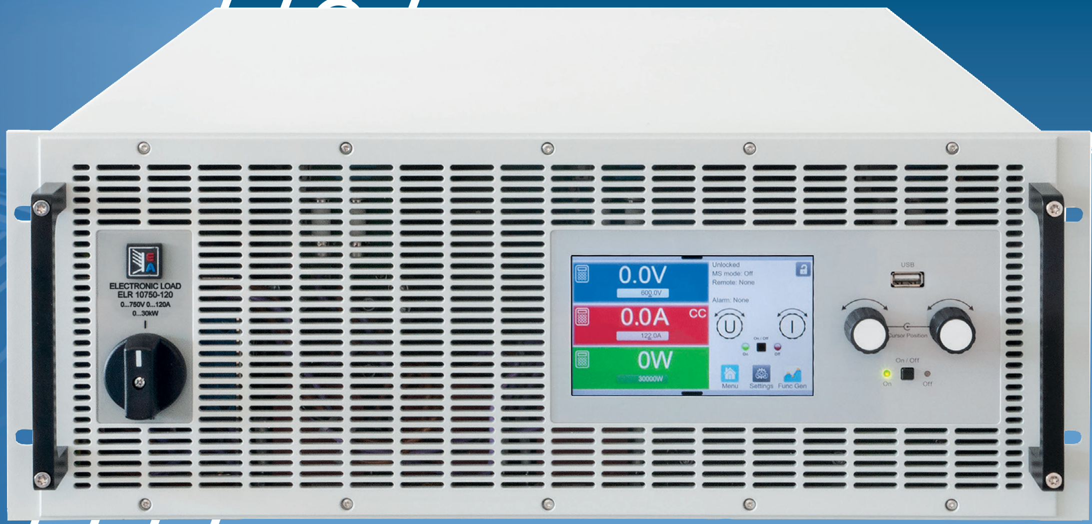
Elektro-Automatik



USER MANUAL

EA-ELR 10000 4U

Programmable electronic DC loads with energy recovery

Use, Remote Control, Function Generator

Revision: 01

TABLE OF CONTENTS

The part of this document that deals with the handling of features on the control panel is only valid for devices with firmwares “KE: 3.10”, “HMI: 4.05” and “DR: 1.0.2.20” or higher.

1. General

1.1 About this document

1.1.1 Preamble

Together with the separate installation manual, this document builds the documentation for use and control of the devices as listed in *«1.1.3 Validity»*. It explains manual operation and other control related features.

1.1.2 Copyright

Modification and partial or complete usage of this document for other purposes as intended are forbidden and breach may lead to legal consequences.

1.1.3 Validity

This document is valid for the following equipment and its variants:

Model
EA-ELR 10080-1000 4U
EA-ELR 10200-420 4U
EA-ELR 10360-240 4U

Model
EA-ELR 10500-180 4U
EA-ELR 10750-120 4U
EA-ELR 10920-125 4U

Model
EA-ELR 11000-80 4U
EA-ELR 11500-60 4U
EA-ELR 12000-40 4U

1.1.4 Symbols and warnings in this document

Warning and safety notices as well as general notices in this document are shown in a box with a symbol as follows. The symbols are also valid, where placed, also to mark specific spots on the device:

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

2. Operation and application (2)

2.1 Operating modes

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

2.1.1 Voltage control / Constant voltage

Voltage control is also called constant voltage operation (**CV**).

The voltage on the DC input of the device is held constant on the adjusted value, unless the current or the power according to $P = U_{DC} * I$ reaches the adjusted current or power limit. In both cases the device will automatically change to constant current or constant power operation, whatever occurs first. Then the voltage can't be held constant anymore and will rise to a value resulting from the currently valid internal resistance of the load.

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

2.1.1.1 Voltage control peaks

When working in constant voltage control (CV) and when the device has to react to a voltage change on the DC input, which is usually caused by the external source, the load requires a small transient time to settle the voltage. Positive voltage steps, i.e. lower to higher voltage, will cause the voltage to overshoot for a short time until compensated by the voltage regulator. The time it takes to settle the voltage can be influenced by switching the voltage control speed between the settings **Slow**, **Normal** and **Fast**, whereas Normal is the default. Also see *«2.2.1.1 Sub menu "Settings"»*.

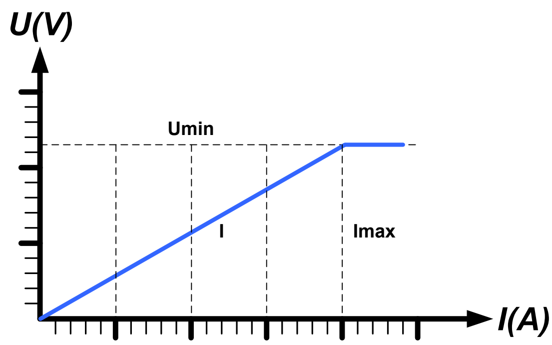
Setting **Slow** will result in a higher transient time and higher deviation from the set value, where **Fast** is vice versa and shortens the peaks. As a side effect and with the regulator being set to **Fast**, the load would react quicker to HF couplings and have a higher oscillation tendency, especially when using remote sensing. The choice of this setting thus depends on the situation. When using remote sensing, a typical recommendation would be to set **Slow** or, in case **Fast** is required for certain reasons, to disconnect the remote sensing terminals temporarily or permanently.

2.1.1.2 Minimum input voltage for maximum current

Due to technical reasons, all models in this series have a minimum internal resistance that requires to provide a specific minimum input voltage (U_{MIN}) in order for the device to be able to sink its rated current (I_{MAX}). This minimum voltage is stated in the technical specifications in section *1.8.3* of the installation manual.

If less voltage than U_{MIN} is supplied, the load proportionally draws less current, which can be calculated easily.

See the principle view to the right.



2.1.2 Current control / constant current / current limiting

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

The current in the DC input of the device is held constant once it reaches the adjusted set value, i. e. limit. Then the device automatically switches to CC. As long as the input current is lower than the adjusted limit, the device will be either in constant voltage or constant power mode. If, however, the power consumption reaches the power set value, the device will switch automatically to power limiting and adjust voltage and current according to $P = U_{IN} * I$.

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

2.1.3 Power control / constant power / power limiting

Power control, also known as power limiting or constant power (CP), keeps the DC power constant if the DC input current, in relation to the DC input voltage, reaches the adjusted limit according to P = U * I.

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

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

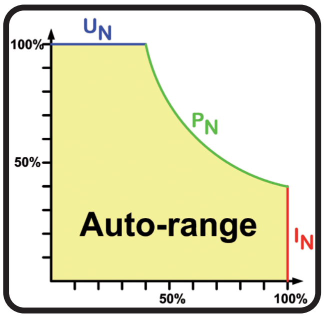


Figure 1 - Power range

2.1.3.1 Power derating

The models in this series are designed for 400 V AC supply , but can also operate on a three-phase supply with 208 V (USA, Japan). In order to limit the AC current when running on the low input voltage, the devices would automatically switch into a derating mode that reduces the available DC power to a maximum of 18 kW.

The switchover is determined once when the device is powered and it depends on the AC supply voltage being present in that moment. Should the voltage go up again later, the device would remain in derating mode as long as it’s powered, because the switchover into and out of derating mode isn’t dynamic. The full rated power is thus only available with AC voltages from 380 V.

Once derated, the device would show a permanent information in the display and all values related to the power are reduced in their adjustment range. This also applies to master-slave operation of derated units.

2.1.4 Resistance control / constant resistance

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

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

2.1.5 Dynamic characteristics and stability criteria

The device is an electronic load which is characterized by short rise and fall times of the current, achieved by a high bandwidth of the internal control circuit.

In case of testing sources with own control circuits, like for example power supplies, a control instability may occur. This instability is caused if the complete system (feeding source and electronic load) has too little phase and gain margin at certain frequencies. 180 ° phase shift at >0 dB amplification fulfills the condition for an oscillation and results in instability. The same can occur when using sources without own control circuit, like batteries, and when the connection cables are highly inductive or inductive-capacitive.

The instability is not caused by a malfunction of the load, but by the behavior of the complete system. An improvement of the phase and gain margin can solve this. In practice, this is primarily done by switching the internal voltage regulator between dynamics modes called **Slow**, **Fast** and **Normal**. The switch is either found in the device settings (see section *2.2.1.1*) or the quick menu (see section *2.2.5*). The user can only try the different settings to see if the desired effect is achieved. Should there be an improvement due to one of these settings, but the oscillation remains, an additional measure can be to install a capacitor directly at the DC input, perhaps alternatively to the remote sense input, if connected to the source. The capacitor’s value to achieve the expected result is not defined and has to be found out. We recommend:

- 80 V models: 1000uF....4700uF
- 200/360 V models: 100uF...470uF
- 500 V models: 47uF...150uF
- 750/920/1000 V models: 22uF...100uF
- 1500/2000 V models: 4.7uF...22uF

2.1.6 Actual value filter

From a certain set of firmware, particularly HMI 4.05 and KE 3.08, the device supports a user-configurable filtering feature. Its purpose is to periodically smoothen the actual values as they are shown on the screen or put out as digital or analog values. The filtering, if activated, is working in a way that it read an adjustable number of samples, i. e. measured actual values of voltage, current and power into an internal buffer, then calculates an average and exports the result as the next new set of actual values.

The user can select between modes **Fixed** and **Moving**, which differ as follows:

- **Fixed**: the selected number of samples is used to calculate the average, then the internal temporary sample buffer is purged and x new values are sampled
- **Moving**: the average is always calculated over the last x samples while the internal buffer isn't purged, but every new sample pushes all previous ones up so the values in the buffer move. This also means, that several subsequent average calculations are done with partially the same samples

Additionally to the mode, the user can select the size of the internal buffer (also called filtering stage) between 2 and 24. Together with the general fact that the device can deliver a new set of actual values every 20 ms, at least when the filtering is turned off, the filter delays every next new set pf values by this factor. It means, with the highest setting of 24 new actual values are only put out on the interfaces and screen approx. every 480 ms.

2.1.7 STBY zero stabilization

This feature, as available from firmwares KE 3.10 and HMI 4.09 for all models of the 10000 series, is deactivated by default and be activated in the settings menu (see section *2.2.1.1*), if needed. The goal is to stabilize the actual voltage value after the DC input has been switched off and after the voltage has sunken below a certain threshold (here: 3 V, model independent). The **STBY** in the name stand for stand-by and refers to the status of the DC input when switched off.

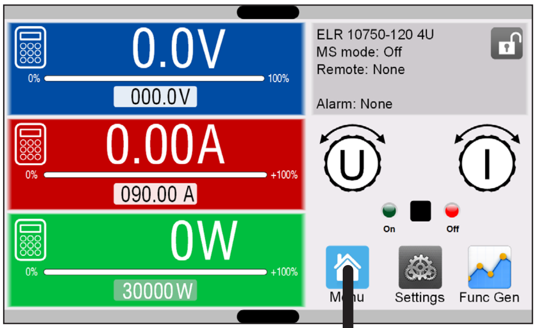
Due to technical reasons, the display actual voltage and the true voltage on the DC input can fluctuate and also remain slightly over 0 V. Those reasons are the switching power supply design, parasitic capacities and measurement errors. This feature, when activated, would set the actual voltage values to 0 V as long as the measured value on the DC input is below the threshold of 3 V. Since the device continuously measure the voltage on its DC input, also when DC is switched off, it would measure the voltage of a connected, external source as well. In both situations, voltage leaps between 3 V and 0 V in both directions are expected and normal. This suppresses the small voltage fluctuations around the zero point.

2.2 Manual operation (2)

⚠	While manually operated and while also being connected to any remote control equipment via any of the interfaces, the device could be taken over into remote control anytime without warning or request for confirmation. It’s thus recommended to block remote control by activating the ‘Local’ mode for the duration of manual operation.

2.2.1 Configuration via the menu

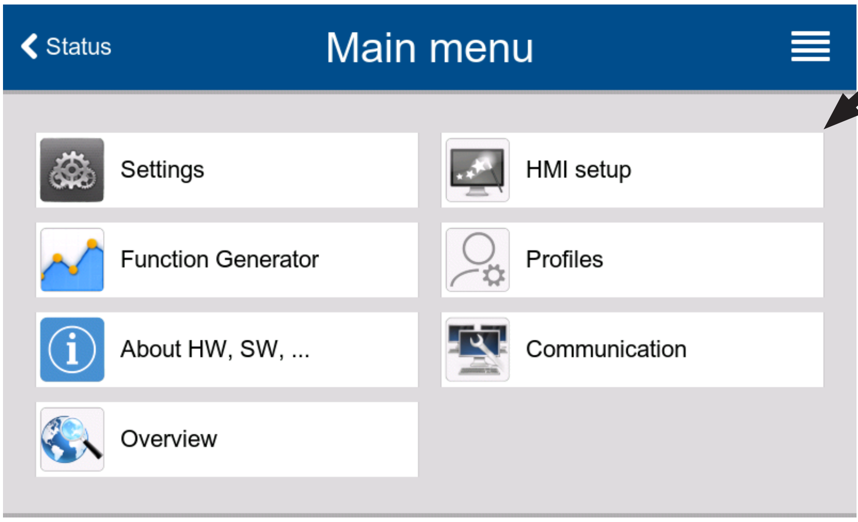
The settings menu is meant for the configuration of all operating parameters which are not constantly required. The menu is accessed by finger touch on the **Menu** touch area, but only while the DC input is switched off. See the figure to the right.



While the DC input is switched on the settings menu will not be shown, but some status information.

Menu navigation is also done by finger touch. Inside menus, all values are adjusted using the numeric pad that pops up when tapping a value.

Many settings are self-explanatory, others are not. Those will be explained on the following pages.



2.2.1.1 Sub menu “Settings”

This sub menu can be accessed directly from the main screen by tapping the Settings button.

Group	Parameters & description
Presets	**U, I, P, R**
	Presetting of all set values via on-screen numeric pad.
Protection	**OVP, OCP, OPP**
	Adjust the thresholds of the protections
Limits	**U-max, U-min etc.**
	Define the adjustment limits (find more information in *«2.2.2 Adjustment limits»*)
User events	**UVD, OVD etc.**
	Define supervision thresholds which can trigger user defined events (find more information in *«3.5.2.1. User defined events»* in the installation manual)
General	**Allow remote control**
	If remote control isn’t allowed, the device can’t be controlled remotely over either the digital or analog interfaces. This situation will be shown as **Local** in the status area on the main display. Also see section *1.9.6.1* in the installation manual.
	Analog interface priority
	Activates or deactivates the priority of the analog interface regarding the action of taking over remote control by pin REMOTE. Find details in *«2.3.4.8 Analog interface priority»*.
	R mode
	Activates or deactivates the internal resistance control. If activated, the set value and actual value of resistance will be shown on the main screen. For details refer to *«2.1.4 Resistance control / constant resistance»* in this document and *«3.4.3 Manual adjustment of set values»* in the installation manual.
	Voltage controller speed
	(Switching the speed only works if the device has already been delivered with firmware KE 3.02 and DR 1.0.2.20 or higher) This switch can be used to select the internal voltage controller speed which, as a result, impacts possible system oscillation. For more information refer to *«2.1.5 Dynamic characteristics and stability criteria»*. • **Slow** = the voltage controller will be a little slower, the oscillation tendency will decrease • **Normal** = the voltage controller is on standard speed (Default) • **Fast** = the voltage controller will be a little faster, the oscillation tendency will increase
	Actual value filter mode
	By selection of **Fixed** or **Moving** it activates a filter function for the actual values (voltage, current, power), as measured on the DC input of the device and shown on the HMI screen, as well as signaled on the analog and digital interfaces. For details refer to *«2.1.6 Actual value filter»*.
	Actual value filter buffer size
	Belongs to **Actual value filter mode**, see above and *«2.1.6 Actual value filter»*. Adjustable range: **2...24**
	STBY zero stabilization
	Activates or deactivates the feature, as described in *«2.1.7 STBY zero stabilization»*.

Group	Parameters & description
Analog interface	**Range**
	Selects the voltage range for the analog set values, actual values and reference voltage output. • **0...5V** = The range is 0...100% for set /actual values, reference voltage will be 5 V • **0...10V** = The range is 0...100% for set /actual values, reference voltage will be 10 V Also see *«2.3.4 Remote control via the analog interface»*
	REM-SB Level
	Selects how the input pin REM-SB of the analog interface shall be working regarding levels (see *«2.3.4.3 Analog interface specification»*) and logic: • **Normal** = Levels and function as described in the table in section *2.3.4.3* • **Inverted** = Levels and function will be inverted Also see *«2.3.4.7 Application examples»*
	REM-SB Action
	Selects how the input pin REM-SB of the analog interface shall operate regarding the DC input condition outside of analog remote control: • **DC Off** = The pin can only switch the DC input off • **DC On/Off** = The pin can switch the DC input off and on again, if it has been switched on before from a different control location
	Pin 6
	Pin 6 of the analog interface (see *«2.3.4.3 Analog interface specification»*) is by default assigned to signal both device alarms OT and PF. This parameter allows to also enable signaling only one of both (3 possible combinations): • **Alarm OT** = Pin 6 signals only alarm OT • **Alarm PF** = Pin 6 signals only alarm PF • **Alarm PF + OT** = Default, pin 6 signals either PF or OT
	Pin 14
	Pin 14 of the analog interface (see section *2.3.4.3*) is by default assigned to only signal the device alarm OVP. This parameter allows to also enable signaling the device alarms OCP and OPP in 7 possible combinations: • **Alarm OVP** = Pin 14 signals only OVP • **Alarm OCP** = Pin 14 signals only OCP • **Alarm OPP** = Pin 14 signals only OPP • **Alarm OVP+OCP** = Pin 14 signals OVP or OCP • **Alarm OVP+OPP** = Pin 14 signals OVP or OPP • **Alarm OCP+OPP** = Pin 14 signals OCP or OPP • **Alarm OVP+OCP+OPP** = Pin 14 signals any of the three alarms
	Pin 15
	Pin 15 of the analog interface (see section *2.3.4.3*) is by default assigned to only signal the control mode CV. This parameter allows to enable signaling the DC input status (2 options): • **Regulation mode** = Pin 15 signals the CV control mode • **DC status** = Pin 15 signals the DC input status

Group	Parameters & description
DC input	**State after power ON**
	Determines the condition of the DC input after power-up. • **Off** = The DC input is always off after switching on the device • **Restore** = The DC input state will be restored from the last switch-off The factory default of this setting, also after a device reset, is “Off”. Setting this to “Restore” solely lies within the responsibility of the operator, as the device could automatically start to supply voltage after boot-up, depending on the restored state of the DC input. Be careful!
	State after PF alarm
	Determines the condition of the DC input after a power fail (PF) alarm: • **Off** = The DC input remains off • **Auto** = The DC input will switch on again after the PF alarm cause is gone, if it has been switched on before the alarm occurred
	State after remote
	Determines the condition of the DC input after leaving remote control either manually or by command: • **Off** = The DC input will always be off after leaving remote control • **Auto** = The DC input will keep the last state
	State after OT alarm
	Determines the condition of the DC input after an overtemperature (OT) alarm, once the device has cooled down: • **Off** = The DC input will remain off • **Auto** = The device will automatically restore the situation before the OT alarm, which usually means the DC input to be on
Master-slave	**Mode**
	Selecting **Master** or **Slave** enables the master-slave mode (MS) and defines the position for the unit in the MS system. For details see *«4.1 Parallel operation in master-slave (MS)»*.
	Termination resistor
	Activates or deactivates the so-called bus termination of the digital master-slave bus via a switchable resistor. Termination should be activated if required, usually when problems with the master-slave bus operation occur.
	Bias resistors
	Additionally to the regular termination resistor (TERM) this activates two bias resistor, if required, to help stabilize the bus further. Tap on the information symbol for a graphical depiction.
	Backlight off after 60s
	If activated, it will switch off the display’s backlight after 60 seconds of inactivity. This settings is primarily intended for slave units where the display isn’t supposed to be permanently on. It’s identical to the setting in menu “HMI setup”.
	Initialize system
	Tapping this touch area will repeat the initialization of the master-slave system in case the detection of all slave units by the master was 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 or one slave has failed.

Group	Parameters & description
USB logging	**Log file separator format**
	Defines the format of CSV files generated from logging files (also see section *2.2.4* in this document, as well as section *1.9.6.5* in the installation manual). This setting also affects other features where a CSV file can be loaded or saved. • **US** = Comma as column separator (US standard for CSV files) • **Default** = Semicolon as column separator (german/european standard for CSV files)
	Logging with units (V,A,W)
	CSV files generated from USB logging by default add physical units to values. This can be deactivated here.
	USB logging
	Activates/deactivates logging to USB stick. For more information refer to *«2.2.4 Recording to USB stick (logging)»*.
	Logging interval
	Defines the time between two records in the log file. Selection: **500ms**, **1s**, **2s**, **5s**
	Start/stop
	Defines how the USB logging is started and stopped. • **Manual** = Logging only starts and stops upon user interaction on the HMI, by accessing touch button  in the quick menu. • **At DC on/off** = Logging starts and stops with every change of state on the DC input, no matter if caused by the user, software or a device alarm. Attention: Every next start will create a new log file.
Reset / Restart	**Reset device to defaults**
	This touch area will initiate a reset of most settings (HMI, profile etc.) to factory default.
	Restart
	Triggers a warm start

2.2.1.2 Sub menu "Profiles"

See *«2.2.6 Loading and saving user profiles»*.

2.2.1.3 Sub menu "Overview"

This menu page displays an overview of the set values (U, I, P or U, I, P, R), device alarm thresholds, event settings, adjustment limits, as well as an alarm history which lists the number of device alarms that occurred since the device has been powered.

2.2.1.4 Sub menu "About HW, SW, ..."

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

2.2.1.5 Sub menu "Function Generator"

See «3. The function generator».

2.2.1.6 Sub menu "Communication"

This sub menu offers settings for digital communication via the built-in interfaces USB and Ethernet and also for the optional interface modules of IF-AB series.

There are furthermore adjustable communication timeouts. For more information about these timeout refer to the external, on USB stick included documentation "Programming guide ModBus & SCPI". The USB itself doesn't require any settings.

Settings for the internal Ethernet port

IF	Settings	Description
Ethernet (internal)	**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 below.
	IP address	Manually allocate an IP address.
	Subnet mask	Manually allocate a subnet mask.
	Gateway	Manually allocate a gateway address, if required.
	DNS address	Manually allocate addresses of a Domain Name Server (DNS), if required.
	Port	Select port in the range 0...65535. Default: **5025** Reserved ports: 502, 537
	Host name	User definable host name
	Domain	User definable domain
	MAC address	of the internal Ethernet port

Settings for the optional interface modules (IF-AB-xxx)

IF	Settings	Description
Profibus	**Node Address**	Selection of the Profibus or node address of the device within range 1...125 via direct input
	Function Tag	String input box for a user-definable text which describes the Profibus slave function tag. Max. length: 32 characters
	Location Tag	String input box for a user-definable text which describes the Profibus slave location tag. Max. length: 22 characters
	Installation Date	String input box for a user-definable text which describes the Profibus slave installation date tag. Max. length: 40 characters
	Description	String input box for a user-definable text which describes the Profibus slave. Max. length: 54 characters
	Manufacturer ID	Registered manufacturer ID with the Profibus organization
	Ident number	Product identification number, same as in the GSD file

IF	Settings	Description
Slot Ethernet / ModBus-TCP (1 & 2 Port)	**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 below.
	IP address	This option is activated by default. An IP address can be manually allocated.
	Subnet mask	Here a subnet mask can be defined if the default subnet mask is not suitable.
	Gateway	Here a gateway address can be allocated if required..
	DNS address	Here the addresses of the first and second Domain Name Servers (DNS) can be defined, if needed.
	Port	Range: 0...65535, default port: **5025** = Modbus RTU Reserved ports: 502, 537
	Host name	User definable host name (default: **Client**)
	Domain	User definable domain (default: **Workgroup**)
	MAC address	of the internal Ethernet port
	Speed / Duplex Port 1	Manual selection of transmission speed (**10MBit**/**100MBit**) and duplex mode (**full**/**half**). It's recommended to use the **Auto** option and only revert to another option if Auto fails.
	Speed / Duplex Port 2	Different Ethernet port settings for 2-port modules are possible, as these include an Ethernet switch

IF	Settings	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
	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
	Station Name	String input box for a user-definable text which describes the Profinet station name. Max. length: 200 characters

IF	Settings	Description
CAN	**Baud rate**	Setup of the CAN bus speed or baud rate in typical value between 10 kbps and 1Mbps. Default: **500 kbps**
	ID Format	Selection of the CAN ID format and range between **Standard** (11 Bit ID, 0h...7ffh) and **Extended** (29 Bit, 0h...1fffffffh)
	Bus termination	Activates or deactivates CAN bus termination with a built-in resistor. Default: off
	Data length	Determines the DLC (data length) of all messages sent from the device. **Auto** = length can vary between 3 and 8 bytes **Always 8 Bytes** = length is always 8, filled up with zeros
	Base ID	Setup of the CAN base ID (11 Bit or 29 Bit, hex format). Default: **0h**
	Broadcast ID	Setup of the CAN broadcast ID (11 Bit or 29 Bit, hex format). Default: **7ffh**
	Base ID Cyclic Read	Setup of the CAN base ID (11 Bit or 29 Bit, hex format) for cyclic read of several object groups. The device will automatically send object data to the IDs defined with this setting. For more information refer to the programming guide. Default: **100h**
	Base ID Cyclic Send	Setup of the CAN base ID (11 Bit or 29 Bit, hex format) for cyclic send of set values along with status. For more information refer to the programming guide. Default: **200h**
	Cyclic Read Time: Status	Activation/deactivation and time setting for the cyclic read of status from the adjusted **Base ID Cyclic Read.** Range: 20...5000 ms. Default: **0ms** (deactivated)
	Cyclic Read Time: Set values	Activation/deactivation and time setting for the cyclic read of set values of U & I from the adjusted **Base ID Cyclic Read + 2**. Range: 20...5000 ms. Default: **0ms** (deactivated)
	Cyclic Read Time: Limit values 1	Activation/deactivation and time setting for the cyclic read of adjustment limits of U & I from the adjusted **Base ID Cyclic Read + 3**. Range: 20...5000 ms. Default: **0ms** (deactivated)
	Cyclic Read Time: Limit values 2	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: **0ms** (deactivated)
	Cyclic Read Time: Actual values	Activation/deactivation and time setting for the cyclic read of actual values from the adjusted **Base ID Cyclic Read + 1**. Range: 20...5000 ms. Default: **0ms** (deactivated)
	Module firmware	CAN module firmware version

IF	Settings	Description
CANopen	**Baud Rate**	CAN bus baud rate selection that is used by the CANopen interface. **Auto** = Automatic detection **LSS** = Baud rate and node address are assigned by the bus master Fixed baud rates: **10 kbps**, **20 kbps**, **50 kbps**, **100 kbps**, **125 kbps**, **250 kbps**, **500 kbps**, **800 kbps**, **1Mbps**
	Node Address	Selection of the CANopen node address in the range **1...127**

IF	Settings	Description
RS232	**Baud rate**	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: **2400Bd**, **4800Bd**, **9600Bd**, **19200Bd**, **38400Bd**, **57600Bd**, **115200Bd**

Further communication related parameters

Group	Parameters & description
Timeouts	**TCP keep-alive (internal) / TCP keep-alive (slot)**
	Activates/deactivates the keep-alive network functionality for the internal Ethernet port or for a standard Ethernet module (IF-AB-ETHxx), if installed in the slot. The keep-alive network packets are used to keep the socket connection open. As long as keep-alive is present in the network, the device will disable the Ethernet timeout. Also see below at **Timeout ETH**.
	Timeout USB/RS232
	Defines the max. time between two subsequent bytes or blocks of a transferred message. For more information about the timeout refer to the external programming documentation "Programming ModBus & SCPI". Default value: **5ms**, Range: 5 ms...65535 ms
	Timeout ETH (internal) / Timeout ETH (slot)
	Defines a timeout after which the device would close the socket connection if there was no command communication between the controlling unit (PC, PLC etc.) and the device for the adjusted time. The timeout is ineffective as long as option **TCP keep-alive** is enabled for the particular interface and the keep-alive network service is running. A setting of 0 would deactivate the timeout permanently. Default value: **5s**, Range: 0 / 5 s...65535 s (0 = timeout deactivated)
	Interface monitoring / Timeout Interface monitoring
	Activates/deactivates the interface monitoring (see *«2.3.3.3 Interface monitoring»*). Default values: off, **5s** / Range: 1 s...65535 s
Protocols	**Communication protocols**
	Enables or disables SCPI or ModBus communication protocols for the device. The change is immediately effective. Only one of both can be disabled.
	ModBus specification compliance
	Allows to switch from **Limited** (default setting) to **Full** which makes the device send messages in ModBus RTU or ModBus TCP format which fully comply to the specification and are compatible to softwares available on the market. With **Limited** the device would still use the old, partially wrong message format (see the separate programming guide for details).

2.2.1.7 Menu "HMI Setup"

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

Group	Parameters & description
Language	Selection of the display language (default: English)
Sound	**Key sound**
	Activates or deactivates sounds when touching a touch area in the display. It can acoustically signal that the action has been accepted.
	Alarm sound
	Activates or deactivates the additional acoustic signal of an alarm or user defined event which has been set to **Action = Alarm**. Also see *«3.5. Alarms and monitoring»* in the installation manual.
Clock	Internal clock and date setup
Backlight	**Backlight off after 60s**
	The choice here is whether the backlight remains permanently on (default) or if it should go off when no input via screen or rotary knob is done for 60 s. As soon as there is input, the backlight returns automatically. Furthermore, the backlight intensity can be adjusted here.
Lock	See *«3.4.5 Locking the control panel (HMI)»* and *«3.4.6 Locking the adjustment limits and user profiles»* in the installation manual.

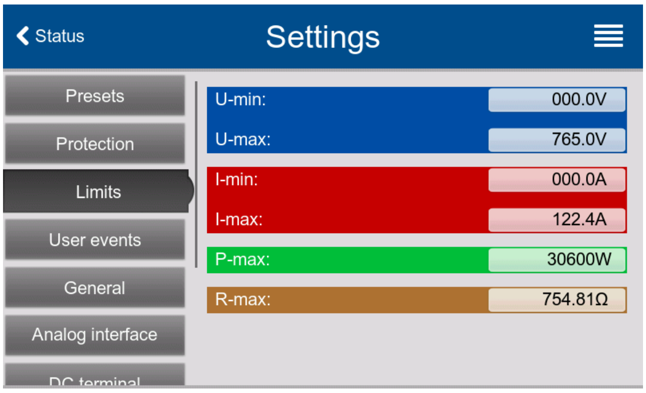
2.2.2 Adjustment limits

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

Defaults are that all set values (U, I, P, R) are adjustable from 0 to 102%, except for the voltage with the 60 V model which is adjustable to 100%.

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. While the DC input is switched off, tap  on the main screen.

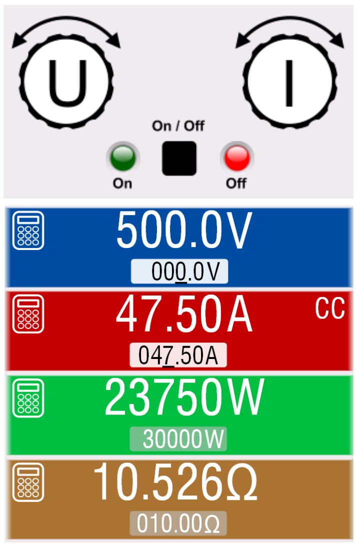
2. Tap on group **Limits** on the left side to open the list of limits. They are grouped and colored for distinction. Values are adjusted by tapping on them, in a window popping up with a numeric pad. Values further down in the list are accessed by swiping the list up.
3. Adjust the desired value and submit with Enter.

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 6000 W while the currently adjusted power set value is 8000 W, then the set value would first have to be reduced to 6000 W or less, in order to set P-max down to 6000 W.

2.2.3 Changing the operating mode

In general, the manual operation of the device distinguishes between three operating modes: U/I, U/P and U/R. They are tied to set value input using the rotary knobs or the on-screen numeric pad. The current assignment can be switched anytime if you want to adjust a set value which is currently not assigned to any of the knobs.

► How to change the operating mode (two options)



1. Unless the device is in remote control or the panel is locked, tap on the depiction of the right-hand knob on the screen (see the figure to the right) to change its assignment between I, P and R (if resistance mode is activated). The knob will display accordingly, with letters.
2. Directly tap on the colored areas with the set values, as shown in the figure to the right. The set value field, when inverted, indicates the assignment to the knob. In the example in the figure it has U and I (sink) assigned, which means U/I mode.

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

In order to change the other values, like P or R while U/I is active, and without switching the assignment all the time, direct input can be used.

The actual operating mode, which is only indicated while the DC input is switched on, solely depends only on the set values. For more information see *«2.1 Operating modes»*.

2.2.4 Recording to USB stick (logging)

Device data can be recorded to USB stick (USB 3.0 is supported, but not all memory sizes) anytime. For specifications of the USB stick and the generated log files refer to *«1.9.6.5. USB port (front side)»* in the installation manual.

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

2.2.4.1 Restrictions

USB logging in this form isn't available or automatically deactivated if the battery test logging in the battery test is activated.

2.2.4.2 Configuration

Also see section *2.2.1.6*. After USB logging has been enabled and the parameters **Logging interval** and **Start/Stop** have been set, logging can be started anytime after leaving the **Settings** menu.

Furthermore see section *2.2.1.1*. There are additional settings for the CSV file itself as generated by the USB logging features. You can switch the column separator format between german/european standard (**Default**) or US american standard (**US**). The other option is used to deactivate the physical unit that is added by default to every set/actual value in the log file. Deactivating this option simplifies the CSV file processing in MS Excel or similar tools.

2.2.4.3 Handling (start/stop)

With setting **Start/stop** to **At DC on/off** logging will start each time the DC input of the device is switched on, no matter if manually with the front button **On/Off** or remotely via analog or digital interface. With setting **Manual** it's different. Logging is then started and stopped only in the quick menu (see the figure to the right).

Button starts logging manually and changed to , which is for manual stop.

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

2.2.4.4 USB logging file format

Type: text file in german/european or US american CSV format (depending on the selected setting)

Layout (default german format shown):

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

Legend:

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

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

R mode: Resistance mode activated/deactivated (also called 'UIR mode')

Output/Input: State of the DC input

Device mode: Actual control mode (also see *«2.1 Operating modes»*)

Error: Device alarms

Time: Elapsed time since logging start

Important to know:

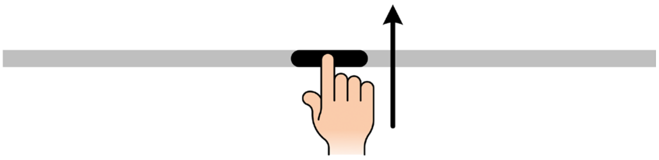
- R set and R actual are only recorded if "R mode" is active (refer to section *2.2.3*)
- Unlike the logging on PC, every log start here creates a new log file with a counter in the file name, starting generally with 1, but minding existing files

2.2.4.5 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** being **At DC on/off**, the logging will also stop on alarms or events with action **Alarm**, because they switch off the DC input
- With setting **Start/stop** being **Manual**, the device will continue to log even on occurring alarms, so this mode can be used to determine the period of temporary alarms like OT or PF

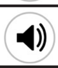
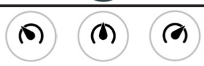
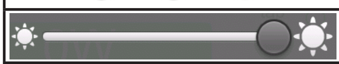
2.2.5 The quick menu

The device offers a quick menu which allows for the quick access to often used features and modes being switched on or off in the “Settings” menu. It can be opened by swiping up from the bottom screen edge or tapping the bar:



Overview:

Tapping a button activates or deactivates the feature. Buttons with black on white indicate an activated feature:

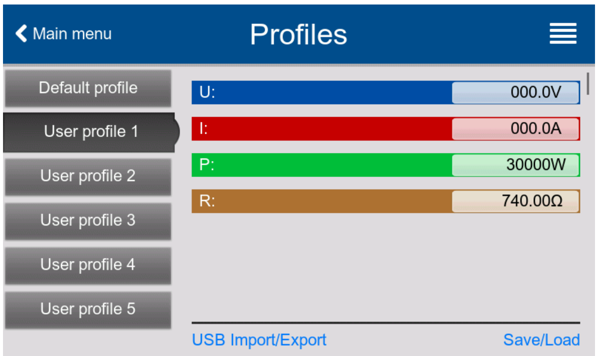
Symbol	Belongs to	Meaning or function
	USB logging	USB logging is running (the symbol is only available when USB logging has been activated in menu “Settings”)
M	Master-slave	Master-slave activated, device is master
S	Master-slave	Master-slave activated, device is slave
Off	Master-slave	Master-slave deactivated
Ω	Resistance mode	R mode = on
	HMI	Alarm sound = on
	HMI	Key sound = on
	HMI	Opens the graph screen
	Operation modes	Switches voltage controller speed between **Slow**, **Normal** (default) and **Fast** (see section *2.1.5*)
	HMI	Adjust backlight intensity
Menu	HMI	Opens the main menu

2.2.6 Loading and saving user profiles

The menu **Profiles** serves to select between a default profile and up to 5 user profiles. A profile is a collection of all settings and set values. Upon delivery or after a factory reset, all 6 profiles have the same settings and all set values are 0. Values adjusted on the main screen or anywhere else belong to a working profile which can be saved to one of the 5 user profiles. These user profiles or the default profile can then be switched. The default profile is read-only.

The purpose of a profile is to load a set of set values, settings limits and monitoring thresholds quickly without having to readjust these. As all HMI settings are saved in the profile, including language, a profile change can also be accompanied by a change in HMI language. On calling up the menu page and selecting a profile the most important settings can be seen, but not changed.

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



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

on the main screen.
2. In the main menu tap on **Profiles**.
3. In the next screen (see the example to the right) choose between user profiles 1-5, which will show the profile's stored settings for your verification.
4. Tap on **Save/Load** and save the settings into the user profile in the coming up requester **Save profile?** with **Save**.

> *All user profiles also allow to just edit some settings or values stored in the profile. When doing so, the changes either need to be saved to the profile with "Save changes" or discarded with "Cancel" before the profile can be loaded.*

Loading a user profile works the same way, but in the requester you would then tap **Load** under **Load profile?**. Alternatively, you may import the profile or export it as file to a USB stick with **USB Import/Export**.

► How to edit a user profile

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

on the main screen.
2. In the main menu tap on **Profiles**.
3. In the next screen choose the user profile to edit, which will show the profile's stored settings for your verification.
4. Tape on the values you want to edit. As soon as any values has been changed, the button **Save/Load** will turn into **Save changes**.
5. Tap on **Save changes** to save the changes into the user profile. At this point, the profile's values are not effective yet.
6. Optional: in order to submit the changes in the user profile to the working profile, tap on **Save/Load** and in the requester **Load profile?** choose **Load**.

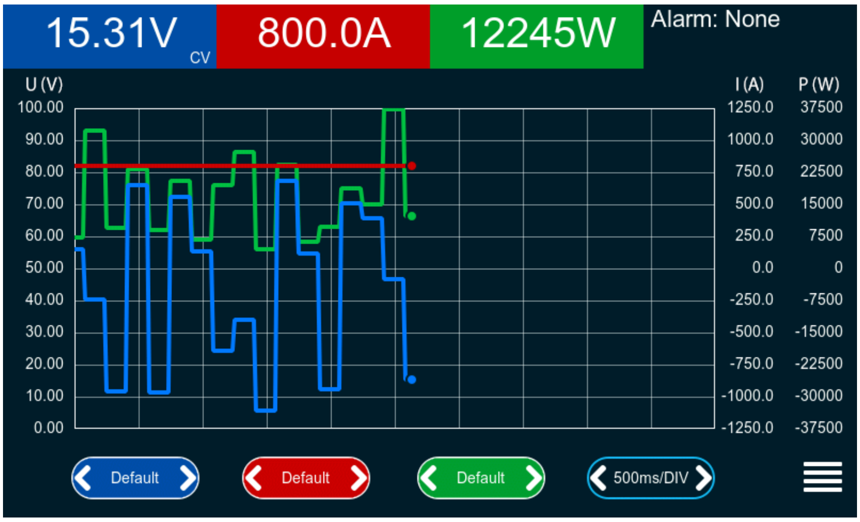
2.2.7 The graph

The devices feature a manually callable, HMI operated visual depiction of the temporal run of the actual values of voltage, current and power, called the graph. However, it isn't a recording feature. For data recording in the background there is still the USB logging feature (see section *2.2.4*).

The graph can be called up anytime any only via the quick menu, whilst in function generator operation it's called up by an extra screen button. When shown, it completely fills the screen.

⚠	Limited control options available while the graph screen is shown! For safety reasons, however, it's possible to switch off the DC input anytime.

Overview:



Controls:

- Tapping the **middle** of the three red/green/blue touch areas deactivates/activate the corresponding plot
- Tapping the **sides** (arrows left/right) of the red/green/blue touch areas increases/decreases the vertical scaling
- Tapping the **sides** (arrows left/right) of the black touch area increases/decreases the horizontal scaling
- Swiping on the three scales (Y axis) moves them up or down
- Tapping the menu touch area (☰) exits the graph screen anytime

2.3 Remote control

2.3.1 General

Remote control is possible via one of the built-in interfaces (analog, USB, Ethernet) or via one of the optional interface modules. One of the digital interfaces is the master-slave bus.

Important here is that only the analog or one of the digital interfaces can be in control. It means that if an attempt was made to switch to remote control via the digital interface whilst analog remote control is active (pin REMOTE = LOW) the device would report an error via the digital interface. In the opposite direction, a switch-over via pin REMOTE would be ignored. However, status monitoring and reading of values are always possible.

2.3.2 Control locations

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

Displayed location	Description
Remote: None	If neither of the other locations is displayed then manual control is active and access from the analog and digital interfaces is allowed.
Remote: <interface_name>	Remote control via any interface is active
Local	Remote control is locked, only manual operation is allowed.

Remote control may be allowed or inhibited using the setting **Allow remote control** (see *«2.2.1.1 Sub menu "Settings"»*). In inhibited condition the status **Local** will be displayed top right. Activating the inhibit can be useful if the device is remotely controlled by software or some electronic device, but it's required to make adjustments on the device or deal with an emergency.

Activating condition **Local** causes the following:

- If remote control via the digital interface is active (e. g. **Remote: USB**), then it's immediately terminated and in order to continue remote control once **Local** is no longer active, it has to be reactivated at the PC
- If remote control via the analog interface is active (**Remote: Analog**), then it's temporarily interrupted until remote control is allowed again by deactivating **Local**, because pin REMOTE continues to signal "remote control = on", unless this has been changed during the **Local** period.

2.3.3 Remote control via a digital interface

2.3.3.1 Selecting an interface

In addition to the built-in USB and Ethernet ports, all models of this series support the following optionally available interface modules:

Short ID	Type	Ports	Description*
IF-AB-CANO	CANopen	1	CANopen slave with generic EDS
IF-AB-RS232	RS232	1	Standard RS232, serial
IF-AB-PBUS	Profibus	1	Profibus DP-V1 slave
IF-AB-PNET1P	ProfiNet	1	Profinet DP-V1 slave
IF-AB-PNET2P	ProfiNet	2	Profinet DP-V1 slave, with switch
IF-AB-CAN	CAN	1	CAN 2.0 A / 2.0 B
IF-AB-ECT	EtherCAT	2	Standard EtherCAT slave with CoE
IF-AB-MBUS1P	ModBus TCP	1	ModBus TCP protocol via Ethernet
IF-AB-MBUS2P	ModBus TCP	2	ModBus TCP protocol via Ethernet

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

2.3.3.2 Programming

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

2.3.3.3 Interface monitoring

Interface monitoring is a configurable functionality introduced in firmwares KE 2.06 and HMI 2.08. Its goal is to monitor (or supervise) the digital communication line between the device and a superior control unit, such as PC or PLC, and to ensure that the device wouldn't continue working uncontrolled in case the communication line fails. A failing line can mean that it's either physically interrupted (damaged cable, bad contact, cable pulled) or the interface port inside the device hangs.

The monitoring is always only valid for one of the digital interfaces, the one being used for remote control. It thus means that the monitoring can become temporarily inactive when the device leaves remote control. It's furthermore based on a user-definable timeout which would run out if not at least one message is sent to the device within the given time frame. After every message, the timeout would start again and reset with the next incoming message. In case it runs out, the following reaction of the device is defined:

- Exit remote control
- In case the DC input is switched on, it will either be switched off or remains on, as defined by the parameter **DC input -> State after remote** (see section *2.2.1.1*)

Notes for the operation:

- The timeout of the monitoring can be changed anytime via remote control; the new value would only be valid after the current timeout has elapsed
- The interface monitoring doesn't deactivate the Ethernet connection timeout (see section *2.2.1.6*), so these two timeouts can overlap

2.3.4 Remote control via the analog interface

2.3.4.1 General

The galvanically isolated, 15-pole analog interface, as built-in and below referenced in short form as **AI**, is located on the rear side of the device offers the following possibilities:

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

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

Analog set values can be supplied by an external voltage or generated from the reference voltage on pin 3. As soon as remote control via the analog interface is activated, the displayed set values will be those provided by the interface. The AI can be operated in the common voltage ranges 0...5 V and 0...10 V, both representing 0...100% of the nominal value. The selection of the voltage range can be done in the device setup. See *«2.2.1 Configuration via the menu»* for details. The reference voltage sent out from pin 3 (VREF) will be adapted accordingly:

0-5V: Reference voltage = 5 V, 0...5 V set value (VSEL, CSEL, PSEL, RSEL) correspond to 0...100% of the rated value or R_{Min}...R_{Max}, 0...100% of the actual values correspond to 0...5 V at the outputs CMON and VMON, at least as long these two pins are still configured for the default (see *«2.2.1 Configuration via the menu»*).

0-10V: Reference voltage = 10 V, 0...10 V set value (VSEL, CSEL, PSEL, RSEL) correspond to 0...100% of the rated value or R_{Min}...R_{Max}, 0...100% of the actual values correspond to 0...10 V at the outputs CMON and VMON, at least as long these two pins are still configured for the default (see *«2.2.1 Configuration via the menu»*).

All set values are always additionally limited to the corresponding adjustment limits (U-max, I-max etc.), which would clip setting excess values for the DC input. Also see *«2.2.2 Adjustment limits»*.

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

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

- Analog remote control of the device must be activated by switching pin REMOTE (5) first. Only exception is pin REM-SB, which can be used independently
- Before the hardware is connected that will control the analog interface, it shall be checked that it can't provide voltage to the pins higher than specified
- Set value inputs, such as VSEL, CSEL, PSEL and RSEL (if R mode is activated), must not be left unconnected (i.e. floating) 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 gives 100%

2.3.4.2 Acknowledging device alarms

In case of a device alarm occurring during remote control via analog interface, the DC input will be switched off the same way as in manual control. The device would indicate an alarm (see section *3.5* in the installation manual) in the front display and, if activated, acoustically and also signal most of them on the analog interface. Which alarms actually are signaled can be set up in the device configuration menu (see *«2.2.1.1 Sub menu "Settings"»*).

Most device alarms have to be acknowledged (also see *«3.5.2. Device alarm and event handling»* in the installation manual). Acknowledgment is done with pin REM-SB switching the DC input off and on again, which represents a HIGH-LOW-HIGH signal (min. 50ms for LOW), when using the default level setting for this pin.

2.3.4.3 Analog interface specification

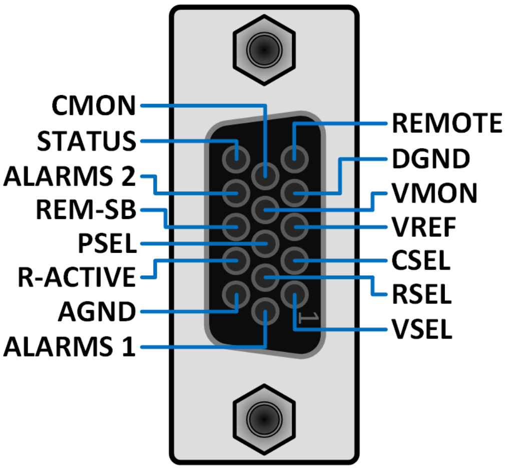
Pin	Name	Type (1	Description	Default levels	Electrical specifications
1	**VSEL**	AI	Voltage set value	0...10 V or 0...5 V correspond to 0..100% of U_{Nom}	Accuracy 0-5 V range: < 0.4% (5 Accuracy 0-10 V range: < 0.2% (5 Input impedance R_i >40 k...100 k
2	**CSEL**	AI	Current set value (source & sink)	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	Switches between manual and remote control	Remote = LOW, U_{Low} <1 V Manual = HIGH, U_{High} >4 V Manual, if pin not wired	Voltage range = 0...30 V I_{Max} = -1 mA at 5 V $U_{LOW\ to\ HIGH\ typ.}$ = 3 V Rec'd sender: Open collector against DGND
6	**ALARMS 1**	DO	Overheating /power fail alarm	Alarm = HIGH, U_{High} > 4 V No alarm = LOW, U_{Low} <1 V	Quasi open collector with pull-up against Vcc (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	Resistance value (source & sink)	0...10 V or 0...5 V correspond to R_{Min}...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	Power set value (source & sink)	0...10 V or 0...5 V correspond to 0..100% of P_{Nom}	
9	**VMON**	AO	Actual voltage	0...10 V or 0...5 V correspond to 0..100% of U_{Nom} (5	Accuracy 0-5 V range: < 0.4% (5 Accuracy 0-10 V range: < 0.2% (5 I_{Max} = +2 mA Short-circuit-proof against AGND
10	**CMON**	AO	Actual current	0...10 V or 0...5 V correspond to 0..100% of I_{Nom} (5	
11	**AGND**	POT	Ground for all analog signals		For xSEL, xMON and VREF
12	**R-ACTIVE**	DI	R mode on / off	On = LOW, U_{Low} <1 V Off = HIGH, U_{High} >4 V Off, if pin not wired	Voltage range = 0...30 V I_{Max} = -1 mA at 5 V $U_{LOW\ to\ HIGH\ typ.}$ = 3 V Rec'd sender: Open collector against DGND
13	**REM-SB**	DI	DC input OFF (DC input ON) (ACK alarms (4)	Off = LOW, U_{Low} <1 V On = HIGH, U_{High} >4 V On, if pin not wired	Voltage range = 0...30 V I_{Max} = +1 mA at 5 V Rec'd sender: Open collector against DGND
14	**ALARMS 2**	DO	Overvoltage alarm Overcurrent alarm Overpower alarm	Alarm = HIGH, U_{High} > 4 V No alarm = LOW, U_{Low} <1 V	Quasi open collector with pull-up against Vcc (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 control active	CV = LOW, U_{Low} <1 V CC/CP/CR = HIGH, U_{High} >4 V	
			DC input	Off = LOW, U_{Low} <1 V On = HIGH, U_{High} >4 V	

(1 AI = Analog Input, AO = Analog Output, DI = Digital Input, DO = Digital Output, POT = Potential
(2 Internal Vcc approx. 10 V
(3 Only one of both signals possible, see section *2.2.1.1*
(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 input of the device

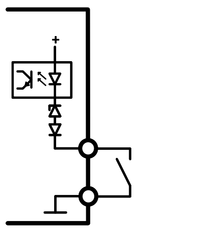
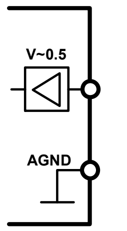
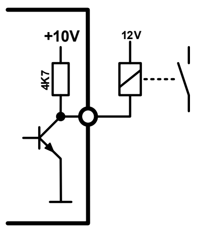
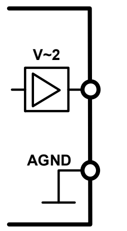
2.3.4.4 Resolution

The analog interface is internally sampled and processed by a digital micro-controller. This causes a limited resolution of analog steps. The effective resolution is the same for set values (VSEL etc.) and actual values (VMON/CMON). It's 26214 steps for 0...100%, when working in the 10 V range. In the 5 V range this resolution halves. Due to tolerances, the truly achievable resolution can be slightly lower.

2.3.4.5 Overview of the D-sub socket



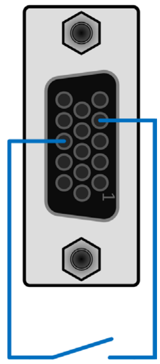
2.3.4.6 Simplified diagram of the pins

	**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.		**Analog Input (AI)** High resistance input (impedance >40 kΩ) for an operation amplifier circuit.
	**Digital Output (DO)** A quasi open collector, realized as high resistance pull-up against the internal supply. In condition LOW it can't drive any load, only sink small current, as shown in the diagram with a relay as example.		**Analog Output (AO)** Output from an operation amplifier circuit, low impedance. See the specifications table above.

2.3.4.7 Application examples

a) Switching the DC input 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 sufficiently low resistance. Check the specification of the controlling application. Also see the pin diagram above.



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

REM-SB cannot serve as a safety stop switch to securely deactivate the DC input in case of emergency! For that an external emergency stop system is required.

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

- **Remote control has been activated**

During remote control via analog interface, only pin REM-SB determines the states of the DC input, according to the level definitions in section *2.3.4.3*. The logical function and the default levels can be inverted by a parameter in the setup menu of the device. See section *2.2.1.1*.

If the pin is unconnected or the connected contact is open, the pin will be HIGH. With setting "Analog interface" -> "REM-SB level" being set to "Normal", it requests to switch the DC input on. So when activating remote control, the DC input will instantly switch on.

- **Remote control has not been activated**

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

DC input	+	Level on pin REM-SB	+	Parameter „REM-SB Level“	→	Behavior
is off	+	HIGH	+	Normal	→	The DC input isn’t locked. It can be switched on by pushbutton “On/Off” (front panel) or via command from digital interface.
		LOW	+	Inverted		
	+	HIGH	+	Inverted	→	The DC input is locked. It can’t be switched on by pushbutton “On/Off” (front panel) or via command from digital interface. When trying to switch on, the device won’t react, but generate a requester in the display or, in remote control, return a communication error.
		LOW	+	Normal		

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

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

b) Remote control of current and power

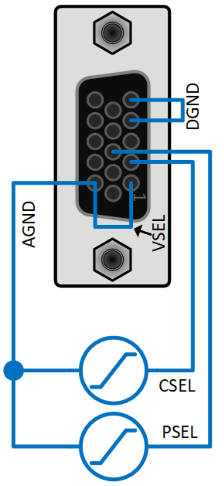
Requires remote control to be activated (pin REMOTE = LOW)

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

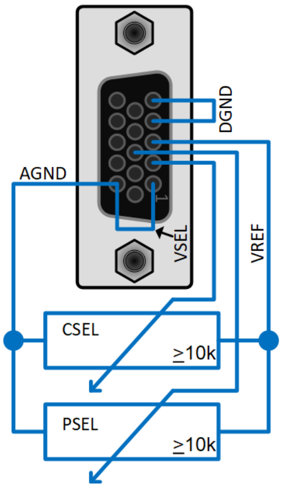
The voltage set value VSEL is directly connected to AGND (=0%), so voltage control cannot interfere constant power or constant current.

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

!	*When using the voltage range 0...5 V the effective resolution of set values and actual values halves.*



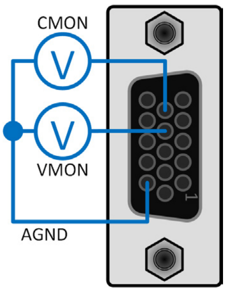
Example with external voltage source



Example with potentiometers

c) Reading actual values

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



2.3.4.8 Analog interface priority

A new functionality, available for all 10000 series devices with analog interface and from firmware KE 3.10 and HMI 4.09, allows the user to prioritize the analog interface over other remote control interfaces. The rule was and is that no interface, analog or digital, is superior to another in regard of the remote control state. It means, that when a device would be in remote control by any digital interface and the remote control is going to be switched over to analog interface, it would require to leave the digital remote control state first via a specific command sent via the interface in control.

With this feature, when activated (see section *2.2.1.1*), the analog interface can take over remote control anytime, except when the condition **Local** is set. In the moment of the switchover, the set values and the DC input status, as given by the pins of the analog interface, would become effective immediately. In the contrary, leaving analog remote control (pin: REMOTE) would neither return the device into the prior state of digital remote control, nor restore the set values and DC condition as they were before. Leaving remote control always keeps the last set of set values, while the DC input condition is determined by the parameter **State after remote** (see section *2.2.1.1*).

3. The function generator

3.1 Introduction

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

The standard functions are based on an **arbitrary generator** and directly accessible and configurable using manual control. In remote control, the fully customizable arbitrary generator replicates these functions with sequence points containing 8 parameters each. The following functions are retrievable, configurable and controllable:

Function	Short description
Sine	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 duration
Ramp	Generation of a linear rise or fall ramp with start and end values and time before and after the ramp
XY table	XY generator, USB stick loadable current curve (table, CSV)
Battery test	Battery charge and discharge test with constant or pulsed current, along with Ah, Wh and time counters
MPP tracking	Simulation of the characteristic tracking behavior of solar inverters when seeking to find the maximum power point (MPP) when being connected to typical sources such as solar panels

3.2 General

3.2.1 Resolution

Amplitudes generated by the arbitrary generator have an effective resolution of approx. 52428 steps. If the amplitude is very low and the time long, the device would generate less steps and set multiple identical values after another, generating a staircase effect.

3.2.2 Minimum slope / maximum ramp time

The requirement to set up a minimim slope and maximum ramp time has been removed since the release of KE 3.02 and DR 1.0.2.20 (newer production dates from 03/2022) and 1.0.9 (older production dates until approx. 01/2022.

Ramps or mixed AC/DC functions where the DC offset varies from start to end can now use the full 36000 seconds.

3.2.3 Method of operation

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

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

The selected function can be used on one of the values U or I, the other two are then constants and have a limiting effect. That means, if, e.g. a voltage of 40 V is applied to the DC input and a sine wave function should operate on the current with an amplitude of 200 A and offset 200 A, then the function generator should create a sine wave progression of current between 0 A (min) and 400 A (max), which will result in an input power between 0 W (min) and 16000 W (max). The input power, however, is limited to its set value. If this were 12000 W, the current would be limited to 300 A and, if clamped to an oscilloscope, it would be displayed as truncated at 300 A and never achieve the target of 400 A.

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

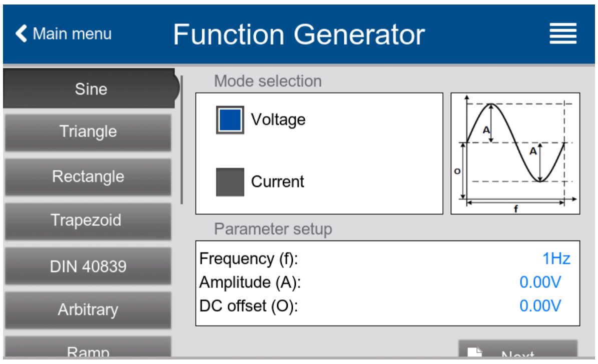
Master-slave systems have further characteristics which have to be considered:

> ⚠ At the end of the configuration, after the function has been loaded and the screen shows the main view of the function generator, there are adjustable set values, the so-called "U/I/P limits". These limits are transferred as set values to all slave units of a master-slave system. It's required to carefully configure these limits, so the MS system can work as expected and the slaves wouldn't impact the function run in a negative way.

3.3 Manual operation

3.3.1 Function selection and control

All the functions listed in section *3.1* can be accessed on the touch screen, configured and controlled. Selection and configuration are only possible while the DC input is switched off.



► How to select a function and adjust parameters

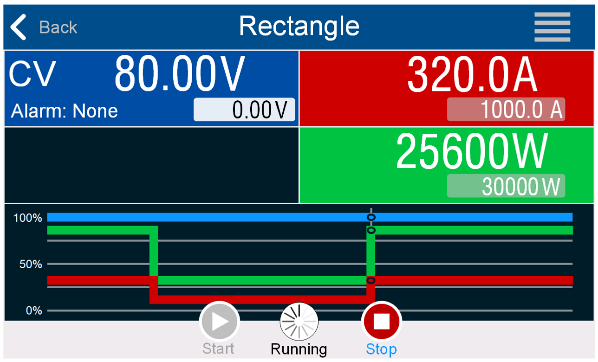
1. While the DC input is switched off, tap on touch area Func Gen on the main screen.
2. In the menu, select the desired function by tapping on the list on the left-hand side. Depending on the selected function, you will have to choose to either apply the function to **Voltage** or **Current**.
3. Adjust the parameters as you desire and then tap on Next.
4. As the last part of the configuration, global set values have to be defined which are considered as static values and come into effect before and after the function run. Correct setup here is important, <u>especially when running the function on a master device of a master-slave system</u>.

> *The global limits of U, I and P become instantly active when coming to the main screen of the function generator, because the DC input is then switched on automatically to settle the start situation. This can be helpful when a function shall not start at 0 V or 0 A. In case the situation requires otherwise, the static values could also be set to 0. There is alternatively a switch called "Set DC input only active during running function" which, when set, would prevent the automatic DC input switch-on after loading.*

5. Exit the configuration and enter the main function generator screen with Next.

Setting the various functions and their parameters is described below. After the function generator screen has been reached, the function is ready to run. Before and while the function is running, some global and also some function related values can be adjusted anytime.

► How to start and stop a function



1. The function can be **<u>started</u>** either by tapping on ▶ or, if the DC input is currently switched off, by pushing the **On/Off** button on the front.

2. The function can either be **<u>stopped</u>** by tapping on ■ or operating the **On/Off** button. However, there is a difference:

   a) The ■ button only stops the function while the DC input <u>remains ON</u> with the static values in effect.

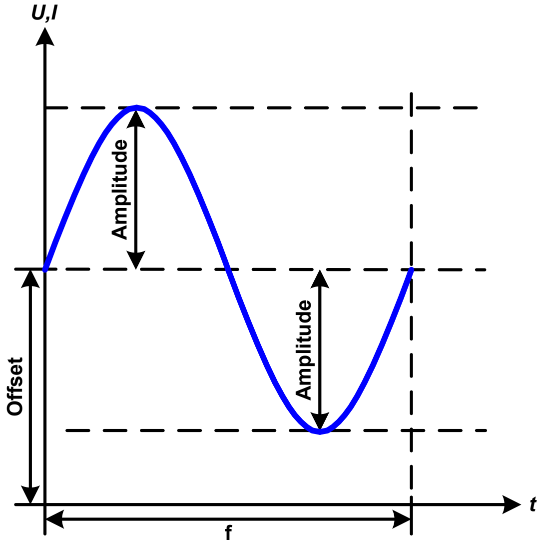
   b) The **On/Off** button stops the function and switches the DC input off.

> *Any device alarm (power fail, overtemperature etc.), protection (OPP, OCP) or event with "Action = Alarm" stops the function progress automatically, switches off the DC input and reports the alarm.*

3.4 Sine wave function

The following parameters can be configured for a sine function:

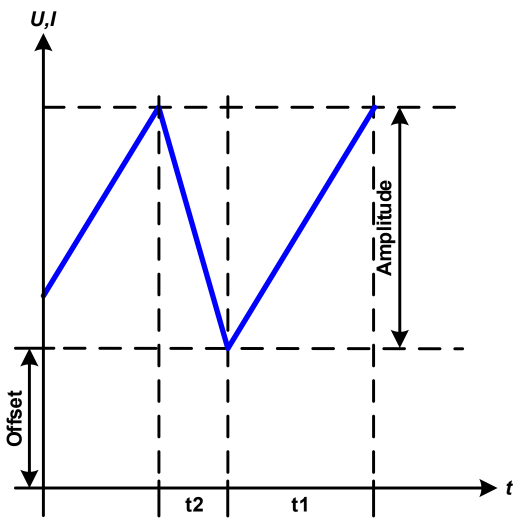
Parameter	Range	Description
Frequency (f)	**1Hz...10000Hz**	Static frequency of the signal to be generated
Amplitude (A)	**0...**(rated value of U or I - **Offset**)	Amplitude of the signal to be generated
Offset (O)	**0...**((U_{Nom} or I_{Nom}) - **Amplitude**)	Offset from the zero point of the mathematical sine curve

Schematic diagram:	Application and result:
	A normal sine wave signal is generated and applied to the selected set value, e.g. current (I). At a constant input voltage the current input of the load will follow a sine wave. For calculating the maximum power input the amplitude and offset values for the current must be added. Example: with an input voltage of 100 V and sin(I) selected, set the amplitude to 30 A and the offset to 50 A. The resulting maximum input power is then achieved at the highest point of the sine wave and is (30 A + 50 A) * 100 V = 8000 W.

3.5 Triangular function

The following parameters can be configured for a triangular function:

Parameter	Range	Description
Amplitude (A)	**0...**(rated value of U or I - **Offset**)	Amplitude of the signal to be generated
Offset (O)	**0...**((U_{Nom} or I_{Nom}) - **Amplitude**)	Offset, based on the foot of the triangular wave
Time t1	**0.1ms...36000000ms**	Rising edge time Δt of the triangular wave signal
Time t2	**0.1ms...36000000ms**	Falling edge time Δt of the triangular wave signal

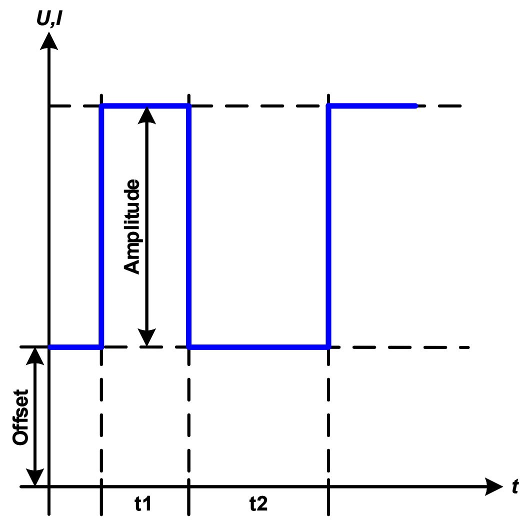
Schematic diagram:	Application and result:
	A triangular wave signal for use on the current or voltage is generated. The positive and negative slope times can be set independently. The offset shifts the signal on the Y axis. The sum of the intervals t1 and t2 gives the cycle time and its reciprocal is the frequency. Example: a frequency of 10 Hz is required and would lead to periodic duration of 100 ms. This 100 ms can be freely allocated to t1 and t2, e.g. 50 ms:50 ms (isosceles triangle) or 99.9 ms:0.1 ms (right-angled triangle or sawtooth).

3.6 Rectangular function

The following parameters can be configured for a rectangular function:

Parameter	Range	Description
Amplitude (A)	0...(rated value of U or I - **Offset**)	Amplitude of the signal to be generated
Offset (O)	0...((U_{Nom} or I_{Nom}) - **Amplitude**)	Offset, based on the foot of the rectangular wave
Time t1	**0.1ms...36000000ms**	Time (pulse width) of the upper level (amplitude)
Time t2	**0.1ms...36000000ms**	Time (pause width) of the lower level (offset)

Schematic diagram:



Application and result:

A rectangular or square wave signal for use on the current or 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 period and its reciprocal the frequency.

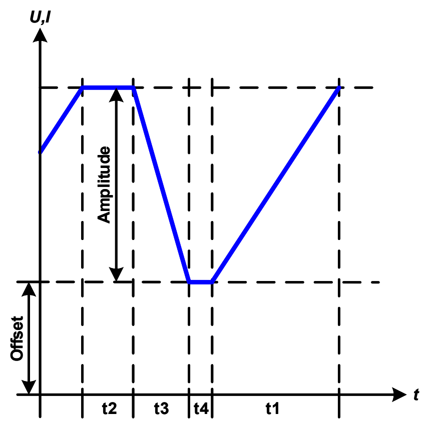
Example: a rectangular wave signal of 25 Hz and a duty cycle of 80% are required. The sum of t1 and t2, the period, is 1/25 Hz = 40 ms. For a duty cycle of 80% the pulse time (t1) is 40 ms*0.8 = 32 ms and the pause time (t2) is 8 ms

3.7 Trapezoidal function

The following parameters can be configured for a trapezoidal function:

Parameter	Range	Description
Amplitude (A)	0...(rated value of U or I - **Offset**)	Amplitude of the signal to be generated
Offset (O)	0...((U_{Nom} or I_{Nom}) - **Amplitude**)	Offset, based on the foot of the trapezium
Time t1	**0.1ms...36000000ms**	Time for the positive slope of the trapezoidal wave signal.
Time t2	**0.1ms...36000000ms**	Time for the top value of the trapezoidal wave signal.
Time t3	**0.1ms...36000000ms**	Time for the negative slope of the trapezoidal wave signal.
Time t4	**0.1ms...36000000ms**	Time for the base value (=offset) of the trapezoidal wave signal

Schematic diagram:



Application and result:

Same as with other functions the generated signal can be applied to the set value of voltage (U mode) or to the current (I mode). The slopes of the trapezium can be varied by adjusting the times for rise and fall separately.

The periodic duration and repetition frequency are the result of the four adjustable time values. With suitable settings the trapezium can be deformed to two triangular or two rectangular pulses. It therefore has universal use.

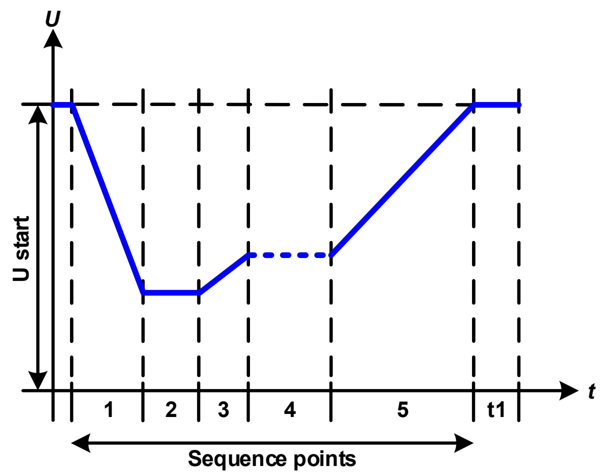
3.8 DIN 40839 function

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

The following parameters can be configured for the single sequence points or the entire function:

Parameter	Range	Seq	Description
Start	**0V...**U_{Nom}	1-5	Start voltage of the ramp in part 1-5 (sequence point)
Uend	**0V...**U_{Nom}	1-5	End voltage of the ramp in part 1-5 (sequence point)
Time	**0.1ms...36000000ms**	1-5	Time of the ramp
Cycles	**0** / **1...999**	-	Number of times to run the entire curve (0 = infinite)
Time t1	**0.1ms...36000000ms**	-	Time after cycle before repetition (cycle <> 1)
U(Start/End)	**0V...**U_{Nom}	-	Voltage setting before and after the function run
I/P	**0A...**I_{Nom}/**0W...**P_{Nom}	-	Set values of current and power

Schematic diagram:



Application and result:

The function's primary use is to load a source, for instance a power supply, which cannot generate the curve itself and would supply a static DC voltage. The load acts as a sink for the rapid fall of the output voltage of the power supply enabling the voltage progress to follow the DIN curve. The only requirement for the source is that it features (an adjustable) current limitation.

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

3.9 Arbitrary function

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

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

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

Parameter	Range	Description
AC start **AC end**	-50%...+50% I_{Nom} or 0%...50% U_{Nom}	Start and end amplitude of the sinusoidal AC part
DC start	±(**AC start**...(rated value - **AC start**))	Start level (offset) of the DC part
DC end	±(**AC end**...(rated value - **AC end**))	End level (offset) of the DC part
Start frequency	**0Hz...10000 Hz**	Start frequency of the sinusoidal AC part
End frequency	**0Hz...10000 Hz**	End frequency of the sinusoidal AC part
Angle	**0°...359°**	Start angle of the sinusoidal AC part
Time	**0.1ms...36000000ms**	Time setting for the selected sequence point

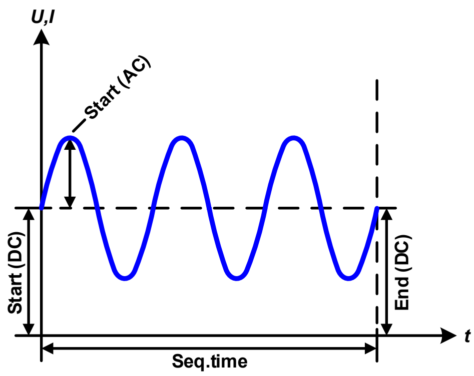
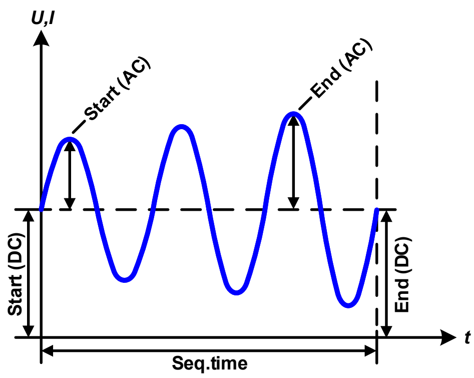
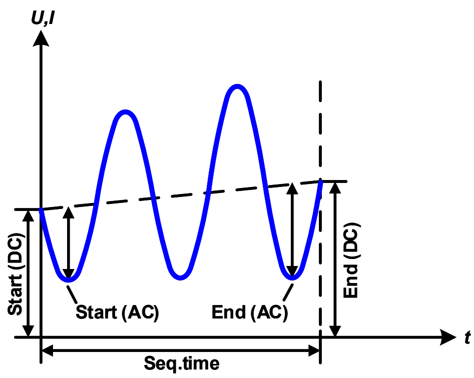
!	*The sequence point time ("Time") and the start and end frequency are related. The minimum value for Δf/s is 9.3. Thus, for example, a setting of start frequency = 1 Hz, end frequency = 11 Hz and time = 5 s would not be accepted as Δf/s is only 2. A time of 1 s would be accepted or, if the time remains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

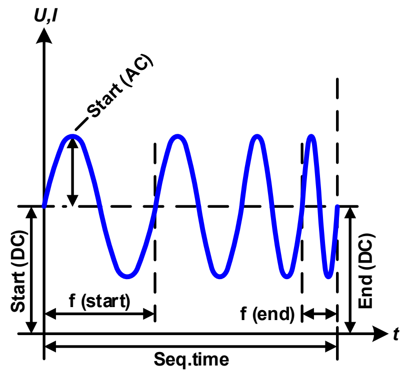
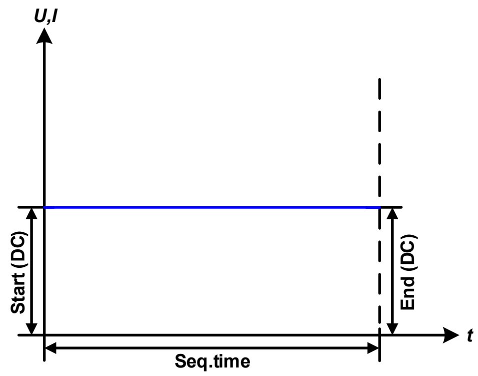
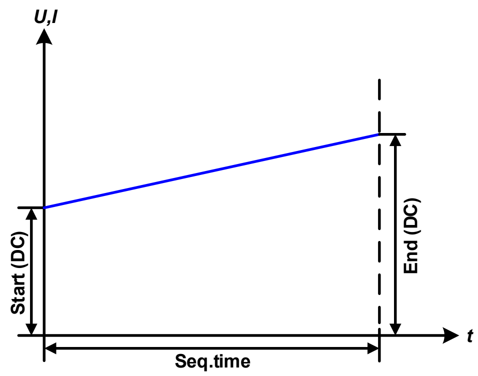
!	*The amplitude change between start and end is related to the sequence time. A minimal change over an extended time is not possible and in such a case the device will report an inapplicable setting.*

After the settings for the selected sequence point have been defined, further points can be configured. Further down, there are some global settings for the arbitrary function:

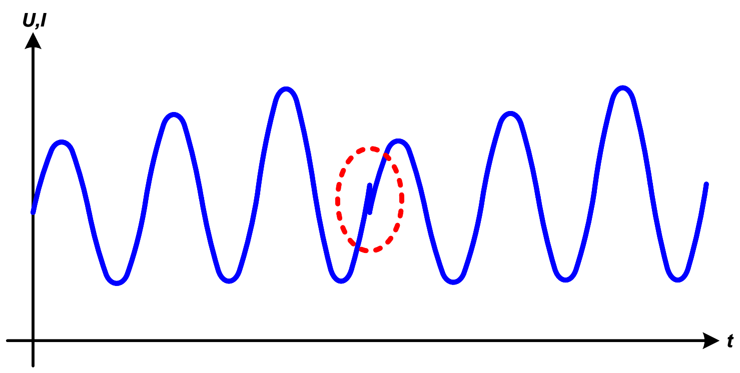
Parameter	Range	Description
Cycles	0 / 1...999	Number of cycles to run the sequence point block (0 = infinite)
Start sequence	1...**End sequence**	First sequence point in the block
End sequence	**Start sequence**...99	Last sequence point in the block

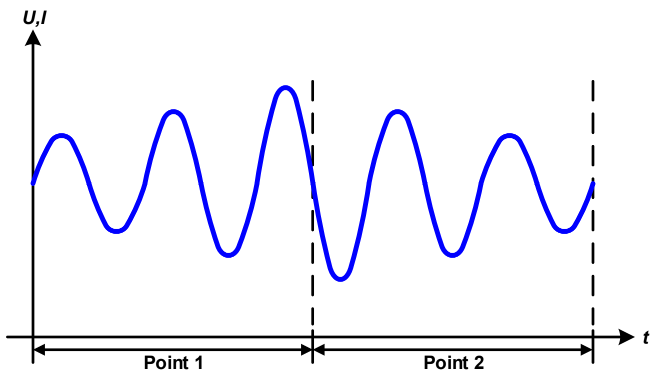
After continuing with Next there are global set values to define as the last part of the function generator setup.

<table>
<tr><th>Schematic diagram:</th><th>Applications and results:</th></tr>
<tr><td>
</td><td>Example 1: Focusing 1 cycle of 1 sequence point:
The DC values for the start and end are the same, also the AC amplitude. With a frequency >0 Hz a sine wave progression of the set value is generated with a defined amplitude, frequency and Y axis offset (DC values for the start and end).
The number of sine waves per cycle depends on the sequence point time and the frequency. If the time was 1 s and the frequency 1 Hz, there would be exactly one sine wave. If the time was 0.5 s at the same frequency, there would only be a half sine wave.</td></tr>
<tr><td>
</td><td>Example 2: Focusing 1 cycle of 1 sequence point:
The DC values at the start and end are the same but those of the amplitude aren't. The end value is higher than the start value so the amplitude increases with each new half sine wave continuously over the sequence point time. This, of course, only if time and frequency allow for multiple waves to be created. For instance, with f=1 Hz and time = 3 s, three full waves would be generated, if the angle is 0°, and reciprocally the same for f=3 s and time=1 s.</td></tr>
<tr><td>
</td><td>Example 3: Focusing 1 cycle of 1 sequence point:
The DC values at the start and end are not equal, as well as the AC start and end values. In both cases the end value is higher than the start value so that offset increases over time, but also the amplitude with each new half sine wave.
Additionally, the first sine wave starts with a negative half wave because the angle has been set to 180°. The start angle can be shifted at will in steps of 1° between 0° and 359°.</td></tr>
</table>

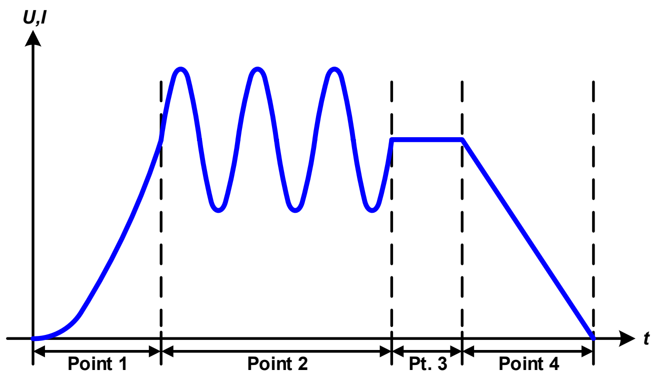
Schematic diagram:	Applications and results:
	**Example 4:** Focusing 1 cycle of 1 sequence point: Similar to example 1, but with a different end frequency. Here it's shown as higher than the start frequency. This impacts the period of the sine waves such that each new wave will be shorter over the total span of the sequence time.
	**Example 5:** 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 generated and only the DC settings will be effective. A ramp with a horizontal progression would result.
	**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 generated and only the DC settings will be effective. Here the DC start and end values are unequal and a steadily increasing ramp would result.

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

Schematic diagram:	Applications and results:
	**Example 7** Focusing 2 cycles of 1 sequence point: One sequence point, configured as in example 3, is run. Since the settings define that the end offset (DC) is higher than the start, the second run will revert to the same start level as the first, regardless of the signal level 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 a careful choice of settings.

<table>
<tr><th>Schematic diagram:</th><th>Applications and results:</th></tr>
<tr><td>
</td><td>Example 8

Focusing 1 cycle of 2 sequence points:

Two sequence points run consecutively. The first one generates a sine wave with increasing amplitude, the second one with a decreasing amplitude. Together they produce a progression as shown on the left. In order to ensure that the wave peak in the middle occurs only once, the first sequence point must end with a positive half wave and the second one start with a negative half wave as shown in the diagram.</td></tr>
<tr><td>
</td><td>Example 9

Focusing 1 cycle of 4 sequence points:

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

Point 2: Three sine waves (ratio of frequency to time is 1:3)

Point 3: Horizontal ramp (f = 0)

Point 4: Falling ramp (f = 0)</td></tr>
</table>

3.9.1 Loading and saving the arbitrary function

The 99 sequence points of the arbitrary function, which can be manually configured with the control panel of the device and which are applicable either to voltage (U) or current (I), can be saved to or loaded from a common USB stick via the front side USB port. Generally, all 99 points are saved or loaded at once using a text file of type CSV which represents a table of values.

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

- The table must contain exactly 99 rows with 8 subsequent values (8 columns) and must not have gaps
- The column separator (semicolon, comma) must be as selected by menu parameter **USB logging -> Log file separator format**; it also defines the decimal separator (dot, comma)
- The files must be stored inside a folder called HMI_FILES which has to be in the root of the USB stick
- The file name must always start with WAVE_U or WAVE_I (not case-sensitive)
- All values in every row and column have to be within the specified range (see below)
- The columns in the table have to be in a defined order which must not be changed

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

Column	Connected to HMI parameter	Range
A	AC start	See the table in *«3.9 Arbitrary function»*
B	AC end	See the table in *«3.9 Arbitrary function»*
C	Start frequency	0...10000 Hz
D	End frequency	0...10000 Hz
E	Angle	0...359°
F	DC start	See the table in *«3.9 Arbitrary function»*
G	DC end	See the table in *«3.9 Arbitrary function»*
H	Time	100...36.000.000.000 µs (36 billion)

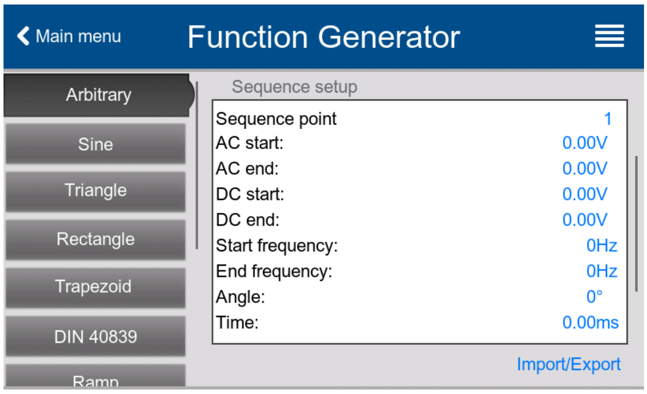
For details about the parameters and the arbitrary function refer to *«3.9 Arbitrary function»*.

Example CSV:

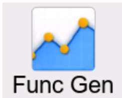
	A	B	C	D	E	F	G	H
1	20,00	30,00	5	5	90	50,00	50,00	50000000
2	30,00	20,00	5	5	90	50,00	50,00	30000000
3	0,00	0,00	0	0	0	0,00	0,00	1000
4	0,00	0,00	0	0	0	0,00	0,00	1000
5	0,00	0,00	0	0	0	0,00	0,00	1000
6	0,00	0,00	0	0	0	0,00	0,00	1000

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 ELR 10080-1000 4U, 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 stick



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

2. While the DC input is switched off, tap on 

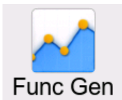
to access the function selection menu. There tap on group **Arbitrary** which will show the settings as shown in the screenshot to the right.

3. Swipe up to go down to the **Sequence setup** part and tap on **Import/Export**, then on **Load** and follow the instructions. If the file open dialog can at least list one compatible file, it will be listed for selection. Select your desired table.

4. To finally load the file, tap on . The selected file is then checked for validity and loaded. In case of format errors, a message will be shown on the screen. The file would have to be checked and tried again.

► How to save a sequence point table to a USB stick

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

2. While the DC input is switched off, tap on 

to access the function selection menu. There tap on group **Arbitrary**.

3. Swipe up to go down to the **Sequence setup** part and tap on **Import/Export**, then on **Save** and follow the instructions. In the file open dialog you can either select an existing file, if at least one compatible file is listed, or you can create a new one by not selecting any file.

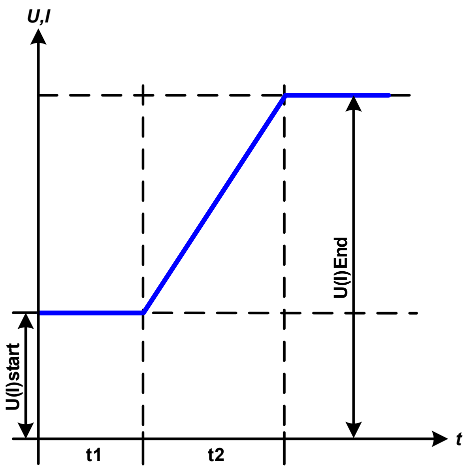
4. Save the file, new or overwriting, with .

3.10 Ramp function

The following parameters can be configured for a ramp function:

Parameter	Range	Description
Start **End**	0V...U_{Nom} or 0A...I_{Nom}	Start/end point of the ramp. Both values can be equal or different, which then results in either a rising, falling or horizontal ramp
Time t1	0.1ms...36000000ms	Time before ramp-up or ramp-down of the signal.
Time t2	0.1ms...36000000ms	Ramp-up or ramp-down time

10 h after reaching the ramp end, the function will stop automatically (i.e. I = 0 A, in case the ramp was assigned to the current), unless it has been stopped manually before.

Schematic diagram:	Application and result:
	This function generates a rising, falling or horizontally running ramp between the start and end values over time t2. Time t1 creates a delay before the ramp starts. The function runs once and stops at the end value. To have a repeating ramp, the Trapezoid function would have to be used instead (see section *3.7*).

3.11 IU table function (XY table)

The IU function offer the user the possibility to set a DC input current dependent on the DC input voltage. The function is table driven with exactly 4096 values, which are distributed over the whole measured range of actual input voltage in the range of 0...125% Unom, of which only 0...102% are effective . The table can either be uploaded from a USB stick through the front side USB port of the device or via remote control (ModBus RTU protocol or SCPI). The functions are:

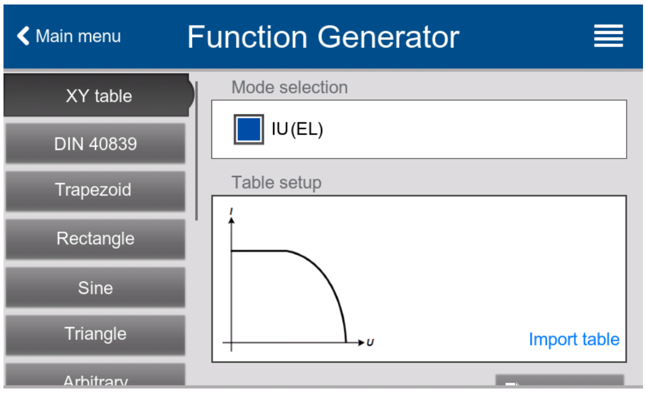
IU function: I = f(U)

In the **IU function**, an internal measuring circuit measures the voltage on the DC input. For every possible actual voltage on the scale of 0...125% the loaded IU table holds a current value, which can be any value between 0 and rated current. The values uploaded from a USB stick will always be interpreted as current values even if the user calculated them as voltage values and loaded them as an IU table due to wrong file naming.

Uploading of a table from a USB stick must use text files in CSV format (.csv). Plausibility is checked when loading, i.e. values not too high, number of values correct etc. which may abort loading when errors are found.*

The 4096 values in the table are only checked for size and count. If all the values were to be graphically plotted into a curve it could include huge step changes in the current. This could lead to complications for the connected source if, for example, the internal voltage measurement swings slightly so that the current jumps back and forth between a few values in the table which, in the worst case, could be bounce between 0 A and the maximum current.

3.11.1 Loading IU tables from USB stick



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

- The file name always begins with IU (not case-sensitive)
- The file must be a text file of type Excel CSV and must only contain one column with exactly 4096 values without gaps
- Values with decimal places must use decimal separator that matches the selection in the general setting **Log file separator format**, which also defines the decimal separator between dot and comma (US default should be dot)
- No value may exceed the rated current of the device model. For example, if you have a 420 A model, none of the 4096 values must be higher than 420 A (the adjustment limits from the device's front panel do not apply here)
- The file(s) has/have to be put inside a folder named HMI_FILES in the root path of the stick

If these specifications are not met, the device won't accept the file and put out an error message in the display. The USB stick may contain multiple IU files with different names and list them for the selection of one.

► How to load an IU table from a USB stick

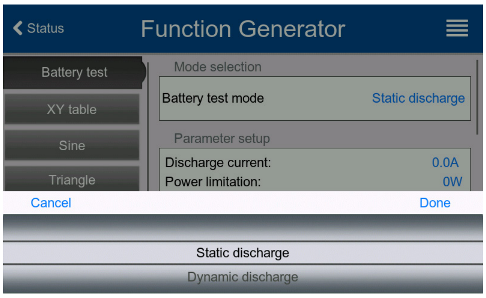
1. While the DC input is switched off, open the function selection menu by tapping on Func Gen, then select group **XY table**.
2. Insert the USB stick, if not already done, then tap on **Import table** and in the file selector coming up select the table you want to load and confirm with ✓. In case the file isn't accepted for any of the above listed reasons, correct the file format and content, then try again.
3. Tap Next to proceed to the next screen where you can adjust the global set values.
4. Finally proceed to the main function screen with Next, to start and control the function (also see *«3.3.1 Function selection and control»).*

3.12 Battery test function

⚠	The battery test function is only a feature to test batteries. It has no battery management functionality. It means, that there is no monitoring of single battery cells. Dead cells cannot be detected and in case there is at least one dead cell in a battery when being discharged by the device, the battery could be destroyed. External battery management hardware and software might be required.

The purpose of the battery test function is to discharge various battery types in industrial product tests or laboratory applications.

Due to the nature of an electronic load it can only work in sink mode, it means only discharge the battery. In combination with a power supply, for example from series PSI 10000, a dynamic charge & discharge can be achieved, like when using the dynamic test modes of series PSB 10000. With a custom software, which integrates the source and the sink device under one GUI, so they work in two-quadrant operation, any test scenario could be realized.

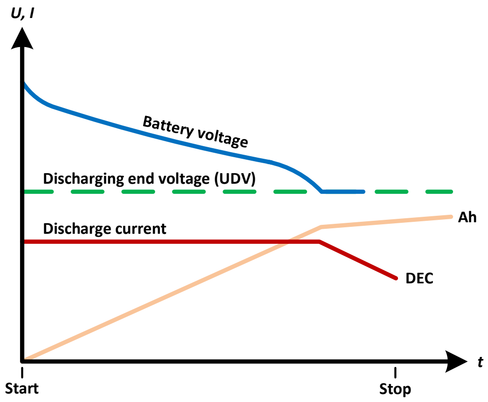


There is a choice of two modes: **Static discharge** (constant current) and **Dynamic discharge**.

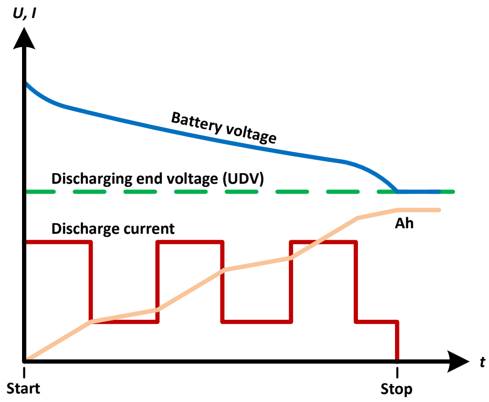
In the **Static discharge** mode, which by default runs in constant current (CC), the device will discharge a battery until it reaches the discharging end voltage (UDV), a point where it switches from to constant voltage mode (CV), discharging the battery further until reaching the discharging end current (DEC), where the test would stop.

For the **Dynamic discharge** mode, there is also a power setting, but it cannot be used to run the dynamic battery test function in pulsed power mode or at least the result would not be as expected. It's recommended to always adjust the power value according to the test parameters, so it doesn't interfere with the pulsed current.

Graphical depiction of both discharging modes:



Static discharge



Dynamic discharge

3.12.1 Settings for the static discharge mode

The following parameters can be configured for the static discharge battery test function:

Value	Range	Description
Discharge current	0A...I_{Nom}	Maximum discharge current (in Ampere)
Discharge end voltage	0V...U_{Nom}	Minimum voltage to discharge a battery to (in Volt)

3.12.2 Settings for the dynamic discharge mode

The following parameters can be configured for the dynamic discharge battery test function:

Value	Range	Description
Discharge current 1	0A...I_{Nom}	Upper resp. lower current setting for pulsed operation (the higher value of both is automatically used as upper level)
Discharge current 2	0A...I_{Nom}	
Power limitation	0W...P_{Nom}	Maximum discharge power (in Watt)
Time t1	1s...36000s	t1 = Time for the upper level of the pulsed current (pulse)
Time t2	1s...36000s	t2 = Time for the lower level of the pulsed current (pause)

3.12.3 Stop conditions

These parameters are valid for all test modes and define additional stop conditions:

Value	Range	Description
Action: Ah limit	**None, Signal, End of test**	Enables the optional stop condition
Discharge capacity	**0Ah...99999.99Ah**	Threshold for the max. capacity to consume from or feed to the battery and after which the test can stop automatically. This is optional, so that also more battery capacity can be consumed or supplied.
Action: Time limit	**None, Signal, End of test**	Enables the optional stop condition
Discharge time	**00:00:00...10:00:00**	Test time in format HH:MM:SS, after which the test can stop automatically. This stop criteria is optional, it means that single tests can also run longer than 10 h.
Discharge end current	**0A**...I_{Nom}	Only used for: **Static discharge**. This test mode doesn't stop when reaching the discharge end voltage, it would only stop when reaching this current threshold.
Discharge end voltage	**0V**...U_{Nom}	Only used for: **Dynamic discharge**. Minimum voltage (in Volt) to where a battery is discharge and where the test will stop.

3.12.4 Displayed values

During the test run, the display will show various values and statuses:

- Actual battery voltage on the DC input
- Discharge end voltage U_{DV} in V (only in discharge mode)
- Charge voltage in V (only in charge mode)
- Actual discharge or charge current
- Actual power
- Total battery capacity (charging & discharging)
- Total battery energy (charging & discharging)
- Elapsed time
- Control mode (CC, CP, CR, CV)

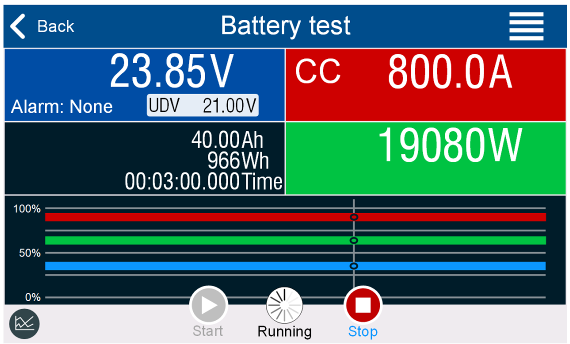


Figure 2 - Example from static discharge

3.12.5 Data recording to USB stick

At the end of the configuration of all test modes there is the option to enable a logging feature:

Value	Range	Description
USB logging	on/off	By setting the check mark, USB logging is enabled and will record data on a properly formatted USB stick, if plugged in to the front USB port. The recorded data differs from the USB log data recorded during "normal" USB logging in all other operation modes of the device.
Logging interval	**100ms - 1s, 5s, 10s**	Writing interval for USB logging

With a USB stick plugged and formatted as required (see section *1.9.6.5* in the installation manual), the device can record data during the test run directly to the stick and in the defined interval. Active USB logging is indicated in the display with a small diskette symbol. After the test has stopped, the recorded data will be available as text file in CSV format.

Log file format example from static discharge mode:

	A	B	C	D	E	F	G
1	Static:Uset	Iset	Pset	Rset	DV	DT	DC
2	0,00V	0,00A	1200W	OFF	0,00V	10:00:00	99999,00Ah
3							
4	Uactual	Iactual	Pactual	Ah	Wh	Time	
5	0,34V	0,00A	0W	0,00Ah	0,00Wh	00:00:00,800	
6	0,28V	0,00A	0W	0,00Ah	0,00Wh	00:00:01,800	
7	0,28V	0,00A	0W	0,00Ah	0,00Wh	00:00:02,800	
8	0,28V	0,00A	0W	0,00Ah	0,00Wh	00:00:03,800	

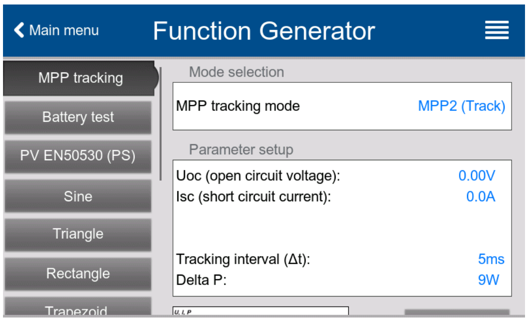
Static = Selected test mode
Iset = Discharging current
Pset = Max. power
Rset = Desired resistance
DV = Discharge end voltage
DT = Discharge end time
DC = Discharge end capacity
U/I/Pactual = Actual values
Ah = Consumed battery capacity
Wh = Consumed energy
Time = Elapsed test time

3.12.6 Possible reasons for a battery test stop

The battery test function run can be stopped due to different reasons:

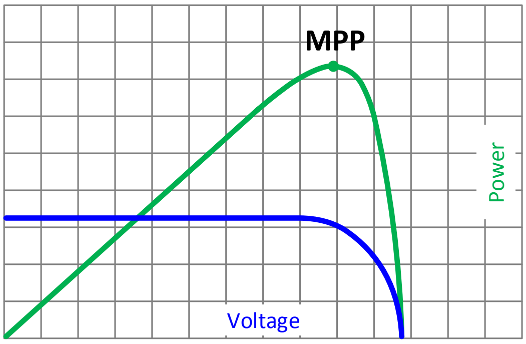
- Manual stop on the HMI with button **Stop**
- After the max. test time has been reached and action **End of test** was preset
- After the max. battery capacity to consume has been reached and action **End of test** was preset
- Any device alarm which would also switch off the DC input, like OT
- Reaching the threshold U_{DV} (discharge end voltage)
- Reaching the threshold for charging end current

3.13 MPP tracking function



MPP stands for the maximum power point (see the principle view to the right) on the power curve of solar panels. Solar inverters, when connected to such panels, constantly track this MPP once it has been found.

An electronic load can easily imitate this behavior and hence be used to test even huge solar panels without having to connect a usually big solar inverter device which also requires to have a load connected to its AC output. Furthermore, all MPP tracking related parameters of the electronic load can be adjusted and it's therefore more flexible than an inverter with its limited DC input range.



For evaluation and analysis purposes, the device can also record measured data, i. e. DC input values such as actual voltage, current or power, to a USB stick or provide them for reading via any digital interface.

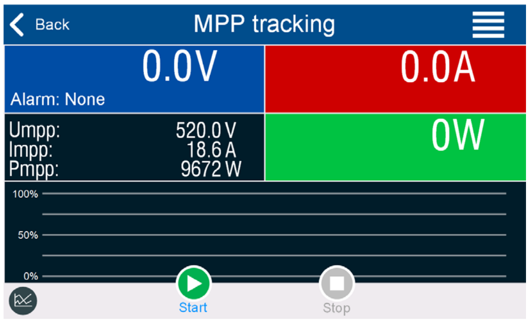
The MPP tracking function offers **four modes**. Unlike with the manual handling of other functions, values for the MPP tracking are only entered by direct input via the touch screen.

3.13.1 Mode MPP1

This mode is also called "Find MPP". It's the simplest option to have the device find the MPP of a connected solar panel. It's only necessary to set three parameters. Value U_{OC} is necessary, because it helps to find the MPP quicker then starting at 0 V or maximum voltage. Actually, it would start at a voltage level slightly above U_{OC}. I_{SC} is used as an upper limit for the current, so the device would not try to draw more current than the panel is specified for. Following parameters can be configured for tracking mode **MPP1**:

Value	Range	Description
U_{OC} (open circuit voltage)	0V...U_{Nom}	Voltage of the unloaded solar panel, taken from the panel specs
I_{SC} (short-circuit current)	0A...I_{Nom}	Short-circuit current, taken from the panel specs
Tracking interval (Δt)	5ms...60000ms	Time between two tracking attempts when finding the MPP

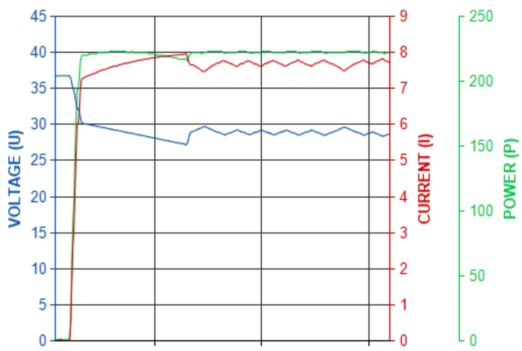
Application and result:



After the three parameters have been set, the function can be started. As soon as the MPP has been found, the function will stop and switch off the DC input. The acquired MPP values of voltage (U_{MPP}), current (I_{MPP}) and power (P_{MPP}) would then be shown in the display.

The time of a function run depends on the parameter Δt. Even with the minimum setting of 5 ms, one run usually already takes a few seconds.

3.13.2 Mode MPP2



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

Typical curves are shown in the picture to the right. There the **Delta P** was set to a quite small value, so the power curve looks almost linear. With a small **Delta P** the load would always track close to the MPP.

The following parameters can be configured for tracking mode **MPP2**:

Value	Range	Description
U_{OC} (open circuit voltage)	**0V**...U_{Nom}	Voltage of the unloaded solar panel, taken from the panel specs
I_{SC} (short-circuit current)	**0A**...I_{Nom}	Short-circuit current, taken from the panel specs
Tracking interval (Δt)	**5ms...60000ms**	Interval for measuring U and I while finding the MPP
Delta P	**0W**...P_{Nom}	Tracking/control tolerance below the MPP

3.13.3 Mode MPP3

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

The following parameters can be configured for tracking mode **MPP3**:

Value	Range	Description
U_{OC} (open circuit voltage)	**0V**...U_{Nom}	Voltage of the unloaded solar panel, taken from the panel specs
I_{SC} (short-circuit current)	**0A**...I_{Nom}	Short-circuit current, taken from the panel specs
U_{MPP} (max. power point)	**0V**...U_{Nom}	Voltage in the MPP
P_{MPP} (max. power point)	**0W**...P_{Nom}	Power in the MPP
Tracking interval (Δt)	**5ms...60000ms**	Interval for measuring U and I while finding the MPP
Delta P	**0W**...P_{Nom}	Tracking/control tolerance below the MPP

3.13.4 Mode MPP4

This mode is different to the others, because it does not track automatically. It rather offers the choice to define a user curve by setting up to 100 points of voltage values, then track this curve, measure current and power and return the results in up to 100 sets of acquired data. The curve points can only be loaded from a USB stick. Start and end point can be adjusted as well, Δt defines the time between two points and the function run can be repeated up to 65535 times. Once the function stops at the end or due to manual interrupt, the DC input is switched off and the measured data is made available. After the function, the acquired set of data with the highest actual power will be shown in the display as voltage (U_{MPP}), current (I_{MPP}) and power (P_{MPP}) of the MPP. Going back one page then allows for data export of the 100 measured results to a USB stick.

The following parameters can be configured for tracking mode **MPP4**:

Value	Range	Description
Start	**1...End**	Start point for the run of x out of 100 subsequent points
End	**Start...100**	End point for the run of x out of 100 subsequent points
Repetitions	**0...65535**	Number of repetitions for the run from Start to End
Tracking interval (Δt)	**5ms...60000ms**	Time before the next point

3.13.4.1 Load curve data from USB stick for mode MPP4

Curve point data (only one voltage value per point), in form of a CSV file, is loaded from a USB stick. See section *1.9.6.5* in the installation manual for the naming convention. Contrary to manual adjustment where you can define and use an arbitrary number of points, loading from a USB stick requires the CSV file to always contain the full number of points (100), because it can't define which one is start and end. However, the on-screen setting for the **Start** and **End** points remains valid. It means, if you actually want to use all 100 points from your loaded curve, you must set the parameters accordingly.

File format definition:

- The file must be a text file with appendix *.csv
- The file must contain only one column of voltage values (0... rated voltage)
- The file must contain exactly 100 values in 100 rows, without gaps
- The decimal separator of broken values must follow the setting "Log file separator format" where selection **US** means dot as decimal separator and selection **Standard** means comma

► How to load a curve data file for MPP4

1. While the DC input is switched off, enter the function generator by tapping on Func Gen. In the selection, swipe up to find group **MPP Tracking** and tap on it.
2. In the area **Mode selection** select **MPP4 (User curve)**. In the lower part under **Parameter** a new tap field **Load MPP4 voltage values** will appear. Tap it.
3. Insert a USB stick, if not already done.
4. The next screen searches the stick for compatible files and lists them. Tap the one you want to load and confirm with ✓.

3.13.4.2 Save result data from the MPP4 mode to a USB stick

After the MPP4 function has run through, the result data can be saved to a USB stick. The device will always save 100 data sets consisting of the actual values of voltage, current and power belonging to the points it has run through. There is no extra numbering. In case the settings **Start** and **End** were not 1 and 100, the true result data can later be filtered from the file. Points which where not adjusted are automatically set to 0 V, therefore it's very important to carefully adjust the start and end points, because with a voltage setting of 0 V an electronic load would draw its rated current. That's because in this mode, current and power are always set to maximum.

Format of the result data file (for naming convention see section *1.9.6.5* in the installation manual):

	A	B	C
1	1,01V	20,960A	21,0W
2	2,99V	20,970A	63,0W
3	3,99V	20,970A	84,0W
4	5,99V	20,940A	125,0W
5	7,00V	20,920A	146,0W
6	8,00V	20,930A	168,0W
7	9,00V	20,950A	188,0W
8	9,99V	20,960A	210,0W
9	10,99V	20,970A	231,0W

Legend:

- Column A: actual voltage of points 1-100 (= U_{MPP})
- Column B: actual current of points 1-100 (= I_{MPP})
- Column C: actual power of points 1-100 (= P_{MPP})
- Rows 1-100: result data sets of all possible curve points

The values in the example table to the left are with physical units. If that's not wanted, they can be turned off in the "General settings" of the device, with parameter "USB logging with units (V,A,W)".

► How to save a curve data file for MPP4

1. After the function has run through, it will stop automatically. Tap on **Back** to go back to the MPP4 configuration screen.
2. Insert a USB stick, if not already done.
3. Below the Next button tap on **Save records**. The next screen searches the stick for compatible files and lists them. Either tap one to select it (overwrite) or don't select any file to create a new file and confirm with ✓.

3.14 Remote control of the function generator

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

- The function generator isn't directly controllable via the analog interface; the only impact to the function run can come from pin REM-SB switching the DC input off and on, which will also stop and restart the function
- The function generator is unavailable if R mode (resistance) is activated

4. Other applications (2)

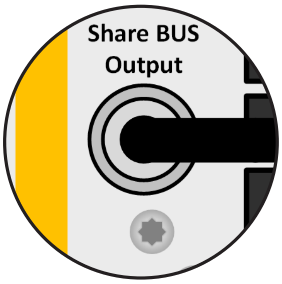
4.1 Parallel operation in master-slave (MS)

Multiple devices of the same kind can be connected in parallel in order to create a system with higher total current and also higher power. For parallel operation in master-slave mode the units are usually connected on their DC inputs, their Share-Bus and their master-slave bus, which is a digital bus that makes the system work as one big unit regarding adjusted values, actual values and status.

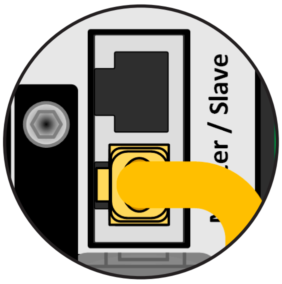
The Share-Bus is intended to balance the units dynamically in their voltage on the DC input, i.e. in CV mode, especially if the master unit runs a dynamic function. In order for this bus to work correctly, at least the DC minus poles of all units have to be connected, because DC minus is the reference for the Share-Bus.

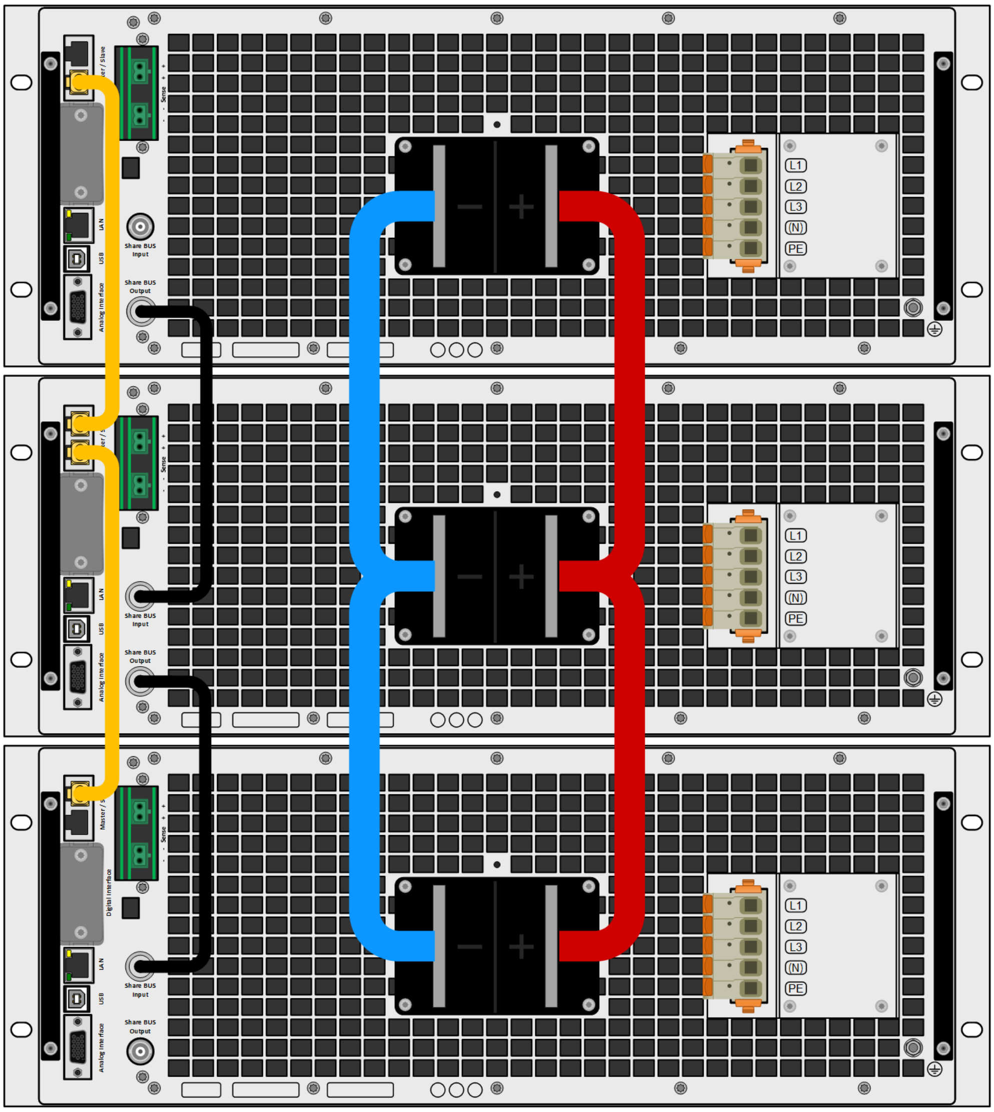
Principle view without source:

Share-Bus connection



Master-slave bus





4.1.1 Restrictions

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

- The MS system reacts partly different in alarm situations (see below in section *4.1.8*)
- Though the Share-Bus makes the system react as dynamic as possible, it's still not as dynamic as single unit operation
- Connection to identical models from other series is supported, but limited to electronic load series from the 10000s, such as PUL 10000

4.1.2 Wiring the DC inputs

The DC input of every unit in the parallel operation is connected with correct polarity to the next unit, using cables or copper bars with a cross section according to the total system current and with short as possible length, so their inductance is as low as possible.

4.1.3 Wiring the Share-Bus

The Share-Bus is wired from unit to unit with standard BNC cables (coaxial, 50 Ω type) with a length of 0.5 m (1.64 ft) or similar. Both sockets are internally connected and are not specifically input or output. The labeling is only for orientation.

> - *A max. of 64 units can be connected via Share-Bus.*
> - *When connecting the Share-Bus before a device had been configured as Master or Slave, an SF alarm will occur.*

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

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

- A maximum of 64 units can be connected via the bus: 1 master and up to 63 slaves.
- Connection only between devices of same kind, i.e. electronic load to electronic load; connection of different power classes is allowed and supported, e. g. one 15 kW 3U with one 30 kW 4U to achieve a total of 45 kW, but requires to have at least firmware KE/HMI 3.02 installed on all units
- Units at the end of the bus must be terminated (see below for more information)

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

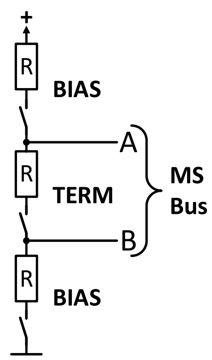
Later operation of the MS system implies:

- The master unit displays, or makes available to be read by the remote controller, the sum of the actual values of all the units
- The 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. For example, if 5 units, each with a power of 30 kW, are connected to a 150 kW system, then the master can be set in the range 0...150 kW.
- Slaves are not operable as long as being controlled by the master
- Slave units 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 as well

► How to connect the master-slave bus

1. Switch off all units and connect the master-slave bus with network cables (CAT3 or better, cables not included). It doesn't matter which of the two master-slave sockets (RJ45, backside) is connected to the next unit.
2. Depending on the desired configuration the units are then also connected at their DC inputs. The two units at the beginning and end of the chain must be terminated, while the master requires a separate setting. See the table below.

   Termination is done with internal electronic switches which are controlled from within the **Settings** menu of the device in group **Master-slave**. This can be done as part of setting up every unit as master or slave, but should be done before the master is going to be set as **Master**, because doing so immediately triggers a bus initialization. In group **Master-Slave** the termination resistors for BIAS and the bus itself (TERM, see the figure to the right) can be set separately. Settings matrix for the units on the MS bus:



Device position	Termination setting(s)
Master (at end of bus)	BIAS + TERM
Master (central in bus)	BIAS
Slave (at end of bus)	TERM
Slave (central in bus)	-

4.1.5 Mixed systems

As mixed systems following is understood (requires at least firmware KE 3.02):

- Different power classes, like 5 kW, 15 kW or 30 kW within one master-slave system
- Different series, such as ELR 10000 with PUL 10000

Combining different power classes can have an unexpected side effect, such that the resulting total power, as displayed by the master after the initialization, isn't the expected one, but lower. This depends on what unit and power class has been picked as master. In such a situation the golden rule is: always select the master from the units with the highest power rating.

Example: you want to connect a 30 kW unit and a 3kW unit in order to achieve 33 kW. Generally, the voltage rating must match, but current and power rating can be different. To be precise, the power rating is decisive. When using the 3 kW unit as master, the total system power will 28 kW, which is even less than the single 30 kW unit. When, however, switching the master to the 30 kW unit, the system will result in 33 kW total power.

4.1.6 Configuring the master-slave operation

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

► Step 1: Configuring all slave units

1. While the DC output is switched off, tap 

 on the main screen to access the **Settings** menu. Swipe up to find group **Master-slave** and tap it.
2. Tapping on the blue button text next to **Mode** will open a selector. By selecting **Slave**, if not already set, the master-slave mode is activated and the device is defined as slave. Additionally, the bus termination can be activated here, if required for the currently configured unit.
3. Leave the Settings menu.

After this, the slave is fully configured for master-slave. Repeat the procedure for all other slave units.

► Step 2: Configuring the master unit

1. While the DC output is switched off, tap 

 on the main screen to access the **Settings** menu. Swipe up to find group **Master-slave** and tap it.
2. Tapping on the blue button text next to **Mode** will open a selector. By selecting **Master**, if not already set, the master-slave mode is activated and the device is defined as master which also automatically enable the BIAS resistor termination, as required for the master.

► Step 3: Initializing the master

When setting a device to Master, it will instantly start to initialize the MS system and the result is displayed in the very same window. In case the initialization is not successful or the number of units or the total power is wrong, it can be repeated in this screen anytime.

Initialization state	Initialized
Number of slaves	1
System voltage	80.00V
System current	2000.0A
System power	60.00kW
System resistance	5.0000Ω
	Initialize system

Tapping **Initialize system** 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 at all, the master will still initialize the MS system with only itself.

> *As long as MS mode remains activated, the initialization process of the master-slave system will be repeated each time the master unit is powered. The initialization can also be repeated manually anytime via the Settings menu, in group "Master-Slave".*

4.1.7 Operating the master-slave system

After successful configuration and initialization of the master and slave units, they will show their status in the status area of their displays. The master would show **MS mode: Master (n Sl)** while the slave(s) would show **MS mode: Slave** plus **Remote: Slave n**, as long they are in remote control by the master.

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

The display on the master unit will reconfigure after initialization and all set values are reset. The master now displays the set and actual values of the total system. Depending on the number of units, the adjustable current and power range will multiply, while the resistance range will decrease, so the following applies:

- The system, represented by the master, can be treated like a standalone unit
- The master shares the set values etc. across the slaves and controls them
- The master is remotely controllable via its analog or one of its digital interfaces
- All settings for the set values U,I, P and R on the master, plus also all related values from supervision, limits etc. should be adapted to the new total values
- All initialized slaves will reset any limits (U_{Min}, I_{Max} etc.), supervision thresholds (OVP, OPP etc.) and event settings (UCD, OVD etc.) to default values, so these don't interfere with the control by the master. As soon as these values are modified on the master, they are transferred 1:1 to the slave(s).
- During MS operation, it might occur that a slave causes an alarm or an event earlier than the master, due to imbalanced current or slightly faster reaction.

!	*In order to easily restore all these settings to what was configured before activating MS operation, it's recommended to make use of the user profiles (see «2.2.6 Loading and saving user profiles»)*

- If one or more slaves report a device alarm, it will be signaled on the master and must also be acknowledged there. so that the slave(s) can continue its/their operation. Since an alarm causes the DC inputs to be switched off and can only reinstate the on/off condition automatically after PF or OT alarms, where the reaction to the alarms is configurable, action from an operator or a remote control software may become necessary.
- Loss of connection to any slave will result in the shutdown of the DC inputs of all units as a safety measure and the master will report this situation in the display with a notification showing "Master-slave protection mode". Then the MS system has to be re-initialized, either with or without prior re-establishment of the connection to the disconnected unit(s).
- All units, even the slaves, can be externally shut down on their DC inputs using the pin REM-SB of the analog interface. This can be used as some kind of "emergency stop", usually by wiring a contact (maker or breaker) to this pin on all units in parallel.

4.1.8 Alarms and other problem situations

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

- 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 input. The slaves will fall back to single operation mode and also switch off their DC input. The MSP alarm can be deleted by initializing the master-slave system again. This can be done either in the MSP alarm requester 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 come back later, they're not automatically initialized and included again in the MS system. Then the init has to be repeated.
- If the master unit is cut from AC supply (power switch, blackout) and comes back 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 accidentally multiple or no units are defined as master the master-slave system can't be initialized

In situations where one or multiple units generate a device alarm like OVP etc., the 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 by any software.
- All units in the MS system supervise their own values regarding overvoltage, overcurrent and overpower and in case of 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.

5. Service and maintenance (2)

5.1 Firmware updates

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

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

However, it's advisable not to install updates promptly. Every update includes the risk of an inoperable device or system. We recommend to install updates only if...

- an imminent problem with your device can directly be solved, especially if we suggested to install an update during a support case
- a new feature has been added which you definitely want to use. In this case, the full responsibility is transferred to you.

The following additionally applies in connection with firmware updates:

- Simple changes in firmwares can have crucial effects on the application the devices are used in. We recommend to study the list of changes in the firmware history very thoroughly.
- Newly implemented features may require an updated documentation (user manual and/or programming guide, as well as LabVIEW VIs), which is often delivered only later, sometimes significantly later

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

Phone: +49 2162 3785 - 0
ea1974@elektroautomatik.com

www.elektroautomatik.com
www.tek.com

 Revision: 01