



LAB-SMS



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TECHNICAL SPECIFICATIONS

AMBIENT CONDITIONS

| | |
|-----------------------|-------------------------|
| Cooling | Fan |
| Operating temperature | 0 - 50 °C |
| Storage temperature | -20 - 70 °C |
| Humidity | < 80 % |
| Operating altitude | < 2000 m |
| Vibration | 10 - 55 Hz/1 min/2G XYZ |
| Shock | < 20 G |
| Weight | 5 kW 19 kg, 10 kW 26 kg |

INPUT SPECIFICATIONS

| Version | 3 kW | 4 kW | 5 kW | 6 kW | 8 kW | 10 kW |
|---|--|---------------------|---------------------|---------------------|---------------------|---------------------|
| Connection | 3 wire (1P+N+E) or 5 wire (3P+N+E) | | | | | |
| Input 1P/230 | 1 x 230 V _{ac} (207-253 V _{ac} 47-63 Hz) | | | | | |
| Input 3P/208 | 3 x 208 V _{ac} (187-229 V _{ac} 47-63 Hz) | | | | | |
| Input 3P/400 | 3 x 400 V _{ac} (360-440 V _{ac} 47-63 Hz) | | | | | |
| Input 3P/440 | 3 x 440 V _{ac} (396-484 V _{ac} 47-63 Hz) | | | | | |
| Input 3P/480 | 3 x 480 V _{ac} (432-528 V _{ac} 47-63 Hz) | | | | | |
| Max. allowed non symmetry | < 3 % | | | | | |
| Input Current (3 phase) 3P/400 model ^{1, 2} | 7,5 A _{eff} | 10 A _{eff} | 12 A _{eff} | 15 A _{eff} | 20 A _{eff} | 25 A _{eff} |
| Inrush Transient Current ² | < 25 A | < 25 A | < 76 A | < 51 A | < 51 A | < 51 A |
| Nominal Current Internal Fuse ³ | 15 A | 15 A | 15 A | 20 A | 25 A | 32 A |
| Breaking Capacity Fuse/Automatic Fuse ³ | built-in Circuit Breaker: KLK 20 A | | | | | |
| Recommended Supply Breaker (value and curve) | 16 A Typ D/K | 16 A Typ D/K | 16 A Typ D/K | 16/32 A Typ D/K | < 32 A Typ D/K | < 32 A Typ D/K |
| Leakage Current | < 35 mA | < 35 mA | < 35 mA | < 35 mA | < 35 mA | < 35 mA |
| Cos phi | > 0,7 | > 0,7 | > 0,7 | > 0,7 | > 0,7 | > 0,7 |
| Harmonic Content ⁴ | 50 Hz = 72 % | | | | | |
| | 100 Hz = 2 % | | | | | |
| | 150 Hz = 0,9 % | | | | | |
| | 200 Hz = 0,1 % | | | | | |
| | 250 Hz = 11 % | | | | | |
| | 350 Hz = 0,6 % | | | | | |
| Efficiency Type ¹ | 94 % | 94 % | 94 % | 94 % | 94 % | 94 % |
| Dissipated Power | 200 W | 260 W | 320 W | 390 W | 520 W | 640 W |

¹ for nominal current and nominal voltage

² for nominal input voltage

³ internal main fuse

⁴ total harmonic distortion input current ([%]/I_{ein})

OUTPUT SPECIFICATIONS

| | |
|---|---------------------------------|
| Static voltage regulation | $\pm 0.05\% + 2\text{ mV}$ |
| Static current regulation | $\pm 0.1\% + 2\text{ mA}$ |
| Dynamic regulation | $< 1\text{-}3\text{ ms (typ.)}$ |
| Ripple | $< 0.2\% \text{ RMS (typ.)}$ |
| Stability | $\pm 0.05\%$ |
| Programming accuracy (V_{out}) | $\pm 0.05\% + 2\text{ mV}$ |
| Programming accuracy (I_{out}) | $\pm 0.05\% + 2\text{ mA}$ |
| Display accuracy (V_{out}) | $< \pm 0.5\%$ |
| Display accuracy (I_{out}) | $< \pm 0.5\%$ |
| Isolation | 3,000 V |
| Over voltage protection | 0 - 120 % V_{max} |
| Circuit protection | OC/OV/OT/OP |
| Line regulation | $< \pm 0.1\% + 2\text{ mV}$ |

AI INTERFACE

| | |
|---|--|
| Digital outputs (CV, Standby, Error) | Output type: Open collector with pull-up resistor 10 k after + 5 V I_{sinkmax} : 50 mA |
| Digital inputs (Ext. Control, Standby) | Input resistance: 47 k Ω Maximum input voltage: 50 V High level: $U_e > 2\text{ V}$ Low level: $U_e < 0.8\text{ V}$ |
| Analog outputs (X_{mon}) | Output resistance: 100 Ω Minimum permissible load resistance: 2 k Ω Minimum load resistance for 0.1 % accuracy: 100 k Ω |
| Analog inputs (X_{set}) | Input resistance: 1 M Ω Maximum permissible input voltage: 25 V |
| Reference voltage | Reference voltage U_{ref} : 10 V $\pm 10\text{ mV}$ Output resistance: $< 10\text{ }\Omega$ Maximum output current: 10 mA (not short-circuit-proof) |
| 5 V - Supply voltage | Output voltage: 5 V $\pm 300\text{ mV}$ Maximum output current: 50 mA (not short-circuit-proof) |

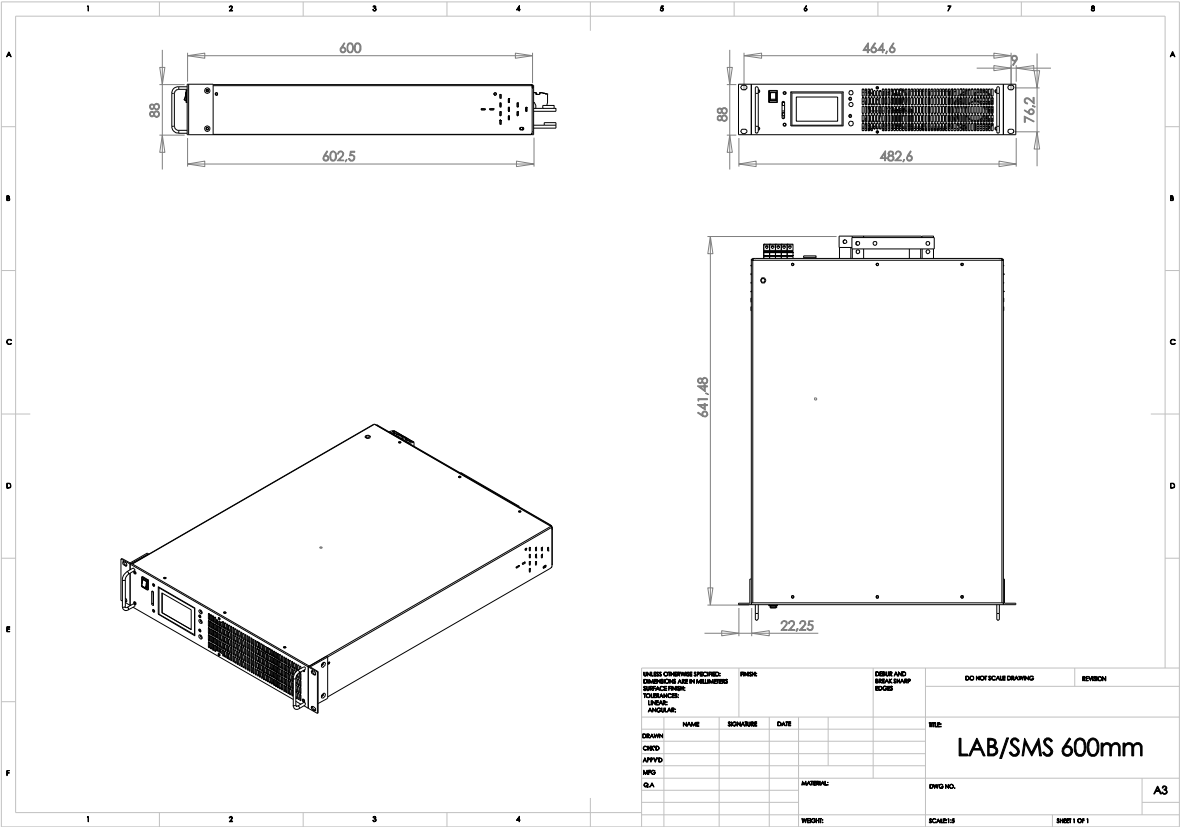
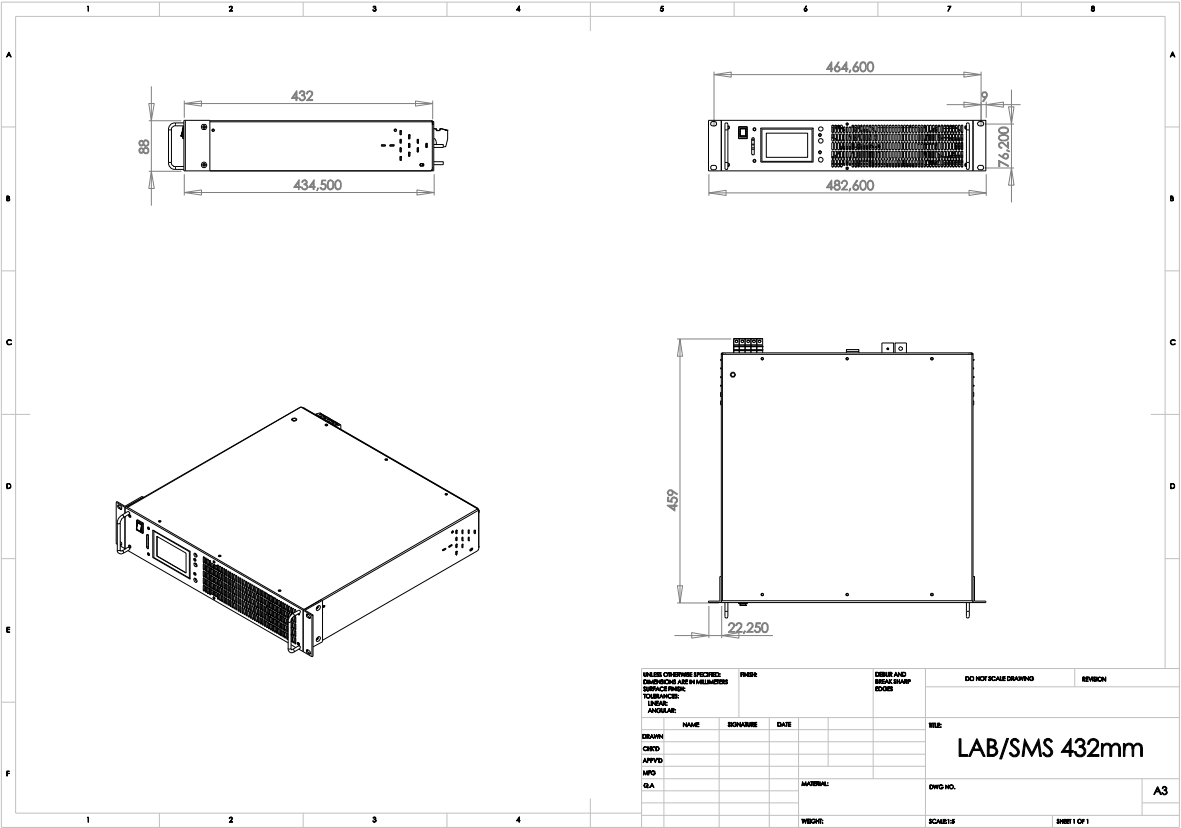
RS 232

| | |
|---------------------------|---|
| Signal inputs (RxD, CTS) | Maximum input voltage: $\pm 25\text{ V}$ Input resistance: 5 k Ω (Type) Switching thresholds: $U_H < -3\text{ V}$, $U_L > +3\text{ V}$ |
| Signal outputs (TxD, RTS) | Output voltage (at $R_{\text{Last}} > 3\text{ k}\Omega$): min $\pm 5\text{ V}$, Type $\pm 9\text{ V}$, max $\pm 10\text{ V}$ Output resistance: $< 300\text{ }\Omega$ Short circuit current: Type $\pm 10\text{ mA}$ |

RS 485

| | |
|-----------------------|------------------------|
| Maximum input voltage | $\pm 5\text{ V}$ |
| Input resistance | $> 12\text{ k}\Omega$ |
| Output current | $\pm 60\text{ mA Max}$ |
| High level | $U_d > 0.2\text{ V}$ |
| Low level | $U_d < -0.2\text{ V}$ |

TECHNICAL DRAWING



IMPORTANT SAFETY INSTRUCTIONS



Please read this manual thoroughly before putting the device into operation. Pay regard to the following safety instructions and keep this manual nearby for future purpose.

This operating manual is based on the state of technology at the time of printing. However, it is possible that despite regular control and correction, the present document contains printing errors or deficiencies. ET System electronic GmbH assumes no liability for any technical, printing or translational errors within this manual.

INITIAL OPERATION

UNPACKING

Please make sure that the shipping carton and the packaging is free of damage. If external damage is found, it is important to record the type of damage. Please keep the original packaging to ensure the device is adequately protected in case it needs to be transported in the future or claims for compensation need to be asserted.

SETTING UP

To avoid electric shocks and product failure, the device should be installed in a temperature and humidity controlled indoor environment. The ambient temperature must not exceed 50 °C. The device must never be exposed to liquids or extreme humidity.

VISUAL INSPECTION

The unit must be examined immediately for defects or damages in transit. Damages caused during transport may be loose or broken control knobs and bent or broken connectors. Do not use the device if any physical damage is apparent. Please inform the carriers and a representative of ET System electronic immediately.

MAINS OPERATION

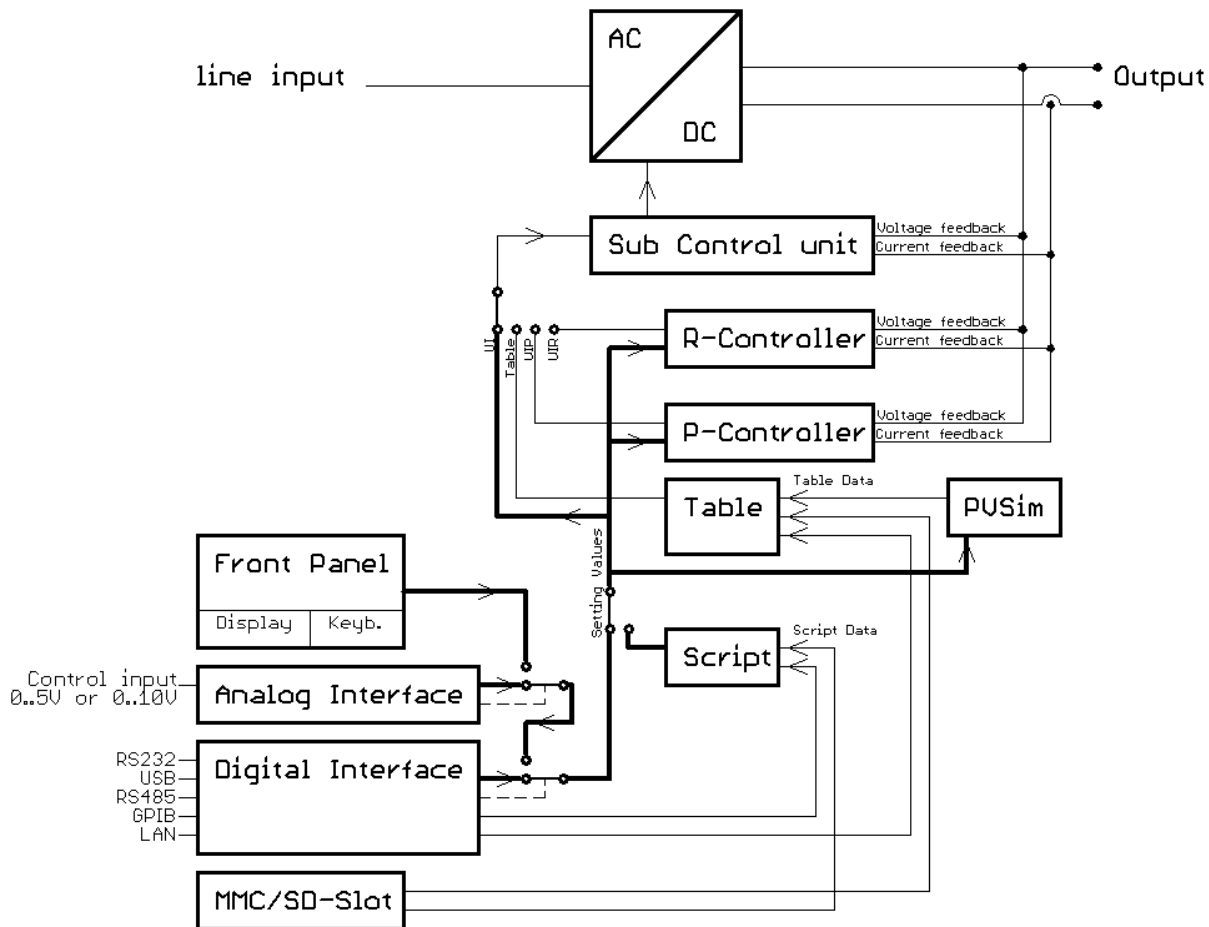
Make sure to verify the model number and voltage stated on the nameplate. Damages due to wrong power feed are not covered by guarantee conditions.



The unit must only be operated when connected directly to the mains. To avoid damage, do not connect the unit to isolating transformers, auto-transformers, magnetic current limiters or similar devices.

FUNCTIONAL DESCRIPTION

The following block diagram gives information about the various adjustment options.



Basically, four different operation modes are available:

| | |
|------------|--|
| UI mode | Unit is operated with current and voltage limitation. |
| UIP mode | Unit is operated with current, voltage and power limitation. |
| UIR mode | Unit is operated with current, voltage and power limitation. Additionally, the set value for voltage is calculated by means of the present output current to simulate an internal resistance.. |
| Table mode | Set values for current and voltage are saved in a table. Therefore, UI characteristics can be easily adjusted. |

There are three different ways to program the table:

| | |
|------------------------|---|
| PV _{sim} mode | The UI characteristic of a solar generator is calculated with the U _o , I _k , U _{mpp} and I _{mpp} parameters and then written to the table. |
| Memory card | The table can be programmed using a script from a memory card. A script is a simple text file (→ <i>Script Control</i>). |
| Digital interface | The table can be programmed using the digital interface (→ <i>Universal Interface, WAVE Command</i> bzw. <i>DAT Command</i>). |

The adjustment of set points and the selection of an operation mode are performed via console (→ *Front Panel Operation*), interface (→ *Universal Interface*) or analog/digital IO (→ *Ext. Control: AI-Interface*).

In order of priority, commands which have been sent by interface come first, by analog/digital-IO come second and by keyboard come third. For example, if the interface specifies the set point, the corresponding values will be sent - irrespective of other settings - to the output.

Another easy way to automate functions is offered by script control (→ *Script Control*). A list of commands is saved to the script memory and enables the user to change the chronological sequence of certain settings. The script memory can be programmed via memory card or digital interface.

Measurement values of the latest output data are permanently available at all interfaces. Therefore, the present output voltage can be read from the display or via digital interface, while the control of the unit is carried out via analog/digital IO.

GENERAL SETTINGS

CONFIGURATION

The configuration menu can be accessed by holding the button **Display** (lower button) for at least 1 second. This opens a menu where general settings of the unit can be changed.

These settings are U_{limit}, I_{limit}, OVP and Remember last setting. Provided the unit is equipped with these options, AI Type and M/S mode can also be selected.

LAB/SMS Config

```

Ulimit  30.000 V
Ilimit   180.0 A
OVP     30.500 V
AI-Type   5 V
Remember last setting: On
M/S-Mode: Off

```

Pushing the rotary pulse encoder selects individual parameters. Turning the rotary pulse encoder selects the desired value. Pushing the button **Display** a second time, opens the configuration menu for digital interface parameters.

CONTRAST

After the unit has been switched on, the display shows the ET System logo. The contrast of the display can be adjusted by using the rotary pulse encoder. Afterwards, the contrast will be saved automatically.

VOLTAGE SETTINGS

U_{LIMIT} AND I_{LIMIT}

U_{limit} limits the maximum output voltage. The output voltage is limited to the selected value, irrespective of the values that have been set at the front panel or at one of the interfaces. The adjustment range is 0 V up to the maximum rated voltage of the device.

I_{limit} limits the maximum output current. The output current is limited to the selected value, irrespective of the values that have been set at the front panel or at one of the interfaces. The adjustment range is 0 A up to the maximum rated current of the device. These settings can only be changed at the display and apply to all interfaces.

OVP (OVER VOLTAGE PROTECTION)

The output is shut immediately if the output voltage exceeds the selected value. The display indicates this status with the word 'OVP'. To reset this error, push the button **Standby**. The OVP value applies to the front panel operation. There may apply different values for the AI-interface and the digital interface. The digital interface is initialized with the value which has been adjusted on the front panel. The adjustment range is 0 V up to the maximum rated voltage of the device + 20%.

AI-TYPE

This feature adjusts the voltage levels of analog input signals and analog output signals. Selectable ranges are 0-5 V and 0-10 V.

REMEMBER LAST SETTING

If this option is activated (,On'), selected parameters will be kept after a blackout. If this option is deactivated (,Off'), standard setting (0V/0A/UI-Mode) will be loaded after supply voltage is enabled.

M/S MODE

The following adjustments can be made if M/S-Mode is activated (→ *Master/Slave-Mode*):

| | |
|-------------|--|
| Off | no master/slave |
| Parallel | parallel connected outputs |
| Serial | serial connected outputs |
| Independent | Independent outputs, change of set values via bus only |

INTERFACE PARAMETER (OPTION)

The display shows all available digital interfaces and their changeable parameters. These parameters can be selected by pushing the rotary pulse encoder and changed by turning the rotary pulse encoder (function of the parameters → *Universal Interface*).

| LAB/SMS Config | | | | | | |
|----------------|------|---|---|---|---|----------|
| Interface | | | | | | |
| Typ | Baud | P | D | S | H | E TO Adr |
| RS232 | 9600 | N | 8 | 1 | N | |
| RS485 | 9600 | N | 8 | 1 | N | 10 4 |
| ---- | | | | | | |

FRONT PANEL OPERATION

CONSOLE AND ROTARY PULSE ENCODER

The front panel consists of a rotary pulse encoder (with button function) and two buttons. The upper button switches the unit into standby or run mode.

The lower button changes the display mode. Pushing and holding this button for 1 second opens the interface configuration menu for interface settings (→ *Display and Settings*) and interface parameters (→ *Interface Parameter*).

The rotary pulse encoder adjusts the set value. Pushing the rotary pulse encoder selects the value to be changed.

DISPLAY AND SETTINGS

Current measurement values (Display)

In normal mode, pushing the button **Display** switches between two different overview screens.

Main display

The main display shows current measure and set values. On the left side of this screen, present voltage and current values are displayed as well as the resulting power ($P = U \cdot I$) and resistance ($R = U \div I$). The set values are displayed on the right side of the screen (‘Preset’) and vary according to the operation mode of the unit.

| LAB/SMS | | Preset | | | |
|----------|----------------|-------------|---------------|------------------|---|
| U | 0,00 V | U | 0,00 V | U | Output voltage |
| I | 0,00 A | I | 0,00 A | I | Output current |
| P | 0 W | | | P | Output power (UIP mode only → <i>UIP mode</i>) |
| R | ----- Ω | | | R _i | Internal resistance (UIR mode only → <i>UIR mode</i>) |
| | | Mode: UI | | U _{mpp} | MPP voltage (PV _{sim} mode only → <i>PV_{sim} mode</i>) |
| | | Standby Loc | | I _{mpp} | MPP current (PV _{sim} mode only → <i>PV_{sim} mode</i>) |

The lower right section of the screen shows the current Control Mode of the unit:

| | |
|-----|---|
| Loc | Front panel operation |
| Scr | Memory card operation |
| AI | Analog interface operation |
| Rem | Interface operation |
| LLO | Interface operation, Front panel operation locked |
| Dis | Unit locked via interlock input (Option) |

The section to the left of the control mode display shows the current Operating Status of the unit:

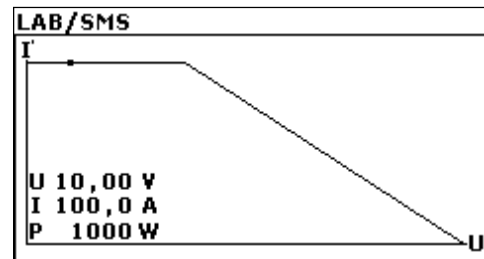
| | |
|---------|--|
| Standby | Standby mode |
| U-Limit | Voltage limitation mode |
| I-Limit | Current limitation mode |
| P-Limit | Power limitation mode |
| OVP | deactivation of the unit by over voltage protection mode |

The section above the operating status display shows the current Operating Mode of the unit:

| | |
|-------------------|--|
| UI | Voltage and current limitation |
| UIP | Voltage, current and power limitation |
| UIR | Voltage and current limitation, simulated internal resistance- |
| PV _{sim} | simulation of a photovoltaic characteristic |
| User | simulation of a user-defined characteristic |

UI display

The output diagram is displayed as an UI characteristic. The picture on the right side shows the operating mode UIR. A small dot shows the actual operating point of the unit. The diagram is always relative to the selected values. For example, the current limitation would be changed from 100 A to 50 A, the internal resistance would be doubled, while the diagram would stay the same. A horizontal part of the diagram corresponds then to 50 A and not to 100 A.



OPERATING MODES

Operating Mode selection

Operating modes can only be selected when the main display is visible. Pushing the rotary pulse encoder switches the focus (selected mode is inverted) through the different modes. Once the option is focused, the operating mode can be selected by turning the rotary pulse encoder. The unit needs to be in standby mode, otherwise the option ,Mode' is not selectable.

Preselectable fixed settings

Fixed settings can be saved and selected which means that front panel operation is inactive. For activation or deactivation, the button **Standby** must be pressed and held when the device is switched on until the ET-System logo fades out. To activate the fixed settings, the device must be switched on and the option ,Remember Last Setting' must be activated. The desired set values can be adjusted and the device must be switched off. The button **Standby** must be pressed and held while the device is switched on until the ET-System logo fades out. The device will load the last set values directly on power up. Front panel operation is inactive. This status is signaled by the word ,Dis' in the lower right corner of the display. To deactivate this mode, the button **Standby** must be pressed when switching on the device.

Operating Mode description

UI Mode

In UI mode, the set values for voltage and current are transferred directly to the switch mode regulator. There is no additional digital control.

UIP Mode

In UIP mode, the set values for voltage and current are transferred directly to the switch mode regulator. If the output current exceeds the previously adjusted limit value, the current set point will be regulated.

UIR Mode

In UIR mode, the voltage set point is regulated in a way that a power supply unit with (adjustable) internal resistance is simulated. The set value for current limiting is transferred directly to the switch mode regulator.

PV_{sim} Mode

In PV_{sim} mode, the diagram of a PV generator is simulated. Given values are open-circuit voltage U_o , short-circuit current I_k , as well as the amounts of voltage and current by which the PV generator delivers the maximum power (U_{mpp} , I_{mpp}). Parameters can be found in the specification sheet of the simulated PV generator.

Values for U_{mpp} may be in a range from 0.6 to $0.95 \cdot U$.

Values for I_{mpp} may be in a range from 0.6 to $0.95 \cdot I$.

Script Mode

In script mode, the unit is controlled by memory card. The display ,Mode' shows the present operating mode ,UI'. The lower right corner of the display shows the word ,Scr', which indicates that script operation was selected. If there is no memory card in the slot, this option cannot be selected. For detailed information about memory card control and about how to build up a script, see → *Script Control*.

UNIVERSAL INTERFACE

All interfaces of the digital interface are equal. There is no shift between the interfaces. For example, the first command can be issued via the IEEE interface while the second command can be issued via the RS232 interface. The return values will be sent from that interface the command was issued from.

COMMANDS

Communication is based on an ASCII protocol. The following chapters describe how to write a command and give an overview over the commands.

Format

A command consists of the command word, a parameter (if necessary) and a terminator. The character for the terminator is Carriage Return **<CR>** or Line Feed **<LF>**.

| Character | ASCII | Dec value | Hex value |
|-----------------|-------|-----------|-----------|
| Carriage Return | <CR> | 13 | 0d |
| Line Fee | <LF> | 10 | 0a |

If the command contains a or <ESC> character, it will not be processed. Therefore, a command can be cancelled while entering. Though, a terminator (**<CR>** or **<LF>**) is necessary.

| Character | ASCII | Dec value | Hex value |
|-----------|-------|-----------|-----------|
| Escape | <ESC> | 27 | 1b |
| Delete | | 127 | 7f |

Commands are not case sensitive and may be mixed up. Therefore, the effect of the following commands is the same: GTL, Gtl, gTL. Decimal places are optional and separated by a full stop '.'. The number of decimal places is not limited. Therefore, the effect of the following commands is the same: UA,10, UA,10.0, UA,10.000000000, UA,0010, UA,010.0000

The number of decimal places to be analyzed depends on parameter and unit type. It corresponds to the number of decimal places, a command without a parameter would return. As a rule, decimal places are analyzed until a resolution of 0.1% is reached.

Example: Evaluation of decimal places

LAB/SMS with 600 V, 25 A
 $600 \text{ V} * 0.1 \% = 0.6 \text{ V} \rightarrow$ one decimal place
 $25 \text{ A} * 0.1 \% = 0.025 \text{ A} \rightarrow$ three decimal places

Optional, after a numerical value, a letter may be added to indicate the unit. However, this letter will not be analyzed.

Example: Attached letter as unit

UA,10.0 V \rightarrow Resets output voltage to 10 V
 UA,10.0 m \rightarrow Caution! The 'm' will not be evaluated, output voltage here is also 10 V

Example: A valid command with corresponding hex values

| | | | | | | | |
|------|------|------|------|------|------|------|------|
| U | A | , | 1 | 0 | . | 2 | <CR> |
| 55 h | 41 h | 2 ch | 31 h | 30 h | 2 eh | 32 h | 0 dh |

Example: Adjustment of output voltage 10 V/5 A (full command sequence)

OVP,100 \rightarrow adjusts OVP to 100 V
 UA,10 \rightarrow adjusts output voltage to 10 V
 IA,5 \rightarrow current limiting 5 A
 SB,R \rightarrow output enabled

Instruction Set

The IEEE-488.2 standard demands several basic commands. Some commands may occur twice for compatibility reasons (once in the ETS version and once in the (old) IEEE-488.2 version). The following syntax is used to describe the commands:

| | | |
|----|-----------------|-----------------------------------|
| [] | Square brackets | → optional parameter |
| <> | Angle bracket | → numerical value |
| {} | Curly bracket | → selection list |
| | Vertical line | → separator within selection list |

Example

GTR[,{0|1|2}] means that the command GTR can be used with or without parameters. If a parameter exists, it has to be 1, 2 or 3. Valid commands are: GTR GTR,1 GTR,2 GTR,3

IA[,<imax>] means that the command IA can be used either with or without parameters. If a parameter exists, it has to be a numerical value.

Quick view of commands

| Command | Description | Result |
|--|-------------------------------|--|
| CLS* or CLS | Clear Status | Deletes the status byte |
| DAT,<U>,<I> | DIP | Data for user-defined characteristic |
| DCL | Device Clear | Initialization data reset |
| GTL | Go To Local | Activates front panel operation |
| GTR[,{0 1 2}] | Go To Remote | Activates digital interface operation |
| IA[,<imax>] | Set I_{max} | Adjusts current limiting |
| ID or *IDN? | Identification | Displays identification string |
| IMPP[,<impp>] | Set I_{mpp} | Adjusts MPP current during PVsim mode. |
| LLO | Local Lockout | Deactivates LOCAL button |
| LIMI | Limit I_a | Reads maximum adjustable current limitation |
| LIMP | Limit P_a | Reads maximum unit output. |
| LIMR | Limit R | Reads adjustable range for R_i within UIR mode. |
| LIMRMAX | Limit R_{max} | Reads maximum adjustable range for R_i within UIR mode. |
| LIMRMIN | Limit R_{min} | Reads minimum adjustable range for R_i within UIR mode. |
| LIMU | Limit U_a | Reads maximum adjustable voltage limitation |
| MODE[,{UI UIP UIR PVSIM USER}[Skript]] | Set Mode | Selects operation mode |
| MU[,<Nr>] | Measure U_a | Measures present output voltage |
| MI[,<Nr>] | Measure I_a | Measures present output current |
| *OPT? | Optional Identification Query | Displays units current hardware/software version |
| OVP[,<U _{ovp} >] | Overvoltage Protection | Adjusts over voltage protection |
| PA[,<P _{limit} >] | Set P_{max} | Adjusts power limitation |
| PCx[,<baud>,<parity>,<data bits>,<stop bits>,<handshake>,<echo>,<timeout>] | Program Communication | Adjusts the interfaces |
| RA[,<R _i >] | Set R_i | Adjusts internal resistance |
| REGLER[,<Nr>,<Kp>,<Ki>,<Kd>] | Controller Parameters | Adjusts controller parameters for UIP, UIR and PVsim mode |
| RI or *RST | Reset Instrument | Resets hardware (no return value) |
| SB[,{S R 1 0}] | Standby | Enables/blocks the output |
| SCR[,<CMD>,<value>]] | Load Script | Programming of script memory |
| SS or *PDU | Save Setup | Saves previously made channel and interface parameter adjustments (no return value) |
| STATUS | Status | Query of the units status (return values in binary format) (also see following table) |
| STB or *STB? | Interface Status | |
| UA[,<ua>] | Set U_a | Adjusts output voltage (if there are no parameters, present set point is displayed) |
| UMPP[,<umpp>] | Set U_{mpp} | Adjusts MPP voltage in PV _{sim} mode (if there are no parameters, present set point is displayed) |
| WAVE | End Userwave Data | Ends transfer of user-defined output characteristic (gradual interpolation of intermediate values) |
| WAVELIN | End Userwave Data | Ends transfer of user-defined output characteristic (linear interpolation of intermediate values) |
| WAVERESET,<Um>,<Im> | Start Userwave Data | Starts transfer of user-defined output characteristic |

Detailed description of commands

CLS* or CLS - Clear Status

This command deletes the status byte. It affects only the status byte of the interface, the command was sent from. No return value. For detailed description of the status byte, see the different interface chapters.

DAT,<U>,<I> - Data

Data for a user-defined characteristic. No return value. For detailed description of this command, see → *Wavereset*.

DCL - Device Clear

This command resets the initialization data. No return value.

Caution: Interface parameters are also reset!

GTL - Go To Local

This command activates front panel operation. If 'Local Lockout' (LLO) was activated before, it will also be reset. No return value.

GTR[,0|1|2] - Go To Remote

This command activates digital interface operation. The parameter is optional and affects the behavior of the unit after it is switched on. This setting is saved permanently. No return value.

Optional parameter 0 = Unit does not automatically switch to remote operation

To activate remote operation, the command GTR needs to be used. This mode is useful, when the unit shall be operated manually and at the same time, measurement values shall be read out via digital interface.

Optional parameter 1 = Unit switches to remote operation when it is first addressed

As soon as the unit receives a command via digital interface, it switches to remote operation. The sole exception of this behavior is the GTL command, which activates the Local Mode. This mode is activated when the unit is delivered.

Optional parameter 2 = Unit switches to remote operation immediately after power on

Remote operation is activated immediately after power on. Front panel operation is deactivated.

IA[,<imax>] - Set I_{max}

This command adjusts current limiting. Entering the command without parameters displays the set value. If the set value is higher than the maximum current of the unit, the range-error-bit within the ESR register of the interface is set. The present set value remains unchanged. If the set value is higher than the I_{limit} value, which was adjusted by the user's settings, but lower than the maximum current of the unit, the current is limited to the I_{limit} value. No error message.

Example: 300 A unit, I_{limit} adjusted to 200 A via configuration menu

| | |
|-----------|--|
| GTR | Remote operation |
| OVP,200 | Over voltage protection 200 V |
| UA,10 | Output voltage 10 V |
| IA,100 | Output current 100 A |
| SB,R | Output open |
| IA,400 | Output current 400 A, this command is ignored, because the current is higher than the maximum current of the device. „Rangeerror“ is set within the status byte. |
| IA,250 | Output current 250 A, since the output current was limited to 200 A via configuration menu, current limiting is set to 200 A. Error bit is not set. |
| IA | Query of the adjusted current. |
| IA,200.0A | Unit answers: $I_{limit} = 200$ A |

In master/slave mode, the current of a programmed device is adjusted. Connected in parallel, the total current is $n \times I_A$.

Example:

In M/S mode, 3 devices are connected parallel. IA,10 programs an output current of 10 A. All connected devices are set to 10 A. Since 3 devices have been connected parallel, the total current is $3 \times 10A = 30A$.

ID or IDN? - Identification

This command displays the identification string. Return value: <ID-String>.

IMPP[,<impp>] - Set I_{mpp}

This command adjusts the MPP current for PV_{sim} mode. Entering the command without parameters displays the set value. If the set value is higher than the maximum current of the unit, the range-error-bit within the ESR register of the interface is set. The present set value remains unchanged. If the set value is higher than the I_{limit} value, which was adjusted by the user's settings, but lower than the maximum current of the unit, the current is limited to the I_{limit} value. No error message follows.

Example:

| | |
|------------|---|
| GTR | Remote operation |
| OVP,200 | Over voltage protection |
| UA,50.5 | Open circuit voltage of a 50.5 V simulated PV generator |
| IA,10 | Short circuit current of a simulated 10 A PV generator |
| UMPP,40.4 | MPP voltage of a simulated 40.4 V PV generator |
| IMPP,8.2 | MPP current of a simulated 8.2 A PV generator |
| MODE,PVSIM | Activates PV simulation mode |
| SB,R | Output open |

In master/slave mode, the current of a programmed device is adjusted. In parallel connection the total current is $n \times I_A$.

LIMI - Limit I_a

With this command, the user can read the maximum adjustable current limiting.

Example: 300A unit, I_{limit} was adjusted to 200 A via configuration menu

| | |
|-------------|-------------------------------------|
| LIMI | Query of maximum adjustable current |
| LIMI,200.0A | Unit answers: $I_{limit} = 200$ A |

LIMP - Limit P_a

With this command, the user can read the unit's maximum output.

Example: 10 kW unit

| | |
|------------|-----------------------|
| LIMP | Query of units output |
| LIMP,10000 | Unit answers: 10 kW |

LIMR - Limit R

With this command, the user can read the adjustable range for R_i within UIR mode.

Example:

| | |
|-------------------|---|
| LIMR | Query of adjustable internal resistance |
| LIMR,0.015R,1.00R | Unit answers: 15 mOhm up to 1 Ohm |

LIMRMAX - Limit R_{max}

With this command, the user can read the maximum adjustable range for R_i within UIR mode.

Example:

| | |
|----------------|---|
| LIMRMAX | Query of maximum adjustable internal resistance |
| LIMRMAX,1.000R | Unit answers: 1 Ohm |

LIMRMIN - Limit R_{min}

With this command, the user can read the minimum adjustable range for R_i within UIR mode.

Example:

LIMRMIN Query of minimum adjustable internal resistance
LIMRMIN,0.015R Unit answers: 15 mOhm

LIMU - Limit U_a

Reads maximum adjustable voltage limitation. This command requests the previously defined maximum output voltage.

Example: 300 V unit was adjusted to 200 V via configuration menu

LIMU Query of maximum adjustable current
LIMU,200.0V Unit answers: $U_{limit} = 200$ V

LLO - Local Lockout

This command deactivates the **Local** button. Unit cannot be switched to local mode by holding the button **Standby**. No return value.

MI[,<Nr>] - Measure I_a

This command measures the present output current.

Example:

GTR Remote operation
OVP,200 Over voltage protection 200 V
UA,10 Output voltage 10 V
IA,1 Output current 1 A
SB,R Output open
MI Measures present output current
MI,0.567A Unit answers: 567 mA

In master/slave mode with parallel connection the total current of all connected devices is displayed. Using the parameter <Nr> will show the value of each connected device. Numbering starts with 0.

Example:

MI,2 displays the measured output current at the bus of device number 3.

MODE[, {UI|UIP|UIR|PVSIM|USER|Skript|0|1|2|3|4|5}] - Set Mode

This command selects the operation mode. Entering the command without parameter displays the presently selected operation mode. Entering the command with parameter activates the operation mode. Alternatively, the operation mode can be indicated as number.

The following table shows the different settings:

| Command | Function |
|-----------------------|---|
| MODE,UI MODE,0 | UI mode is activated |
| MODE,UIP MODE,1 | UIP mode is activated |
| MODE,UIR MODE,2 | UIR mode is activated |
| MODE,PVSIM MODE,3 | PV _{sim} mode is activated |
| MODE,USER MODE,4 | User-defined UI characteristic is activated. The characteristic is defined with the commands DAT , WAVE , WAVELIN and WAVERESET . |
| MODE,SKRIPT MODE,5 | Script mode is activated. The script is read from the memory card or loaded after the command SCR has been entered. |

MU[,<Nr>] - Measure U_a

This command shows the measurement value of the present output voltage.

Example:

| | |
|----------|---------------------------------|
| GTR | Remote operation mode |
| OVP,200 | Over voltage protection 200 V |
| UA,10 | Output voltage 10 V |
| IA,1 | Output current 1 A |
| SB,R | Output open |
| MU | Measures present output voltage |
| MU,10.0V | Unit answers: 10 V |

In master/slave mode with serial connection the total current of all connected devices is displayed. Using the parameter <Nr> will show the value of each connected device. Numbering starts with 0.

Example:

MU,1 displays the measured output voltage at the bus of device number 2.

***OPT? - Optional Identification Query**

This command does an optional identification query, which means it displays the software version.

Example:

| | |
|----------------|---|
| *OPT? | Query of version number |
| 08.06.2012 V42 | Unit answers: Version 42 vom 08.06.2012 |

OVP[,<U_{ovp}>] - Over Voltage Protection

This command adjusts the over voltage protection. Entering the command without parameter displays the present set point. If the set point is higher than a maximum of 1.2 x voltage of the unit, the range error bit within the ESR register of the interface is set. The present set point remains unchanged.

Example:

| | |
|---------|-------------------------------|
| GTR | Remote operation mode |
| OVP,200 | Over voltage protection 200 V |
| UA,100 | Output voltage 100 V |
| IA,10 | Output current 10 A |
| SB,R | Output open |

PA[,<P_{limit}>] - Set P_{limit}

This command adjusts the power limitation for UIP mode. Entering the command without parameter displays the present set point. If the set point is higher than the maximum power of the unit, the range error bit within the ESR register of the interface is set. The present set point remains unchanged.

Example:

| | |
|----------|-------------------------------|
| GTR | Remote operation mode |
| MODE,UIP | UIP mode activated |
| OVP,200 | Over voltage protection 200 V |
| UA,100 | Output voltage 100 V |
| IA,10 | Output current 10 A |
| PA,500 | Power limitation 500 W |
| SB,R | Output open |

In master/slave mode the power of a programmed device is adjusted. Total output is n x PA.

Example:

2 devices are in M/S mode. The command PA,100 sets the power output to 100 W. Both connected device are adjusted to 100 W. The total output is $2 \times 100 \text{ W} = 200 \text{ W}$.

PCx[,<baud>,<parity>,<data bits>,<stop bits>,<handshake>,<echo>,<timeout>] - Program Communication

This command adjusts the interfaces. The LAB/HP has a maximum of 3 digital interfaces (x = 1, 2 or 3). The corresponding commands are **PC1**, **PC2** or **PC3**. Type and number of parameters depend on the type of interface. Currently there are no settings available for GPIB and LAN. Entering the command without parameter displays present interface parameters.

| Parameter | Function |
|-------------|--|
| <baud> | Baud rate in bps |
| <parity> | Data parity O = Odd = Uneven parity E = Even = Even parity N = None = No parity bit |
| <data bits> | Number of data bits |
| <stop bits> | Number of stop bits |
| <handshake> | Handshake H = Hardware S = Software N = None (no handshake) |
| <echo> | Character echo E = Echo = echo on N = None = echo off |
| <timeout> | Timeout in ms when switching between sending and receiving (RS485 only) |

Allowed parameters for RS232 interface:

PCx,<baud>,<parity>,<data bits>,<stop bits>,<handshake>,<echo>

| Parameter | Function |
|------------|---|
| Baud: | 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 62500, 115200 |
| Parity: | O, E, N |
| Data bits: | 7, 8 |
| Stop bits | 1, 2 |
| Handshake: | H, S, N |
| Echo: | E, N |

Allowed parameters for USB interface:

PCx,<baud>,<parity>,<data bits>,<stop bits>,<handshake>,<echo>

| Parameter | Function |
|------------|---|
| Baud: | 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 62500, 115200 |
| Parity: | O, E, N |
| Data bits: | 7, 8 |
| Stop bits | 1, 2 |
| Handshake: | H, S, N |
| Echo: | E, N |

Note: The USB interface of the PC is controlled like a virtual COM port and therefore the parameters correspond to those of the RS232 interface.

Allowed parameters for RS485 interface:

PCx,<baud>,<parity>,<data bits>,<stop bits>,<timeout>

| Parameter | Function |
|-----------|----------|
|-----------|----------|

| | |
|------------|---|
| Baud: | 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 62500, 115200 |
| Parity: | O, E, N |
| Data bits: | 7, 8 |
| Stop bits | 1, 2 |
| Timeout: | 0...100 |

If the interface parameters must be changed permanently, the data has to be saved after the **PCx** command with the command **<SS>**. No return value.

Example:

```
PC1          Query of first interface parameters
PC1,RS232,9600,N,8,2,N,E  Unit answers: PC1 is a RS232 interface, 9600 bauds, 8 data bits, 2 stop bits, no handshake, no
                           parity, echo on.
PC1,115200,N,8,2,N,E      Adjust baud rate to 115200 baud.
                           The new baud rate is active immediately after the command has been sent!
PC2          Query of second interface parameters
PC2,RS485,9600,N,8,1,1    Unit answers: PC2 is a RS485 interface, 9600 bauds, 8 data bits, 1 stop bit.
                           Timeout when switching between receiving and sending is 1 ms.
PC2,9600,N,8,1,50        Increase timeout to 50ms.
PC3          Query of third interface parameters
PC3, EMPTY      Unit answers: Interface 3 is not available in this unit.
SS              Save settings.
```

RA[,<Ri>] - Set Ri

This command adjusts the internal resistance for UIR mode. Entering the command without parameters displays the present set point. If the set point is out of adjustment range the range error bit of the interface is set in the ESR register. The present set point remains unchanged. Adjustment range can be requested with the commands **LIMRMAX** and **LIMRMIN**.

Example:

```
GTR          Remote operation mode
MODE,UIR      UIR mode activated
OVP,200       Over voltage protection 200 V
UA,100        Output voltage 100 V
IA,10         Output current 10 A
RA,0.1        Internal resistance 0,1 Ohm
SB,R          Output open
```

REGLER[,<Nr>,<Kp>,<Ki>,<Kd>] - Controller Parameter

Settings for controller parameters in UIP, UIR and PV_{sim} mode. Entering the command without parameters displays the present settings as a table. The number of the parameter determines the parameter set which is to be adjusted.

```
0      Controller for UIP
1      Controller for UIR
2      Controller for PVsim
```

The range of values for controller parameters is 0 - 30000. New settings can permanently be saved with the command **SS**. For a detailed description of the controller parameters see → *Controller*.

Example:

```
REGLER      Read present settings
Type P I D   Unit answers:
P 10 20 5    UIP Mode Kp = 20 Ki = 10 Kd = 5
Ri 20 20 2    UIR Mode Kp = 20 Ki = 20 Kd = 5
Pv 10 5 5     PV Mode Kp = 10 Ki = 5 Kd = 5
REGLER,0,10,10,5  New controller parameters for UIP mode
REGLER,1,22,18,5  New controller parameters for UIR mode
SS           Save new settings
```

RI or *RST - Reset Instrument

The unit executes a hardware reset. No return value.

SB[, {S|R|1|0}] - Standby

This command enables/disables the output. Entering the command without parameters displays the present standby status. The commands **SB,S** and **SB,1** switch the unit to standby mode, the output is disabled. The commands **SB,R** and **SB,0** disable the standby mode, the output is enabled.

Example:

```
GTR           Remote operation mode
OVP,200       Over voltage protection 200 V
UA,100        Output voltage 100 V
IA,10         Output current 10 A
SB,R          Output is active
SB            Retrieve standby status
SB,R          Unit answers: output is active
```

SCR[, <CMD>[, <value>]] - Load Script

With this command the script memory can be programmed. The command **SCR** without parameters initializes the programming procedure. The command **SCR** with parameters writes the commands into the script memory. The order of the commands corresponds to the order of commands of the script. Script commands and their parameters are described in the chapter → *Script Control*.

Example:

```
GTR           Remote operation mode
OVP,200       Over voltage protection 200 V
SCR           Initialisation of script programming
SCR,U,12      1. script command: U = 12 V
SCR,I,15      2. script command: I = 15 A
SCR,UI        3. script command: mode UI
SCR,RUN       4. script command: activate output
SCR,LOOPCNT,10 5. start address loop
SCR,U,12      6. script command: U = 12 V
SCR,DELAY,8   7. script command: wait 8 ms
SCR,U,1       8. script command: U = 1 V
SCR,DELAY,1000 9. script command: wait 1 s
MODE,SKRIPT   Activate script mode
SB,R          Start script
```

SS or *PDU - Save Setup

Saves present unit parameters (interface parameter and controller parameter). No return value.

STATUS - Status

Query of device status. Return value in binary units. Function of the bits within the status byte:

| Bit | Function |
|-----|--|
| D15 | Number of units in M/S mode. If no other device is |
| D14 | connected, 1 is displayed, if two devices are connected to |
| D13 | the bus, 2 is displayed etc. If M/S mode was disabled via |
| D12 | configuration menu, 0 is displayed. |
| D11 | - reserved - |
| D10 | - reserved - |
| D9 | - reserved - |
| D8 | Limit mode, unit in power limitation mode |
| D7 | Limit mode, unit in current limitation mode |
| D6 | Local lockout (1 = LLO active, 0 = LLO not active) |
| D5 | Local (1 = front panel operation) |
| D4 | Remote (1 = digital interface operation) |
| D3 | - reserved - |
| D2 | - reserved - |
| D1 | Standby (1 = unit in standby mode) |

| | |
|----|--|
| D0 | OVP (1 = shut down by over voltage protection) |
|----|--|

Example:

STATUS Status query
 STATUS,0000000100010000 Unit answers: Remote operation mode, power limitation

UA[,<U_{max}>] - Set U_{max}

This command adjusts the voltage limitation. Entering the command without parameters displays the present set point. If the set point exceeds the maximum voltage of the unit, the range error bit within the ESR register of the interface is set. The present set point remains unchanged. If the set point is higher than the selected value for U_{limit}, but lower than the unit's maximum voltage, voltage limitation is restricted to U_{limit}. There is no error message.

Example:

GTR Remote control operation
 OVP,320 Over voltage protection 320 V
 UA,100 Output voltage 100 V
 IA,10 Output current 10 A
 SB,R Output is active
 UA,400 Output voltage 400 V. This command is ignored because the voltage is higher than the maximum voltage of the unit. Range error is set within the status byte.
 UA,250 Output voltage 250 V. Since the output voltage was limited to 200 V via configuration menu, voltage limitation is adjusted to 200 V. An error bit is not set.
 UA Query of adjusted voltage
 UA,200.0V Unit answers: set point U_a = 200 V

In master/slave mode the voltage of the programmed device is set. In master/slave serial connection the total voltage is n x UA.

Example:

3 devices are connected in series while in M/S mode. With UA,10 an output voltage of 10V is programmed. Therefore all connected devices are adjusted to 10V. Since three devices are connected in series, the total voltage is 3 x 10 V = 30 V.

UMPP[,<Umpp>] - Set U_{mpp}

This command adjusts the MPP voltage for PV_{sim} mode. Entering the command without parameters displays the present set point. If the set point is higher than the maximum voltage of the unit, the range error bit within the ESR register of the interface is set. The present set point remains unchanged. If the set point is higher than the U_{limit} value which was adjusted in the configuration menu, but lower than the maximum voltage of the unit, the voltage limitation is restricted to U_{limit}. There is no error message.

Example:

GTR Remote operation mode
 OVP,200 Over voltage protection 200 V
 UA,50.5 Open circuit voltage of a simulated PV generator 50.5 V
 IA,10 Short-circuit current of a simulated PV generator 10 A
 UMPP,40.4 MPP voltage of a simulated PV generator 40.4 V
 IMPP,8.2 MPP current of a simulated PV generator 8.2 A
 MODE,PVSIM Activate PV_{sim} mode
 SB,R Output active

In master/slave mode the MPP voltage of the programmed device is adjusted. When connected in series, the MPP total voltage is n x UMPP.

WAVE - End Userwave Data

This command ends the transfer of a user defined output characteristic. Interpolation of interim values is layered. For detailed information about the function of this command see → *Wavereset*.

WAVELIN - End Userwave Data

This command ends the transfer of a user defined output characteristic. Interpolation of interim values is linear. For detailed information about the function of this command see → *Wavereset*.

WAVERESET,<U_{max}><I_{max}> - Start Userwave Data

Starts the transfer of a user defined output characteristic. The parameters U_{max} and I_{max} define the maximum voltage of the output characteristic. Afterwards, the fulcrums of the UI characteristic can be entered using the command **DAT**. The characteristic ends with the commands **WAVE** or **WAVELIN**.

Example:

| | |
|------------------|--|
| GTR | Remote operation mode |
| OVP,200 | Over voltage protection 200 V |
| WAVERESET,100,10 | Output characteristic with a maximum of 100 V and 10 A |
| DAT,90,1 | Fulcrum 90 V, 1 A |
| DAT,50,5 | Fulcrum 50 V, 5 A |
| DAT,10,9 | Fulcrum 10 V, 9 A |
| WAVELIN | End of characteristic, linear interpolation |
| MODE,USER | Activates the created UI characteristic |
| SB,R | Output active |

For more information and examples of user defined characteristics see → *Wave, Wavelin and Programming of characteristics (Script Operation)*.

Response String

The response string has the following format:

command comma value unit <CR> <LF>

The value is a floating point string with a '.' as delimiter.

| Command | Response | Command | Response |
|---------|--------------------|---------|-------------|
| IA | IA,12.34A | MU | MU,10.0V |
| LIMU | LIMU,500.0V | PA | PA,12W |
| LIMI | LIMI,30.00A | RA | RA,0.015R |
| LIMP | LIMP,15000W | UA | UA,100.0V |
| LIMRMIN | LIMRMIN,0.015R | UMPP | UMPP,90.2V |
| LIMRMAX | LIMRMAX,0.110R | IMPP | IMPP,10.01A |
| LIMR | LIMR,0.015R,0.110R | OVP | OVP,600.0V |

Example: Command as ASCII and HEX protocol

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|----|----|----|----|
| L | I | M | U | , | 5 | 0 | 0 | . | 0 | V | | |
| 4C | 49 | 4D | 55 | 2C | 35 | 30 | 30 | 2E | 30 | 56 | 0D | 0A |

The digits after the decimal point correspond to the resolution of the unit.

Example

UA at a 600 V unit UA,123.4V
 UA at a 50 V unit UA,23.44V

The digits before the decimal point depend on the present measurement value.

Example: 600 V unit

UA,10.4V
 UA,220.3V
 UA,1.1V

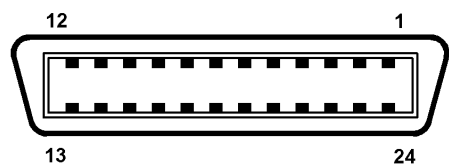
Example: 50 V unit

UA,1.23V
 UA,10.47V
 UA,0.01V

EXT. CONTROL: COMPUTER

GPIB

Connection is carried out with a 24pin Centronics connector. The device address is adjusted with the DIP switches S1-S5. Here, S1 has the lowest priority and S5 the highest.



| No | Name | Function |
|---------|--------|--------------------|
| 1 | DIO1 | Data line 1 |
| 2 | DIO2 | Data line 2 |
| 3 | DIO3 | Data line 3 |
| 4 | DIO4 | Data line 4 |
| 5 | EOI | End or Identify |
| 6 | DAV | Data Valid |
| 7 | NRFD | Not Ready For Data |
| 8 | NDAC | No Data Accepted |
| 9 | IFC | Interface Clear |
| 10 | SRQ | Service Request |
| 11 | ATN | Attention |
| 12 | SHIELD | Shield |
| 13 | DIO5 | Data line 5 |
| 14 | DIO6 | Data line 6 |
| 15 | DIO7 | Data line 7 |
| 16 | DIO8 | Data line 8 |
| 17 | REN | Remote Enable |
| 18 - 23 | GND | Ground |
| 24 | SGND | Signal Ground |

Table: Device address

| S1 | S2 | S3 | S4 | S5 | Address |
|-----|-----|-----|-----|-----|---------|
| Off | Off | Off | Off | Off | 0 |
| On | Off | Off | Off | Off | 1 |
| Off | On | Off | Off | Off | 2 |
| On | On | Off | Off | Off | 3 |
| Off | Off | On | Off | Off | 4 |
| On | Off | On | Off | Off | 5 |
| Off | On | On | Off | Off | 6 |
| On | On | On | Off | Off | 7 |
| Off | Off | Off | On | Off | 8 |
| On | Off | Off | On | Off | 9 |
| Off | On | Off | On | Off | 10 |
| On | On | Off | On | Off | 11 |
| Off | Off | On | On | Off | 12 |
| On | Off | On | On | Off | 13 |
| Off | On | On | On | Off | 14 |
| On | On | On | On | Off | 15 |
| S1 | S2 | S3 | S4 | S5 | Address |
| Off | Off | Off | Off | On | 16 |
| On | Off | Off | Off | On | 17 |
| Off | On | Off | Off | On | 18 |
| On | On | Off | Off | On | 19 |
| Off | Off | On | Off | On | 20 |
| On | Off | On | Off | On | 21 |
| Off | On | On | Off | On | 22 |
| On | On | On | Off | On | 23 |
| Off | Off | Off | On | On | 24 |
| On | Off | Off | On | On | 25 |
| Off | On | Off | On | On | 26 |
| On | On | Off | On | On | 27 |
| Off | Off | On | On | On | 28 |
| On | Off | On | On | On | 29 |
| Off | On | On | On | On | 30 |
| On | On | On | On | On | 31 |

The device address is read in only when the unit is switched on. Changing the DIP switches while the unit is active will not change the device address!

Table: Device equipment (according to IEEE-488.1)

| | |
|-----|--|
| SH1 | Source Handshake function available |
| AH1 | Acceptor Handshake function available |
| T6 | Talker, Serial Poll, end addressing by MLA |
| L4 | Listener function, end addressing by MTA |
| SR1 | Service request available |
| RL1 | Remote/Local function available |
| PP0 | No parallel poll function |
| DC1 | Device clear function available |
| DT0 | No trigger function |
| C0 | no controller function |
| E1 | Open-collector driver |

Status Word

The status word can be read with the command **<STB>** or **<*STB?>**. Return value: STB,xxxxxxx

Table: Reading the status word

| Bit | Function |
|-----|---|
| D7 | n/a |
| D6 | SRQ is set, if SRQ was requested |
| D5 | ESB is set, if a byte was set within the SES register |
| D4 | MAV is set, if a message is available |
| D3 | n/a |
| D2 | see table |
| D1 | see table |
| D0 | see table |

Table: Error messages

| D3 | D2 | D1 | D0 | Error |
|----|----|----|----|----------|
| 0 | 0 | 0 | 1 | Syntax |
| 0 | 0 | 1 | 0 | Command |
| 0 | 0 | 1 | 1 | Range |
| 0 | 1 | 0 | 0 | Unit |
| 0 | 1 | 0 | 1 | Hardware |
| 0 | 1 | 1 | 0 | Read |

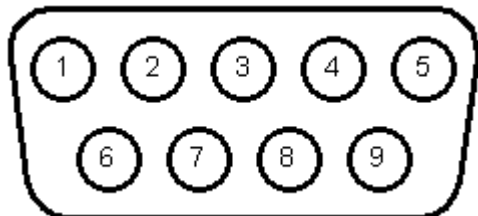
ESR-Register - Event-Status-Register

The ESR register can be read using the command **<*ESR?>**. Return value: ESR,xxxxxxx. After the query, the ESR register is deleted.

| Bit | Function |
|-----|------------------------|
| D7 | Power on |
| D6 | Command error |
| D5 | User request |
| D4 | Execution error |
| D3 | Device dependent error |
| D2 | Query error |
| D1 | Request control |
| D0 | Operation complete |

RS232 INTERFACE

The connection of the RS232 interface is carried out with a 9pin sub D connector. A null modem cable must be used as connector cable.



| No | Name | Function |
|----|------|---|
| 1 | N.C. | |
| 2 | RxD | Data line from PC to unit |
| 3 | TxD | Data line from unit to PC |
| 4 | N.C. | |
| 5 | GND | GND |
| 6 | N.C. | |
| 7 | RTS | Reception of the unit, signal direction from unit to PC (only required for active Hardware handshake) |
| 8 | CTS | Reception of the PC, signal direction from PC to unit (only required for active Hardware handshake) |
| 9 | N.C. | |

The interface can be operated using the following parameters:

Baud rate: 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 62500, 115200

Parity: O = Odd = uneven parity

E = Even = even parity

N = None = no parity bit

Number of data bits: 7 or 8

Number of stop bits: 1 or 2

Handshake: H = Hardware

S = Software

N = None (no handshake)

The defined character for XON is 0 x 11 and for XOFF it is 0 x 13.

Interface parameters in delivery state are 9600 baud, no parity, 8 data bits, 1 stop bit, echo on. The status word can be read with the command **<STB>** or **<*STB?>**. The following functions are assigned to the bits:

| Bit | Function |
|-----|--|
| D15 | Parity error |
| D14 | Over run error |
| D13 | Framing error |
| D12 | Timeout error |
| D11 | Echo on |
| D10 | used internally, can be 1 or 0 |
| D9 | Hardware handshake (RTS/CTS) |
| D8 | Software handshake (XON/XOFF) |
| D7 | Parity enable |
| D6 | Parity mode (1 = odd, 0 = even) |
| D5 | Stop bit (1 = 2 stop bits; 0 = 1 stop bit) |
| D4 | Data format (1 = 8 bit; 0 = 7 bit) |
| D3 | used internally, can be 1 or 0 |
| D2 | → Table |
| D1 | → Table |
| D0 | → Table |

Table: Error messages

| D2 | D1 | D0 | Error |
|----|----|----|----------|
| 0 | 0 | 1 | Syntax |
| 0 | 1 | 0 | Command |
| 0 | 1 | 1 | Range |
| 1 | 0 | 0 | Unit |
| 1 | 0 | 1 | Hardware |
| 1 | 1 | 0 | Read |

If echo is on, the interface confirms each incoming character by sending the same character back to the sender. The interface parameters can be adjusted via software and the command `<PCx>`. These settings can be saved with the command `<SS>`.

Interface Reconfiguration

In case, the user has forgotten the active setup, there are two ways of reconfiguring the interface:

- sending the command `<PCx>` from one of the other interfaces
- using the display to configure the interface → *Interface Parameters*

RS485 INTERFACE

The interface works with the following parameters:

| | |
|----------------------|---|
| Baud rate: | 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 62500, 115200 |
| Parity: | O = Odd = uneven parity E = Even = even parity N = None = no parity bit |
| Number of data bits: | 7 or 8 |
| Number of stop bits: | 1 or 2 |
| Timeout: | 0-100 ms |

A timeout is the time between receipt and sending of a message. The connected device is selected by entering the command and placing the number of the device and '#' before it. When using the word ,ALL' instead of a number, the following command will be executed by all connected devices (e. g. `#1,ID`; `#22,GTR`, `#ALL,GTL`).

Example:

#1,ID
#22,GTR
#ALL,GTL

The status word can be read with the command `<STB>` or `<*STB?>`. The following functions are assigned to the bits:

| Bit | Function |
|-----|--|
| D15 | Parity error |
| D14 | Over run error |
| D13 | Framing error |
| D12 | Timeout error |
| D11 | n/a |
| D10 | n/a |
| D9 | n/a |
| D8 | n/a |
| D7 | Parity enable |
| D6 | Parity mode (1 = odd, 0 = even) |
| D5 | Stop bit (1 = 2 Stop bits; 0 = 1 Stop bit) |
| D4 | Data format (1 = 8 bit; 0 = 7 bit) |
| D3 | n/a |
| D2 | → Table |

| | | | |
|-----------------------|---------|----|----------|
| D1 | → Table | | |
| D0 | → Table | | |
| Table: Error messages | | | |
| D2 | D1 | D0 | Error |
| 0 | 0 | 1 | Syntax |
| 0 | 1 | 0 | Command |
| 0 | 1 | 1 | Range |
| 1 | 0 | 0 | Unit |
| 1 | 0 | 1 | Hardware |
| 1 | 1 | 0 | Read |

Interface parameters are configured via software using the command **<PCx>**. The settings can be saved with the command **<SS>**.

Interface Reconfiguration

In case, the user has forgotten the active setup, there are two ways of reconfiguring the interface:

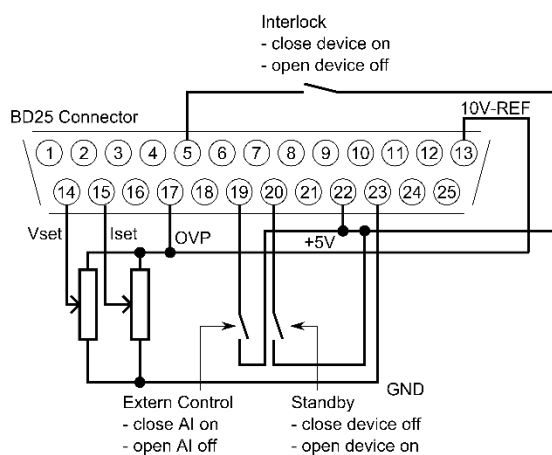
- sending the command **<PCx>** from one of the other interfaces
- using the display to configure the interface → *Interface Parameters*

EXT. CONTROL: AI INTERFACE (OPTION)

The device can be controlled via control signals and by using the analog/digital In/Out.

PIN ASSIGNMENT AI INTERFACE

| No (BD25) | Dir | Name | Function |
|-----------|-------------|-----------------|---|
| 1 | analog out | U_{mon} | Monitor set point U |
| 2 | analog out | I_{mon} | Monitor set point I |
| 3 | analog out | P_{mon} | Monitor actual value P |
| 4 | analog out | OVP_{mon} | Monitor actual value OVP |
| 5 | digital in | Soft-Interlock | Interlock function (Caution: Interlock does not correspond to the machinery directives) |
| 6 | -nc- | - | - |
| 7 | digital out | CV | Signals „Const. Voltage“ mode |
| 8 | analog out | U_{istmon} | Monitor output voltage |
| 9 | gnd | GND | - |
| 10 | digital out | Standby | Signals standby |
| 11 | gnd | GND | - |
| 12 | -nc- | - | - |
| 13 | REF10 | 10 V- V_{ref} | Output 10 V reference voltage |
| 14 | analog in | U_{set} | Set point U |
| 15 | analog in | I_{set} | Set point I |
| 16 | analog in | In 2 | - |
| 17 | analog in | OVP_{set} | Set point OVP |
| 18 | analog in | In 4 | - |
| 19 | digital in | Ext. Control | Activates analog control |
| 20 | digital in | Standby | Activates standby |
| 21 | analog out | I_{istmon} | Monitor output current |
| 22 | pwr | + 5 V | Output 5 V supply voltage |
| 23 | gnd | GND | - |
| 24 | digital out | Error | Signals shut down by OVP |
| 25 | gnd | GND | - |
| 26 | -nc- | - | - |



All digital outputs are OC outputs with a pull-up resistance after + 5 V. All analog inputs and outputs can be operated in 0-5 V or in 0-10 V mode.

ANALOG INPUT

Set points are adjusted as dc voltage (0-5 V or 0-10 V) on the analog inputs. The voltage range can be chosen in the configuration menu. To save all changes after changing the voltage range, the unit must be restarted.

Set Point U (U_{Set})

Set point output voltage. The set point refers to the rated voltage of the unit.

Example:

LAB/SMS at 600 V output voltage, AI is adjusted to 10 V, desired output voltage = 100 V.
 $U_{\text{Set}} = 10 \text{ V} \cdot 100 \text{ V} \div 600 \text{ V} = 1,667 \text{ V}$

Set Point I (I_{Set})

Example:

LAB/SMS at 100 A output voltage, AI is adjusted to 10 V, desired output current = 2 A.
 $I_{\text{Set}} = 10 \text{ V} \cdot 2 \text{ A} \div 100 \text{ A} = 0.200 \text{ V}$

Set Point OVP (U_{OVP})

The output is deactivated immediately if the output voltage exceeds the adjusted value. This error is indicated on the display with the word „Error“. To rest this error, standby mode must be activated. Adjustment range is 0 V up to the maximum rated voltage of the device + 20%.

Example:

LAB/SMS with 600 V output voltage, AI is adjusted to 10 V, desired OVP voltage = 650 V.
Adjustment range: $600 \text{ V} + 20\% = 720 \text{ V}$
 $U_{\text{Set}} = 10 \text{ V} \cdot 650 \text{ V} \div 720 \text{ V} = 9.028 \text{ V}$

ANALOG OUTPUT

On the analog outputs, present measurement values are displayed as dc voltage values (regardless of the actual operation mode). Therefore the AI interface can be used for monitor purposes. Maximum voltage is 5 V / 10 V.

Monitor Set Point U (U_{mon})

Present set point of the output voltage. Measurement value refers to the rated voltage of the device.

Example:

LAB/SMS at 600 V output voltage, AI is adjusted to 10 V, voltage at output $U_{\text{mon}} = 2 \text{ V}$.
Present set point: $U_{\text{Set}} = 2 \text{ V} \cdot 600 \text{ V} \div 10 \text{ V} = 120 \text{ V}$

Monitor Set Point I (I_{mon})

Present set point of the output current. Measurement value refers to the rated current of the device.

Example:

LAB/SMS at 100 A output current, AI adjusted to 10 V, voltage at output $I_{\text{mon}} = 2 \text{ V}$.
Present set point: $I_{\text{Set}} = 2 \text{ V} \cdot 100 \text{ V} \div 10 \text{ V} = 20 \text{ A}$

Monitor Actual Value P (P_{mon})

Present set point for output power. It is calculated by the controller from measurement values of output voltage and output current. Measure value refers to the rated power of the device.

Example:

LAB/SMS at 15 kW rated power, AI adjusted to 10 V, voltage at output $P_{\text{mon}} = 5 \text{ V}$.
Present output power $P_{\text{out}} = 5 \text{ V} \cdot 15 \text{ kW} \div 10 \text{ V} = 7.5 \text{ kW}$

Analog Output OVP (U_{OVPmon})

Present set point for over voltage protection. Measurement value refers to the rated voltage of the device + 20%.

Example:

LAB/SMS at 600 V output voltage, AI adjusted to 10 V, voltage at output $U_{mon} = 2$ V. Signal refers to $600\text{ V} + 20\% = 720\text{ V}$.
Present set point: $U_{ovp} = 2\text{ V} \cdot 720\text{ V} \div 10\text{ V} = 144\text{ V}$

Monitor Output Voltage (U_{istmon})

Present measure value point value for output voltage. Measurement value refers to the rated voltage of the device.

Example:

LAB/SMS at 600 V output voltage, AI adjusted to 10 V, voltage at output $U_{istmon} = 6$ V.
Present output voltage $U_{out} = 6\text{ V} \cdot 600\text{ V} \div 10\text{ V} = 360\text{ V}$

Monitor Output Current (I_{istmon})

Present measure value for output current. Measurement value refers to the rated current of the device.

Example:

LAB/SMS at 100 A output current, AI adjusted to 10 V, voltage at output $I_{istmon} = 4$ V.
Present output current $I_{out} = 4\text{ V} \cdot 100\text{ A} \div 10\text{ V} = 40\text{ A}$

DIGITAL INPUT

The digital inputs can be used to adjust the operation mode for the analog control. Inputs are low active.

Activation (Ext. Control)

The input 'Ext. Control' can be used to choose the operation mode 'AI'. The AI interface is activated by an applied voltage of + 5 V up to + 10 V. Front panel operation is deactivated. Operation mode is marked as 'AI' on the display. The digital interface takes priority over the AI interface. The settings from AI interface have no effect if the device is toggled to 'Remote'.

Soft-Interlock

The Interlock deactivates the unit immediately, when the connection between interlock input (Pin 5) and +5 V voltage is opened. In this case, the output of the unit cannot be activated, neither by interface nor by front panel. The difference between Soft-Interlock and Interlock is that a Soft-Interlock does not correspond to the machinery directives. If the Soft-Interlock is triggered, the unit switches into Interlock-Mode.

Blocking (Standby)

The standby mode is activated by an applied voltage of + 5 V up to + 10 V.
The output signal is enabled, if the input 'Standby' is toggled inactive.

DIGITAL OUTPUT

On the digital outputs, actual device adjustments are displayed (irrespective of the actual operation mode). Therefore the AI interface may be used for monitoring functions also. Gauges are consistent with a negative logic: S = Set = log. 0; R = Reset = log. 1

A set output has a voltage level of < 0.6 V. A reset output has a voltage level of > 1.2 V.

Blocking (Standby)

The blocking of the output is set, if the unit is in standby mode.

CONST. VOLTAGE MODE (CV)

Constant voltage mode is set, when the unit is in constant voltage mode.

ERROR

An error is set, if the unit has been shut down by OVP. To reset this error, the standby mode must be activated.

EXT. STEUERUNG: ETHERNET (LAN)

To communicate with the LAB/SMS via network, it is necessary to assign an IP address to the device first. In delivery status, the device automatically draws an IP from the network. In its practical operation, this behavior is unfavorable, because after each activation the device has a new IP address. Therefore, to each device an individual, permanent IP address should be assigned.

The status word can be read with the command `<STB>` or `<*STB?>`. Only bits from D0 up to D2 are in use. All other bits can be 1 or 0.

Table: Error messages

| D2 | D1 | D0 | Error |
|----|----|----|----------|
| 0 | 0 | 1 | Syntax |
| 0 | 1 | 0 | Command |
| 0 | 1 | 1 | Range |
| 1 | 0 | 0 | Unit |
| 1 | 0 | 1 | Hardware |
| 1 | 1 | 0 | Read |

MANUAL ASSIGNMENT OF AN IP UNDER MICROSOFT WINDOWS®

After the console has been opened, clicking on ‚Start‘ and ‚Ausführen‘ opens an input field. After this, the command `cmd` or `command` opens a DOS window. The following has to be entered: `arp -s xxx.xxx.xxx.xxx yy-yy-yy-yy-yy-yy`. ‚xxx‘ is the desired IP address, ‚yy‘ is the MAC address of the unit, which can be read from the unit's back panel.

The entry of the IP has been added to the ARP table. The device has no new IP yet. Execute telnet with new IP on port 1: `telnet xxx.xxx.xxx.xxx 1`. ‚xxx‘ is the desired new IP address. Connection fails but the new IP address is thus assigned to the device. The assignment of the IP is still dynamical, which means that these settings get lost after the device has been cut off from the network. The user interface can be loaded by entering the new IP address: <http://xxx.xxx.xxx.xxx>. By selecting the menu item ‚Config‘, the IP address can be adjusted. Java must be supported by your browser to adjust the IP.

MAC: 00-20-4a-93-27-63

IP-Adress: 169 254 209 45

Sub-Mask: 255 255 0 0

Gateway: 169 254 209 0

☐ Dynamic IP

MONITORING THE DEVICE VIA BROWSER

The user interface opens via direct request of the IP address: <http://xxx.xxx.xxx.xxx>. The item menu ‚Control‘ opens the control of the unit. Java must be supported by your browser to control the device.

| Control | |
|---------|---|
| Mode: | <div> <div>UI</div> <div>Standby</div> <div>Remote</div> </div> |
| Status: | U-Limit |

| Set | | Data | |
|-----|--|------|-------------|
| U | <div> <div></div> <div></div> <div>27.85</div> <div>V</div> </div> | U | 27.85 V |
| I | <div> <div></div> <div></div> <div>0.941</div> <div>A</div> </div> | I | 0.945 A |
| | | P | 26.3 W |
| | | R | 29.4709 Ohm |



When controlling the device via browser, another control via telnet must not be active!

CONTROLLING THE DEVICE VIA TELNET

The device can be controlled directly via port 10001. After the console has been opened, a click on ‚Start‘ and ‚Ausführen‘ opens an input field. After the commands *cmd* or *command* have been entered, a DOS window opens with: telnet xxx.xxx.xxx.xxx 10001.

Alternatively, many terminal programs offer the possibility to establish a TCP/IP or telnet connection.



When controlling the device via port 10001, the user interface of the device must not be open in a browser!

CONTROLLING THE DEVICE VIA BROWSER

The user interface can be opened via IP address: <http://xxx.xxx.xxx.xxx>. The menu ‚Display‘ opens the monitoring of the unit. Java must be supported by your browser to control the device. Displayed are all present measurement values, which are updated every 2 seconds. When using the monitoring function, automatic toggle to remote operation when receiving a command should be deactivated (command *<GTR,0>*).

| Data | Status |
|---------------|----------------|
| U 27.85 V | Mode: UI |
| I 0.945 A | Status: Run |
| P 26.3 W | Control: Remot |
| R 29.4709 Ohm | Limit: U |

EXT. CONTROL: USB

The USB interface provides a virtual COM port for the PC. Via this port, the unit can be controlled as with a normal RS232 interface, e. g. with a terminal program. Corresponding drivers for all current operating systems are available as download: <http://www.ftdichip.com/Drivers/VCP.htm>.

The status word can be read with the command **<STB>** or **<*STB?>**.

| Bit | Function |
|-----|--|
| D15 | Parity error |
| D14 | Over run error |
| D13 | Framing error |
| D12 | Timeout error |
| D11 | Echo on |
| D10 | used internally, can be 1 or 0 |
| D9 | Hardware handshake (RTS/CTS) |
| D8 | Software handshake (XON/XOFF) |
| D7 | Parity enable |
| D6 | Parity mode (1 = odd, 0 = even) |
| D5 | Stop bit (1 = 2 Stop bits; 0 = 1 Stop bit) |
| D4 | Data format (1 = 8 bit; 0 = 7 bit) |
| D3 | used internally, can be 1 or 0 |
| D2 | → Table |
| D1 | → Table |
| D0 | → Table |

Table: Error messages

| D2 | D1 | D0 | Error |
|----|----|----|----------|
| 0 | 0 | 1 | Syntax |
| 0 | 1 | 0 | Command |
| 0 | 1 | 1 | Range |
| 1 | 0 | 0 | Unit |
| 1 | 0 | 1 | Hardware |
| 1 | 1 | 0 | Read |

The defined character for XON is 0 x 11 and for XOFF it is 0 x 13.

Interface parameters are adjusted by software with the command **<PCx>** and afterwards they can be saved with the command **<SS>**.

Interface Reconfiguration

In case, the user has forgotten the active setup, there are two ways of reconfiguring the interface:

- sending the command **<PCx>** from one of the other interfaces
- using the display to configure the interface → *Interface Parameters*

DATA LOG FUNCTION (OPTION)

The device has a data log function. A memory card may be used as data logger. All measurement values will be saved, separated by tabulators, in a text file. The time interval may be adjusted from 1-4294967 s (= 71 minutes). To activate the data log function, a memory card must be inserted. The root directory of the memory card must contain a text file named "LABLOG.txt". The new data will be written into this file.



The memory card must be inserted or removed in standby mode only!

In case, that the first entry of the first line of the file is "interval=xxxx" (xxxx = time in seconds), the memory interval is adjusted accordingly. The entry must be written in lower case letters and without space characters. If the interval remains unspecified, the memory interval is 60 seconds.

Example:

interval=30

The data log function is active whenever the device is not operating in standby mode. The function is indicated by a small memory card symbol in the upper right corner of the main display. Whenever a new data set is written, the symbol will be displayed as filled for ca. 1 second. In case the memory card is full, the symbol will be crossed out.

FORMAT OF THE SAVED DATA

The first entry shows the present operation mode. The second entry shows the present operation mode followed by ,U_{dc}' and ,I_{dc}'.

Example:

| | | |
|------|----------------|-------|
| USER | I-Limit 1,0 | 10,02 |
| USER | OVP 0,0 | 0,00 |
| UI | U-Limit 100,01 | 0,10 |
| UIP | U-Limit 100,0 | 0,10 |

SCRIPT MODE

Operation sequences may be programmed in a script which can be read in from a memory card. A script is a text file, which includes a sequence of commands. Alternatively, the script memory can be programmed via digital interface using the command **SCR**. For more information about the use of this command see → *Commands*. The device is able to process up to 1000 commands.

EXECUTING/LOADING A SCRIPT

The script must be saved on a MMC or SD card as text file with .txt or .scr ending.

The mode ,Scr' must be selected from the main display. Pushing the rotary pulse encoder will open the file selection menu. The script file can be selected. An error message appears if, the file could not be read correctly or, if the read in setup is invalid (e. g. IA 40 at a 10 A unit). To return to the file selection menu, the rotary pulse encoder or the button **Display** must be pushed again. The script has been loaded and can be started by pushing the button **Standby**.

The last five commands of the script are displayed in the field ,Preset'. The actual command is placed on top. The script ends when button **Standby** is pushed and device is toggled to standby mode.

COMMANDS

Syntax

Upper and lower case are nonrelevant. Therefore, the following commands deliver the same results: *PMAX 100 Pmax 100 pMaX 100*. Delimiters must be placed between two commands or between command and parameter. Valid delimiters are: blank, tabulator, LineFeed <LF>, Carriage Return <CR> and equal sign (=).

Numerical values must be placed as basic units and may not be followed by characters. Valid delimiters for decimal places are: point and comma. No characters must be attached: U 12,345 U 10.00 U 12. The command UAC 12.114V is invalid, because it is followed by a character.

All commands may be written consecutively, but must be separated by blanks: U 10 I 1 UIP LOOP RUN. Due to its unclear syntax, this style is not recommendable.

Quick view of commands

| Command | Description | Result |
|---------------------|--------------------------------|--|
| ; or # | comment | Entering commented text. |
| DELAY<t>, DELAYS<t> | delay | Delays execution of the script for duration of time t. |
| I<l in ampère> | output current | Set point output current. |
| IMPP<l in ampère> | MPP current | MPP current in ampère for PV simulation. |
| LOOP, LOOPCNT | Loop | Define return address. |
| PMAX | maximum output UIP mode | Maximum output for UIP mode. |
| PV | PVsim mode | Activate PVsim mode. |
| RI | internal resistance UIR mode | Set point internal resistance in ohm for UIR mode. |
| RUN | open output | Enable output. |
| STANDBY | close output | Disable output. |
| U | set point output voltage | Set point output voltage in V. |
| UI | UI mode | Activate UI mode. |
| UIP | UIP mode | Activate UIP mode. |
| UIR | UIR mode | Activate UIR mode. |
| UMPP | set point MPP voltage | Set point MPP voltage (for PV simulation) |
| USER | set points current and voltage | Generates set points for current and voltage using the internal table. |
| WAIT | wait | Waits for user action. |
| WAVE, WAVELIN | characteristic programming | Characteristic programming. |

Detailed description of commands

; or # - Comment

Comment on text. All characters from ; or # up to end of line will be ignored. This function is not available when programming via digital interface.

Example:

```
# This is a comment
UIP # This command activates the UIP mode
; Comments can also start with a semicolon
```

DELAY, DELAYS – Time delay

The commands **DELAY** and **DELAYS** delay the execution of the script. The following number defines the duration of the delay in ms (milliseconds). Maximum duration of delay is 65535 ms.

Example:

```
UI          # UI mode
U 10        # Output voltage 10 V
I 1         # Output current 1 A
RUN         # Activate output
DELAY 200   # Wait 200 ms
U 100       # Adjust output voltage to 100 V
DELAYS 10   # Wait 10 seconds
STANDBY     # Deactivate output
```

I - Set point output current

This command adjusts the set point for the output current in ampere.

Example:

```
I 9.8      # Output current 9.8 A
```

IMPP - Set point MPP current

This command adjusts the set point for the MPP current for PV simulation in ampere.

Example:

```
IMPP 8.123  # MPP current 8.123 A
```

LOOP, LOOPCNT - Return Loop

Usually the script ends with the last command. A return address can be defined with the command **<LOOP>**. From this point on, the processing will continue after the last command of the script. To interrupt the program, button **Standby** must be pushed. The command **<LOOPCNT>** equals the command **<LOOP>**. But here, the command defines the number of loops. The maximum number is 65535.

Example:

```
# This example activates the output for 10s, then deactivates it for 2s
# and starts from the beginning. This will continue until the user interrupts the
# process by pushing the button Standby.
```

```
UI          # UI mode
U 100       # Output voltage 100 V
I 10        # Output current 10 A
LOOP        # Start address
RUN         # Activate output
DELAYS 10   # Wait 10s
STANDBY     # Deactivate output
DELAYS 10   # Wait 2s
```

```
# This example works like the previous one.
# The cycle is executed only 10 times, and then the script ends.
```

```
UI          # UI mode
U 100       # Output voltage 100 V
I 10        # Output current 10 A
LOOPCNT 10  # Start address
RUN         # Activate output
DELAYS 10   # Wait 10s
STANDBY     # Deactivate output
DELAYS 10   # Wait 2s
```

PMAX - maximum output in UIP mode

Maximum output for the UIP mode.

PV - Pv_{sim} mode

Activates the PV_{sim} mode.

Example:

```
PVSIM      #Activate PV simulation
```

RI - Internal resistance UIR mode

This command adjusts the set point for the internal resistance in UIR mode.

RUN - Activate output

The command **RUN** resets the standby mode and activates the output.

Example:

```
RUN        # Activate output
```

STANDBY - Deactivate output

The command **STANDBY** deactivates the output and activates standby mode.

Example:

```
STANDBY    # Deactivate output
```

U - Set point output voltage

Set point for output voltage in V.

Example:

```
U 100      # Output voltage 100 V
```

UI - UI-Modus

This command activates the UI mode. Unit works current and voltage regulated.

Example:

```
UI         # UI mode
```

UIP - UIP mode

This command activates the UIP mode. Unit works current, voltage and power regulated.

UIR - UIR mode

This command activates the UIR mode. Unit works current and voltage regulated. Additionally, an internal resistance is simulated.

UMPP - Set point UMPP voltage

Set point for MPP voltage for PV simulation in V.

Example:

```
UMPP 80.42  # MPP voltage 80.42 V
```

USER - Set points current and voltage

This command generates the set points for current and voltage by using the internal table. Thereby, different UI characteristics can be created. The tables can be created beforehand by using the command **WAVE**.

WAIT - Waiting for user action

The program is stopped until the user pushes the button **Standby**.

Example:

```
; Starter characteristic:
UI           ; UI mode
I 10         ; Current limitation 10 A
U 12         ; Output voltage 12 V (->100%)
RUN          ; Activate output
LOOP         ; Start address after end of the script
WAIT         ; Waits until rotary pulse encoder is pushed
U 10,5       ; 1. ramp
U 9          ; Command is processed within 1 ms. Therefore the
U 7,5        ; ramp has 5 interim values.
U 6
U 4,5
DELAY 15     ; 15 ms pause
U 4,8        ; 2. ramp
U 5,1        ; Command is processed within 1 ms. Therefore
U 5,4        ; the ramp has 5 interim values.
U 5,7
U 6
DELAY 2000   ; 2000 ms pause
U 6,6        ; 3. ramp
U 7,2        ; Command is processed within 1 ms. Daher
U 7,8        ; The ramp has 10 interim values.
U 8,4
U 9
U 9,6
U 10,2
U 10,8
U 11,4
U 12
```

WAVE, WAVELIN - Characteristic programming

The command **WAVE** is used to start the characteristic programming. The command is followed by numerical values, which indicate the desired voltage and current. Finally, followed by the command with a prefixed '-' characteristic (**-WAVE**).

```
WAVE
<U1> <I1>
<U2> <I2>
<U3> <I3>
...
<Un> <In>
-WAVE
```

The command **WAVELIN** equals the command **WAVE**.

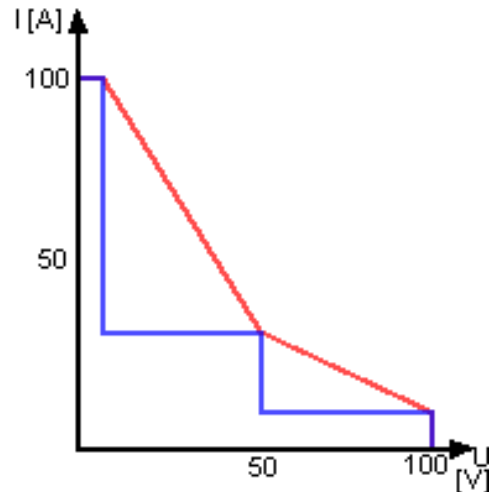
```
WAVELIN
<U1> <I1>
<U2> <I2>
<U3> <I3>
...
<Un> <In>
-WAVELIN
WAVELIN
```

With the **WAVELIN** command, the interim values between the fulcrums are linear interpolated, with the **WAVE** command they are layered (see example). Characteristics which are not constant or negative in their course are accepted but the behavior of the unit may not be predicable.

Example:

```
; Characteristic with layered interim values
; This script delivers the blue characteristic in the diagram
WAVE      ; Start of the table
100 10    ; 100 V 10 A
50  25    ; 50 V 25 A
10  100   ; 10 V 100 A
-WAVE     ; End of the table
RUN       ; Output active
```

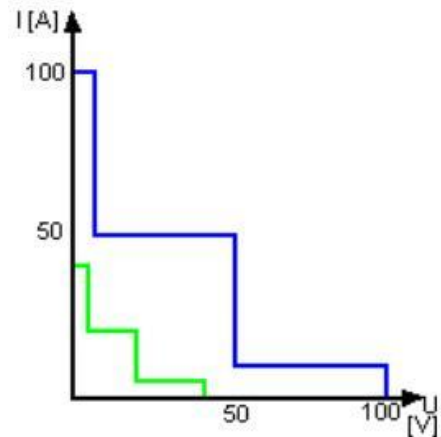
```
; Characteristic with linear interim values
; This script delivers the red characteristic
WAVE      ; Start of the table
100 10    ; 100 V 10 A
50  25    ; 50 V 25 A
10  100   ; 10 V 100 A
-WAVELIN  ; End of the table
RUN       ; Output active
```



If output voltage or output current is changed afterwards, the characteristic keeps its course. Though values are stretched or compressed to the new range.

Example:

```
# This script generates a blue characteristic
# After a 10 second delay it switches to the green characteristic:
WAVE      # Start of the table
100 10    # 100 V 10 A
50  50    # 50 V 50 A
10  100   # 10 V 100 A
-WAVE     # End of the table
U 100     # Output Voltage 100 V
I 100     # Output Current 100 A
USER      # Select characteristic
RUN       # Output open
DELAY 10000 # Wait 10 seconds
U 50      # Output Voltage 50 V
I 50      # Output Current 50 A
```



CONTROLLER

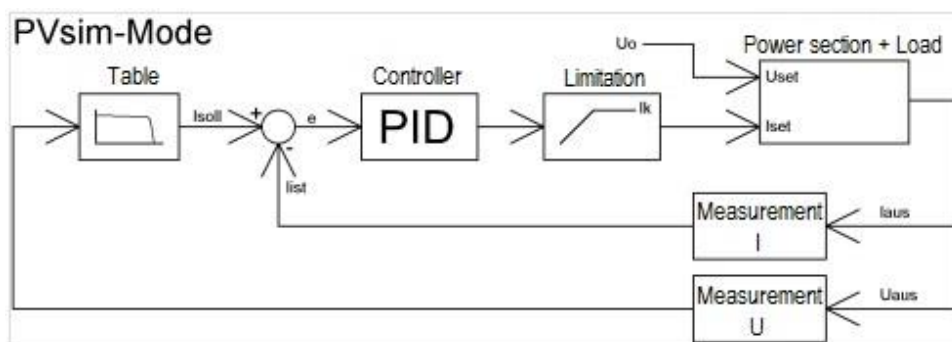
The software contains three digital PID controllers. Each controller is assigned to the UIR, UIP and PVsim mode. When required, the controller parameters can be changed via universal interface.



Improper adjustment of the controller can lead to controller oscillations which may damage connected devices!

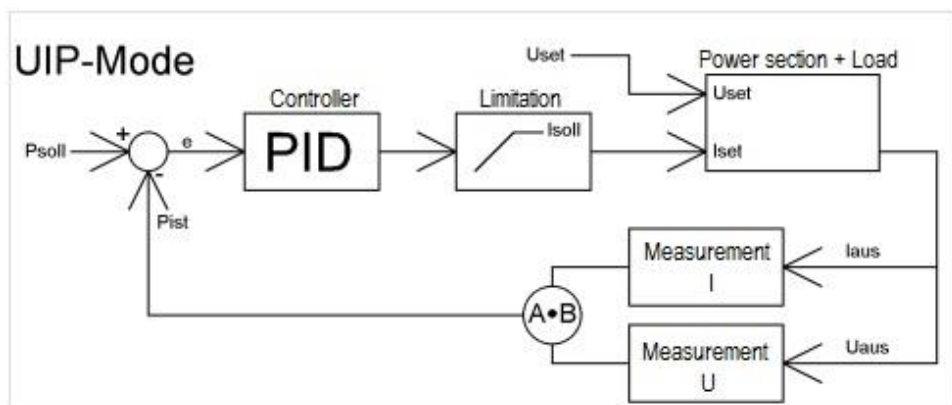
CONTROLLER STRUCTURE PVSIM MODE AND USER MODE

The current set point is calculated from the output voltage and a table. This set point stands for the input signal of the PID controller after it was subtracted from the actual value. The PID controller releases the current set point for the power supply. The current set point is limited to the short circuit current, as a maximum. The voltage set point of the power supply is permanently set to the open circuit voltage of the table. In PVsim mode the current is regulated while the voltage is fixed.



CONTROLLER STRUCTURE UIP MODE

The output voltage is multiplied with the output current. The result is subtracted from the power set point. This signal is the input signal of the PID controller, which releases the current set point for the power supply. The current set point is limited to the current set point, as a maximum. The voltage set point of the power supply is permanently set to the voltage set point. In UIP mode the current is regulated, while the voltage is fixed.

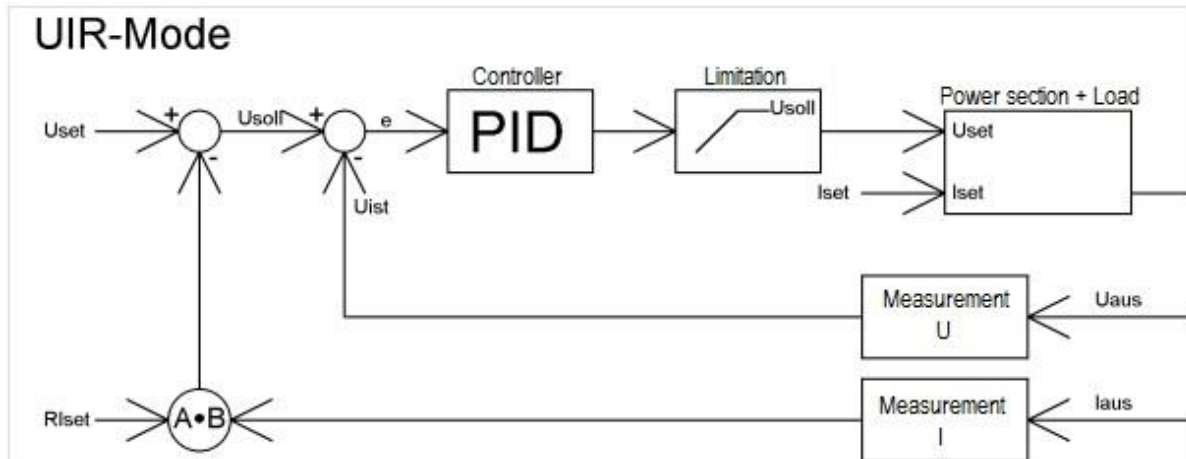


CONTROLLER STRUCTURE UIR MODE

The measured output current is multiplied with the adjusted internal resistance. The result is subtracted from the adjusted set point and is then the set point for the voltage controller:

$$U_{soll} = U_{set} - I_a \cdot R_i$$

The output signal is limited to the voltage set point. The current set point of the power supply is permanently set to I_{soll} . In UIR mode the voltage is regulated while the current is fixed.



CONTROLLER PARAMETERS

common differential equation of a PID controller:

$$y = K_p \cdot \left(e + \frac{1}{T_n} \int e(t) dt + T_v \frac{de}{dt} \right)$$

| | |
|----|--------------------------|
| E | Controller deviation |
| Kp | Proportional coefficient |
| Tn | Reset time |
| Tv | Derivative time |

Since the digital controller is a discrete-time system, the integral is replaced by a summation and the differential by a difference:

$$y = K_p \left(e_i + \frac{T_s}{T_n} \sum_{m=-\infty}^{m=i} e_m + \frac{T_v}{T_s} (e_i - e_{i-1}) \right)$$

T_s Sampling time

The following equation puts the controller into practice within the software:

$$y = 0,1 \cdot P \cdot e_i + 0,001 \cdot I \cdot \sum_{m=-\infty}^{m=i} e_m + 0,1 \cdot D \cdot (e_i - e_{i-1})$$

Parameters P, I and D are calculated as follows:

$$P = 10 \cdot K_p \quad I = \frac{1000 \cdot K_p \cdot T_s}{T_n} \quad D = \frac{10 \cdot K_p \cdot T_v}{T_s}$$

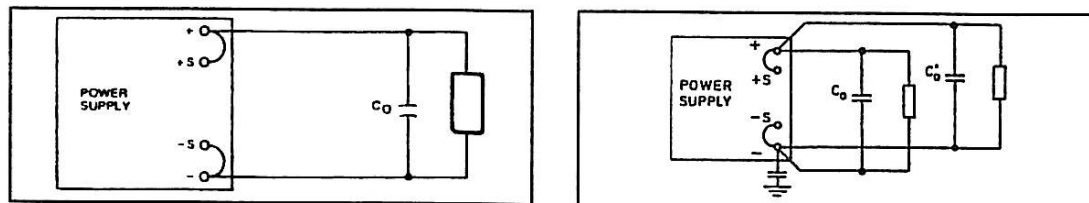
T_s Sampling time = 300 us

Controller parameters can be programmed via digital interface using the command **REGLER**.

SENSE MODE

LOAD CONNECTION WITHOUT SENSOR CONDUCTOR

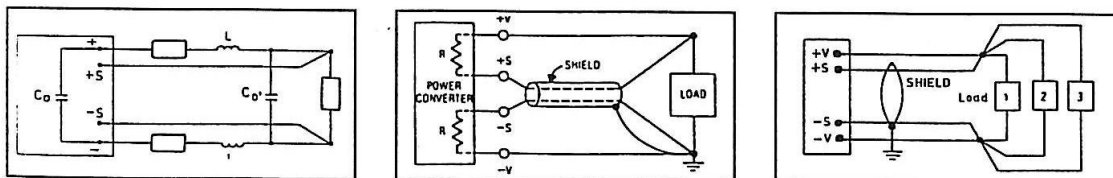
Almost all our power supplies are provided with sensor conductor connectors to compensate the voltage drop on the load. In case, these connectors are not in use, they must be short-circuited with correct polarity to the load outputs and directly to the output connectors. By no means, current may flow over the sense connectors. In case of multiple loads, the user has to provide a central load distribution point. To reduce peak loads and for an HF impedance terminator, a 1-10 μF capacitor should be connected to the output.



LOAD CONNECTION WITH SENSOR CONDUCTOR

The following points must be considered, when existing sense cables are connected directly to the load or to the central load distribution point:

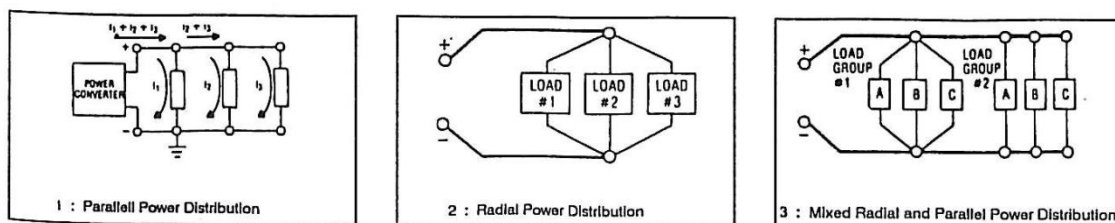
- remove existing sense cable bridges from the power supply
- directly connect + sense and - sense with correct polarity to the load distribution point
- connect + sense and - sense conductors to a 1-47 μF capacitor
- protect sense cable or at least twist + sense and - sense
- select load line cross section, so that voltage drop is $< 0.4 \text{ V}$
- avoid overload of power supplies (voltage drop per line x current)



If thus you paid attention to the points stated above, oscillation occurs through load or power induction and complex load situations, please contact our company ET System.

LOAD DISTRIBUTION WITHOUT SENSOR CONDUCTOR

To ensure a proper use, a central load distribution situation is essential. Illustration 2 shows a correct load distribution. Illustration 1 shows an insufficient supply of load 2, load 3 etc. via parallel load conductors. In practice, it may occur that an optimal distribution is not possible. Illustration 3 shows a mixed distribution, where at least the largest consumers are supplied centrally.



MASTER/SLAVE MODE (M/S MODE)

In master/slave mode, multiple LAB/SMS units are connected via the ETS-Bus. To establish the connection, any commercially available USB cables Type A are used. However, the interface is not an USB interface.



The ETS interface must not be connected to an USB interface!

The interface has two connectors which are connected in parallel. By these, multiple units can be easily connected in parallel. When multiple units are connected and active, each unit has assigned its own address. A symbol in the upper right corner of the display indicates that the units are operating in M/S mode. There is no ‚Master‘ in the narrow sense. Set points are forwarded via bus to all connected units. On each unit, the parameters can be adjusted. Changes are automatically forwarded via ETS bus to all connected units. It is irrelevant, whether the set points are adjusted using the front panel or via interface. The command LLO on a digital interface deactivates front panel operation at all connected units.

Example: 2 units connected to the bus, unit 1 with front panel operation and digital interface, unit 2 with front panel operation only

- GTR Remote operation mode, set points can be adjusted via digital interface or via front panel of unit 2. Unit 1 could be toggled to local mode by pushing the button Standby. The display of unit 1 shows the word ‚Rem‘ (Remote), the display of unit 2 shows the word ‚Loc‘ (Local).
- LLO Local lockout, both units cannot be operated via front panel. This status is indicated on both displays by the word ‚LLO‘.

Note: Master/Slave mode is currently not working in combination with memory card!



If set points are given via analog interface, only one unit must be run via AI!

OPERATION MODES IN MASTER/SLAVE MODE

The master/slave mode can be selected in the configuration menu of the unit.

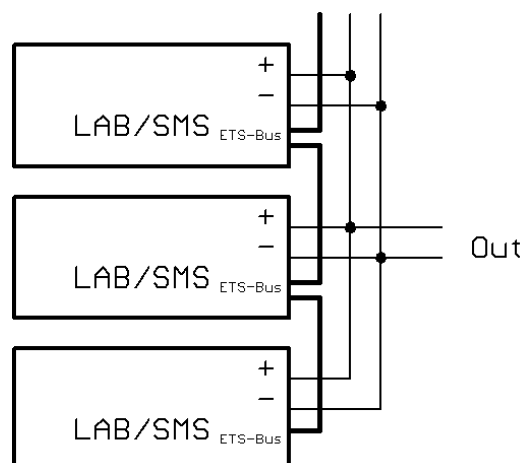
M/S Mode Off

No active master/slave mode, regardless of whether units are connected or not.

M/S Mode Parallel

The control assumes that outputs are connected in parallel. Set points are respectively converted. Displays will show the total current as measure point. Current distribution between the individual units is not necessarily symmetrical. Thus, the total current will be limited to the adjusted value.

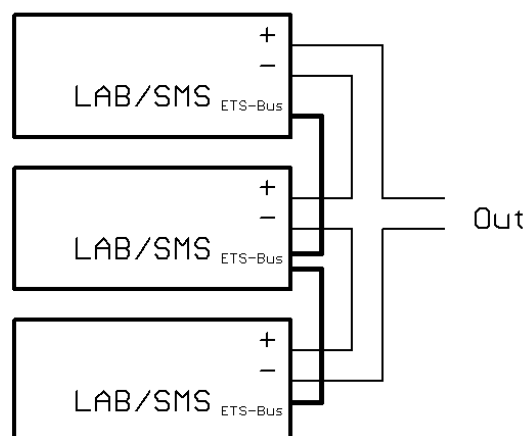
| LAB/SMS | | Preset | |
|---------|---------|----------|---------------|
| U | 0.00 V | U | 10.0 = 10.0 V |
| I | 0.00 A | I | 1.0*2= 2.0 A |
| P | 0.00 W | | |
| R | ----- Ω | | |
| Id: 03 | | Mode: UI | Standby Loc |



M/S mode Serial

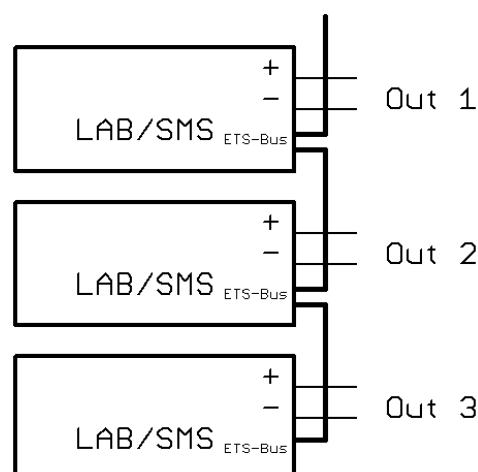
The control assumes that outputs are connected in series. Set points are respectively converted. Displays will show the total voltage as measure point. Voltage distribution between the individual units is not necessarily symmetrical. Thus, the total voltage will be limited to the adjusted value.

| LAB/SMS | | Preset | |
|---------|---------|----------|----------------|
| U | 0.00 V | U | 10.0*2= 20.0 V |
| I | 0.00 A | I | 1.0 = 1.0 A |
| P | 0.00 W | | |
| R | ----- Ω | | |
| Id: 03 | | Mode: UI | Standby Loc |



M/S mode Independent

The control assumes that the outputs are independent. Set points are exchanged via bus only. The display equals the standard display.



OVERVIEW OF THE CONNECTED UNITS

Pushing the button **Display** twice will open a menu, which displays the data of the first four LAB/HP units connected to the bus. Indicated are voltage, current and power of the individual units. Additionally, the complete data of the system will be displayed.

| LAB/SMS | | ms | |
|---------|------|----------|-------------|
| Id | U[V] | I[A] | P[W] |
| 02 | 0.0 | 0.0 | 0.0 |
| 03 | 0.0 | 0.0 | 0.0 |
| Sum | 0.0 | 0.0 | 0.0 |
| Id: 03 | | Mode: UI | Standby Loc |

CONTROLLING THE UNIT IN MASTER/SLAVE MODE VIA DIGITAL INTERFACE

Set points that are sent via digital interface define the set points for the presently connected device. These set points are also transmitted to the other devices, which means that the total voltage and the total current can be higher.

Example: 3 devices on the bus

GTR Remote operation mode active
 OVP,30 Adjust over voltage protection to 30 V
 IA,10 Adjust output current to 10 A
 UA,15 Adjust output voltage to 15 V
 SB,R Output open

All devices connected to the bus are adjusted to 15 V/10 A. When these devices are parallel connected, the resulting output voltage is 15 V and 30 A (= 3 x 10 A). When the devices are serial connected, the resulting output voltage is 45 V (= 3 x 15 V) and 10 A.

The measurement values consider the selected configuration of the unit. The commands **MU** and **MI** can be used to read the total voltage and the total current of the whole system. Individual data for each device connected to the bus can be read using a parameter.

Example: 3 devices on the bus in parallel mode

GTR Remote Operation Mode active
 OVP,30 Adjust Over Voltage Protection to 30 V
 IA,10 Adjust Output Current to 10 A
 UA,15 Adjust Output Voltage to 15 V
 SB,R Output open
 MI Measures present current
 MI,28.4A Unit answers: 28,4 A
 MI,0 Measures present current of the first device
 MI,9.1A Unit answers: 9,1 A
 GTR Remote Operation Mode active
 MI,9.4A Unit answers: 9,4 A
 MI,2 Measures present current of the third device
 MI,9.9A Unit answers: 9,9 A

APPENDIX

EQUIVALENT LEAKAGE CURRENT MEASUREMENT ACCORDING TO VDE 0701

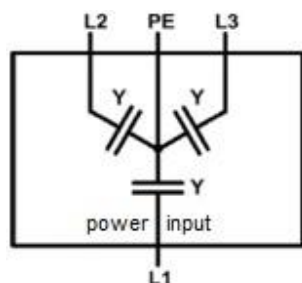
The equivalent leakage current measuring according to DIN VDE 0701-1 may deliver results beyond the norm.

Cause: Measurements are primarily performed on so-called EMC-filters at the AC input of the units. These filters are built symmetrical, that means capacitors are installed between L1/2/3 and PE. While measuring, L1, L2 and L3 are connected together and the current flow to PE is measured. Therefore up to 3 capacitors are connected parallel which doubles or triples the measured leakage current. This is permissible according to the norm.

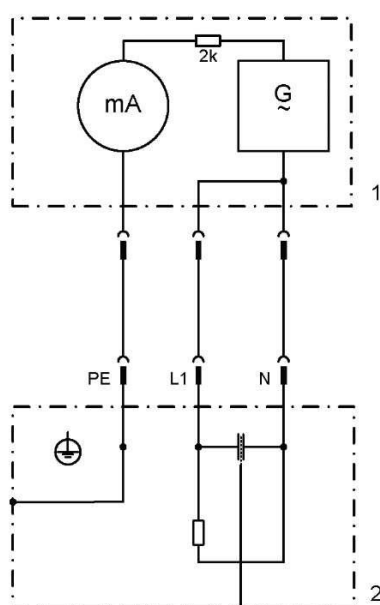
Quotation from the norm of 2008, appendix D:

„When measuring protection conductor currents with the equivalent leakage current measuring method, it is important to note that devices with protective grounds and symmetrical circuits may have results, due to the wiring, that are up to three or four times higher than the leakage current of one phase.“

Graphical representation of a balanced circuit:



Example illustration from the norm protective ground measuring - equivalent leakage current measuring method:



Note: The illustration shows the measurement method for two-phase power supplies. In the three-phase version, phase N is replaced by L2 and/or L3.