar, whereas the Hyperterminal program can also be adjusted to automatic identification.

In all other cases, use the basic settings shown above. Transmission rate 9600 baud, 8 data bits, 1 stop bit, no parity.

The transmitted text should be saved in a text file *.txt for further import, e.g. in MS Excel.

Under MS Excel, for example, the test table may be converted to daily power delivery information (See page 41, Chapter 10.4, Typical Daily Yield).

Since the connected PC has to remain in operation throughout the entire power delivery process, data transmission should be effected by skilled users having a certain know-how of EDP, or by companies specialized in error diagnostics. Continuous data transfer is not recommended due to energy reasons.

7. Technical Data of PVI 2600-2.0 kW and PVI 2600-2.6kW

Input – Electrical Data

Type	**PVI 2600 – 2.0KW**	**PVI 2600 – 2.6KW**
DC-rated power	2150 W	2750 W
Max. PV generator power	2650 W	3200 W
MPP range	350 – 600 V_{DC}	
No-load voltage	Up to 750 V_{DC}	
Monitoring of input voltage	Stand-by starting at U_e > 300 V_{DC} Night shut-down starting at U_e < 250 V_{DC}	
DC voltage ripple	< 2 % r.m.s.	
DC input current	3.9…6.6 A_{dcrat}	5.0…8.5A_{DCrat}
Polarity safeguard	Short-circuit diode	
Overvoltage protection	Varistors	

Output – Electrical Data

Rated power, continuous	2000 W_{AC}	2600 W_{AC}
Max. power	2500 W_{AC}	3000 W_{AC}
Mains voltage	161… 264 V	
Rated current	8.7 A	11.3 A
Max. current	11.3 A	14.9 A
Monitoring of delivered current	Temperature-dependent reduction of delivered current	
Power factor	≈1	
Frequency	50Hz ± 1%	
Distortion factor according to VDE 0383	< 3% at rated power <5% over the entire range	

Inverter - Electrical Data

Degree of efficiency	At a rated load of 100%: min. 95%
European degree of efficiency	92.5%
Consumption	Stand-by: <0 W during night shutdown Operation: < 11W
Minimum power delivery	20W
Temperature monitoring	>60°C temperature-dependent power adjustment >80°C disconnection from the mains
Circuit concept	Grid-coupled, without transformer
Frequency	20 kHz
Principle	Single-phase full bridge in IGBT technique
Mains monitoring	3-phase monitoring, VDEW-compliant

Inverter – Mechanical and Technical Data

Optical displays	PV-generator (green) Power Delivery (green) Disturbance (red) LCD display (2 x 16 characters)
Operating elements	2 keys for display operation
Connections	PCB terminals inside the system/unit Insertion of cables via PG fittings
Temperature	0… +50°C
Temperature monitoring	> 65°C: temperature-dependent power adjustment > 80°: disconnection from the mains
Cooling	Convection cooling
Humidity	0...95%, no condensation
Protection	IP21, according to EN 60529
Noise emission	< 35dB (noiseless)
Enclosure	Aluminum wall housing
Dimensions W x D x H	Approx. 355 x 505 x 155 mm
Weight	12 kg

Standards and Regulations

Protection Class of the device: 1 (Basic insulation + PE connection) Protection Class of connected modules: 2
VDEW Conformance (VDEW = Association of German Power-Generating Plants): According to the rules of the Association of Power-Generating Plants: Guideline for the parallel operation of photovoltaic power generating plants; guidelines for the parallel operation of independent power generating plants on the low-voltage grid of Electrical Supply Companies.
EMC test procedures according to EN50081-1, EN50082-1 EMC threshold values according to EN55014 Backdraft on the grid: DIN EN 60555 (DIN VDE 0838) Harmonic currents: EN61000-3-2 Class A Low-voltage directive: DIN EN 50178 (4.98) (VDE 0160) Semiconductor inverters: DIN EN 60146 Part 1-1 (3.94) (VDE 0558 Part 1)
CE marking according to Guideline 93/68/EWG Including: Low-voltage directive for electrical operations according to Guideline 71/23/EWG Electromagnetic compatibility according to Guideline 89/336/EWG

8. Blue Planet as Part of a PV Installation

8.1. Set-up

An example of the set-up of a grid-coupled PV installation and Blue Planet PVI 2600 is given in the following unipolar circuit diagrams. A differentiation is made between installations in which all solar modules are connected in series as one string, and installations in which two strings are connected in parallel.

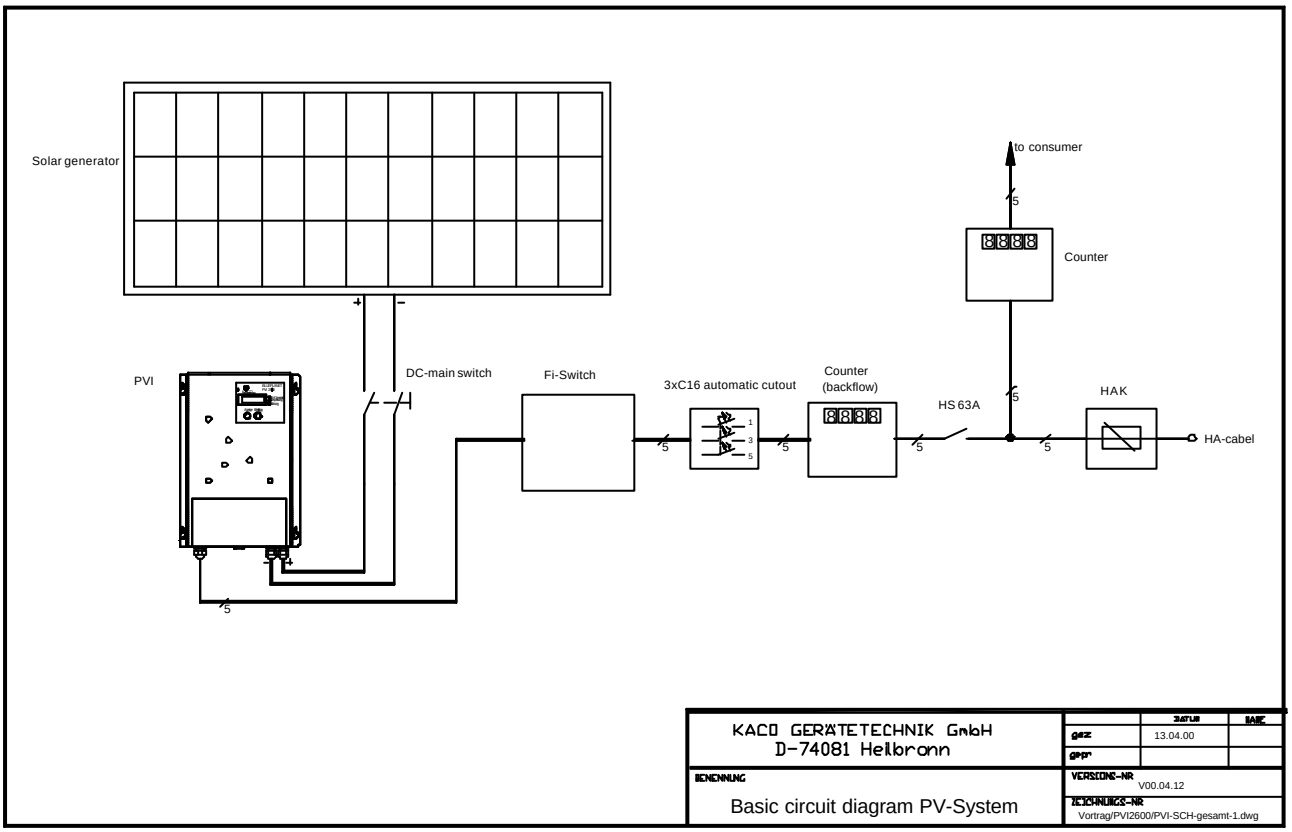


Figure 2 Unipolar circuit diagram for a one-lead installation (all modules connected in series).

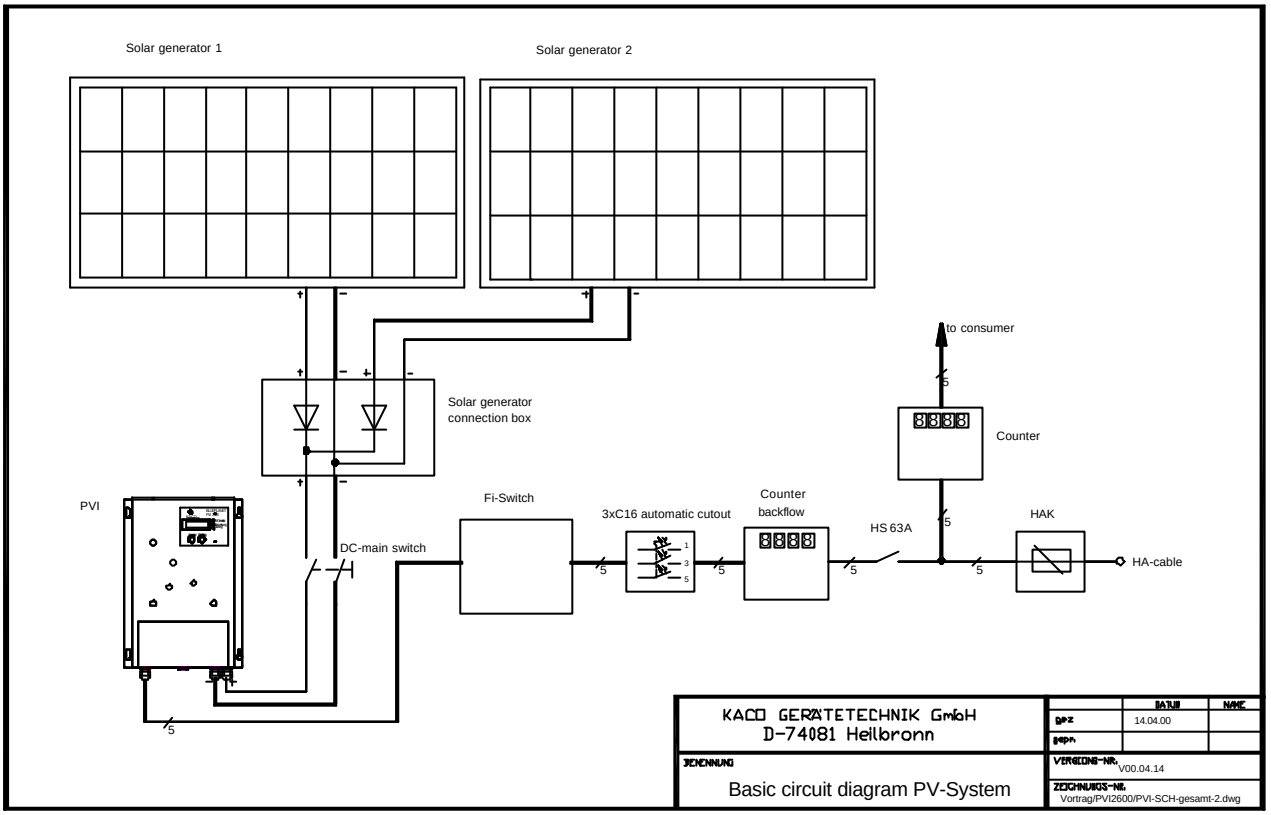


Figure 3 Unipolar circuit diagram for an installation with two leads connected in series.

Overview of components:

1.) Solar generator:
See page 34, Chapter 8.3, selection of solar modules for the solar generator

2.) Connection box for the solar generator:

Parallel connection of two generator leads is effected in the connection box of the solar generator. To avoid damage and losses in solar “harvest“, the two strings are often decoupled via diodes. Whether or not such diodes are necessary depends on the solar generator being used. Please contact your solar installation expert for further questions.

3.) DC Main Switch:
A DC main switch must be provided between the inverter and solar generator in order to disconnect the inverter from generator voltage. When selecting this switch, the current and voltage ratings of the solar generator must be taken into account. As an alternative for a DC main switch, multi-contact connectors may be used as an isolating point in the DC lead of the inverter. However, the line fuses of the inverter must be deactivated prior to disconnecting the multi-contact connectors, preventing the switch from carrying current and preventing the formation of an arc, which would destroy the connector.

4.) FI Circuit Breaker
To protect against the risk of personal injuries, a four-pole circuit breaker should be provided. In accordance with DIN/VDE 0664, this circuit breaker should be enabled at pulsing DC fault currents. Alternatively, FI circuit breakers can be used starting from a nominal fault current of 30 mA.

5.) Line fuses:
The inverter lead should be provided with 16A standard safety fuses or Neozed fuses.

6.) Power meter:
The required power meter is specified and installed by the responsible Electrical Supply Company (the tolerance of these meters is at ± 2%).

7.) Line Power Main Switch:
Electrical Supply Companies usually request that a main switch be provided. This switch is installed according to the Electrical Supply Company's specifications, and usually, three 63A main switches are used.

8.2. Acceptance of the PV installation and Documents required by the Electrical Supply Company

The provider of your solar installation will apply for acceptance of your PV system by the Electrical Supply Company. Moreover, this manual includes most documents that are required for application and acceptance of your PV installation.

Although the application and acceptance conditions of the individual Electrical Supply Companies may vary, the starting-up procedure is usually as described below:

1.) Filing of documents with the Electrical Supply Company (this is done by the provider of your solar installation)
2.) Installation of the system
3.) Installation of the power meter by your Electrical Supply Company
4.) Acceptance of the installation by the Electrical Supply Company

The following documents will be required:

1. Application, completed by an authorized and approved provider of solar installations.
2. Site plan showing the borders of the premises and the installation site.
2. Overall circuit plan of the entire installation, including the resources used (unipolar diagram, see page 30, Chapter 8.1, Set-Up of the Installation).
3. Data sheet for independent power generating systems (VDEW formsheet 08/94) (this formsheet will be completed by the provider of your solar installation).
4. Description of the safety feature (indicating the type, circuitry, make and function – this will also be done by your provider).
6. Description of the inverter or, respectively, declaration of conformity provided by the manufacturer
8. Information on the short-circuit safety of the switching elements.

8.3. Selection of Solar Modules for the Solar Generator

The selection of the solar generator is of central importance for the design of a PV installation. It is vital to ensure that the solar generator is compatible with the inverter.

The on-site conditions, amongst other things, will determine whether to select a single-string installation or an installation having two parallel strings. Due to the savings in installation costs, however, a single-string configuration is preferred in many cases.

Please observe the following data for dimensioning your solar generator:

Feature	**PVI 2600 - 2,0**	**PVI 2600 - 2,6**
Max. generator power	2560 W_p	3200 W_p
Min. no-load voltage U_0	Higher than 410 V_{DC}	Higher than 410 V_{DC}
Max. no-load voltage U_0	Less than 750V_{DC} (at a solar cell temperature of -10°C)	Less than 750V_{DC} (at a solar cel temperature of -10°C)
MPP voltage U_{MPP}	350 .... 600V_{DC} (at a solar cell temperature of +70°C)	350 .... 600V_{DC} (at a solar cell temperature of +70°C)
Number of solar modules, if 12-V modules are used:	22 ... 30 ea.	22 ... 30 ea.
Number of solar modules, if 24-V modules are used:	11 ... 15 ea.	11 ... 15 ea.

Max. number of modules: Consult KACO to obtain a special approval for max. 31 ea. 12-V modules.

Attention! These data refer to standard modules and Central European conditions. The solar generator should be dimensioned on the basis of the following calculations:

Dimensioning of the Solar Generator:
The number of PV modules connected in series must be selected in such a way that the output voltage of the PV generator is maintained within the admissible input voltage range of the inverter – even in the event of extreme external temperatures. In Central Europe, module temperatures between –10°C and +70°C should be assumed. The voltage/ temperature coefficient is approx. –80 mV/°C for 12-V modules and approx. –160 V/°C for 24-V modules.

1. U_o (-10°C) < max. input voltage ($750V_{DC}$)
Even at very low external temperatures (-10°C) , the no-load voltage of the connected string must remain within the admissible input voltage range. For example, if the temperature falls from 25°C to –10 °C, the no-load voltage of 12-V modules increases by approx. 2.8 V per module (5.6 V for 24-V modules). The no-load voltage of the entire string must be less than 750V.

2. U_{Mpp} (+70°C) > min. Input voltage ($350V_{DC}$)
Even at very high external temperatures (+70°C) the MPP of the connected string should remain within the admissible input voltage range. If the temperature rises from 25°C to 70 °C, the MPP voltage of 12-V modules falls by approx. 3.6 V per module (7.2 V for 24-V modules). The MPP voltage of the entire string should be 350 V.
Even if the MPP voltage is beyond the admissible input range, the installation nevertheless continues to work properly. However, the delivered power is slightly less than the maximum yield.

Provided that the input voltage is within the admissible input voltage range, the inverter will not be damaged if a connected PV generator should supply current above the max. usable input current

If the PV generator should supply more than 3.3 kW for a short time, particularly due to clouds and relatively low module temperatures, it is possible that the inverter switches off for safety reasons and automatically switches on again after approx. 2-3 minutes. The overload status is shown on the display in plain language.

8.4. Orientation of the Solar Generator

The solar generator represents the most substantial cost factor of a solar installation. Therefore, it is very important to obtain maximum energy yields. To achieve this goal, solar generators located in Central Europe should be orientated towards the South at an angle of inclination of 30°, and shading of whatever kind should be prevented under all circumstances.

In many cases, the recommended angle of inclination cannot be implemented for technical reasons. To achieve the high energy yield of a solar generator with optimal orientation (South, inclination angle of 30°), the efficiency of the solar generator can be increased by the values listed in our table below (data in %):

Inclination in °	**Deviation from the South Axis in °**									
	90	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**0**
0° (horizontal)	11	11	11	11	11	11	11	11	11	11
10°	11	11	11	11	5	5	5	5	5	5
20°	11	11	11	5	5	5	5	5	5	0
30°	18	11	11	11	5	5	5	5	0	0
40°	18	18	18	11	11	5	5	5	5	0
50°	25	25	18	18	11	11	11	11	5	5
60°	33	33	25	25	18	18	18	18	11	11
70°	43	43	33	33	25	25	25	25	25	25
80°	54	54	43	43	43	43	33	33	33	33
90° (vertical)	67	67	67	54	54	54	54	54	54	54

For roofs that are orientated towards the East/West we recommend two-string PV installations. To ensure optimum yield of the installation, the first string should be installed on the East side of the roof, whereas the second string should be installed on the West side of the roof.

In exposed mountain areas or in Southern areas it is recommended to reduce the efficiency ranges. Please consult your specialist dealer or notify us if you require any further assistance.
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9. EU Declaration of Conformity

The device described below:

PV Line Input Inverter

Description:	Blue Planet PVI 2600-2.0 kW and PVI 2600-2.6kW
Power:	2000W and 2600 W
Input:	350 – 750 VDC
Output:	230V / 50Hz

Is confirmed to be compliant with the protection requirements set forth in The Council Directive for the Harmonization of Legal Stipulations of the Member States concerning Electromagnetic Compatibility (89/336/EWG) and the Low Voltage Regulations (72/23 EWG).

The assessment of the product concerning its Electromagnetic Compatibility is based on the following standards:

Interference immunity:	ENV 50140 - A / ENV 50141 - A / EN 61000 - 4 - 2 - B IEC 801 - 4
Radiated Interference:	EN 50 081 / EN 55014

The assessment and determination of Electrical Safety is based on the following standard:

DIN VDE 0558 / EN 60146

This declaration has been given by

KACO GERÄTETECHNIK GmbH
Kreuzäckerstraße 35
74081 Heilbronn

and authorized by its responsible representative,

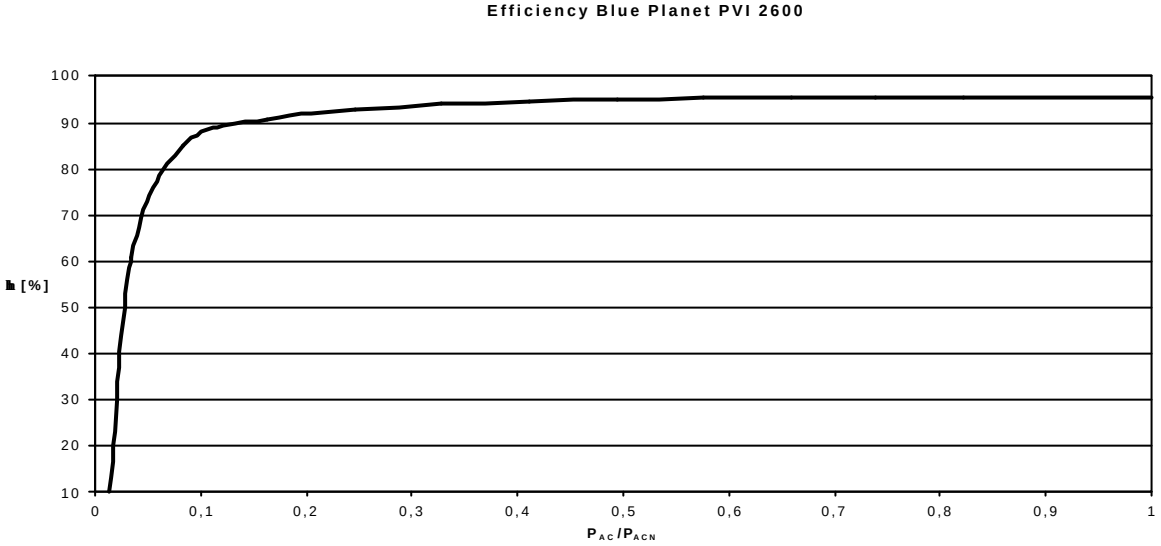
Matthias Haag
Quality Assurance Commissioner

Heilbronn, 15th July, 1999
KACO GERÄTETECHNIK GmbH
i. V.

Matthias Haag
Quality Assurance Commissioner

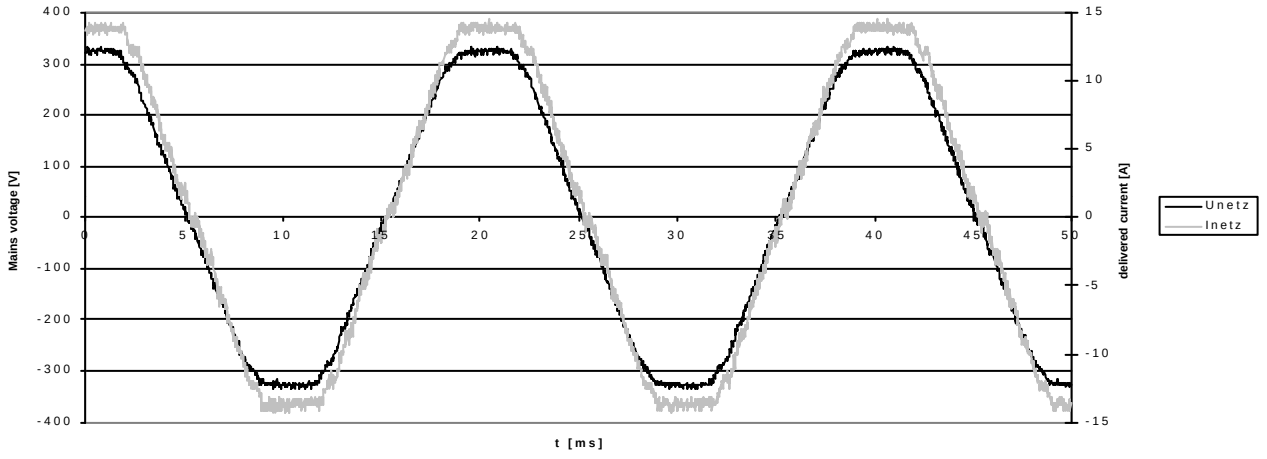
10. Diagrams

10.1. Efficiency



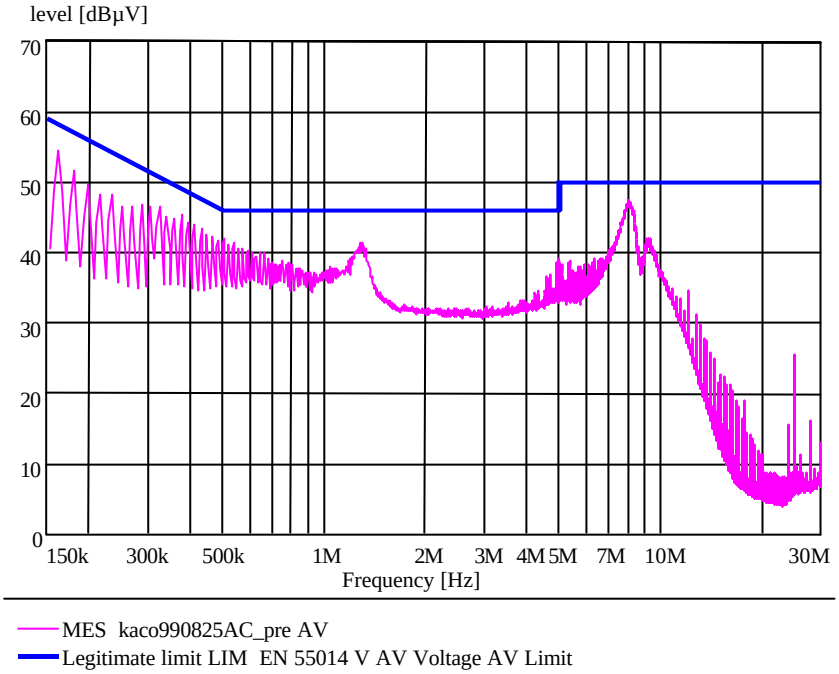
Inverter efficiency is a crucial factor. The above diagram shows the efficiency of Blue Planet at various input voltages.

10.2. Delivered Current

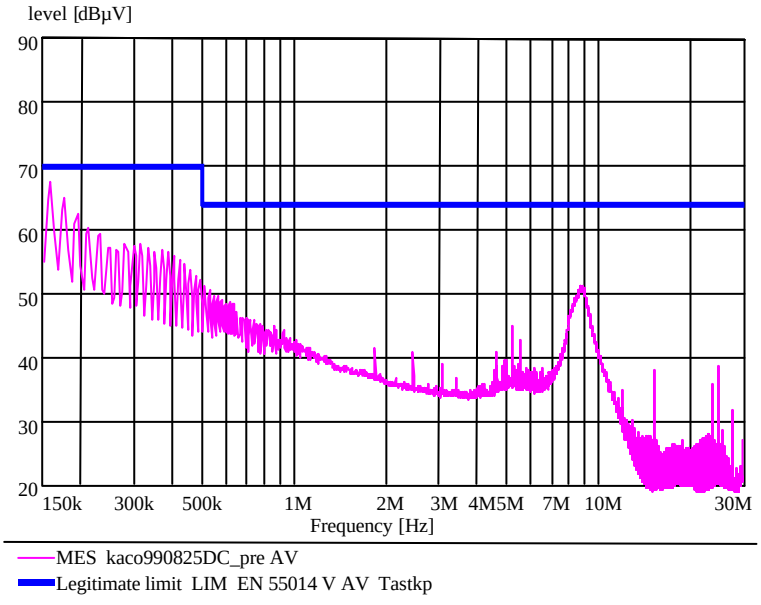


Line voltage and curve shape of the delivered current.

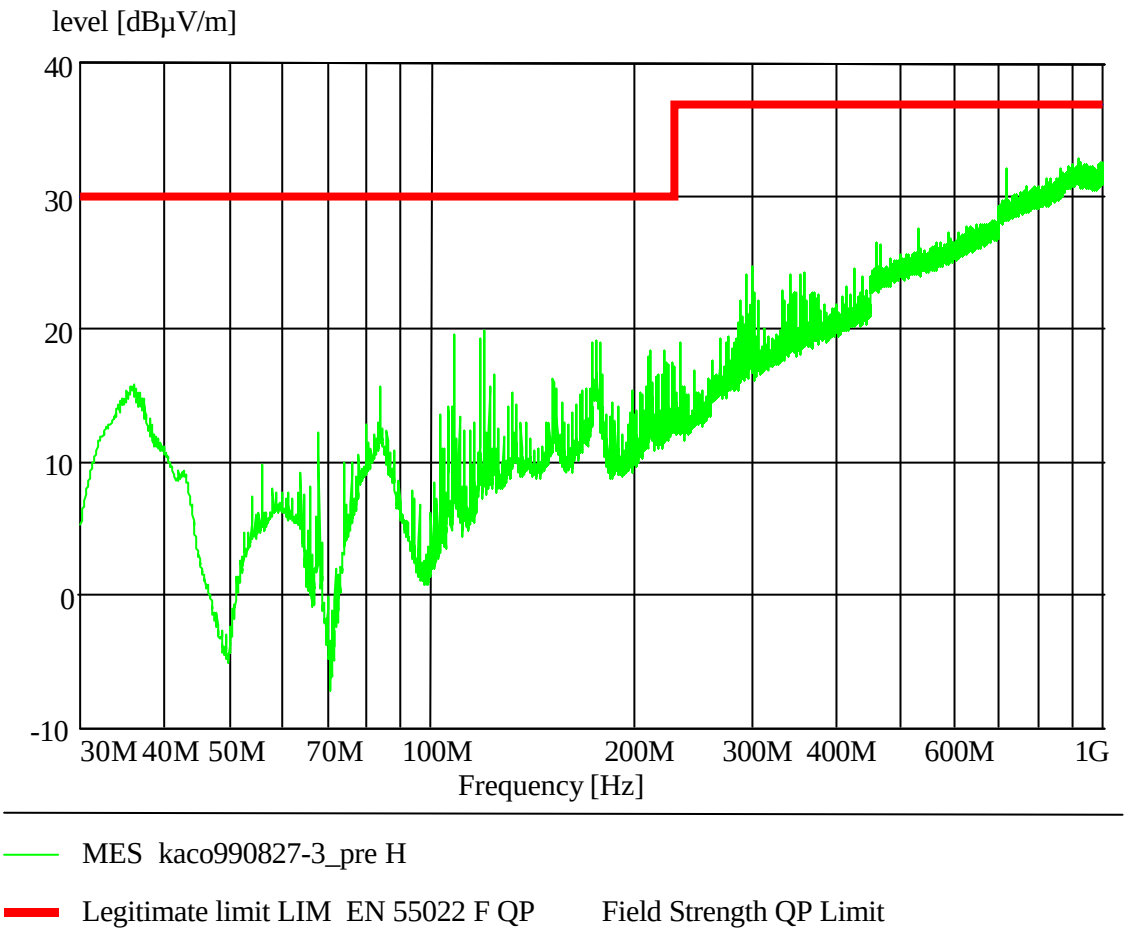
10.3. EMC Measurements



RF voltages on the mains side



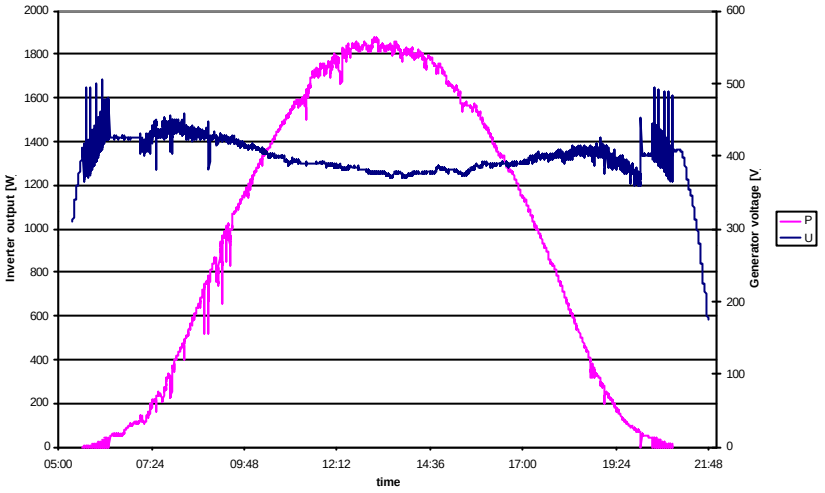
RF voltages on the mains side



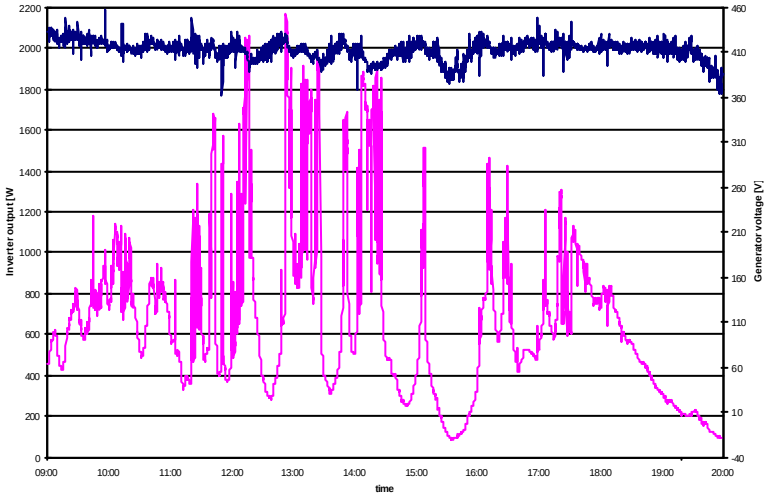
Radiated Interference

10.4. Typical daily yield

The following two diagrams show typical daily yields of Blue Planet PVI 2600-2.0 kW. Data were obtained via data transmission to a PC by means of an integrated standard RS232 interface.



Daily power delivery and solar generator voltage on a sunny summer's day.



Daily power delivery and solar generator voltage on a partly cloudy, partly sunny summer's day.

11. Guarantee and Service

Guarantee
KACO GERÄTETECHNIK GmbH grants a 2-years‘ guarantee on the Blue Planet PVI 2600 inverter, which starts from the date of installation and expires 30 months after delivery by KACO at the very latest.

Throughout this time KACO GERÄTETECHNIK GmbH will guarantee proper functioning of the devices as well as free factory-repair of any defects that we are accountable for.

If your device should show any signs of a defect or malfunction during this guarantee period, please consult your specialized dealer or installer.

Guarantee claims shall not be accepted under the following circumstances:
- Devices were not used for their intended purpose
- Improper installation; installation was not carried out in accordance with the relevant standards
- Improper operation
- Devices were operated with defective protective features
- Devices were changed or manipulated by the user
- External influence or Act of God
- Insufficient ventilation of the system
- Non-conformance with valid safety regulations (VDE an others) or Act of God (lightning, overvoltage, tempest, fire)
- Transport damages

In the event that a guarantee claim should have to be settled the defective unit(s) must be disassembled and returned to the factory of KACO GERÄTETECHNIK GmbH. Return shipments must be effected in their original or similar transport packaging. The costs of return shipments cannot be borne by KACO GERÄTETECHNIK GmbH.

KACO shall not grant any guarantee service unless the defective device has been returned together with a copy of the original invoice. The type label on the device must be fully readable. In the event that these conditions should not be met, KACO shall reserve the right to reject any guarantee obligations.

The warranty period for rework or replacements shall be 6 months after delivery of the original device, but at least until the end of the original guarantee period granted for the delivered device.

Service

High quality and longevity of our inverters were a central issue for us - already at the time of product development. Our more than 60 years of experience in the field of current inverters are backing up this philosophy.

Despite all quality-assuring measures, however, disturbances may occur in very rare cases. KACO GERÄTETECHNIK GmbH will offer a maximum of assistance if one of these cases should arise. KACO GERÄTETECHNIK GmbH will take every effort to remedy any defects fast and without unnecessary bureaucracy. Please contact our service department directly – and you will be aided and supported very quickly. For example, you will be able to make fast appointments for factory repair.

Moreover, we are offering a guarantee on the availability of spare parts for 15 years from the purchasing date.

12. Troubleshooting and Fault Diagnostics

12.1. Troubleshooting

Within the scope of our continuously expanding Quality Assurance System, our goal is to rule out any faults and defects. You have purchased a product that has left our factory in a proper condition. Each individual device has successfully passed extensive inspection tests for their operation and functioning of protective devices, as well as a long-duration test at our factory.

Should your PV installation not work properly despite all these measures, we recommend the following procedure for remediation:

Check the solar generator and mains connections leading to the PVI 2600, observing all safety instructions given in this manual. Please observe the inverter carefully and take note of the display messages and LED displays.

Below is a summary of possible error and recommended remedies:

Error	Cause	Remedy / Explanation
Inverter shows an unrealistic daily peak value	Line voltage failure	Even if an incorrect daily peak value is displayed the inverter continues to work properly and without any yield losses. Values are reset overnight. If you wish to reset the display immediately, disconnect the inverter and the DC line voltage supply and switch on the inverter again.
Daily yield values do not correspond to the values shown on the power meter of the Electrical Supply Company.	Tolerances of the inverter's measuring elements	Measuring errors are caused by tolerances of the measuring elements. The tolerances of the individual measuring values are shown on page 18, Chapter 6.3, Display Operation and Settings. The daily yield value may deviate from the value shown on the power meter by up to 20%.
No display shown	1.) Device is in the night shut-down mode 2.) No line voltage is present 3.) Solar generator voltage is less than 300 V	The inverter shuts down over night. If the display should not be illuminated during a normal time of the day, you should check on the power meter whether or not the device delivers power. If power is delivered, the display module is defective, and the inverter has to be returned to KACO for repair. If no power is delivered you should check that line voltage is present and that the solar generator voltage is higher than 300 V. If this is the case, but the inverter still fails to delivery power, the device has to be returned to KACO for repair.

Error	Cause	Remedy / Explanation
Inverter does not start	4.) Device is in its night shut-down mode 5.) No line voltage is present 6.) The solar generator voltage is less than 300 V	The inverter shuts down over night. If the display should not be illuminated during a normal time of the day, you should check on the power meter whether or not the device delivers power. If power is delivered, the display module is defective, and the inverter has to be returned to KACO for repair. If no power is delivered you should check that line voltage is present and that the solar generator voltage is higher than 300 V. If this is the case, but the inverter still fails to delivery power, the device has to be returned to KACO for repair.
Inverter is active, but does not deliver power – the display reads: Start from 410 V Measurement: xxx V (measured voltage is less than 410V)	Insufficient generator voltage	After sunrise, at sunset, and during times of low insolation due to bad weather conditions the generator voltage or, respectively, generator power fed from the roof may be insufficient for power delivery.
Inverter is active, but does not delivery power – the display reads: Start from 410 V Measurement: xxx V (measured voltage is higher than 410V)	The inverter has interrupted its power delivery due to a malfunction.	After an interruption of the power delivery due to a malfunction (Line power failure, overtemperature, overload, etc.) the inverter always waits for 3-4 minutes before resuming its power delivery operation. In the event of line failures, several interruptions are possible during the day. If more than 10 interruptions should occur over several weeks, you should contact your solar installation provider.
Although there is sufficient insolation, the inverter terminates the power delivery process shortly after starting-up.	Defective mains isolation relay in the inverter.	Although there is enough insolation, the inverter delivers power for a few seconds only and switches off again. During this short time of power delivery it shows a power delivery between 0 – 5 W. If insufficient generator power can be ruled out in this case, the mains isolation relay is presumably defective and prevents the inverter from being activated.
Mains fuse is initiated	1.) Insufficient mains fuse rating 2.) Inverter hardware is damaged	1.) At times of high insolation the inverter is capable of delivering current up to 14A, depending on the type of solar generator. Therefore, the mains fuse should have a rating of at least 16A. 2.) The mains fuse acts immediately if the inverter changes to power delivery (i.e. on termination of the start-up period). In this case, the inverter hardware is damaged, and the device has to be returned to KACO for repair.

If the defect found should not be able to be remedied by means of the measures described above, please contact your solar installation provider or our Service Department.

Please have the following information ready to enable our Service Department to respond quickly and properly:

Inverter Data

1) Serial number of the device
2) Inverter type
3) Short description of error
4) Is the error reproducible? If so, please provide a short description.
5) Does the error occur sporadically?
6) Describe the insolation conditions prevailing when the error occurred.
7) Hour of the day

Solar generator data:

1.) Module type, manufacturer (please send data sheet, if available).
2.) Number of modules connected in series
3.) Number of strings
4.) Generator power

If it should become necessary to return the PVI 2600 for repair, please use the original packaging.

12.2 Transport damages

To ensure high quality and reliability, Blue Planet PVI 2600 has been subjected to extensive tests and inspections at our inspection site. Our inverters leave our factory in a proper electrical and mechanical condition. Special packaging is used to ensure that nothing can happen during transport. Yet, transport damages are possible, although these damages are usually the carrier's responsibility.

Please inspect the inverter carefully after delivery. If you should discover any damages on the packaging which imply damage to the inverter, or if you can state obvious inverter damage, please notify the responsible carrier immediately.

If necessary, your solar installation provider or KACO will assist you in this matter. In any case, written damage reports must have been submitted to the carrier within six days after receipt of the goods at the very latest.

Notes:

Notes:

KACO

GERÄTETECHNIK

Our product range:

INVERTERS

FREQUENCY CONVERTERS

DC / DC - CONVERTERS

CHARGE RECTIFIERS

POWER SUPPLIES

COMBINATED POWER SUPPLY UNITS

CHARGING STATIONS

FUSED DC VOLTAGE SUPPLIES

EMERGENCY POWER SUPPLIES

UNINTERRUPTIBLE POWER SUPPLIES (UPS)

Your solar installation provider: