Elektro-Automatik

Operating Manual

ELR 9000 HP Slave

Electronic DC Load with Energy Recovery

Doc ID: ELR9HSEN
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Date: 09/2018

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1. General

1.1 About this document

1.1.1 Retention and use

This document is to be kept in the vicinity of the equipment for future reference and explanation of the operation of the device. This document is to be delivered and kept with the equipment in case of change of location and/or user.

1.1.2 Copyright

1.1.3 Validity

This manual is valid for the following devices, including derived variants.

Model	Article nr.
ELR 9080-510 HP Slave	33 290 446
ELR 9200-210 HP Slave	33 290 447
ELR 9360-120 HP Slave	33 290 448
ELR 9500-90 HP Slave	33 290 449
ELR 9750-60 HP Slave	33 290 450
ELR 91000-40 HP Slave	33 290 451
ELR 91500-30 HP Slave	33 290 452

1.1.4 Symbols and warnings

Warning and safety notices as well as general notices in this document are shown in a box with a symbol as follows:

	**Symbol for a life threatening danger**
	Symbol for general safety notices (instructions and damage protection bans)
	*Symbol for general notices*

1.2 Warranty

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

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

1.3 Limit 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. EA Elektro-Automatik accepts no liability for losses due to:

- Usage for purposes other than defined
- Use by untrained personnel
- Rebuilding by the customer
- Technical changes
- Use of non 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 EA Elektro-Automatik for scrapping, 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:

1.5 Product key

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

ELR 9 1500 - 30 HP 3U Slave

Slave = Ancillary unit for master-slave operation
3U = 19” rack enclosure with 3 units of height
HP = Higher power (compared to series ELR 9000)
Maximum current of the device in Ampere
Maximum voltage of the device in Volt
Series : **9** = Series 9000
Type identification: **ELR** = Electronic Load with Recovery

1.6 Intended usage

The equipment is intended to be used, if a power supply or battery charger, only as a variable voltage and current source, or, if an electronic load, only as a variable current sink.

Typical application for a power supply is DC supply to any relevant user, for a battery charger the charging of various battery types and for electronic loads the replacement of Ohm resistance by an adjustable DC current sink in order to load relevant voltage and current sources of any type.

- 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.

1.7 Safety

1.7.1 Safety notices

Mortal danger - Hazardous voltage

- **Electrical equipment operation means that some parts will be under dangerous voltage. Therefore all parts under voltage must be covered!**
- **All work on connections must be carried out under zero voltage (input not connected to voltage sources) and may only be performed by qualified and informed persons. Improper actions can cause fatal injury as well as serious material damage.**
- **This electronic load device uses an inverter and in case of a failure the intermediate circuit voltage can be present on the DC input, even if there is no voltage source connected - it is recommended to never touch the metal parts of the DC input terminals with bare hands!**
- **There also can be dangerous potential between negative DC input to PE or positive DC input to PE due to charged X capacitors, especially after disconnecting a source! This potential only discharges very slowly or not at all!**
- **Always follow 5 safety rules when configuring 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**

- The equipment must only be used as intended
- The equipment is only approved for use within the connection limits stated on the product label.
- Do not insert any object, particularly metallic, through the ventilator slots
- Avoid any use of liquids near the equipment. Protect the device from wet, damp and condensation.
- For power supplies and battery chargers: do not connect users, particularly low resistance, to devices under power; sparking may occur which can cause burns as well as damage to the equipment and to the user.
- For electronic loads: do not connect power sources to equipment under power, sparking may occur which can cause burns as well as damage to the equipment and to the source.
- 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 is not necessary to open the device.
- Do not connect external power sources with reversed polarity to DC input or outputs! The equipment will be damaged.
- For power supply devices: avoid where possible connecting external power sources to the DC output, and never those that can generate a higher voltage than the nominal voltage of the device.
- For electronic loads: do not connect a power source to the DC input which can generate a voltage more than 120% of the nominal input voltage of the load. The equipment is not protected against over voltage and may be irreparably damaged.
- Never insert a network cable which is connected to Ethernet or its components into the master-slave socket on the back side of the device!
- Always configure the various protecting features against overcurrent, overpower etc. for sensitive sources to what the currently used application requires

1.7.2 Responsibility of the user

The equipment is in industrial operation. Therefore the operators are governed by the 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
- must use the designated and recommended safety equipment.

Furthermore, anyone working with the equipment is responsible for ensuring that the device is at all times technically fit for use.

1.7.3 Responsibility of the operator

Operator is any natural or legal 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 governed by the 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 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 check 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.

1.7.4 User requirements

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.

Delegated persons are those who have been properly and demonstrably instructed in their tasks and the attendant dangers.

Qualified persons are those 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.

1.7.5 Alarm signals

Alarm conditions, not danger situations, are signalled on the front of this slave device in form of a red LED "**Error**" (also see section *1.8.4*.). Because the models of this series are designed to run as slave units in a master-slave system, the master unit will indicate alarms in its own available ways. Refer to the manual of series ELR 9000 HP for more information about this matter.

The LED collects all of the below listed alarm situations. If there is supervision of the slave units being used, alarms can be decoded by querying a status from the device via any of the two USB ports.

Global meaning of alarm situations as indicated by LED "Error":

Signal **OT** (OverTemperature)	• Overheating of the device • DC input will be switched off • Non-critical
Signal **OVP** (OverVoltage)	• Overvoltage shutdown of the DC input occurs due to high voltage entering the device • Critical! The device and/or the load could be damaged
Signal **OCP** (OverCurrent)	• Shutdown of the DC input due to excess of the preset limit • Non-critical, protects the source from excessive current drain
Signal **OPP** (OverPower)	• Shutdown of the DC input due to excess of the preset limit • Non-critical, protects the source from excessive power drain
Signal **PF** (Power Fail)	• DC input shutdown due to AC undervoltage or defect in the AC input • Critical on overvoltage! AC mains input circuit could be damaged

1.8 Technical data

1.8.1 Approved operating conditions

- Use only inside dry buildings
- Ambient temperature 0-50 °C
- Operational altitude: max. 2000 m above sea level
- Max. 80% relative humidity, non-condensing

1.8.2 General technical data

Indication: 6x colour LEDs

Controls: 1 pushbutton

The nominal values for the device determine the maximum adjustable ranges.

1.8.3 Specific technical data

15 kW	Model Slave			
	ELR 9080-510 HP	ELR 9200-210 HP	ELR 9360-120 HP	ELR 9500-90 HP
AC supply				
Voltage	342...528 V			
Phases	3ph, PE			
Frequency	50/60 Hz ±10%			
Leakage current	< 3.5 mA			
Power factor	> 0.99			
DC Input				
Max. input voltage U_{Max}	80 V	200 V	360 V	500 V
Max. input power P_{Max}	15 kW	15 kW	15 kW	15 kW
Max. input current I_{Max}	510 A	210 A	120 A	90 A
Overvoltage protection range	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}
Overcurrent protection range	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}
Overpower protection range	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}
Max. allowed input voltage	1.2 * U_{Nom}	1.2 * U_{Nom}	1.2 * U_{Nom}	1.2 * U_{Nom}
Min. input voltage for I_{Max}	0.73 V	2.3 V	2.3 V	4.6 V
Input capacitance	ca. 2310 µF	ca. 930 µF	ca. 930 µF	ca. 294 µF
Temperature coefficient for set values Δ / K	Voltage / current: 100 ppm			
Voltage regulation				
Adjustment range	0...81.6 V	0...204 V	0...367.2 V	0...510 V
Stability at ΔI	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Accuracy (1 (@23±5°C / 73±9°F)	< 0.1% U_{Max}	< 0.1% U_{Max}	< 0.1% U_{Max}	< 0.1% U_{Max}
Remote sensing compensation	max. 5% U_{Max}			
Current regulation				
Adjustment range	0...520.2 A	0...214.2 A	0...122.4 A	0...91.8 A
Stability at ΔU	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}
Accuracy (1 (@23±5°C / 73±9°F)	< 0.2% I_{Max}	< 0.2% I_{Max}	< 0.2% I_{Max}	< 0.2% I_{Max}
Compensation 10-90% ΔU_{DC}	< 0.6 ms	< 0.6 ms	< 0.6 ms	< 0.6 ms
Power regulation				
Adjustment range	0…15300 W	0…15300 W	0…15300 W	0…15300 W
Stability at ΔI / ΔU	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}
Accuracy (1 (@23±5°C / 73±9°F)	< 1% P_{Max}	< 1% P_{Max}	< 1% P_{Max}	< 1% P_{Max}
Efficiency (2	≤ 92.5%	≤ 93.5%	≤ 93.5%	≤ 94.5%
Resistance regulation				
Adjustment range	0.006…10 Ω	0.033…50 Ω	0.1...180 Ω	0.16…340 Ω
Accuracy (@23±5°C / 73±9°F)	≤1% of max. resistance ± 0.3% of rated current			
Insulation	Allowed potential shift (floating voltage) on the DC input:			
Input (DC) to enclosure	±400 V DC	±725 V DC	±725 V DC	±1500 V DC
Input (AC) to input (DC)	±400 V DC	±1000 V DC	±1000 V DC	±1800 V DC
Input (AC) <-> PE	2.5 kV DC			
Input (AC) <-> Input DC)	2.5 kV DC			

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted value and the true (actual) value on the DC input.
Example: the 510 A model has min. 0.2% current accuracy, that calculates as 1.2 A. When adjusting the current to 500 A, the actual current on the DC input is allowed to differ by a maximum of 1.2 A, which means it may be between 498.8 A and 501.2 A.
(2 Typical value at 100% input voltage and 100% power

15 kW	Model Slave			
	ELR 9080-510 HP	ELR 9200-210 HP	ELR 9360-120 HP	ELR 9500-90 HP
Environment				
Cooling	Temperature controlled fans, front inlet, rear exhaust			
Ambient temperature	0..50 °C (32...122°F)			
Storage temperature	-20...70 °C (-4...158°F)			
Humidity	< 80%, not condensing			
Miscellaneous				
Overvoltage category	2			
Protection class	1			
Pollution degree	2			
Operational altitude	< 2000 m (1.242 mi)			
Standards	EN 61010-1:2011-07, EN 50160:2011-02 (grid class 2), EN 61000-6-2:2016-05, EN 61000-6-3:2011-09 (radiation class B)			
Digital interfaces				
Featured	1x USB (front side) for quick value setup 1x USB (rear side) for communication and service			
Galvanic isolation to the device	Max. 1500 V DC			
Terminals				
Rear side	Share Bus, DC input, AC input, remote sensing, USB, master-slave bus			
Front side	USB			
Dimensions				
Enclosure (WxHxD)	19“ x 3U x 668 mm (26.3”)			
Total (WxHxD)	483 mm x 133 mm x 775 mm (19” x 5.2” x 30.5”)			
Weight	~32 kg (70.5 lb)	~32 kg (70.5 lb)	~32 kg (70.5 lb)	~32 kg (70.5 lb)
Article number	33290446	33290447	33290448	33290449

15 kW	Model Slave		
	ELR 9750-60 HP	ELR 91000-40 HP	ELR 91500-30 HP
AC supply			
Voltage	342...528 V		
Phases	3ph, PE		
Frequency	50/60 Hz ±10%		
Leakage current	< 3.5 mA		
Power factor	> 0.99		
DC Input			
Max. input voltage U_{Max}	750 V	1080 V	1500 V
Max. input power P_{Max}	15 kW	15 kW	15 kW
Max. input current I_{Max}	60 A	40 A	30 A
Overvoltage protection range	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}
Overcurrent protection range	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}
Overpower protection range	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}
Max. allowed input voltage	1.2 * U_{Nom}	1.2 * U_{Nom}	1.2 * U_{Nom}
Min. input voltage for I_{Max}	6.9 V	6.9 V	9.2 V
Input capacitance	ca. 180 µF	ca. 310 µF	ca. 33 µF
Temperature coefficient for set values Δ / K	Voltage / current: 100 ppm		
Voltage regulation			
Adjustment range	0...765 V	0...1101.6 V	0...1530 V
Stability at ΔI	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Accuracy (1 (@23±5°C / 73±9°F)	< 0.1% U_{Max}	< 0.1% U_{Max}	< 0.1% U_{Max}
Remote sensing compensation	max. 5% U_{Max}		
Current regulation			
Adjustment range	0...61.2 A	0...40.8 A	0...30.6 A
Stability at ΔU	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}
Accuracy (1 (@23±5°C / 73±9°F)	< 0.2% I_{Max}	< 0.2% I_{Max}	< 0.2% I_{Max}
Compensation 10-90% ΔU_{DC}	< 0.6 ms	< 0.6 ms	< 0.6 ms
Power regulation			
Adjustment range	0…15300 W	0…15300 W	0…15300 W
Stability at ΔI / ΔU	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}
Accuracy (1 (@23±5°C / 73±9°F)	< 1% P_{Max}	< 1% P_{Max}	< 1% P_{Max}
Efficiency (2	≤ 94.5%	≤ 93.5%	≤ 94.5%
Resistance regulation			
Adjustment range	0.4…740 Ω	0.8...1300 Ω	2.5…3000 Ω
Accuracy (@23±5°C / 73±9°F)	≤1% of max. resistance ± 0.3% of rated current		
Insulation	Allowed potential shift (floating voltage) on the DC input:		
Input (DC) to enclosure	±1500 V DC	±1500 V DC	±1500 V DC
Input (AC) to input (DC)	±1800 V DC	±1800 V DC	±1800 V DC
Input (AC) <-> PE	2.5 kV DC		
Input (AC) <-> Input DC)	2.5 kV DC		

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted value and the true (actual) value on the DC input.
Example: the 510 A model has min. 0.2% current accuracy, that calculates as 1.2 A. When adjusting the current to 500 A, the actual current on the DC input is allowed to differ by a maximum of 1.2 A, which means it may be between 498.8 A and 501.2 A.
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15 kW	Model Slave		
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Environment			
Cooling	Temperature controlled fans, front inlet, rear exhaust		
Ambient temperature	0..50 °C (32...122°F)		
Storage temperature	-20...70 °C (-4...158°F)		
Humidity	< 80%, not condensing		
Miscellaneous			
Overvoltage category	2		
Protection class	1		
Pollution degree	2		
Operational altitude	< 2000 m (1.242 mi)		
Standards	EN 61010-1:2011-07, EN 50160:2011-02 (grid class 2), EN 61000-6-2:2016-05, EN 61000-6-3:2011-09 (radiation class B)		
Digital interfaces			
Featured	1x USB (front side) for quick value setup 1x USB (rear side) for communication and service		
Galvanic isolation to the device	Max. 1500 V DC		
Terminals			
Rear side	Share Bus, DC input, AC input, remote sensing, USB, master-slave bus		
Front side	USB		
Dimensions			
Enclosure (WxHxD)	19“ x 3U x 669 mm (26.3”)		
Total (WxHxD)	483 mm x 133 mm x 775 mm (19” x 5.2” x 30.5”)		
Weight	~32 kg (70.5 lb)	~32 kg (70.5 lb)	~32 kg (70.5 lb)
Article number	33290450	33290451	33290452

1.8.4 Views

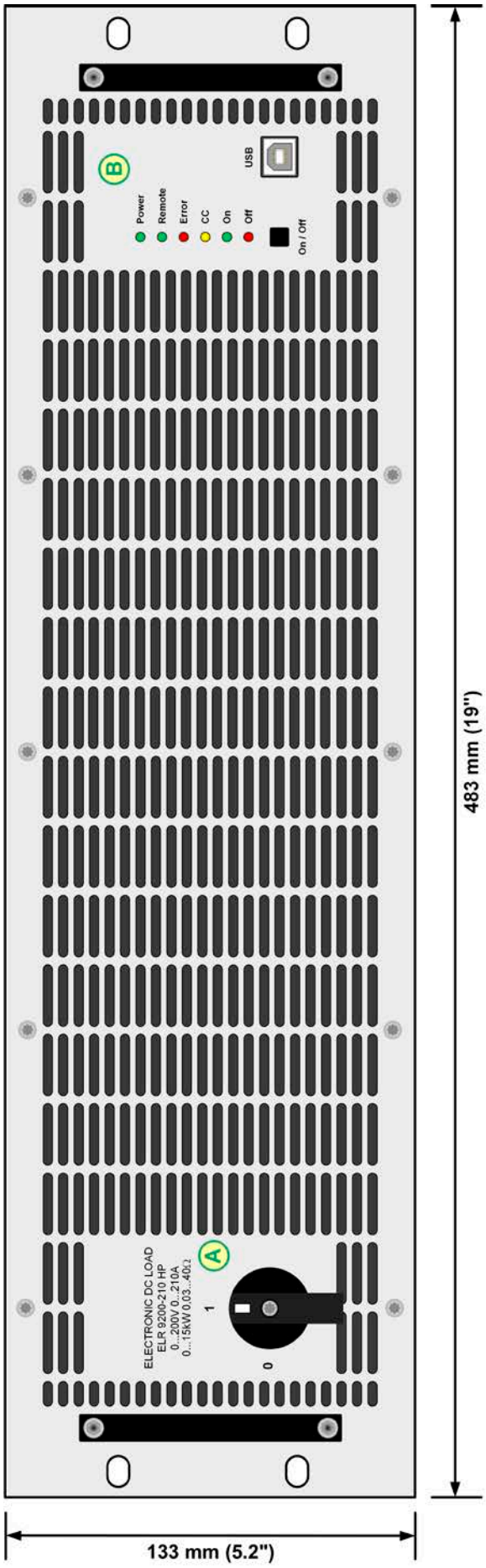


Figure 1 - Front view

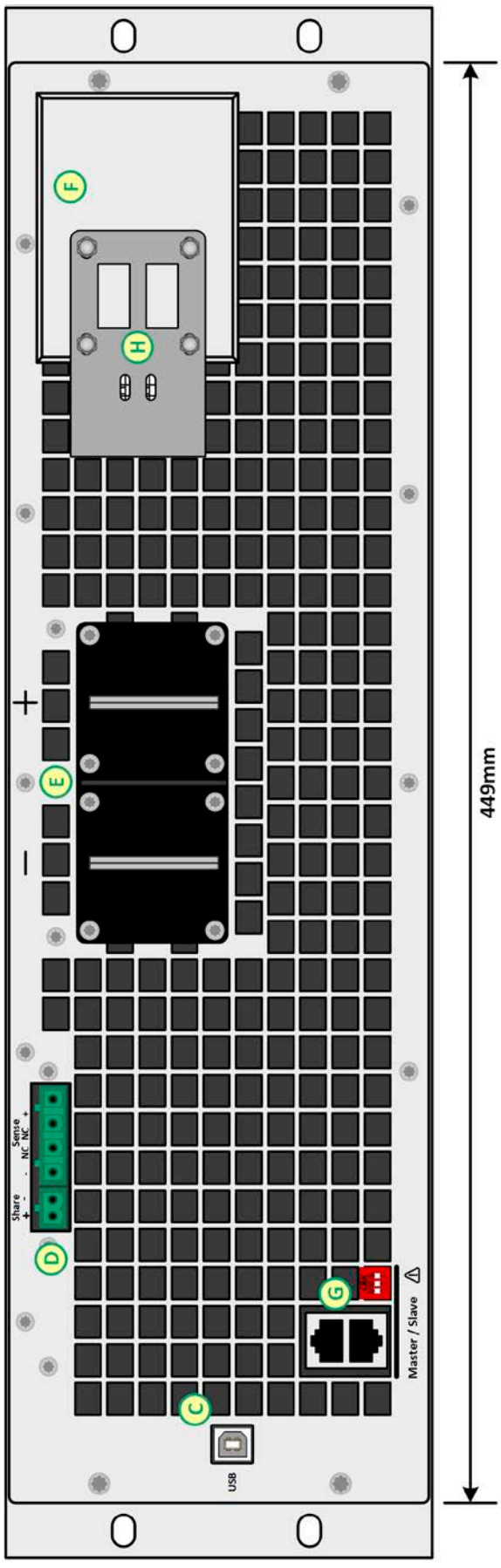


Figure 2 - Rear view

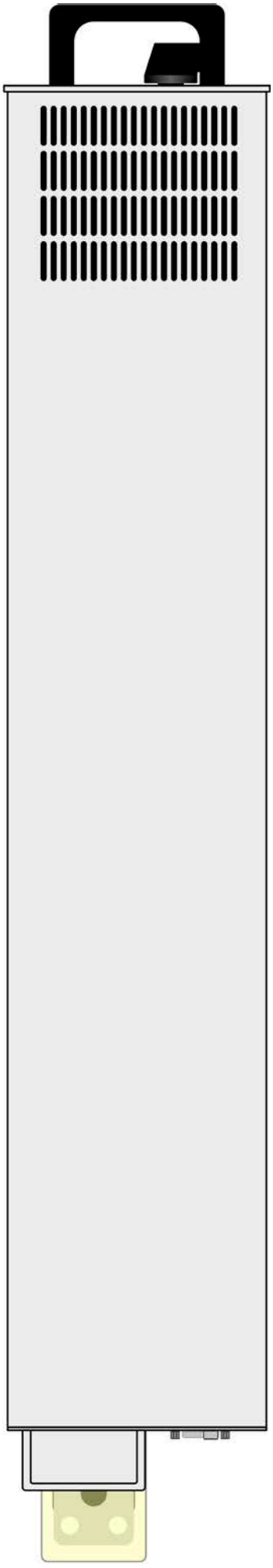


Figure 3 - Left-hand view

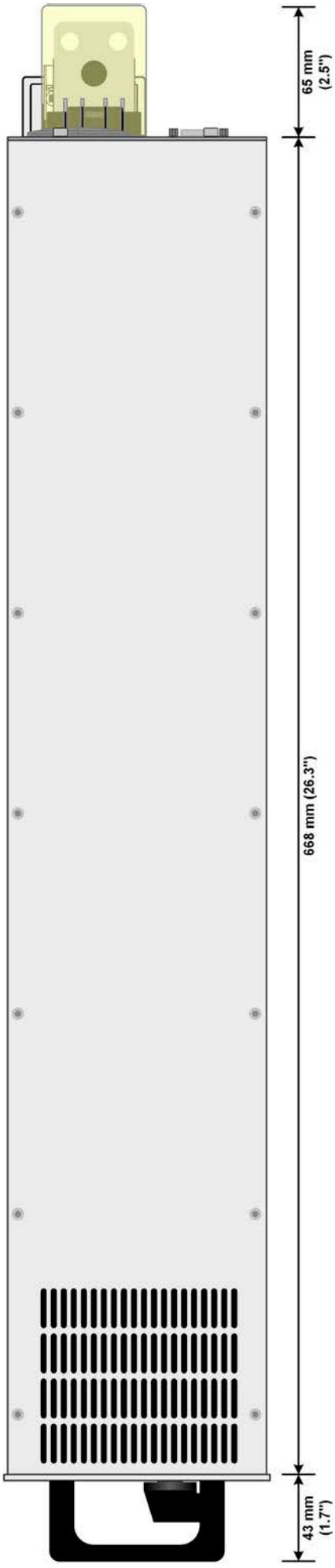


Figure 4 - Right-hand view

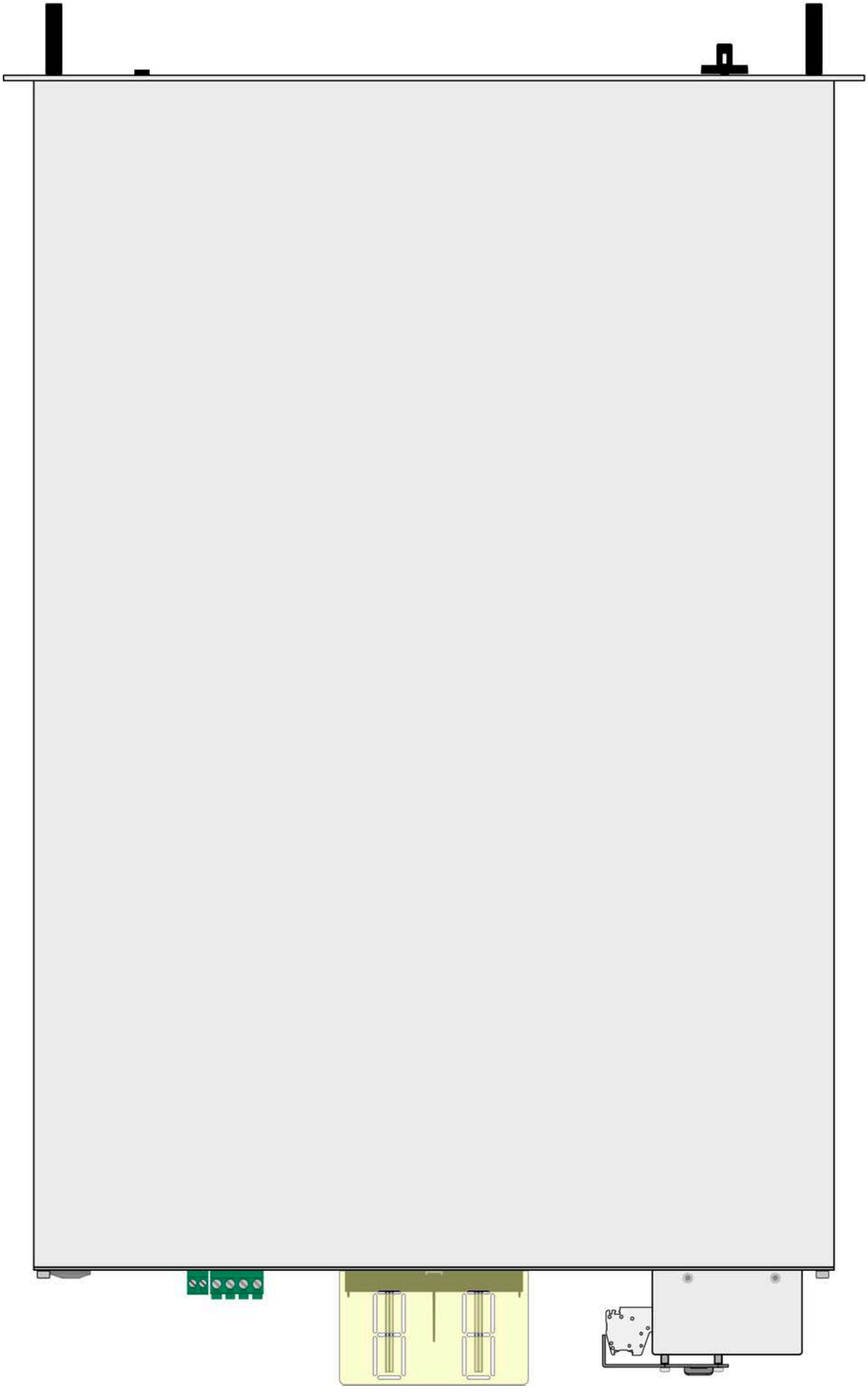


Figure 5 - Top view

1.8.5 Control elements

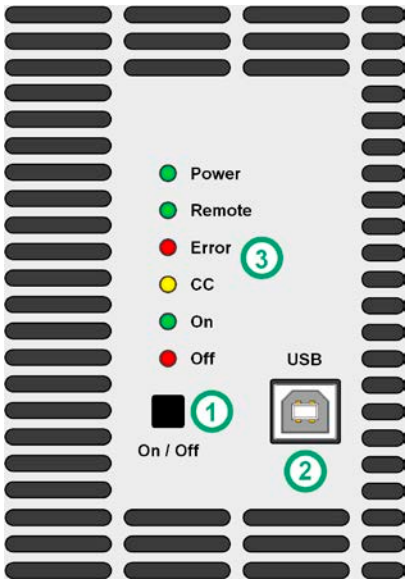


Figure 6 - Control Panel

Overview of the elements of the control panel

For a detailed description see section *„1.9.4. The control panel (HMI)“.*

(1)	**On/Off button** Can be used to switch the DC input on or off during manual operation, while LED “Remote” = off
(2)	**USB port** For quick and easy access to the most important DC input related values when the device is not in master-slave mode. This port has reduced functionality compared to the rear port.
(3)	**Status indicators (LED)** These six color LEDs show the device status. For details refer to *1.9.4*.

1.9 Construction and function

1.9.1 General description

The electronic loads of the ELR 9000 HP Slave are designed to extend the power of compatible models from series ELR 9000 HP. The slave models are reduced to basic functions and will usually run in remote control from a master of a master-slave system. They can be added and connected to existing devices of series ELR 9000 HP or ELR 9000 HP 15/24U.

By default, the devices have an USB port on the rear side which serves various purposes, such as servicing (firmware updates), monitoring during master-slave operation or even remote control when the unit is being used in stand-alone operation.

The additional USB port on the front side is used for quick access to all the DC input related parameters and settings. The configuration via this port can be done with the included software **EA Power Control** (on USB stick) or via any custom made control application.

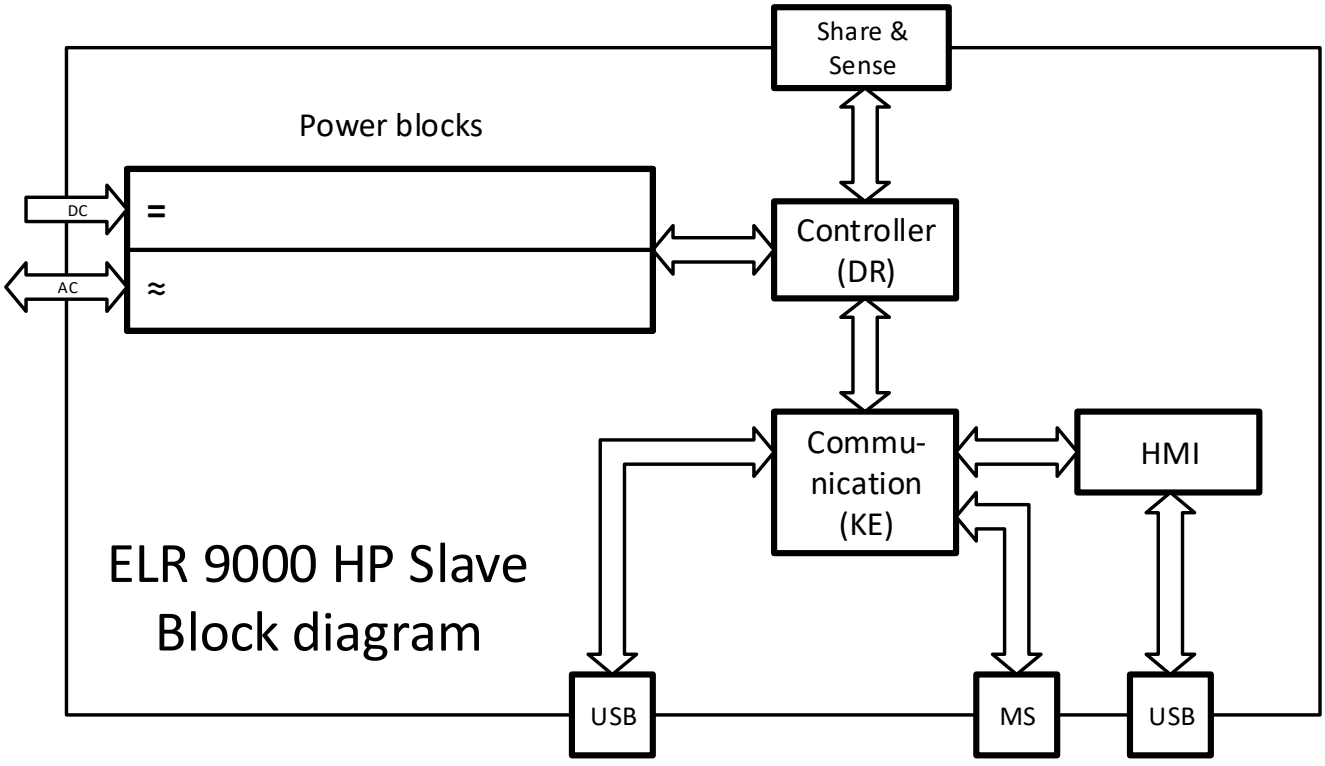
The devices offer as standard the possibility for parallel connection in Share bus operation to achieve a constant current sharing, plus a genuine master-slave connection with totalling of the slave units' values. This kind of operation allows for up to 16 units to be combined to a single system with a total power of up to 240 kW.

All models are controlled by three microprocessors. These enable an exact and fast measurement and display of actual values.

1.9.2 Block diagram

The 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.



1.9.3 Scope of delivery

1 x Electronic load device

1 x Share Bus plug

1 x Remote sensing plug

1 x 1.8 m USB cable

1 x Set of DC terminal cover(s)

1 x Share/Sense terminal cover (only models from 750 V)

1 x USB stick with documentation and software

1 x AC connector plug (clamp type)

1 x Set for strain relief (premounted)

1.9.4 The control panel (HMI)

The HMI (**H**uman **M**achine **I**nterface) consists of six coloured LEDs, a pushbutton and an USB-B port.

1.9.4.1 Status indicators (LED)

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

LED	Colour	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 or any of the USB ports 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 can signalise all alarms as listed in *„3.6. Alarms and monitoring“.*
CC	yellow	Constant current regulation (CC) is active. It means, if the LED is not lit it indicates either CV, CP or CR mode. Also see *„3.2. Operating modes“.*
On	green	DC input is switched on
Off	red	DC input is switched off

1.9.4.2 USB port

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

1. The ELR 9000 HP Slave shall run as stand-alone device which is not controlled by a ELR 9000 HP master.
2. The ELR 9000 HP Slave shall, due to the lack of a suitable ELR 9000 HP master device, be the master of other ELR 9000 HP Slave devices.

Both situations are only secondary, as the primary and normal function of a ELR 9000 HP Slave is to be a slave in a master-slave system where it is assigned all required settings and values from the master.

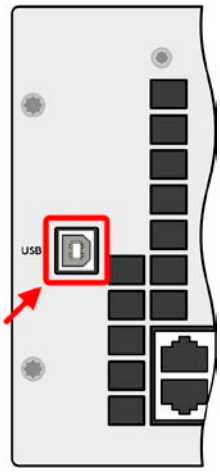
When running any of the above listed situations following applies for the USB port:

- Reduced instruction set for master-slave configuration, DC input values (U, I, P, R) and protections (OVP, OCP, OPP). For details about the instruction set see *„3.5. Remote control“.*
- Taking over remote control in order to change the configuration is only possible while the unit is not online with the master, which either requires to temporarily deactivate master-slave on the master or to switch the master off

1.9.4.3 Pushbutton “On / Off”

This button can be used to switch the DC input on or off during manual control, i.e. the device is not in remote control by a master or via any of the USB ports (LED “Remote” = off). Once pushed to switch the DC input on, the device would regulate the DC input to the last values it has stored. Since these values are not displayed, operating that button has to be done with caution.

1.9.5 USB port type B (rear side)

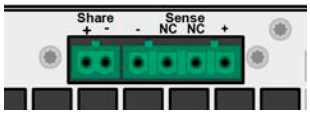


The USB-B port on the rear side of the device is provided for communication with the device, i.e. monitoring during master-slave operation or full remote control in stand-alone operation, as well as for firmware updates. The included USB cable can be used to connect the device to a PC (USB 2.0 or 3.0). 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.

The device can be addressed via this port either using the international standard ModBus protocol or by SCPI language. The device recognises the message protocol automatically.

This USB port has no priority over either the other USB port on the front or remote control from a master unit and can, therefore, only be used for remote control alternatively to these. However, monitoring is always available.

1.9.6 Share connector

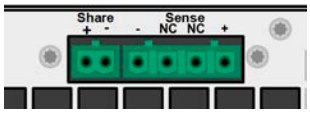


The 2 pole socket (“Share”) on the back side of the device is provided for connection to equally named sockets on compatible electronic loads when establishing parallel connection where symmetric current distribution is required, as well as compatible power supplies to build a two-quadrants operation setup. For details about this feature refer to *„3.7.1. Parallel operation in master-slave (MS)“* and *„3.7.3. Two quadrants operation (2QO)“*. Following power supply and electronic load series are compatible:

- PSI 9000 2U - 24U / PSI 9000 3U Slave
- ELR 9000 / ELR 9000 HP / ELR 9000 HP Slave
- EL 9000 B 3U - 24U / EL 9000 B HP / EL 9000 B 2Q
- PSE 9000
- PS 9000 1U / 2U / 3U *

* From hardware revision 2, see type label (in case it does not show “Revision” on type label, it is revision 1)

1.9.7 Sense connector (remote sensing)



The devices of series ELR 9000 HP Slave are supposed to run as slave units in a master-slave system where the remote sensing feature is only used and connected to the master unit. For stand-alone operation outside of a master-slave setup this feature can be wired and used on the Slave mode as well.

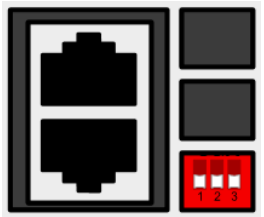
In order to compensate for voltage drops along the DC cables from the source, the Sense input can be connected to the source. The maximum possible compensation is given in the technical data.

1.9.7.1 Restrictions

Remote sensing is only intended for constant voltage (CV) operation and it is recommended to have the “**Sense**” input only connected to the source when running the load in CV mode. Primarily in other regulation modes, but also in CV, the sense cables can cause unwanted side effects, like oscillation, based on their length and inductance. Also see *3.2.5*.

⚠	In order to ensure safety and to comply to international directives, insulation of high voltage models, i. e. such with a nominal voltage of 500 V or higher, is ensured by using only the two outer pins of the 4-pole terminal. The inner two pins, marked with NC, must remain unconnected.

1.9.8 Master-Slave bus



A further port is provided on the rear side of the device, comprising two RJ45 sockets, which enables multiple identical devices to be connected via a digital bus (RS485) to create a master-slave system. For a ELR 9000 HP Slave device this interface is essential, because it is configured and controlled regarding values and status via this port by a master unit.

Connection is made using standard CAT5 cables. These can theoretically have a length of up to 1200 m, but it is recommended to keep the connections as short as possible.

2. Installation & commissioning

2.1 Transport and storage

2.1.1 Transport

- The handles on the front side of the device are **not** for carrying!
- 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 input terminal, rotary knobs).
- Do not transport when switched on or connected!
- When relocating the device 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 device, as due to its weight a fall can have serious consequences.

2.1.2 Packaging

It is recommended to keep the complete transport packaging for the lifetime of the device for relocation or return to Elektro-Automatik 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 device it is 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 transport, with or without packaging, or before commissioning, the device 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 in operation.

2.3 Installation

2.3.1 Safety procedures before installation and use

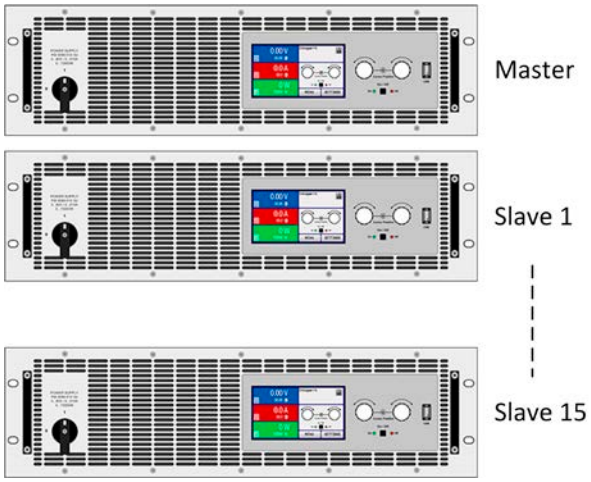
- The device may, depending on the model, have a considerable weight. Therefore the proposed location of the device (table, cabinet, shelf, 19” rack) must be able to support the weight without restriction.
- When using a 19” rack, rails suitable for the width of the housing and the weight of the device are to be used. (see *„1.8.3. Specific technical data“*).
- Before connecting to the mains ensure that the supply voltage is as shown on the product label. Overvoltage on the AC supply can cause device damage.
- For electronic loads: Before connecting a voltage source to the DC input make sure, that the source can not generate a voltage higher than specified for a particular model or install measures which can prevent damaging the device by overvoltage input.
- For energy recovering electronic loads: Before connecting the AC input/output to a public grid, it is essential to find out if the operation of this device is allowed at the target location and if it is required to install supervision hardware, i.e. automatic isolation unit (AIU, ENS).

2.3.2 Preparation

2.3.2.1 Planning the master-slave system

Before any further planning of installation and wiring it's recommend to decide how the master-slave system shall be configured. The smallest setup would consist of 1x ELR 9000 HP and 1x ELR 9000 HP Slave. Both, master and slave unit, must be of same rating regarding voltage, current and power. Because the ELR 9000 HP Slave models are only available with 15 kW power, they will only match the corresponding models of ELR 9000 HP series. "Match" is here related to the use of the master-slave bus, which wouldn't accept different models. It means, that paralleling an ELR 9080-170 HP with an ELR 9080-510 HP is technically possible and acceptable due to the same voltage rating, but not supported regarding master-slave.

There are several possible combinations of standard models and Slave models:



Combination 1:

Multiple ELR 9000 HP (with display)

All models of the standard series can be combined to themselves in master-slave (up to 16 units on one bus)

Advantage of this combination: every unit could be master or slave; the slave show their own actual values and the entire system can also be controlled manually.

Disadvantage of this combination: higher costs compared to a system with ELR 9000 HP Slave models

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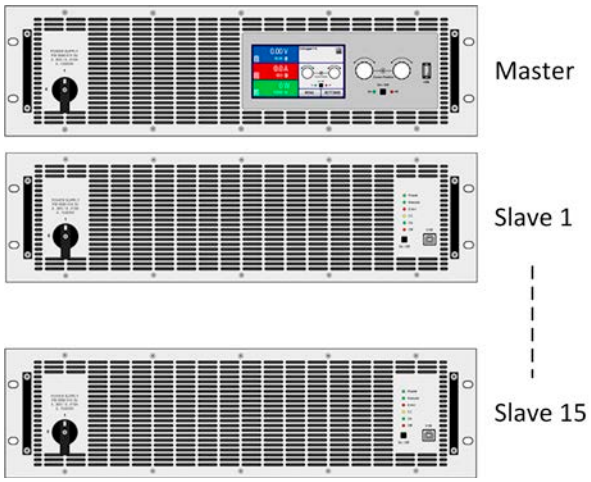


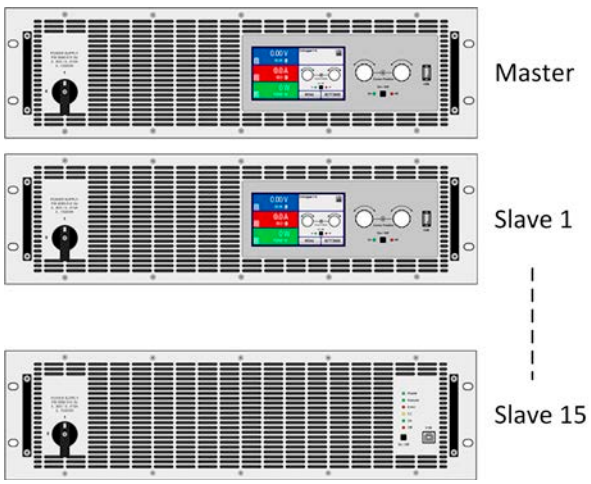
Combination 2:

One ELR 9000 HP with one or multiple ELR 9000 HP Slave

This is the intended combination for models of ELR 9000 HP Slave series, as it can be found in series ELR 9000 HP 15U and ELR 9000 HP 24U, for example.

Advantage of this combination: lower costs

Disadvantages of this combination: in case the master fails, the entire system cannot work. After reconfiguring any Slave unit to be master, which can be done via software and remote control, the system can continue to operate. Other: only 15 kW models of both series can be used.



Combination 3:

Multiple ELR 9000 HP with one or multiple ELR 9000 HP Slave

An already existing MS system with only ELR 9000 HP is going to be extended by one or multiple ELR 9000 HP Slave units.

Advantage of this combination: in case of a failing master, any other ELR 9000 HP unit can be quickly reconfigured to be master.

Disadvantages of this combination: higher costs, because even some of the slave units may have a display and control panel which they actually don't need. Other: only 15 kW models of both series can be used.

2.3.2.2 AC supply

Mains connection of an energy back-feeding electronic load of ELR 9000 HP series is done via the included 5 pole plug on the back of the device. Wiring of the plug is at least 3 strand or, for some models, 4 strand of suitable cross section and length. Connecting all conductors (3 phase, N, PE), though not required, is totally acceptable and is even recommended, because the cable could then be used for any other device model or series with the same type of AC connector.

For recommendations for cable cross sections see *„2.3.4. Mains connection (AC)“.*

2.3.2.3 DC input

Dimensioning of the DC wiring to the voltage source should also reflect the following:

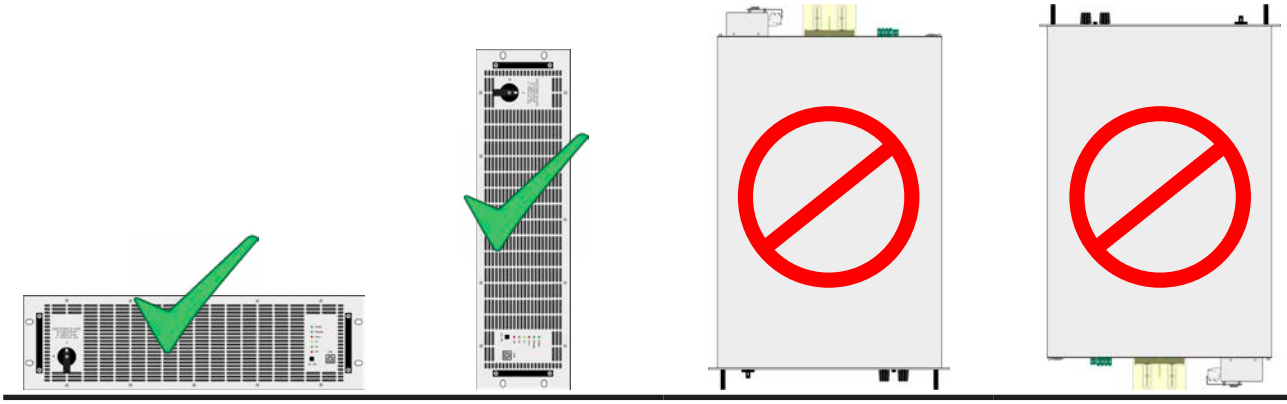
- The cable cross section should always be specified for at least the maximum current of the device.
- Continuous operation at the approved limit generates heat which must be removed, as well as voltage loss which depends on cable length and heating. To compensate for these the cable cross section should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

2.3.3 Installing the device

- Select the location for the device so that the connection to the source is as short as possible.
- Leave sufficient space behind the device, minimum 30 cm, for ventilation of warm air that will be exhausted even with devices which feed back up to 90% of the consumed energy.

A device in a 19” housing 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).

Acceptable and unacceptable installation positions:



Standing surface

2.3.4 Mains connection (AC)

- Connection to an AC mains supply may only be carried out by qualified personnel!
- Cable cross section must be suitable for the maximum input/output current of the device (see table below)!
- Before plugging in the input plug ensure that the device is switched off by its mains switch!
- Ensure that all regulations for the operation of and connection to the public grid of energy back-feeding equipment have been applied and all necessary conditions have been met!
- When operating multiple ELR units in parallel on the same grid, the cross section of the AC cables has to match the increased output current from the energy recovery

The device is delivered with a 5 pole AC plug. Depending on model, the plug is connected to a 2-phase or 3-phase AC supply, according to the labelling on the plug. Required for the mains connection, with or without grid protection system, are following phases:

	Without grid protection	With grid protection	
Nominal power	**Supply connector**	**Supply connector**	**Supply type**
≥15 kW	L1, L2, L3, PE	L1, L2, L3, PE	Three-phase

The PE conductor is imperative and must always be wired!

2.3.4.1 Cross sections

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 lists the maximum input current and recommended minimum cross section for each phase:

	L1		L2		L3		PE
Rated power	**ø**	**I_{max}**	**ø**	**I_{max}**	**ø**	**I_{max}**	**ø**
15 kW	2.5 mm²	23 A	2.5 mm²	23 A	2.5 mm²	23 A	same as phase

2.3.4.2 AC cable

The included connection plug can receive crimped cable ends of up to 6 mm². The longer the connection cable, the higher the voltage loss due to the cable resistance. Therefore the mains cables should be kept as short as possible or have a bigger cross section.

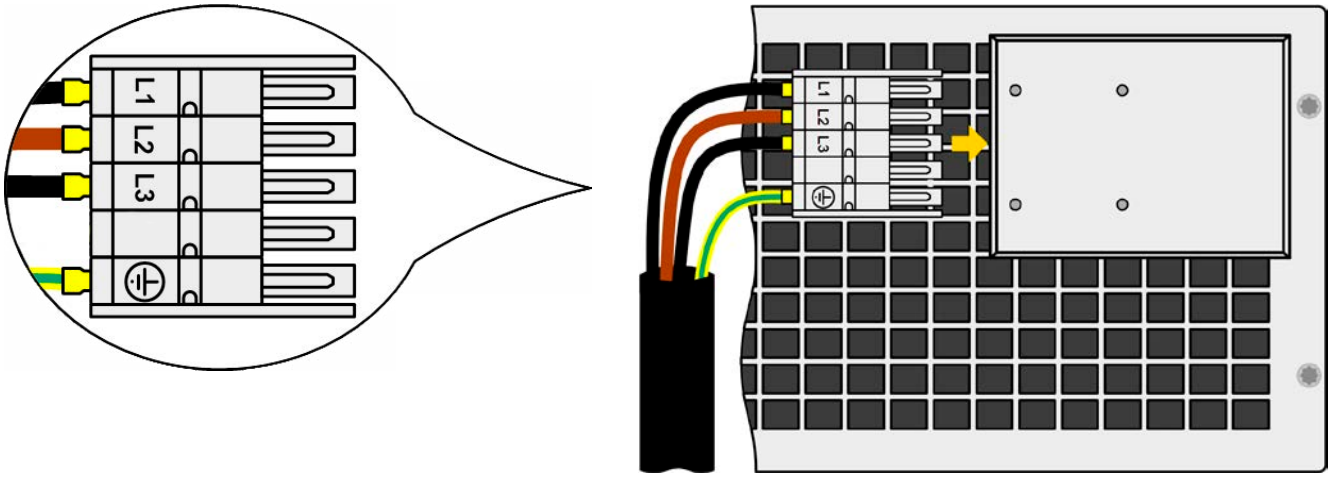


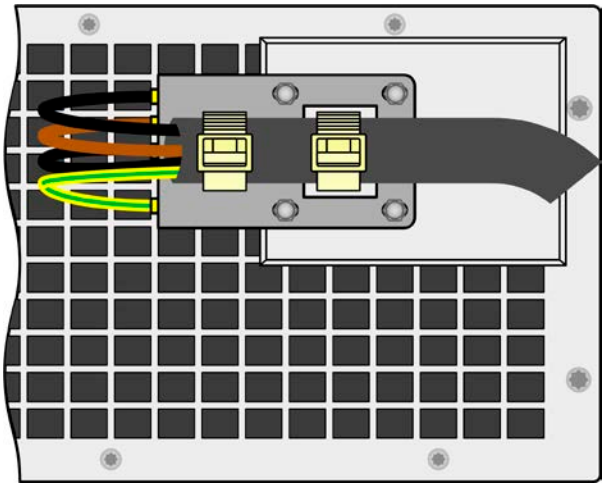
Figure 7 - Example for a supply connection cable (cable not included in the delivery)

2.3.4.3 Strain relief and plug fixture

There is a standard fixture mounted to the AC input connection block on the rear. It is used to prevent the AC plug from loosening and disconnecting due to vibrations or similar. The fixture is also used as strain relief.

Using the 4x M3 acorn nuts, it is recommend to mount the fixture to the AC filter block every time the AC plug has been plugged again.

It is furthermore recommended to install the strain relief by using suitable cable straps (not included), as depicted in the figure to the right.

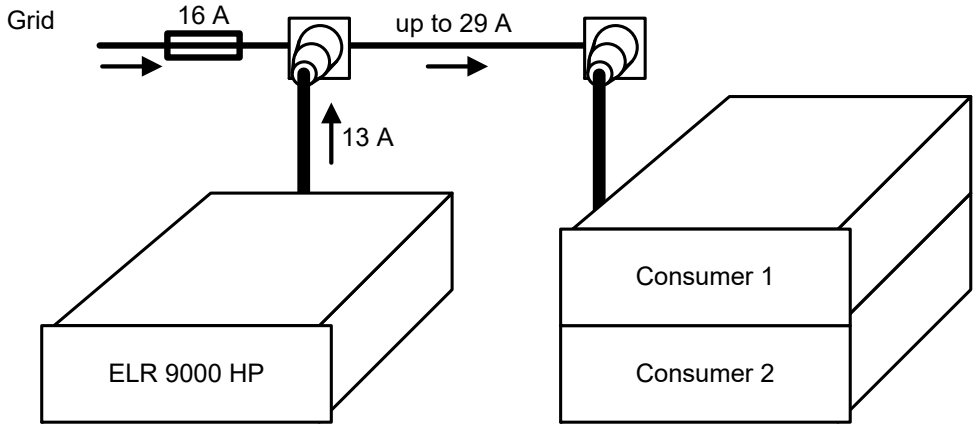


2.3.4.4 Installation concept for energy recovering devices

The scheme below depicts an often unconsidered problem: the current load of the local electric installation. The devices of series ELR 9000 HP recover energy and feed it back to the local or public grid. The recovered current then adds to the grid current and this can lead to an overload of the existing installation. Considering any two connection points, no matter of what kind, there is usually no extra fusing installed. In case of a defect in the AC part (i.e. short-circuit) of any consumer device or if 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. This applies to all power ratings.

The existing installation concept must be taken into regard when connecting further units and consumers in order to avoid damages and accidents.

Schematic depiction with 1 recovering load:



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.

2.3.5 Connection to DC sources

- In the case of a device with a high nominal current and hence a thick and heavy DC connection cable it is necessary to take account of the weight of the cable and the strain imposed on the DC connection. Especially when mounted in a 19” cabinet or similar, where the cable hangs on the DC input, a strain reliever has to be used.
- When powered, the device will always draw a minimum current of 0.1% of the rated current, even when the DC input is switched off. While the DC input is switched on, the set value of current determines the behaviour.

The DC load input is on the back 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.

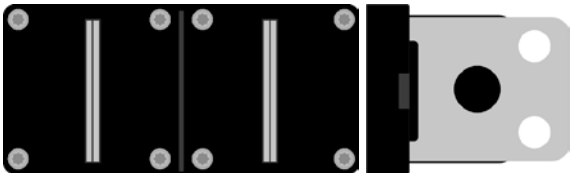
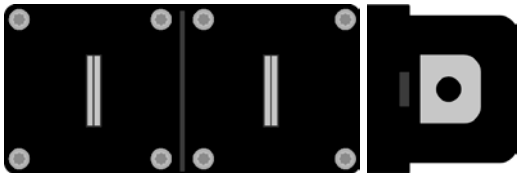
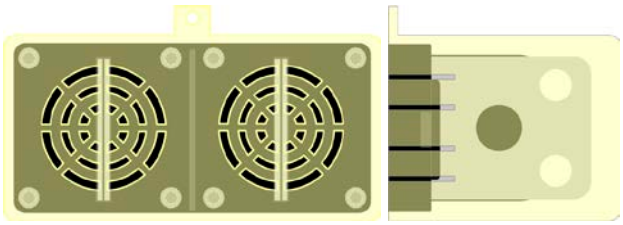
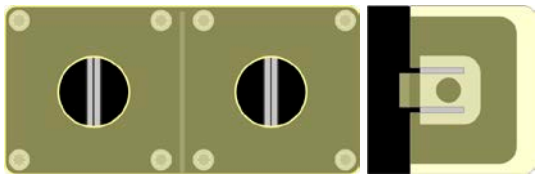
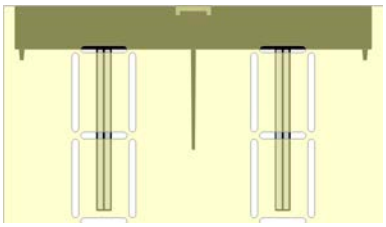
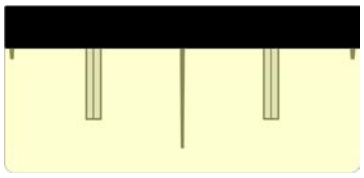
For cables up to 1.5 m and average ambient temperature up to 50 °C, we recommend:

up to **30 A**:	6 mm²	up to **70 A**:	16 mm²
up to **90 A**:	25 mm²	up to **140 A**:	50 mm²
up to **170 A**:	70 mm²	up to **210 A**:	95 mm²
up to **340 A**:	2x70 mm²	up to **510 A**:	2x120 mm²

per connection pole (multi-conductor, insulated, openly suspended). Single cables of, for example, 70 mm² may be replaced by 2x35 mm² etc. If the cables are long then the cross section must be increased to avoid voltage loss and overheating.

2.3.5.1 DC terminal types

The table below shows an overview of the various DC terminals. It is recommended that connection of load cables always utilizes flexible cables with ring lugs.

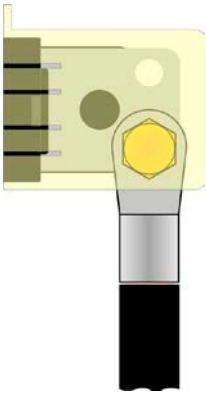
Type 1: Models up to 360 V nominal voltage	**Type 2: Models from 500 V nominal voltage**
	
M8 bolt on a metal rail Recommendation: ring connector with a 8 mm hole	M6 bolt on a metal rail Recommendation: ring connector with a 6 mm hole
	
	

2.3.5.2 Cable lead and plastic cover

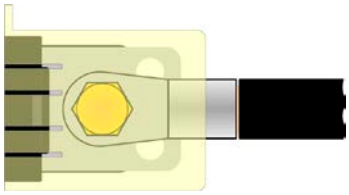
A plastic cover for contact protection is included for the DC terminal. It should always be installed. The cover for type 2 (see picture above) is fixed to the connector itself, for type 1 to the back of the device. Furthermore the cover for type 1 has break outs so that the supply cable can be laid in various directions.

The connection angle and the required bending radius for the DC cable must be taken into account when planning the depth of the complete device, especially when installing in a 19” cabinet or similar. For type 2 connectors only a horizontal lead can be used to allow for installation of the cover.

Examples of the type 1 terminal:



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



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

2.3.6 Grounding of the DC input

Grounding one of the DC input poles is allowed. Doing so can result in a potential shift of the grounded pole against PE.

Because of insulation, there is a max. allowed potential shift of the DC input poles, which also depends on the device model. Refer to *„1.8.3. Specific technical data“* for details.

- Digital and analog interface are galvanically isolated from the DC input and should never be grounded, but under no circumstances if any of the DC input poles is grounded too, because this will cancel the galvanic isolation
- If grounding one of the DC input poles check if any pole of the load is already grounded. This could lead to a short circuit!

2.3.7 Connection of remote sensing

Important, note: Remote sensing is only for situations when the device is operated stand-alone. Being a slave in a master-slave system, only the master receives the remote sense signal and regulates the slave accordingly via the Share bus.

Both pins “NC” on the “Sense” terminal must not be connected!

- *Remote sensing is only effective during constant voltage operation (CV) and for other regulation modes the sense input should be disconnected if possible, because connecting it generally increases the oscillation tendency.*
- *The cross section of the sensing cables is noncritical. Recommendation for cables up to 5 m: use at least 0.5 mm². Furthermore, always use cables with suitable specification, especially for the high voltage models*
- *Sensing cables should be twisted and laid close to the DC cables to damp oscillation. If necessary, an additional capacitor should be installed at the source to eliminate oscillation*
- *Sensing cables must be connected + to + and - to - at the source, otherwise the sense input of the electronic load can be damaged. For an example see Figure 8 below.*

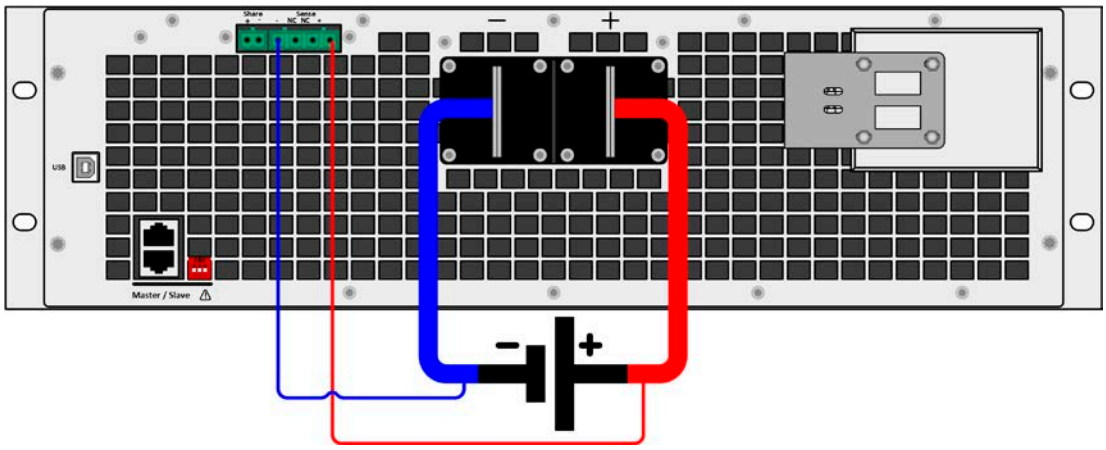


Figure 8 - Example for remote sensing wiring

2.3.8 Connecting the “Share” bus

The “Share” bus connector on the back side is intended to balance the current of multiple units in parallel operation, especially when using the integrated function generator of the master unit. Alternatively, it can be connected to a compatible power supply, in order to run a two-quadrants operation. For further information about this mode of operation can be found in section *„3.7.3. Two quadrants operation (2QO)“* .

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

- Connection is only permitted between up to 16 units and only between compatible devices as listed in section *„1.9.6. Share connector“*
- If a two-quadrants operation system has to be set up where multiple power supplies are connected to one electronic load unit or a group of electronic loads, all units should be connected via Share bus.
- When not using one or several units of a system configured with Share bus, because less power is required for an application, it is recommended to disconnect the unit’s from the Share bus, because even when not powered they can have a negative impact on the control signal on the bus due to their impedance. Disconnection can be done by simply unplugging them from the bus or using switches.
- The Share bus is referenced to DC minus. When grounding DC plus, the DC minus will shift its potential and so will the Share bus

2.3.9 Connecting the USB port (rear side)

In order to remotely control the device via this port, connect the device with a PC using the included USB cable and switch the device on.

2.3.9.1 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 7 or 10. But it is strongly recommended to use and install the included driver installer (on USB stick) to gain maximum compatibility of the device to our softwares.

2.3.9.2 Driver installation (Linux, MacOS)

We cannot provide drivers or installation instructions for these operating systems. Whether a suitable driver is available can be found out by searching the Internet.

2.3.9.3 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“.

2.3.10 Initial commission

For the first start-up after purchasing and installing 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!

2.3.11 Commission after a firmware update or a long period of non use

In case of a firmware update, return of the device following repair or a location or configuration change, similar measures should be taken to those of initial start up. Refer to *„2.3.10. Initial commission“.*

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

3. Operation and application

3.1 Personal safety

- In order to guarantee safety when using the device, it is 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 accept dangerous voltages, the included DC terminal cover, or an equivalent, must always be used
- Whenever the DC input is being re-configured, the device should be disconnected from the mains, not only switched off on the DC input! Also switch off or even disconnect the source!

3.2 Operating modes

An electronic load is internally controlled by different control or regulation circuits, which shall bring voltage, current and power to the adjusted values and hold them constant, if possible. These circuits follow typical laws of control systems engineering, resulting in different operating modes. Every operating mode has its own characteristics which is explained below in short form.

3.2.1 Voltage regulation / Constant voltage

Constant voltage operation (CV) or voltage regulation is a subordinate operating mode of electronic loads. In normal operation, a voltage source is connected to electronic load, which represents a certain input voltage for the load. If the set value for the voltage in constant voltage operation is higher than the actual voltage of the source, the value cannot be reached. The load will then take no current from the source. If the voltage set value is lower than the input voltage then the load will attempt to drain enough current from the source to achieve the desired voltage level. If the resulting current exceeds the maximum possible or adjusted current value or the total power according to $P = U_{IN} * I_{IN}$ is reached, the load will automatically switch to constant current or constant power operation, whatever comes first. Then the adjusted input voltage can no longer be achieved.

3.2.1.1 Speed of the voltage controller

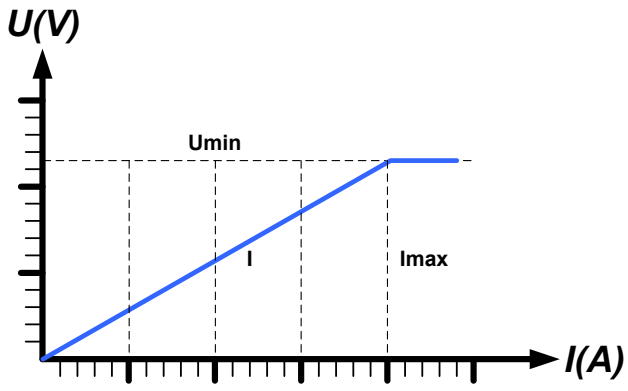
The internal voltage controller can be switched between “Slow” and “Fast” via the configuration in remote control. Factory default value is “Slow”. Which setting to select depends on the actual situation in which the device is going to be operated, but primarily it depends of the type of voltage source. An active, regulated source such as a switching mode power supply has its own voltage control circuit which works concurrently to the load’s circuit. Both might work against each other and lead to oscillation. If this occurs it is recommended to set the controller speed to “Slow”.

In other situations, e.g. operating the function generator and applying various functions to the load’s input voltage and setting of small time increments, it might be necessary to set the voltage controller to “Fast” in order to achieve the expected results.

3.2.1.2 Minimum voltage for maximum current

Due to technical reasons, all models in this series have a minimum internal resistance that makes the unit to be provided with a minimum input voltage (U_{MIN}) in order to be able to draw the full current (I_{MAX}). This minimum input voltage varies from model to model and is listed in the technical specifications in *1.8.3*. If less voltage than U_{MIN} is supplied, the load proportionally draws less current, which can be calculated easily.

See principle view to the right.



3.2.2 Current regulation / constant current / current limitation

Current regulation is also known as current limitation or constant current mode (CC) and is fundamental to the normal operation of an electronic load. The DC input current is held at a predetermined level by varying the internal resistance according to Ohm's law R = U / I such that, based on the input voltage, a constant current flows. Once the current has reached the adjusted value, the device automatically switches to constant current mode. However, if the power consumption reaches the adjusted power level, the device will automatically switch to power limitation and adjust the input current according to $I_{MAX} = P_{SET} / U_{IN}$, even if the maximum current set value is higher. The current set value, as determined by the user, is always and only an upper limit.

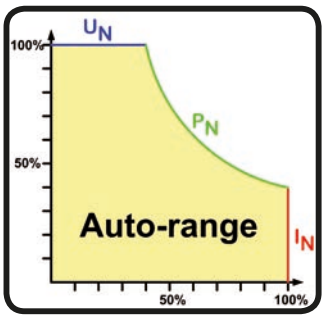
While the DC input is switched on and constant current mode is active, the condition "CC mode active" will be signalled on the control panel with LED "CC" and also stored as internal status which can be read via digital interface.

3.2.3 Resistance regulation / constant resistance

Inside electronic loads, whose operating principle is based on a variable internal resistance, constant resistance mode (CR) is almost a natural characteristic. The load attempts to set the internal resistance to the user defined value by determining the input current depending on the input voltage according to Ohm's law $I_{IN} = U_{IN} / R_{SET}$. The internal resistance is naturally limited between almost zero and maximum (resolution of current regulation too inaccurate). As the internal resistance cannot have a value of zero, the lower limit is defined to an achievable minimum. This ensures that the electronic load, at very low input voltages, can consume a high input current from the source, up to the maximum.

3.2.4 Power regulation / constant power / power limitation

Power regulation, also known as power limitation or constant power (CP), keeps the DC input power of the device at the adjusted value, so that the current flowing from the source, together with the input voltage, achieves the desired value. Power limitation then limits the input current according to $I_{IN} = P_{SET} / U_{IN}$ as long as the power source is able to provide this power.



Power limitation operates according to the auto-range principle such that at lower input voltages higher current can flow and vice versa, in order to maintain constant power within the range P_N (see diagram to the right).

Constant power operation impacts the internal set current value. This means that the maximum set current may not be reachable if the set power value according to I = P / U sets a lower current. The user defined and displayed set current value is always the upper limit only.

3.2.5 Dynamic characteristics and stability criteria

The electronic load is characterised by short rise and fall times of the current, which are achieved by a high bandwidth of the internal regulation circuit.

In case of testing sources with own regulation circuits at the load, like for example power supplies, a regulation instability may occur. This instability is caused if the complete system (feeding source and electronic load) has too little phase and gain margin at certain frequencies. 180 ° phase shift at > 0dB amplification fulfils the condition for an oscillation and results in instability. The same can occur when using sources without own regulation circuit (eg. batteries), if the connection cables are highly inductive or inductive-capacitive.

The instability is not caused by a malfunction of the load, but by the behaviour of the complete system. An improvement of the phase and gain margin can solve this. In practice, a capacity is directly connected to the DC input of the load. The value to achieve the expected result is not defined and has to be found out. We recommend:

80 V models: 1000uF....4700uF
200 V models: 100uF...470uF
360 V & 500 V models: 47uF...150uF
750 V models: 22uF...100uF
1500 V models: 4.7uF...22uF

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 „3.6. Alarms and monitoring“.

As a basic principle, all alarm conditions are signalled optically (by LED “Error” on the front) and via the digital interface ports. For later acquisition, an alarm counter can be read via digital interface.

Some alarms require acknowledgement before the DC input can be switched on again, in those cases where the alarm caused the DC input to switch off. Acknowledgement in normal master-slave operation is done on the master unit. In other situations, like during manual operation it can be done with the pushbutton “On / Off” on the front or else by sending a specific command via digital interface.

3.3.1 Power Fail

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

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

As soon as a power fail occurs, the device will stop to sink power and switch off the DC input. In case the power fail was an undervoltage and is gone later on, the alarm won’t be signalled further and doesn’t have to be acknowledged.

Switching off the device with the mains switch can not be distinguished from a mains blackout and thus the device will signalise a PF alarm every time the device is switched off. This can be ignored.

3.3.2 Overtemperature

An overtemperature alarm (OT) can occur from an excess temperature inside the device and temporarily causes it to stop supplying power. After cooling down, the device will automatically continue to supply power, while the condition of the DC input remains and the alarm doesn’t require to be acknowledged.

3.3.3 Overvoltage

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

- the connected voltage source provides a higher voltage to the DC input than set in the overvoltage alarm thresholds (OVP, 0...110% U_{NOM})

This function serves to warn the user of the electronic load optically that the connected voltage source has generated an excessive voltage and thereby could damage or even destroy the input circuit and other parts of the device.

The device is not fitted with protection from external overvoltage.

3.3.4 Overcurrent

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

- The input current in the DC input exceeds the adjusted OCP limit.

This function serves to protect the voltage and current source so that this is not overloaded and possibly damaged, rather than offering protection to the electronic load.

3.3.5 Overpower

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

- the product of the input voltage and input current in the DC input exceeds the adjusted OPP limit.

This function serves to protect the voltage and current source so that this is not overloaded and possibly damaged, rather than offering protection to the electronic load.

3.4 Manual operation

Manual operation is a secondary functionality for this type of device. It is intended to run under constant remote control by a master unit. Thus the number of available functions in manual control is reduced, compared to a standard ELR 9000 HP device.

3.4.1 Powering the device

The device should, as far as possible, always be switched on using the rotary switch on the front of the device. Alternatively this can take place using an external cutout (contactor, circuit breaker) of suitable current capacity.

In a master-slave system it is normal that not all units are powered at the same time or some units not at all. In order for the master to initialise all slaves correctly it will wait some time after start. In case not all slaves have been initialised the procedure to find and enumerate the slave can be repeated, either directly on the screen of the master, here a device from ELR 9000 HP series, or in the MENU. Alternatively, this can also be done via remote control.

After switching on, the device indicates the boot phase with LED “Power” on the front being **orange**. Once it has finished starting and is ready for operation, LED “Power” changes to **green**.

There is a configurable option which determines the condition of the DC input after power-up. Factory setting here is “**OFF**”. Changing it to “**Restore**” will cause the device to restore the last DC input condition, either on or off.

In master-slave operation and when the device is being slave, 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 slaves’ settings.

3.4.2 Switching the device off

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

The DC input 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 input on or off

As long as the Slave unit is not in remote control by a master unit or by a software via USB interface, the DC input can be manually switched on or off with the pushbutton “**On / Off**”. This is for situations where the Slave 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 input related parameters via the front USB port. The button can also be used to acknowledge device alarms signalled by LED “Error”.

Configuration of parameters via one of the USB ports is considered as remote control and is thus described in *3.5*.

3.5 Remote control

3.5.1 General

Remote control is essential when operating devices of this series, for example during master-slave. It is furthermore possible to take over remote via one of the built-in USB ports. Important here is that only one of the digital interfaces or a master unit can be in control. It means that if, for example, an attempt were to be made to switch to remote control via the digital interface whilst master-slave mode is running the device would report an error via the digital interface. In the opposite direction, the master unit could not initialise a Slave unit being in USB remote control. In both cases, however, status **monitoring** and reading of values via any of the USB ports is always possible.

3.5.2 Remote control via the rear USB

The rear USB port offers the same set of commands as with a “normal” ELR 9000 HP device, but only while the Slave device is not in control by a master device or currently not in status “Slave”. Then the same programming documentation “Programming SCPI & ModBus” is valid for the user, as well as the ModBus register list “Modbus_Register_ELR9000_KEx.xx+_EN.pdf”.

Control via software EA Power Control is also possible via this port and unrestricted.

3.5.3 Remote control via the front USB

The main purpose of the front USB port is quick access to the most important DC input related parameters, such as set values and protections. Reading values and status is always possible, setting them only while the Slave device is not in control by a master device.

Outside of master-slave, the device could be controlled remotely with software **EA Power Control**, but also from custom applications. In order to do so, a programming documentation is delivered with the device on USB stick.

The number of available commands is restricted on this USB port, but it supports both, SCPI and ModBus RTU communication protocols. As part of the programming documentation, there is an **extra ModBus register list** (Modbus_Register_Slave_Front_HMIx.xx+_EN.pdf) for the front USB port.

In the programming guide there is a section for all SCPI commands, as available with the rear USB port. Here is an overview what commands are available with the front port. Details about the commands can be found in the “Programming SCPI & ModBus” document, also called **programming guide**.

*IDN?	[SOURce:]POWer:PROTection[:LEVel]
*CLS	[SOURce:]POWer:PROTection[:LEVel]?
*RST	[SOURce:]RESistance
*ESE	[SOURce:]RESistance?
*ESE?	[SOURce:]RESistance:LIMit:HIGH?
*ESR	[SOURce:]VOLTage
*STB?	[SOURce:]VOLTage?
MEASure:[SCALar:]CURRent[:DC]?	[SOURce:]VOLTage:LIMit:HIGH?
MEASure:[SCALar:]POWer[:DC]?	[SOURce:]VOLTage:LIMit:LOW?
MEASure:[SCALar:]VOLTage[:DC]?	[SOURce:]VOLTage:PROTection[:LEVel]
INPut[:STATe]	[SOURce:]VOLTage:PROTection[:LEVel]?
INPut[:STATe]?	STATus:OPERation?
[SOURce:]CURRent	STATus:QUEStionable?
[SOURce:]CURRent?	SYSTem:ALARm:ACTion:PFAil
[SOURce:]CURRent:LIMit:HIGH?	SYSTem:ALARm:ACTion:PFAil?
[SOURce:]CURRent:LIMit:LOW?	SYSTem:ALARm:COUNt:OCURrent?
[SOURce:]CURRent:PROTection[:LEVel]	SYSTem:ALARm:COUNt:OPOWer?
[SOURce:]CURRent:PROTection[:LEVel]?	SYSTem:ALARm:COUNt:OTEMperature?
[SOURce:]IRRAdiation	SYSTem:ALARm:COUNt:OVOLtage?
[SOURce:]IRRAdiation?	SYSTem:ALARm:COUNt:PFAil?
[SOURce:]POWer	SYSTem:COMMunicate:TIMEOUT?
[SOURce:]POWer?	SYSTem:CONFig:MODE
[SOURce:]POWer:LIMit:HIGH?	SYSTem:CONFig:MODE?
[SOURce:]POWer:LIMit:LOW?	SYSTem:CONFig:OCD

SYSTem:CONFig:OCD?	SYSTem:CONFig:USER:TEXT?
SYSTem:CONFig:OCD:ACTion	SYSTem:CONFig:UVD
SYSTem:CONFig:OCD:ACTion?	SYSTem:CONFig:UVD?
SYSTem:CONFig:OPD	SYSTem:CONFig:UVD:ACTion
SYSTem:CONFig:OPD?	SYSTem:CONFig:UVD:ACTion?
SYSTem:CONFig:OPD:ACTion	SYSTem:DEVice:CLAss?
SYSTem:CONFig:OPD:ACTion?	SYSTem:ERRor:ALL?
SYSTem:CONFig:OUTPut:RESTore	SYSTem:ERRor:NEXT?
SYSTem:CONFig:OUTPut:RESTore?	SYSTem:ERRor?
SYSTem:CONFig:OVD	SYSTem:LOCK
SYSTem:CONFig:OVD?	SYSTem:LOCK?
SYSTem:CONFig:OVD:ACTion	SYSTem:LOCK:OWNer?
SYSTem:CONFig:OVD:ACTion?	SYSTem:NOMinal:CURRent?
SYSTem:CONFig:UCD	SYSTem:NOMinal:POWer?
SYSTem:CONFig:UCD?	SYSTem:NOMinal:RESistance:MAXimum?
SYSTem:CONFig:UCD:ACTion	SYSTem:NOMinal:RESistance:MINimum?
SYSTem:CONFig:UCD:ACTion?	SYSTem:NOMinal:VOLTage?

3.5.4 Programming

Programming details about the communication protocols etc. are to be found in the documentation “Programming Guide ModBus & SCPI“ which is supplied on the included USB stick or which is available as download from the manufacturer’s website.

3.6 Alarms and monitoring

3.6.1 Definition of terms

The device signalises alarms (see *„3.3. Alarm conditions“*) such as overvoltage (OV) or overheating (OT) via the front LED “Error” and as readable status via digital interface. When running the device as Slave as part of a master-slave system, the alarm is also reported to the master and if the master is with display, the alarm is indicated there as well. Basically, device alarms will switch off the DC input, primarily in order to protect the connected load and secondarily to protect the device itself.

Monitoring or supervision is also available in form of user-defineable events. Configuration of alarm thresholds and events, as well as reading status can only be done via the USB ports.

3.6.2 Device alarm and event handling

Important to know:

- The current drained from a switching power supply or similar sources can be much higher than expected due to capacities on the source’s output, even if the source is current limited, and might thus trigger the overcurrent shutdown OCP or the overcurrent event OCD of the electronic load, in case these supervision thresholds are adjusted to too sensitive levels
- When switching off the DC input of the electronic load while a current limited source still supplies energy, the output voltage of the source will rise immediately and due to response and settling times in effect, the output voltage can have an overshoot of unknown level which might trigger the overvoltage shutdown OVP or overvoltage supervision event OVD, in case these thresholds are adjusted to too sensitive levels

A device alarm incident will usually lead to DC input switch-off and the front LED “Error” is lit to make the user aware. Some alarms must be acknowledged. While the Slave device is in control of a master device, all alarms are acknowledged on the master unit. Refer to the user manual of the master. After acknowledging the alarm on the master, the LED “Error” on the alarm causing slave unit should be off.

For all other situations, the front button “On / Off” or a specific command sent via digital interface in remote control is used to acknowledge alarms.

► How to acknowledge an alarm (during manual control)

1. In case the DC input is switched off and the LED “Error” is lit, use button “On / Off”.
2. The LED should go off and with another push on “On / Off”, the DC input could be switched on again. If the LED remains lit, the alarm cause could still be present.

Some device alarms, specifically their thresholds, are configurable via **EA Power Control** software or custom tools:

Alarm	Meaning	Description	Range
OVP	**O**ver**V**oltage **P**rotection	Triggers an alarm if the DC input voltage reaches the defined threshold. The DC input will be switched off.	0 V...1.1*U_{Nom}
OCP	**O**ver**C**urrent **P**rotection	Triggers an alarm if the DC input current reaches the defined threshold. The DC input will be switched off.	0 A....1.1*I_{Nom}
OPP	**O**ver**P**ower **P**rotection	Triggers an alarm if the DC input power reaches the defined threshold, The DC input will be switched off.	0 W...1.1*P_{Nom}

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

Alarm	Meaning	Description
PF	**P**ower **F**ail	Signalises various problems with the AC part. Triggers an alarm if the AC supply is out of specification or when the device is cut from supply, for example when switching it off with the power switch. The DC input will be switched off.
OT	**O**ver**Tem-perature**	Triggers an alarm if the internal temperature exceeds a certain limit. The DC input will be switched off.

Alarm	Meaning	Description
MSP	**M**aster-**S**lave **P**rotection	Triggers an alarm if the master of an initialised master-slave system loses contact to any slave unit or if a slave has not yet been initialised by the master. The DC input will be switched off. The alarm can be cleared by either deactivating master-slave mode or reinitialising the MS system.

3.6.2.1 User defined events

The monitoring functions of the device can be configured for user defined events. By default, events are deactivated (action = NONE). Contrary to device alarms, the events only work while the DC input is switched on. It means, for instance, that you cannot detect undercurrent (UVD) anymore after switching the DC input off though there won't be current flow anymore.

The following events can be configured independently and can, in each case, trigger the actions NONE, SIGNAL, WARNING or ALARM.

Action	Impact
NONE	User defined event is disabled.
SIGNAL/WARNING	On reaching the condition which triggers the event with action **SIGNAL** or **WARNING** a bit in the status register of the device will be set. That register can be read via USB. With this series, actions **SIGNAL** and **WARNING** are equal.
ALARM	On reaching the condition which triggers the event with action **ALARM** a bit in the status register of the device will be set and the DC input will be switched off. Both conditions can be read via USB from the status register.

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

As soon as an event is set up with an action other than "NONE" while the DC input is still switched on, it can immediately occur and switch the DC input off. It is thus recommended to configure events only while the DC input is switched off.

3.7 Other applications

3.7.1 Parallel operation in master-slave (MS)

Running the Slave models of series ELR 9000 HP Slave in master-slave operation is the primary function. The devices usually work as slave units which are enumerated and controlled by a master device. Instructions for configuration and use of master can be found in its user manual, one of ELR 9000 HP series.

This section is about a different situation where a Slave model is supposed to be the master unit as substitute of a missing or not matching master model. Running the Slave as master is basically possible, though all setup and control is only done via the USB ports and by software. Since the front USB port is restricted in its functions and does not support master-slave configuration, we recommend to use the rear USB port for all communication.

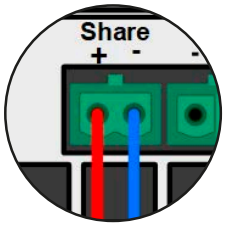
3.7.1.1 Introduction

Multiple devices with identical ratings can be connected in parallel in order to create a system with higher total current and hence higher power. This can be done using the standard models with display or the new slave models (ELR 9000 HP Slave, available from mid 2018). Only disadvantage: the slave models are only available as 15 kW versions, so they only match the 15 kW standard models.

For parallel operation in master-slave mode the units are usually connected with their DC inputs, their Share bus and their master-slave bus. The master-slave bus is a digital bus which makes the system work as one big unit regarding adjusted values, actual values and status.

The Share bus is intended to balance the units dynamically in their power, especially if the master unit runs a function. In order for this bus to work correctly, at least the DC minus poles of all units have to be connected, because DC minus is the reference for the Share bus.

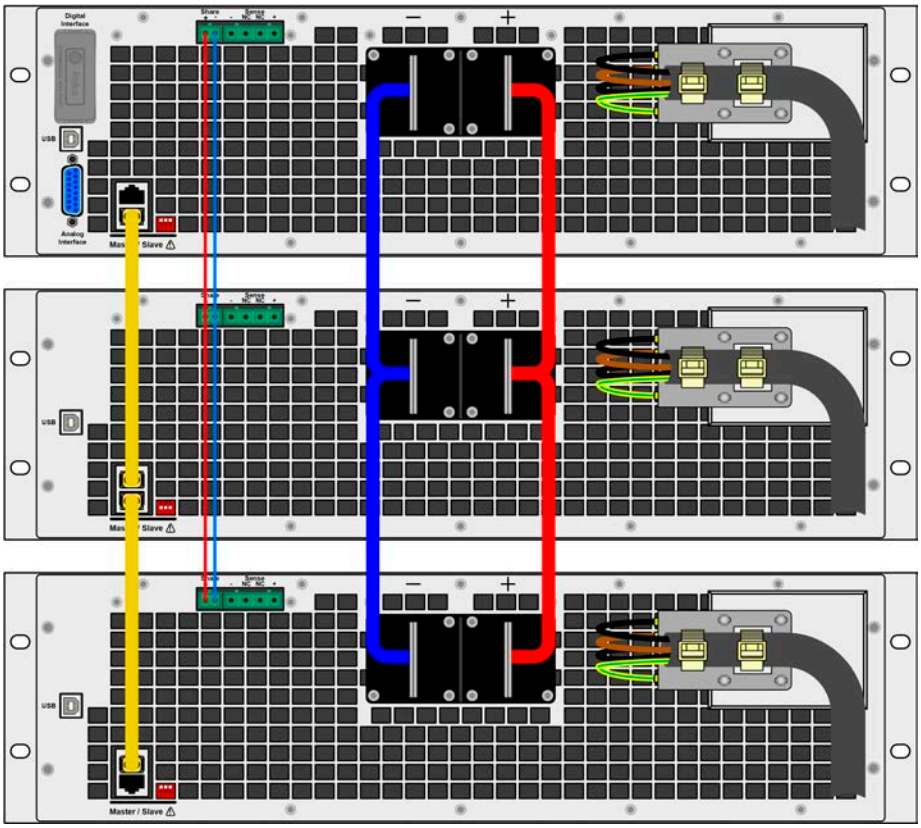
Principle view (without source connected):



Share Bus connection

Master-slave bus

Bus termination



3.7.1.2 Restrictions

Compared to normal operation of a single device, master-slave operation has some limitations:

- The MS system reacts differently to alarm situations than a single unit (see below in *3.7.1.7*)
- Using the Share bus makes the system reacts as dynamically as possible, but it is still not as dynamic as single unit operation
- A device which was configured as slave has limited operability (only access to MENU possible)

3.7.1.3 Wiring the DC inputs

The DC input of every unit in the parallel operation is simply connected to the next unit using cables with cross section according to the maximum current and with short as possible length.

3.7.1.4 Wiring the Share bus

The Share bus is wired from unit to unit with an ideally twisted pair of cables with non-critical cross section. We recommend to use 0.5 mm² to 1 mm².

- The Share bus is poled. Take care for correct polarity of the wiring!
- In order for the Share bus to work correctly it requires at least to connect all DC minus inputs of the devices

A max. of 16 units can be connected via Share bus.

3.7.1.5 Wiring and set-up of the master-slave bus

The master-slave connectors are built-in and must first be connected via network cables (≥CAT3, patch cable) and then MS can be configured manually (recommended) or by remote control. The following applies:

- A maximum 16 units can be connected via the bus: 1 master and up to 15 slaves
- Only devices of same kind, i.e. electronic load to electronic load, and of the same model, such as ELR 9080-170 HP Slave to ELR 9080-170 HP Slave or also ELR 9080-170 HP
- Units at the end of the bus must be terminated (see below)

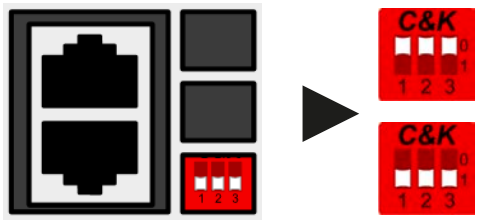
The master-slave bus must not be wired using crossover cables!

Later operation of the MS system implies:

- The master unit calculates the sum of the actual values of all the units and makes them available to read via the digital interfaces
- The ranges for setting the values, adjustment limits, protections (OVP etc.) and user events (UVD etc.) of the master are adapted to the total number of units. Thus, if e.g. 5 units each with a power of 15 kW are connected together to a 75 kW system, then the master can be set in the range 0...75 kW.
- lave units with master-slave mode setting “Slave” are not operable as long as being controlled by the master
- Slave units will indicate the alarm “MSP” via LED “Error” on their control panel, as long as they not have been initialised by the master. The same alarm is signalled after a connection drop to the master unit occurred.
- In case the function generator of the master unit is going to be used, the Share bus must be connected as well

► How to connect the master-slave bus

1. Switch off all units that are to be connected and connect them together with a network cable (CAT3 or better, not included). It doesn’t matter which of the two master-slave connection sockets (RJ45, backside) is connected to the next unit.
2. Also connect all units at the DC side.
3. The two units at the beginning and end of the chain should be terminated, if long connection cables are used. This is achieved using a 3-pole DIP switch which is positioned on the back side of the unit next to the MS connectors.



Position: not terminated (default)

Position: fully terminated

Now the master-slave system has to be configured on each other unit. It is recommended to configure first all the slave units and then the master unit.

The configuration itself can be done with **EA Power Control** or custom software. The programming guide, as included in the delivery on USB stick, explains remote configuration for master-slave in custom applications.

3.7.1.6 Operating the master-slave system

After the first initialisation after any reconfiguration of the system the master can be operated and controlled like a single stand-alone unit. While software **EA Power Control** automatically detects MS mode and adapts the rated values to what the MS system represents, this has to be considered in custom applications. The master will offer a set of system ratings, readable with extra registers resp. SCPI commands. These ratings could change every time the system is initialised for master-slave, depending on the number of slaves.

The following applies:

- The master can be treated as a standalone unit
- The master shares the set values across the slaves and controls them
- The master is remotely controllable via the analog or digital interfaces, if available
- All settings for the set values U,I and P (monitoring, settings limits etc.) will be adapted to the new total values
- All initialised slaves will reset any limits (U_{Min}, I_{Max} etc.), supervision thresholds (OVP, OPP etc.) and event settings (UCD, OVD etc.) to default values, so these don't interfere the control by the master. As soon as these values are modified on the master, they are transferred 1:1 to the slaves. Later, during operation, it might occur that a slave causes an alarm or event rather than the master, due to imbalanced current or slightly faster reaction
- If one or more slaves report an device alarm, it will be displayed on the master and must be acknowledged there so that the slave(s) can continue their operation. Since most alarms cause the DC inputs to be switched off and the can only be reinstated on the master unit, user interaction (operator) may be required or alarm handling by a remote control software.
- Loss of connection to any slave will result in shutdown of all DC inputs, as a safety measure, and the master will report this situation in the display with a pop-up "Master-slave safety mode". Then the MS system has to be re-initialised, either with or without re-establishing connection to the disconnected unit(s) before.

3.7.1.7 Alarms and other problem situations

Master-slave operation, due to the connection of multiple units and their interaction, can cause additional problem situations which do not occur when operating individual units. For such occurrences the following regulations have been defined:

- If the DC part of one or more slave units is switched off due to defect, overheating etc., the whole MS system shuts down the power intake and human interaction is required
- If one or more slave units are cut from AC supply (power switch, blackout, supply undervoltage) while the master is still running and they come back later, they're not automatically initialised and included again in the MS system. Then the initialisation has to be repeated.
- If the DC input of the master unit is switched off due to a defect or overheating, then the total master-slave system cannot provide input power and the DC inputs of all slaves are automatically switched off, too
- If the master unit is cut from AC supply (power switch, blackout) and comes back later, the unit will automatically initialise the MS system again, finding and integrating all active slaves. In this case, MS can be restored automatically.
- If accidently multiple or no units are defined as master the master-slave system cannot be initialised

In situations where one or multiple units generate a device alarm like OV, PF or OT following applies:

- Any alarm of a slave is indicated on the slave's HMI and on the master's display
- If multiple alarms happen simultaneously, the master only indicates the most recent one. In this case, the particular alarms can be read from the slave units displays. This also applies to remote control or remote supervision, because the master can only report the most recent alarm.
- All units in the MS system supervise their own values regarding overvoltage, overcurrent and overpower and in case of alarm they report the alarm to the master. In situations where the current is probably not balanced between the units, it can occur that one unit generates an OC alarm though the global OC limit of the MS system was not reached. The same can occur with the OP alarm.

3.7.1.8 Important to know

	*In case one or several units of a parallel system are not going to be used and remain switched off, depending on the number of active units and the dynamics of the operation it may become necessary to disconnect the inactive units from the Share bus, because even when not powered the units can have a negative impact on the Share bus due to their impedance.*

3.7.2 Series connection

	Series connection is not a permissible operating method for electronic loads and must not be installed or operated under any circumstances!

3.7.3 Two quadrants operation (2QO)

3.7.3.1 Overview

The so-called two-quadrants operation, which is based on the source-sink principle, couples a power supply and an electronic load via a control signal. It enables the automatic switchover between either the source or the sink being active. 2QO is also allowed for master-slave systems. A master-slave system built from electronic loads is then considered as one big sink and will be handled and controlled as such. The same configuration is doable with several power supplies building a big source. More information about setup, configuration and use of a 2QO system can be found in the user manual of the master load series ELR 9000 HP or also in the manuals of compatible power supply series such as PSI 9000 WR.

For the operation of two master-slave system in 2QO, being connected via Share bus, the same restriction as with master-slave operation applies: the max. number of 16 units on the Share bus.

4. Service and maintenance

4.1 Maintenance / cleaning

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

Cleaning the internal fans can be performed with a vacuum cleaner or similar. For this the device needs to be opened.

4.2 Fault finding / diagnosis / repair

If the device suddenly performs in an unexpected way, which indicates a fault, or it has an obvious defect, this can not 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 Elektro-Automatik (with or without warranty). If a return for checking or repair is to be carried out, ensure that:

- the supplier has been contacted and it is clarified how and where the device 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 shipping destination is abroad, the necessary customs papers are attached.

4.2.1 Firmware updates

Firmware updates should only be installed when they can eliminate existing bugs in the firmware in the device or contain new features.

The firmware of the control panel (HMI), of the communication unit (KE) and the digital controller (DR), if necessary, is updated via the rear side USB port. For this the software EA Power Control is needed which is included with the device or available as download from our website together with the firmware update, or upon request.

However, be advised not to install updates promptly. Every update includes the risk of an inoperable device or system. We recommend to install updates only if...

- an imminent problem with your device can directly be solved, especially if we suggested to install an update during a support case
- a new feature has been added which you definitely want to use. In this case, the full responsibility is transferred to you.

Following also applies in connection with firmware updates:

- Simple changes in firmwares can have crucial effects on the application the devices are use in. We thus recommend to study the list of changes in the firmware history very thoroughly.
- Newly implemented features may require an updated documentation (user manual and/or programming guide, as well as LabView VIs), which is often delivered only later, sometimes significantly later

5. Contact and support

5.1 Repairs

Repairs, if not otherwise arranged between supplier and customer, will be carried out by EA Elektro-Automatik. For this the device must generally be returned to the manufacturer. No RMA number is needed. It is sufficient to package the device adequately and send it, together with a detailed description of the fault and, if still under guarantee, a copy of the invoice, to the following address.

5.2 Contact options

Questions or problems with 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.

Address	e-Mail	Telephone
EA Elektro-Automatik Helmholtzstr. 31-37 41747 Viersen Germany	Technical support: support@elektroautomatik.de All other topics: ea1974@elektroautomatik.de	Switchboard: +49 2162 / 37850 Support: +49 2162 / 378566

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