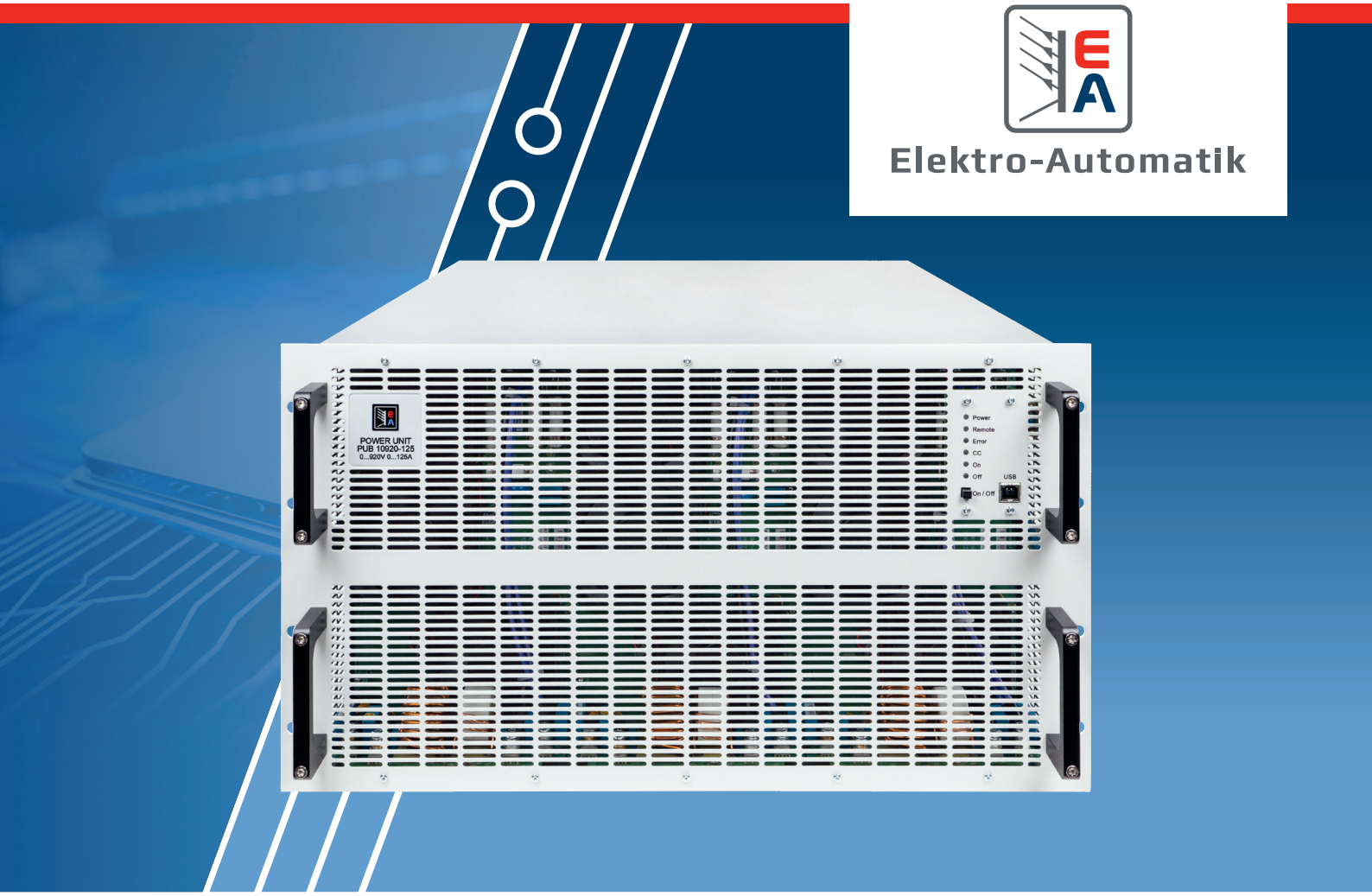
Elektro-Automatik



INSTALLATION MANUAL

10000 SERIES IN 6U

Programmable DC power supply units and DC load units

Safety, Installation, Commission

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1. General

1.1 About this document

1.1.1 Preamble

This document serves as installation and commission guide for the device models as listed in section *«1.1.3 Validity»*. The safety notices in *«1.7 Safety»* are important and must be adhered. Manual operation, remote control and other features of the devices are handled in the separate user manual.

1.1.2 Copyright

Modification and partial or complete extracts of this document for other purposes as intended are forbidden and breach may lead to legal consequences.

1.1.3 Validity

This document is valid for the following all devices in the following series:

Series
EA-PU 10000 6U
EA-PUB 10000 6U
EA-PUL 10000 6U

1.1.4 Symbols and warnings in this document

Warning and safety notices as well as general notices in this document are shown in a box with a symbol as follows. The symbols are also valid, where placed, to mark specific spots on the device:

	**Symbol for a life threatening danger (electric shock hazard)**
	**Symbol for risk** (of damage to the equipment). If placed on the device it requires the user to read the operating guide prior to start operation.
	Symbol for general safety notices (instructions and damage protection bans) or important information for operation
	*Symbol for general notices*

1.1.5 Note about terminology

Due to international endeavors of tech companies to ban the commonly used term “master-slave” (usually abbreviated as MS), the feature “Master-Slave” has been renamed to “Master-Auxiliary” in 2024. This primarily concerns the documentation, specifically the installation manual and the user manual of the devices. Since the term “slave” is used in several other regards, files and documentation which are not processed retrospectively, it might occur that users will still encounter the term “master-slave”.

1.2 Warranty

EA Elektro-Automatik guarantees the functional competence of the applied technology and the stated performance parameters. The warranty period begins with the delivery of equipment free from defects.

Terms of guarantee are included in the general terms and conditions (TOS) of EA Elektro-Automatik.

1.3 Limitation of liability

All statements and instructions in this manual are based on current norms and regulations, up-to-date technology and our long term knowledge and experience. The manufacturer accepts no liability for losses due to:

- Usage for purposes other than designed
- Use by untrained personnel
- Rebuilding by the customer
- Technical changes
- Use of not authorized spare parts

The actual delivered device(s) may differ from the explanations and diagrams given here due to latest technical changes or due to customized models with the inclusion of additionally ordered options.

1.4 Disposal of equipment

A piece of equipment which is intended for disposal must, according to European laws and regulations (ElektroG, WEEE) be returned to the manufacturer for disposal, unless the person operating the piece of equipment or another, delegated person is conducting the disposal. Our equipment falls under these regulations and is accordingly marked with the following symbol:



	The device contains a Lithium battery cell. Disposal of this battery follows the above stated rule or specific local regulations.

1.5 Product key

Decoding of the product description on the label, using an example:

EA-PUB 10360 - 480 6U xxx

xxx	Options and special versions: **WC** = Water cooling installed
6U	Construction (only stated on type label): **6U** = 19" frame with 6 height units
480	Maximum current of the device in Ampere
10360	Maximum voltage of the device in Volt (“10360” = 360 V)
10/11/12	Series: **10/11/12** = Series 10000
EA-PUB	Type identification: **PU** = Power Unit (power supply) **PUB** = Power Unit Bidirectional (power supply) **PUL** = Power Unit Load (electronic load)

1.6 Intended usage

The equipment is intended to be used only as a variable voltage and current source or only as a variable current sink. Furthermore it's only intended to be used installed and operated in suitable equipment (19" rack or similar), together with a rigid, non-retractable AC supply connection.

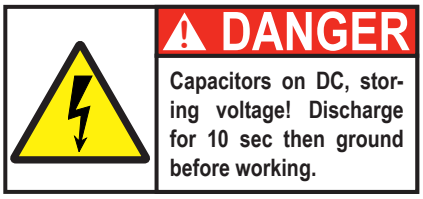
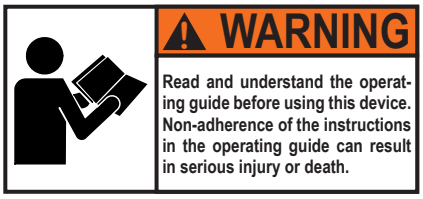
Typical application for a voltage source is the DC power supply to any relevant consumer, including when used as battery charger to test charge various battery types, and for current sinks the replacement of an ohmic resistor by an adjustable electronic DC load in order to load relevant voltage and current sources of any type.

Additionally to the functionality of a bidirectional device being source or sink of electrical energy on the DC side, they are also so-called recuperating devices and therefore don't just drain energy on the AC side, but also supply energy to the grid when being sinks on the DC side. This is where the term "bidirectional" comes from. In sink mode the devices become energy recoverers, but are not defined or considered as energy generation equipment. The same applies for electronic loads which only work in one direction.



- Claims of any sort due to damage caused by non-intended usage will not be accepted
- All damage caused by non-intended usage is solely the responsibility of the operator

1.6.1 Symbols and warnings on the device

Decal	Explanation
	This warning is primarily related to the reconfiguration of the device on the DC terminal which, for safety reasons, also requires to cut the device from AC (external main switch). The same applies to disconnection and reconnection of the AC terminal.
	Even after disconnection of the DC terminal from an external source, there can still be dangerous voltage potential present between the DC terminal poles and/or between DC and the enclosure. For safety reasons the DC terminal must be short-circuited after the capacitors have been discharged and it must also be grounded, i. e. connected to PE.
	There can always be a voltage potential on metallic, openly touchable parts on electrical devices, though the voltage level may not be hazardous. Caution is still advisable, as this potential can still cause mild electrical shock or sparking.
	This is valid for any use of the device.

1.7 Safety

1.7.1 Safety notices



Mortal danger - Hazardous voltage

- **Electrical equipment operation means that some parts accessible on the outside of the device can be under high voltage. Therefore all parts under voltage must be covered during operation! This basically applies to all models.**
- **The DC terminal is isolated from the AC input and not connected to ground internally. Hence there can be dangerous potential between the DC poles and PE, for instance caused by a connected external source application. Due to charged capacitors this could even be true if the DC terminal or the device are already switched off.**
- **Air-cooled models: Do not insert any object, particularly metallic, through the ventilation slots!**
- **For every reconfiguration on the AC or DC connectors, specifically those which can have a dangerous voltage potential, the device must be cut completely from the AC supply (main switch on the distant end of the AC cable); it doesn't suffice to only use the power switch on the front**
- **Always follow 5 safety rules when working with electric devices:**
  - **Disconnect completely**
  - **Secure against reconnection**
  - **Verify that the system is dead**
  - **Carry out earthing and short-circuiting**
  - **Provide protection from adjacent live parts**



- Air-cooled models: avoid any use of liquids near the equipment. Protect the device from wetness, damp and condensation.
- Do not connect external power sources with reversed polarity to the DC terminal! The equipment will be damaged, even when completely powered off.
- Never connect external power sources to the DC terminal that can generate a higher voltage than the rated voltage of the device!
- Never insert a network cable which is connected to Ethernet or its components into the sockets labeled "Master-Slave-Bus" on the rear side of the device!



- The equipment must only be used as intended
- The equipment is only approved for use within the connection limits stated on the product label.
- ESD regulations must be applied when plugging interface cards or modules into the relative slot
- Interface cards or modules may only be attached or removed after the device is switched off. It's not necessary to open the device.
- Always configure the various protecting features against overcurrent, overvoltage etc. for sensitive loads to what the target application requires!
- When operating the device as electronic load: always make sure that the energy recovery can feed back the inverted energy and that it does not switch to isolated operation. For situations of isolated operation a supervision device (grid protection) has to be installed
- It's not permitted to run the device on AC sources such as generators or UPS equipment. It must only be connected to a power grid!
- The equipment isn't meant to be operated in private facilities, because it can't sufficiently prevent to interfere with local radio reception (mobile phones, TV etc.)

1.7.2 Responsibility of the operator

An operator is any natural person who uses the equipment or delegates the usage to a third party, and is responsible during its usage for the safety of the user, other personnel or third parties.

The equipment is in industrial operation. Therefore the operators are subject to legal safety regulations. In addition to the warning and safety notices in this manual, the relevant safety, accident prevention and environmental regulations must also be applied. In particular the operator has to

- be acquainted with the relevant job safety requirements
- identify other possible dangers arising from the specific usage conditions at the work station via a risk assessment
- introduce the necessary steps in the operating procedures for the local conditions
- regularly control that the operating procedures are current
- update the operating procedures where necessary to reflect changes in regulation, standards or operating conditions.
- define clearly and unambiguously the responsibilities for operation, maintenance and cleaning of the equipment.
- ensure that all employees who use the equipment have read and understood the manual. Furthermore the users are to be regularly schooled in working with the equipment and the possible dangers.
- provide all personnel who work with the equipment with the designated and recommended safety equipment

Furthermore, the operator is responsible for ensuring that the device is at all times technically fit for use.

1.7.3 Requirements to the user

Any activity with equipment of this type may only be performed by persons who are able to work correctly and reliably and satisfy the requirements of the job.

- Persons whose reaction capability is negatively influenced by e.g. drugs, alcohol or medication may not operate the equipment.
- Age or job related regulations valid at the operating site must always be applied.



Danger for unqualified users

Improper operation can cause person or object damage. Only persons who have the necessary training, knowledge and experience may use the equipment.

The group of people allowed to operate the equipment is additionally limited to:

Delegated persons: these are persons who have been properly and verifiably instructed in their tasks and the respective dangers.

Qualified persons: these are persons who are able through training, knowledge and experience as well as knowledge of the specific details to carry out all the required tasks, identify dangers and avoid personal and other risks.

1.7.4 Responsibility of the user

The equipment is in industrial operation. Therefore the operators are subject to legal safety regulations. Alongside the warning and safety notices in this manual the relevant safety, accident prevention and environmental regulations must also be applied. In particular the users of the equipment:

- must be informed of the relevant job safety requirements
- must work to the defined responsibilities for operation, maintenance and cleaning of the equipment
- before starting work must have read and understood the operating manual

1.7.5 Alarm signals

The equipment offers various possibilities for signaling alarm conditions, however, not for danger situations. The signals are visual (via an LED on the control panel) or electronic (status output of the analog interface and digitally readable status bits). All alarms will cause the device to switch off the DC terminal. For details about the different alarms refer to section *«3.3 Alarm conditions»*.

The meaning of the signals is as follows:

Signal **OT** (OverTemperature)	• Overheating of the device • DC terminal will be switched off • Non-critical
Signal **OVP** (OverVoltage)	• Overvoltage shutdown of the DC terminal due to high voltage entering the device or generated by the device itself due to a defect • Critical! The device and/or the load could be damaged
Signal **OCP** (OverCurrent)	• Shutdown of the DC terminal due to excess of the preset limit • Non-critical, protects the load or source from excessive current consumption
Signal **OPP** (OverPower)	• Shutdown of the DC terminal due to excess of the preset limit • Non-critical, protects the load or source from excessive power consumption
Signal **PF** (Power Fail)	• DC terminal shutdown due to AC undervoltage or defect in the AC section • Critical on overvoltage! AC section could be damaged
Signal **MAP** (Master-Auxiliary Protection)	• DC terminal shutdown due to communication problems on the master-auxiliary bus • Non-critical
Signal **SF** (Share Bus Fail)	• DC terminal shutdown due to signal distortion on the Share bus • Non-critical

1.7.6 Functionality test

The operator of the device must decide when to check the device for correct functionality, by whom and how often. The "when" could either be before every use or after it has been relocated or reconfigured or perhaps in a defined interval.

Should the set values not be adjustable as instructed below it could simply be due to adjustment limits interfering. When reaching a limit adjusting value can't be signaled by the device. In remote control an invalid value would be rejected, together with an error message.

1.7.6.1 Test procedure for power supply devices

1. Disconnect all cables (DC, Sense, Share bus, analog interface, USB), except for AC.
2. Connect a suitable voltage meter to the DC terminal.
3. Switch the device on. Adjust a voltage of 10% U_{Nom} using remote control via the front or rear USB port while the current and power set values for source mode should be at maximum and those for sink mode at 0. Then switch the DC output on and verify with the multimeter that the adjusted voltage is available on the DC terminal. Also compare it to the actual voltage value read via remote command query.
4. Repeat the same thing at 100% U_{Nom}.
5. Switch the DC output off and bridge the DC terminal with a cable or copper bar of suitable current capability of at least I_{Nom}. If available, add a current measuring device (transducer, current probe).
6. Adjust the current for source mode to 10% I_{Nom}, switch the DC output on and measure the current with the external measuring device, if available, and compare to the actual current measured by the device which can be read via remote query command or at least compare the read actual current with the set value.
7. Repeat the same thing at 100% I_{Nom}.

Only if the current and voltage are supplied by the device as adjustable in the range of 0-100% FS, the device can be considered as fully operational.

1.7.6.2 Test procedure for electronic load devices

1. Disconnect all cables (Sense, Share-Bus, analog interface, USB), except for AC.
2. Connect an external DC source that can at least deliver as much current and voltage as the rating of the device under test (DUT) and set it to 10% U_{Nom} voltage of the DUT and full current.
3. Place a suitable ampere meter (shunt, current transducer) in line with or around one of the DC cables.
4. Switch the device on. Using remote control via the front or rear USB port, adjust a current of 10% I_{Nom} while the voltage set value is set to 0 and the power set values to maximum. Then switch the DC input on and measure the current with the ammeter and verify that the adjusted current is flowing. Also compare it to the actual current value read via remote command query.
5. Repeat the same thing at 100% U_{Nom}.
6. Should the external DC source be adjustable in current, limit the current to 90% I_{Nom} of the DUT while setting the voltage to 102% U_{Nom} of the DUT. Add a voltage multimeter on the DC input.
7. On the DUT, adjust 10% U_{Nom} and measure with the multimeter on the DC input to verify the adjusted voltage is met. Also compare it to the actual voltage value read via remote command query.
8. Repeat the same thing at 90% or 100% U_{Nom}.

Only if the current and voltage are supplied by the device as adjustable in the range of 0-100% FS, the device can be considered as fully operational.

1.8 Technical Data

1.8.1 Approved operating conditions

1.8.1.1 Ambiance

The allowed ambient temperature range for operation is 0 °C (32 °F) to 50 °C (122 °F). During storage or transport, the allowed range extends to -20 °C (-4 °F) to 70 °C (158 °F). In case water condensation occurred due to transport, the device must be acclimatized prior to operation for at least 2 hours, ideally in a place with good air circulation.

The device is intended to be operation in dry rooms. It must not be exposed or operated to extreme dust, high air humidity, danger of explosion and aggressive chemicals polluting the air. The operating position isn't arbitrary (see *«2.3.3 Installing the device»*),but in any case it requires a sufficient air circulation. The device is allowed to be operated in altitude up to 2000 m (approx. 6,560 ft) above sea level. Technical specifications (here: ratings), when given with tolerance, are valid for a unit warmed up for at least 30 minutes and for an ambient temperature of 23 °C (73 °F). Specifications without tolerance are typical values from an average device.

1.8.1.2 Cooling

Power dissipated inside the device heats up air flowing through the device. With air-cooled models, entry is on the front and exhaust at the back. Depending on the internal temperature, the fan speed is automatically regulated up or down, whereas a certain minimum speed is maintained because some internal components even heat up when the device is idle.

Dust in the air can obstruct the air flow with time, so it's important to keep the air flow unimpeded at least outside of the device be leaving sufficient room behind it. Since it's usually installed inside cabinets, the cabinet doors are required to be meshed.

At the same time, the ambient temperature should be kept at low levels, perhaps by external means such as an air condition. Should the device heat up internally and the cooling block temperature exceed 80 °C (160 °F), the device will protect itself from overheating by automatically switching off the DC terminal. It could then only continue to operate and switch the DC terminal on again after cooling down for some time.

For the water-cooled versions, water is the main cooling agent, flowing through the internal cooling blocks. The air inside the almost hermetically body circulates, engaged by fans, to cool the remaining components not sitting on the cooling blocks, but which heat up over time.

1.8.2 General technical data

Display:	6 LED with different colors
Controls:	1 pushbutton

1.8.3 Specific technical data

General specifications	
AC input	
Voltage, Phases	380 V - 480 V ±10%, 3ph AC
Frequency	45 - 65 Hz
Power factor	ca. 0.99
Leakage current	<10 mA
Inrush current *1	@400 V: ca. 32 A per phase
Overvoltage category	III
DC input/output static	
Load regulation CV	≤0.05% FS (0 - 100% load, at constant AC input voltage and temperature)
Line regulation CV	≤0.01% FS (380 V - 480 V AC ±10%, at constant load and temperature)
Stability CV	≤0.02% FS (during 8 h of operation, after 30 minutes warm-up, at constant AC input voltage, load and temperature)
Temperature coefficient CV	≤30ppm/°C (after 30 minutes of warm-up)
Compensation (remote sense)	≤5% $U_{Nominal}$
Load regulation CC	≤0.1% FS (0 - 100% load, at constant AC input voltage and temperature)
Line regulation CC	≤0.01% FS (380 V - 480 V AC ±10%, at constant load and temperature)
Stability CC	≤0.02% FS (during 8 h of operation, after 30 minutes warm-up, at constant AC input voltage, load and temperature)
Temperature coefficient CC	≤50ppm/°C (after 30 minutes of warm-up)
Load regulation CP	≤0.3% FS (0 - 100% load, constant AC input voltage and constant temperature)
Load regulation CR	≤0.3% FS + 0.1% FS of current (0 - 100% load, constant AC input voltage and constant temperature)
Protective functions	
OVP	Overvoltage protection, adjustable 0 - 110% $U_{Nominal}$
OCP	Overcurrent protection, adjustable 0 - 110% $I_{Nominal}$
OPP	Overpower protection, adjustable 0 - 110% $P_{Nominal}$
OT	Overtemperature protection (DC terminal shuts down in case of insufficient cooling)
DC input/output dynamic	
Rise time 10 - 90% / Fall time 90 - 10%	CV *2: ≤10 ms CC *3: ≤2 ms
Measurement accuracy	
Voltage	≤0.05% FS
Current	≤0.1% FS
Insulation	
AC input to DC terminal	3750 Vrms (1 minute, creepage distance >8 mm)
AC input to case (PE)	2500 Vrms
DC terminal to case (PE)	Depending on the model, see model tables
DC terminal to interfaces	1000 V DC (360 V model), 1500 V DC (models from 500 V output)
Interfaces digital	
Built-in, galvanically isolated	USB, Ethernet (100 MBit), USB front panel, all for communication
Optional, galvanically isolated	CAN, CANopen, RS232, ModBus TCP, Profinet, Profibus, EtherCAT, Ethernet
Interface analog	
Built-in, galvanically isolated	15 pole D-Sub
Signal range	0 - 10 V or 0 - 5 V (switchable)
Inputs	U, I, P, R, remote control on/off, DC input/output on/off, resistance mode on/off
Outputs	Monitor U and I, alarms, reference voltage, DC input/output status, CV/CC regulation mode
Accuracy U / I / P / R	0 - 10 V: ≤0.2%, 0 - 5 V: ≤0.4%

*1 Calculated for the peak value of the stated voltage including 10% tolerance, at 23°C ambient and first switch-on (cold start)
*2 Valid for power supplies, unidirectional or bidirectional, in source mode operation
*3 Valid for electronic loads or bidirectional power supplies in sink mode operation

General specifications	
Device configuration	
Parallel operation	Up to 64 units of any power class in series 10000 starting from 5 kW, with Master-Slave bus and Share-Bus
Safety and EMC	
Safety	EN 61010-1 IEC 61010-1 UL 61010-1 CSA C22.2 No 61010-1 BS EN 61010-1
EMC	EN 55011, class A, group 1 CISPR 11, class A, group 1 FCC 47 CFR part 15B, unintentional radiator, class A EN 61326-1 include tests according to: - EN 61000-4-2 - EN 61000-4-3 - EN 61000-4-4 - EN 61000-4-5 - EN 61000-4-6
Appliance class	I
Ingress Protection	IP20
Environmental conditions	
Operating temperature	0 - 50 °C (32 - 122 °F)
Storage temperature	-20 - 70 °C (-4 - 158 °F)
Humidity	≤80% relative humidity, non-condensing
Altitude	≤2000 m (≤6,600 ft)
Pollution degree	2
Mechanical construction	
Cooling	Forced air flow from front to rear (temperature controlled fans), optional: water cooling
Dimensions (W x H x D)	Enclosure: 483 mm (19 in) x 266 mm (6U) x 668 mm (26.3 in) Overall depth: min. 818 mm (min. 32.2 in)
Weight	76 kg (168 lb)
Weight with water cooling	82 kg (180 lb)

Technical specifications	PU 10360-480	PU 10500-360	PU 10750-240	PU 10920-250
DC output				
Voltage range	0 - 360 V	0 - 500 V	0 - 750 V	0 - 920 V
Ripple in CV (rms)	≤55 mV (BWL 300 kHz *1)	≤70 mV (BWL 300 kHz *1)	≤200 mV (BWL 300 kHz *1)	≤250 mV (BWL 300 kHz *1)
Ripple in CV (pp)	≤320 mV (BWL 20 MHz *1)	≤350 mV (BWL 20 MHz *1)	≤800 mV (BWL 20 MHz *1)	≤1200 mV (BWL 20 MHz *1)
Current range	0 - 480 A	0 - 360 A	0 - 240 A	0 - 250 A
Power range	0 - 60000 W	0 - 60000 W	0 - 60000 W	0 - 60000 W
Resistance range	0.025 Ω - 45 Ω	0.04 Ω - 85 Ω	0.1 Ω - 185 Ω	0.125 Ω - 275 Ω
Output capacitance	3480 µF	1560µF	765 µF	465 µF
Efficiency (up to)	95.8% *2	96.5% *2	96.5% *2	96.5% *2
AC input				
P_{Max}	63 kW	63 kW	63 kW	63 kW
Phase current *3	@400 V: ≤106 A	@400 V: ≤106 A	@400 V: ≤106 A	@400 V: ≤106 A
Insulation				
Negative DC pole <-> PE	±1000 V DC	±1500 V DC	±1500 V DC	±1500 V DC
Positive DC pole <-> PE	+1000 V DC	+2000 V DC	+2000 V DC	+2000 V DC
Product codes				
Standard	01113010	01113011	01113012	01113013
Standard + Water Cooling	01463001	01463002	01463003	01463004

Technical specifications	PU 11000-160	PU 11500-120	PU 12000-80	
DC output				
Voltage range	0 - 1000 V	0 - 1500 V	0 - 2000 V	
Ripple in CV (rms)	≤300 mV (BWL 300 kHz *1)	≤400 mV (BWL 300 kHz *1)	≤500 mV (BWL 300 kHz *1)	
Ripple in CV (pp)	≤1600 mV (BWL 20 MHz *1)	≤2400 mV (BWL 20 MHz *1)	≤3000 mV (BWL 20 MHz *1)	
Current range	0 - 160 A	0 - 120 A	0 - 80 A	
Power range	0 - 60000 W	0 - 60000 W	0 - 60000 W	
Resistance range	0.2 Ω - 325 Ω	0.4 Ω - 750 Ω	0.85 Ω - 1350 Ω	
Output capacitance	387 µF	173 µF	85 µF	
Efficiency (up to)	95.8% *2	96.5% *2	96.5% *2	
AC input				
P_{Max}	63 kW	63 kW	63 kW	
Phase current *3	@400 V: ≤106 A	@400 V: ≤106 A	@400 V: ≤106 A	
Insulation				
Negative DC pole <-> PE	±1500 V DC	±1500 V DC	±1500 V DC	
Positive DC pole <-> PE	+2000 V DC	+2000 V DC	+2000 V DC	
Product codes				
Standard	01113014	01113015	01113016	
Standard + Water Cooling	01463005	01463006	01463007	

*1 BWL = Bandwidth limit on the measuring oscilloscope
*2 At 100% power and 100% output voltage
*3 Calculated for the default AC supply voltage in the stated range, minus 10% tolerance, at maximum output power and 10% power loss from AC to DC

Technical specifications	PUB 10360-480	PUB 10500-360	PUB 10750-240	PUB 10920-250
DC output				
Voltage range	0 - 360 V	0 - 500 V	0 - 750 V	0 - 920 V
Ripple in CV (rms)	≤55 mV (BWL 300 kHz *1)	≤70 mV (BWL 300 kHz *1)	≤200 mV (BWL 300 kHz *1)	≤250 mV (BWL 300 kHz *1)
Ripple in CV (pp)	≤320 mV (BWL 20 MHz *1)	≤350 mV (BWL 20 MHz *1)	≤800 mV (BWL 20 MHz *1)	≤1200 mV (BWL 20 MHz *1)
U_{Min} for I_{Max} (sink)	2.5 V	1.1 V	1.2 V	2 V
Current range	0 - 480 A	0 - 360 A	0 - 240 A	0 - 250 A
Power range	0 - 60000 W	0 - 60000 W	0 - 60000 W	0 - 60000 W
Resistance range	0.025 Ω - 45 Ω	0.04 Ω - 85 Ω	0.1 Ω - 185 Ω	0.125 Ω - 275 Ω
Output capacitance	3480 µF	1560µF	765 µF	465 µF
Efficiency sink/source (up to)	95.8% *2	96.5% *2	96.5% *2	96.5% *2
AC input				
P_{Max}	63 kW	63 kW	63 kW	63 kW
Phase current *3	@400 V: ≤106 A	@400 V: ≤106 A	@400 V: ≤106 A	@400 V: ≤106 A
Insulation				
Negative DC pole <-> PE	±1000 V DC	±1500 V DC	±1500 V DC	±1500 V DC
Positive DC pole <-> PE	+1000 V DC	+2000 V DC	+2000 V DC	+2000 V DC
Product codes				
Standard	01123011	01123012	01123013	01123014
Standard + Water Cooling	01563001	01563002	01563003	01563004

Technical specifications	PUB 11000-160	PUB 11500-120	PUB 12000-80	
DC output				
Voltage range	0 - 1000 V	0 - 1500 V	0 - 2000 V	
Ripple in CV (rms)	≤300 mV (BWL 300 kHz *1)	≤400 mV (BWL 300 kHz *1)	≤500 mV (BWL 300 kHz *1)	
Ripple in CV (pp)	≤1600 mV (BWL 20 MHz *1)	≤2400 mV (BWL 20 MHz *1)	≤3000 mV (BWL 20 MHz *1)	
U_{Min} for I_{Max} (sink)	3.4 V	3.2 V	3.7 V	
Current range	0 - 160 A	0 - 120 A	0 - 80 A	
Power range	0 - 60000 W	0 - 60000 W	0 - 60000 W	
Resistance range	0.2 Ω - 325 Ω	0.4 Ω - 750 Ω	0.85 Ω - 1350 Ω	
Output capacitance	387 µF	173 µF	85 µF	
Efficiency sink/source (up to)	95.8% *2	96.5% *2	96.5% *2	
AC input				
P_{Max}	63 kW	63 kW	63 kW	
Phase current *3	@400 V: ≤106 A	@400 V: ≤106 A	@400 V: ≤106 A	
Insulation				
Negative DC pole <-> PE	±1500 V DC	±1500 V DC	±1500 V DC	
Positive DC pole <-> PE	+2000 V DC	+2000 V DC	+2000 V DC	
Product codes				
Standard	01123015	01123016	01123017	
Standard + Water Cooling	01563005	01563006	01563007	

*1 BWL = Bandwidth limit on the measuring oscilloscope
*2 At 100% power and 100% output voltage
*3 Calculated for the default AC supply voltage in the stated range, minus 10% tolerance, at maximum output power and 10% power loss from AC to DC

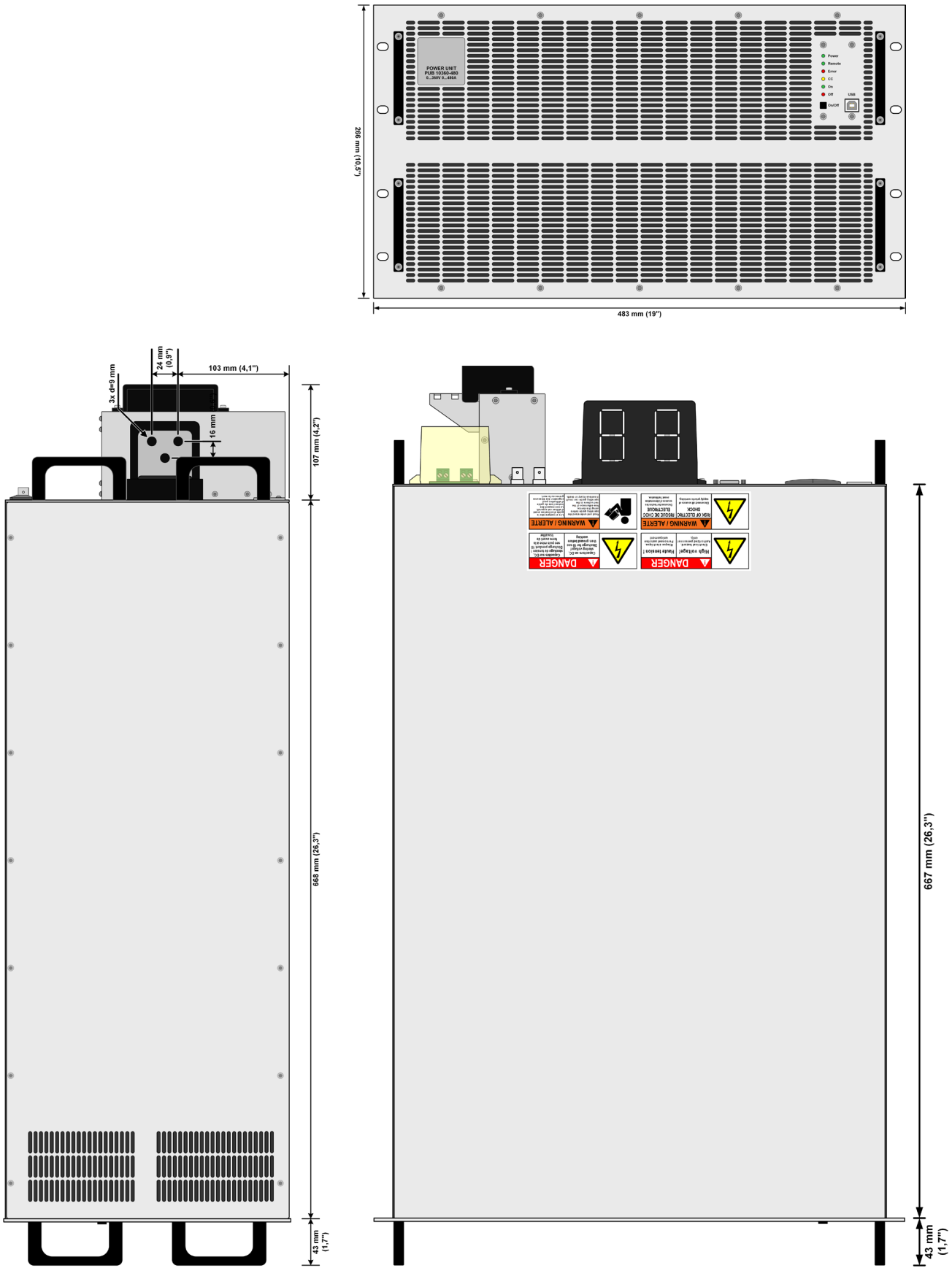
Technical specifications	PUL 10360-480	PUL 10500-360	PUL 10750-240	PUL 10920-250
DC input				
Voltage range	0 - 360 V	0 - 500 V	0 - 750 V	0 - 920 V
U_{Min} for I_{Max}	2.5 V	1.1 V	1.2 V	2 V
Current range	0 - 480 A	0 - 360 A	0 - 240 A	0 - 250 A
Power range	0 - 60000 W	0 - 60000 W	0 - 60000 W	0 - 60000 W
Resistance range	0.025 Ω - 45 Ω	0.04 Ω - 85 Ω	0.1 Ω - 185 Ω	0.125 Ω - 275 Ω
Input capacitance	3480 µF	1560µF	765 µF	465 µF
Efficiency (up to)	95.8% *1	96.5% *1	96.5% *1	96.5% *1
AC input				
P_{Max}	58 kW	58 kW	58 kW	58 kW
Phase current *2	@400 V: ≤93 A	@400 V: ≤93 A	@400 V: ≤93 A	@400 V: ≤93 A
Insulation				
Negative DC pole <-> PE	±1000 V DC	±1500 V DC	±1500 V DC	±1500 V DC
Positive DC pole <-> PE	+1000 V DC	+2000 V DC	+2000 V DC	+2000 V DC
Product codes				
Standard	01133009	01133010	01133011	01133012
Standard + Water Cooling	01663001	01663002	01663003	01663004

Technical specifications	PUL 11000-160	PUL 11500-120	PUL 12000-80	
DC input				
Voltage range	0 - 1000 V	0 - 1500 V	0 - 2000 V	
U_{Min} for I_{Max}	3.4 V	3.2 V	3.7 V	
Current range	0 - 160 A	0 - 120 A	0 - 80 A	
Power range	0 - 60000 W	0 - 60000 W	0 - 60000 W	
Resistance range	0.2 Ω - 325 Ω	0.4 Ω - 750 Ω	0.85 Ω - 1350 Ω	
Input capacitance	387 µF	173 µF	85 µF	
Efficiency (up to)	95.8% *1	96.5% *1	96.5% *1	
AC input				
P_{Max}	58 kW	58 kW	58 kW	
Phase current *2	@400 V: ≤93 A	@400 V: ≤93 A	@400 V: ≤93 A	
Insulation				
Negative DC pole <-> PE	±1500 V DC	±1500 V DC	±1500 V DC	
Positive DC pole <-> PE	+2000 V DC	+2000 V DC	+2000 V DC	
Product codes				
Standard	01133013	01133014	01133015	
Standard + Water Cooling	01663005	01663006	01663007	

*1 At 100% power and 100% input voltage
*2 Calculated for the default AC supply voltage in the stated range, minus 10% tolerance, at maximum DC input power and max. efficiency of 96.5%

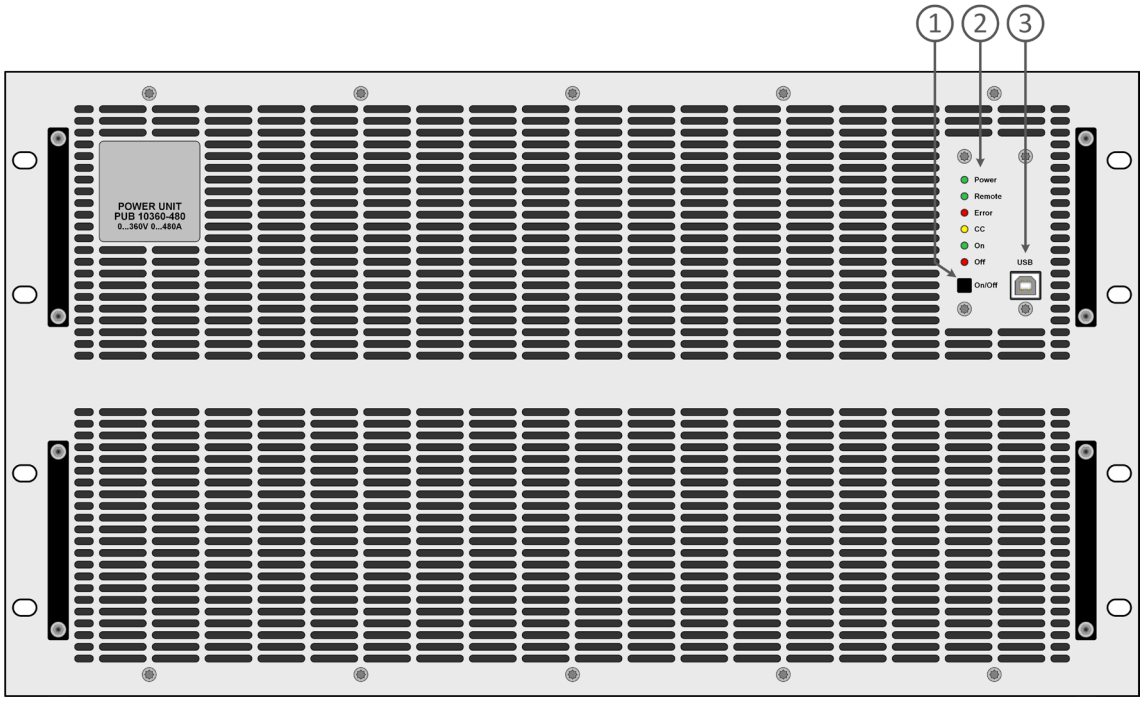
1.8.4 Views

1.8.4.1 Technical drawings 10000 6U



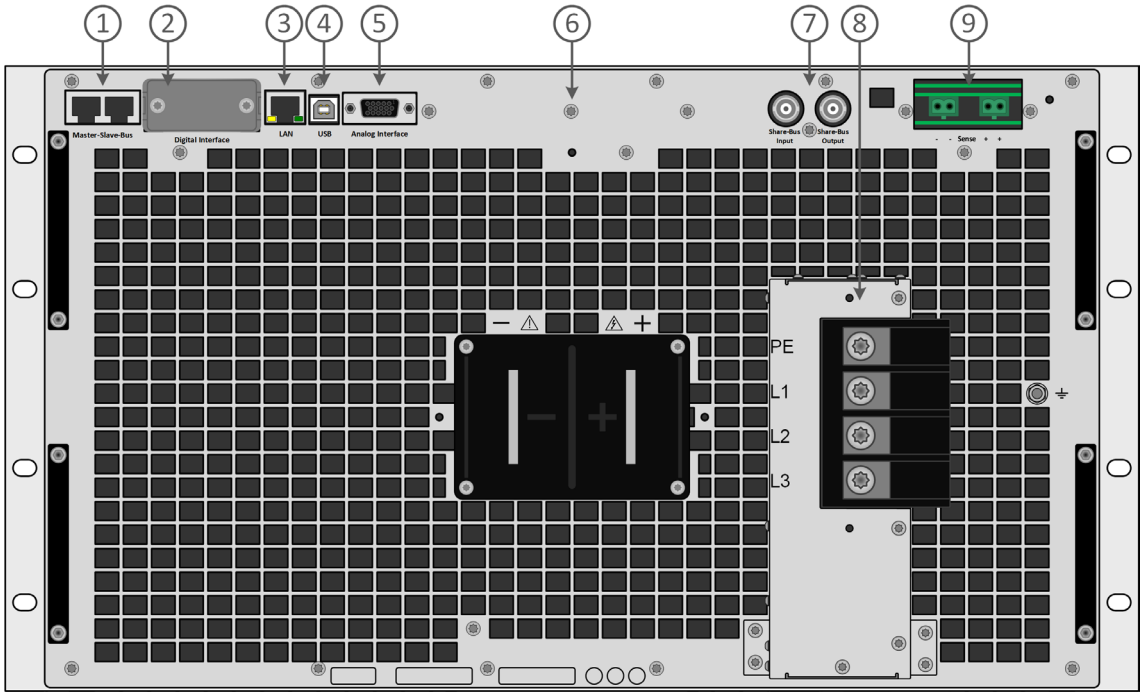
Side view of the air-cooled version shown

1.8.4.2 Front panel description 10000 6U



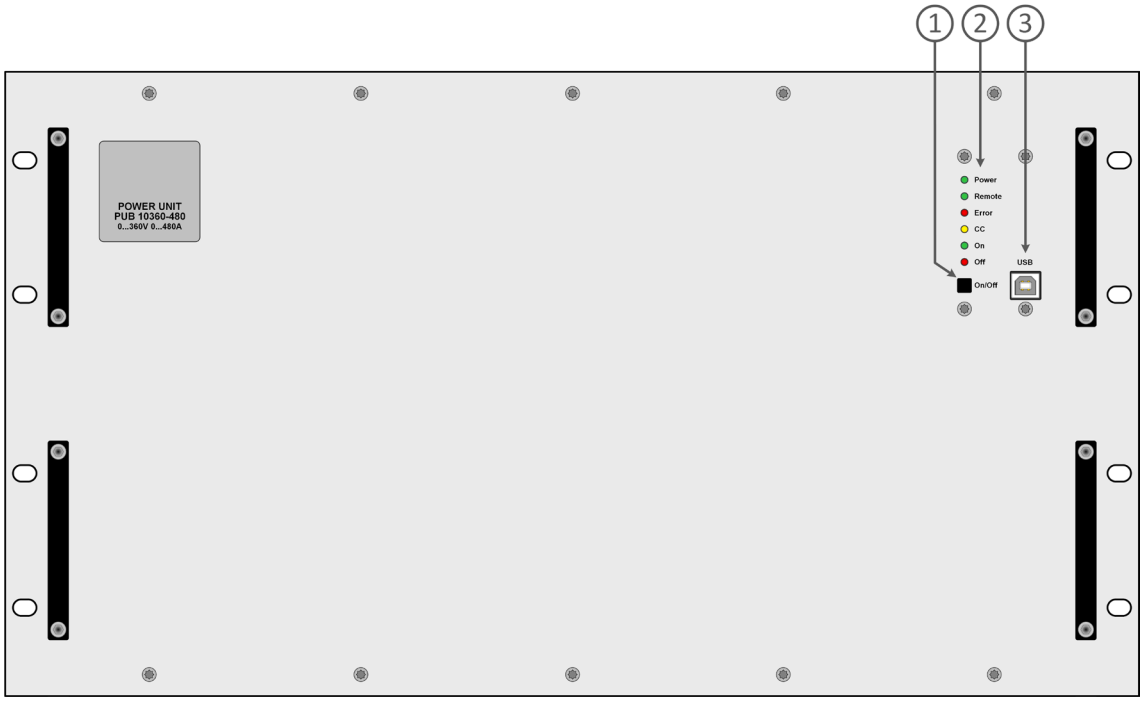
1. DC on/off pushbutton
2. LED status display
3. USB interface

1.8.4.3 Rear panel description 10000 6U



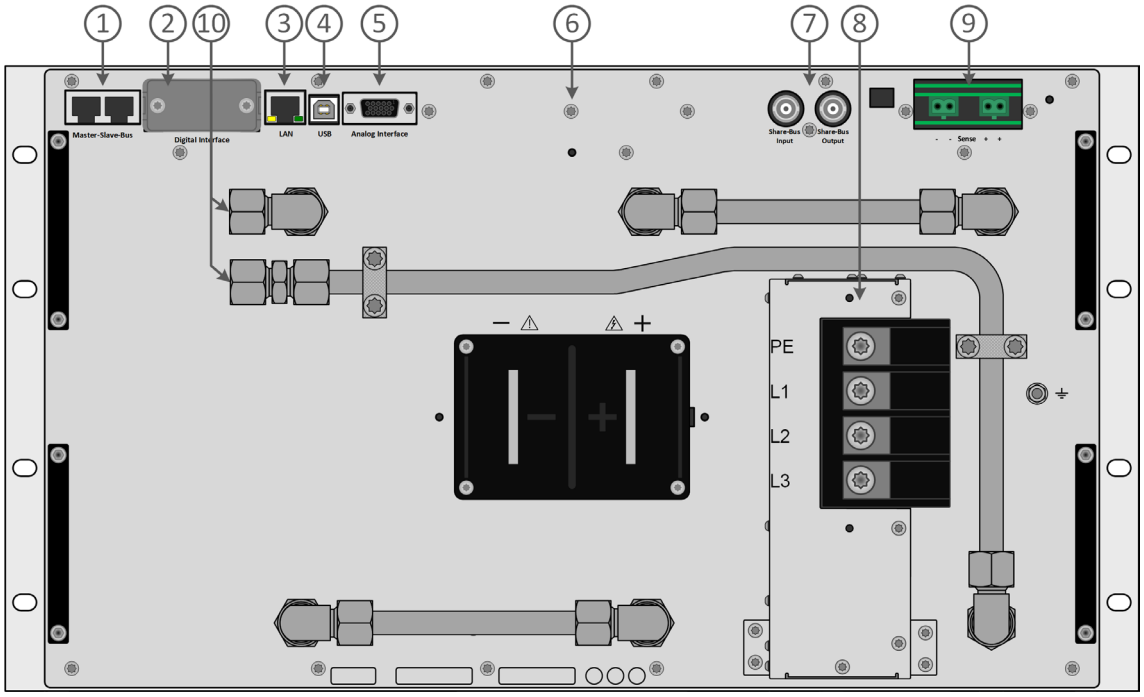
1. Master-auxiliary bus connectors to set up a system for parallel connection
2. Slot for optional interfaces
3. Ethernet interface
4. USB interface n
5. Connector (DB15 female) for isolated analog programming, monitoring and other functions
6. DC connector (copper blades)
7. Share bus connectors to set up a system for parallel connection
8. AC input connector
9. Remote sense connectors

1.8.4.4 Front panel description PUB 10000 6U WC (water cooling option)



1. DC on/off pushbutton
2. LED status display
3. USB interface

1.8.4.5 Rear panel description PUB 10000 6U WC (water cooling option)



1. Master-auxiliary bus connectors to set up a system for parallel connection
2. Slot for optional interfaces
3. Ethernet interface
4. USB interface n
5. Connector (DB15 female) for isolated analog programming, monitoring and other functions
6. DC connector (copper blades)
7. Share bus connectors to set up a system for parallel connection
8. AC input connector
9. Remote sense connectors
10. Water inlet and outlet

1.8.5 Control elements

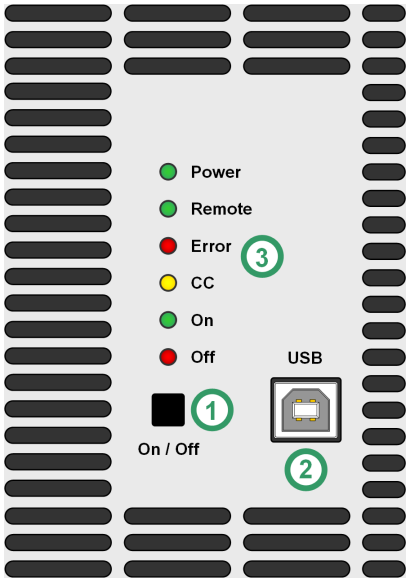


Figure 1- Control Panel

Overview of the elements on the control panel

For a detailed description see section *«1.9.6 The control panel (HMI)»*.

(1)	**On/Off button** Can be used to switch the DC terminal on or off during manual operation, while LED “Remote” is off *Pin REM-SB on the analog interface, when set to a logical level which would request to turn DC off, can block switching DC on by this pushbutton.*
(2)	**USB port** For quick and easy access to the most important DC terminal related values when the device isn’t in master-auxiliary mode. This port has reduced functionality compared to the rear port.
(3)	**Status indicators (LED)** These six color LEDs show the device status.

1.9 Construction and function

1.9.1 General description

The devices in the 10000 series with 6U height represent matching models to the 10000 series in 4U. They serve as extension modules, so called power units, which are intended to build master-auxiliary systems with higher total power. For example, devices from series PSB 10000 4U or PSBE 10000 4U, which both have a color touch display, can serve as master unit for one or several PUB 10000 6U units, but all 6U models can also serve as master for other 10000 series power supplies, should the control be solely remote.

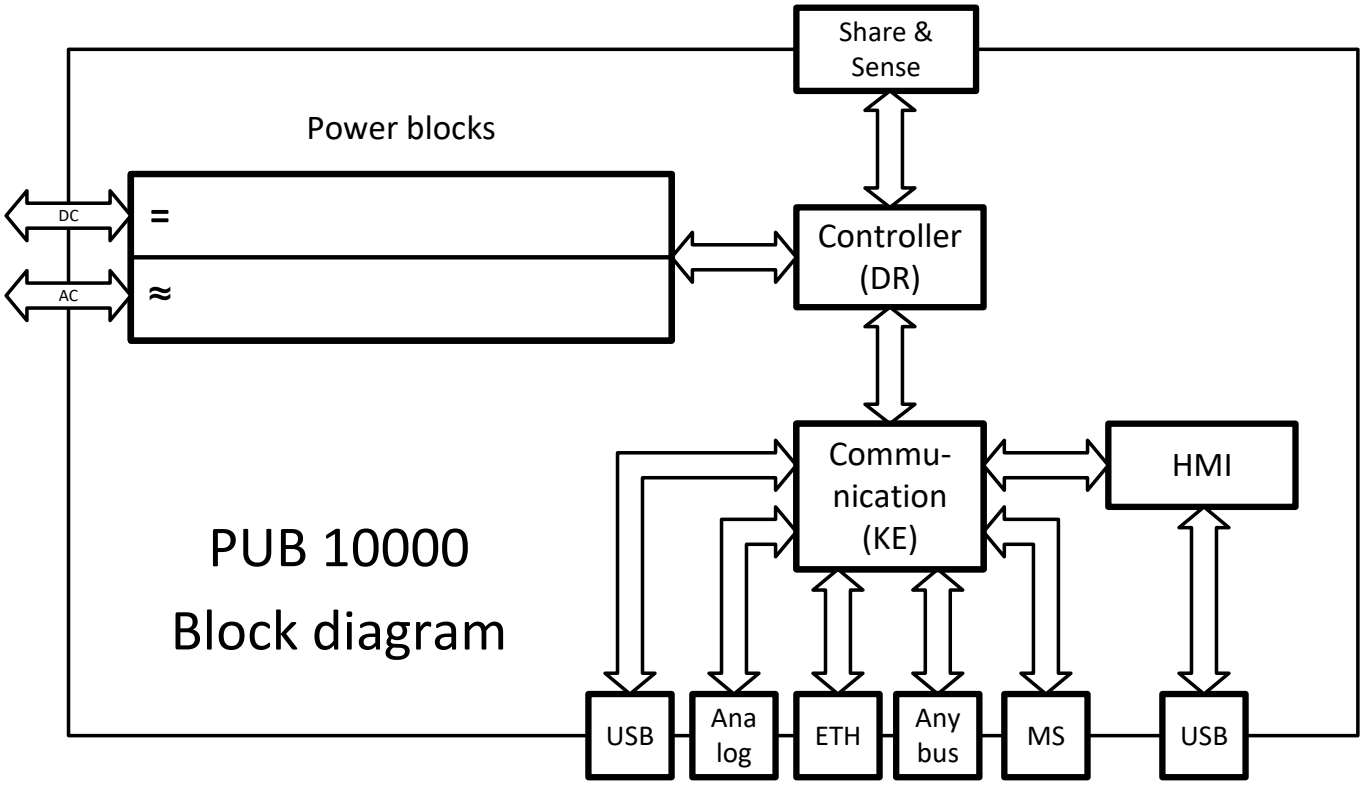
For remote control the devices are provided as standard with USB and Ethernet ports on the rear side, as well as a galvanically isolated analog interface. Via optional plug-in interface modules, another digital interface such as for RS232, Profibus, ProfiNet, ModBus TCP, CAN, CANopen or EtherCAT can be added. These enable the devices to be connected to standard industrial buses simply by changing or adding a small module.

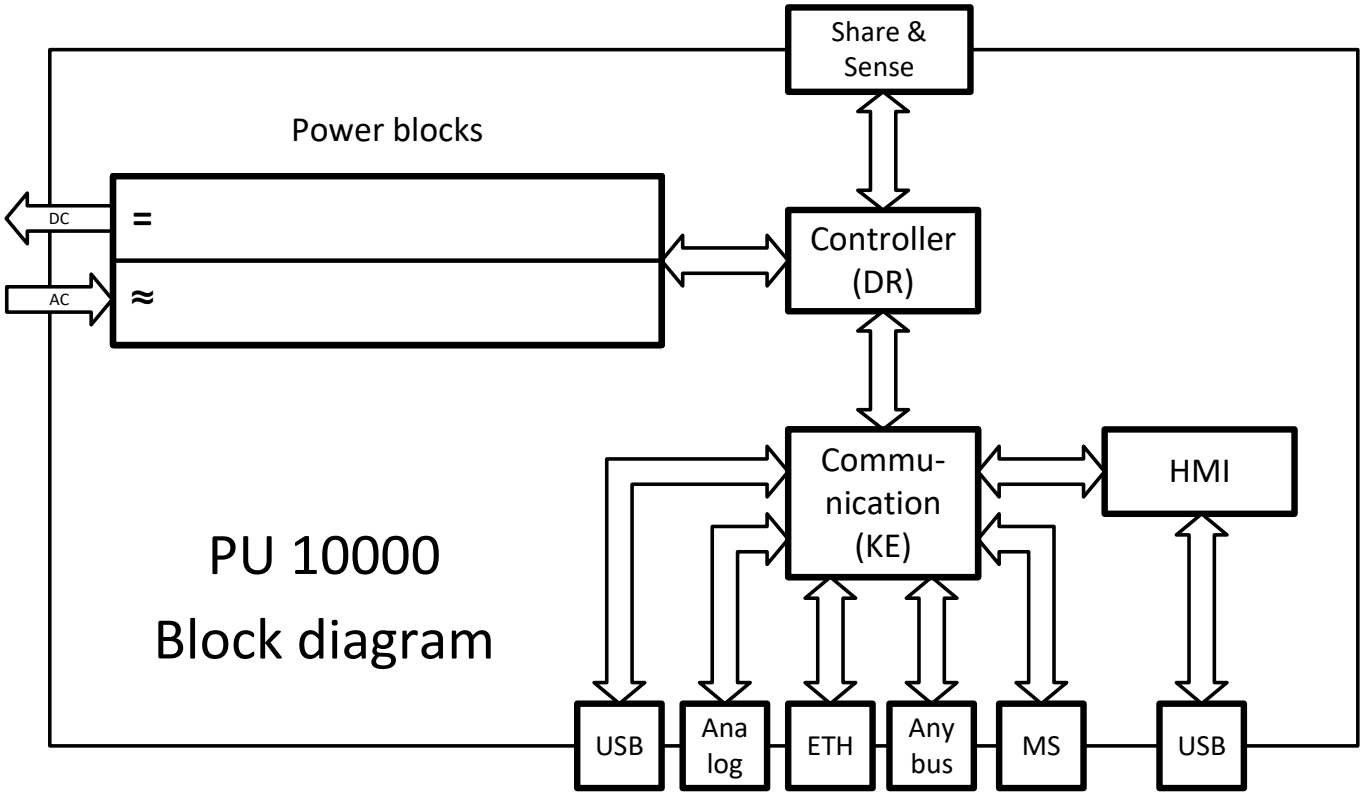
Alternatively to the air-cooled versions there are also water-cooled version available which are usually configured and offered in cabinet systems with a complete water cooling distribution inside. For DIY water-cooled systems single units can also be obtained upon request.

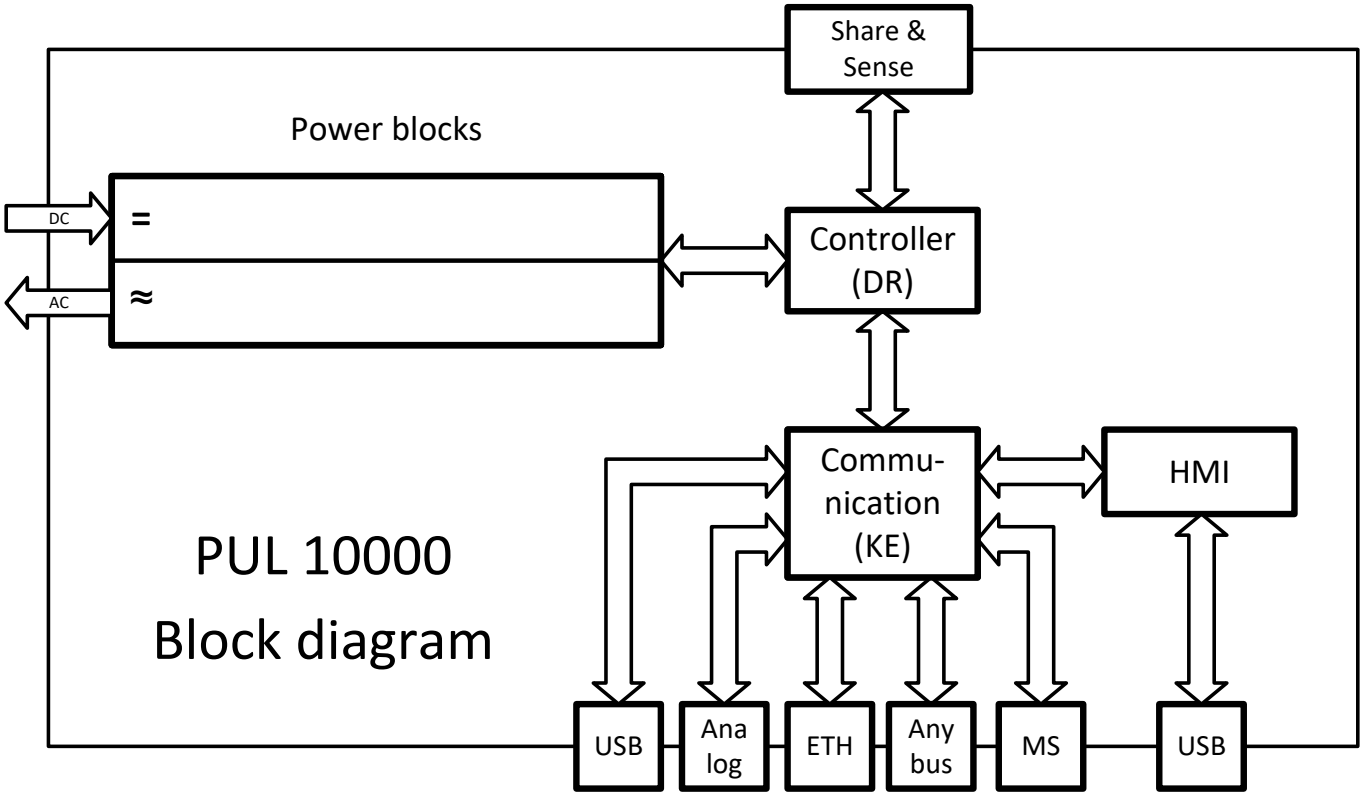
1.9.2 Block diagrams

A block diagram illustrates the main components inside the device and their relationships.

There are digital, microprocessor controlled components (KE, DR, HMI), which can be target of firmware updates.




Share &
Sense
Power blocks
DC
=
AC
≈
Controller
(DR)
Commu-
nication
(KE)
HMI
PU 10000
Block diagram
USB
Ana
log
ETH
Any
bus
MS
USB


Share &
Sense
Power blocks
DC
=
AC
≈
Controller
(DR)
Commu-
nication
(KE)
HMI
PUL 10000
Block diagram
USB
Ana
log
ETH
Any
bus
MS
USB

1.9.3 Scope of delivery

1 x Power supply device (standard or bidirectional) or Electronic load device

2 x Remote sensing plugs

1 x 1.8 m (5.9 ft) USB cable

1 x DC terminal cover

1 x Sense terminal cover

1 x USB stick with documentation and software

1 x AC terminal cover

1 x Set for AC cable strain relief (bracket & cable ties)

1.9.4 Accessories

For all models in this series, with or without water cooling option installed, the following accessories are available:

IF-AB Interface modules	Pluggable and retrofittable, digital interface modules for RS232, CANopen, Profibus, ProfiNet, ModBus TCP, EtherCAT or CAN are available. Details about the interface modules and the programming of the device using those interfaces can be found in separate documentation. It's usually available on the USB stick, which is included with the device, or as PDF download on the manufacturers website.
LICENSE Software licenses	All devices are shipped with a free remote control software for Windows, called **EA Power Control**. Besides free-to-use apps this software has other apps like Multi Control, the Graph and the Function Generator, which can be unlocked with a purchasable license code. These three apps are combined under the license "Multi Control". One license per PC required. There is a single license and a 5-pack available, also a 14-day trial license which can be obtained upon request. More information is available in the user manual of this software or on our website.
EABS Battery simulation	EABS is short for EA Battery Simulator and is an optionally available, USB dongle licensed Windows software. In combination with the bidirectional power supplies of series PSB 9000, PSBE 9000, PSB 10000, PSBE 10000 or PUB 10000 it simulates either a single lithium-ion cell or lead-acid battery or multiple in series and/or parallel connection. The simulation works with battery typical values such as capacity, temperature, state of charge, internal resistance and cell voltage, plus adjustable test conditions.

1.9.5 Options

These options are usually ordered together with the device, as they are permanently built in or preconfigured during the manufacturing process.

POWER RACKS 19" rack	Racks in various configurations up to 42U as parallel systems are available, or mixed with electronic load devices to create test systems. Further information are available on our web-site or obtained upon request
WC Water cooling	Replaces the standard cooling blocks of the internal power blocks by three interconnected, water cooled blocks with two taps led out for supply. This option helps to avoid heating up the environment due to exhausted hot air caused by a certain power dissipation when a single device or a fully equipped cabinet runs as source. As a side effect, this type of cooling also reduces audible noise.

1.9.6 The control panel (HMI)

The HMI (Human Machine Interface) consists of six colored LEDs, a pushbutton and a USB port of type B.

1.9.6.1 Status indicators (LED)

The six colored LEDs on the front indicate various statuses of the device:

LED	Color	Indicates what when lit?
Power	orange / green	Orange = device is in boot phase or internal error occurred Green = device is ready for operation
Remote	green	Remote control by master-auxiliary or any of the control interfaces is active. In this situation, manual control with button On/Off is locked.
Error	red	At least one unacknowledged device alarm is active. The LED signalizes all alarms as listed in *«3.5 Alarms and monitoring»*.
CC	yellow	Constant current control (CC) is active. It means, if the LED isn't lit it indicates either CV, CP or CR mode. Also see *«2.1 Operating modes»* in the user manual.
On	green	DC terminal is switched on
Off	red	DC terminal is switched off

1.9.6.2 Front USB port

The front USB port is easier to access than the one on the rear side and intended for quick setup of DC terminal related values and settings. Doing so is only necessary and possible in these two situations:

1. The 6U device isn't currently controlled by a master in master-auxiliary operation.
2. The 6U device shall, due to the lack of a suitable 4U master device with display, be the master of other 4U or 6U devices.

Both situations are only secondary, as the primary and normal function of a 6U model is to be an auxiliary unit in a master-auxiliary system where it's assigned all required settings and values from the master.

When running the device in any of the above listed situations following applies for the front USB port:



- Reduced instruction set for master-auxiliary configuration, set values (U, I, P, R) and protections (OVP, OCP, OPP). For details about the instruction set see *«2.2 Remote control»* in the user manual
- Taking over remote control in order to change the configuration is only possible while the unit isn't online with the master, which either requires to temporarily deactivate master-auxiliary on the master or to switch the master off.
- The front USB has no priority over any other remote control interface

1.9.6.3 Pushbutton "On / Off"

This button can be used to switch the DC terminal on or off during manual control, i. e. the device isn't in remote control by a master or via any of the USB ports (LED "Remote" = off), but only if the DC terminal isn't blocked by pin REM-SB from the analog interface.



After the DC terminal is switched on, the device would regulate the DC terminal to the last values it has stored. Since the DC terminal related values aren't displayed with these device, operating that button has to be done with caution.

The button can furthermore be used to quickly and without the need of a PC turn the device into auxiliary mode. This is done by pressing and holding the button for at least 10 seconds. The switchover into mode "Auxiliary" is confirmed by the LED "Error" lighting up, indicated an MSP alarm (see section *«3.5 Alarms and monitoring»* for more information about this alarm) which is normal for not yet initialized aux units.

1.9.7 USB port (rear side)

The USB-B port on the rear side of the device is provided for communication with the device and for firmware updates. The included USB cable can be used to connect the device to a PC (USB 2.0 or 3.0). The driver is delivered with the device and installs a virtual COM port. Details for remote control can be found on the web site of the manufacturer or on the included USB stick.

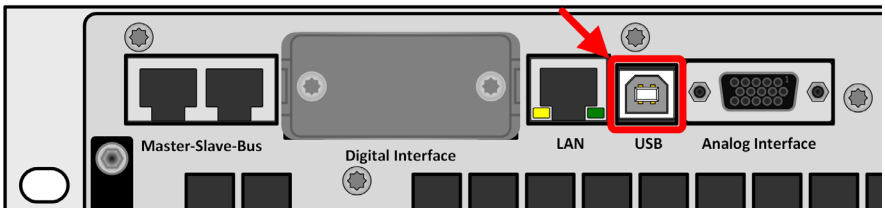


Figure 2 - USB port

Via this port, the device can be addressed either using the international standard ModBus RTU protocol or SCPI language. The device recognizes the message protocol automatically.

If remote control is in operation the USB port has no priority over a probably installed interface module (see below), the front USB port or the analog interface and can, therefore, only be used alternatively to these. However, monitoring is always available.

1.9.8 Interface module slot

This slot on the rear side of the device can receive various modules of the IF-AB interface series. The table below lists the optionally available interface types.
The modules are installed by the user and can be retrofitted anytime. A firmware update of the device may be necessary in order to recognize and support certain modules.

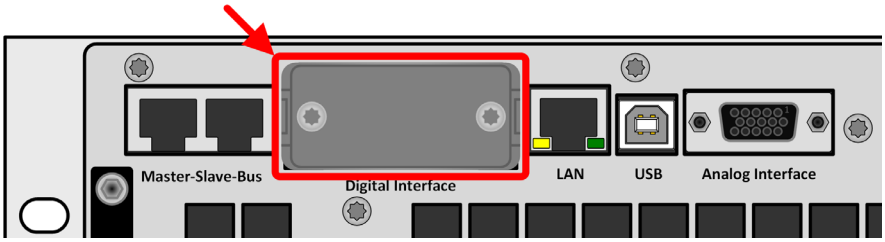


Figure 3 - Interface module slot

Article number	Name	Description/Connectors
35400100	IF-AB-CANO	CANopen, 1x DB9, male
35400101	IF-AB-RS232	RS 232, 1x DB9, male (null modem)
35400103	IF-AB-PBUS	Profibus DP-V1 Slave, 1x DB9, female
35400104	IF-AB-ETH1P	Ethernet, 1x RJ45
35400105	IF-AB-PNET1P	ProfiNET IO, 1x RJ45
35400107	IF-AB-MBUS1P	ModBus TCP, 1x RJ45
35400108	IF-AB-ETH2P	Ethernet, 2x RJ45
35400109	IF-AB-MBUS2P	ModBus TCP, 2x RJ45
35400110	IF-AB-PNET2P	ProfiNET IO, 2x RJ45
35400111	IF-AB-CAN	CAN 2.0 A / 2.0 B, 1x DB9, male
35400112	IF-AB-ECT	EtherCAT, 2x RJ45

The modules can be installed by the user and hence retrofitted anytime. A firmware update of the device may be necessary in order to recognize and support certain modules.

⚠	Switch your device off before adding or removing modules!

1.9.9 Analog interface

This 15-pole Sub-D socket on the back side of the device is provided for remote control of the device via analog or digital signals.

If remote control is in operation this analog interface can only be used alternately to the digital interface. However, monitoring is always available.

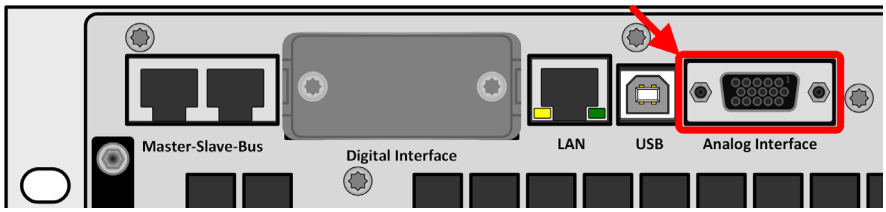


Figure 4 - Analog interface

The input voltage range of the set values and the output voltage range of the monitor values, as well as reference voltage level can be switched with a setting between 0-5 V and 0-10 V, in each case corresponding to 0-100%.

1.9.10 "Share-Bus" connector

The two BNC sockets (50 Ω type) labeled "Share BUS" form a digital, passed-through Share bus. This bus is bidirectional and connects the bus master unit via "Share BUS Output" to the next device ("Share BUS Input") etc., for use in parallel operation (master-auxiliary). BNC cables of suitable length can be obtained from us or electronics stores.

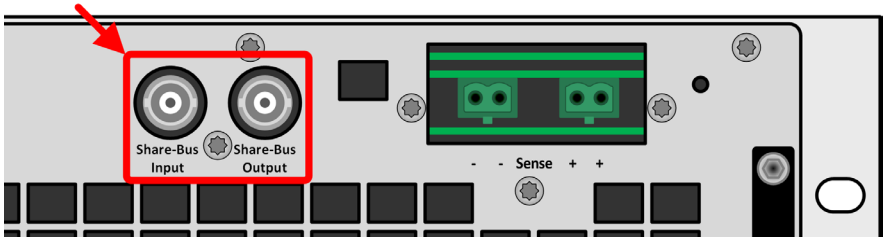


Figure 5 - Share bus

Basically, all 10000 series are compatible on this share bus, though only connection of the same device type, i. e. power supply with power supply or electronic load with electronic load is supported by the devices for master-auxiliary.

For a 10000 6U series device, identical 6U series models can be used as aux units. A 6U device can furthermore be the aux or master of 10000 4U series devices of the same type, meaning power supply or electronic load, and matching rated voltage.

1.9.11 "Sense" connector (remote sensing)

In order to compensate for voltage drops along the DC cables to an external load or source, depending on what is currently connected, the Sense input (2 plugs included in delivery, one each for positive and negative pole) can be connected to the load resp. external source. The maximum possible compensation is given in the technical specifications.

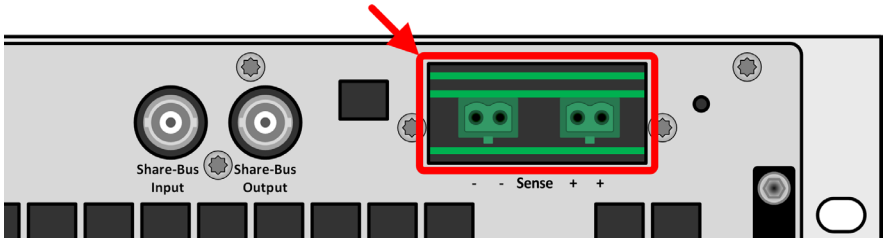


Figure 6 - Remote sensing connectors

	In a master-auxiliary system it's intended to wire remote sensing only to the master which would then forward the compensation to the auxiliary units via Share bus.

	**The Sense cover must be installed during operation, because there can be hazardous voltage on the sense lines! Reconfiguration on the Sense connectors is only permissible if the device is disconnected from AC supply and all DC sources!**

1.9.12 Master-auxiliary bus

There is a further set of connectors on the rear side of the device, comprising two RJ45 sockets, which enables multiple compatible devices to be connected via a digital bus (RS485) in order to create a master-auxiliary system. On the rear side, the sockets would still be labeled in their previous form as "Master-Slave-Bus". Connection is made using standard CAT5 cables.

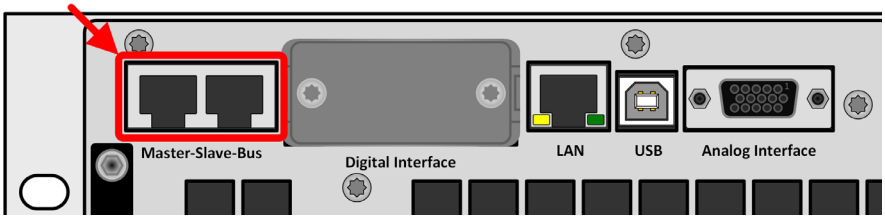


Figure 7 - Master-auxiliary bus ports

It's recommended to keep the connections as short as possible and to terminate the bus as required. The termination is done via digital switches that can be activated by remote control via SCPI or ModBus command, as well as in the Settings app of **EA Power Control**.

1.9.13 Ethernet port

The RJ45 LAN/Ethernet port on the rear side of the device is provided for communication with the device in terms of remote control or monitoring. The user has basically two options of access:

1. A website (HTTP, port 80) which is accessible in a standard browser via the IP or the host name given for the device.

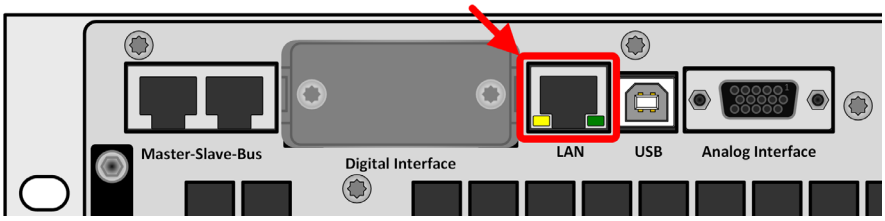


Figure 8 - LAN port

This website offers a configuration page for network parameters, as well as an input box for SCPI commands to control the device remotely by manually entering commands.

2. TCP/IP access via a freely selectable port (except 80 and other reserved ports). The standard port for this device is 5025. Via TCP/IP and the selected port, communication to the device can be established in most of the common programming languages.

Using this LAN port, the device can either be controlled by commands from SCPI or ModBus RTU protocol, while automatically detecting the type of message.

Access via ModBus TCP protocol is only supported by the optionally and separately available ModBus TCP interface module. See *«1.9.8 Interface module slot»*.

The network setup can be done manually or by DHCP. Transmission speed and duplex mode are on automatic mode.

If remote control is in operation the Ethernet port has no priority over any other interface and can, therefore, only be used alternatively to these. However, monitoring is always available.

1.9.14 Water cooling

Models with water cooling are optionally available as a replacement of the default models with air-cooling. This option is built in during the manufacturing process, so retrofitting isn't possible. Cooling the device with water instead of air comes with a few advantages:

- Less ambient noise generated by the device
- Better cooling at higher ambient temperatures
- No direct emission of heat into the ambiance of the device

However, there are also disadvantages:

- The device isn't allowed to run under load without an active water flow
- Water flow inside an electronic device includes a higher risk of damage caused by a leak or by condensation from air humidity, i.e. bedewing

The water taps are located on the rear side of the device, also see the rear view drawing in section *1.8.4*. Details about the connection, requirements and use of the water cooling can be found in section *2.3.4*.

2. Installation & commissioning

2.1 Transport and storage

2.1.1 Transport



- The handles on the front and rear side of the device are **not** for carrying! Their purpose is to move the device in or out of a cabinet slot.
- Because of its weight, transport by hand should be avoided where possible. If unavoidable then only the housing should be held and not on the exterior parts (handles, DC terminal, rotary knobs).
- Do not transport when switched on or connected!
- When relocating the equipment use of the original packing is recommended
- The device should always be carried and mounted horizontally
- Use suitable safety clothing, especially safety shoes, when carrying the equipment, as due to its weight a fall can have serious consequences.

2.1.2 Packaging

It's recommended to keep the complete transport packaging for the lifetime of the device for relocation or return to the manufacturer for repair. Otherwise the packaging should be disposed of in an environmentally friendly way.

2.1.3 Storage

In case of long term storage of the equipment it's recommended to use the original packaging or similar. Storage must be in dry rooms, if possible in sealed packaging, to avoid corrosion, especially internal, through humidity.

2.2 Unpacking and visual check

After every relocation, with or without packaging, or before commissioning, the equipment should be visually inspected for damage and completeness using the delivery note and/or parts list (see section *«1.9.3 Scope of delivery»*). An obviously damaged device (e.g. loose parts inside, damage outside) must under no circumstances be put into operation.

2.3 Installation

2.3.1 Safety procedures before installation and use



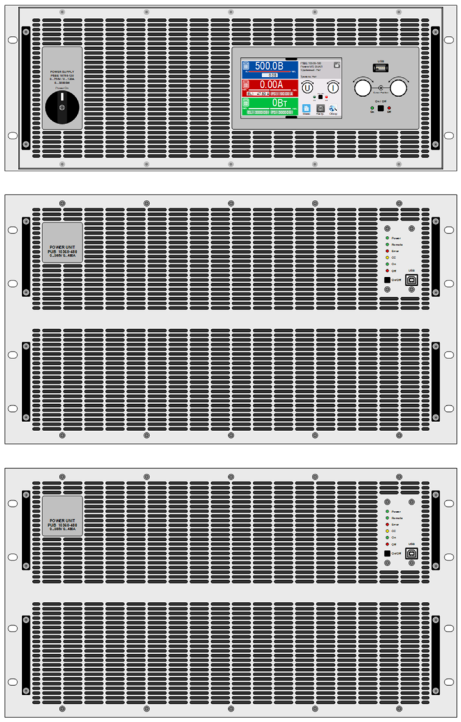
- The device has a considerable weight. Therefore the proposed location of the equipment (table, cabinet, shelf, 19" rack) must be able to support the weight without restriction.
- When using a 19" rack, rails suitable for the width of the housing and the weight of the device are to be used (see *«1.8 Technical Data»*
- Before connecting to the mains, ensure the supply voltage is as shown on the product label. Overvoltage on the AC supply can cause equipment damage.
- Bidirectional devices and electronic loads feature an energy recovery function which, similar to solar energy equipment, feeds energy back into the local or public grid. When feeding back into the public grid, it must not be operated without paying attention to the guidelines from the local energy supplying company and it must be investigated before the installation or at the latest before initial commission, if there is a requirement to install a network & system protection device!

2.3.2 Preparation

2.3.2.1 Planning a master-auxiliary system

Due to the primary use of 10000 series devices in 6U being auxiliary units in a master-auxiliary system, before any further planning of installation and wiring it's recommend to decide how the master-auxiliary system shall be configured. The smallest setup would consist of 1x 10000 series device in 4U/3U/2U, when using a master with display, and 1x 10000 in 6U or 2x 10000 in 6U.

Both, master and aux unit, must be of same rating regarding voltage, ideally also current and power, though it's possible to connect models of different current and power ratings in master-auxiliary, as long as they are all from the 10000 series. There are several possible combinations of standard models and the power units:



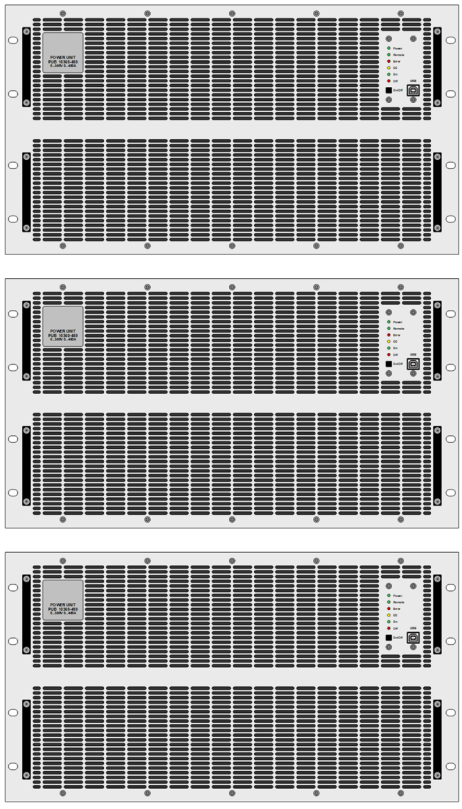
Combination 1:

One 4U master with one or multiple 6U as aux

This is a very comfortable combination, as it allows to have a master which sums up all values on its display. Four of these aux units plus the 4U master with their total height of 28U fit very well into a 38U cabinet/rack.

Advantage of this combination: lower costs compared to a system where all units are with display. The 6U with the double rated power in only 50% more height add an even higher benefit to the system. This type of master features a USB host port which can be used to record data to USB stick or to quickly load profiles or function generator setups aside from remote control.

Disadvantages of this combination: in case the master fails, the entire system can't either work or at least not use the function generator anymore. After reconfiguring any aux unit to be the master, which can be done via software and remote control, the system can continue to operate with reduced features, but without a values display. However, it can of course be controlled remotely via software.



Combination 2:

Multiple 6U

An already existing MS system with 6U device is going to be extended by one or multiple 6U units or a new system is built. One of the usually identical devices is picked to be the master and configured accordingly. This combination has the highest potential of cost saving and is ideal when being part of a bigger system where it's intended to be used via remote control only. Five of these units fit very well into a 42U cabinet/rack.

Advantage of this combination: saves costs and space, packs more power in the same height as combination 1.

Disadvantages of this combination: changing the configuration requires access via a PC, either on the front or rear USB port.

2.3.2.2 Selecting cables

The required AC supply connection for these devices is a fixed connection. It's done via the 4 pole AC terminal on the rear. Wiring of the terminal must be 4 wire (3x L, PE) of suitable cross section. For recommendations for a cable cross section see *«2.3.5 Connection to AC supply»*. Dimensioning of the DC wiring to the load/consumer has to reflect the following:

- The cable cross section should always be specified for at least the maximum current of the device.
- Continuous operation at the approved limit generates heat which must be removed, as well as voltage loss which depends on cable length and heating. To compensate for these the cable cross section should be increased and the cable length reduced.

2.3.2.3 Additional measure for energy recovering devices

Bidirectional devices are so-called recuperating devices, at least when they're working in sink mode. In this mode they feed back a specific amount of energy into the local or public grid. The same applies permanently for electronic loads. Both device types can't sink energy without this functionality. The goal is to consume the recovered energy completely in the local power grid of a company or plant. In case it occurs that more energy is recuperated than consumed, the excess will be fed back into the public grid which usually isn't allowed without further precautions.

The operator of the device must,owing to circumstances, contact the local electric utility and clarify what's allowed and if a so-called network & system protection is required to be installed. There are several different international provisions and standards, such as the German VDE-AR-N 4105/4110 or the British ENA EREC G99 which regulate this situation.

The device itself provides a basic protection and would shut down energy feed back in case it can't work, but a full protection against frequency shift or voltage deviation can only be accomplished by such an NS protection device, which will also prevent isolation operation. We offer NS protection solutions. They already fulfill the German AR-N 4105 and 4410, as well as the Italian CEI 0-21 or the British G59/G98/G99.

Concept of an NS protection system:

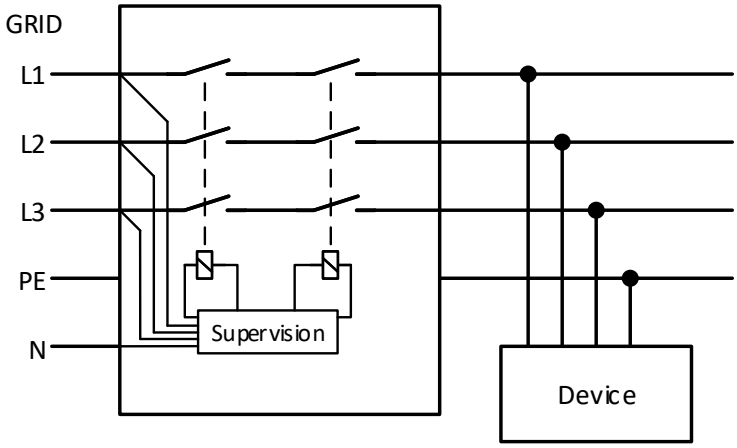


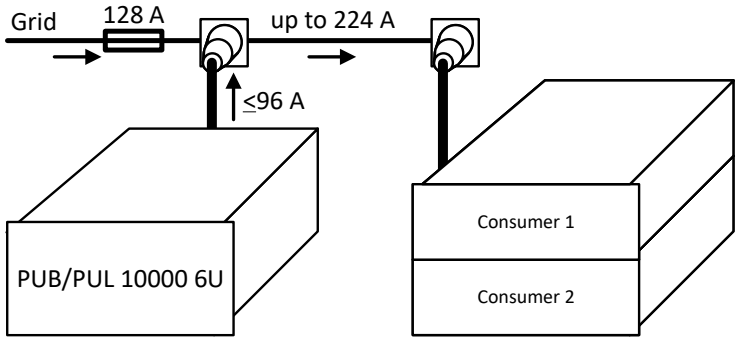
Figure 9 - Principle of an NS protection network

2.3.2.4 Installation concept for energy recovering devices

A bidirectional device working in sink mode or an electronic load recovers energy and feeds it back into the local power grid of a company or big electric plant. The recovered current adds to the grid current (see schematic below) and this can lead to an overload of the existing electric installation. Considering any two outlets, no matter of what type they are, there is usually no extra fusing installed in between. In case of a defect in the AC part (i.e. short-circuit) of any consumer device or when there are multiple devices connected which could take a higher power, the total current could flow across wires which are not laid out for this higher current. It could lead to damage or even fire in the wires or connection points.

In order to avoid damages and accidents, the existing installation concept must be taken into consideration before installing such recovering devices.

Schematic depiction with 1 recovering device and consumers:



When running a higher number of recovering, i. e. energy backfeeding units on the same leg of the installation, the total currents per phase increases accordingly.

2.3.3 Installing the device

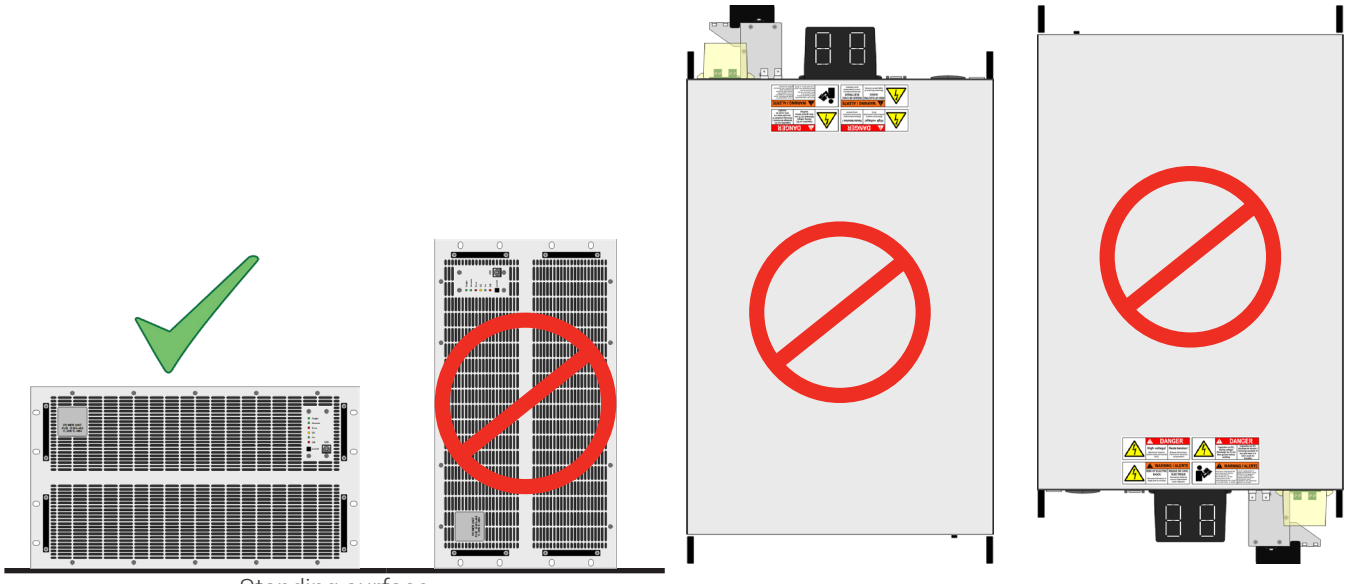
- Select the location for the device so that the connection to the load resp. source is as short as possible.
- Leave sufficient space, at least 30 cm (1 ft), behind the equipment for ventilation (only required for the standard air-cooled version)
- The device must not be operated without a proper touch protection on the AC connector, which is either only accomplished by installation of the device in a 19" rack/cabinet with lockable doors or by applying further measures (additional cover etc.)

All models in this series require to be installed and operated in a closed appliance, such as a cabinet. It's also mandatory to install a rigid AC connection. Open operation on a desk or similar isn't permissible.

A device in a 19" chassis will usually be mounted on suitable rails and installed in 19" racks or cabinets. The depth of the device and its weight must be taken into account. The handles on the front are for sliding in and out of the cabinet. Slots on the front plate are provided for fixing the device (fixing screws not included).

The unacceptable positions, as shown below, are also valid for the vertical mounting of the device onto a wall (room or inside a cabinet). The required air flow would be insufficient.

Acceptable and unacceptable installation positions (air or water cooled, air cooled shown):



2.3.4 Connection to water supply (WC models)

If already available, the water supply should be connected and any further measures related to water cooling installation should be carried out before the AC supply for the device is connected, let alone the unit is powered. Correct installation and connection, test for **watertightness** and later operation remain the sole responsibility of the operator or end user.

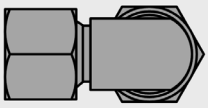
2.3.4.1 Requirements

The water pipe construction is identical with all models in this series but due to the rated current and hence different heat dissipation per minute in the internal cooling block, a model depending requirement to the water and the ambiance must be met:

Model	**360 V to 2000 V**
Internal water flow:	Series
Ambient temperature:	Max. +50 °C (122 °F)
Water intake temperature (min):	See dew point tables below
Water intake temperature (max):	+26 °C (91 °F)
Flow rate:	Min. 7 l/minute (1.85 gal/minute)
Corrosion protection:	Ethylene glycol
Water hardness:	Soft (calcium carbonate < 2 mmol/l)
Water pressure:	Min. 1 bar (14 psi), max. 4 bar (58 psi)

2.3.4.2 Connection point

The device has three separate internal cooling blocks, each with its own water pipe. All pipes are led out and connected outside of the device. The water flows through all three pipes in series. On the rear of the device it has two taps (tee pieces) for water connection:



Tap: 10 mm hose, M19 nut

Which one of the two taps is used for intake and outlet is arbitrary. For later use it's only important to have a sufficient amount of water flowing through the pipes, along with a certain water intake temperature.

The hose connection is either directly done on the tee or end piece, using the metric thread, or by using a hose tail swivel, for example one from company Schwer Fittings, type SA-DKL90. This swivel is already sealing upon mounting, using a 24° metal cone. The hose is required to have an outer diameter of 9 mm to max. 10 mm.

2.3.4.3 Operation and supervision

Once the water cooling is installed and running, there is one primary value left to supervise permanently, the so-called dew point. Depending on the temperature of water at the intake in combination with the humidity of ambient air and also the air inside the device water can condensate, i. e. dew inside the device. This must be avoided under all circumstances! It means, it might be required to have a regulated radiation system in order to react to varying ambient conditions.

The dew point is defined in several norms, for instance DIN 4108. The table below defines the dew point (air humidity to water) **in °C in the upper table** and **in °F in the lower table** at specific ambient temperatures and air humidity levels. The intake water temperature must always be higher than the dew point:

Ambient	**Relative air humidity in per cent**										
	45%	**50%**	**55%**	**60%**	**65%**	**70%**	**75%**	**80%**	**85%**	**90%**	**95%**
14°C	2.2	3.76	5.1	6.4	7.58	8.67	9.7	10.71	11.64	12.55	13.36
15°C	3.12	4.65	6.07	7.36	8.52	9.63	10.7	11.69	12.62	13.52	14.42
16°C	4.07	5.59	6.98	8.29	9.47	10.61	11.68	12.66	13.63	14.58	15.54
17°C	5	6.48	7.92	9.18	10.39	11.48	12.54	13.57	14.5	15.36	16.19
18°C	5.9	7.43	8.83	10.12	11.33	12.44	13.48	14.56	15.41	16.31	17.25
19°C	6.8	8.33	9.75	11.09	12.26	13.37	14.49	15.47	16.4	17.37	18.22
20°C	7.73	9.3	10.72	12	13.22	14.4	15.48	16.46	17.44	18.36	19.18
21°C	8.6	10.22	11.59	12.92	14.21	15.36	16.4	17.44	18.41	19.27	20.19
22°C	9.54	11.16	12.52	13.89	15.19	16.27	17.41	18.42	19.39	20.28	21.22
23°C	10.44	12.02	13.47	14.87	16.04	17.29	18.37	19.37	20.37	21.34	22.23
24°C	11.34	12.93	14.44	15.73	17.06	18.21	19.22	20.33	21.37	22.32	23.18
25°C	12.2	13.83	15.37	16.69	17.99	19.11	20.24	21.35	22.27	23.3	24.22
26°C	13.15	14.84	16.26	17.67	18.9	20.09	21.29	22.32	23.32	24.31	25.16
27°C	14.08	15.68	17.24	18.57	19.83	21.11	22.23	23.31	24.32	25.22	26.1

Ambient	Relative air humidity in per cent										
	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
28°C	14.96	16.61	18.14	19.38	20.86	22.07	23.18	24.28	25.25	26.2	27.18
29°C	15.85	17.58	19.04	20.48	21.83	22.97	24.2	25.23	26.21	27.26	28.18
30°C	16.79	18.44	19.96	21.44	23.71	23.94	25.11	26.1	27.21	28.19	29.09
32°C	18.62	20.28	21.9	23.26	24.65	25.79	27.08	28.24	29.23	30.16	31.17
34°C	20.42	22.19	23.77	25.19	26.54	27.85	28.94	30.09	31.19	32.13	33.11
36°C	22.23	24.08	25.5	27	28.41	29.65	30.88	31.97	33.05	34.23	35.06
38°C	23.97	25.74	27.44	28.87	30.31	31.62	32.78	33.96	35.01	36.05	37.03
40°C	25.79	27.66	29.22	30.81	32.16	33.48	34.69	35.86	36.98	38.05	39.11
45°C	30.29	32.17	33.86	35.38	36.85	38.24	39.54	40.74	41.87	42.97	44.03
50°C	34.76	36.63	38.46	40.09	41.58	42.99	44.33	45.55	46.75	47.9	48.98

Ambient	Relative air humidity in per cent										
	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
58°F	36	38.8	41.2	43.6	45.7	47.7	49.5	51.3	53	54.6	56.1
59°F	37.7	40.4	43	45.3	47.4	49.4	51.3	53.1	54.8	56.4	58
61°F	39.4	42.1	44.6	47	49.1	51.1	53.1	54.8	56.6	58.3	60
63°F	41	43.7	46.3	48.6	50.8	52.7	54.6	56.5	58.1	59.7	61.2
65°F	42.7	45.4	47.9	50.3	52.4	54.4	56.3	58.3	59.8	61.4	63.1
67°F	44.3	47	49.6	52	54.1	56.1	58.1	59.9	61.6	63.3	64.8
68°F	46	48.8	51.3	53.6	55.8	58	59.9	61.7	63.4	65.1	66.6
70°F	47.5	50.4	52.9	55.3	57.6	59.7	61.6	63.4	65.2	66.7	68.4
72°F	49.2	52.1	54.6	57.1	59.4	61.3	63.4	65.2	67	68.6	70.2
74°F	50.8	53.7	56.3	58.8	60.9	63.2	65.1	66.9	68.7	70.5	72.1
76°F	52.5	55.3	58	60.4	62.8	64.8	66.6	68.6	70.5	72.2	73.8
77°F	54	56.9	59.7	62.1	64.4	66.4	68.5	70.5	72.1	74	75.6
79°F	55.7	58.8	61.3	63.9	66.1	68.2	70.4	72.2	74	75.8	77.3
81°F	57.4	60.3	63.1	65.5	67.7	70	72.1	74	75.8	77.4	79
83°F	59	61.9	64.7	66.9	69.6	71.8	73.8	75.8	77.5	79.2	81
85°F	60.6	63.7	66.3	68.9	71.3	73.4	75.6	77.5	79.2	81.1	82.8
86°F	62.3	65.2	68	70.6	74.7	75.1	77.2	79	81	82.8	84.4
90°F	65.6	68.6	71.5	73.9	76.4	78.5	80.8	82.9	84.7	86.3	88.2
94°F	68.8	72	74.8	77.4	79.8	82.2	84.1	86.2	88.2	89.9	91.6
97°F	72.1	75.4	77.9	80.6	83.2	85.4	87.6	89.6	91.5	93.7	95.2
101°F	75.2	78.4	81.4	84	86.6	89	91.1	93.2	95.1	96.9	98.7
104°F	78.5	81.8	84.6	87.5	89.9	92.3	94.5	96.6	98.6	100.5	102.4
113°F	86.6	90	93	95.7	98.4	100.9	103.2	105.4	107.4	109.4	111.3
122°F	94.6	98	101.3	104.2	106.9	109.4	111.8	114	116.2	118.3	120.2

2.3.4.4 Notes

- The water flow should be started prior to powering the device, but at least prior to switching the DC terminal on

2.3.5 Connection to AC supply

- Connection to an AC supply must only be carried out by qualified personnel and the device must always be run directly on a power grid (transformers are permitted) and not on generators or UPS equipment!
- Cable cross section must be suitable for the maximum input current of the device! See tables below.
- According to standard EN 61010-1, the device must be fused externally and the fuse rating must be appropriate to the maximum AC current rating and AC cable cross section
- Ensure that all regulations for the operation of the device and connection to the public grid of energy recovering equipment have been considered and requirements have been met!
- WC models: For safety reasons it's recommended to install a 30 mA RCD for every water-cooled unit (option WC) or at least one per three units
- The devices don't feature a power switch, so they definitely require to be powered by external means, such as a contactor or a main switch or directly at the required external 3-phase circuit breaker
- In a cabinet system with 1 - 5 units per cabinet and when powering all units in the cabinet at once by the external switching installation, very high inrush current can appear. The external switching installation must be capable of these high currents!

2.3.5.1 AC supply requirements

No matter what particular variant the device is, standard or WC, the rated AC supply voltage on the type label is decisive. They all use a regular three-phase supply without N. Specification:

Rated DC power	Inputs on AC terminal	Supply type	Configuration
60 kW	L1, L2, L3, PE	Three-phase (3P)	Delta

The PE conductor is imperative and must always be wired to the AC plug!

2.3.5.2 Cross section

For the selection of a suitable cable cross section**,** the rated AC current of the device and the cable length are decisive. Based on the connection of a **single unit** the table below lists the maximum input current and recommended minimum cross section for each phase. The value to pick also heavily depends on the available cable type. Due to the high AC current of this device series, the cross section is minimum 16 mm² (special cable, e. g. NSGAÖU) or 35 mm² (standard cable):

	L1		L2		L3		PE
Power	**ø**	**I_{max}**	**ø**	**I_{max}**	**ø**	**I_{max}**	**ø**
60 kW at 380/400/480 V	≥16 mm²	112 A	≥16 mm²	112 A	≥16 mm²	112 A	≥16 mm²

2.3.5.3 AC terminal, AC cable and connection

The AC terminal is a screw type and designed for the use of ring or fork cable lugs. The minimum cable requirements are defined in section *2.3.5.2* while the maximum usable cross section depends on the selected lug. The lug itself is restricted to be for M6 and to have a maximum width of 15 mm, due to the AC terminal construction.

The longer the connection cables, the higher the voltage loss due to the cable resistance. Therefore the mains cables should be kept as short as possible or have an even bigger cross section than required. Each of the 4 phases (3x L plus PE) requires a wire.

The included AC terminal cover should be mounted all the time when operating the device. For the strain relief caused by the thick and heavy wires a bracket is already installed on the side of the AC filter box. Cable ties to fix the wire are included in the scope of delivery. See section *«2.3.5.4 Mounting the strain relief»*.

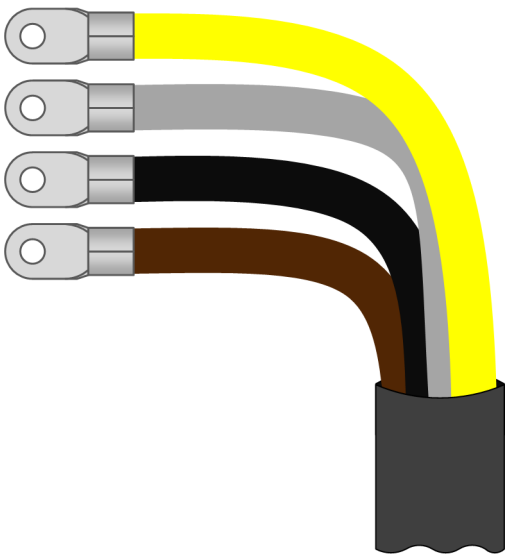


Figure 10 - Example for an AC cable (wire bundling)

2.3.5.4 Mounting the strain relief

All models and variants include a strain relief for the AC cable in their scope of delivery. This strain relief is recommended to be used by the installer, unless a different kind of strain relief is intended and installed. Installation steps:

1. Arrange the wires that go to the AC terminal horizontally and in front of the pre-mounted bracket, as depicted in *Figure 11* below.
2. Fix two wires each with one or two cable ties (recommended).
3. Place AC cover. The required screws are pre-installed on the AC filter enclosure.

In case it becomes necessary to remove the device from the installation place (cabinet or other), the bracket for the strain relief can remain tied to the wires, because it can be dismounted from the side of the AC filter box (4x screw). The rest would be to unscrew the four AC cable ends with the lugs.

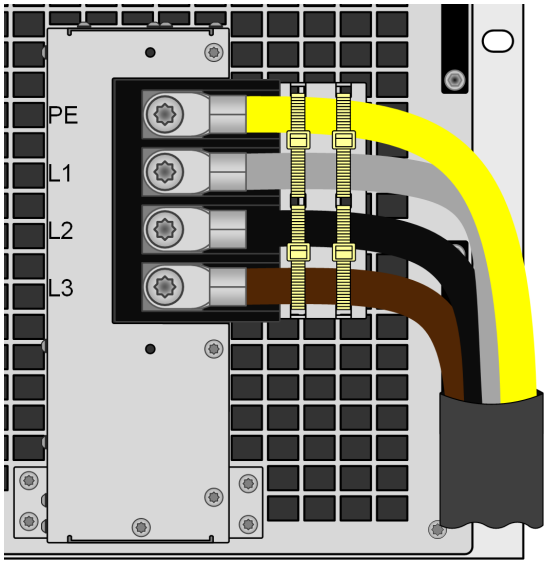


Figure 11 - Fully installed strain relief

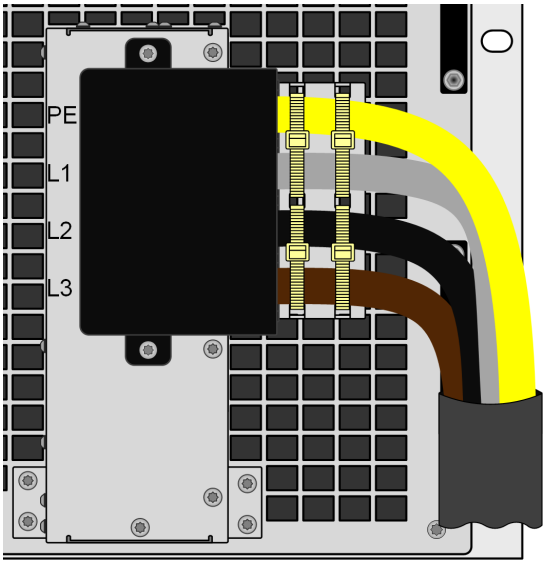


Figure 12 - Complete AC connection

2.3.5.5 Grounding the enclosure

All devices feature a grounding point on the rear plate, as depicted in the figure to the right

For reasons of safety for people working with the device which, amongst other measures, is achieved by keeping the leakage current as low as possible, the enclosure can be grounded here additionally to the AC input grounding. It requires a separate protective earth line (PE), being connected to the grounding point. The cross section of that line must be at least the same as with the ground conductor in the AC supply cables.

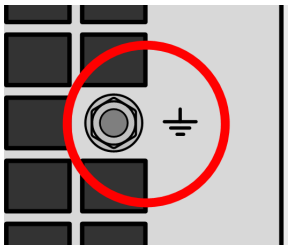


Figure 13 - Grounding point

2.3.6 Connection to DC loads or DC sources

- In case of a model with a high rated DC current and hence thick and heavy DC connection cables it's necessary to take account of the weight of the cables and the strain imposed on the DC connection. Especially when mounted in a 19" cabinet or similar, where the cable could hang on the DC terminal, any kind of strain reliever must be used.
- Apart from the proper cross section of DC cables the proper electric strength (withstand voltage) of the cables must be considered.

No false polarity protection inside! When connecting sources with false polarity the device will be damaged, also when the device isn't powered!

When connected to DC, an external source charges the internal capacities on the DC terminal, even when the device isn't powered. Dangerous voltage levels can be present on the DC terminal, even after disconnection of that external source.

The DC terminal is located on the rear side of the device and **is not** protected by a fuse. The cross section of the connection cable is determined by the current consumption, cable length and ambient temperature.

For cables **up to 5 m (16.4 ft)** and average ambient temperature **up to 30°C (86°F)**, we recommend:

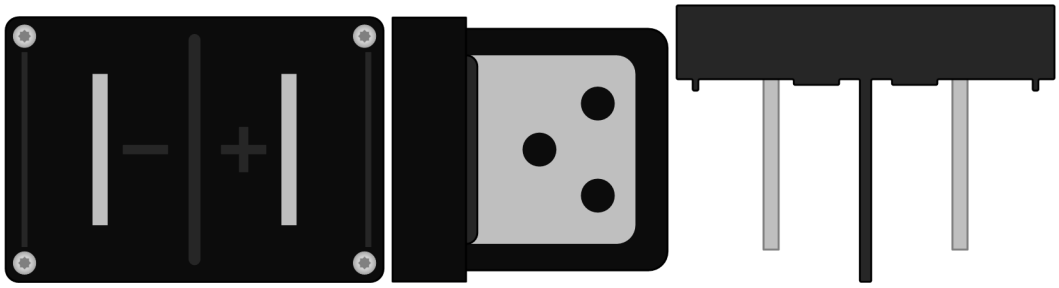
up to **80 A**:	16 mm²	up to **120 A**:	35 mm²
up to **160 A**:	50 mm²	up to **240 A**:	95 mm²
up to **360 A**:	2x70 mm²	up to **480 A**:	2x 95 mm²

per connection pole (multi-conductor, insulated, openly suspended). Single cables of, for example, 70 mm² may be replaced by e.g. 2x 35 mm² etc. If the cables are long then the cross section must be increased to avoid voltage loss and overheating.

2.3.6.1 DC terminal

The table below shows an overview of the various DC terminals. It's recommended that connection of DC cables generally utilizes flexible cables with ring lugs.

All models

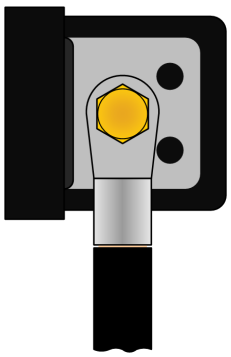


M8 bolt on a metal rail

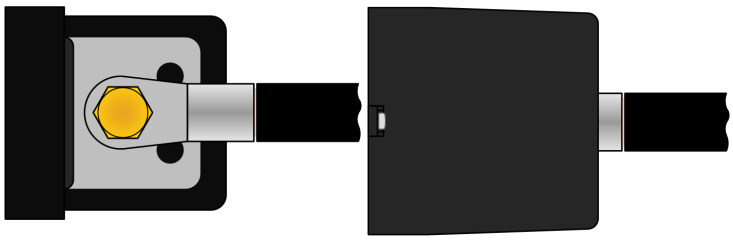
Recommendation: ring lug with a hole for M8 or similar

2.3.6.2 Cable lead and plastic cover

Included in the delivery of the device is a plastic cover for contact protection. It should always be installed. There are break-outs so that the DC cable can be laid in various directions. Examples:



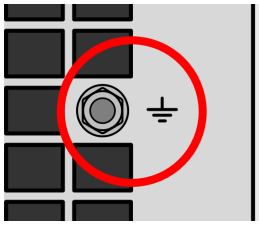
- 90° up or down
- space saving in depth
- no bending radius



- horizontal lead
- space saving in height
- large bending radius

2.3.7 Grounding of the DC terminal

The extra grounding point on the rear plate, as marked in the figure to the right, can be used to ground one of the DC terminal poles. Doing so causes a potential shift on the opposite pole against PE. Due to insulation, the maximum allowed potential shift especially of the negative DC terminal pole is limited and also depends on the device model. Refer to *«1.8.3 Specific technical data»* for the levels.



Both poles on the DC terminal are floating, which is considered as a basic protection in terms of safety of persons. Grounding any DC terminal voids that basic protection.

In case any DC pole is grounded, the operator of the device must reinstate the basic protection for human safety by installing appropriate external means, for instance a cover, everywhere the potential of the DC terminal is connected to.

2.3.8 Connection of remote sensing

- *Remote sensing is only effective during constant voltage operation (CV) and for other control modes the sense input should be disconnected, if possible, because connecting it generally increases the oscillation tendency*
- *The cross section of the sense cables is noncritical. Recommendation for cables up to 5 m (16.4 ft): use at least 0.5 mm²*
- *Sense cables shouldn't be twisted, but laid close to the DC cables, i. e. Sense- cable close to DC- cable to the load etc. to damp or avoid possible oscillation. If necessary, an additional capacitor should be installed at the load/consumer to eliminate oscillation*
- *The Sense+ cable must be connected to DC+ on the load and Sense- to DC- at the load, otherwise the sense input of the power supply can be damaged. For an example see Figure 14 below.*
- *In master-auxiliary operation, the remote sensing should be connected to the master unit only*
- *The dielectric strength of the sense wires must always at least match the DC voltage rating!*

Dangerous voltage possible on the sense connectors! The sense cover must always be installed.

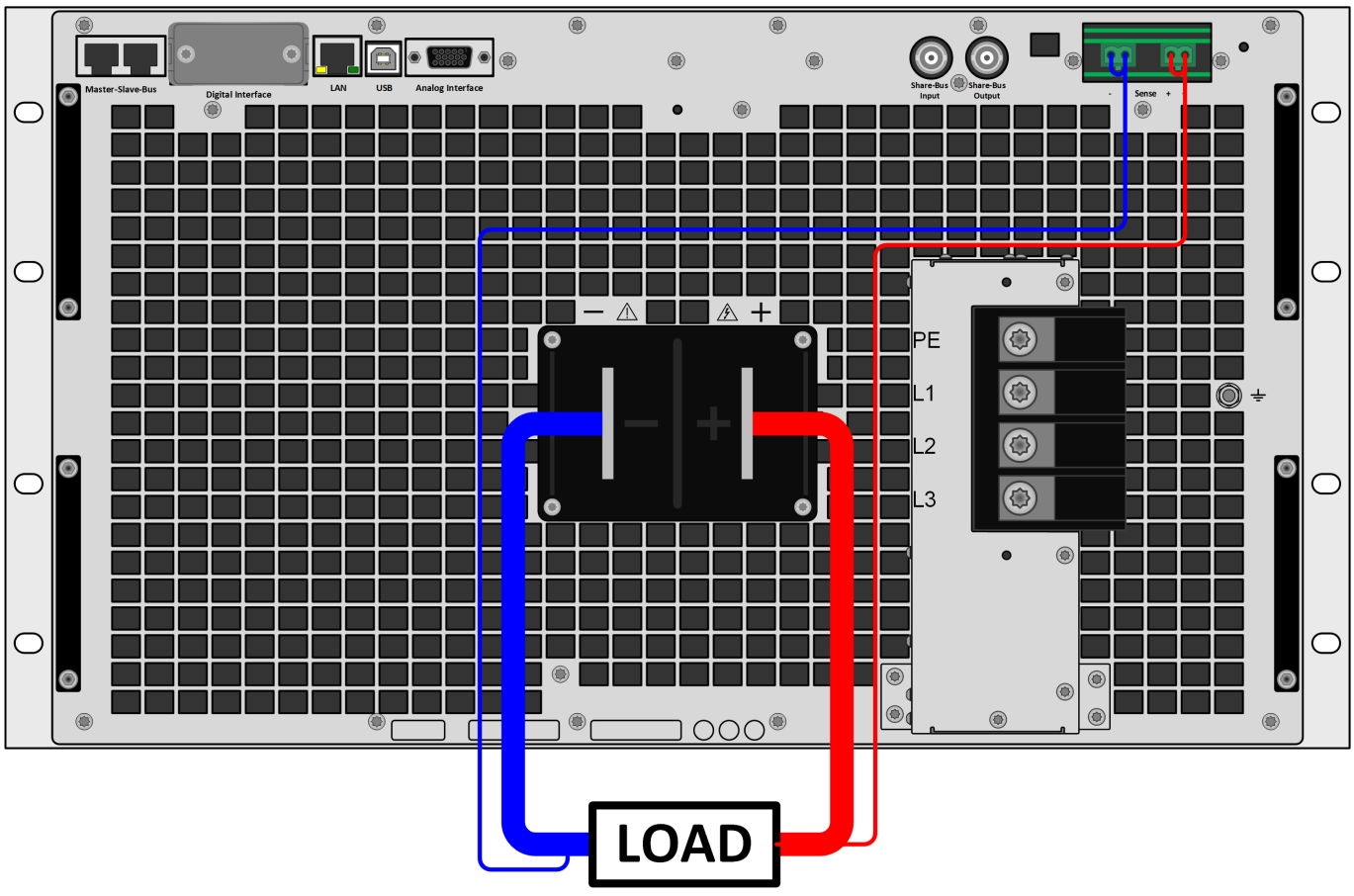
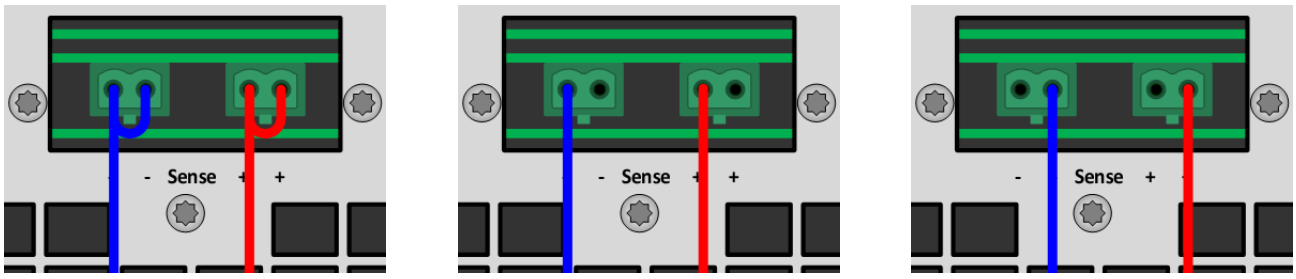


Figure 14 - Example for remote sensing wiring (DC terminal and Sense terminal covers left away for illustrative purposes)

Allowed connection schemes:



2.3.9 Installation of an interface module

The optionally obtainable interface modules can be retrofitted by the user and are exchangeable with each other. The settings for the currently installed module vary and need to be checked and, if necessary, corrected on initial installation and after module exchange.

- Common ESD protection procedures apply when inserting or exchanging a module.
- The device must be switched off before insertion or removal of a module
- Never insert any other hardware other than an interface module into the slot
- If no module is in use it's recommended that the slot cover is mounted in order to avoid internal dirtying of the device and changes in the air flow (models with air-cooling)

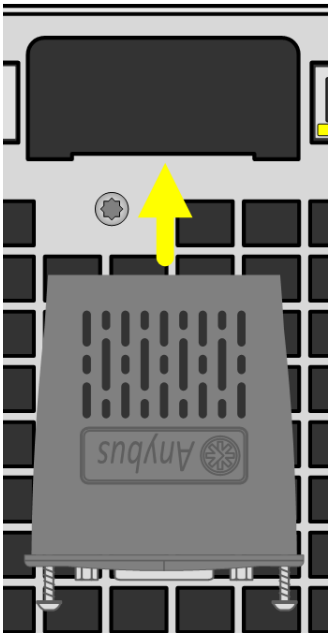
Installation steps:

1.



Remove the slot cover. If needed, use a screw driver.

2.

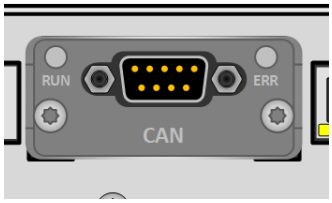


Insert the interface module into the slot. The shape ensures correct alignment.

When inserting take care that it's held as close as possible to a 90° angle to the rear wall of the device. Use the green PCB which you can recognize on the open slot as guide. At the end is a socket for the module.

On the bottom side of the module are two plastic nibs which must click into the green board (PCB) so that the module is properly aligned on the rear wall of the device.

3.



The screws (Torx 8) are provided for fixing the module and should be fully screwed in. After installation, the module is ready for use and can be connected.

Removal follows the reverse procedure. The screws can be used to assist in pulling out the module.

2.3.10 Connection of the analog interface

The 15 pole connector (type: D-sub, VGA) on the rear side is an analog interface. To connect this to a controlling hardware (PC, electronic circuit), a standard plug is necessary (not included in the scope of delivery). It's generally advisable to switch the device completely off before connecting or disconnecting this connector, but at least the DC terminal.

2.3.11 Connection of the Share bus

The "Share BUS" connectors on the rear side (2x BNC type) can be used to connect to the Share bus of further units. The main purpose of the Share bus is to balance the voltage of multiple units in parallel operation, especially when using the integrated function generator of the master unit. For further information about parallel operation refer to section *«2.3.1 Parallel operation in master-auxiliary (MA)»* in the user manual.

For the connection of the share bus the following must be paid attention to:



- Connection is only permitted between compatible devices (see *«1.9.10 "Share-Bus" connector»* for details) and between a max. of 64 units
- The Share bus of this series works in two directions, for source and sink mode. It's compatible to a few other device series, but it requires careful planning of the entire system, if devices are going to be connected which solely work as sink (el. load) or as source (power supply).

2.3.12 Connection of the USB port (rear side)

In order to remotely control the device via any of the two USB port (front and rear), connect the device with a PC using the included USB cable and switch the device on.

2.3.12.1 Driver installation (Windows)

On the initial connection with a PC the operating system will identify the device as new hardware and will try to install a driver. The required driver is for a Communications Device Class (CDC) device and is usually integrated in current operating systems such as Windows 10 or 11. But it's strongly recommended to use and install the included driver installer (on USB stick) to gain maximum compatibility of the device to our softwares.

2.3.12.2 Driver installation (Linux, MacOS)

We can't provide drivers or installation instructions for these operating systems. Whether a suitable driver is available is best carried out by searching the Internet.

2.3.12.3 Alternative drivers

In case the CDC drivers described above are not available on your system, or for some reason do not function correctly, commercial suppliers can help. Search the Internet for suppliers using the keywords "cdc driver windows" or "cdc driver linux" or "cdc driver macos".

2.4 Initial commission

For the first start-up after installation of the device, the following procedures have to be executed:

- Confirm that the connection cables to be used are of a satisfactory cross section!
- Check if the factory settings of set values, safety and monitoring functions and communication are suitable for your intended application of the device and adjust them if required, as described in the manual!
- In case of remote control via PC, read the additional documentation for interfaces and software!
- In case of remote control via the analog interface, read the section in this manual concerning analog interfaces!

2.5 Commission after a firmware update or a long period of non-use

In case of a firmware update, return of the equipment following repair or a location or configuration change, similar measures should be taken to those of initial start up. Refer to *«2.4 Initial commission»*.

Only after successful checking of the device as listed, it may be operated as usual.

3. Operation and application (1)

3.1 Terms

The 10000 series include different device types. One type is bidirectional and it's a combination of a power supply and an electronic load. This type can work alternately in one of two superior operation modes which are distinguished from each other in several parts of this document below:

- **Source / source mode:**
  - the device works as a power supply, generating and providing DC voltage to an external DC load
  - in this mode, the DC terminal is considered as DC output
- **Sink / sink mode:**
  - the device works as an electronic load, sinking DC energy from an external DC source
  - in this mode, the DC terminal is considered as DC input

3.2 Important notes

3.2.1 Personal safety



- In order to guarantee safety when using the device, it's essential that only persons operate the device who are fully acquainted and trained in the required safety measures to be taken when working with dangerous electrical voltages
- For models which can generate a voltage which is dangerous by contact, or are connected to such, the included DC terminal cover or an equivalent must always be used
- Read and follow all safety warnings in section *1.7.1*!

3.2.2 General



- When running the device in source mode, unloaded operation is not considered as a normal operation mode and can therefore lead to false measurements, for example when calibrating the device
- The optimal working point of the device is between 50% and 100% voltage and current
- It's recommended not to run the device below 10% voltage and current, in order to make sure technical values like ripple and transient times can be met

3.3 Alarm conditions



This section only gives an overview about device alarms. What to do in case your device indicates an alarm condition is described in section «3.5 Alarms and monitoring».

Alarm conditions are those coming from the hardware of the device. As a basic principle, all alarm conditions are signaled visually (LED on the front as collection error), as a readable status via the digital interface and as signal on the analog interface (collection error). The indication on the analog interface is by default configured to signal only OT and OVP, but can be adapted. Once a collection error has occurred, the specific alarm can only be acquired via digital interface. For acquisition and statistics of already disappeared alarms, alarm counters can be read via digital interface.

3.3.1 Power Fail

Power Fail (PF) indicates an alarm condition which may have various causes:

- AC input voltage became too low during runtime (mains undervoltage, mains failure)
- Defect in the input circuit (PFC)

As soon as a power fail occurs, the device will stop to supply power and switch the DC terminal off. In case the power fail was due to an undervoltage and disappears later on, the device can automatically continue to work as before. This depends on a setting which is either available in the Settings app of **EA Power Control** under **Other -> DC input/output state after PF alarm** or as ModBus/SCPI command. The default setting would keep the DC terminal switched "Off" and leave the alarm on the front panel for notification.



Powering the device down can't be distinguished from an AC supply blackout and therefore the device will signalize a PF alarm every time it's actually powered down.

3.3.2 Overtemperature

An overtemperature alarm (OT) can occur from an excess temperature inside the device and temporarily causes it to switch the DC terminal off. After cooling down, the device can automatically switch the DC terminal back on. This is determined via a setting that can either be access in the Settings app of **EA Power Control** under **Other -> DC input/output state after OT alarm** or via ModBus/SCPI command.

3.3.3 Overvoltage protection

An overvoltage alarm (OVP) will switch off the DC terminal and can occur if:

- the device itself, when running in source mode, or an external source (in sink mode) supplied a voltage to the DC terminal higher than set for the overvoltage alarm threshold (OVP, 0...110% U_{Nom}) or the connected load somehow returns voltage higher than this threshold
- the OVP threshold has been adjusted too close above the output setting of a power supply device and if the device is in CC control mode and then experiences a negative load step, this will make the voltage rise quickly, resulting in an voltage overshoot for a short moment which can already trigger the OVP

This function serves to warn the user optically via LED “Error” that the device has probably experienced an excessive voltage from outside which could have damaged it.



- The device is not fitted with protection from external overvoltage and could even be damaged when not powered
- The changeover from operation modes CC -> CV in source mode can cause voltage overshoots

3.3.4 Overcurrent protection

An overcurrent alarm (OCP) will switch off the DC terminal and can occur if:

- the current in the DC terminal reaches the adjusted OCP limit.

This function serves to protect the connected load application of a power supply or the external source of an electronic load or bidirectional power supply in sink mode, so it’s not overloaded and possibly damaged due to an excessive current.

3.3.5 Overpower protection

An overpower alarm (OPP) will switch off the DC terminal and can occur if:

- the product of the voltage and current in the DC terminal reaches the adjusted OPP limit.

This function serves to protect the connected load application of a power supply or the external source of an electronic load or bidirectional power supply in sink mode, so it’s not overloaded and possibly damaged due to an excessive power.

3.3.6 Share bus fail

The Share bus fail alarm (short: SF) is related to the physical Share bus (connectors on the rear side of the device) and the condition whether it’s connected to at least one other device or not. The alarm is also related to the configuration of master-auxiliary mode.

Depending on the situation, the Share bus of the involved devices must either be connected or disconnected or else the alarm might occur, preventing to switch the DC terminal on. Should the alarm occur in the middle of normal operation, it would switch the DC terminal off. Possible causes for an SF alarm:

- After powering the device and/or before initializing master-auxiliary operation: see table below
- After master-auxiliary initialization and in the middle of operation: physical defect of the Share bus cable

Possible situations after powering a device or after the configuration has been changed:

Master-auxiliary mode	Share bus cable	Result	Necessary action
off	Disconnected	Normal condition outside of master-auxiliary. Operation unrestricted.	None
off	Connected	SF alarm will occur on every unit connected on the Share bus	Remove the Share bus cable and clear the alarm
Master	Disconnected	No SF alarm on the master. The master will initialize the MS system, but if at least one aux with SF alarm has been detected, this alarm will be signaled on the master, blocking th DC terminal from being switched on.	Connect all devices which are supposed to be in the MS system on the Share bus and initialize the MS system
Master	Connected	There should be no SF alarm, given that only 1 master and x aux units are in the system	None

Master-auxiliary mode	Share bus cable	Result	Necessary action
Auxiliary	Disconnected	SF alarm occurs and can't be cleared. The master would initialize the system, but the system cannot switch DC on, because the aux reports its SF alarm to the master.	Connect all devices which are supposed to be in the MS system on the Share bus and initialize the MS system
Auxiliary	Connected	While booting and later when the master automatically tries to initialize the MS system there should be no SF alarm on all involved devices, given that only 1 master and x aux units are in the system and all have identical firmware versions installed. In case the system is initialized only later on, the aux will signal SF.	None

3.4 Manual operation (1)

3.4.1 Switching the device on

Devices in 6U of height don't feature a power switch or something similar on the device body. The device is solely intended for installation into a rack or cabinet that is either powered by a manual main switch or other switching equipment, such as contactors. It means, that no matter if operated as stand-alone unit or not, there must always be an external power switch.

In case the device is part of a master-auxiliary system, typically installed in a cabinet, then it's common to power all involved units at once via the above mentioned main switch. Depending on the local installation and existing safety devices (RCD etc.), powering multiple units at once could trigger main circuit breakers, RCDs or fuses due to the inrush current. One solution to prevent the fuses from tripping would be to power the single units in the cabinet one by one using the dedicated CB. Another would be to disseminate the units into groups of devices, perhaps 2 or 3, to multiple AC main terminals in the cabinet. In case that the units be powered one by one it's recommended to power the master unit at last.

Once powered, the device indicates the boot phase with LED "Power" on the front being orange. Once it has finished booting and is ready for operation, LED "Power" would change to green.

There is a configurable option which determines the condition of the DC terminal after power-up. Factory setting here is "Off". Changing it to "Restore" will cause the device to restore the DC terminal condition from last switch-off, hence either on or off.

In master-auxiliary operation and when the device is being an auxiliary unit, which is the default mode of operation for models of this series, all values and conditions are stored and restored by the master, overwriting the aux units' settings upon initialization.



For the time of the start phase the analog interface can signal undefined statuses on its digital outputs. This must be ignored until the device has finished booting and is ready to work.

3.4.2 Switching the device off

On switch-off, the last DC terminal condition and the most recent set values are saved. Furthermore, a PF alarm (power failure) will be signaled via LED "Error", but can be ignored.

The DC terminal is immediately switched off and after a short while fans will shut down and after another few seconds the device will be completely powered off.

3.4.3 Switching the DC terminal on or off

As long as the device isn't an auxiliary unit and under remote control by a master unit or by a software via any digital interface, the DC terminal can be manually switched on or off with the pushbutton "On / Off", as located on the front. This is for situations where the device needs to be operated stand-alone or as substitute of a failed or missing master. The same situation also allows for access to all DC terminal related parameters via the front USB port. The button can furthermore be used to acknowledge device alarms signaled by LED "Error".

Configuration of parameters via one of the USB ports, front or rear, is considered as remote control and is thus described in section «*2.2 Remote control*» of the user manual.

3.5 Alarms and monitoring

3.5.1 Definition of terms

There is a clear distinction between device alarms (see *«3.3 Alarm conditions»*), such as overvoltage protection OVP or overheating protection OT, and user defined events such as OVD (overvoltage detection). Whilst device alarms only switch the DC terminal off, user defined events can do more. They would also switch the DC terminal off with setting Action = Alarm, but not with setting **Signal** or **Warning**. The actions driven by user defined events can be selected by remote control, using SCPI commands or ModBus register access. There are also configurable in the Settings app of **EA Power Control**. Following event actions are available:

Action	Impact and signaling
None	User defined event is disabled.
Signal / Warning	There is no distinction between action **Signal** and **Warning** on devices which have no display, thus here they lead to the same reaction. On reaching the condition which triggers the event, the action **Signal** or **Warning** will let the LED "Error" in the front panel light up. This status can't be read via any interface
Alarm	On reaching the condition which triggers the event, the action **Alarm** will let the LED "Error" on the front panel be lit steadily. Furthermore the DC terminal is switched off. The status can be queried via the digital interfaces.

3.5.2 Device alarm and event handling



Important to know:
When switching off the DC terminal of a bidirectional device in sink mode or an electronic load while a current limited source still supplies energy, the output voltage of the source can rise immediately and due to transient times the output voltage can have an overshoot to an unknown level and with a duration of several milliseconds, which might trigger the overvoltage alarm (OVP) or the overvoltage supervision event (OVD) of the 10000 series device in case these thresholds are adjusted to sensitive levels.

A device alarm incident will usually lead to DC terminal switch-off and be indicated via LED "Error" on the front panel and via any of the alarm pins on the analog interface, as well as stored as status readable via digital interfaces. An alarm must always be acknowledged.

► How to acknowledge an alarm on the front panel (during manual control)

1. Press button "On / Off" once to acknowledge. The LED "Error" should go out. This also means that all alarms are cleared and the DC terminal could be switch on by pressing the button a second time. In case the LED doesn't go out, at least one alarm is still present or a new alarm has occurred immediately after pressing the button a second time to switch DC on. This could be due to wrong supervision settings (OVP, OVD etc.).

► How to acknowledge an alarm during digital remote control

1. When using a ModBus based interface by writing a coil, specifically register 411. When using SCPI with the standard error query SYST:ERR:ALL?.

► How to acknowledge an alarm during analog remote control

1. See *«2.2.4.2 Acknowledging device alarms»* in the user manual.

Some device alarms are configurable, separately for source and sink mode:

Short	Long	Description	Range	Indication
OVP	**O**ver**V**oltage **P**rotection	Triggers an alarm as soon as the voltage on the DC terminal reaches the defined threshold. The DC terminal will be switched off.	0 V...1.1*U_{Nom}	LED, analog & digital interfaces
OCP	**O**ver**C**urrent **P**rotection	Triggers an alarm as soon as the current in the DC terminal reaches the defined threshold. The DC terminal will be switched off.	0 A...1.1*I_{Nom}	LED, analog & digital interfaces
OPP	**O**ver**P**ower **P**rotection	Triggers an alarm as soon as the output or input power reaches the defined threshold. The DC terminal will be switched off.	0 W...1.1*P_{Nom}	LED, analog & digital interfaces

These device alarms can't be configured and are based on hardware:

Short	Long	Description	Indication
PF	**P**ower **F**ail	AC supply over- or undervoltage. Triggers an alarm in case the AC supply is out of specification or when the device is cut from AC supply. The DC terminal will be switched off. The condition of the DC terminal after a temporary PF alarm can be determined by the a setting in **EA Power Control** under **Other->DC input/output state after PF alarm** or by direct remote control command (SCPI, ModBus).	LED, analog & digital interfaces
		Acknowledging a PF alarm during runtime can only occur approx. 15 seconds after the cause of the alarm has gone. Switching the DC terminal on again requires approximately another 5 seconds of waiting time.	
OT	**O**ver**Temperature**	Triggers an alarm in case the internal temperature reaches a certain limit. The DC terminal will be switched off. The condition of the DC terminal after cooling down can be determined by a setting in **EA Power Control** under **Other-> DC input/output state after OT alarm** or by direct remote control command (SCPI, ModBus).	LED, analog & digital interfaces
MAP	**M**aster-**A**uxiliary **P**rotection	Triggers an alarm in case the master unit loses contact to any aux unit. The DC terminal will be switched off. The alarm can be cleared by reinitializing the MS system.	LED, digital interfaces
SF	**S**hare Bus **F**ail	Can occur in situations where the Share bus signal is damped too much due to wrong or damaged (short-circuit) BNC cables or simply when at least one of the Share bus connectors is wired to another device while the alarm reporting one isn't configured for master-auxiliary operation. For details also see section *3.3.6*.	LED, digital interfaces

3.5.2.1 User defined events

The monitoring functions of the device can be configured for user defined events. By default, events are deactivated (**Action** set to **None**). Contrary to device alarms, the events only work while the DC terminal is switched on. It means, for instance, that you can't detect undervoltage (UVD) anymore after switching the DC terminal off and the voltage would still be sinking (when using a power supply).

The following events can be configured:

Event	Meaning	Description	Range
UVD	**U**nder**V**oltage **D**etection	Triggers an event if the DC voltage falls below the defined threshold.	0 V...U_{Nom}
OVD	**O**ver**V**oltage **D**etection	Triggers an event if the DC voltage exceeds the defined threshold.	0 V...U_{Nom}
UCD	**U**nder**C**urrent **D**etection	Triggers an event if the DC current falls below the defined threshold.	0 A...I_{Nom}
OCD	**O**ver**C**urrent **D**etection	Triggers an event if the DC current exceeds the defined threshold.	0 A...I_{Nom}
OPD	**O**ver**P**ower **D**etection	Triggers an event if the DC power exceeds the defined threshold.	0 W...P_{Nom}

These events shall not be confused with alarms such as OT and OVP which are for device protection. User defined events can, however, if set to action "Alarm", switch off the DC terminal and thus protect the load, like a sensitive electronic application.

4. Other applications (1)

4.1 Series connection of power supplies



- Besides being able to work as a power supply, a bidirectional device can also work as an electronic load (sink mode). Series connection in sink mode operation isn't supported and must thus not be connected and operated (can void warranty claim)!
- Series connection in source mode operation only at one's own risk!

A series connection of bidirectional power supplies in source mode operation is possible, but requires extra measures to ensure the devices cannot enter sink mode. This is achieved by setting the power and current set values for sink mode to zero.

There is furthermore a technical limit of the achievable total voltage which depends on the strength of insulation of the DC plus and DC minus poles, as given in the technical specifications in section *1.8.3*. These specifications determine how many units with the same or different voltage rating can be operated in series and in case there are different models, it also determines which model can be in what position.

Basic rule: when connecting models with different voltage ratings in series, their current and power ratings are usually also different, which result in a global current and power limit of the series that is defined by the unit with the smallest current or power rating.

4.2 Series connection of electronic loads



Series connection of electronic loads isn't permissible and must thus not be operated! Reason: possible, asymmetrical distribution of the DC input voltage due to different internal control conditions. In worst case and with at least two units being wired in series connection, one unit could have a very low internal resistance and the other a very high one which would cause the one load with the high resistance to "see" almost the full DC input voltage which will most likely damage the DC input stage, as well as insulation.

5. Service and maintenance (1)

5.1 Maintenance / cleaning

The device needs no recurring maintenance. Cleaning may be needed for the internal fans, the frequency of cleaning is dependent on the surroundings. The fans serve to cool the components which are heated by the inherent power loss. Heavily dirt filled fans can lead to insufficient airflow and therefore the DC terminal would switch off too early due to overheating or possibly lead to defects.

In case there is requirement for such a maintenance, please contact us.

5.1.1 Battery replacement

The device contains a Lithium cell battery of type CR2032, which is placed on the so-called KE board that is mounted to the right-hand side wall (when looking from the front) of the device. The battery is specified for a life span of at least 5 years, but due to ambient condition, especially temperature, this span could be lower. The battery is used to buffer the internal real-time clock and if it becomes necessary to replace the battery, it can be done on-site by a qualified person while maintaining typical ESD precautionary measures. The KE board would have to be loosened and lifted up carefully to access the battery.

5.2 Fault finding / diagnosis / repair

If the equipment suddenly behaves in an unexpected way, which indicates a fault, or it has an obvious defect, this can't and must not be repaired by the user. Contact the supplier in case of suspicion and elicit the steps to be taken.

It will then usually be necessary to return the device to the supplier (with or without guarantee). If a return for checking or repair is to be carried out, ensure that:

- the supplier has been contacted and it's clarified how and where the equipment should be sent.
- the device is in fully assembled state and in suitable transport packaging, ideally the original packaging.
- optional extras such as an interface module is included if this is in any way connected to the problem.
- a fault description in as much detail as possible is attached.
- if the shipping destination is abroad, the necessary customs papers are attached.

5.2.1 Trouble-shooting device problems

Problem situation	Possible hazard	Probability	Safety measures to take by the operator	Residual risk
A voltage source with reversed polarity has been connected to the DC terminal	Damage of the internal secondary power stage	Low	With all applications which require to connect an external source to the device, especially if the source is a battery, attach an extra warning sign onto the device which instructs the user to be extra careful, watching the polarity. As an additional measure, include fuses in line with the DC cables which could attenuate or even prevent damage to the device.	Low

6. Contact and support

6.1 Repairs/Technical support

Repairs, unless otherwise agreed between the user and the supplier, will be carried out by the manufacturer. For this purpose, the device must be sent to the manufacturer. In order to ensure a fast and smooth handling of a support request or a repair, we kindly ask you to first visit the support section of our website at **www.elektroautomatik.com/en/service**, and submit your support or repair request by filling out the respective form field ("Support Request" or "Repair Request"). Without this data input, no service request can be initiated.

6.2 Contact options

Questions or problems with the operation of the device, use of optional components, with the documentation or software, can be addressed to technical support either by telephone or e-Mail.

Headquarter	eMail addresses	Telephone
EA Elektro-Automatik GmbH Helmholtzstr. 31-37 41747 Viersen Germany	Technical support: support@elektroautomatik.com All other topics: ea1974@elektroautomatik.com	Switchboard: +49 2162 / 37850 Support: +49 2162 / 378566

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