Elektro-Automatik

Operating Guide

PSI 9000 T

DC Laboratory Power Supply

Attention! This document is only valid for devices with firmware "KE: 3.09" and "HMI: 2.04" and "DR: 1.0.2" or higher. For availability of updates for your device check our website or contact us.

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1. General

1.1 About this document

1.1.1 Retention and use

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

1.1.2 Copyright

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

1.1.3 Validity

This manual is valid for the following equipment:

Model	Article number
PSI 9040-20 T	06200540
PSI 9080-10 T	06200541
PSI 9200-04 T	06200542
PSI 9040-40 T	06200543
PSI 9080-20 T	06200544
PSI 9200-10 T	06200545
PSI 9040-40 T	06200546

Model	Article number
PSI 9080-40 T	06200547
PSI 9200-15 T	06200548
PSI 9500-06 T	06200549
PSI 9040-60 T	06200550
PSI 9080-60 T	06200551
PSI 9200-25 T	06200552
PSI 9500-10 T	06200553

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

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

1.4 Disposal of equipment

A piece of equipment which is intended for disposal must, according to European laws and regulations (ElektroG, WEEE) be returned to the manufacturer for 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 - 40 T

T	Construction (not printed everywhere) **T** = Tower model
40	Maximum current of the device in Ampere
080	Maximum voltage of the device in Volt
9	Series : **8** = Series 8000 or 800, **9** = Series 9000
PSI	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 will not be accepted.
- All damage caused by non-intended usage is solely the responsibility of the operator.

1.7 Safety

1.7.1 Safety notices

Mortal danger - Hazardous voltage

- **Electrical equipment operation means that some parts can be under dangerous voltage. Therefore all parts under voltage must be covered! This basically applies to all models, though 40 V models according to SELV can't generate hazardous DC voltage.**
- **All work on connections must be carried out under zero voltage (output not connected to 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 cables or connectors directly after unplugging from mains supply as the danger of electric shock remains.**
- **Never touch the contacts on DC output terminal directly after switching off the DC output, because there still can dangerous voltage present, which has to still to sink to safe levels by the internal discharge circuit! There also can be dangerous potential between negative DC output to PE or positive DC output to PE due to charged X capacitors, which may not discharge at all!**

- 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 loads, 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 cards or modules may only be attached or removed after the device is switched off. It isn't 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 back side of the device!
- Always configure the various protecting features against overvoltage overpower etc. for sensitive loads to what the currently used application requires

1.7.2 Responsibility of the user

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

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

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

1.7.3 Responsibility of the operator

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

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

- be acquainted with the relevant job safety requirements
- identify other possible dangers arising from the specific usage conditions at the work station via a risk assessment
- introduce the necessary steps in the operating procedures for the local conditions
- regularly 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.

1.7.5 Alarm signals

The equipment offers various possibilities for signalling alarm conditions, however, not for danger situations. They are signalled optically (on the display as text) and electronically (pin/status output of an analog interface) and digitally (digital 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, non-condensing

1.8.2 General technical data

Display: Colour TFT touch screen with gorilla glass, 3.5”, 320pt x 240pt, capacitive

Controls: 2 rotary knobs with pushbutton functions, 2 pushbutton

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

1.8.3 Specific technical data

320 W	Model		
	PSI 9040-20 T	*PSI 9080-10 T*	*PSI 9200-04 T*
AC input			
Voltage range	90...264 V AC		
Connection	1 phase (L,N,PE)		
Frequency	45-65 Hz		
Fusing	MT 8 A		
Leak current	< 3.5 mA		
Power factor	≈ 0.99		
Inrush current @ 230 V	≈ 23 A		
DC output			
Max. output voltage U_{Max}	40 V	80 V	200 V
Max. output current I_{Max}	20 A	10 A	4 A
Max. output power P_{Max}	320 W	320 W	320 W
Overvoltage protection range	0...44 V	0...88 V	0...220 V
Overcurrent protection range	0...22 A	0...11 A	0...4.4 A
Overpower protection range	0…352 W	0…352 W	0…352 W
Output capacitance	4760 µF	3400 µF	720 µF
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm		
Voltage regulation			
Adjustment range	0...40.8 V	0...81.6 V	0...204 V
Accuracy (1 (at 23 ± 5°C)	< 0.1% U_{Max}	< 0.1% U_{Max}	< 0.1% U_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}
Load regulation at 0...100% load	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Rise time 0...100% (@full load)	Max. 30 ms	Max. 60 ms	Max. 65 ms
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (3	≤ 0.2% U_{Max}	≤ 0.2% U_{Max}	≤ 0.2% U_{Max}
Ripple (2	< 20 mV_{PP} < 2 mV_{RMS}	< 20 mV_{PP} < 2 mV_{RMS}	< 50 mV_{PP} < 6 mV_{RMS}
Remote sensing compensation	Max. 5% U_{Max}	Max. 5% U_{Max}	Max. 5% U_{Max}
Output voltage fall time (at no load) after switching DC output off	-	Down from 100% to <60 V: less than 10 s	
Current regulation			
Adjustment range	0...20.4 A	0...10.2 A	0...4.08 A
Accuracy (1 (at 23 ± 5°C)	< 0.2% I_{Max}	< 0.2% I_{Max}	< 0.2% I_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}
Load regulation at 0...100% ΔU_{OUT}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}
Ripple (2	< 1 mA_{RMS}	< 1 mA_{RMS}	< 1.5 mA_{RMS}
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (3	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}
Power regulation			
Adjustment range	0…326.4 W	0…326.4 W	0…326.4 W
Accuracy (1 (at 23 ± 5°C)	< 1% P_{Max}	< 1% P_{Max}	< 1% P_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% P_{Max}	< 0.05% P_{Max}	< 0.05% P_{Max}
Load reg. at 10-90% ΔU_{OUT} * ΔI_{OUT}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
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 RMS value: LF 0...300 kHz, PP value: HF 0...20MHz
(3 The display error adds to the error of the related actual value on the DC output

320 W	Model		
	PSI 9040-20 T	*PSI 9080-10 T*	*PSI 9200-04 T*
Power regulation			
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (2	≤ 0.8% P_{Max}	≤ 0.8% P_{Max}	≤ 0.8% P_{Max}
Efficiency (4	≤ 92%	≤ 92%	≤ 93%
Internal resistance regulation			
Adjustment range	0...80 Ω	0...160 Ω	0...960 Ω
Accuracy (1	≤ 2% of max. resistance ± 0.3% of maximum current		
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Analog interface (optional) (3			
Set value inputs	U, I, P, R		
Actual value output	U, I		
Control signals	DC on/off, remote control on/off, resistance mode on/off		
Status signals	CV, OVP, OT		
Insulation			
Output (DC) to enclosure (PE)	DC minus: permanent max. ±400 V DC plus: permanent max. ±400V + output voltage		
Input (AC) to output (DC)	Max. 2500 V, short-term		
Miscellaneous			
Cooling	Temperature controlled fan (60 mm), side 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		
Overvoltage category	2		
Protection class	1		
Pollution degree	2		
Operational altitude	< 2000 m		
Digital interfaces			
Built-in (default)	1x USB-B for communication, 1x USB-A for functions		
Built-in (optional)	1x LAN for communication		
Terminals			
Rear side	AC input, analog interface (optional), USB-B, Ethernet (optional)		
Front side	DC output, USB-A, remote sensing		
Dimensions			
Enclosure (WxHxD)	92 x 237 x 352 mm		
Total (WxHxD)	92 x 239 x min. 401 mm		
Weight	≈ 7.5 kg	≈ 7.5 kg	≈ 7.5 kg
Article number	06200540	06200541	06200542

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
(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 49*
(4 Typical value at 100% output voltage and 100% power

640 W	Model		
	PSI 9040-40 T	*PSI 9080-20 T*	*PSI 9200-10 T*
AC input			
Voltage range	90...264 V AC		
Connection	1 phase (L,N,PE)		
Frequency	45-65 Hz		
Fusing	MT 8 A		
Leak current	< 3.5 mA		
Power factor	≈ 0.99		
Inrush current @ 230 V	≈ 23 A		
DC output			
Max. output voltage U_{Max}	40 V	80 V	200 V
Max. output current I_{Max}	40 A	20 A	10 A
Max. output power P_{Max}	640 W	640 W	640 W
Overvoltage protection range	0...44 V	0...88 V	0...220 V
Overcurrent protection range	0...44 A	0...22 A	0...11 A
Overpower protection range	0…704 W	0…704 W	0…704 W
Output capacitance	4760 µF	3400 µF	720 µF
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm		
Voltage regulation			
Adjustment range	0...40.8 V	0...81.6 V	0...204 V
Accuracy (1 (at 23 ± 5°C)	< 0.1% U_{Max}	< 0.1% U_{Max}	< 0.1% U_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}
Load regulation at 0...100% load	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Rise time 0...100% (@full load)	Max. 30 ms	Max. 60 ms	Max. 65 ms
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (3	≤ 0.2% U_{Max}	≤ 0.2% U_{Max}	≤ 0.2% U_{Max}
Ripple (2	< 20 mV_{PP} < 2 mV_{RMS}	< 20 mV_{PP} < 2 mV_{RMS}	< 50 mV_{PP} < 6 mV_{RMS}
Remote sensing compensation	Max. 5% U_{Max}	Max. 5% U_{Max}	Max. 5% U_{Max}
Output voltage fall time (at no load) after switching DC output off	-	Down from 100% to <60 V: less than 10 s	
Current regulation			
Adjustment range	0...40.8 A	0...20.4 A	0...10.2 A
Accuracy (1 (at 23 ± 5°C)	< 0.2% I_{Max}	< 0.2% I_{Max}	< 0.2% I_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}
Load regulation at 0...100% ΔU_{OUT}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}
Ripple (2	< 1 mA_{RMS}	< 1 mA_{RMS}	< 1.5 mA_{RMS}
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (3	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}
Power regulation			
Adjustment range	0…652.8 W	0…652.8 W	0…652.8 W
Accuracy (1 (at 23 ± 5°C)	< 1% P_{Max}	< 1% P_{Max}	< 1% P_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% P_{Max}	< 0.05% P_{Max}	< 0.05% P_{Max}
Load reg. at 10-90% ΔU_{OUT} * ΔI_{OUT}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
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 RMS value: LF 0...300 kHz, PP value: HF 0...20MHz
(3 The display error adds to the error of the related actual value on the DC output

640 W	Model		
	PSI 9040-40 T	*PSI 9080-20 T*	*PSI 9200-10 T*
Power regulation			
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (2	≤ 0.8% P_{Max}	≤ 0.8% P_{Max}	≤ 0.8% P_{Max}
Efficiency (4	≤ 92%	≤ 92%	≤ 93%
Internal resistance regulation			
Adjustment range	0...40 Ω	0...80 Ω	0...480 Ω
Accuracy (1	≤ 2% of max. resistance ± 0.3% of maximum current		
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Analog interface (optional) (3			
Set value inputs	U, I, P, R		
Actual value output	U, I		
Control signals	DC on/off, remote control on/off, resistance mode on/off		
Status signals	CV, OVP, OT		
Insulation			
Output (DC) to enclosure (PE)	DC minus: permanent max. ±400 V DC plus: permanent max. ±400V + output voltage		
Input (AC) to output (DC)	Max. 2500 V, short-term		
Miscellaneous			
Cooling	Temperature controlled fan (60 mm), side 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		
Overvoltage category	2		
Protection class	1		
Pollution degree	2		
Operational altitude	< 2000 m		
Digital interfaces			
Built-in (default)	1x USB-B for communication, 1x USB-A for functions		
Built-in (optional)	1x LAN for communication		
Terminals			
Rear side	AC input, analog interface (optional), USB-B, Ethernet (optional)		
Front side	DC output, USB-A, remote sensing		
Dimensions			
Enclosure (WxHxD)	92 x 237 x 352 mm		
Total (WxHxD)	92 x 239 x min. 401 mm		
Weight	≈ 7.5 kg	≈ 7.5 kg	≈ 7.5 kg
Article number	06200543	06200544	06200545

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
(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 49*
(4 Typical value at 100% output voltage and 100% power

1000 W	Model		
	PSI 9040-40 T	***PSI 9080-40 T***	***PSI 9200-15 T***
AC input			
Voltage range	90...264 V AC		
Connection	1 phase (L,N,PE)		
Frequency	45-65 Hz		
Fusing	T 16 A		
Leak current	< 3.5 mA		
Power factor	≈ 0.99		
Inrush current @ 230 V	≈ 23 A		
DC output			
Max. output voltage U_{Max}	40 V	80 V	200 V
Max. output current I_{Max}	40 A	40 A	15 A
Max. output power P_{Max}	1000 W	1000 W	1000 W
Overvoltage protection range	0...44 V	0...88 V	0...220 V
Overcurrent protection range	0...44 A	0...44 A	0...16.5 A
Overpower protection range	0…1100 W	0…1100 W	0…1100 W
Output capacitance	6120 µF	6120 µF	1020 µF
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm		
Voltage regulation			
Adjustment range	0...40.8 V	0...81.6 V	0...204 V
Accuracy (1 (at 23 ± 5°C)	< 0.1% U_{Max}	< 0.1% U_{Max}	< 0.1% U_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}
Load regulation at 0...100% load	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Rise time 0...100% (@full load)	Max. 40 ms	Max. 40 ms	Max. 40 ms
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (3	≤ 0.2% U_{Max}	≤ 0.2% U_{Max}	≤ 0.2% U_{Max}
Ripple (2	< 25 mV_{PP} < 4 mV_{RMS}	< 25 mV_{PP} < 4 mV_{RMS}	< 150 mV_{PP} < 23 mV_{RMS}
Remote sensing compensation	Max. 5% U_{Max}	Max. 5% U_{Max}	Max. 5% U_{Max}
Output voltage fall time (at no load) after switching DC output off	-	Down from 100% to <60 V: less than 10 s	
Current regulation			
Adjustment range	0...40.8 A	0...40.8 A	0...15.3 A
Accuracy (1 (at 23 ± 5°C)	< 0.2% I_{Max}	< 0.2% I_{Max}	< 0.2% I_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}
Load regulation at 0...100% ΔU_{OUT}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}
Ripple (2	< 6 mA_{RMS}	< 6 mA_{RMS}	< 1.8 mA_{RMS}
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (3	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}
Power regulation			
Adjustment range	0…1020 W	0…1020 W	0…1020 W
Accuracy (1 (at 23 ± 5°C)	< 1% P_{Max}	< 1% P_{Max}	< 1% P_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% P_{Max}	< 0.05% P_{Max}	< 0.05% P_{Max}
Load reg. at 10-90% ΔU_{OUT} * ΔI_{OUT}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
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 RMS value: LF 0...300 kHz, PP value: HF 0...20MHz
(3 The display error adds to the error of the related actual value on the DC output

1000 W	Model		
	PSI 9040-40 T	*PSI 9080-40 T*	*PSI 9200-15 T*
Power regulation			
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (2	≤ 0.8% P_{Max}	≤ 0.8% P_{Max}	≤ 0.8% P_{Max}
Efficiency (4	≤ 92%	≤ 92%	≤ 92%
Internal resistance regulation			
Adjustment range	0...30 Ω	0...60 Ω	0...360 Ω
Accuracy (1	≤ 2% of max. resistance ± 0.3% of maximum current		
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Analog interface (optional) (3			
Set value inputs	U, I, P, R		
Actual value output	U, I		
Control signals	DC on/off, remote control on/off, resistance mode on/off		
Status signals	CV, OVP, OT		
Insulation			
Output (DC) to enclosure (PE)	DC minus: permanent max. ±400 V DC plus: permanent max. ±400V + output voltage		
Input (AC) to output (DC)	Max. 2500 V, short-term		
Miscellaneous			
Cooling	Temperature controlled fan (60 mm), side 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		
Overvoltage category	2		
Protection class	1		
Pollution degree	2		
Operational altitude	< 2000 m		
Digital interfaces			
Built-in (default)	1x USB-B for communication, 1x USB-A for functions		
Built-in (optional)	1x LAN for communication		
Terminals			
Rear side	AC input, analog interface (optional), USB-B, Ethernet (optional)		
Front side	DC output, USB-A, remote sensing		
Dimensions			
Enclosure (WxHxD)	92 x 237 x 412 mm		
Total (WxHxD)	92 x 239 x min. 461 mm		
Weight	≈8.5 kg	≈8.5 kg	≈8.5 kg
Article number	06200546	06200547	06200548

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
(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 49*
(4 Typical value at 100% output voltage and 100% power

1000 / 1500 W	Model		
	PSI 9500-06 T	*PSI 9040-60 T*	*PSI 9080-60 T*
AC input			
Voltage range without derating	90...264 V AC	150...264 V AC	150...264 V AC
Voltage range with derating	-	90...150 V AC	90...150 V AC
Connection	1 phase (L,N,PE)		
Frequency	45-65 Hz		
Fusing	T 16 A		
Leak current	< 3.5 mA		
Power factor	≈ 0.99		
Inrush current @ 230 V	≈ 23 A		
DC output			
Max. output voltage U_{Max}	500 V	40 V	80 V
Max. output current I_{Max}	6 A	60 A	60 A
Max. output power P_{Max}	1000 W	1500 W	1500 W
Max. output power P_{Max} with derating	-	1000 W	1000 W
Overvoltage protection range	0...550 V	0...44 V	0...88 V
Overcurrent protection range	0...6.6 A	0...66 A	0...66 A
Overpower protection range	0…1100 W	0…1650 W	0…1650 W
Output capacitance	130 µF	6120 µF	6120 µF
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm		
Voltage regulation			
Adjustment range	0...510 V	0...40.8 V	0...81.6 V
Accuracy (1 (at 23 ± 5°C)	< 0.1% U_{Max}	< 0.1% U_{Max}	< 0.1% U_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.02% U_{Max}	< 0.02% U_{Max}	< 0.02% U_{Max}
Load regulation at 0...100% load	< 0.05% U_{Max}	< 0.05% U_{Max}	< 0.05% U_{Max}
Rise time 0...100% (@full load)	Max. 30 ms	Max. 40 ms	Max. 40 ms
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (3	≤ 0.2% U_{Max}	≤ 0.2% U_{Max}	≤ 0.2% U_{Max}
Ripple (2	< 155 mV_{PP} < 33 mV_{RMS}	< 25 mV_{PP} < 4 mV_{RMS}	< 25 mV_{PP} < 4 mV_{RMS}
Remote sensing compensation	Max. 5% U_{Max}	Max. 5% U_{Max}	Max. 5% U_{Max}
Output voltage fall time (at no load) after switching DC output off	Down from 100% to <60 V: less than 10 s	-	Down from 100% to <60 V: less than 10 s
Current regulation			
Adjustment range	0...6.12 A	0...61.2 A	0...61.2 A
Accuracy (1 (at 23 ± 5°C)	< 0.2% I_{Max}	< 0.2% I_{Max}	< 0.2% I_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% I_{Max}	< 0.05% I_{Max}	< 0.05% I_{Max}
Load regulation at 0...100% ΔU_{OUT}	< 0.15% I_{Max}	< 0.15% I_{Max}	< 0.15% I_{Max}
Ripple (2	< 8 mA_{RMS}	< 6 mA_{RMS}	< 6 mA_{RMS}
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (3	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}
Power regulation			
Adjustment range	0…1020 W	0…1530 W	0…1530 W
Accuracy (1 (at 23 ± 5°C)	< 1% P_{Max}	< 1% P_{Max}	< 1% P_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% P_{Max}	< 0.05% P_{Max}	< 0.05% P_{Max}
Load reg. at 10-90% ΔU_{OUT} * ΔI_{OUT}	< 0.75% P_{Max}	< 0.75% P_{Max}	< 0.75% P_{Max}

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
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 RMS value: LF 0...300 kHz, PP value: HF 0...20MHz
(3 The display error adds to the error of the related actual value on the DC output

1000 / 1500 W	*Model*		
	PSI 9500-06 T	***PSI 9040-60 T***	***PSI 9080-60 T***
Power regulation			
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Display: Accuracy (2	≤ 0.8% P_{Max}	≤ 0.8% P_{Max}	≤ 0.8% P_{Max}
Efficiency (4	≤ 93%	≤ 92%	≤ 92%
Internal resistance regulation			
Adjustment range	0...1080 Ω	0...20 Ω	0...40 Ω
Accuracy (1	≤ 2% of max. resistance ± 0.3% of maximum current		
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*		
Analog interface (optional) (3			
Set value inputs	U, I, P, R		
Actual value output	U, I		
Control signals	DC on/off, remote control on/off, resistance mode on/off		
Status signals	CV, OVP, OT		
Insulation			
Output (DC) to enclosure (PE)	DC minus: permanent max. ±400 V DC plus: permanent max. ±400V + output voltage		
Input (AC) to output (DC)	Max. 2500 V, short-term		
Miscellaneous			
Cooling	Temperature controlled fan (60 mm), side 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		
Overvoltage category	2		
Protection class	1		
Pollution degree	2		
Operational altitude	< 2000 m		
Digital interfaces			
Built-in (default)	1x USB-B for communication, 1x USB-A for functions		
Built-in (optional)	1x LAN for communication		
Terminals			
Rear side	AC input, analog interface (optional), USB-B, Ethernet (optional)		
Front side	DC output, USB-A, remote sensing		
Dimensions			
Enclosure (WxHxD)	92 x 237 x 412 mm		
Total (WxHxD)	92 x 239 x min. 461 mm		
Weight	≈8.5 kg	≈8.5 kg	≈8.5 kg
Article number	06200549	06200550	06200551

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
(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 49*
(4 Typical value at 100% output voltage and 100% power

1500 W	Model	
	PSI 9200-25 T	PSI 9500-10 T
AC input		
Voltage range without derating	150...264 V AC	
Voltage range with derating	90...150 V AC	
Connection	1 phase (L,N,PE)	
Frequency	45-65 Hz	
Fusing	T 16 A	
Leak current	< 3.5 mA	
Power factor	≈ 0.99	
Inrush current @ 230 V	≈ 23 A	
DC output		
Max. output voltage U_{Max}	200 V	500 V
Max. output current I_{Max}	25 A	10 A
Max. output power P_{Max}	1500 W	1500 W
Max. output power P_{Max} with derating	1000 W	1000 W
Overvoltage protection range	0...220 V	0...550 V
Overcurrent protection range	0...27,5 A	0...11 A
Overpower protection range	0…1650 W	0…1650 W
Output capacitance	1020 µF	130 µF
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm	
Voltage regulation		
Adjustment range	0...204 V	0...510 V
Accuracy (1 (at 23 ± 5°C)	< 0.1% U_{Max}	< 0.1% U_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.02% U_{Max}	< 0.02% U_{Max}
Load regulation at 0...100% load	< 0.05% U_{Max}	< 0.05% U_{Max}
Rise time 0...100% (@full load)	Max. 40 ms	Max. 30 ms
Settling time after load step	< 1.5 ms	< 1.5 ms
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*	
Display: Accuracy (3	≤ 0.2% U_{Max}	≤ 0.2% U_{Max}
Ripple (2	< 150 mV_{PP} < 33 mV_{RMS}	< 155 mV_{PP} < 33 mV_{RMS}
Remote sensing compensation	Max. 5% U_{Max}	Max. 5% U_{Max}
Output voltage fall time (at no load)after switching DC output off	Down from 100% to <60 V: less than 10 s	
Current regulation		
Adjustment range	0...25.5 A	0...10.2 A
Accuracy (1 (at 23 ± 5°C)	< 0.2% I_{Max}	< 0.2% I_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% I_{Max}	< 0.05% I_{Max}
Load regulation at 0...100% ΔU_{OUT}	< 0.15% I_{Max}	< 0.15% I_{Max}
Ripple (2	< 1.8 mA_{RMS}	< 8 mA_{RMS}
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*	
Display: Accuracy (3	≤ 0.2% I_{Max}	≤ 0.2% I_{Max}
Power regulation		
Adjustment range	0…1530 W	0…1530 W
Accuracy (1 (at 23 ± 5°C)	< 1% P_{Max}	< 1% P_{Max}
Line regulation at ±10% ΔU_{AC}	< 0.05% P_{Max}	< 0.05% P_{Max}
Load reg. at 10-90% ΔU_{OUT} * ΔI_{OUT}	< 0.75% P_{Max}	< 0.75% P_{Max}

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
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 RMS value: LF 0...300 kHz, PP value: HF 0...20MHz
(3 The display error adds to the error of the related actual value on the DC output

1500 W	Model	
	PSI 9200-25 T	*PSI 9500-10 T*
Power regulation		
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*	
Display: Accuracy (2	≤ 0.8% P_{Max}	≤ 0.8% P_{Max}
Efficiency (4	≤ 92%	≤ 92%
Internal resistance regulation		
Adjustment range	0...240 Ω	0...1500 Ω
Accuracy (1	≤ 2% of max. resistance ± 0.3% of maximum current	
Display: Resolution	See section *„1.9.5.4. Resolution of the displayed values“*	
Analog interface (optional) (3		
Set value inputs	U, I, P, R	
Actual value output	U, I	
Control signals	DC on/off, remote control on/off, resistance mode on/off	
Status signals	CV, OVP, OT	
Insulation		
Output (DC) to enclosure (PE)	DC minus: permanent max. ±400 V DC plus: permanent max. ±400V + output voltage	
Input (AC) to output (DC)	Max. 2500 V, short-term	
Miscellaneous		
Cooling	Temperature controlled fan (60 mm), side 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	
Overvoltage category	2	
Protection class	1	
Pollution degree	2	
Operational altitude	< 2000 m	
Digital interfaces		
Built-in (default)	1x USB-B for communication, 1x USB-A for functions	
Built-in (optional)	1x LAN for communication	
Terminals		
Rear side	AC input, analog interface (optional), USB-B, Ethernet (optional)	
Front side	DC output, USB-A, remote sensing	
Dimensions		
Enclosure (WxHxD)	92 x 237 x 412 mm	
Total (WxHxD)	92 x 239 x min. 461 mm	
Weight	≈8.5 kg	≈8.5 kg
Article number	06200552	06200553

(1 Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
(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 49*
(4 Typical value at 100% output voltage and 100% power

1.8.4 Views

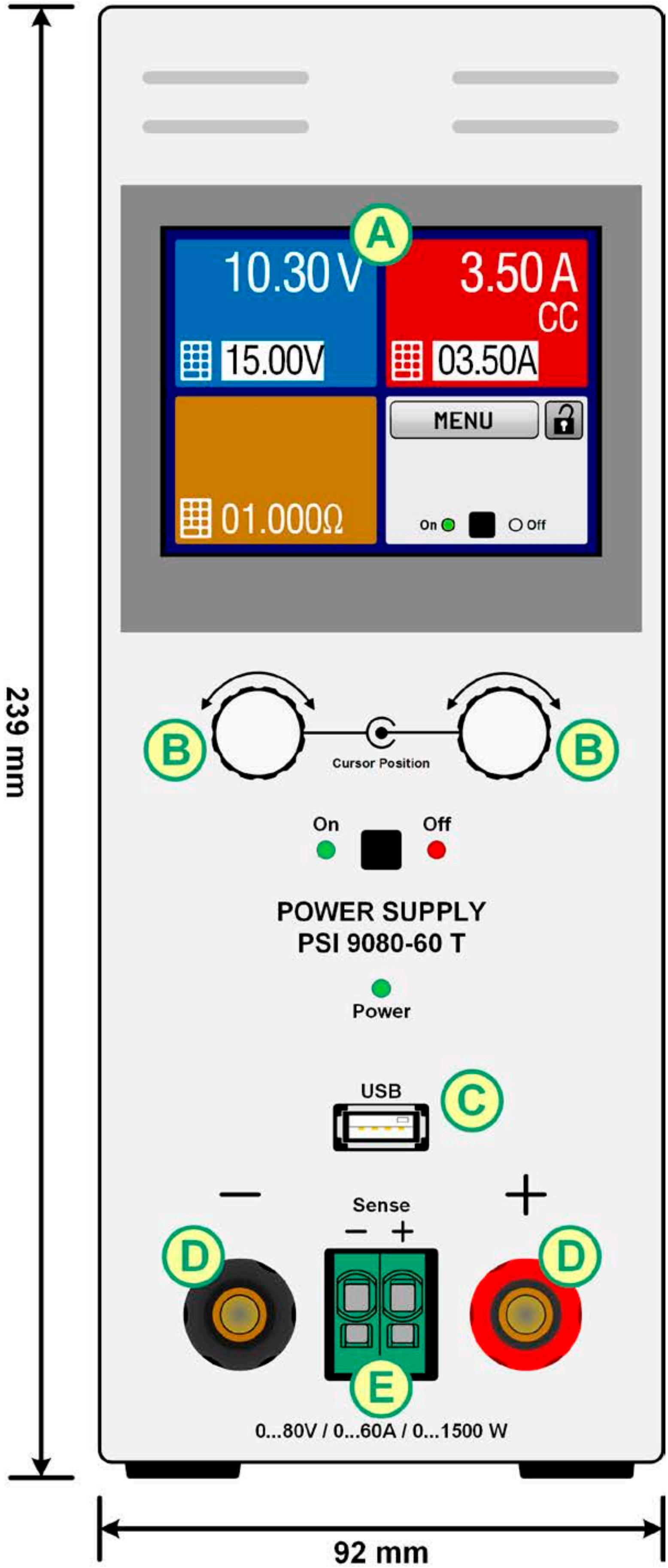


Figure 1 - Front view

A - Control panel with display
B - Knobs
C - USB port
D - DC output
E - Remote sensing connector

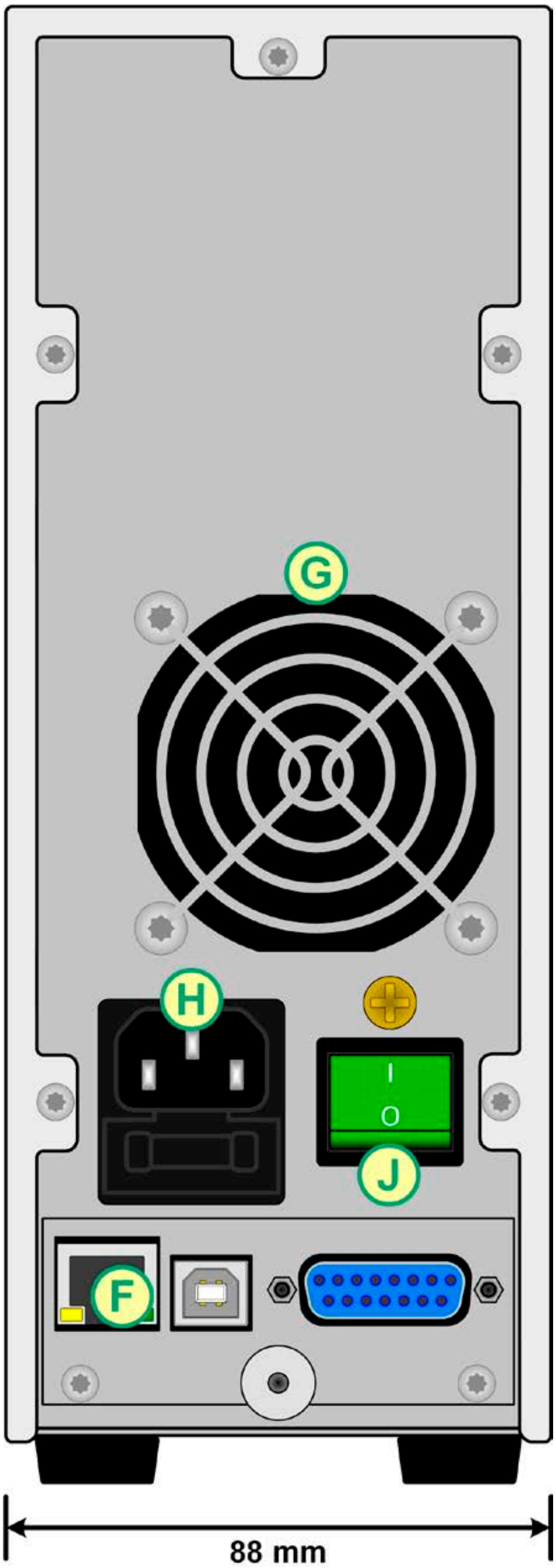


Figure 2 - Rear view (320 W / 640 W version shown)

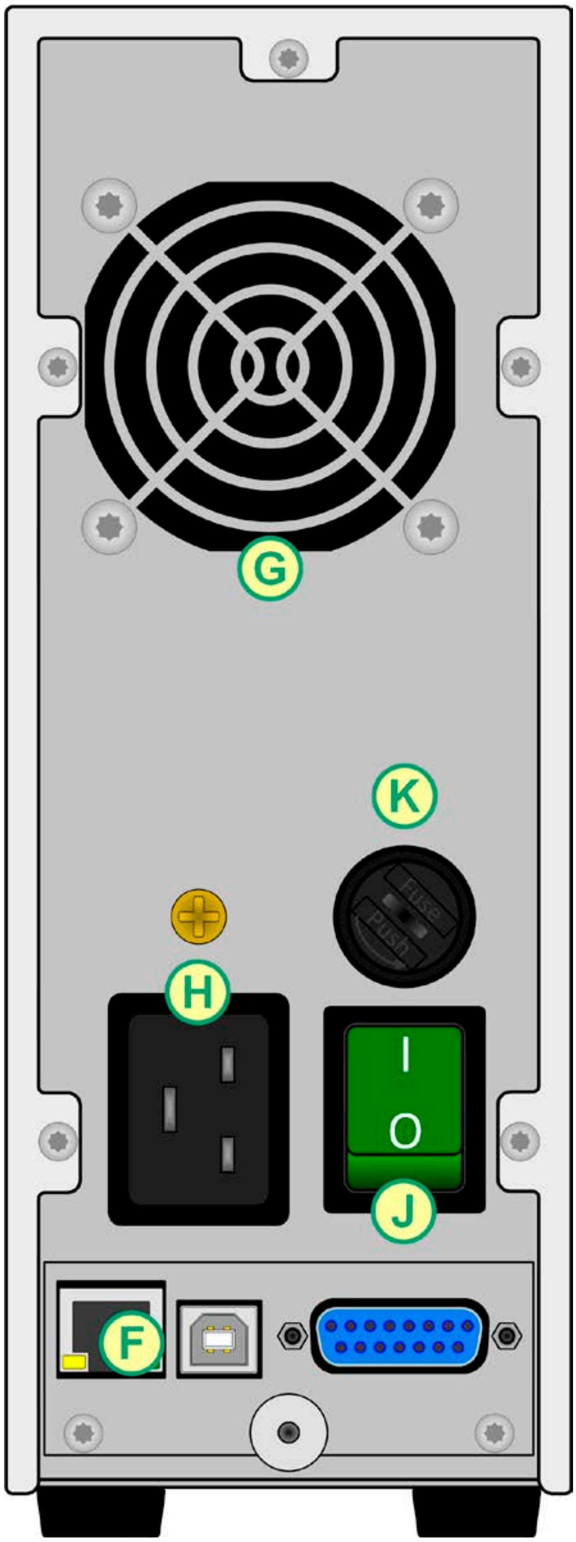


Figure 3 - Rear view (1000 W / 1500 W version shown)

⚠	Do not loosen the grounding point (brass screw above power switch or AC inlet) in order to connect PE cables! The device is supposed to be grounded via the AC cord, while the grounding point is used to connect the enclosure to PE.

F - Control interfaces (digital, analog)
G - Exhaust
H - AC input connection
J - Power switch
K - AC input fuse

Figure 4 - Top view

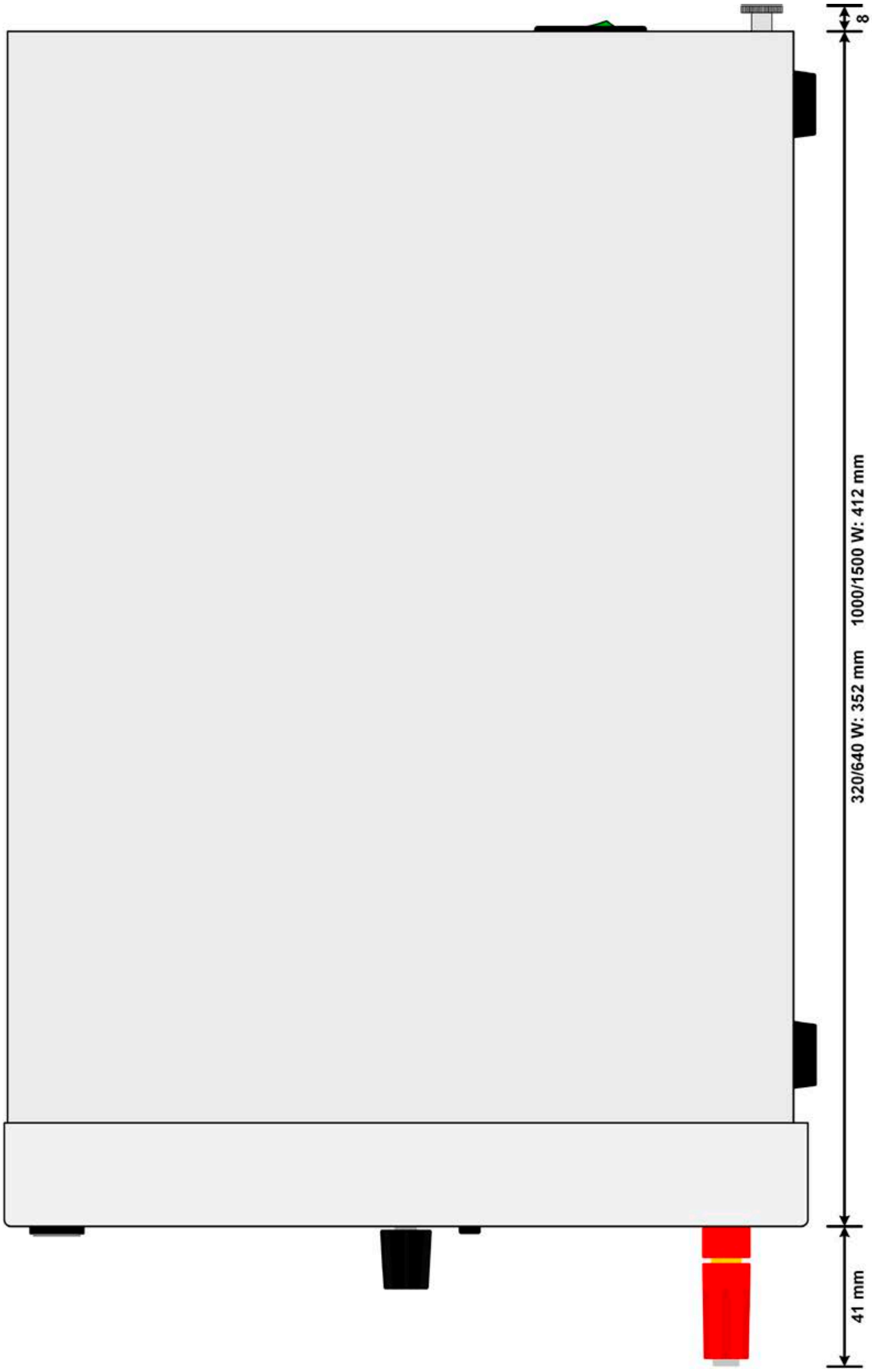


Figure 5 - Side view

1.8.5 Control elements

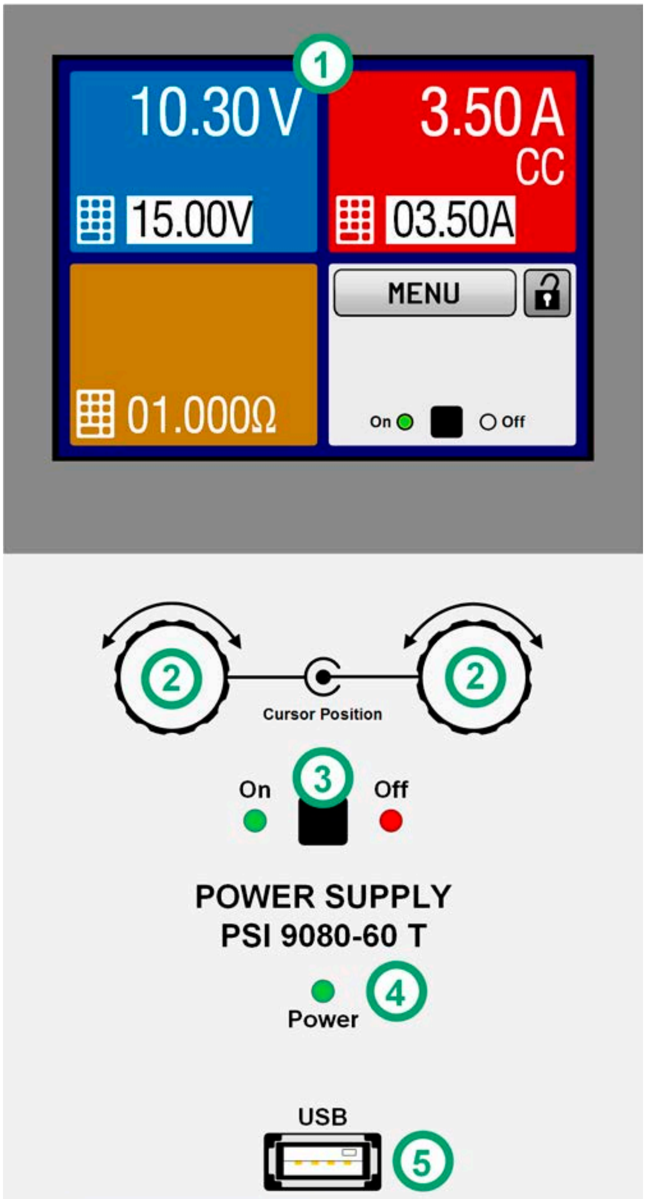


Figure 6 - Control panel

Overview of the operating panel

For a detailed description see section *„1.9.5. The control panel (HMI)“*.

(1)	**Touchscreen display** Used for selection of set values, menus, conditions and display of actual values and status. The touchscreen can be operated with the fingers or with a stylus.
(2)	**Rotary knob with push button function** Left knob (turn): adjusting the voltage set value, or setting the parameter values in the menu. Left knob (push): selection of the decimal position to be changed (cursor) for the assigned value. 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) for the assigned value.
(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)	**LED “Power”** Indicates different colours during the start of the device and remains green for the period of operation.
(5)	**USB host port** For the connection of standard USB sticks. See section *„1.9.5.5. USB port (front side)“* for more details.

1.9 Construction and function

1.9.1 General description

The DC laboratory power supplies of the PSI 9000 T series are especially suitable for the use in test and development applications, in laboratories and research. The "T" in the series names stands for tower and point for the upright enclosure design which saves space on laboratory desks and in test equipment racks.

Apart from standard features of power supplies, typical waves (sine, rectangular, triangular and other) can be generated by the integrated function generator. Curves for the arbitrary generator, which the basic waves are based on, can be stored on and uploaded from an USB flash drive.

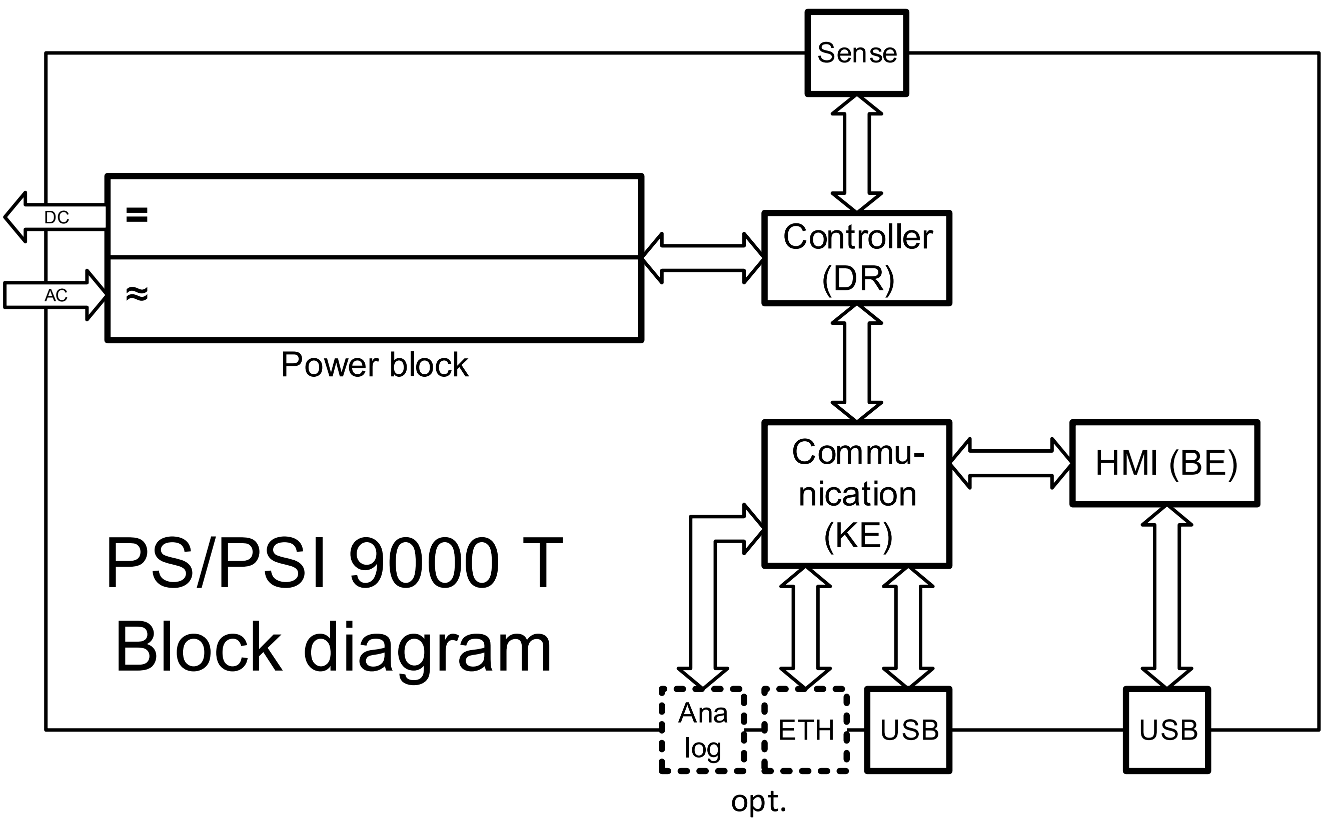
For remote control using a PC or PLC the devices are provided as standard with an USB port on the back side, which can be optionally extended to a 3-way interface with USB, Ethernet and analog port which is retrofittable by the user. All interface ports are galvanically isolated from the DC output. The configuration of the interfaces, if necessary at all, is simple. Thus the power supplies may, for example, be operated with other power supplies or even other types of equipment or controlled by external hardware 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), which can be target of firmware updates.



1.9.3 Scope of delivery

1 x Power supply device PSI 9000 T

1 x Mains cord 2 m (IEC, 16 A, 1000/1500 W models) or 1.5 m (IEC, 10 A, 320/640 W models) both with Schuko plug or, depending on shipping destination, command plug cable for 30 A (UK and other)

1 x USB cable, 1.8 m

1 x USB stick with software and documentation

1.9.4 Optional accessories

The below listed optional accessories can be purchased separately from the device and can be installed by the user:

IF-KE4 Ordering nr. 33 100 231	Exchangeable interface module with USB and Ethernet ports, as well as a 15-pole analog interface (D-Sub type). All interfaces are galvanically isolated from the DC output. The module can be retrofitted by the end user.

1.9.5 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.

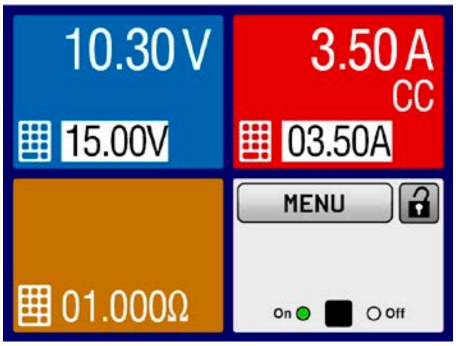
1.9.5.1 Touchscreen display

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 screen is separated into four areas of equal size, of which three are used to show actual and set values and one to display status information:

Actual voltage display
Voltage set value input

Actual power display
Power set value input
Resistance set value input



Actual current display
Current set value input

Touch areas MENU and LOCK
Status area

!	Touch areas may be enabled or disabled: MENU Black text or symbol = Enabled	MENU Grey text or symbol = Disabled

- **Actual / set values area (blue, red, green, orange)**

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 while resistance mode is activated. The fourth value, P or R depending on the current display mode, is then only accessible via MENU and only while the DC output is switched off.

When the DC output is switched on, the actual regulation mode **CV, CC, CP** or **CR** is displayed in the corresponding area, like depicted in the figure above with “CC” in the red area for current.

The set values can be adjusted with the rotary knobs below the touch screen or can be entered directly via the touchscreen. When adjusting with the knobs, pushing the knob will select the digit to adjust. Logically, the values are increased by 1 in clockwise turning and decreased by 1 in anti-clockwise turning, until reaching any limit (see *„3.4.4. Adjustment limits“*).

General display and settings ranges:

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

- **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 via....
Analog	....the analog interface
USB	....the USB port
Ethernet	....the Ethernet port
Local	The device has been locked by the user explicitly against remote control
Alarm:	Alarm condition which has not been acknowledged or still exists.
Event:	A user defined event has occurred which isn't yet acknowledged.
Function:	Function generator activated (during manual control)
FG	Function generator activated (during digital remote control)
/ ERR	Data logging to USB stick active or failed

1.9.5.2 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 the MENU. For a detailed description of the individual functions see section *„3.4 Manual operation" on page 38.*

1.9.5.3 Pushbutton function of the knobs

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

1.9.5.4 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.

Adjustable resolution and display formats for the touch panel 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 value	**Digits**	**Min. incre-ment**	**Nominal value**	**Digits**	**Min. incre-ment**	**Nominal value**	**Digits**	**Min. in-crement**	**Nominal value**	**Digits**	**Min. incre-ment**
40 V / 80 V	4	0.01 V	4 A / 6 A	4	0.001 A	320 W	4	0,1 W	20 Ω - 80 Ω	5	0.001 Ω
200 V	5	0.01 V	10 A / 15 A	5	0.001 A	640 W	4	0,1 W	160 Ω - 960 Ω	5	0.01 Ω
500 V	4	0.1 V	20 A / 25 A	5	0.001 A	1000 W	4	1 W	1500 Ω / 2250 Ω	5	0.1 Ω
			40 A / 60 A	4	0.01 A	1500 W	4	1 W			

In manual operation every set value can be set in the increments given above. In this case the actual output values set by the device will lie within percentage tolerances as shown in the technical data sheets. These will influence the actual values.

1.9.5.5 USB port (front side)

The frontal USB port, located below the LED “Power”, is intended for the connection of standard USB sticks. Such a stick can be used for several things, such as loading curves for the arbitrary function generator or record data during all operation modes.

USB 2.0 sticks are accepted and must be **FAT32** formatted and have a **maximum capacity of 32 GB**. USB 3.0 sticks are also supported, 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 would be assigned the letter G.

The control panel of the device can read the following file types from an USB stick:

profile_<nr>.csv	Previously 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.
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.

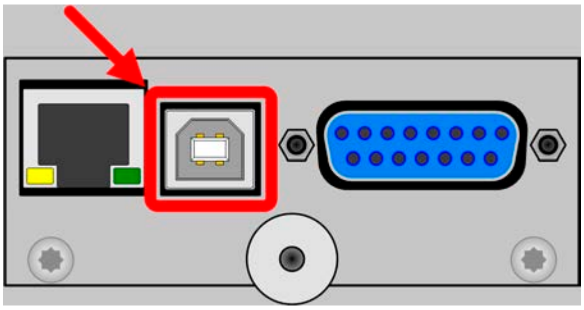
The control panel of the device can save the following file types to an USB stick:

profile_<nr>.csv	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 can be stored by in the folder.
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.
wave_u<nr>.csv wave_i<nr>.csv	Function generator for an arbitrary function, 99 sequence of either voltage (U) or current (I), depending on the selection

1.9.6 USB port (back side)

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

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 automatically.



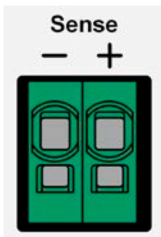
Picture shows optional available IF-KE4 interface module

If remote control is going to be activated, the USB interface has no priority over any other interface and can therefore only be used alternatively to them. However, monitoring is always available, no matter if and via what interface the device is remotely controlled.

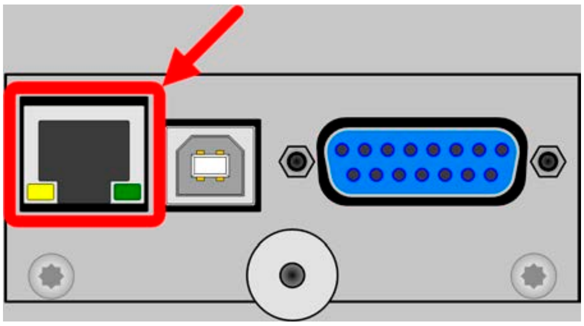
1.9.7 “Sense” connector (remote sensing)

In order to compensate for voltage drops along the DC cables to the load, the **Sense** input (between the DC output terminals) can be connected to the load. The device will automatically detect when the sense input is wired (Sense+) and compensate the output voltage accordingly.

The maximum possible compensation is given in the technical specifications.



1.9.8 Ethernet port



The Ethernet port is optional. Also see section *1.9.4*.

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

1. A website (HTTP, port 80) which is accessible in a standard browser under the IP or the host name given for the device. This website offers to configuration page for network parameters, as well as a input box for SCPI commands.

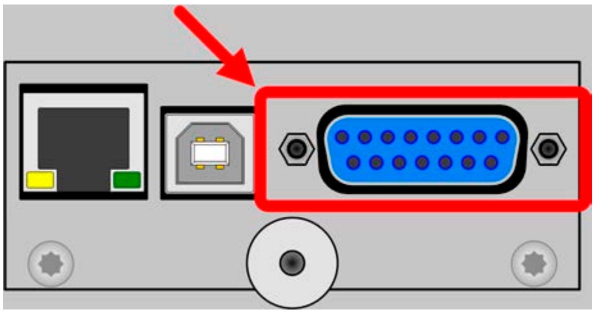
2. TCP/IP access via a freely selectable port (except 80 and other reserved ports). The standard port for this device is 5025. Via TCP/IP and this port, communication to the device can be established in most of the common programming languages.

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

The network setup can be done manually or by DHCP. The transmission speed is set to “Auto negotiation” and means it can use 10MBit/s or 100MBit/s. 1GB/s isn’t supported. Duplex mode is always full duplex.

If remote control is going to be activated, the Ethernet interface has no priority over any other interface and can therefore only be used alternatively to them. However, monitoring is always available, no matter if and via what interface the device is remotely controlled.

1.9.9 Analog interface



The analog interface is optional. Also see section *1.9.4*.

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

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%.

If remote control is going to be activated, the analog interface has no priority over any other interface and can therefore only be used alternatively to them. However, monitoring is always available, no matter if and via what interface the device is remotely controlled.

!	*The analog interface is only analog (per definition of the word) to the outside. Internally it’s processed by a microcontroller which causes it to have a limited resolution and sample rate.*

2. Installation & commissioning

2.1 Storage

2.1.1 Packaging

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

2.1.2 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

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

Mains connection for a PSI 9000 T series device is done via the included 1.5 meters or 2 meters long (depending on the power rating and input current) three-pole mains cord. In case a different AC connection is used, make sure that the other cable has at least a cross section suitable for the rated input current (stated on type label).

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

- The cable cross section should always be selected 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/or the cable length reduced.

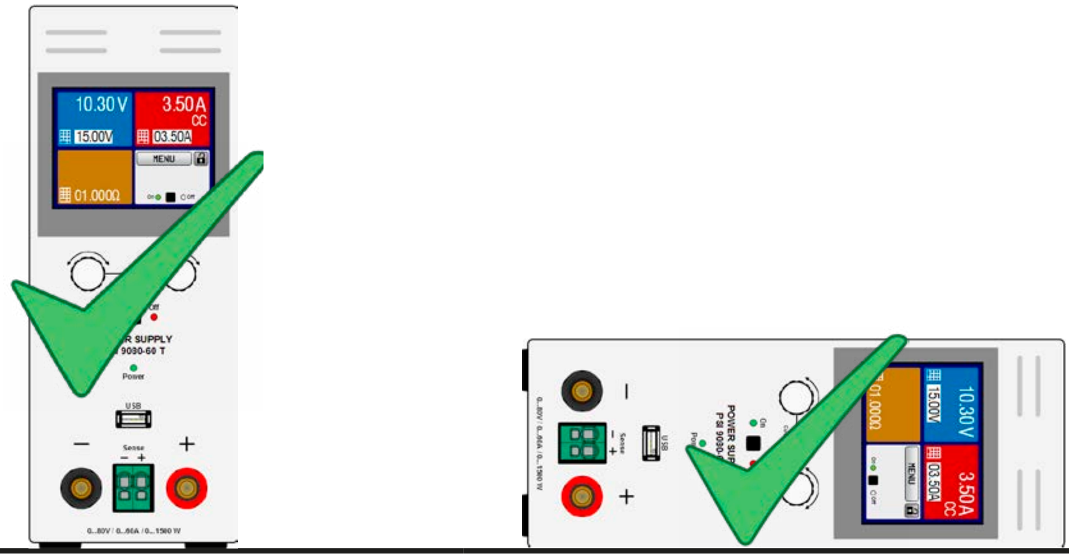
2.3.3 Installing the device

- Select the location for the device so that the connection to the load is as short as possible.
- Leave sufficient space behind the equipment, minimum 30cm, for ventilation.
- Never obstruct the air inlets on the sides!
- Never place any objects on top of the unit!

2.3.3.1 Placement on horizontal standing surfaces

The device is designed as a desktop unit and must only be operated on horizontal surfaces, which are capable of securely carrying the weight of the device.

Acceptable and inacceptable operating positions:

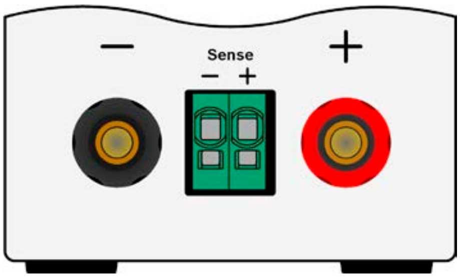


Standing surface

Standing surface

2.3.4 Connection to DC loads

- Connection to and operation with transformerless DC-AC inverters (for example solar inverters) is restricted, because the inverter can shift the potential of negative output (DC-) against PE (ground), which is limited to max. ±400 V DC.
- When using any model which is rated for 40 A or higher current, attention has to be paid to where the load is connected on the DC output terminals. The front-side 4mm connection point is rated for **max. 32 A**!
- Connection of voltage sources which can generate a voltage higher than 110% nominal of the device model isn't allowed!
- Connection of voltage sources with reversed polarity isn't allowed!



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

For cables **up to 5 m** and average ambient temperature up to 50°C, we recommend:

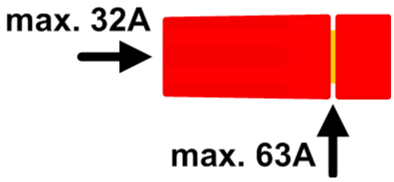
up to **10 A**:	0.75 mm² (AWG18)	up to **15 A**:	1.5 mm² (AWG14)
up to **20 A**:	4 mm² (AWG10)	up to **40 A**:	10 mm² (AWG8)
up to **60 A**:	16 mm² (AWG4)		

per lead (multi-conductor, insulated, openly suspended). Single cables of, for example, 16 mm² may be replaced by e. g. 2x 6 mm² etc. If the cables are long then the cross section must be increased to avoid voltage loss and overheating.

2.3.4.1 Possible connections on the DC output

The DC output on the front is of type clamp & plug and can be used with:

- 4 mm system plugs (Büschel, banana, safety) for **max. 32 A!**
- Spade lugs (6 mm or bigger)
- Soldered cable ends (only recommended for small currents up to 10 A)



When using any type of lugs or cable end sleeves, only use those with insulation in order to ensure electric shock protection!

2.3.5 Grounding of the DC output

It's allowed to ground the DC output. Grounding the DC plus pole is only allowed for models where a nominal output voltage of less than 400 V, else the potential shift on the DC minus could exceed the 400 V DC limit.

Series connection isn't intended for this series. In case it's unavoidable for an application, the same max. potential shift of ±400 V DC on the DC minus pole applies.

2.3.6 Connection of remote sensing

- Remote sensing is only effective during constant voltage operation (CV) and for other regulation modes the sense input should be disconnected, if possible, because connecting it generally increases the oscillation tendency.
- The cross section of the sense cables is noncritical. However, it should be increased with increasing cable length. Clamp terminal **Sense** is suitable for cross section of 0.2 mm² (AWG24) to 10 mm² (AWG8)
- Sense cables should be twisted and laid close to the DC cables to damp oscillation. If necessary, an additional capacitor can be installed at the load/consumer to eliminate oscillation
- The sense cables must be connected + to + and - to - at the load, otherwise both systems may be damaged

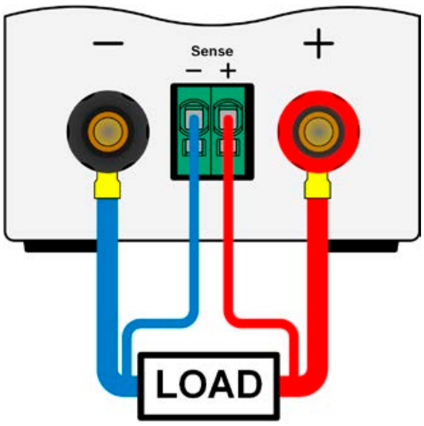


Figure 7 - Principle of remote sensing wiring

The connector Sense is a clamp terminal. It means for the remote sensing cables:

- Insert cables: crimp sleeves onto the cable ends and simply push them into the bigger square hole
- Remove cables: use a small flat screwdriver and push into the smaller square hole next to the bigger one to loosen the cable clamp, then remove cable end

2.3.7 Connecting the analog interface

The optionally available 15 pole connector (Type: Sub-D, D-Sub) on the rear side is an analog interface. To connect this to a controlling hardware (PC, electronic circuit), a standard plug is necessary (not included in the scope of delivery). It'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. Unless absolutely required, do not connect any ground of the analog interface (AGND) to the DC minus output as this will cancel the galvanic isolation.

2.3.8 Connecting the USB port (rear side)

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

2.3.8.1 Driver installation (Windows)

On the initial connection with a PC the operating system will identify the device as new hardware and will start 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.

2.3.8.2 Driver installation (Linux, MacOS)

We can't provide drivers or installation instructions for these operating systems. Whether a suitable driver is available is best found out by searching the Internet. With newer versions of Linux or MacOS, a generic CDC driver should be "on board".

2.3.8.3 Alternative drivers

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

2.3.9 Initial commission

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

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

2.3.10 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 *„2.3.9. Initial commission“.*

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

3. Operation & 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, all cables with lugs have to be crimped with insulated lugs. If necessary, install additional measures for protection against physical contact, such as a cover
- Whenever the load and DC output are being re-configured, the device should be switched off completely, not only the DC output!

3.2 Operating modes

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

- *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 and current*
- *It's recommended to not run the device below 10% voltage and current, in order to make sure technical values like ripple and transient times can be met*

3.2.1 Voltage regulation / Constant voltage

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

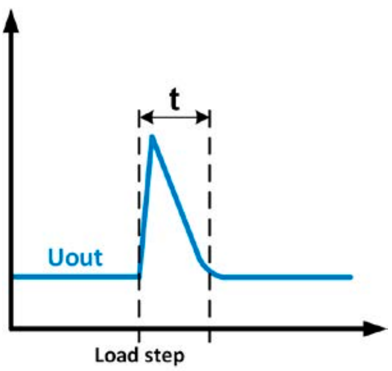
The DC output voltage of a power supply is held constant at the adjusted value, unless the output current or the output power according to $P = U_{OUT} * I_{OUT}$ reaches the adjusted current or power limit. In both cases the device would automatically change to constant current or constant power regulation, 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 via digital interface.

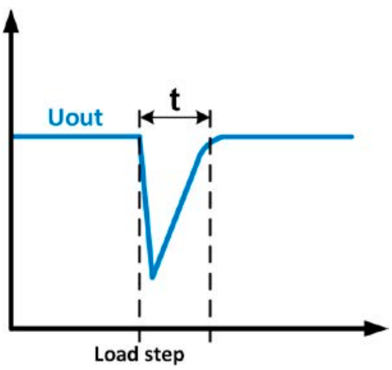
3.2.1.1 Transient time after load step

For constant voltage mode (CV), the technical date "Settling 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.

3.2.2 Current regulation / constant current / current limiting

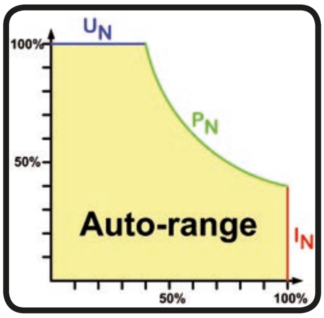
Current regulation is also known as current limiting or constant current mode (**CC**).

The actual current as supplied by the power supply is determined by the actual output voltage and the load's true resistance. As soon as the output current reaches the adjusted limit the device will automatically switch to constant current mode.

If, however, the power consumption reaches the set maximum power value first, the device will switch automatically to power limiting and set the output current according to $I_{MAX} = P_{SET} / U_{IN}$, even if the maximum current value is higher. Power regulation is superior and the current set value, as determined by the user, is always and only an upper limit.

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

3.2.3 Power regulation / constant power / power limiting



Power regulation, also known as power limiting or constant power (abbreviation: **CP**), keeps the DC output power of a power supply constant if the actual output current flowing to the load in relation to the actual output voltage reaches the adjusted limit according to $P = U * I$ resp. $P = U^2 / R_{LOAD}$. The power limiting then would regulate the output current according to $I = sqr(P / R_{LOAD})$.

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, the condition "CP mode active" will be shown on the graphic display by the abbreviation **CP**, as well stored as status which can be read via digital interface.

3.2.3.1 Power derating

Due to fusing and cross sections of conductors and the extended supply voltage range, power supply models with 1500 W rated output power have a fixed derating, which becomes active below a certain input voltage level (for the level see *„1.8.3. Specific technical data"*). It would derate the maximum available output power down to approx. 1000 W. The derating only affects the power output, so the full range for power set value adjustment remains, though the device will not provide full output power anymore. In this situation, constant power operation can't be indicated by status CP. Active derating can only be detected by reading the actual values and comparing them to the set values.

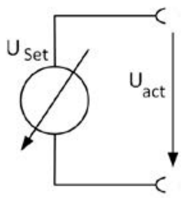
> **!** *There is no CP status available if the adjusted power set value is higher than the derated actual output power of the device. It means, derating isn't signalled anywhere.*

3.2.4 Internal resistance regulation

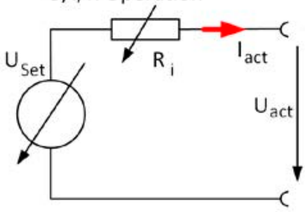
Internal resistance control (abbreviation: CR) of power supplies is the simulation of a virtual internal resistor which is in series to the voltage source and thus also in series to the load. According to Ohm's law, this causes a voltage drop, which will result in a difference between the adjusted output voltage and 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 in a fast ARM controller. Clarification:

U/I/P Operation



U/I/R Operation



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

$$P_{Ri} = (U_{Set} - U_{Act}) * I_{Act}$$

> **!** *While resistance mode is activated the function generator will be unavailable and the actual power value provided by the device doesn't include the simulated power dissipation of Ri.*

3.3 Alarm conditions

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

As a basic principle, all alarm conditions are signalled optically (text + message in the display) and as a readable status and alarm counter via the digital interface. In addition, the alarms OT 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) or internal auxiliary supply

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 will be 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 signalise a PF alarm every time the device is switched off. This can be ignored.

3.3.2 Overtemperature

An overtemperature alarm (OT) can occur if an excess temperature inside the device causes it to stop supplying power temporarily. 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 threshold (OVP, 0...110% U_{Nom}) or the connected load somehow returns voltage higher than set for the overvoltage alarm limit
- 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 an voltage overshoot for a short moment which can already trigger the OVP

This function serves 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 mode 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 exceeds 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 exceeds 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.

3.4 Manual operation

3.4.1 Switching on the device

The device should, as far as possible, always be switched on using the toggle switch on the rear of the device. After switching on, the display will first show the company logo, followed by a language selection which will close automatically after 3 seconds and later manufacturer's name and address, device type, firmware version(s), serial number and item number.

In setup (see section *„3.4.3. Configuration via MENU"),* in the second level menu "**General settings**" is an option "**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 on power-up is always 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 OVP. Those signal must be ignored until the device has finished booting and is ready to work.*

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.

3.4.3 Configuration via MENU

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

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

Menu navigation is by finger touch. Values are set using the rotary knobs. The assignments of the rotary knobs, if multiple values can be set in a particular menu, isn't always depicted. Following rule for such situations: upper value -> left knob, lower value .> right knob.

Some setting parameters are self-explanatory, others are not. Those are explained on the following pages.

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3.4.3.1 Menu “Settings”

This is main menu for all settings related to the general operation of the device and of the interface(s).

Sub menu	Description
Output Settings	Allows for adjustment of set values related to the DC output, alternatively to the handling in the main screen of the display
Protection	Allows for adjustment of protection thresholds (here: OVP, OCP, OPP) related to the DC output. Also see section *„3.3. Alarm conditions“*
Limit Settings	Allows for adjustment of adjustment limits for set values. Also see section *„3.4.4. Adjustment limits“*
General Settings	Settings for the operation of the device and its interface(s). Details below
Reset device	Touch area **Start** will initiate a reset of all settings (HMI, profile etc.) to default values, as shown in the menu structure diagrams on the previous pages, and all set values to 0
Calibrate device	Touch area **Start** starts a calibration routine (see *„4.3. Calibration“*), but only if the device is in U/I/P mode, i.e. R mode not activated.
Event Settings	Allows for adjustment of supervision features related to the DC output. Also see section *„3.6.2.1. User defined events“*

3.4.3.2 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 *1.9.5.1*
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 ON** = DC output will switch on again after the PF alarm cause is gone and if it was switched on before the alarm occurred
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 (**Yes**) or deactivates (**No**) the internal resistance control. If activated, the resistance set value of the simulated internal resistor can be adjusted additionally to the other set values. For more refer to *„3.2.4. Internal resistance regulation“* and *„3.4.6. Manual adjustment of set values“*
USB file separator format	Switches the decimal point format of values and also the CSV file separator for USB logging and for other features where 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**
Analog interface range	Selects the voltage range for the analog input values, actual values and reference voltage output. • **0...5 V** = Range corresponds to 0...100% set/actual values, reference voltage is 5 V • **0...10 V** = Range corresponds to 0...100% set/actual values, reference voltage is 10 V See also section *„3.5.4 Remote control via the analog interface (AI)“ on page 48*

Setting	Description
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“ on page 49*) 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 input REM-SB: • **DC OFF** = the pin can only be used to switch the DC output off • **DC AUTO** = the pin can be used to switch the DC output off and on again, if it has been switched on before at least from a different control location

3.4.3.3 Menu “Profiles”

See *„3.9 Loading and saving an user profile“ on page 55.*

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”

Apart from settings related to the USB logging feature, all settings for the digital interface(s) on the rear side are configured here. Upon delivery, the device only features an USB port which doesn’t require configuration. It can be extended by an Ethernet/LAN port by installing the optional 3-way interface board IF-KE4. After installation or a complete device reset, the Ethernet port has following **default settings** assigned:

- DHCP: off
- IP: 192.168.0.2
- Subnet mask: 255.255.255.0
- Gateway: 192.168.0.1
- Port: 5025
- DNS: 0.0.0.0

Those settings can be changed anytime and configured to meet local requirements. Furthermore, there are global communication settings available regarding timing and protocols.

Sub menu “**IP Settings 1**”

Element	Description
Adr. Source	**DHCP**: With setting DHCP the device will instantly try to get network parameters (IP, subnet mask, gateway, DNS) assigned from a DHCP server after power-on or when changing from **Manual** to **DHCP** and submitting the change with button ENTER. If the DHCP configuration attempt fails, the device will use the settings from **Manual**. In this case, the overview in screen **View settings** will indicate the DCHP status as **DHCP (failed)**, otherwise as **DHCP(active)** **Manual** (default setting): uses either the default network parameters (after reset) or the last user setting. Those parameters are not overwritten from selection **DHCP** and are thus available when switching to **Manual** again.
IP address	Only available with setting **Manual**. Default value: 192.168.0.2 Manual setting of the device’s IP address in standard IP format (setting will be stored)
Subnet mask	Only available with setting **Manual**. Default value: 255.255.255.0 Manual setting of the subnet mask in standard IP format (setting will be stored)
Gateway	Only available with setting **Manual**. Default value: 192.168.0.1 Manual setting of the gateway address in standard IP format (setting will be stored)

Sub menu "**IP Settings 2**"

Element	Description
DNS address	Default value: 0.0.0.0 Permanent manual setting of the network address of a domain name server (short: DNS) which has to be present in order to translate the host name to the device's IP, so the device could alternatively access by the host name
Port	Default value: 5025 Adjust the socket port here, which belongs to the IP address and serves for TCP/P access when controlling the device remotely via Ethernet

Sub menu "**TCP Keep-Alive**"

Element	Description
Enable TCP Keep-Alive	Default setting: disabled Enables/disables listening to the keep-alive functionality of the LAN which disable the Ethernet timeout (**Timeout ETH**, see below) as long as keep-alive is on.

Sub menu "**Logging**"

Element	Description
Enable USB logging	Default setting: disabled Enables/disables the "log to USB stick" feature. Once enabled, you can define the log interval (multiple steps, 500 ms ... 5 s) and choose between **Start/stop with DC on/off** or **Manual start/stop**. With a properly formatted USB stick (also see *1.9.5.5*) plugged, logging to USB stick can be used anytime. For more refer to *„3.4.9. Recording to USB stick (logging)"*.

Sub menu "**Com Protocols**" (communication protocols)

Element	Description
SCPI / ModBus	Default setting: both enabled Enables/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.

Sub menu "**Com Timeout**" (communication timeout)

Element	Description
Timeout USB (ms)	Default value: 5 USB/RS232 communication timeout in milliseconds. 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 (s)	Default value: 5 Socket timeout in seconds. Defines the time after which the device disconnects the Ethernet socket automatically due to inactivity, unless the **TCP keep-alive** option is enabled and keep-alive packets are broadcasted in the network.

3.4.3.8 Menu “HMI Setup”

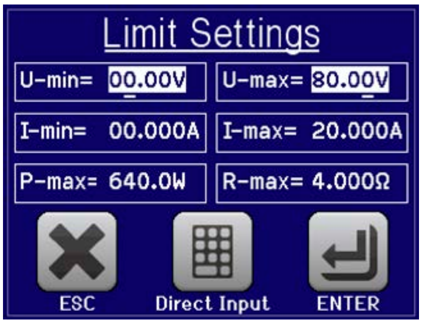
These settings refer exclusively to the control panel (HMI).

Element	Description
Language	Selection of the display language between German, English, Russian or Chinese. This selection screen is also shown for 3 seconds during the startup phase of the device.
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 brightness can be selected in 10 steps.
HMI Lock	See *“„3.7 Control panel (HMI) lock“ on page 54.*
Status Page	When enabled, this option switches the main screen of the device display to a simpler version with only voltage and current plus status.
Limits Lock	Allows for the lock of safety relevant parameters with a PIN code, here the so-called adjustment limits. See *„3.8. Limits lock“* for more information. While the lock is active, the menu to set these adjustment limits isn’t accessible. The PIN used here is the same as for the HMI PIN lock (see above). The lock is also effective on the user profiles, because they contain a set of values for the limit settings, as well as on the feature “Reset device”.

3.4.4 Adjustment limits

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

The limits settings could be locked by a PIN (see MENU, “Limits lock”)



By default, all set values (U, I, P, R) are adjustable from 0 to 102% of the rated value. 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.

► How to configure the adjustment limits

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

2. Tap on  and then on  to open the menu page for the adjustment limits.

3. In each case a pair of upper and lower limits for U/I or the upper limit for P/R is assigned to the rotary knobs and can be adjusted. Tap another pair to switch the selection.
4. Accept the settings with .

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

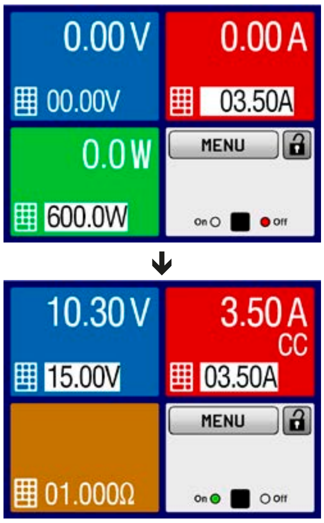
The adjustment limits are coupled to the set values. It means, that the upper limit may not be set lower than the corresponding set value. Example: If you wish to set the limit for the power set value (P-max) to 1000 W while the currently adjusted power set value is 1100 W, then the set value first would have to be reduced to 1000 W or less.

3.4.5 Changing the operating mode

In general, the manual operation of a PSI 9000 T distinguishes between two operating modes: UIP and UIR.

With mode UIR selected, the resistance set value is adjustable additionally to the ones of U and I, while in UIP the power set value replaces the resistance value. The resistance, as adjustable set value, is only available after activation of the resistance mode (short: UIR) in the MENU (also see *„3.4.3.2. Menu “General Settings”“*). In UIR mode, the device simulates a physically non-existent internal resistance which is in line with the load’s resistance. Also see *„3.2.4. Internal resistance regulation“*.

► How to switch the operation mode between UIP and UIR



1. Activate the resistance mode in the MENU. After leaving the menu again, the area which was filled green before and showed the set and actual values of power now is filled with an orange-brown and will show the set value of resistance.
2. Going back to UIP mode is done vice versa, by deactivating UIR mode in the MENU again. The lower left area is then switched back to green fill and power values are shown again.

Depending on the selection, a different value (U, P or R) is assigned to the left-hand rotary knob while the right-hand knob is always assigned to the current (I).

Switching to UIR mode doesn’t deactivate the set value of power. It means, the adjusted power value is still in effect. During UIR mode, the power set value can only be accessed and adjusted in the MENU.

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 the two rotary knobs on the front of the device are always assigned to two of the values in manual operation. Default assignment is voltage and current.

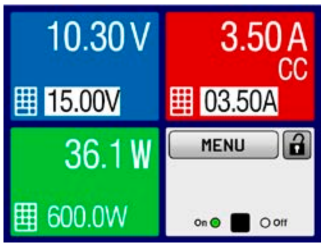
As a fourth value there is the internal resistance, for which the resistance mode (R mode, also called UIR mode) has to be activated in the MENU. Refer to *„3.4.3. Configuration via MENU“* and *„3.2.4. Internal resistance regulation“* for details.

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%.

> ! *Entering a value changes it at any time, no matter if the DC output is switched on or off. As long as the output is still switched of, the set values can be considered as presets which only become active when switching the DC output on. The characteristics of the output voltage depends on how you do it. There are two options: either set voltage/current/power first and then switch the DC output on or vice versa.*

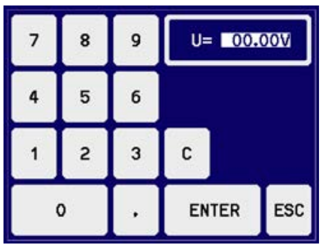
> ! *When adjusting the set values, upper or lower limits may come into effect. See section „3.4.4. Adjustment limits“. Once a limit is reached, the display will show a note like “Limit: U-max” etc. for 1.5 seconds next to the adjusted value or will refuse to accept a value entered by direct input.*

► How to adjust values 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 with the two assigned set values being inverted.
2. If, as shown in the example, the assignment is voltage (U, left-hand knob) and current (I, right-hand knob) and you wish to set the power the assignment of the left-hand knob can be changed by tapping the green area for power. This will switch the knob to power adjustment and highlight the power value.
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 (the selected digit will be underlined):

► How to adjust values via direct input



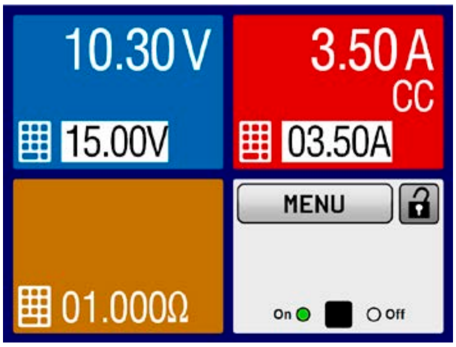
1. In the main screen, depending on the rotary knob assignment, values can be set for voltage (U), current (I), power (P) or resistance (R) via direct input by tapping on the small keypad symbol in the set/actual value display areas, e.g in the uppermost area of voltage.
2. Enter the required value using 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 reverts to the main page and the set values take effect.

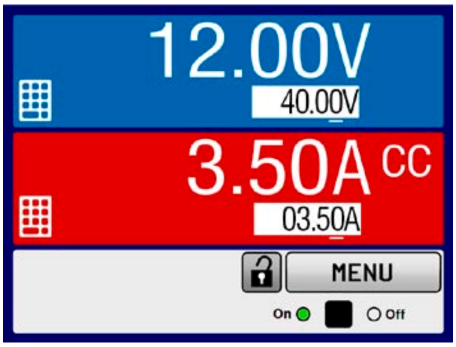
3.4.7 Switching the main screen view

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 **bigger characters**, so they read 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



Limitations of the alternative status page:

In alternative status page mode, the set values of power and resistance are not 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 at the same position

3.4.8 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 could be disabled by pin REM-SB of the optional analog interface, if installed. For more information refer to 3.4.3.2 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, as long as a change isn't restricted by an alarm or the device is locked in "remote". The DC output condition is displayed as either "On" or "Off" next to LEDs on the front and with corresponding color.

► 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 48.*

► 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.

3.4.9 Recording to USB stick (logging)

Device data can be recorded to USB stick (2.0, 3.0, not all vendors supported) anytime. For specifications of the USB stick and the generated log files refer to section *„1.9.5.5. 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.

3.4.9.1 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.

3.4.9.2 Handling (start/stop)

With setting **Start/stop with DC 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.

3.4.9.3 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

3.4.9.4 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 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

3.5 Remote control

3.5.1 General

Remote control is possible via the built-in USB port (rear side) or the optionally available interfaces Analog and Ethernet (also see sections *1.9.4, 1.9.8* and *1.9.9*). Important here is that only the analog or any of the digital interfaces 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 locations from where the device is controlled. Essentially there are two: at the device (manual operation) and outside (remote control). The following locations are defined:

Displayed location	Description
-	If neither of the other locations is displayed then manual control is active and access from the analog and digital interfaces is allowed. This location 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 *„3.4.3.2. Menu "General Settings""*). In inhibited condition the status **Local** will be displayed in the bottom right area. Activating the lock 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: USB** etc.), then it's immediately terminated and in order to continue remote control once **Local** is no longer active, it can 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

The device only supports the built-in digital interfaces USB and Ethernet (optionally available).

For USB, a standard USB cable is included in the delivery, as well as a driver for Windows on USB stick. The USB interface requires no setup in the MENU.

The Ethernet interface typically requires network setup (manual or DHCP), but can also be used with its default parameters right from the start.

3.5.3.2 General

For the network port installation refer to *„1.9.8. Ethernet port"*.

The digital interface require little or no setup for operation and can be directly used with their default configuration. All specific settings will be permanently stored, but could also be reset to defaults with the setup menu item **Reset Device**.

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

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

3.5.3.3 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 EA Elektro-Automatik website.

3.5.4 Remote control via the analog interface (AI)

3.5.4.1 General

The optionally available, galvanically isolated, 15-pole analog interface (short: AI, also see section *1.9.9*) is located on the back side of the device after installation and offers the following possibilities:

- Remote control of current, voltage, power and internal resistance
- Remote status monitoring (CV)
- Remote alarm monitoring (OT, OVP, 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 and power set by the rotary knobs, 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 put in operation. Analog set values can be fed in by an external voltage or generated by the reference voltage on pin 3. As soon as remote control via the analog interface is activated, the values displayed will be those provided by the interface.

The AI can be operated in the common voltage ranges 0...5 V and 0...10 V in each case 0...100% of the nominal value. The selection of the voltage range can be done in the device setup. See section *„3.4.3. Configuration via MENU“* for details.

The reference voltage sent out from Pin 3 (VREF) will be adapted accordingly and is then:

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

0-10 V: .Reference voltage = 10 V, 0...10 V set values (VSEL, CSEL, PSEL RSEL) correspond to 0...100% nominal values, 0...100% actual values correspond to 0...10 V at the actual value outputs (CMON, 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. Important notes for use of the interface:

!	*After powering the device and during the start phase the AI signals undefined statuses on the output pins. Those must be ignored until is ready to work.*

- Analog remote control of the device must be activated by switching pin REMOTE (5) first. 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). In case any of the set values isn't used for adjustment, the corresponding pin can be tied to a defined level or connected to pin VREF (solder bridge or similar) so it gives 100%

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 approx. 16384 (14 bits). 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 *3.5.4.4*), for example the overvoltage alarm (OV), which is considered as critical.

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. While alarms OT and OV can be monitored via the corresponding pins of the interface, other alarms like overcurrent (OC) can't. Those could only be monitored and detected via the actual values of voltage and current being all zero contrary to the set values.

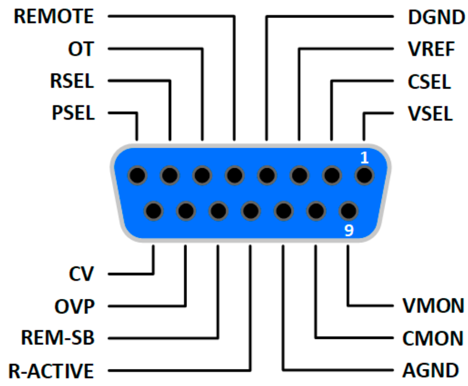
Some device alarms have to be acknowledged. Also see *„3.6.2. Device alarm and event handling“.* Acknowledgement is done with pin REM-SB switching the DC output off and on again, means a HIGH-LOW-HIGH edge (min. 50 ms for LOW).

3.5.4.4 Analog interface specification

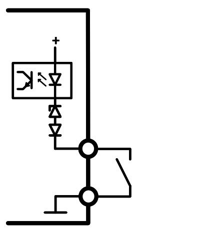
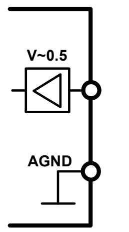
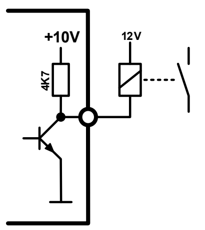
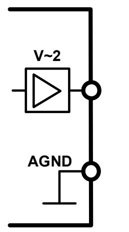
Pin	Name	Type*	Description	Levels	Electrical specification-
1	VSEL	AI	Set voltage value	0…10 V or. 0...5 V correspond to 0..100% of U_{Nom}	Accuracy 0-5 V range: < 0.4% **** Accuracy 0-10 V range: < 0.2% **** Input impedance R_i >40 k...100 k
2	CSEL	AI	Set current value	0…10 V or. 0...5 V correspond to 0..100% of I_{Nom}	
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	Switching manual / remote control	Remote = LOW, U_{Low} <1 V Manual = HIGH, U_{High} >4 V Manual, when unconnected	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	OT / PF	DO	Overheating alarm or Power Fail	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 resistance value	0…10 V or. 0...5 V correspond to 0..100% of R_{Max}	Accuracy 0-5 V range: < 0.4% **** Accuracy 0-10 V range: < 0.2% **** Input impedance R_i >40 k...100 k
8	PSEL	AI	Set power value	0…10 V or. 0...5 V correspond to 0..100% of P_{Nom}	Accuracy 0-5 V range: < 0.4% **** 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 < 0.2% at I_{Max} = +2 mA Short-circuit-proof against AGND
10	CMON	AO	Actual current	0…10 V or. 0...5 V correspond to 0..100% of I_{Nom}	
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 unconnected	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 unconnected	Voltage range = 0…30 V I_{Max} = +1 mA at 5 V Rec'd sender: Open collector against DGND
14	OVP	DO	Overvoltage alarm	Alarm OV = HIGH, U_{High} > 4 V No alarm OV = 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	CV	DO	Constant voltage regulation active	CV = LOW, U_{Low} <1 V CC/CP/CR = 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 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

3.5.4.5 Overview of the Sub-D Socket

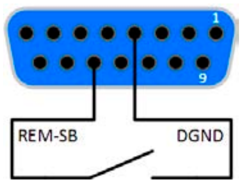


3.5.4.6 Simplified diagram of the pins

	**Digital Input (DI)** 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.		**Analog Input (AI)** High resistance input (impedance >40 k....100 kΩ) of an operational amplifier circuit.
	**Digital Output (DO)** 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.		**Analog Output (AO)** 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.*

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 levels 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 *3.4.3.2*.

> *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’. So when activating remote control, the DC output will instantly switch on.*

- **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 on 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 popup in the display appears resp. an error message will be returned.
		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 on 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 "On/Off" (front panel) or digital command.
		LOW	+	Inverted		
	+	HIGH	+	Inverted	→	The DC output will be switched off and remain locked. Later it can be switched on again by toggling the pin first and then either using pushbutton "On/Off" (front panel) or digital command.
		LOW	+	Normal		

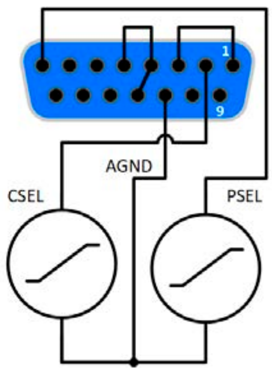
b) Remote control of current and power

Requires remote control to be activated (Pin REMOTE = LOW)

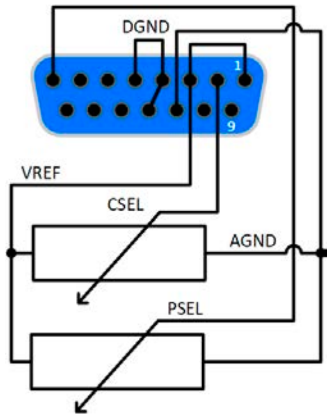
The set values PSEL and CSEL are generated from, for example, the reference voltage VREF, using potentiometers for each. Hence the power supply can selectively work in current limiting or power limiting mode. According to the specification of max. 5 mA load for the VREF output, potentiometers of at least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



Example with external voltage source

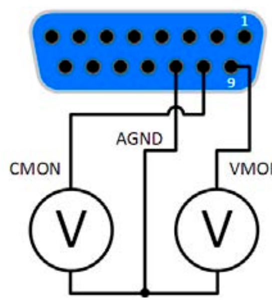


Example with potentiometers

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

c) Reading actual values

The AI provides the DC output values as current and voltage monitor. These can be read using a standard multimeter or similar.



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, and user defined events, such as **OVD** (overvoltage detection). Whilst device alarms serve to protect the device and the connected load by initially switching off the DC output, user defined events can switch off the DC output (**Action = ALARM**), but can also simply make the user aware by a pop-up in the display. The actions driven by user defined events can be selected:

Action	Impact	Example
NONE	User defined event is disabled.	
SIGNAL	On reaching the condition which triggers the event, the action **SIGNAL** will show a text message in the status area of the display.	
WARNING	On reaching the condition which triggers the event, the action **WARNING** will show a text message in the status area of the display and pop up an additional warning message. If the alarm sound is activated, it will also emit a signal.	
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. f the alarm sound is activated, it will also emit a signal. Furthermore the DC output is switched off. Certain device alarms are also signalled to the analog interface or can be queried via the digital interface.	

3.6.2 Device alarm and event handling

A device alarm incident will usually lead to DC output switch-off. Some alarms must be acknowledged (see below), which can only happen if the cause of the alarm isn’t persistent anymore. Other alarms acknowledge themselves if the cause has vanished, like the OT and the PF alarm.

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

1. In case the alarm is indicated as a pop-up, tap **OK.**
2. In case the alarm has already been acknowledged, but is still displayed in the status area, then first tap the status area to call the pop-up again, then acknowledge with **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:

Alarm	Meaning	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 IF, digital IF
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}	Display, digital IF
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}	Display, digital IF

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

Alarm	Meaning	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 the cause of a temporary power fail is gone can be determined. See *3.4.3.*	Display, analog & digital interface
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 can be determined. See *3.4.3.*	Display, analog & digital interface

► How to configure the device alarms

1. While the DC output is switched off, tap the touch area 

on the main screen.
2. In the menu tap on **Settings** and then on **Protection Settings**.
3. Set the thresholds for the device alarms relevant to your application if the default value of 110% is too high.

The set values can be entered using the ten-key tab. This will appear by tapping the touch area "Direct input".

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

These events are not to 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 the load, like a sensitive electronic application.

► How to configure user defined events

1. While the DC output is switched off, tap the touch area 

on the main screen.
2. In the menu tap on **Settings**, then on **Page 2** and there on **Event Settings**.
3. Switch between parameters for voltage, current and power monitoring with the touch areas **Event U**, **Event I** and **Event P** on the right side.
4. 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"*). Switching between the upper and lower values is done by tapping the stroked area.
5. Accept the settings with 

.

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

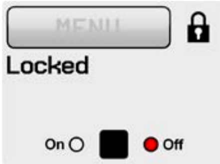
!	*User events are an integral part of the actual user profile. Thus, if another user profile, or the default profile, is selected and used, the events will be either differently or not configured.*

!	*The set values can be entered using the ten-key tab. This will appear by tapping the touch area "Direct input" on the particular page.*

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 .
2. In the settings page **HMI Lock Setup** you are then asked to chose between a complete HMI lock (check mark set for **Lock HMI**) or a partial lock where the On/Off button on the front of the device is still usable (check mark also set for **On/Off**). You may also 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.

⚠	Be careful with the "Enable PIN" option if you are unsure what PIN is currently set. If you are unsure, use "Change PIN" to define a new one.

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 Limits lock

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 **Limit Settings** and **Profiles** will then become inaccessible until the lock is removed. Tapping a locked menu page. i.e. touch area is greyed out, will give the option to unlock the access by entering the PIN.

► How to lock the limits settings

1. While the DC output is switched off, tap the touch area MENU on the main screen.
2. In the menu tap on **Page 2**, then **HMI Settings** and there **HMI Lock**.
3. In the settings page set the check mark for **Lock limits** and also **Enable PIN**.

Enabling the PIN for the limits lock is recommended. The PIN is also used for the HMI lock.

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

Be careful with the “Enable PIN” option if you are unsure what PIN is currently set. If you are unsure, use “Change PIN” to define a new 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. In the menu tap on **Page 2**, then **HMI Settings** and there **HMI Lock**.
3. In the settings page **HMI Lock Setup** unselect the check mark for Lock Limits. In the next pop-up tap on **Unlock** and then you will be asked to enter the 4-digit PIN.
4. Deactivate the lock by submitting the correct PIN with .

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 (working profile) as an user profile

1. While the DC output is switched off, tap the touch area MENU on the main screen
2. In the menu page, tap on **Page 2** and then on **Profiles**.
3. In the selection screen (see image to the right) choose between user profiles 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. Tap on touch area **Save/Load** and in the next screen save the user profile with touch area **Save**.

► **How to load an user profile to work with**

1. While the DC output is switched off, tap the touch area **MENU** on the main screen
2. In the menu page, tap on **Page 2** and then on **Profiles**.
3. In the selection screen (see image to the right) choose between user profiles 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. Tap on touch area **Save/Load** and in the next screen load the user profile with touch area **Load**.

User profiles can also be loaded from and saved to a properly formatted USB stick (see section *1.9.5.5* for details).

► **How to load an user profile from USB stick or save to**

1. While the DC output is switched off, tap the touch area **MENU** on the main screen
2. In the menu page, tap on **Page 2** and then on **Profiles**.
3. In the selection screen (see image to the right) choose between user profiles 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. Tap on touch area **Import/Export** and in the next screen either save the profile to USB stick by tapping on **Save to USB** or load it from the stick with **Load from USB**.

> - *When loading a profile from USB stick it will overwrite all previously stored values of the selected user profile*
> - *The number in the profile file name isn't related to the user profile number from which it once was saved or to which is it going to be loaded*
> - *The selector for picking a profile file to load can only list the first 10 files in the folder*
> - *Profile files are checked for validity upon load to determine if the stored values match the device*

After a profile has been loaded from USB stick it doesn't become effective automatically. Like when switching between profiles, it requires to load the user profile into the working profile. See above for the steps.

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 them to the set value of voltage or current.

All functions are based on a customisable **arbitrary** generator. In manual operation, the separate functions are available for selection and configuration on the front panel. In remote control, all functions are configured using so-called sequences with 8 parameters each.

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
Arbitrary	Generation of a process with up 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

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

3.10.2 General

3.10.2.1 Restrictions

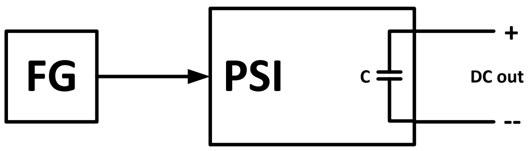
The function generator isn't accessible, neither for manual access, nor for remote control, if

- resistance mode (R/I adjustment mode, also called UIR mode) is active.

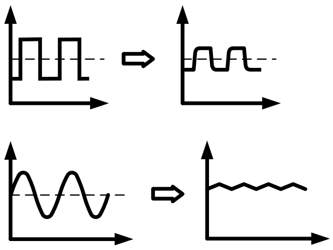
3.10.2.2 Principle

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 of the selected wave, its amplitude and the devices' output capacitance. The effects of the power supply on the wave can only be partially compensated. For instance, it's possible to decrease the output voltage sinking time at low load conditions by adding a base load, one that is either permanently connected or temporarily switched.

The minimum values of all adjustable parameters of the function generator, like for example a time of 0.1 ms, are not defined to match what a power supply device resp. every particular model can truly achieve.

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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).

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 9080-40 T is going to be used, with 80 V and 40 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 29 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 settings interact, the following should be noted:

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

The selected function can be applied to the set value of either U or I, the other two set values are then constants and have a limiting effect. That means if, for example, a voltage of 10 V is set, a load is connected and a sine wave function should operate on the current with an amplitude of 20 A and an offset of 20 A, then the DC output is expected to create a sine wave progression of current between 0 A (min) and 40 A (max), which will result in an output power between 0 W (min) and 400 W (max).The output power, however, is limited to the power set value. If this was 300 W then the current would be limited to 30 A and when viewing the progression on an oscilloscope it could be seen as truncated at 30 A and never reach the targeted 40 A.

3.10.4 Manual operation

Via the touch screen any of the available functions can be accessed, configured and controlled. Selection and configuration are only possible while the DC output is switched off.

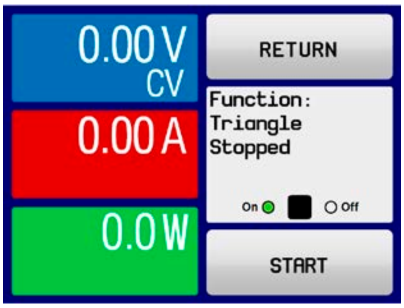
► How to select a function and adjust parameters

1. While the DC output is switched off, tap the touch area MENU on the main screen. If the menu doesn't appear it's because the DC output is still switched on or the touch area is locked due to the device being possibly in remote control.
2. In the menu tap on **Page 2**, then **Function Generator** and there on the desired function.
3. Then you are requested to select to what physical value the function 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.

With all functions and also the arbitrary generator, if there is a difference between start and end value of the curve and that difference is too low (min. $\Delta Y/\Delta t$), also depending on the time that is defined for one function run, the function generator will not accept the settings and pop up an error.

5. Do not forget to adjust the overall limits of voltage, current and power, which you can access with touch area **NEXT**.

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



► **How to load a function**

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

.

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 settle the start situation. These static values represent start and end values for the progress of the function, so that the function doesn't need to start from 0. Only exception: when applying any 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, the DC output 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.

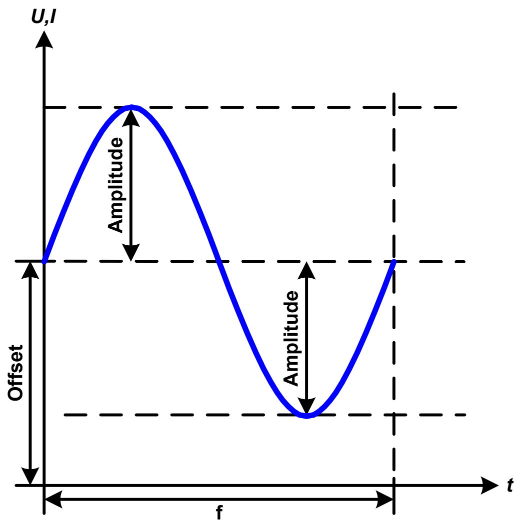
!	*Any device alarm (overvoltage, overtemperature etc.), protection (OPP, OCP) or event with action = Alarm stops the function progress automatically, switches off the DC output and reports the alarm.*

3.10.5 Sine wave function

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

Value	Range	Description
Ampl.	0...(Nominal value - (Offset)) of U, I	Amplitude of the signal to be generated
Offset	(Ampl.)...(Nom. value - (Ampl.)) of U, I	Offset, based on the zero point of the mathematical sine curve, may not be smaller than the amplitude.
Freq.	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.

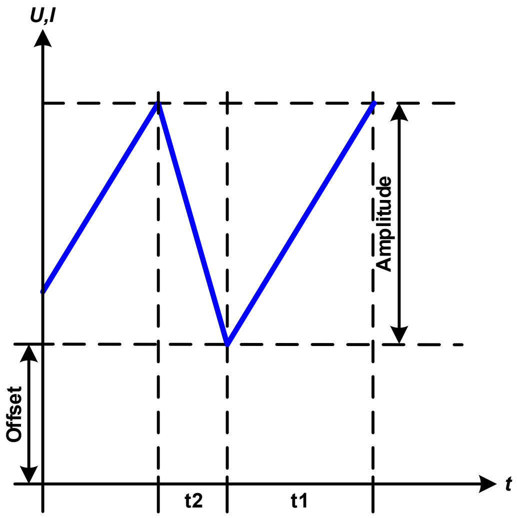
Example: an output voltage of 30 V is set together with sin(I) with an amplitude of 12 A and an offset of 15 A. The resulting maximum power output is then achieved at the highest point of the sine wave and is (12 A + 15 A) * 30 V = 810 W.

3.10.6 Triangular function

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

Value	Range	Description
Ampl.	0...(Nominal value - (Offset)) of U, I	Amplitude of the signal to be generated
Offset	0...(Nominal value - (Ampl.)) of U, I	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.

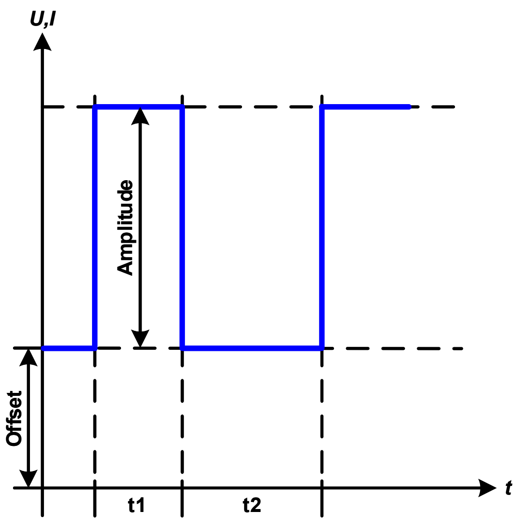
Example: a frequency of 10 Hz is required and would lead to periodic duration of 100 ms. This 100 ms can be freely allocated to t1 and t2, e. g. 50 ms:50 ms (isosceles triangle) or 99.9 ms:0.1 ms (right-angled triangle or sawtooth).

3.10.7 Rectangular function

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

Value	Range	Description
Ampl.	0...(Nominal value - (Offset)) von U, I	Amplitude of the signal to be generated
Offset	0...(Nominal value - (Ampl.)) von U, I	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 (only effective in current limiting) or output voltage 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 cycle time and its reciprocal is the frequency.

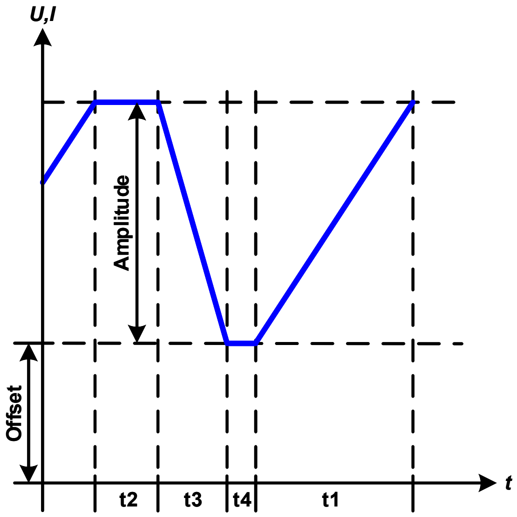
Example: a rectangular wave signal of 25 Hz and a duty cycle of 80% are required. The sum of t1 and t2, the period, is 1/25 Hz = 40 ms. For a duty cycle of 80% the pulse time (t1) is 40 ms*0.8 = 32 ms and the pause time (t2) is 8 ms.

3.10.8 Trapezoidal function

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

Value	Range	Description
Ampl.	0...(Nominal value - (Offset)) of U, I	Amplitude of the signal to be generated
Offset	0...(Nominal value - (Ampl.)) of U, I	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 slopes of the trapezium can be varied by setting different times for rise and fall.

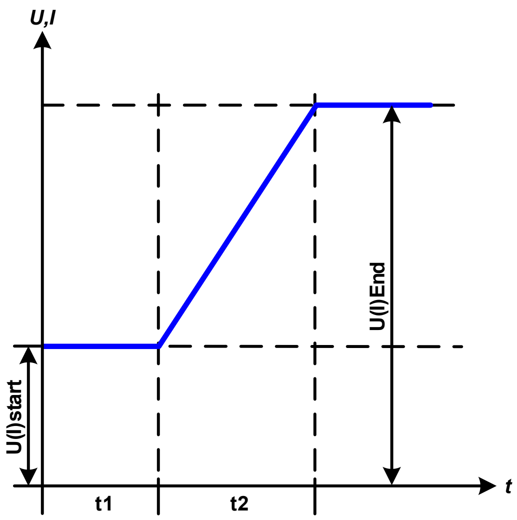
The periodic duration and repetition frequency are the result of four time elements. With suitable settings the trapezium can be deformed to a triangular or rectangular wave. It has, therefore, universal use.

3.10.9 Ramp Function

The following parameters can be configured for a ramp function.

Value	Range	Description
Start	0...Nominal value of U, I	Start value (U,I)
End	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.

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 value **Start** (A.start), unless the load at the DC output shouldn't be provided with voltage before the start of the ramp. In that case the static values should be set to zero.

10 hours 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.

3.10.10 Arbitrary function

The arbitrary (freely definable) function or function generator offers the user a wider scope of options. There are 99 curve segments (here: sequence points) available for use on either current (I) or voltage (U), all of which have the same set of parameters but can be differently configured, so that a complex function curve can be "constructed". An arbitrary number out of the 99 sequence points can run in a sequence point block and this block can then be repeated up to 999 times or infinitely. Since the function must be assigned to either current or voltage, mix assignments of sequence point to both is not possible.

The arbitrary curve can overlay a linear progression (DC) with a sine curve (AC) whose amplitude and frequency is shaped between start and end. When both, start frequency and end frequency, are 0 Hz the AC overlay has no impact and only the DC part is effective. Each sequence point is allocated a sequence point time in which the AC/DC curve from start to end will be generated.

The following parameters can be configured for each sequence point in the arbitrary function:

Value	Range	Description
ACs	0...50% nominal value of U, I	Start amplitude of the sine wave part of the sequence point
ACe	0...50% nominal value U, I	End amplitude of the sine wave part of the sequence point
DCs	ACs...(Nominal value - ACs) of U, I	Start value (offset) of the DC part of the sequence point
DCe	ACe...(Nominal value - ACe) of U, I	End value (offset) of the DC part of the sequence point
S.Freq	0 Hz...10000 Hz	Start frequency of the sine wave part of the sequence point (AC)
E.Freq	0 Hz...10000 Hz	End frequency of the sine wave part of the sequence point (AC)
Angle	0°...359°	Start angle of the sine wave part of the sequence point (AC)
Time	0.1 ms...36000 s	Time for the selected sequence point

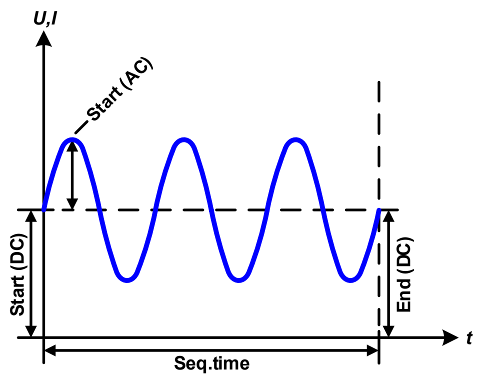
The sequence point time ("Time") and the start and end frequency are related. The minimum value for Δf/s is 9.3. Thus, for example, a setting of S.Freq = 1 Hz, E.Freq = 11 Hz and Time = 5 s would not be accepted as Δf/s is only 2. A sequence point time of 1 s would be accepted or, if the time remains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

After the settings for the selected sequence point are accepted with SAVE, further can be configured. When tapping button NEXT a second settings screen appears in which global settings for all 99 sequence 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 in the sequence point block
End seq.	Start seq. ... 99	Last sequence in the sequence point block
Seq. cycles	∞ or 1...999	Number of cycles of the sequence point block.

Schematic diagram:



Applications and results:

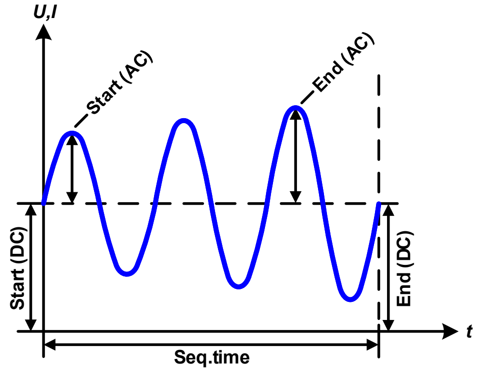
Example 1

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.

Schematic diagram:

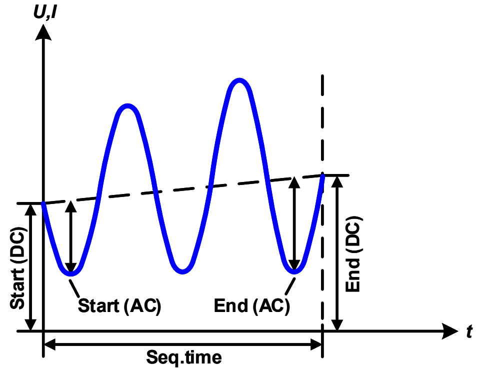


Applications and results:

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 time and frequency allow for multiple waves to be created. e. g. for f=1 Hz and 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.

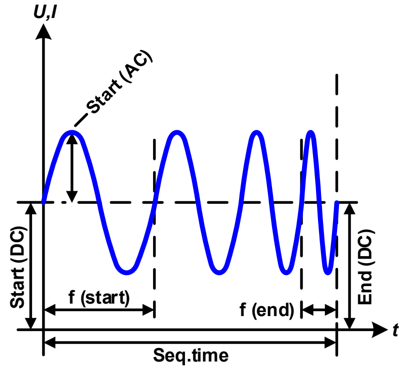


Example 3

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.

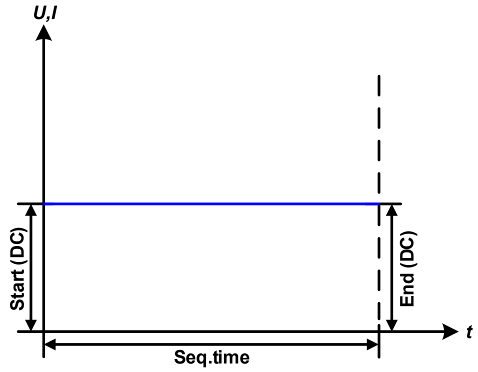
Additionally the first sine wave starts with a negative half wave because the angle is set at 180°. The start angle can be shifted at will in 1° steps between 0° and 359°.



Example 4

Focusing 1 cycle of 1 sequence point:

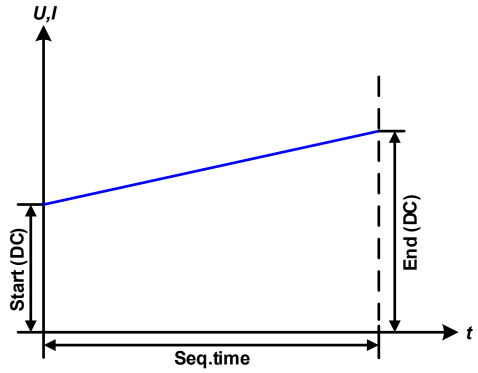
Similar to example 1 but with another end frequency. Here this is shown as higher than the start frequency. This impacts the period of the sine waves such that each new wave will be shorter over the total span of the sequence point time.



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

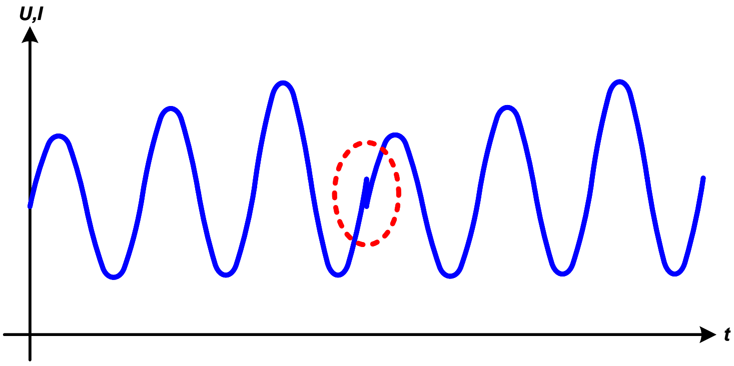
Focusing 1 cycle of 1 sequence point:

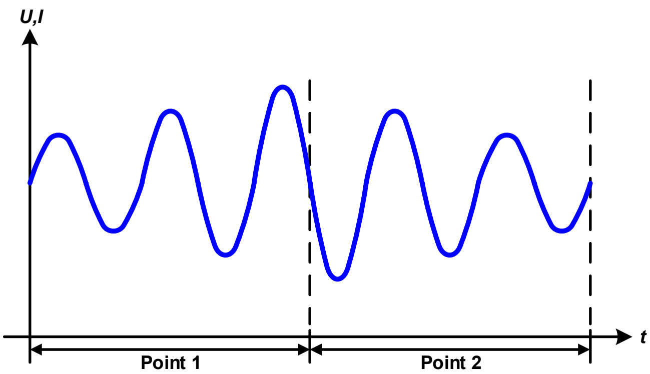
Similar to example 1 but with a start and end frequency of 0 Hz. Without a frequency no sine wave part (AC) will be created and only the DC settings will be effective. Here start and end values are unequal and a steadily increasing ramp is generated.

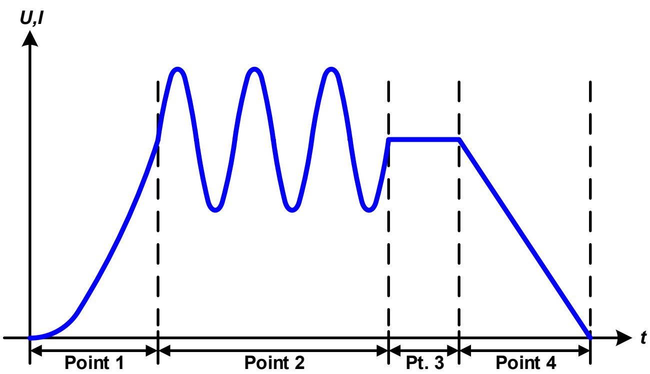
By linking together a number of differently configured sequences, complex progressions can be created. Smart configuration of the arbitrary generator can be used to match triangular, sine, rectangular or trapezoidal wave functions and thus, e. g. a sequence of rectangular waves with differing amplitudes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

!	*Assignment to U or I makes 99 sequences available for the use on either current or voltage, but not on a mix of both. That means that a point 1 which produces a ramp up on current can't be followed by sequence 2 which applies a sine wave to the voltage.*

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 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 generates a sine wave with increasing amplitude, the second with a decreasing amplitude. Together they produce a progression as shown left. In order to ensure that the maximum wave in the middle occurs only once, the first sequence point must end with a positive half wave and the second one 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 point time is 1:3)

Point 3: Horizontal ramp (f = 0)

Point 4: Falling ramp (f = 0)

3.10.10.1 Loading and saving the arbitrary function

The 99 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 pointss are saved or loaded using a text file of type CSV (semicolon separator), which represents a table of values.

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

- The table must contain exactly 99 rows (100 rows are also accepted for compatibility reasons) with 8 subsequent values (8 columns) and must not have gaps
- The column separator (semicolon, comma) must be as selected by parameter "USB file separator format"; it also defines the decimal separator (dot, comma)
- The files must be stored inside a folder called HMI_FILES which has to be in the root of the USB stick
- The file name must always start with WAVE_U or WAVE_I (not case-sensitive)
- 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	Description	Range
A	ACs	AC start level	0...50% U or I
B	ACe	AC end level	0...50% U or I
C	S.Freq	Start frequency	0...10000 Hz
D	E.Freq.	End frequency	0...10000 Hz
E	Angle		0...359°
F	DCs	DC start level	0...(Nominal value of U or I) - AC Start
G	DCe	DC end level	0...(Nominal value of U or I) - AC End
H	Time		100...36.000.000.000 (36 billion µs)

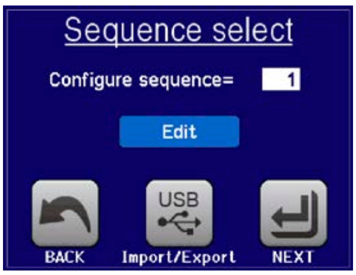
For details about the parameter and the arbitrary function refer to *„3.10.10. Arbitrary function"*.

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 sequences are configured, while all others are set to default values. The table could be loaded as WAVE_U or WAVE_I when using, for example, the model PSI 9080-60 T, 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 at all.

► How to load a sequence point table from an USB stick:



1. Do not plug the USB stick 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 selector, as depicted to the right.
3. Tap touch area 

, then 

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

in the bottom right corner. The selected file is then checked and loaded, if valid. In case it isn't valid, the device will show an error message. Then the file must be corrected and the steps repeated.

► **How to save a sequence point table (99 point) 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**
3. Tap on 

, then 

. 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 tapping on the file name, otherwise select -NEW FILE- for a new file.
5. Finally save the sequence table with 

.

3.10.11 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

3.11 Other applications

3.11.1 Series connection

Series connection of two or multiple devices is basically possible, but for reasons of safety and isolation following restrictions apply:

- Both, negative (DC-) and positive (DC+) output poles are coupled to PE via type X capacitors, limiting the max. allowed potential shift (see technical specs for rating)
- Remote sensing must not be connected!
- Series connection is only allowed with devices of the same kind and model, i.e. power supply with power supply like, for instance, PSI 9080-60 T with PSI 9080-60 T

Series connection isn't explicitly supported by additional connections and signals on the devices. Nothing else than output current and voltage is shared. It means, all units have to be controlled separately regarding set values and DC output status, whether it's manual or remote control.

According to the limit of the potential shift that comes with series connection (also see section *„2.3.5. Grounding of the DC output")*, models with a certain nominal output voltage must not be connected in series at all, for example a 500 V model. There the DC minus is only isolated up to ±400 V DC against PE. On the opposite, two 200 V units are allowed to be connected in series.

The analog interfaces of units in series connection are allowed to be wired in parallel, because they are galvanically isolated from the device and the DC output. The grounds (AGND, DGND) on the analog interface are also allowed to be directly connected to PE, like it automatically happens when controlling and directly connecting it to a PC.

3.11.2 Parallel operation

Multiple devices of same kind and ideally same model can be connected in parallel in order to create a system with higher total current and hence higher power. This can be achieved by connecting all units to the DC load in parallel, so the single currents can add. There is no support for a balancing between the individual units, like in form of a master-slave system. All power supplies would have to be controlled and set up separately. However, it's possible to have a parallel control by the signals on the analog interface, as this one is galvanically isolated from the rest of the device. There are few general points to consider and adhere:

- Always make parallel connections only with device of same voltage, current and power rating
- Never connect the ground signal of any analog interface with the negative DC output, because it will void the galvanic isolation. This rule is especially important when going to connect any DC output pole to ground (PE) or to shift its potential.
- Never connect DC cables from power supply to power supply, but instead from every power supply device directly to the load, else the total current will exceed the current rating of the DC output clamp

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 usually featured with true battery chargers as a protection against overvoltage or reversed polarity.

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 isn't powered.

4. Service and maintenance

4.1 Maintenance / cleaning

The device needs no maintenance. Cleaning may be needed for the internal fan, the frequency of cleanse is depending on the ambient conditions. The fan serves to cool the components which are heated by the inherent power loss. A heavily dirt filled fan 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 probably requires to be opened.

4.2 Fault finding / diagnosis / repair

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

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

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

4.2.1 Replacing a defect mains fuse

The device is protected one 5x20 mm fuse (for value check fuse body or technical specifications in *1.8.3*) which is located on the rear of the device, inside a fuse holder (separate or in the AC socket, depends on the model). To replace the fuse, the device isn't required to be opened. Just remove the power cord and unscrew the fuse holder with a flat screw driver. The replacement fuse must be of same value and type.

4.2.2 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

4.3 Calibration

4.3.1 Preface

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

In order to determine if a value is out of tolerance, the parameter must be verified first with measurement tools of high accuracy and with at least half the error of the 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 9080-60 T at the max. 60A, which is stated with a max. error of 0.2%, you can only do that by using a suitable shunt with max. 0.1% error or less. Also, when measuring such high currents, it's recommended to keep the process short, in order to avoid the shunt heating up too much. It's furthermore recommended to use a shunt with at least 25% reserve.

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

4.3.2 Preparation

For a successful calibration and, if required, 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 shunt voltage when readjusting the current
- If the current is also going to be calibrated: a suitable DC current shunt, ideally specified for at least 1.25 times the max. output current of the PSI and with a max. error that is half or less than the max. current error of the PSI device
- Normal ambient temperature of approx. 20-25°C
- Warmed up PSI unit, which has been run for at least 10 minutes under 50% power
- An adjustable load, such as an electronic load, which is capable of consuming at least 102% of the max. voltage and current of the PSI device

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

- Let the PSI device warm up in connection with the voltage / current source
- In case the remote sensing input is going to be calibrated, prepare a cable for the remote sensing connector to DC output, but leave it yet unconnected
- Abort any form of remote control
- Install the shunt between PSI device and load and make sure the shunt is cooled somehow
- Connect external measurement device to the DC output or to the shunt, depending on whether the voltage is going to be calibrated first or the current

4.3.3 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 front of the device has to be disconnected.*

The calibration procedure, as explained below, is an example with model PSI 9080-60 T. Other models are treated the same way, with values according to the particular PSI model and the required load.

4.3.3.1 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 ≈3 A, and 0 V (if the load is electronic).
2. While the DC output is switched off enter MENU, then tap on **Settings**, then on **Page 2** and there on **Calibrate device**.
3. In the next screen select **Voltage calibration**, then **Calibrate output val.** 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 point 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 sample model with 60 A this would be 61.2 A, rounded to 61 A.
2. While the DC output is switched off enter MENU, then tap on **Settings**, then on **Page 2** and there on **Calibrate device**.
3. In the next screen select **Current calibration**, then **Calibrate output val.** and **NEXT**. The device will switch the DC output on, set a certain current limit while loaded and show the measured output current as **I-mon**.
4. The next screen requests you to enter the output current **Measured value=** measured with the shunt. Enter it using the keypad, assure yourself the value is correct and submit with **ENTER**.
5. Repeat point 4. for the next three steps (total of four steps).

4.3.3.2 Calibrating the remote sensing

In case you are generally using the remote sensing feature, it's recommended to also readjust this parameter 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 remote sensing voltage

1. Connect a load and set its current to approx. 5% of the nominal current of the power supply, in this example ≈3 A, and 0 V (if the load is electronic). Connect the remote sensing input (Sense) to the DC terminal of the load with correct polarity and connect a multimeter there in parallel.
2. While the DC output is switched off enter MENU, then tap on **Settings**, then on **Page 2** and there on **Calibrate device**.
3. In the next screen select **Sense volt. calibration**, then **Calibrate output val.** 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 sensing voltage **Measured data=** from the multimeter. Enter it using the keypad, that appears when tapping the value. Assure yourself the value is correct and submit with **ENTER**.
5. Repeat point 4. for the next three steps (total of four steps).

4.3.3.3 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 value on display, wait at least 2 seconds for the value to settle and then tap **NEXT** until you are through all steps.

4.3.3.4 Save and exit

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

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

Last but not least save the calibration data permanently by tapping 

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> ⚠ Leaving the calibration selection menu without tapping "Save and exit" will discard calibration data and the procedure would have to be repeated!

5. Contact and support

5.1 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 address below.

5.2 Contact options

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

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

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