

Operating Manual

ELR 5000 / ELM 5000

Multichannel DC Load with Energy Recovery



Attention! This document is only valid for devices with firmwares "HMI: 2.04" and "DR: 2.01" or higher. For availability of updates for your device check our website or contact us.

Doc ID: ELR5EN
Revision: 06
Date: 02/2019



TABLE OF CONTENTS

1 GENERAL

1.1	About this document	4
1.1.1	Retention and use	4
1.1.2	Copyright	4
1.1.3	Validity	4
1.1.4	Symbols and warnings	4
1.2	Warranty	4
1.3	Limit of liability	4
1.4	Disposal of equipment	5
1.5	Product key	5
1.6	Intended usage	5
1.7	Safety	6
1.7.1	Safety notices	6
1.7.2	Responsibility of the user	6
1.7.3	Responsibility of the operator	7
1.7.4	User requirements	7
1.7.5	Alarm signals	8
1.8	Technical data	8
1.8.1	Approved operating conditions	8
1.8.2	General technical data	8
1.8.3	Specific technical data	9
1.8.4	Views	11
1.8.5	Control elements	14
1.9	Construction and function	15
1.9.1	General description	15
1.9.2	Block diagram	15
1.9.3	Scope of delivery	16
1.9.4	Accessories	16
1.9.5	The control panel (HMI)	17
1.9.6	Ethernet port	19
1.9.7	"Sense" connector (remote sensing)	19

2 INSTALLATION & COMMISSIONING

2.1	Transport and storage	20
2.1.1	Transport	20
2.1.2	Packaging	20
2.1.3	Storage	20
2.2	Unpacking and visual check	20
2.3	Installation	20
2.3.1	Safety procedures before installation and use	20
2.3.2	AC connection (EU model, 230 V wall socket)	21
2.3.3	AC connection (US model, 208 V)	21
2.3.4	Installing the rack	22
2.3.5	Installing load modules	22
2.3.6	Grounding of the DC input	23
2.3.7	Connection to DC sources	23
2.3.8	Connection of remote sensing	25
2.3.9	Connection of LAN cable	25
2.3.10	Initial commission	25
2.3.11	Commission after a firmware update or a long period of non use	25

3 OPERATION AND APPLICATION

3.1	Personal safety	26
3.2	Regulation modes	26
3.2.1	Voltage regulation / Constant voltage	26
3.2.2	Current regulation / constant current / current limitation	26
3.2.3	Resistance regulation / constant resistance	27
3.2.4	Power regulation / constant power / power limitation	27
3.2.5	Dynamic characteristics and stability criteria	27
3.3	Alarm conditions	28
3.3.1	Power Fail	28
3.3.2	Overtemperature	28
3.3.3	Overvoltage	28
3.3.4	Overcurrent	28
3.3.5	Overpower	28
3.4	Manual operation	29
3.4.1	Powering the device	29
3.4.2	Switching the device off	29
3.4.3	Configuration via MENU	29
3.4.4	Adjustment limits	32
3.4.5	Manual adjustment of set values	32
3.4.6	Switching the DC input on or off	33
3.5	Remote control	34
3.5.1	General	34
3.5.2	Controls locations	34
3.5.3	Remote control via Ethernet	34
3.6	Alarms and monitoring	35
3.6.1	Definition of terms	35
3.6.2	Device alarm handling	35
3.7	Control panel (HMI) lock	37
3.8	The sequence generator	38
3.8.1	Introduction	38
3.8.2	Method of operation	38
3.8.3	Manual operation	40
3.8.4	Remote control of the sequence generator	42
3.9	MPP tracking	43
3.9.1	Mode MPP1	43
3.9.2	Mode MPP2	43
3.9.3	Mode MPP3	44
3.9.4	Mode MPP4	44
3.10	Other applications	45
3.10.1	Series connection	45
3.10.2	Parallel operation	45

4 SERVICING AND MAINTENANCE

4.1	Maintenance / cleaning	45
4.2	Fault finding / diagnosis / repair	45
4.3	Firmware updates	45

5 CONTACT AND SUPPORT

5.1	Repairs	46
5.2	Contact options	46

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

Reprinting, copying, also partially, usage for other purposes as foreseen of this manual are forbidden and breach may lead to legal process.




1.1.3 Validity

This manual is valid for the following equipment:

Model	Article nr.	Model	Article nr.	Model	Article nr.
ELR 5000 Rack 6U	33 130 336	ELM 5080-25	33 220 430	ELR 5200-12	33 220 431

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)
	<i>Symbol for general notices</i>

1.2 Warranty

EPS Stromversorgung 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 EPS Stromversorgung.

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. EPS Stromversorgung 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 EPS Stromversorgung 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 5080 - 25 xx

				Field for identification of special models: S01...S0x = Special models 01 etc.
				Maximum current of the device in Ampere
				Maximum voltage of the device in Volt
				Series : 5 = Series 5000
				Type identification: ELR = Electronic Load with Recovery ELM = Electronic Load Module

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.
- Never touch cables or connectors directly after unplugging from mains supply as the danger of electric shock remains.
- 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.
- Always follow 5 safety rules when working with electric devices:
 - Disconnect completely
 - Secure against reconnection
 - Verify that the system is dead
 - Carry out earthing and short-circuiting
 - Provide protection from adjacent live parts



- 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 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.
- Do not connect external power sources with reversed polarity to DC input or outputs! The equipment will be damaged.
- 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.

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

The equipment offers various possibilities for signalling alarm conditions, however, not for danger situations. The signals may be optical (on the display as text) or digital. All alarms will cause the device to switch off the DC input or prevent it from being switched on.

The meaning of the signals is as follows:

Signal OT (OverTemperature)	<ul style="list-style-type: none"> • Overheating of the electronic load module • DC input will be switched off • Non-critical
Signal OVP (OverVoltage)	<ul style="list-style-type: none"> • Shutdown of the DC input due to excess of the preset limit • Critical! The device could be damaged
Signal OCP (OverCurrent)	<ul style="list-style-type: none"> • Shutdown of the DC input due to excess of the preset limit • Non-critical, protects the source from excessive current drain
Signal OPP (OverPower)	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • DC input shutdown due to AC undervoltage or defect in the AC input or due to overheating of the DC-AC inverter stage • Critical on AC overvoltage! AC mains input circuit could be damaged
Signal Sense	<ul style="list-style-type: none"> • Sense connection not wired resp. connection has been interrupted or the max. possible voltage compensation for remote sensing has been reached • Non-critical, but requires interaction by the user

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, not condensing

1.8.2 General technical data

Display: Colour touch screen, 320pt x 240pt, resistive

Controls: 1 rotary knob with pushbutton function, 1 button

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

1.8.3 Specific technical data

Rack	Model	
	ELR 5000 6U	
AC mains supply		
Supply voltage	EU model: 195...253 V (L-N)	US model: 195...253 V (L-L)
Supply connection	EU model: L,N,PE	US model: two phases + PE
Supply frequency	45...66 Hz	
Fusing	T16 A	
Efficiency ⁽¹⁾	≥ 92%	
Power factor	> 0.99	
Nominal power	3000 W	
Leakage current	< 3.5 mA	
Environment		
Cooling	Temperature controlled fans (air outlet on rear)	
Ambient temperature	0..50 °C	
Storage temperature	-20...70 °C	
Dimensions		
Enclosure (WxHxD)	19" x 6 U x 500 mm	
Weight	12.25 kg (rack only)	
Standards	EN 60950, EN 61000-6-2, EN 61000-6-4, EN 50160	
Article number	EU model: 33130336	US model: 33138336

Load module	Model	
	ELM 5080-25	ELM 5200-12
DC Input		
Max. input voltage U_{Max}	80 V	200 V
Max. input power P_{Max}	320 W	320 W
Max. input current I_{Max}	25 A	12 A
Overvoltage protection range	$0...1.1 * U_{Max}$	$0...1.1 * U_{Max}$
Overcurrent protection range	$0...1.1 * I_{Max}$	$0...1.1 * I_{Max}$
Overpower protection range	$0...1.1 * P_{Max}$	$0...1.1 * P_{Max}$
Max. allowed input voltage	100 V	250 V
Min. input voltage for I_{Max}	1 V	1.5 V
Temperature coefficient for set values Δ / K	Voltage / current: 100 ppm	Voltage / current: 100 ppm
Voltage regulation		
Adjustment range	0...81.6 V	0...204 V
Stability at ΔI	$< 0.05\% U_{Max}$	$< 0.05\% U_{Max}$
Accuracy ⁽²⁾ (at $23 \pm 5^\circ C$)	$< 0.1\% U_{Max}$	$< 0.1\% U_{Max}$
Display: Adjustment resolution	see section „1.9.5.4. Resolution of the displayed values“	
Display: Accuracy ⁽³⁾	≤0.2%	≤0.2%
Remote sensing compensation	~ 5% U_{Max}	~ 5% U_{Max}
Current regulation		
Adjustment range	0...25.5 A	0...12.24 A
Stability at ΔU	$< 0.15\% I_{Max}$	$< 0.15\% I_{Max}$
Accuracy ⁽²⁾ (at $23 \pm 5^\circ C$)	$< 0.2\% I_{Max}$	$< 0.2\% I_{Max}$
Display: Adjustment resolution	see section „1.9.5.4. Resolution of the displayed values“	
Display: Accuracy ⁽²⁾	≤0.2%	≤0.2%

(1) Typical value at 100% input voltage and 100% power

(2) 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: a 80 V model has min. 0.2% current accuracy, that is a calculated 50 mA for 25 A nominal. When adjusting a set value of 5 A, the actual value is allowed to differ a maximum of 50 mA, which means it might be between 4.95 A and 5.05 A.

(3) The display accuracy adds to the general accuracy on the DC input

Load module	Model	
	ELM 5080-25	ELM 5200-12
Current regulation		
Ripple	400 mA _{PP} , 80 mA _{RMS}	200 mA _{PP} , 70 mA _{RMS}
Power regulation		
Adjustment range	0...326.4 W	0...326.4 W
Stability at $\Delta I / \Delta U$	< 0.75% P _{Max}	< 0.75% P _{Max}
Accuracy ⁽¹⁾ (at 23 ± 5 °C)	< 1.3% P _{Max}	< 1.5% P _{Max}
Display: Adjustment resolution	see section „1.9.5.4. Resolution of the displayed values“	
Display: Accuracy ⁽²⁾	≤0.2%	
Insulation		
Input (DC) to enclosure	DC minus: permanent max. ±400 V DC plus: permanent max. ±400 V + max. input voltage	
Input (AC) to input (DC)	Max. 2500 V, short-term	
Environment		
Cooling	Temperature controlled fan (air outlet on rear)	
Ambient temperature	0..50 °C	
Storage temperature	-20...70 °C	
Digital interfaces		
Featured	1x USB for sequences and HMI firmware updates, 1x Ethernet for communication	
Galvanic isolation to the device	max. 1500 V DC	
Terminals		
Front side	1x RJ45, 1x USB type A, 1x Screw terminal (4-pole)	
Standards	EN 61010	
Dimensions		
Enclosure (WxHxD)	81 x 132.5 x 310 mm	81 x 132.5 x 310 mm
Weight	2.35 kg	2.35 kg
Article number	33220430	33220431

(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: a 80 V model has min. 0.2% power accuracy, that is a calculated 640 mW for 320 W nominal. When adjusting a set value of 250 W, the actual value is allowed to differ a maximum of 640 mW, which means it might be between 249.36 W and 250.64 W.

(2 The display accuracy adds to the general accuracy on the DC input

1.8.4 Views

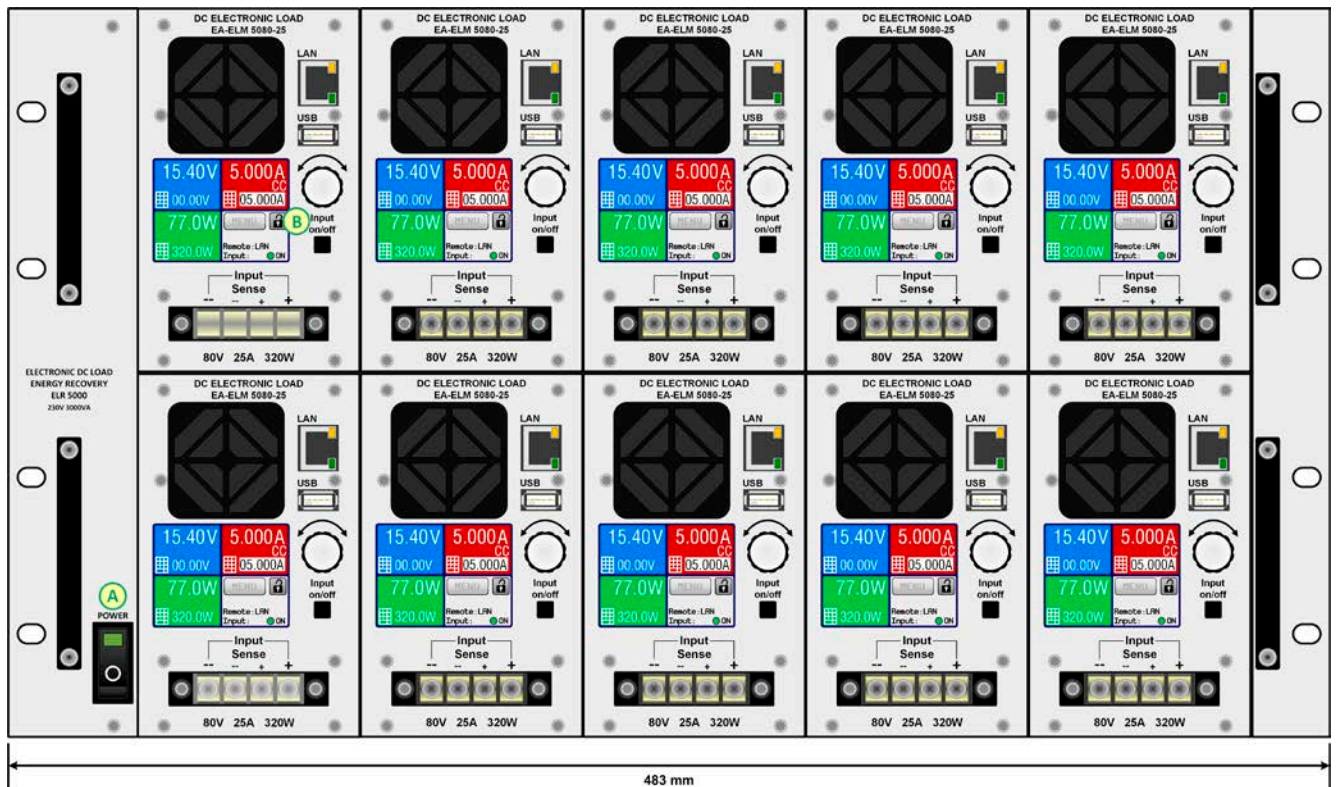


Figure 1 - Front side view of rack, fully equipped

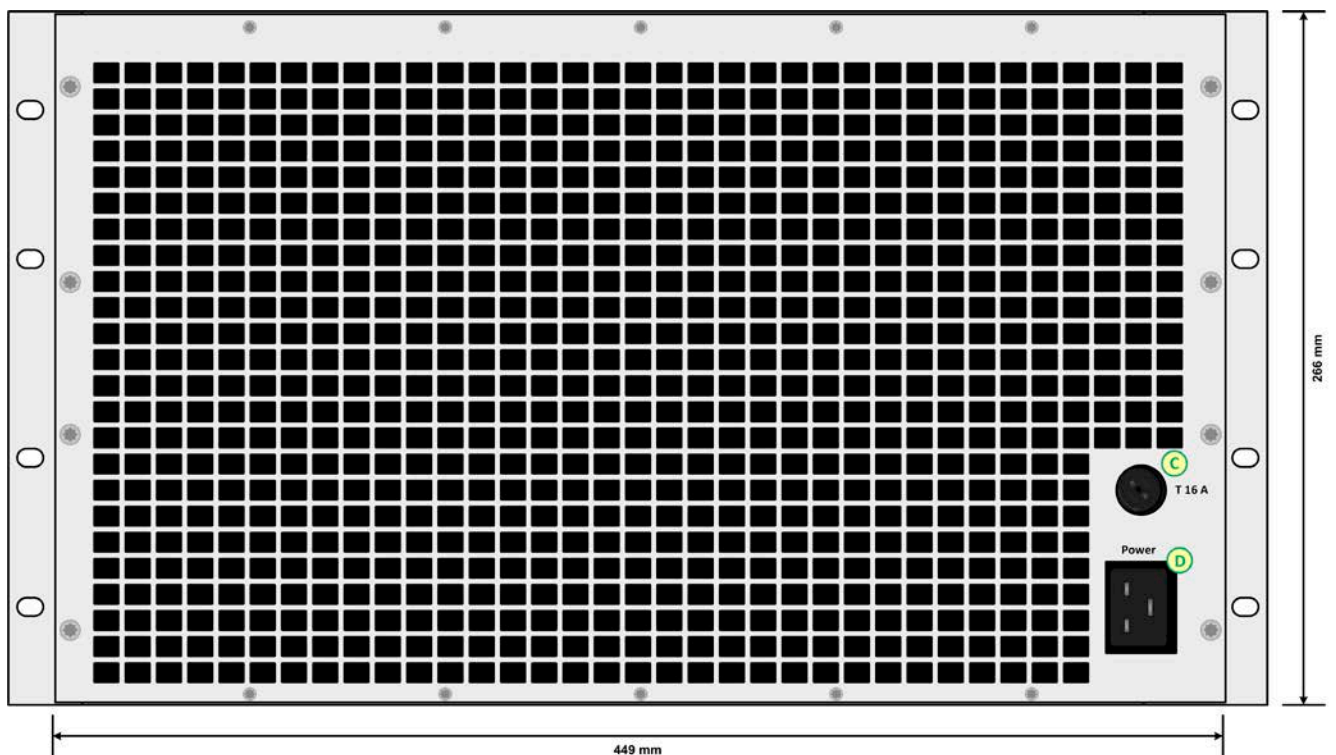


Figure 2 - Back side view of rack (EU model rev. 01)

A - Power switch

B - Load module with fan, DC input and control panel

C - Mains fuse

D - AC supply socket

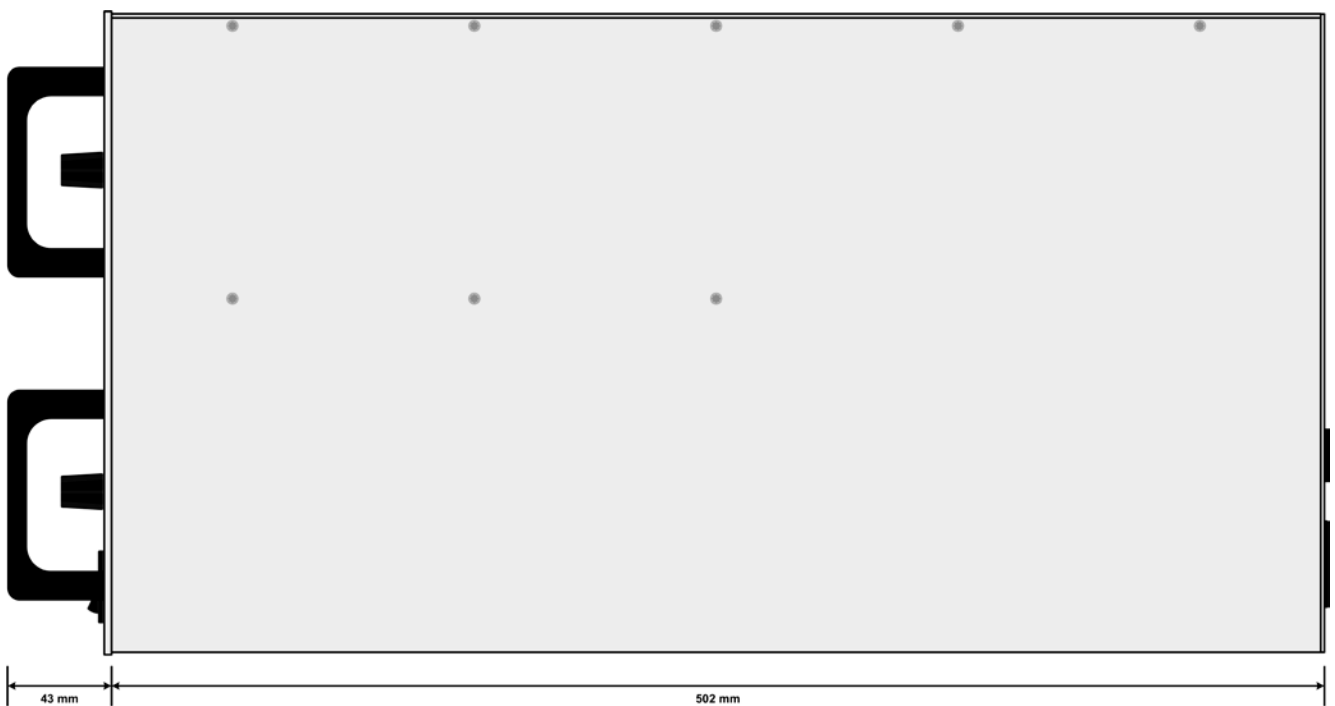
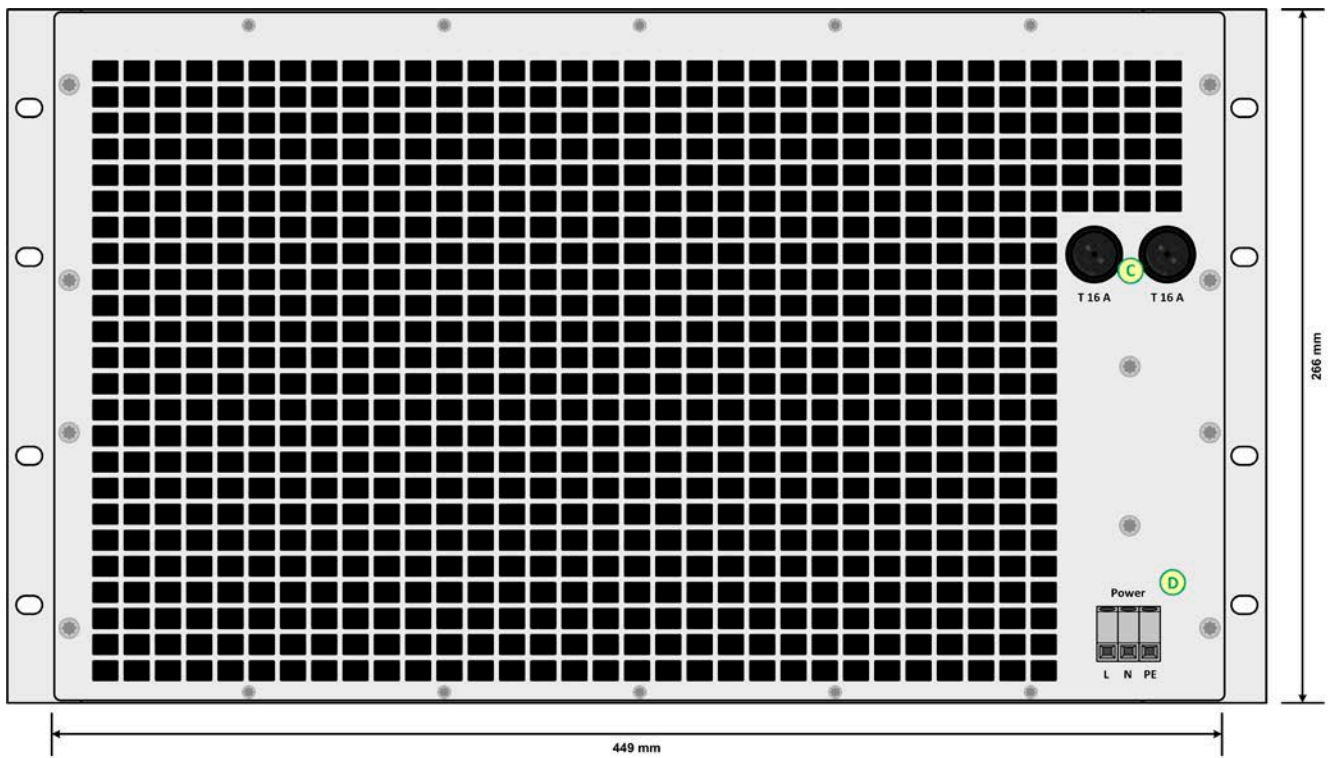




Figure 5 - Top view of load module



Figure 6 - Side view of load module

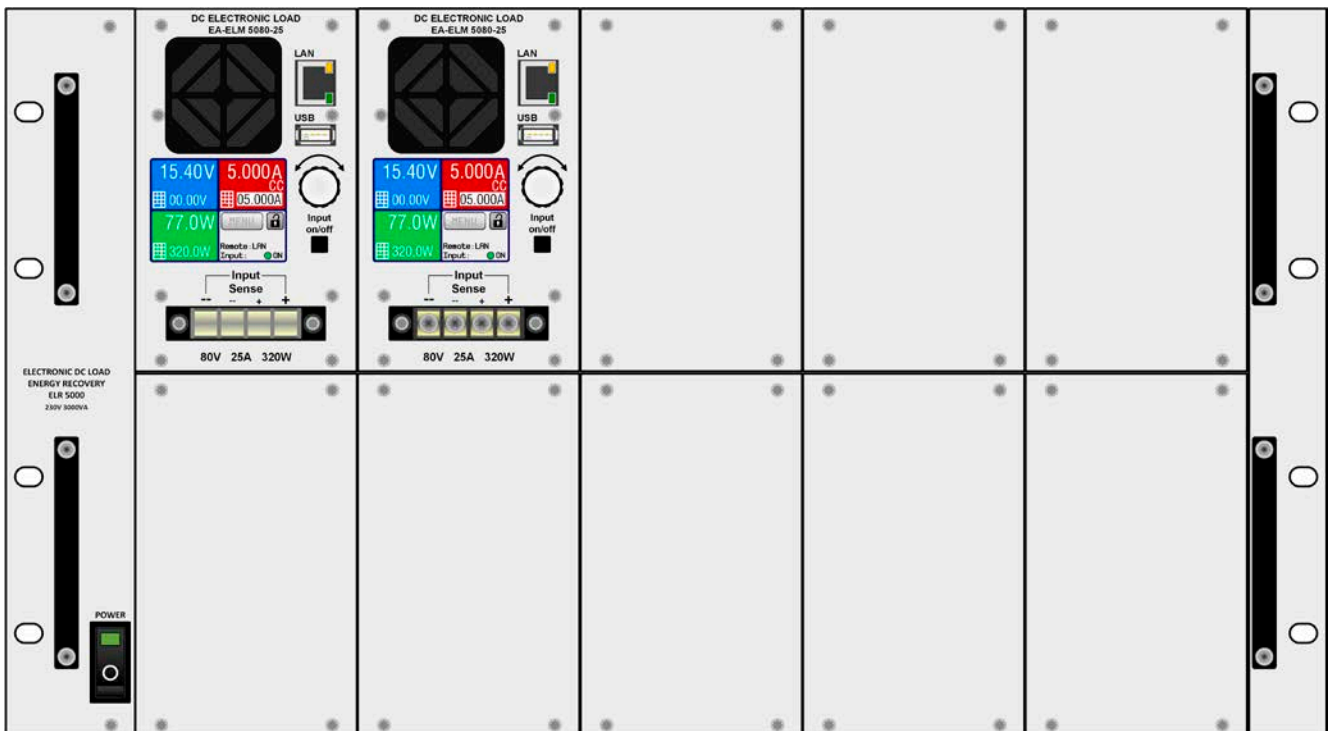


Figure 7 - Front side view of rack, partially equipped and with dummy plates

1.8.5 Control elements

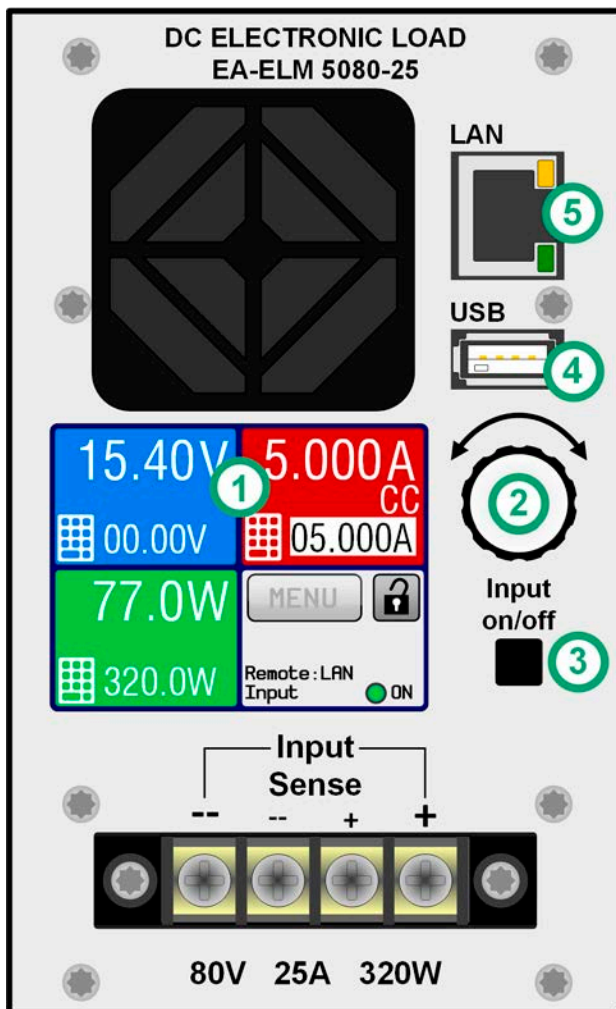
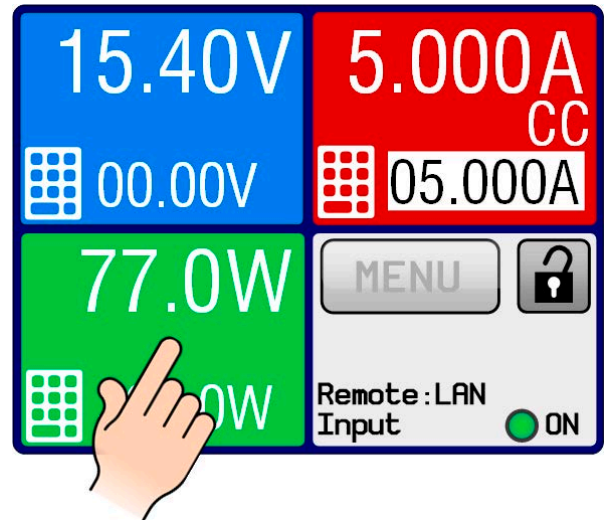


Figure 8 - Control panel



Overview of the elements on the control panel

For a detailed description see section „1.9.5. The control panel (HMI)“ and „1.9.5.2. Rotary knob“.

	Touchscreen display
(1)	Used for selection of set values, menus, display of status and of actual values. The touchscreen can be operated with a finger or with a pen (stylus).
	Rotary knob with push button function
(2)	Knob (turn): adjusting the voltage, current or power set values, or setting the parameter values in the menu. Knob (push): selection of the decimal position to be changed (cursor) in the current value selection.
	On/Off Button for DC input
(3)	Used to toggle the DC input between on and off, also used to start a sequence run. The LED “ON” in the display indicates the state of the DC input, no matter if the device is manually controlled or remotely.
	USB-A port
(4)	For the connection of standard USB sticks up to 32GB, formatted to FAT32, to load or save the 100 sequences for the sequence manager can be loaded or saved. It is also used to install firmware updates.
	Ethernet port
(5)	Communication port for control and monitoring of the module. Uses HTTP (website) and standard TCP.

1.9 Construction and function

1.9.1 General description

The electronic multi-channel DC load of series ELR/ELM 5000 is a combination of a 19" 6U rack (ELR 5000) and up to 10 units of electronic DC load modules, which can be installed in the rack. The system can be operated standalone or mounted in suitable cabinets.

The load modules are removable, retrofittable and can be installed in an arbitrary number (1-10) and position by the end user. A mixed setup of 80 V and 200 V versions is also possible. The modules run separate from each other and form a multi-channel DC load for industrial applications, for instance to test multiple E.U.T at once.

Beyond standard features of electronic loads, set point based runs can be generated by the integrated sequence generator. It offers 100 points for arbitrary configurations of voltage, current, power and time each. The resulting sequence can be stored to or loaded from an USB stick. This is enabled by an USB port on the front side which is standard with these load modules.

For remote control the load modules are provided as standard with an Ethernet port on the front side as well. Network configuration is simple and done on the touchscreen control panel. With this port the loads may, for example, be operated together with other load types or even different kind of equipment, all controlled by a PC, PLC or mini PCs, like a Raspberry Pi or PXI.

Remote control and/or monitoring is supported by the devices via the protocols ModBus RTU and the prolific SCPI.

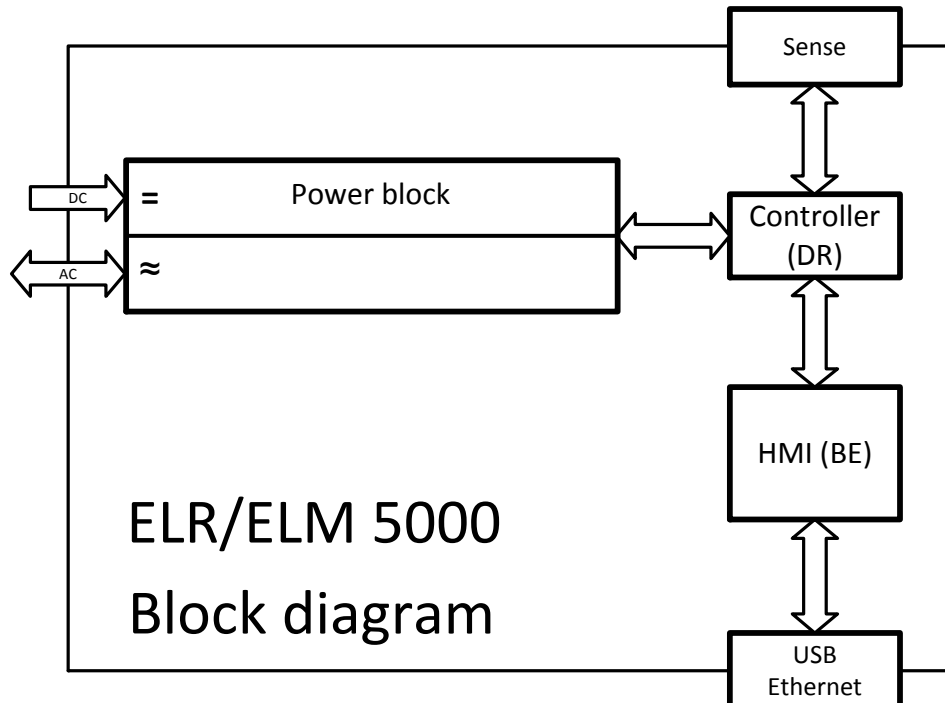
The generated DC energy is converted through a high efficiency internal inverter and fed back as AC energy into the 230 V (EU model) resp. 208 V (US model) mains.

All models are controlled by 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 (DR & HMI), which can be target of firmware updates.



1.9.3 Scope of delivery**ELR 5000 rack:**

1 x 19" 6U rack

1 x Set of screws (50 pcs, for fixation of load modules or dummy plates)

1 x USB stick with documentation and software

ELM 5000 load module:

1 x Electronic load device

1 x USB stick with documentation and software

1.9.4 Accessories

For these devices the following accessories are available:

Dummy plate FP ELM Ordering number: 33220499	Retrofittable, easy to install dummy plate for the unoccupied load module slots of the ELR 5000 rack. For personnel safety and better cooling air stream, it is imperative to use these dummy plates in case the rack is not fully equipped with ELM 5000 load modules. Screws for fixing the plates are included.
Network switch ELM Netgear JGS524 Ordering number: 35410200	24 port Ethernet switch in 1U height, used to connect up to 2 fully equipped ELR 5000 racks to one Ethernet port of a PC, server or another switch. Type: Netgear JGS524. The housing of the switch can be reconfigured to be a 19" rack module with the included mounting brackets.

**Caution!**

For reasons of safety it is not allowed to operate the electronic load rack while the front is not completely closed. In case the rack is not going to be fully equipped with load modules, a corresponding number of dummy plates must be installed!

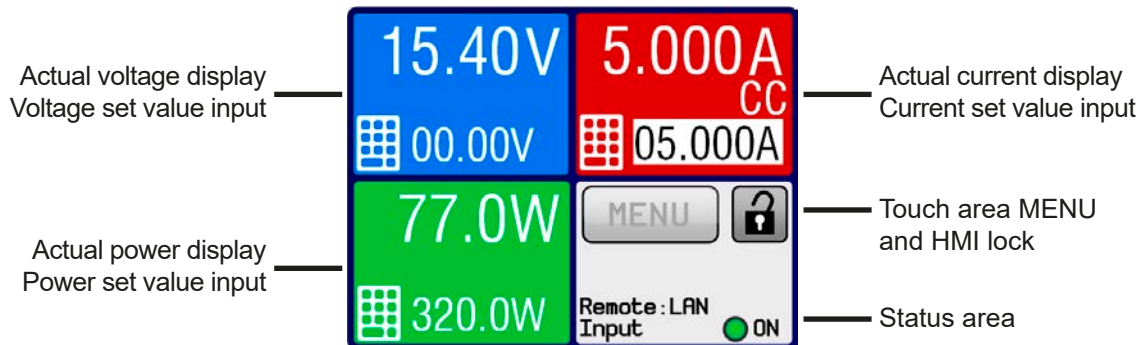
1.9.5 The control panel (HMI)

The HMI (Human Machine Interface) consists of a display with touchscreen, a rotary knob, a button and an USB port.

1.9.5.1 Touchscreen display

The graphic touchscreen display is divided into four areas. The complete display is touch sensitive and can be operated by finger or stylus to control the equipment. Only exception: switching the DC input on or off can only be done using the pushbutton right next to the display.

In the main screen, like depicted below, the three coloured areas are used to show actual values and to enter set values while if manual control mode is active:



Touch areas may be enabled or disabled:

MENU

Black text = Enabled


MENU

Grey text = Disabled

• Actual / set values areas (blue, red, green)

In normal operation the DC input values (large numbers) and set values (small numbers) for voltage, current and power are displayed.

While the DC input is switched on, the actual regulation mode **CV**, **CC** or **CP** is displayed below the corresponding actual value's physical unit, as exemplified in the figure above with CC. More about regulation modes in „3.2. Regulation modes“.

The currently selected set value can be adjusted with the rotary knob next to the display screen or can be entered directly via the touchscreen. During manual control, the set value selection is done by tapping the coloured areas. Alternatively to value adjustment with the knob, values can be entered directly with a ten-key pad by tapping on the small ten key pad icon ().

Pushing the knob will select the digit to be changed. Logically, the values are increased by clockwise turning and decreased by anti-clockwise turning.

General display and setting ranges:

Display	Unit	Range	Description
Actual voltage	V	0-125% U_{Nom}	Actual value of DC input voltage
Set value voltage	V	0-100% U_{Nom}	Set value for limiting the DC input voltage
Actual current	A	0.2-125% I_{Nom}	Actual value of DC input current
Set value current	A	0-100% I_{Nom}	Set value for limiting the DC input current
Actual power	W	0-125% P_{Nom}	Calculated actual value of input power, $P = U \cdot I$
Set value power	W	0-100% P_{Nom}	Set value for limiting DC input power
Adjustment limits	A, V, kW	0-102% nom	U-max, I-min etc., related to the physical quantities
Protection settings	A, V, kW	0-110% nom	OVP, OCP etc., related to the physical quantities

• Status area (grey)

This area displays various status texts:

Display	Description
Locked	The HMI is locked
Remote: LAN	The device is under remote control via the built-in Ethernet interface
Local	The device has been locked by the user explicitly against remote control
Alarm:	Alarm condition which has not been acknowledged or still exists.
SEQ:	(only in remote mode) Sequence generator activated

1.9.5.2 Rotary knob



As long as the device is in manual operation the rotary knob is used to adjust set values as well as parameters in the setup menu (MENU) or the sequence generator. For a detailed description of the individual functions see section „3.4 Manual operation“ on page 29.

1.9.5.3 Button function of the rotary knob

The rotary knob also has a pushbutton function, which is used in all menus and in the main screen to move the cursor of the selected value clockwise (left to right), as shown below:

10.000 A → 10.000 A → 10.000 A

1.9.5.4 Resolution of the displayed values

In the display, set values can be adjusted in certain increments. The number of decimal places depends on the device model. The values have 4 or 5 digits. Actual and set values always have the same number of digits.

Adjustment resolution and number of digits of set values in the display:

Voltage, OVP, U-min, U-max			Current, OCP, I-min, I-max			Power, OPP, P-max		
Nominal	Digits	Increment	Nominal	Digits	Increment	Nominal	Digits	Increment
80 V	4	0.01 V	12 A / 25 A	5	0.001 A	320 W	4	0.1 W
200 V	5	0.01 V						

1.9.5.5 USB port

The frontal USB port, located to the right of the rotary knob, is intended for the connection of standard USB sticks. It can be used to save or load sequence files for the sequence generator. USB sticks must be formatted in **FAT32** and should have a **maximum capacity of 32GB**. Higher storage capacity may be accepted as well. USB 2.0 sticks are well supported, USB 3.0 may be supported.

All supported file types must be held in a designated folder in the root path of the USB drive in order to be found. This folder must be named **HMI_FILES**, such that a PC would recognise the path G:\HMI_FILES if the drive were to be assigned the letter G. The control panel can read the following file types from an USB stick:

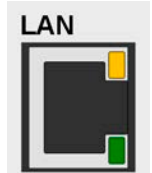
*.bin	Firmware updates <u>only</u> for the control panel. The folder name format is given, like 96230108_FW-ELR-MUL-HMI_V201.bin, and probably listed in short form as FW-ELR-MUL-HMI_V201.bin. Other BIN files won't be recognised or listed.
wave_<arbitrary_text>.csv	Sequence for sequence generator for use on voltage (U), current (I) and power (P) The name must begin with wave_, the rest is user defined.

1.9.6 Ethernet port

The Ethernet port on the front side of the device is provided for communication with the device and also for firmware updates (coming in 2016).

Details about remote control can be found in external documentation on the web site of EPS Stromversorgung or on the included USB stick. A general programming guide is available.

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

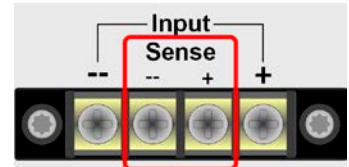


1.9.7 “Sense” connector (remote sensing)



Wiring of remote sensing is always required!

If „Sense“, but at least **Sense+**, is not wired or the connection is interrupted due to a cable fault, the load module will measure and display the DC input voltage only from a **minimum voltage of 4.8 V**. From this value, the display will also show „**Error: Sense**“, which is considered as a temporary alarm and which prevents switching on the DC input.



1.9.7.1 Purpose

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

1.9.7.2 Limitation

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. In other modes, the load module cannot correctly measure voltage and thus power. An example: the source is set to 15 V, the load draws 4 A, input “Sense” is connected to the source. Due to the current and long cables, the load module only has 10 V on the DC input. So it actually consumes $10\text{ V} \cdot 4\text{ A} = 40\text{ W}$. But since it always measures the DC voltage in the “Sense” input, which is connected to the source having 15 V, it measures and displays $15\text{ V} \cdot 4\text{ A} = 60\text{ W}$, while still taking 40 W of power.

1.9.7.3 Maximum compensation

As soon as the max. possible compensation is reached, i.e. the potential difference between DC input and Sense input would exceed the max. compensation, an error “Sense” is displayed and the DC input will be switched off. This error can also occur if the Sense+ conductor is interrupted somehow.

The situation where the error occur due to reaching the max. possible compensation voltage can only be avoided by either using shorter cables to the source or replacing them with some of bigger cross section.

1.9.7.4 Non-use

In case the Sense input is not wired to the source, it **has to be directly connected to the DC input** of the load module. This can be done using the included small bridge cables.

2. Installation & commissioning

2.1 Transport and storage

2.1.1 Transport



- The handles on the front side of the rack are **not** for carrying!
- Because of the weight of the rack, when equipped with load modules, 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 knob).
- Do not transport when switched on or connected!
- When relocating the equipment use of the original packing is recommended
- The device should always be carried and mounted horizontally
- Use suitable safety clothing, especially safety shoes, when carrying the equipment, as due to its weight a fall can have serious consequences

2.1.2 Packaging

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

2.1.3 Storage

In case of long term storage of the equipment it 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 equipment should be visually inspected for damage and completeness using the delivery note and/or parts list (see section „1.9.3. Scope of delivery“). An obviously damaged device (e.g. loose parts inside, damage outside) must under no circumstances be put in operation.

2.3 Installation

2.3.1 Safety procedures before installation and use



- The rack may, depending on the number of installed load modules, have a considerable weight. Therefore the proposed location of the equipment (table, cabinet, shelf, 19" rack) must be able to support the weight without restriction.
- When using a 19" rack, rails suitable for the width of the housing and the weight (see „1.8.3. Specific technical data“) of the device are to be used
- Before connecting to the mains ensure that the supply voltage is as shown on the product label. Overvoltage on the AC supply can cause equipment 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: this device is not intended to backfeed energy into the public grid. In case it is unavoidable to do so, it is essential to find out if the energy recuperation of this device is allowed at the target location and if it is required to install supervision hardware, i.e. an automatic isolation unit (AIU, ENS)

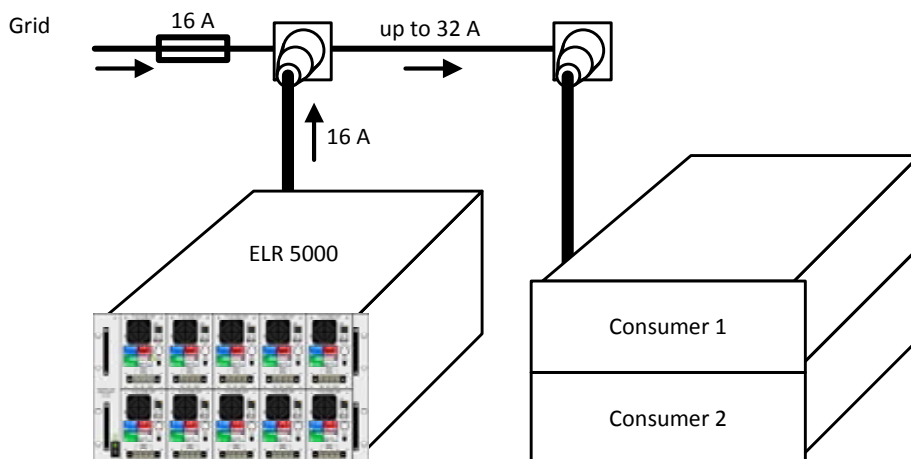
2.3.2 AC connection (EU model, 230 V wall socket)

Mains connection of an energy back-feeding electronic load rack of ELR 5000 series is done via the terminal on the rear side (230 V, 16 A, L, N, PE). The installer has to make a 3-strand cable with suitable length and cross section. Recommended wire cross section for a length up to 5 m and ambient temperature of up to 30°: 1.5 mm².

2.3.2.1 Installation concept for energy recovering devices

The recovered current adds to the grid current (see schematic below) and this can lead to overload of the existing installation. Considering any two outlets, no matter of what kind they are, but especially when being wall sockets, 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.

The existing installation concept must be taken into regard when connecting further ELR 5000 racks 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.

2.3.3 AC connection (US model, 208 V)

The US model of the ELR 5000 rack must be installed on a 208 V AC two-phase or three-phase (plus PE) supply only. This should be done using the included mains cable with open conductor ends, which are stripped and crimped. Alternatively, if a longer cable is required, we recommend to either extend the included cable or create a custom cable with correct IEC 19 plug for the device side and a proper 208 V two-phase (plus PE) plug or any other suitable connection on the supply side, all with cables rated for at least 16 A.



This device is an energy source. When running, it can generate ~208 V AC voltage on the AC connector, with approx. 16 A current. Make sure that the installation point is fused accordingly and that all conductors used are of sufficient cross section. Also mind that the recovered energy adds to the one from the public grid.



The included AC connection cable or any custom created one for this ELR 5000 rack device must only be used with this device!

Colour code of the included cable:

Green-Yellow: PE

Blue and Brown / Black: phases

2.3.3.1 Installation concept for energy recovering devices

Also see section 2.3.2.1. In the US connection scheme, the total current is distributed over two phases, but can still be too high for the installation.

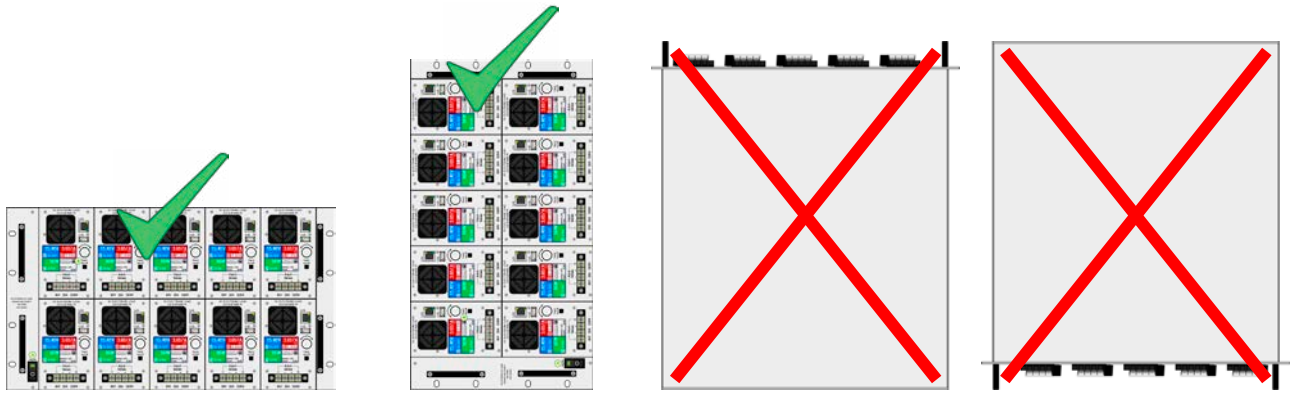
2.3.4 Installing the rack



- Select the location for the device so that the connection to the source is as short as possible.
- Leave sufficient space behind the equipment, 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

2.3.5 Installing load modules

Before installing any number of load modules the first time or before removing modules or changing the configuration, notice following:



- Always switch off the rack with the power switch and if possible, remove mains cord
- Remove voltage sources from DC input of all load modules about to be inserted/removed
- In case the rack was operating shortly before it has been switched off in order to insert/remove modules, wait at least 30 seconds before proceeding to the next action
- Never insert any module while the rack is switched on! If you are not sure whether the indication on the power switch is right, disconnect mains cord.

2.3.5.1 Inserting modules

The modules are intended to be inserted from left to right, because one module is the guide for next one. With this intention in mind, the modules could be numbered with position 1 (left) to 5 (right). When going to install a module in position 4 while the one for position 3 is not yet installed, it will be more difficult to find the correct position. But the installation is possible anyway.

Proceed as follows:

1. Insert the module at the desired position and push it into the rack so that it stands out for approx. 2 cm. Upper or lower row, as desired.
2. Push the module to the left, until it finds stop at the rack guidance (position 1) or the module to the left.
3. Push the module into the rack until full stop. You should notice a short tactile resistance before it finally rests.
4. Fix the module on the front plate with four of the included screws (M2.5x8, metric thread).
5. Continue the same way with further modules, if required.

Depiction:

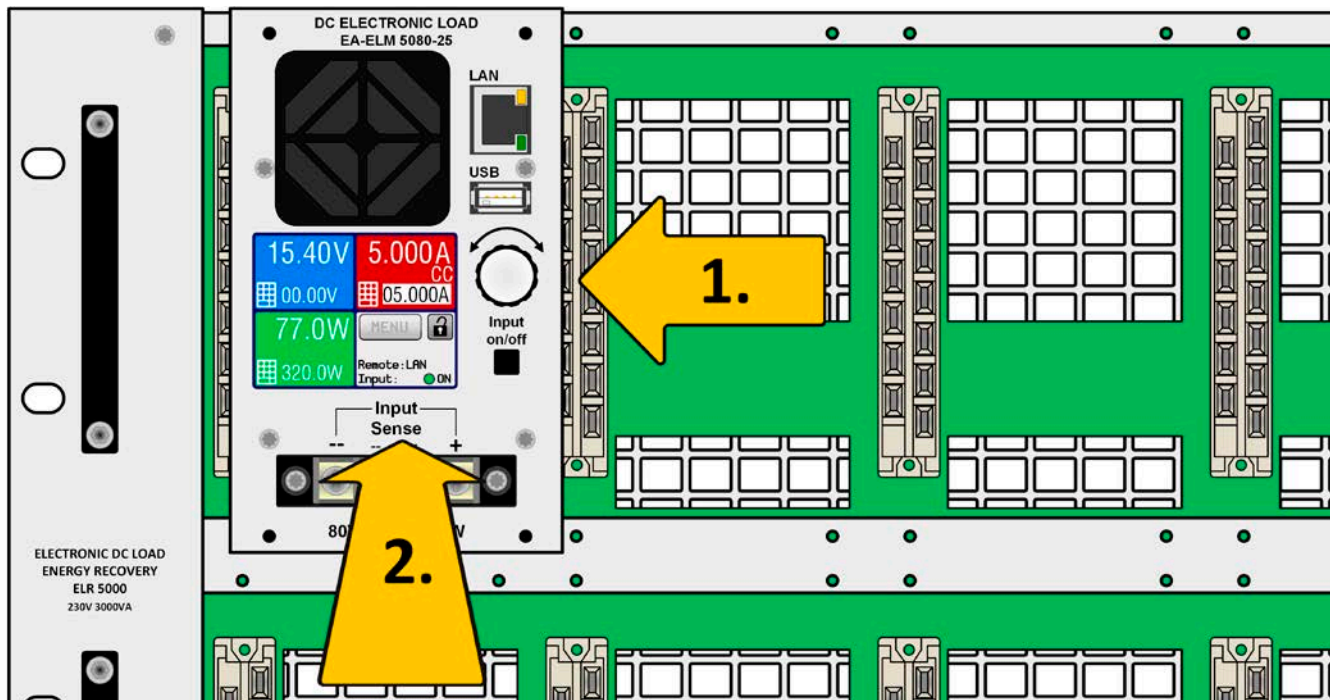


Figure 9 - Demonstration of module installation

2.3.6 Grounding of the DC input

Grounding, i. e. connect to earth potential, one of the DC input poles is permitted. A suitable PE access point can only be found outside of the ELR 5000 rack. The rack itself is grounded via the mains cord.

2.3.7 Connection to DC sources

The DC load input is on the front side of the module and is **not** protected by a fuse. The cross section of the connection cable is determined by the nominal current of the particular model, the cable length and ambient temperature. For cables up to 1.5 m and average ambient temperature up to 50 °C, we recommend:

up to **12 A**: 1 mm²

up to **25 A**: 2.5 mm²

per connection pole (multi-conductor, insulated). Single cables with for example 2.5 mm² may be replaced by 2x 1 mm² etc. If the cables are longer, then the cross section must be increased to avoid voltage loss and overheating.



For the safety of persons and in order to avoid physical contact with dangerous voltage levels it is highly recommend to always crimp insulated lugs to cable ends.

2.3.7.1 Cable lead and plastic cover

It is intended to connect the DC input cables (also for Sense) from the bottom side of the DC terminal:

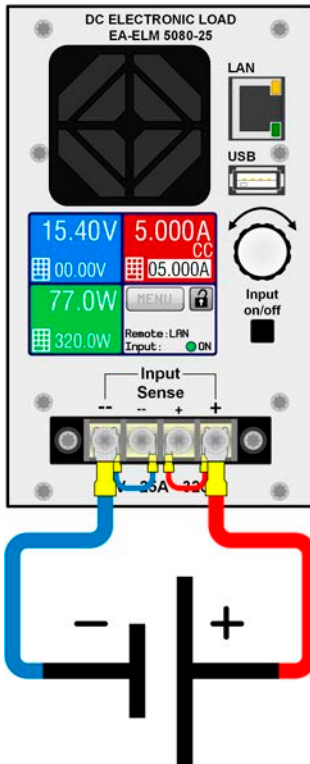


Figure 10 - Wiring example without remote sense (bridged)

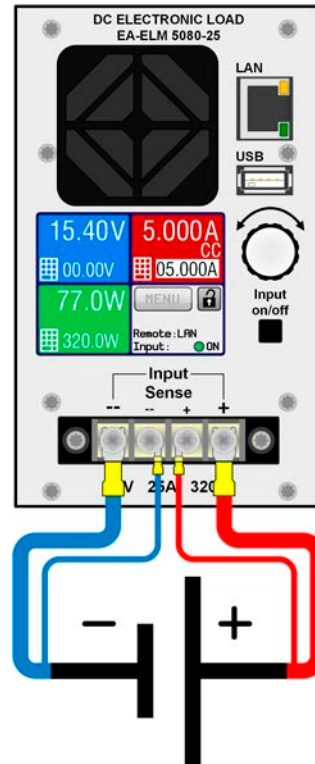


Figure 11 - Wiring example with remote sense connected to source

For the connection of DC power cables we recommend to either use cable end-sleeves or spade lugs.

Required for the DC terminal:

- Cable end-sleeves (insulated): 0,5 mm² ... 4 mm², max. length of the end-sleeve 8 mm
- Spade lugs (insulated): 4mm



When wiring the DC input(s) and the network port(s) at the same time it is imperative to keep distance between both lines! DC cables and network cables must not be tied together!

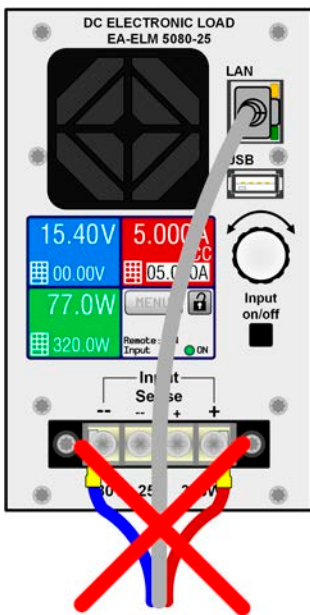


Figure 12 - Not allowed wiring

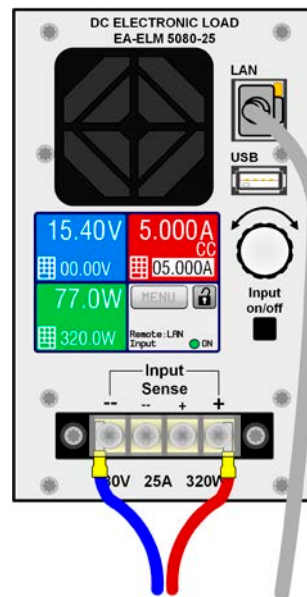


Figure 13 - Allowed wiring (example)

The wiring example in *Figure 13* is only one possible solution. It would even be better to let the LAN cable lead away to the top, so it does not obstruct the knob and the touch display remains fully accessible.

A plastic cover for contact protection on the DC terminal is included. It must always be installed.

2.3.8 Connection of remote sensing



- 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
- 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 Sense+ to + and Sense- to - at the source, otherwise the sense input of the electronic load can be damaged. For an example see *Figure 11*.

The load modules can be operated using remote sense or not. Remote sense can help to achieve a more accurate voltage regulation and thus only makes sense when being used in constant voltage (CV) operation.

If remote sense is not used, the sense connectors on the DC terminal on the front must still be wired between DC+ and Sense+, as well as DC- and Sense-. Only then the device can correctly measure and regulate the input voltage.

For both situations see the wiring examples in *Figure 10* and *Figure 11*.

2.3.9 Connection of LAN cable

In order to be able to remotely control one or multiple load modules, connecting the devices to a network is required. No matter how many load module in the rack are connected to the LAN, it is always imperative to not lay the LAN cables together with the DC cables or even bundle them.

We recommend to take care for as much space as possible between the LAN cables and DC cables, for safety reasons and to avoid crosstalk. The LAN cables of multiple load units can, however, be put together because they share the same reference, though they are galvanically separated from each other.

Also see *Figure 12* and *Figure 13* in 2.3.7.

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!

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

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

If there was a firmware update, it is recommended to reset the device to defaults by using the menu function “Reset device”.

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 Regulation 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 resp. regulation modes. Every regulation 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 source is connected to the electronic load and that source provides a certain input voltage to 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 draw no current from the source. If the voltage set value is lower than the input voltage the load will attempt to draw as much current from the source as required to reach the desired voltage level. If the that current would reach the adjusted current limit or the total power would reach the limit according to $P = U_{IN} \cdot I_{IN}$, the load would automatically switch to constant current or constant power operation, whatever comes first. The adjusted input voltage could then no longer be maintained or not at all achieved.

While the DC input is switched on and constant voltage mode is active, the condition "CV mode active" will be indicated on the graphics display by the abbreviation **CV**, as well it will be stored as internal status which can be read via digital interface.

3.2.1.1 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. The technical specifications list U_{MIN} for every model. If less voltage than U_{MIN} is supplied, the load proportionally draws less current than adjusted.

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 actual current has reached the adjusted value, the device automatically switches to constant current mode. However, if the power consumption reaches the adjusted power level first, 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. Power regulation has priority over current regulation. The each other regulation circuit is permanently active and cannot be deactivated.

While the DC input is switched on and constant current mode is active, the condition "CC mode active" will be indicated on the graphics display by the abbreviation **CC**, as well it will be stored as internal status which can be read via digital interface.

3.2.3 Resistance regulation / constant resistance

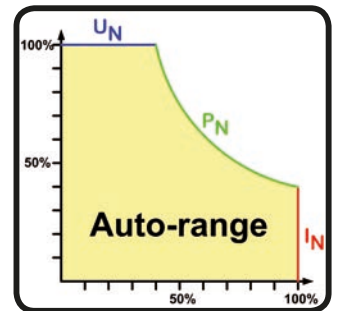
Not available with load modules of series ELM 5000.

3.2.4 Power regulation / constant power / power limitation

Power regulation, also known as power limitation or constant power (**CP**), is supposed to keep the DC input power of the device at the adjusted value, so that the current flowing from the source, together with the input voltage, reaches the desired level. The power regulation circuit would then limit the input power by impacting on the input current according to $I_{IN} = P_{SET} / U_{IN}$ as long as the source is able to provide the requested electrical power. 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.

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). This principle allows for higher voltage or current levels at the same power rating.

While the DC input is switched on and constant power operation is active, the condition "CP mode active" will be indicated on the graphics display by the abbreviation **CP**, as well it will be stored as internal status which can be read via digital interface.



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 model: 1000uF....4700uF

200 V model: 100uF...470uF

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 (text + message in the display) and as a readable status, as well as alarm counter. For later acquisition, that alarm counter can be read from the display or 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 due to an AC undervoltage and is gone later on, the alarm will vanish from display and doesn't require to be acknowledged.

The condition of the DC input after a gone PF alarm can be determined in the MENU. See 3.4.3.



Switching off the rack with the mains switch can not be distinguished from a mains blackout and thus the load module(s) will signalise a PF alarm every time the racks is powered off. This can be ignored.

3.3.2 Overtemperature

An overtemperature alarm (OT) can occur if an excess temperature inside the device causes it to stop sinking power temporarily. This can occur due to a defect of the internal fan regulation or due to excessive ambient temperature. Though the device recovers most of the consumed energy with a high efficiency, it requires cooling.

After cooling down, the device will automatically continue to work, 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 limits (OVP, 0...110% U_{NOM})

This function serves to warn the user of the electronic load 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

3.4.1 Powering the device

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

After switching on, the display of all installed load modules will first show the company logo, followed by some device related information and a language selection. In setup (see section „3.4.3. Configuration via MENU“), in the second level menu **“General settings”** is an option **“DC input after power ON”** in which the user can determine the condition of the DC input after power-up. Factory setting here is **“OFF”**, meaning that the DC input on power-up is always switched off. **“Restore”** means that the last condition of the DC input will be restored, either on or off. All set values are also and always restored.

3.4.2 Switching the device off

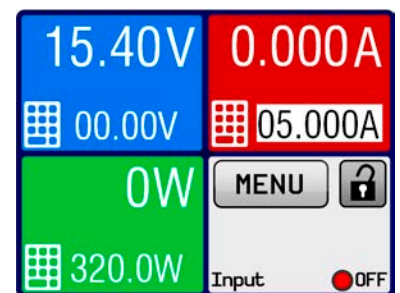
On switch-off, the last input condition and the most recent set values and input status are saved. Furthermore, a PF alarm (power failure) will be reported, but can be ignored in this situation.

The DC input is immediately switched off and after another few seconds the device will be completely powered off.

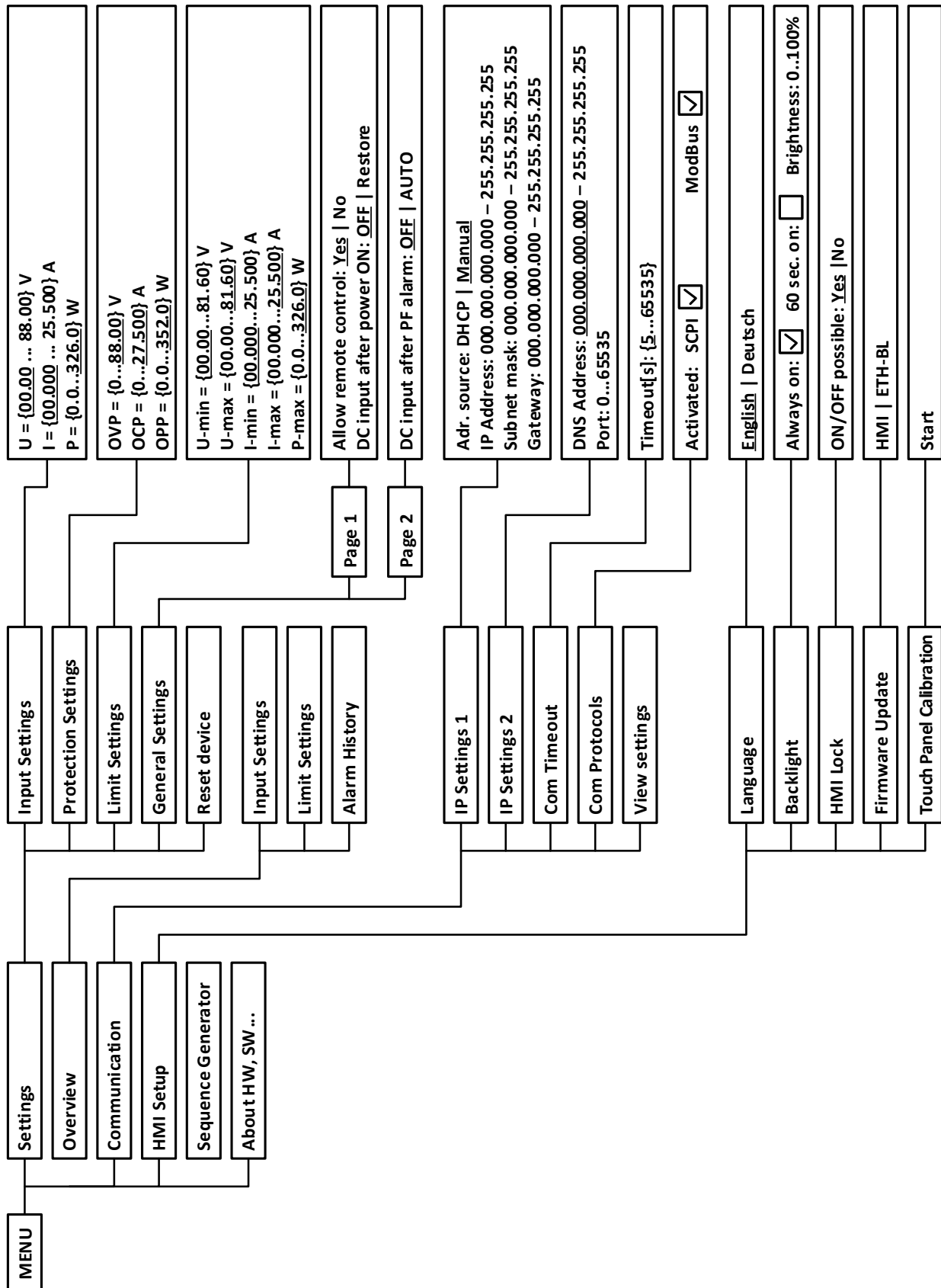
3.4.3 Configuration via MENU

The MENU serves to configure all operating parameters which are not constantly required. The menu can be accessed by tapping the MENU touch area, but only while the DC input is switched OFF. See figures to the right.

Menu navigation is by touch only (finger or pen). Values are set using the rotary knob or direct input via touch screen. The assignment of the knob to the adjustable value is indicated by the selected value being inverted (black on white). Selecting another value can only be done by tapping on it.



The menu structure is shown schematically on the next page. Some setting parameters are self-explanatory, others are not. Those will be explained on the next pages.



Parameters in curly brackets describe the selectable range, underlined parameters show the default value after delivery or reset.



3.4.3.1 Menu “Settings”

This menu branches to several sub menus:

Menu item	Description
Input Settings	Alternative way to adjust set values for voltage, current and power. Refer to section 3.4.5.
Protection Settings	Adjustment of protection thresholds. Refer to 3.4.5 and 3.3.
Limit Settings	Adjustment limits are defined here. Refer to 3.4.4.
General Settings	Refer to section 3.4.3.2 below.
Reset device	Touch area “ ENTER ” will initiate a reset of all settings and all set values, as well as other parameters of the load module to factory defaults

3.4.3.2 Menu “General Settings”

Setting	P.	Description
Allow remote control	1	Selection “ No ” means that the load module cannot be remotely controlled via the digital interface. If remote control is not allowed, the status will be shown as “ Local ” in the status area on the main display. Also see section 1.9.5.1
DC input after power ON	1	Determines the condition of the DC input of the particular load module after powering the rack. <ul style="list-style-type: none"> • OFF = DC input is always off after switching on the rack. • Restore = DC input condition will be restored to the condition prior to switch off.
DC input after PF alarm	2	Determines how the DC input of the particular load module shall react after a power fail (PF) alarm has occurred: <ul style="list-style-type: none"> • OFF = DC input will be switched off and remain until user action • Auto ON = If the DC input was switched on before the alarm occurred, it will switch on again after the PF alarm cause is gone

3.4.3.3 Menu “Overview”

This menu page has several sub menu pages which display overviews of the set values (U, I, P), occurred alarms and the so-called adjustment limits. These values can only be viewed here.

3.4.3.4 Menu “About HW, SW...”

This menu page displays an overview of device relevant data such as serial number, article number etc.

3.4.3.5 Menu “Sequence Generator”

See „3.8 The sequence generator“ on page 38.

3.4.3.6 Menu “Communication”

This submenu offers settings for digital communication via the Ethernet interface. There is, for instance, a communication timeout, which is used to close the socket connection after an adjustable period of no communication.

In the screen for “Com Protocols” you can enable both or disable one of the two supported communication protocols, ModBus RTU and SCPI. This can help to avoid mixing both protocols and to receive unexpected messages, for example when expecting a SCPI response and getting a ModBus RTU response instead.

3.4.3.7 Menu “HMI Setup”

These settings refer exclusively to the control panel (HMI).

Element	Description
Language	Selection of the display language between German and English
Backlight	The choice here is whether the backlight remains permanently on or if it should be switched off when no input via screen or rotary knob is made for 60 s. As soon as input is made, the backlight returns automatically. Furthermore the backlight intensity can be adjusted here.
HMI Lock	See „3.7 Control panel (HMI) lock“ on page 37.
Firmware Update	With this function the firmware of the control panel can be updated using an USB stick. For details refer to „4.3 Firmware updates“ on page 45.

Element	Description
Touch Panel Calibration	Starts a calibration process for the touch screen. After calibration the touch areas should react better and more accurately to finger touches. After every device reset which resets the device to factory defaults it will require to perform touch panel calibration again.

3.4.4 Adjustment limits

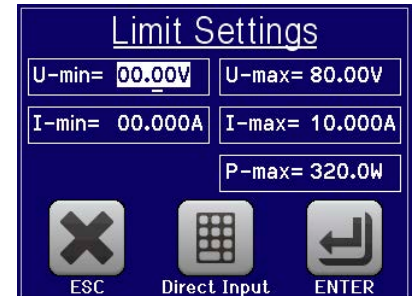


Adjustment limits are only effective on the related set values, no matter if using manual adjustment or remote control!





Adjustment are intended to prevent the deliberate setting of wrong, i. e. too high values, primarily when using direct input or remote control.

By default, all set values (U, I, P) are adjustable from 0 to 102% of rated value. This may be obstructive in some cases, especially for protection of applications against overcurrent. Therefore upper and lower limits for current (I) and voltage (U) can be set which limit the range of the adjustable set values.

For power (P) only an upper value limit can be set.



► How to configure the adjustment limits

- On the main screen, tap , then  and then .
- Tap the desired value to select it for adjustment.
- Adjust the value(s) with the rotary knob or per direct input.
- Accept the settings with .



The adjustment limits are coupled to the set values. It means, that the upper limit may not be set lower than the corresponding set value. Example: If you wish to set the limit for the power set value (P-max) to 200 W while the currently adjusted power set value is 250 W, then the set value first would have to be reduced to 200 W or less in order to set P-max down to 200 W.

3.4.5 Manual adjustment of set values

The set values for voltage, current and power are the fundamental operating possibilities of an electronic load and hence the rotary knob on the front of the device is always assigned to one of the three values in manual operation. Default assignment is the voltage.

The set values can be entered manually in two ways: via rotary knob or direct input.



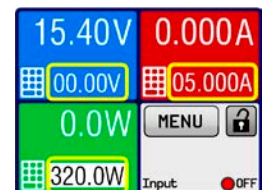
Entering a value changes it at any time, whether the input is switched on or off.



When adjusting the set values, upper or lower limits may come into effect. See section „3.4.4. Adjustment limits“. Once a limit is reached, the display will show a text “Limit: U-max” etc. for 1.5 seconds above the selected set value.


► How to adjust values with the rotary knob






- First check if the value you want to change is already assigned to the rotary knob. The main screen shows the assignment as depicted in the figure to the right, by displaying the selected value in inverted form (white background).
- If, as shown in the example, the assignment is voltage (U, left) and current (I, right), and it is required to set the power, then the assignments can be changed by tapping this touch area. A set of selection fields then appears.
- After successful selection, the desired value can be set within the defined limits. Selecting a digit is done by pushing the rotary knob which shifts the cursor from right to left (selected digit will be underlined):

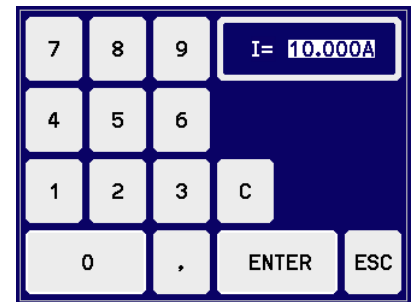


10.000 A → 10.000 A → 10.000 A

► How to adjust values via direct input

1. Tap on the small keypad symbol in the set/actual value display areas of the main screen or, when being in a menu, tap on the button labelled **"Direct Input"**.
2. Enter the required value using the ten-key pad. Similar to a pocket calculator the key  clears the input.

Decimal values are set by tapping the point key. For example, 54.3 V is set with     and .



3. The display reverts to the main page and the set values take effect.



If a value is entered which is higher than the adjustment limit, a message appears and the entered value is not accepted.

3.4.6 Switching the DC input on or off

The DC input of the load module can be manually or remotely switched on and off. This can be restricted in manual operation by the control panel being locked.

► How to manually switch the DC input on or off

1. As long as the control panel (HMI) is not fully locked press the button **"On/Off"**. Otherwise the device will not react to button presses.
2. The button toggles between on and off, as long as a change is not restricted by an alarm or the device is locked in **"Remote"**. The condition is displayed as either **"Input: On"** or **"Input: Off"**.

► How to remotely switch the DC input on or off via the digital interface

1. See the external documentation "Programming Guide ModBus & SCPI" if you are using custom software, or refer to the external documentation of LabView VIs or other documentation provided by EPS Stromversorgung.

3.5 Remote control

3.5.1 General

Remote control is possible via the built-in Ethernet/LAN port. If remote control of the device is going to be used, i.e. settings status or values, it generally requires to switch the device into remote control mode by a dedicated command via the digital interface. Remote control can, however, be inhibited by a setting in the device menu or be aborted on the device's HMI. This is a safety feature which allows the user to interact with the device in case of an emergency.

For status monitoring and reading of values, activating remote control is not required. Reading is always possible and allowed.



The user is required to take over remote control by a command before you can remotely change any value or status of the device.

3.5.2 Controls locations

Control locations are those locations from where the device can be controlled. Essentially there are two: at the device (manual control) and external (remote control). The following locations are defined:

Displayed location	Description
-	If neither of the other locations is displayed then manual control is active and access from the digital interface is allowed. This location is not explicitly displayed
Remote	Remote control via any interface is active
Local	Remote control is locked, only manual operation is allowed.

Remote control may be allowed or inhibited using the setting “**Allow remote control**” (see “3.4.3.2. Menu “General Settings”). In inhibited condition, the status “**Local**” will be displayed in the status area. Activating local mode can be useful if the device is remotely controlled by software or some electronic device, but it is required to make adjustments at the device or deal with emergency, which would not be possible remotely.

Activating condition “**Local**” causes the following:

- If remote control via the digital interface is active (“**Remote**”), then it is immediately terminated and in order to continue remote control once “**Local**” is no longer active, it has to be reactivated from the control device (PC)
- If manual control is active, i.e. no remote control, an attempt to switch to remote control with the corresponding command is refused by the device and replied with an error message.

3.5.3 Remote control via Ethernet

After a device reset to factory defaults or when receiving a new load module, following network parameters are set:

- IP address: 192.168.0.2
- Subnet mask: 255.255.255.0
- Gateway: 192.168.0.1
- Port: 5025
- Host name: Client
- Domain: Workgroup
- DNS: 0.0.0.0
- TCP keep-alive: off
- DHCP: off

This means that in order to integrate a new load module into a network, it must be assigned a unique IP. This can be done using DHCP, which has to be activated before, or manually on the device's HMI or its website.

Once the module has been correctly set up and connected to the network, it can be accessed anytime using a socket connection to its IP and port. The TCP connection supports messages in SCPI or ModBus RTU protocol format. For further information see the programming documentation on the included USB stick.

The device features an adjustable Ethernet timeout, which is set to 5 seconds by default. In case the connection shall remain open even when not communicating, the setting has to be increased in the MENU of the device.

3.6 Alarms and monitoring

3.6.1 Definition of terms

Equipment alarms (see „3.3. Alarm conditions“) such as overcurrent (OCP) primarily serve to protect the source, which is connected to the load module, and secondarily to protect the load itself. All alarms will cause the load device to switch off the DC input and signal the condition on the display as text, but also as readable status via digital interface. There are following signal types:

Action	Impact	Example
Error	On reaching the condition which triggers an event of type Error the display of the particular load module will only show a text message in the status area of the display. An event of type Error can also occur while the DC input is switched off and will then inhibit to switch it on as long as the error is persistent.	Error: Sense
Alarm	On reaching the condition which triggers an event of type Alarm the display of the particular load module will show a text message in the status area of the display with an additional alarm pop-up. Furthermore the DC input is switched off. Certain device alarms can be queried via the digital interface. An event of type Alarm can also occur while the DC input is switched off and will then inhibit to switch it on as long as the alarm is persistent.	Alarm: OVP

3.6.2 Device alarm handling

Important to know:



- The current drained from a switching power supply or similar sources can be much higher than expected. It is due to capacities on the source's output, and even if the source is current limited it could trigger the overcurrent shutdown OCP or the overpower shutdown OPP on the electronic load, in case these supervision thresholds are adjusted too sensitively
- 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 could trigger the overvoltage shutdown OVP on the electronic load, in case this threshold is adjusted too sensitively
- The device cannot record alarms in the order of their occurrence. The alarm listing always show all present alarms, but unsorted

A device alarm incident will usually lead to DC input switch-off and the appearance of an alert text in the display. **Some alarms must be acknowledged, thus they are kept in the display until acknowledgement.** If the alarm condition of alarms which don't have to be acknowledged no longer exists, e.g. the device has cooled down following overheating, the alarm indication will disappear.

The status area of the display will only show the alarm with the highest priority (see table below). In case of multiple alarm occurring the same time, for example an overvoltage alarm during an overtemperature condition, they can be listed by tapping on the status area where the alarm is indicated. This will bring up an alarm list in a pop-up. In the MENU, there is furthermore an alarm counter for all device alarms. Every load module counts has its own alarm counter.

► How to acknowledge an alarm in the display (during manual control)

1. While the alarm is indicated as text in the status area of the display, tap on the alarm text. A pop-up will be displayed, listing the currently active alarms (see example to the right).
2. Tap in the **OK** button. The pop-up will close and in case the alarm or alarms are not active anymore, the alarm status in the status area will be cleared. Possibly remaining alarms are again shown according to priority.

Alarm: OVP



In order to acknowledge in digital remote control refer to the external documentation "Programming ModBus & SCPI".

Some device alarms have an adjustable threshold:

Alarm	Prio	Meaning	Description	Range
OVP	1	OverVoltage Protection	Triggers an alarm if the DC input voltage reaches the defined OVP threshold. The DC input will be switched off. The electronic load module is, however, not protected against possible damage due to overvoltage. This alarm serves to notice possible overvoltage situations coming from the source.	0 V...1.1*U _{Nom}
OCP	2	OverCurrent Protection	Triggers an alarm if the DC input current reaches the defined OCP threshold. The DC input will be switched off.	0 A....1.1*I _{Nom}
OPP	3	OverPower Protection	Triggers an alarm if the DC input power reaches the defined OPP 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	Prio	Meaning	Description
PF	5	Power Fail	Signalises various problems with the DC-AC inverter in the rack. Triggers an alarm if the AC supply is out of specification or when the device is cut from supply (e.g. when switching it off with the power switch) or the inverter overheats. The DC input will be switched off.
OT	4	OverTemperature	Triggers an alarm if the internal temperature of the load module exceeds a certain limit. The DC input will be switched off.

These are displayed the same way as device alarms, but with text "Error" and are not handled as alarms:

Error	Prio	Meaning	Description
Sense	6	Sense not connected	This error is a) either triggered if the remote Sense connectors are not correctly wired or interrupted or b) if the difference between input voltage on the DC input and the Sense input is too big (see technical specifications). In situation a) it is sufficient if Sense+ is not connected or interrupt. This error will inhibit to switch on the DC input.

► How to configure the adjustable device alarms

1. Tap the touch area , then  and then .
2. Select the value you want to adjust by tapping on it.
3. Set the limits for the equipment alarm relevant to your application if the default value of 110% is unsuitable.





The set values can also be entered using the ten-key tab. This will appear by tapping the button "Direct Input" in the same screen.

3.7 Control panel (HMI) lock

In order to avoid the accidental alteration of a value during manual operation, the rotary knob, the pushbutton and the touchscreen can be locked so that no alteration of values will be accepted without prior unlocking.


► How to lock the HMI

1. In the main page, tap the lock symbol  (upper right corner).
2. The settings page “**HMI Lock Setup**” will appear, asking you to chose whether the On/Off button is still usable (“**ON/OFF possible = Yes**”) during the lock or if the HMI will be completely locked (“**ON/OFF possible = No**”).
3. Activate the lock with . The status “**Locked**” is then shown as in the figure to the right.



If an attempt is made to alter something whilst the HMI is locked, a requester appears in the display asking if the lock should be disabled.

► How to unlock the HMI

1. Tap any part of the touchscreen of the locked HMI, or turn the rotary knob or press the button “On/Off” (only in complete lock).
2. This request pop-up will appear: .
3. Unlock the HMI by tapping on “Tap to unlock” within 5 seconds, otherwise the pop-up will disappear and the HMI remains locked.

3.8 The sequence generator

3.8.1 Introduction

The built-in sequence generator is able to create a progress of U, I and P over time.

This progress is based on 100 freely configurable sequence points, which build a sequence. Configuration of the sequence and handling of the sequence run can be done manually or via remote control. The entire sequence is stored in the load module unit and the single sequence points can be selected, edited and run in an arbitrary number.

Furthermore, the sequence can be saved to or loaded from an USB stick via the front side USB port. This allows for quick switching of multiple different sequences, which can be edited or created on a PC due to the open sequence file format (CSV).

3.8.2 Method of operation

The points of a configured sequence are processed one by one, switching to the next point after the adjusted time has elapsed, setting values of the next point in a step. It means, there is no linear progression between two points and thus the resulting curve is rectangular. It is not possible to generate ramps, however, it is possible to use very small steps in amplitude and time to achieve a stairway shaped progression which is similar to a ramp (see examples below, *Figure 16*).

The user can select any number of sequence points (1-100) to run by setting a start and end point. They are processed in ascending order and without delay. The selected points form a block. This block can be repeated 1-999 times or infinitely, until the run stops automatically or by manual interaction.

Examples for possible sequence progressions (P = point of a sequence):

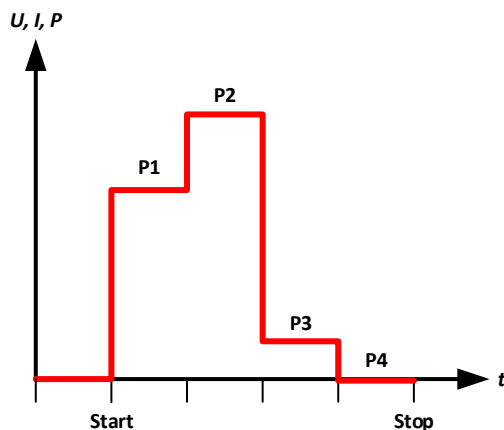


Figure 14 - Simple sequence with equal periods

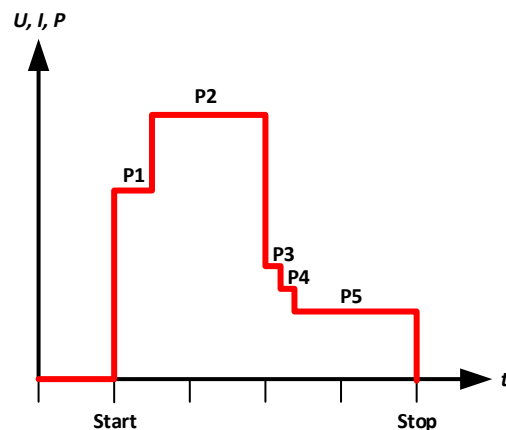


Figure 15 - Simple sequence with varying periods

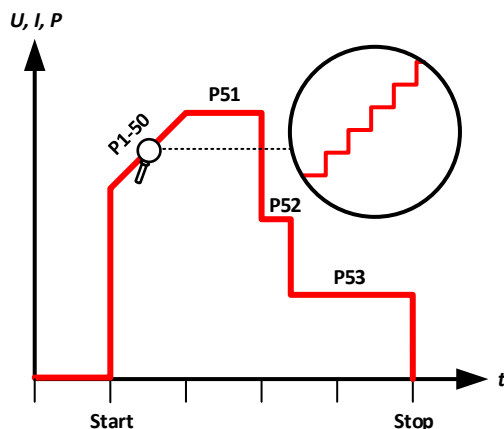


Figure 16 - Sequence with simulated ramp of 50 steps

3.8.2.1 General procedure

Following procedure is required for the configuration of the sequence generator (SEQ) and the sequence run:

1. **Check and set the global conditions** for the sequence run:
 - a. Adjust set values for **U, I and P** in the main screen of the load module. These apply after an automatic or manual sequence stop and as long as the DC input is still switched on. Also see below at „3.8.2.3. Behaviour“.
 - b. Adjust protection values, such as OVP, OCP and OPP in order to avoid affecting the sequence run just from their value. Alarms exceeding these thresholds can occur the same way in the SEQ and will switch off the DC input and stop the sequence run.
2. **Select the sequence generator** in the MENU (page 2), in submenu **Function Generator**. This can only be done while the DC input is off.
3. **Configure all necessary sequence points** (if not done yet).
4. **Configure the sequence run**.
5. **Load the sequence** (the electronic load module won't switch on the DC input after loading).
6. **Control the sequence generator**.
 - a. **Start** the sequence either with touch area **“Start”** or with pushbutton **“On/Off”**.
 - b. **Stop** the sequence at will, i.e. manually, or let it run until the end (all points and repetitions processed) where it will automatically stop. A manual stop can be done two ways, either with touch area **“Stop”** or with pushbutton **“On/Off”**, while there is a difference:
 - **“Stop”**: the sequence will stop immediately, the DC input remains switched on, the set values of U, I and P from the main screen setting (see step 1.) will be set and the SEQ cannot be left yet.
 - **“On/Off”**: the sequence will stop immediately, the DC input will be switched off and the SEQ can be left
7. **Exit the sequence generator**.
 - a. This can only be done after the sequence run has been stopped and the DC input has been switched off.

3.8.2.2 Limitations

Following limitations apply:

- In case a sequence run is stopped anywhere in the middle, the sequence cannot be continued and will be processed from the very beginning at the next start

3.8.2.3 Behaviour

After loading a sequence and before starting the sequence run, the DC input of the load module is generally switched off and will automatically be switched off when starting. However, when stopping a sequence with the touch area **“Stop”**, which only stops the sequence run, the DC input remains on and the device will set certain U, I and P values.

Following possible scenarios:

Desired behaviour	Solution
The load module shall not draw any current after the stop	Set the current set value to 0 in the main screen, before entering the SEQ
The load module shall draw a specific current after the stop	Set the current set value to your desired, specific value in the main screen, before entering the SEQ
The load module shall draw the same current after the stop as in the last processed sequence point	Set the current set value to the same value as in the last sequence point you configured for the sequence run. After every change to the start or end point or when altering the settings of the last sequence point, you would have to return to the main screen and adapt the set value of current value again. This behaviour won't unfortunately work as expected in case the sequence run is stopped before the last point, perhaps due to an alarm or manual stop.

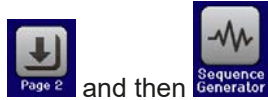
3.8.3 Manual operation

3.8.3.1 Accessing and configuring the sequence generator

Via the touchscreen the sequence generator (SEQ) can be called up, configured and controlled. Selection and configuration are only possible when the input is switched off.

► How to access the SEQ

1. Make sure the DC input of the load module is switched off.
2. Tap the touch area **MENU** on the main screen and in the menu tap on



3. The first screen of the SEQ will always be the sequence point selection, as shown in the example to the right.

► How to configure a sequence point

1. If there is one or several sequence points to configure, select the first one in the screen **"Seq. point select"** by using the rotary knob and start editing it by tapping on touch area **"Edit"**. The edit screen for the selected sequence point will be loaded (see example to the right).
2. Adjust the values for U, I and P, as well as the time, with the rotary knob as usual. Direct input is not available here. Selecting a different value is by tapping on it. The time value defines how long the settings for U, I and P are valid when processing the particular sequence point.
3. Once you are finished with setting a point, you may choose to save the changes and return to the select sequence point screen by tapping **"SAVE"** or if you are going to edit subsequent points (next or previous), use the two touch areas **"Prev.seq."** and **"Next seq."**.

Following adjustment ranges apply for the parameters of all sequence points:

Parameter	Adjustment range	Description
U	0...U _{Nom}	Voltage set value of the sequence point over the given time
I	0...I _{Nom}	Current set value of the sequence point over the given time
P	0...P _{Nom}	Power set value of the sequence point over the given time
Time	1 ms ... 36000 s	Period of the sequence point in seconds

The adjustment limits ("Limits") do not apply here. The time of all sequence points sums up to the total run time of one sequence cycle. With this, a minimum time of 1 ms (1 sequence) and a maximum time of 1000 h (100 sequences).

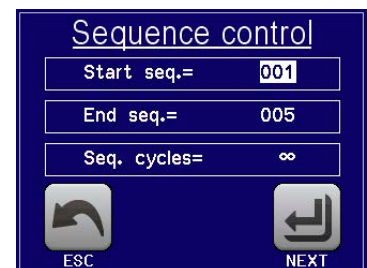
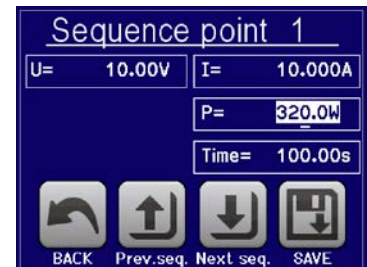
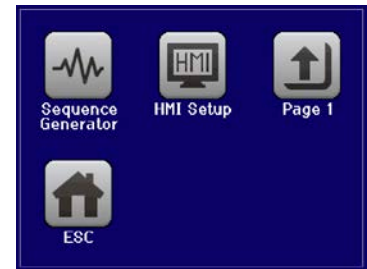
► How to configure the sequence

1. In the screen **"Seq. point select"** (see above) tap on touch area **"NEXT"**. This will open screen **"Sequence control"** (see example to the right).
2. Select the block of sequence points to process for the next run by setting the first (**Start seq.**) and last (**End seq.**) point.
3. Also set the number of **Seq. cycles** (1-999 or infinite).
4. Confirm your settings with touch area **"NEXT"** or abort with **"ESC"**.




With tapping on "NEXT", the device will finally load the sequence, switch to the actual sequence generator screen SEQ. The sequence run can now be started.



If any of the sequence points in the block has not explicitly been set while configuring the points, it will either have default values (U = 0, I = 0, P = 320 W, t = 0.3 s) or the ones which have been set the last time.



► How to start and stop a sequence

1. The sequence can be **started** either by tapping  or pushing the “On/Off” button, if the DC input is currently switched off. The sequence then starts immediately with the parameters of the start sequence point. In case **START** is used while the DC input is still switched off, the DC input will be switched on automatically.
2. The sequence can be **stopped** either by tapping  or pushing the “On/Off” button. However, there is a difference:
 - a)  only stops the sequence run, the DC input remains ON with the static values in effect.
 - b) The “On/Off” button stops the sequence run and switches the DC input off.



Any device alarm (overvoltage, overtemperature etc.) stops the sequence run automatically, switches off the DC input and reports the alarm in the display.



In order to exit the sequence generator SEQ after stopping the run with touch area “STOP”, the DC input would have to be switched off first.

3.8.3.2 Loading and saving of sequences

The device can store one sequence at a time. It is possible to quickly switch to another sequence by loading it from an USB stick via USB port on the front side of the load module. It accepts USB sticks in FAT32 format and up to 32 GB of storage space. Sticks with USB 3.0 and/or higher storage capacity may work, but this is not guaranteed.

Limitations:

- Generally, all 100 sequence points of a sequence are saved or loaded at once
- The device can only list a max. of 5 sequence files. Those up to 5 files are not necessarily the first 5 sequence files in the folder when listed alphabetically. It is thus recommend not to have more than 5 sequence files at once in this folder.
- If you intend to save the currently active sequence to USB stick and into a new file (-NEW FILE-, see below), it is only possible if there are not already more than 4 other sequence files in the same folder

For the **file name** of sequence files there are following requirements:

- The file(s) must be stored inside a folder called HMI_FILES which has to be in the root of the USB driver
- The file name must always start with WAVE_ (not case-sensitive)

For the **file format** of sequence files there are following requirements:

- The file(s) must contain exactly 100 rows with 4 subsequent, semicolon separated values, i.e. 4 columns when viewed in Excel or similar
- Values with decimal places can have comma or dot as decimal separator, but only one per value. Example: 1,0 or 1.0 are OK, but 10,000,000 or 10.000.000 is not accepted.
- All values in every row and column have to be within the specified range (see below)
- The columns in the table have to be in a defined order which must not be changed

Following value ranges are given for use in the sequence file with its 100 rows, related to the manual configuration of the sequence generator (column headers named like in Excel):

Column	Parameter	Range
A	Set value of voltage	0...100% U
B	Set value of current	0...100% I
C	Set value of power	0...100% P
D	Time in milliseconds	1...36,000,000 (36 million ms = 10 h)

Example CSV:

	A	B	C	D
1	00,00	1,000	320	20000
2	00,00	1,000	320	1000
3	00,00	3,000	320	1000
4	00,00	00,000	320	300
5	00,00	00,000	320	300
6	00,00	00,000	320	300

The example shows that only the first three sequence points are configured, while all others are set to default values.

The view is Excel style, which doesn't interpret a text like 00,000 as value, but it doesn't matter, because when saving the file as CSV all becomes text again.

► How to load a sequence file from an USB stick:

1. Do not yet plug the USB stick or remove it, if currently plugged.
2. Access the sequence generator with **MENU -> Page 2-> Sequence generator**, to see its main screen, as depicted to the right.



3. Tap touch area **Import/Export**, then **LOAD from USB** and follow the instructions on screen. If at least one valid file has been recognized the device will show a list of files to select from. For file and path naming, as well as limitations regarding the number of displayable files, see above. Select a file by tapping on the file name.



4. Tap touch area **LOAD from USB** in the bottom right corner. The selected file is then checked and loaded, if valid. In case it is not valid, the device will show an error message. Then the file must be corrected and the steps repeated or you could load a different file.



► How to save the currently active sequence to an USB stick:

1. Do not yet plug the USB stick or remove it, if currently plugged.
2. Access the sequence generator with **MENU -> Page 2-> Sequence generator**.



3. Tap touch area **Import/Export**, then **SAVE to USB**. The device will request you to plug the USB stick now.
4. After plugging it, the device will try to access the USB stick and find the folder HMI_FILES and read the content. If there are already sequence files present, they will be listed and you can either select one for overwriting, otherwise select **-NEW FILE-** for the creation of a new file.



5. Finally save the sequence with **SAVE to USB**.

3.8.4 Remote control of the sequence generator

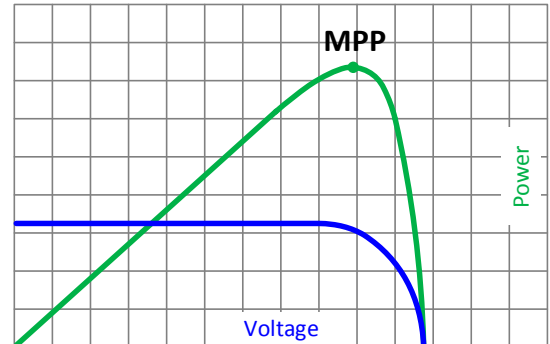
The sequence generator can be remotely controlled, but configuration and control of the single functions, as well as loading sequence point data with individual commands is different from manual operation. The external documentation "Programming Guide ModBus & SCPI" explains the approach.

3.9 MPP tracking

The MPP in the name of this function stands for “maximum power point” (see principle view to the right), a commonly known name for this particular point on the power curve of solar panels. Solar inverters, when connected to such panels, constantly track this MPP.

The electronic load simulates this behaviour. It can be used to test even huge solar panels without having to connect a usually big solar inverter device which also requires to have a load connected to its AC output. Furthermore, all MPP tracking related parameters of the load can be adjusted and it so is much more flexible than an inverter with its limited DC input range.

The MPP tracking function, as it is manually usable on the HMI, offers three modes. A fourth mode is available for remote control via any of the optionally available digital interfaces (USB, Ethernet).



3.9.1 Mode MPP1

This mode is also called “find MPP”. It is the simplest option to have the electronic load find the MPP of a connected solar panel. It requires to set only three parameters. Value U_{OC} is necessary, because it helps to find the MPP quicker as if the load would start at 0 V or maximum voltage. Actually, it would start at a voltage level slightly above U_{OC} .

I_{SC} is used as an upper limit for the current, so the load would not try to draw more current than the panel is specified for.

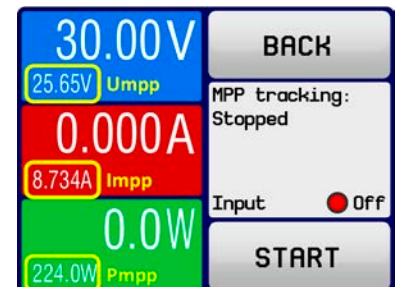
When setting up the parameters, it must be observed that $U_{OC} * I_{SC}$ can't exceed the rated power of the load module.

Following parameters have to be configured for tracking mode **MPP1**, the others can be ignored:

Value	Range	Description
U_{OC}	0...Rated value of U	Voltage of the solar panel when unloaded, taken from the panel specs
I_{SC}	0...Rated value of I	Short-circuit current, max. specified current of the solar panel

Application and result:

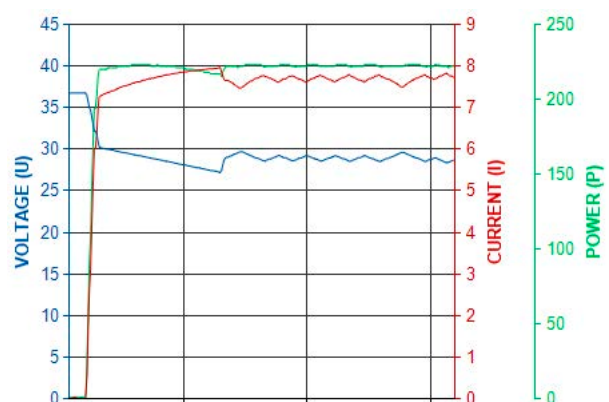
After the two parameters have been set, the function can be started. As soon as the MPP has been found, the function will stop and switch off the DC input. The acquired MPP values of voltage (U_{MPP}), current (I_{MPP}) and power (P_{MPP}) are then shown in the display. The time of a function run depends on a parameter named Δt (default: 5 ms) which is not configurable on the HMI, but in remote control via Ethernet. Even with the minimum setting of 5 ms one run take already a few seconds.



3.9.2 Mode MPP2

This mode tracks the MPP, so it is closest to the operation of a solar inverter. Once the MPP is found, the function won't stop, but try to track the MPP permanently. Due to the nature of solar panels this can only be done below the level of the MPP. As soon as this point is reached, the voltage starts to sink further and so does the actual power. The additional parameter ΔP defines how much the power may sink before the direction is reversed and the voltage starts to rise again until the load reaches the MPP. The result is a zigzag shaped curve of both, voltage and current.

A typical curve display is shown in the picture to the right. For the example, the ΔP was set to a quite small value, so the power curve looks almost linear. With a small ΔP the load would always track close to the MPP.



Following parameters can be configured for tracking mode **MPP2**:

Value	Range	Description
U_{OC}	0...Rated value of U	Voltage of the solar panel when unloaded, taken from the panel specs
I_{SC}	0...Rated value of I	Short-circuit current, max. specified current of the solar panel
ΔP	0...Rated value of P	Tracking/regulation tolerance below the MPP

3.9.3 Mode MPP3

Also called “fast track”, this mode is very similar to mode MPP2, but without the initial step which is used to find the actual MPP, because mode MPP3 would directly jump to the power point defined by user input (U_{MPP} , P_{MPP}). In case the MPP values of the equipment under test are known, this can save a lot of time in repetitive tests. The rest of the function run is the same as with MPP2 mode. During and after the function, the least acquired MPP values of voltage (U_{MPP}), current (I_{MPP}) and power (P_{MPP}) are shown in the display.

Following parameters can be configured for tracking mode **MPP3**:

Value	Range	Description
U_{OC}	0...Rated value of U	Voltage of the solar panel when unloaded, taken from the panel specs
I_{SC}	0...Rated value of I	Short-circuit current, max. specified current of the solar panel
U_{MPP}	0...Rated value of U	Voltage in the MPP
P_{MPP}	0...Rated value of P	Power in the MPP
ΔP	0...Rated value of P	Tracking/regulation tolerance below the MPP

3.9.4 Mode MPP4

This is not available for manual configuration and use on the HMI.

MPP4 is different to the other modes, because it does not track automatically. It rather offers the choice to define a user curve by setting up to 100 points of voltage values, then track this curve, measure current and power and return the results in up to 100 sets of acquired data.

Start and end point can be adjusted arbitrarily, Δt defines the time between two points and the function run can be repeated up to 65535 times. Once the function stops at the end or by manual interrupt, the DC input is switched off and the measured data is made available.

Configuration, control and analysis are all done using any of the optionally available, digital interfaces (USB, Ethernet). This mode is supported by ModBus RTU and SCPI protocol, as well as by the software EPS Power Control, which is included with the interface option on USB stick.

3.10 Other applications

3.10.1 Series connection



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

3.10.2 Parallel operation

Multiple devices of same kind and model can be connected in parallel in order to create a system with higher total current and hence higher power.

The ELM 5000 does not offer particular support for parallel operation. The user can, however, achieve good results when setting up the single load modules correctly.



If the rack a mixed installation with 80 V and 200 V modules, make sure not to connect them in parallel or connect the 80 V type with a source for 200 V, else the unit(s) will be damaged!

4. Servicing 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 equipment 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 EPS Stromversorgung (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 equipment should be sent.
- the device is in fully assembled state and in suitable transport packaging, ideally the original packaging.
- a fault description in as much detail as possible is attached.
- if shipping destination is abroad, the necessary customs papers are attached.

4.3 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), if necessary, is updated via the front side Ethernet port. For this the software "EPS 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 EPS Stromversorgung. For this the equipment must generally be returned to the manufacturer. No RMA number is needed. It is sufficient to package the equipment 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
EPS Stromversorgung Alter Postweg 101 86159 Augsburg Germany	All other topics: info@eps-germany.de	Switchboard: +49 821 / 570451-0

