



mPower™ DC Power Supplies 310 and 320 Series

Operating Guide and Reference



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There may be updates to this documentation and the software it describes at:
<http://www.marway.com/mpower-dc-power-supply>

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1 General

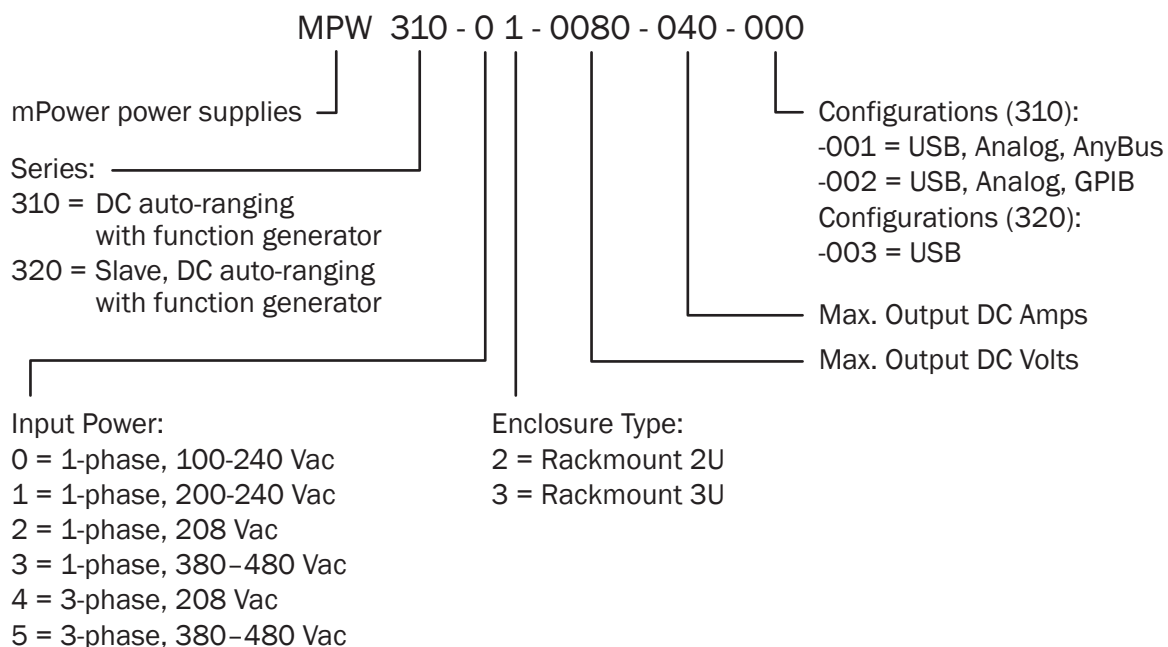
1.1 Documentation Symbols

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

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

1.2 Product Key

The mPower DC model number uses the following pattern, using an example:



1.3 Intended Product Usage

The equipment is intended to be used as a general purpose power supply only as a variable voltage and current source.

1.4 Safety Notices

Mortal danger - Hazardous voltage



- This is electrical equipment with some parts operating with dangerous voltage. All exposed components which can have live voltage must be covered.
- All work on connections must be carried out under zero voltage (output disconnect), 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. Verify there is zero voltage with a handheld meter.
- Never touch the contacts on DC output terminal directly after switching off the DC output, because there still can dangerous voltage present, sinking more or less slowly depending on the load. There also can be dangerous potential between negative DC output to GND or positive DC output to GND due to charged capacitors. Verify there is zero voltage with a handheld meter.
- Always follow 5 safety rules when working with electric devices:
 - Disconnect completely.
 - Secure against reconnection.
 - Verify that the system has zero voltage.
 - Carry out earthing and short-circuiting.
 - Provide protection from adjacent live parts.



- The equipment must only be used as intended.
- The equipment is only approved for use within the connection limits stated on the product label.
- Do not insert any object, particularly metallic, through the ventilator slots
- Avoid any use of liquids near the equipment. Protect the unit from wet, damp and condensation.
- Do not connect loads, particularly low resistance, to power supplies under power; sparking may occur which can cause burns as well as damage to the equipment and to the user.
- 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 unit is switched off. It's not necessary to open the unit.
- Do not connect external power sources with reversed polarity to DC input or outputs. The equipment will be damaged.
- 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 unit.
- Never insert a CAT5 cable which is connected to Ethernet into the master-slave socket on the back of the unit.
- Always configure the various protecting features against overvoltage etc. for sensitive loads to what the target application requires.

2 Physical Overview

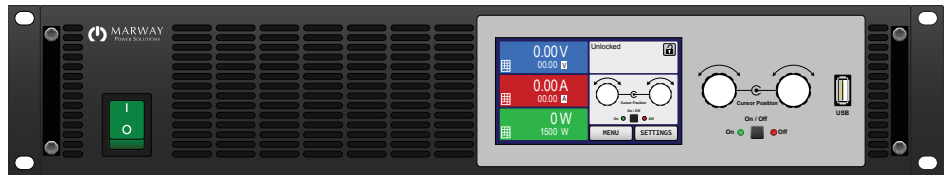
2.1 Applicable Models

This User Guide covers 310 Series 2U, 3U models, and 320 Series 3U models in both 208 Vac and 380–480 Vac ranges. Each shares many control and connectivity features, though there are distinctions in power connections, and in the case of the 320 slave units, simplified user controls and connectivity options.

310 Series

208 Vac (310-02, 310-12)

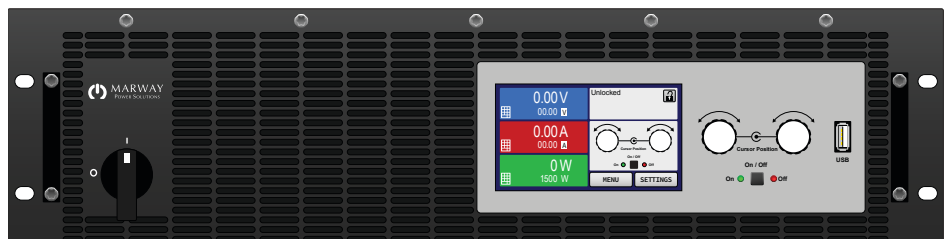
Configurations –001, –002



310 Series

208 Vac (310-23, 310-43)

Configurations –001, –002



320 Series

208 Vac (320-23, 320-43)

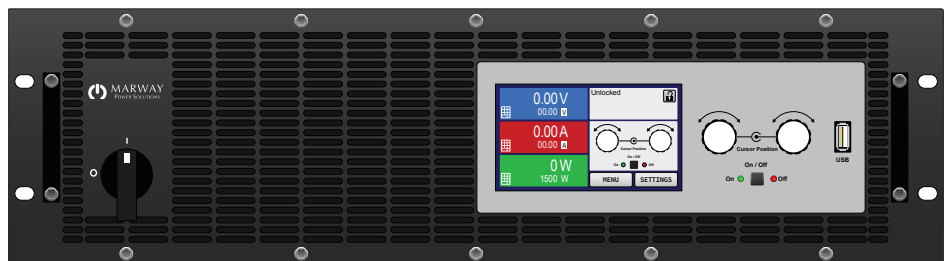
Configuration –003



310 Series

380–480 Vac (310-33, 310-53)

Configurations –001, –002



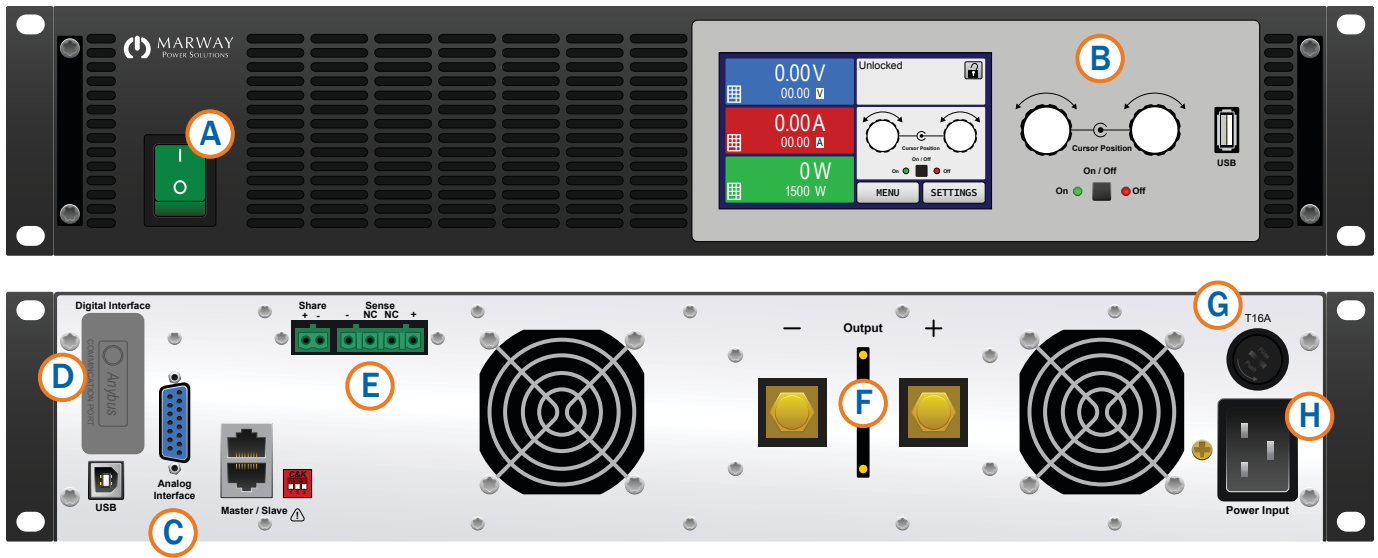
320 Series

380–480 Vac (320-33, 320-53)

Configuration –003



2.2 310 Series 2U Views



- A - Main Power switch
- B - Control panel
- C - Built-in remote interfaces
USB, Analog, Master-Slave

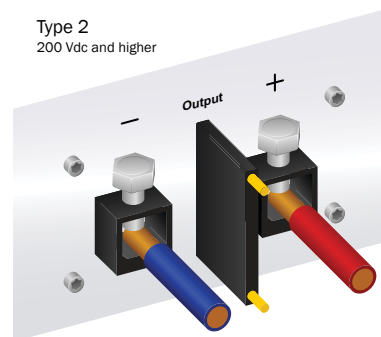
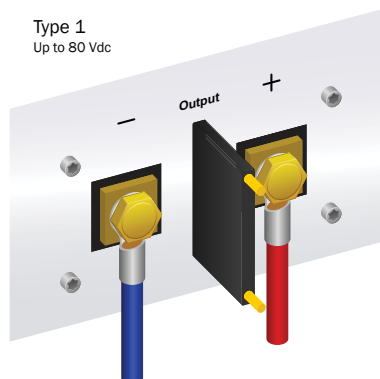
- D - Remote interface expansion port
- E - Share Bus and remote sensing connectors
- F - DC output (Type 1)

- G - AC input fuse
- H - AC input connector

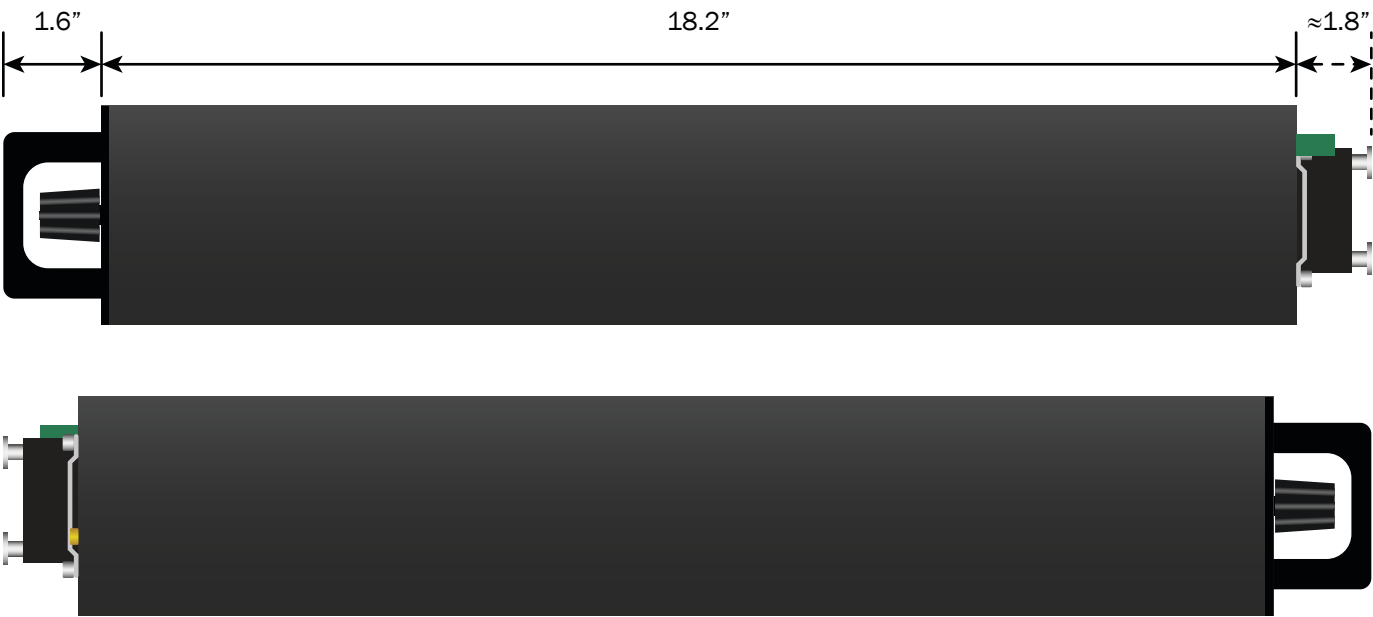


Do not loosen the grounding point (brass screw next to AC inlet) in order to connect GND cables! The device is supposed to be grounded via the AC cord, while the grounding point is used to connect the enclosure to GND.

There are two types of DC terminals. Which one is used depends on the DC output voltage rating of the unit. For more details about these connections, see [4.4.2.1 310-02/310-12 DC terminal types on page 27](#).



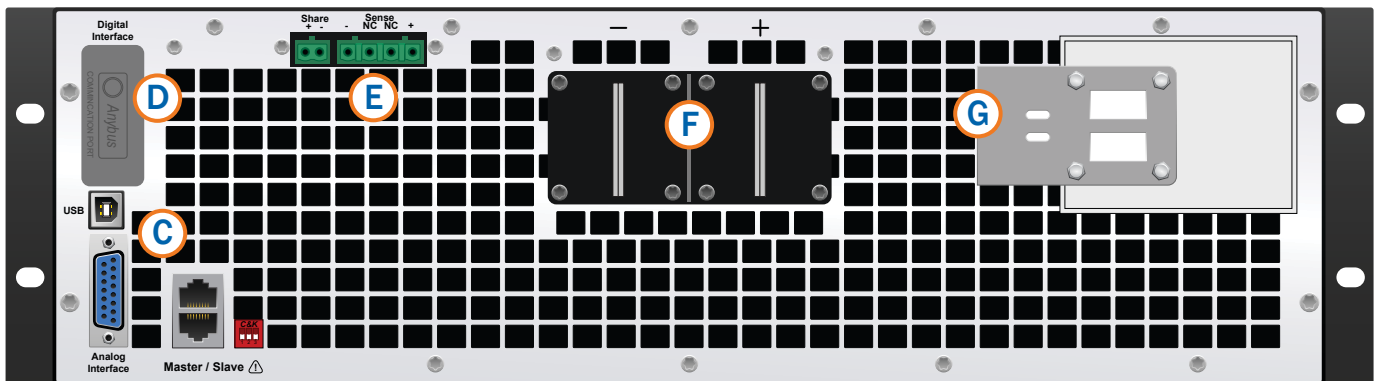
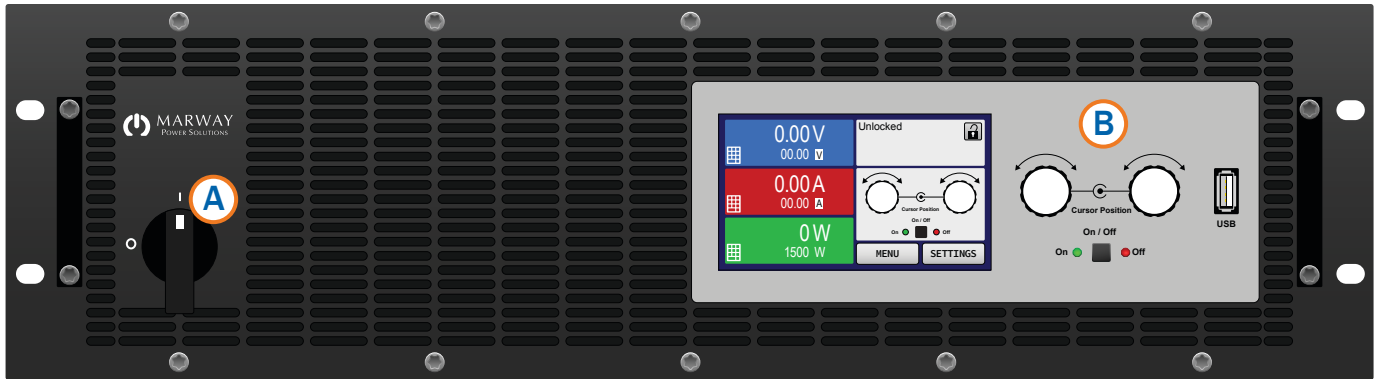
2U sides shown with 2U Type 1 DC terminal cover. Note that DC outlet dimensions varies by type, with the maximum being noted, but does not include cable bend radius.



2U top view, shown with cover for 2U Type 1 terminals

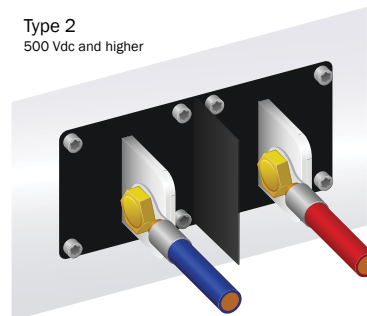


2.3 310 Series 3U Views



- A - Power switch
- B - Control panel
- C - Built-in remote interfaces
USB, Analog, Master-Slave
- D - Remote interface expansion port
- E - Share Bus and remote sensing connectors
- F - DC output terminals
- G - AC input connector (Type 1)

There are two types of DC terminals. Which one is used depends on the DC output voltage rating of the unit. For more details about these connections, see [4.5.2.1 310-23/310-43 DC terminal types on page 32](#).



3U sides shown with 3U Type 1 DC terminals and cover. Note that DC outlet dimensions varies by type, with the maximum being noted, but does not include cable bend radius.

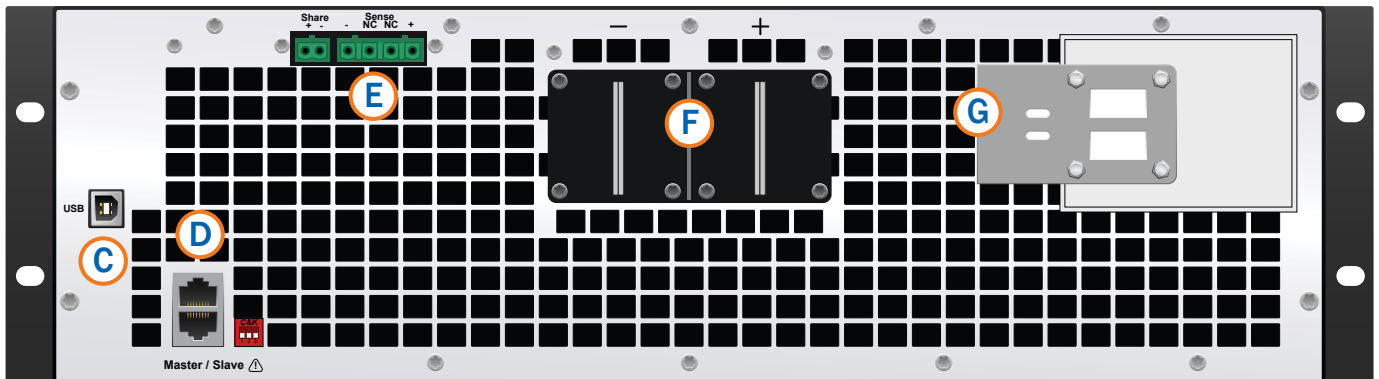
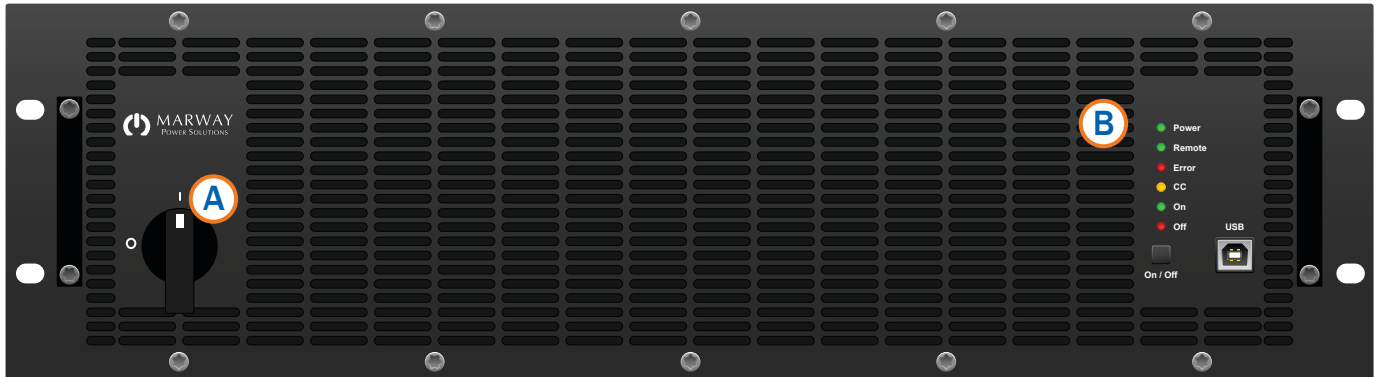


3U top view, shown with cover for 3U Type 1 terminals



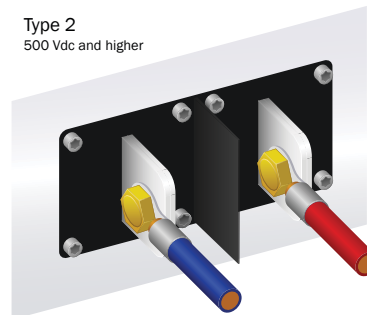
2.4 320 Series 3U Views

The 320 Series slave configuration has fewer front control features, and fewer interface buses on the rear panel. The slave systems are dimensionally the same as the standard 3U units (pictured in the previous section).



- A - Power switch
- B - Control panel
- C - USB remote interface
- D - Master-Slave control interface
- E - Share Bus and remote sensing connectors
- F - DC output terminals
- G - AC input connector (Type 1)

There are two types of DC terminals. Which one is used depends on the DC output voltage rating of the unit. For more details about these connections, see [4.6.2.1 310-33/310-53 DC terminal types on page 37](#).



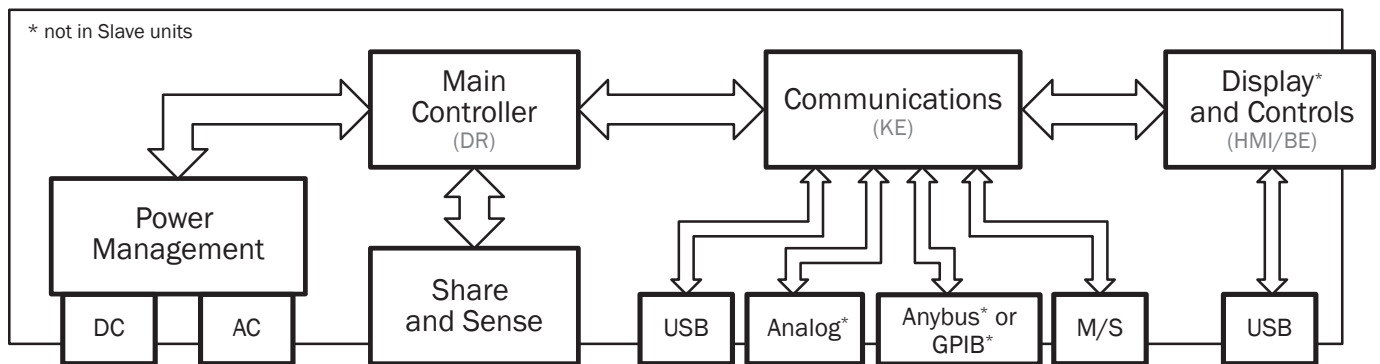
3 Control Features Overview

3.1 General Description

The mPower DC power supplies are especially suited to test and industrial applications due to their accuracy, programmability, wide selection of power ranges, and each unit's advance auto-ranging power delivery. Apart from basic functionality as a power supply, set point curves can be generated with the integrated function generator (sine, rectangular, triangular and other curve types). An arbitrary generator can create curves with up to 99 points which can be saved to, and loaded from, a USB flash drive.

The mPower DC series featuring autoranging and function generator include the 310 Series (a.k.a *standard* units) and 320 Series (a.k.a. *slave* units). The bulk of this guide, especially with operation topics, describes the standard systems, with specific sections for the 320 Series slave units included where needed.

This block diagram illustrates the main functions inside the power supply, and their relationships. Note that slave systems do not have the Anybus/GPIB option, nor the Analog interface.



3.1.1 Standard configuration

The 310 Series standard system is the full featured product with digital touchscreen display, and a multitude of remote interfaces. These systems are designed for stand-alone use, and as masters in a multi-unit, parallel system made up of one master and one or more slave systems.

The digital display can be used for basic control, for creating voltage, current, and other setpoints, and for programming the function generator. These tasks can also be done over the remote interfaces.

For remote control, all models include as standard a USB port on the rear panel, as well as a galvanically isolated analog interface. Additionally, optional digital interface modules provide connectivity via Ethernet, Profibus, ProfiNet, ModBus TCP, CAN, CANopen, EtherCAT, RS232 and others. These enable mPower systems to connect to standard industrial buses simply by replacing or adding a small plug-in module. Using these modules, the mPower power supplies may, for example, be operated with other power supplies or even other types of equipment controlled by a PC or PLC.

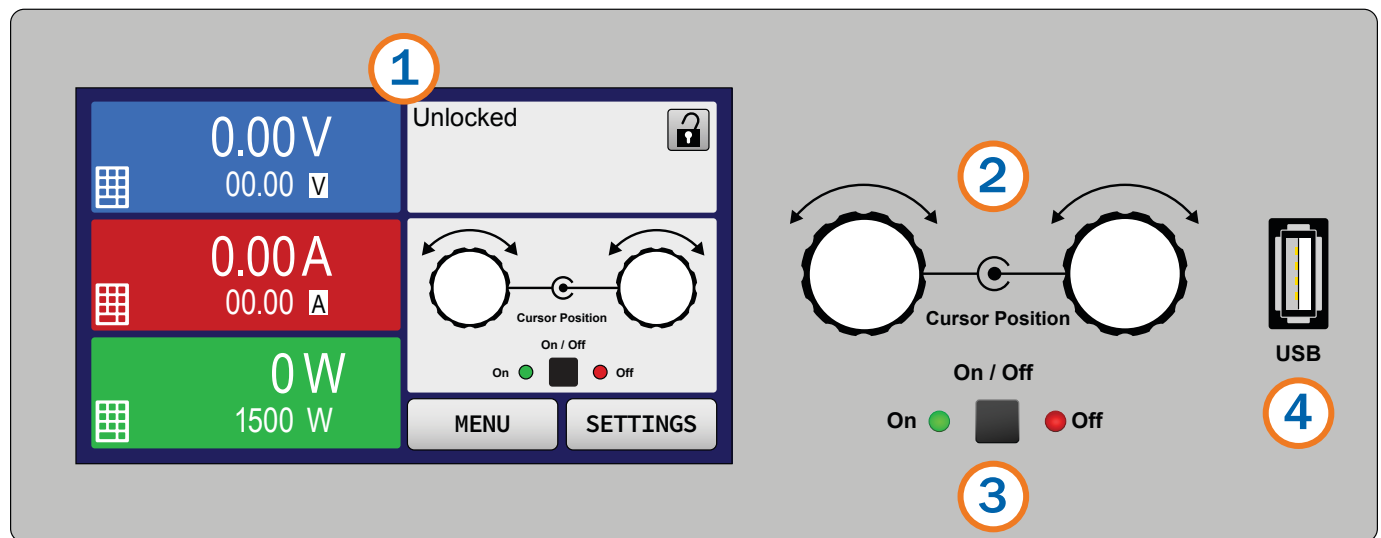
The systems offer as standard the ability to operate in parallel using the Share Bus for constant current sharing. Additionally, a genuine master-slave connection is also provided as standard. Up to 16 units can be combined as a single system having the current capacity of the sum of the systems.

3.1.2 Slave configuration

The 320 Series slave systems have the same internal power and auto-ranging capabilities as the standard units. The 320 Series have a simpler control system, and fewer remote interfaces to make them a more cost effective option for creating large power capacities through multi-unit parallel setups.

3.2 310 Series Control Panel

The standard unit control panel (a.k.a. Human Machine Interface, “HMI”) consists of a touchscreen display, two rotary knobs, a DC output pushbutton, and a USB-A port. A main On/Off switch is located on the left of the unit front panel.



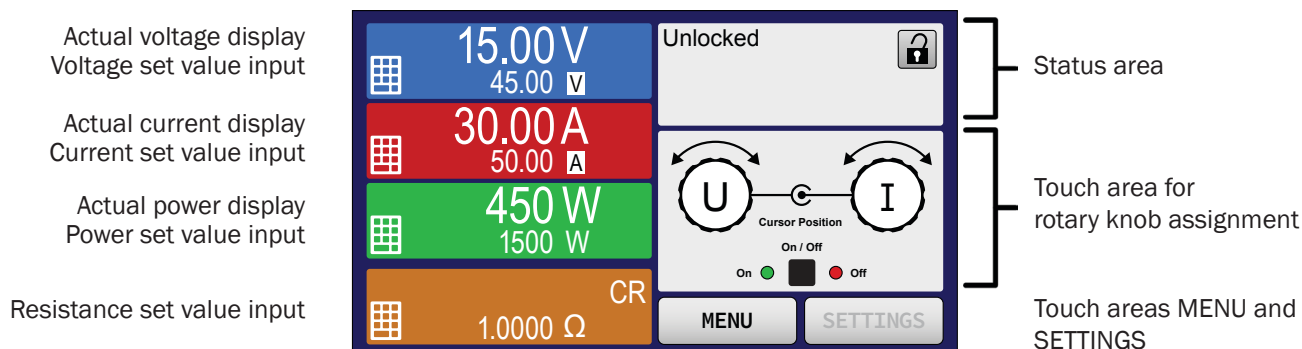
Overview of the elements on the control panel

(1)	Touchscreen display Used for selection of set values, menus, status and display of actual values and status. The touchscreen can be operated with the fingers or with a stylus.
(2)	Rotary knob with push button function Left knob (turn): adjusting the voltage set value, or setting the parameter values in the menu. Left knob (push): selection of the decimal position to be changed (cursor) 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 unit is manually controlled or remotely
(4)	USB-A port For the connection of standard USB flash drives. See section 3.4. USB Port, Front Side for more details.

3.2.1 Touchscreen display

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

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



Touch areas may be enabled or disabled:



Black text or symbol = enabled.



Grey text or symbol = disabled.

Actual / set values area (left hand side)

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

While the DC output is switched on, the actual regulation mode, CV, CC, CP or CR is displayed next to the corresponding actual value, as shown in the figure above.

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



General display and settings ranges:

Display	Unit	Range	Description
Actual voltage	V	0-125% U_{Nom}	Actual values of DC output voltage
Set value of voltage ⁽¹⁾	V	0-102% U_{Nom}	Set value for limiting the DC output voltage
Actual current	A	0.2-125% I_{Nom}	Actual value of DC output current
Set value of current ⁽¹⁾	A	0-102% I_{Nom}	Set value for limiting the DC output current
Actual power	W	0-125% P_{Nom}	Actual value of output power, $P = U * I$
Set value of power ⁽¹⁾	W	0-102% P_{Nom}	Set value for limiting DC output power
Set value of internal resistance ⁽¹⁾	Ω	0-100% R_{Max}	Set value for the simulated internal resistance
Adjustment limits	A, V, 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 values, such as OVD for voltage and UCD for current

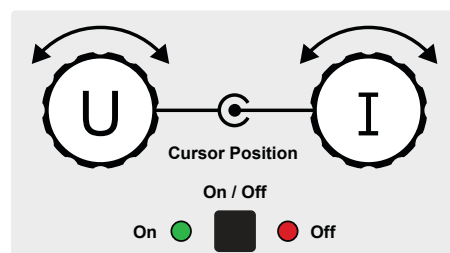
Status display (upper right)

This area displays various status texts and symbols:

Display	Description
Locked	The HMI is locked
Unlocked	The HMI is unlocked
Remote:	The unit is under remote control from:
Analog	the built-in analog interface
USB & others	the built-in USB port or a plug-in interface module
Local	The unit 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 is not yet acknowledged.
Master	Master-slave mode activated, unit is master
Slave	Master-slave mode activated, unit is slave
Function:	Function generator activated, function loaded
 / 	Data logging to USB flash drive active or failed

Area for assigning the rotary knobs

The two rotary knobs next to the display screen can be assigned to various functions. This area shows the actual assignments. These can be changed by tapping this area, as long as it's not locked. The display changes to:



The physical quantities below the depiction of the knobs shows the current assignment. The left knob is always assigned to the voltage U, while the right knob can be changed by tapping the depiction. The area will then show the assignment as either I, P, or R. :

U I

Left rotary knob: voltage
Right rotary knob: current

U P

Left rotary knob: voltage
Right rotary knob: power

U R

Left rotary knob: voltage
Right rotary knob: resistance



The other set values can't be adjusted via the rotary knobs, unless the assignment is changed. However, values can be entered directly with a ten-key pad by tapping on the keypad icon. Alternatively, the assignment can also be changed by tapping the colored set value areas. This method of entering values allows for set value steps.

3.2.2 Rotary knobs



As long as the unit is in manual operation, the two rotary knobs are used to adjust set values, as well as setting the parameters in SETTINGS and MENU. For a detailed description of the individual functions [see section 6 310 Series Operation on page 49](#).

3.2.3 Pushbutton function of the knobs

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



3.2.4 Resolution of the displayed values

In the display, set values can be adjusted in fixed increments. The number of decimal places depends on the model. The values have 3 to 5 digits. Actual and set values always have the same number of digits.

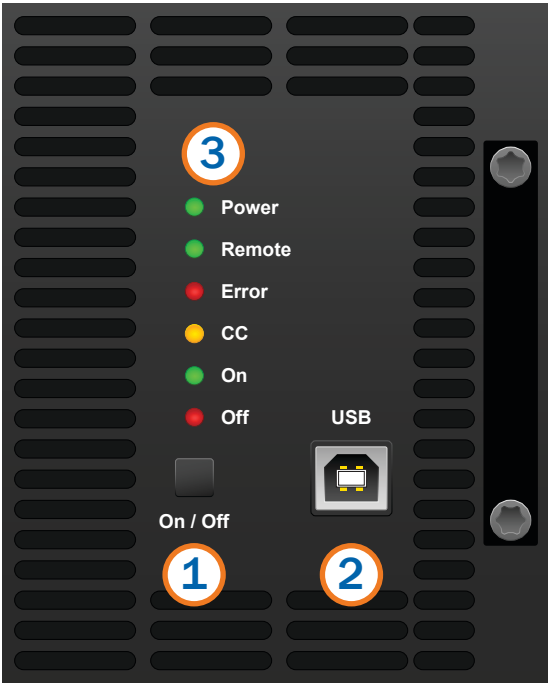
Adjustment resolution and number of digits of set values in the display:

Voltage, OVP, UVD, OVD, U-min, U-max			Current, OCP, UCD, OCD, I-min, I-max			Power, OPP, OPD, P-max			Resistance, R-max		
Nominal	Digits	Min. step width	Nominal*	Digits	Min. step width	Nominal*	Digits	Min. step width	Nominal	Digits	Min. step width
≤80 V	4	0.01 V	4 A / 6 A	4	0.001 A	≤3000 W	4	1 W	<10 Ω	5	0.0001 Ω
200 V	5	0.01 V	10 A - 25 A	5	0.001 A	MS <10 kW	3	0.01 kW	10 Ω - 60 Ω	5	0.001 Ω
≥360 V	4	0.1 V	30 A - 60 A	4	0.01 A	MS ≥10 kW	4	0.01 kW	120 Ω - 750 Ω	5	0.01 Ω
			≥120 A	4	0.1 A				1080 Ω - 5625 Ω	5	0.1 Ω
			MS ≥300 A	4	0.1 A						
			MS ≥1200 A	5	0.1 A						

* MS = Master-slave

3.3 320 Series Control Panel

The 320 Series control panel is simplified compared to the 310 Series units. It consists of status indicators, output on/off, and a USB-A port.



Overview of the elements on the control panel

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

3.4 USB Port, Front Side

3.4.1 310 Series units

The front USB port is intended for the connection of standard USB flash drives. A flash drive can be used for loading or saving sequences for the function generator, as well as for recording measured data during running operation.

USB 2.0 drives are widely accepted. USB 3.0 drives work, but not from all manufacturers. The drive must be FAT32

formatted, and should have a maximum capacity of 32 GB. 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 recognize the path G:\HMI_FILES if the drive were to be assigned the letter G.

The control panel of the unit can read the following file types and names from a USB flash drive:

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.
profile_<arbitrary_text>.csv	Previously saved user profile. A max. of 10 files to select from is shown when loading a user profile.
iu<arbitrary_text>.csv ui<arbitrary_text>.csv	IU or UI table for the XY function generator. The name must begin with iu or ui, the rest can be user defined.
pvc<arbitrary_text>.csv fc<arbitrary_text>.csv	PV or FC table for the XY function generator. The name must begin with pv or fc, the rest can be user defined.
pv_day_et_<arbitrary_text>.csv pv_day_ui_<arbitrary_text>.csv	Day trend data file to load for the simulation modes DAY I/T and DAY U/I of the extended PV function.

The control panel of the unit can save the following file types and names to a USB flash drive:

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.
profile_<nr>.csv	Saved user profile. The number in the file name is a counter and not related to the actual user profile number in the HMI. A max. of 10 files to select from is shown when loading a user profile.
pvc<nr>.csv	PF function table data, as calculated by the unit. Can be loaded again.
fc<nr>.csv	FC function table data, as calculated by the unit. Can be loaded again.
wave_u<nr>.csv wave_i<nr>.csv	Set point data (here: sequence points) from arbitrary function generator of either voltage U or current I
pv_record_<nr>.csv	Data from the data recording option in the extended PV function per EN 50530.

3.4.2 320 Series units

For slave units, the main purpose of the front USB port is remote control access to the most important DC output related parameters, such as set values and protections. Reading values and status is always possible, but setting them is possible only while the slave system is not in control by a master unit.

Since remote control for slave units would normally be managed through the Share and Master-Slave buses, it is expected that the rear USB port would often not be wired up. The front port is intended to be a more convenient ad-hoc access point than the rear USB port.

3.5 USB Port, Rear Side

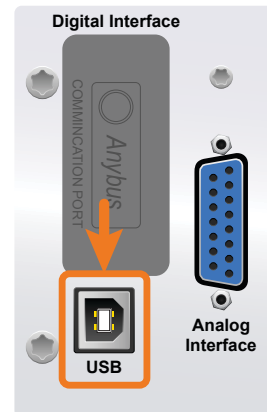
The rear USB port is included on both 310 and 320 Series units.

The USB port on the back of the power supply is provided for connection to a PC for control communication and for firmware updates. The driver is available as a download and installs as a virtual COM port. Details for remote control can be found in the *Programming Guide* on our web site.

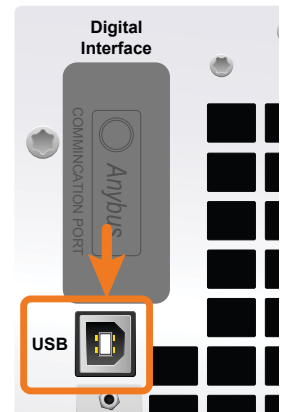
The power supply can be addressed via this port using either the international standard ModBus RTU protocol, or by SCPI language. The power supply will recognise the message protocol used automatically.

If remote control is in operation, the USB port has no priority over either the interface module or the analog interface. Therefore, only one interface should be used at any one time. However, monitoring is always available on any port at any time.

2U Models



3U Models



3.6 Anybus Module Slot

Anybus is available only on the 310 Series. It is not available on slave units.

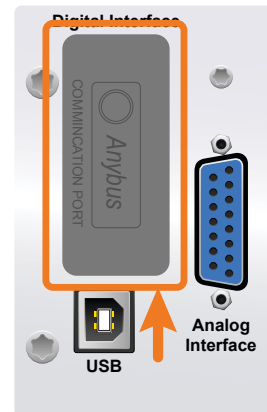
This slot, on the back of 310 Series units with a -001 configuration, is available to accept modules of the IF-AB interface series.

Be aware that when remote control is in operation, no specific port has priority over the others. If more than one interface (USB, AnyBus, analog) is connected, commands can come from any of them at any time. Therefore, only one interface should be used at any one time. However, monitoring is always available on any port at any time.

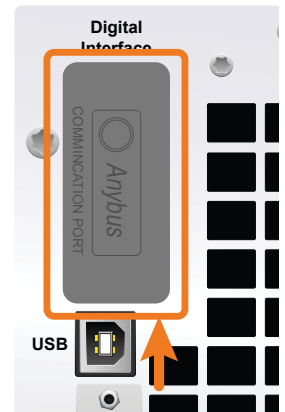
(The illustration shows a cover over the port's panel opening with no module installed.)

The following modules are available as separately purchased options. The modules are field installed by the user, and can be changed as needed.

2U Models



3U Models



Part Number	Name	Description
MPW OPT3-001	IF-AB-RS232	RS 232, 1x Sub-D 9pole male (null modem)
MPW OPT3-002	IF-AB-PBUS	Profibus DP-V1 Slave, 1x Sub-D 9pole female
MPW OPT3-003	IF-AB-CANO	CANopen, 1x Sub-D 9pole male
MPW OPT3-004	IF-AB-MBUS1P	ModBus TCP, 1x RJ45
MPW OPT3-005	IF-AB-MBUS2P	ModBus TCP, 2x RJ45
MPW OPT3-006	IF-AB-ETH1P	Ethernet, 1x RJ45
MPW OPT3-007	IF-AB-ETH2P	Ethernet, 2x RJ45
MPW OPT3-008	IF-AB-PNET1P	ProfiNET IO, 1x RJ45
MPW OPT3-009	IF-AB-PNET2P	ProfiNET IO, 2x RJ45
MPW OPT3-010	IF-AB-CAN	CAN, 1x Sub-D 9pole male
MPW OPT3-011	IF-AB-ECT	EtherCAT, 2x RJ45

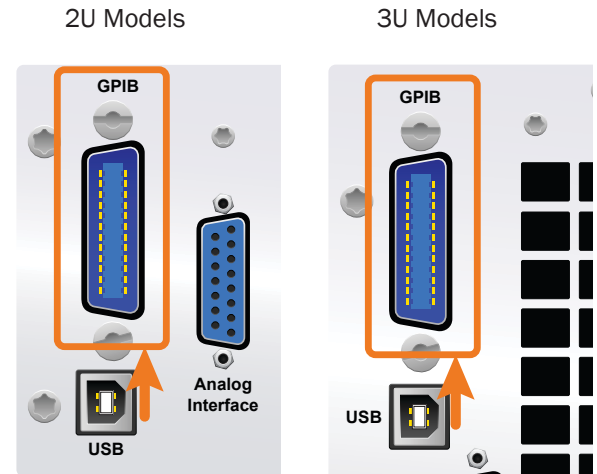
3.7 GPIB Port

GPIB is available as an alternative option to Anybus on the 310 Series units. It is not available on the 320 Series.

The optional GPIB connector is included on 310 Series units with a -002 configuration. The power supply then offers a three-way interface with GPIB, USB, and analog. (The Anybus modules cannot be used with GPIB installed, and the GPIB interface is not field replaceable.)

The connection to a PC or other GPIB port is done with standard GPIB cables which can have straight or 90° connectors.

When using a cable with 90° connectors, the USB port will be blocked.



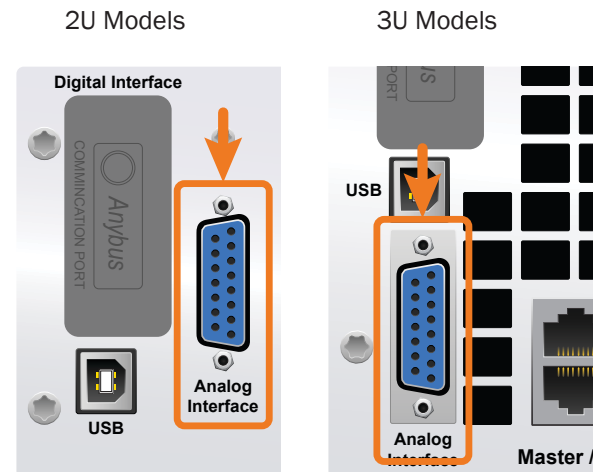
3.8 Analog Interface

The analog interface is not available on the 320 Series units.

This 15-pin, Sub-D socket on the back of the unit is provided for remote control via analog and 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 system as 0-5 V or 0-10 V, in each case for 0-100%.

Be aware that when remote control is in operation, no specific port has priority over the others. If more than one interface (USB, AnyBus, analog) is connected, commands can come from any of them at any time. Therefore, only one interface should be used at any one time. However, monitoring is always available on any port at any time.



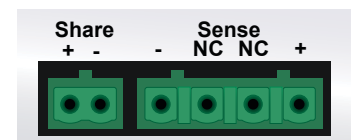
3.9 Sense Connector

The sense connector is included on both standard units and slave units.

Use the Sense connection for constant voltage operation (CV), and where the adjusted output voltage has to be held constant on the load, and not on the power supply's DC output.

In order to compensate for voltage drops along the DC cables to the load, the Sense input can be connected to the load.

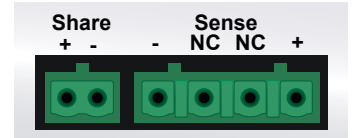
In order to ensure safety, insulation of high voltage models (i.e. those with a nominal voltage of 500 V or higher, requires using only the two outer pins of the 4-pole terminal. The inner two pins, marked with NC (no connect), must remain unconnected.



3.10 Share Connector

The share connector is included on both standard units and slave units.

The 2-pole Phoenix socket named Share on the back of the unit is provided for connection to equally named sockets on other mPower power supplies to achieve a balanced load current distribution during parallel connection. When multiple units are combined in parallel into a single-point controlled system, the Share bus connectors are wired together. See [10.1. Master-Slave Parallel Operation](#).



3.11 Master-Slave Connectors

The master-slave connector is included on both standard units and slave units.

A port is provided on the back side of the unit, comprising two RJ45 sockets, which enables multiple identical systems to be connected via a digital bus (RS485) to create a master-slave system. Connection is made using standard CAT5 cables. These can theoretically have a length of up to 1200 m, but it's recommended to keep the connections as short as possible. See [10.1. Master-Slave Parallel Operation](#).



3.12 Share vs. Master-Slave

There are two buses involved in the operation of multiple units in parallel: the Share bus, and the Master-Slave bus. Ideally, both buses are to be connected when operating multiple units in parallel with one unit designated as a master unit, and additional units designated as slave units.

The role of the Share bus is primarily to manage the sharing of current load between multiple units. Additionally, some set values are also managed across this bus. For this to work, all units must be the same model. If you are already familiar with the share bus as used on the 1U 301/311 units, then using the share bus on the 2U and 3U units can be done in a similar manner (the controls will be a bit different). However, the master-slave system available on the 2U and 3U units adds worthwhile advantages.

The role of the master-slave bus is to facilitate a greater sharing of data between the master and slave units. This bus extends the capabilities originally developed for the share bus (while leaving the share bus protocol alone for compatibility). When using only the share bus, each individual unit is responsible for showing its own actual values, status, and errors. Current is shared and managed, but an operator must check each unit individually for data. Data about the entire parallel system cannot be managed from the master unit.

The master-slave bus makes it possible for the master unit to display the full true capacity of the parallel system, and to acquire detailed data about the status of the system as a whole, making operation much simpler.

See section [10.1. Master-Slave Parallel Operation](#) for more details about the setup of a multi-unit parallel system.

4 Installation

4.1 Transport and Storage

4.1.1 Transport



- The handles on the front side of the unit are not for carrying!
- Because of its weight, transport by hand should be avoided where possible. If unavoidable then only the housing should be held and not on the exterior parts (handles, DC output terminal, rotary knobs).
- Do not transport when switched on or connected!
- When relocating the equipment use of the original packing is recommended
- The unit should always be carried and mounted horizontally
- Use suitable safety clothing, especially safety shoes, when carrying the equipment, as due to its weight a fall can have serious consequences.

4.1.2 Packaging

It's recommended to keep the complete transport packaging for the lifetime of the power supply for relocation or return to the manufacturer for repair.

4.1.3 Storage

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

4.2 Unpacking and Visual Check

After every transport, with or without packaging, or before commissioning, the equipment should be visually inspected for damage. An obviously damaged unit (e.g. loose parts inside, damage outside) must under no circumstances be put into service.

4.3 Installation Preparation

4.3.1 Safety considerations before installation

Review safety notes in section [1.4. Safety Notices](#)



- The product may, depending on the model, have considerable weight. Therefore, the proposed location of the equipment (table, cabinet, shelf, 19" rack) must be able to support the weight.
- When using a 19" rack, rails suitable for the width of the housing and the weight of the unit are to be used. (see [13. Appendix: Model Specifications](#))
- 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.

4.3.2 Mounting the unit

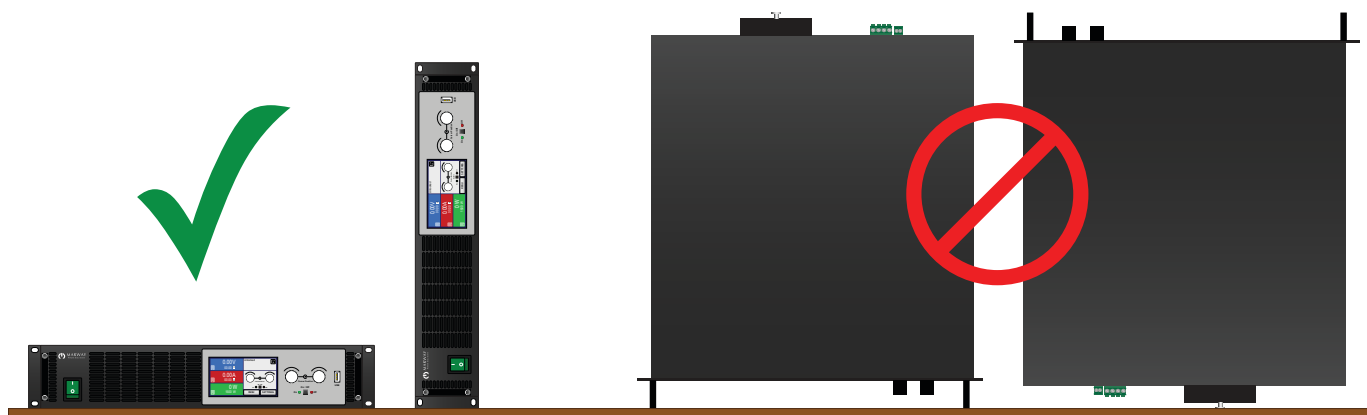


- Select the location for the equipment so that the connection to the load is as short as possible.
- Leave sufficient space behind the equipment, minimum 30 cm (1 ft), for ventilation.
- The unit is not stackable.
- Do not put anything with a total weight of more than 1 kg (2.5 lb) on top of the unit.

With all models, mounting brackets are included to mount the unit in a 19" rack. A rackmount installation will usually mount the power supply on suitable weight-rated rails (not included), and installed in 19" racks or cabinets. The depth of the power supply and rack, and its weight must be taken into account when selecting rails. The handles on the front are for sliding in and out of the cabinet. Slots on the mounting brackets of the front panel are for securing the unit to the rack's vertical rails to prevent inadvertent movement on the slides.

If the unit will be used in a table top setting, the brackets may be removed, and self-adhesive feet attached to the bottom of the unit.

Acceptable and unacceptable installation positions relative to a table surface.



4.4 310 Series 2U Power Connections

4.4.1 310-02/310-12 AC input connections

Mains connection for a 2U mPower DC unit is done via the included cable. In case a different AC wiring is required, make sure that the substitute cable has wiring with at least AWG 12 conductors.

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



- The cable cross section should always be specified for at least the maximum current of the unit even if the planned usage will be at lower currents.
- Continuous operation at the approved limit generates heat which must be removed, as well as voltage loss which depends on cable length and heating. To compensate for these, the cable cross section should be increased and the cable length kept to a minimum.



- The unit can be connected to any wall socket or multi-socket outlet, as long as that connection features a safety contact (GND), and is rated for 16 A continuous duty.
- When connecting the unit to a multi-socket outlet, along with other electric devices, it's important to consider the total power consumption of all devices on the outlet, so that the maximum current (power ÷ minimum voltage) does not exceed the definition for the wall socket, the multi-socket outlet and/or main distribution.
- Before connecting the input plug, ensure that the main power switch is OFF.

The default input values of all models in this series are: 230 V, 16 A, 50/60 Hz. It's internally fused at 16 A.

The unit is delivered with a 3-conductor power cord for standard wall socket connection and supply. If it shall be connected to a 2-phase or 3-phase supply, following phases are required:

Nominal power	Phases	Supply type
1 kW - 3 kW	L1 or L2 or L3, N, GND	Wall socket

4.4.2 310-02/310-12 DC output connections



- In the case of a unit with a high nominal current, and therefore a thick, heavy DC connection cable, it's necessary to take into account the weight of the cable, and the strain imposed on the DC connection. Especially when mounted in a 19" cabinet or similar, where the cable hangs on the DC output, a strain reliever should be used.
- 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 GND. Mind the maximum allowed potential shift (see technical specifications).

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

For cables up to 1.5 m (5 ft) and average ambient temperature up to 50 °C (122 °F), we recommend:

up to 10 A:	0.75 mm ² (AWG 18)	up to 40 A:	6 mm ² (AWG 8)
up to 15 A:	1.5 mm ² (AWG 14)	up to 60 A:	16 mm ² (AWG 4)
up to 30 A:	4 mm ² (AWG 10)	up to 120 A:	35 mm ² (AWG 1)

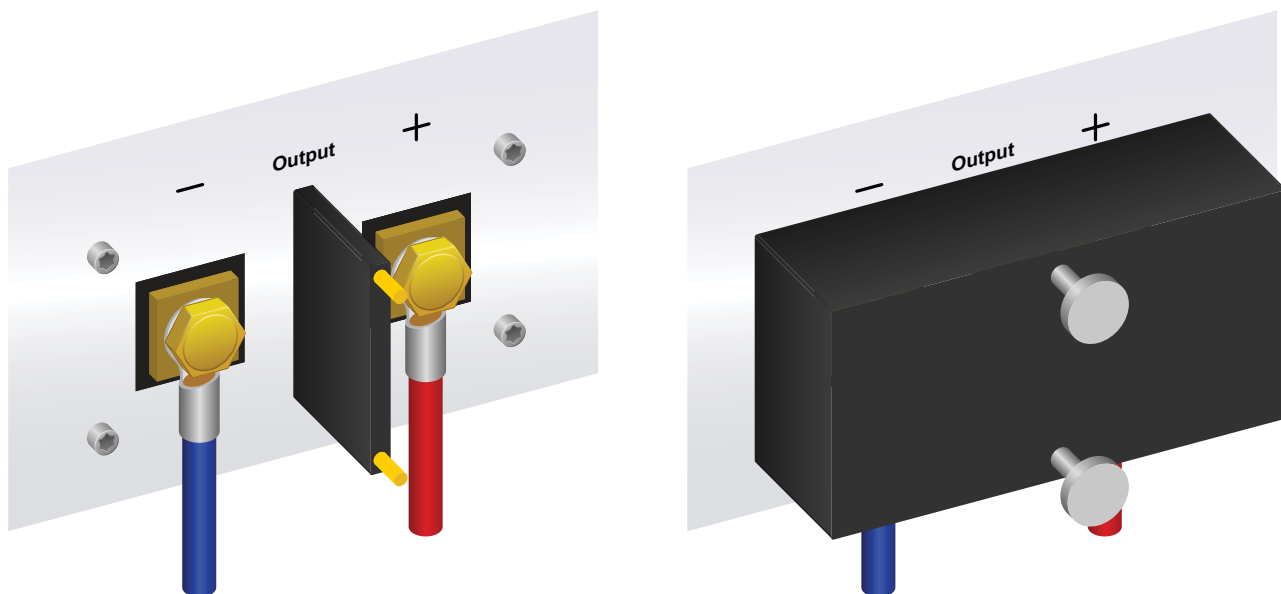
per lead (multi-conductor, insulated, openly suspended). Single cables of, for example, 35 mm² may be replaced by e.g. 2x 16 mm² etc. If the cables are long then the cross section must be increased to avoid voltage loss and overheating.

4.4.2.1 310-02/310-12 DC terminal types

The illustrations below show an overview of the two DC terminal types used on 2U units. The type on any particular unit depends on its output voltage rating. It's recommended that connection of load cables always utilize flexible cables with ring lugs.

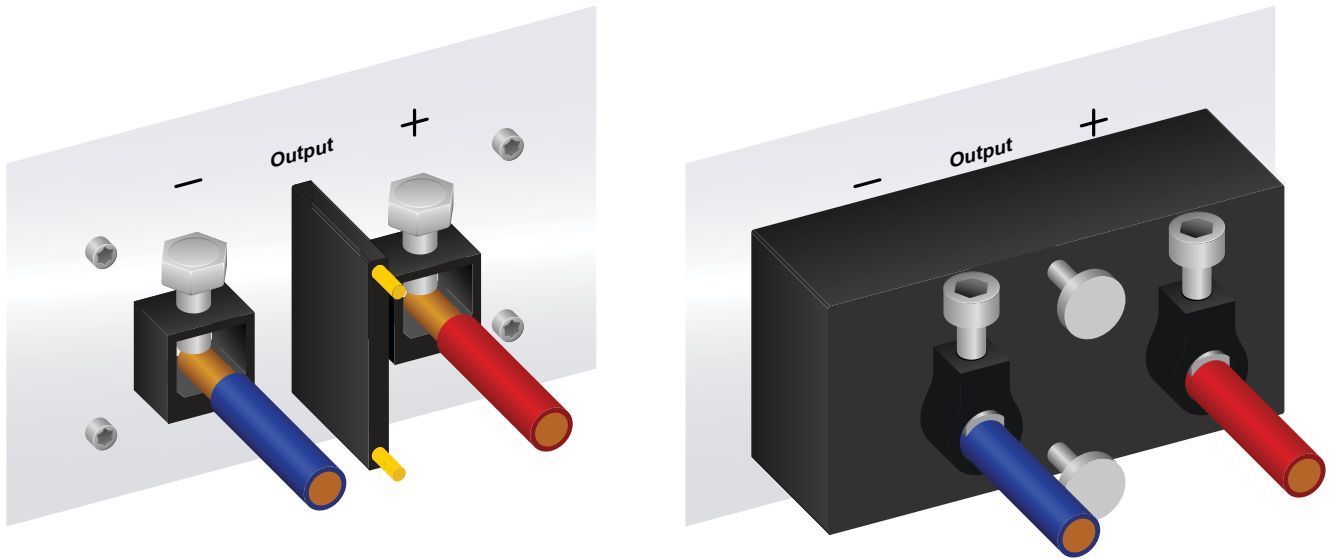
310-02/310-12 Type 1 output terminals

This type (shown with cover off and on) is used on models up to, and including, 80 Vdc. The terminal bolt is an M8 into a brass block, and should be used with an M8 ring lug (8.4mm hole).



310-02/310-12 Type 2 output terminals

This type (shown with cover off and on) is used on models from 200 Vdc and greater. The screw clamp bolt is an M6, and should be used with an M6 ring lug (6.5mm hole). The cover has an additional clamp to help stabilize the wire.



4.4.2.2 310-02/310-12 cable lead and plastic cover

A plastic cover for contact protection is included for the DC terminals. It should always be installed. Both cover types are fixed to the DC terminal separator, by knurled nuts. The cover for type 1 has breakouts so that the supply cable can be laid in various directions. The cover for type 2 includes built-in strain relief aids, but additional support may be needed.



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

4.4.3 310-02/310-12 DC output grounding

No matter if the power supply is operated stand-alone or in series connection with others, it is always only allowed to ground one of all DC output poles. The following also has to be considered:

Because of isolation, there is a maximum allowed potential shift of the DC output poles, which also depends on the model. Refer to [13. Appendix: Model Specifications](#) for details.

The DC minus pole of a stand-alone unit can be grounded right away, but it should only be done if absolutely necessary, because the DC output is connected to GND via X capacitors in order to gain better high frequency filtering.



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

4.5 310 Series 3U Power Connections

4.5.1 310-23/310-43 AC power connections



- Connection to an AC mains supply may only be carried out by qualified personnel.
- Cable cross section must be suitable for the maximum input current of the unit (see tables below).
- Before connecting the input plug, ensure that the main power switch is OFF.
- It is recommended to always connect all three phases, even if the unit doesn't require them, because then no phase can be missing.

Phase requirements:

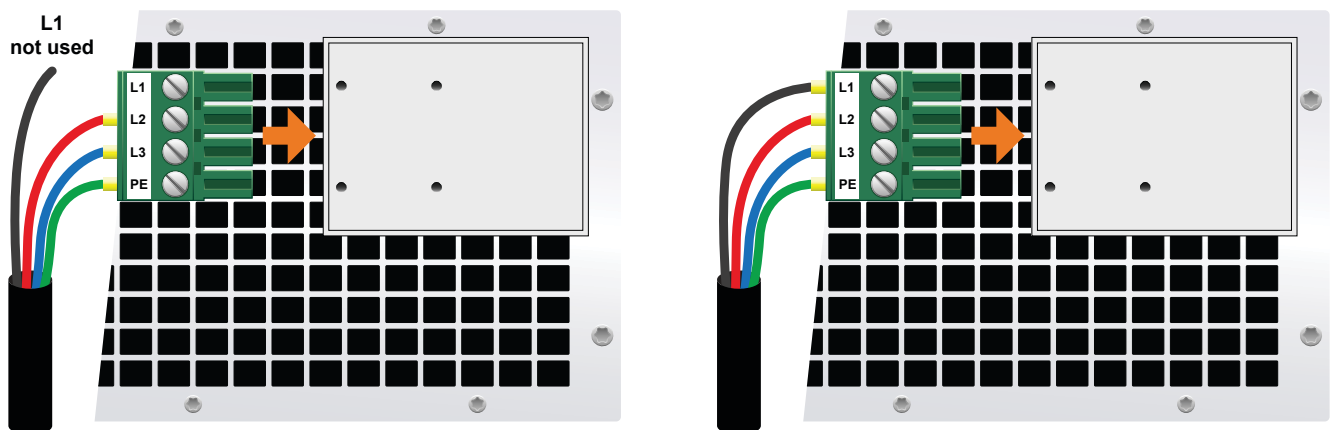
The 208 V models (310-23/310-43 series) are delivered with a 4 pole mains plug. Depending on the model, the unit requires a supply with 2 or 3 phases and 208 V, which must be wired according to the labelling on the plug.

Nominal power	Inputs on AC plug	Supply type
5 kW	L2, L3, GND	Three-phase
≥10 kW	L1, L2, L3, GND	Three-phase

Phase connection schemes:

5kw models use only L2 and L3 connections (left illustration). 10kw and higher units use all three connections (right illustration).

The 5kw connection illustration below shows the L1 not connected for informational purposes only to show that it is not used. It is recommended that the conductor actually be connected to prevent possible hazards from an untethered cable.



Cable cross sections:

For the wiring cross section, the power of the unit and the cable length are determining factors. The table below shows the maximum output current for each phase, based on the connection of a stand-alone unit:

Nominal power	L1		L2		L3	
	Ø	I _{max}	Ø	I _{max}	Ø	I _{max}
5 kW	(N.C.)	(N.C.)	AWG 12	32 A	AWG 12	32 A
10 kW	AWG 8	56 A	AWG 8	32 A	AWG 8	32 A
15 kW	AWG 8	56 A	AWG 8	56 A	AWG 8	56 A

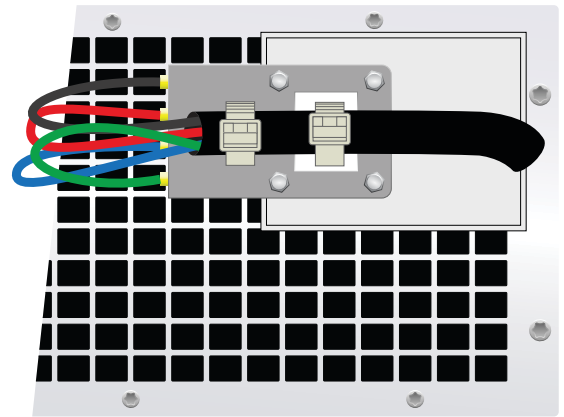
The included connector can receive loose/soldered cable ends of up to 16 mm² (AWG 6). The longer the connection cable, the higher the voltage loss due to the cable resistance. Therefore, the mains cables should be kept as short as possible, or use a bigger cross section.

4.5.1.1 310-23/310-43 strain relief fixture

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

Using the 4x M3 acorn nuts, mount the fixture to the AC filter block each time the AC plug is plugged in.

Position the cable as shown, and used cable ties to complete the strain relief functionality.



4.5.1.2 310-23/310-43 AC connection variants

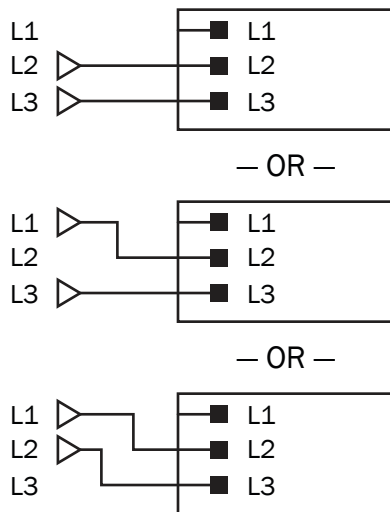
Depending on the maximum power rating of a specific model, it requires two or three phases of a three-phase AC supply. In case multiple units with 2-phase requirements are connected to the same main terminal, it is recommended to arrange units on different supply phases to better balance the current distribution on the three phases.

The 10 kW and higher power models already consume balanced current on all three phases. As long as only these models are installed, no unbalanced AC load is expected.

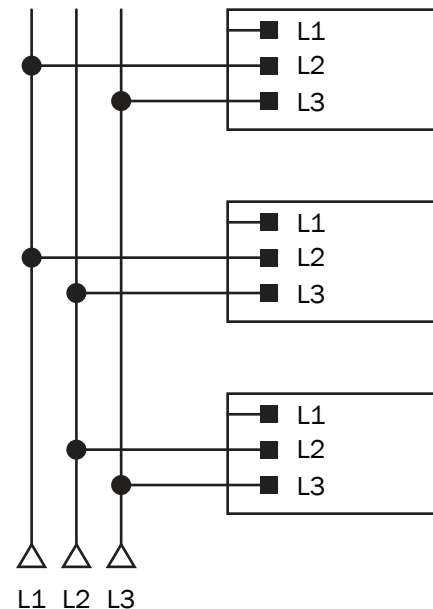
Mixed installations with 2-phase and 3-phase models are not automatically balanced.

Suggestions to assign phases:

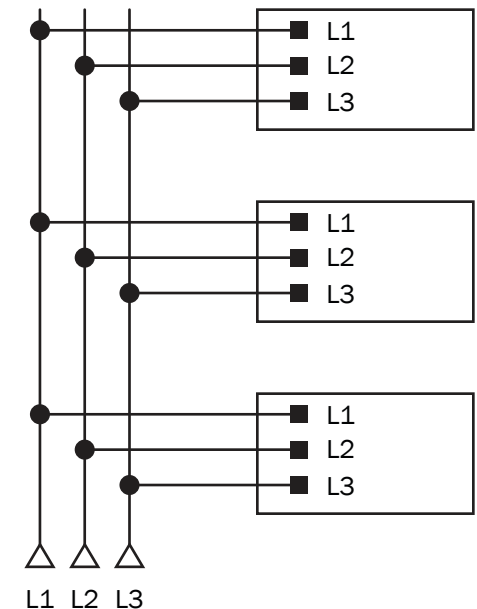
Single unit with 2-phase
3 options



Multiple units with 2-phase
Mix connections to balance the load



Multiple units with 3-phase
All connections to corresponding phases



4.5.2 310-23/310-43 DC output connections



- In the case of a unit with a high nominal current, and therefore a thick, heavy DC connection cable, it's necessary to take into account the weight of the cable, and the strain imposed on the DC connection. Especially when mounted in a 19" cabinet or similar, where the cable hangs on the DC output, a strain reliever should be used.
- 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 GND. Mind the maximum allowed potential shift (see technical specifications).

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

For cables up to 1.5 m (5 ft) and average ambient temperature up to 50 °C (122 °F), we recommend:

up to 30 A:	6 mm ² (AWG 8)	up to 170 A:	70 mm ² (AWG 3/0)
up to 70 A:	16 mm ² (AWG 4)	up to 210 A:	95 mm ² (AWG 4/0)
up to 90 A:	25 mm ² (AWG 2)	up to 340 A:	2x 70 mm ² (2x AWG 3/0)
up to 140 A:	50 mm ² (AWG 1/0)	up to 510 A:	2x 120 mm ² (2x 250 MCM)

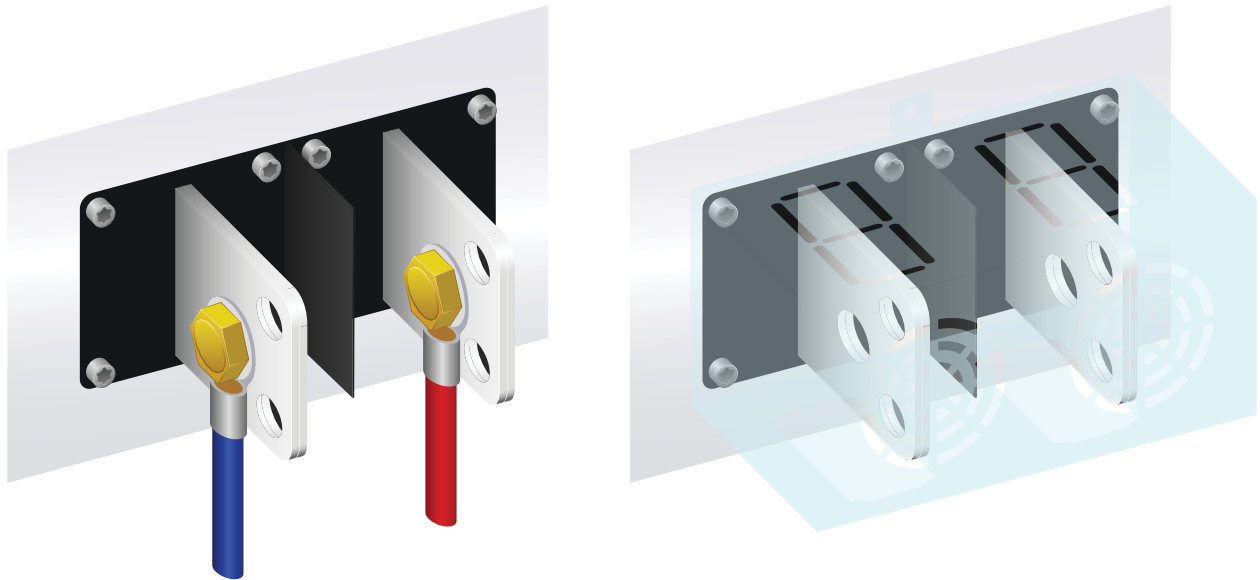
per connection pole (multi-conductor, insulated, openly suspended). Single cables of, for example, 70 mm² may be replaced by e.g. 2x35 mm² etc. If the cables are long then the cross section must be increased to avoid voltage loss and overheating.

4.5.2.1 310-23/310-43 DC terminal types

The illustrations below show an overview of the two DC terminal types used on 310-23/310-43 units. The type on any particular unit depends on its output voltage rating. It's recommended that connection of load cables always utilize flexible cables with ring lugs.

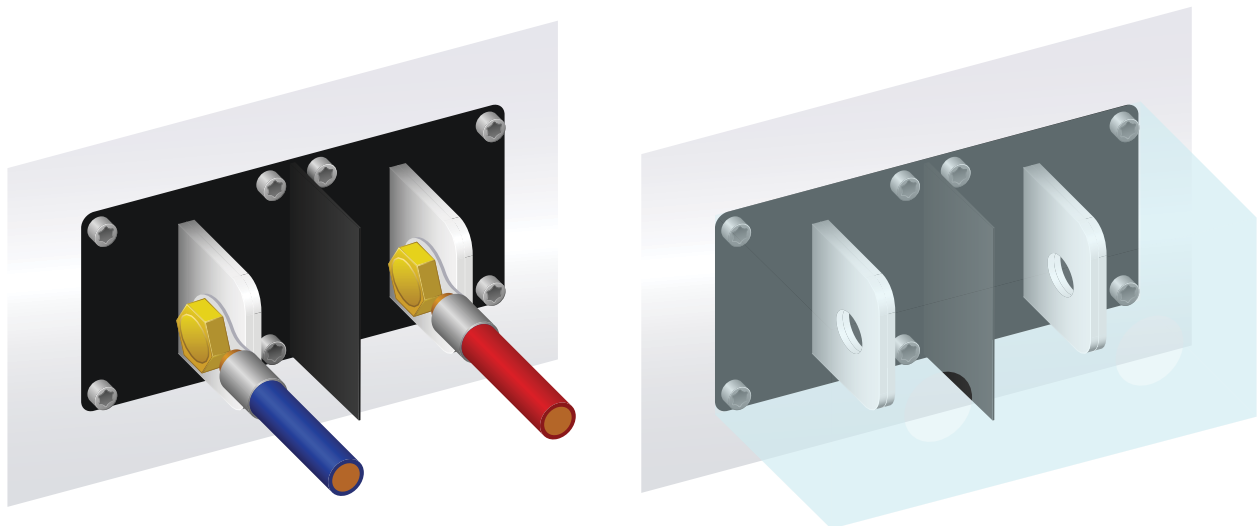
310-23/310-43 Type 1 output terminals

This type (shown with cover off and on) is used on models up to, and including, 360 Vdc. The terminal bolt is an M8 used with a ring lug.



310-23/310-43 Type 2 output terminals

This type (shown with cover off and on) is used on models from 500 Vdc and greater. The terminal bolt is an M6 used with a ring lug.



4.5.2.2 310-23/310-43 DC connector cover

A clear plastic cover for contact protection is included for the DC terminal. It should always be installed. The cover for type 1 it is connected to the back of the unit, whereas for type 2, it is fixed to the DC connector itself. The cover for type 1 also has breakouts so that the supply cable can be laid in various directions. Type 2 connections can be horizontal only.



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

4.5.3 310-23/310-43 DC output grounding

No matter if the power supply is operated stand-alone or in series connection with others, it is always only allowed to ground one of all DC output poles. The following also has to be considered:

Because of isolation, there is a maximum allowed potential shift of the DC output poles, which also depends on the model. Refer to [13. Appendix: Model Specifications](#) for details.

The DC minus pole of a stand-alone unit can be grounded right away, but it should only be done if absolutely necessary, because the DC output is connected to GND via X capacitors in order to gain better high frequency filtering.



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

4.6 310 Series 3U Power Connections

4.6.1 310-33/310-53 AC input connection



- Connection to an AC mains supply may only be carried out by qualified personnel.
- Cable cross section must be suitable for the maximum input current of the unit (see tables below).
- Before connecting the input plug, ensure that the main power switch is OFF.
- It is recommend to always connect all three phases, even if the unit doesn't require them, because then no phase can be missing.

Phase requirements:

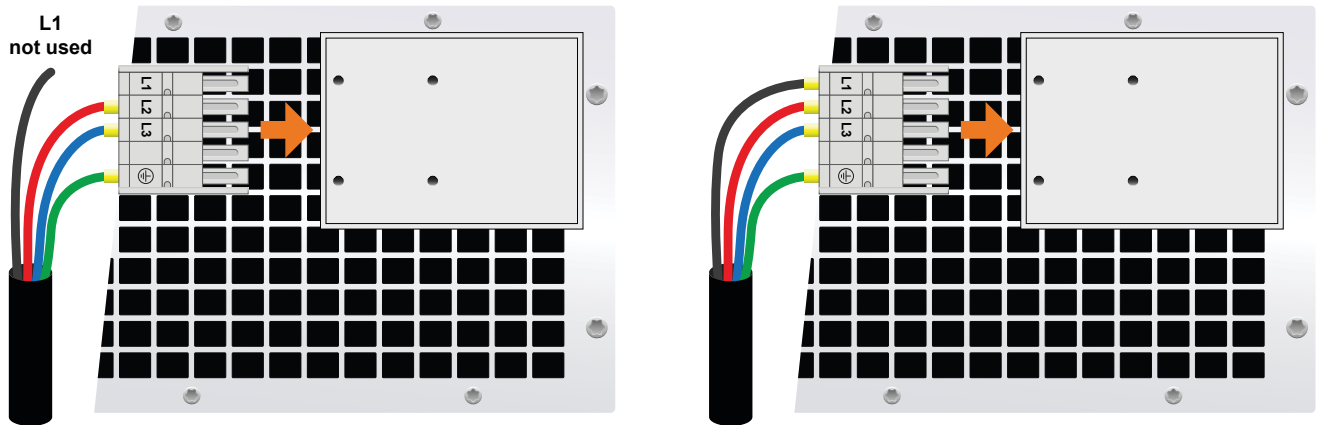
The equipment is delivered with a 5 pole mains plug. Depending on model, this will be connected with a 2-phase or 3-phase mains supply, which has to be connected according to the labeling on the plug.

Nominal power	Phases	Supply type
5 kW	L2, L3, GND	Three-phase
10 - 15 kW, > 15 kW	L1, L2, L3, GND	Three-phase

Phase connection schemes:

5kw models use only L2 and L3 connections (left illustration). 10kw and higher units use all three connections (right illustration).

The 5kw connection illustration below shows the L1 not connected for informational purposes only to show that it is not used. It is recommended that the conductor actually be connected to prevent possible hazards from an untethered cable.



Cable cross sections:

For the wiring cross section, the power of the unit and the cable length are determining factors. The table below shows the maximum output current for each phase, based on the connection of a stand-alone unit:

Nominal power	L1		L2		L3		GND
	Ø	I _{max}	Ø	I _{max}	Ø	I _{max}	Ø
5 kW	(N.C.)	(N.C.)	2.5 mm ²	16 A	2.5 mm ²	16 A	2.5 mm ²
10 kW	4 mm ²	28 A	4 mm ²	16 A	4 mm ²	16 A	4 mm ²
15 kW	4 mm ²	28 A	4 mm ²	28 A	4 mm ²	28 A	4 mm ²

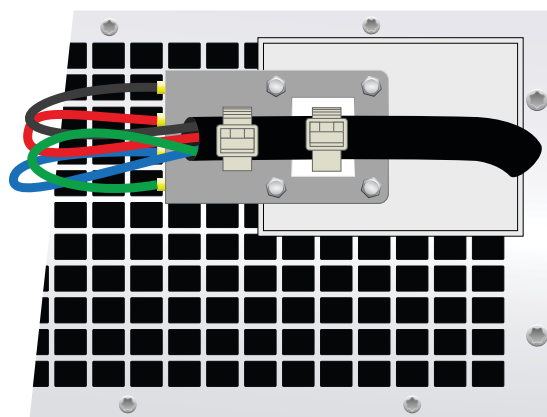
The included connector can receive loose/soldered cable ends of up to 6 mm² (AWG 8). The longer the connection cable, the higher the voltage loss due to the cable resistance. Therefore, the mains cables should be kept as short as possible, or use a bigger cross section.

4.6.1.1 310-33/310-53 strain relief fixture

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

Using the 4x M3 acorn nuts, mount the fixture to the AC filter block each time the AC plug is plugged in.

Position the cable as shown, and used cable ties to complete the strain relief functionality.



4.6.1.2 310-33/310-53 AC connection variants

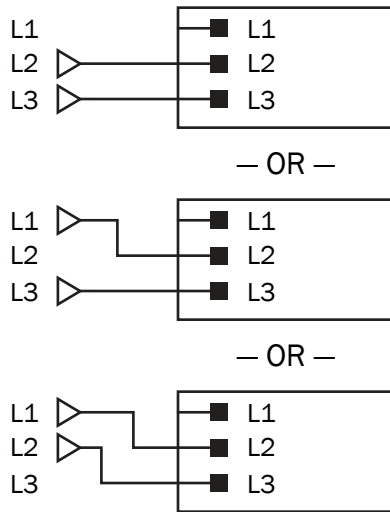
Depending on the maximum power rating of a specific model, it requires two or three phases of a three-phase AC supply. In case multiple units with 2-phase requirements are connected to the same main terminal, it is recommended to arrange units on different supply phases to better balance the current distribution on the three phases.

The 10 kW and higher power models already consume balanced current on all three phases. As long as only these models are installed, no unbalanced AC load is expected.

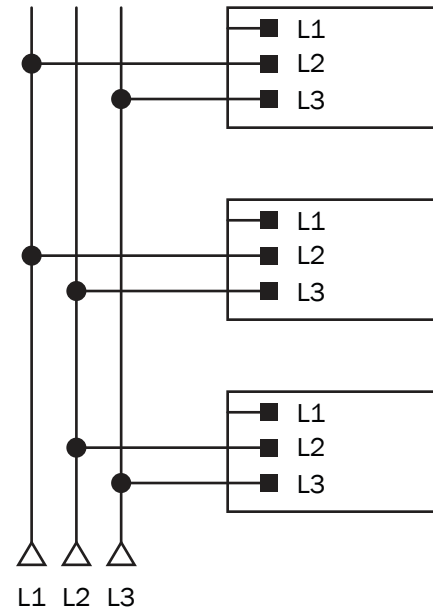
Mixed installations with 2-phase and 3-phase models are not automatically balanced.

Suggestions for assigning phases:

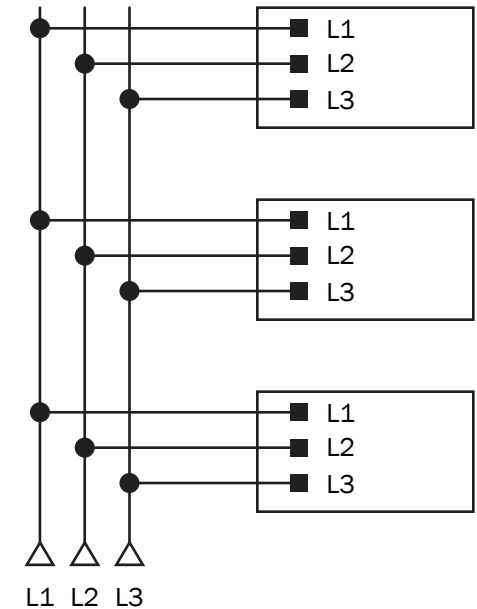
Single unit with 2-phase
3 options



Multiple units with 2-phase
Mix connections to balance the load



Multiple units with 3-phase
All connections to corresponding phases



4.6.2 310-33/310-53 DC outlet connections



- In the case of a unit with a high nominal current, and therefore a thick, heavy DC connection cable, it's necessary to take into account the weight of the cable, and the strain imposed on the DC connection. Especially when mounted in a 19" cabinet or similar, where the cable hangs on the DC output, a strain reliever should be used.
- 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 GND. Mind the maximum allowed potential shift (see technical specifications).

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

For cables up to 1.5 m (5 ft) and average ambient temperature up to 50 °C (122 °F), we recommend:

up to 30 A:	6 mm ² (AWG 8)	up to 170 A:	70 mm ² (AWG 3/0)
up to 70 A:	16 mm ² (AWG 4)	up to 210 A:	95 mm ² (AWG 4/0)
up to 90 A:	25 mm ² (AWG 2)	up to 340 A:	2x 70 mm ² (2x AWG 3/0)
up to 140 A:	50 mm ² (AWG 1/0)	up to 510 A:	2x 120 mm ² (2x 250 MCM)

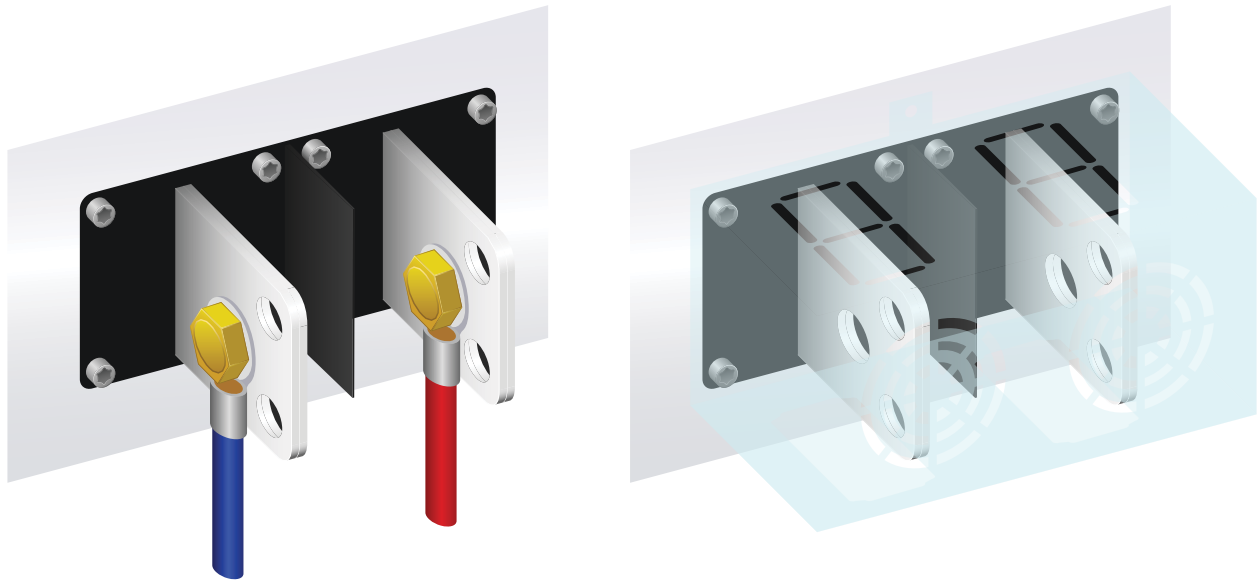
per connection pole (multi-conductor, insulated, openly suspended). Single cables of, for example, 70 mm² may be replaced by e.g. 2x35 mm² etc. If the cables are long then the cross section must be increased to avoid voltage loss and overheating.

4.6.2.1 310-33/310-53 DC terminal types

The illustrations below show an overview of the two DC terminal types used on 310-33/310-53 units. The type on any particular unit depends on its output voltage rating. It's recommended that connection of load cables always utilize flexible cables with ring lugs.

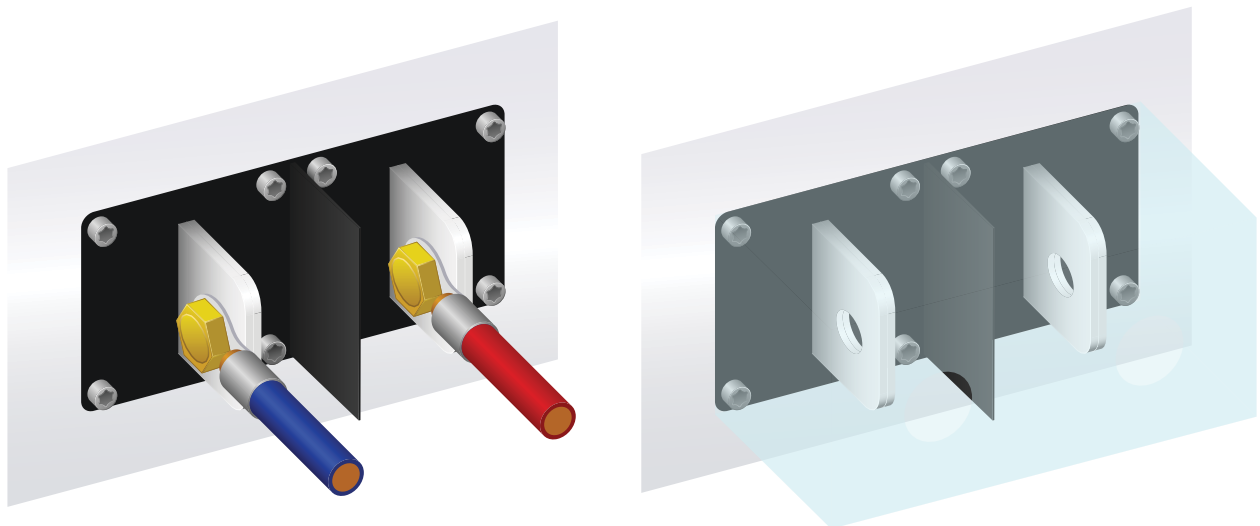
310-33/310-53 Type 1 output terminals

This type (shown with cover off and on) is used on models up to, and including, 360 Vdc. The terminal bolt is an M8 used with a ring lug.



310-33/310-53 Type 2 output terminals

This type (shown with cover off and on) is used on models from 500 Vdc and greater. The terminal bolt is an M6 used with a ring lug.



4.6.2.2 310-33/310-53 DC connector cover

A clear plastic cover for contact protection is included for the DC terminal. It should always be installed. The cover for type 1 it is connected to the back of the unit, whereas for type 2, it is fixed to the DC connector itself. The cover for type 1 also has breakouts so that the supply cable can be laid in various directions. Type 2 connections can be horizontal only.



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

4.6.3 310-33/310-53 DC output grounding

No matter if the power supply is operated stand-alone or in series connection with others, it is always only allowed to ground one of all DC output poles. The following also has to be considered:

Because of isolation, there is a maximum allowed potential shift of the DC output poles, which also depends on the model. Refer to [13. Appendix: Model Specifications](#) for details.

The DC minus pole of a stand-alone unit can be grounded right away, but it should only be done if absolutely necessary, because the DC output is connected to GND via X capacitors in order to gain better high frequency filtering.



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

4.7 Remote Sensing Connection

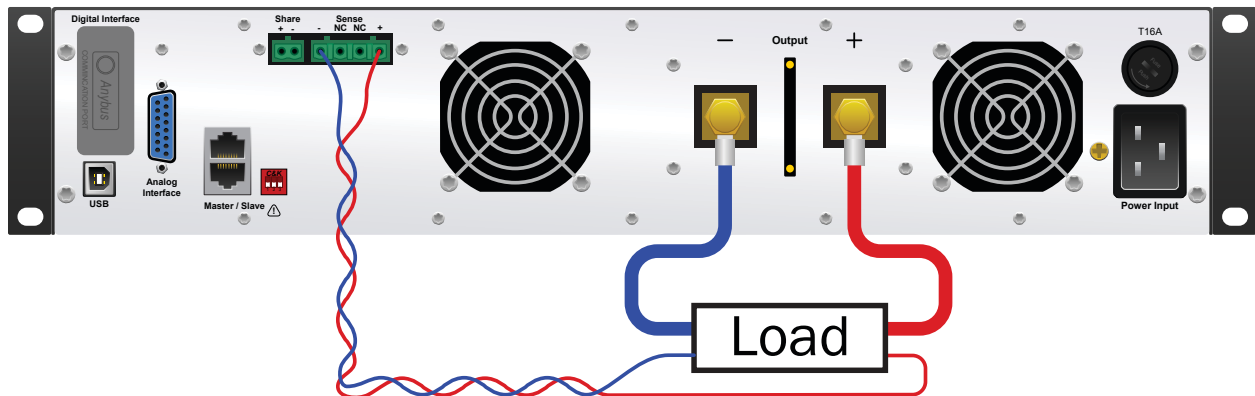


- Both pins “NC” of the Sense connector must not be wired.
- Be aware of the voltage rating of the sense cables, especially with models of ≥ 500 V.
- The two screws next to connectors Share/Sense must always be mounted.



- Remote sensing is only effective during constant voltage operation (CV). 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 non-critical. However, it should be increased with increasing cable length. Recommendation for cables up to 5 m (16.4 ft): 0.5 mm^2 .
- Sense cables should be twisted and laid close to the DC cables to damp oscillation. If necessary, an additional capacitor should be installed at the load to eliminate oscillation.
- The sense cables must be connected + to + and - to - at the load, otherwise both systems may be damaged.
- In master-slave operation, the remote sensing should be connected to the master unit only.

For both the 2U (shown) and 3U units, the connection scheme is the same.



4.8 Share Bus Connection

The Share bus connector on the back side is intended to balance the current of multiple units in parallel operation, especially when using the integrated function generator of the master unit. See [10.1. Master-Slave Parallel Operation](#) for connection details.

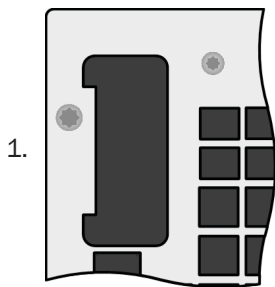
4.9 AnyBus Module Installation

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



- Use common ESD protection procedures when inserting or exchanging a module.
- The power supply main power must be switched off before insertion or removal of a module.
- Never insert any other hardware other than an interface module into the slot.
- If no module is in use, it's recommended that the slot cover be mounted in order to avoid internal accumulation of dust and debris.

Installation steps:

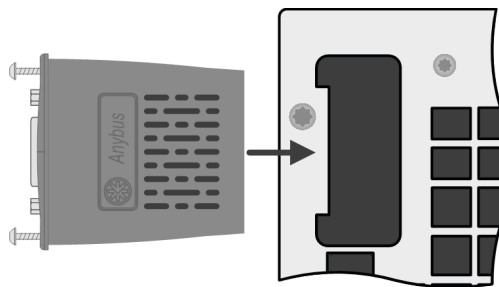


1.

With the help of a Torx 8 screw driver either remove the slot cover (dummy module) an already installed module.

The screws can be used to assist in pulling out the module.

Make sure the screws are fully retracted. If not, unscrew them further and remove the module.

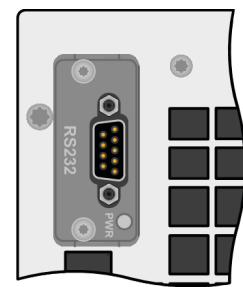


2.

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

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

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



3.

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

4.10 Analog Interface Connection

The 15-pin, Sub-D connector on the rear of the system is an analog interface. To connect this to a controlling hardware unit (PC, electronic circuit), a corresponding plug is necessary. It's generally advisable to switch the power supply completely off before connecting or disconnecting this connector, but at least the DC output. See [section 6.2.4.4 Analog interface specification on page 65](#) for more details about the connector.



The analog interface is galvanically isolated from the system 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.

4.11 Connecting the USB Port (rear side)

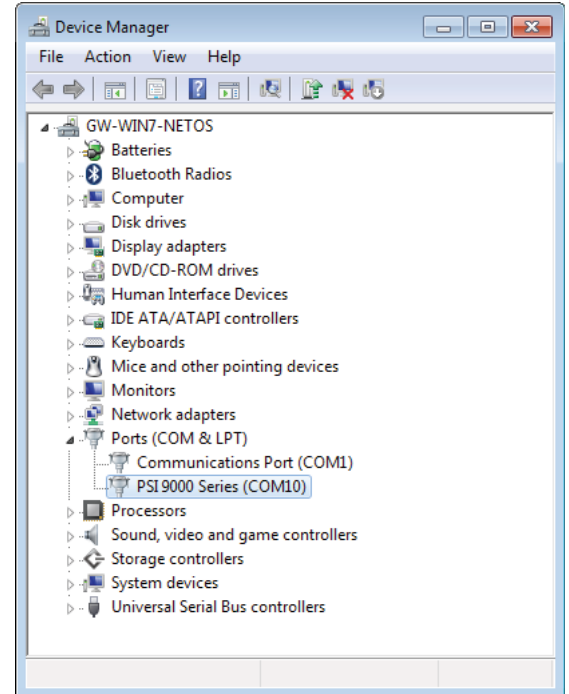
4.11.1 Driver installation (Windows)

On the initial connection with a PC, the operating system will identify the unit as new hardware, and will try to install a driver. The required driver is for a Communications Device Class (CDC) device, and is usually integrated in current operating systems such as Windows 7 or 10. It is strongly recommended to install and use the mPower USB driver installer (available from our web site) to gain maximum compatibility between the computer and power supply.

4.11.1.1 Discovering COM Port in Windows

Once the driver is installed, and one or more power supplies connected by USB to a PC, you will need to determine which COM port is used for which power supply. It is easier to do this if you attach one power supply at a time, so it is easier to find which COM port is the newest.

Attach a power supply, and turn on the AC power (it does not need any DC output connections). In Windows navigate to Control Panels > Device Manager, and look for Ports in the list, and expand it. You will find one or more entries for PSI 9000 Series — this is the name of the driver for the mPower DC 310/320. Next to those names you will see (COMnn) where nn will be a single or double-digit number. That is the COM port number. As you add one unit at a time, it should be apparant which COM has been added (and therefore which unit it connects to).



4.11.2 Driver installation (Linux, MacOS)

We do not have drivers or installation instructions for these operating systems. Whether a suitable driver is available is best carried out by searching the Internet for a CDC driver.

4.11.3 Alternative drivers

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

4.12 Extension with 320 Series Units

The 15 kW models of the 3U 310 Series can be extended by specialized slave units of the same rating to increase total power in a parallel connection setup of up to 16 units in total.

The 320 Series slave units (see [3.1.2. Slave configuration](#)) have a reduced control panel and fewer remote interfaces, making them a cost effective option for multi-unit setups. They are configurable, but only using remote control, for example using the [EA Power Control](#) software, or writing your own script with USB commands.

The parallel connection system uses master-slave operation (see [10.1. Master-Slave Parallel Operation](#)) and the Share bus. Slave units can be added incrementally as required. Every unit comes with a master-slave cable to connect to the next unit. Cables for Share bus and DC output are to be manufactured by the user.

The configuration of the master unit (a standard model with display), is either done on the unit itself, or via software in remote control. The slave units don't require setup as they are preconfigured when shipped to be slaves on the master-slave bus. However, if a slave's configuration has been changed (e.g. was used in stand-alone mode), then the configuration will have to be reset to be a slave.

5 Operation Essentials

This section is about operation elements common to the standard and slave series models.

5.1 Important Notes

5.1.1 Personal safety



- In order to guarantee safety when using the power supply, it's essential that only persons who are fully acquainted and trained in the required safety measures to be taken when working with dangerous electrical voltages be allowed to operate the unit.
- For models which can generate a voltage which is dangerous by contact, or is connected to such, the included DC terminal cover, or an equivalent, must always be installed.
- Whenever the load and DC output are being re-configured, the unit should be completely disconnected from the AC main power source—not just simply switched off.

5.1.2 General



- Unloaded operation is not considered as a normal operation mode, and can thus lead to false measurements, for example when calibrating the unit.
- The optimal working point of the system is between 50% and 100% voltage and current. Operating as low as approximately 33% can be done to make the most out of the auto-ranging capabilities.
- It's recommended to not run the system below 10% voltage and current in order to make sure technical values like ripple and transient times can be met.

5.2 Regulation Modes

A power supply is internally controlled by different regulation circuits, which bring voltage, current, and power to specific 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.

5.2.1 Voltage regulation

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

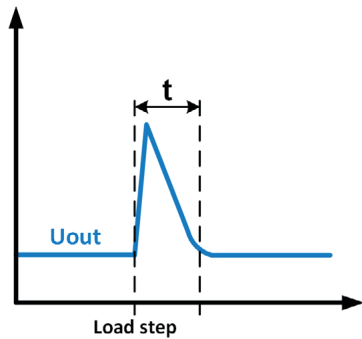
The DC output voltage of a power supply is held constant on the adjusted value, unless the output current or the output power according to $P = U_{OUT} \cdot I_{OUT}$ reaches the adjusted current or power limit. In both cases, the system will automatically change to constant current or constant power operation, whichever 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, this mode will be indicated in several ways: the condition “CV mode active” will be indicated on the graphic display by the abbreviation CV, a CV message will be passed as a signal to the analog interface, and the CV status can be read as a status message on the digital interfaces.

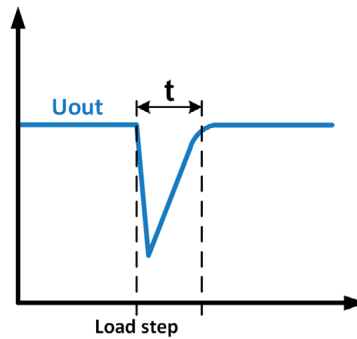
5.2.1.1 Transient time after load step

For constant voltage mode, the technical data “Settling time after load step” (see [13. Appendix: Model Specifications](#)) defines a time that is required by the internal voltage regulator of the power supply to settle the output voltage after a load change. Negative load changes (high load to lower load), will cause the output voltage to overshoot for a short time until compensated by the voltage regulator. With a positive load change (low load to high load), the output collapses for a moment. The amplitude of the overshoot or collapse varies depending on the model, the currently adjusted output voltage, and the capacity on the DC output—and therefore cannot be stated with a specific value.

Load change transients



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.

5.2.2 Current regulation

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

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

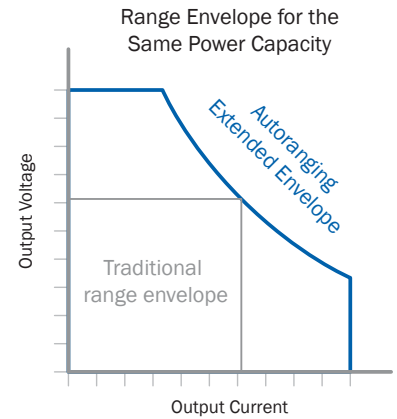
While the DC output is switched on, and constant current mode is active, this mode will be indicated in several ways: the condition “CC mode active” will be indicated on the graphic display by the abbreviation CC, a CC message will be passed as a signal to the analog interface, and the CC status can be read as a status message on the digital interfaces.

5.2.3 Power regulation

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

Power limiting operates according to the auto-range principle such that at lower output voltages, higher current flows, and vice versa in order to maintain constant power within the range P_N (autoranging line in the diagram to the right).

While the DC output is switched on, and constant power mode is active, this mode will be indicated in several ways: the condition “CP mode active” will be indicated on the graphic display by the abbreviation CP, a CP message will be passed as a signal to the analog interface, and the CP status can be read as a status message on the digital interfaces.



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

5.2.3.1 Power derating

Some models of the mPower 310 series offer an extended AC supply voltage range, but are optimized for the use at 230 Vac, $\pm 10\%$. Below a certain supply voltage, these models will automatically start to derate (i.e. reduce the maximum available output power). The derating happens on the AC input side and thus the system won’t indicate the derating as a “CP” condition.

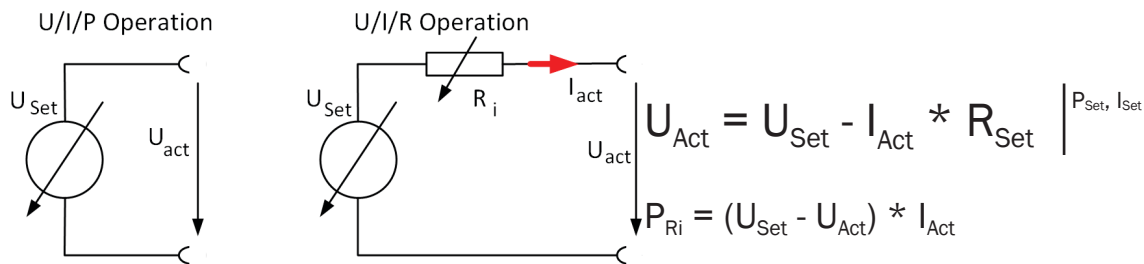
Depending on the rated power of the particular model, the derating starts at different supply voltages:

- 310 Series 1.5 kW models
 - Above approximately 150 Vac, maximum output power is available.
 - Below approximately 150 Vac, maximum power is reduced to 1000 W.
 - Below approximately 90 Vac, DC output is shut off.
- 310 Series 3 kW models
 - Above approximately 207 Vac, maximum output power is available.
 - Below approximately 207 Vac, maximum power is reduced to 2500 W.
 - Below approximately 180 Vac, DC output is shut off.

5.2.4 Resistance regulation

Internal resistance control (“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 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 is not active.

The adjustable resistance range of a particular model is given in the technical specifications. The voltage setting in dependency of the resistance set value, and the output current is done by calculation of the microcontroller. Therefore, it will be significantly slower than the other regulation modes.



With resistance mode being activated, the function generator will be unavailable, and the actual power value provided by the system does not include the simulated power dissipation of R_i .

5.3 Alarm Conditions



This section only gives an overview about hardware alarms. What to do in case your unit indicates an alarm condition is described in section [8. Alarms and Monitoring](#).

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

5.3.1 Power Fail

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

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

As soon as a power fail occurs, the system will stop to supply power and switch off the DC output.



Switching off the unit by the mains switch can't be distinguished from a mains blackout and thus the system will indicate a PF alarm every time the unit is switched off. This can be ignored.



The on/off state of the DC output after a PF alarm during normal operation can be configured. See [6.1.3. Configuration via MENU](#).

5.3.2 Overtemperature

An overtemperature alarm (OT) can occur due to excess temperature inside the power supply, and temporarily causes it to switch off the power stage(s). This can occur if the ambient temperature exceeds the maximum ambient temperature rating for the unit. After cooling down, the power supply can automatically switch the power stage back on, depending on the setting of parameter "DC terminal after OT alarm". See section [6.1.3.1. Menu "General Settings"](#).

5.3.3 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 system is in CC mode, and if it then experiences a negative load step, it will make the voltage rise quickly, resulting in a voltage overshoot for a short moment which can trigger the OVP.
- The changeover from operation modes CC to CV can generate voltage overshoots.

This function serves to warn the user audibly or visually that the system probably has generated an excessive voltage which could damage the connected load application.



- The system is not fitted with protection from external overvoltage.

5.3.4 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 is not overloaded, and possibly damaged due to an excessive current.

5.3.5 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 is not overloaded and possibly damaged due to an excessive power consumption.

6 310 Series Operation

6.1 Manual Control

6.1.1 Switching on the unit

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

After the unit is switched on, the display will first show some unit related information (model, firmware versions etc.), and then a language selection screen for 3 seconds. A few seconds later it will show the main screen.

In setup (see section 6.1.3. **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 ERROR or OVP. Those signal must be ignored until the system has finished booting and is ready to work.

6.1.2 Switching off the unit

At power-off, the last output on/off state, 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, after a short while, fans will shut down, and after another few seconds the unit will be completely powered off. Use a meter to be sure power has fully dissipated from the output.

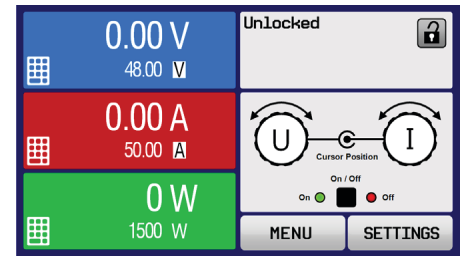
6.1.3 Configuration via MENU

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

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

Menu navigation is by touch. Values are set using the rotary knobs which can be assigned to different purposes. The assignments of the rotary knobs, if multiple values can be set in a particular menu, is not always depicted. Use the following rule for such situations: upper value is adjusted by the left knob, lower value > right knob.

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



6.1.3.1 Menu “General Settings”

Setting	Description
Allow remote control	Selection NO means that the unit cannot be remotely controlled over either the digital or analog interfaces. If remote control is not allowed, the status will be shown as local in the status area on the main display. See also section 3.2.1 .
Analog interface range	Selects the voltage range for the analog set inputs, actual value outputs and reference voltage output. 0–5 V = corresponds to 0–100% set / actual values, reference voltage 5 V 0–10 V = corresponds to 0–100% set / actual values, reference voltage 10 V See also section 6.2.4 Remote control via the analog interface on page 63
Analog interface Rem-SB	Selects how the input pin Rem-SB of the analog interface shall be working regarding levels (see 6.2.4.4 Analog interface specification on page 65) and logic: Normal = Levels and function as described in the table in 6.2.4.4 Inverted = Levels and function will be inverted
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
Analog interface pin 6	Pin 6 of the analog interface (see section 6.2.4.4) is by default assigned to only signal the hardware alarms OT and PF. This parameter allows to also enable signaling only one of both (3 possible combinations): Alarm OT = Enable/disable signaling of alarm OT on pin 6 Alarm PF = Enable/disable signaling of alarm PF on pin 6
Analog interface pin 14	Pin 14 of the analog interface (see section 6.2.4.4) is by default assigned to only signal the hardware alarm OVP. This parameter allows to also enable signaling further hardware alarms (7 possible combinations): Alarm OVP = Enable/disable signaling of alarm OVP on pin 14 Alarm OCP = Enable/disable signaling of alarm OCP on pin 14 Alarm OPP = Enable/disable signaling of alarm OPP on pin 14
Analog interface pin 15	Pin 15 of the analog interface (see section 6.2.4.4) is by default assigned to only signal the regulation mode CV. This parameter allows to enable signaling a different status (2 options): Regulation mode = Enable/disable signaling of CV reg mode on pin 15 DC status = Enable/disable signaling of DC terminal status on pin 15
DC output after OT alarm	Determines how the DC power stages shall react after an overtemperature (OT) alarm has occurred and the power stages have cooled down again: OFF = DC power stage(s) will be off AUTO = The system will automatically restore the situation before the OT alarm, which usually means the DC power stage(s) to be on
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 unit. Restore = DC output condition will be restored to the condition prior to switch off.

Setting	Description
DC output after PF alarm	Determines how the DC output shall react after a power fail (PF) alarm has occurred: OFF = DC output will be switched off and remain until user action AUTO = DC output will switch on again after the PF alarm cause is gone and if it was switched on before the alarm occurred
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 can be adjusted additionally to the other set values. For details refer to 10.1. Master-Slave Parallel Operation
USB decimal point 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)
Log value with unit (V,A,W)	CSV files generated from USB logging by default add physical units to values. This can be deactivated by setting this option to No .
Calibrate device	Touch control Start starts a calibration routine (see 11.3. Calibration), but only if the system is in U/I or U/P mode.
Reset device to defaults	Touch control 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
Restart device	Will initiate a warm start of the system
Master-slave mode	Selecting MASTER or SLAVE enables the master-slave mode (MS) and sets the selected position for the unit in the MS system. Default setting: OFF . This applies to the digital MS bus, and the analog Share bus. For details see sections 10.1. Master-Slave Parallel Operation .
Repeat master init.	Touch control Initialize will repeat the initialization of the master-slave system in case the automatic enumeration of the slave units by the master is once unsuccessful so the system would have less total power than expected or has to be repeated manually in case the master unit couldn't detect a missing slave

6.1.3.2 Menu “User Events”

See [8.1.2 User defined events on page 73](#).

6.1.3.3 Menu “Profiles”

See [6.5 Loading and Saving a User Profile on page 70](#).

6.1.3.4 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.

6.1.3.5 Menu “About HW, SW”

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

6.1.3.6 Menu “Function Generator”

See 9 Function Generator on page 77.

6.1.3.7 Menu “Communication”

This sub menu offers settings for digital communication via the optional or built-in interface. The touch area for the installed interface module or the optional GPIB port opens one or more settings pages, depending on the interface in use. There is also an adjustable communication timeout. In the screen for “Com Protocols” you can enable both or disable one of the two supported communication protocols, ModBus and SCPI. This can help to avoid mixing both protocols, and to receive unreadable messages, for example when expecting a SCPI response, and getting a ModBus response instead.



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

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

IF	Level 1	Description
GPIB	Node Address	Adjustment of the GPIB node address (only with option -002 installed) in the range 1–30

IF	Level 1	Level 2	Level 3	Description
Ethernet / ModBus-TCP, 1 & 2 Port	IP Settings 1	DHCP		The IF allows a DHCP server to allocate an IP address, a subnet mask and a gateway. If no DHCP server is in the network then network parameters will be set as defined in item "Manual"
		Manual	IP address	This option is activated by default. An IP address can be manually allocated.
			Gateway	Here a gateway address can be allocated if required..
			Subnet mask	Here a subnet mask can be defined if the default subnet mask is not suitable.
		DNS address 1 DNS address 2		Here the addresses of the first and second Domain Name Servers (DNS) can be defined, if needed.
		Port		Range: 0–65535. Default ports: 5025 = Modbus RTU (all Ethernet interfaces) Reserved ports which must not be set with this parameter: 502 = Modbus TCP
	IP Settings 2-P1 IP Settings 2-P2	AUTO		Settings for the Ethernet port such as transmission speed are set automatically.
		Manual	Half duplex	Manual selection for transmission speed (10MBit/100MBit) and duplex mode (full/half). It's recommended to use the "AUTO" option and only revert to "Manual" if these parameters fail. Different Ethernet port settings for 2-port modules are possible, as these include an Ethernet switch
			Full duplex	
			10MBit	
			100MBit	
	Host name			Free choice of host name (default: Client)
	Domain name			Free choice of Domain (default: Workgroup)
	TCP Keep-Alive	Enable TCP keep-alive		

IF	Level 1	Description
Profinet/IO, 1 & 2 Port	Host name	Free choice of host name (default: Client)
	Domain name	Free choice of Domain (default: Workgroup)
	Function Tag	String input box for a user-definable text which describes the Profinet slave function tag. Max. length: 32 characters
	Location Tag	String input box for a user-definable text which describes the Profinet slave location tag. Max. length: 22 characters
	Station Name	String input box for a user-definable text which describes the Profinet station name. Max. length: 54 characters
	Description	String input box for a user-definable text which describes the Profibus slave. Max. length: 54 characters
	Installation Date	String input box for a user-definable text which describes the Profibus slave installation date tag. Max. length: 40 characters

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

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

Element	Description
Com Timeout	<p>Timeout USB/RS232 (in milliseconds) Default value: 5, Range: 5–65535 Defines the max. time between two subsequent bytes or blocks of a transferred message. For more information about the timeout refer to the external programming documentation <i>Programming Guide</i>.</p> <p>Timeout ETH (in seconds) Default value: 5, Range: 5–65535 If there was no communication between the controlling unit (PC, PLC etc.) and the system for the adjusted time, it will close the socket connection. This timeout will be ineffective as long as the option “TCP keep-alive” (see above, table for Ethernet module) is activated and “keep-alive” is working as expected within the network. Setting “0” deactivates the timeout permanently.</p>
Com Protocols	Enables or disables SCPI or ModBus communication protocols for the system. The change is immediately effective after submitting it with ENTER button. Only one of both can be disabled.
Logging	<p>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 the control method. For more refer to 6.1.10. Logging to USB flash drive.</p>

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

6.1.3.8 Menu “HMI Setup”

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

Element	Description
Language	Selection of the display language between German, English (default), Russian or Chinese
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 6.3 Control Panel Lock on page 69 .
Limits Lock	See 6.4 Limits Lock on page 69
Key Sound	Activates or deactivates sounds when touching a touch area in the display. It can usefully signal that the action has been accepted.
Alarm Sound	Activates or deactivates the additional audible signal of an alarm or user defined event which has been set to Action = ALARM . See also 8 Alarms and Monitoring on page 73 .

Element	Description
Status page	Enables/disables two display related options for the main screen with actual and set values: Show meter bar: in U/I/P mode, i.e. resistance mode not activated, a meter bar for 0-100% actual values of voltage, current and power is shown. See 6.1.8. The meter bars . Alternative status page: switches the main screen of the system with its actual and set values of voltage, current, power and - if activated - resistance to a simpler display with only voltage and current, plus status. See 6.1.7. Switching the main screen view . Default setting: both disabled

6.1.4 Adjustment limits (Limits)

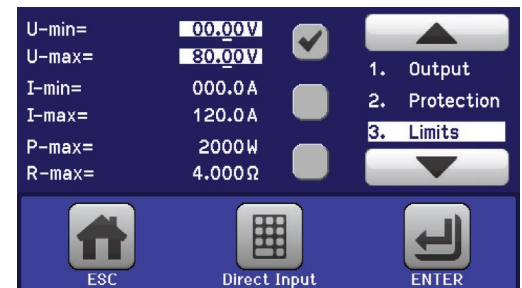


Adjustment limits are only effective on the related set values, no matter if using manual adjustment or remote control setting.

By default, all set values (U, I, P, R), and the corresponding adjustment limits, are adjustable from 0 to 102% of 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 **SETTINGS**.
2. Tap the up and down arrows to select **3. Limits**.
3. In each case, a pair of upper and lower limits for U/I or the upper limit for P/R are assigned to the rotary knobs and can be adjusted. Tap another checkbox ☐ to adjust another setting.
4. Tap Enter to accept the changes.



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 2000 W, it would require to first reduce the set value to 1000 W or less.

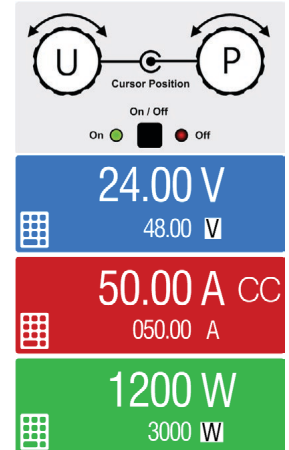
6.1.5 Changing the operating mode

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

► How to change the operating mode:

1. Unless the unit is in remote control or the panel is locked, the operating mode can be switched at any time. There are two options: either tap the depiction of the right-hand knob (see figure to the right) to change its assignment between I, P and R, which is displayed on the knob depiction, or
2. Tap on the colored areas with the set values, like shown in the figure to the right. The units next to the set values, when inverted, indicates the assignment of the knob. In the example in the figure it has U and P assigned, which means U/P mode.

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



In order to avoid constant changing of the assignments, it's possible, e.g. with selection U/I being active, to change the other value P by direct input. See section 6.1.6.

The actual operating mode, while the DC output is switched on, solely depends only on the set values. For more information see section 5.2. Regulation Modes.

6.1.6 Manual adjustment of set values

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

As a fourth value there is the internal resistance, for which the resistance mode (R mode) has to be activated in the MENU first. Refer to 6.1.3. Configuration via MENU and 5.2.4. Resistance regulation for details.

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



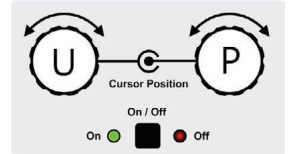
Entering a value changes it immediately, and no matter if the DC output is switched on or off.



When adjusting the set values, upper or lower limits may come into effect. See section 6.1.4. Adjustment limits (Limits). Once a limit is reached, the display will show a note like "Limit: U-max" etc. for 1.5 seconds next to the adjusted value.

► How to adjust values with the rotary knobs

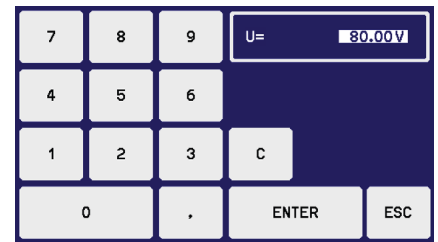
1. First, check whether the value to be changed is assigned to one of the rotary knobs. The main screen displays the assignment as depicted in the figure to the right.
2. If, as shown in the example, the assignment is voltage (U, left) and power (P, right), and it's required to set the power, then the assignments can be changed by tapping this touch area. A set of selection fields then appears.
3. After successful selection, the desired value can be set within the defined limits. Selecting a digit is done by pushing the rotary knob which shifts the cursor right to left (the target digit will be underlined).



120.00 A → 120.00 A → 120.00 A

► How to adjust values via direct input:

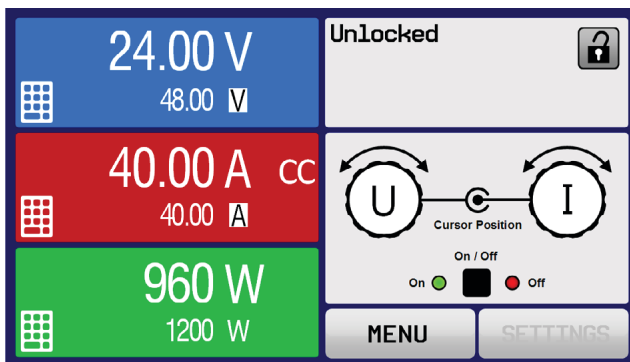
1. In the main screen, depending on the rotary knob assignment, values can be set for voltage (U), current (I), power (P) or resistance (R) via direct input by tapping on the set/actual value display areas, e.g in the uppermost area of voltage.
2. Enter the required value using the ten-key pad. The C button clears the input. Complete the entry by tapping the ENTER button.
3. The display will switch to the main page, and the set values take effect.



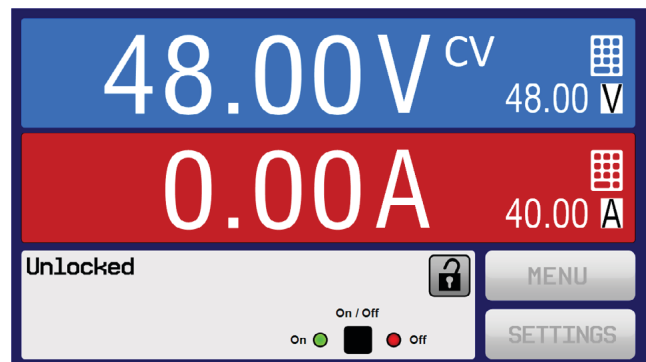
6.1.7 Switching the main screen view

The main screen, also called status page, with its set values, actual values, and system status can be switched from the standard view mode with three or four values to a simpler mode with only voltage and current displayed. The advantage of the alternative view mode is that actual values are displayed with much bigger characters, so they can be read from a greater distance. Refer to 6.1.3.8. Menu "HMI Setup" to see where to switch the view mode in the MENU.

Standard status page



Alternative status page



Limitations of the alternative status page:

- Set and actual values of power are not displayed, and the set value of power is only indirectly accessible.
- The set value of resistance is not displayed, and only indirectly accessible.
- No access to the settings overview (MENU) while the DC output is on.



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.

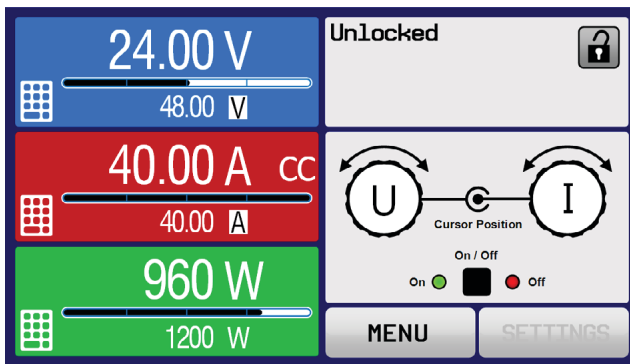
Rules for manual handling of the HMI in alternative status page mode:

- 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.

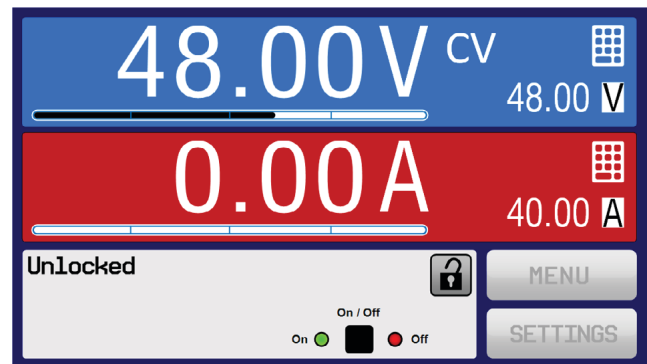
6.1.8 The meter bars

In addition to the values being displayed as numbers, a meter bar for U, I and P can be enabled in **MENU**. The meter bars remain hidden as long as resistance mode is activated. Refer to [6.1.3.8. Menu “HMI Setup”](#) to see where to enable the meter bars in **MENU**.

Standard status page with meter bar



Alternative status page with meter bar



6.1.9 Switching the DC output on or off

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



Switching the DC output on during manual operation or digital remote control can be disabled by pin REM-SB of the built-in analog interface. For more information refer to [6.1.3.1](#).

► How to manually switch the DC output on or off

1. As long as the control panel is not 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 is not restricted by an alarm or the system is locked in remote mode.

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

See section “6.2.4 Remote control via the analog interface on page 63.

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

1. See the external documentation *Programming Guide* if you are using custom software, or refer to the external documentation from LabView VIs or other software provided by the manufacturer.

6.1.10 Logging to USB flash drive

System data can be recorded to USB flash drive any time. For specifications of the USB flash drive and the generated log files refer to section 3.4. **USB Port, Front Side**.

The logging stores files of CSV format on the drive. 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 **MENU**.

6.1.10.1 Logging configuration 1



After USB logging has been enabled, and the parameters **Logging interval** and **Start/Stop** have been set, logging can be started anytime from within **MENU** or after leaving it, depending on the selected start/stop mode. See section 6.1.3.7.

6.1.10.2 Logging configuration 2

There are additional settings for the CSV file itself as generated by the USB logging features. You can switch the column separator format between **Default** (for the German/European standard semicolon), **US** (for the American standard comma). Another option is to deactivate the physical unit information that is added by default to every value in the log file. Deactivating this option simplifies the CSV file processing in MS Excel. Also see section 6.1.3.1.

6.1.10.3 Handling (start/stop)

With setting **Start/stop** with **DC output ON/OFF**, logging will start each time the DC output of the unit 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**, logging is started and stopped only in the logging configuration page in **MENU**.

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

6.1.10.4 Log file format

The log is a CSV text file. Formatting uses European or American details governed by the settings **USB logging with units (V,A,W)** and **USB decimal point format** in the General Settings of **MENU**.

- Column 1: **U set**, voltage decimal with optional trailing "V"
- Column 2: **U actual**, voltage decimal with optional trailing "V"
- Column 3: **I set**, current decimal with optional trailing "A"
- Column 4: **I actual**, current decimal with optional trailing "A"
- Column 5: **P set**, power integer with optional trailing "W"
- Column 6: **P actual**, power integer with optional trailing "W"
- Column 7: **R set**, resistance decimal
- Column 8: **R actual**, resistance decimal
- Column 9: **R mode**, ON or OFF
- Column 10: **Output/Input**, ON or OFF
- Column 11: **Device mode**, CV, CC, CP, CR
- Column 12: **Error**, hardware error codes
- Column 13: **Time**, elapsed time since logging start



- **R set** and **R actual** are recorded only if **UIR mode** is active (refer to section 6.1.5).
- Every log start creates a new log file with a counter in the file name, starting generally with 1, but minding existing files.

6.1.10.5 Special notes and limitations

- Max. log file size (due to FAT32 formatting): 4 GB.
- Max. number of log files in folder HMI_FILES: 1024.
- With setting **Start/stop with DC output ON/OFF**, the logging will also stop on alarms or events with action Alarm since they switch off the DC output.
- With setting **Manual start/stop** the system 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.

6.2 Remote Control

6.2.1 General

Remote control is possible via the built-in analog or USB port, or via one of the optional interface modules (only with -001 models) or via the GPIB port (only for -002 models). It is important to understand that only the analog, or one digital interface can be in control at any one time. This means that if, for example, an attempt were to be made to switch to remote control via the digital interface while analog remote control is active (Pin Remote = LOW), the system 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 on both interfaces.

6.2.2 Control locations

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

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

Remote control may be allowed or prevented using the setting **Allow remote control** (see [6.1.3.1. Menu “General Settings”](#)). When prevented, the status **Local** will be displayed top right. Activating the lock can be useful if the system is remotely controlled by software or some electronic device, but it's required to make adjustments at the unit or deal with an emergency, which would not be possible remotely.

Activating condition **Local** causes the following:

- If **Remote** control via the digital interface is active, then it's immediately terminated. In order to continue remote control once **Local** is no longer active, it has to be reactivated at the PC.
- If **Remote** control via the analog interface is active, 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.

6.2.3 Remote control via a digital interface

6.2.3.1 Selecting an interface

In addition to the built-in USB port, the 310 Series -001 models support the optionally available Anybus interface modules listed in [3.6 Anybus Module Slot on page 21](#).

310 Series with the GPIB option installed (-002) include a pre-installed GPIB port next to the default USB port.

6.2.3.2 General

With the 310 Series -001 models, one of the plug-in and retrofittable modules listed in [3.6. Anybus Module Slot](#) can be installed. It can take over remote control of the system instead of using the built-in USB port on the back, or analog interface. For installation see section [4.9. AnyBus Module Installation](#).

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

6.2.3.3 Programming

Programming details for the interfaces, the communication protocols etc. are to be found in the documentation *Programming Guide* which is available as a download from our website.

6.2.4 Remote control via the analog interface

6.2.4.1 General

The built-in, galvanically isolated, 15-pin analog interface on the rear panel of the unit offers the following possibilities:

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

Setting the set values of voltage, current, and power via the analog interface must always be done concurrently. This means that, for example, the voltage can't be given via the analog interface, and current and power set by the rotary knobs, or vice versa. The internal resistance* set value can additionally be adjusted.

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

The analog interface can be operated in the common voltage ranges 0–5 V or 0–10 V, both representing 0–100% of the nominal value. The selection of the voltage range can be done in the system setup. See section [6.1.3. Configuration via MENU](#) for details. The reference voltage sent out from pin 3 (VREF) will be adapted accordingly:

0-5 V: Reference voltage = 5 V, 0–5 V set value signal for VSEL, CSEL and PSEL correspond to 0–100% nominal value or $R_{Min} - R_{Max}$ with RSEL, 0–100% actual values correspond to 0–5 V at the actual value outputs CMON and VMON.

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

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

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



After powering the unit and during the start phase, the analog interface indicates undefined statuses on the output pins such as ERROR or OVP. Those must be ignored until the unit is ready to operate.

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



The analog interface is galvanically isolated from the DC output. Therefore do not connect any ground of the analog interface to the DC- or DC+ output, if not absolutely necessary.

6.2.4.2 Resolution and sample rate

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 26,214. Due to tolerances, the truly achievable resolution may be slightly lower.

There is a maximum sample rate of 500 Hz. This means the system can provide analog set values and states on digital pins 500 times per second.

6.2.4.3 Acknowledging hardware alarms

In case of a hardware alarm occurring during remote control via analog interface, the DC terminal will be switched off the same way as in manual control. The system would indicate an alarm (see 8.4) in the front display and, if activated, audibly, and also signal most of them on the analog interface. Which alarms actually are signaled can be set up in the configuration menu (see 6.2.4.4).

Some hardware alarms (OVP, OCP and OPP) have to be acknowledged. Also see 8.4. **Alarm Acknowledgement.** Acknowledgment is done with pin REM-SB switching the DC terminal off and on again, means a HIGH-LOW-HIGH edge (min. 50ms for LOW), when using the default level setting for this pin.

6.2.4.4 Analog interface specification

Pin	Name	Type ^[1]	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% ^[4] Accuracy 0–10 V range: < 0.2% ^[4] 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	Ground for all digital signals		For control and status signals.
5	REMOTE	DI	Switching internal / remote control	Remote = LOW, $U_{Low} < 1$ V Internal = HIGH, $U_{High} > 4$ V Internal = Open	Voltage range = 0–30 V $I_{Max} = -1$ mA at 5 V U_{Low} to HIGH typ. = 3 V Rec'd sender: Open collector against DGND
6	ALARMS 1	DO	Overheating or power fail alarm	Alarm = HIGH, $U_{High} > 4$ V No alarm = LOW, $U_{Low} < 1$ V	Quasi open collector with pull-up against V_{cc} ^[2] 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% ^[5] Accuracy 0–10 V range: < 0.2% ^[5] 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% von P_{Nom}	
9	VMON	AO	Actual voltage	0–10 V or 0–5 V correspond to 0–100% von U_{Nom}	Accuracy 0–5 V range: < 0.4% ^[5] Accuracy 0–10 V range: < 0.2% ^[5] 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% von I_{Nom}	
11	AGND	POT	Ground for all analog signals		For -SEL, -MON, VREF Signals
12	R-ACTIVE	DI	R mode on / off	On = LOW, $U_{Low} < 1$ V Off = HIGH, $U_{High} > 4$ V Off = Open	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 ^[4])	Off = LOW, $U_{Low} < 1$ V On = HIGH, $U_{High} > 4$ V On = Open	Voltage range = 0–30 V $I_{Max} = +1$ mA at 5 V Rec'd sender: Open collector against DGND
14	ALARMS 2	DO	Overvoltage alarm Overcurrent alarm Overpower alarm	Alarm = HIGH, $U_{High} > 4$ V No alarm = LOW, $U_{Low} < 1$ V	Quasi open collector with pull-up against V_{cc} ^[2] With 5 V on the pin max. flow +1 mA $I_{Max} = -10$ mA at $U_{CE} = 0.3$ V, $U_{Max} = 30$ V Short-circuit-proof against DGND
15	STATUS ³	DO	Constant voltage regulation active DC terminal	CV = LOW, $U_{Low} < 1$ V CC/CP/CR = HIGH, $U_{High} > 4$ V On = LOW, $U_{Low} < 1$ V Off = HIGH, $U_{High} > 4$ V	

[1] AI = Analog Input, AO = Analog Output, DI = Digital Input, DO = Digital Output, POT = Potential

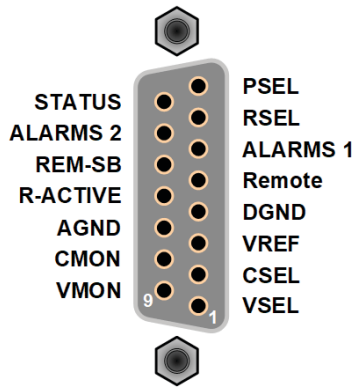
[2] Internal V_{cc} approx. 10 V

[3] Only one of both signals possible, see configuration settings.

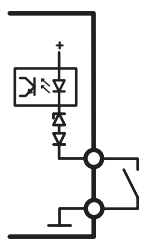
[4] Only during remote control

[5] The error of a set value input adds to the general error of the related value on the DC output of the unit

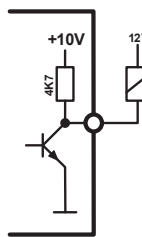
6.2.4.5 Overview of the connector



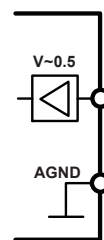
6.2.4.6 Simplified diagram of the pins



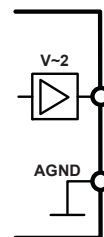
Digital Input (DI)
It requires to use a switch with low resistance (relay, switch, circuit breaker etc.) in order to send a clean signal to the DGND.



Digital Output (DO)
A quasi open collector, realized as high resistance pull-up against the internal supply. In condition LOW it can carry no load, merely switch, as shown in the diagram with a relay as example.



Analog Input (AI)
High resistance input (impedance $>40\text{ k}\Omega$ – $.100\text{ k}\Omega$) for an OA circuit.



Analog Output (AO)
Output from an OA circuit, with low impedance. See specifications table above.

6.2.4.7 Analog interface examples

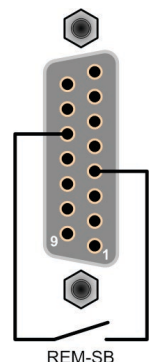
Switching the DC output with pin REM-SB



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.

The analog bus pin REM-SB is used to switch the DC terminals of the unit on and off. This functionality is possible even without remote control mode being active. It can be used to block the DC terminal from being switched on by manual or digital interface controls. It can also be used to switch the DC 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).



The following scenarios illustrate REM-SB pin uses:

A. Remote control has been activated

During remote control via analog interface, only pin REM-SB determines the state of the DC output, according to the levels definitions in 6.2.4.4. (Note that the logical function and the default levels can be inverted by a parameter in the setup menu. See the setting Analog interface Rem-SB in 6.1.3.1.)



If the pin is unconnected, or a connected contact is open, the pin will be HIGH. With parameter Analog interface REM-SB being set to normal, this triggers DC output on. So, when activating remote control, the DC output will instantly switch on.

B. Remote control has not been activated

In this mode of operation pin “REM-SB” can serve as a 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”	→	Behavior
is off	+	HIGH	+	Normal	→	The DC output isn’t locked. It can be switched on by pushbutton “On/Off” (front panel), or via digital interface command.
		LOW	+	Inverted		
	+	HIGH	+	Inverted	→	The DC output is locked. It cannot be switched on by pushbutton “On/Off” (front panel), or via digital interface command. When trying to switch DC output on, an error message will be generated.
		LOW	+	Normal		

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

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

Remote control of current and power

Requires remote control to be activated (pin REMOTE = LOW).

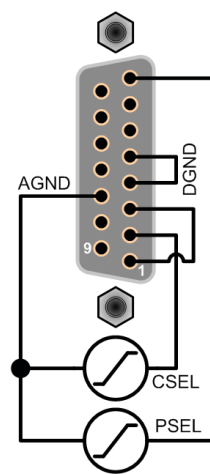
The set values PSEL and CSEL are generated from, for example, the reference voltage VREF, using potentiometers for each. Hence the power supply can selectively work in current limiting or power limiting mode. According to the specification of max. 5 mA for the VREF output, potentiometers of at least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

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

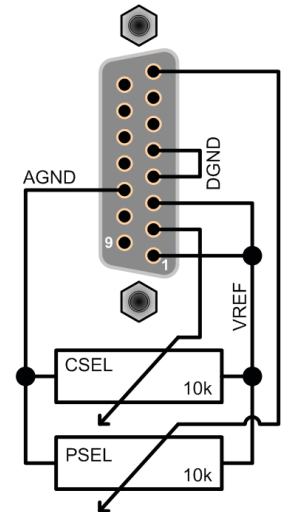
If the control voltage is supplied by an external source, it's necessary to consider the input voltage ranges for set values (0–5 V or 0–10 V).



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



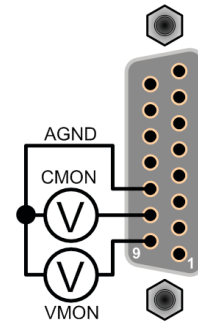
Example with external voltage source



Example with potentiometers

Reading actual values


The analog interface provides the DC output values as current and voltage. These can be read using a standard multimeter or digital meter.



6.3 Control Panel 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. These controls are collectively also known as the human-machine interface, or HMI. You can choose between a simple lock and a PIN lock, which requires to enter the correct PIN every time someone wants to unlock the HMI.

► How to lock the HMI

1. In the main page, tap the lock symbol  (upper right corner).
2. In the settings page HMI Lock, choose between **Lock all** (a complete HMI lock), or **ON/OFF possible** (where the On/Off button is still usable).
3. Choose whether to activate the additional PIN with **Enable PIN**. When enabled, the system will request this PIN every time you want to unlock the HMI, until the PIN is deactivated.
4. Confirm the settings by pressing the **YES** button.

If an attempt is made to alter something while the HMI is locked, a prompt 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 (if **Lock all** was enabled) press the button “On/Off”.
2. This pop-up dialog 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, another dialog will prompt for the PIN before it finally unlocks the HMI.

6.4 Limits Lock

In order to avoid the alteration of the adjustment limits (also see [6.1.4. Adjustment limits \(Limits\)](#)) by an unprivileged user, the screen with the adjustment limit settings (“Limits”) can be locked by a PIN code. The menu pages “3.Limits” in **SETTINGS** and “Profiles” in **MENU** will then become inaccessible until the lock is removed by entering the correct PIN or in case it has been forgotten, by resetting the system as last resort. The same PIN as with the HMI lock is used here.

► How to lock the “Limits”

1. While the DC output is switched off, tap **MENU** on the main screen.
2. In the menu tap **HMI Setup**, then **Limits Lock**.
3. In the next page, set the check mark for **Lock**.
4. Tap **ENTER** to activate the lock.



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

► How to unlock the limits settings

1. While the DC output is switched off, tap **MENU** on the main screen.
2. In the menu, tap **HMI Setup**, then **Limits Lock**.
3. In the next page, tap **Unlock**, then you will be asked to enter the PIN.
4. Deactivate the lock by entering the correct PIN, and submitting with **ENTER**.

6.5 Loading and Saving a User Profile

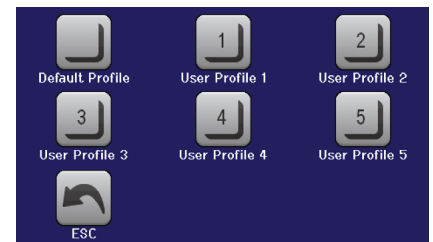
The menu **Profiles** serves to select between a default profile and up to five user profiles. A profile is a collection of all settings and set values. Upon delivery, or after a reset, all six profiles have the same settings and all set values are 0. If the user changes settings or sets target values then these create a working profile which can be saved to one of the five 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 collection of set values, settings limits, and monitoring thresholds quickly without having to readjust these. As all HMI settings are saved in the profile, including language, a profile change can also be accompanied by a change in HMI language.

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

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

1. Tap **MENU** on the main screen
2. In the menu page, tap **Profiles**.
3. In the selection screen (shown to the right), choose between User Profile 1 through 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. Press **Save** to record the profile.



7 320 Series Operation

320 Series slave units are intended to run under constant remote control by a master unit. Therefore, there is limited functionality relative to the 310 Series standard units as the slave units are intended to be a cost-effective alternative to using multiple standard units in parallel operation.

When shipped, a slave unit is configured by default for remote slave operation. It does not need configured to be connected as a slave to a master-slave setup.

Though not really the purpose of the slave units, it is possible to configure a slave unit as a stand-alone system. It can be operated remotely using the **EA Power Control** software, or through custom scripting of one of the the USB ports. The unit can then also be reset to be a slave (factory defaults) using the same software.

Important here is that only one of the digital interfaces or a master unit can be in control. If an attempt were to be made to switch to remote control via the digital interface while master-slave mode is running, the system would report an error via the digital interface. Similarly, the master unit cannot initialize a slave unit which is in USB remote control. In both cases, however, status monitoring and reading of values via any of the USB ports is always possible.

7.1 Manual Control

Manual operation is possible, though not a primary function, for the slave systems. Slave units are shipped configured to operate as a slave by default. They can be configured to run stand-alone, or even operate as a master unit. However, configuration details will have to be managed by the **EA Power Control** software, or through custom scripting of the USB interface. The unit can then also be reset to be a slave (factory defaults) using the same software.

7.1.1 Powering the system on

In manual operation, the system would normally be switched on/off using the rotary switch on the front of the unit. Alternatively, an external switching system (contactor, circuit breaker) of suitable current capacity can be used where there's an advantage in creating a remotely located control panel.

In a master-slave system it is normal that not all units are powered at the same time, or some units not at all. In order for the master to initialize all slaves correctly it will wait some time after starting up. In case not all slaves are initialized, the procedure to find and enumerate the slaves can be repeated, either directly on the screen of the master (in MENU). Alternatively, this can also be done via remote control.

After switching on, the system indicates the startup phase with LED "Power" on the front being orange. Once it has finished starting, and is ready for operation, LED "Power" changes to green.

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

In master-slave operation when the system is being run as a slave, all values and conditions are stored and restored by the master, overwriting the slave's settings.

7.1.2 Powering the system off

At power off, the last output condition, and the most recent set values are saved. The DC output is immediately switched off, and after a short while, the fans will shut down. After another few seconds the unit will be completely powered off.

During the shutdown, a power failure alarm will be signaled and the Error indicator illuminated, but can be ignored (a purposeful shutdown is not distinguished from an unscheduled loss of input power).

7.1.3 Switching the DC output on/off

Normally, the DC on/off control would be done remotely by the master. However, if the slave unit is not in remote control by a master unit, or by software via USB interface, the DC output can be manually switched on or off with the On / Off pushbutton. This is for situations where the slave unit needs to be operated stand-alone. The button can also be used to acknowledge hardware alarms signaled by the Error indicator.

7.2 Remote Control

Slave units are intended to run under constant remote control by a master unit. When shipped, a slave unit is configured by default for remote slave operation. It does not need configured to be connected as a slave to a master-slave setup.

If a unit had been previously configured to run as a stand-alone system (perhaps by automated script, or with the **EA Power Control** software), it can be reset to be a slave (factory defaults) using the same software.

7.2.1 Remote control via the rear USB

The rear USB port offers the same set of commands as with a standard system, but only while the slave system is not in control by a master unit, and not in Slave status. The **EA Power Control** software can be used to easily change the configuration of the system.

For automated script control, the programming documentation *Programming Guide* is applicable, as well as the ModBus register list. Both are available on the web site.

7.2.2 Remote control via the front USB

The main purpose of the front USB port is convenient access to the most important DC output related parameters, such as set values and protections. Reading values and status is always possible, even while the system is being operated as a slave. Making changes to settings is possible only while the slave system is not in control by a master unit.

The front and rear USB ports, are not the same. There is a limited set of commands on the front USB port, but it supports both SCPI and ModBus RTU communication protocols. As part of the programming documentation, there is an extra ModBus register list for the commands which are specific to the front USB port.

7.2.3 Programming

Programming details about the communication protocols are to be found in the documentation *Programming Guide* available from our web site.

8 Alarms and Monitoring

8.1 Available Alarms

There is a distinction between hardware alarms and user defined events. Hardware alarms always involve switching off the DC output to protect the unit and the connected load. User defined events can switch off the DC output, but can also simply give an audible signal to make the user aware.

8.1.1 Hardware alarms

The system includes several hardware alarms. All alarms will cause the system to switch off the DC output to protect the unit and load. The hardware alarms include:

Signal OT (OverTemperature)	Overheating of the unit. DC output will be switched off. Non-critical
Signal OVP (OverVoltage)	Overvoltage shutdown of the DC output due to high voltage entering the unit or generated by the unit itself due to a defect. Critical. The unit 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 loss or under/overvoltage. Critical on overvoltage. AC input circuit could be damaged.

8.1.2 User defined events

By default, user defined events are deactivated. While hardware alarms are monitored whenever the unit is on, user events are monitored only while the DC output is switched on. This means, for instance, that the system does not detect ac undervoltage (UVD) while the DC output is off. The following events can be configured independently and can, in each case, trigger the actions NONE, SIGNAL, WARNING or ALARM as described later on.

Event	Meaning	Description	Range
UVD	UnderVoltage Detection	Triggers an event if the output voltage falls below the defined threshold.	$0\text{ V}-U_{\text{Nom}}$
OVD	OverVoltage Detection	Triggers an event if the output voltage exceeds the defined threshold.	$0\text{ V}-U_{\text{Nom}}$
UCD	UnderCurrent Detection	Triggers an event if the output current falls below the defined threshold.	$0\text{ A}-I_{\text{Nom}}$
OCD	OverCurrent Detection	Triggers an event if the output current exceeds the defined threshold.	$0\text{ A}-I_{\text{Nom}}$
OPD	OverPower Detection	Triggers an event if the output power exceeds the defined threshold.	$0\text{ W}-P_{\text{Nom}}$

8.2 Alarm Indication

8.2.1 310 Series units



On 310 Series units, alarms are indicated visually as text on the display, audibly on a built-in buzzer, and electronically as a status output on the analog interface, and as a status state on the USB port.

8.2.2 320 Series units

Hardware alarms are indicated on 320 Series units using the shared Error LED, and as readable status states on the USB interface. When running the system in Slave mode as part of a master-slave system, the alarm is also reported to the master. If the master is a 310 Series unit, the alarm is indicated in text on the display as well.

8.3 Alarm Configuration

The response action generated by user defined events can be configured as outlined in the table below.

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

Some hardware alarms are configurable:

Alarm	Meaning	Description	Range	Indication
OVP	OverVoltage Protection	Triggers an alarm if the DC output voltage reaches the defined threshold. The DC output will be switched off.	$0\text{ V} - 1.1 * U_{\text{Nom}}$	Display, analog IF, digital IF
OCP	OverCurrent Protection	Triggers an alarm if the DC output current reaches the defined threshold. The DC output will be switched off.	$0\text{ A} - 1.1 * I_{\text{Nom}}$	Display, analog IF, digital IF
OPP	OverPower Protection	Triggers an alarm if the DC output power reaches the defined threshold. The DC output will be switched off.	$0\text{ W} - 1.1 * P_{\text{Nom}}$	Display, analog IF, digital IF

These hardware alarms can't be configured:

Alarm	Meaning	Description	Indication
PF	Power Fail	AC supply over or under voltage. Triggers an alarm if the AC supply is out of specification, AC power is lost, or when the unit is powered off by the main On/Off switch. The DC output will be switched off.	Display, analog IF, digital IF
OT	OverTemperature	Triggers an alarm if the internal temperature reaches a certain limit. The DC output will be switched off.	Display, analog IF, digital IF
MSP	Master-Slave Protection	Triggers an alarm if the master of an initialized master-slave system loses contact to any slave unit, or if a connected slave has not been initialized by the master. The DC output will be switched off. The alarm can be cleared by either deactivating master-slave mode or reinitializing the MS system.	Display, digital interface

8.3.1 Configuration of standard units

► How to configure the hardware alarms

1. While the DC output is switched off, tap **SETTINGS** on the main screen.
2. On the right side, tap the down arrow to select **2. Protect**.
3. If the default value of 110% is unsuitable, set the limits for the equipment alarm relevant to your application.



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

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

► How to configure the alarm sound

1. While the DC output is switched off, tap **MENU** on the main screen.
2. In the menu page, tap **HMI Settings**.
3. In the following menu page, tap **Alarm Sound**.
4. In the settings page, tap the button to select between alarm sound on or off, and confirm by tapping **Enter**.

► How to configure user defined events

1. Tap **SETTINGS** on the main screen.
2. On the right side, use the arrows to select **4.1 Event U** or **4.2 Event I** or **4.3 Event P** (voltage, current, power).
3. Set the monitoring limits with the left rotary knob, and the triggered action with the right knob relevant to the application.
4. Tap **Enter** to accept the settings.



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

8.3.2 Configuration of slave units

Normally, when operating as a slave, the master's settings become shared with the slaves. To configure settings of a slave unit operated in stand-alone mode, use the **EA Power Control** software.

8.4 Alarm Acknowledgement

8.4.1 Standard units

A hardware alarm incident will usually lead to DC output being switched off, the appearance of a pop-up in the middle of the display, and, if activated, an audible signal. A hardware alarm must always be acknowledged.

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

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



► How to acknowledge an alarm using remote control

In order to acknowledge an alarm using analog remote control, see [6.2.4.5. Overview of the connector](#). To acknowledge in digital remote (USB or Anybus), refer to the documentation *Programming Guide*.

8.4.2 Slave units

While the slave unit is being controlled by a master unit, all alarms are acknowledged on the master unit as described above. After acknowledging the alarm on the master, the LED “Error” on the alarmed slave unit should be off.

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

► How to acknowledge an alarm (during manual control)

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

9 Function Generator

9.1 Introduction

The built-in function generator of the Standard units (with displays) is able to create various signal forms and apply these to the set value of voltage or current. The function generator is not built into the slave series units.

The standard functions are based on an arbitrary generator and directly accessible and configurable using manual control. For remote control, the fully customizable arbitrary generator replicates the functions with sequences containing eight 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
DIN 40839	Simulated automobile engine start curve according to DIN 40839 / EN ISO 7637, split into 5 curve sequences, each with a start voltage, final voltage and time
Arbitrary	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 total duration
Ramp	Generation of a linear rise or fall ramp with start and end values and time before and after the ramp
UI, IU	XY generator, USB flash drive loadable current or voltage curves (table, CSV)
PV, FC	Functions to simulate a solar panel (PV function) or fuel cells (FC function), both with table calculation based upon adjustable parameters, plus opportunity to store on USB flash drive

9.2 General

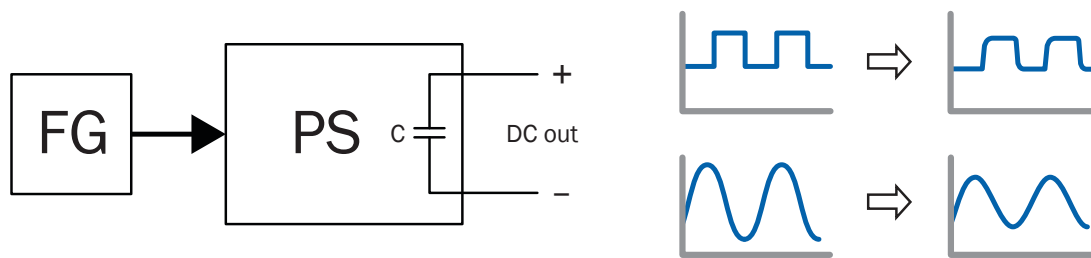
9.2.1 Limitations

The function generator is not accessible, neither for manual access nor for remote control, if resistance mode (U/R adjustment, also called UIR operation) is active.

9.2.2 Principle

The power supply unit cannot be considered a high power function generator, because it's only post-connected to the function generator. 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 function generator 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.

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 power supply model. The effects of the power supply on the wave can only be partially compensated. A high-speed modification can help to decrease rise and fall times. This has a positive impact on periodic functions like rectangle or sine wave. Alternatively, the resulting wave form on the DC output can also be improved by attaching additional load (fixed & ohmic or variable & electronic).

9.2.3 Resolution

Amplitudes generated by the arbitrary generator have an effective resolution of approx. 52,428 steps. If the amplitude is very low and the time long, the system would generate fewer 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). The XY generator, which works in table mode, has an effective resolution of 3,276 steps for the set value range of 0-100% rated value.

9.2.4 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.

9.2.5 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 ignored by the system. Calculating the minimum slope can help to determine if a certain ramp over time can be achieved by the system or not. Example: model 310-12-0080-120 is going to be used, with 80 V and 120 A rating. Formula: minimum slope = $0.000725 \cdot \text{rated value} / \text{s}$. For the example model, it results in $\Delta U / \Delta t$ of 58 mV/s and $\Delta I / \Delta t$ of 87 mA/s. The maximum time which can be achieved with the minimum slope then calculates as approximately 1,379 seconds according to formula $t_{\text{Max}} = \text{rated value} / \text{min. slope}$.

9.3 Method of Operation

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

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

Master-slave systems have further characteristics which have to be considered.



At the end of the configuration of every standard function, you are prompted to set up global set values, the U/I/P limits. These limits are transferred to all slave units of master-slave systems. It's recommended to carefully configure them so the MS system can work as expected, so the slaves won't impact the function operation in a negative way.

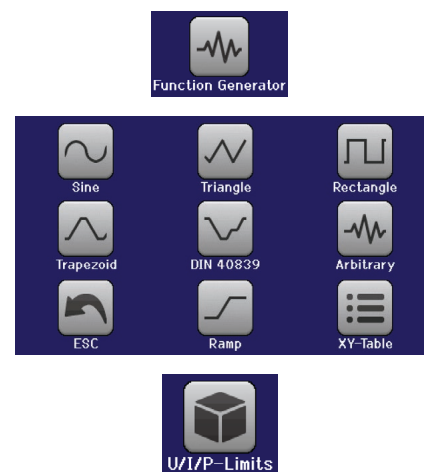
9.4 Manual Operation

9.4.1 Function selection and control

Via the touchscreen one of the functions described in 9.11 can be selected, configured and controlled. This is only permissible while the DC terminal is switched off.

► How to select a function and adjust parameters

1. While the DC output is switched off, tap **MENU** on the main screen.
2. In the menu overview, tap **Function Generator**, then on the desired function. Note: this touch area is locked in R mode (adjustable resistance).
3. Depending on the choice of function there follows a request to which value the function generator is going to be applied: **U** or **I**.
4. Adjust the parameters as you desire, such as offset, amplitude and frequency for a sine wave, for example.
5. Do not forget to adjust the overall limits of voltage, current and power, which you can access with the **U/I/P Limits** button.



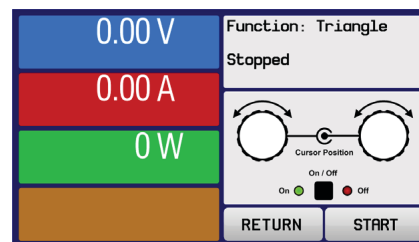
When entering function generator mode, those limits are reset to safe values, which can prevent the function from working at all. For example, if you apply the selected function to the output current, then the overall current limit should not interfere and should at least be as high as offset + amplitude.

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

► How to load a function

1. After setting the values for the required signal generation, tap the **Load** button.

The system will then load the data into the internal controller, and update the display. Shortly afterwards, the static values are set (power and voltage or current), the DC output is switched on, and the **START** button enabled. At this point, the function can 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 condition. These static values represent start and end values for the progress of the function, so that the function does not need to start from 0. An 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 stopped 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 remains ON with the static values.
 - b) The On/Off button stops the function, and switches off the DC output.



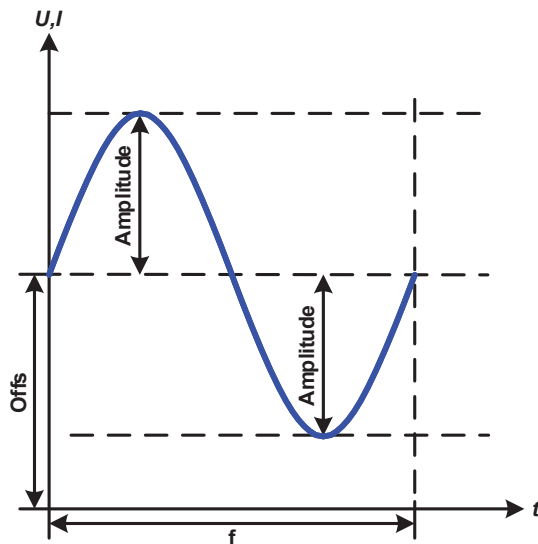
Hardware alarms such as overvoltage, overheating or power fail stops the function progress automatically, and the DC output is switched off.

9.5 Sine Wave Function

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

Value	Range	Description
I(A), U(A)	0–(Nominal value - (Offs)) of U, I	A = Amplitude of the signal to be generated
I(Offs), U(Offs)	(A)–(Nominal value - (A)) of U, I	Off = Offset, based on the zero point of the mathematical sine curve, may not be smaller than the amplitude.
f (1/t)	1–10000 Hz	Static frequency of the signal to be generated

Schematic diagram:



Application and result:

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

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

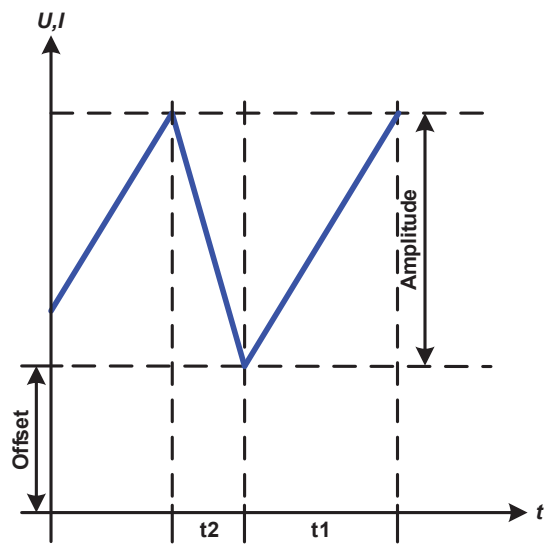
Example: an output voltage of 60 V is set together with sin(I) with an amplitude of 12 A and an offset of 15 A. The resulting maximum power output is then achieved at the highest point of the sine wave and is $(12 \text{ A} + 15 \text{ A}) * 60 \text{ V} = 1620 \text{ W}$.

9.6 Triangular Function

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

Value	Range	Description
I(A), U(A)	0–(Nominal value - (Offs)) of U, I	A = Amplitude of the signal to be generated
I(Offs), U(Offs)	0–(Nominal value - (A)) of U, I	Offs = 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.

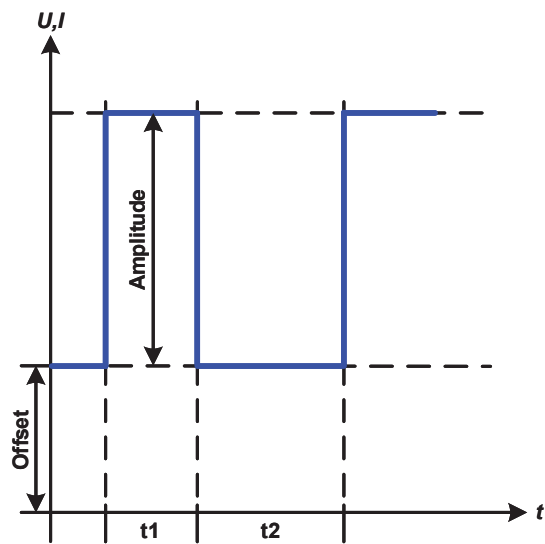
Example: a frequency of 10 Hz is required and would lead to periodic duration of 100 ms. This 100 ms can be freely allocated to t1 and t2, e.g. 50 ms:50 ms (isosceles triangle) or 99.9 ms:0.1 ms (right-angled triangle or sawtooth).

9.7 Rectangular Function

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

Value	Range	Description
I(A), U(A)	0–(Nominal value - (Offs)) von U, I	A = Amplitude of the signal to be generated
I(Offs), U(Offs)	0–(Nominal value - (A)) von U, I	Offs = 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.

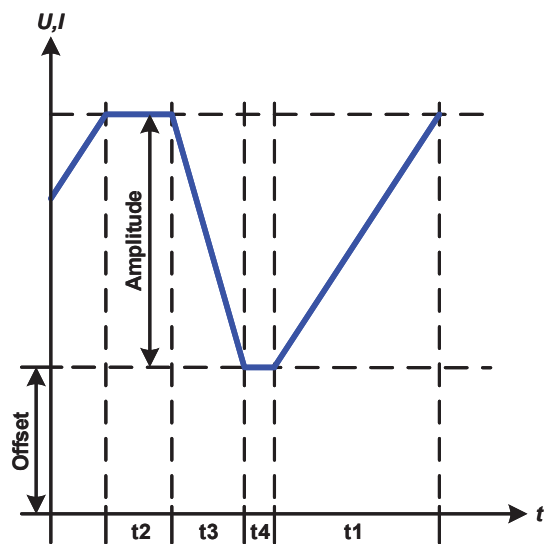
Example: a rectangular wave signal of 25 Hz and a duty cycle of 80% are required. The sum of t1 and t2, the period, is $1/25 \text{ Hz} = 40 \text{ ms}$. For a duty cycle of 80% the pulse time (t1) is $40 \text{ ms} \cdot 0.8 = 32 \text{ ms}$ and the pause time (t2) is 8 ms.

9.8 Trapezoidal Function

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

Value	Range	Description
I(A), U(A)	0–(Nominal value - (Offs)) of U, I	A = Amplitude of the signal to be generated
I(Offs), U(Offs)	0–(Nominal value - (A)) of U, I	Offs = 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.

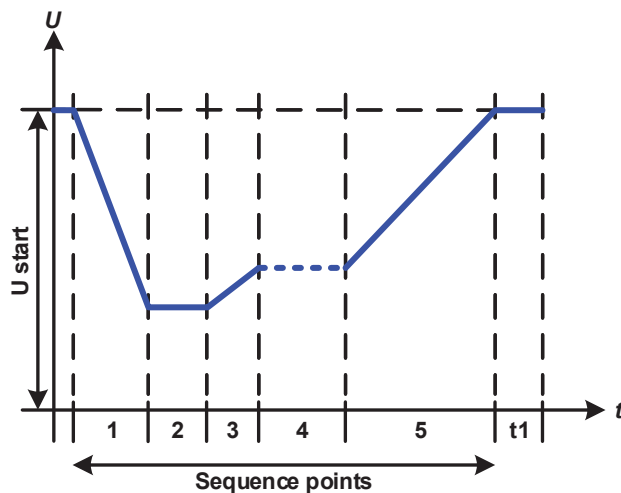
9.9 DIN 40839 Function

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

The following parameters can be configured for the DIN40839 function:

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

Schematic diagram:



Application and result:

The function is not suitable for standalone operation of a power supply, but optimal for power supply in conjunction with an electronic load, for example one from ELR 9000 series. The load acts as a sink for the rapid fall of the output voltage of the power supply enabling the output voltage progress to follow the DIN curve.

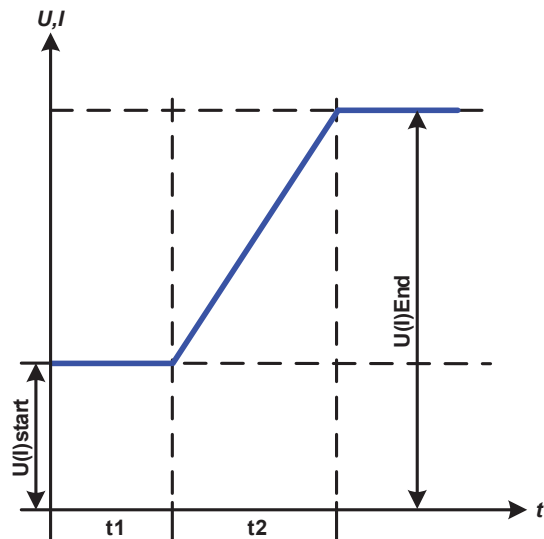
The curve conforms to test impulse 4 of the DIN. With suitable settings, other test impulses can be simulated. If the curve in sequence point 4 should be a sine wave, then these 5 sequence points have to be transferred to the arbitrary generator.

9.10 Ramp Function

The following parameters can be configured for a ramp function.

Value	Range	Description
Ustart / Istart	0–Nominal value of U, I	Start value (U,I)
Uend / Iend	0–Nominal value of U, I	End value (U, I)
t1	0,1 ms–36000 s	Time before ramp-up or ramp-down of the signal
t2	0.1 ms–36000 s	Ramp-up or ramp-down time

Schematic diagram:



Application and result:

This function generates a rising or falling ramp between start and end values over the time t_2 . Time t_1 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 those in Ustart/Istart, unless the load at the DC output should not be provided with voltage before the start of the ramp. In that case the static values should be set to zero.



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

9.11 Arbitrary Function

The arbitrary (freely definable) function offers the user further capabilities. There are 99 sequence points available to use for current I or voltage U, all of which have the same parameters, but which can be differently configured so that a complex function process can be built up. The 99 sequence points, or a portion of them, can run one after another in a sequence block, and this block can then be repeated many times or endlessly. A sequence point or sequence block acts only on current or voltage, thus a mix of assignment to current I or voltage U 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:

Value	Range	Description
Is(AC) / Ie(AC)	0–50% of I_{Nom}	Start/end amplitude of the sine wave part (I mode)
Us(AC) / Ue(AC)	0–50% of U_{Nom}	Start/end amplitude of the sine wave part (U mode)
fs(1/T) / fe(1/T)	0 Hz–10000 Hz	Start/end frequency of the sine wave part (AC)
Angle	0°–359°	Start angle of the sine wave part (AC)
Is(DC)	$Is(AC) - (I_{Nom} - Is(AC))$	Start value of the DC part (I mode)
Ie(DC)	$Ie(AC) - (I_{Nom} - Ie(AC))$	End value of the DC part (I mode)
Us(DC)	$Us(AC) - (U_{Nom} - Us(AC))$	Start value of the DC part (U mode)
Ue(DC)	$Ue(AC) - (U_{Nom} - Ue(AC))$	End value of the DC part (U mode)
Seq.time	0.1 ms–36000 s	Time for the selected sequence point



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

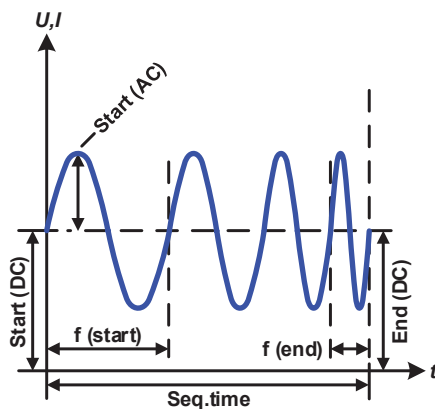
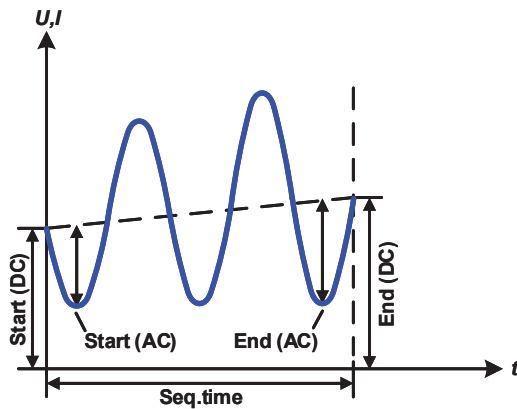
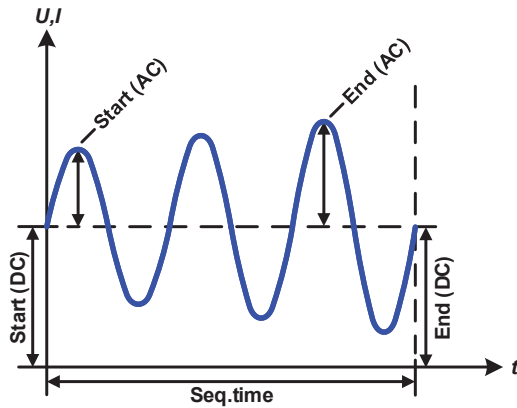
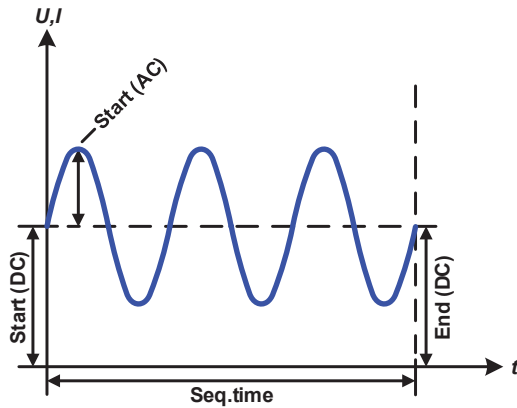


The amplitude change between start and end is related to the sequence time. An arbitrarily small change over an extended time is not possible. See section 9.2.5. **Minimum slope / maximum ramp time** for more information.

After the settings for the selected sequence point are accepted with **SAVE**, further points can be configured. In a second settings screen, which can be reached by tapping **NEXT** in the sequence point selection screen, following global settings for all 99 points are adjustable:

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

Example 2

Focusing 1 cycle of 1 sequence point:

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

Example 3

Focusing 1 cycle of 1 sequence point

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

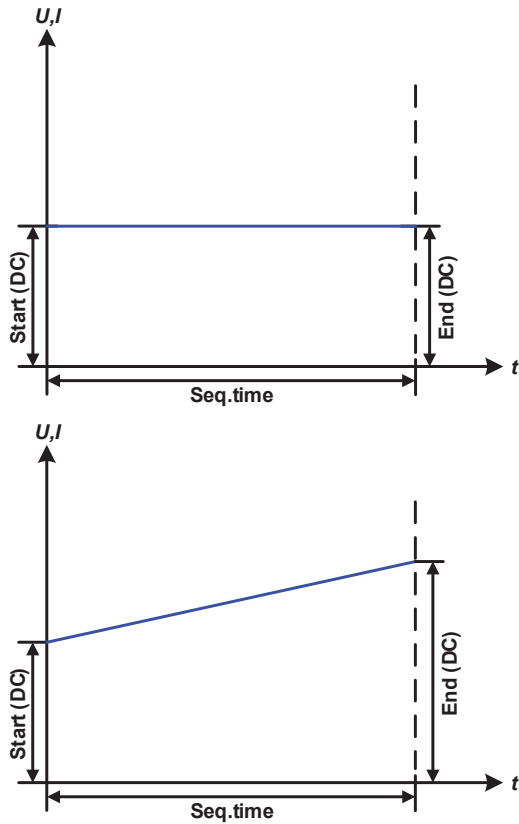
Additionally the first sine wave starts with a negative half wave because the angle is set at 180° . The start angle can be shifted at will in 1° steps between 0° and 359° .

Example 4

Focusing 1 cycle of 1 sequence point:

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

Schematic diagram:



Applications and results:

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.

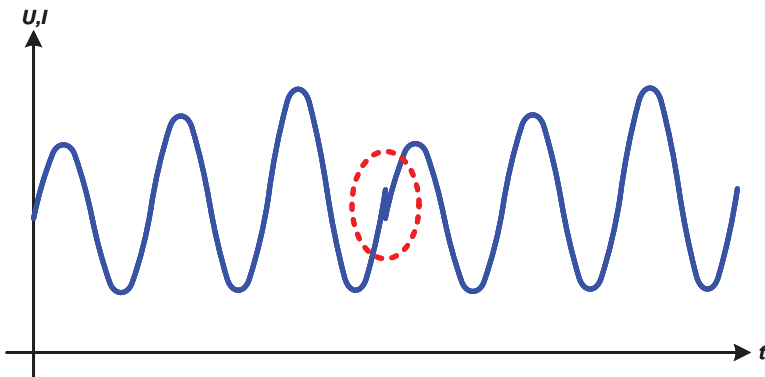
Example 6

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 sequence points, 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 curve of rectangular waves with differing amplitudes or duty cycles could be produced.

Schematic diagram:



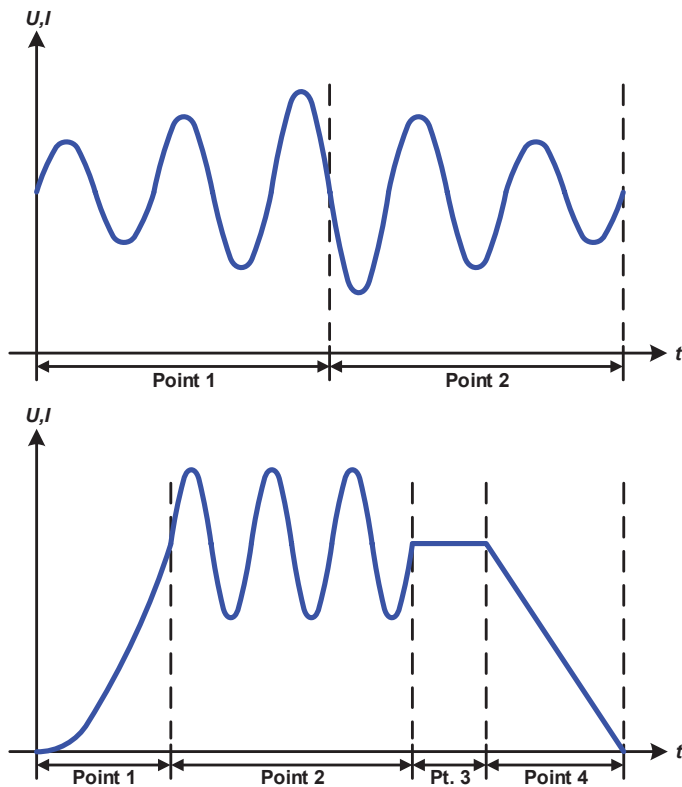
Applications and results:

Example 7

Focusing 2 cycles of 1 sequence point:

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

Schematic diagram:



Applications and results:

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 one 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:

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

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

Sequence point 3: Horizontal ramp ($f = 0$)

Sequence point 4: Falling ramp ($f = 0$)

9.11.1 Loading and saving the arbitrary function

The 99 sequence points of the arbitrary function can be saved to or loaded from a USB flash drive using the front USB port. Generally, all 99 points are saved or loaded using a text file of type CSV (semicolon separator), which represents a table of values.

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

- The table must contain exactly 99 rows (100 are also accepted for compatibility) with 8 columns with no gaps.
- The column separator (semicolon or comma) must be as selected by MENU parameter **USB file separator format**; it also defines the decimal separator (period, comma).
- The files must be stored inside a folder called **HMI_FILES** which must be in the root of the USB drive.
- The file name must always start with **WAVE_U** or **WAVE_I** (not case-sensitive)
- All values in every row and column must be within the specified range (see below).
- The columns in the table must be in a defined order which must not be changed.

The following value ranges are given for use in the table, related to the manual configuration of the arbitrary generator (column headers like in Excel):

Column	Parameter	Range
A	AC start amplitude	0–50% U or I
B	AC end amplitude	0–50% U or I
C	Start frequency	0–10000 Hz
D	End frequency	0–10000 Hz
E	AC start angle	0–359°
F	DC start offset	0–(Nominal value of U or I) - AC start amplitude
G	DC end offset	0–(Nominal value of U or I) - AC end amplitude
H	Sequence point time in μ s	100–36.000.000.000 (36 billion μ s)

For details about the parameter and the arbitrary function refer to [9.11. Arbitrary Function](#).

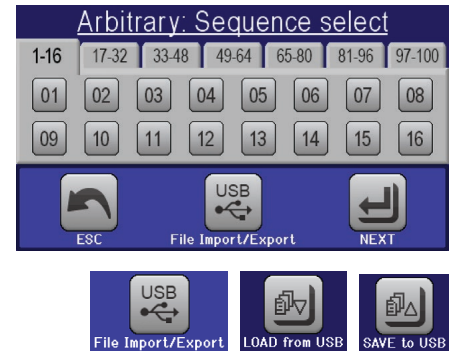
Example CSV:

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

The example shows that only the first two sequence points are configured, while all others are set to default values. The table could be loaded as **WAVE_U** or **WAVE_I** when using, for example, the model 310-12-0080-120, 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 a USB flash drive:**

1. Do not plug the USB drive yet, or pull it out if already plugged in.
2. Access the function selection menu of the function generator with **MENU > Function Generator > Arbitrary > U/I**, to see the main screen of sequence point selector, as depicted to the right.
3. Tap **File Import/Export**, then **LOAD from USB**, and follow the instructions on screen. If at least one valid file has been recognized the system will show a list of files to select from with checkbox controls.
4. Tap **Load from USB** in the bottom right corner. The selected file is then checked and loaded, if valid. In case it's not valid, the an error message will be displayed. Then the file must be corrected and the steps repeated.



► **How to save a sequence point table to a USB flash drive:**

1. Do not plug the USB drive yet, or pull it out if already plugged in.
2. Access the function selection menu of the function generator via **MENU > Function Generator > Arbitrary**.
3. Tap **File Import/Export**, then **SAVE to USB**. The software will prompt you to plug in the USB flash drive.
4. After plugging it in, the software will try to access the drive, 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 select one for overwriting by tapping the checkbox next to it. Otherwise select **NEW FILE** to start a new file.
5. Finally, save the sequence table by tapping **SAVE to USB**.

9.12 UI and IU Table Functions (XY table)

The UI and IU functions offer the user the possibility to set a DC output current dependent on the DC output voltage, or a DC output voltage dependent on the DC output current. The function is table driven with exactly 4,096 values, which are distributed over the whole measured range of actual output voltage or output current in the range of 0–125% U_{nom} or I_{nom} . The table can either be uploaded from a USB flash drive through the front USB port, or via remote control (ModBus or SCPI protocol). The functions are:

UI function: $U = f(I)$

IU function: $I = f(U)$

In the UI function, the equipment measuring circuit determines the level from 0 to maximum of the output current. For each of the 4,096 possible values for output current a voltage value is maintained by the user in the UI table which can be any value between 0 and nominal value. The values uploaded from a USB flash drive will always be interpreted as voltage values even if the user calculated them as current values, and incorrectly loaded them as an UI table.

In the IU function, the assignment of the values is the other way round, but the behavior is the same.

Thus, the behavior of the load or the current and power consumption can be controlled with dependence on output voltage and step changes can be created.

The UI function is very well suited for the simulation of fuel cell characteristics. Whereas the IU function suite is useful for the simulation of solar panels in photovoltaics related tests.



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

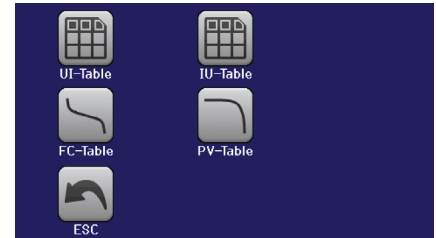


The 4,096 values in the table are only checked for size and count. If all the values were to be graphically plotted, a curve would be created which could include significant step changes in current or voltage. That could lead to complications for connected loads if, for example, the internal current measurement in the power supply swings slightly so that the voltage jumps backwards and forwards between two values in the table, which, in the worst case, could be 0 V and the maximum voltage.

9.12.1 Loading UI and IU tables from a USB drive

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

- The file name always begins with IU or UI (not case-sensitive), depending on which function you load the table for.
- The file must be a text file of type Excel CSV (semicolon as separator), and must only contain one column with exactly 4096 values without gaps.
- Values with decimal places must use a decimal separator as depending on the selection with parameter **USB file separator format** (the value **US** uses separator = comma and decimal separator = period).
- No value may exceed the nominal value of the power supply. For example, if you have an 80 V model, and you are going to load a table with values for voltage, none of the 4,096 values may be higher than 80 V (the adjustment limits from the front panel do not apply here).
- All files must be put inside a folder named **HMI_FILES** in the root of the USB flash drive.



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

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

1. Do not plug the USB drive yet, or pull it out if already plugged in.
2. Open the function selection menu of the function manager with **MENU > Function Generator > XY Table**.
3. In the next screen, select the desired function with either **UI Table** or **IU Table**.
4. Configure the global parameters for U, I and P, if necessary.
5. Tap **LOAD from USB**, and plug the USB drive when prompted in order to select one a file from the drive. In case the file is not accepted, the system will report an error in the display, and also indicate what is wrong with the file.
6. Once the file is accepted, you will be requested to remove the USB drive.
7. Submit and load the function by tapping **LOAD** to start and control it as with other function (also see [9.4.1. Function selection and control](#)).

9.13 Simple PV Function (Photovoltaics)

9.13.1 Preface

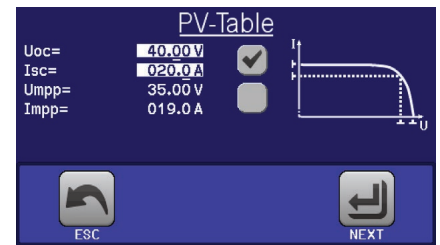
This function uses the standard XY generator to make the power supply simulate solar panels or solar cells with certain characteristics. The system calculates an IU table from four typical values.

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

The most important characteristics of a solar panel are:

- the short-circuit current (I_{SC}), the max. panel current at almost 0 V
- the open circuit voltage (U_{OC}), which almost reaches its maximum value even in low light situations
- the maximum power point (MPP), at which the solar panel can provide the maximum output power

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



9.13.2 Safety notices



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

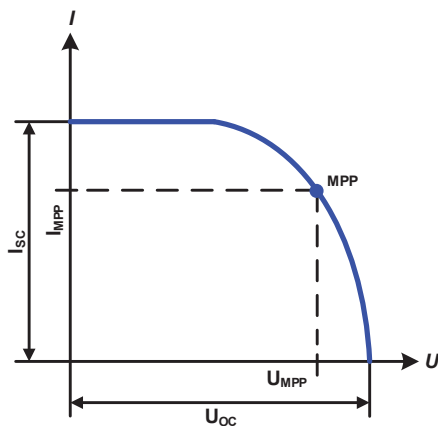
9.13.3 Usage

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

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

Value	Range	Description
U_{oc}	U_{mpp} –Nominal unit voltage	Open circuit voltage at no load
I_{sc}	I_{mpp} –Nominal unit current	Short-circuit current at max. load and low voltage
U_{mpp}	0 V– U_{oc}	DC output voltage at the MPP
I_{mpp}	0 A– I_{sc}	DC output current at the MPP

Schematic diagram:

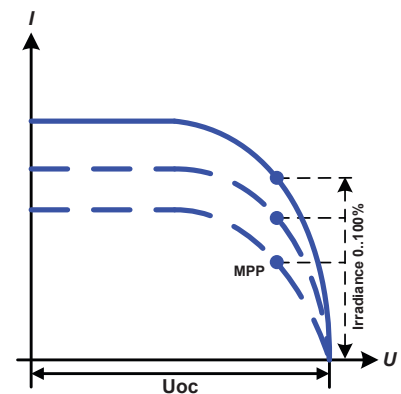


Application and result:




Adjust all four parameters on screen to the desired values. Whether the calculated IU and P curves, which result from those values, make sense or not can be verified with a tool like Excel by generating a diagram.

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

Varying this parameter shifts the MPP and the PV curve along the Y axis. Also see diagram to the right. The value Irradiance is here used as a factor for the current I_{mpp} . The curve itself is not permanently re-calculated.



► How to configure the PV table

1. In the function generator menu, tap , then , then .
2. Adjust the four parameters as required for the simulation.
3. Adjust the global limits for voltage and power in the next screen, which is accessed with the **NEXT** button. The voltage (U) setting should be at least as high as U_{oc} , or higher.
4. Complete the process by tapping **LOAD**.

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

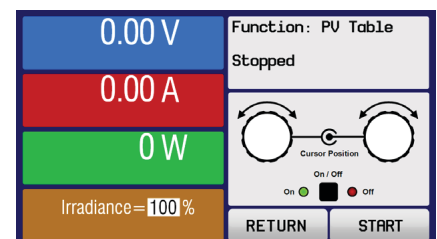


The function can be saved to USB flash drive as a table after calculation, then read via any of the digital interfaces.

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

► How to work with the PV table function

1. With an appropriate load connected, for example a solar inverter, start the function as described in 9.4.1.
2. Adjust value Irradiance with the left rotary knob between 100% (default) and 0%, in order to simulate different light situations. The actual values on the display indicate the working point and can show whether the simulation has arrived at the MPP or not.
3. Stop the function run anytime as described in 9.4.1.



9.14 FC Table Function (Fuel Cell)

9.14.1 Preface

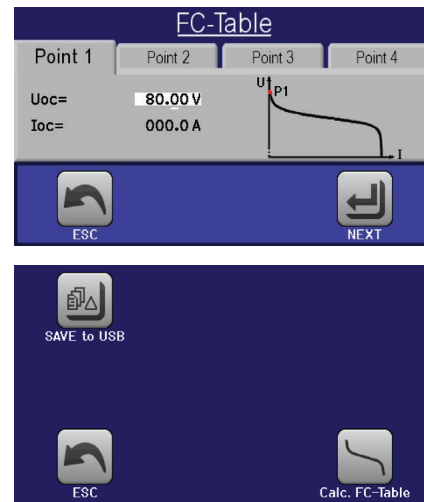
The FC table function is used to simulate the characteristics of voltage and current of a fuel cell. This is achieved by setting up some parameters which define points on a typical fuel cell curve, which is then calculated as UI table and passed to the internal function generator.

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

Generally, following rules apply when setting up those values:

- $U_{\text{Point1}} > U_{\text{Point2}} > U_{\text{Point3}} > U_{\text{Point4}}$
- $I_{\text{Point4}} > I_{\text{Point3}} > I_{\text{Point2}} > I_{\text{Point1}}$
- Values of zero are not accepted

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



9.14.2 Usage

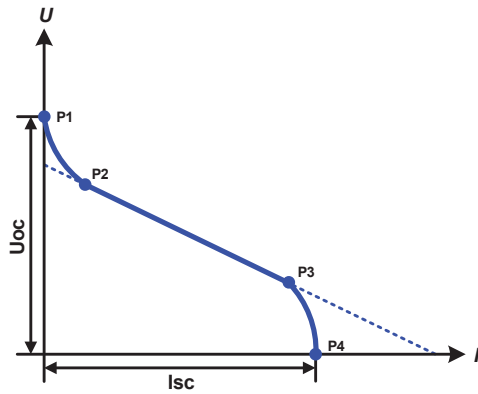
The following parameters can be set for the FC table function:

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



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

Schematic diagram:



Application and result:

After setting up the four supporting points P1 thru P4, whereas P1 is at position U_{oc} and 0 A and P4 is at position I_{sc} and 0 V, the system will calculate the function as UI table and load it to the XY generator.

Depending on the load current, which can be between 0 A and I_{sc} , the system will set a variable output voltage, whose progress between 0 V and U_{oc} should result in a curve similar to the one depicted to the left.

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

► How to configure the FC table



1. In the function generator menu, tap **XY-Table**, then **FC-Table**, then **Calc. FC-Table**.
2. Adjust the parameters of the four supporting points, as required for the simulation.
3. Adjust the global limits for voltage and power in the screen which you access with **NEXT**.
4. Complete the process by tapping **LOAD**.

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

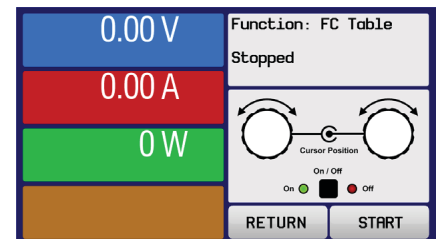


The function can be saved to USB flash drive as a table, as well as read via any of the digital interfaces. While operating in remote control, the function cannot be loaded or controlled.

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

► How to work with the FC table function

1. With an appropriate load connected, for example a DC-DC converter, start the function as described in 9.4.1.
2. The output voltage will be set depending on the load current, which is defined by the connected load, and will decrease with increasing current. Without any load, the voltage will rise to the adjusted U_{oc} value.
3. Stop the function run anytime as described in 9.4.1.



9.15 Extended PV Function and EN 50530

9.15.1 Introduction

This extended PV table function according to standard EN 50530 is used to simulate solar panels in order to test and rate solar inverters. It's available since firmware versions KE 2.19 and HMI 2.11 and offers manual configuration and control, as well as remote control. It's also based on the XY generator, same as the simple PV table function from 9.13, but enables more specific tests and evaluations due to adjustable parameters. Which parameters are available is explained below. The impact of the parameters on the PV curve and the simulation is described in the standard paper of EN 50530, which user can refer to in case more detailed description is required. This section only deals about configuration and control of the PV simulation.

9.15.2 Differences to the basic PV function

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

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

9.15.3 Technologies and parameters

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

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

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

Abbr.	Name	Manual	cSi	Thin film	Unit
FFu	Fill factor for voltage	>0-1 (0.8)	0.8	0.72	-
FFi	Fill factor for current	>0-1 (0.9)	0.9	0.8	-
Cu	Scaling factor for U_{oc} ⁽¹⁾	>0-1 (0.08593)	0.08593	0.08419	-
Cr	Scaling factor for U_{oc} ⁽¹⁾	>0-1 (0.000109)	0.000109	0.0001476	m ² /W
Cg	Scaling factor for U_{oc} ⁽¹⁾	>0-1 (0.002514)	0.002514	0.001252	W/m ²
alpha	Temperature coefficient for I_{sc} ⁽²⁾	>0-1 (0.0004)	0.0004	0.0002	1/°C
beta	Temperature coefficient for U_{oc} ⁽¹⁾	-1-<0 (-0.004)	-0.004	-0.002	1/°C

(1) U_{oc} = Open circuit voltage of a solar panel

(2) I_{sc} = Short-circuit current (=max. current) of a solar panel

9.15.4 Simulation mode

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

Mode U/I	Controllable simulation. Voltage (U_{MPP} , in V) and current (I_{MPP} , in A) in the maximum power point (MPP) are variable during runtime. The purpose of this mode is to directly shift the MPP into various directions.
Mode E/T	Controllable simulation. During runtime, the irradiation (E from german “Einstrahlung”, in W/m^2) and surface temperature (T, in $^{\circ}C$) of the simulated solar panel are adjustable. This also impacts the curve and the resulting MPP. The purpose of this mode is to analyze the impact of temperature and/or irradiation on the performance of a solar panel.
Mode DAY U/I	Automatic simulation run, processing a day trend curve consisting of up to 100,000 points defined by values for U_{MPP} , I_{MPP} and time.
Mode DAY E/T	Automatic simulation run, processing a day trend curve consisting of up to 100,000 points defined by values for irradiation, temperature and time.

9.15.5 Day trend

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

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

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

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

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

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

Column A = Index

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

Column B = Irradiation (E) in W/m^2

- Allowed range: 0–1500

Column C = Temperature (T) in $^{\circ}C$

- Allowed range: -40–80

Column D = Dwell time in milliseconds (ms)

- Allowed range: 500–1.800.000

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



Attention! The values in columns B and C are real values which must not exceed the ratings of the power supply or the system will not load the file.

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

Column A = Index

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

Column B = Voltage U_{MPP} in V

- Allowed range: 0–rated output voltage of the unit

Column C = Current I_{MPP} in A

- Allowed range: 0–rated output current of the unit

Column D = Dwell time in milliseconds (ms)

- Allowed range: 500–1.800.000

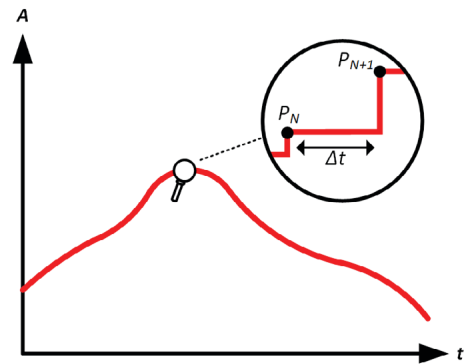


The number format and the column separator in the CSV files is determined by the regional settings of the PC or the software used to create the files. The format must match the selection for the mPower setting **USB file separator format** in the General Settings menu of the system, or the system will not load the file. For example, an American Excel should by default use the period as decimal separator, and the comma as column separator, which would match the selection **USB file separator format = US**.

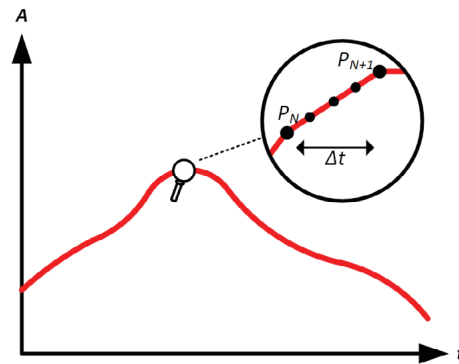
9.15.6 Interpolation

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

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



Without interpolation - the curve results in steps



With interpolation - the curve remains linear

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

9.15.7 Data recording

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

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

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

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

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

Index = Ascending number

U_{actual} = Actual voltage on the DC output

I_{actual} = Actual current on the DC output

P_{actual} = Actual power on the DC output

$U_{MPP} / I_{MPP} / P_{MPP}$ = Voltage, current and power in the MPP of the currently calculated PV curve



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

9.15.8 Configuration step by step



Starting point

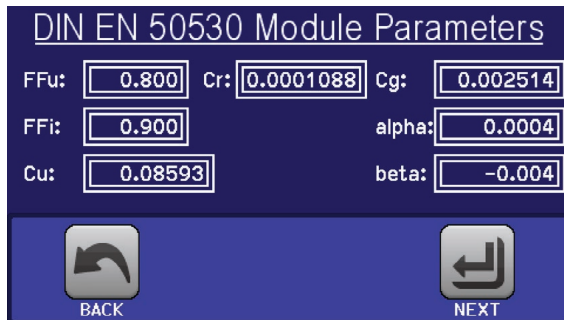
In **MENU > Function Generator > 2nd page > XY-Table** you will find the PV functions. Select **PV DIN EN 50530**.



Step 1: Technology selection

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

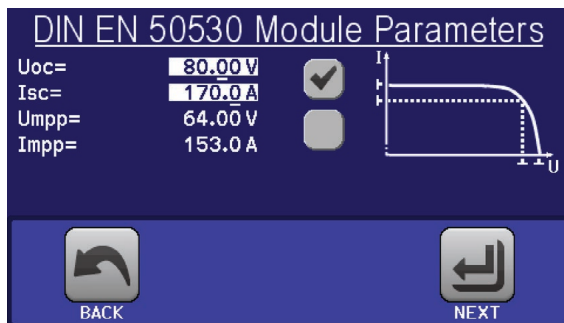
When selecting **Thin film** or **cSI** the configuration continues with Step 2.



Step 1-1: Adjust technology parameters

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

When resetting the system, these values are reset to defaults which are the same as with technology **cSI**. Also see the overview in 9.15.3. It means they don't necessarily have to be adjusted. If any of the other technologies was selected, this screen would be skipped and these parameters set to the defined values.



Step 2: Enter the solar panel's base parameters

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

$$U_{MPP} = U_{OC} \times FF_u \quad / \quad I_{MPP} = I_{SC} \times FF_i$$

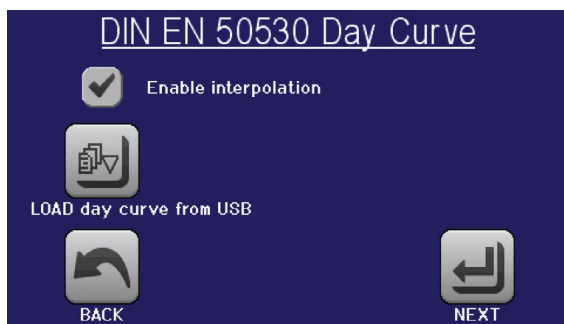


Step 3: Select simulation mode

For a description of the available simulation modes see 9.15.4.

Furthermore, the recording feature can be enabled here. The recorded data can later be stored to USB drive as CSV file with button **SAVE** records to **USB**, after returning to this screen from the simulation run. Also see section 9.15.7.

When selecting **E/T** or **U/I** the configuration continues with Step 4.



Step 3-1: Load day trend data

If mode **DAY E/T** or **DAY U/I** was selected this additional screen will appear where you can load the required day trend data (1-100,000 points) with button **LOAD** day curve from USB flash drive and from a CSV file with a specific format (see 9.15.5) and name (see 3.4).

There is furthermore the option to enable the interpolation feature (see 9.15.6).



Step 4: Global limits

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

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

Recommendation: leave both values untouched

The configuration will be finished, and the settings submitted by pressing **LOAD**. The function generator would then switch to control mode.

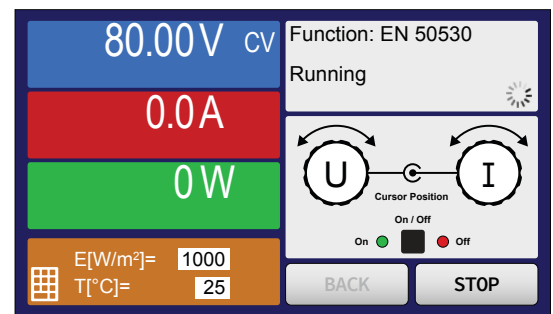
9.15.9 Controlling the simulation

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

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

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

In case any of the day trend modes would have been selected, the display area would be empty. These modes run automatically once started, and will stop when the sum of the dwell times of all points is reached. The other modes, E/T and U/I, would only stop due to user interaction or due to a hardware alarm.



9.15.10 Stop criteria

The simulation run could unintentionally stop due to several reasons:

1. A hardware alarm occurred, which would switch off the DC output (PF, OVP, OCP, OPP).
2. An user event occurred whose action has been defined to cause an alarm, which means to switch off DC.
3. Day trend mode has finished.

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

9.15.11 Test analysis

After a simulation is stopped for whatever reason, recorded data can be saved to a USB flash drive, or read via digital interface (assuming data recording was previously activated in the configuration). Activating the data recording feature during the simulation run is not possible when manually controlling the function generator, but is possible through remote control. When saving to a USB flash drive, all data recorded up to the current index counter will be saved. Using the digital interface, there is the option to read any specific portion of the data, which will also have an impact on the time required to read the data.

The data can later be used to visualize, analyze, and determine characteristics of the simulated solar panel, and also of the solar inverter which is usually used as a load when running such tests.

9.15.12 Reading the PV curve

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

When reading the PV table, you will receive up to 4,096 current values.

9.16 Function Generator Remote Control

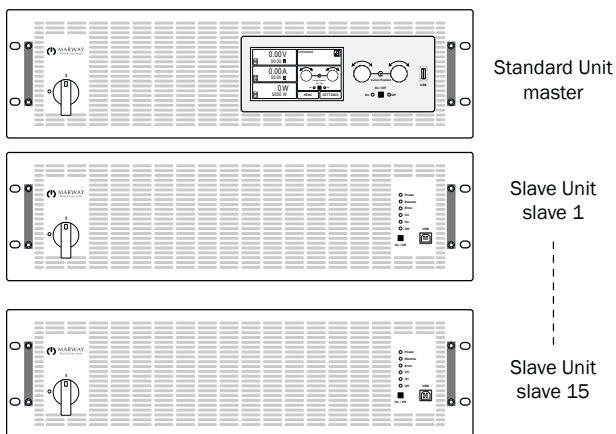
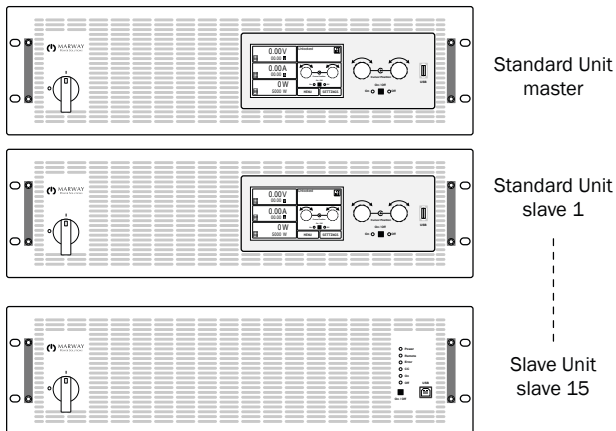
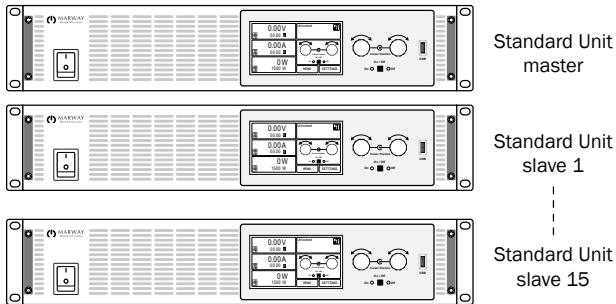
The function generator can be remotely controlled, but configuration and control of the functions with individual commands is different from manual operation. The external documentation *Programming Guide* explains the approach. In general:

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

10 Parallel and Series operation

10.1 Master-Slave Parallel Operation

Multiple power supplies of the same model number can be connected in parallel in order to create a system with higher total current and power. This can be done using the standard models (with touch display and control panel), or in the case of the 3U 15kW capacity, using dedicated 3U 15kW slave models (320 Series variants of the 15kW 310-43 and 310-53 models). The 320 Series slave models are intended to run as slave only, and thus have no display, and other simplification to reduce cost when building large capacity systems.



The term “slave” can get confusing here as the word is used to represent the role of a specific unit, or the configuration of a model.

A 310 Series unit can be used in the *role* of either a master or a slave. We see this in the first and second diagrams to the left. In the top set of units, all units are 310 Series. In the center set, the first two systems are 310 Series. Here, the 310 units are being used in the role of slaves (and masters).

In the center and bottom sets, we see 320 Series units (those without displays) being used in the slave role as well. It is technically possible, with some limited capability, for a 320 Series model to function as in the master role, but that’s not shown.

The 320 Series slave models are available only in 3U, 15 kW configurations. All other setups of multiple units in parallel operation will be created using standard 310 series units (the top diagram). This is required for all 310 Series combinations of 2U models, and all 3U models less than 15 kW.

When working with the 3U, 15 kW models, you have the option of using all 310 series units, or mixing the 310 and 320 units (center and bottom diagrams). Having more than one 310 unit available provides some flexibility in the event the master unit has problems. Using all 320 Series models lowers the total cost of the setup.

10.1.1 Limitations

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

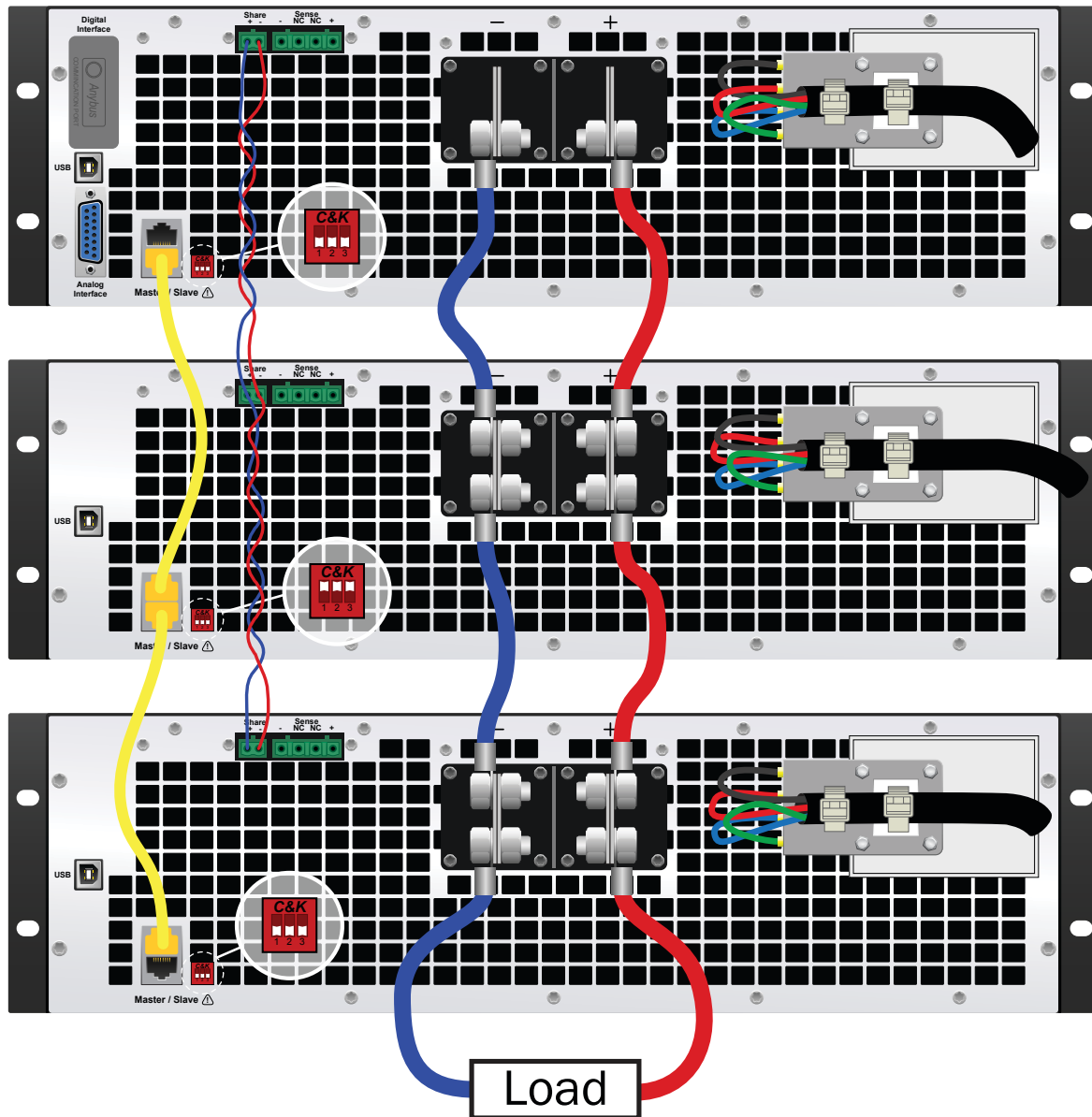
- The MS system reacts differently to alarm situations (see below in [10.1.7](#)).
- Using the Share bus helps the system react as dynamically as possible, but it’s still not as responsive as a single-unit operation.

10.1.2 Parallel wiring connections

For parallel operation in master-slave mode, the units are usually connected with their DC outputs, their Share bus, and their master-slave bus. This configurations makes the system work as one big unit with the master managing adjusted values, actual values, and status reporting of all connected units.

Connection diagram

Shown with 310 Series master and 320 Series slave 3U units, but the setup for multiple 310 Series 2U or 3U units is the same.



10.1.3 Wiring the DC outputs

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

10.1.4 Wiring the Share bus

The Share bus is wired from unit to unit ideally with a twisted pair of cables. Wire gauge is not critical, but we recommend to use 20ga or 18ga.



- Share bus polarity is critical. Take care that wiring has the correct polarity connections.
- In order for the Share bus to work correctly, it requires at least to connect all DC minus outputs of the units.
- When not using one or several units of a system configured with Share bus, because less power is required for an application, it is recommended to disconnect the unused units from the Share bus. Even when not powered, unused connections can have a negative impact on the control signal on the bus due to their impedance. Unplug or switch out connections from unused units.
- The Share bus is referenced to DC minus. When building a series connection (where allowed, depending on model), the DC minus will shift its potential, and so will the Share bus.



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

10.1.5 Wiring and set-up of the RJ45 master-slave bus

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

- A maximum of 16 units can be connected via the bus: 1 in master mode, and up to 15 in slave mode.
- Connection only between units of same same model, such as 310-02-0080-060 to 310-02-0080-060.
- Units at both ends of the bus must be terminated.



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

Operation of the MS system implies:

- The master unit displays, or makes available to be read by the remote controller, the sum of the actual values of all the units
- The ranges for setting the values, adjustment limits, protections (OVP etc.) and user events (UVD etc.) of the master are adapted to the total number of units. Thus, if 5 units, each with a power of 1.5 kW, are connected together to create a 7.5 kW system, then the master can be set in the range 0–7.5 kW.
- Standard units in slave operation will show the alarm **MSP** in the display as long as they not have been initialized by the master. The same alarm is signaled after a connection drop to the master unit occurred.
- In case the function generator of the master unit is going to be used, the Share bus must be connected.

► How to connect the master-slave bus:

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



Now the master-slave system must be configured on each unit. It's recommended to configure first all the slave units, and then the master unit.

► Step 1: Configuring slave units

Configuring standard models (with touch displays)

1. Tap **MENU** then **GENERAL SETTINGS** and press the down arrow until reaching the master-slave settings.
2. Activate the MS mode by tapping **SLAVE**. A warning prompt will appear which has to be acknowledged with **OK**, otherwise the change will be reverted.
3. Accept the settings by tapping **ENTER**.
4. The slave is then configured for master-slave operation. Repeat the procedure for all other slave units.

Configuring slave models (no touch displays):

1. The configuration can be done with the **EA Power Control** software.
2. Connect the Slave series model via the rear USB port or via Ethernet interface to a PC.
3. Start the software EA Power Control, and let the software find the unit.
4. Open the app **Settings** for the particular unit, change to tab **Master-Slave**, and there set the parameter **Master-slave mode** to **SLAVE**.
5. The slave is then configured for master-slave operation. Repeat the procedure for all other slave model units.

► Step 2: Configuring the master unit

1. Tap **MENU** then **GENERAL SETTINGS** and press the down arrow until reaching the master-slave settings.
2. Specify the unit as master by tapping **MASTER**. A warning prompt will appear which has to be acknowledged with **OK**, otherwise the change will be reverted.
3. Accept the settings by tapping **ENTER**.

► Step 3: Initializing the master

The master unit and the whole master-slave system must now be initialized, which is done automatically after the master unit has been activated for MS. In the main page, after quitting the setting menus, a pop-up will appear.



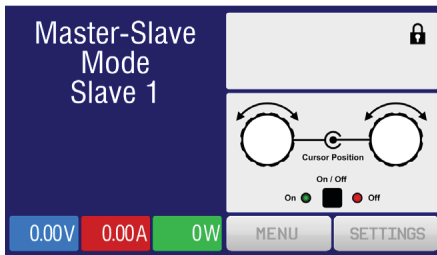
Tapping Initialize repeats the search for slaves in case the detected number of slaves is less than expected, the system has been reconfigured, not all slave units are already set as Slave, or the cabling/termination is still not OK. The result window shows the number of slaves, plus the total current, power and resistance of the MS system.

In case there are no slaves found, the master will still initialize the MS system with only itself.



The initialization process of the master and the master-slave system will, as long as MS mode is still activated, be repeated each time the units are powered. The initialization can be repeated anytime via the MENU in **GENERAL SETTINGS**.

10.1.6 Operating the master-slave system



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

This means, as long as a slave unit is in control by the master, it won't display any set or actual values, but it will show the DC output status and possible alarms.

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

The display on the master unit changes after initialization, and all set values are reset. The master now displays the set and actual values of the total system.

The following notes apply to the system as a whole:

- The master can be treated as a standalone unit.
- The master shares the set values across the slaves and controls them.
- The master is remotely controllable via the analog or digital interfaces.
- All settings for the set values U, I and P (monitoring, settings limits etc.) will be adapted to the new total values.
- All initialized slaves will reset any limits (U_{Min} , I_{nom} etc.), supervisor thresholds (OVP, OPP etc.) and event settings (UCD, OVD etc.) to default values so these don't interfere in the control by the master.



In order to easily restore all these settings values to what was before activating MS operation, it's recommended to make use of the user profiles (see [6.5. Loading and Saving a User Profile](#))

- If one or more slaves report a hardware alarm, this will be displayed on the master, and must be acknowledged there so that the slave(s) can continue operation. Since an alarm causes the DC output to be switched off, and it can only reinitialize automatically after PF or OT alarms, it can be required to switch it on again by the operator, or by a remote control software.
- Loss of connection to any slave will result in shutdown of all DC outputs, as a safety measure, and the master will report this situation in the display with a pop-up **Master-slave safety mode**. Then the MS system has to be reinitialized, either with or without re-establishing connection to the disconnected unit(s).
- All units, even the slaves, can be externally shut down on the DC outputs using the pin REM-SB of the analog interface. This can be used as a kind of emergency off, where a contact (make or break) is wired to this pin on all units in parallel.

10.1.7 Alarms and other problem situations

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

- Generally, if the master loses connection to any slave, it will generate an MSP (master-slave protection) alarm, pop up a message on the screen, and switch off its DC output. The slaves will fall back to single operation mode, but also switch off their DC output. The MSP alarm can be deleted by initializing the master-slave system again. This can be done either in the MSP alarm pop-up screen, or in the MENU of the master, or via remote control. Alternatively, the alarm is also cleared by deactivating master-slave on the master unit
- If one or more slave units are cut from AC supply (power switch, blackout, supply undervoltage) and AC is restored later, they're not automatically initialized and included again in the MS system. MS initialization has to be repeated.
- If the master unit is cut from AC supply (power switch, blackout) and AC is restored later, the unit will automatically initialize the MS system again, finding and integrating all active slaves. In this case, MS can be restored automatically.
- If the DC output of the master unit is switched off due to a defect or overheating, then the total master-slave system cannot provide output power and the DC outputs of all slaves are automatically switched off too
- If multiple units are defined as master the master-slave system can't be initialized.

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

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



- In case one or several units of a parallel system are not going to be used and remain switched off, depending on the number of active units and the dynamics of the operation it may become necessary to disconnect the inactive units from the Share bus, because even when not powered the units can have a negative impact on the Share bus due to their impedance.
- Slave units with a display have an extra option in the configuration page for master-slave which can be activated to switch off the back light of the display after some time. This can be helpful, because after initialization of the MS system the slaves' displays are not needed anymore. The feature itself is, however, identical to the option in the HMI settings.

10.2 Series Connection

Series connection of two or multiple units is basically possible. But for reasons of safety and isolation, some restrictions apply:



- Both, negative (DC-) and positive (DC+) output poles, are coupled to GND via type X capacitors, limiting the max. allowed potential shift (see technical specs for values)
- The Share Bus must not be wired and used!
- Remote sensing must not be used!
- Series connection is only allowed with units of the same kind and model, for example 310-02-0080-060 with 310-02-0080-060.

Series connection in Master-Slave mode is not supported. It means, all units have to be controlled separately regarding set values and DC output status, whether it's manual control or digital remote control.

According to the limit of the potential shift that comes with series connection, units with a certain nominal output voltage must not be connected in series at all. For example, it's not permissible to connect two or more 360 V models in series, because the DC minus is only isolated up to ± 400 V DC against GND. 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 system and the DC output. The grounds (AGND, DGND) on the analog interface are also allowed to be directly connected to GND, like it automatically happens when controlling and directly connecting it to a PC.

11 Service and Maintenance

11.1 Maintenance / Cleaning

The unit needs no maintenance. Cleaning may be needed for the internal fans, the frequency of which depends on the operating environment. The fans serve to cool the components which are heated by the inherent power loss. Heavily dirt filled fans can lead to insufficient airflow, and therefore the DC output would switch off too early due to overheating or possibly lead to defects.

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

11.2 Troubleshooting / Diagnosis / Repair

If the equipment suddenly performs in an unexpected way, which indicates a fault, or it has an obvious defect, this can not and must not be repaired by the user. Contact the factory for support.

It will usually be necessary to return the unit to the factory. If a return for testing or repair is to be carried out, ensure that:

- the factory has been contacted and it's clarified how and where the equipment should be sent, and that a Return Material Authorization (RMA) has been assigned.
- the unit is in fully assembled state and in suitable transport packaging, ideally the original packaging.
- optional extras such as an Interface 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.

11.2.1 Firmware updates



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

The firmware of the control panel, the communication unit, and the digital controller, if necessary, may be updated via the rear USB port. The software **EA Power Control** is needed which is available as a 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 system. We recommend to install updates only if

- an imminent problem with your unit 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.

The following also applies in connection with firmware updates:

- Simple changes in firmwares can have crucial effects on the application the units 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 (*Operating Guide* and/or *Programming Guide*, as well as LabView VIs), which is often delivered only later, sometimes significantly later.

11.3 Calibration

11.3.1 Preface

The mPower DC units 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 maximum value. There are several reasons which could make it necessary to readjust a unit: component aging, component deterioration, extreme ambient conditions, high frequent use.

In order to determine if a value is out of tolerance, the parameter must be verified first with measurement tools of high accuracy, and with no more than half the tolerance error of an mPower unit. Only then can a comparison between values displayed on the power supply, and true DC output values be meaningful.

For example, if you want to verify and possibly readjust the output current of model 310-12-0080-120 at the maximum 120A, which is stated with a maximum error of 0.2%, you can only do that by using a suitable shunt with maximum of 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 maximum error of the unit under calibration.

11.3.2 Preparation

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

- A measurement device (multimeter) for voltage, with a maximum error of half an mPower unit'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 125% the maximum output current of the mPower unit, and with a maximum error that is half or less than the maximum current error of the mPower unit.
- Normal ambient temperature of approx. 20-25 °C.
- Warmed up unit, which has been run for at least 10 minutes at 50% power.
- An adjustable load, such as an electronic load, which is capable of consuming at least 102% of the maximum voltage and current of the mPower unit.

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

- Let the mPower unit warm up connected to 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 unconnected for now.
- Abort any form of remote control, deactivate master-slave mode, deactivate resistance mode.
- Install the shunt between mPower unit and load, and make sure the shunt can be kept cooled (probably by a fan).
- Connect the 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.

11.3.3 Calibration procedure

After the preparation details noted above, the unit 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.



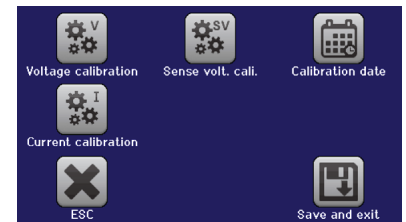
When calibrating the output voltage, the remote input Sense on the rear of the unit has to be disconnected.

The calibration procedure, as explained below, is an example with model mPower 310-12-0080-120. Other models are treated the same way, with values according to the particular PSI model and the required load.

11.3.3.1 Calibrating the set values

► How to calibrate the 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 ≈ 6 A, and 0 V (if the load is electronic).
2. In the display, tap **MENU**, then **General Settings**, then **Calibrate device**, and tap **START**.
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 which appears when tapping the value. Submit with **ENTER**.
5. Repeat point 4 for the next three steps (total of four steps).



► How to calibrate the current

1. Set the load to approximately 102% nominal current of the unit. For the sample model with 120 A, this would be 122.4 A, rounded to 123 A.
2. In the display, tap **MENU**, then **General Settings**, then **Calibrate device**, and then tap **START**.
3. In the next screen, select: **Current calibration**, then **Calibrate output val** and **NEXT**. The system will switch on the DC output, set a certain current limit while loaded by the load/sink and show the measured output current as I-mon.
4. The next screen requests you to enter the output current **Measured value=** measured with the shunt. Enter it using the keypad. Submit with **ENTER**.
5. Repeat point 4 for the next three steps (total of four steps).

11.3.3.2 Calibrating the remote sensing

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


► How to calibrate the output voltage for remote sensing

1. Connect a load and set its current to approx. 5% of the nominal current of the power supply, in this example ≈ 6 A, and 0 V (if the load is electronic). Connect a multimeter to the DC terminal of the load and connect the remote sensing input (Sense) to the DC terminal of the load with correct polarity.
2. In the display, tap **MENU**, then **General Settings**, then **Calibrate device**, and then tap **START**.
3. In the next screen, select: **Sense volt cali**, then **Calibrate output val** and **NEXT**.
4. The next screen requests you to enter the measured sensing voltage **Measured value=** from the multimeter. Enter it using the keypad, that appears when tapping the value. Submit with **ENTER**.
5. Repeat point 4 for the next three steps (total of four steps).

11.3.3.3 Calibrating the actual values

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. Proceed with the above steps and instead of **Calibrate output value** select **Calibrate actual val** in the sub menus. After the system shows measured values on display, wait at least 2s for measured value to settle and then tap **NEXT** until you are through all steps.

11.3.3.4 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.

Lastly, save the calibration data permanently by tapping **Save and Exit**.



Leaving the calibration selection menu without tapping **Save and exit** will discard calibration data and the procedure would have to be repeated.

12 Contact and support

12.1 Repairs

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

12.2 Contact Options

Questions or problems with operation of the unit, use of optional components, with the documentation or software, can be addressed to technical support either by telephone or email.

Address	Email	Telephone
Marway Power Solutions 1721 S. Grand Ave. Santa Ana, CA 92705	Technical support: support@marway.com All other issues: info@marway.com	714-917-6200

13 Appendix: Model Specifications

13.1 Approved Operating Conditions

- Use only inside dry buildings
- Ambient temperature 0-50 °C (32-122 °F)
- Operational altitude: max. 2000 m (1.242 mi) above sea level
- Max. 80% relative humidity, non-condensing

13.2 Model Data-Table Footnotes

Note that throughout the specs, Unom (nominal voltage), Inom (nominal current), and Pnom (nominal power) all refer to the product's rated values. Therefore, a unit rated for 360 V, 40 A, and 5 kW has a Unom of 360, an Inom of 40, and a Pnom of 5 or 5000 depending on whether the specification calls out kW or W.

For the model-specific data tables on the following pages, these are the referenced footnotes.

1. Related to the nominal values, the accuracy defines the maximum deviation between an adjusted values and the true (actual) value.
 - Example: an 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 up to 80 mV, which means it might be between 4.92 V and 5.08 V.
2. The display error adds to the error of the related actual value on the DC output.
3. RMS value: LF 0–300 kHz, PP value: HF 0–20MHz.
4. Typical value at 100% output voltage and 100% power.
5. Allowed float (potential shift) on the DC output.
6. Not available on, or not applicable to, slave models (-002).

13.3 MPW 310-02 : 2U, 1,000 Watt, 100–240 Vac 1ph

2U 1,000 W 100–240 Vac (a)	40 V : 40 A 310-02-0040-040	80 V : 40 A 310-02-0080-040	200 V : 15 A 310-02-200-015
AC Input			
Voltage range, frequency	90–264 Vac, 45–66 Hz	90–264 Vac, 45–66 Hz	90–264 Vac, 45–66 Hz
Connection	1ph,N,GND	1ph,N,GND	1ph,N,GND
Fusing	T16 A	T16 A	T16 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	≈ 0.99	≈ 0.99	≈ 0.99
DC Output			
Max. output voltage U _{nom}	40 V	80 V	200 V
Max. output current I _{nom}	40 A	40 A	15 A
Max. output power P _{nom}	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	5440 μF	5440 μF	800 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 / 73±9 °F)	< 0.1% U _{Nom}	< 0.1% U _{Nom}	< 0.1% U _{Nom}
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{Nom}	< 0.02% U _{Nom}	< 0.02% U _{Nom}
Load regulation at 0–100% load	< 0.05% U _{Nom}	< 0.05% U _{Nom}	< 0.05% U _{Nom}
Rise time 10–90%	Max. 30 ms	Max. 30 ms	Max. 30 ms
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}
Ripple ³	< 114 mV _{PP} < 8 mV _{RMS}	< 114 mV _{PP} < 8 mV _{RMS}	< 164 mV _{PP} < 34 mV _{RMS}
Remote sensing compensation	Max. 5% U _{Nom}	Max. 5% U _{Nom}	Max. 5% U _{Nom}
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 / 73±9 °F)	< 0.2% I _{Nom}	< 0.2% I _{Nom}	< 0.2% I _{Nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{Nom}	< 0.05% I _{Nom}	< 0.05% I _{Nom}
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{Nom}	< 0.15% I _{Nom}	< 0.15% I _{Nom}
Ripple ³	< 3.7 mA _{RMS}	< 3.7 mA _{RMS}	< 2.2 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}

2U 1,000 W 100–240 Vac (a) cont'd		40 V : 40 A 310-02-0040-040	80 V : 40 A 310-02-0080-040	200 V : 15 A 310-02-200-015
Power regulation				
Adjustment range	0–1020 W	0–1020 W	0–1020 W	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{Nom}	< 1% P _{Nom}	< 1% P _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.8% P _{Nom}	≤ 0.8% P _{Nom}	≤ 0.8% P _{Nom}	
Efficiency ⁴	≈ 92%	≈ 92%	≈ 93%	
Internal resistance regulation				
Adjustment range	0–30.6 Ω	0–61.2 Ω	0–408 Ω	
Accuracy ¹	≤ 1% of max. resistance ± 0.3% of maximum current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Analog interface ⁶				
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, OCP, OPP, PF, OT, DC on/off			
Galvanic isolation to the device	Max. 400 V DC			
Sample rate of inputs & outputs	500 Hz			
Insulation				
Output (DC) to enclosure (GND)	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 fans, front inlet, rear exhaust			
Ambient temperature	0–50 °C (32–122 °F)			
Storage temperature	-20–70 °C (-4–158 °F)			
Humidity	< 80%, not condensing			
Standards	EN 60950:2006 + A11: 2009 + A1:2010 + A12:2011 + AC:2011 + A2:2013 EN 61326-1:2013-07			
Overvoltage category	2			
Protection class	1			
Pollution degree	2			
Operational altitude	< 2000 m (1.242 mi)			
Digital interfaces				
Standard	1x USB-B for communication, 1x USB-A for functions			
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB			
Galvanic isolation from device	Max. 400 V DC			
Terminals				
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot			
Front side	USB-A			
Dimensions				
Enclosure (WxHxD)	19" x 2U x 463 mm (18.2")			
Total (WxHxD)	483 x 88 x min. 535 mm (19" x 3.5" x 21.1") (depending on DC out terminal type)			
Weight	≈ 12 kg (26.5 lb)	≈ 12 kg (26.5 lb)	≈ 12 kg (26.5 lb)	

2U 1,000 W 100–240 Vac (b)	360 V : 10 A 310-02-0360-010	500 V : 6 A 310-02-0500-006	750 V : 4 A 310-02-0750-004
AC Input			
Voltage range, frequency	90–264 Vac, 45–66 Hz	90–264 Vac, 45–66 Hz	90–264 Vac, 45–66 Hz
Connection	1ph,N,GND	1ph,N,GND	1ph,N,GND
Fusing	T16 A	T16 A	T16 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	≈ 0.99	≈ 0.99	≈ 0.99
DC Output			
Max. output voltage U _{nom}	360 V	500 V	750 V
Max. output current I _{nom}	10 A	6 A	4 A
Max. output power P _{nom}	1000 W	1000 W	1000 W
Overvoltage protection range	0–396 V	0–550 V	0–825 V
Overcurrent protection range	0–11 A	0–6.6 A	0–4.4 A
Overpower protection range	0–1100 W	0–1100 W	0–1100 W
Output capacitance	330 µF	120 µF	40 µF
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm		
Voltage regulation			
Adjustment range	0–367.2 V	0–510 V	0–765 V
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.1% U _{Nom}	< 0.1% U _{Nom}	< 0.1% U _{Nom}
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{Nom}	< 0.02% U _{Nom}	< 0.02% U _{Nom}
Load regulation at 0–100% load	< 0.05% U _{Nom}	< 0.05% U _{Nom}	< 0.05% U _{Nom}
Rise time 10–90%	Max. 30 ms	Max. 30 ms	Max. 30 ms
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}
Ripple ³	< 210 mV _{PP} < 59 mV _{RMS}	< 190 mV _{PP} < 48 mV _{RMS}	< 212 mV _{PP} < 60 mV _{RMS}
Remote sensing compensation	Max. 5% U _{Nom}	Max. 5% U _{Nom}	Max. 5% U _{Nom}
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	0–10.2 A	0–6.12 A	0–4.08 A
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{Nom}	< 0.2% I _{Nom}	< 0.2% I _{Nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{Nom}	< 0.05% I _{Nom}	< 0.05% I _{Nom}
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{Nom}	< 0.15% I _{Nom}	< 0.15% I _{Nom}
Ripple ³	< 1.6 mA _{RMS}	< 0.5 mA _{RMS}	< 0.3 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}

2U 1,000 W 100–240 Vac (b) cont'd		360 V : 10 A 310-02-0360-010	500 V : 6 A 310-02-0500-006	750 V : 4 A 310-02-0750-004
Power regulation				
Adjustment range	0–1020 W	0–1020 W	0–1020 W	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{Nom}	< 1% P _{Nom}	< 1% P _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.8% P _{Nom}	≤ 0.8% P _{Nom}	≤ 0.8% P _{Nom}	
Efficiency ⁴	≈ 93%	≈ 93%	≈ 93%	
Internal resistance regulation				
Adjustment range	0–1101.6 Ω	0–2550 Ω	0–5737.5 Ω	
Accuracy ¹	≤ 1% of max. resistance ± 0.3% of maximum current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Analog interface ⁶				
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, OCP, OPP, PF, OT, DC on/off			
Galvanic isolation to the device	Max. 400 V DC			
Sample rate of inputs & outputs	500 Hz			
Insulation				
Output (DC) to enclosure (GND)	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 fans, front inlet, rear exhaust			
Ambient temperature	0–50 °C (32–122 °F)			
Storage temperature	-20–70 °C (-4–158 °F)			
Humidity	< 80%, not condensing			
Standards	EN 60950:2006 + A11: 2009 + A1:2010 + A12:2011 + AC:2011 + A2:2013 EN 61326-1:2013-07			
Overvoltage category	2			
Protection class	1			
Pollution degree	2			
Operational altitude	< 2000 m (1.242 mi)			
Digital interfaces				
Standard	1x USB-B for communication, 1x USB-A for functions			
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB			
Galvanic isolation from device	Max. 400 V DC			
Terminals				
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot			
Front side	USB-A			
Dimensions				
Enclosure (WxHxD)	19" x 2U x 463 mm (18.2")			
Total (WxHxD)	483 x 88 x min. 535 mm (19" x 3.5" x 21.1") (depending on DC out terminal type)			
Weight	≈ 12 kg (26.5 lb)	≈ 12 kg (26.5 lb)	≈ 12 kg (26.5 lb)	

13.4 MPW 310-02 : 2U, 1,500 Watt, 100–240 Vac 1ph

2U 1,500 W 100–240 Vac (a)	40 V : 60 A 310-02-0040-060	80 V : 60 A 310-02-0080-060	200 V : 25 A 310-02-0200-025
AC Input			
Voltage range, frequency	150–264 Vac, 45–66 Hz to acheive maximum power output 100–150 Vac, 45–66 Hz yields derated 1000 W power output		
Connection	1ph,N,GND	1ph,N,GND	1ph,N,GND
Fusing	T16 A	T16 A	T16 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	≈ 0.99	≈ 0.99	≈ 0.99
DC Output			
Max. output voltage U _{nom}	40 V	80 V	200 V
Max. output current I _{nom}	60 A	60 A	25 A
Max. output power P _{nom}	1500 W with input ≥ 150 Vac 1000 W with input ≤ 150 Vac		
Overvoltage protection range	0–44 V	0–88 V	0–220 V
Overcurrent protection range	0–66 A	0–66 A	0–27.5 A
Overpower protection range	0–1650 W	0–1650 W	0–1650 W
Output capacitance	5440 μF	5440 μF	800 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 / 73±9 °F)	< 0.1% U _{Nom}	< 0.1% U _{Nom}	< 0.1% U _{Nom}
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{Nom}	< 0.02% U _{Nom}	< 0.02% U _{Nom}
Load regulation at 0–100% load	< 0.05% U _{Nom}	< 0.05% U _{Nom}	< 0.05% U _{Nom}
Rise time 10–90%	Max. 30 ms	Max. 30 ms	Max. 30 ms
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}
Ripple ³	< 114 mV _{PP} < 8 mV _{RMS}	< 114 mV _{PP} < 8 mV _{RMS}	< 164 mV _{PP} < 34 mV _{RMS}
Remote sensing compensation	Max. 5% U _{Nom}	Max. 5% U _{Nom}	Max. 5% U _{Nom}
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	0–61.2 A	0–61.2 A	0–25.5 A
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{Nom}	< 0.2% I _{Nom}	< 0.2% I _{Nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{Nom}	< 0.05% I _{Nom}	< 0.05% I _{Nom}
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{Nom}	< 0.15% I _{Nom}	< 0.15% I _{Nom}
Ripple ³	< 5.6 mA _{RMS}	< 5.6 mA _{RMS}	< 1.3 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}

2U 1,500 W 100–240 Vac (a) cont'd		40 V : 60 A 310-02-0040-060	80 V : 60 A 310-02-0080-060	200 V : 25 A 310-02-0200-025
Power regulation				
Adjustment range	0–1530 W	0–1530 W	0–1530 W	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{Nom}	< 1% P _{Nom}	< 1% P _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.8% P _{Nom}	≤ 0.8% P _{Nom}	≤ 0.7% P _{Nom}	
Efficiency ⁴	≈ 92%	≈ 92%	≈ 93%	
Internal resistance regulation				
Adjustment range	0–20.4 Ω	0–40.8 Ω	0–244.8 Ω	
Accuracy ¹	≤ 1% of max. resistance ± 0.3% of maximum current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Analog interface ⁶				
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, OCP, OPP, PF, OT, DC on/off			
Galvanic isolation to the device	Max. 400 V DC			
Sample rate of inputs & outputs	500 Hz			
Insulation				
Output (DC) to enclosure (GND)	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 fans, front inlet, rear exhaust			
Ambient temperature	0–50 °C (32–122 °F)			
Storage temperature	-20–70 °C (-4–158 °F)			
Humidity	< 80%, not condensing			
Standards	EN 60950:2006 + A11: 2009 + A1:2010 + A12:2011 + AC:2011 + A2:2013 EN 61326-1:2013-07			
Overvoltage category	2			
Protection class	1			
Pollution degree	2			
Operational altitude	< 2000 m (1.242 mi)			
Digital interfaces				
Standard	1x USB-B for communication, 1x USB-A for functions			
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB			
Galvanic isolation from device	Max. 400 V DC			
Terminals				
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot			
Front side	USB-A			
Dimensions				
Enclosure (WxHxD)	19" x 2U x 463 mm (18.2")			
Total (WxHxD)	483 x 88 x min. 535 mm (19" x 3.5" x 21.1") (depending on DC out terminal type)			
Weight	≈ 12 kg (26.5 lb)	≈ 12 kg (26.5 lb)	≈ 12 kg (26.5 lb)	

2U 1,500 W 100–240 Vac (b)		360 V : 15 A 310-02-0360-015	500 V : 10 A 310-02-0500-010	750 V : 6 A 310-02-0750-006
AC Input				
Voltage range, frequency	150–264 Vac, 45–66 Hz to acheive maximum power output 100–150 Vac, 45–66 Hz yields derated 1000 W power output			
Connection	1ph,N,GND	1ph,N,GND	1ph,N,GND	
Fusing	T16 A	T16 A	T16 A	
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA	
Power factor	≈ 0.99	≈ 0.99	≈ 0.99	
DC Output				
Max. output voltage U _{nom}	360 V	500 V	750 V	
Max. output current I _{nom}	15 A	10 A	6 A	
Max. output power P _{nom}	1500 W with input ≥ 150 Vac 1000 W with input ≤ 150 Vac			
Overvoltage protection range	0–396 V	0–550 V	0–825 V	
Overcurrent protection range	0–16.5 A	0–11 A	0–6.6 A	
Overpower protection range	0–1650 W	0–1650 W	0–1650 W	
Output capacitance	330 µF	120 µF	40 µF	
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm			
Voltage regulation				
Adjustment range	0–367.2 V	0–510 V	0–765 V	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.1% U _{Nom}	< 0.1% U _{Nom}	< 0.1% U _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{Nom}	< 0.02% U _{Nom}	< 0.02% U _{Nom}	
Load regulation at 0–100% load	< 0.05% U _{Nom}	< 0.05% U _{Nom}	< 0.05% U _{Nom}	
Rise time 10–90%	Max. 30 ms	Max. 30 ms	Max. 30 ms	
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}	
Ripple ³	< 210 mV _{PP} < 59 mV _{RMS}	< 190 mV _{PP} < 48 mV _{RMS}	< 212 mV _{PP} < 60 mV _{RMS}	
Remote sensing compensation	Max. 5% U _{Nom}	Max. 5% U _{Nom}	Max. 5% U _{Nom}	
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	0–15.3 A	0–10.2 A	0–6.12 A	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{Nom}	< 0.2% I _{Nom}	< 0.2% I _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{Nom}	< 0.05% I _{Nom}	< 0.05% I _{Nom}	
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{Nom}	< 0.15% I _{Nom}	< 0.15% I _{Nom}	
Ripple ³	< 2.4 mA _{RMS}	< 0.7 mA _{RMS}	< 0.5 mA _{RMS}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}	

2U 1,500 W 100–240 Vac (b) cont'd		360 V : 15 A 310-02-0360-015	500 V : 10 A 310-02-0500-010	750 V : 6 A 310-02-0750-006
Power regulation				
Adjustment range	0–1530 W	0–1530 W	0–1530 W	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{Nom}	< 1% P _{Nom}	< 1% P _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.7% P _{Nom}	≤ 0.8% P _{Nom}	≤ 0.85% P _{Nom}	
Efficiency ⁴	≈ 93%	≈ 93%	≈ 93%	
Internal resistance regulation				
Adjustment range	0–734.4 Ω	0–1530 Ω	0–3825 Ω	
Accuracy ¹	≤ 1% of max. resistance ± 0.3% of maximum current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Analog interface ⁶				
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, OCP, OPP, PF, OT, DC on/off			
Galvanic isolation to the device	Max. 400 V DC			
Sample rate of inputs & outputs	500 Hz			
Insulation				
Output (DC) to enclosure (GND)	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 fans, front inlet, rear exhaust			
Ambient temperature	0–50 °C (32–122 °F)			
Storage temperature	-20–70 °C (-4–158 °F)			
Humidity	< 80%, not condensing			
Standards	EN 60950:2006 + A11: 2009 + A1:2010 + A12:2011 + AC:2011 + A2:2013 EN 61326-1:2013-07			
Overvoltage category	2			
Protection class	1			
Pollution degree	2			
Operational altitude	< 2000 m (1.242 mi)			
Digital interfaces				
Standard	1x USB-B for communication, 1x USB-A for functions			
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB			
Galvanic isolation from device	Max. 400 V DC			
Terminals				
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot			
Front side	USB-A			
Dimensions				
Enclosure (WxHxD)	19" x 2U x 463 mm (18.2")			
Total (WxHxD)	483 x 88 x min. 535 mm (19" x 3.5" x 21.1") (depending on DC out terminal type)			
Weight	≈ 12 kg (26.5 lb)	≈ 12 kg (26.5 lb)	≈ 12 kg (26.5 lb)	

13.5 MPW 310-12 : 2U, 3,000 Watt, 200–240 Vac 1ph

2U 3,000 W 200–240 Vac (a)	40 V : 120 A 310-12-0040-120	80 V : 120 A 310-12-0080-120	200 V : 50 A 310-12-0200-050
AC Input			
Input voltage, frequency	207–264 Vac, 45–66 Hz to acheive maximum power output 180–207 Vac, 45–66 Hz yields derated 2500 W power output		
Input connection	1ph,N,GND	1ph,N,GND	1ph,N,GND
Input fuse (internal)	T16 A	T16 A	T16 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	> 0.99	> 0.99	> 0.99
DC Output			
Max. output voltage U _{nom}	40 V	80 V	200 V
Max. output current I _{nom}	120 A	120 A	50 A
Max. output power P _{nom}	3000 W with input ≥ 207 Vac 2500 W with input ≤ 207 Vac		
Overvoltage protection range	0–44 V	0–88 V	0–220 V
Overcurrent protection range	0–132 A	0–132 A	0–55 A
Overpower protection range	0–3300 W	0–3300 W	0–3300 W
Output capacitance	10880 μF	10880 μF	1600 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 / 73±9 °F)	< 0.1% U _{Nom}	< 0.1% U _{Nom}	< 0.1% U _{Nom}
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{Nom}	< 0.02% U _{Nom}	< 0.02% U _{Nom}
Load regulation at 0–100% load	< 0.05% U _{Nom}	< 0.05% U _{Nom}	< 0.05% U _{Nom}
Rise time 10–90%	Max. 30 ms	Max. 30 ms	Max. 30 ms
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}
Ripple ³	< 114 mV _{PP} < 8 mV _{RMS}	< 114 mV _{PP} < 8 mV _{RMS}	< 164 mV _{PP} < 34 mV _{RMS}
Remote sensing compensation	Max. 5% U _{Nom}	Max. 5% U _{Nom}	Max. 5% U _{Nom}
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	0–122.4 A	0–122.4 A	0–51 A
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{Nom}	< 0.2% I _{Nom}	< 0.2% I _{Nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{Nom}	< 0.05% I _{Nom}	< 0.05% I _{Nom}
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{Nom}	< 0.15% I _{Nom}	< 0.15% I _{Nom}
Ripple ³	< 11 mA _{RMS}	< 11 mA _{RMS}	< 6.5 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}

2U 3,000 W 200–240 Vac (a) cont'd		40 V : 120 A 310-12-0040-120	80 V : 120 A 310-12-0080-120	200 V : 50 A 310-12-0200-050
Power regulation				
Adjustment range	0–3060 W	0–3060 W	0–3060 W	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{Nom}	< 1% P _{Nom}	< 1% P _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.8% P _{Nom}	≤ 0.8% P _{Nom}	≤ 0.85% P _{Nom}	
Efficiency ⁴	≈ 92%	≈ 92%	≈ 93%	
Internal resistance regulation				
Adjustment range	0–10.2 Ω	0–20.4 Ω	0–122.4 Ω	
Accuracy ¹	≤ 1% of max. resistance ± 0.3% of maximum current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Analog interface ⁶				
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, OCP, OPP, PF, OT, DC on/off			
Galvanic isolation to the device	Max. 400 V DC			
Sample rate of inputs & outputs	500 Hz			
Insulation				
Output (DC) to enclosure (GND)	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 fans, front inlet, rear exhaust			
Ambient temperature	0–50 °C (32–122 °F)			
Storage temperature	-20–70 °C (-4–158 °F)			
Humidity	< 80%, not condensing			
Standards	EN 60950:2006 + A11: 2009 + A1:2010 + A12:2011 + AC:2011 + A2:2013 EN 61326-1:2013-07			
Overvoltage category	2			
Protection class	1			
Pollution degree	2			
Operational altitude	< 2000 m (1.242 mi)			
Digital interfaces				
Standard	1x USB-B for communication, 1x USB-A for functions			
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB			
Galvanic isolation from device	Max. 400 V DC			
Terminals				
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot			
Front side	USB-A			
Dimensions				
Enclosure (WxHxD)	19" x 2U x 463 mm (18.2")			
Total (WxHxD)	483 x 88 x min. 535 mm (19" x 3.5" x 21.1") (depending on DC out terminal type)			
Weight	≈ 15 kg (33 lb)	≈ 15 kg (33 lb)	≈ 15 kg (33 lb)	

2U 3,000 W 200–240 Vac (b)		360 V : 30 A 310-12-0360-030	500 V : 20 A 310-12-0500-020	750 V : 12 A 310-12-0750-012
AC Input				
Input voltage, frequency	207–264 Vac, 45–66 Hz to acheive maximum power output 180–207 Vac, 45–66 Hz yields derated 2500 W power output			
Input connection	1ph,N,GND	1ph,N,GND	1ph,N,GND	
Input fuse (internal)	T16 A	T16 A	T16 A	
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA	
Power factor	> 0.99	> 0.99	> 0.99	
DC Output				
Max. output voltage U _{nom}	360 V	500 V	750 V	
Max. output current I _{nom}	30 A	20 A	12 A	
Max. output power P _{nom}	3000 W with input ≥ 207 Vac 2500 W with input ≤ 207 Vac			
Overvoltage protection range	0–396 V	0–550 V	0–825 V	
Overcurrent protection range	0–33 A	0–22 A	0–13.2 A	
Overpower protection range	0–3300 W	0–3300 W	0–3300 W	
Output capacitance	660 µF	240 µF	80 µF	
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm			
Voltage regulation				
Adjustment range	0–367.2 V	0–510 V	0–765 V	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.1% U _{Nom}	< 0.1% U _{Nom}	< 0.1% U _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{Nom}	< 0.02% U _{Nom}	< 0.02% U _{Nom}	
Load regulation at 0–100% load	< 0.05% U _{Nom}	< 0.05% U _{Nom}	< 0.05% U _{Nom}	
Rise time 10–90%	Max. 30 ms	Max. 30 ms	Max. 30 ms	
Settling time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}	≤ 0.2% U _{Nom}	
Ripple ³	< 210 mV _{PP} < 59 mV _{RMS}	< 190 mV _{PP} < 48 mV _{RMS}	< 212 mV _{PP} < 60 mV _{RMS}	
Remote sensing compensation	Max. 5% U _{Nom}	Max. 5% U _{Nom}	Max. 5% U _{Nom}	
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	0–30.6 A	0–20.4 A	0–12.24 A	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{Nom}	< 0.2% I _{Nom}	< 0.2% I _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{Nom}	< 0.05% I _{Nom}	< 0.05% I _{Nom}	
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{Nom}	< 0.15% I _{Nom}	< 0.15% I _{Nom}	
Ripple ³	< 5 mA _{RMS}	< 1.5 mA _{RMS}	< 0.9 mA _{RMS}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}	≤ 0.2% I _{Nom}	

2U 3,000 W 200–240 Vac (b) cont'd		360 V : 30 A 310-12-0360-030	500 V : 20 A 310-12-0500-020	750 V : 12 A 310-12-0750-012
Power regulation				
Adjustment range	0–3060 W	0–3060 W	0–3060 W	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{Nom}	< 1% P _{Nom}	< 1% P _{Nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	< 0.05% P _{Nom}	
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	< 0.75% P _{Nom}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.85% P _{Nom}	≤ 0.85% P _{Nom}	≤ 0.8% P _{Nom}	
Efficiency ⁴	≈ 93%	≈ 93%	≈ 93%	
Internal resistance regulation				
Adjustment range	0–367.2 Ω	0–765 Ω	0–1912.5 Ω	
Accuracy ¹	≤ 1% of max. resistance ± 0.3% of maximum current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Analog interface ⁶				
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, OCP, OPP, PF, OT, DC on/off			
Galvanic isolation to the device	Max. 400 V DC			
Sample rate of inputs & outputs	500 Hz			
Insulation				
Output (DC) to enclosure (GND)	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 fans, front inlet, rear exhaust			
Ambient temperature	0–50 °C (32–122 °F)			
Storage temperature	-20–70 °C (-4–158 °F)			
Humidity	< 80%, not condensing			
Standards	EN 60950:2006 + A11: 2009 + A1:2010 + A12:2011 + AC:2011 + A2:2013 EN 61326-1:2013-07			
Overvoltage category	2			
Protection class	1			
Pollution degree	2			
Operational altitude	< 2000 m (1.242 mi)			
Digital interfaces				
Standard	1x USB-B for communication, 1x USB-A for functions			
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB			
Galvanic isolation from device	Max. 400 V DC			
Terminals				
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot			
Front side	USB-A			
Dimensions				
Enclosure (WxHxD)	19" x 2U x 463 mm (18.2")			
Total (WxHxD)	483 x 88 x min. 535 mm (19" x 3.5" x 21.1") (depending on DC out terminal type)			
Weight	≈ 15 kg (33 lb)	≈ 15 kg (33 lb)	≈ 15 kg (33 lb)	

13.6 MPW 310-23 : 3U, 5,000 Watt, 208 Vac 2ph

3U 5,000 W 208 Vac	80 V : 170 A 310-23-0080-170	200 V : 70 A 310-23-0200-070	360 V : 40 A 310-23-0360-040	500 V : 30 A 310-23-0500-030	750 V : 20 A 310-23-0750-020
AC Input					
Voltage (L-L), Frequency	208 V, ± 10%, 45–65 Hz				
Connection	2ph,GND	2ph,GND	2ph,GND	2ph,GND	2ph,GND
Fusing (internal)	2x T32 A	2x T32 A	2x T32 A	2x T32 A	2x T32 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	> 0.99	> 0.99	> 0.99	> 0.99	> 0.99
DC Output					
Max. output voltage U _{nom}	80 V	200 V	360 V	500 V	750 V
Max. output current I _{nom}	170 A	70 A	40 A	30 A	20 A
Max. output power P _{nom}	5 kW	5 kW	5 kW	5 kW	5 kW
Overvoltage protection range	0–88 V	0–220 V	0–396 V	0–550 V	0–825 V
Overcurrent protection range	0–187 A	0–77 A	0–44 A	0–33 A	0–22 A
Overpower protection range	0–5.50 kW	0–5.50 kW	0–5.50 kW	0–5.50 kW	0–5.50 kW
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm				
Output capacitance (approx.)	8500 μF	2500 μF	400 μF	250 μF	100 μF
Voltage regulation					
Adjustment range	0–81.6 V	0–204 V	0–367.2 V	0–510 V	0–765 V
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}
Load regulation at 0–100% load	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}
Rise time 10–90% ΔU	Max. 30 ms	Max. 30 ms	Max. 30 ms	Max. 30 ms	Max. 30 ms
Transient time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				
Display: Accuracy ^{2,6}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}
Ripple ³	< 200 mV _{PP} < 16 mV _{RMS}	< 300 mV _{PP} < 40 mV _{RMS}	< 550 mV _{PP} < 65 mV _{RMS}	< 350 mV _{PP} < 70 mV _{RMS}	< 800 mV _{PP} < 200 mV _{RMS}
Remote sensing compensation	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}
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	0–173.4 A	0–71.4 A	0–40.8 A	0–30.6 A	0–20.4 A
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}
Ripple ³	< 80 mA _{RMS}	< 22 mA _{RMS}	< 5.2 mA _{RMS}	< 16 mA _{RMS}	< 16 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				
Display: Accuracy ^{2,6}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}
Internal resistance regulation					
Adjustment range	0–14 Ω	0–85 Ω	0–270 Ω	0–500 Ω	0–1125 Ω
Accuracy ¹	≤2% of max. resistance ± 0.3% of rated current				
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				

3U 5,000 W 208 Vac cont'd	80 V : 170 A 310-23-0080-170	200 V : 70 A 310-23-0200-070	360 V : 40 A 310-23-0360-040	500 V : 30 A 310-23-0500-030	750 V : 20 A 310-23-0750-020
Power regulation					
Adjustment range	0–5.1 kW	0–5.1 kW	0–5.1 kW	0–5.1 kW	0–5.1 kW
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				
Display: Accuracy ^{2,6}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}
Efficiency ⁴	~ 93%	~ 95%	~ 95%	~ 95,5%	~ 94%
Analog interface ⁶					
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				
Galvanic isolation to the device	Max. 1500 V DC				
Sample rate of inputs & outputs	500 Hz				
Insulation ⁵					
Negative terminal to GND max.	±400 V DC	±725 V DC	±725 V DC	±1500V DC	±1500V DC
Positive terminal to GND max/	±400 V DC	±1000 V DC	±1000 V DC	±1800 V DC	±1800 V DC
AC input <-> GND	2.5 kV DC				
AC input <-> DC output	2.5 kV DC				
Miscellaneous					
Cooling	Temperature controlled fans, front inlet, rear exhaust				
Ambient temperature	0..50 °C (32–122 °F)				
Storage temperature	-20–70 °C (-4–158 °F)				
Humidity	< 80%, not condensing				
Standards	IEC 61010:2010 EMC TÜV approved acc. IEC 61000-6-2:2005 and IEC 61000-6-3:2006 Class B				
Overvoltage category	2				
Protection class	1				
Pollution degree	2				
Operational altitude	< 2000 m (1.242 mi)				
Digital interfaces					
Standard	1x USB-B for communication, 1x USB-A for functions				
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB				
Galvanic isolation from device	Max. 1500 V DC				
Terminals					
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot				
Front side	USB-A				
Dimensions					
Enclosure (WxHxD)	19" x 3U x 682 mm (26.8")				
Total (WxHxD)	483 x 133 x 787 mm (19" x 5.2" x 31")				
Weight	~ 17 kg (37.5 lb)	~ 17 kg (37.5 lb)	~ 17 kg (37.5 lb)	~ 17 kg (37.5 lb)	~ 17 kg (37.5 lb)

13.7 MPW 310-43 : 3U, 10,000 Watt, 208 Vac 3ph

3U 10,000 W 208 Vac (a)	80 V : 340 A 310-43-0080-340	200 V : 140 A 310-43-0200-140	360 V : 80 A 310-43-0360-080
AC Input			
Voltage (L-L)	208 V, ± 10%; 45–66 Hz		
Connection	3ph,GND	3ph,GND	3ph,GND
Fusing (internal)	4x T32 A	4x T32 A	4x T32 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	> 0.99	> 0.99	> 0.99
DC Output			
Max. output voltage U _{nom}	80 V	200 V	360 V
Max. output current I _{nom}	340 A	140 A	80 A
Max. output power P _{nom}	10 kW	10 kW	10 kW
Overvoltage protection range	0–88 V	0–220 V	0–396 V
Overcurrent protection range	0–374 A	0–154 A	0–88 A
Overpower protection range	0–11.00 kW	0–11.00 kW	0–11.00 kW
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm		
Output capacitance (approx.)	16900 μF	5040 μF	800 μF
Voltage regulation			
Adjustment range	0–81.6 V	0–204 V	0–367.2 V
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}
Line regulation at ±10% ΔUAC	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}
Load regulation at 0–100% load	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}
Rise time 10–90% ΔU	Max. 30 ms	Max. 30 ms	Max. 30 ms
Transient time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}
Ripple ³	< 320 mV _{PP} < 25 mV _{RMS}	< 300 mV _{PP} < 40 mV _{RMS}	< 550 mV _{PP} < 65 mV _{RMS}
Remote sensing compensation	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}
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	0–348.8 A	0–142.8 A	0–81.6 A
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}
Line regulation at ±10% ΔUAC	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}
Load regulation at 0–100% ΔUOUT	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}
Ripple ³	< 160 mA _{RMS}	< 44 mA _{RMS}	< 10.4 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}
Internal resistance regulation			
Adjustment range	0–7 Ω	0–42 Ω	0–135 Ω
Accuracy ¹	≤2% of max. resistance ± 0.3% of rated current		
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		

3U 10,000 W 208 Vac (a) cont'd	80 V : 340 A 310-43-0080-340	200 V : 140 A 310-43-0200-140	360 V : 80 A 310-43-0360-080
Power regulation			
Adjustment range	0–10.2 kW	0–10.2 kW	0–10.2 kW
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}
Line regulation at ±10% ΔUAC	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}
Load reg. at 10-90% ΔUOUT * ΔIOUT	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.8% P _{nom}	≤ 0.85% P _{nom}	≤ 0.8% P _{nom}
Efficiency ⁴	~ 93%	~ 95%	~ 93%
Analog interface ⁶			
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		
Galvanic isolation to the device	Max. 1500 V DC		
Sample rate of inputs & outputs	500 Hz		
Insulation ⁵			
Negative terminal to GND max.	±400 V DC	±725 V DC	±725 V DC
Positive terminal to GND max.	±400 V DC	±1000 V DC	±1000 V DC
AC input <-> GND	2.5 kV DC		
AC input <-> DC output	2.5 kV DC		
Miscellaneous			
Cooling	Temperature controlled fans, front inlet, rear exhaust		
Ambient temperature	0..50 °C (32–122 °F)		
Storage temperature	-20–70 °C (-4–158 °F)		
Humidity	< 80%, not condensing		
Standards	IEC 61010:2010 EMC TÜV approved acc. IEC 61000-6-2:2005 and IEC 61000-6-3:2006 Class B		
Overvoltage category	2		
Protection class	1		
Pollution degree	2		
Operational altitude	< 2000 m (1.242 mi)		
Digital interfaces			
Standard	1x USB-B for communication, 1x USB-A for functions		
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB		
Galvanic isolation from device	Max. 1500 V DC		
Terminals			
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot		
Front side	USB-A		
Dimensions			
Enclosure (WxHxD)	19" x 3U x 682 mm (26.8")		
Total (WxHxD)	483 x 133 x 787 mm (19" x 5.2" x 31")		
Weight	~ 24 kg (52.9 lb)	~ 24 kg (52.9 lb)	~ 24 kg (52.9 lb)

3U 10,000 W 208 Vac (b)		500 V : 60 A 310-43-0500-060	750 V : 40 A 3410-3-0750-040	1000 V : 30 A 310-43-1000-030
AC Input				
Voltage (L-L)	208 V, ± 10%; 45–66 Hz			
Connection	3ph,GND	3ph,GND	3ph,GND	
Fusing (internal)	4x T32 A	4x T32 A	4x T32 A	
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA	
Power factor	> 0.99	> 0.99	> 0.99	
DC Output				
Max. output voltage U _{nom}	500 V	750 V	1000 V	
Max. output current I _{nom}	60 A	40 A	30 A	
Max. output power P _{nom}	10 kW	10 kW	10 kW	
Overvoltage protection range	0–550 V	0–825 V	0–1100 V	
Overcurrent protection range	0–66 A	0–44 A	0–33 A	
Overpower protection range	0–11.00 kW	0–11.00 kW	0–11.00 kW	
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm			
Output capacitance (approx.)	500 μF	210 μF	127 μF	
Voltage regulation				
Adjustment range	0–510 V	0–765 V	0–1020 V	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}	
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}	
Load regulation at 0–100% load	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}	
Rise time 10–90% ΔU	Max. 30 ms	Max. 30 ms	Max. 30 ms	
Transient time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	
Ripple ³	< 350 mV _{PP} < 70 mV _{RMS}	< 800 mV _{PP} < 200 mV _{RMS}	< 1600 mV _{PP} < 350 mV _{RMS}	
Remote sensing compensation	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}	
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	0–61.2 A	0–40.8 A	0–30.6 A	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}	
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}	
Ripple ³	< 32 mA _{RMS}	< 32 mA _{RMS}	< 22 mA _{RMS}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	
Internal resistance regulation				
Adjustment range	0–250 Ω	0–562 Ω	0–1000 Ω	
Accuracy ¹	≤2% of max. resistance ± 0.3% of rated current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			

3U 10,000 W 208 Vac (b) cont'd	500 V : 60 A 310-43-0500-060	750 V : 40 A 310-43-0750-040	1000 V : 30 A 310-43-1000-030
Power regulation			
Adjustment range	0–10.2 kW	0–10.2 kW	0–10.2 kW
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.85% P _{nom}	≤ 0.85% P _{nom}	≤ 0.85% P _{nom}
Efficiency ⁴	~ 95%	~ 94%	~ 95%
Analog interface ⁶			
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		
Galvanic isolation to the device	Max. 1500 V DC		
Sample rate of inputs & outputs	500 Hz		
Insulation ⁵			
Negative terminal to GND max.	±1500V DC	±1500V DC	±1500V DC
Positive terminal to GND max.	±1800 V DC	±1800 V DC	±1800 V DC
AC input <-> GND	2.5 kV DC		
AC input <-> DC output	2.5 kV DC		
Miscellaneous			
Cooling	Temperature controlled fans, front inlet, rear exhaust		
Ambient temperature	0..50 °C (32–122 °F)		
Storage temperature	-20–70 °C (-4–158 °F)		
Humidity	< 80%, not condensing		
Standards	IEC 61010:2010 EMC TÜV approved acc. IEC 61000-6-2:2005 and IEC 61000-6-3:2006 Class B		
Overvoltage category	2		
Protection class	1		
Pollution degree	2		
Operational altitude	< 2000 m (1.242 mi)		
Digital interfaces			
Standard	1x USB-B for communication, 1x USB-A for functions		
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB		
Galvanic isolation from device	Max. 1500 V DC		
Terminals			
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot		
Front side	USB-A		
Dimensions			
Enclosure (WxHxD)	19" x 3U x 682 mm (26.8")		
Total (WxHxD)	483 x 133 x 787 mm (19" x 5.2" x 31")		
Weight	~ 24 kg (52.9 lb)	~ 24 kg (52.9 lb)	~ 24 kg (52.9 lb)

13.8 MPW 310-43 : 3U, 15,000 Watt, 208 Vac 3ph

320 Series slave model specs are essentially identical to these 310 Series model counterparts, except that slave models do not have a display, analog interface, or optional digital interfaces, and the front USB port is type B.

3U 15,000 W 208 Vac (a)	80 V : 510 A 310-43-0080-510	200 V : 210 A 310-43-0200-210	360 V : 120 A 310-43-0360-120	500 V : 90 A 310-43-0500-090
AC Input				
Voltage (L-L)	208 V, ± 10%; 45–66 Hz			
Connection	3ph,GND	3ph,GND	3ph,GND	3ph,GND
Fusing (internal)	6x T32 A	6x T32 A	6x T32 A	6x T32 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	> 0.99	> 0.99	> 0.99	> 0.99
DC Output				
Max. output voltage U _{nom}	80 V	200 V	360 V	500 V
Max. output current I _{nom}	510 A	210 A	120 A	90 A
Max. output power P _{nom}	15 kW	15 kW	15 kW	15 kW
Overvoltage protection range	0–88 V	0–220 V	0–396 V	0–550 V
Overcurrent protection range	0–561 A	0–231 A	0–132 A	0–99 A
Overpower protection range	0–16.50 kW	0–16.50 kW	0–16.50 kW	0–16.50 kW
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm			
Output capacitance (approx.)	25380 μF	7560 μF	1200 μF	760 μF
Voltage regulation				
Adjustment range	0–81.6 V	0–204 V	0–367.2 V	0–510 V
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}
Load regulation at 0–100% load	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}
Rise time 10–90% ΔU	Max. 30 ms	Max. 30 ms	Max. 30 ms	Max. 30 ms
Transient time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}
Ripple ³	< 320 mV _{PP} < 25 mV _{RMS}	< 300 mV _{PP} < 40 mV _{RMS}	< 550 mV _{PP} < 65 mV _{RMS}	< 350 mV _{PP} < 70 mV _{RMS}
Remote sensing compensation	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}
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	0–520.2 A	0–214.2 A	0–122.4 A	0–91.8 A
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}
Ripple ³	< 240 mA _{RMS}	< 66 mA _{RMS}	< 15.6 mA _{RMS}	< 48 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}
Internal resistance regulation				
Adjustment range	0–5 Ω	0–28 Ω	0–90 Ω	0–166 Ω
Accuracy ¹	≤2% of max. resistance ± 0.3% of rated current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			

3U 15,000 W 208 Vac (a)	80 V : 510 A 310-43-0080-510	200 V : 210 A 310-43-0200-210	360 V : 120 A 310-43-0360-120	500 V : 90 A 310-43-0500-090
Power regulation				
Adjustment range	0–15.3 kW	0–15.3 kW	0–15.3 kW	0–15.3 kW
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}	≤ 0.85% P _{nom}	≤ 0.85% P _{nom}
Efficiency ⁴	~ 93%	~ 95%	~ 94%	~ 95%
Analog interface ⁵				
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			
Galvanic isolation to the device	Max. 1500 V DC			
Sample rate of inputs & outputs	500 Hz			
Insulation ⁵				
Negative terminal to GND max.	±400 V DC	±725 V DC	±725 V DC	±1500V DC
Positive terminal to GND max.	±400 V DC	±1000 V DC	±1000 V DC	±1800 V DC
AC input <-> GND	2.5 kV DC			
AC input <-> DC output	2.5 kV DC			
Miscellaneous				
Cooling	Temperature controlled fans, front inlet, rear exhaust			
Ambient temperature	0..50 °C (32–122 °F)			
Storage temperature	-20–70 °C (-4–158 °F)			
Humidity	< 80%, not condensing			
Standards	IEC 61010:2010 EMC TÜV approved acc. IEC 61000-6-2:2005 and IEC 61000-6-3:2006 Class B			
Overvoltage category	2			
Protection class	1			
Pollution degree	2			
Operational altitude	< 2000 m (1.242 mi)			
Digital interfaces				
Standard	1x USB-B for communication, 1x USB-A for functions			
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB			
Galvanic isolation from device	Max. 1500 V DC			
Terminals				
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot			
Front side	USB-A			
Dimensions				
Enclosure (WxHxD)	19" x 3U x 682 mm (26.8")			
Total (WxHxD)	483 x 133 x 787 mm (19" x 5.2" x 31")			
Weight	~ 30 kg (66.1 lb)	~ 30 kg (66.1 lb)	~ 30 kg (66.1 lb)	~ 30 kg (66.1 lb)

3U 15,000 W 208 Vac (b)		750 V : 60 A 310-43-0750-060	1500 V : 30 A 310-43-1500-030
AC Input			
Voltage (L-L)	208 V, ± 10%; 45–66 Hz		
Connection	3ph,GND	3ph,GND	
Fusing (internal)	6x T32 A	6x T32 A	
Leak current	< 3.5 mA	< 3.5 mA	
Power factor	> 0.99	> 0.99	
DC Output			
Max. output voltage U _{nom}	750 V	1500 V	
Max. output current I _{nom}	60 A	30 A	
Max. output power P _{nom}	15 kW	15 kW	
Overvoltage protection range	0–825 V	0–1650 V	
Overcurrent protection range	0–66 A	0–33 A	
Overpower protection range	0–16.50 kW	0–16.50 kW	
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm		
Output capacitance (approx.)	310 μF	84 μF	
Voltage regulation			
Adjustment range	0–765 V	0–1530 V	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.1% U _{nom}	< 0.1% U _{nom}	
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{nom}	< 0.02% U _{nom}	
Load regulation at 0–100% load	< 0.05% U _{nom}	< 0.05% U _{nom}	
Rise time 10–90% ΔU	Max. 30 ms	Max. 30 ms	
Transient time after load step	< 1.5 ms	< 1.5 ms	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	
Ripple ³	< 800 mV _{PP} < 200 mV _{RMS}	< 2400 mV _{PP} < 400 mV _{RMS}	
Remote sensing compensation	Max. 5% U _{nom}	Max. 5% U _{nom}	
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	0–61.2 A	0–30.6 A	
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 0.2% I _{nom}	< 0.2% I _{nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{nom}	< 0.05% I _{nom}	
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{nom}	< 0.15% I _{nom}	
Ripple ³	< 48 mA _{RMS}	< 26 mA _{RMS}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	
Internal resistance regulation			
Adjustment range	0–375 Ω	0–1500 Ω	
Accuracy ¹	≤2% of max. resistance ± 0.3% of rated current		
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		

3U 15,000 W 208 Vac (b) cont'd	750 V : 60 A 310-43-0750-060	1500 V : 30 A 310-43-1500-030
Power regulation		
Adjustment range	0–15.3 kW	0–15.3 kW
Accuracy ¹ (at 23±5 °C / 73±9 °F)	< 1% P _{nom}	< 1% P _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{nom}	< 0.05% P _{nom}
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{nom}	< 0.75% P _{nom}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values	
Display: Accuracy ^{2,6}	≤ 0.85% P _{nom}	≤ 0.85% P _{nom}
Efficiency ⁴	~ 94%	~ 95%
Analog interface⁶		
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	
Galvanic isolation to the device	Max. 1500 V DC	
Sample rate of inputs & outputs	500 Hz	
Insulation⁵		
Negative terminal to GND max.	±1500V DC	±1500V DC
Positive terminal to GND max.	±1800 V DC	±1800 V DC
AC input <-> GND	2.5 kV DC	
AC input <-> DC output	2.5 kV DC	
Miscellaneous		
Cooling	Temperature controlled fans, front inlet, rear exhaust	
Ambient temperature	0..50 °C (32–122 °F)	
Storage temperature	-20–70 °C (-4–158 °F)	
Humidity	< 80%, not condensing	
Standards	IEC 61010:2010 EMC TÜV approved acc. IEC 61000-6-2:2005 and IEC 61000-6-3:2006 Class B	
Overvoltage category	2	
Protection class	1	
Pollution degree	2	
Operational altitude	< 2000 m (1.242 mi)	
Digital interfaces		
Standard	1x USB-B for communication, 1x USB-A for functions	
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB	
Galvanic isolation from device	Max. 1500 V DC	
Terminals		
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot	
Front side	USB-A	
Dimensions		
Enclosure (WxHxD)	19" x 3U x 682 mm (26.8")	
Total (WxHxD)	483 x 133 x 787 mm (19" x 5.2" x 31")	
Weight	~ 30 kg (66.1 lb)	~ 30 kg (66.1 lb)

13.9 MPW 310-33 : 3U, 5,000 Watt, 380–480 Vac 2ph

3U 5,000 W 380–480 Vac	80 V : 170 A 310-33-0080-170	200 V : 70 A 310-33-0200-070	360 V : 40 A 310-33-0360-040	500 V : 30 A 310-33-0500-030	750 V : 20 A 310-33-0750-020
AC Input					
Voltage (L-L)	342–528 Vac; 45–66 Hz				
Connection	2ph, GND	2ph, GND	2ph, GND	2ph, GND	2ph,GND
Fusing (internal)	2x T16 A	2x T16 A	2x T16 A	2x T16 A	2x T16 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	> 0.99	> 0.99	> 0.99	> 0.99	> 0.99
DC Output					
Max. output voltage U _{nom}	80 V	200 V	360 V	500 V	750 V
Max. output current I _{nom}	170 A	70 A	40 A	30 A	20 A
Max. output power P _{nom}	5 kW	5 kW	5 kW	5 kW	5 kW
Overvoltage protection range	0–88 V	0–220 V	0–396 V	0–550 V	0–825 V
Overcurrent protection range	0–187 A	0–77 A	0–44 A	0–33 A	0–22 A
Overpower protection range	0–5.5 kW	0–5.5 kW	0–5.5 kW	0–5.5 kW	0–5.5 kW
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm				
Output capacitance (approx.)	8500 μF	2500 μF	400 μF	250 μF	100 μF
Voltage regulation					
Adjustment range	0–81.6 V	0–204 V	0–367.2 V	0–510 V	0–765 V
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}
Load regulation at 0–100% load	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}
Rise time 10–90% ΔU	Max. 30 ms	Max. 30 ms	Max. 30 ms	Max. 30 ms	Max. 30 ms
Transient time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				
Display: Accuracy ^{2,6}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}
Ripple ³	< 200 mV _{PP} < 16 mV _{RMS}	< 300 mV _{PP} < 40 mV _{RMS}	< 550 mV _{PP} < 65 mV _{RMS}	< 350 mV _{PP} < 70 mV _{RMS}	< 800 mV _{PP} < 200 mV _{RMS}
Remote sensing compensation	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}
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	0–173.4 A	0–71.4 A	0–40.8 A	0–30.6 A	0–20.4 A
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}
Ripple ³	< 80 mA _{RMS}	< 22 mA _{RMS}	< 5 mA _{RMS}	< 16 mA _{RMS}	< 16 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				
Display: Accuracy ^{2,6}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}
Internal resistance regulation					
Adjustment range	0–14.28 Ω	0–86.7 Ω	0–275.4 Ω	0–510 Ω	0–1147.5 Ω
Accuracy ¹	≤1% of max. resistance ± 0.3% of maximum current				
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				

3U 5,000 W 380–480 Vac cont'd	80 V : 170 A 310-33-0080-170	200 V : 70 A 310-33-0200-070	360 V : 40 A 310-33-0360-040	500 V : 30 A 310-33-0500-030	750 V : 20 A 310-33-0750-020
Power regulation					
Adjustment range	0–5.1 kW	0–5.1 kW	0–5.1 kW	0–5.1 kW	0–5.1 kW
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				
Display: Accuracy ^{2,6}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}
Efficiency ⁴	≈ 93%	≈ 95%	≈ 95%	≈ 95,5%	≈ 94%
Analog interface ⁶					
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, PF				
Galvanic isolation to the device	≤725 V DC	≤725 V DC	≤725 V DC	≤1500 V DC	≤1500 V DC
Sample rate of inputs & outputs	500 Hz				
Insulation ⁵					
Negative terminal to GND max.	±400 V DC	±725 V DC	±725 V DC	±1500 V DC	±1500 V DC
Positive terminal to GND max.	±400 V DC	±1000 V DC	±1000 V DC	±1800 V DC	±1800 V DC
AC input <-> GND	2.5 kV DC				
AC input <-> DC output	2.5 kV DC				
Miscellaneous					
Cooling	Temperature controlled fans, front inlet, rear exhaust				
Ambient temperature	0–50 °C (32–133 °F)				
Storage temperature	-20–70 °C (-4–158 °F)				
Humidity	< 80%, not condensing				
Standards	EN 61010-1:2007-11, EN 61000-6-2:2016-05, EN 61000-6-3:2011-09 Class B				
Overvoltage category	2				
Protection class	1				
Pollution degree	2				
Digital interfaces					
Standard	1x USB-B for communication, 1x USB-A for functions				
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB				
Galvanic isolation from device	≤725 V DC	≤725 V DC	≤725 V DC	≤1500 V DC	≤1500 V DC
Terminals					
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, interface module slot				
Front side	USB-A				
Dimensions					
Enclosure (WxHxD)	19" x 3U x 670 mm (26.4")				
Total (WxHxD)	483 x 133 x 775 mm (19" x 5.2" x 30.5")				
Weight	≈18 kg (39.7 lb)	≈18 kg (39.7 lb)	≈18 kg (39.7 lb)	≈18 kg (39.7 lb)	≈18 kg (39.7 lb)

13.10 MPW 310-53 : 3U, 10,000 Watt, 380–480 Vac 3ph

3U 10,000 W 380–480 Vac	80 V : 340 A 310-53-0080-340	200 V : 140 A 310-53-0200-140	360 V : 80 A 310-53-0360-080	500 V : 60 A 310-53-0500-060	750 V : 40 A 310-53-0750-040
AC Input					
Voltage (L-L)	342–528 Vac; 45–66 Hz				
Connection	3ph,GND	3ph,GND	3ph,GND	3ph,GND	3ph,GND
Fusing (internal)	4x T16 A	4x T16 A	4x T16 A	4x T16 A	4x T16 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	> 0.99	> 0.99	> 0.99	> 0.99	> 0.99
DC Output					
Max. output voltage U _{nom}	80 V	200 V	360 V	500 V	750 V
Max. output current I _{nom}	340 A	140 A	80 A	60 A	40 A
Max. output power P _{nom}	10 kW	10 kW	10 kW	10 kW	10 kW
Overvoltage protection range	0–88 V	0–220 V	0–396 V	0–550 V	0–825 V
Overcurrent protection range	0–374 A	0–154 A	0–88 A	0–66 A	0–44 A
Overpower protection range	0–11 kW	0–11 kW	0–11 kW	0–11 kW	0–11 kW
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm				
Output capacitance (approx.)	16900 μF	5040 μF	800 μF	500 μF	210 μF
Voltage regulation					
Adjustment range	0–81.6 V	0–204 V	0–367.2 V	0–510 V	0–785 V
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}
Load regulation at 0–100% load	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}
Rise time 10–90% ΔU	Max. 30 ms	Max. 30 ms	Max. 30 ms	Max. 30 ms	Max. 30 ms
Transient time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				
Display: Accuracy ^{2,6}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}
Ripple ³	< 320 mV _{PP} < 25 mV _{RMS}	< 300 mV _{PP} < 40 mV _{RMS}	< 550 mV _{PP} < 65 mV _{RMS}	< 350 mV _{PP} < 70 mV _{RMS}	< 800 mV _{PP} < 200 mV _{RMS}
Remote sensing compensation	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}
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	0–346.8 A	0–142.8 A	0–81.6 A	0–61.2 A	0–40.8 A
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}
Ripple ³	< 160 mA _{RMS}	< 44 mA _{RMS}	< 11 mA _{RMS}	< 32 mA _{RMS}	< 32 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				
Display: Accuracy ^{2,6}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}
Internal resistance regulation					
Adjustment range	0–7.14 Ω	0–42.84 Ω	0–137.7 Ω	0–255 Ω	0–573.24 Ω
Accuracy ¹	≤1% of max. resistance ± 0.3% of maximum current				
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				

3U 10,000 W 380–480 Vac cont'd	80 V : 340 A 310-53-0080-340	200 V : 140 A 310-53-0200-140	360 V : 80 A 310-53-0360-080	500 V : 60 A 310-53-0500-060	750 V : 40 A 310-53-0750-040
Power regulation					
Adjustment range	0–10.2 kW	0–10.2 kW	0–10.2 kW	0–10.2 kW	0–10.2 kW
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 1% P _{nom}	< 1% P _{nom}	< 1.2% P _{nom}	< 1% P _{nom}	< 1% P _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values				
Display: Accuracy ^{2,6}	≤ 0.8% P _{nom}	≤ 0.85% P _{nom}	≤ 0.8% P _{nom}	≤ 0.85% P _{nom}	≤ 0.85% P _{nom}
Efficiency ⁴	≈ 93%	≈ 95%	≈ 93%	≈ 95%	≈ 94%
Analog interface ⁶					
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, OCP, OPP, OT, PF, DC output on/off				
Galvanic isolation to the device	≤725 V DC	≤725 V DC	≤725 V DC	≤1500 V DC	≤1500 V DC
Sample rate of inputs & outputs	500 Hz				
Insulation ⁵					
Negative terminal to GND max.	±400 V DC	±725 V DC	±725 V DC	±1500 V DC	±1500 V DC
Positive terminal to GND max.	±400 V DC	±1000 V DC	±1000 V DC	±1800 V DC	±1800 V DC
AC input <-> GND	2.5 kV DC				
AC input <-> DC output	2.5 kV DC				
Miscellaneous					
Cooling	Temperature controlled fans, front inlet, rear exhaust				
Ambient temperature	0–50 °C (32–133 °F)				
Storage temperature	-20–70 °C (-4–158 °F)				
Humidity	< 80%, not condensing				
Standards	EN 61010-1:2007-11, EN 61000-6-2:2016-05, EN 61000-6-3:2011-09 Class B				
Overvoltage category	2				
Protection class	1				
Pollution degree	2				
Digital interfaces					
Standard	1x USB-B for communication, 1x USB-A for functions				
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB				
Galvanic isolation from device	≤725 V DC	≤725 V DC	≤725 V DC	≤1500 V DC	≤1500 V DC
Terminals					
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot				
Front side	USB-A				
Dimensions					
Enclosure (WxHxD)	19" x 3U x 670 mm (26.4")				
Total (WxHxD)	483 x 133 x 775 mm (19" x 5.2" x 30.5")				
Weight	≈25 kg (55.1 lb)	≈25 kg (55.1 lb)	≈25 kg (55.1 lb)	≈25 kg (55.1 lb)	≈25 kg (55.1 lb)

13.11 MPW 310-53 : 3U, 15,000 Watt, 380–480 Vac 3ph

320 Series slave model specs are essentially identical to these 310 Series model counterparts, except that slave models do not have a display, analog interface, or optional digital interfaces, and the front USB port is type B.

3U 15,000 W 380–480 Vac (a)	80 V : 510 A 310-53-0080-510	200 V : 210 A 310-53-0200-210	360 V : 120 A 310-53-0360-120	500 V : 90 A 310-53-0500-090
AC Input				
Voltage (L-L)	342–528 Vac, 45–66 Hz			
Connection	3ph,GND	3ph,GND	3ph,GND	3ph,GND
Fusing (internal)	6x T16 A	6x T16 A	6x T16 A	6x T16 A
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA	< 3.5 mA
Power factor	> 0.99	> 0.99	> 0.99	> 0.99
DC Output				
Max. output voltage U_{nom}	80 V	200 V	360 V	500 V
Max. output current I_{nom}	510 A	210 A	120 A	90 A
Max. output power P_{nom}	15 kW	15 kW	15 kW	15 kW
Overvoltage protection range	0–88 V	0–220 V	0–396 V	0–550 V
Overcurrent protection range	0–561 A	0–231 A	0–132 A	0–99 A
Overpower protection range	0–16.5 kW	0–16.5 kW	0–16.5 kW	0–16.5 kW
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm			
Output capacitance (approx.)	25380 μ F	7560 μ F	1200 μ F	760 μ F
Voltage regulation				
Adjustment range	0–81.6 V	0–204 V	0–367.2 V	0–510 V
Accuracy ¹ (at 23 \pm 5°C / 73 \pm 9°F)	< 0.1% U_{nom}	< 0.1% U_{nom}	< 0.1% U_{nom}	< 0.1% U_{nom}
Line regulation at \pm 10% ΔU_{AC}	< 0.02% U_{nom}	< 0.02% U_{nom}	< 0.02% U_{nom}	< 0.02% U_{nom}
Load regulation at 0–100% load	< 0.05% U_{nom}	< 0.05% U_{nom}	< 0.05% U_{nom}	< 0.05% U_{nom}
Rise time 10–90% ΔU	Max. 30 ms	Max. 30 ms	Max. 30 ms	Max. 30 ms
Transient time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms	< 1.5 ms
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	\leq 0.2% U_{nom}	\leq 0.2% U_{nom}	\leq 0.2% U_{nom}	\leq 0.2% U_{nom}
Ripple ³	< 320 mV _{PP} < 25 mV _{RMS}	< 300 mV _{PP} < 40 mV _{RMS}	< 550 mV _{PP} < 65 mV _{RMS}	< 350 mV _{PP} < 70 mV _{RMS}
Remote sensing compensation	Max. 5% U_{nom}	Max. 5% U_{nom}	Max. 5% U_{nom}	Max. 5% U_{nom}
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	0–520.2 A	0–214.2 A	0–122.4 A	0–91.8 A
Accuracy ¹ (at 23 \pm 5°C / 73 \pm 9°F)	< 0.2% I_{nom}	< 0.2% I_{nom}	< 0.2% I_{nom}	< 0.2% I_{nom}
Line regulation at \pm 10% ΔU_{AC}	< 0.05% I_{nom}	< 0.05% I_{nom}	< 0.05% I_{nom}	< 0.05% I_{nom}
Load regulation at 0–100% ΔU_{OUT}	< 0.15% I_{nom}	< 0.15% I_{nom}	< 0.15% I_{nom}	< 0.15% I_{nom}
Ripple ³	< 240 mA _{RMS}	< 66 mA _{RMS}	< 16 mA _{RMS}	< 48 mA _{RMS}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	\leq 0.2% I_{nom}	\leq 0.2% I_{nom}	\leq 0.2% I_{nom}	\leq 0.2% I_{nom}
Internal resistance regulation				
Adjustment range	0–5.1 Ω	0–28.56 Ω	0–91.8 Ω	0–169.32 Ω
Accuracy ¹	\leq 1% of max. resistance \pm 0.3% of maximum current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			

3U 15,000 W 380–480 Vac (a) cont'd	80 V : 510 A 310-53-0080-510	200 V : 210 A 310-53-0200-210	360 V : 120 A 310-53-0360-120	500 V : 90 A 310-53-0500-090
Power regulation				
Adjustment range	0–15.3 kW	0–15.3 kW	0–15.3 kW	0–15.3 kW
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.8% P _{nom}	≤ 0.8% P _{nom}	≤ 0.85% P _{nom}	≤ 0.85% P _{nom}
Efficiency ⁴	≈ 93%	≈ 95%	≈ 94%	≈ 95%
Analog interface ⁶				
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, OCP, OPP, OT, PF, DC output on/off			
Galvanic isolation to the device	≤725 V DC	≤725 V DC	≤725 V DC	≤1500 V DC
Sample rate of inputs & outputs	500 Hz			
Insulation ⁵				
Negative terminal to GND max.	±400 V DC	±725 V DC	±725 V DC	±1500 V DC
Positive terminal to GND max.	±400 V DC	±1000 V DC	±1000 V DC	±1800 V DC
AC input <-> GND	2.5 kV DC			
AC input <-> DC output	2.5 kV DC			
Miscellaneous				
Cooling	Temperature controlled fans, front inlet, rear exhaust			
Ambient temperature	0–50 °C (32–133 °F)			
Storage temperature	-20–70 °C (-4–158 °F)			
Humidity	< 80%, not condensing			
Standards	EN 61010-1:2007-11, EN 61000-6-2:2016-05, EN 61000-6-3:2011-09 Class B			
Overvoltage category	2			
Protection class	1			
Pollution degree	2			
Digital interfaces				
Standard	1x USB-B for communication, 1x USB-A for functions			
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB			
Galvanic isolation from device	≤725 V DC	≤725 V DC	≤725 V DC	≤1500 V DC
Terminals				
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot			
Front side	USB-A			
Dimensions				
Enclosure (WxHxD)	19" x 3U x 670 mm (26.4")			
Total (WxHxD)	483 x 133 x 775 mm (19" x 5.2" x 30.5")			
Weight	≈ 32 kg (70.5 lb)	≈ 32 kg (70.5 lb)	≈ 32 kg (70.5 lb)	≈ 32 kg (70.5 lb)

3U 15,000 W 380–480 Vac (b)		750 V : 60 A 310-53-0750-060	1000 V : 40 A 310-53-1000-040	1500 V : 30 A 310-53-1500-030
AC Input				
Voltage (L-L)	342–528 Vac, 45–66 Hz			
Connection	3ph,GND	3ph,GND	3ph,GND	
Fusing (internal)	6x T16 A	6x T16 A	6x T16 A	
Leak current	< 3.5 mA	< 3.5 mA	< 3.5 mA	
Power factor	> 0.99	> 0.99	> 0.99	
DC Output				
Max. output voltage U _{nom}	750 V	1000 V	1500 V	
Max. output current I _{nom}	60 A	40 A	30 A	
Max. output power P _{nom}	15 kW	15 kW	15 kW	
Overvoltage protection range	0–825 V	0–1100 V	0–1650 V	
Overcurrent protection range	0–66 A	0–44 A	0–33 A	
Overpower protection range	0–16.5 kW	0–16.5 kW	0–16.5 kW	
Temperature coefficient for set values Δ/K	Voltage / current: 100 ppm			
Output capacitance (approx.)	310 μF	133 μF	84 μF	
Voltage regulation				
Adjustment range	0–765 V	0–1020 V	0–1560 V	
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 0.1% U _{nom}	< 0.1% U _{nom}	< 0.1% U _{nom}	
Line regulation at ±10% ΔU _{AC}	< 0.02% U _{nom}	< 0.02% U _{nom}	< 0.02% U _{nom}	
Load regulation at 0–100% load	< 0.05% U _{nom}	< 0.05% U _{nom}	< 0.05% U _{nom}	
Rise time 10–90% ΔU	Max. 30 ms	Max. 30 ms	Max. 30 ms	
Transient time after load step	< 1.5 ms	< 1.5 ms	< 1.5 ms	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	≤ 0.2% U _{nom}	
Ripple ³	< 800 mV _{PP} < 200 mV _{RMS}	< 2000 mV _{PP} < 300 mV _{RMS}	< 2400 mV _{PP} < 400 mV _{RMS}	
Remote sensing compensation	Max. 5% U _{nom}	Max. 5% U _{nom}	Max. 5% U _{nom}	
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	0–61.2 A	0–40.8 A	0–30.6 A	
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 0.2% I _{nom}	< 0.2% I _{nom}	< 0.2% I _{nom}	
Line regulation at ±10% ΔU _{AC}	< 0.05% I _{nom}	< 0.05% I _{nom}	< 0.05% I _{nom}	
Load regulation at 0–100% ΔU _{OUT}	< 0.15% I _{nom}	< 0.15% I _{nom}	< 0.15% I _{nom}	
Ripple ³	< 48 mA _{RMS}	< 10 mA _{RMS}	< 26 mA _{RMS}	
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			
Display: Accuracy ^{2,6}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	≤ 0.2% I _{nom}	
Internal resistance regulation				
Adjustment range	0–382.5 Ω	0–1326 Ω	0–1530 Ω	
Accuracy ¹	≤1% of max. resistance ± 0.3% of maximum current			
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values			

3U 15,000 W 380–480 Vac (b) cont'd	750 V : 60 A 310-53-0750-060	1000 V : 40 A 310-53-1000-040	1500 V : 30 A 310-53-1500-030
Power regulation			
Adjustment range	0–15.3 kW	0–15.3 kW	0–15.3 kW
Accuracy ¹ (at 23 ± 5 °C / 73±9 °F)	< 1% P _{nom}	< 1% P _{nom}	< 1% P _{nom}
Line regulation at ±10% ΔU _{AC}	< 0.05% P _{nom}	< 0.05% P _{nom}	< 0.05% P _{nom}
Load reg. at 10-90% ΔU _{OUT} * ΔI _{OUT}	< 0.75% P _{nom}	< 0.75% P _{nom}	< 0.75% P _{nom}
Display: Resolution ⁶	See section 3.2.4. Resolution of the displayed values		
Display: Accuracy ^{2,6}	≤ 0.85% P _{nom}	≤ 0.85% P _{nom}	≤ 0.85% P _{nom}
Efficiency ⁴	≈ 94%	≈ 94%	≈ 95%
Analog interface ⁶			
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, OCP, OPP, OT, PF, DC output on/off		
Galvanic isolation to the device	≤1500 V DC	≤1500 V DC	≤1500 V DC
Sample rate of inputs & outputs	500 Hz		
Insulation ⁵			
Negative terminal to GND max.	±1500 V DC	±1500 V DC	±1500 V DC
Positive terminal to GND max.	±1800 V DC	±1800 V DC	±1800 V DC
AC input <-> GND	2.5 kV DC		
AC input <-> DC output	2.5 kV DC		
Miscellaneous			
Cooling	Temperature controlled fans, front inlet, rear exhaust		
Ambient temperature	0–50 °C (32–133 °F)		
Storage temperature	-20–70 °C (-4–158 °F)		
Humidity	< 80%, not condensing		
Standards	EN 61010-1:2007-11, EN 61000-6-2:2016-05, EN 61000-6-3:2011-09 Class B		
Overvoltage category	2		
Protection class	1		
Pollution degree	2		
Digital interfaces			
Standard	1x USB-B for communication, 1x USB-A for functions		
Options ⁶	310 option (-001 models): open slot for Anybus IF-AB modules 310 option (-002 models): 1x GPIB		
Galvanic isolation from device	≤1500 V DC	≤1500 V DC	≤1500 V DC
Terminals			
Rear side	Share Bus, DC output, AC input, remote sensing, analog interface, USB-B, master-slave bus, Interface module slot		
Front side	USB-A		
Dimensions			
Enclosure (WxHxD)	19" x 3U x 670 mm (26.4")		
Total (WxHxD)	483 x 133 x 775 mm (19" x 5.2" x 30.5")		
Weight	≈ 32 kg (70.5 lb)	≈ 32 kg (70.5 lb)	≈ 32 kg (70.5 lb)

14 Appendix: Control Software

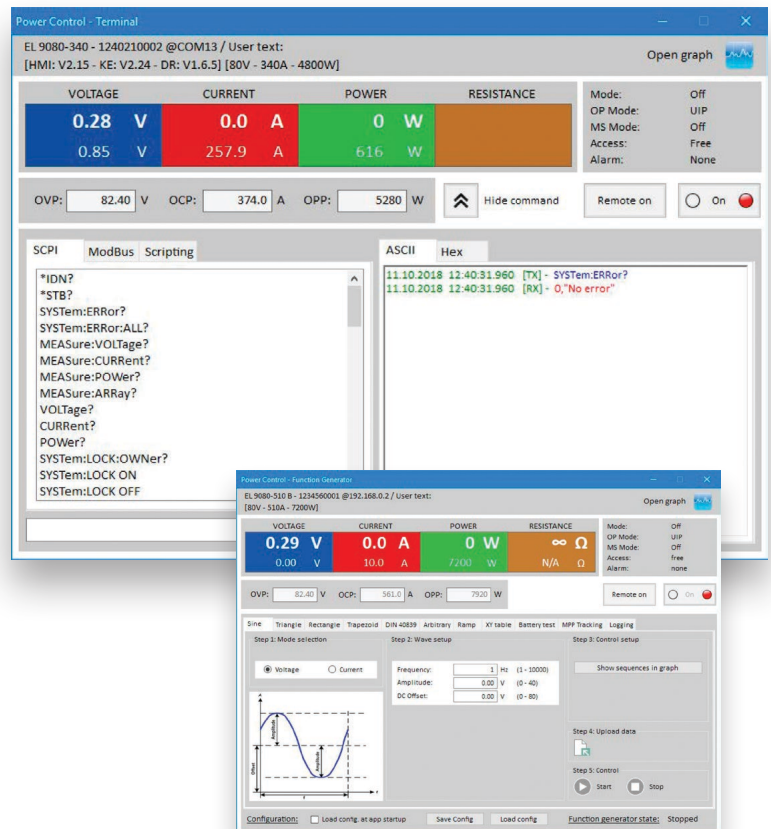
14.1 EA Power Control

In addition to using the built-in control panel to manage the power supply, there is software from Elektro-Automatik available for Windows® computers which can be used to monitor, configure, and program the power supply.

With the standard units, configuration, and setup for various applications can be accomplished using the built-in user interface controls. However, using the EA Power Control software (for Windows 7 and Windows 10), a number of these tasks are easier to accomplish and manage.

- Use for a single unit and for multiple units.
- Use on standard models and slave models.
- Monitor actual values.
- Modify set values.
- Adjust all configuration settings.
- Send Modbus/SCPI commands.
- Manage Modbus/SCPI script files.
- Program the function generator.

The software can be downloaded from Marway's web site.



mPower™ DC Power Supplies 310, 320 Series

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