Operating Guide

PSI 9000 15U/24U
DC High Efficiency Power Supply

Elektro-Automatik

Doc ID: PSI915UEN
Revision: 05
Date: 09/2020

CE

TABLE OF CONTENTS

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 3

4 OTHER INFORMATION

5 SERVICE AND MAINTENANCE

6 CONTACT AND SUPPORT

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 4

1. General

1.1 About this document

1.1.1 Retention and use

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

1.1.2 Copyright

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

1.1.3 Validity

This manual is valid for the following equipment:

Model	Article nr.	Model	Article nr.	Model	Article nr.
PSI 9080-1020 15U	06400601	PSI 9080-2040 24U	06400613	PSI 9080-3060 24U	06400625
PSI 9200-420 15U	06400602	PSI 9200-840 24U	06400614	PSI 9200-1260 24U	06400626
PSI 9360-240 15U	06400603	PSI 9360-480 24U	06400615	PSI 9360-720 24U	06400627
PSI 9500-180 15U	06400604	PSI 9500-360 24U	06400616	PSI 9500-540 24U	06400628
PSI 9750-120 15U	06400605	PSI 9750-240 24U	06400617	PSI 9750-360 24U	06400629
PSI 91500-60 15U	06400606	PSI 91500-120 24U	06400618	PSI 91500-180 24U	06400630
PSI 9080-1530 15U	06400607	PSI 9080-2550 24U	06400619	PSI 91000-80 15U	06400631
PSI 9200-630 15U	06400608	PSI 9200-1050 24U	06400620	PSI 91000-120 15U	06400632
PSI 9360-360 15U	06400609	PSI 9360-600 24U	06400621	PSI 91000-160 24U	06400633
PSI 9500-270 15U	06400610	PSI 9500-450 24U	06400622	PSI 91000-200 24U	06400634
PSI 9750-180 15U	06400611	PSI 9750-300 24U	06400623	PSI 91000-240 24U	06400635
PSI 91500-90 15U	06400612	PSI 91500-150 24U	06400624		

1.1.4 Symbols and warnings

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

⚠	**Symbol for a life threatening danger**
⚠	Symbol for general safety notices (instructions and damage protection bans) or important information for operation
❗	*Symbol for general notices*

1.2 Warranty

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

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

1.3 Limitation of liability

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

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

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 5

1.4   Disposal of equipment

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

1.5   Product key

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

PSI 9 080 - 3060 24U

Construction: **15U / 24U** = Cabinet with 15 U or 24 U of effective height
Maximum current of the device in Ampere
Maximum voltage of the device in Volt
Series: **9** = Series 9000
Type identification: **PSI** = Power Supply Intelligent

1.6   Intended usage

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

Typical application for a power supply is DC supply to any relevant user, for a battery charger the charging of various battery types and for electronic loads the replacement of an ohmic resistor 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 won't be accepted. • All damage caused by non-intended usage is solely the responsibility of the operator.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 6

1.7 Safety

1.7.1 Safety notices

Mortal danger - Hazardous voltage

- **Electrical equipment operation means that some parts can be under dangerous voltage. Therefore all parts under voltage must be covered!**
- **All work on DC connections must be carried out under zero voltage, i.e. DC output not connected to a load and may only be performed by qualified and informed persons. Improper actions can cause fatal injury as well as serious material damage.**
- **Never touch AC cables or AC connectors and terminal directly after unplugging from mains supply as the danger of electric shock remains!**
- **Never touch the contacts on the DC output terminal directly after switching off the DC output, because there still can dangerous voltage present, sinking more or less slowly depending on the load! There also can be dangerous potential between negative DC output to PE or positive DC output to PE due to charged X capacitors.**

- 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 load, particularly such with low resistance, to devices under power; sparking may occur which can cause burns as well as damage to the equipment and to the load.
- 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 modules may only be installed or removed after the device is switched off. It's 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 isn't 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 rear side of the device!
- Always configure the various protecting features against overcurrent, overpower etc. for sensitive loads to what the target application requires!

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 7

1.7.2   Responsibility of the user

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

- must be informed of the relevant job safety requirements

- must work to the defined responsibilities for operation, maintenance and cleaning of the equipment

- before starting work must have read and understood the operating manual

- must use the designated and recommended safety equipment.

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

1.7.3   Responsibility of the operator

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

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

- be acquainted with the relevant job safety requirements

- identify other possible dangers arising from the specific usage conditions at the work station via a risk assessment

- introduce the necessary steps in the operating procedures for the local conditions

- regularly control that the operating procedures are current

- update the operating procedures where necessary to reflect changes in regulation, standards or operating conditions.

- define clearly and unambiguously the responsibilities for operation, maintenance and cleaning of the equipment.

- ensure that all employees who use the equipment have read and understood the manual. Furthermore the users are to be regularly schooled in working with the equipment and the possible dangers.

- provide all personnel who work with the equipment with the designated and recommended safety equipment

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

1.7.4   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.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 8

1.7.5 Alarm signals

The equipment offers various possibilities for signalling alarm conditions, however, not for danger situations. The signals may be optical (on the display as text), acoustic (piezo buzzer) or electronic (pin/status output of an analog interface). All alarms will cause the device to switch off the DC output.

The meaning of the signals is as follows:

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

1.8 Technical Data

1.8.1 Approved operating conditions

• Use only inside dry buildings
• Ambient temperature 0-50°C
• Operational altitude: max. 2000 m above sea level
• Max 80% relative humidity, not condensing

1.8.2 Control panel

Display: Colour TFT touch screen with gorilla glass, 4.3", 480pt x 272pt, capacitive

Controls: 2 rotary knobs with pushbutton function, 1 pushbutton

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

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 9

1.8.3   Technical specifications

Global	
AC input	
Voltage (L-L)	340...460 V_{AC}. 45 - 65 Hz
Connection	Three phase supply (L1, L2, L3, PE)
Fusing (internal)	Circuit breaker, 3x 32 A per unit (characteristics K)
Power factor	≈ 0.99
DC output	
Temperature coefficient of the set values Δ/K	Voltage / current: 100 ppm
Voltage regulation	
Accuracy [1] (at 23 ± 5°C)	< 0.1% U_{Nom}
Line regulation at ±10% ΔU_{AC}	< 0.02% U_{Nom}
Load regulation at 0...100% load	< 0.05% U_{Nom}
Rise time 10...90% ΔU	Max. 30 ms
Transient time after load step	< 1.5 ms
Display: Resolution	See section „*1.9.6.4. Resolution of the displayed values*"
Display: Accuracy [4]	≤ 0.2% U_{Nom}
Remote sensing compensation	Max. 5% U_{Nom}
Fall time at no load after switching DC output off	Down from 100% to <60 V: less than 10 s
Current regulation	
Accuracy [1] (at 23 ± 5°C)	< 0.2% I_{Nom}
Line regulation at ±10% ΔU_{AC}	< 0.05% I_{Nom}
Load regulation at 0...100% ΔU_{OUT}	< 0.15% I_{Nom}
Display: Resolution	See section „*1.9.6.4. Resolution of the displayed values*"
Display: Accuracy [4]	≤ 0.2% I_{Nom}
Power regulation	
Accuracy [1] (at 23 ± 5°C)	< 1% P_{Nom}
Line regulation at ±10% ΔU_{AC}	< 0.05% P_{Nom}
Load reg. at 10-90% ΔU_{OUT} * ΔI_{OUT}	< 0.75% P_{Nom}
Display: Resolution	See section „*1.9.6.4. Resolution of the displayed values*"
Display: Accuracy [4]	≤ 0.4% P_{Nom}
Internal resistance regulation	
Accuracy [1]	≤2% of max. resistance ± 0.3% of maximum current
Display: Resolution	See section „*1.9.6.4. Resolution of the displayed values*"
Analog interface [3]	
Set value inputs	U, I, P, R
Actual value output	U, I
Control signals	DC output on/off, remote control on/off, resistance control on/off
Status signals	CV, OVP, OCP, OPP, OT, PF, DC output on/off
Insulation	
AC input <-> PE	2.5 kV DC
AC input <-> DC output	2.5 kV DC

[1] Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value on the DC output
Example: a 80 V model has min. 0.1% voltage accuracy, that is 80 mV. When adjusting the voltage to 5 V, the actual value is allowed to differ max. 80 mV, which means it might be between 4.92 V and 5.08 V.
[2] The display error adds to the error of the related actual value on the DC output
[3] For technical specifications of the analog interface see „*3.5.4.4 Analog interface specification*" on page 50

Global	
Miscellaneous	
Cooling	Temperature controlled fans, front inlet, rear exhaust
Ambient temperature	0..50°C
Storage temperature	-20...70°C
Humidity	< 80%, not condensing
Standards	EN 61010-1:2011-07 EN 61000-6-2:2016-05, EN 61000-6-3:2011-09 Class B
Overvoltage category	2
Protection class	1
Pollution degree	2
Operational altitude	< 2000 m
Leakage current (symmetric line filter)	30 kW: < 7 mA 45 kW: < 10.5 mA 60 kW: < 14 mA 75 kW: < 17.5 mA 90 kW: < 21 mA
Digital interfaces	
Featured	1x USB-B for communication, 1x USB-A for functions, 1x GPIB
Slot (master unit)	Optional: CANopen, Profibus, Profinet, RS232, CAN, Ethernet, ModBus TCP, Ether-CAT
Terminals	
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, interface module slot, GPIB (optional)
Front side	USB-A
Dimensions	
Cabinet (WxHxD)	15U version: 60 x 95 x 100 cm (with emergency off option: 60 x 110 x 100 cm) 24U version: 60 x 135 x 100 cm with emergency off option: 60 x 150 x 100 cm)

30 kW in 15U	**PSI 9080-1020 15U**	**PSI 9200-420 15 U**	**PSI 9360-240 15U**	**PSI 9500-180 15U**	**PSI 9750-120 15 U**	**PSI 91000-80 15U**	**PSI 91500-60 15U**
Ratings							
Max. output voltage U_{Max}	80 V	200 V	360 V	500 V	750 V	1000 V	1500 V
Max. output current I_{Max}	1020 A	420 A	240 A	180 A	120 A	80 A	60 A
Max. output power P_{Max}	30 kW	30 kW	30 kW	30 kW	30 kW	30 kW	30 kW
Adjustment ranges							
Voltage	0...81.6 V	0...204 V	0...367.2 V	0...510 V	0...765 V	0...1020 V	0...1530 V
Current	0...1040.4 A	0...428.4 A	0...244.8 A	0...183.6 A	0...122.4 A	0...81.6 A	0...61.2 A
Power	0…30.6 kW	0…30.6 kW	0…30.6 kW	0…30.6 kW	0…30.6 kW	0…30.6 kW	0…30.6 kW
Resistance	0...2.5 Ω	0...14 Ω	0...45 Ω	0...83 Ω	0...187.5 Ω	0...405 Ω	0...750 Ω
Overvoltage protection	0...88 V	0...220 V	0...396 V	0...550 V	0...825 V	0...1100 V	0...1650 V
Overcurrent protection	0...1122 A	0...462 A	0...264 A	0...198 A	0...132 A	0...88 A	0...66 A
Overpower protection	0...33 kW	0…33 kW	0…33 kW	0…33 kW	0…33 kW	0…33 kW	0…33 kW
Ripple [1]							
Voltage (CV operation)	<320 mV$_{PP}$ <25 mV$_{RMS}$	<300 mV$_{PP}$ <40 mV$_{RMS}$	<550 mV$_{PP}$ <65 mV$_{RMS}$	<350 mV$_{PP}$ <70 mV$_{RMS}$	<800 mV$_{PP}$ <200 mV$_{RMS}$	<2000 mV$_{PP}$ <300 mV$_{RMS}$	<2400 mV$_{PP}$ <400 mV$_{RMS}$
Output (circa)	50.8 mF	15 mF	2.4 mF	1.5 mF	620 µF	266 µF	168 µF
Current (CC operation)	<240 mA$_{RMS}$	<66 mA$_{RMS}$	<16 mA$_{RMS}$	<48 mA$_{RMS}$	<48 mA$_{RMS}$	<10 mA$_{RMS}$	<26 mA$_{RMS}$
Efficiency [2]	≤ 93%	≤ 95%	≤ 94%	≤ 95%	≤ 94%	≤ 94%	≤ 95%
Insulation	Allowed float (potential shift) on the DC output:						
DC minus <-> PE (max.)	±400 V DC	±400 V DC	±400 V DC	±725 V DC	±725 V DC	±1000 V DC	±1500 V DC
DC plus <-> PE (max.)	±400 V DC	±600 V DC	±600 V DC	±1000 V DC	±1000 V DC	±1500 V DC	±1800 V DC
Weight	≈ 160 kg	≈ 160 kg	≈ 160 kg	≈ 160 kg	≈ 160 kg	≈ 160 kg	≈ 160 kg
Article number [3]	06400601	06400602	06400603	06400604	06400605	06400631	06400606

(1 RMS value: LF 0...300 kHz, PP value: HF 0...20MHz
(2 Typical value at 100% output voltage and 100% power
(3 Article number of the standard version, models with options will have a different article number

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 11

45 kW in 15U	PSI 9080-1530 15U	PSI 9200-630 15 U	PSI 9360-360 15U	PSI 9500-270 15U	PSI 9750-180 15 U	PSI 91000-120 15U	PSI 91500-90 15U
Ratings							
Max. output voltage U_{Max}	80 V	200 V	360 V	500 V	750 V	1000 V	1500 V
Max. output current I_{Max}	1530 A	630 A	360 A	270 A	180 A	120 A	90 A
Max. output power P_{Max}	45 kW	45 kW	45 kW	45 kW	45 kW	45 kW	45 kW
Adjustment ranges							
Voltage	0...81.6 V	0...204 V	0...367.2 V	0...510 V	0...765 V	0...1020 V	0...1530 V
Current	0...1560.6 A	0...642.6 A	0...367.2 A	0...275.4 A	0...183.6 A	0...122.4 A	0...91.8 A
Power	0…45.9 kW	0…45.9 kW	0…45.9 kW	0…45.9 kW	0…45.9 kW	0…45.9 kW	0…45.9 kW
Resistance	0...1.67 Ω	0...9.33 Ω	0...30 Ω	0...55.33 Ω	0...125 Ω	0...270 Ω	0...500 Ω
Overvoltage protection	0...88 V	0...220 V	0...396 V	0...550 V	0...825 V	0...1100 V	0...1650 V
Overcurrent protection	0...1683 A	0...693 A	0...396 A	0...297A	0...198 A	0...132 A	0...99 A
Overpower protection	0…49.5 kW	0…49.5 kW	0…49.5 kW	0…49.5 kW	0…49.5 kW	0…49.5 kW	0…49.5 kW
Ripple [1]							
Voltage (CV operation)	<320 mV$_{PP}$ <25 mV$_{RMS}$	<300 mV$_{PP}$ <40 mV$_{RMS}$	<550 mV$_{PP}$ <65 mV$_{RMS}$	<350 mV$_{PP}$ <70 mV$_{RMS}$	<800 mV$_{PP}$ <200 mV$_{RMS}$	<2000 mV$_{PP}$ <300 mV$_{RMS}$	<2400 mV$_{PP}$ <400 mV$_{RMS}$
Output (circa)	76.2 mF	22.7 mF	3.6 mF	2.28 mF	930 µF	399 µF	250 µF
Current (CC operation)	<240 mA$_{RMS}$	<66 mA$_{RMS}$	<16 mA$_{RMS}$	<48 mA$_{RMS}$	<48 mA$_{RMS}$	<10 mA$_{RMS}$	<26 mA$_{RMS}$
Efficiency [2]	≤ 93%	≤ 95%	≤ 94%	≤ 95%	≤ 94%	≤ 94%	≤ 95%
Insulation	Allowed float (potential shift) on the DC output:						
DC minus <-> PE (max.)	±400 V DC	±400 V DC	±400 V DC	±725 V DC	±725 V DC	±1000 V DC	±1500 V DC
DC plus <-> PE (max.)	±400 V DC	±600 V DC	±600 V DC	±1000 V DC	±1000 V DC	±1500 V DC	±1800 V DC
Weight	≈ 190 kg	≈ 190 kg	≈ 190 kg	≈ 190 kg	≈ 190 kg	≈ 190 kg	≈ 190 kg
Article number [3]	06400607	06400608	06400609	06400610	06400611	06400632	06400612

60 kW in 24U	PSI 9080-2040 24U	PSI 9200-840 24U	PSI 9360-480 24U	PSI 9500-360 24U	PSI 9750-240 24U	PSI 91000-160 24U	PSI 91500-120 24U
Ratings							
Max. output voltage U_{Max}	80 V	200 V	360 V	500 V	750 V	1000 V	1500 V
Max. output current I_{Max}	2040 A	840 A	480 A	360 A	240 A	160 A	120 A
Max. output power P_{Max}	60 kW	60 kW	60 kW	60 kW	60 kW	60 kW	60 kW
Adjustment ranges							
Voltage	0...81.6 V	0...204 V	0...367.2 V	0...510 V	0...765 V	0...1020 V	0...1530 V
Current	0...2080.8 A	0...856.8 A	0...489.6 A	0...367.2 A	0...244.8 A	0...163.2 A	0...122.4 A
Power	0…61.2 kW	0…61.2 kW	0…61.2 kW	0…61.2 kW	0…61.2 kW	0…61.2 kW	0…61.2 kW
Resistance	0...1.25 Ω	0...7 Ω	0...22.5 Ω	0...41.5 Ω	0...93.75 Ω	0...203 Ω	0...375 Ω
Overvoltage protection	0...88 V	0...220 V	0...396 V	0...550 V	0...825 V	0...1100 V	0...1650 V
Overcurrent protection	0...2244 A	0...924 A	0...528 A	0...396 A	0...264 A	0...176 A	0...132 A
Overpower protection	0…66 kW	0…66 kW	0…66 kW	0…66 kW	0…66 kW	0…66 kW	0…66 kW
Ripple [1]							
Voltage (CV operation)	<320 mV$_{PP}$ <25 mV$_{RMS}$	<300 mV$_{PP}$ <40 mV$_{RMS}$	<550 mV$_{PP}$ <65 mV$_{RMS}$	<350 mV$_{PP}$ <70 mV$_{RMS}$	<800 mV$_{PP}$ <200 mV$_{RMS}$	<2000 mV$_{PP}$ <300 mV$_{RMS}$	<2400 mV$_{PP}$ <400 mV$_{RMS}$
Output (circa)	102 mF	30 mF	4.8 mF	3 mF	1.2 mF	532 µF	336 µF
Current (CC operation)	<240 mA$_{RMS}$	<66 mA$_{RMS}$	<16 mA$_{RMS}$	<48 mA$_{RMS}$	<48 mA$_{RMS}$	<10 mA$_{RMS}$	<26 mA$_{RMS}$
Efficiency [2]	≤ 93%	≤ 95%	≤ 94%	≤ 95%	≤ 94%	≤ 94%	≤ 95%
Insulation	Allowed float (potential shift) on the DC output:						
DC minus <-> PE (max.)	±400 V DC	±400 V DC	±400 V DC	±725 V DC	±725 V DC	±1000 V DC	±1500 V DC
DC plus <-> PE (max.)	±400 V DC	±600 V DC	±600 V DC	±1000 V DC	±1000 V DC	±1500 V DC	±1800 V DC
Weight	≈ 260 kg	≈ 260 kg	≈ 255 kg	≈ 255 kg	≈ 255 kg	≈ 255 kg	≈ 255 kg
Article number [3]	06400613	06400614	06400615	06400616	06400617	06400633	06400618

(1 RMS value: LF 0...300 kHz, PP value: HF 0...20MHz
(2 Typical value at 100% output voltage and 100% power
(3 Article number of the standard version, models with options will have a different article number

75 kW in 24U	*PSI 9080-2550 24U*	*PSI 9200-1050 24U*	*PSI 9360-600 24U*	*PSI 9500-450 24U*	*PSI 9750-300 24U*	*PSI 91000-200 24U*	*PSI 91500-150 24U*
Ratings							
Max. output voltage U$_{Max}$	80 V	200 V	360 V	500 V	750 V	1000 V	1500 V
Max. output current I$_{Max}$	2550 A	1050 A	600 A	450 A	300 A	200 A	150 A
Max. output power P$_{Max}$	75 kW	75 kW	75 kW	75 kW	75 kW	75 kW	75 kW
Adjustment ranges							
Voltage	0...81.6 V	0...204 V	0...367.2 V	0...510 V	0...765 V	0...1020 V	0...1530 V
Current	0...2601 A	0...1071 A	0...612 A	0...459 A	0...306 A	0...204 A	0...153 A
Power	0…76.5 kW	0…76.5 kW	0…76.5 kW	0…76.5 kW	0…76.5 kW	0…76.5 kW	0…76.5 kW
Resistance	0...1 Ω	0...5.6 Ω	0...18 Ω	0...33.2 Ω	0...75 Ω	0...162 Ω	0...300 Ω
Overvoltage protection	0...88 V	0...220 V	0...396 V	0...550 V	0...825 V	0...1100 V	0...1650 V
Overcurrent protection	0...2805 A	0...1155 A	0...660 A	0...495 A	0...330 A	0...220 A	0...165 A
Overpower protection	0…82.5 kW	0…82.5 kW	0…82.5 kW	0…82.5 kW	0…82.5 kW	0…82.5 kW	0…82.5 kW
Ripple [1]							
Voltage (CV operation)	<320 mV$_{PP}$ <25 mV$_{RMS}$	<300 mV$_{PP}$ <40 mV$_{RMS}$	<550 mV$_{PP}$ <65 mV$_{RMS}$	<350 mV$_{PP}$ <70 mV$_{RMS}$	<800 mV$_{PP}$ <200 mV$_{RMS}$	<2000 mV$_{PP}$ <300 mV$_{RMS}$	<2400 mV$_{PP}$ <400 mV$_{RMS}$
Output (circa)	127 mF	38 mF	6 mF	3.8 mF	1.5 mF	665 µF	420 µF
Current (CC operation)	<240 mA$_{RMS}$	<66 mA$_{RMS}$	<16 mA$_{RMS}$	<48 mA$_{RMS}$	<48 mA$_{RMS}$	<10 mA$_{RMS}$	<26 mA$_{RMS}$
Efficiency [2]	≤ 93%	≤ 95%	≤ 94%	≤ 95%	≤ 94%	≤ 94%	≤ 95%
Insulation	Allowed float (potential shift) on the DC output:						
DC minus <-> PE (max.)	±400 V DC	±400 V DC	±400 V DC	±725 V DC	±725 V DC	±1000 V DC	±1500 V DC
DC plus <-> PE (max.)	±400 V DC	±600 V DC	±600 V DC	±1000 V DC	±1000 V DC	±1500 V DC	±1800 V DC
Weight	≈ 290 kg	≈ 290 kg	≈ 285 kg	≈ 285 kg	≈ 285 kg	≈ 285 kg	≈ 285 kg
Article number [3]	06400619	06400620	06400621	06400622	06400623	06400634	06400624

90 kW in 24U	*PSI 9080-3060 24U*	*PSI 9200-1260 24U*	*PSI 9360-720 24U*	*PSI 9500-540 24U*	*PSI 9750-360 24U*	*PSI 91000-240 24U*	*PSI 91500-180 24U*
Ratings							
Max. output voltage U$_{Max}$	80 V	200 V	360 V	500 V	750 V	1000 V	1500 V
Max. output current I$_{Max}$	3060 A	1260 A	720 A	540 A	360 A	240 A	180 A
Max. output power P$_{Max}$	90 kW	90 kW	90 kW	90 kW	90 kW	90 kW	90 kW
Adjustment ranges							
Voltage	0...81.6 V	0...204 V	0...367.2 V	0...510 V	0...765 V	0...1020 V	0...1530 V
Current	0...3121.2 A	0...1285.2 A	0...734.3 A	0...550.8 A	0...367.2 A	0...244.8 A	0...183.6 A
Power	0…91.8 kW	0…91.8 kW	0…91.8 kW	0…91.8 kW	0…91.8 kW	0…91.8 kW	0…91.8 kW
Resistance	0...0.833 Ω	0...4.67 Ω	0...15 Ω	0...27.67 Ω	0...62.5 Ω	0...135 Ω	0...250 Ω
Overvoltage protection	0...88 V	0...220 V	0...396 V	0...550 V	0...825 V	0...1100 V	0...1650 V
Overcurrent protection	0...3366 A	0...1386 A	0...792 A	0...594 A	0...396 A	0...264 A	0...198 A
Overpower protection	0…99 kW	0…99 kW	0…99 kW	0…99 kW	0…99 kW	0…99 kW	0…99 kW
Ripple [1]							
Voltage (CV operation)	<320 mV$_{PP}$ <25 mV$_{RMS}$	<300 mV$_{PP}$ <40 mV$_{RMS}$	<550 mV$_{PP}$ <65 mV$_{RMS}$	<350 mV$_{PP}$ <70 mV$_{RMS}$	<800 mV$_{PP}$ <200 mV$_{RMS}$	<2000 mV$_{PP}$ <300 mV$_{RMS}$	<2400 mV$_{PP}$ <400 mV$_{RMS}$
Output (circa)	127 mF	38 mF	6 mF	3.8 mF	1.5 mF	800 µF	420 µF
Current (CC operation)	<240 mA$_{RMS}$	<66 mA$_{RMS}$	<16 mA$_{RMS}$	<48 mA$_{RMS}$	<48 mA$_{RMS}$	<10 mA$_{RMS}$	<26 mA$_{RMS}$
Efficiency [2]	≤ 93%	≤ 95%	≤ 94%	≤ 95%	≤ 94%	≤ 94%	≤ 95%
Insulation	Allowed float (potential shift) on the DC output:						
DC minus <-> PE (max.)	±400 V DC	±400 V DC	±400 V DC	±725 V DC	±725 V DC	±1000 V DC	±1500 V DC
DC plus <-> PE (max.)	±400 V DC	±600 V DC	±600 V DC	±1000 V DC	±1000 V DC	±1500 V DC	±1800 V DC
Weight	≈ 325 kg	≈ 320 kg	≈ 315 kg	≈ 315 kg	≈ 315 kg	≈ 315 kg	≈ 315 kg
Article number [3]	06400625	06400626	06400627	06400628	06400629	06400635	06400630

(1 RMS value: LF 0...300 kHz, PP value: HF 0...20MHz
(2 Typical value at 100% output voltage and 100% power
(3 Article number of the standard version, models with options will have a different article number
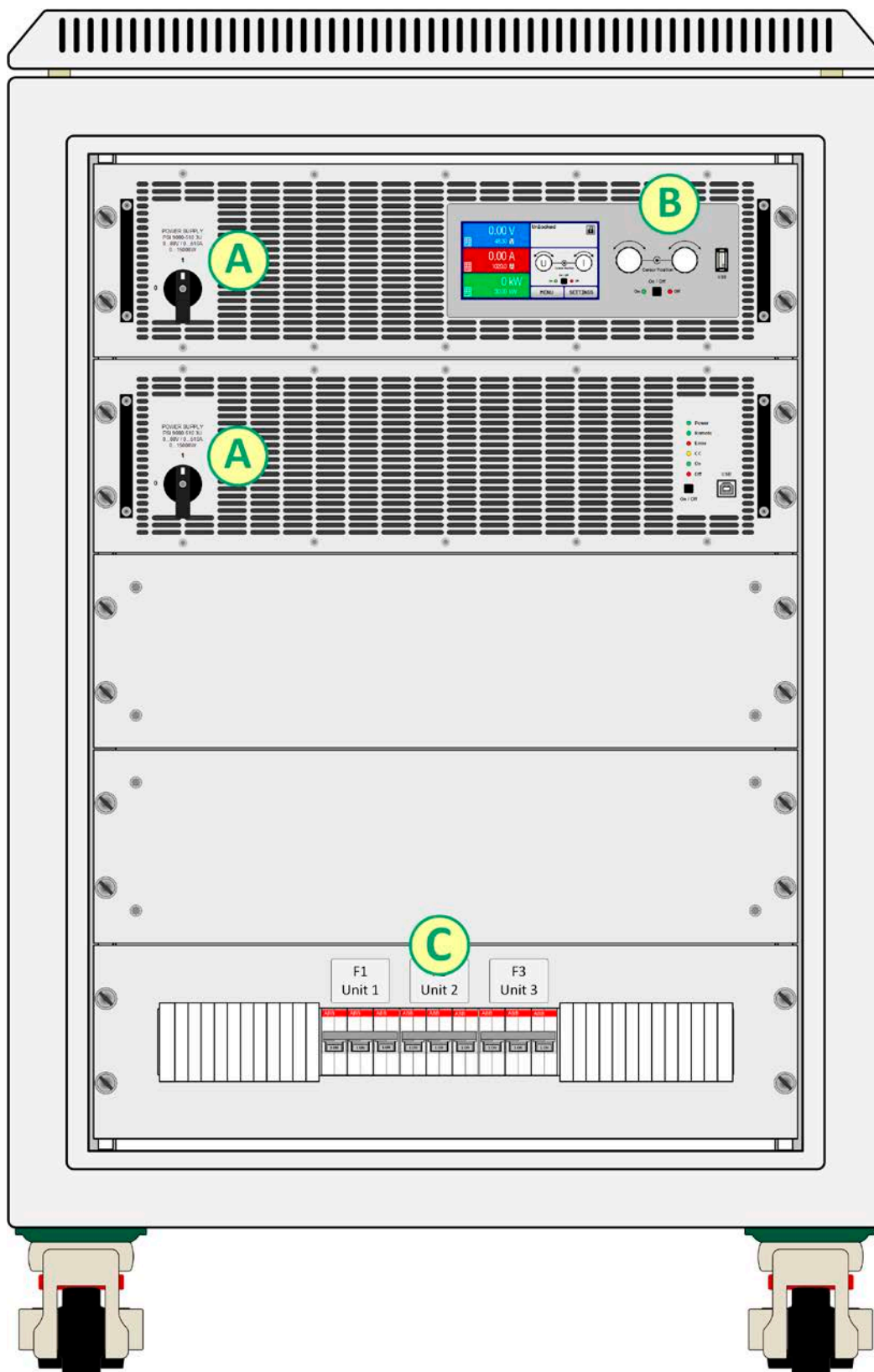
1.8.4   Views

Figure 1 - Front side (30 kW model in 15U)

A - Power switch

B - Control panel

C - AC input fuses

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

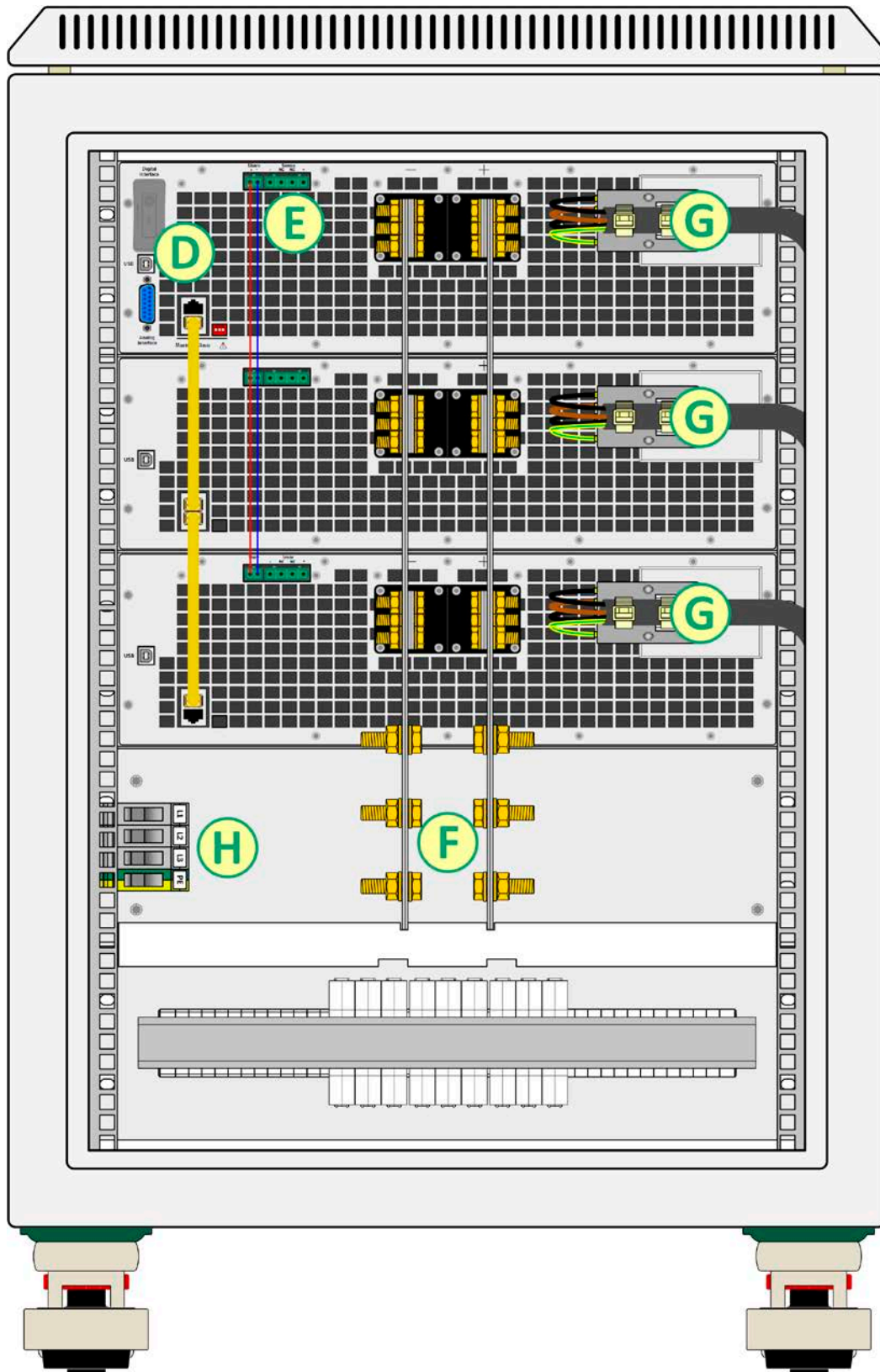**www.elektroautomatik.de**
ea1974@elektroautomatik.de

Page 14

Figure 2 - Rear side (45 kW model shown, other models look similar)

D - Digital and analog interfaces

E - Share Bus and remote sensing connection

F - DC output

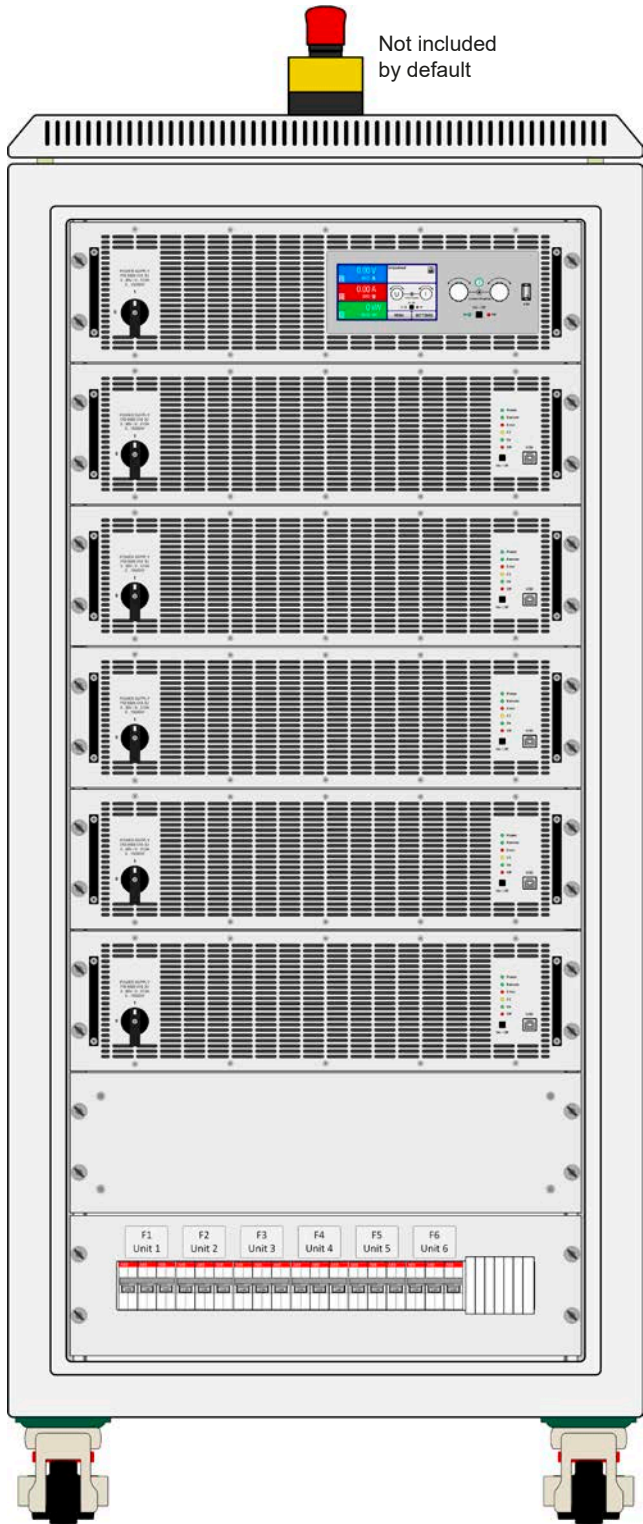G - AC input connection of the single units

H - AC input of cabinet

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 15

Not included
by default

Figure 3 - Front side (90 kW model in 24U) and optional emergency off switch
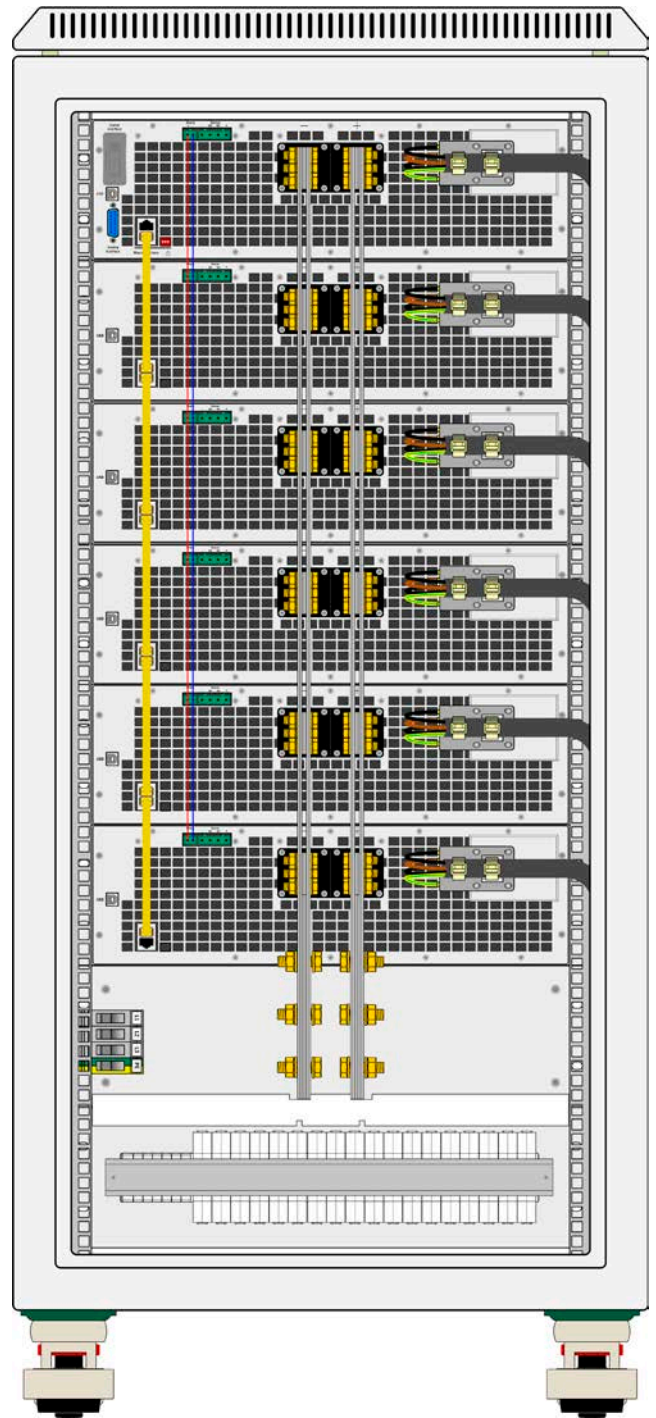
Figure 4 - Rear side (90 kW model in 24 U)

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de
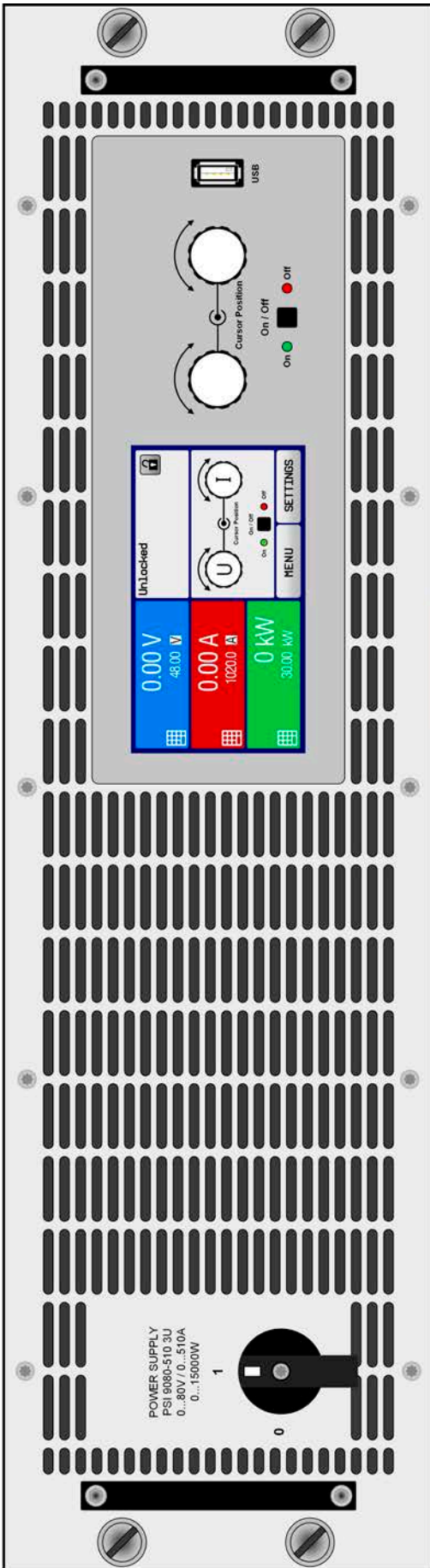
Page 16

Figure 5 - Front side of master unit, with control panel
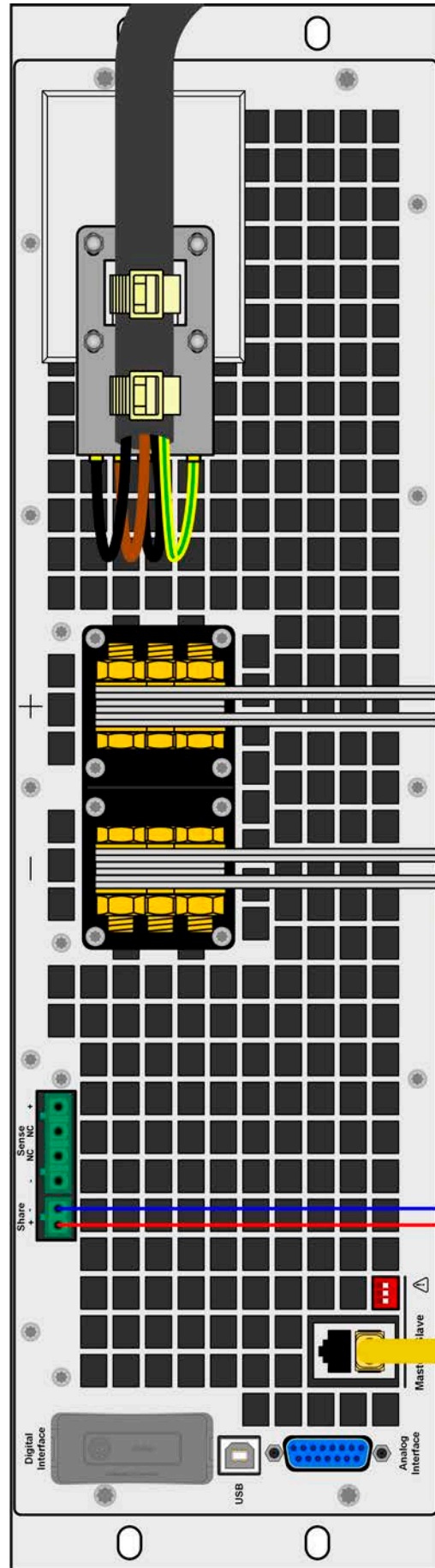
Figure 6 - Rear side of master unit, with all connectors

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
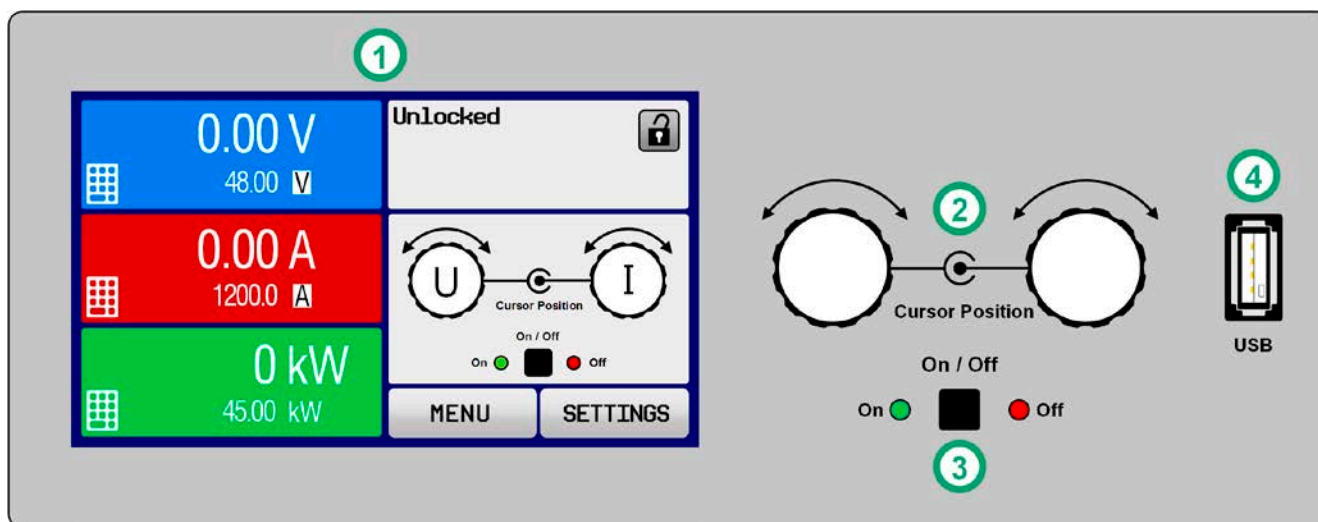ea1974@elektroautomatik.de

Page 17

1.8.5   Control elements

Figure 7- Control Panel

Overview of the elements of the control panel

For a detailed description see section „*1.9.6. The control panel (HMI)"*.

(1)	**Touchscreen display** Used for selection of set values, menus, status 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 set value, 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, power or resistance 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 output** Used to toggle the DC output between on and off, also used to start a function run. The LEDs "On" and "Off" indicate the state of the DC output, no matter if the device is manually controlled or remotely
(4)	**USB port** For the connection of standard USB sticks. See section „*1.9.6.5. USB port (front side)"* for more details..

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 18

1.9 Construction and function

1.9.1 General description

The electronic high performance power supplies of the PSI 9000 15U and PSI 9000 24U series have been designed for industrial high current and high power demands. Configured as mobile 19" cabinets in either 15 or 24 units of height they allow for operation in many different situations, such as electro-plating or high capacity battery test and charging.

Both series are based on the 15 kW models of series PSI 9000 3U and thus offer the same set of functions and control options.

For remote control using a PC or PLC the devices are provided as standard with an USB-B slot on the rear side, as well as a galvanically isolated analog interface.
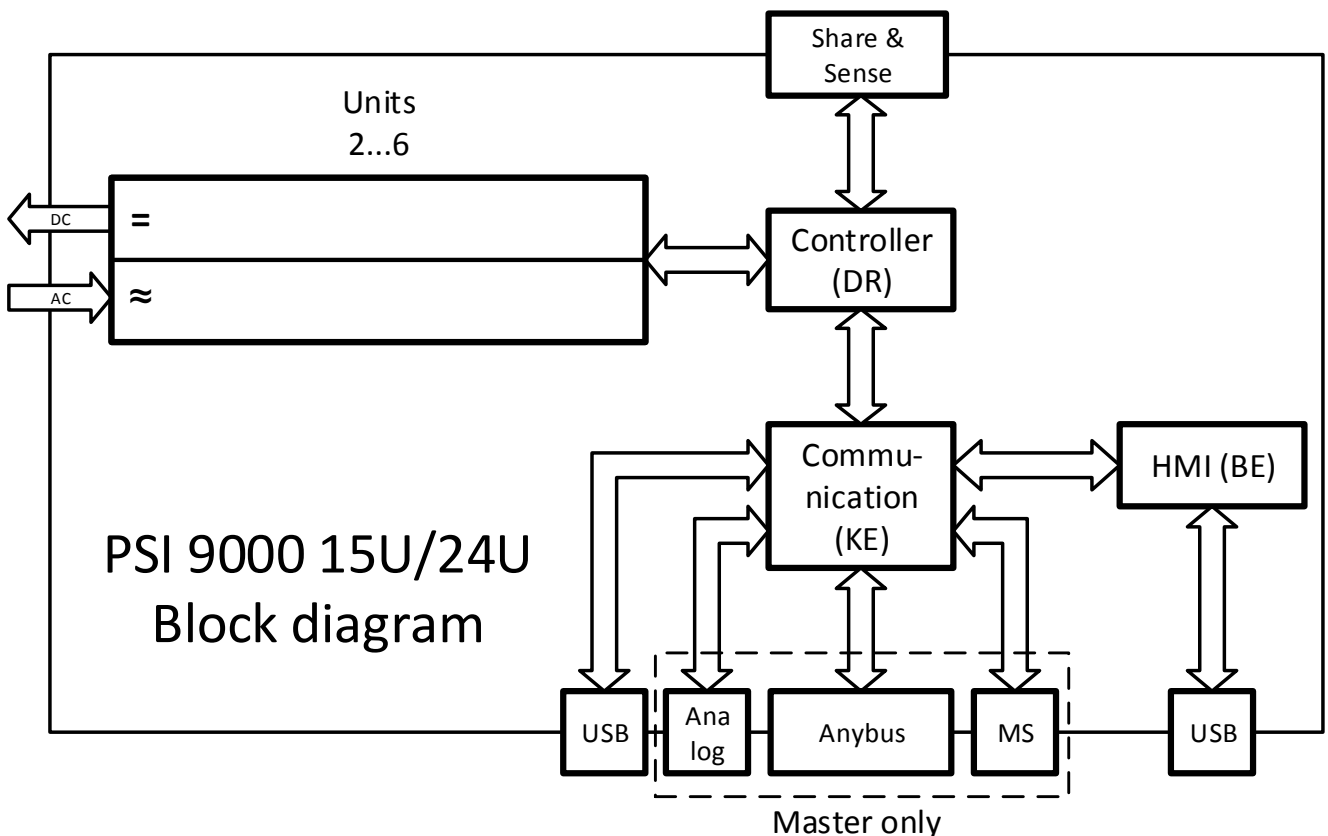
Via optional plug-in modules, other digital interfaces such as Ethernet, RS232, Profibus, ProfiNet, ModBus TCP, CANopen, CAN or EtherCAT can be added. These enable the devices to be connected to standard industrial buses simply by changing or adding a small module. The configuration, if necessary at all, is quick and easy. Thus the power supplies may, for example, be operated with other power supplies or even other types of equipment or controlled by a PC or PLC, all using the digital interfaces.

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

1.9.2 Block diagram

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

There are digital, microprocessor controlled components (KE, DR, HMI) inside which can be target of firmware updates. The units are separate power modules, each with their own AC input and DC output. There is a master unit and up to 5 slave units which don't feature a control panel (HMI).

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 19

1.9.3 Scope of delivery

1 x Power supply cabinet with 2-6 installed PSI 9000 3U units

1 x 1.8 m USB cable

1 x USB stick with documentation and software (for the cabinet, further USB sticks from the power module may be included)

1.9.4 Accessories

For these devices the following accessories are available:

IF-AB Digital interface modules	Pluggable and retrofittable interface modules for RS232, CANopen, Ethernet, Profibus, ProfiNet, ModBus TCP, CAN or EtherCAT are available. Details about the interface modules and the programming of the device using those interfaces can be found in separate documentation. It's usually available on the USB stick which is included with the device or as PDF download on the manufacturers website.
PSI 9000 SLAVE Additional slave units	Some models in this series have one or two spare slots for additional slave units which can be retrofitted by the operator of the cabinet (see „*2.3.16. Adding further units*"). The slave units can be ordered by their article number and retrofitted on location. A patch cable for master-slave bus connection of the additional slave is included. Retrofitting also requires to install further DC bus bars, depending on the number of units to add and the final current the system will have. Contact us for details and a proper quote. Following slave units are available: | Model	Article number	Can be installed in
---	---	---
PSI 9080-510 3U Slave	06290364	PSI 9080-1020 15U PSI 9080-2040 24U PSI 9080-2530 24U
PSI 9200-210 3U Slave	06290365	PSI 9200-420 15U PSI 9200-840 24U PSI 9200-1050 24U
PSI 9360-120 3U Slave	06290366	PSI 9360-240 15U PSI 9360-480 24U PSI 9360-600 24U
PSI 9500-90 3U Slave	06290367	PSI 9500-180 15U PSI 9500-360 24U PSI 9500-450 24U
PSI 9750-60 3U Slave	06290368	PSI 9750-120 15U PSI 9750-240 24U PSI 9750-300 24U
PSI 91500-30 3U Slave	06290369	PSI 91500-60 15U PSI 91500-120 24U PSI 91500-150 24U	

1.9.5 Options

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

|	
EMERGENCY OFF Emergency off system	Optional emergency off system consisting of a manual emergency off switch (mounted on top of the cabinet), a contactor and a connector for additional external contacts (breaker) to extend the circuit. In an emergency off situation the contactor will cut all units in the cabinet from AC supply so they stop supplying DC power.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 20

1.9.6 The control panel (HMI)

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

1.9.6.1 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 values and set values and the right hand side is used to display status information:
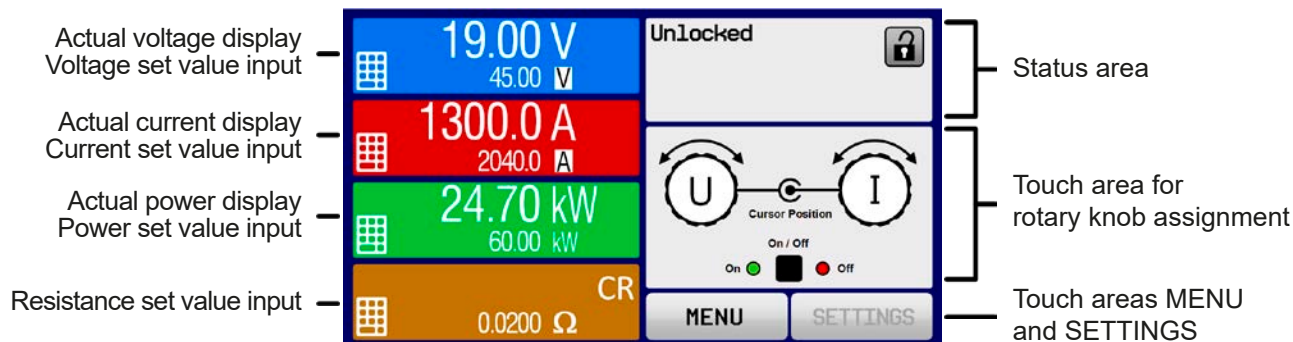
	Touch areas may be enabled or disabled:	
	MENU Black text or symbol = Enabled SETTINGS Grey text or symbol = Disabled	
	This applies to all touch areas on the main screen and all menu pages..	

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

In normal operation the DC output values (large numbers) and set values (small numbers) for voltage, current and power are displayed. Resistance set value of the variable internal resistance is only displayed by active resistance mode.

When the DC output is switched on, the actual regulation mode, **CV, CC, CP** or **CR** is displayed next to the corresponding actual values, as show in the figure above.

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 turning and decreased by anti-clockwise turning.

General display and setting ranges:

Display	Unit	Range	Description
Actual voltage	V	0-125% U_{Nom}	Actual values of DC output voltage
Set value of voltage [1]	V	0-102% U_{Nom}	Set value for limiting the DC output voltage
Actual current	A	0.2-125% I_{Nom}	Actual value of DC output current
Set value of current [1]	A	0-102% I_{Nom}	Set value for limiting the DC output current
Actual power	kW	0-125% P_{Nom}	Actual value of output power, P = U * I
Set value of power [1]	kW	0-102% P_{Nom}	Set value for limiting DC output power
Set value of internal resistance[1]	Ω	0-100% R_{Max}	Set value for the simulated internal resistance
Adjustment limits	A, V, kW	0-102% nom	U-max, I-min etc., related to the physical values
Protection settings	A, V, kW	0-110% nom	OVP, OCP etc., related to the physical values

[1] Valid also for values related to these physical quantities, such as OVD for voltage and UCD for current

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 21

• **Status display (upper right)**

This area displays various status texts and symbols:

| Display	Description
Locked	The HMI is locked
Unlocked	The HMI is unlocked
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:	An user defined event has occurred which isn't yet acknowledged.
Master	Master-slave mode activated, device is master
Function:	Function generator activated, function loaded
💾 / 💾ERR	Data logging to USB stick active or failed

• **Area for assigning the rotary knobs**

The two rotary knobs next to the display screen can be assigned to various functions. This area shows the actual assignments. These can be changed by tapping this area, as long as it's not locked. The display changes to:
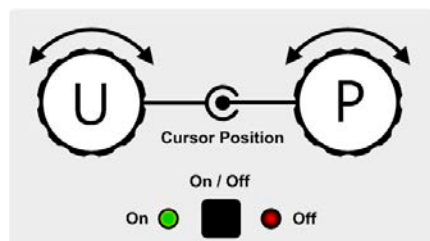
The physical quantities on the depiction of the knob shows the current assignment. With a power supply, the left knob is always assigned to the voltage U, while the right knob can be switched by tapping the depiction.

The area will then show the assignment:

U I	**U P**	**U R**
Left rotary knob: voltage	Left rotary knob: voltage	Left rotary knob: voltage
Right rotary knob: current	Right rotary knob: power	Right rotary knob: resistance

The other set values can't be adjusted via the rotary knobs, unless the assignment is changed. However, values can be entered directly with a ten-key pad by tapping on the small icon . Alternatively to the knob depiction, the assignment can also be changed by tapping the coloured set value areas.

1.9.6.2 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 SETTINGS and MENU. For a detailed description of the individual functions see section „*3.4. Manual operation*".

1.9.6.3 Pushbutton function of the knobs

The rotary knobs also have a pushbutton function which is used in all value adjustment to move the cursor by rotation as shown:

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 22

1.9.6.4 Resolution of the displayed values

In the display, set values can be adjusted in fixed 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			Current, OCP, UCD, OCD, I-min, I-max			Power, OPP, OPD, P-max			Resistance, R-max		
Nominal	Digits	Increment	Nominal	Digits	Increment	Nominal	Digits	Increment	Nominal	Digits	Increment
80 V	4	0.01 V	60 A / 90 A	4	0.01 A	30 kW	4	0.01 kW	0.8333 Ω - 9.33 Ω	5	0.0001 Ω
200 V	5	0.01 V	120 A - 180 A	4	0.1 A	45 kW	4	0.01 kW	14 Ω - 93.75 Ω	5	0.001 Ω
360 V	4	0.1 V	240 A - 840 A	4	0.1 A	60 kW	4	0.01 kW	125 Ω - 750 Ω	5	0.01 Ω
500 V	4	0.1 V	1020 A - 2550 A	5	0.1 A	75 kW	4	0.01 kW			
750 V	4	0.1 V	3060	4	1 A	90 kW	4	0.01 kW			
1000 V	5	0.1 V				105 kW	4	0.1 kW			
1500 V	5	0.1 V				120 kW	4	0.1 kW			

1.9.6.5 USB port (front side)

The frontal USB port, located to the right of the rotary knobs, is intended for the connection of standard USB sticks and can be used for loading or saving sequences for the arbitrary and the XY generator.

USB 2.0 sticks are accepted and must be **FAT32** formatted and have a **maximum capacity of 32GB**. USB 3.0 sticks also work, but not from all manufacturers.

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 device can read the following file types from a stick:

File name	Description	Section
wave_u<arbitrary_text>.csv wave_i<arbitrary_text>.csv	Function generator for an arbitrary function on voltage (U) or current (I) .The name must begin with *wave_u / wave_i*, the rest is user defined.	*3.10.10.1*
profile_<arbitrary_text>.csv	Saved user profile. The number in the file name is a counter and not related to the actual user profile number in the HMI. A max. of 10 files to select from is shown when loading an user profile.	*3.9*
pv<arbitrary_text>.csv fc<arbitrary_text>.csv	PV or FC table for the XY function generator. The name must begin with *pv* or *fc*, the rest can be user defined.	*3.10.13* *3.10.14*
pv_day_et_<arbitrary_text>.csv pv_day_ui_<arbitrary_text>.csv	Day trend data file to load for the simulation modes DAY I/T and DAY U/I of the extended PV function.	*3.10.15.5*
iu<arbitrary_text>.csv ui<arbitrary_text>.csv	IU or UI table for the XY function generator. The name must begin with *iu* or *ui*, the rest can be user defined.	*3.10.12*

The control panel of the device can save the following file types to an USB stick:

File name	Description	Section
usb_log_<nr>.csv	File with log data recorded during normal operation in all modes. The file layout is identical to the those generated from the Logging feature in EA Power Control. The <nr> field in the file name is automatically counted up if equally named files already exist in the folder.	*3.4.10*
profile_<nr>.csv	Saved user profile. The number in the file name is a counter and not related to the actual user profile number in the HMI. A max. of 10 files to select from is shown when loading an user profile.	*3.9*
wave_u_<nr>.csv wave_i_<nr>.csv	Sequence point data (here: sequences) of either voltage U or current I from arbitrary function generator	*3.10.10.1*
pv_record_<nr>.csv	Data from the data recording option in the extended PV function according to EN 50530.	*3.10.15.7*

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 23

1.9.7   USB port (rear side)

The USB port on the rear side of the topmost unit (master) is provided for communication with the device and for firmware updates of the master. For the other units (slaves) in the cabinet, firmware updates are applied via the particular USB port of the units.

The included USB cable can be used to connect the master unit to a PC (USB 2.0 or 3.0). The driver is delivered with the device on USB stick and installs a virtual COM port. Details for remote control can be found on the web site of the manufacturer or also on the included USB stick.

The device can be addressed via this port either using the international standard ModBus RTU protocol or by SCPI language. The device recognises the message protocol used automatically.
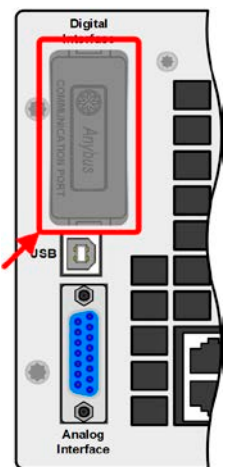
If remote control is in operation the USB port has no priority over either the interface module (see below) or the analog interface and can, therefore, only be used alternatively to these. However, monitoring is always available.
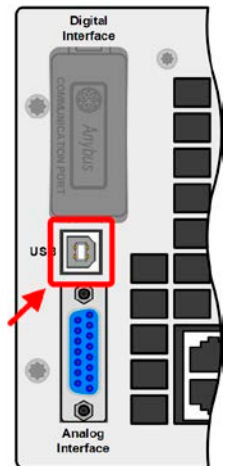
1.9.8   Interface module slot

This slot on the rear side of the topmost unit (master) can be used to install a digital interface module of the IF-AB interface series. The following options are available:

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
35400107	IF-AB-MBUS1P	ModBus TCP, 1x RJ45
35400108	IF-AB-ETH2P	Ethernet, 2x RJ45
35400109	IF-AB-MBUS2P	ModBus TCP, 2x RJ45
35400110	IF-AB-PNET2P	ProfiNET IO, 2x RJ45
35400111	IF-AB-CAN	CAN 2.0 A / 2.0 B, 1x Sub-D 9-pole, male
35400112	IF-AB-ECT	EtherCAT, 2x RJ45

The modules are installed by the user and can be retrofitted anytime. A firmware update of the device may be necessary in order to recognize and support certain modules. In this case it's sufficient to update the master unit.

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.
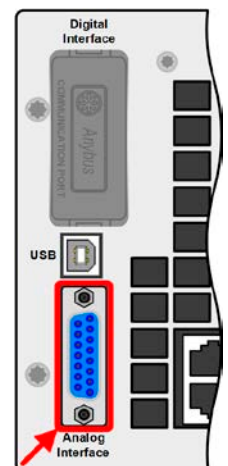
> ⚠ Switch off device before adding or removing modules!

1.9.9   Analog interface

This 15 pole Sub-D socket on the rear side of the topmost unit (master) is provided for remote control of the device via analog or digital signals.

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

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 0-5 V and 0-10 V, in each case for 0-100%.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 24

1.9.10 "Share" connector

This 2 pole WAGO connector on the rear side of the units is used by the master to balance the load between all units. It must not be connected externally or used in a different way and must always remain plugged at all units to ensure safe and proper operation of the power supply cabinet. In case additional power modules are added (where possible) to extend the available total power, the Share bus connection must also be extended to integrate the additional unit(s). The required wires aren't included with the new slave, but it's recommended to use the wire type, same colour and same cross section.
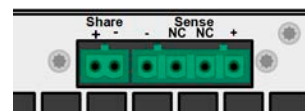
1.9.11 "Sense" connector (remote sensing)

In order to compensate for voltage drops along the DC cables to the load, the Sense input can be connected to the load. The maximum possible compensation is given in the technical specifications.
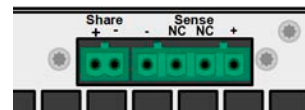
> ⚠️
> * In order to ensure safety and to comply to international directives, insulation of high voltage models, i. e. such with a nominal voltage of 500 V or higher, is ensured by using only the two outer pins of the 4-pole terminal. The inner two pins, marked with NC, must remain unconnected.
> * The two screws next to the Share bus and Sense connectors must remain firmly tightened all time, no matter if the safety cover (only with models from 750 V) is mounted or not!

1.9.12 Master-Slave bus

A master-slave bus is provided on the rear side of the units, which enables the master units to control the slave via the included standard CAT5 cables. The bus configuration is in permanent use and must not be modified, unless single slave units are temporarily removed from the cabinet for repair or maintenance purposes. In these situations it may be required to activate the bus termination feature, at least when the master unit reports bus problems and missing slave(s).

> ⚠️
> The master-slave bus must not be connected to units outside of the cabinet!

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 25

2. Installation & commissioning

2.1 Transport and storage

2.1.1 Transport

- The handles on the front side of the units aren**'t** for carrying, but only for insertion into or removal from the cabinet!
- Because of the weight of the units, 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 output terminal, rotary knobs).
- Do not move the cabinet when switched on or connected!
- The cabinet must only be operated on horizontal surfaces which are capable of carrying the total weight of the cabinet plus at least a few persons who are operating it
- In case the cabinet is going to be moved to a different location, make sure for the entire way that the carrying capacity of the ground and possible elevators is sufficient as well the cabinet is secured against tipping and rolling off
- Use suitable safety clothing, especially safety shoes, when carrying the equipment, as due to the weight of an unit or the entire cabinet a drop can have serious consequences.

2.1.2 Storage

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

2.2 Unpacking and visual check

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

2.3 Installation

2.3.1 Safety procedures before installation and use

- The cabinet has a considerable weight. Therefore the proposed location of the equipment, as well as the entire way of transport must be able to support the weight without restriction.
- After putting the cabinet into final position it's recommend to secure it against rolling off by unscrewing the retractable pedestals
- Before connecting to the mains ensure that the supply voltage is as shown on the product label. Overvoltage on the AC supply can cause equipment damage.

2.3.2 Preparation

For the AC supply connection of the cabinet several things are required:

- A 4-wire three-phase cable with suitable length and sufficient cross section. Such a cable isn't included in the delivery. See below for recommendations about cable types, cross sections and stripping lengths.
- The external connection point has to fused according the to AC ratings of the cabinet. See below for recommendations about fuse types and fuse values.

For the DC side connection to the load suitable cables have to be made which aren't included in the delivery.

Dimensioning of the DC wiring to the load/consumer has to reflect the following:

- The cable cross section should always be specified for at least the maximum current of the device.
- Continuous operation at the approved limit generates heat which must be removed, as well as voltage loss which depends on cable length and heating. To compensate for these the cable cross section should be increased and the cable length reduced. It's furthermore recommended to select and used cables with high temperature specification (105°C and up).
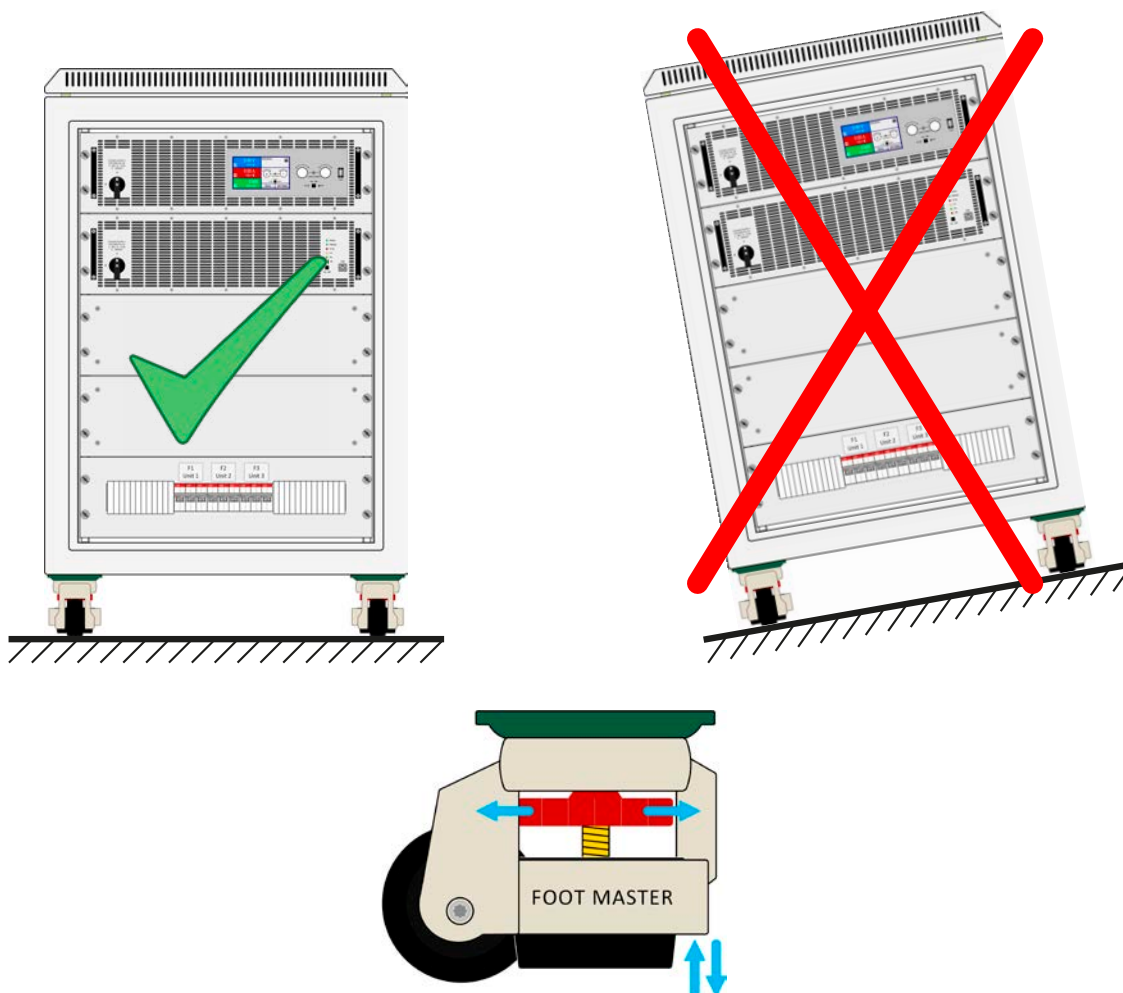
EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 26

2.3.3   Installing the device

> ⚠️
> - Select the location for the device so that the connection to the load is as short as possible
> - Leave sufficient space behind the equipment for ventilation, at least 50 cm
> - For models with installed emergency off switch (optional, see *1.9.5*) it's required to leave an additional space of at least 30 cm on top of the cabinet

The cabinet must only be installed and operated on horizontal grounds. Even when secured against rolling off it could start sliding when being installed on a slanting ground.

It's recommended to secure the cabinet against rolling off **after** transport to the target location and **before** starting to connect any wiring. It can be done by unscrewing the pedestals in the wheels.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 27

2.3.4   Connection to AC supply

> ⚠️
> - Connection to an AC mains supply must only be carried out by qualified personnel!
> - Cable cross section must be suitable for the maximum input current of the device (see table below)!
> - Before plugging in the input plug ensure that the device is switched off by its mains switch!

The cabinet is delivered with a 4 pole screw terminal to connect the AC supply. The terminal is accessible from the rear side. When connecting it to a 3-phase supply via suitable cables, it has to be wired according to the labelling printed onto the terminal. Required for the mains connection are following phases:

Power rating	Phases	Supply type
all	L1, L2, L3, PE	Three-phase

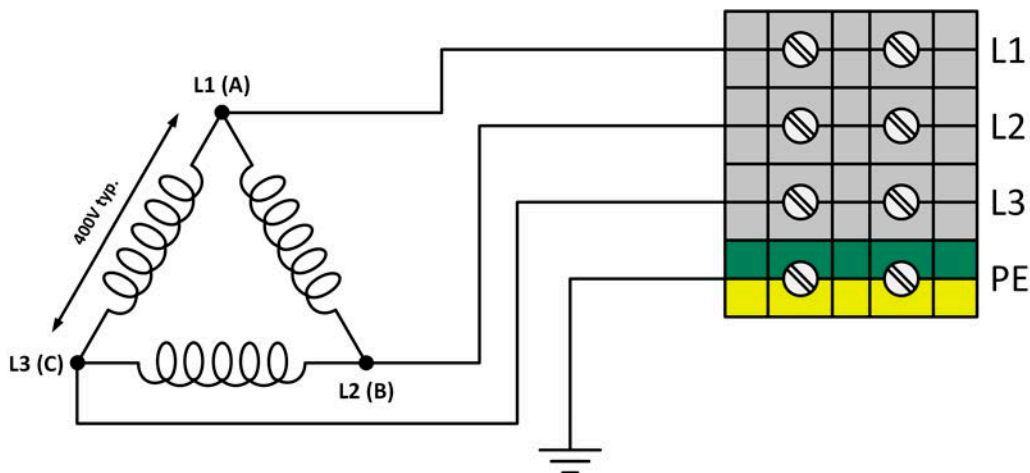> ⚠️   **The PE conductor is imperative and must always be wired!**

For the sizing of wiring **cross section,** the power rating resp. rated max. input of the cable and the cable length are decisive. The table below lists the maximum input current, the recommended minimum cross section per lead (standard cables) for a length of up to 5 m and an ambient temperature up to 30°C, as well as the required external fusing. The phase current is balanced with all models in this series.

Based on the connection of a **single cabinet**:

| Power rating | I_{max} | Cross sections | | Stripping length | External fusing | |
		Clamp spec.	Rec'd cable		Value	Type
30 kW	3x 56 A	0.75 - 35 mm²	10 mm²	16 mm	3x 63 A	Circuit breaker (C or K), NH fuse
45 kW	3x 84 A	0.75 - 35 mm²	25 mm²	16 mm	3x 100 A	NH fuse
60 kW	3x 112 A	35 - 95 mm²	35 mm² (*	33 mm	3x 120 A	NH fuse
75 kW	3x 140 A	35 - 95 mm²	50 mm²	33 mm	3x 160 A	NH fuse
90 kW	3x 168 A	35 - 95 mm²	70 mm²	33 mm	3x 200 A	NH fuse

(* Must not be less, because this is also the minimum allowed cross section for the terminal

Connection scheme:

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 28

2.3.5 Connection to DC loads

⚠️ Connection to transformerless DC-AC inverters (for example solar inverters) is restricted, because the inverter can shift the potential of negative output (DC-) against PE (ground). Refer to section „*1.8.3. Technical specifications*" for the allowed max. potential shift.

The DC output is located on the rear side of the cabinet and isn't protected by any kind of fuse. The cross section of the connection cables is determined by the current consumption, cable length and ambient temperature.

For cables **up to 5 m** of length and an average ambient temperature **up to 30°C** we recommend cross sections **per DC pole** (multi-conductor, insulated, openly suspended, standard cable) as listed in the table below. For longer cables or higher ambient temperatures the cross section must be increased accordingly in order to avoid high voltage loss and overheating.

The cables are usually crimped with ring lugs and are tightened to the connection point at the lower end of the DC bus bars. The mounting hole diameter of the ring lug should match the one of the connection point. This restricts the number of applicable cable cross sections, for example because a M8 ring lug can take a max. of 95 mm² or 150 mm², depending on the manufacturer of the ring lug. The number of cables which are required increases when using a smaller cross section per cable, but the cables also become better manageable.

Rated power	I_{Max}	Connection points	Minimum required cross section <u>per</u> DC pole
30 kW	60 A	3x M8	1x 10 mm²
	80 A	3x M8	1x 16 mm²
	120 A	3x M8	1x 35 mm² or 2x 16 mm²
	180 A	3x M8	1x 70 mm² or 2x 25 mm²
	240 A	6x M10	1x 95 mm² or 2x 35 mm²
	420 A	6x M10	2x 70 mm² or 3x 50 mm²
	1020 A	6x M10	4x 95 mm² or 6x 50 mm²
45 kW	90 A	3x M8	1x 25 mm²
	120 A	3x M8	1x 35 mm² or 2x 16 mm²
	180 A	3x M8	1x 70 mm² or 2x 25 mm²
	270 A	3x M8	2x 50 mm² or 3x 25 mm²
	360 A	6x M10	2x 70 mm² or 3x 35 mm²
	630 A	6x M10	2x 150 mm² or 3x 70 mm²
	1530 A	6x M10	5x 120 mm² or 6x 95 mm²
60 kW	120 A	3x M8	1x 35 mm² or 2x 16 mm²
	160 A	3x M8	1x 70 mm² or 2x 25 mm²
	240 A	3x M8	1x 95 mm² or 2x 35 mm²
	360 A	3x M8	2x 70 mm² or 3x 35 mm²
	480 A	6x M10	2x 95 mm² or 3x 50 mm²
	840 A	6x M10	3x 120 mm² or 4x 95 mm²
	2040 A	6x M10	6x 150 mm² or 8x 95 mm²
75 kW	150 A	3x M8	1x 50 mm² or 2x 16 mm²
	200 A	3x M8	1x 70 mm² or 2x 25 mm²
	300 A	3x M8	2x 50 mm² or 3x 25 mm²
	450 A	3x M8	2x 95 mm² or 3x 50 mm²
	600 A	6x M10	2x 150 mm² or 3x 70 mm²
	1050 A	6x M10	4x 120 mm² or 6x 50 mm²
	2550 A	6x M10	8x 150 mm² or 10x 95 mm²
90 kW	180 A	3x M8	1x 70 mm² or 2x 25 mm²
	240 A	3x M8	1x 95 mm² or 2x 35 mm²
	360 A	3x M8	2x 70 mm² or 3x 35 mm²
	540 A	3x M8	2x 120 mm² or 3x 70 mm²
	720 A	6x M10	3x 95 mm² or 4x 70 mm²
	1260 A	6x M10	4x 150 mm² or 6x 70 mm²
	3060 A	6x M10	10x 150 mm² or copper bar with min. 720 mm²

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 29

2.3.5.1 Connection points

Every cabinet has bus bars on the DC output, which have 3 or 6 connection points on their lower end. Each connection point can be used to screw one or two cables. The table in section *2.3.5* lists the number and size of the connection points for every rated output current and power. The connection points as seen from the side:
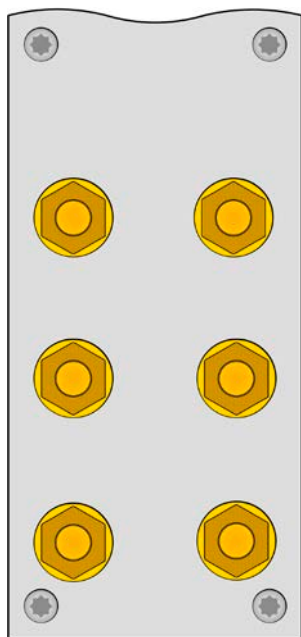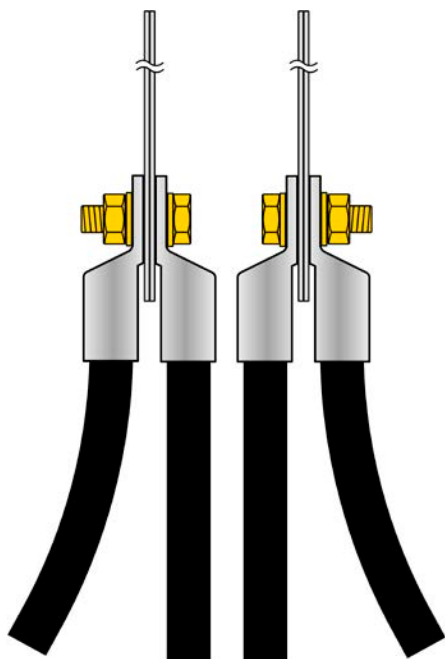

6x M10 for up to 12 cables

3x M8 for up to 6 cables

Connection example for two cables on one connection point with M10 ring lugs for 150 mm² cables:

⚠	The included cover for the DC output bars must always be installed when operating the cabinet, no matter if the rear door is closed or not!

⚠	The copper bars can become very hot, especially with models rated for high currents. This is mostly due the bars being positioned in the warm or hot stream of air exhausted on the rear of the units. This heat submits to the DC cables and can lead to damage or even dissolution of the sheathing. It's thus recommend to use cables with higher temperature capability, such as ones for 105°C.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 30

2.3.6 Grounding of the DC output

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

Because of insulation, there is a max. allowed potential shift of the DC output poles, which also depends on the device model. Refer to *"1.8.3. Technical specifications"* for details.

2.3.7 Connecting the "Share" bus

The "Share" bus on the rear side is intended to balance the current of the units in the cabinet and must not be removed, unless a unit is going to be removed for repair or maintenance purposes. The cover which is mounted on top of the connectors "Sense" and "Share" with some models must always be thoroughly installed.

In case of adding a unit or two, where possible, in order to extend the total power, the Share bus must extended.

2.3.8 Connection of remote sense

Though every unit in the cabinet has a "Sense" connector, remote sensing when being used is only wired to the master unit. This unit is responsible for the voltage regulation and remote sensing compensation in constant voltage operation. It forwards the regulation signal to the slave units via the Share bus.

⚠️	• Both pins „NC" of the Sense connector must not be wired! • With models of 750 V or higher voltage rating, the included cover for the terminals Sense and Share has to be mounted all the time and the cables used for sensing must have a suitable electric strength!

| ❗	• *Remote sensing is only effective during constant voltage operation (CV) and for other regulation modes the sense input should be disconnected, if possible, because connecting it generally increases the oscillation tendency.* • *The cross section of the sense cables is noncritical. Recommendation for cables up to 5 m: use at least 0.5 mm²* • *Sense cables should be twisted and laid close to the DC cables to damp oscillation. If necessary, an additional capacitor should be installed at the load/consumer to eliminate oscillation* • *The + sense cables must be connected to + on the load and - sense to - at the load, otherwise the sense input of the power supply can be damaged. For an example see Figure 8 below.*
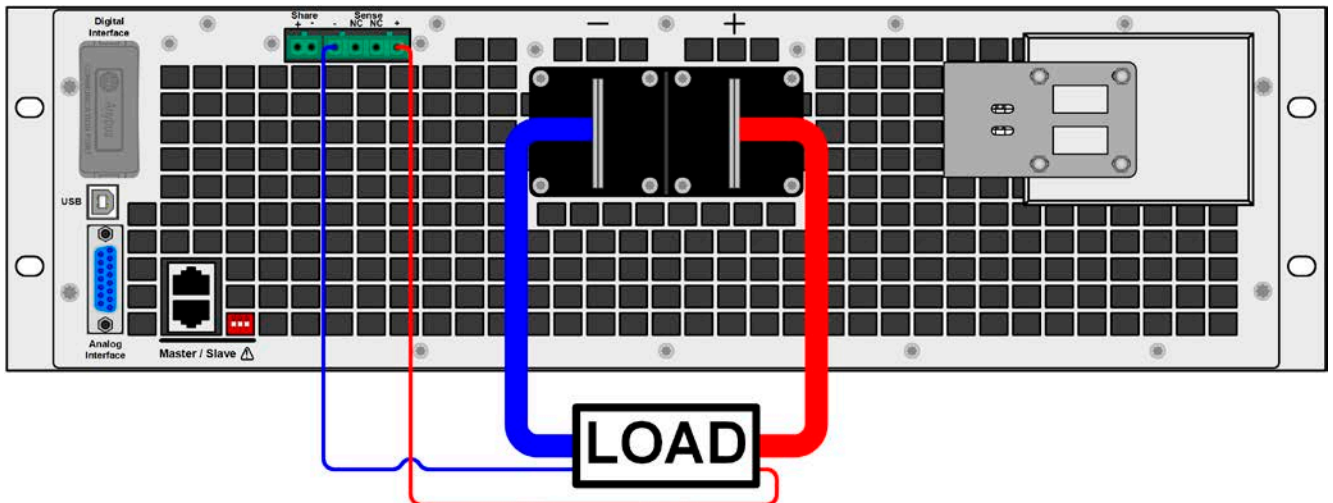
Figure 8 - Principle of remote sensing wiring on the master unit

2.3.9 Installation of an interface module

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

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

Installation steps:

1.
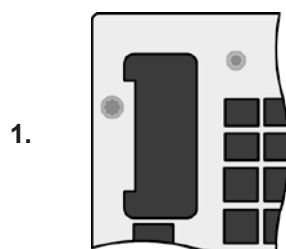
Remove the slot cover. If needed use a screw driver.

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

2.
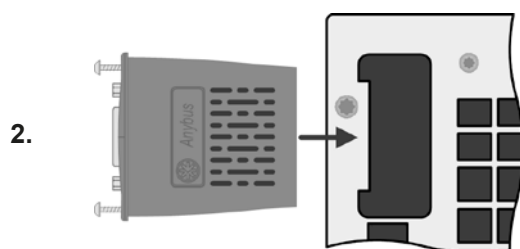
Insert the interface module into the slot. The shape ensures correct alignment.

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

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

3.
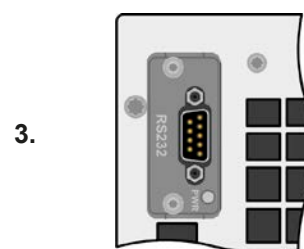
The screws (Torx 8) are provided for fixing the module and should be fully screwed in. After installation, the module is ready for use and can be connected.

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

2.3.10 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) and a standard plug are necessary (not included in the scope of delivery). It's generally advisable to switch the device completely off before connecting or disconnecting this connector, but at least the DC output.

> ⚠️ 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 output 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 master unit to a PC using the included USB cable and switch the device on. The USB ports on the slave units are only for service purposes, such as firmware updates.

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 try to install a driver. The required driver is for a Communication Device Class (CDC) device and is usually integrated in current operating systems such as Windows 7 or 10. But it's strongly recommended to use the included driver installer (on USB stick) to gain maximum compatibility of the device to our softwares.

2.3.11.2 Driver installation (Linux, MacOS)

We can't provide drivers or installation instructions for these operating systems. Whether a suitable driver is available is best carried out by searching the Internet. Newer versions of Linux or MacOS may already include a suitable CDC driver.

2.3.11.3 Alternative drivers

In case the CDC driver described above isn't 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".

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 32

2.3.12   Initial commission

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

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

2.3.14   Removing units

In case of a defect of a slave unit it's possible for the cabinet to continue running with the remaining units. In order to remove an unit for repair or to replace it, a certain procedure is required (see below). After that and when powering the cabinet again, the master unit will automatically detect the altered configuration and present itself accordingly in the display or to remote control software. With the standard configuration being temporarily unavailable, the rated current and power of the cabinet are reduced, as well as the device name will change according to the product key as described in *1.5*.

Following steps are to perform to remove a slave unit:

1. Power off the cabinet with an external main switch or by switching off all units with their rotary mains switch on the front.
2. For the unit going to be removed:
    a. Remove the strain relief (strap) from the AC supply cable.
    b. Loosen the fixture that fixes the AC input connector plug.
    c. Remove the AC connector plug.
    d. Remove the plug from connector "Share". If master unit: remove plug from connector "Sense", if being used.
    e. Remove the patch cable or both, if unit is in the middle, from the master-slave bus connectors. Later, for the operation of the cabinet without the removed unit, the bus must be connected again from the upper to the lower unit by using a longer cable.
    f. If master unit: remove any other possibly connected cable from the digital or analog
    g. Loosen the nuts/bolts on the DC output and remove them (2-6 pieces). Before doing so make sure that the DC output doesn't have dangerous voltage anymore, probably by checking it with a multimeter.
    h. Remove the screws on the front (4x).
    i. Carefully and slowly retract the unit from the cabinet.

2.3.15   Inserting units

The procedure of inserting units again is the same like when removing an unit, only vice versa. See steps described in *„2.3.14. Removing units“*. Before going to insert an unit make sure the cabinet is completely switched off or better, disconnected from AC supply.

2.3.16   Adding further units

Some models have one or two spare positions for further slave units to install later in order to extend the total power. The slave units can be purchased and delivered separately and installed on location. See *„1.9.4. Accessories“* for details. There are a few things to consider before extending the cabinet:

- When installing one or two additional slaves, the previous cabinet configuration will be modified regarding total current, total power and the device name. The ratings as printed on the type label will become invalid. Actually, even the article number isn't valid anymore. This doesn't affect operation, but in cases of seeking support or returning a cabinet for repair, it's an important detail
- Existing cables on the AC and DC side would have to be replaced by bigger ones matching the higher current
- The slave units to add must be of the same model as the already existing slave units
- Depending on the resulting current after the installation of additional units, further bars on the DC bus have to be installed. Contact us so we can assemble the correct set for you.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 33

Adding a unit follows the same procedure as described in *2.3.14* and *.2.3.15.* Following base configurations can be extended:

Power rating before	Type	Free slots	Power rating after	Current rating after
30 kW	15U	1	45 kW	1,5 x nominal current before
45 kW	15U	-	-	-
60 kW	24U	2	75 kW	1, 25 x nominal current before
			90 kW	1,5 x nominal current before
75 kW	24U	1	90 kW	1,2 x nominal current before
90 kW	24U	-	-	-

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 34

3. Operation and application

3.1 Personal safety

⚠️
- In order to guarantee safety when using the device, it's essential that only persons operate the device who are fully acquainted and trained in the required safety measures to be taken when working with dangerous electrical voltages
- For models which can generate a voltage which is dangerous by contact, or is connected to such, the included DC terminal cover or an equivalent must always be used
- Whenever the load and DC output are being re-configured, the device should be disconnected from the mains, not only the DC output switched off!

3.2 Operating modes

A power supply is internally controlled by different control circuits, which shall regulate voltage, current and power to the adjusted values and hold them constant, if possible. These circuits follow typical laws of control systems engineering, resulting in different operating modes. Each operating mode has its own characteristics which are explained below in short form.

ⓘ
- *Unloaded operation isn't considered as a normal operation mode and can thus lead to false measurements, for example when calibrating the device*
- *The optimal working point of the device is between 50% and 100% voltage or current*
- *It's recommended to not run the device below 10% voltage and current, in order to meet technical values like ripple or transient times*

3.2.1 Voltage regulation / Constant voltage

Voltage regulation is also called constant voltage operation (CV).

The DC output voltage of a power supply is held constant on the adjusted value, unless the output current or the output power according to $P = U_{OUT} * I_{OUT}$ reaches the adjusted current or power limit. In both cases the device will automatically change to constant current or constant power operation, whatever occurs first. Then the output voltage can't be held constant anymore and will sink to a value resulting from Ohm's law.

While the DC output is switched on and constant voltage mode is active, then the condition "CV mode active" will be indicated on the graphic display by the abbreviation CV and this message will be passed as a signal to the analog interface, as well stored as status which can also be read as a status message via digital interface.

3.2.1.1 Transient time after load step

For constant voltage mode (CV), the technical date "Transient time after load step" (see *1.8.3*) defines a time that is required by the internal voltage regulator of the device to settle the output voltage after a load step. Negative load steps, i.e. high load to lower load, will cause the output voltage to overshoot for a short time until compensated by the voltage regulator. The same occurs with a positive load step, i.e. low load to high load. There the output collapses for a moment. The amplitude of the overshoot resp. collapse depends on the device model, the currently adjusted output voltage and the capacity on the DC output and can thus not be stated with a specific value.

Depictions:
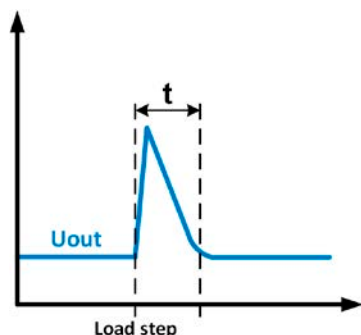
Example for neg. load step: the DC output will rise above the adjusted value for a short time. t = transient time to settle the output voltage.
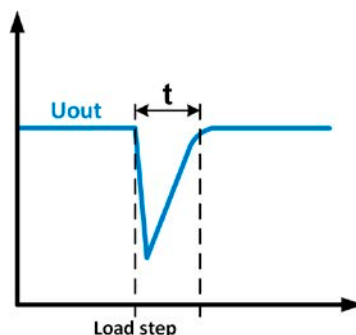
Example for pos. load step: the DC output will collapse below the adjusted value for a short time. t = transient time to settle the output voltage.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 35

3.2.2 Current regulation / constant current / current limiting

Current regulation is also known as current limiting or constant current mode (CC).

The DC output current is held constant by the power supply, once the output current to the load reaches the adjusted limit. Then the power supply automatically switches to CC. The current flowing from the power supply is determined by the output voltage and the load's true resistance. As long as the output current is lower than the adjusted current limit, the device will be either in constant voltage or constant power mode. If, however, the power consumption reaches the set maximum power value, the device will switch automatically to power limiting and sets the output current according to $I_{MAX} = P_{SET} / U_{IN}$, even if the maximum current value is higher. The current set value, as determined by the user, is only an upper limit.

While the DC output is switched on and constant current mode is active, then the condition "CC mode active" will be indicated on the graphic display by the abbreviation CC and this message will be passed as a signal to the analog interface, as well stored as status which can also be read as a status message via digital interface.

3.2.3 Power regulation / constant power / power limiting

Power regulation, also known as power limiting or constant power (CP), keeps the DC output power of a power supply constant if the current flowing to the load in relation to the output voltage and the resistance of the load reaches the adjusted value according to $P = U * I$ resp. $P = U^2 / R$. The power limiting then regulates the output current according to $I = sqr(P / R)$, where R is the load's resistance.

Power limiting operates according to the auto-range principle such that at lower output voltages higher current flows and vice versa in order to maintain constant power within the range P_N (see diagram to the right).
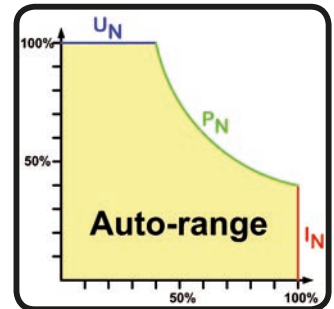
While the DC output is switched on and constant power mode is active, then the condition "CP mode active" will be shown on the graphic display by the abbreviation CP, as well stored as status which can also be read as a status message via digital interface.

> *When using remote sensing, the power supply can deliver a higher voltage on the DC output than adjusted, which results in additional power and may also cause the device to enter power limitation without explicitly indicating "CP" in the display.*

3.2.4 Internal resistance regulation

Internal resistance control (abbr. CR) of power supplies is the simulation of a virtual internal resistor which is in series to the voltage source and thus also in series to the load. According to Ohm's law, this causes a voltage drop which will result in a difference between the adjusted output voltage and the actual output voltage. This will work in constant current mode as well as in constant power mode, but here the output voltage will differ even more from the adjusted voltage, because then constant voltage isn't active.

The adjustable resistance range of a particular model is given in the technical specifications. The voltage setting in dependency of the resistance set value and the output current is done by calculation of a fast FPGA microcontroller, being only a little slower than other controllers inside the control circuit. Clarification:

$$U_{Act} = U_{Set} - I_{Act} * R_{Set} \Big|^{P_{Set}, I_{Set}}$$

$$P_{Ri} = (U_{Set} - U_{Act}) * I_{Act}$$
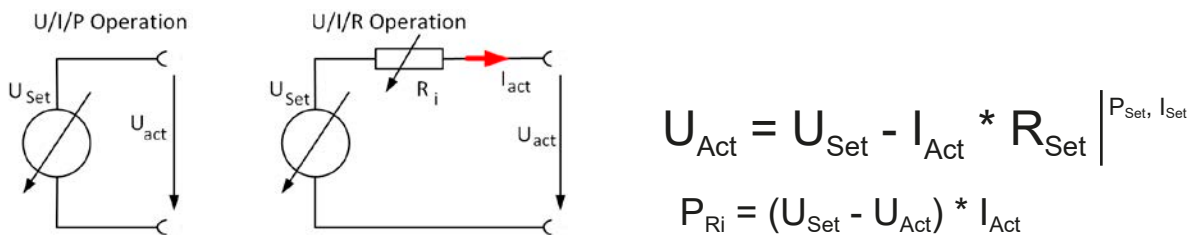
> *With resistance mode being activated the function generator will be unavailable and the actual power value provided by the device doesn't include the power dissipation of Ri.*

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 36

3.3   Alarm conditions

> *This section only gives an overview about device alarms. What to do in case your device indicates an alarm condition is described in section „3.6. Alarms and monitoring".*

As a basic principle, all alarm conditions are signalled optically (text + message in the display), acoustically (if activated) and as a readable status and alarm counter via the digital interface. In addition, the alarms OT, PF and OVP are reported as signals on the analogue interface. For later acquisition, an alarm counter can be read from the display or via digital interface.

3.3.1   Power Fail

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

- AC input voltage too low (mains undervoltage, mains failure)
- Defect in the input circuit (PFC)
- Not all required AC input phases are connected (see *„2.3.4. Connection to AC supply"* for requirements)

As soon as a power fail occurs, the device will stop to supply power and switch off the DC output. In case the power fail was an undervoltage and is gone later on, the alarm will vanish from display and doesn't require to be acknowledged. The condition of the DC output after a PF alarm during normal operation can be set up. See *„3.4.3. Configuration via MENU"*.

> *Switching off the device by the mains switch can't be distinguished from a mains blackout and thus the device will signalize a PF alarm every time the device is switched off. This can be ignored.*

3.3.2   Overtemperature

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

3.3.3   Overvoltage protection

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

- the power supply itself, as a voltage source, generates an output voltage higher than set for the overvoltage alarm limit (OVP, 0...110% U_{Nom}) or the connected load somehow returns voltage higher than set for the overvoltage alarm threshold.
- the OV threshold has been adjusted too close above the output voltage. If the device is in CC mode and if it then experiences a negative load step, it will make the voltage rise quickly, resulting in a voltage overshoot for a short moment which can already trigger the OVP.

This function's purpose is to warn the user of the power supply acoustically or optically that the device probably has generated an excessive voltage which could damage the connected load application.

> • The device isn't fitted with protection from external overvoltage
> • The changeover from operation modes CC -> CV can generate voltage overshoots

3.3.4   Overcurrent protection

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

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

This function serves to protect the connected load application so that this isn't overloaded and possibly damaged due to an excessive current.

3.3.5   Overpower protection

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

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

This function serves to protect the connected load application so that this isn't overloaded and possibly damaged due to an excessive power consumption.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 37

3.4 Manual operation

3.4.1 Switching on the device

The power supply cabinets of this series are master-slave systems with one master unit and up to 5 slave units. In order for the master to find and initialise the slaves the fastest way after powering the cabinet, it should be powered last. **Recommendation: power the units in the cabinet from bottom to top, one by one.**

After switching on, the display will first show some device related information (model, firmware versions etc.) and then a language selection screen for 3 seconds. A few seconds later it will show the main screen with the pop-up from the master-slave init.

In the setup (see section „*3.4.3. Configuration via MENU"*) in the second level menu **General settings** is an option **DC output after power ON** in which the user can determine the condition of the DC output after power-up. Factory setting here is **OFF**, meaning that the DC output after power-up will remain switched off. **Restore** means that the last condition of the DC output will be restored, either on or off. All set values are always saved and restored.

> ⓘ *For the time of the start phase the analog interface can signal undefined statuses on the output pins such as ALARMS 1. Those signal must be ignored until the device has finished booting and is ready to work.*

> ⓘ *It's allowed to power a lesser number of slave units or just the master unit if the demand for power with the current application is lower than what the cabinet can bring. Every unit can provide 15 kW. The master unit automatically detects the situation.*

3.4.2 Switching off the device

On switch-off the last output condition and the most recent set values are saved. Furthermore, a PF alarm (power failure) will be reported, but can be ignored. The DC output 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.

Due to the master-slave configuration of the cabinet it's recommended to switch off the master first.

Recommendation: switch off the units in the cabinet from top to bottom, one by one.

3.4.3 Configuration via MENU

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

If the DC output is switched on the settings menu won't be shown, only status information.

Menu navigation is by finger touch. Values are set using the rotary knobs. The assignment of the knobs to the adjustable values isn't indicated in menu pages, but there is an assignment rule: upper value -> left-hand knob, lower values -> right-hand knob.
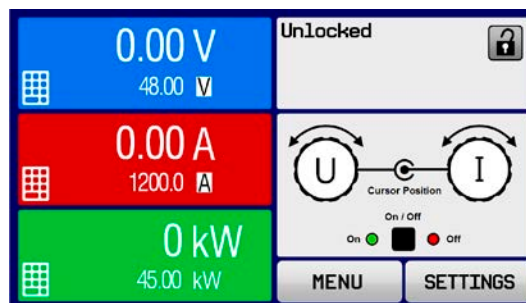
Some setting parameters are self-explanatory, others aren't. The latter will be explained on the pages following.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 38

3.4.3.1 Menu "General Settings"

Setting	Description
Allow remote control	Selection "**NO**" means that the device can't be remotely controlled over either the digital or analog interfaces. If remote control isn't allowed, the status will be shown as "**Local**" in the status area on the main display. See also section *1.9.6.1*
Analog interface range	Selects the voltage range for the analog set values, actual output values and reference voltage output. • **0...5 V** = Range is 0...100% set /actual values, reference voltage 5 V • **0...10 V** = Range is 0...100% set /actual values, reference voltage 10 V See also section *„3.5.4. Remote control via the analog interface (AI)"*
Analog interface Rem-SB	Selects how the input pin REM-SB of the analog interface shall be working regarding levels (see *„3.5.4.4. Analog interface specification"*) and logic: • **Normal** = Levels and function as described in the table in *3.5.4.4* • **Inverted** = Levels and function will be inverted Also see *„3.5.4.7. Application examples"*
Analog Rem-SB action	Selects the action on the DC output that is initiated when changing the level of analog pin REM-SB: • **DC OFF** = the pin can only be used to switch the DC output off • **DC ON/OFF** = the pin can be used to switch the DC output off and on again, if it has been switched on before at least once from a different control location
Analog interface pin 6	Pin 6 of the analog interface (see section *3.5.4.4*) is by default assigned to only signal the device alarms OT and PF. This parameter allows to also enable signaling only one of both (3 possible combinations): • **Alarm OT** = Enable/disable signaling of alarm OT on pin 6 • **Alarm PF** = Enable/disable signaling of alarm PF on pin 6
Analog interface pin 14	Pin 14 of the analog interface (see section *3.5.4.4*) is by default assigned to only signal the device alarm OVP. This parameter allows to also enable signalling further device alarms (7 possible combinations): • **Alarm OVP** = Enable/disable signaling of alarm OVP on pin 14 • **Alarm OCP** = Enable/disable signaling of alarm OCP on pin 14 • **Alarm OPP** = Enable/disable signaling of alarm OPP on pin 14
Analog interface pin 15	Pin 15 of the analog interface (see section *3.5.4.4*) is by default assigned to only signal the regulation mode CV. This parameter allows to enable signalling a different device status (2 options): • **Regulation mode** = Enable/disable signaling of CV reg mode on pin 15 • **DC status** = Enable/disable signaling of DC terminal status on pin 15
DC output after OT alarm	Determines how the DC output shall react after an overtemperature alarm has occurred and the unit or units have cooled down again: • **OFF** = DC output will be switched off and remain until user action • **AUTO** = The DC output of the system will switch on again if it was switched on before the alarm occurred
DC output after power ON	Determines the condition of the DC output after power-up. • **OFF** = DC output is always off after switching on the device. • **Restore** = DC output condition will be restored to the condition prior to switch off.
DC output after PF alarm	Determines how the DC output shall react after a power fail (PF) alarm has occurred: • **OFF** = DC output will be switched off and remain until user action • **AUTO** = DC output will switch on again after the PF alarm cause is gone and if it was switched on before the alarm occurred

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 39

Setting	Description
DC output after remote	Determines the condition of the DC output after leaving remote control either manually or by command. • **OFF** = DC output will be always off when switching from remote to manual • **AUTO** = DC output will keep the last condition
Enable R mode	Activates the internal resistance control with **Yes** or deactivates it with **No**. If activated, the resistance set value of the simulated internal resistor can be adjusted additionally to the other set values. For details refer to „*3.2.4. Internal resistance regulation*"
USB decimal point format	Switches the decimal point format of values and also the CSV decimal point and column separator for USB logging (also see *1.9.6.5* and *3.4.10*), as well as for other features where a CSV file can be loaded **US** = Comma separator (US standard for CSV files) **Default** = Semicolon separator (german/european standard for CSV files)
USB logging with units (V,A,W)	CSV files generated from USB logging by default add physical units to values. This can be deactivated by setting this option to **No**
Calibrate device	Touch area **Start** starts a calibration routine (see „*5.3. Calibration*"), but only if the device is in U/I or U/P mode.
Reset device to defaults	Touch area **Start** will initiate a reset of all settings (HMI, profile etc.) to factory default, as shown in the menu structure diagrams on the previous pages
Restart device	Will initiate a warm start of the device
Master-slave mode	Selecting **OFF** disables the master-slave mode (MS) in which the cabinet is running by default. Since the MS mode is essential for this type of power supply device, this setting should never be altered.
Repeat master init.	Touch area **Initialize** will repeat the initialization of the master-slave system in case the automatic enumeration of the slave units by the master is once unsuccessful so the system would have less total power than expected or has to be repeated manually in case the master unit couldn't detect a missing slave

3.4.3.2   Menu "User Events"

See „*3.6.2.1 User defined events*" on page 54.

3.4.3.3   Menu "Profiles"

See „*3.9 Loading and saving an user profile*" on page 56.

3.4.3.4   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 settings limits. These can only be displayed, not changed.

3.4.3.5   Menu "About HW, SW..."

This menu page displays an overview of device relevant data such as serial number, article number etc., as well as an alarm history which lists the number of device alarms that probably occurred since the device has been powered.

3.4.3.6   Menu "Function Generator"

See „*3.10 The function generator*" on page 57.

3.4.3.7   Menu "Communication"

This sub menu offers settings for digital communication via the optional or built-in interface. The touch area for the installed interface module opens one or more settings pages, depending on the interface type. There are furthermore adjustable communication timeout settings, of which the one for USB can make it possible to successfully transfer fragmented messages using higher values. In the screen for **Com Protocols** it's possible to enable both or disable one of the two supported communication protocols, ModBus and SCPI. This can help to avoid mixing both protocols and to receive unreadable messages, for example when expecting a SCPI response and getting a ModBus response instead.

> For all Ethernet interfaces with two ports: „P1" is related to port 1 and „P2" to port 2, like printed on the module face. The two ports share the same IP.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 40

IF	Level 1	Level 2	Level 3	Description
Ethernet / ModBus-TCP, 1 & 2 Port	IP Settings 1	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 item "Manual"
		Manual	IP address	This option is activated by default. An IP address can be manually allocated.
			Gateway	Here a gateway address can be allocated if required..
			Subnet mask	Here a subnet mask can be defined if the default subnet mask isn't suitable.
		DNS address 1 DNS address 2		Here the addresses of the first and second Domain Name Servers (DNS) can be defined, if needed.
		Port		Range: 0...65535. Default ports: **5025** = Modbus RTU (all Ethernet interfaces) Reserved ports which must not be set with this parameter: **502** = Modbus TCP (Modbus-TCP interface only) other typical reserved ports
	IP Settings 2-P1 IP Settings 2-P2	AUTO		Settings for the Ethernet port such as transmission speed are set automatically.
		Manual	Half duplex	Manual selection for transmission speed (10MBit/100MBit) and duplex mode (full/half). It's recommended to use the "AUTO" option and only revert to "Manual" if these parameters fail.
			Full duplex	
			10MBit	
			100MBit	
	Host name			Free choice of host name (default: Client)
	Domain name			Free choice of Domain (default: Workgroup)
	TCP Keep-Alive	Enable TCP keep-alive		

IF	Level 1	Description
Profinet/IO, 1 & 2 Port	Function Tag	String input box for an user-definable text which describes the Profinet slave function tag. Max. length: 32 characters
	Location Tag	String input box for an user-definable text which describes the Profinet slave location tag. Max. length: 22 characters
	Station Name	String input box for an user-definable text which describes the Profinet station name. Max. length: 200 characters
	Description	String input box for an user-definable text which describes the Profibus slave. Max. length: 54 characters
	Installation Date	String input box for an user-definable text which describes the Profibus slave installation date tag. Max. length: 40 characters

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 an user-definable text which describes the Profibus slave function tag. Max. length: 32 characters
	Location Tag	String input box for an user-definable text which describes the Profibus slave location tag. Max. length: 22 characters
	Installation Date	String input box for an user-definable text which describes the Profibus slave installation date tag. Max. length: 40 characters
	Description	String input box for an user-definable text which describes the Profibus slave. Max. length: 54 characters

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 41

IF	Ebene 1	Level 2	Level 3	Description
CAN	Base ID			Setup of the CAN base ID (11 Bit or 29 Bit, hex format). Default: **0h**
	Baud Rate			Setup of the CAN bus speed or baud rate in typical value between 10 kbps and 1Mbps. Default: **500 kbps**
	Termination			Activates or deactivates CAN bus termination with a built-in resistor. Default: **OFF**
	Broadcast ID			Setup of the CAN broadcast ID (11 Bit or 29 Bit, hex format). Default: **7ffh**
	ID Format			Selection of the CAN ID format between **Base** (11 Bit ID, 0h...7ffh) and **Extended** (29 Bit, 0h...1fffffffh)
	Cyclic Communication	Base ID Cyclic Read		Setup of the CAN base ID (11 Bit or 29 Bit, hex format) for cyclic read of up to 5 object groups (see "**Cyclic Read Timing**"). The device will automatically send specific object data to the IDs defined with this setting. For more information refer to the programming guide. Default: **100h**
		Base ID Cyclic Send		Setup of the CAN base ID (11 Bit or 29 Bit, hex format) for cyclic send of the three set values for U, I and P along with status in one single message. For more information refer to the programming guide. Default: **200h**
		Cyclic Read Timing	Status	Activation/deactivation and time setting for the cyclic read of status to the adjusted „**Base ID Cyclic Read + 1**" Range: 20...5000 ms. Default: 0 (deactivated)
			Actual val.	Activation/deactivation and time setting for the cyclic read of actual values to the adjusted „**Base ID Cyclic Read + 2**" Range: 20...5000 ms. Default: 0 (deactivated)
			Set val.	Activation/deactivation and time setting for the cyclic read of set values of U & I to the adjusted „**Base ID Cyclic Read + 3**" Range: 20...5000 ms. Default: 0 (deactivated)
			Limits 1	Activation/deactivation and time setting for the cyclic read of adjustment limits of P & R to the adjusted „**Base ID Cyclic Read + 4**" Range: 20...5000 ms. Default: 0 (deactivated)
			Limits 2	Activation/deactivation and time setting for the cyclic read of adjustment limits of P & R to the adjusted „**Base ID Cyclic Read + 4**"
	Data Length			Determines the DLC (data length) of all messages sent from the device. **AUTO** = length varies between 3 and 8 bytes, depending on object **Always 8 Bytes** = length is always 8, filled up with zeros

IF	Level 1	Level 2	Description
CANopen	Node Address		Selection of the CANopen node address in the range 1...127
	Baud Rate	AUTO	Automatic detection of the bus baud rate or 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: 10 kbps, 20 kbps, 50 kbps, 100 kbps, 125 kbps, 250 kbps, 500 kbps, 800 kbps, 1Mbps (1Mbps = 1 Mbit/s, 10 kbps = 10 kbit/s)

IF	Level 1	Description
RS232	-	The baud rate is selectable, other serial settings can't be changed and are defined like this: 8 data bits, 1 stop bit, parity = none. Baud rates: 2400, 4800, 9600, 19200, 38400, 57600, 115200

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 42

Element	Description
Com Timeout	**Timeout USB/RS232** (in milliseconds) Default value: 5, Range: 5...65535 Defines the max. time between two subsequent bytes or blocks of a transferred message. For more information about the timeout refer to the external programming documentation "Programming Guide ModBus & SCPI". **Timeout ETH** (in seconds) Default value: 5, Range: 5...65535 If there was no communication between the controlling unit (PC, PLC etc.) and the device for the adjusted time, the device will close the socket connection. The timeout becomes inactive as long as the **TCP Keep-alive** (see tables above) listener is activated for Ethernet based interface modules and as long as keep-alive is valid in the local network.
Com Protocols	Enables or disables SCPI or ModBus communication protocols for the device. The change is immediately effective after submitting it with ENTER button. Only one of both can be disabled.
Logging	Enables/disables the USB stick logging feature. Once enabled, you can define the log interval in multiple step sizes (500 ms ... 5 s) and the control method. For more information refer to *„3.4.10. Recording to USB stick (logging)"*.

3.4.3.8 Menu "HMI Setup"

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

Element	Description
Language	Selection of the display language between German, English, Russian or Chinese
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 *„3.6 Alarms and monitoring" on page 53*.
HMI Lock	See *„3.7 Control panel (HMI) lock" on page 55*.
Backlight	The choice here is whether the backlight remains permanently on or if it should be switched off when no input via screen or rotary knob is made for 60 s. As soon as input is made, the backlight returns automatically. Furthermore, the backlight intensity can be adjusted here.
Status page	Enables/disables two display related options for the main screen with actual and set values: **Show meter bar**: in U/I/P mode, i. e. resistance mode not activated, a meter bar for 0-100% actual values of voltage, current and power is shown. See *„3.4.8. The meter bars"*. **Alternative status page**: switches the main screen of the device with its actual and set values of voltage, current, power and - if activated - resistance to a simpler display with only voltage and current, plus status. See *„3.4.7. Switching the main screen view"*. Default setting: both disabled
Limits Lock	See *„3.8 Lock the adjustment limits" on page 55*

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 43

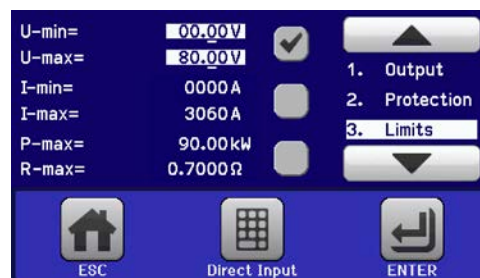## 3.4.4   Adjustment limits

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

Defaults are that all set values (U, I, P, R) and the corresponding adjustment limits are adjustable from 0 to 102%.

The full range may be obstructive in some cases, especially for protection of applications against overvoltage. Therefore upper and lower limits for current (I) and voltage (U) can be set separately, which then limit the range of the adjustable set values.

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

U-min=	00.00 V
U-max=	80.00 V
I-min=	0000 A
I-max=	3060 A
P-max=	90.00 kW
R-max=	0.7000 Ω

1. Output
2. Protection
3. Limits

ESC   Direct Input   ENTER

► **How to configure the adjustment limits**

1. On the main screen, tap **SETTINGS** to access the SETTINGS menu.

2. Tap the 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 adjusted. Tap the selection area for another choice ☐.

4. Accept the settings with ⏎.

❗	*The set values can be entered directly using the ten-key pad. This appears when the touch area "Direct Input" is tapped (bottom centre)*

❗	*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 60.00 kW while the currently adjusted power set value is 80.00 kW, then the set value first would have to be reduced to 60.00 kW or less, in order to set P-max down to 60.00 kW.*

3.4.5   Changing the operating mode

In general, the manual operation of a PSI 9000 15U/24U distinguishes between two resp. three operating modes, U/I and U/P and U/R, which are tied to set value input using the rotary knobs or ten-key pad. This assignment must be changed if one of the three resp. four set values is to be adjusted which is currently not accessible.

► **How to change the operating mode:**

1. Unless the device is in remote control or the panel is locked, you switch the operation anytime. There are two options: either tap the depiction of the right-hand knob (see figure to the right) to change its assignment between I, P and R, which is displayed on the knob depiction, or

2. You directly tap on the coloured areas with the set values, like shown in the figure to the right. The unit next to the set values, when inverted, indicates the assignment of the knob. In the example in the figure it has U and P assigned, which means U/P mode.
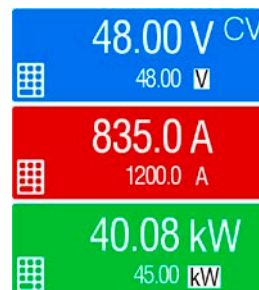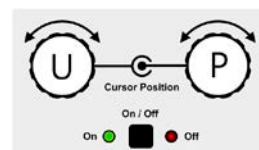
Depending on the selection the right rotary knob will be assigned different setting values, the left knob is always assigned to the voltage.

The actual operating mode, which is only indicated while the DC output is switched on, solely depends on the set values. For more information see section *„3.2. Operating modes".*

U ⟷ P
Cursor Position
On / Off
On ● ▪ ● Off

48.00 V CV
48.00 V

835.0 A
1200.0 A

40.08 kW
45.00 kW

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 44

3.4.6 Manual adjustment of set values

The set values for voltage, current and power are the fundamental operating possibilities of a power supply and hence in manual operation the two rotary knobs on the front of the device are always assigned to two of the values.

As a fourth value there is the internal resistance, for which the resistance mode (R mode) has to be activated in the MENU first. Refer to *„3.4.3. Configuration via MENU"* and *„3.2.4. Internal resistance regulation"* for details.

Set values can be entered manually in two ways: via **rotary knob** or **direct input**. While manual adjustment with the knobs alter values continuously, direct input allows for even huge value steps, such as 0-100%.

> *When adjusting set values, upper or lower limits may come into effect. See section „3.4.4. Adjustment limits". Once a limit is reached, the display will show a note like "Limit: U-max" etc. for 1.5 seconds next to the adjusted value or will refuse to accept a value entered by direct input.*

► How to adjust set values U, I, P or R with the rotary knobs

1. First check if the value you want to change is already assigned to one of the rotary knobs. The main screen displays the assignment as depicted in the figure to the right.

2. If, as shown in the example, the assignment is voltage (U, left) and power (P, right), and it's required to set the current, then the assignments can be changed by tapping this touch area. A set of selection fields then appears.

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 from right to left (selected digit will be underlined):
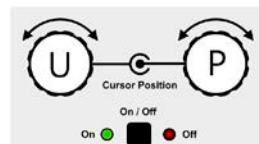
►How to adjust values via direct input:

1. In the main screen, depending on the rotary knob assignment, values can be set for voltage (U), current (I), power (P) or 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, 54.3 V is set with [5] [4] [.] [3] and [ENTER].

3. The display then switches back to the main page and the set values take effect.
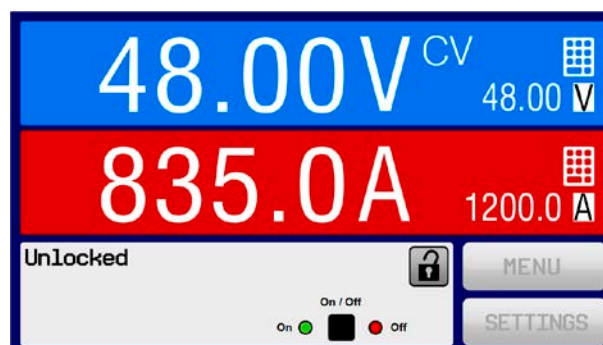
3.4.7 Switching the main screen view

The main screen, also called status page, with its set values, actual values and device status can be switched from the standard view mode with three or four values to a simpler mode with only voltage and current display. The advantage of the alternative view mode is that actual values are displayed with **much bigger numbers**, so they can be read from a larger distance. Refer to *„3.4.3.8. Menu "HMI Setup""* to see where to switch the view mode in the MENU. Comparison:

Standard status page   Alternative status page

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 45
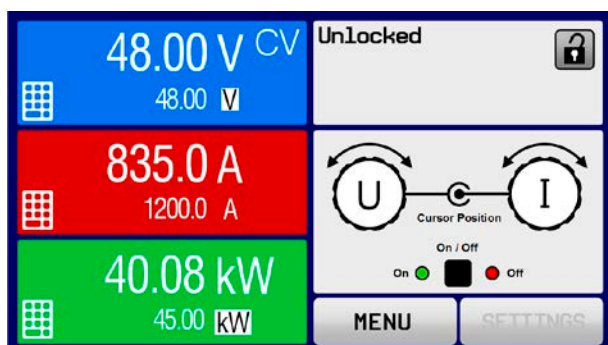
Limitations of the alternative status page:

- Set and actual values of power aren't displayed and the set value of power is only indirectly accessible
- The set value of resistance isn't displayed and only indirectly accessible
- No access to the settings overview (MENU button) while the DC output is on

> *In alternative status page mode, the set values of power and resistance aren't adjustable while the DC output is switched on. They can only be accessed and adjusted in SETTINGS while the DC output is off.*
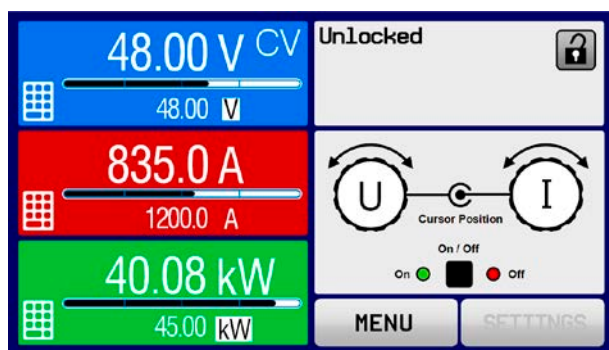
Rules for manual handling of the HMI in alternative status page mode:

- The two rotary knobs are assigned to voltage (left knob) and current (right knob) all the time, except for menus
- Set values input is the same as in standard status page mode, with knobs or by direct input
- Regulation modes CP and CR are displayed alternatively to CC in the same position

3.4.8 The meter bars

Additionally to the actual values being displayed as numbers, meter bars for U, I and P can be enabled in the MENU. The meter bars remain hidden as long as resistance mode, i. e. U/I/R is activated. Refer to *„3.4.3.8. Menu "HMI Setup""* to see where to enable the meter bars in the MENU. Depiction:

Standard status page with meter bar   Alternative status page with meter bar
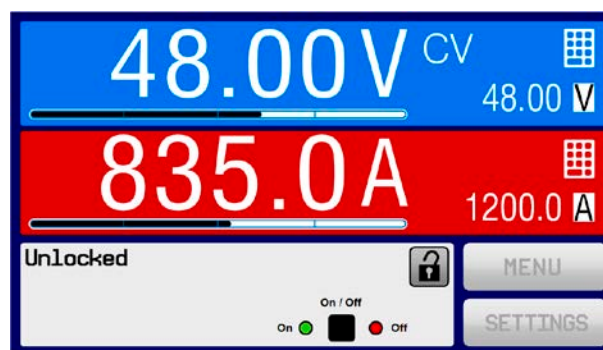
3.4.9 Switching the DC output on or off

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

> *Switching the DC output on during manual operation or digital remote control can be disabled by pin REM-SB of the built-in analog interface. For more information refer to 3.4.3.1 and example a) in 3.5.4.7.*

► **How to manually switch the DC output on or off**

1. As long as the control panel isn't fully locked press the button ON/OFF. Otherwise you are asked to disable the HMI lock first.
2. This button toggles between on and off, so long as a change isn't restricted by an alarm or the device is locked in "remote".

► **How to remotely switch the DC output on or off via the analog interface**

1. *See section "„3.5.4 Remote control via the analog interface (AI)" on page 49.*

► **How to remotely switch the DC output 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 from LabView VIs or other software provided by the manufacturer.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 46

3.4.10 Recording to USB stick (logging)

Device data can be recorded to USB stick (preferably 2.0 / 3.0 may work, but not all vendors are supported) anytime. For specifications of the USB stick and the generated log files refer to section *„1.9.6.5. USB port (front side)"*.

The logging stores files of CSV format on the stick. The layout of the log data is the same as when logging via PC with software EA Power Control. The advantage of USB logging over PC logging is the mobility and that no PC is required. The logging feature just has to be activated and configured in the MENU.

3.4.10.1 Configuration

Also see section *3.4.3.7*. After USB logging has been enabled and the parameters **Logging interval** and **Start/ Stop** have been set, logging can be started anytime from within the MENU or after leaving it, depends on the selected start/stop mode.

3.4.10.2 Handling (start/stop)

With setting **Start/stop with DC output ON/OFF** logging will start each time the DC output of the device is switched on, no matter if manually with the front button "On/Off" or remotely via analog or digital interface. With setting **Manual start/stop** it's different. Logging is then started and stopped only in the MENU, in the logging configuration page.

Soon after logging has been started, the symbol ▣ indicates the ongoing logging action. In case there is an error while logging, such as USB stick full or removed, it will be indicated by another symbol (▣ERR). After every manual stop or switching the DC output off the logging is stopped and the log file closed.

3.4.10.3 Log file format

Type: text file in european CSV format

Layout:

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	U set	U actual	I set	I actual	P set	P actual	R set	R actual	R mode	Output/Input	Device mode	Error	Time
2	2,00V	11,92V	1,20A	1,20A	7344W	15W	N/A	N/A	OFF	ON	CC	NONE	00:00:00,942
3	2,00V	11,90V	1,20A	1,20A	7344W	15W	N/A	N/A	OFF	ON	CC	NONE	00:00:01,942
4	2,00V	11,89V	1,20A	1,20A	7344W	15W	N/A	N/A	OFF	ON	CC	NONE	00:00:02,942
5	2,00V	11,87V	1,20A	1,20A	7344W	15W	N/A	N/A	OFF	ON	CC	NONE	00:00:03,942

Legend:

U set / I set / P set / R set: Set values

U actual / I actual / P actual / R actual: Actual values

Error: device alarms

Time: elapsed time since logging start

Device mode: actual regulation mode (also see *„3.2. Operating modes"*)

Important to know:

- R set and R actual are only recorded if UIR mode is active (refer to section *3.4.5*)
- Unlike the logging on PC, every log start here creates a new log file with a counter in the file name, starting generally with 1, but minding existing files

3.4.10.4 Special notes and limitations

- Max. log file size (due to FAT32 formatting): 4 GB
- Max. number of log files in folder HMI_FILES: 1024
- With setting **Start/stop with DC output ON/OFF**, the logging will also stop on alarms or events with action **Alarm**, because they switch off the DC output
- With setting **Manual start/stop** the device will continue to log even on occurring alarms, so this mode can be used to determine the period of temporary alarms like OT or PF

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 47

3.5 Remote control

3.5.1 General

In this cabinet device, remote control is only considered for the master unit. Slave unit can only be monitored, by any available interface. Remotely controlling the master is possible via its built-in analog or USB port or via one of the optional interface modules (IF-AB series).

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.

3.5.2 Control locations

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

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

Remote control may be allowed or inhibited using the setting **Allow remote control** (see „*3.4.3.1. Menu "General Settings"*"). In <u>inhibited</u> condition the status **Local** will be displayed top right. Activating the inhibit can be useful if the device is remotely controlled by software or some electronic device, but it's required to make adjustments at the device or deal with emergency, which would not be possible remotely.

Activating condition **Local** causes the following:

• If remote control via the digital interface is active (**Remote:**), then it's immediately terminated and in order to continue remote control once **Local** is no longer active, it has to be reactivated at the PC

• If remote control via the analog interface is active (**Remote: Analog**), then it's temporarily interrupted until remote control is allowed again by deactivating **Local**, because pin REMOTE continues to signal "remote control = on", unless this has been changed during the **Local** period.

3.5.3 Remote control via a digital interface

3.5.3.1 Selecting an interface

All models of series PSI 9000 15U/24U support the following optionally available interface modules in the standard interface slot on the master unit:

Short ID	Type	Ports	Description*
IF-AB-CANO	CANopen	1	CANopen slave with generic EDS
IF-AB-RS232	RS232	1	Standard RS232, serial
IF-AB-PBUS	Profibus	1	Profibus DP-V1 slave
IF-AB-ETH1P	Ethernet	1	Ethernet TCP
IF-AB-PNET1P	ProfiNet	1	Profinet DP-V1 slave
IF-AB-MBUS	ModBus TCP	1	ModBus TCP and ModBus RTU over Ethernet
IF-AB-ETH2P	Ethernet	2	Ethernet TCP, with 2-port Ethernet switch
IF-AB-MBUS2P	ModBus TCP	2	ModBus TCP and ModBus RTU over Ethernet, with 2-port switch
IF-AB-PNET2P	ProfiNet	2	Profinet DP-V1 slave, with 2-port Ethernet switch
IF-AB-CAN	CAN	1	CAN 2.0 A / 2.0 B Slave
IF-AB-ECT	EtherCAT	2	Basic EtherCAT slave with CANopen over Ethernet

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

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 48

3.5.3.2   General information about the interface modules

The master unit in the cabinet can have one of the plug-in and retrofittable modules listed in *3.5.3.1* installed. It can take over remote control of the device alternatively to the built-in USB type B on the rear side or analog interface. For installation see section „*2.3.9. Installation of an interface module*" 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 reconfiguration will be necessary.

3.5.3.3   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 USB stick or which is available as download from the manufacturer's website.

3.5.4   Remote control via the analog interface (AI)

3.5.4.1   General

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

- Remote control of current, voltage, power and internal resistance
- Remote status monitoring (CV, DC output)
- Remote alarm monitoring (OT, OVP, OCP, OPP, PF)
- Remote monitoring of actual values
- Remote on/off switching of the DC output

Setting the **three** set values of voltage, current and power via the analog interface always takes place concurrently. It means, that for example the voltage can't be given via the AI and current while the power is set by the rotary knob, or vice versa. The internal resistance set value can additionally be adjusted, if resistance mode is activated.

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

The AI can be operated in the common voltage ranges 0...5 V and 0...10 V, both representing 0...100% of the nominal value. The selection of the voltage range can be done in the device setup. See section „*3.4.3. Configuration via MENU*" for details. The reference voltage sent out from pin 3 (VREF) will be adapted accordingly:

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

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

All set values are always additionally limited to the corresponding adjustment limits (U-max, I-max etc.), which would clip setting excess values for the DC output. Also see section „*3.4.4. Adjustment limits*".

Before you begin, please read these important notes about the use of the interface:

- Analog remote control of the device must be activated by switching pin REMOTE (5) <u>first</u>. Only exception is pin REM-SB, which can be used independently
- Before the hardware is connected that will control the analog interface, it shall be checked that it can't provide voltage to the pins higher than specified
- Set value inputs, such as VSEL, CSEL, PSEL and RSEL (if R mode is activated), must not be left unconnected (i.e. floating) during analog remote control. In case any of the set values isn't used for adjustment, it can be tied to a defined level or connected to pin VREF (solder bridge or different), so it gives 100%

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 49

3.5.4.2 Resolution

The analog interface is internally sampled and processed by a digital microcontroller. This causes a limited resolution of analog steps. The resolution is the same for set values (VSEL etc.) and actual values (VMON/CMON) and is 26214 when working with the 10 V range. In the 5 V range this resolution halves. Due to tolerances, the truly achievable resolution can be slightly lower.

3.5.4.3 Acknowledging device alarms

Device alarms (see *3.6.2*) are always indicated in the front display and some of them are also reported as signal on the analog interface socket (see table below).

In case of a device alarm occurring during remote control via analog interface, the DC output will be switched off the same way as in manual control. Some device alarms have to be acknowledged (see *„3.6.2. Device alarm and event handling")*. Acknowledgment during analog remote control is done with pin REM-SB sending a HIGH-LOW-HIGH edge (min. 50 ms for LOW), given that the logical level setting for this pin is on default.

3.5.4.4 Analog interface specification

Pin	Name	Type*	Description	Default levels	Electrical specifications
1	VSEL	AI	Set voltage value	0…10 V or. 0...5 V correspond to 0..100% of U_{Nom}	Accuracy 0-5 V range: < 0.4% *****
2	CSEL	AI	Set current value	0…10 V or. 0...5 V correspond to 0..100% of I_{Nom}	Accuracy 0-10 V range: < 0.2% ***** Input impedance R_i >40 k...100 k
3	VREF	AO	Reference voltage	10 V or 5 V	Tolerance < 0.2% at I_{max} = +5 mA Short-circuit-proof against AGND
4	DGND	POT	Digital ground		For control and status signals
5	REMOTE	DI	Switch between manual and re-mote control	Remote = LOW, U_{Low} <1 V Manual = HIGH, U_{High} >4 V Manual, when not wired	Voltage range = 0…30 V I_{Max} = -1 mA at 5 V $U_{LOW to HIGH typ.}$ = 3 V Rec'd sender: Open collector against DGND
6	ALARMS 1	DO	Overheating or power fail alarm	Alarm = HIGH, U_{High} > 4 V No Alarm = LOW, U_{Low} <1 V	Quasi open collector with pull-up against Vcc ** With 5 V on the pin max. flow +1 mA I_{Max} = -10 mA at U_{CE} = 0,3 V U_{Max} = 30 V Short-circuit-proof against DGND
7	RSEL	AI	Set internal resis-tance value	0…10 V or. 0...5 V correspond to 0..100% of R_{Max}	Accuracy 0-5 V range: < 0.4% *****
8	PSEL	AI	Set power value	0…10 V or. 0...5 V correspond to 0..100% of P_{Nom}	Accuracy 0-10 V range: < 0.2% ***** Input impedance R_i >40 k...100 k
9	VMON	AO	Actual voltage	0…10 V or. 0...5 V correspond to 0..100% of U_{Nom}	Accuracy 0-5 V range: < 0.4% *****
10	CMON	AO	Actual current	0…10 V or. 0...5 V correspond to 0..100% of I_{Nom}	Accuracy 0-10 V range: < 0.2% ***** at I_{Max} = +2 mA Short-circuit-proof against AGND
11	AGND	POT	Analog ground		For -SEL, -MON, VREF signals
12	R-ACTIVE	DI	R mode on / off	Off = LOW, U_{Low} <1 V On = HIGH, U_{High} >4 V On, when not wired	Voltage range = 0…30 V I_{Max} = -1 mA at 5 V $U_{LOW to HIGH typ.}$ = 3 V Rec'd sender: Open collector against DGND
13	REM-SB	DI	DC output OFF (DC output ON) (ACK alarms ****)	Off = LOW, U_{Low} <1 V On= HIGH, U_{High} >4 V On, when not wired	Voltage range = 0…30 V I_{Max} = +1 mA at 5 V Rec'd sender: Open collector against DGND
14	ALARMS 2	DO	Overvoltage alarm Overcurrent alarm Overpower alarm	Alarm = HIGH, U_{High} > 4 V No alarm = LOW, U_{Low} <1 V	Quasi open collector with pull-up against Vcc ** With 5 V on the pin max. flow +1 mA I_{Max} = -10 mA at U_{CE} = 0,3 V, U_{Max} = 30 V Short-circuit-proof against DGND
15	STATUS***	DO	Constant voltage regulation active	CV = LOW, U_{Low} <1 V CC/CP/CR = HIGH, U_{High} >4 V	
			DC output	Off = LOW, U_{Low} <1 V On = HIGH, U_{High} >4 V	

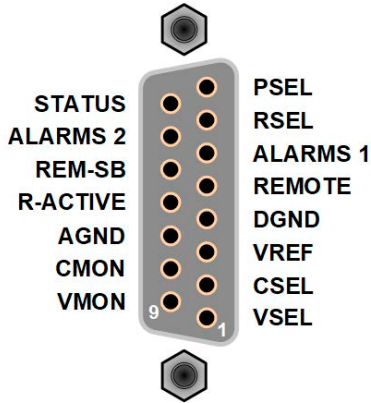* AI = Analog Input, AO = Analog Output, DI = Digital Input, DO = Digital Output, POT = Potential
** Internal Vcc approx. 10 V
*** Only one of both signals possible, see section *3.4.3.1*
**** Only during remote control
***** The error of a set value input adds to the general error of the related value on the DC output of the device

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 50

3.5.4.5   Overview of the Sub-D Socket


```
STATUS      PSEL
ALARMS 2    RSEL
REM-SB      ALARMS 1
R-ACTIVE    REMOTE
AGND        DGND
CMON        VREF
VMON        CSEL
            VSEL
```

3.5.4.6   Simplified diagram of the pins

	Digital Input (DI)		**Analog Input (AI)**
	The DI is internally pulled up and thus it requires to use a contact with low resistance (relay, switch, contactor etc.) in order to clearly pull the signal down to DGND.		High resistance input (impedance >40 k....100 kΩ) of an operational amplifier circuit.
	Digital Output (DO)		**Analog Output (AO)**
	A quasi open collector, realized as high resistance pull-up against the internal supply. The design doesn't allow the pin to be loaded, but to switch signals by sinking current.		Output from an operational amplifier circuit, with low impedance. See specifications table above.

3.5.4.7   Application examples

a) Switching the DC output with pin REM-SB

> ⓘ *A digital output, e. g. from a PLC, may be unable to cleanly pull down the pin as it may not be of low enough resistance. Check the specification of the controlling application. Also see pin diagrams above.*
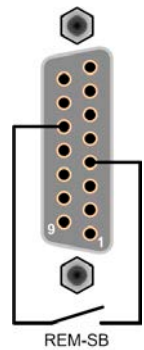
REM-SB

In remote control, pin REM-SB is used to switch the DC output of the device on and off. This function is also available without remote control being active and can on the one hand block the DC output from being switched on in manual or digital remote control and on the other hand the pin can switch the DC output on or off, but not standalone. See below at "Remote control has not been activated".

It's recommended that a low resistance contact such as a switch, relay or transistor is used to switch the pin to ground (DGND).

Following situations can occur:

- **Remote control has been activated**

During remote control via analog interface, only pin REM-SB determines the states of the DC output, according to the level definitions in *3.5.4.4*. The logical function and the default levels can be inverted by a parameter in the setup menu of the device. See *3.4.3.1*.

> ⓘ *If the pin is unconnected or the connected contact is open, the pin will be HIGH. With parameter "Analog interface REM-SB" being set to "normal", it requests "DC output on". It means, when activating remote control, the DC output will instantly switch on.*

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 51

- **Remote control isn't active**

In this mode of operation pin "REM-SB" can serve as lock, preventing the DC output from being switched on by any means. This results in following possible situations:

DC output	+	Level of pin REM-SB	+	Parameter „Analog interface Rem-SB"	→	Behaviour
is off	+	HIGH	+	Normal	→	The DC output isn't locked. It can be switched on by pushbutton "On/Off" (front panel) or via command from digital interface.
		LOW	+	Inverted		
	+	HIGH	+	Inverted	→	The DC output is locked. It can't be switched on by pushbutton "On/Off" (front panel) or via command from digital interface. When trying to switch on, a pop-up in the display resp. an error message will be generated.
		LOW	+	Normal		

In case the DC output is already switched on, toggling the pin will switch the DC output off, similar to what it does in analog remote control:

DC output	+	Level of pin REM-SB	+	Parameter „Analog interface Rem-SB"	→	Behaviour
is on	+	HIGH	+	Normal	→	The DC output remains on, nothing is locked. It can be switched on or off by pushbutton or digital command.
		LOW	+	Inverted		
	+	HIGH	+	Inverted	→	The DC output will be switched off and locked. Later it can be switched on again by toggling the pin. During lock, pushbutton or digital command can delete the request to switch on by pin.
		LOW	+	Normal		

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 power supply can selectively work in current limiting or power limiting mode. According to the specification of max. 5 mA load for the VREF output, potentiometers of at least 10 kΩ must be used.

The voltage set value VSEL is directly connected to VREF and will thus be permanently 100%.

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

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

Example with external voltage source

Example with potentiometers
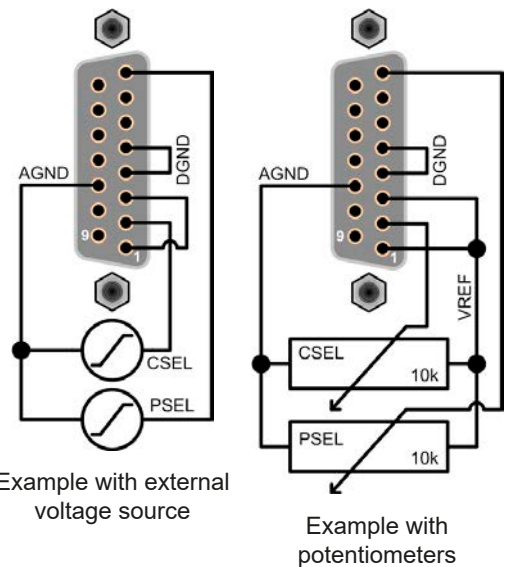
c) Reading actual values
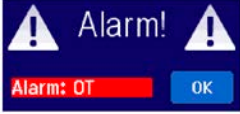
The AI provides the DC input values as current and voltage monitor. These can be read using a standard multimeter or similar.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 52
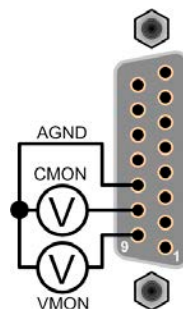
3.6 Alarms and monitoring

3.6.1 Definition of terms

There is a clear distinction between device alarms (see „*3.3. Alarm conditions*") such as overvoltage protection or overheating protection, and user defined events such as **OVD** (overvoltage detection). 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.	Event: OPD
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, plus emit an acoustic signal (if activated).	⚠ Warning! ⚠ Event: UVD OK
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 output is switched off. Certain device alarms are also signaled to the analog interface or can be queried via the digital interface.	⚠ Alarm! ⚠ Alarm: OT OK

3.6.2 Device alarm and event handling

A device alarm incident will usually lead to DC output 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. An alarm must always be acknowledged.

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

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

⚠ Alarm! ⚠ Alarm: OT OK

In order to acknowledge an alarm during analog remote control, see „*3.5.4.3. Acknowledging device alarms*". To acknowledge in digital remote control, refer to the external documentation "Programming Guide ModBus & SCPI".

Some device alarms are configurable:

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

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

Short	Long	Description	Indication
PF	**P**ower **F**ail	AC supply over- or undervoltage. Triggers an alarm if the AC supply is out of specification or when the device is cut from supply, for example when switching it off with the power switch. The DC output will be switched off. The condition of the DC output after a temporary power fail has gone can be configured. See section *3.4.3.1.*	Display, analog & digital interfaces
OT	**O**ver**T**emperature	Triggers an alarm if the internal temperature reaches a certain limit. The DC output will be switched off. The condition of the DC output after cooling down from the overheating can be configured. See section *3.4.3.1.*	Display, analog & digital interfaces

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 53

Short	Long	Description	Indication
MSP	**M**aster-**S**lave **P**rotection	Triggers an alarm if the master unit loses contact to any slave unit. The DC output will be switched off. The alarm can be cleared by reinitializing the MS system.	Display, digital interfaces

► How to configure the device alarms

1. While the DC output is switched off tap the touch area **SETTINGS** on the main screen.
2. On the right side tap the arrow to select "**2. Protection**".
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 after tapping the touch area "Direct input".*

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 "_„3.4.3. Configuration via MENU"_)

1. While the DC output is switched off tap the touch area **MENU** on the main screen
2. In the menu page, tap **HMI Setup** in the following page, tap **Alarm Sound**.
3. In the settings page tap on the symbol to either enable or disable the alarm sound and confirm with ⏎.

3.6.2.1 User defined events

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

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 as soon as the output voltage falls below the defined threshold.	$0\ V...U_{Nom}$
OVD	**O**ver**V**oltage **D**etection	Triggers an event as soon as the output voltage reaches the defined threshold.	$0\ V...U_{Nom}$
UCD	**U**nder**C**urrent **D**etection	Triggers an event as soon as the output current falls below the defined threshold.	$0\ A...I_{Nom}$
OCD	**O**ver**C**urrent **D**etection	Triggers an event as soon as the output current reaches the defined threshold.	$0\ A...I_{Nom}$
OPD	**O**ver**P**ower **D**etection	Triggers an event as soon as the output power reaches the defined threshold.	$0\ W...P_{Nom}$

> *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 output and thus protect sensitive electronic applications.*

How to configure user defined events

1. While the DC output is switched off tap the touch area **SETTINGS** on the main screen.
2. On the right side tap the 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 _„3.6.1. Definition of terms"_).
4. Accept the settings with ⏎.

> *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 could either be differently configured or not at all.*

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 54

3.7   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.
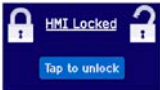
► **How to lock the HMI**

1. In the main page, tap the lock symbol (upper right corner).

2. In the settings page **HMI Lock** you are then asked to chose between a complete HMI (**Lock all**) lock or one where the On/Off button is still usable (**ON/OFF possible**), resp. chose to activate the additional PIN (**Enable PIN**). The device would later request to enter this PIN every time you want to unlock the HMI, until the PIN is deactivated again.

3. Activate the lock with . The status **Locked** as shown in the figure to the right.
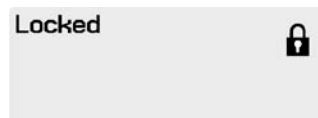
If an attempt is made to alter something whilst the HMI is locked, a requester appears in the display asking if the lock should be disabled.

► **How to unlock the HMI**

1. Tap any part of the touchscreen of the locked HMI, or turn one of the rotary knobs or press the button "On/Off" (only in "Lock all" 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. In case the additional **PIN code lock** has been activated in the menu **HMI Lock**, another requester will pop up, asking you to enter the **PIN** before it finally unlocks the HMI.

3.8   Lock the adjustment limits

In order to avoid the alteration of the adjustment limits (also see „*3.4.4. Adjustment limits*") by an unprivileged user, the screen with the adjustment limit settings ("Limits") can be locked by a PIN code. The menu pages "**3.Limits**" in SETTINGS and "**Profiles**" in MENU will then become inaccessible until the lock is removed by entering the correct PIN or in case it has been forgotten, by resetting the device as last resort.

► **How to lock the Limits**

1. While the DC output is switched off, tap the touch area **MENU** on the main screen.

2. In the menu tap **HMI Setup** and on the next page tap **Limits Lock**.

3. In the next page set the check mark for **Lock:**.

> ❗ *The same PIN as with the HMI lock is used here. It should be set before activating the Limits lock. See „3.7. Control panel (HMI) lock"*

4. Activate the lock by leaving the settings page with .

> ⚠️ Be careful to enable the lock if you are unsure what PIN is currently set. In doubt use ESC to exit the menu page. In menu page "HMI Lock" you can define a different PIN, but not without entering the old one.

► **How to unlock the limits settings**

1. While the DC output is switched off, tap the touch area **MENU** on the main screen.

2. IIn the menu tap **HMI Setup** and on the next page tap **Limits Lock**.

3. In the next page tap on touch area **Unlock** and then you will be asked to enter the 4-digit PIN.

4. Deactivate the lock by entering the correct PIN and submitting with ENTER.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 55

3.9 Loading and saving an 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.

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 an user profile:**

1. Tap the touch area **MENU** 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 .

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 56

3.10   The function generator

3.10.1   Introduction

The built-in **function generator** (short: **FG**) is able to create various signal forms and apply these to the set value of voltage or current.

In manual operation, all generator functions are available for access on the front panel. In remote control, only the customisable **arbitrary** generator and a **XY** function are available. The arbitrary generator can replicate all manually serviceable functions, except UI and IU. For those, the XY function is assigned.

The following functions are retrievable, configurable and controllable:

Function	Short description
Sine wave	Sine wave generation with adjustable amplitude, offset and frequency
Triangle	Triangular wave signal generation with adjustable amplitude, offset, rise and fall times
Rectangular	Rectangular wave signal generation with adjustable amplitude, offset and duty cycle
Trapezoid	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 segments (sequence points), each with a start voltage, final voltage and time
Arbitrary	Generation of a process with from to 99 freely configurable curve points, each with a start and end value (AC/DC), start and end frequency, phase angle and duration
Ramp	Generation of a linear rise or fall ramp with start and end values and time before and after the ramp
UI, IU PV, FC	Table (.csv) with values for U or I, uploaded from an USB stick, as well as functions to simulate a solar panel (PV function) or fuel cells (FC function)

> 🛈   *Whilst R mode is activated, access to the function generator isn't available.*

3.10.2   General

3.10.2.1   Limitations

The function generator isn't accessible, neither for manual access, nor for remote control, if resistance mode, also called UIR mode, is active.

3.10.2.2   Principle

The power supply unit can't be considered as high power function generator, because it's only post-connected to the FG. Thus the typical characteristics of a voltage and current source remain. Rise and fall times, caused by capacitor charge/discharge, affect the resulting signal on the DC output. While the FG is able to generate a sine wave with 1000 Hz or more, the power supply will never be able to follow the generated signal 1:1.

Depiction of principle: Affect of the power supply on functions:
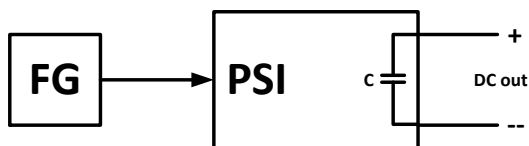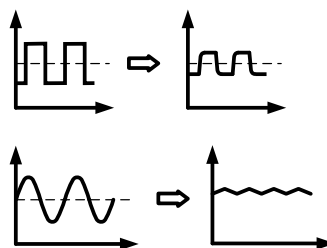
The resulting wave form on the DC output heavily depends on the frequency or period of the selected wave, its amplitude and output capacitance. The effects of the power supply on the wave can't be compensated.

3.10.2.3   Resolution

Amplitudes generated by the arbitrary generator have an effective resolution of approx. 52428 steps. If the amplitude is very low and the time long, the device would generate less steps and set multiple identical values after another, generating a staircase effect. It's furthermore not possible to generate every possible combination of time and a varying amplitude (slope).

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 57

3.10.2.4 Possible technical complications

Operation of switching mode power supplies as a voltage source can, when applying a function to the output voltage, lead to damage of the output capacitors due to continuous charging/discharging which causes overheating. Furthermore the actual voltage progression may differ from what's expected.

3.10.2.5 Minimum slope / maximum ramp time

When using a rising or falling offset (i.e. DC part) at functions like ramp, trapezoid, triangle and even sine wave, a minimum slope, calculated from the rated values of voltage or current, is required or else the adjusted settings would be neglected by the device. Calculating the minimum slope can help to determine if a certain ramp over time can be achieved by the device or not. Example: model PSI 9080-1020 is going to be used, with 80 V and 1020 A rating. **Formula: minimum slope = 0.000725 * rated value / s**. For the example model it results in $\Delta U/\Delta t$ of 58 mV/s and $\Delta I/\Delta t$ of 740 mA/s. The maximum time which can be achieved with the minimum slope then calculates as approximately 1379 seconds according to formula t_{Max} **= rated value / min. slope.**

3.10.3 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 always works with the three set values U, I and P, also in function generator mode.

The selected function can be applied to U or I set value, while all other set values are then constants and have a limiting effect. That means if, for example, a voltage of 30 V is set for the DC output, a load is connected and a sine wave function should operate on the current with an amplitude of 800 A and offset 1000 A, then the function generator will create a sine wave progression of current between 200 A (low peak) and 1800 A (high peak), which will result in an output power between 6 kW (min) and 54 kW (max). The output power, however, is limited to its set value. If this were 45 kW then, in this case, the current would be limited to 1500 A and, if clamped to an oscilloscope, it would be seen to be truncated at 1500 A and never reach the target of 1800 A.

3.10.4 Manual operation

3.10.4.1 Function selection and control

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

▶ **How to select a function and adjust parameters**

1. While the DC output is switched off tap touch area **MENU** on the main screen.

2. In the menu overview tap on the touch area [Function Generator] and then on the desired function.
   Note: This touch area is locked as long as R mode (adjustable resistance) is activated.

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 example.

5. Adjust the overall limits of voltage, current and power, which you can access with touch area [U/I/P-Limits].

Setting the various functions is described below.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 58

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 values are set (power and voltage or current), the DC output is switched on and the touch area [START] enabled. Only then can the function be started.
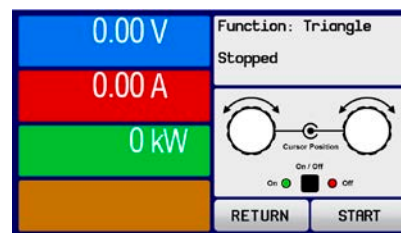
> **(!)** *The static values are applied to the DC output immediately after loading the function, because it switches the DC output on automatically in order to set the start situation. They represent start and end values for the progress of the function, so that it doesn't need to start from 0. Only exception: when applying a function to the current (I), there is no adjustable static current value, so the function would always start from 0 A.*

►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 output is currently switched off. The function then starts immediately. In case START is used while the DC output is still switched off, it will be switched on automatically.

2. The function can be **stop**ped either by tapping [STOP] or operating the "On/Off" button. However, there is a difference:

a) The [STOP] button stops only the function, the DC output <u>remains ON</u> with the static values.

b) The "On/Off" button stops the function and switches off the DC output.

> **(!)** *A device alarm such as overvoltage, overheating or power failure stops the function progress automatically and the DC output is switched off.*

3.10.5   Sine wave function

The following parameters can be configured for a sine 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)	(A)...(Nominal value - (A)) of 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...10000 Hz	Static frequency of the signal to be generated

Schematic diagram:
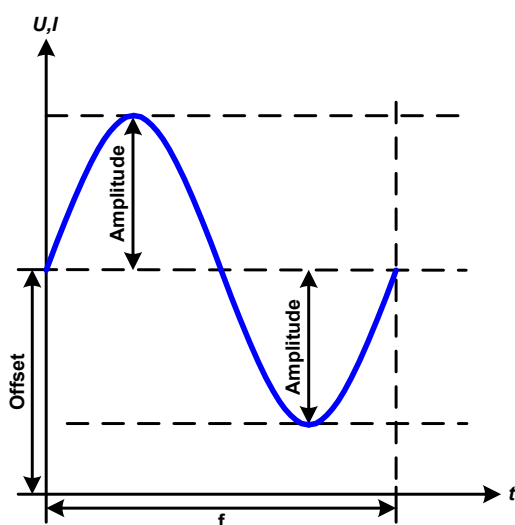
Application and result:

A normal sine wave signal is generated and applied to the selected set value, e. g. voltage (U). At a constant load resistance, the output voltage and thus also the output current will follow a sine wave.

For calculating the maximum power output the amplitude and offset values for the current have to be added.

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

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 59

3.10.6   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	0.1 ms...36000 s	Rising edge time Δt of the triangular wave signal
t2	0.1 ms...36000 s	Falling edge time Δt of the triangular wave signal

Schematic diagram:
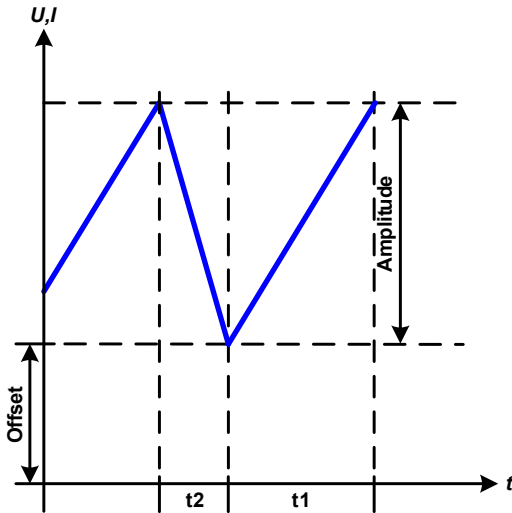
Application and result:

A triangular wave signal for output current (only effective in current limiting) or output voltage is generated. The positive and negative slope times 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 10 Hz is required and would lead to periodic duration of 100 ms. This 100 ms can be freely allocated to t1 and t2, e. g. 50 ms:50 ms (isosceles triangle) or 99.9 ms:0.1 ms (right-angled triangle or sawtooth).

3.10.7   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	0.1 ms...36000 s	Time (pulse width) of the upper level (amplitude)
t2	0.1 ms...36000 s	Time (pause width) of the lower level (offset)

Schematic diagram:
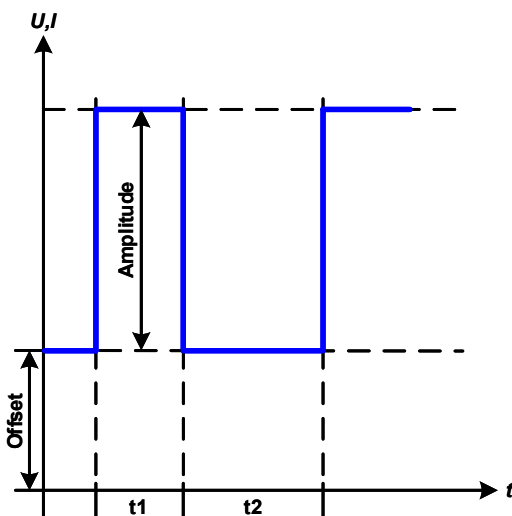
Application and result:

A rectangular or square wave signal for output current (direct) or output 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.

Intervals t1 and t2 can be used to define a duty cycle. The sum of t1 and t2 gives the period and its reciprocal is the frequency.

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

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 60

3.10.8 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	0.1 ms...36000 s	Time for the positive slope of the trapezoidal wave signal.
t2	0.1 ms...36000 s	Time for the top value of the trapezoidal wave signal.
t3	0.1 ms...36000 s	Time for the negative slope of the trapezoidal wave signal.
t4	0.1 ms...36000 s	Time for the base value (offset) of the trapezoidal wave signal

Schematic diagram:
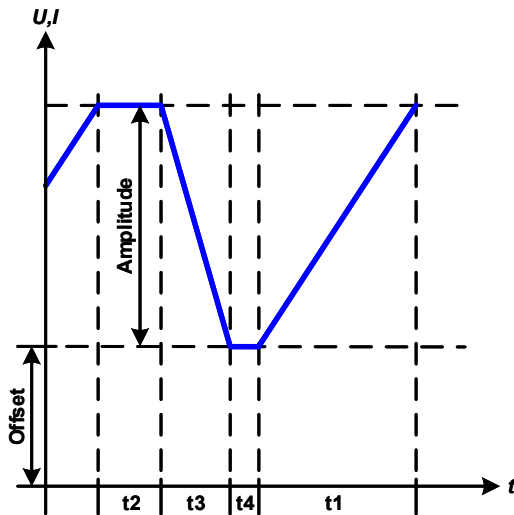
Application and result:

Here a trapezoidal signal can be applied to a set value of U or I. The ramps of the trapezium can be varied by setting different times for rise and fall.

The periodic duration and repetition 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.

3.10.9 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 sequence points (see diagram below) which each have the same parameters. The standard values from the DIN are set already as default values for the five points.

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	0.1 ms...36000 s	1-5	Time of the ramp
Seq.cycles	∞ or 1...999	-	Number of repetitions of the entire curve
Time t1	0.1 ms...36000 s	-	Time after cycle before repetition (cycle <> 1)

Schematic diagram:
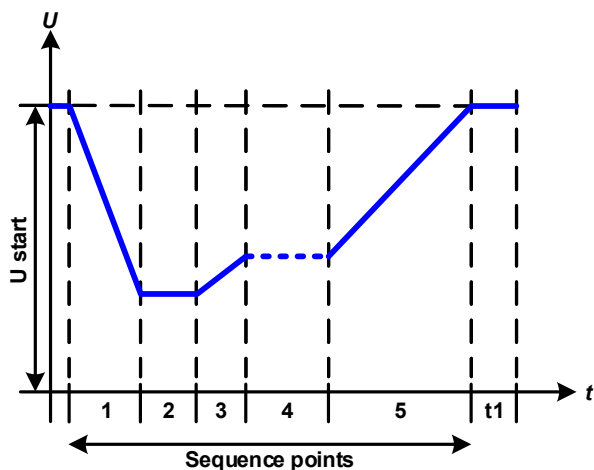
Application and result:

The function isn't suitable for standalone operation of a power supply, but optimal for power supply in conjunction with an electronic load. 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 point 4 should be a sine wave, then these 5 points would have to be transferred to the arbitrary generator.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 61

3.10.10 Arbitrary function

The arbitrary, i. e. freely definable function offers the user a wider scope. There are 99 freely configurable sequence points available. While all have the same set of parameters, they can be configured differently so that a complex function process can be created. The 99 sequence points or a part of them can run one after another in a sequence point block and this block can then be repeated up to 999 times or infinitely. A sequence point or sequence point block is always assigned to either current or voltage, thus a mix of assignment to current or voltage isn't possible.

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) = 0 Hz, the AC values have no impact and only the DC part is effective. Each sequence point is allocated a 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	Description
Is(AC)	0...50% Nominal value of I	Start amplitude of the sine wave part of the curve
Ie(AC)	0...50% Nominal value of I	End amplitude of the sine wave part of the curve
fs(1/T)	0 Hz...10000 Hz	Start frequency of the sine wave part of the curve
fe(1/T)	0 Hz...10000 Hz	End frequency of the sine wave part of the curve
Angle	0°...359°	Start angle of the sine wave part of the curve
Is(DC)	Is(AC)...(Nominal value - Is(AC)) of I	Start value of the DC part of the curve
Ie(DC)	Ie(AC)...(Nominal value - Ie(AC)) of I	End value of the DC part of the curve
Seq.time	0.1 ms...36000 s	Time for the selected sequence point

> **(!)** *The sequence point 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 = 1 Hz, fe = 11 Hz and Seq.time = 5 s would not be accepted as Δf/s is only 2. A seq. time of 1 s would be accepted, or, if the time remains at 5 s, then fe = 51 Hz must be set.*

> **(!)** *The amplitude change between start and end is related to the sequence time. A minimal change over an extended time isn't possible and in such a case the device will report an inapplicable setting.*

After the settings for the selected sequence point are accepted with SAVE, further sequence points can be configured. If the button NEXT is touched a second settings screen appears in which global settings for all 99 points are displayed. The following parameters can be set for the total run of an arbitrary function:

Value	Range	Description
Start seq.	1...End seq.	First sequence point in the block
End seq.	Start seq...99	Last sequence point in the block
Seq. Cycles	∞ or 1...999	Number of cycles of the block.

After continuing with NEXT there are global set values to define as last part of the function generator setup.

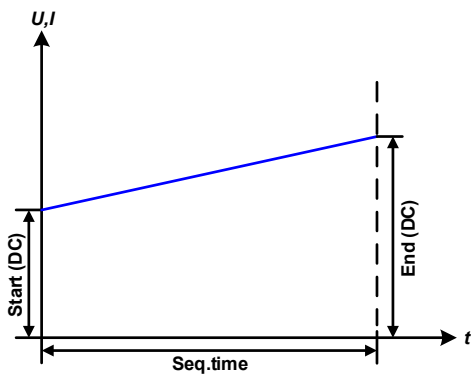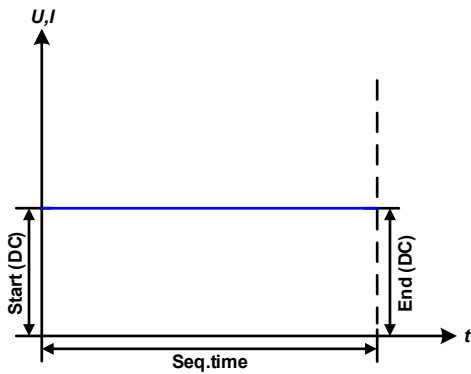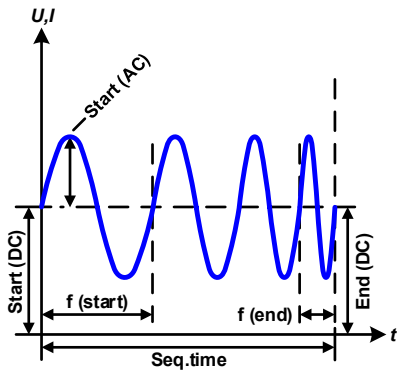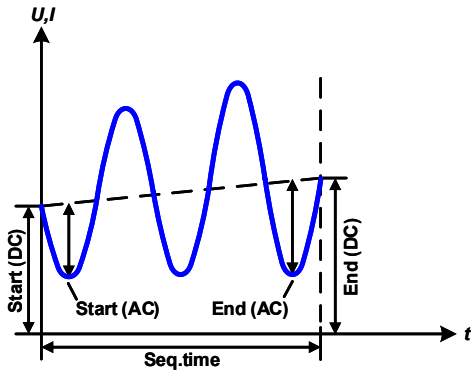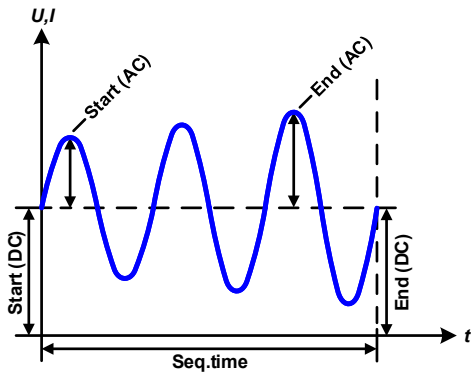Schematic diagram:
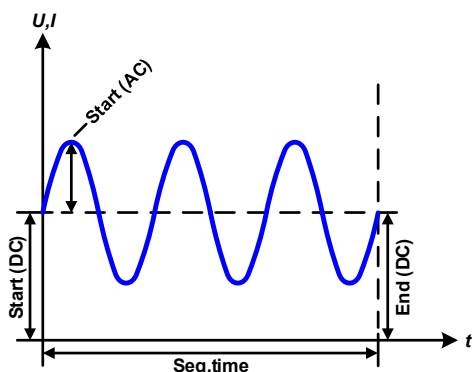
Applications and results:

Example 1

Focusing 1 cycle of 1 sequence point:

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 point time and the frequency. If the time were 1 s and the frequency 1 Hz, there would be exactly 1 sine wave. If the time were 0.5 s at the same frequency, there would only be a half sine wave.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 62

Schematic diagram:

Applications and results:

Example 2

Focusing 1 cycle of 1 sequence point:

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 point time and frequency allow for multiple waves to be created. e. g. for f=1 Hz and **Seq. time** = 3 s, three complete waves would be generated (for angle = 0°) and reciprocally the same for f=3 s and **Seq. time**=1 s.

Example 3

Focusing 1 cycle of 1 sequence point:

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

Focusing 1 cycle of 1 sequence point:

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 point time.

Example 5

Focusing 1 cycle of 1 sequence point:

Similar to example 1 but with a start and end frequency of 0 Hz. 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.
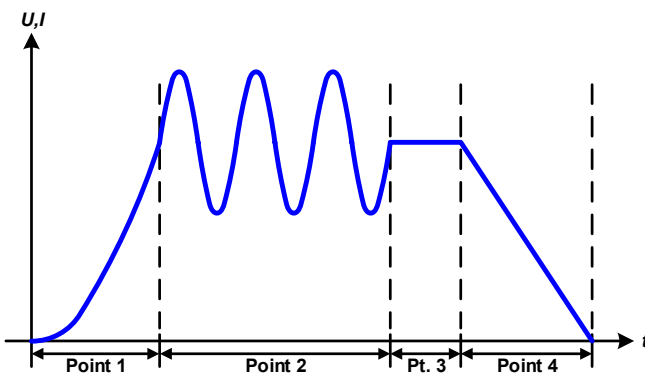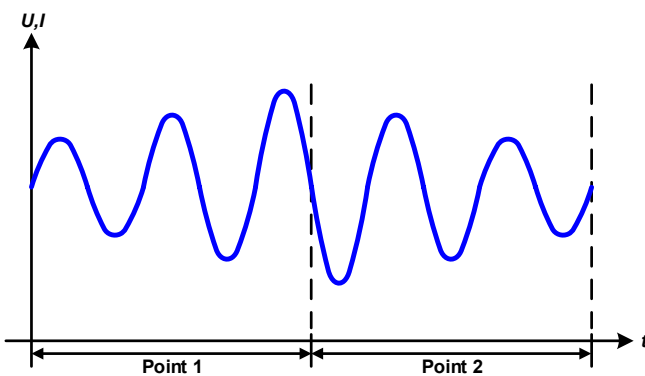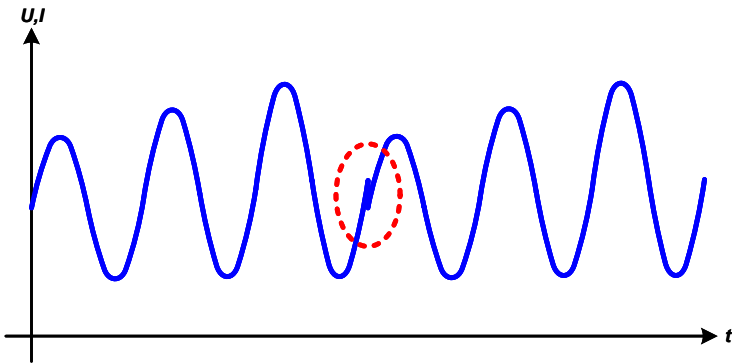
Example 6

Focusing 1 cycle of 1 sequence point:

Similar to example 1 but with a start and end frequency of 0 Hz. 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.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 63

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.

Schematic diagram:

Applications and results:

Example 7

Focusing 2 cycles of 1 sequence point:

A sequence point configured as in example 3 is run. As the settings demand that the end offset (DC) is higher than the start, the second sequence point 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

Focusing 1 cycle of 2 sequence points:

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

Example 9

Focusing 1 cycle of 4 sequence points:

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

Point 2: 3 Sine waves (ratio of frequency to sequence time: 1:3)

Point 3: Horizontal ramp (f = 0)

Point 4: Falling ramp (f = 0)

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 64

3.10.10.1 Loading and saving the arbitrary function

The sequence points 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 stick via the front side USB port. Generally, all 99 sequence point 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 point table for the arbitrary generator, following requirements have to be met:

- The table must contain exactly 99 rows with 8 subsequent values and must not have gaps (once 100 were specified, so 100 are still accepted for reason of compatibility)
- 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)
- The CSV file format must match the selection at setting "USB decimal point format" (see *3.4.3.7*)
- 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 amplitude	0...50% U or I
B	AC end amplitude	0...50% U or I
C	Start frequency	0...10000 Hz
D	End frequency	0...10000 Hz
E	AC start angle	0...359°
F	DC start offset	0...(Nominal value of U or I) - AC start amplitude
G	DC end offset	0...(Nominal value of U or I) - AC end amplitude
H	Time in µs	100...36.000.000.000 (36 billion µs)

For details about the parameter and the arbitrary function refer to „*3.10.10. 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 sequence points 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 PSI 9080-1020 3U, 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 point table from an USB stick:**

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** -> **Arbitrary** -> **U / I** to see the main screen of sequence point selector, as depicted to the right.
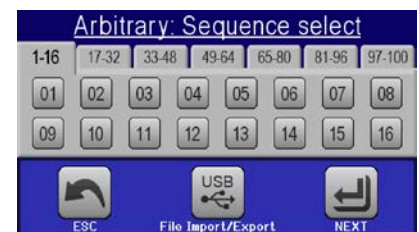
3. Tap touch area [File Import/Export], then [LOAD from USB] and follow the instructions on screen. If at least one valid files has been recognized (for file and path naming see above), the device will show a list of files to select from with ✓.

4. Tap touch area [LOAD from USB] in the bottom right corner. The selected file is then checked and loaded, if valid. In case it's not valid, the device will show an error message. Then the file must be corrected and the steps repeated.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 65

► **How to save a sequence point table to an USB stick:**

1. Do not plug the USB stick yet or remove it.

2. Access the function selection menu of the function generator via MENU -> **Function Generator** -> **Arbitrary** -> **U / I.**

3. Tap on [USB File Import/Export], then [SAVE to USB]. The device will request you to plug the USB stick now.

4. After plugging it, the device will try to access the stick 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 [SAVE to USB].

3.10.11 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	0,1 ms...36000 s	Time before ramp-up or ramp-down of the signal.
t2	0.1 ms...36000 s	Ramp-up or ramp-down time

Schematic diagram:
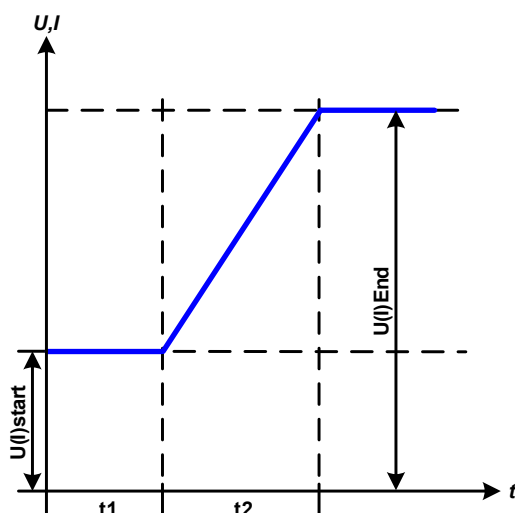
Application and result:

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. To have a repeating ramp, function Trapezoid would have to be used instead (see *3.10.8*).

Important to consider are the static values of U and I which define the start levels at the beginning of the ramp. It's recommended that these values are set equal to those in parameter **Us** (**Is**), 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.

> ❗ *10h after reaching the ramp end, the function will stop automatically (i.e. I = 0 A resp. U = 0 V), unless it has been stopped manually before.*

3.10.12 UI and IU table functions

The UI and IU functions are bases on an XY generator and its XY table. They offer the possibility to set a DC output current dependent on the DC output voltage or vice versa. The functions are table driven by exactly 4096 values which are distributed over the entire measuring range of actual output voltage or output , which is defined as 0...102% U_{Nom} or I_{Nom}. The table can either be uploaded from an USB stick through the front side USB port of the device or via remote control (ModBus protocol or SCPI). The functions are defined like this:

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 output current. For each of the 4096 possible values for output 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 an USB stick will always be interpreted as voltage values even if the user calculated them as current values and incorrectly loaded them as a UI table. The UI function suits very good for the simulation of fuel cell characteristics.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 66

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 output voltage and step changes can be created.

The IU function suit very good for the simulation of solar panels in photovoltaics related tests.

Uploading of a table from an USB stick 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 won't 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 for connected loads if, for example, the internal current measurement in the power supply swings slightly so that the voltage jumps backwards and forwards between two values in the table, which, in the worst case, could be 0 V and the maximum voltage.

3.10.12.1 Loading UI and IU tables from USB drive

The so-called UI or IU value tables can be loaded from a file via a standard USB stick that is formatted as FAT32. In order to load the file, it has to meet following specifications:

- The file name always begins with IU or UI (not case-sensitive), depending on which of the two functions you load the table for

- The file must be a text file of type Excel CSV (semicolon as separator) and must only contain one column with exactly 4096 real values without gaps

- The CSV file format must match the selection at setting **USB decimal point format** (see *3.4.3.7*)

- No value may exceed the device ratings. For example, if you have an 80 V model and you are going to load a table with values for voltage, none of the 4096 values may be higher than 80 V (the adjustment limits don't apply here)

- The file(s) has/have to be put inside a folder named HMI_FILES in the root of the stick

If these specifications aren't met, the device won't accept the file and put out an error message in the display. Files with names beginning different to UI or IU aren't recognized for this purpose. The USB drive may contain multiple UI/IU files with different names and list them for the selection of one.

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

1. Do not plug the USB drive yet or pull it out if already plugged.

2. Open the function selection menu of the function manager with MENU -> **Function Generator** -> **XY Table**.

3. In the next scree select the desired function with either **UI Table** or **IU Table**.

4. Configure the global parameters for U, I and P, if necessary.

5. Tap touch area **LOAD from USB** and plug the USB drive when requested, in order to select one out of X compatible files from the drive. In case the file isn't accepted, the device will report an error in the display and also tell what's wrong with the file.

6. Once the file is accepted, you will be requested to remove the USB drive.

7. Submit and load the function with **LOAD** to start and control it as with other function (also see *„3.10.4.1. Function selection and control").*

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 67

### 3.10.13   Simple PV (photovoltaics) function

3.10.13.1 Preface

This function uses the standard XY generator to let the power supply simulate solar panels or solar cells with certain characteristics. The device calculates an IU table from four typical values.

While the function is running, the user can adjust a parameter "Irradiance" between 0% (darkness) and 100% (bright light) in 1% steps to simulate different light situations.

The most important characteristics of a solar cell are:

- the short-circuit current (I_{SC}), the max. current at almost 0 V

- the open circuit voltage (U_{OC}), which almost reaches its maximum value even in low light situations

- the maximum power point (MPP), at which the solar panel can provide the maximum output power

The voltage of the MPP (here: U_{MPP}) lies typically 20% below U_{OC}, the current of the MPP (here: I_{MPP}) lies typically 5% below I_{SC}. In case there are no definite values for the simulated solar cell available, Impp and Umpp can be set to this rule of thumb. The device limits the I_{MPP} value to I_{SC} as upper limit, the same applies to U_{MPP} and U_{OC}.
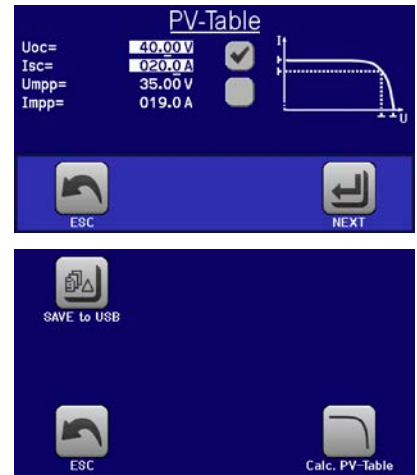
3.10.13.2 Safety notices

| ⚠️ | Due to high capacities on the DC outputs of the power supplies of this series, not every available solar inverter can be operated without problems. Check the technical specifications of the solar inverter and probably contact the manufacturer for an evaluation. |

3.10.13.3 Usage

In the PV table function, which is based upon the XY generator with IU characteristics, the MPP is defined by the two adjustable parameters Umpp and Impp (also see diagram below). These parameters are usually stated in data sheets of solar panels and have to be entered here.

The following parameters can be set for the PV table function:

| Value	Range	Description
Uoc	Umpp...Nominal device voltage	Open circuit voltage at no load
Isc	Impp...Nominal device current	Short-circuit current at max. load and low voltage
Umpp	0 V...Uoc	DC output voltage at the MPP
Impp	0 A...Isc	DC output current at the MPP

Schematic diagram:
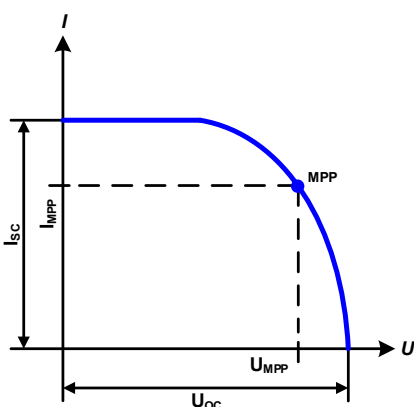
Application and result:

Adjust all four parameters on screen to the desired values. Whether the calculated IU and P curves which result from those values make sense or not can be verified with tools which can visualize the curve data, such as EA Power Control (only with unlocked Function Generator app) where you could enter the same values and have the curve visualized upon button click.

While the simulation is running, the user can see from the actual values (voltage, current, power) of the DC output, where the operating point of the power supply resp. of the simulated solar panel is. The adjustable value **Irradiance** (0%...100% in 1% steps, see screenshot below) helps to simulate different light situations from darkness (no power output) to the minimal amount of light that is required to make the panel provide full power.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 68

Varying this parameter shifts the MPP and the PV curve along the Y axis. Also see diagram to the right. The value Irradiance is here used as a factor for the current Impp. The curve itself isn't permanently re-calculated.
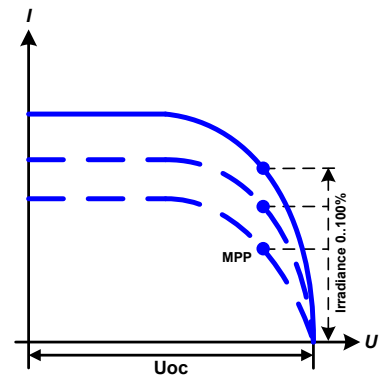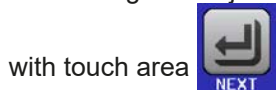
► How to configure the PV table

1. In the function generator menu tap on [XY-Table], then [PV-Table] and then [Calc. PV-Table].

2. Adjust the four parameters as required for the simulation.

3. Do not forget to adjust the global limits for voltage and power in the next screen which you can access with touch area [NEXT]. The voltage (U) setting should be at least as high as U_{oc}, or higher.

4. After setting the values for the required signal generation, tap on touch area [LOAD].

While loading, the IU function is calculated and sent to the internal XY generator. After this, the function is ready to run.

From the screen where the XY function generator is controlled manually (start/stop), you can go back to the first screen of PV table function and use the formerly locked touch area to save the table to USB drive. In order to do so, follow the on-screen instructions. The table can be used to analyse the values or to visualise it in Excel or similar tools.

► How to work with the PV table function

1. With an appropriate load connected, for example a solar inverter, start the function as described in *3.10.4.1*.

2. Adjust value **Irradiance** with any rotary knob between 100% and 0%, in order to reproduce different light situations for the simulated panel. The actual values on the display indicate the working point and can show whether the simulation has arrived at the MPP or not.

3. Stop the function run anytime as described in *3.10.4.1*.
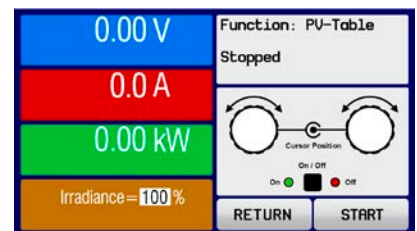
3.10.14 FC table function (fuel cell)
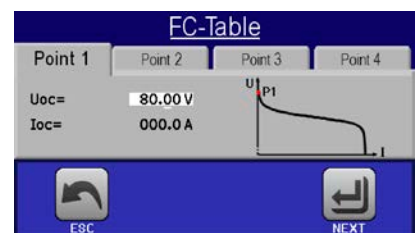
3.10.14.1 Preface

The FC table function is used to simulate the characteristics of voltage and current of a fuel cell. This is achieved by setting up some parameters which define points on a typical fuel cell curve, which is then calculated as UI table and passed to the internal function generator.

The user has to adjust value for four support points. The device will request to enter them step by step, indicating the actual point on screen with small graphics. When finished, these points will be used to calculate the curve.

Generally, following rules apply when setting up those values:

- $U_{Point1} > U_{Point2} > U_{Point3} > U_{Point4}$

- $I_{Point4} > I_{Point3} > I_{Point2} > I_{Point1}$

- Values of zero aren't accepted

It means, the voltage has to decrease from point 1 to point 4, while the current has to increase. In case the rules aren't followed, the device will reject the values with an error and reset them to 0.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 69

3.10.14.2 Usage

The following parameters can be set for the FC table function:

Value	Range	Description
Point 1: Uoc	0 V...U_{Nom}	Open circuit voltage at no load
Point 2+3: U	0 V...U_{Nom}	Voltage and current define the position of these two points in the U-I coordinate system, which represent two supporting points on the curve to be calculated
Point 2+3: I	0 A...I_{Nom}	
Point 4: Isc	0 A...I_{Nom}	DC output current under short-circuit

> *All these parameters all freely adjustable and thus an unrealistic curve could result. In some situations, the device would show a "Calculation error" after you tapped LOAD and loading of the function will be aborted. In this situation, check your settings, probably revise and try again.*

Schematic diagram:
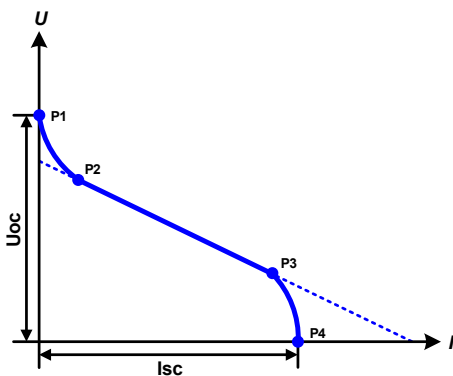
Application and result:

After setting up the four supporting points P1 thru P4, whereas P1 is at position Uoc and 0 A and P4 is at position Isc and 0 V, the device will calculate the function as UI table and load it to the XY generator.

Depending on the load current, which can be between 0 A and Isc, the device will set a variable output voltage, whose progress between 0 V and Uoc should result in a curve similar to the one depicted to the left.

The slope between P2 and P3 is depending on the values adjusted for P2 and P3 and can be freely modified as long as P3's voltage is lower than the one of P2 and P3's current is higher than the one of P2.

► **How to configure the FC table**

1. In the function generator menu tap on , then and then .
2. Adjust the parameters of the four supporting points, as required for the simulation.
3. Do not forget to adjust the global limits for current and power in the screen which you can access with

   touch area . The voltage set value should here be at least as high as U_{OC}.

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

After the function has been loaded to the internal XY generator, the simulation is ready to start.

From the screen where the XY function generator is controlled manually (start/stop), you can go back to the first screen of the FC table function and use the formerly locked touch area to save the table to USB drive. In order to do so, follow the on-screen instructions. The table can be used to analyse the values or to visualise it in Excel or similar tools.

► **How to work with the FC table function**

1. With an appropriate load connected, for example a DC-DC converter, start the function as described in *3.10.4.1*.
2. The output voltage will be set depending on the load current, which is defined by the connected load, and will decrease with increasing current. Without any load, the voltage will rise to the adjusted Uoc value.
3. Stop the function run anytime as described in *3.10.4.1*.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 70
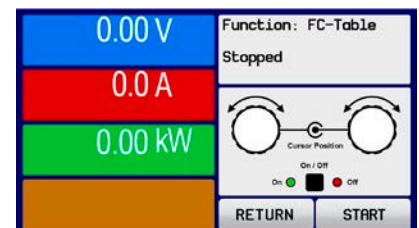
3.10.15 Extended PV function according to EN 50530

3.10.15.1 Introduction

This extended PV table function according to standard EN 50530 is used to simulate solar panels in order to test and rate solar inverters. It's available since firmware versions KE 2.19 and HMI 2.11 and offers manual configuration and control, as well as remote control. It's also based on the XY generator, same as the simple PV table function from *3.10.13*, but enables more specific tests and evaluations due to adjustable parameters. Which parameters are available is explained below. The impact of the parameters on the PV curve and the simulation is described in the standard paper of EN 50530, which user can refer to in case more detailed description is required. This section only deals about configuration and control of the PV simulation.

3.10.15.2 Differences to the basic PV function

The extended PV function has five additional or different characteristics compared to the simple PV function:

- The simulation distinguishes between a single test run and an automatic test run, called day trend, which is based upon an user-defined curve built from up to 100,000 points
- There are two invariable and one variable panel technology available to choose from
- There are more parameters available to adjust during runtime
- It allows for data recording during runtime and to save the data either to USB stick or read via digital interface
- It allows to select between two different parameter sets to adjust during runtime

3.10.15.3 Technologies and technology parameters

When configuring the PV simulation it's required to select the solar panel technology to simulate. The technologies **cSI** and **Thin film** are invariable in their parameters, while technology **Manual** is variable in all parameters, but within specific limits. This allows for the variation of the simulation and when copying the fixed parameter values from **cSi** or **Thin film** to **Manual**, it even enables their variation as well.

One advantage of the invariable technologies is that their technology parameters are automatically set to their defined defaults in the configuration procedure.

Overview of the technology parameters used in the PV curve calculation and their defaults:

Abbr.	Parameter	**Manual**	**cSI**	**Thin film**	Unit
FFu	Fill factor for voltage	>0...1 (0.8)	0.8	0.72	-
FFi	Fill factor for current	>0...1 (0.9)	0.9	0.8	-
Cu	Scaling factor for U_{OC} [1]	>0...1 (0.08593)	0.08593	0.08419	-
Cr	Scaling factor for U_{OC} [1]	>0...1 (0.000109)	0.000109	0.0001476	m²/W
Cg	Scaling factor for U_{OC} [1]	>0...1 (0.002514)	0.002514	0.001252	W/m²
alpha	Temperature coefficient for I_{SC} [2]	>0...1 (0.0004)	0.0004	0.0002	1/°C
beta	Temperature coefficient for U_{OC} [1]	-1...<0 (-0.004)	-0.004	-0.002	1/°C

[1] Uoc = Open circuit voltage of a solar panel

[2] Isc = Short-circuit current (=max. current) of a solar panel

3.10.15.4 Simulation mode

Apart from the panel technology there is also a simulation mode to select. Four options:

Mode **U/I**	Controllable simulation. Voltage (U_{MPP}, in V) and current (I_{MPP}, in A) in the maximum power point (MPP) are variable during runtime. The purpose of this mode is to directly shift the MPP into various directions.
Mode **E/T**	Controllable simulation. During runtime, the irradiation (E from german "Einstrahlung", in W/m²) and surface temperature (T, in °C) of the simulated solar panel are adjustable. This also impacts the curve and the resulting MPP. The purpose of this mode is to analyse the impact of temperature and/or irradiation on the performance of a solar panel.
Mode **DAY U/I**	Automatic simulation run, processing a day trend curve consisting of up to 100,000 points defined by values for U_{MPP}, I_{MPP} and time.
Mode **DAY E/T**	Automatic simulation run, processing a day trend curve consisting of up to 100,000 points defined by values for irradiation, temperature and time.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 71

3.10.15.5 Day trend

The so-called day trend is a special simulation mode for long-term tests. It processes a curve consisting of up to 100,000 user-definable points. For every processed point on that curve, the PV curve is calculated anew.

Every point is defined by 3 values of which one is the dwell time. When defining long dwell times the day trend curve can be supported by an interpolation feature which can be optionally activated. It will calculate and set intermediate points between two succeeding curve points. Hence it should be considered to run the day trend with or without interpolation.

The day curve points have to be loaded into the device, either from a CSV file on USB stick or via digital interface. The user selects the number of points according to the requirements of the simulation.

Formats of the CSV files to load from USB stick when manually configuring the function:

* For **Mode DAY E/T** (required file name format: PV_DAY_ET_<arbitrary_text>.csv)

	A	B	C	D
1	1	100	25	300000
2	2	101	25	2000
3	3	102	25	2000
4	4	103	25	2000
5	5	104	25	2000
6	6	105	25	2000
7	7	106	25	2000
8	8	107	25	2000
9	9	108	25	2000

Column A = **Index**

An ascending number between 1 and 100,000 (the first empty index will cause the simulation to stop)

Column B = **Irradiation** (E) in W/m²

Allowed range: 0...1500

Column C = **Temperature** (T) in °C

Allowed range: -40...80

Column D = **Dwell time** in milliseconds (ms)

Allowed range: 500...1.800.000

* For **Mode DAY U/I** (required file name format: PV_DAY_UI_<arbitrary_text>.csv)

> ⚠️ Attention! The values in columns B and C are real values which must not exceed the ratings of the device or the device will neglect to load the file.

	A	B	C	D
1	1	63.5	120.3	500
2	2	63.6	121.1	500
3	3	63.7	121.9	500
4	4	63.8	122.7	500
5	5	63.9	123.5	500
6	6	64	124.3	500
7	7	64.1	125.1	500
8	8	64.2	125.9	500
9	9	64.3	126.7	500

Column A = **Index**

An ascending number between 1 and 100,000 (the first empty index will cause the simulation to stop)

Column B = **Voltage U_{MPP}** in V

Allowed range: 0...rated output voltage of the device

Column C = **Current I_{MPP}** in A

Allowed range: 0...rated output current of the device

Column D = **Dwell time** in milliseconds (ms)

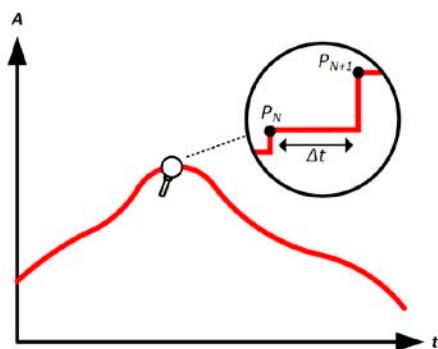Allowed range: 500...1.800.000

> ℹ️ *The number format and the column separator in the CSV files is determined by the regional settings of the PC or the software used to create the files. The format must match the selection for the device setting "USB decimal point format" in the General Settings menu of the device, else the device would neglect loading the file. For example, an american Excel should by default use the dot as decimal separator and the comma as column separator, which would match the selection "USB decimal point format = US".*
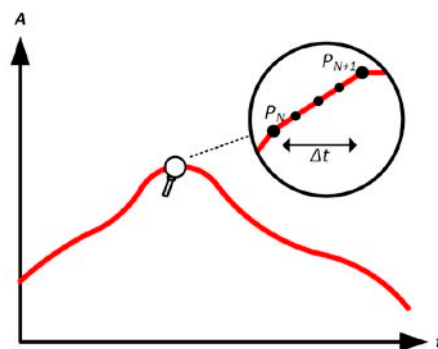
3.10.15.6 Interpolation

The interpolation feature can calculate and set intermediate steps when running the PV function in day trend mode, i. e. **DAY E/T** or **DAY U/I**. The calculation is always done between to succeeding points on the day trend curve. The dwell time of every curve point is adjustable between 500 and 1,800,000 milliseconds (see above, format of the day trend data file). While there are no extra points calculated when using the minimum time of 500 ms, following applies to higher dwell time definitions:

* The number of intermediate steps is determined from the dwell time and spread as equally as possible, where any of the steps can have its own dwell time between 500 and 999 ms
* The intermediate steps also respect the slope between the current and the next day trend curve point and thus every step also includes a corresponding value alteration

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 72

Visualisation:

Without interpolation - the curve results in steps

With interpolation - the curve remains linear

An example: the dwell time of the 3450th curve point is defined as 3 minutes, which is 180 seconds. There will be 180 / 0.5 -1 = 359 intermediate steps calculated and set until reaching the 3451st point. In mode DAY U/I the MPP voltage changes from 75 V to 80 V and the MPP current changes from 18 A to 19 A. When calculated, this would mean a $\Delta U/\Delta t$ of 27.7 mV/s and a $\Delta I/\Delta t$ of 5.5 mA/s. Depending on the device in use, such small steps in voltage or current may not be doable. However, the device would try to set the first intermediate step with 75.0138 V and 18.0027 A.

3.10.15.7 Data recording

There is the option to record data during the simulation run, in any mode. The data can be stored to USB stick once the simulation is finished or read via digital interface, which even allows for reading the data while the simulation is still running.

As long as the simulation is running, the device will record one data set every 100 ms into an internal buffer. This interval isn't adjustable. The max. number of data sets, here also called indexes, is 576,000. This results in a max. record time of 16 hours. The indexes are internally counted with every new record. When reaching the max. number, the index will restart from 1, overwriting former data. Every index will contain 6 values.

When configuring the PV simulation, the recording feature is locked at first (button greyed out). Only when stopping the simulation and leaving the control screen back to the configuration, the button becomes accessible. It then allows to store a CSV with a specific number of rows. This number depends on the current index counter. Contrary to remote control where it's possible to address every index of the max. 576,000 the save to USB feature will always store all indexes between 1 and the counter. Every next simulation run also resets the counter.

CSV file format when saving the recorded data to USB stick (in the example all values are with unit):

	A	B	C	D	E	F	G
1	Index	U actual	I actual	P actual	Umpp	Impp	Pmpp
2	1	0,29V	0,000A	0,0W	0,00V	0,000A	0,0W
3	2	0,29V	0,000A	0,0W	0,00V	0,000A	0,0W
4	3	0,29V	0,000A	0,0W	0,00V	0,000A	0,0W
5	4	0,29V	0,000A	0,0W	0,00V	0,000A	0,0W
6	5	0,30V	0,000A	0,0W	0,00V	0,000A	0,0W
7	6	0,28V	0,000A	0,0W	0,00V	0,000A	0,0W
8	7	0,28V	0,000A	0,0W	0,00V	0,000A	0,0W
9	8	0,28V	0,000A	0,0W	0,00V	0,000A	0,0W

Index = Ascending number

Uactual = Actual voltage on the DC output

Iactual = Actual current on the DC output
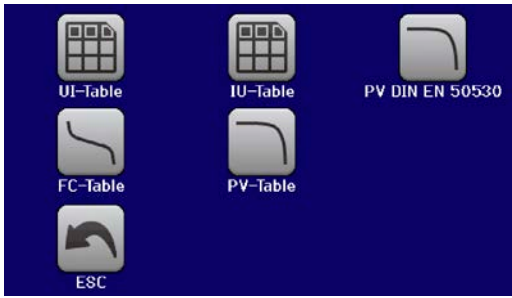
Pactual = Actual power on the DC output

Umpp / Impp / Pmpp = Voltage, current and power in the MPP of the currently calculated PV curve

> *The global parameter "USB logging with units (V,A,W)" in the General Settings of the device MENU selects whether the values in the CSV file are with or without physical unit. Default is with unit. Another parameter, "USB decimal point format" selects whether the device saves the CSV with comma (US) or semicolon (Standard) and defines the decimal point (dot and comma). The example CSV above shows the european format with decimal comma.*

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 73

3.10.15.8 Configuration step by step

Starting point

In MENU->Function Generator->2nd page->XY-Table you will find the PV functions. Select **PV DIN EN 50530**.

Step 1: Technology selection

The extended PV function requires to select the panel technology of the solar panel which is going to be simulated. In case **cSI** or **Thin Film** don't match your requirements or you aren't sure about their technology parameters, select **Manual**.

When selecting **Thin film** or **cSI** the configuration continues with **Step 2**.
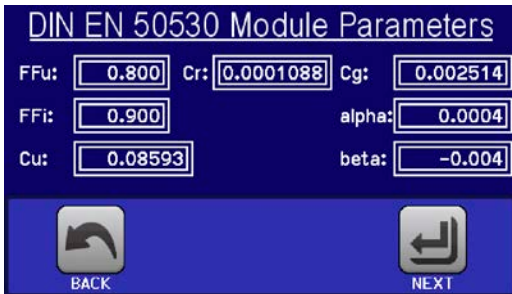
Step 1-1: Adjust technology parameters

If technology **Manual** was selected in the previous screen, all displayed technology parameters can be adjusted by tapping on them and entering the desired value. It's recommended to adjust these values very carefully, because wrong settings can result in a PV curve which doesn't work as expected.

When resetting the device, these values are reset to defaults which are the same as with technology **cSI**. Also see the overview in *3.10.15.3.* It means they don't necessarily have to be adjusted. If any of the other technologies was selected, this screen would be skipped and these parameters set to the defined values.

Step 2: Enter the solar panel's base parameters

The open circuit voltage (U_{OC}), the short-circuit current (I_{SC}), as well as voltage (U_{MPP}) and current (I_{MPP}) in the expected MPP are the base parameters to calculate a PV curve from. U_{OC} and I_{SC} are upper limits which are usually read from the data sheet of a solar panel and entered here for the simulation. Two parameters each are connected via the fill factors:

$$U_{MPP} = U_{OC} \times FFu \quad / \quad I_{MPP} = I_{SC} \times FFi$$

Step 3: Select simulation mode

For a description of the available simulation modes see *3.10.15.4.*

Furthermore, the recording feature can be enabled (=activated) here. The recorded data can later be stored to USB drive as CSV file with button **SAVE records to USB**, after returning to this screen from the simulation run. Also see section *3.10.15.7.*

When selecting **E/T** or **U/I** the configuration continues with **Step 4**.
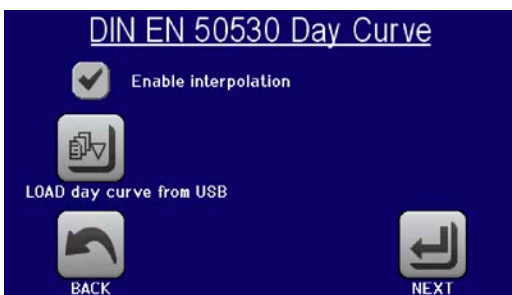
Step 3-1: Load day trend data

If mode **DAY E/T** or **DAY U/I** was selected this additional screen will appear where you can load the required day trend data (1-100,000 points) with button LOAD day curve from USB stick and from a CSV file with a specific format (see *3.10.15.5*) and name (see *1.9.6.5*).

There is furthermore the option to enable (=activate) the interpolation feature (see *3.10.15.6*).

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 74

Step 4: Global limits

This configuration screen allows to limit voltage and power globally for the simulation. The current, in this table based simulation, is taken from the calculated PV table which also is an IU table.

The output voltage of the power supply is already defined by setting up U_{OC} in step 2, so it's recommended to adjust value U to same or higher, else the PV curve may not be working as expected. The power should not be limited at all.

Recommendation: leave both values untouched

The configuration will be finished and the settings submitted with button . The function generator would then switch to control mode.

3.10.15.9 Controlling the simulation

After loading the configured parameters the FG will switch to control mode. Now the simulation can be started with either the "On/Off" button or touch area **START**.

According to the configured simulation mode, the orange-brown display area would show the adjustable simulation parameters, which could only be modified via direct input, not by the rotary knobs, because with every step of the knob the curve would be re-calculated.

The screen example on the right shows simulation mode **E/T**.

In case any of the day trend modes would have been configures, the display area would be empty. These modes run automatically once started and will stop when the total time of all points' dwell time is reached. The other modes, **E/T** and **U/I**, would only stop by user interaction or due to a device alarm.
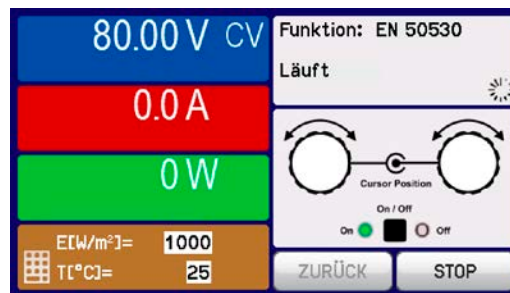
3.10.15.10 Stop criteria

The simulation run could unintentionally stop due to several reasons:

1. A device alarm occurred, which would switch off the DC output (PF, OVP, OCP, OPP)

2. An user event occurred whose action has been defined to cause an alarm, which means to switch off DC

3. Day trend mode has finished

Situation 2 can be avoided by carefully setting up other parameters, unrelated to the function generator. With the simulation stop in all three situation the data recording would also stop.

3.10.15.11 Test analysis

After simulation stop by whatever reason recorded data can be saved to USB stick or read via digital interface, of course only of data recording has been activated in the configuration. Activating the data recording feature during the simulation run isn't possible when manually controlling the FG, but in remote control. When saving to USB stick, it would always save all data recorded until the current index counter. Via digital interface there is the option read any portion of the data, which will also have an impact on the time required to read the data.

The data can later be used to visualise, analyse and determine characteristics of the simulated solar panel and also of the solar inverter which is usually used as load when running such tests. More details can be found in the standard paper.

3.10.15.12 Reading the PV curve

The last PV curve (or table) which has been calculated during the simulation run can later be read from the device via digital interface (partly or completely) or stored to USB stick. This can serve to verify the adjusted parameters. When running mode DAY E/T or DAY U/I this makes less sense, because there the curve would re-calculated with every processed index and the read curve would always be the one belonging to the last day trend curve point.

When reading the PV table, you will receive up to 4096 current values. The table data could be visualised in an XY diagram in tools like Excel.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 75

3.10.16 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 isn't controllable via the analog interface
- The function generator is unavailable if R mode (resistance) is activated
- Some functions are based on the arbitrary generator, some on the XY generator. Therefore, both generators have to be controlled and configured separately

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 76

3.11 Other applications

3.11.1 Parallel operation in master-slave (MS)

Parallel operation of multiple cabinets isn't intended. In case the total power of one cabinet is insufficient for the planned application, certain models can be extended by 15 kW or 30 kW of power. See „*1.9.5. Options*" and „*2.3.16. Adding further units*".

For other solutions, please contact our support. See „*6. Contact and support*".

3.11.2 Series connection

Series connection of two or multiple cabinets isn't intended.

3.11.3 Operation as battery charger

A power supply can be used as a battery charger, but with some restrictions, because it misses a battery supervision and a physical separation from the load in form of a relay or contactor, which is featured with real battery chargers as a form of protection.

Following has to be considered:

- No false polarity protection inside! Connecting a battery with false polarity will damage the power supply severely, even if it's not powered.
- All models of this series have an internal discharge circuit and a base load, which both ensure faster discharge of voltage when switching the DC output off or ramping voltage down. While the discharge circuit only works while the DC output is off, the base load would, though very slowly, discharge the battery even while the power supply isn't powered at all. It's thus recommended to only leave battery is connected until it's fully charged.

3.11.4 Two quadrants operation (2QO)

3.11.4.1 Introduction

This way of operation refers to the use of a source, in this case a power supply of series PSI 9000 15U/24U, and a sink, in this case one or several electronic loads of series ELR 9000 or EL 9000 B. The source and the sink function alternatingly in order to test a device, such as a battery, by deliberately charging and discharging it as part of a functional or final test.

The user can decide whether the system is operated manually or the power supply only as the dominant unit or both devices should be controlled by PC. We recommend to focus on the power supply, which is intended to control the load via the Share Bus connection. The two quadrants operation is only suitable for constant voltage operation (CV).

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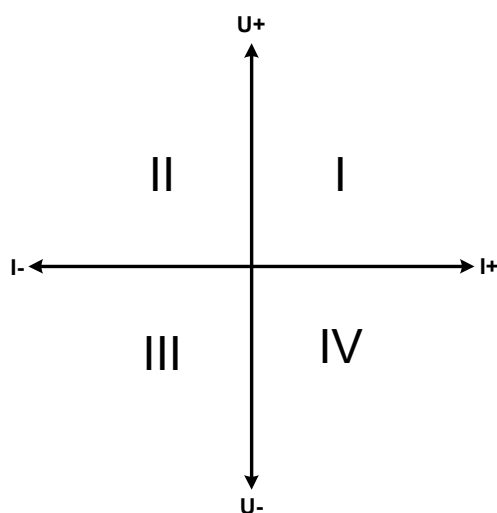
A combination of source and sink can only map the quadrants I + II. This means that only positive voltages are possible. The positive current is generated by the source or application and the negative current flows into the load..

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.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 77
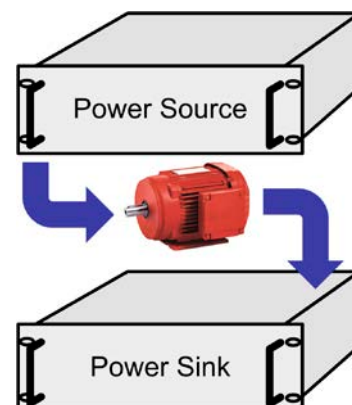
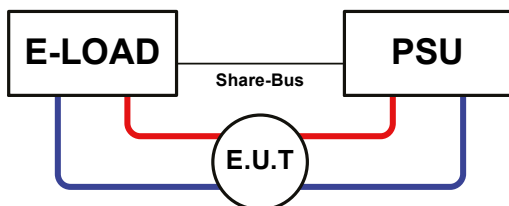#### 3.11.4.2 Connecting devices to a 2QO

There are several ways to connect source(s) and sink(s) to make a 2QO, but for this power supply series this configuration is recommend:

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

This is the most common configuration for 2QO. The nominal values for U,I and P of the two devices should match, such as EL 9080-1530 B 15U and PSI 9080-1530 15U. The system is controlled by the power supply. The load system will be configured as slave regarding the Share bus connection.

3.11.4.3 Settings on the devices

Regarding the general 2QO operation no extra setup is required on the power supply cabinet. Given that multiple electronic loads are used as sink, which also form a master-slave system, there is a parameter to set for the load system's master unit. Set the checkmark on "PSI/EL system" in page "Master-slave mode" of the General Settings in MENU. This will cause the load system to act as slave on the Share bus.

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 on all units to the desired levels, which will then switch off the DC output resp. the DC input in case of excess.

3.11.4.4 Restrictions

After the electronic load system has been connected via the Sharebus with the power supply system as controlling device, the load can't limit their input voltage anymore to what you adjust as "U set" on the device. The correct voltage level comes from the source, which controls the sink's voltage via Share bus.

3.11.4.5 Application example

Charging and discharging a set of 8 batteries with 24 V/300 Ah, using configuration A from above.

- Power supply PSI 9080-1020 15U with: I_{Set} = 240 A (charging current, 1/10 of Ah), P_{Set} = 30 kW
- Electronic load EL 9080-1020 B 15U set to: I_{Set} = discharging current for the battery (eg. 500 A), P_{Set} = 14.4 kW, plus probably UVD = 20 V with event type "Alarm" to stop discharging at a certain low voltage threshold
- Assumption: battery has a voltage of 26 V at test start
- DC input(s) and DC output(s) of all units switched off

> In this combination of devices it's recommended to always switch on the DC output of the source first and then the DC input of the sink.

1. Discharge of the battery to 24 V

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

Reaction: the e-load will load the battery with a maximum current of 100 A in order to discharge it to 24 V. The power supply delivers 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 24 V. Once the battery voltage has reached 24 V with a discharge current of approx. 0 A, the voltage will be maintained at this level by charging from the power supply.

> The power supply determines the voltage setting of the load via the Share bus. In order to avoid deep discharge of the battery due to accidentally setting the voltage on the power to a very low value, it's recommended to configure the undervoltage detection feature (UVD) of the load, so it will switch off the DC input when reaching minimum allowed discharge voltage. The settings of the load, as given via the Share bus, can't be read from the load's display.

2. Charging the battery to 27 V

Setup: Voltage on the power supply set to 27 V

Reaction: the power supply will charge the battery with a maximum current of 40 A, 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's controlled via the Share bus and set to a certain voltage, which is still higher than the actual battery voltage and the actual output voltage of the power supply. When reaching 27 V, the power supply will deliver only the current needed to maintain battery voltage.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 78

4.   Other information

4.1   Special characteristics of master-slave operation

The units in the cabinet run in master-slave operation. This can cause additional problem situations which do not occur when operating units outside of master-slave. For such occurrences the following regulations have been defined:

- If the DC part of one or more slave units is switched off due to a defect or overheating etc., the entire cabinet shuts down the power output and human interaction is required

- If one or more slave units are cut from AC supply (power switch, blackout, supply undervoltage) and come back later, they're usually automatically initialised and included again in the MS system. In situations where the automatic initialisation fails, it can be repeated manually in the MENU of the master unit.

- If the DC output of the master unit is switched off due to a defect or overheating, then the cabinet can't provide output power anymore

- If the master unit is cut from AC supply (power switch, blackout) and comes back later, it will automatically initialise the MS system again, finding and integrating all active slaves and making it possible to continue running the cabinet if being supervised by a control software which can handle such events

In situations of device alarms like OV or PF etc. following applies:

- Alarms can be generated by any slave unit in the cabinet, whereas the slave unit can't indicate anything and the master unit only displays the alarm itself, but not which unit actually caused it. This can only be monitored by software and when reading the alarm status of all units in the cabinet separately, because every unit has its own alarm counter

- If multiple alarms happen simultaneously, the master only indicates the most recent alarm in the display, but the alarm counter collects them all

- All units in the MS system supervise their own values regarding overvoltage, overcurrent and overpower and in case of alarm slave units report to the master unit. In situations where the current is probably not balanced between the units, it can occur that one unit generates an OCP alarm though the global OCP limit of the cabinet was not reached. The same can occur with the OPP alarm.

- All units in the cabinet feature an option to automatically switch off the display after some time of no use. This is primarily for the slave units which are not operated manually. This option is, however, not controlled from the master via the master-slave bus, so it has to manually set with every unit. The master can also make use of this option. In order to show the display content again it suffices to shortly tap on the screen.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 79

5. Service and maintenance

5.1 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 power loss. Heavily dirt filled fans can lead to insufficient airflow and therefore the DC output 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. The fans are located behind the front panels of the units.

5.2 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't and must not be repaired by the user. Contact the supplier in case of suspicion and elicit the steps to be taken.

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

• the supplier has been contacted and it's clarified how and where the equipment should be sent.

• the device is in fully assembled state (complete cabinet) or in disassembled state (units removed and separate) and in suitable transport packaging.

• optional extras such as a digital interface module are 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.

5.2.1 Firmware updates

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

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

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

• an imminent problem with your device can directly be solved, especially if we suggested to install an update during a support case

• a new feature has been added which you definitely want to use. In this case, the full responsibility is transferred to you.

Following also applies in connection with firmware updates:

• Simple changes in firmwares can have crucial effects on the application the devices are use in. We thus recommend to study the list of changes in the firmware history very thoroughly.

• Newly implemented features may require an updated documentation (user manual and/or programming guide, as well as LabView VIs), which is often delivered only later, sometimes significantly later

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 80

5.3   Calibration

5.3.1   Preface

All PSI 9000 series feature a function to re-adjust the most important output values when doing a calibration with possible requirement of re-adjustment in case these values have moved out of tolerance. The re-adjustment is limited to compensate small differences of up to 2% of the max. value. There are several reasons which could make it necessary to readjust a unit: component aging, component deterioration, extreme ambient conditions, high frequent use or after a unit has been repaired on location or a local service centre.

In a cabinet of PSI 9000 15/24U series there can be 2-6 units which each could have a tolerance, either in positive or negative direction. Hence it's required to calibrate the units separately. While the calibration of the master unit can be done on the control panel, the slave units can only be calibrated via USB and a software. The calibration procedure, as described below, refers to the master unit. The actual calibration can be done while the master unit remains in the cabinet and all slave units are powered off.

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 PSI device. Only then a comparison between values displayed on the PSI device and true DC output values is possible.

For example, if you want to verify and possibly readjust the output current of model PSI 9080-1020 3U which has 1020 A maximum current, stated with a max. error of 0.2%, you can only do that by using a specific measuring tool with max. 0.1% error or less. When measuring such high currents, it's recommended to use a current sensor, also called current transducer.

5.3.2   Preparation

For a successful calibration and readjustment, a few tools and certain ambient conditions are required:

- A measurement device (multimeter) for voltage, with a max. error of half the PSI's voltage error. That measurement device can also be used to measure the voltage on the current sensor when readjusting the current
- If the current is also going to be calibrated: a suitable current sensor, ideally specified for at least 1.25 times the max. output current of the PSI and with a max. error that is half or less than the max. current error of the PSI device to calibrate
- Normal ambient temperature of approx. 20-25°C
- Warmed up PSI unit, which has been run for at least 10 minutes under 50% power
- One or two adjustable loads, preferably electronic ones, which are capable of consuming at least 102% of the max. voltage and current of the PSI device and which are calibrated and precise

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

- Let the PSI device warm up for at least 10 minutes under 50% load, 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 output, but leave it yet unconnected
- Abort any form of remote control, deactivate master-slave mode, deactivate R mode (resistance)
- Connect external measurement device to the DC output or to the current sensor, depending on whether the voltage is going to be calibrated first or the current

5.3.3   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's recommended to do so.

Important:

> *When calibrating the output 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 PSI 9080-1020 3U. Other models are treated the same way, with values according to the particular PSI model and the required load.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 81

5.3.3.1   Calibrating the set values

► How to calibrate the output voltage

1. Connect a multimeter to the DC output. Connect a load and set its current to approx. 5% of the nominal current of the power supply, in this example ≈50 A, and 0 V (if the load is electronic).

2. In the display, tap MENU, then **General Settings**, then down to **Calibrate device** and then tap **START**.

3. In the next screen select: **Voltage calibration**, then **Calibrate output value** and **NEXT**. The power supply will switch the DC output on, set a certain output voltage and show the measured value as **U-mon**.

4. The next screen requests you to enter the measured output voltage from the multimeter at **Measured value=**. 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).
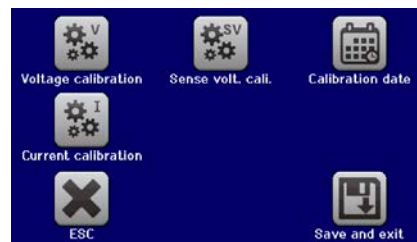
► How to calibrate the output current

1. Set the load to approx. 102% nominal current of the PSI device, for the example model with 1020 A this would be 1040.4 A, rounded to 1040 A.

2. In the display, tap MENU, then **General Settings**, then down to **Calibrate device** and then tap **START**.

3. In the next screen select: **Current calibration**, then **Calibrate output value** and **NEXT**. The device will switch on the DC output, set a certain current limit while loaded by the load/sink and show the measured output current as **I-mon**.

4. The next screen requests you to enter the output current **Measured value=** measured with your current sensor. Enter it using the keypad and assure yourself the value is correct and submit with **ENTER**.

5. Repeat step 4. for the next three steps (total of four steps).

5.3.3.2   Calibrating the remote sensing

In case you are generally using the remote sensing feature, it's recommended to also calibrate this feature for best results. The procedure is identical to the calibration of voltage, except for it requires to have the sensing connector (Sense) on the rear to be plugged and connected with correct polarity to the DC output of the PSI.

► How to calibrate the output voltage for remote sensing

1. Connect a load and set its current to approx. 5% of the nominal current of the power supply, in this example ≈50 A, and 0 V (if the load is electronic). Connect a multimeter to the DC input of the load and connect the remote sensing input (Sense) to the DC input of the load with correct polarity.

2. In the display of the PSI tap MENU, then **General Settings**, then down to **Calibrate device** and then tap **START**.

3. In the next screen select: **Sense volt. cali.**, then **Calibrate output value** and **NEXT.**

4. The next screen requests you to enter the measured sensing voltage **Measured value=** from your 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).

5.3.3.3   Calibrating the actual values

The actual values of output voltage (with and without remote sensing) and output current are calibrated almost the same way as the set values, but here you don't need to enter anything, just confirm the displayed values. Please proceed the above steps and instead of **Calibrate output val.** select **Calibrate actual val.** in the sub menus. After the device shows the measured values on display, wait at least 2 seconds for the measured value to settle and then tap NEXT until you are through all steps.

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 82

5.3.3.4 Save and exit

After calibration you may furthermore enter the current date as "calibration date" by tapping [Calibration date] in the selection screen and enter the date in format YYYY / MM / DD.

Last but not least save the calibration data permanently by tapping [Save and exit] .
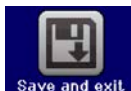
> ⚠️ Leaving the calibration selection menu without tapping "Save and exit" will discard calibration data and the procedure would have to be repeated!

6. Contact and support

6.1 Repairs

Repairs, if not otherwise arranged between supplier and customer, will be carried out by the manufacturer. For this the device must generally be returned to the manufacturer. No RMA number is needed. It's 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.

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

EA Elektro-Automatik GmbH
Helmholtzstr. 31-37 • 41747 Viersen
Germany

Fon: +49 2162 / 3785-0
Fax: +49 2162 / 16230

www.elektroautomatik.de
ea1974@elektroautomatik.de

Page 83

EA Elektro-Automatik GmbH & Co. KG
Development - Production - Sales

Helmholtzstraße 31-37
41747 Viersen
Germany

Fon: +49 2162 / 37 85-0
Fax: +49 2162 / 16 230
Mail: ea1974@elektroautomatik.de
Web: www.elektroautomatik.de