Elektro-Automatik GmbH

Operating Manual

ELR 9000

Electronic DC Load with Energy Recovery



Attention! This document is only valid for devices with firmware “KE: 2.01” or higher. For availability of updates for your device, please contact us.

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TABLE OF CONTENTS

1 GENERAL

1.1 About this document 5
1.1.1 Retention and use 5
1.1.2 Copyright 5
1.1.3 Validity 5
1.2 Explanation of symbols 5
1.3 Warranty 5
1.4 Limit of liability 5
1.5 Disposal of equipment 6
1.6 Product key 6
1.7 Intended usage 6
1.8 Safety 7
1.8.1 Safety notices 7
1.8.2 Responsibility of the user 7
1.8.3 Responsibility of the operator 8
1.8.4 User requirements 8
1.8.5 Alarm signals 9
1.9 Technical Data 9
1.9.1 Approved operating conditions 9
1.9.2 General technical data 9
1.9.3 Specific technical data 10
1.9.4 Views 16
1.10 Construction and function 20
1.10.1 General description 20
1.10.2 Block diagram 20
1.10.3 Scope of delivery 21
1.10.4 Accessories 21
1.10.5 Options 21
1.10.6 The control panel (HMI) 22
1.10.7 USB-Port Type B (Back side) 25
1.10.8 Interface module slot 25
1.10.9 Analog interface 25
1.10.10 “Share” connector 26
1.10.11 “Sense” connector (remote sensing) 26
1.10.12 Master-Slave bus 26

2 INSTALLATION & COMMISSIONING

2.1 Transport and storage 27
2.1.1 Transport 27
2.1.2 Packaging 27
2.1.3 Storage 27
2.2 Unpacking and visual check 27
2.3 Installation 27
2.3.1 Safety procedures before installation and use 27
2.3.2 Preparation 28
2.3.3 Installing the device 28
2.3.4 Mains connection (AC) 29
2.3.5 Connection to DC sources 30
2.3.6 Grounding of the DC input 31
2.3.7 Connection of remote sensing 31
2.3.8 Connecting the “Share” bus 32
2.3.9 Installation of an AnyBus interface module 32
2.3.10 Connecting the analog interface 33
2.3.11 Connecting the USB port (rear side) 33
2.3.12 Initial commission 34
2.3.13 Commission after a firmware update or a long period of non use 34

3 OPERATION AND APPLICATION

3.1 Personal safety 35
3.2 Operating modes 35
3.2.1 Voltage regulation / Constant voltage 35
3.2.2 Current regulation / constant current / current limitation 35
3.2.3 Resistance regulation / constant resistance 36
3.2.4 Power regulation / constant power / power limitation 36
3.2.5 Alarm conditions 37
3.3 Manual operation 38
3.3.1 Powering the device 38
3.3.2 Switching the device off 38
3.3.3 Configuration via MENU 38
3.3.4 Adjustment limits (“Limits”) 45
3.3.5 Changing the operating mode 46
3.3.6 Manual adjustment of set values 46
3.3.7 Switching the DC input on or off 47
3.4 Remote control 48
3.4.1 General 48
3.4.2 Controls locations 48
3.4.3 Remote control via a digital interface 48
3.4.4 Remote control via the analog interface (AI) 49
3.5 Alarms and monitoring 52
3.5.1 Definition of terms 52
3.5.2 Device alarm and event handling 52
3.6 Control panel (HMI) lock 55
3.7 Loading and saving a user profile 55
3.8 The function generator 56
3.8.1 Introduction 56
3.8.2 General 56
3.8.3 Method of operation 56
3.8.4 Manual operation 57
3.8.5 Sine wave function 58
3.8.6 Triangular function 58
3.8.7 Rectangular function 59
3.8.8 Trapezoidal function 60
3.8.9 DIN 40839 function 60
3.8.10 Arbitrary function 61
3.8.11 Ramp Function 65
3.8.12 UI and IU table functions (XY table) 65
3.8.13 Remote control of the function generator 66

3.9 Other applications 67
3.9.1 Parallel operation in master-slave mode (MS) 67
3.9.2 Series connection 70
3.9.3 Two quadrant operation (2QO) 70

4 SERVICING AND MAINTENANCE

4.1 Maintenance / cleaning 72
4.2 Fault finding / diagnosis / repair 72
4.2.1 Replacing a defect mains fuse 72
4.3 Firmware updates 73
4.3.1 HMI update 73
4.3.2 Device firmware update 73
4.4 Calibration 74
4.4.1 Preface 74
4.4.2 Preparation 74
4.4.3 Calibration procedure 74

5 ACCESSORIES AND OPTIONS

5.1 Overview 76

6 SERVICE & SUPPORT

6.1 General 76
6.2 Contact options 76

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1. General

1.1 About this document

1.1.1 Retention and use

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

1.1.2 Copyright

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 including derived variants.

Model	Article nr..
ELR 9080-170	33 200 401
ELR 9250-70	33 200 402
ELR 9500-30	33 200 403
ELR 9750-22	33 200 404
ELR 9080-340	33 200 405

Model	Article nr..
ELR 9250-140	33 200 406
ELR 9500-60	33 200 407
ELR 9750-44	33 200 408
ELR 91000-30	33 200 409
ELR 9080-510	33 200 410

Model	Article nr..
ELR 9250-210	33 200 411
ELR 9500-90	33 200 412
ELR 9750-66	33 200 413
ELR 91500-30	33 200 414

Changes and modifications for special models will be listed in a separate document.

1.2 Explanation of symbols

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

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

1.3 Warranty

The manufacturer guarantees the functional competence of the applied technology and 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 (TOS) of the manufacturer.

1.4 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. The manufacturer accepts no liability for losses due to:

- Ignoring the manual
- Usage for purposes other than designed
- 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.

1.5 Disposal of equipment

A piece of equipment which is intended for disposal must, according to European laws and regulations (ElektroG, WEEE) be returned to the manufacturer for 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:



1.6 Product key

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

ELR 9 1500 - 30 xx zzz

zzz	Field for identification of installed options and/or special models **S01**...**S0x** = Special models
xx	Construction (not always given) **2U / 3U / 4U** = 19” frame with 2U, 3U or 4U **T** = “Tower” - vertical standing model **DT** = “Desktop” model **R** = “Rack mount” model in frame for wall mounting
30	Maximum current of the device in Ampere
1500	Maximum voltage of the device in Volt
9	Series : **8** = Series 8000 or 800, **9** = Series 9000 etc.
ELR	Type identification: **PS** = Power Supply, usually programmable **PSI** = Power Supply Intelligent, always programmable **EL** = Electronic Load, always programmable **ELR** = Electronic Load with Recovery **BC** = Battery Charger, not programmable **BCI** = Battery Charger Intelligent, programmable

- Special devices are always derivations of standard models and can vary in input voltage and current from those given.
- Identifications printed on the housings are usually abbreviated compared to the product label.

1.7 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.

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1.8 Safety

1.8.1 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.**



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

1.8.2 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.

1.8.3 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.

1.8.4 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.

All work on electrical equipment may only be performed by qualified electricians. **Qualified electricians** are those who through training, knowledge and experience as well as knowledge of the specific details are able to carry out work properly on electrical equipment, identify dangers and avoid personal and other risks.



Danger for unauthorised persons

- Uninstructed persons are unaware of dangers in the work area and are classed as unauthorised.
- Unauthorised persons are to be kept away from the work area. If in doubt they should be addressed and requested to leave.
- Work should cease as long as unauthorised persons are present

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1.8.5 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) acoustic (piezo buzzer) or electronic (pin/status output of an analog interface). All alarms will cause the device to switch off the DC input.

The meaning of the signals is as follows:

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

1.9 Technical Data

1.9.1 Approved operating conditions

- Use only inside dry buildings
- Ambient temperature 0-50°C
- Operational altitude: max. 2000m above sea level
- Max 80% RH up to 30°C, linear decrease to 50% RH at 50°C

1.9.2 General technical data

Display: Graphic touchscreen, 192pt x 182pt, resistive

Controls: 2 rotary knobs with switch functions. 1 button.

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

1.9.3 Specific technical data

3.5kW	Model			
	ELR 9080-170	*ELR 9250-70*	*ELR 9500-30*	*ELR 9750-22*
AC Input/Output				
Input/output voltage	195...253V L-N	195...253V L-N	195...253V L-N	195...253V L-N
Input/output connection	L,N,PE	L,N,PE	L,N,PE	L,N,PE
Input/output frequency	50/60Hz ±10%	50/60Hz ±10%	50/60Hz ±10%	50/60Hz ±10%
Input/output fuse (internal)	T16A	T16A	T16A	T16A
Efficiency (2	92.5%	93.5%	94.5%	94.5%
DC Input				
Max. input voltage U_{Max}	80V	250V	500V	750V
Max. input power P_{Max}	3500W	3500W	3500W	3500W
Max. input current I_{Max}	170A	70A	30A	22A
Overvoltage protection range	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}
Overcurrent protection range	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}
Overpower protection range	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}
Max. allowed input voltage	100V	300V	600V	850V
Min. input voltage for I_{Max}	0.73V	2.3V	4.6V	6.8V
Voltage regulation				
Adjustment range	0...80V	0...250V	0...500V	0...750V
Stability at ±10% ΔU_{AC}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}
Stability at ΔI	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Accuracy (1	< 0.3% U_{Max}	< 0.3% U_{Max}	< 0.3% U_{Max}	< 0.3% U_{Max}
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*			
Display: Accuracy (3	≤ 0.2%			
Remote sensing compensation	max. 5% U_{Max}			
Current regulation				
Adjustment range	0...170A	0...70A	0...30A	0...22A
Stability at ±10% ΔU_{AC}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}
Stability at ΔU	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}
Accuracy (1	< 0.4% I_{Max}	< 0.4% I_{Max}	< 0.4% I_{Max}	< 0.4% I_{Max}
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*			
Display: Accuracy (3	≤0.2%			
Compensation 10-90% ΔU_{DC}	< 0.6ms	< 0.6ms	< 0.6ms	< 0.6ms
Power regulation				
Adjustment range	0…3500W	0…3500W	0…3500W	0…3500W
Stability at ±10% ΔU_{AC}	< 0.05%	< 0.05%	< 0.05%	< 0.05%
Stability at ΔI / ΔU	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}
Accuracy (1	< 1.25% P_{Max}	< 1.5% P_{Max}	< 1.4% P_{Max}	< 1.5% P_{Max}
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*			
Display: Accuracy (3	≤ 0.2%			
Resistance regulation				
Adjustment range	0.01…12Ω	0.09…120Ω	0.42…480Ω	0.8…1100Ω
Accuracy (1	≤2% of max. resistance ± 0.3% of maximum current			
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*			
Display: Accuracy (3	≤0.2%			

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.

Example: a 80V model has min. 0.3% voltage accuracy, that is 240mV. When adjusting the voltage to 5V, the actual value is allowed to differ max. 240mV, which means it might be between 4.76V and 5.24V.

(2 Typical value at 100% input voltage and 100% power

3) Set values as in the display or as data readable via digital interfaces are more accurate than the corresponding value on the DC input. Their accuracy subtracts from the general accuracy. For actual values it is vice versa. There the display accuracy adds to the general accuracy, so the error (i.e. deviation) will be higher.

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3.5kW	Model			
	ELR 9080-170	*ELR 9250-70*	*ELR 9500-30*	*ELR 9750-22*
Analog interface (3				
Set value inputs	U, I, P	U, I, P	U, I, P	U, I, P
Actual value output	U, I	U, I	U, I	U, I
Control signals	DC on/off, Remote on/off	DC on/off, Remote on/off	DC on/off, Remote on/off	DC on/off, Remote on/off
Status signals	CV, OVP, OT	CV, OVP, OT	CV, OVP, OT	CV, OVP, OT
Galvanic isolation to the device	max. 1500V DC	max. 1500V DC	max. 1500V DC	max. 1500V DC
Programming (analog+digital)				
Resolution: Voltage (U)	~ 25mV	~ 76mV	~ 153mV	~ 229mV
Accuracy: Voltage (U)	≤ 226mV	≤ 706mV	≤ 1413mV	≤ 2219mV
Resolution: Current (I)	~ 52mA	~ 22mA	~ 9mA	~ 7mA
Accuracy: Current (I)	≤ 617mA	≤ 254mA	≤ 109mA	≤ 80mA
Resolution: Power (P)	~ 4.2W	~ 5.4W	~ 4.6W	~ 5.1W
Accuracy: Power (P)	≤ 42W	≤ 48W	≤ 44W	≤ 47W
Environment				
Cooling	Temperature controlled fans			
Ambient temperature	0..50°C			
Storage temperature	-20...70°C			
Digital interfaces				
Featured	1x USB-B for communication, 1x USB-A for updates and functions			
Slot for optional AnyBus modules	CANopen, Profibus, Profinet, RS232, Devicenet, Ethernet, ModBus			
Galvanic isolation to the device	max. 1500V DC			
Terminals				
Rear side (3	Share Bus, DC input, AC input/output, remote sensing, analog interface, USB-B, master-slave bus, AnyBus module slot			
Front side	USB-A			
Dimensions				
Enclosure (WxHxD)	19“ x 3U x 609mm			
Total (WxHxD)	483mm x 133mm x 714mm			
Standards	EN 60950, EN 50160 (grid class 2)			
Weight	17kg	17kg	17kg	17kg
Article number	33200401	33200402	33200403	33200404

(3 For technical specifications of the analog interface see *„3.4.4.2 Analog interface specification“ on page 50*

7kW	Model				
	ELR 9080-340	ELR 9250-140	ELR 9500-60	ELR 9750-44	ELR 91000-30
AC Input/Output					
Input/output voltage	195...253V L-N 340...440V L-L	195...253V L-N 340...440V L-L	195...253V L-N 340...440V L-L	195...253V L-N 340...440V L-L	195...253V L-N 340...440V L-L
Input/output connection	L1, L3, N, PE	L1, L3, N, PE	L1, L3, N, PE	L1, L3, N, PE	L1, L3, N, PE
Input/output frequency	50/60Hz ±10%	50/60Hz ±10%	50/60Hz ±10%	50/60Hz ±10%	50/60Hz ±10%
Input/output fuse (internal)	T16A	T16A	T16A	T16A	T16A
Efficiency (2	92.5%	93.5%	94.5%	94.5%	94.5%
DC Input					
Max. input voltage U_{Max}	80V	250V	500V	750V	1000V
Max. input power P_{Max}	7kW	7kW	7kW	7kW	7kW
Max. input current I_{Max}	340A	140A	60A	44A	30A
Overvoltage protection range	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}
Overcurrent protection range	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}
Overpower protection range	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}
Max. allowed input voltage	100V	300V	600V	850V	1200V
Min. input voltage for I_{Max}	0.73V	2.3V	4.6V	6.9V	9.2V
Voltage regulation					
Adjustment range	0...80V	0...250V	0...500V	0...750V	0...1000V
Stability at ±10% ΔU_{AC}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}
Stability at ΔI	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Accuracy (1	< 0.3% U_{Max}	< 0.3% U_{Max}	< 0.3% U_{Max}	< 0.3% U_{Max}	< 0.3% U_{Max}
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*				
Display: Accuracy (3	≤ 0.2%				
Remote sensing compensation	max. 5% U_{Max}				
Current regulation					
Adjustment range	0...340A	0...140A	0...60A	0...44A	0...30A
Stability at ±10% ΔU_{AC}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}
Stability at ΔU	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}
Accuracy (1	< 0.4% I_{Max}	< 0.4% I_{Max}	< 0.4% I_{Max}	< 0.4% I_{Max}	< 0.4% I_{Max}
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*				
Display: Accuracy (3	≤ 0.2%				
Compensation 10-90% ΔU_{DC}	< 0.6ms	< 0.6ms	< 0.6ms	< 0.6ms	< 0.6ms
Power regulation					
Adjustment range	0…7kW	0…7kW	0…7kW	0…7kW	0…7kW
Stability at ±10% ΔU_{AC}	< 0.05%	< 0.05%	< 0.05%	< 0.05%	< 0.05%
Stability at ΔI / ΔU	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}
Accuracy (1	< 1.3% P_{Max}	< 1.5% P_{Max}	< 1.4% P_{Max}	< 1.5% P_{Max}	< 1.4% P_{Max}
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*				
Display: Accuracy (3	≤ 0.2%				
Resistance regulation					
Adjustment range	0.005…6Ω	0.04…60Ω	0.21…240Ω	0.43…550Ω	0.83...950Ω
Accuracy (1	≤2% of max. resistance ± 0.3% of maximum current				
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*				
Display: Accuracy (3	≤0.2%				

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.

Example: a 80V model has min. 0.3% voltage accuracy, that is 240mV. When adjusting the voltage to 5V, the actual value is allowed to differ max. 240mV, which means it might be between 4.76V and 5.24V.

(2 Typical value at 100% input voltage and 100% power

3) Set values as in the display or as data readable via digital interfaces are more accurate than the corresponding value on the DC input. Their accuracy subtracts from the general accuracy. For actual values it is vice versa. There the display accuracy adds to the general accuracy, so the error (i.e. deviation) will be higher.

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7kW	Model				
	ELR 9080-340	***ELR 9250-140***	***ELR 9500-60***	***ELR 9750-44***	***ELR 91000-30***
Analog interface (3					
Set value inputs	U, I, P	U, I, P	U, I, P	U, I, P	U, I, P
Actual value output	U, I	U, I	U, I	U, I	U, I
Control signals	DC on/off, Remote on/off	DC on/off, Remote on/off	DC on/off, Remote on/off	DC on/off, Remote on/off	DC on/off, Remote on/off
Status signals	CV, OVP, OT	CV, OVP, OT	CV, OVP, OT	CV, OVP, OT	CV, OVP, OT
Galvanic isolation to the device	max. 1500V DC	max. 1500V DC	max. 1500V DC	max. 1500V DC	max. 1500V DC
Programming (analog+digital)					
Resolution: Voltage (U)	~ 25mV	~ 76mV	~ 153mV	~ 229mV	~ 305mV
Accuracy: Voltage (U)	≤ 226mV	≤ 706mV	≤ 1413mV	≤ 2219mV	≤ 2826mV
Resolution: Current (I)	~ 104mA	~ 43 mA	~ 19mA	~ 14mA	~ 9mA
Accuracy: Current (I)	≤ 1234mA	≤ 508mA	≤ 218mA	≤ 160mA	≤ 109mA
Resolution: Power (P)	~ 8.4W	~ 11W	~ 9W	~ 10W	~ 9.2W
Accuracy: Power (P)	≤ 84W	≤ 96W	≤ 88W	≤ 93W	≤ 89W
Environment					
Cooling	Temperature controlled fans				
Ambient temperature	0..50°C				
Storage temperature	-20...70°C				
Digital interfaces					
Featured	1x USB-B for communication, 1x USB-A for updates and functions				
Slot for optional AnyBus modules	CANopen, Profibus, Profinet, RS232, Devicenet, Ethernet, ModBus				
Galvanic isolation to the device	max. 1500V DC				
Terminals					
Rear side (3	Share Bus, DC input, AC input/output, remote sensing, analog interface, USB-B, master-slave bus, AnyBus module slot				
Front side	USB-A				
Dimensions					
Enclosure (WxHxD)	19“ x 3U x 609mm				
Total (WxHxD)	483mm x 133mm x 714mm				
Standards	EN 60950, EN 50160 (grid class 2)				
Weight	24kg	24kg	24kg	24kg	24kg
Article number	33200405	33200406	33200407	33200408	33200409

(3 For technical specifications of the analog interface see *„3.4.4.2 Analog interface specification“ on page 50*

10.5kW	Model				
	ELR 9080-510	ELR 9250-210	ELR 9500-90	ELR 9750-66	ELR 91500-30
AC Input/Output					
Input/output voltage	195...253V L-N 340...440V L-L	195...253V L-N 340...440V L-L	195...253V L-N 340...440V L-L	195...253V L-N 340...440V L-L	195...253V L-N 340...440V L-L
Input/output connection	L1,L2,L3,N,PE	L1,L2,L3,N,PE	L1,L2,L3,N,PE	L1,L2,L3,N,PE	L1,L2,L3,N,PE
Input/output frequency	50/60Hz ±10%	50/60Hz ±10%	50/60Hz ±10%	50/60Hz ±10%	50/60Hz ±10%
Input/output fuse (internal)	T16A	T16A	T16A	T16A	T16A
Efficiency (2	92.5%	93.5%	94.5%	94.5%	94.5%
DC Input					
Max. input voltage U_{Max}	80V	250V	500V	750V	1500V
Max. input power P_{Max}	10.5kW	10.5kW	10.5kW	10.5kW	10.5kW
Max. input current I_{Max}	510A	210A	90A	66A	30A
Overvoltage protection range	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}	0...1.1 * U_{Max}
Overcurrent protection range	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}	0...1.1 * I_{Max}
Overpower protection range	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}	0...1.1 * P_{Max}
Max. allowed input voltage	100V	300V	600V	850V	1750V
Min. input voltage for I_{Max}	0.73V	2.3V	4.6V	6.9V	9.2V
Voltage regulation					
Adjustment range	0...80V	0...250V	0...500V	0...750V	0...1500V
Stability at ±10% ΔU_{AC}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}
Stability at ΔI	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Accuracy (1	< 0.3% U_{Max}	< 0.3% U_{Max}	< 0.3% U_{Max}	< 0.3% U_{Max}	< 0.3% U_{Max}
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*				
Display: Accuracy (3	≤0.2%				
Remote sensing compensation	max. 5% U_{Max}				
Current regulation					
Adjustment range	0...510A	0...210A	0...90A	0...66A	0...30A
Stability at ±10% ΔU_{AC}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}
Stability at ΔU	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}
Accuracy (1	< 0.4% I_{Max}	< 0.4% I_{Max}	< 0.4% I_{Max}	< 0.4% I_{Max}	< 0.4% I_{Max}
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*				
Display: Accuracy (3	≤0.2%				
Compensation 10-90% ΔU_{DC}	< 0.6ms	< 0.6ms	< 0.6ms	< 0.6ms	< 0.6ms
Power regulation					
Adjustment range	0…10.5kW	0…10.5kW	0…10.5kW	0…10.5kW	0…10.5kW
Stability at ±10% ΔU_{AC}	< 0.05% P_{Max}	< 0.05% P_{Max}	< 0.05% P_{Max}	< 0.05% P_{Max}	< 0.05% P_{Max}
Stability at ΔI / ΔU	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}
Accuracy (1	< 1.3% P_{Max}	< 1.5% P_{Max}	< 1.4% P_{Max}	< 1.5% P_{Max}	< 1.4% P_{Max}
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*				
Display: Accuracy (3	≤0.2%				
Resistance regulation					
Adjustment range	0.003…4Ω	0.03…40Ω	0.14…160Ω	0.29…360Ω	1.2…1450Ω
Accuracy (1	≤2% of max. resistance ± 0.3% of maximum current				
Display: Adjustment resolution	see section *„1.10.6.4. Resolution of the displayed values“*				
Display: Accuracy (3	≤0.2%				

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.

Example: a 80V model has min. 0.3% voltage accuracy, that is 240mV. When adjusting the voltage to 5V, the actual value is allowed to differ max. 240mV, which means it might be between 4.76V and 5.24V.

(2 Typical value at 100% input voltage and 100% power

3) Set values as in the display or as data readable via digital interfaces are more accurate than the corresponding value on the DC input. Their accuracy subtracts from the general accuracy. For actual values it is vice versa. There the display accuracy adds to the general accuracy, so the error (i.e. deviation) will be higher.

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10.5kW	Model				
	ELR 9080-510	*ELR 9250-210*	*ELR 9500-90*	*ELR 9750-66*	*ELR 91500-30*
Analog interface (3					
Set value inputs	U, I, P	U, I, P	U, I, P	U, I, P	U, I, P
Actual value output	U, I	U, I	U, I	U, I	U, I
Control signals	DC on/off, Remote on/off	DC on/off, Remote on/off	DC on/off, Remote on/off	DC on/off, Remote on/off	DC on/off, Remote on/off
Status signals	CV, OVP, OT	CV, OVP, OT	CV, OVP, OT	CV, OVP, OT	CV, OVP, OT
Galvanic isolation to the device	max. 1500V DC	max. 1500V DC	max. 1500V DC	max. 1500V DC	max. 1500V DC
Programming (analog+digital)					
Resolution: Voltage (U)	~ 25mV	~ 76mV	~ 153mV	~ 229mV	~ 458mV
Accuracy: Voltage (U)	≤ 226mV	≤ 706mV	≤ 1413mV	≤ 2219mV	≤ 4239mV
Resolution: Current (I)	~ 156mA	~ 64 mA	~ 28mA	~ 21mA	~ 9mA
Accuracy: Current (I)	≤ 1849mA	≤ 761mA	≤ 326mA	≤ 239mA	≤ 109mA
Resolution: Power (P)	~ 12.5W	~ 16W	~ 14W	~ 15W	~ 14W
Accuracy: Power (P)	≤ 126W	≤ 144W	≤ 133W	≤ 140W	≤ 133W
Environment					
Cooling	Temperature controlled fans				
Ambient temperature	0..50°C				
Storage temperature	-20...70°C				
Digital interfaces					
Featured	1x USB-B for communication, 1x USB-A for updates and functions				
Slot for optional AnyBus modules	CANopen, Profibus, Profinet, RS232, Devicenet, Ethernet, ModBus				
Galvanic isolation to the device	max. 1500V DC				
Terminals					
Rear side (3	Share Bus, DC input, AC input/output, remote sensing, analog interface, USB-B, master-slave bus, AnyBus module slot				
Front side	USB-A				
Dimensions					
Enclosure (WxHxD)	19“ x 3U x 609mm				
Total (WxHxD)	483mm x 133mm x 714mm				
Standards	EN 60950, EN 50160 (grid class 2),				
Weight	31kg	31kg	31kg	31kg	31kg
Article number	33200410	33200411	33200412	33200413	33200414

(3 For technical specifications of the analog interface see *„3.4.4.2 Analog interface specification“ on page 50*

1.9.4 Views

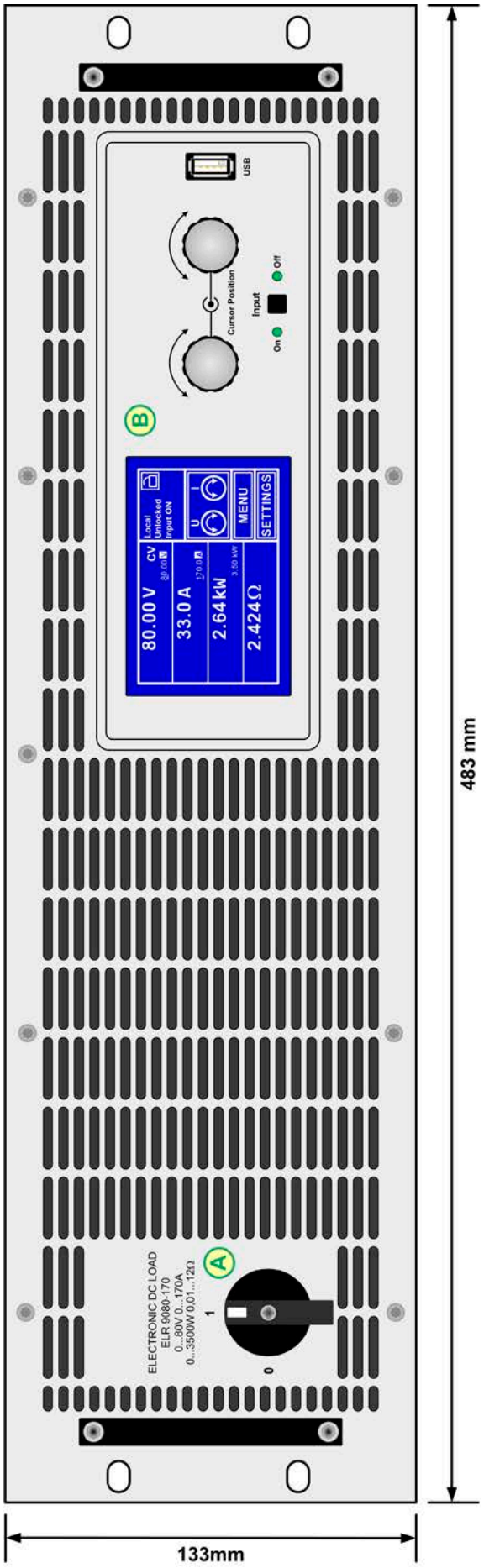

Figure 1 - Front side

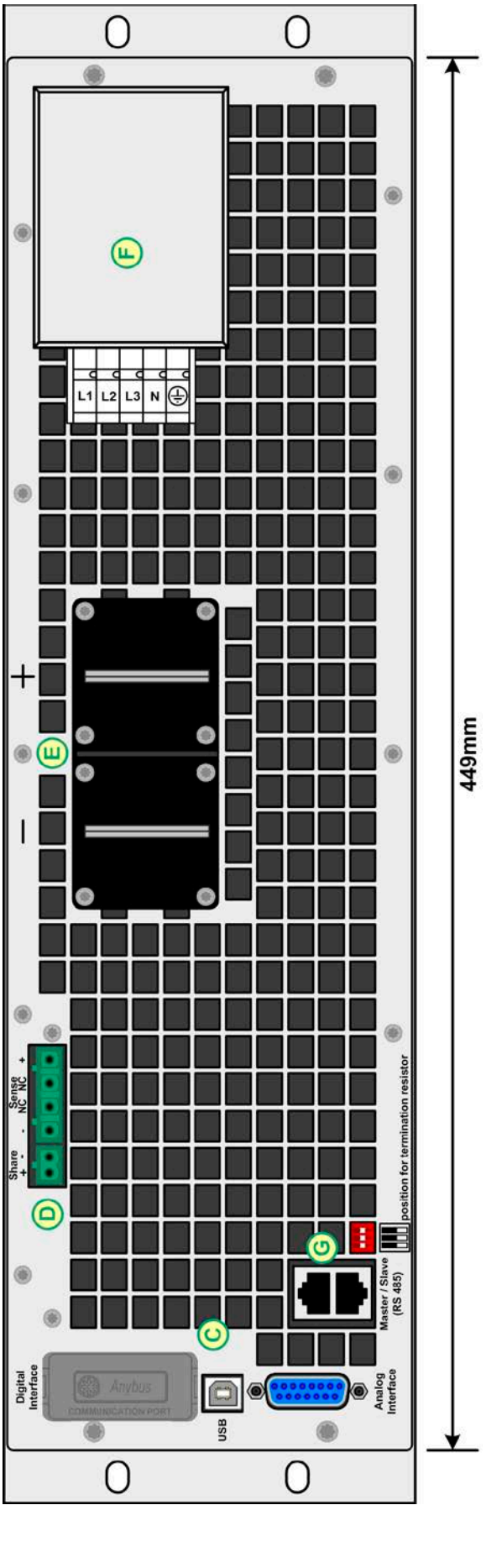

Figure 2 - Back side

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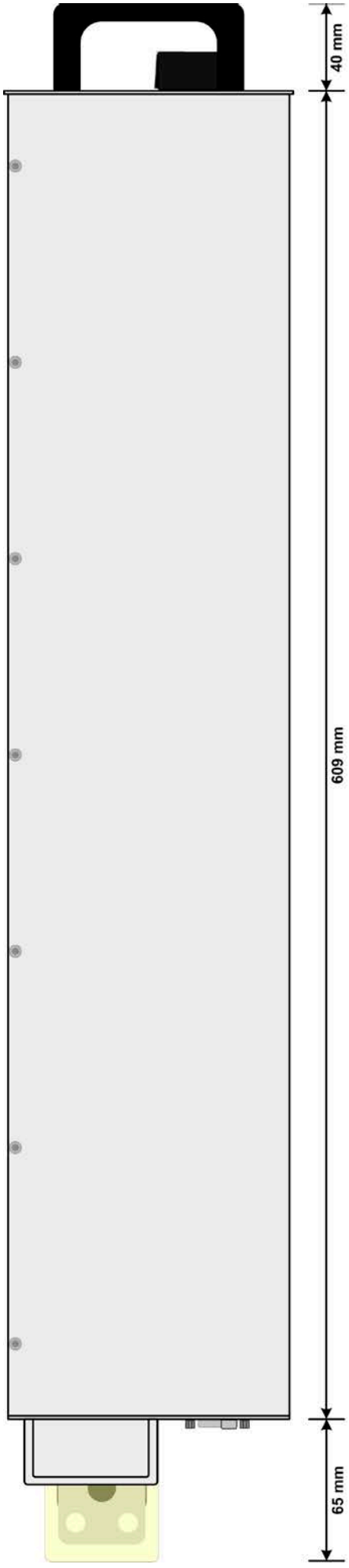

Figure 3 - Left hand side

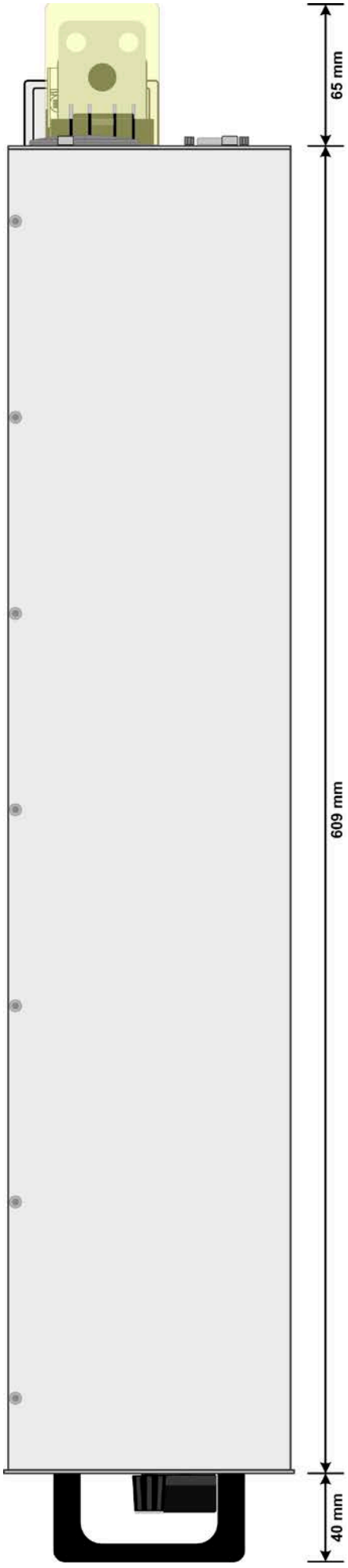

Figure 4 - Right hand side

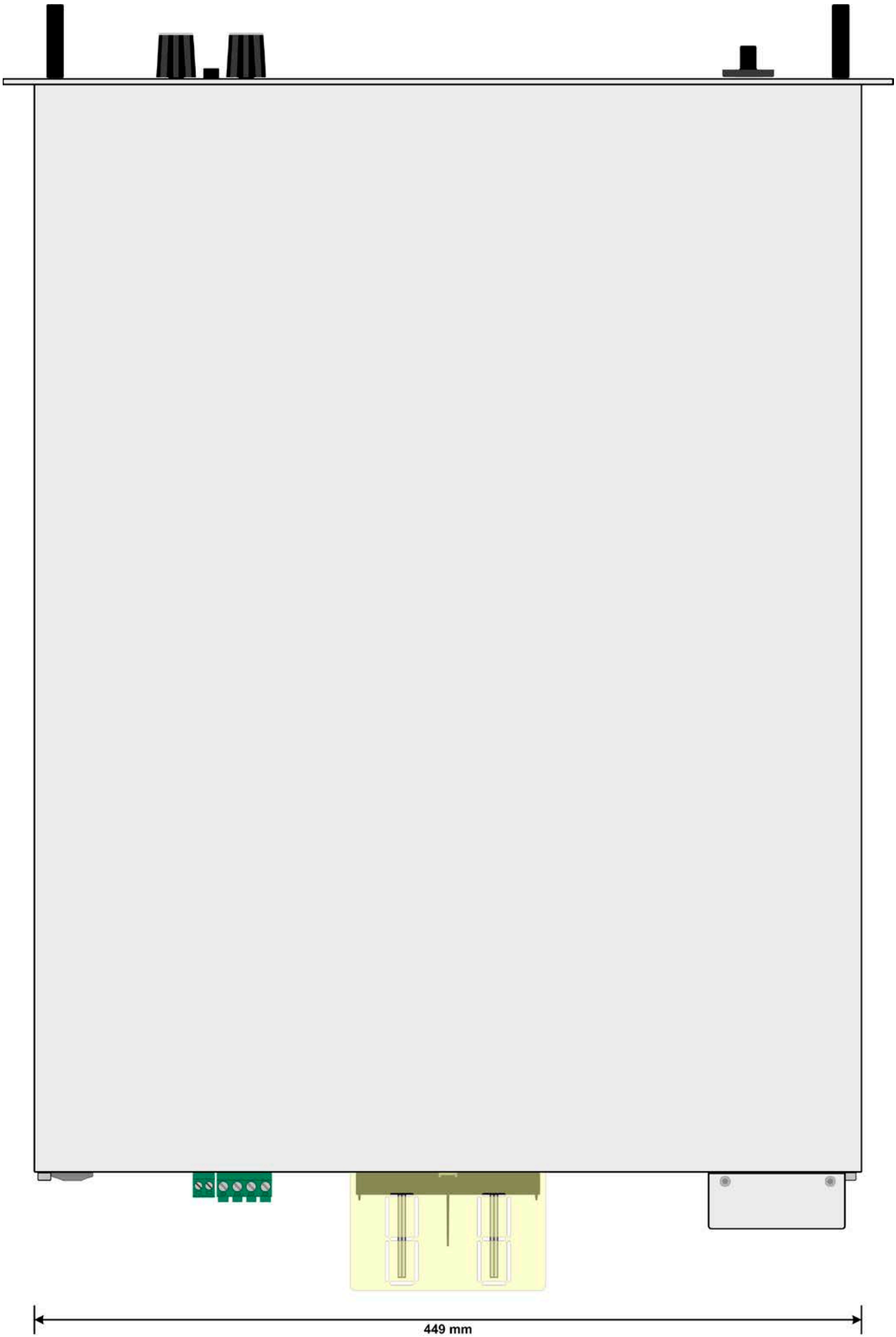

Figure 5 - View from above

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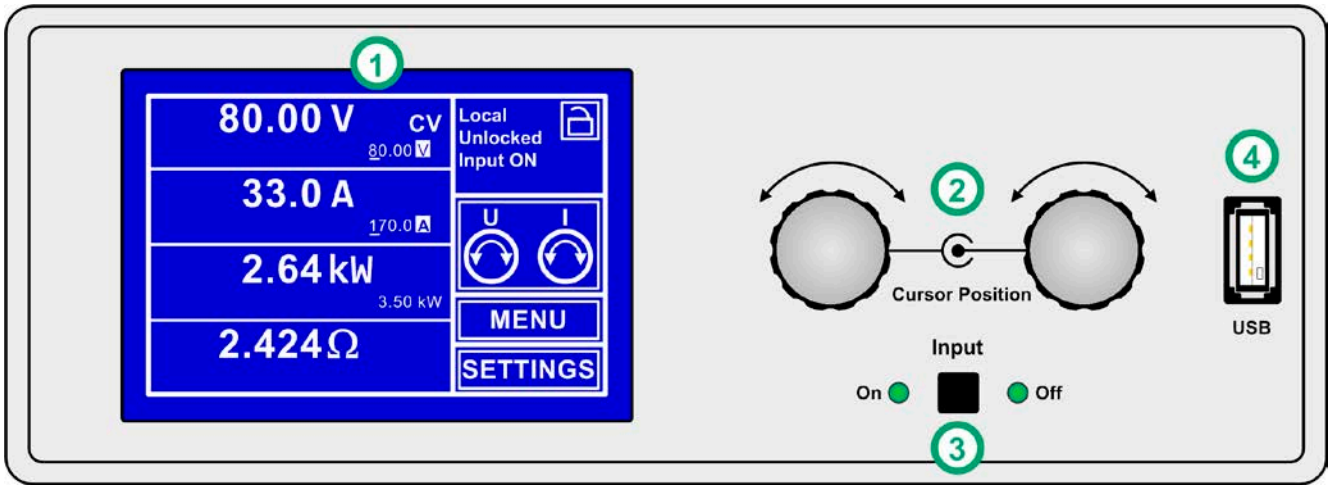


Figure 6 - Control Panel

Overview of the elements of the operating panel

For a detailed description see section *„1.10.6. The control panel (HMI)“* and *„1.10.6.2. Pushbuttons“.*

(1)	**Touchscreen display (resistive)** Used for selection of set values, menus, conditions and display of actual values and status. The touchscreen can be operated with the fingers or with a stylus.
(2)	**Rotary knob with push button function** Left knob (turn): adjusting the voltage, power or resistance set values, or setting the parameter values in the menu. Left knob (push): selection of the decimal position to be changed (cursor) in the current value selection. Right knob (turn): adjusting the current set value, or setting parameter values in the menu. Right knob (push): selection of the decimal position to be changed (cursor) in the current value selection.
(3)	**On/Off Button for DC input** Used to toggle the DC input between on and off, also used to start a function run. The LEDs “On” and “Off” indicate the state of the DC input, no matter if the device is manually controlled or remotely
(4)	**USB-A port** For the connection of standard USB sticks up to 32GB, formatted to FAT32. Value tables for the function generator (UI and IU functions) may be loaded or 100 arbitrary function sequences can be loaded or saved.

1.10 Construction and function

1.10.1 General description

The electronic high performance loads of the ELR 9000 series are especially suitable for test systems and industrial controls due to their compact construction of a 19” enclosure with 3 height units (3U). Apart from basic functions of electronic loads, set point curves can be produced in the integrated function generator (sine, rectangular, triangular and other curve types). Arbitrary curves can be stored on and uploaded from a USB flash drive.

For remote control using a PC or PLC the devices are provided as standard with a USB-B slot on the back side as well as a galvanically isolated analog interface.

Via optional plug-in interface modules other digital interfaces such as Profibus, ProfiNet, ModBus, CANopen and more can be added. These enable the devices to be connected to standard industrial buses simply by changing or adding a small module. The configuration, if at all necessary,.is simple. Thus the loads may, for example, be operated with other loads or even other types of equipment or controlled by a PC or PLC, all using the digital interfaces.

In addition the devices offer the possibility to connect to compatible power supplies via a Shared Bus, in order to create a so-called two-quadrants system. This operation mode uses the source-sink principle for testing devices, components and other parts in many industrial areas.

A genuine master-slave connection with totalling of the slave units is also provided as standard. Operating in this way allows up to 10 units to be combined to a single system with a total power of up to 255kW.

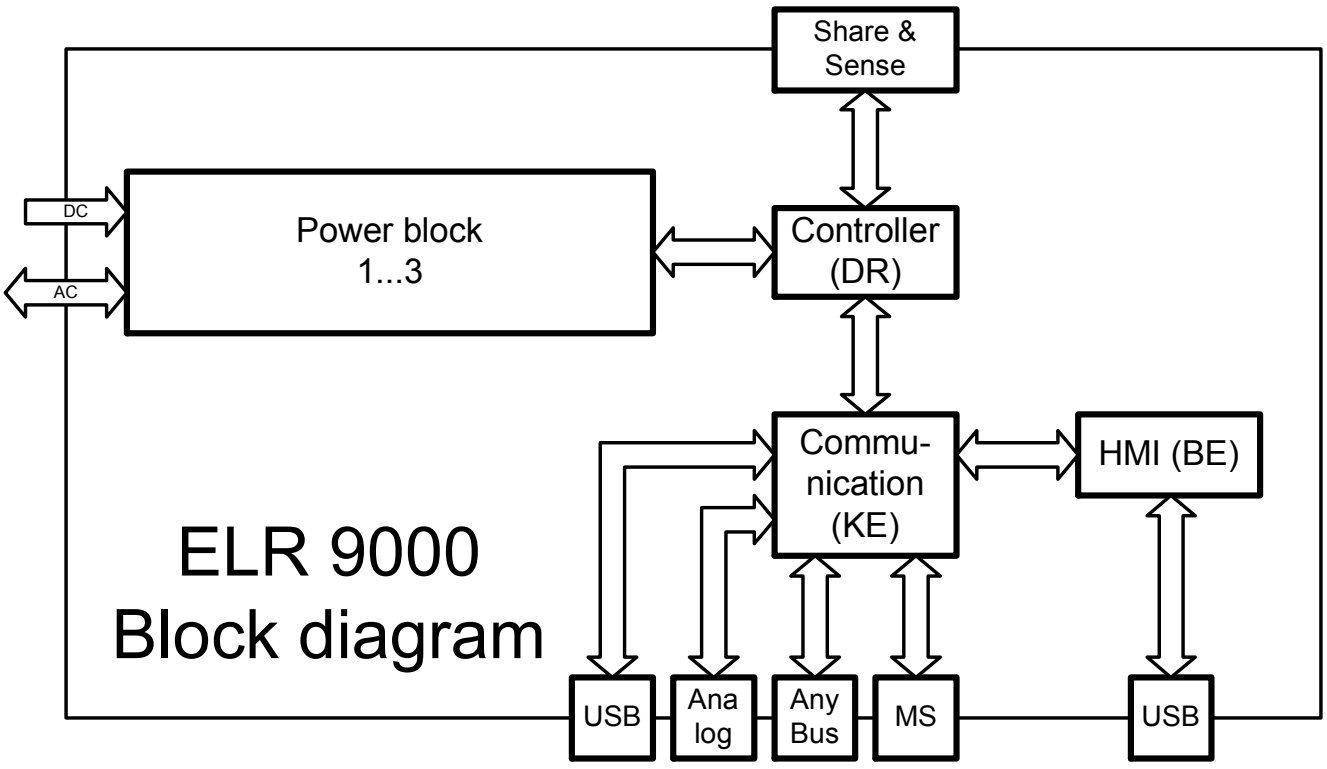
The generated DC energy is converted through a high efficiency internal inverter and fed back as AC energy into the 230V mains.

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

1.10.2 Block diagram

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

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



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1.10.3 Scope of delivery

1 x Electronic load device

1 x Printed operating manual

1 x Share Bus plug

1 x Remote sensing plug

1 x 1.8m USB cable

1 x Set of DC terminal cover(s)

1 x CD “Drivers & Tools“

1.10.4 Accessories

For these devices the following accessories are available:

Digital interface modules **IF-AB**	Pluggable and retrofittable AnyBus interface modules for RS232, CANopen, Ethernet, Profibus, ProfiNet, ModBus or Devicenet are available. Others upon request. Details about the interface modules and the programming of the device using those interfaces can be found in separate documentation. It is usually available on the CD, which is included with the device, or as PDF download on the manufacturers website.
Automatic Isolation Unit **ENS**	External automatic isolation unit (AIU, former german term: ENS) with contactors (for one ELR 9000 up to 10.5kW) resp. without contactors (bigger system where contactors are installed by the user), which might be required to be installed for the operation of an energy recovering device which is connected to a public grid. This option can be purchased separately and retrofitted by the user on location.

1.10.5 Options

These options are not retrofittable as they are permanently built in during the manufacturing process.

CABINET 19“-rack	Racks in various configurations up to 42U as parallel systems are available, or mixed with power supply devices to create test systems. Further information in our catalogue or upon request

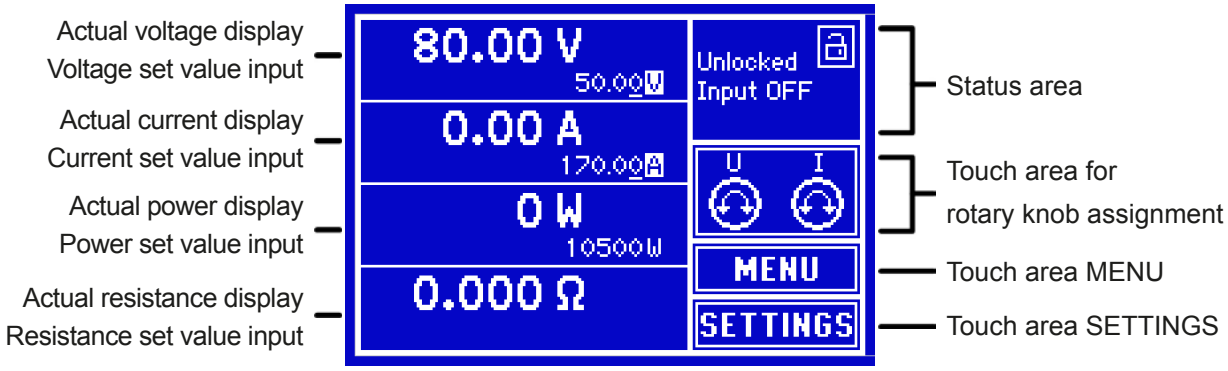
1.10.6 The control panel (HMI)

The HMI (**H**uman **M**achine **I**nterface) consists of a display with touchscreen, two rotary knobs, a button and a USB-A port.

1.10.6.1 Touchscreen display

The graphic touchscreen display is divided into a number of areas. The complete display is touch sensitive and can be operated by finger or stylus to control the equipment.

In normal operation the left hand side is used to show actual and set values and the right hand side to display status information:



Touch areas may be locked. Unlocked touch areas have a frame:



Touch areas are unlocked



SETTINGS touch area is locked

This is true for all touch areas on the main screen and all menu pages..

- **Actual / set values area (left hand side)**

In normal operation the DC input values (large numbers) and set values (small numbers) for voltage, current and power are displayed. The resistance set value is only displayed by active R/I mode.

When the DC input is switched on, the actual regulation mode **CV, CC, CP** or **CR** is displayed next to the corresponding actual values.

The set values can be adjusted with the rotary knobs next to the display screen or can be entered directly via the touchscreen. When adjusting with the knobs, pushing the knob will select the digit to be changed. Logically, the values are increased by clockwise rotation and decreased by anti-clockwise turning.

General display and settings area:

Display	Unit	Range	Description
Actual voltage	V	0-125% U_{Nenn}	Actual values of DC input voltage
Set value voltage (1	V	0-100% U_{Nenn}	Set value for limiting the DC input voltage
Actual current	A	0-125% I_{Nenn}	Actual value of DC input current
Set value current (1	A	0-100% I_{Nenn}	Set value for limiting the DC input current
Actual power	W	0-125% P_{Nenn}	Calculated actual value of input power, P = U * I
Set value power (1	W	0-100% P_{Nenn}	Set value for limiting DC input power
Actual resistance	Ω	0...99.999 Ω	Calculated actual internal resistance, R = U_{IN} / I_{IN}
Set value internal resistance(1	Ω	x(2-100% R_{Max}	Set value for the target internal resistance

The value with pink background is only displayed in R/I mode.

(1 Valid also for values related to these physical units, such as OVD for voltage and UCD for current

(2 Lower limit for resistance set value varies. See table in section *1.10.6.3*

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- **Status display (upper right)**

This area displays various status texts and symbols:

Display	Description
Locked	The HMI is locked
Unlocked	The HMI is unlocked
Input ON	DC input is switched on
Input OFF	DC input is switched off
Remote	The device is under remote control from....
Analog	....the built in analog interface
USB & others	....the built in USB port or a plug-in interface module
Local	The device has been locked by the user explicitly against remote control
Alarm:	Alarm condition which has not been acknowledged or still exists.
Event:	A user defined event has occured which is not yet acknowledged.

- **Area for assigning the rotary knobs**

The two rotary knobs next to the display screen can be assigned to various functions. These are assigned as standard, and always after switching on the device, to power set value (left knob) and current set value (right knob). This touch area shows the actual assignments. These can be changed by tapping the touch area, as long as this area is not locked. The display changes to:



Standard on power up



Tapping one of the three alternatives selects:



Setting voltage and current



Setting power and current



Setting resistance and current

Other set values cannot be adjusted via the rotary knob unless the assignments are changed. However, values can be entered directly into the touch areas for voltage, current or power using a ten-key pad.

After the selection the area shows the assignment as follows:



Left rotary knob: voltage
Right rotary knob: current



Left rotary knob: power
Right rotary knob: current



Left rotary knob: resistance
Right rotary knob: current

1.10.6.2 Pushbuttons

The device has 3 pushbuttons on the control panel. The “On/Off” button is used to switch the DC input on or off, as well as to start associated functions. Certain conditions can disable this button The rotary knobs also have a pushbutton function which is used in all menu options for value adjustment to move the cursor by rotation as shown:



1.10.6.3 Rotary knobs



As long as the device is in manual operation the two rotary knobs are used to adjust set values as well as setting the parameters in the pages SETTINGS and MENU. For a detailed description of the individual functions see section *"3.3 Manual operation" on page 37*. Both rotary knobs have an additional push function whereby the decimal position of the value to be set is moved. In this way, for example, the set value current for a device with nominal 510A can be adjusted in increments of 10A or 0.1A. *(also see „1.10.6.2 Pushbuttons" on page 23)*

1.10.6.4 Resolution of the displayed values

In the display, set values can be adjusted in variable 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, UVD, OVD, U-min, U-max		
Nominal	**Digits**	**Min. Increment**
80V	4	0.01V
250V	5	0.01V
500V	4	0.1V
750V	4	0.1V
1000V	5	0.1V
1500V	5	0.1V

Current, OCP, UCD, OCD, I-min, I-max		
Nominal	**Digits**	**Min. Increment**
22A / 30A	4	0.01A
44A / 60A	4	0.01A
66A / 70A	4	0.01A
90A	4	0.01A
140A / 170A	4	0.1A
210A	4	0.1A
340A / 510A	4	0.1A

Power, OPP, OPD, P-max		
Nominal	**Digits**	**Min. Increment**
3.5kW	3	10W
7kW	3	10W
10.5kW	4	10W

Resistance, R-max		
Nominal	**Digits**	**Min. Increment**
4Ω / 6Ω	4	0.001Ω
12Ω	5	0.001Ω
40Ω / 60Ω	4	0.01Ω
120Ω / 160Ω	5	0.01Ω
240Ω	5	0.01Ω
360Ω / 480Ω	5	0.01Ω
550Ω / 950Ω	5	0.01Ω
1100Ω	4	1Ω
1450Ω	4	1Ω



In manual operation every set value can be set in the increments given above. In remote operation via analog or digital interfaces other increments apply (see *„1.9.3 Specific technical data" on page 10*). In this case the actual input values set by the device will lie within percentage tolerances as shown in the technical data sheets. These will influence the actual values.

1.10.6.5 USB-Port (Front side)

The frontal USB port, located to the right of the rotary knobs, is intended for the connection of standard USB flash drives (flash drive). This can be used for:

- Up or down loading from sequences for the arbitrary and UI-IU function generator
- Updating HMI firmware (new languages, functions)

USB flash drives must be **FAT32** formatted and have a **maximum capacity of 32GB**. All supported files 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 of the electronic load can read the following file types from a flash drive:

*.bin	Firmware updates only for the control panel. The file name format is given like 96230058_FW-BE1_V114.bin, listed in short form as FW-BE1_V114.bin. Other files won't be recognised or listed.
wave_u<your_name>.csv wave_i<your_name>.csv	Function generator arbitrary curve for voltage (U) or current (I) The name must begin with *wave_u / wave_i*, the rest is user defined.
iu<your_name>.csv	IU table for the function generator. The table values are interpreted as current values between 0A and 125% I_{Nom} (see technical specs). Any value higher than that will abort loading and report an error. The name must begin with *iu*, the rest can be user defined.
ui<your_name>.csv	UI table for the function generator. The table values are interpreted as voltage values between 0V and 125% U_{Nom} (see technical specs). Any value higher than that will abort loading and report an error. The name must begin *with ui*, the rest can be user defined.

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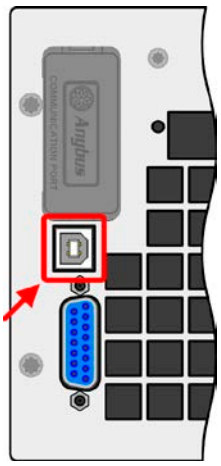
1.10.7 USB-Port Type B (Back side)

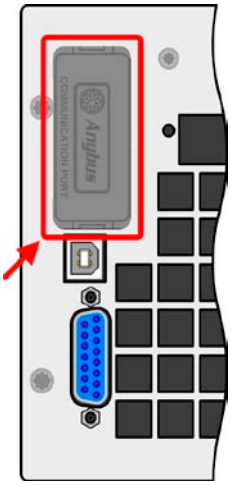


The USB-B port on the back side of the device is provided for communication with the device and for firmware updates. The included USB cable can be used to connect the device to a PC (USB 2.0 or 3.0). The driver is delivered on the included CD and installs a virtual COM port. Details for remote control can be found on the web site of the manufacturer or on the included CD. A general programming introduction for the USB port is available (date: 02-18-2014)

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

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

1.10.8 Interface module slot



This slot on the back side of the device is available for various modules of the AnyBus CompactCom (abbr.: ABCC) type of the IF-AB interface series. The following options are available (date: 02-18-2014):

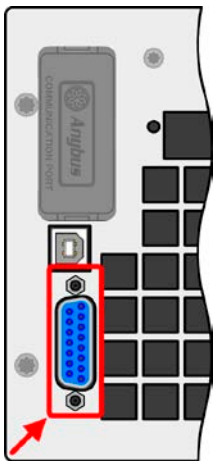
Article number	Name	Description
35400100	IF-AB-CANO	CANopen, 1x Sub-D 9pole male
35400101	IF-AB-RS232	RS 232, 1x Sub-D 9pole male (null modem)
35400103	IF-AB-PBUS	Profibus DP-V1 Slave, 1x Sub-D 9pole female
35400104	IF-AB-ETH1P	Ethernet, 1x RJ45
35400105	IF-AB-PNET1P	ProfiNET IO, 1x RJ45
35400106	IF-AB-DNET	Devicenet, 1x Wago plug 5-pole
35400107	IF-AB-MBUS1P	ModBus TCP, 1x RJ45
35400108	IF-AB-ETH2P	Ethernet, 2x RJ45
35400109	IF-AB-MBUS2P	ModBus TCP, 2x RJ45
35400110	IF-AB-PNET2P	ProfiNET IO, 2x RJ45

The modules are installed by the user and can be retrofitted without problem. A firmware update of the device may be necessary in order to recognize and support certain modules.

If remote control is in operation the interface module has no priority over either the USB port or the analog interface and can, therefore, only be used alternately to these. However, monitoring is always available.

Switch off device before adding or removing modules!

1.10.9 Analog interface

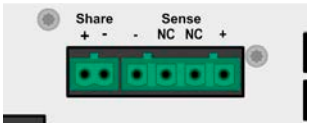


This 15 pole Sub-D socket on the back side of the device is provided for remote control of the device via analog signals or switching conditions.

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

The input voltage range of the set values and the output voltage range of the monitor values, as well as reference voltage level can be switched in the settings menu of the device between 0-5V and 0-10V, in each case for 0-100%.

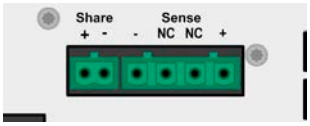
1.10.10 “Share” connector



The 2 pole socket (“Share”) on the back side of the device is provided for connection to equally named sockets on compatible electronic loads when establishing parallel connection where symmetric current distribution is required, as well as compatible power supplies to build a two-quadrants operation setup. For details about that feature refer to *„3.9.1. Parallel operation in master-slave mode (MS)“* and *„3.9.3. Two quadrant operation (2QO)“*. Following power supply and electronic load series are compatible:

- PS 9000 2U/3U (new from 2014)
- PSI 9000 2U/3U (new from 2014)
- ELR 9000

1.10.11 “Sense” connector (remote sensing)



If the input voltage has to be dependant on the source location rather than the DC input of the electronic load, then the input “Sense” can be connected to the source where the DC connection is made. This compensates, up to a certain limit, the voltage difference between the source and the load input, which is caused by the high current through the load cables. The maximum possible compensation is given in the technical data.

1.10.12 Master-Slave bus



A further port is provided on the back side of the device, comprising two RJ45 sockets, which enables multiple devices of the same model to be connected via a digital bus (RS485) to create a master-slave system. Connection is made using standard CAT5 cables. It can theoretically have a length of up to 1200m, but it is recommended to keep the connections as short as possible.

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2. Installation & commissioning

2.1 Transport and storage

2.1.1 Transport



- The handles on the front side of the device are **not** for carrying!
- Because of its weight, transport by hand should be avoided where possible. If unavoidable then only the housing should be held and not on the exterior parts (handles, DC input terminal, rotary knobs).
- Do not transport when switched on or connected!
- When relocating the 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 the manufacturer for repair. Otherwise the packaging should be disposed of in an environmentally friendly way.

2.1.3 Storage

In case of long term storage of the equipment it 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 *„1.10.3. Scope of delivery“*). An obviously damaged device (e.g. loose parts inside, damage outside) must under no circumstances be put in operation.

2.3 Installation

2.3.1 Safety procedures before installation and use



- The device may, depending on the model, have a considerable weight. Therefore the proposed location of the equipment (table, cabinet, shelf, 19” rack) must be able to support the weight without restriction.
- When using a 19” rack, rails suitable for the width of the housing and the weight of the device are to be used. (see *„1.9.3. Specific technical data“*)
- Before connecting to the mains ensure that the connection 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: Before connecting the AC input/output to a public grid, it is essential to find out if the operation of this device is allowed at the target location and if it is required to install supervision hardware, i.e. automatic isolation unit (AIU, ENS)

2.3.2 Preparation

Mains connection of an energy back-feeding electronic load of ELR 9000 series is done via the included 5 pole plug on the back of the device. Wiring of the plug is at least 3 strand or, for some models, 5 strand of suitable cross section and length. For recommendations for cable cross section see *„2.3.4. Mains connection (AC)“.*

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

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

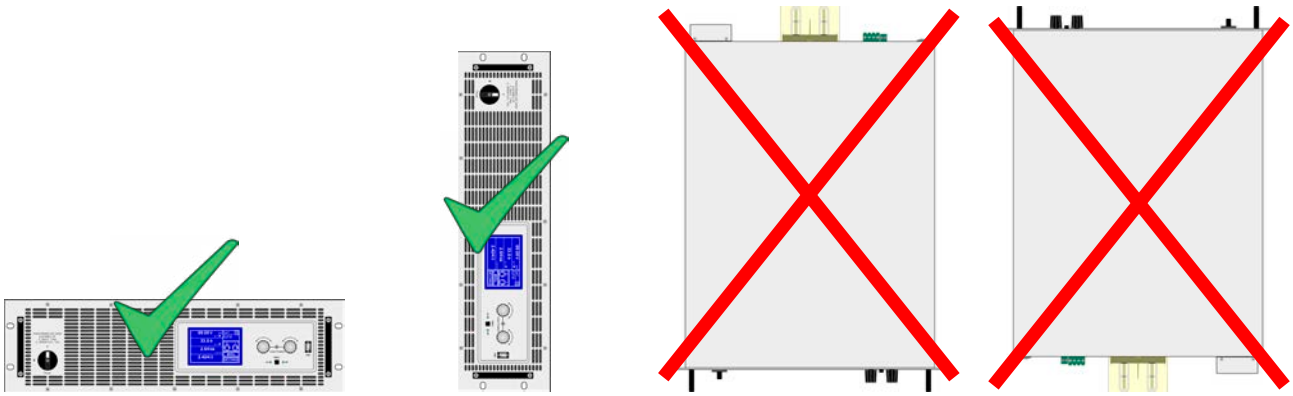
2.3.3 Installing the device

- Select the location for the device so that the connection to the source is as short as possible.
- Leave sufficient space behind the equipment, minimum 30cm, 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).

On some models the mounting brackets provided to fix the device in a 19” cabinet can be removed so that the device can be operated on any flat surface as a desk top device.

Acceptable and unacceptable installation positions:



Standing surface

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2.3.4 Mains connection (AC)

- Connection to an AC mains supply may only be carried out by qualified personnel.
- Cable cross section must be suitable for the maximum input/output current of the device (see table below)
- Before plugging in the input plug ensure that the device is switched off by its mains switch
- Ensure that all regulations for the operation of and connection to the public grid of energy back-feeding equipment have been applied and all necessary conditions have been met.

The equipment is delivered with a 5 pole mains plug. Depending on model, this will be connected with a 2-phase or 3-phase mains supply, which has to be connected according to the description on the plug and the table below. Required for the mains connection, with or without AIU (automatic isolation unit, monitoring the mains for correct energy recovery), are following phases:

	Without AIU		With AIU	
Nominal power	**Supply connector**	**Supply type**	**Supply connector**	**Supply type**
3500W	L2, N, PE	Single phase (wall etc.)	L1, L2, L3, N, PE	Three-phase
7000W	L1, L3, N, PE	Three-phase	L1, L2, L3, N, PE	Three-phase
10500W	L1, L2, L3, N, PE	Three-phase	L1, L2, L3, N, PE	Three-phase
>10500W	L1, L2, L3, N, PE	Three-phase	L1, L2, L3, N, PE	Three-phase

The N conductor is imperative and must always be wired!

If using an automatic isolation unit (AIU), all phases of a three-phase supply are required, because the mains monitoring feature of the AIU always monitors on three phases.

For the dimensioning of the wiring **cross section** the power of the device and the cable length are decisive. The maximum output current of the energy back-feeding feature per phase is calculated by the formula I_{AC} = Nominal power * Efficiency / 230V. The table below tells the maximum output current of every phase, as well as the recommended minimum cross section.

Based on the connection of a **standalone unit**:

	L1		L2		L3		N	
Nominal power	**ø**	**I_{max}**	**ø**	**I_{max}**	**ø**	**I_{max}**	**ø**	**I_{max}**
3500W	-	-	1.5mm²	16A	-	-	1.5mm²	16A
7000W	1.5mm²	16A	-	-	1.5mm²	16A	1.5mm²	16A
10500W	1.5mm²	16A	1.5mm²	16A	1.5mm²	16A	1.5mm²	16A

The included connection plug can receive cable ends of up to 4mm². The longer the connection cable, the higher the voltage loss due to the cable resistance. If the voltage loss is too high then the feedback will not function reliably or not at all. Therefore the mains cables should be kept as short as possible.

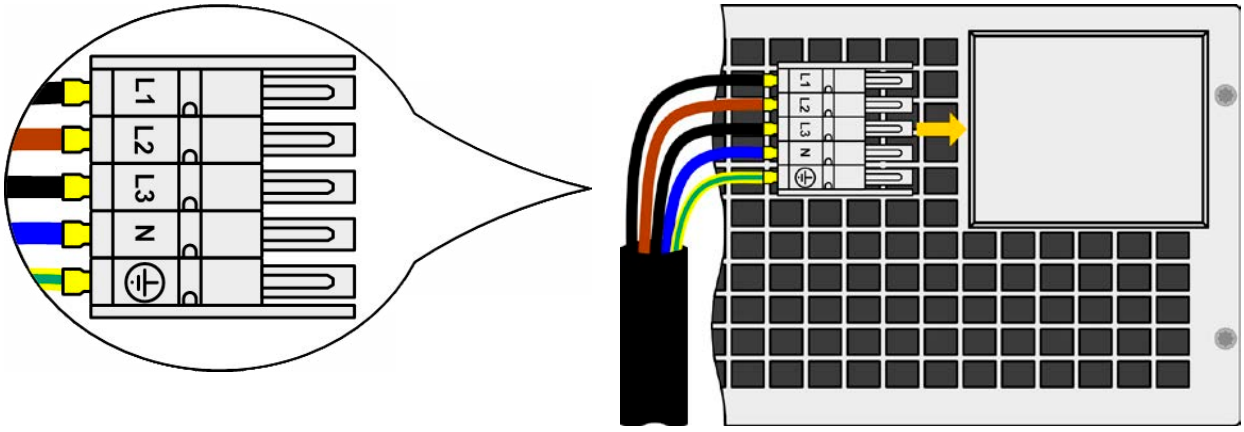


Figure 7 - Example for a supply connection cable (cable not included in the delivery)

2.3.5 Connection to DC sources

In the case of a device with a high nominal current and hence a thick and heavy DC connection cable it is necessary to take account of the weight of the cable and the strain imposed on the DC connection. Especially when mounted in a 19" cabinet or similar, where the cable hangs on the DC input, a strain reliever has to be used.

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

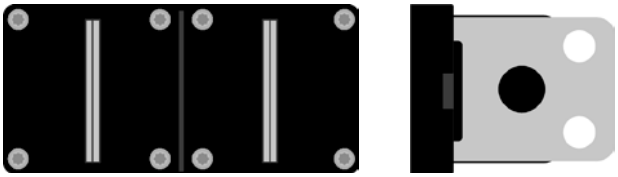
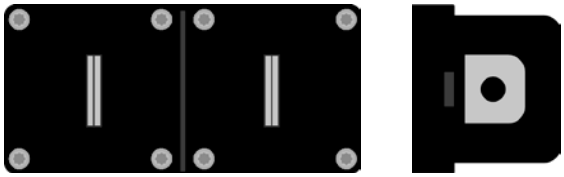
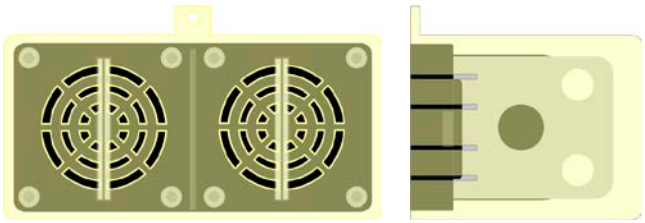
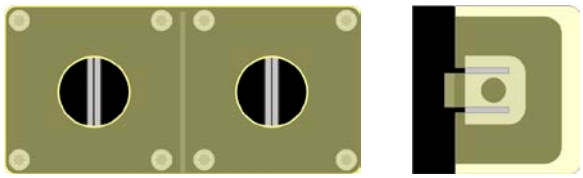
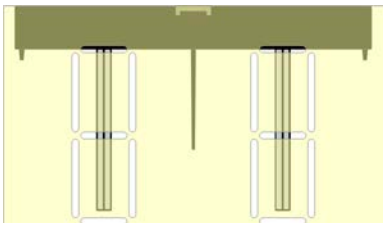
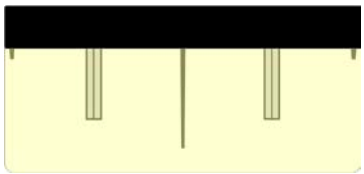
For cables up to 1.5m and average ambient temperature up to 50°C, we recommend:

up to **30A**:	6mm²	up to **70A**:	16mm²
up to **90A**:	25mm²	up to **140A**:	50mm²
up to **170A**:	70mm²	up to **210A**:	95mm²
up to **340A**:	2x70mm²	up to **510A**:	2x120mm²

per connection pole (multi-conductor, insulated, openly suspended). Single cables of, for example, 70mm² may be replaced by 2x35mm² etc. If the cables are long then the cross section must be increased to avoid voltage loss and overheating.

2.3.5.1 DC terminal types

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

Type 1: Models from 60A input current	**Type 2: Models up to 44A input current**
	
M10 bolt on a metal rail Recommendation: ring connector with a 10mm hole	M6 bolt on a metal rail Recommendation: ring connector with a 6mm hole
	
	

2.3.5.2 Cable lead and plastic cover

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

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

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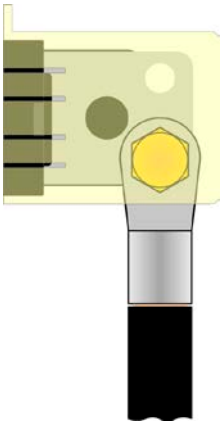
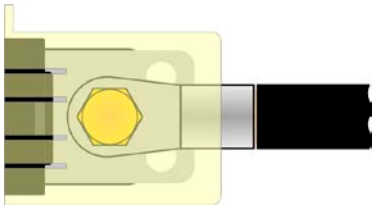
Examples of the type 1 terminal:



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



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

2.3.6 Grounding of the DC input

Individually operated devices can always be grounded from the DC minus pole, i.e. can be directly connected to PE. The DC plus pole, however, if it is to be grounded, may only be so for input voltages up to 300V.

For this reason, for all models which can support an input voltage higher than 300V grounding of the DC plus pole is not allowed.

- Do not ground the DC plus pole on any model with >300V nominal voltage
- If grounding one of the input poles ensure that no output poles of the source (e.g. power supply) are grounded. This could lead to a short-circuit!

2.3.7 Connection of remote sensing

In order to compensate the voltage loss along a DC cable up to a certain degree, the device provides the possibility to connect the remote sensing input “Sense” to the source. The device recognizes the remote sensing mode automatically and regulates the input voltage (only in CV operation) at the source rather than at its own DC input. In the technical specifications (see section *„1.9.3. Specific technical data“*) the level of maximum possible compensation is given. If that is insufficient, the cable cross section must be increased.

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

- The cross section of the sensing cables is noncritical. However, it should be increased with increasing cable length. Recommendation for a cable up to 5m is 0.5mm²
- 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
- The sensing cables must be connected + to + and - to - at the source, otherwise both systems may be damaged
- In master-slave operation, the remote sensing should be connected to the master unit only

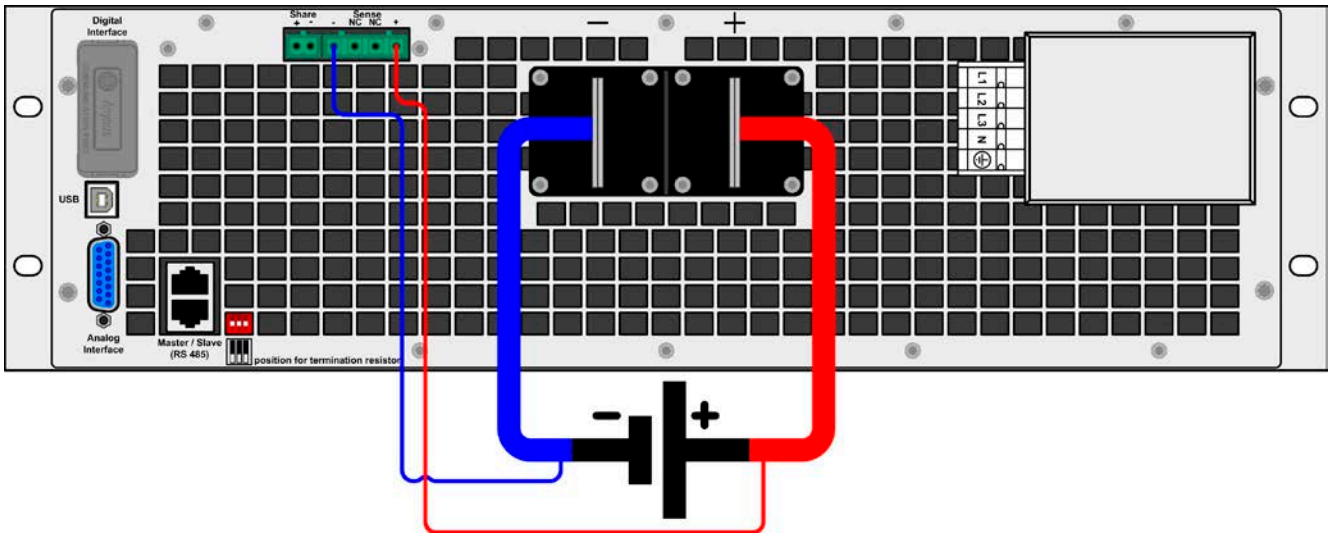


Figure 8 - Example for remote sensing wiring

2.3.8 Connecting the “Share” bus

The “Share” bus connector on the back side is intended to balance the current of multiple units in parallel operation, especially when using the integrated function generator of the master unit. Alternatively, it can be connected to a compatible power supply, like from series PS 9000 3U or PSI 9000 3U, in order to run a two-quadrants operation. For further information about this mode of operation can be found in section *„3.9.3. Two quadrant operation (2QO)“* .

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

- Share bus connection is only allowed between up to 10 units and only between compatible devices as listed in section *„1.10.10. “Share” connector“*
- If a two-quadrants operation system has to be set up where multiple power supplies are connected to one electronic load unit or a group of electronic loads, all units should be connected via Share bus. One power supply unit is then configured as Share bus master, similar to true master-slave operation. The group of power supplies may use the master-slave bus for true master-slave operation, the group of loads may not, because there must be only one master unit on the Share bus.

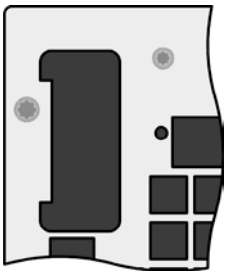
2.3.9 Installation of an AnyBus interface module

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

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

Installation steps:

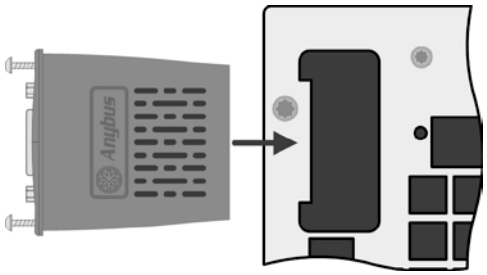
1.



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

Check that the fixing screws of an already installed module are fully retracted. If not, unscrew them (Torx 8) and remove module.

2.

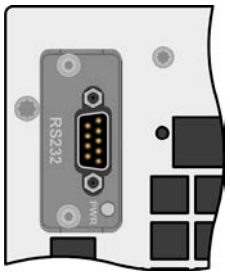


Insert the interface module into the slot. The shape ensures correct alignment.

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

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

3.



Slide the module into place as far as it will go.

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

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

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2.3.10 Connecting the analog interface

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



The analog interface is galvanically isolated from the device internally. Therefore do not connect any ground of the analog interface (AGND) to the DC minus input as this will cancel the galvanic isolation.

2.3.11 Connecting the USB port (rear side)

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

2.3.11.1 Driver installation (Windows)

On the initial connection with a PC the operating system will identify the device as new hardware and will install the driver. The driver is a Communications Device Class (CDC) type and is usually integrated in current operating systems such as Windows 7 or XP and is therefore not provided additionally. There are, however, versions such as Windows 7 Embedded in which the class of driver is not installed or does not function.

On the included CD is a driver information file (*.inf) which can install the device as a virtual COM port (VCOM).

Following recognition, the USB equipment will first be listed in the Windows Device Manager as “other hardware” (Windows 7) and the driver may possibly not be fully installed. In this case take the following steps:

In Device Manager click with right mouse button on the not fully installed hardware. Select “Update driver”

1. Windows will ask if the driver should be automatically searched or whether it should be located and installed manually. Select the latter (second choice in the dialogue window).
2. In the next dialogue window the driver source path will be determined. Click on “Search” and enter the folder of the USB driver from the “Drivers & Tools” CD or the path to the downloaded and unpacked driver. Allow Windows to install the driver. A message that the driver is not digitally signed can be submitted with “Ignore”.

2.3.11.2 Driver installation (Linux, MacOS)

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

2.3.11.3 Alternative drivers

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

2.3.12 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 that the default settings for set values, safety and monitoring functions and communication are suitable for your application and change them where necessary, as described in the manual
- In case of remote control via PC, read the additional documentation for interfaces and software
- In case of remote control via the analog interface, read the section in this manual concerning analog interfaces and, where needed, other appropriate documentation especially concerning the use of such interfaces

2.3.13 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 *„2.3.12. Initial commission“.*

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

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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 source and DC input are being re-configured, the device should be disconnected from the mains, not only the DC input switched off!

3.2 Operating modes

3.2.1 Voltage regulation / Constant voltage

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

While the DC input is switched on and constant voltage mode is active, then the condition “CV mode active” will be shown on the graphics display by the abbreviation CV, as well it will be passed as a signal to the analog interface and stored as internal status which can be read via digital interface.

3.2.1.1 Speed of the voltage controller

The internal voltage controller can be switched between “slow” and “fast” (see *„3.3.3.1. Menu “General Settings”“).* Factory default value is “slow”. Which setting to select depends on the actual situation in which the device is going to be operated, but primarily it depends of the type of voltage source. An active, regulated source such as a switching mode power supply has its own voltage control circuit which works concurrently to the load’s circuit. Both might work against each other and lead to oscillation. If this occurs it is recommended to set the controller speed to “slow”.

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

3.2.1.2 Minimum voltage for maximum current

Due to technical reasons, all models in this series have a minimum internal resistance that make 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 models and is primarily depending on the minimum internal resistance (R_{MIN}). The technical specifications list U_{MIN} for every model. If less voltage than U_{MIN} is supplied, the load proportionally draws less current, even less 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 current has reached the adjusted value, the device automatically switches to constant current mode. However, if the power consumption reaches the adjusted power level, the device will automatically switch to power limitation and adjust the input current according to $I_{MAX} = P_{SET} / U_{IN}$, even if the maximum current set value is higher. The current set value, as determined by the user, is always and only an upper limit.

While the DC input is switched on and constant current mode is active, the condition “CC mode active” will be shown on the graphics display by the abbreviation CC, as well it will be passed as a signal to the analog interface and stored as internal status which can be read via digital interface.

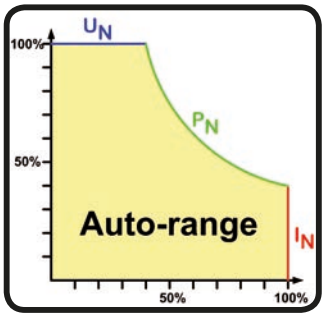
3.2.3 Resistance regulation / constant resistance

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

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

3.2.4 Power regulation / constant power / power limitation

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



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

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

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

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3.2.5 Alarm conditions

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

As a basic principle, all alarm conditions are signalled optically (Text + message in the display), acoustically (if acoustic alarm is activated and no remote control going on) and as a readable status via the digital interface. With any alarm occurring, the DC input of the device is switched off. In addition, the alarms OT and OVP are reported as signals on the analogue interface.

3.2.5.1 Power Fail

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

- AC input voltage too high (mains overvoltage)
- AC input voltage too low (mains undervoltage, mains failure)
- Defect in the input circuit (PFC)
- Not all required AC input phases are connected (see *„2.3.4. Mains connection (AC)“* for requirements)

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

3.2.5.2 Overtemperature

An overtemperature alarm (OT) can occur if an excess temperature inside the device causes to switch off the DC input. This alarm condition is shown as the message “Alarm: OT” in the display. In addition, the condition will be passed as a signal to the analog interface where it can also be read as an alarm code, as well as alarm code which can be read via digital interface.

An OT alarm has a lower priority than an OV alarm (overvoltage). If an OV alarm occurs during an OT alarm, then the message “OT” will be overwritten by “OV”

3.2.5.3 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 acoustically or optically that the connected voltage source has generated an excessive voltage and thereby could damage or even destroy the input circuit and other parts of the device.

The device is not fitted with protection from external overvoltage.

3.2.5.4 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.

3.2.5.5 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.

3.3 Manual operation

3.3.1 Powering the device

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

After switching on, the display will first show the manufacturers logo (approx. 10s) followed by the manufacturers name, address, device type, firmware version(s), serial number and item number (approx. 3s). In setup (see section *„3.3.3. Configuration via MENU“* in the second level menu “General settings” is an option “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, DC input condition and master-slave operation mode are restored.

3.3.2 Switching the device off

On switch-off, the last input condition and the most recent set values and input status, as well as activated master-slave operation are saved. Furthermore, a PF alarm (power failure) will be reported, but has to be ignored here.

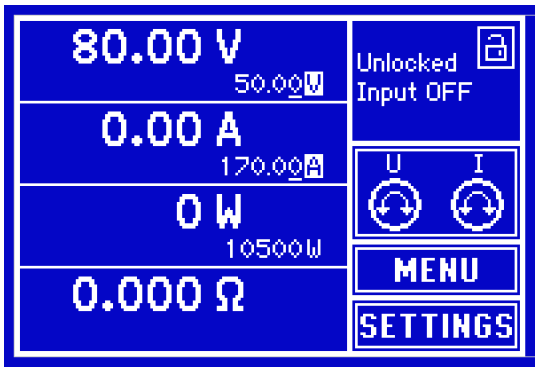
The DC input is immediately switched off and after a short while fans will shut down and after another few seconds the device will be completely powered off.

3.3.3 Configuration via MENU

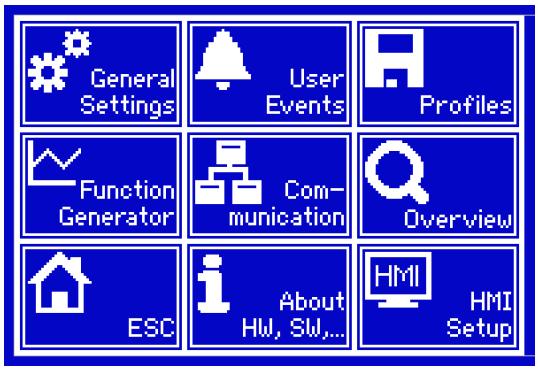
The MENU serves to configure all operating parameters which are not constantly required. These can be set by finger touch on the MENU touch area, but only if the DC input is switched OFF. See figure to the right.

If the DC input is switched on the settings menu will not be shown, only status information.

Menu navigation is by finger touch. Values are set using the rotary knobs. The assignments of the rotary knobs, if multiple values can be set in a particular menu, are shown on the menu pages in the lower middle.



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



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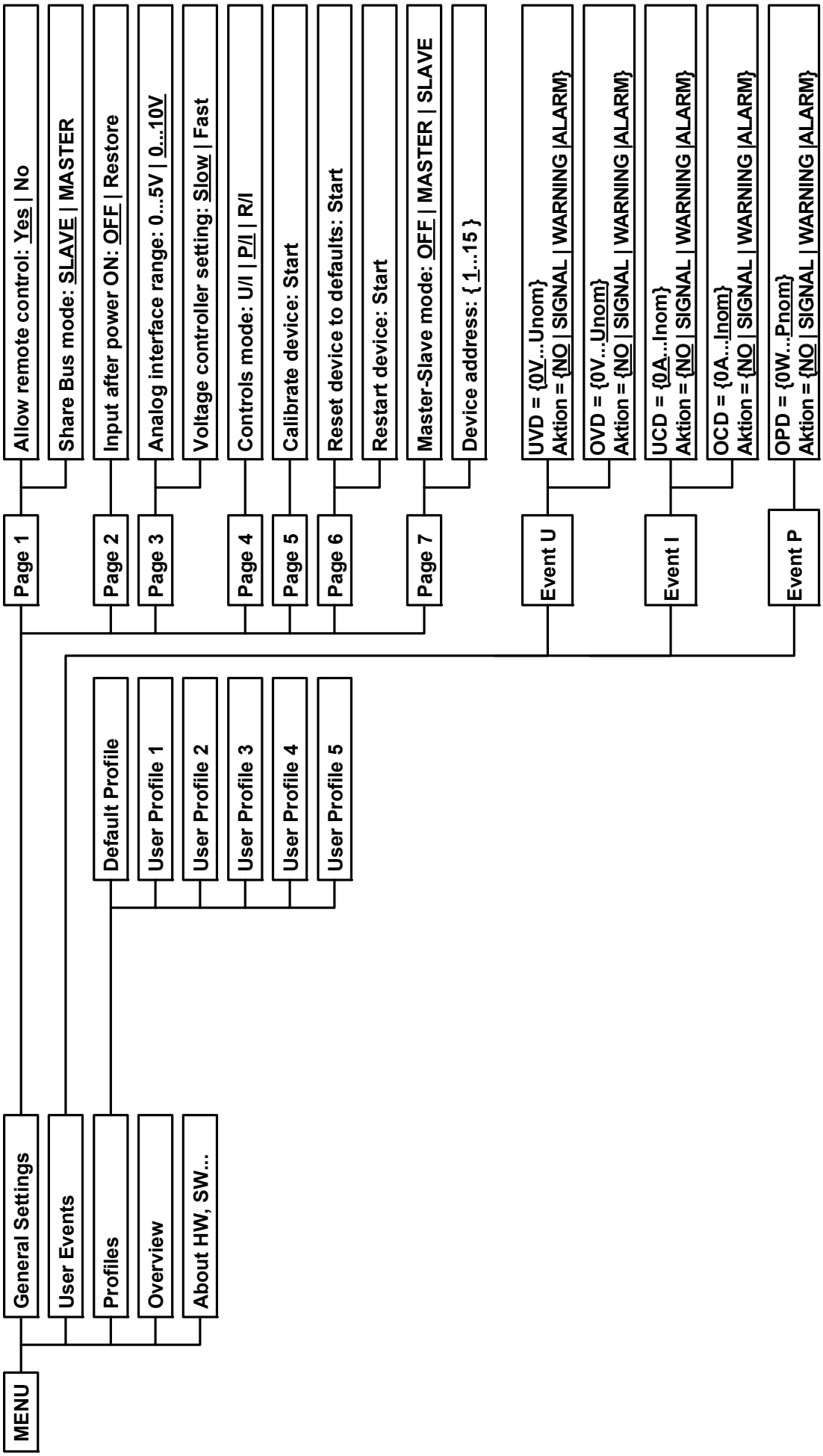
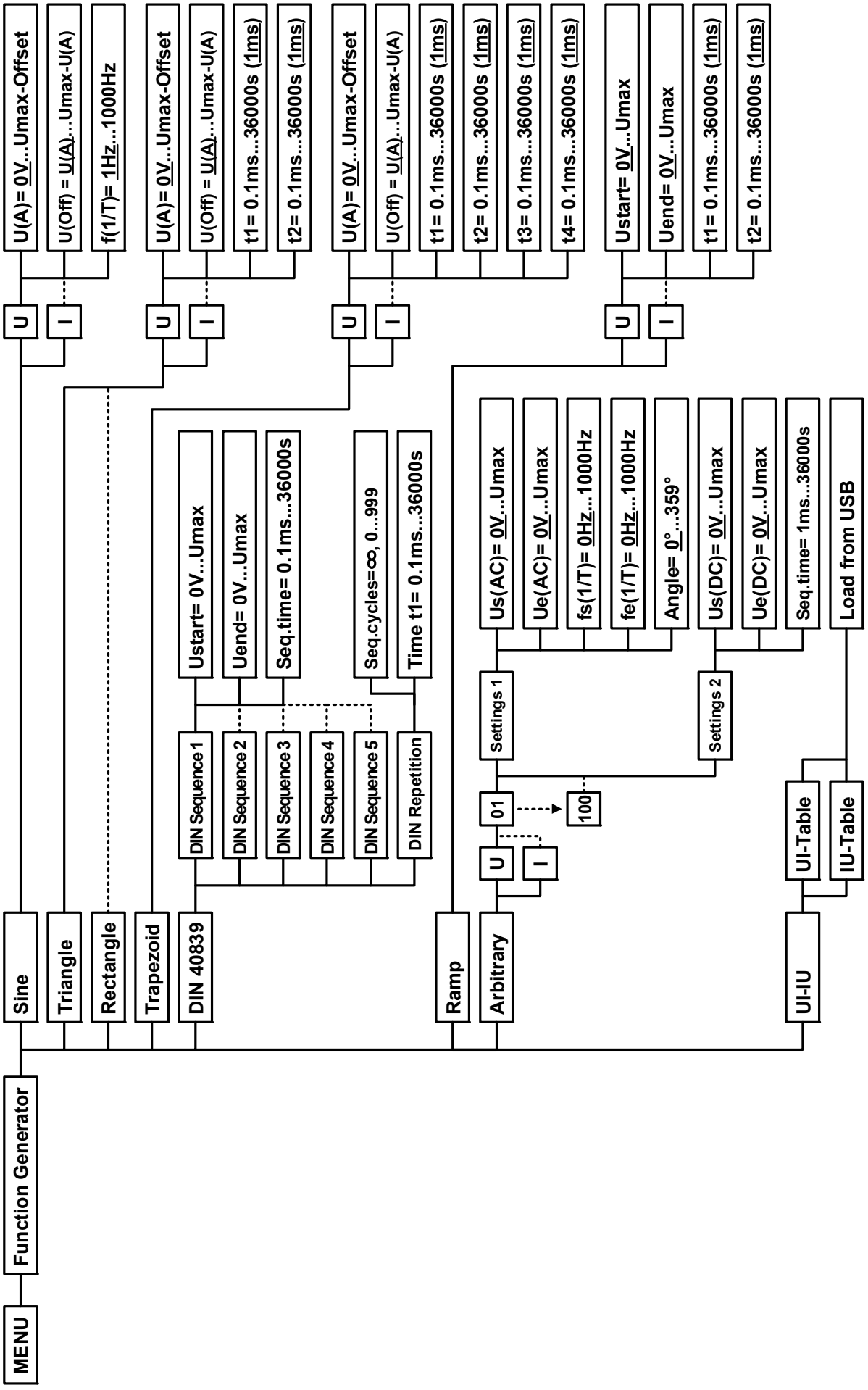


Parameters in curly brackets describe the selectable range, underlined parameters show the default value after delivery or reset.



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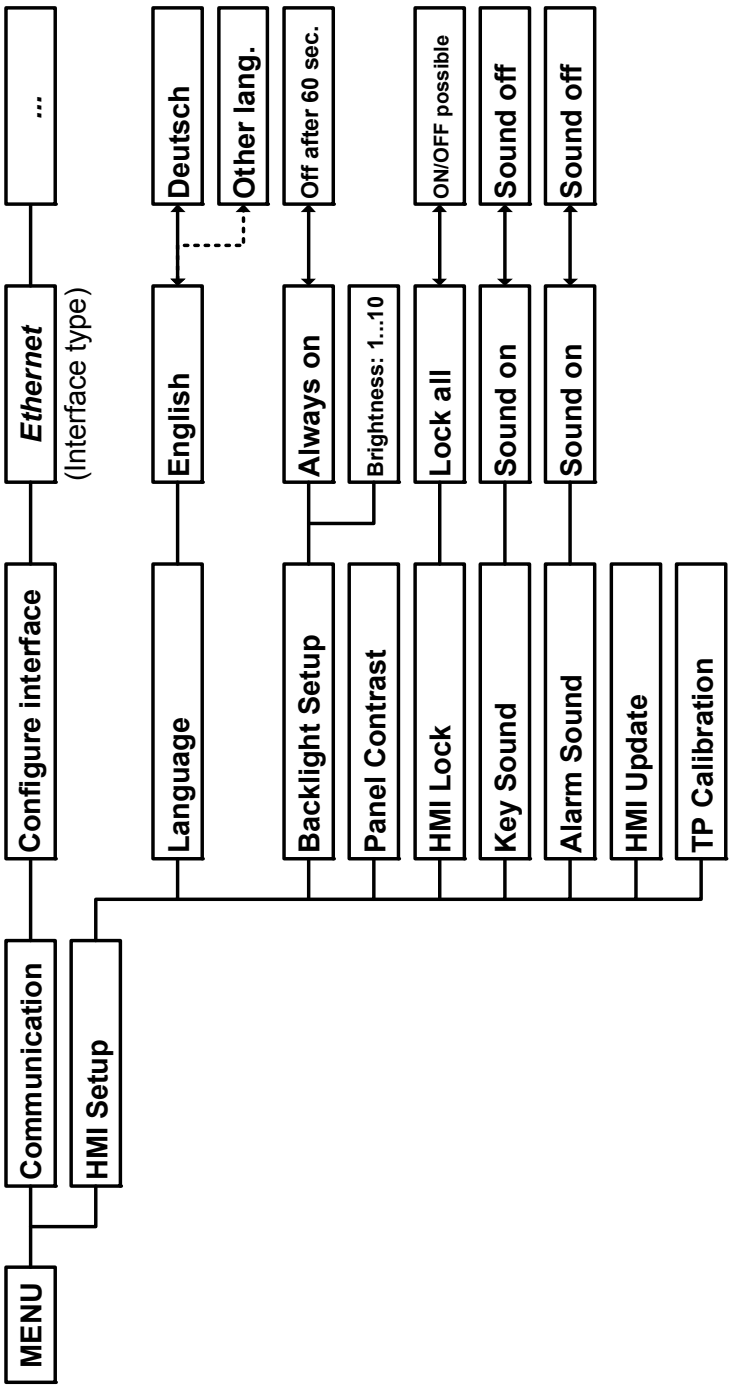
MENU
Communication
HMI Setup
Configure interface
Ethernet
(Interface type)
...
Language
English
Deutsch
Other lang.
Backlight Setup
Always on
Off after 60 sec.
Brightness: 1...10
Panel Contrast
HMI Lock
Lock all
ON/OFF possible
Key Sound
Sound on
Sound off
Alarm Sound
Sound on
Sound off
HMI Update
TP Calibration

3.3.3.1 Menu “General Settings”

Element	S.	Description
Allow remote control	1	Selection “NO” means that the device cannot be remotely controlled over either the digital or analog interfaces. If remote control is not allowed, the status will be shown as “Local” in the status area on the main display. Also see section *1.10.6.1*
Share Bus mode	1	For Two quadrant operation (see *„3.9.3. Two quadrant operation (2QO)“*), which used the Share Bus connection. Setting SLAVE (default) is here used for the electronic load in this connection, so this setting is usually left untouched.
Input after power ON	2	Determines the condition of the DC input after power-up. • OFF = DC input is always off after switching on the device. • Restore = DC input condition will be restored to the condition prior to switch off.
Analog interface range	3	Selects the voltage range for the analog set input values, actual output values and reference voltage output. • 0...5V = Range is 0...100% set /actual values, reference voltage 5V • 0...10V = Range is 0...100% set /actual values, reference voltage 10V See also section *„3.4.4. Remote control via the analog interface (AI)“*
Voltage controller settings	3	Selects the regulation speed of the internal voltage regulator between slow and fast. See *„3.2.1.1. Speed of the voltage controller“*
Controls mode	4	Changes the operating mode and assignments of the rotary knobs between U/I, P/I and R/I, similar to the main page. • U/I = Set voltage and current via rotary knobs. • P/I = Set power and current via rotary knobs • R/I = Set resistance and current via rotary knobs
Calibrate device	5	Touch area “Start” starts a calibration routine (see *„4.4. Calibration“*), but only if the device is in U/I or P/I mode.
Reset device to defaults	6	Touch area “Start” will initiate a reset of all settings (HMI, profile etc.) to default values, as shown in the menu structure diagrams on the previous pages, and all set values to 0
Restart device	6	Touch area “Start” will let the device perform a warm start
Master-Slave mode	7	Option “OFF” (default) disables the master-slave mode (MS), while options MASTER or SLAVE set the device to the selected position. For details about the MS mode see section *„3.9.1. Parallel operation in master-slave mode (MS)“*
Device address	7	Assigns the device address between 1 and 9 for a slave in the MS system. A master is automatically assigned address 0, which can not be changed.

3.3.3.2 Menu “User Events”

See *„3.5.2.1 User defined events“ on page 53.*

3.3.3.3 Menu “Profiles”

See *„3.7 Loading and saving a user profile“ on page 55.*

3.3.3.4 Menu “Overview”

This menu page displays an overview of the set values (U, I, P or U, I, P, R) and alarm settings as well as adjustment limits. These can only be displayed, not changed.

3.3.3.5 Menu “About HW, SW...”

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

3.3.3.6 Menu “Function Generator”

See *„3.8 The function generator“ on page 56.*

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3.3.3.7 Menu “Communication”

Here settings for digital communication via the optional interface modules (abbr. IF) of the IF-AB series are made. The touch area “Configure interface” opens one or more settings pages, depending on the module in use.

For all Ethernet interfaces with two ports: „P1“ is related to port 1 and „P2“ to port 2, like printed on the module face. Two-port interfaces will use one IP only.

IF	Level 1	Level 2	Level 3	Description
Ethernet / ModBus-TCP, 1 & 2 Port	**IP Settings**	**DHCP**		The IF allows a DHCP server to allocate an IP address, a subnet mask and a gateway. If no DHCP server is in the network then network parameters will be set as defined in point “Manual”
		Manual	**IP**	This option is activated by default. An IP address can be maually allocated.
			Gateway	Here a gateway address can be allocated if required..
			Subnet	Here a subnet mask can be defined if the default subnet mask is not suitable.
		DNS 1		Here the addresses of the first and second Domain Name Servers (DNS) can be defined, if needed. A DNS is only necessary if the device has Internet access and should call Internet URLs, e.g. an internal eMail system, in order to send an eMail.
		DNS 2		
		Port		Range: 0...65535. Default ports: 5025 = Modbus RTU (all Ethernet interfaces) 502 = Modbus TCP (Modbus-TCP interface only)
	IP Com Settings P1 **IP Com Settings P2**	**AUTO**		Settings for the Ethernet port such as transmission speed are set automatically.
		Manual	**Half dup**	Manual selection for transmission speed (10MBit/100MBit) and duplex mode (full/half). It is recommended to use the “AUTO” option and only revert to “Manual” if these parameters fail.
			Full dup	
			10MBit	
			100MBit	
	Host name			Free choice of host name (default: Client)
	Domain name			Free choice of Domain (default: Workgroup)
	SMTP Settings	**Server IP**		Mail server address, used to send eMails via this mail server, in order to e.g. report an alarm.
		Username		Login to Mailserver, Username
		Password		Login to Mailserver, Password

IF	Level 1	Description
Profibus DP	**Node Address**	Selection of the Profibus or node address of the device within range 1...125 via direct input
	Function Tag	String input box for a user-definable text which describes the Profibus slave function tag. Max. length: 32 characters
	Location Tag	String input box for a user-definable text which describes the Profibus slave location tag. Max. length: 22 characters
	Installation Date	String input box for a user-definable text which describes the Profibus slave installation date tag. Max. length: 40 characters
	Description	String input box for a user-definable text which describes the Profibus slave. Max. length: 54 characters

IF	Level 1	Description
RS232	-	There are no configurable parameters for this module. It always uses these serial settings: Baud rate = 115200 Baud, 8 data bits, 1 stop bit, parity = none

IF	Level 1	Level 2	Level 3	Description
Profinet/IO, 1 & 2 Port	IP Settings	DHCP		The IF allows a DHCP server to allocate an IP address, a subnet mask and a gateway. If no DHCP server is in the network then network parameters will be set as defined in point “Manual”
		Manual	IP	This option is activated by default. An IP address can be maually allocated.
			Gateway	Here a gateway address can be allocated if required..
			Subnet	Here a subnet mask can be defined if the default subnet mask is not suitable.
		DNS 1		Here the addresses of the first and second Domain Name Servers (DNS) can be defined, if needed. A DNS is only necessary if the device has Internet access and should call Internet URLs, e.g. an internal eMail system, in order to send an eMail.
		DNS 2		
		Port		Range: 0...65535. Default ports: 5025 = Modbus RTU (for Modbus & SCPI)
	Host name			Free choice of host name (default: Client)
	Domain name			Free choice of Domain (default: Workgroup)
	SMTP Settings	Server IP		Mail server address, used to send eMails via this mail server, in order to e.g. report an alarm.
		Username		Login to Mailserver, Username
		Password		Login to Mailserver, Password
	Function Tag	String input box for a user-definable text which describes the Profinet slave function tag. Max. length: 32 characters		
	Location Tag	String input box for a user-definable text which describes the Profinet slave location tag. Max. length: 22 characters		
	Station Name	String input box for a user-definable text which describes the Profinet station name. Max. length: 54 characters		
	Description	String input box for a user-definable text which describes the Profibus slave. Max. length: 54 characters		
	Installation Date	String input box for a user-definable text which describes the Profibus slave installation date tag. Max. length: 40 characters		

IF	Level 1	Description
Devicenet	Node Address	Selection of the Devicenet node address in the range 0...63 via direct input
	Baud Rate	Selection of the data communication speed with 125kbps, 250kbps or 500kbps (1kbps = 1024 Baud) as bus baud rate. Selection „AUTO“ will let the slave device wait for the master to initiate bus traffic in order to detect the baud rate on the bus automatically

IF	Level 1	Level 2	Description
CANopen	Node Address		Selection of the CANopen node address in the range 1...127 via direct input
	Baud Rate	AUTO	Automatic detection of the bus baud rate.(speed)
		LSS	Automatically sets baud rate and node address
		Manual	Manual selection of the baud rate that is used by the CANopen interface. Possible selections: 10kbps, 20kbps, 50kbps, 100kbps, 125kbps, 250kbps, 500kbps, 800kbps, 1Mbps (1Mbps = 1 Mbit/s, 10kbps = 10kbit/s)

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3.3.3.8 Menu “HMI settings”

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

Element	Description
Language	Selection of the display language. Currently (date: 02-18-2014) available are: German, English Additional languages (up to three can be integrated) can be implemented on demand and installed into the HMI via update. The default then would be English plus one or two additional language such as Italian, Spanish etc.
Backlight Setup	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 60s. As soon as input is made, the backlight returns automatically. Furthermore the brightness can be selected in 10 steps.
Panel Contrast	Here the user can adjust the display contrast to suit best.
HMI Lock	See *„3.6 Control panel (HMI) lock“ on page 55.*
Key Sound	Activates or deactivates sounds when touching a touch area in the display. It can usefully signal that the action has been accepted.
Alarm Sound	Activates or deactivates the additional acoustic signal of an alarm or user defined event which has been set to “Action = ALARM”. See also *„3.5 Alarms and monitoring“ on page 52.*
HMI Update	With this function the firmware of the control panel can be updated using a USB flash drive. For details refer to *„4.3.1 HMI update“ on page 73.*
TP Calibration	Starts a calibration process for the touchscreen. After calibration the touch areas should react better and more accurately to finger touches. Internal settings are saved, but a general reset of the device will reset them to the factory defaults and a recalibration will be needed.

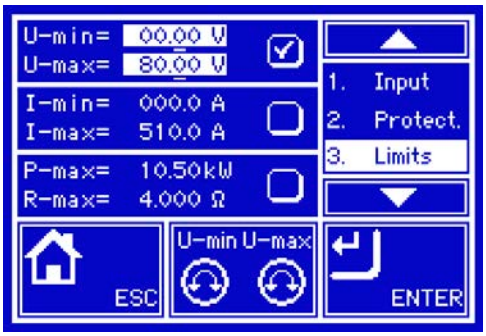
3.3.4 Adjustment limits (“Limits”)

Adjustment limits are only effective in manual operation and only on the set values in the main display screen!

Defaults are that all set values (U, I, P, R) are adjustable from 0 to 100%.

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) and resistance (R) only upper value limits can be set.



► How to configure the adjustment limits:

1. Tap the touch area SETTINGS in the main page.
2. Tap the white arrows ▲ ▼, to select “**3. Limits”.**
3. In each case a pair of upper and lower limits for U/I or the upper limit for P/R are assigned to the rotary knobs and can be set. Tap the selection area for another choice ▢.
4. Accept the settings with ENTER.

The set values can be entered directly using the ten-key pad. This appears when the touch area for rotary knob assignment is tapped (bottom center)

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 3.00kW while the currently adjusted power set value is 3.50kW, then the set value first would have to be reduced to 3.00kW or less, in order to set P-max down to 3.00kW.

3.3.5 Changing the operating mode

In general, the manual operation of an ELR 9000 distinguishes between three operating modes which are tied to set value input using the rotary knobs or ten-key pad. This assignment must be changed if one of the four set values is to be adjusted which is currently not available.

► How to change the operating mode

1. On the main screen tap the touch area in the middle of the right side



2. Now one of the three touch areas can be selected:



Primarily setting voltage and current



Primarily setting power and current



Primarily setting resistance and current

Depending on the selection the left rotary knob will be assigned different setting values, the right knob is always current.

In order to avoid constant changing of the assignments it is possible, e.g with selection R/I, to change the other values U and P by direct input. Also see section 3.3.6.

The actual operating mode of the load that is effective while the DC input is switched on, solely depends on the set values. For more information see section *„3.2. Operating modes“.*

3.3.6 Manual adjustment of set values

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

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 „3.3.4. Adjustment limits (“Limits”)“. Once a limit is reached, the display will show a note like “Limit: U-max” etc. for 1.5 seconds next to the adjusted value.

► How to adjust values with the rotary knobs

1. First check whether the value to be changed is assigned to one of the rotary knobs. The main screen displays the assignment:



2. If, as shown in the example, the assignment is voltage (U) left and the current (I) right, and it is required to change the resistance or power, then the assignments can be changed by tapping this touch area. A set of selection areas then appears in which the assignments can be changed.



3. 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 clockwise (digit will be underlined):



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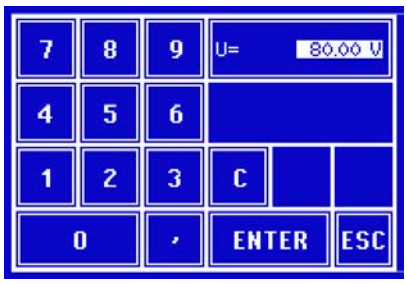
► How to adjust values via direct input



1. In the main screen, depending on the rotary knob assignment, values can be set for voltage (U), current (I), power (P) and resistance (R) via direct input by tapping on the set/actual value display areas, e.g. in the uppermost area of voltage.
2. Enter the required value using the ten-key pad. Similar to a pocket calculator the key [C] clears the input.

   Decimal values are set by tapping the point key. For example, 54.3V is set with [5] [4] [,] [3] and [ENTER].
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 reset to 0 and not accepted.

3.3.7 Switching the DC input on or off

The DC input of the device can be manually or remotely switched on and off. This can be restricted in manual operation by locking the control panel.

► How to manually switch the DC input on or off

1. As long as the control panel is not completely locked press the pushbutton ON/OFF.
2. This 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 analog interface

1. See section *„3.4.4. Remote control via the analog interface (AI)“.*

► 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 a software manufacturer.

3.4 Remote control

3.4.1 General

Remote control is principally possible via the built-in analog or USB port or via one of the optional interface modules (AnyBus CompactCom). Important here is that only the analog or one digital interface can be in control. It means that if, for example, an attempt were to be made to switch to remote control via the digital interface whilst analog remote control is active (Pin Remote = LOW) the device would report an error via the digital interface. In the opposite direction a switch-over via Pin Remote would be ignored. In both cases, however, status monitoring and reading of values are always possible.

3.4.2 Controls locations

Control locations are those locations from where the device is control. Essentially there are two: at the device (manual control) and outside (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 analog and digital interfaces is allowed. This location is not explicitly displayed
Remote	Remote control via interface is active
Local	Remote control is locked, only manual operation is allowed.

Remote control may be allowed or locked using the setting **"Allow remote control"** (see *„3.3.3.1. Menu "General Settings""*). In a locked condition the status **"Local"** will be displayed top right. Activating the lock 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 the lock and status **"Local"** causes the following:

- If remote control via the digital interface is active ("**Remote**"). then remote control is immediately terminated and must be reactivated at the PC once "**Local**" is no longer active.
- If remote control is via the analog interface is active ("**Remote**") then remote operation is only interrupted until remote control is allowed again, because pin "Remote" continues to signal "remote control = on". Exception: if the level of pin "Remote" is changed to HIGH during the "**Local**" phase.

3.4.3 Remote control via a digital interface

3.4.3.1 Selecting an interface

The device supports, in addition to the built-in USB port, the following optional interface modules for the user to select from:

Short ID	Art. nr.	Type	Ports	Description*
IF-AB-CANO	35400100	CANopen	1	CANopen slave with generic EDS
IF-AB-RS232	35400101	RS232	1	Standard RS232, serial
IF-AB-PBUS	35400103	Profibus	1	Profibus DP-V1 slave
IF-AB-ETH1P	35400104	Ethernet	1	Ethernet TCP
IF-AB-PNET1P	35400105	ProfiNet	1	Profinet DP-V1 slave
IF-AB-DNET	35400106	Devicenet	1	Full Devicenet slave
IF-AB-MBUS	35400107	ModBus TCP	1	ModBus protocol via Ethernet
IF-AB-ETH2P	35400108	Ethernet	2	Ethernet TCP, with switch
IF-AB-MBUS2P	35400109	ModBus TCP	2	ModBus protocol via Ethernet
IF-AB-PNET2P	35400110	ProfiNet	2	Profinet DP-V1 slave, with switch

* For technical details of the various modules see the extra documentation "Programming Guide Modbus & SCPI"

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3.4.3.2 General

One of the plug-in and retrofittable modules listed in *3.4.3.1* can be installed. It can take over remote control of the device alternatively to the built-in USB type B on the back side or analog interface. For installation see section *„1.10.8. Interface module slot“* and separate documentation.

The modules require little or no settings for operation and can be directly used with their default configuration. All specific settings will be permanently stored such that, after changeover between the various models, no re-configuration will be necessary.

Via the digital interface primarily the set values (voltage, current, power) and device conditions can be set and monitored. Furthermore, depending on the interface module used, various other functions are supported as described in separate programming documentation.

Changing to remote control will retain the last set values for the device until these are changed. Thus a simple voltage control by setting a target value is possible without changing any other values.

3.4.3.3 Programming

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

3.4.4 Remote control via the analog interface (AI)

3.4.4.1 General

The built-in, galvanically separated, 15-pole analog interface (short: AI) is on the back side of the device offers the following possibilities:

- Remote control of current, voltage and power
- Remote status monitoring (CC/CP, CV)
- Remote alarm monitoring (OT, OVP)
- Remote monitoring of actual values
- Remote on/off switching of the DC input

Setting the three set values via the analog interface always takes place concurrently. It means, that for example the voltage can not be given via the AI and current and power set by the rotary knobs, or vice versa.

The OVP set value and other supervision (events) and alarm thresholds cannot be set via the AI and therefore must be adapted to the given situation before the AI is put in operation. Analog set values can be fed in by an external voltage or generated by the reference voltage on pin 3. As soon as remote control via the analog interface is activated, the values displayed will be those provided by the interface.

The AI can be operated in the common voltage ranges 0...5V and 0...10V in each case 0...100% of the nominal value. The selection of the voltage range can be done in the device setup. See section *„3.3.3. Configuration via MENU“* for details. The reference voltage sent out from Pin 3 (VREF) will be adapted accordingly and is then:

0-5V: Reference voltage = 5V, 0...5V set values (VSEL, CSEL, PSEL) correspond to 0...100% nominal values, 0...100% actual values correspond to 0...5V at the actual value outputs (CMON, VMON).

0-10V: .Reference voltage = 10V, 0...10V set values (VSEL, CSEL, PSEL) correspond to 0...100% nominal values, 0...100% actual values correspond to 0...10V at the actual value outputs (CMON, VMON).

Input of excess set values (e.g. >5V in selected 5V range or >10V in the 10V range) are clipped by setting the set value at 100%.

Notes for use of the interface.

- Analog remote control of the device must be activated by switching pin “REMOTE” (5) first
- Before the hardware is connected that will control the analog interface, all wiring should be laid and the hardware is to be checked that it can’t provide voltage to the pins higher than specified



The analog interface is galvanically separated from DC input. Therefore do not connect any ground of the analog interface to the DC- or DC+ input!

3.4.4.2 Analog interface specification

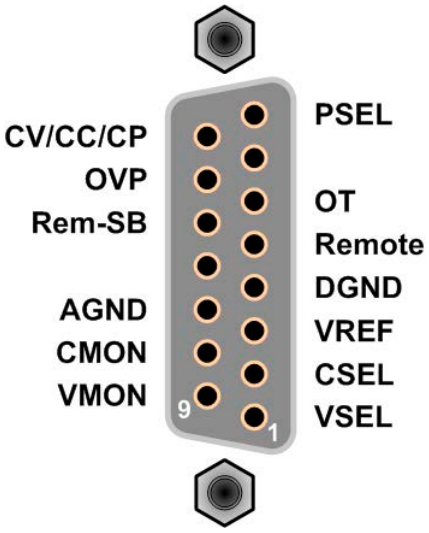
Pin	Name	Type*	Description	Levels	Electrical properties
1	VSEL	AI	Set voltage value	0…10V or. 0...5 V correspond to 0..100% of U_{Nom}	Accuracy < 0.2% Input impedance R_i >40k...100k
2	CSEL	AI	Set current value	0…10V or. 0...5 V correspond to 0..100% of I_{Nom}	
3	VREF	AO	Reference voltage	10V or 5V	Tolerance < 0.2% at I_{max} = +5mA Short-circuit-proof against AGND
4	DGND	POT	Ground for all digital signals		For control and status signals.
5	REMOTE	DI	Switching internal / remote control	Remote = LOW, U_{Low} <1V Internal = HIGH, U_{High} >4V Internal = Open	Voltage range = 0…30V I_{Max} = -1mA bei 5V $U_{LOW\ to\ HIGH\ typ.}$ = 3V Rec'd sender: Open collector against DGND
6	OT	DO	Overheating or power fail*** alarm	Alarm OT= HIGH, U_{High} > 4V No Alarm OT= LOW, U_{Low} <1V	Quasi open collector with pull-up against Vcc ** With 5V output max. flow +1mA I_{Max} = -10mA at U_{CE} = 0,3V U_{Max} = 30V Short-circuit-proof against DGND
7	-	-	-	-	-
8	PSEL	AI	Set power value	0…10V or. 0...5 V correspond to 0..100% von P_{Nom}	Accuracy < 0.5% Input impedance R_i >40k...100k
9	VMON	AO	Actual voltage	0…10V or. 0...5 V correspond to 0..100% von U_{Nom}	Accuracy < 0.2% at I_{Max} = +2mA Short-circuit-proof against AGND
10	CMON	AO	Actual current	0…10V or. 0...5 V correspond to 0..100% von I_{Nom}	
11	AGND	POT	Ground for all analog signals		For -SEL, -MON, VREF Signals
12	-	-	-	-	-
13	REM-SB	DI	DC input OFF	Off = LOW, U_{Low} <1V On= HIGH, U_{High} >4V On = Open	Voltage range = 0…30V I_{Max} = +1mA bei 5V Rec'd sender: Open collector against DGND
14	OVP	DO	Overvoltage alarm	Alarm OV = HIGH, U_{High} > 4V No alarm OV = LOW, U_{Low} <1V	Quasi open collector with pull-up against Vcc ** With 5V output max. flow +1mA I_{Max} = -10mA at U_{CE} = 0,3V, U_{Max} = 30V Short-circuit-proof against DGND
15	CV	DO	Constant voltage regulation active	CV = LOW, U_{Low} <1V CC/CP = HIGH, U_{High} >4V	

* AI = Analog Input, AO = Analog Output, DI = Digital Input, DO = Digital Output, POT = Potential

** Internal Vcc approx. 10V

*** Mains blackout, mains over- or undervoltage or PFC error

3.4.4.3 Overview of the Sub-D Socket



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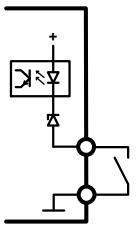
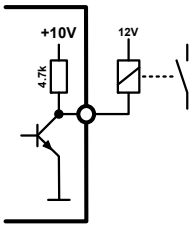
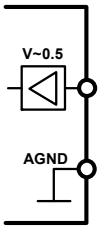
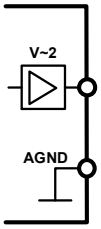
3.4.4.4 Simplified diagram of the pins

	**Digital Input (DI)** The internal circuit requires that a switch with low resistance should be used (relay, switch, circuit breaker etc.) in order to send a clean signal to the DGND. A digital output from a circuit or PLC may not be sufficient if not an “open collector”.
	**Digital Output (DO)** A quasi open collector, realised as high resistance pull-up against the internal supply. In condition LOW it can carry no load, merely switch, as shown in the diagram with a relay as example.

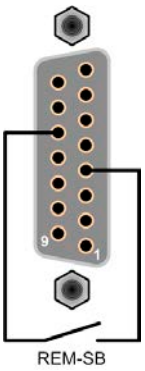
	**Analog Input (AI)** High resistance input (impedance >40k....100kΩ) for an OA circuit.
	**Analog Output (AO)** Output from an OA circuit, only minimally impedant. See specifications table above.

3.4.4.5 Application examples

a) Switching off the input via the pin “Rem-SB”

The pin Rem-SB can be used in remote control to switch the input on and off. It is recommended that a low resistance contact such as a switch, relay or transistor is used to switch the pin to ground (DGND).

A digital output, e.g. from a PLC, may be unable to cleanly effect this as it may not be of low enough resistance. Check the specification of the controlling application. See also 3.4.4.4 above.



b) Remote control of current and power.

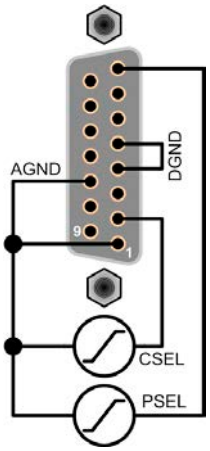
Requires remote control to be activated (Pin “Remote” = LOW)

The set values PSEL and CSEL are generated from, for example, the reference voltage VREF using potentiometers for each. Hence the electronic load can selectively work in current limiting or power limiting mode. According to the specification of max. 5mA for the VREF output, potentiometers of at least 10kΩ must be used.

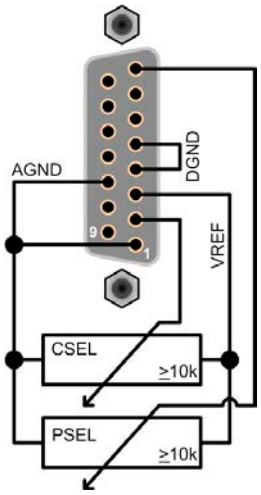
The voltage set value VSEL is permanently assigned to AGND (ground) and therefore has no influence on constant current or power operation.

If the control voltage is fed in from an external source it is necessary to consider the input voltage ranges for set values (0...5V or 0...10V).

Use of the input voltage range 0...5V for 0...100% set value halves the effective resolution.



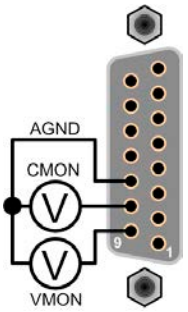
Example with external voltage source



Example with potentiometers

c) Reading actual values

Via the AI the input values of current and voltage can be monitored. These can be read using a standard multimeter or similar.



3.5 Alarms and monitoring

3.5.1 Definition of terms

There is a clear distinction between equipment alarms (see "*3.2.5 Alarm conditions*") such as overvoltage or overheating, and user defined events such as e.g **OVD** overvoltage monitoring. Whilst device alarms serve to protect the device by initially switching off the DC output, user defined events can switch off the DC output (Action = ALARM), but can also simply give an acoustic signal to make the user aware. The actions driven by user defined events can be selected:

Action	Impact	Example
NONE	User defined event is disabled.	
SIGNAL	On reaching the condition which triggers the event, the action SIGNAL will show a text message in the status area of the display.	
WARNING	On reaching the condition which triggers the event, the action WARNING will show a text message in the status area of the display and pop up an additional warning message.	
ALARM	On reaching the condition which triggers the event, the action ALARM will show a text message in the status area of the display with an additional alarm pop-up, and additionally emit an acoustic signal (if activated). Furthermore the DC input is switched off. Certain device alarms are also signalled to the analog interface or can be queried via the digital interface.	

3.5.2 Device alarm and event handling



Important to know:

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

A device alarm incident will usually lead to DC input switch-off, the appearance of a pop-up in the middle of the display and, if activated, an acoustic signal to make the user aware. The alarm must always be acknowledged. If the alarm condition no longer exists, e.g. the device has cooled down following overheating, the alarm indication will disappear. If the condition persists, the display remains and, following elimination of the cause, must be acknowledged again.

► How to acknowledge an alarm in the display

2. If the alarm is indicated as a pop-up, tap **OK.**
3. If the alarm has already been acknowledged, but is still displayed in the status area, then first tap the status area to make the alert pop up again and then acknowledge with **OK.**



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Some device alarms are configurable:

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

► How to configure the device alarms

1. Tap the touch area SETTINGS on the main screen.
2. On the right side tap the white arrow to select "**2. Protect**".
3. Set the limits for the equipment alarm relevant to your application if the default value of 110% is unsuitable.

The set values can be entered using the ten-key tab. This will appear by tapping the touch area that shows the rotary knob assignments.

The user also has the possibility of selecting whether an additional acoustic signal will be sounded if an alarm or user defined event occurs.

► How to configure the alarm sound (also see **"***„3.3.3. Configuration via MENU"*)

1. Tap the touch area MENU on the main screen
2. In the menu page, tap "**HMI Settings"**
3. In the following menu page, tap "**Alarm Sound"**
4. In the settings page select "**Sound on**" or "**Sound off**" and confirm with ENTER.

3.5.2.1 User defined events

The monitoring functions of the device can be configured for user defined events. Default is that this is deactivated (action = NONE). The following events can be configured independently and can, in each case, trigger the actions NONE, SIGNAL, WARNING or ALARM.

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

These events should not be confused with alarms such as OT and OVP which are for device protection. User defined events can, however, if set to action ALARM, switch off the DC input and thus protect the source (power supply, battery)

► How to configure user defined events

1. Tap the touch area 

on the main screen.
2. On the right side tap the white arrows  to select "**4.1 Event U**" or "**4.2 Event I**" or "**4.3 Event P**".
3. Set the monitoring limits with the left hand rotary knob and the triggered action with the right hand knob relevant to the application (also see *„3.5.1. Definition of terms"*).
4. Accept the settings with 

.

As soon as an event is set up with an action other than "NONE" and with accepted settings, an incident can occur whether the DC input is switched on or off. On leaving the pages "**User events**" or "**Settings**" an event can be directly displayed.

	User events are an integral part of the actual user profile. Thus, if another user profile, or the default profile, is selected and used, the events will be either differently or not configured.

	*The set values can be entered using the ten-key tab. This will appear by tapping the touch area on the particular page, e.g. "**4.1 Event U**", showing the rotary knob assignments.*

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3.6 Control panel (HMI) lock

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

► How to locking the HMI



1. In the main page, tap the lock symbol  (upper right corner).
2. In the settings page you can select between the complete HMI (“**Lock all**”) lock or except for the On/Off button (“**ON/OFF possible**”)
3. Activate the lock with 

. The status “**Locked**” is displayed as .

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 one of the rotary knobs or press the button “On/Off” (in complete lock situation).
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.

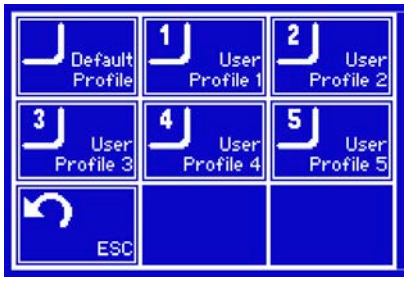
3.7 Loading and saving a user profile

The menu “**Profiles**” serves to select between a default profile and up to 5 user profiles. A profile is a collection of all settings and set values. Upon delivery, or after a reset, all 6 profiles have the same settings and all set values are 0. If the user changes settings or sets target values then these create a working profile which can be saved to one of the 5 user profiles. These profiles or the default one can then be switched. The default profile is read-only. Loading the default profile is equivalent to a reset.

The purpose of a profile is to load a set of set values, settings limits and monitoring thresholds quickly without having to readjust these. As all HMI settings are saved in the profile, including language, a profile change can also be accompanied by a change in HMI language.

On calling up the menu page and selecting a profile the most important settings can be seen, but not changed.

► How to save the current values and settings as a user profile



1. Tap the touch area 

on the main screen
2. In the menu page, tap 

.
3. In the selection screen (right) choose between user profile 1-5 in which the settings are to be saved. The profile will then be displayed and the values can be checked, but not changed.
4. Save using the touch area 

3.8 The function generator

3.8.1 Introduction

The built-in function generator is, like the equally named electronic devices, able to create various signal forms and apply these to set values for voltage or current.



With R/I being activated, access to the function generator is not available.

The generator functions can be manually operated completely on the device. In remote control, only the customisable arbitrary generator and a XY function are available, which can be configured and controlled via digital communication. The arbitrary generator can replicate all manually serviceable functions, except UI and IU For UI/IU, the XY function is assigned.

The following functions are retrievable, configurable and controllable:

Function	Usable on	Short description
Sine wave	U, I	Sine wave generation with adjustable amplitude, offset and frequency
Triangle	U, I	Triangular wave signal generation with adjustable amplitude, offset, gain and decay times
Rectangular	U, I	Rectangular wave signal generation with adjustable amplitude, offset and duty cycle
Trapezoid	U, I	Trapezoidal wave signal generation with adjustable amplitude, offset, rise time, pulse time, fall time, idle time
DIN 40839	-	Simulated automobile engine start curve according to DIN 40839 / EN ISO 7637, split into 5 curve sequences, each with a start voltage, final voltage and time
Arbitrary	U, I	Generation of a process with up to 100 freely configurable steps, each with a start and end value (AC/DC), start and end frequency, phase angle and total duration
Ramp	U, I	Generation of a linear rise or fall ramp with start and end values and time before and after the ramp
UI-IU	-	Table (.csv) with values for U or I, uploaded from a USB flash drive

3.8.2 General

3.8.2.1 Limitations

The function generator is not accessible, neither for manual acces, nor for remote control, if

- master-slave mode has been activated and the device was configured as slave.
- resistance modes (R/I adjustment mode, also called UIR mode) is active.

3.8.2.2 Resolution of X (Time) and Y (Amplitude)

The function generator can set 4096 steps between 0 ... 100% of any nominal value. The intervals to create a linear or other rise/fall are calculated depending on the amplitude and then set.

If the amplitude is very low and the time long, only few intervals will be set as otherwise many identical values will be set one after another, generating a staircase effect.

3.8.3 Method of operation

In order to understand how the function generator works and how the value settings interact, the following should be noted:

The device operates always with the three set values U,I and P, also in function generator mode.

The selected function can be used on one of the values U or I, the other two are then constants and have a limiting effect. That means, if, e.g. a voltage of 10V is applied to the DC input and a sine wave function should operate on the current with an amplitude of 20A and offset 20A, then the function generator will create a sine wave progression of current between 0A (min) and 40A (max), which will result in an input power between 0W (min) and 400W (max).The input power, however, is limited to its set value. If this were 300W then, in this case, the current would be limited to 30A and, if clamped to an oscilloscope, it would be seen to be capped at 30A and never achieve the target of 40A.

Another case is when working with a function which is applied to the input voltage. If here the static voltage is set higher than the amplitude plus offset then at function start there will be no reaction, as the voltage regulation limits down to 0 with an electronic load, other than current or power. The correct settings for each of the other set values is therefore essential.

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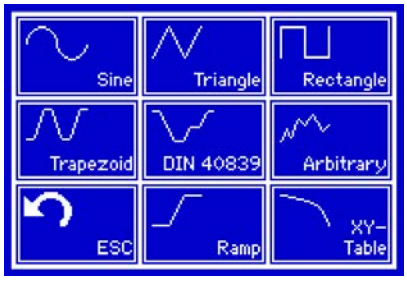
3.8.4 Manual operation

3.8.4.1 Function selection and control

Via the touchscreen one of the functions described above can be called up, configured and controlled. Selection and configuration are only possible when the input is switched off.



► How to select a function and adjust parameters

1. Tap the touch area MENU on the main screen. If the menu does not appear it is because the DC input is still switched on or the touch area is locked due to the device being possibly in remote control.
2. In the menu overview tap on the touch area Function Generator and then on the desired function.
   Note: this touch area is locked in master-slave mode or in R mode (adjustable resistance).
3. Depending on the choice of function there follows a request to which value the function generator is going to be applied: U or I.
4. Adjust the parameters as you desire, like offset, amplitude and frequency for a sine wave.

> *For the AC part of a function and if the difference between start and end value of amplitude or frequency is too low (min. increment of 0.58%), depending on the time that is defined for one function run, the function generator will not accept the settings and pop up an error.*

5. Do not forget to adjust the global limits of voltage, current and power, which you can access with touch area U/I/P Limits. With the function assigned to the current, the current setting here in this screen is not a global limit, but a static value that will be in effect before the function runs and after it has/was stopped and as long as the DC input is switched on. For the voltage it is equivalent.

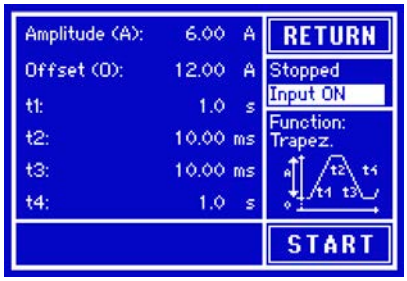
> *When entering function generator mode, those global limits are reset to safe values, which might prevent the function from working at all. For example, if you apply the selected function to the output current, then the overall current limit should not interfere and should at least be as high as offset + amplitude.*

Setting the various functions is described below. After setting it up, the function can be loaded.

► How to load a function

1. After setting the values for the required signal generation, tap on the touch area LOAD.

The device will then load the data into the internal controller and changes the display. Shortly afterwards the static value is set, the DC input is switched on and the touch area START released. Only then the function can be started.



> *The static value is applied to the DC input immediately after loading the function, because the DC input is switched on automatically in order to settle the start situation. The static value represents start and end value for the progress of the function, so that the function does not need to start from 0.*

► **How to start and stop a function**

1. The function can be started either by tapping START or pushing the “On/Off” button, if the DC input is currently switched off. The function then starts immediately. In case START is used while the DC input is still switched off, the DC input will be switched on automatically.

> *During the progress of the functions **sine wave, rectangular wave, triangular wave, trapezoidal wave** or **ramp*** no actual values are displayed*.*

2. The function can be stopped either by tapping STOP or pushing the “On/Off” button. However, there is a difference:

   a) The STOP are only stops the function, the DC input remains ON with the static value in effect.

   b) The “On/Off“ button stops the function and switches the DC input off.

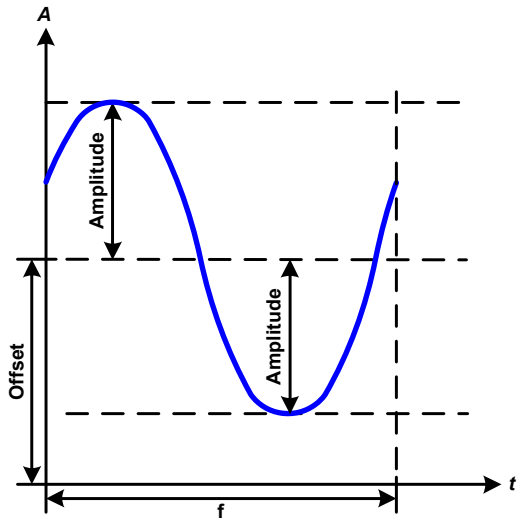
> *Any device alarm (overvoltage, overtemperature etc.) or protection (OPP, OCP) or event with action = Alarm stops the function progress automatically, switched of the DC input and reports the alarm in the display.*

3.8.5 Sine wave function

The following parameters can be configured for a sine function:

Value	Range	Description
I(A), U(A)	0...(Nominal value - (Off)) von U, I	A = Amplitude of the signal to be generated
I(Off), U(Off)	(A)...(Nominal value - (A)) von U, I	Off = Offset, based on the zero point of the mathematic sine curve, may not be smaller than the amplitude.
f (1/t)	1...1000Hz	Static frequency of the signal to be generated

Schematic diagram:



Application and result:

A normal sine wave signal is generated and applied to the selected set value, e.g. current (I). At a constant input voltage the current input of the load will follow a sine wave.

For calculating the maximum power input the amplitude and offset values for the current must be added.

Example: with an input voltage of 100V and sin(I) selected, set the amplitude to 30A and the offset to 50A. The resulting maximum input power is then achieved at the highest point of the sine wave and is (30A + 50A) * 100V = 8000W.

3.8.6 Triangular function

The following parameters can be configured for a triangular wave function:

Value	Range	Description
I(A), U(A)	0...(Nominal value - (Off)) of U, I	A = Amplitude of the signal to be generated
I(Off), U(Off)	0...(Nominal value - (A)) of U, I	Off = Offset, based on the foot of the triangular wave
t1	0.1ms...36000s	Time for the positive slope of the triangular wave signal.
t2	0.1ms...36000s	Time for the negative slope of the triangular wave signal

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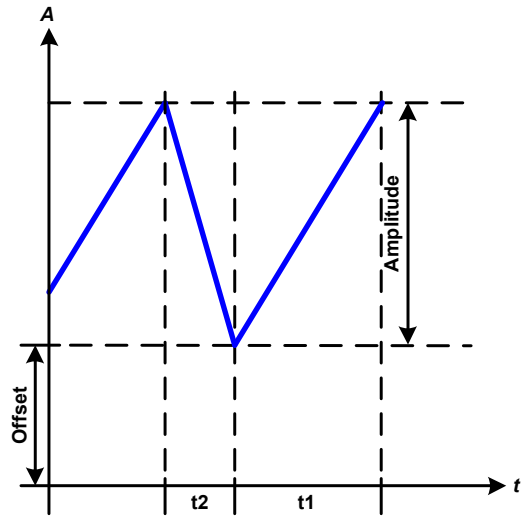
Schematic diagram:



Application and result:

A triangular wave signal for input current (direct) or input voltage (indirect) is generated. The positive and negative slope times are variable and can be set independently.

The offset shifts the signal on the Y-axis.

The sum of the intervals t1 and t2 gives the cycle time and its reciprocal is the frequency.

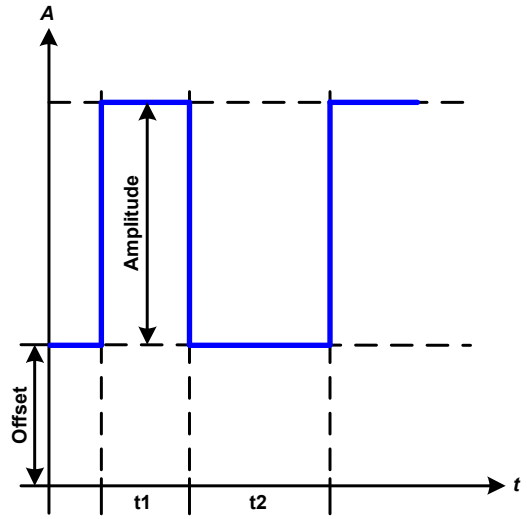
Example: a frequency of 10Hz is required and would lead to periodic duration of 100ms. This 100ms can be freely allocated to t1 and t2, e.g. 50ms:50ms (isosceles triangle) or 99.9ms:0.1ms (right-angled triangle or sawtooth).

3.8.7 Rectangular function

The following parameters can be configured for a rectangular wave function:

Value	Range	Description
I(A), U(A)	0...(Nominal value - (Off)) of U, I	A = Amplitude of the signal to be generated
I(Off), U(Off)	0...(Nominal value - (A)) of U, I	Off = Offset, based on the foot of the rectangular wave
t1	0.1ms...36000s	Time (pulse) of the top value (amplitude) of the rectangular wave.
t2	0.1ms...36000s	Time (pause) of the base value (offset) of the rectangular wave.

Schematic diagram:



Application and result:

A rectangular or square wave signal for input current (direct) or input voltage (indirect) is generated. The intervals t1 and t2 define how long the value of the amplitude (pulse) and how long the value of the offset (pause) are effective.

The offset shifts the signal on the Y-axis

With the intervals t1 and t2 the pulse-pause relationship (duty cycle) can be defined. The sum of t1 and t2 gives the cycle time and its reciprocal is the frequency.

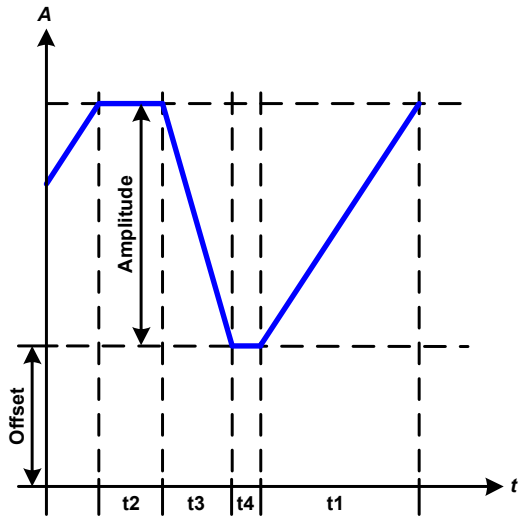
Example: a rectangular wave signal of 25Hz and a duty cycle of 80% are required. The sum of t1 and t2, the period, is 1/25Hz = 40ms. For a duty cycle of 80% the pulse time (t1) is 40ms*0.8 = 32ms and the pause time (t2) is 8ms

3.8.8 Trapezoidal function

The following parameters can be configured for a trapezoidal curve function:

Value	Range	Description
I(A), U(A)	0...(Nominal value - (Off)) of U, I	A = Amplitude of the signal to be generated
I(Off), U(Off)	0...(Nominal value - (A)) of U, I	Off = Offset, based on the foot of the trapezium
t1	0.1ms...36000s	Time for the negative slope of the trapezoidal wave signal
t2	0.1ms...36000s	Time for the top value of the trapezoidal wave signal
t3	0.1ms...36000s	Time for the negative slope of the trapezoidal wave signal
t4	0.1ms...36000s	Time for the base value (offset) of the trapezoidal wave signal

Schematic diagram:



Application and result:

Here a trapezoidal signal can be applied to a set value of U or I. The slopes of the trapezium can be different by setting different times for gain and decay.

The periodic duration and repeat frequency are the result of four time elements. With suitable settings the trapezium can be deformed to a triangular or rectangular wave. It has, therefore, universal use.

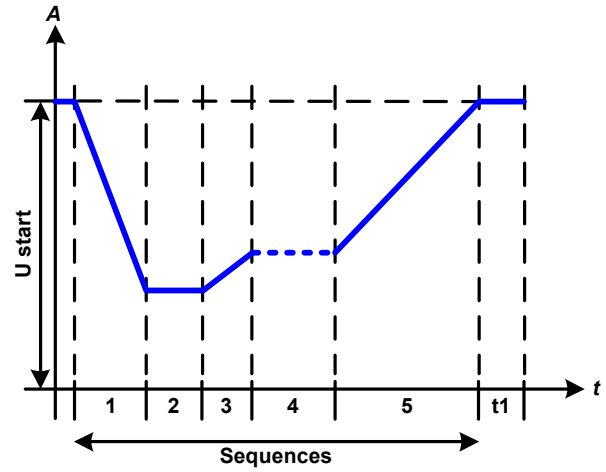
3.8.9 DIN 40839 function

This function is based on the curve defined in DIN 40839 / EN ISO 7637 (test impulse 4), and is only applicable to voltage. It shall replicate the progress of automobile battery voltage during engine starting. The curve is divided into 5 sequences (see diagram below) which each have the same parameters. The standard values from the DIN are set already as default values for the five sequences.

The following parameters can be configured for the DIN40839 function:

Value	Range	Seq	Description
Ustart	0...Nominal value of U	1-5	Start voltage of the ramp
Uend	0...Nominal value of U	1-5	End voltage of the ramp
Seq.time	0.1ms...36000s	1-5	Time of the ramp
Seq.cycles	∞ or 1...999	-	Number of repetitions of the entire curve
Time t1	0.1ms...36000s	-	Time after cycle before repetition (cycle <> 1)

Schematic diagram:



Application and result:

The function is not suitable for standalone operation of an electronic load, but optimal for an electronic load in conjunction with a compatible power supply, e.g. from the PS 9000 3U series, which is controlled by the load via Share Bus (see power supply device manual and *„3.9.3. Two quadrant operation (2QO)“*). The load acts as a sink for the rapid fall of the output voltage of the power supply enabling the output voltage progress to follow the DIN curve.

The curve conforms to test impulse 4 of the DIN. With suitable settings, other test impulses can be simulated. If the curve in sequence 4 should be a sine wave, then these 5 sequences have to be transferred to the arbitrary generator.

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3.8.10 Arbitrary function

The arbitrary (freely definable) function offers the user further scope. Up to 100 sequences are available for use for current I and voltage U, all of which have the same parameters but which can be differently configured so that a complex function process can be built up. The 100 sequences can run one after another in a sequence block, and this sequence block can then be repeated many times or endlessly. From the 100 sequences a block can be freely defined to run from sequence x to sequence y. A mix of assignment to current I or voltage U is not possible; a sequence or sequence block acts only on current or voltage.

The arbitrary curve overlays a linear progression (DC) with a sine curve (AC), whose amplitude and frequency are shaped between start and end values. If the start frequency (Fs) = end frequency (Fe) = 0Hz the AC values have no impact and only the DC part is effective. Each sequence is allocated a sequence time in which the AC/DC curve from start to finish will be generated.

The following parameters can be configured for each sequence in the arbitrary function (the table lists parameters for current, for voltage it would be Us, Ue etc.)

Value	Range	Seq.	Description
Is(AC)	0...50% Nominal value I	1-100	Start amplitude of the sine wave part of the curve (AC)
Ie(AC)	0...50% Nominal value I	1-100	End amplitude of the sine wave part of the curve (AC)
fs(1/T)	0Hz...1000Hz	1-100	Start frequency of the sine wave part of the curve (AC)
fe(1/T)	0Hz...1000Hz	1-100	End frequency of the sine wave part of the curve (AC)
Angle	0°...359°	1-100	Start angle of the sine wave part of the curve (AC)
Is(DC)	Is(AC)...(Nominal value - Is(AC)) of I	1-100	Start value of the DC part of the curve
Ie(DC)	Ie(AC)...(Nominal value - Ie(AC)) of I	1-100	End value of the DC part of the curve
Seq.time	0.1ms...36000s	1-100	Time for the selected sequence

The sequence time (seq. time) and the start and end frequency are related. The minimum value for Δf/s is 9.3. Thus, for example, a setting of fs = 1Hz, fe = 11Hz and Seq.time = 5s would not be accepted as Δf/s is only 2. A seq. time of 1s would be accepted, or, if the time remains at 5s, then fe = 51Hz must be set.

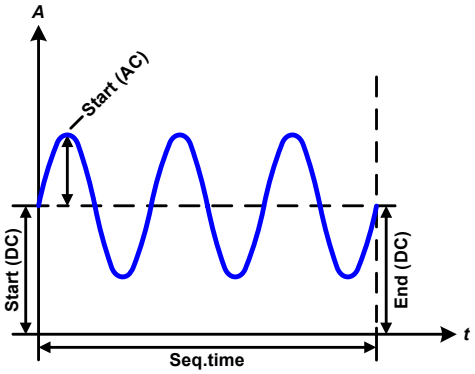
The amplitude change between start and end is related to the sequence time. A minimal change over an extended time is not possible and in such a case the device will report an inapplicable setting.

After the settings for the selected sequence are accepted with SAVE, further sequences can be configured. If the button NEXT is touched a second settings screen appears in which global settings for all 100 sequences are displayed.

The following parameters can be set for the total run of an arbitrary function:

Value	Range	Description
Startseq.	1...Endseq.	First sequence in the sequence block
Endseq.	100...Startseq.	Last sequence in the sequence block
Seq. Cycles	∞ oder 1...999	Number of cycles of the sequence block.

Schematic diagram:



Applications and results:

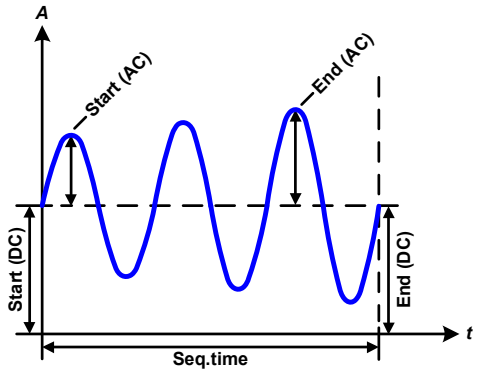
Example 1

Focussing 1 cycle of 1 sequence from 100

DC values for start and end are the same, also the AC amplitude. With a frequency >0 a sine wave progression of the set value is generated with a defined amplitude, frequency and Y-shift (offset, DC value at start and end)

The number of sine waves per cycle depend on the sequence time and the frequency. If the sequence time were 1s and the frequency 1Hz, there would be exactly 1 sine wave. If the time were 0.5s at the same frequency, there would only be a half sine wave.

Schematic diagram:

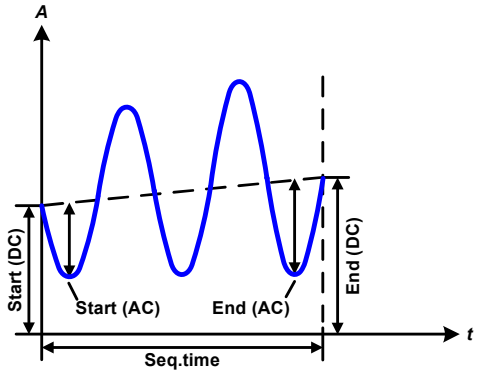


Applications and results:

Example 2

Focussing 1 cycle of 1 sequence from 100:

The DC values at start and end are the same but the AC (amplitude) not. The end value is higher than the start so that the amplitude increases with each new half sine wave continuously through the sequence. This, of course, only if the sequence time and frequency allow for multiple waves to be created. e.g. for f=1Hz and Seq. time = 3s, three complete waves would be generated (for angle = 0°) and reciprocally the same for f=3s and Seq. time=1s.

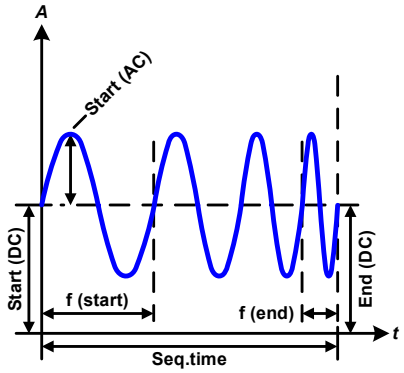


Example 3

Focussing 1 cycle of 1 sequence from 100:

The DC values at start and end are unequal, as are also the AC values. In both cases the end value is higher than the start so that the offset increases from start to end (DC) and the amplitude also with each new half sine wave.

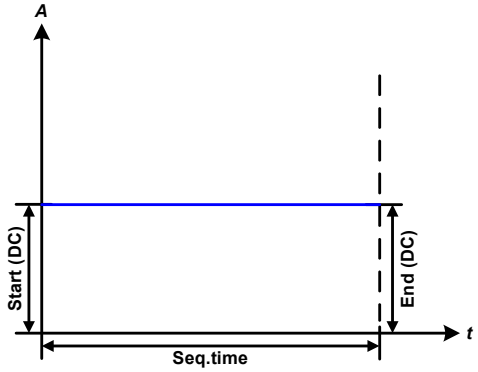
Additionally the first sine wave starts with a negative half wave because the angle is set at 180°. The start angle can be shifted at will in 1° steps between 0° and 359°.



Example 4

Focussing 1 cycle of 1 sequence from 100:

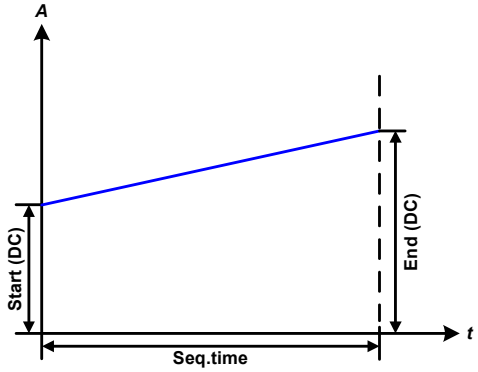
Similar to example 1 but with another end frequency. Here this is shown as higher than the start frequency. This impacts the period of the sine waves such that each new wave will be shorter over the total span of the sequence time.



Example 5

Focussing 1 cycle of 1 sequence from 100:

Similar to example 1 but with a start and end frequency of 0Hz. Without a frequency no sine wave part (AC) will be created and only the DC settings will be effective. A ramp with a horizontal progression is generated.



Example 6

Focussing 1 cycle of 1 sequence from 100:

Similar to example 1 but with a start and end frequency of 0Hz. Without a frequency no sine wave part (AC) will be created and only the DC settings will be effective. Here start and end values are unequal and a steadily increasing ramp is generated.

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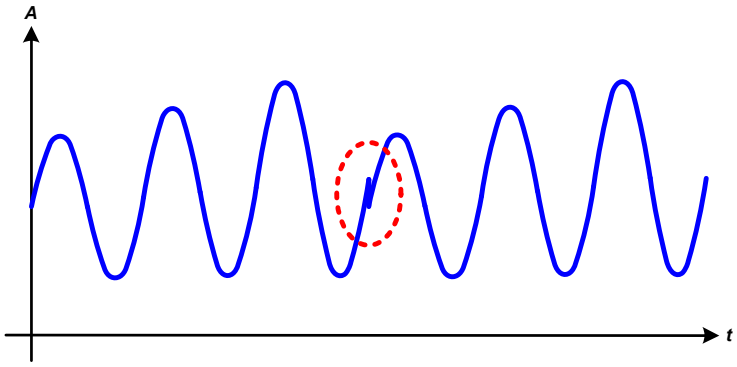
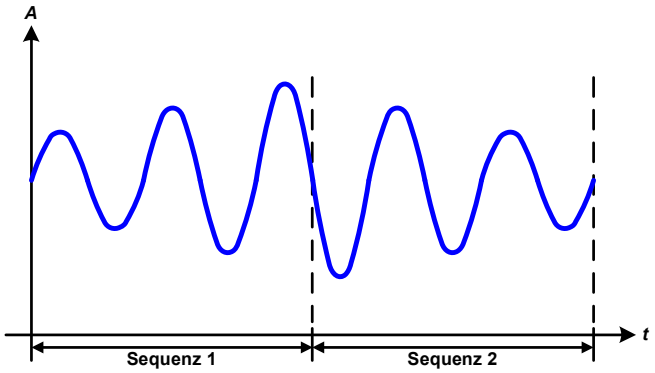
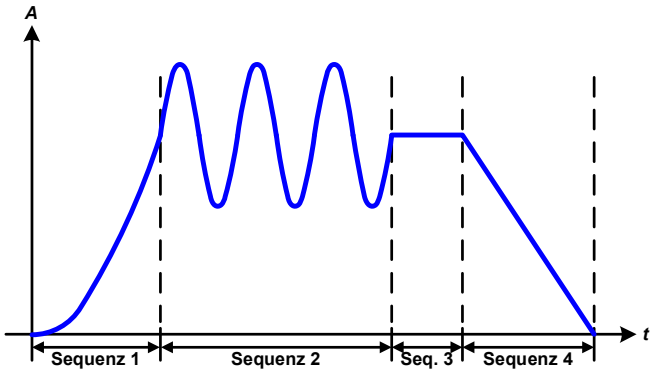
By linking together a number of differently configured sequences, complex progressions can be created. Smart configuration of the arbitrary generator can be used to match triangular, sine, rectangular or trapezoidal wave functions and thus, e.g. a sequence of rectangular waves with differing amplitudes or duty cycles could be produced.

Assignment to either U or I makes up to 100 sequences available for either current or voltage but not a mix. That means that a sequence X which produces a ramp up on current cannot be followed by sequence Y which applies a sine wave to the voltage.

Schematic diagrams:







Applications and results:

Example 7

Focussing 1 cycle of 2 sequences from 100:

A sequence configured as in example 3 is run. As the settings demand that the end offset (DC) is higher than the start, the second sequence run will revert to the same start level as the first, regardless of the values achieved at the end of the first run. This can produce a discontinuity in the total progression (marked in red) which may only be compensated with careful choice of settings.

Example 8

Focussing 1 cycle of 2 sequences from 100:

Two sequences run consecutively. The first generates a sine wave with increasing amplitude, the second with a decreasing amplitude. Together they produce a progression as shown left. In order to ensure that the maximum wave in the middle occurs only once, the first sequence must end with a positive half wave and the second start with a negative half wave as shown in the diagram..

Example 9

Focussing 1 cycle of 4 sequences from 100:

Sequence 1: 1/4th of sine wave (angle = 270°)

Sequence 2: 3 Sine waves (relationship frequency to sequence time: 1:3)

Sequence 3: Horizontal ramp (f = 0)

Sequence 4: Falling ramp (f = 0)

3.8.10.1 Loading and saving the arbitrary function

The 100 sequences of the arbitrary function, which can be manually configured with the control panel of the device and which are applicable either to voltage (U) or current (I), can be saved to or loaded from a common USB flash drive via the front side USB port. Generally, all 100 sequences are saved or loaded using a text file of type CSV (semicolon separator), which represents a table of values.

In order to load a sequence table for the arbitrary generator, following requirements have to be met:

- The table must contain exactly 100 rows with 8 subsequent values (8 columns, separated by semicolons) and must not have gaps
- The files must be stored inside a folder called HMI_FILES which has to be in the root of the USB drive
- The file name must always start with WAVE_U or WAVE_I (not case-sensitive)
- Values with decimal places must use the comma as decimal separator
- 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 table, related to the manual configuration of the arbitrary generator (column headers like in Excel):

Column	Parameter	Range
A	AC Start	0...50% U or I
B	AC End	0...50% U or I
C	Frequency Start	0...1000Hz
D	Frequency End	0...1000Hz
E	Start angle AC	0...359°
F	DC Start	0...(Nominal value of U or I) - AC Start
G	DC End	0...(Nominal value of U or I) - AC End
H	Time in µs	100...36.000.000.000 (36 billion µs)

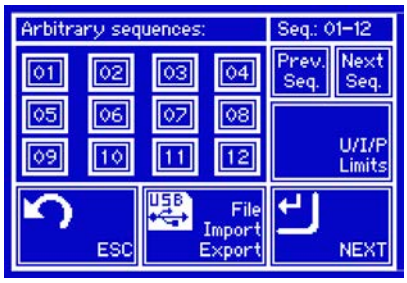
For details about the parameter and the arbitrary function refer to *„3.8.10. Arbitrary function“.*

Example CSV:

	A	B	C	D	E	F	G	H
1	20,00	30,00	5	5	90	50,00	50,00	50000000
2	30,00	20,00	5	5	90	50,00	50,00	30000000
3	0,00	0,00	0	0	0	0,00	0,00	1000
4	0,00	0,00	0	0	0	0,00	0,00	1000
5	0,00	0,00	0	0	0	0,00	0,00	1000
6	0,00	0,00	0	0	0	0,00	0,00	1000

The example shows that only the first two sequences are configured, while all others are set to default values. The table could be loaded as WAVE_U or WAVE_I when using, for example, the model ELR 9080-170, because the values would fit both, voltage and current. The file naming, however, is unique. A filter prevents you from loading a WAVE_I file after you have selected “Arbitrary --> U” in the function generator menu. The file would not be listed as selectable at all.

► How to load a sequence table (100 sequences) from a USB flash drive:



3. Do not plug the USB drive yet or remove it.
4. Access the function selection menu of the function generator with MENU -> Function Generator -> Arbitrary.
5. Tap touch area 

, then 

and follow the instructions on screen. If at least one valid files has been recognized (for file and path naming see above), the device will show a list of files to select from with ☑.
6. Tap touch area 

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.

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► **How to save a sequence table (100 sequences) to a USB flash drive:**

1. Do not plug the USB flash drive yet or remove it.
2. Access the function selection menu of the function generator via MENU -> Function Generator -> Arbitrary
3. Tap on 

, then 

. The device will request you to plug the USB flash drive now.
4. After plugging it, the device will try to access the flash drive and find the folder HMI_FILES and read the content. If there are already WAVE_U or WAVE_I files present, they will be listed and you can either select one for overwriting with , otherwise select -NEW FILE- for a new file.
5. Finally save the sequence table with 

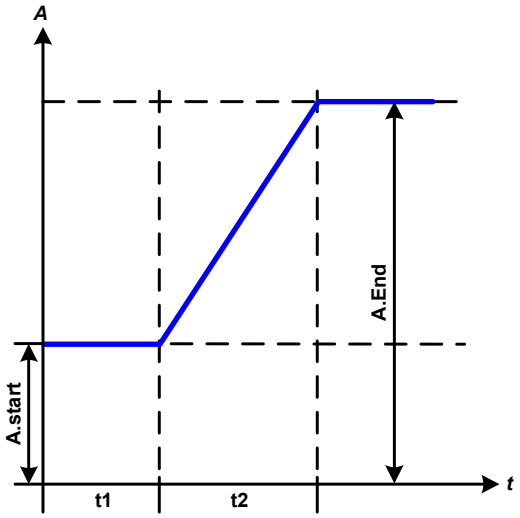
.

3.8.11 Ramp Function

The following parameters can be configured for a ramp function.

Value	Range	Description
Ustart / Istart	0...Nominal value of U, I	Start value (U,I)
Uend / Iend	0...Nominal value of U, I	End value (U, I)
t1	0.1ms...36000s	Time before ramp-up or ramp-down of the signal.
t2	0.1ms...36000s	Ramp-up or ramp-down time

Schematic diagram:



Application and result:

This function generates a rising or falling ramp between start and end values over the time t2. Time t1 creates a delay before the ramp starts.

The function runs once and stops at the end value.

Important to consider are the static values of U and I which define the start levels at the beginning of the ramp. It is recommended that these values are set equal to those in A.start, unless the load at the DC output should not be provided with voltage before the start of the ramp. In that case the static values should be set to zero.

3.8.12 UI and IU table functions (XY table)

The UI and IU functions offer the user the possibility to set a DC input current dependant on the DC input voltage, or a DC input voltage dependant on the DC input current. The function is table driven with exactly 4096 values, which are distributed over the whole measured range of actual input voltage or input current in the range of 0...125% Unom or Inom. The table can either be uploaded from a USB flash drive through the front side USB port of the device or via remote control (ModBus protocol or SCPI). The functions are:

UI function: U = f(I)

IU function: I = f(U)

In the **UI function**, the equipment measuring circuit determines the level from 0 to maximum of the input current. For each of the 4096 possible values for input current a voltage value is maintained by the user in the UI table which can be any value between 0 and nominal value. The values uploaded from a USB flash drive will always be interpreted as voltage values even if the user calculated them as current values and incorrectly loaded them as a UI table.

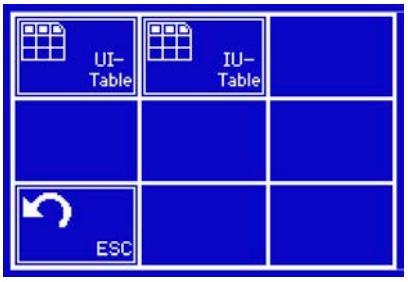
In the **IU function** the assignment of the values is the other way round, the behaviour, however, the same.

Thus the behaviour of the load or the current and power consumption can be controlled with dependance on input voltage and step changes can be created.

Uploading of a table from a USB flash drive must use text files in CSV format (.csv). Plausibility is checked on loading (values not too high, number of values correct),and possible errors reported in which case the table will not be loaded.

The 4096 values in the table are only checked for size and count. If all the values were to be graphically plotted a curve would be created which could include significant step changes in current or voltage. That could lead to complications in the loading of the source if, e.g., the internal voltage measurement in the electronic load swings slightly so that the load jumps backwards and forwards between two values in the table, which, in the worst case, could be 0A and the maximum current.

3.8.12.1 Loading UI and IU tables from USB drive



The so-called UI / IU function generator requires to load tables from a common FAT32 formatted USB drive via the front side USB port. The files are required to have a certain format and to meet following specifications:

- The files names must always begin with IU or UI (not case-sensitive), depending on the target function you want to load the table to
- The file must be a text file of type Excel CSV (semicolon as separator) and must only contain one column with exactly 4096 values without gaps
- Values with decimal places must use the comma as decimal separator
- None of values may exceed the related maximum value of the device. For example if you have a 80V model you are going to load the table for the UI function, it is assumed that all the values in the table are for voltage and thus must not be bigger than 80 (the adjustment limits of the device are not in effect here)
- The files must be stored inside a folder called HMI_FILES with has to be in the root of the USB drive

If the file naming, path and file content specifications are not met, the file is either not recognized at all or rejected. So it is, for example, impossible to load a UI table (file name starts with UI) for the IU function and vice versa. The USB drive may contain multiple files of which up to 10 are listed as a selection before loading.

► How to load a UI or IU table from USB flash drive:

1. Do not plug the USB drive yet or remove it.
2. Access the function selection menu of the function generator with MENU -> Function Generator -> XY Table. In the next screen, either select “UI Table” or “IU Table”.
3. In the next screen you may also configure additional limits for U, I and P.
4. Tap on touch are 

and plug the USB drive when upon request. The device will try to read the flash drive and to find compatible files, which are then listed for selection. Select the desired file.
5. In case the file is not accepted because it does not meet the specifications, the device will report an error and reject the file. Correct the file or file name and repeat the above steps.
6. Once the file/table is successfully loaded, you are requested to remove the USB drive.
7. Load the function with 

, in order to start and operate the feature as described in *„3.8.4.1. Function selection and control“.*

3.8.13 Remote control of the function generator

The function generator can be remotely controlled but configuration and control of the functions with individual commands is different from manual operation. The external documentation “Programming Guide ModBus & SCPI” explains the approach. In general the following apply:

- The function generator is not controllable via the analog interface
- The function generator is unavailable if the device is in master-slave or in R/I mode
- All functions are based on the arbitrary generator and therefore, only this is available for remote control

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3.9 Other applications

3.9.1 Parallel operation in master-slave mode (MS)

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. For true master-slave operation, the units have to be connected with their DC inputs, their master-slave bus and their Share bus. The master-slave bus is a digital bus which makes the system work as one big unit regarding adjusted values, actual values and status. The Share bus will balance the units in their internal current regulation, especially if the master unit runs a function like sine wave etc.

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

- The function generator is not available on slave units as long as MS is activated
- The MS system reacts differently to alarm situations (see below in *3.9.1.5*)
- Resistance setting and control (CR) is not available

3.9.1.1 Wiring the DC inputs

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

3.9.1.2 Wiring the Share bus

The Share bus is wired from unit to unit with an ideally twisted pair of cables with non-critical cross section. We recommend to use 0.5mm² to 1.0mm².

The Share bus is poled. Take care for correct polarity of the wiring!

A max. of 10 units can be connected via Share bus.

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

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

- Type of connection: RS485 with 115200Bd
- A maximum 10 units can be connected via the bus: 1 master and up to 9 slaves.
- Only devices of same kind, i.e. electronic load to electronic load, and of the same model, such as ELR 9080-170 to ELR 9080-170.
- Units at the end of the bus must be terminated (see below)

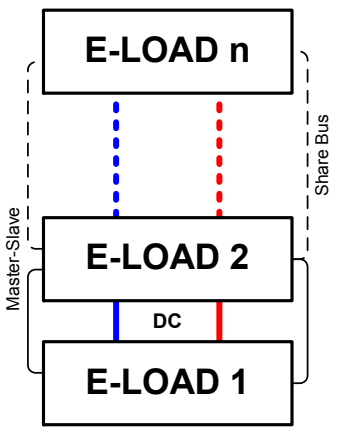
The master-slave bus (RS485) must <u>not</u> be wired using crossover cables!

Later operation of the MS system implies:

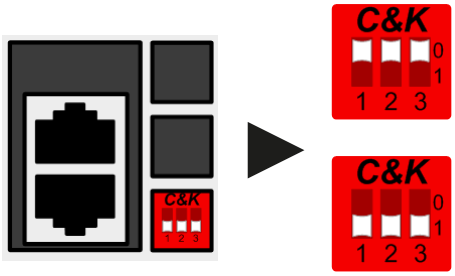
- the master unit displays, or makes available to be read by the remote controller, the sum of the actual values of all the units
- the range for setting the values of the master is adapted to the total number of units, thus, if e.g. 5 units each with a power of 7kW are connected together to a 35kW system, then the master can be set in the range 0...35kW.

► How to connect the master-slave bus

1. Switch off all units that are to be connected and connect them together with a network cable (CAT3 or better, not included). It doesn't matter which of the two master-slave connection sockets (RJ45, backside) is connected to the next unit.
2. Also connect all units at the DC side. See figure to the right.



3. The two units at the beginning and end of the chain should be terminated, if long connection cables are used. This is achieved using a 3-pole DIP switch which is positioned on the back side of the unit next to the MS connectors.



Position: not terminated (standard)

Switches 2 and 3 serve as a BIAS network and should be switched on to avoid undefined bus noise.

Position: terminated

Switch 1 enables the bus termination resistor, switches 2 and 3 enable additional BIAS resistors

Now the master-slave system must be configured on each unit. It is recommended to configure first all the slave units and then the master unit. If it is done the other way around, or slaves are added later, the master must be re-initialised so that it recognizes all the slaves and sets itself up accordingly.

► Step 1: Configuring all slave units

1. Enter MENU then GENERAL SETTINGS and press ▼ until reaching PAGE: 7.
2. Specify the unit as slave with SLAVE. This also activates master-slave mode (MS).
3. Set the address of the slave between 1 and 9 with the left hand rotary knob. Ensure that no address is allocated twice.
4. Accept the settings with the touch area ENTER and return to the main page. The slave unit is now configured.

► Step 2: Configuring the master unit

1. Enter MENU then GENERAL SETTINGS and press ▼ until reaching PAGE 7.
2. Specify the unit as master with MASTER. This also activates master-slave mode (MS).
3. Accept the settings with the touch area ENTER and return to the main page.

► Step 3: Initialising the master

The master unit and the whole master-slave system still need to be initialised. In the main screen of the master unit, after quitting the setting menus, a pop-up will appear:



The master unit has automtically started a search for slave units on the MS bus, in order to initialise them and to configure itself for set and actual values according to the number of detected units. If one or multiple slaves are found then this screen will show the number of slaves, the device addresses of the detected slave and the total current, total voltage and total power of the MS system.

If no slaves were found or the expected number of slaves is not displayed, then the settings of all the slaves and the master, together with the cabling have to be checked and the setup process repeated with Initialize button.

The initialisation process of the master-slave system will, as long as MS mode is activated, be repeated each time the units are powered on.

Initialisation can be repeated at any time via MENU / GENERAL SETTINGS / PAGE 8.

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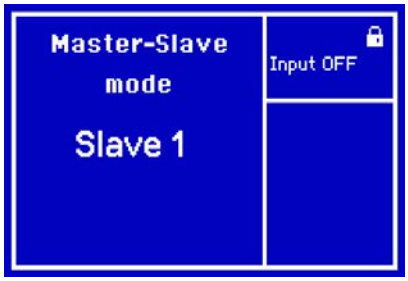
3.9.1.4 Operating the master-slave system

After successful configuration and initialisation of the master and slave units, these will show their status in the displays. While the master merely shows “Master” in the status area, the slave(s) will continuously show like this, as long they are in remote control by the master:



The slaves can no longer be controlled manually or remotely, neither via the analog nor via digital interfaces. They can, if needed, be monitored by reading actual values and status.

The display on the master unit changes after initialisation and all set values are reset. The master now displays the set and actual values of the total system. Depending on the number of units, the total current and power will multiply. The following applies:

- The master can be treated as a standalone unit
- The master shares the set values across the slaves and controls them
- The master is remotely controllable via the analog or digital interfaces
- All settings for the set values U,I and P (monitoring, settings limits etc.) will be adapted to the new total values
- All initialised slave will reset any limits (Umin, Imax etc.), supervision thresholds (OVP, OPP etc.) and event settings (UCD, OVD etc.) to default values, so these don’t interfere the control by the master

> *In order to easily restore all these settings after leaving MS operation, it is recommended to make use of the user profiles (see „3.7. Loading and saving a user profile“)*

- If one or more slaves report an device alarm, this will be displayed on the master and must be acknowledged there so that the slave(s) can continue operation. If the alarm had caused the DC input to be switched off then this will be reinstated automatically by the master unit once the alarm has been acknowledged

3.9.1.5 Alarms and other problem situations

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

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

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

- Any alarm of a slave is indicated on the slave’s display and on the master’s display
- If multiple alarms happen simultaneously, the master only indicates the most recent one. In this case, the particular alarms can be read from the slave units displays. This also applies for remote control or remote supervision, because the master can only report the most recent alarm.

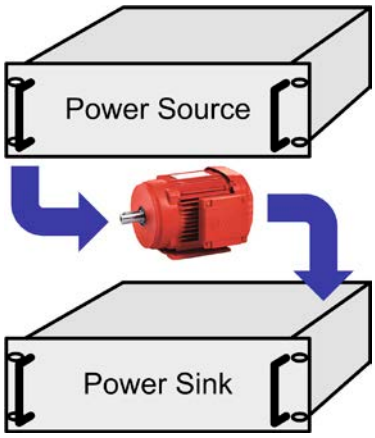
3.9.2 Series connection

Series connection is not a permissible operating method for electronic loads and must not be installed or operated under no circumstances!

3.9.3 Two quadrant operation (2QO)

3.9.3.1 Introduction

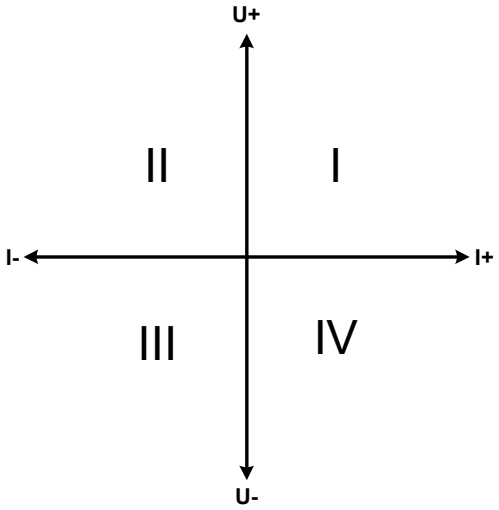
This kind of operation refers to the use of a source, in this case a power supply from a compatible series (see section *„1.10.10. "Share" connector"*) and a sink, in this case a series ELR 9000 electronic load. The source and the sink function alternately in order to test a device, such as a battery, by deliberate charging and discharging as part of a functional or final test.



The user can decide either to operate the system manually or only the power supply device as the driving unit or to control both devices by PC. We recommend to focous on the power supply, which is intended to control the load's behaviour regarding voltage and current via the Share Bus connection.

Two quadrant operation is only suitable for constant voltage operation (CV).

Clarification:



A combination of source and sink can only map the quadrants I + II. This means that only positive voltages are possible. The positive current is generated by the source or application and the negative current flows into the load.

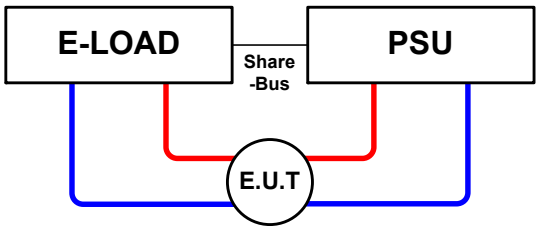
The maximum approved limits for the application should be set in the power supply. This can be done via the interface. The electronic load should preferably be in operating mode CV. The load will then, using the Share Bus, control the output voltage of the power supply.

Typical applications:

- Fuel cells
- Capacitor tests
- Motor driven applications
- Electronic tests where a high dynamic discharge is required.

3.9.3.2 Connecting devices to a 2QO

There are a number of possibilities to connect source(s) and sink(s) to make a 2QO:

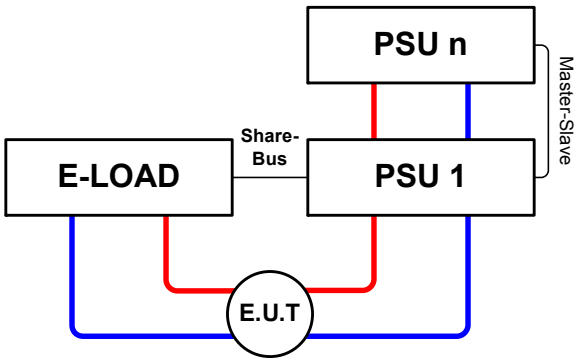


Configuration A:

1x e-load and 1x power supply, plus 1x test object (E.U.T).

This is the most common configuration and the least problematic.

The nominal values for U,I and P of the two devices should match, such as ELR 9080-170 und PSI 9080-170 3U.



Configuration B:

1x e-load and multiple power supplies, plus 1x test object (E.U.T).

For adapting the total power of the source to the possibly higher input power of the load, the power supplies are connected via Master-Slave and the load current is shared across the power supplies. Additionally, the Share bus between the PSU units can be wired.

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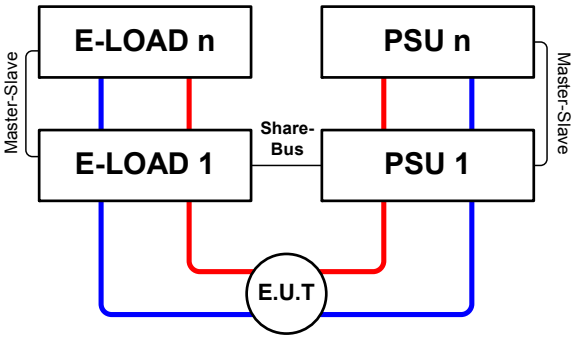

Configuration C:

Multiple e-loads and Multiple power supplies, plus 1 test object (E.U.T), for increased total performance.

The combination of load units and power supply units each create a block, a system with certain power. Here it is also necessary to match the nominal values of the two systems., i.e an 80V DC input of the loads to a max. 80V DC output of the power supplies.

In case the Share bus is additionally wired, the max. number of 10 units on the Share bus can not be exceeded. Furthermore, for the master load in the system of loads, the setting “Share bus mode” has to be set to “Slave”.

3.9.3.3 Settings on the devices

Regarding the general 2QO operation, there no special settings. Just the parameter “Share Bus mode” (see *3.3.3.1*) needs to be set to SLAVE on the load unit, in case it is not. On the power supply you need to set this parameter to MASTER, unless it is already the master unit of a master-slave system. Refer to the documentation of the power supply for further information.

For safety of the connected E.U.T / D.U.T and to prevent damage, we recommend to adjust supervision thresholds like OVP, OCP or OPP, which will switch off the DC output/input of the source and/or sink in case of excess.

3.9.3.4 Application example

Charging and discharging a battery, 24V/400Ah, using the wiring example in configuration A.

- Power supply PSI 9080-170 3U set to: Imax = 50A, Pmax = 5000W
- Electronic load ELR 9080-170 set to: Imax = 100A, Pmax = 3500W, U = 0V or any other minimum value to which the battery is allowed to be discharged to
- Assumption: battery has a voltage of 26V at test start

1. Discharging the battery to 24V

Requirements: Voltage on the power supply set to 24V, DC output of power supply and DC input of load activated

Reaction: the e-load will load the battery with a maximum of 100A in order to discharge it to 24V. The power supplies no current at this moment, because the battery voltage is still higher than what is adjusted on the power supply. The load will gradually reduce the input current in order to maintain the battery voltage at 24V. Once the battery voltage has reached 24V with a discharge current of approx. 0A, the voltage will be maintained at this level by charging from the power supply.

2. Charging the battery to 27V

Requirements: Voltage on the power supply set to 27V

Reaction: the power supply will charge the battery with a maximum current of 50A, which will gradually reduce with increasing voltage as a reaction to the changing internal resistance of the battery. The load absorbs no current at this charging phase, because it is controlled via the Share bus to set 27V, which is still higher than the actual battery voltage. When reaching 27V, the power supply will deliver only the current needed to maintain battery voltage.

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

- the supplier has been contacted and it 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.
- optional extras such as an AnyBus interface module is included if this is in any way connected to the problem.
- a fault description in as much detail as possible is attached.
- if shipping destination is abroad, the necessary customs papers are attached.

4.2.1 Replacing a defect mains fuse

The device is protected by up to six 6,3x32mm fusible cut-outs (T16A, 500V, ceramic) inside the device. To replace these the device must be opened. Inside are 1.3 power modules in black plastic housings, each of which holds two of the fuses.



Opening the device and replacing the fuses may only be carried out by technically trained persons!

Tools required: Torx 10 screwdriver, flat screwdriver ca.5mm, multimeter

► Step 1: Opening the device

1. Switch off at the mains switch and remove plug. Disconnect or switch off DC source and wait until the DC voltage has sunk to zero.
2. Remove the top cover of the device (5 screws at the back, 3 on the front, 4 on each side, all Torx 10)
3. Remove the plastic cover(s) of the power modules.

► Step 2: Replacing a defect fuse.

1. As it is not usually known which fuse is defect, they should all be checked. The fuses are on the front side wall (looking from the front of the device) of the power modules and are covered with a soft plastic cap.
2. Remove the soft plastic cap from the fuse to be tested and carefully prise out the fuse with a flat screwdriver.
3. Check whether the fuse is intact with a multimeter, and if defective, replace with a similar type (size, values, lag)
4. Repeat step 2 for all fuses.

Once all fuses have been checked and replaced, and if no other defect is apparent, the device can be reassembled (step 1 in reverse order).

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4.3 Firmware updates

4.3.1 HMI update

The control panel (HMI) can be updated via the front or back USB ports, whereby the back USB port requires a PC with suitable software and the front USB needs only a FAT32 formatted USB stick with the update file. Hence the latter option is much simpler.

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

► How to update the control panel firmware:

1. If not already available, obtain a USB flash drive (capacity up to 32GB) and ensure that it is formatted as FAT32.
2. Create a folder with the name HMI_FILES (case sensitive!) in the root directory of the flash drive and copy the firmware update file to this folder. The file name must follow the begin with “update_hmi” (example: update_hmi_v100.bin) or with a number (example: 96230058_FW-BE1_V201.bin).
3. Tap the touch area MENU, then HMI SETTINGS, then HMI UPDATE and confirm the security question with ENTER. The HMI will then read and list the contents of the HMI_FILES folder.
4. Select and tick the update file to be used and tap the touch area LOAD FROM USB. The control panel will then be updated.
5. Switch the equipment off, wait until it is completely out, then switch back on.

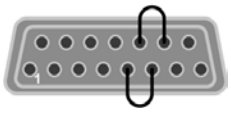
4.3.2 Device firmware update

The firmware of the device, if necessary, is updated via the backside USB port. For this a software tool, a so-called “update tool” is needed which is available from the manufacturer (as download from the manufacturer’s website or upon request), together with the firmware update. The update tool guides the user through the update process.

In case the update tool is not available, or if the update somehow went wrong and the device will not work correctly, there is an alternative procedure. Required tools: 1x Sub-D plug 15-pole, some wire, solder iron, update file (*.bin).

► How to manually update the device firmware:

1. Power off device. If not already available, prepare the 15 pole D-Sub plug like this (figure shows backside):



Bridge between pin 5 and 6

Bridge between pin 13 and 14

2. Plug the Sub-D onto the analog interface socket and connect the (included) USB-B cable between the USB port on the rear and the PC. Switch device on by mains switch.
3. The PC should mount a new removable drive named “EA UPDATE”, for example with driver lett G:. If not, wait some time and repeat steps 1 and 2.
4. Open that new drive in Windows Explorer (or similar). It should contain one file “firmware.bin”. Delete the file.
5. Copy the new firmware file, which always has to be with extension *.bin, to that drive. Wait for the copy procedure to finish.
6. Switch the device off and remove the Sub-D plug from the analog interface socket.
7. Restart the device by switching it on - the display shows some information during the startup process, amongst them the new device firmware version as for example “KE: 2.01”.

The firmware update is finished then.

4.4 Calibration

4.4.1 Preface

The devices of series ELR 9000 feature a function to re-adjust the most important input values when doing a calibration and in case these values have moved out of tolerance. The re-adjustment is limited to compensate small differences of up to 1% or 2% of the max. value. There are several reasons which could make it necessary to re-adjust a unit: component aging, component deterioration, extreme ambient conditions, high frequent use

In order to determine if a value is out of tolerance, the parameter must be verified first with measurement tools of high accuracy and with at least half the error of the ELR device. Only then a comparison between values displayed on the ELR device and true DC input values is possible.

For example, if you want to verify and possibly re-adjust the input current of model ELR 9080-510 which has 510A maximum current, stated with a max. error of 0.4%, you can only do that by using a high current shunt with max. 0.2% error or less. Also, when measuring such high currents, it is recommended to keep the process short, in order to avoid the shunt heating up too much. It is furthermore recommended to use a shunt with at least 25% reserve.

When measuring the current with a shunt, the measurement error of the multimeter on the shunt adds to the error of the shunt and the sum of both must not exceed the given max. 0.4% of the device.

4.4.2 Preparation

For a successful calibration and re-adjustment, a few tools and certain ambient conditions are required:

- A measurement device (multimeter) for voltage, with a max. error of half the ELR's voltage error. That measurement device can also be used to measure the shunt voltage when re-adjusting the current
- If the current is also going to be calibrated: a suitable DC current shunt, ideally specified for at least 1.25 times the max. input current of the ELR and with a max. error that is half or less than the max. current error of the ELR device
- Normal ambient temperature of approx. 20-25°C
- Warmed up ELR unit, which has been run for at least 10 minutes under 50% power
- An adjustable voltage & current source which is capable of providing at least 102% of the max. voltage and current of the ELR device, or separate voltage source and current source units

Before you can start calibrating, a few measures have to be taken:

- Let the ELR device warm up in connection with the voltage / current source
- In case the remote sensing input is going to be calibrated, prepare a cable for the remote sensing connector to DC input, but leave it yet unconnected
- Abort any form of remote control, deactivate master-slave mode, set device to **U/I** mode
- Install the shunt between source and ELR device and make sure the shunt is cooled somehow. For example , you might want to place it in the warm air stream coming out of the rear of the ELR device. This helps the shunt to warm up as well to operation temperature
- Connect external measurement device to the DC input or to the shunt, depending on whether the voltage is going to be calibrated first or the current

4.4.3 Calibration procedure

After the preparation, the device is ready to be calibrated. From now on, a certain sequence of parameter calibration is important. Generally, you don't need to calibrate all three parameters, but it is recommended to do so.

Important:



The input current calibration should be done before any voltage calibration, because the calibrated input current is used for voltage calibration.
When calibrating the input voltage, the remote input sense on the rear of the device has to be disconnected.

The calibration procedure, as explained below, is an example with model ELR 9080-170. Other models are treated the same way, with values according to the particular ELR model and the required power source.

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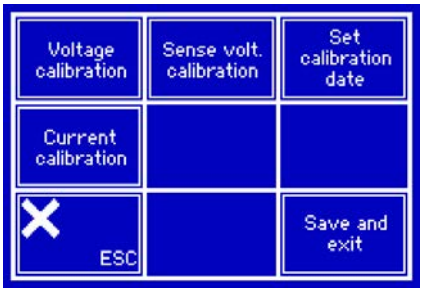
► How to calibrate the voltage



1. Adjust the connected voltage source to approx. 102% of the maximum voltage specified for the ELR device. For the example with an 80V ELR this would be 81.6V for the source. Set the current limitation of the voltage source to 5% of the nominal current specified for ELR device, for this example it is 8.5A. Check again, that for voltage calibration, the sensing connector on the rear of the device is not connected.
2. In the display, tap MENU, then „**General Settings**“, then go to **Page 5** and then tap **START**.
3. In the next screen select: **Voltage calibration**. The load will switch the DC input on and start to measure the input voltage (**U-mon**).
4. The next screen requests you to enter the measured input voltage at **Measured data=** from the multimeter. Enter it using the keypad, that appears when tapping the value. Assure yourself the value is correct and submit with **ENTER**.
5. Repeat step 4. for the next three steps (total of four steps).

If the externally measured value is somehow too different from the internally measured value (**U-mon**), then the calibration procedure will fail and the parameter can not be readjusted by the user. The same will happen when trying to calibrate the voltage at an input value other than 100%.

► How to calibrate the current

1. Adjust the current source to approx. 102% nominal current of the ELR device, for the sample model with 170A this would be 173.4A, rounded to 174A. Make sure the source can provide more current than the ELR can draw, else the sources's voltage will collapse. Set the output voltage of the current source to 10% of the nominal voltage specified for ELR, in the example 8V, and switch the DC output of the source on.
2. In the display, tap MENU, then „**General Settings**“, then go to **Page 5** and then tap **START**.
3. In the next screen select: **Current calibration**. The load will switch on the DC input and start to measure (**I-mon**).
4. The next screen requests you to enter the input current **Measured data=** measured with the shunt. Enter it using the keypad, assure yourself the value is correct and submit with **ENTER**.
5. Repeat step 4. for the next three steps (total of four steps).

If the externally measured value happens to be too different from the internally measured value (**I-mon**), then the calibration procedure will fail. The same will happen when trying to readjust the current at an input value other than 100%.

In case you are generally using the remote sensing feature (Sense), it is recommended to readjust this parameter too, for best results. The procedure is identical to the calibration of voltage, except for it requires to have the sensing connector on the rear to be plugged and connected with correct polarity to the DC input of the ELR.

► How to calibrate the remote sensing voltage

1. Adjust the connected voltage source to approx. 102% of the maximum voltage specified for the ELR device. For example with an 80V ELR this would be 81.6V for the source. Set the current limitation of the voltage source to 5% of the nominal current specified for ELR device, for this example it is 8.5A. Check again, that for voltage calibration, the sensing connector on the rear of the device is not connected.
2. In the display, tap MENU, then „**General Settings**“, then go to **Page 5** and then tap **START**.
3. In the next screen select: **Sense volt. calibration**
4. The next screen requests you to enter the measured sensing voltage **Measured data=** from the multimeter. Enter it using the keypad, that appears when tapping the value. Assure yourself the value is correct and submit with **ENTER**.
5. Repeat step 4. for the next three steps (total of four steps).

After calibration you may furthermore enter the current date as “calibration date” by tapping 

in the selection screen and enter the date in format YYYY / MM / DD.

Last but not least save the calibration data permanently by tapping 

.

Leaving the calibration selection menu without “Save and exit” will discard calibration data and the procedure would have to be repeated!

5. Accessories and options

5.1 Overview

Accessories and options are, when necessary, delivered with their own documentation and are not detailed further in this document.

6. Service & Support

6.1 General

Repairs, if not otherwise arranged between supplier and customer, will be carried out by the manufacturer. 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.

6.2 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
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