LAB-SMP

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1 INFO & CONTACT ADDRESSES

ET System electronic GmbH was founded in 1986 in the heart of the Rhine-Neckar-Triangle. As a subsidiary of a leading electricity utility group, the company quickly took on a leading role in the area of laboratory power electronics and associated electrical measurement. The existing know-how in power technologies in the 90s gave rise to the "Power Solutions" product division as a strong extension of the historical "Test & Measurement" range.

Since 1997, we have been working successfully as an independent, privately held company with customers in all lines of business from industry, medical care, railway technology and automotive electronics.

By means of our high vertical range of manufacture and our ever expanding development division we can fast and flexibly adjust to our customers' requirements. Necessary approvals such as CSA, UL, VDE, TÜV etc. are flexibly carried out by qualified personnel. The approval procedures are performed within the scope of development planning and thus do not negatively impact the start of manufacturing. Permanent manufacturing control through accredited laboratories and an ISO 9001 compliant quality management system guarantee a constant high-level series-production quality.

We offer repairs and adjustment for units outside of our warranty period. Please contact your local distributor for further information:

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2 TECHNICAL SPECIFICATIONS

2.1 AMBIENT CONDITIONS

Cooling	Fan
Operating temperature	0 - 50 °C
Storage temperature	-20 - 70 °C
Humidity	< 80 % non condensing
Operating altitude	< 2000 m
Weight	1,2 kW 7 kg | 2,4 kW 7,6 kg

2.2 INPUT SPECIFICATIONS

LAB/SMP models (by max output power)	1.2 kW	2.4 kW
Connection	3 wire (1P+N+E)	
AC socket on rear panel	IEC-C14	IEC-C20
Input voltage	1,2 kW 90 – 264 VAC / PFC | 2,4 kW 230 VAC +/-10 % / PFC	
Input current [1,2]	≈ 6.5 A	≈ 13 A
Inrush transient current[2]	≈ 25 A	≈ 25 A
Main input fuse rating	10 A	16 A
Main input fuse type and location	built-in fast acting PCB mounted cartridge fuse	
Recommended supply breaker value & curve[2]	10 A type D	16 A type D
Leakage current	≈ 1.5 mA	≈ 1.5 mA
THD input current	≈ 3.75 %	≈ 10.75 %
THD input voltage	≈ 1.87 %	≈ 2.55 %
Power factor	≈ 0.99	≈ 0.99
Efficiency type [1]	≈ 88 % (with PFC)	≈ 89 % (with PFC)
Dissipated power [1]	≈ 165 W	≈ 350 W

2.3 OUTPUT SPECIFICATIONS

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

[1] for nominal output voltage and nominal output current
[2] for nominal input voltage 230VDC / 50Hz

2.4 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 kΩ Maximum input voltage: 50 V High level: U_e > 2 V Low level: U_e < 0.8 V
Analog outputs (X_{mon})	Output resistance: 100 Ω Minimum permissible load resistance: 2 kΩ Minimum load resistance for 0.1 % accuracy: 100 kΩ
Analog inputs (X_{set})	Input resistance: 1 MΩ Maximum permissible input voltage: 25 V
Reference voltage	Reference voltage U_{ref}: 10 V ± 10 mV Output resistance: < 10 Ω Maximum output current: 10 mA (not short-circuit-proof)
5 V - Supply voltage	Output voltage: 5 V ± 300 mV Maximum output current: 50 mA (not short-circuit-proof)

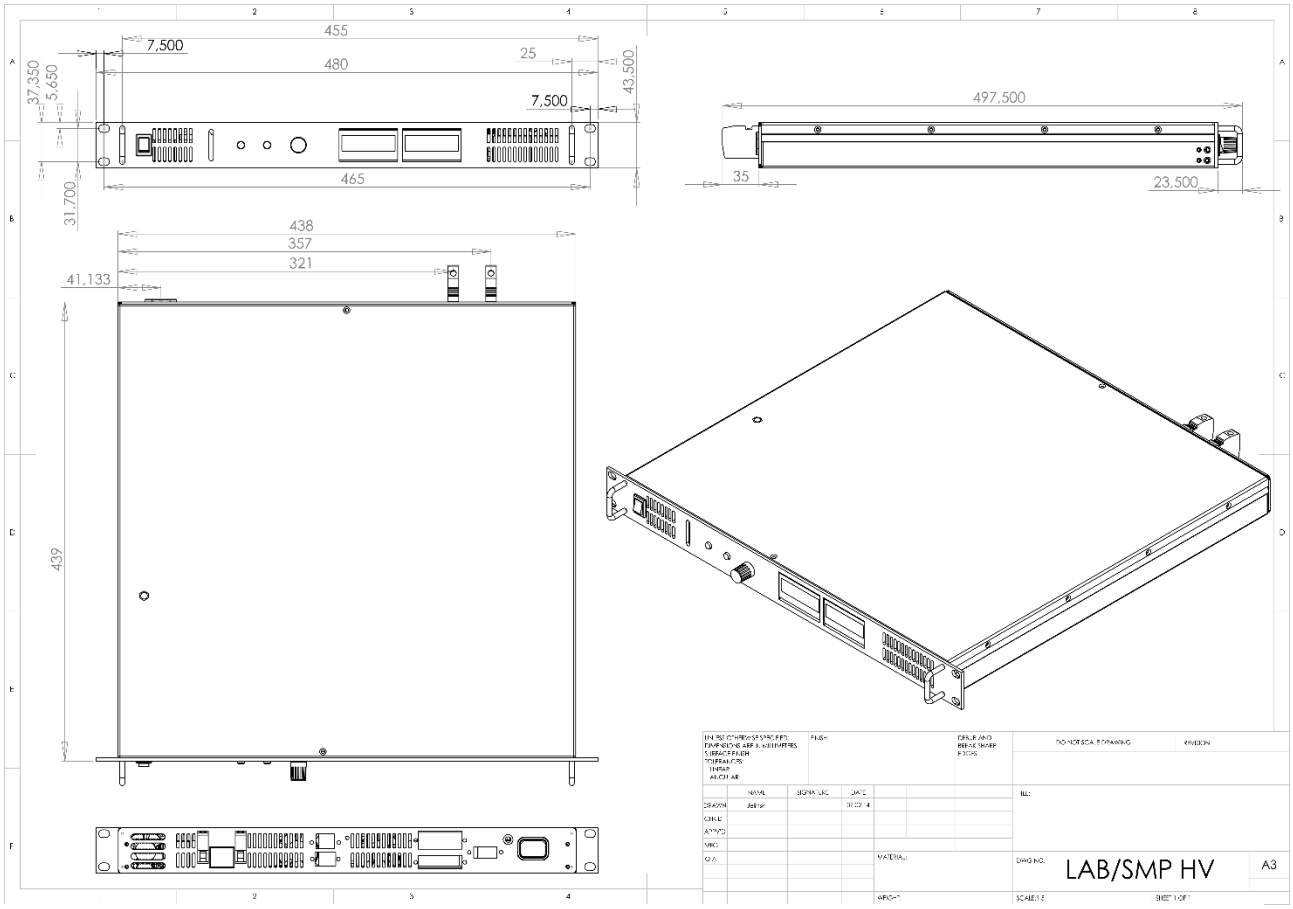
2.5 RS 232

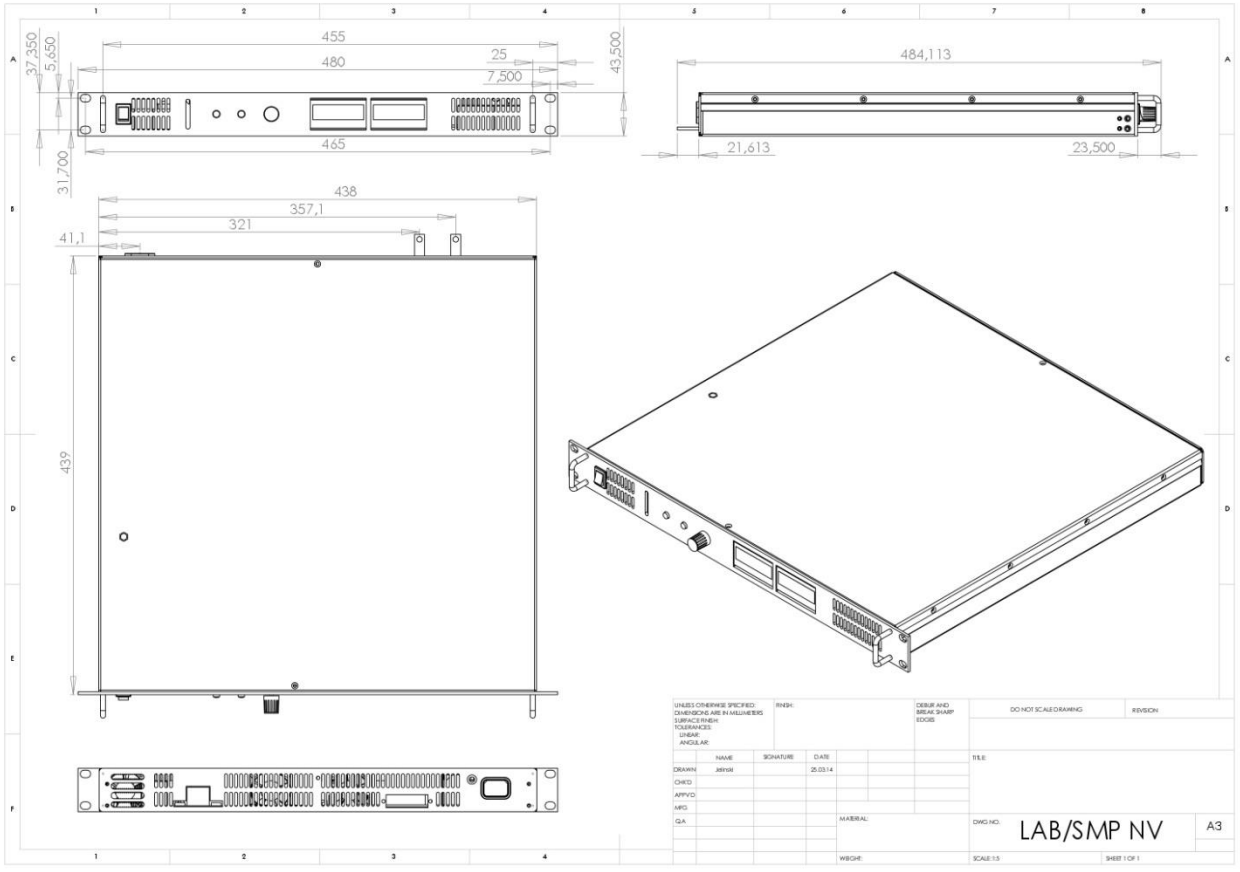
Signal inputs (RxD, CTS)	Maximum input voltage: ± 25 V Input resistance: 5 kΩ (Type) Switching thresholds: U_H < - 3 V, U_L > + 3 V
Signal outputs (TxD,RTS)	Output voltage (at R_{Last} > 3 kΩ): min ± 5 V, Type ± 9 V, max ± 10 V Output resistance: < 300 Ω Short circuit current: Type ± 10 mA

2.6 RS 485

Maximum input voltage	± 5 V
Input resistance	> 12 kΩ
Output current	± 60 mA Max
High level	U_d > 0.2 V
Low level	U_d < - 0.2 V

3 TECHNICAL DRAWING





4 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.

4.1 INITIAL OPERATION

4.1.1 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.

4.1.2 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.

4.1.3 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.

4.1.4 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.

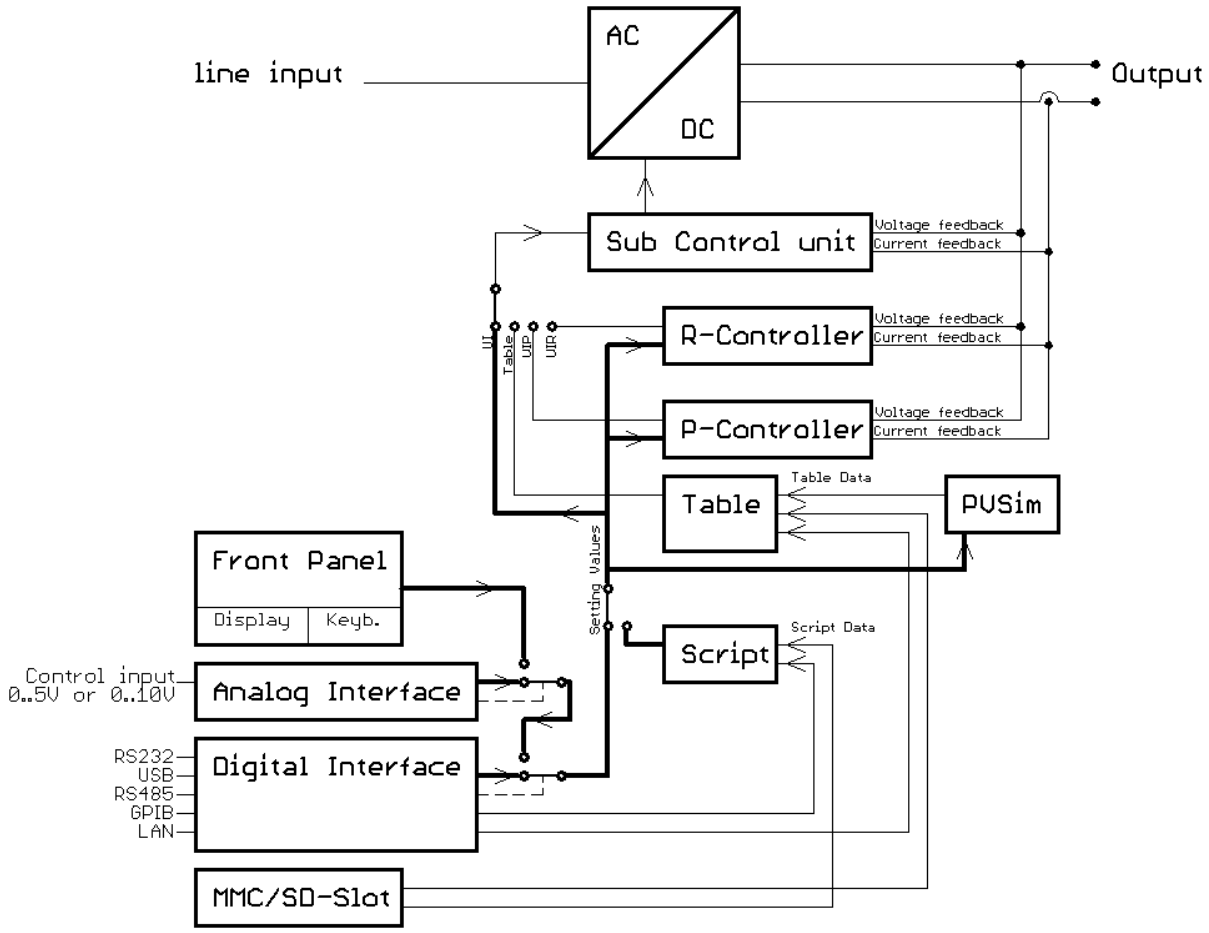
The unit must only be operated when connected directly to the mains. To avoid damage, do not connect the unit to isolating transformers, auto-transformers, magnetic current limiters or similar devices.

4.2 INTENDED USE

The device corresponds to protection class I and has a galvanic isolation between the input and the output circuit. The device must be grounded on the input side, since the grounding ensures protection against contact. In the case of locally variable devices, the earth is connected to the device by means of a cold-plug connector, and the ground is connected to the screw terminal provided for locally-variable devices (screw contacts at the grid input). In the case of devices with high leakage current (marking on the device), the existing grounding bolt must additionally be connected to the domestic installation earth. For compliance with the EMC and safety regulations (CE, approvals), the device may only be operated with PE connected. The device may only be operated by trained personnel and in accordance with the instructions for use. Typical fields of application are laboratories, industry and service engineering. Applications which can lead to injuries or death in the event of a fault in the device are not permitted.

5 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 Uo, Ik, Umpp and Impp 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 (→ *Script Control*).
Digital interface	The table can be programmed using the digital interface (→ *Universal Interface*, *WAVE Command* bzw. *DAT Command*).

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 to the output, irrespective of other settings.

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.

6 GENERAL SETTINGS

6.1 FRONT PANEL DESCRIPTION

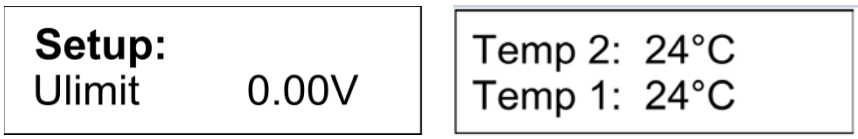
The picture above shows a schematic view on the front panel of the LAB/SMP. There are 3 buttons to control the unit.

Basic functions of the control buttons:

Standby	release or lock the output, quit OVP
Display	short press: change displayed information, long press: change between main menu and setup menu
Select	press: change selected menu point, rotate: change selected value

6.2 CONFIGURATION

The configuration menu can be accessed by holding the button ***Display*** for at least 1 second. This opens a menu where general settings of the unit can be changed. To browse through the different options, the button ***Select*** must be pushed. To change a setting the button ***Select*** must be rotated.



Setup options:

U_{limit}	0 V-V_{max}; set maximum output voltage which is selectable at the front panel
I_{limit}	0 V-V_{max}; set maximum output current which is selectable at the front panel
OVP	0 V- 1.2 x V_{max}; set over voltage protection activation value
AI-Mode	5 V/10 V; select the AI-control voltage range
Remember Last Setting	ON/OFF; activate or deactivate the settings memory after a power down the unit

The displayed temperature is the temperature of the heat sinks. Temperature 1 is the temperature of the PFC heat sink and temperature 2 is the temperature of the power unit heat sink.

6.3 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 ***Select***. Afterwards, the contrast settings will be saved automatically.

7 VOLTAGE SETTINGS

7.1 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 they apply to all interfaces.

7.2 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 %.

7.3 AI-TYPE

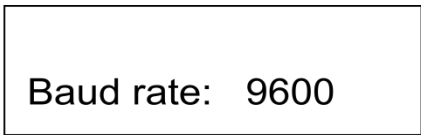
This feature adjusts the voltage levels of analog input signals and analog output signals. Selectable ranges are 0-5 V and 0-10 V.

7.4 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.

7.5 INTERFACE PARAMETER (OPTION)

The display shows all available digital interfaces and their changeable parameters. To see interface parameters, push the button ***Display*** for 1 second. Push this button again to see the first interface and its changeable parameters, which can be selected by pushing the rotary pulse encoder and changed by turning the rotary pulse encoder (function of the parameters → *Universal Interface*).



8 FRONT PANEL OPERATION

8.1 DISPLAY AND SETTINGS

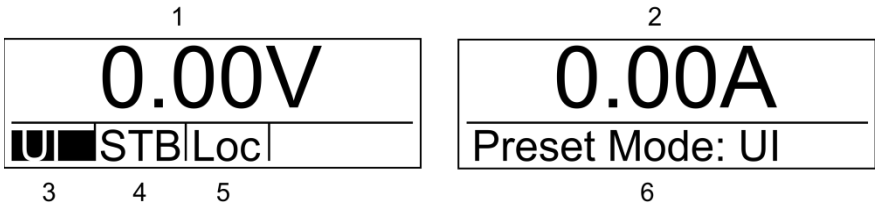
8.1.1 Current measurement values (Display)

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

8.1.2 Main display

The main display shows current measure and set values. The display is divided in two separate displays. After enabling the unit, the measured values for output voltage and putput current (position 1 and 2) are displayed. On the right display (position 6) the actual set value (Preset V_{set}) is shown. To change this value, the rotary pulse encoder ***Display***

must be turned. Pushing the button ***Select***, toggles through the next set parameters (in UI mode it will be output current). To open the mode select menu (left display, position 3) where different operation modes are available, the button ***Select*** must be pushed again.



Selectable parameters according to operation mode:

U	Output voltage
I	Ouput current
P	Output power (UIP mode only → *UIP mode*)
R_i	Internal resistance (UIR mode only → *UIR mode*)
U_{mpp}	MPP voltage (PV_{sim} mode only → *PVsim mode*)
I_{mpp}	MPP current (PV_{sim} mode only → *PVsim mode*)

Selectable options in current control mode (left display, position 5):

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)

Available modes for operating status of the unit (left display, position 4):

STB	Standby mode
CV	Voltage limitation mode
C	Current limitation mode
CP	Power limitation mode
OVP	Deactivation of the unit by over voltage protection

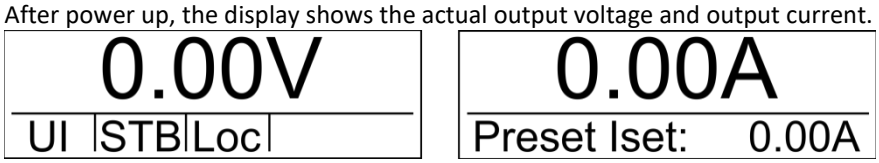
Available operation modes of the unit (left display, position 3):

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

8.2 OPERATING MODES

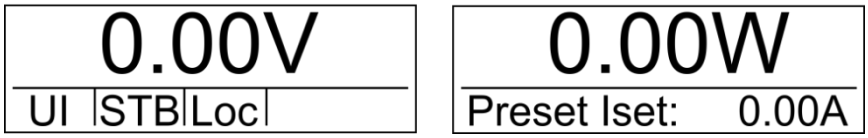
8.2.1 Main display 1 (V / A)

After power up, the display shows the actual output voltage and output current.



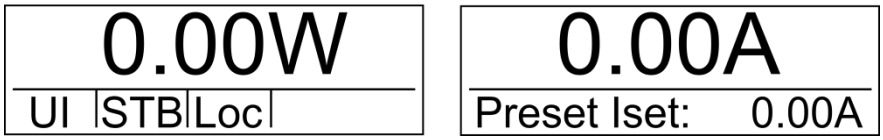
8.2.2 Main display 2 (V / W)

After pushing the button ***Select*** once, actual output voltage and output power are shown on the display.



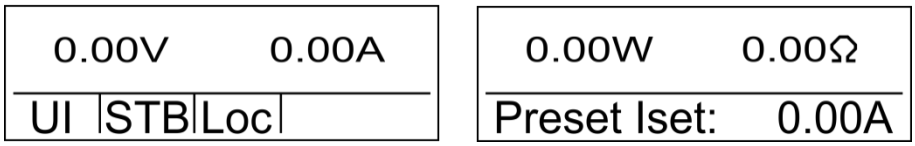
8.2.3 Main display 3 (W / A)

After pushing the button ***Display*** twice, actual output power and output current are shown on the display.



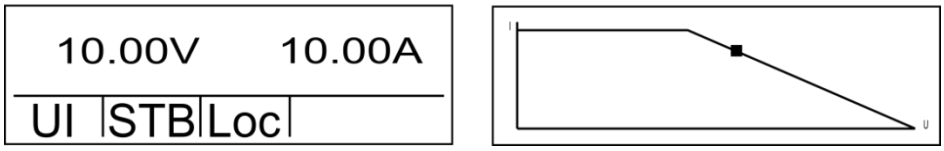
8.2.4 Main display 4 (V / A / W /Ω)

After pushing the button ***Display*** thrice, actual output voltage and output current are shown on the left display and actual output power (P = U ∗ I) and load resistor (R = V ÷ C) are shown on the right display. The values for power and resistor will be calculated from the actual values of the output voltage and the output current.



8.2.5 Main display 5/diagram screen

After pushing the button ***Display*** four times, actual output voltage and output current are shown on the left display. The output characteristic of the power supply is shown on the right display. The X-axis shows the output voltage and the Y-axis shows the output current.



The picture above shows the UIR mode of the power supply. The dot marks the actual operation point of the unit. The diagram is always scaled for the maximum allowed output current (this value can be set in the setup menu (I_{limit})) and the maximum allowed output voltage (this value can be set in the setup menu (U_{limit})).

9 OPERATING MODE DESCRIPTION

9.1 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.

9.2 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.

9.3 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.

9.4 PVSIM 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 * U.
Values for I_{mpp} may be in a range from 0.6 to 0.95 * I.

9.5 SCRIPT MODE

In script mode, the unit is controlled by memory card. The display status ‚*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*.

10 UNIVERSAL INTERFACE (OPTION)

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.

10.1 COMMANDS

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

10.1.1 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 <DEL> 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	<DEL>	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/HP with 600 V, 25 A
600 V * 0.1 % = 0.6 V → one decimal place
25 A * 0.1 % = 0.025 A → 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 → Resets output voltage to 10 V
UA,10.0 m → 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 → adjusts OVP to 100 V
UA,10 → adjusts output voltage to 10 V
IA,5 → current limiting 5 A
SB,R → output enabled

10.1.2 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.

10.1.3 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

10.1.4 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 optional parameter affects the future behavior of the unit after switch on. Setting is saved permanently. No return value.

Optional parameter 0 = Deactivates automatic remote operation
The command GTR must be entered to activate the unit's remote operation mode. This mode is useful if the unit shall be operated manually and at the same time, measurement values shall be read out via the digital interface.

Optional parameter 1 = Activates remote operation on first addressing
Unit switches to remote operation when receiving a command via digital interface. The only exception is the GTL command, which switches the unit to local mode.

Optional parameter 2 = Activates remote operation immediately after switch on
After the unit was switched on, remote mode is immediately activated. Front panel operation is deactivated.

IA[,<imax>] - Set Imax

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

ID or IDN? - Identification

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

IMPP[,<impp>] - Set Impp

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

LIMI - Limit Ia

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 Pa

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 Rmax

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 Rmin

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 Ua

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 Ia

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

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 Ua

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

**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[,<Uovp>] - 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[,<Plimit>] - Set Plimit

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

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 PV_{sim}

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	
D14	
D13	
D12	
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[,<Umax>] - Set Umax

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

UMPP[,<Umpp>] - Set Umpp

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

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,<Umax><Imax> - 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)*.

10.1.5 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.

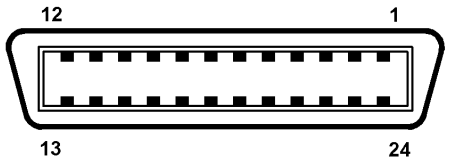
Example: 600 V unit
UA,10.4V
UA,220.3V
UA,1.1V

Example: 50 V unit
UA,1.23V
UA,10.47V
UA,0.01V

11 EXT. CONTROL: COMPUTER

11.1 GPIB (OPTION)

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

11.1.1 Status Word

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

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

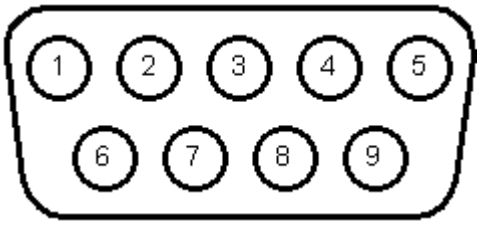
11.1.2 ESR-Register - Event-Status-Register

The ESR register can be read using the command ***<*ESR?>***. Return value: ESR,xxxxxxxx. 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

12 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

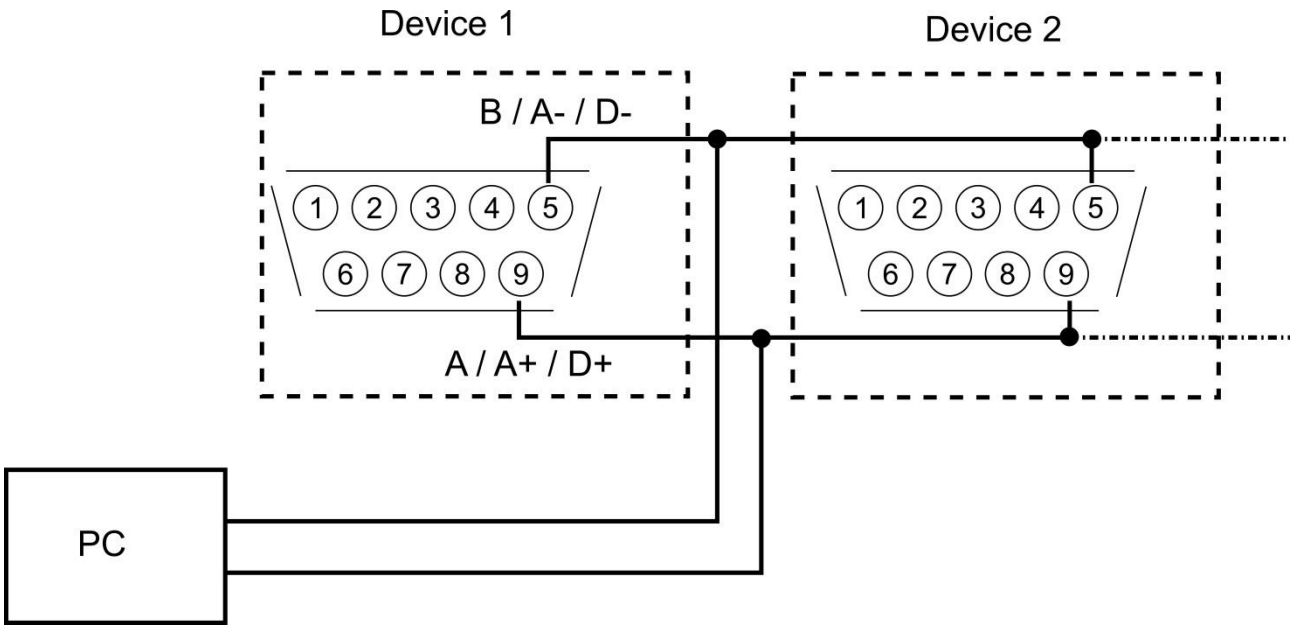
If echo is on, the interface confirms each incoming character by sending the same character back to the sender. The interface parameters can be adjusted via software and the command ***<PCx>***. These settings can be saved with the command ***<SS>***.

12.1 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*

13 RS485 INTERFACE (OPTION)



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>***.

13.1 Interface Reconfiguration

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

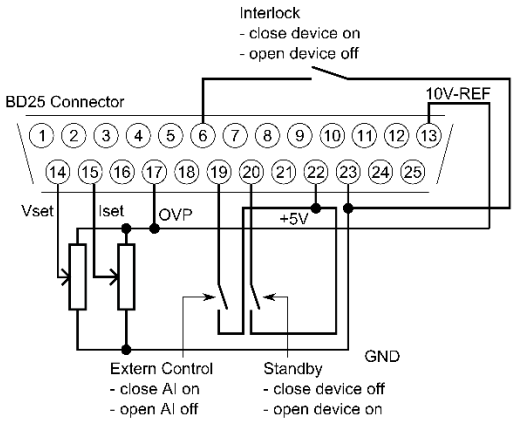
- sending the command ***<PCx>*** from one of the other interfaces
- using the display to configure the interface → *Interface Parameters*

14 EXT. CONTROL: AI INTERFACE

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

14.1 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	-nc-	-	-
6	digital in	Soft-Interlock	Interlock function (Caution: Interlock does not correspond to the machinery directives)
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.

14.2 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.

14.2.1 Set Point U (U_{set})

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

Example:

LAB/HP at 600 V output voltage, AI is adjusted to 10 V, desired output voltage = 100 V.
U_{set} = 10 V * 100 V ÷ 600 V = 1,667 V

14.2.2 Set Point I (I_{set})

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

Example:

LAB/HP at 100 A output voltage, AI is adjusted to 10 V, desired output current = 2 A.
I_{set} = 10 V * 2 A ÷ 100 A = 0.200 V

14.2.3 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/HP with 600 V output voltage, AI is adjusted to 10 V, desired OVP voltage = 650 V.
Adjustment range: 600 V + 20% = 720 V
U_{set} = 10 V * 650 V ÷ 720 V = 9.028 V

14.3 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.

14.3.1 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/HP at 600 V output voltage, AI is adjusted to 10 V, voltage at output U_{mon} = 2 V.
Present set point: U_{set} = 2 V * 600 V ÷ 10 V = 120 V

14.3.2 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/HP at 100 A output current, AI adjusted to 10 V, voltage at output I_{mon} = 2 V.
Present set point: I_{set} = 2 V * 100 V ÷ 10 V = 20 A

14.3.3 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/HP at 15 kW rated power, AI adjusted to 10 V, voltage at output P_{mon} = 5 V.
Present output power P_{out} = 5 V * 15 kW ÷ 10 V = 7.5 kW

14.3.4 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/HP at 600 V output voltage, AI adjusted to 10 V, voltage at output U_{mon} = 2 V. Signal refers to 600 V + 20% = 720 V.
Present set point: U_{ovp} = 2 V * 720 V ÷ 10 V = 144 V

14.3.5 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/HP at 600 V output voltage, AI adjusted to 10 V, voltage at output U_{istmon} = 6 V.
Present output voltage U_{out} = 6 V * 600 V ÷ 10 V = 360 V

14.3.6 Monitor Output Current (I_{Istmon})

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

Example:

LAB/HP at 100 A output current, AI adjusted to 10 V, voltage at output I_{istmon} = 4 V.
Present output current I_{out} = 4 V * 100 A ÷ 10 V = 40 A

14.4 Digital Input

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

14.4.1 Activation (Ext. Control)

The input ‚Ext. Control' can be used to chose 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*'.

14.4.2 Soft-Interlock

The Interlock deactivates the unit immediately, if the connection between interlock input (Pin 6) and GND is interruped. 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.

14.4.3 Blocking (Standby)

An applied voltage of + 5 V up to + 10 V activates the standby mode.
The output signal is enabled, if the input ‚*Standby*' is toggled inactive.

14.5 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.

14.5.1 Blocking (Standby)

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

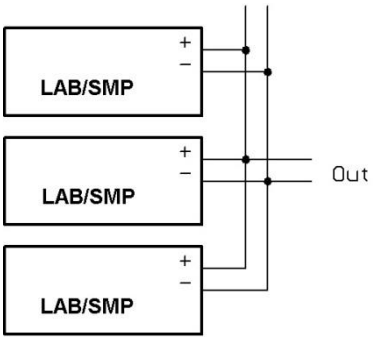
14.6 Const. Voltage mode (CV)

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

14.7 Error

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

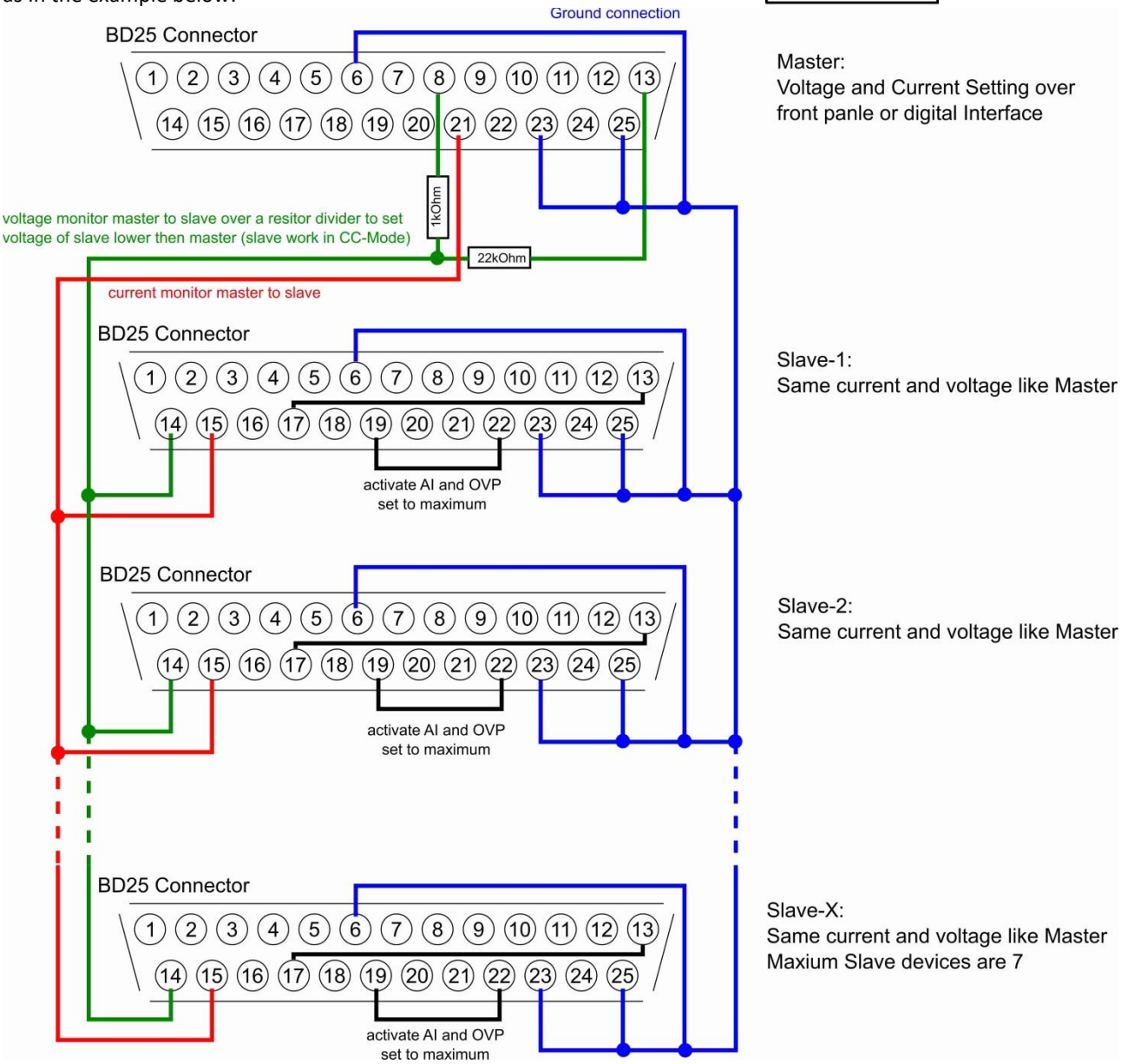
15 PARALLEL OPERATION



If higher output currents are required it is possible to have the power supplies operate in a parallel operation. For this you must connect all plus and minus output together. Take care for connecting square of cables.

15.1 AUTO-LOAD-SHARE PARALLEL OPERATION

For precise control in parallel operation, the analog connection is configured as in the example below:



The top power supply is used here as a master, the others are regarded as slaves.
The values for current and voltage are set on the master device via the front panel or digital interface. The OVP is set by Master.
The output current I_{out} is calculated as follows

$I_{out} = (n+1) \times I_{Master}$
n is the number of slave devices and I_{Master} is set current at the master device.

For reasons of stability, no more than 8 devices should be connected in parallel.

16 EXT. CONTROL: ETHERNET (LAN) (OPTION)

To communicate with the LAB/SMP/E 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.

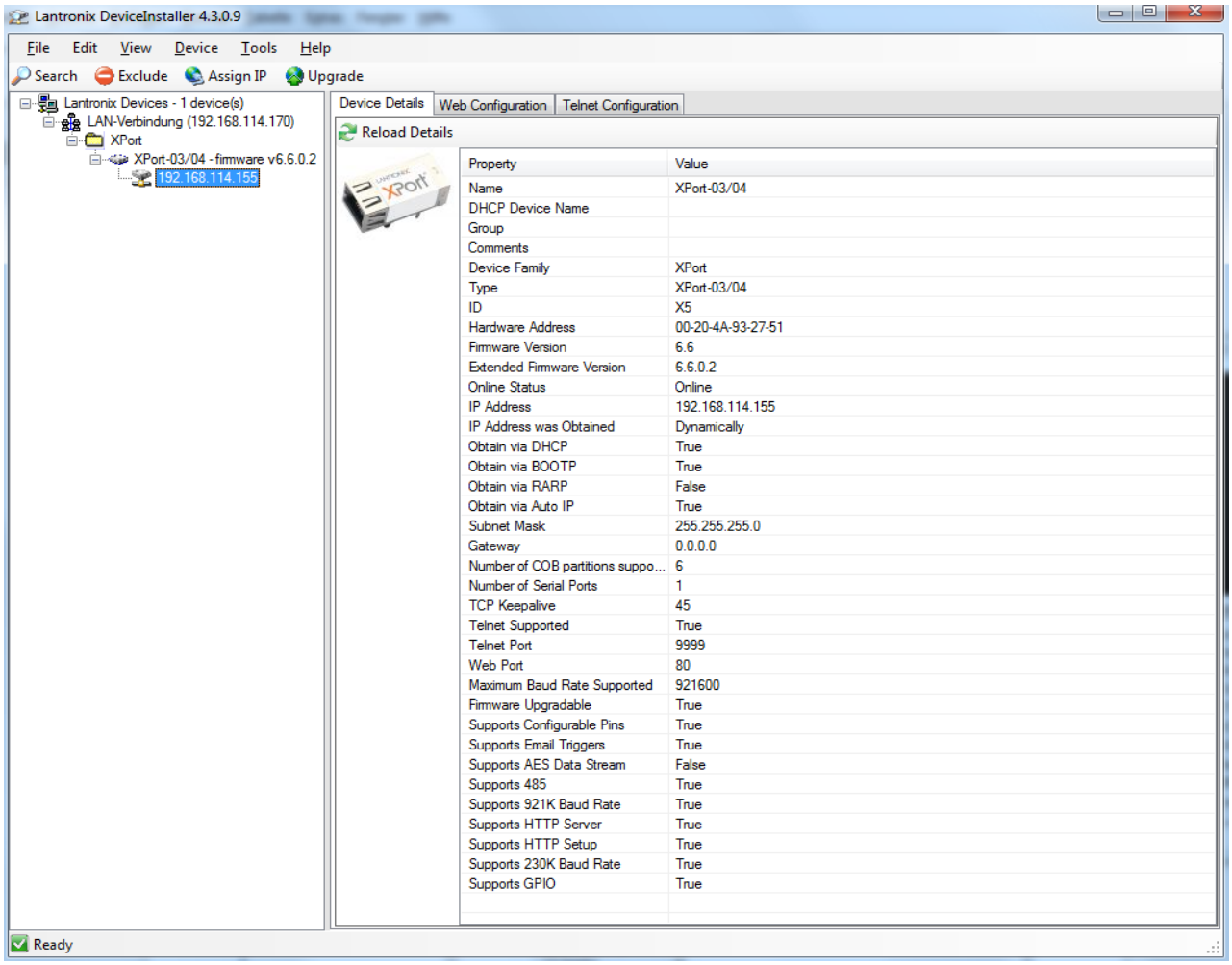
The status word can be read with the command ***<STB>*** or ***<*STB?>***. Only bits from D0 up to D2 are in use. All other bits can be 1 or 0.

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

16.1 DETERMINATING THE IP USING THE DEVICE INSTALLER BY LANTRONIX

With the program Deviceinstaller, Lantronix offers a program to easily detect a device within the network. After executing the program and clicking the button ***Search***, all XPORTS within the network are displayed. The current assigned (dynamical) IP will also be displayed. This IP can be entered in the address line of a browser.
If you want to set a static IP Adress use “Assign IP”.



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

16.2 Controlling the device via Telnet

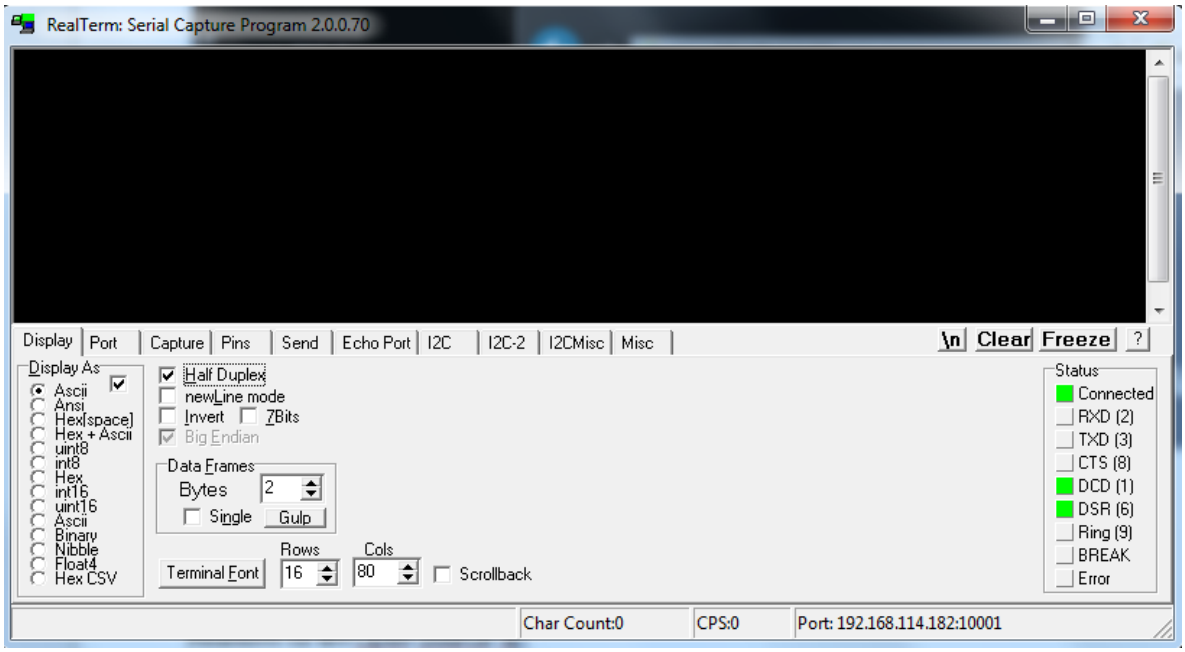
The device can be controlled directly via port 10001. After the console has been opened, a click on ‚Start' and ‚Ausführen' opens an input field. After the commands ***cmd*** or ***command*** have been entered, a DOS window opens with: telnet xxx.xxx.xxx.xxx 10001.
Alternatively, many terminal programs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

16.3 Telnet connection with Realterm

Realterm is a free OpenSource terminal program, which may be downloaded here: http://realterm.sourceforge.net/

After the program was installed and executed, the box ***Half Duplex*** must be checked within the tab ***Display***.



The IP address must be entered within the tab ***Port*** in the following format: xxx.xxx.xxx.xxx:10001. Afterwards the button ***Open*** must be clicked. In the terminal box the desired commands can be sent to the device.

For more Information please look at:
http://www.et-system.de/en/produkte/applications-special-units.html

17 EXT. CONTROL: USB (OPTION)

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>***.

17.1 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*

18 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.

18.1 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

19 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.

19.1 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.

19.2 Commands

19.2.1 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.

19.2.2 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<I in ampère>	output current	Set point output current.
IMPP<I 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.

19.2.3 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 - Pvsim 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
```

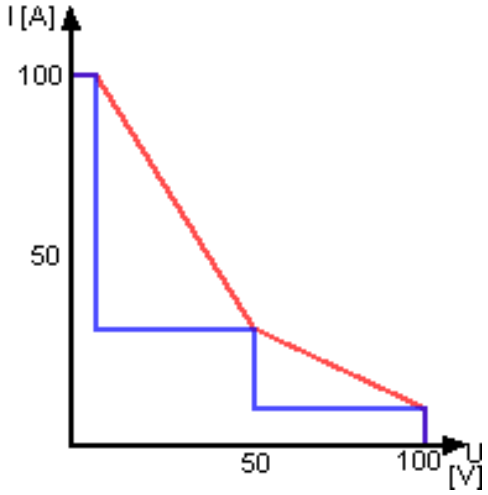
The command ***WAVELIN*** equals the command ***WAVE***.

```
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:

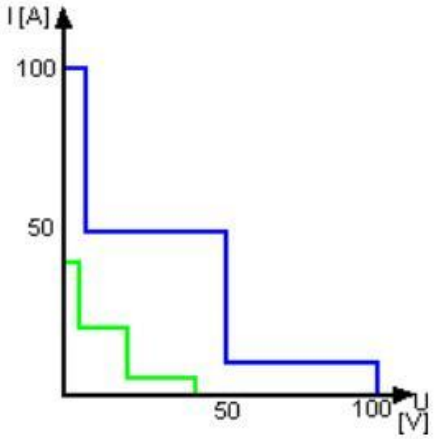
```
; Characteristic with layered interim values
; This script delivers the blue characteristic in the diagram
WAVE        ; Start of the table
100  10     ; 100 V 10 A
50    25    ; 50 V 25 A
10  100     ; 10 V 100 A
-WAVE       ; End of the table
RUN         ; Output active

; 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
```



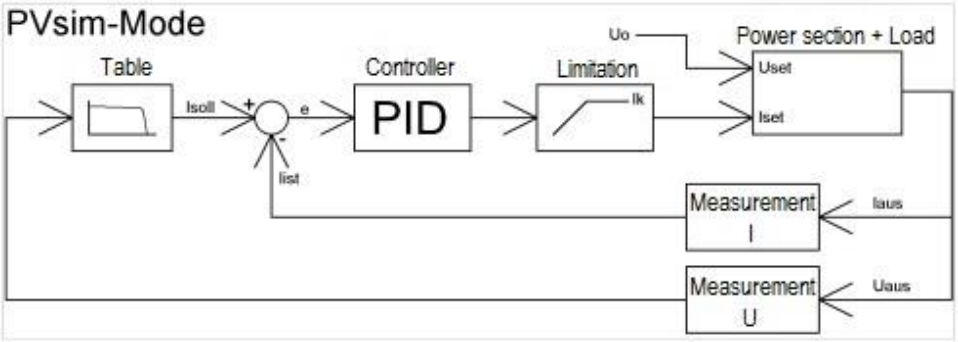
20 CONTROLLER

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!

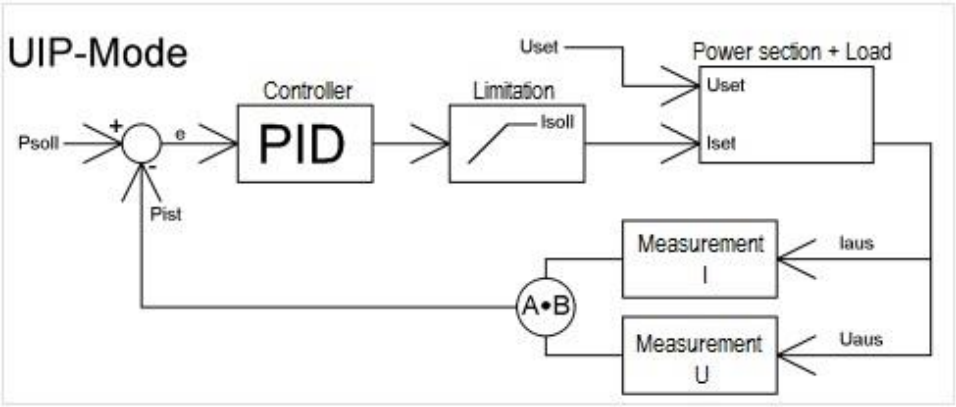
20.1 CONTROLLER STRUCTURE PVSIM MODE AND USER MODE

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.



20.2 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.

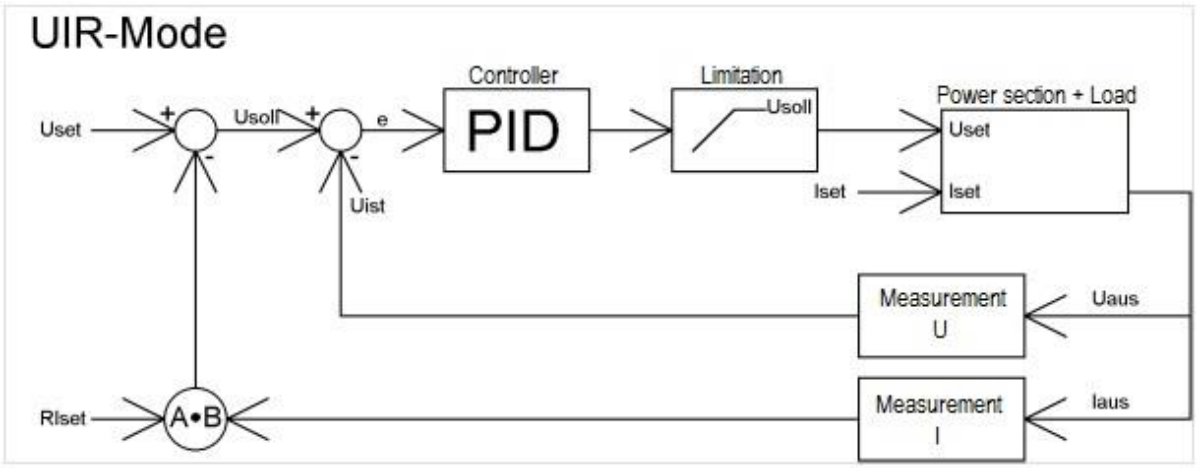


20.3 Controller Structure UIR Mode

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:

$U_{soll} = U_{set} - I_a * R_i$

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.



20.4 Controller parameters

common differential equation of a PID controller:

$$y = Kp \cdot \left(e + \frac{1}{Tn} \int e(t)dt + Tv \frac{de}{dt} \right)$$

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:

$$y = Kp \left(e_i + \frac{Ts}{Tn} \sum_{m=-\infty}^{m=i} e_m + \frac{Tv}{Ts} (e_i - e_{i-1}) \right)$$

Ts	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:

$$P = 10 \cdot Kp \quad I = \frac{1000 \cdot Kp \cdot Ts}{Tn} \quad D = \frac{10 \cdot Kp \cdot Tv}{Ts}$$

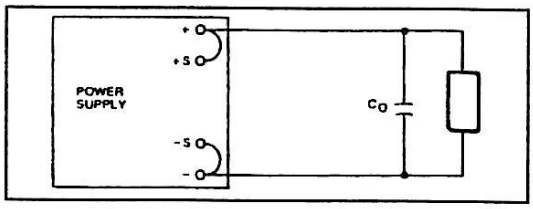
Ts	Sampling time = 300 us

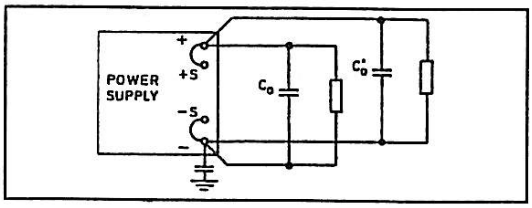
Controller parameters can be programmed via digital interface using the command ***REGLER***.

21 SENSE MODE

21.1 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.

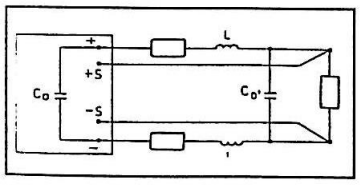


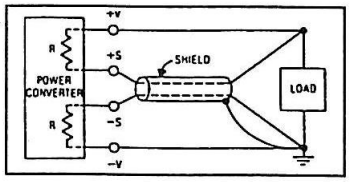


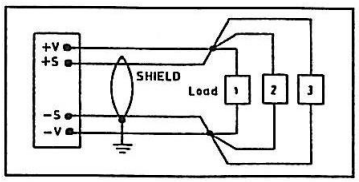
21.2 LOAD CONNECTION WITH SENSOR CONDUCTOR

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 V
- avoid overload of power supplies (voltage drop per line x current)



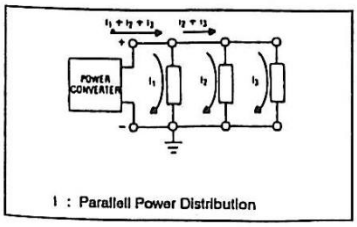


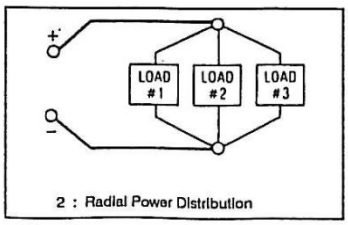


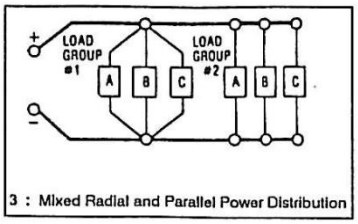
If thus you paid attention to the points stated above, oscillation occurs through load or power induction and complex load situations, please contact our company ET System.

21.3 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.

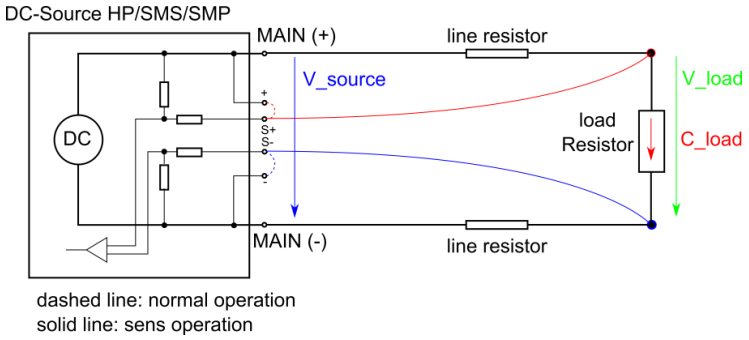






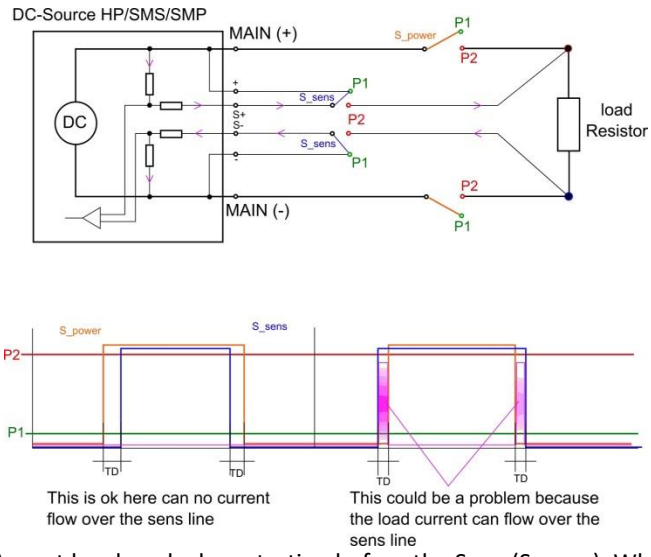
22 GENERAL INFORMATION FOR SENSING

The sensing line moves the measuring point of the output voltage measurement to the load. The voltage measurement is carried out with a differential amplifier, the last resistor in the chain being "short-circuited" with a low-resistance parallel resistor. When the sensing line is opened, the output voltage increases between 1% and 2% of the nominal voltage, depending on the model. The displayed voltage on the display does not change. When the Sens is connected to the load, the power resistor is mathematically transformed into the device, resulting in a residual error of up to 0.5% depending on the load line used. More detailed information can be obtained from the manufacturer.



22.1 WARNING INSTRUCTIONS FOR USING RELAYS TO THE LOAD DRAFT

In an application where the load is for example should be dropped with a relay and the Sens is used at the same time, care must be taken to ensure that the load current can not flow through the sensing lines as this can lead to the destruction of the sensor. This is shown schematically in the following figure.



The circuit breaker (S_power) must be closed when starting before the Sens (S_sens). When switching off, the Sens must first be opened and then the circuit breaker can be opened. Otherwise, a current flow may occur across the sensing line, and this may be particularly critical when disconnecting.

23 APPENDIX

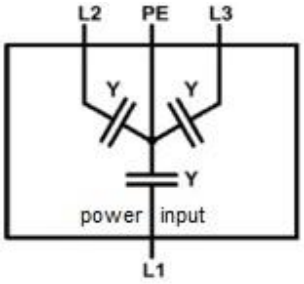
23.1 EQUIVALENT LEAKAGE CURRENT MEASUREMENT ACCORDING TO VDE 0701

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.

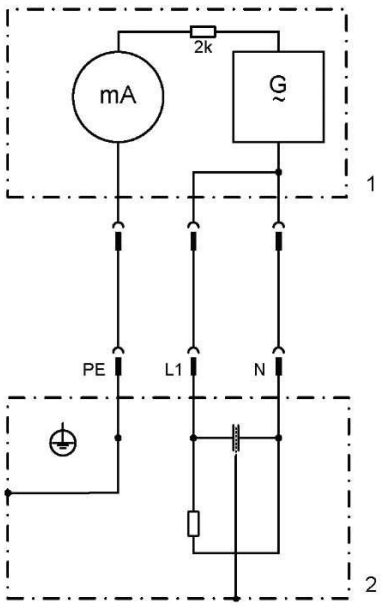
Quotation from the norm of 2008, appendix D:

> „*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:

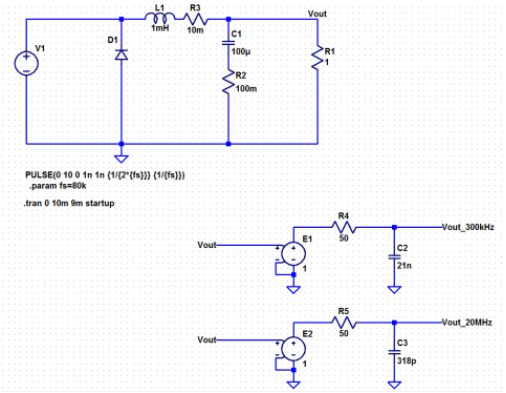


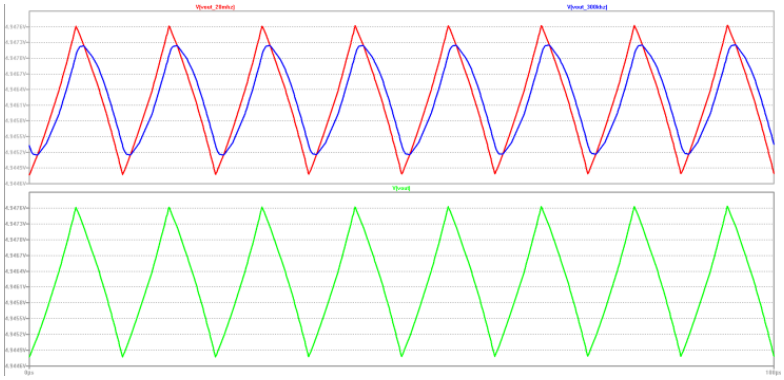
Note: The illustration shows the measurement method for two-phase power supplies. In the three-phase version, phase N is replaced by L2 and/or L3.

24 ET-SYSTEM RIPPEL MEASURMENT SPECIFICATION

24.1 THEORETICAL ANALYSIS

The component of the output ripple is built by the output current and the equivalent series resistor of the output



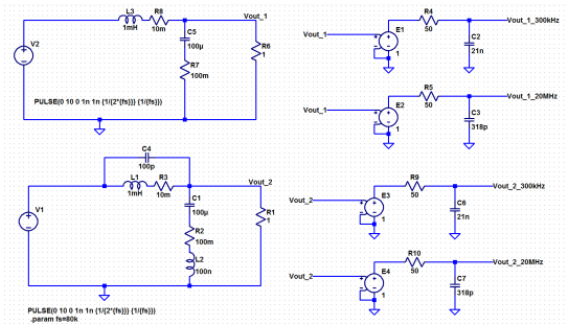


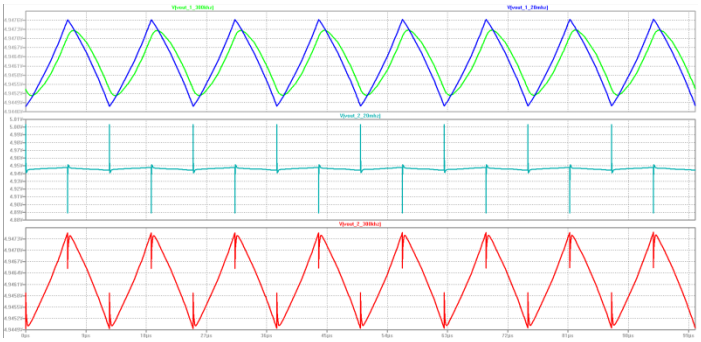
capacitor. Picture 1 show a basic circuit which was used to simulate the ripple.

Picture 2 show the ripple without spikes. Picture 2 shows also the different between the used measurement bandwidth. At this example the switching frequency of the converter was 80kHz (this is also the switching frequency of the LAB/HP and LAB/SMS series).The red line shows the measured ripple by using a bandwidth of 20MHz and the blue line shows the measured ripple by using a measure bandwidth of 300kHz.

This example shows that the measurement bandwidth have a strong influence of the measurement result.

The spike or noise of the ripple will generate by the switching noise of the power supply. The spikes which will be measured strongly depend on the used measurement method. One point is the using measurement bandwidth the other point is the test setup. The influence of the measurement method is show at picture 4. Picture 3 show the



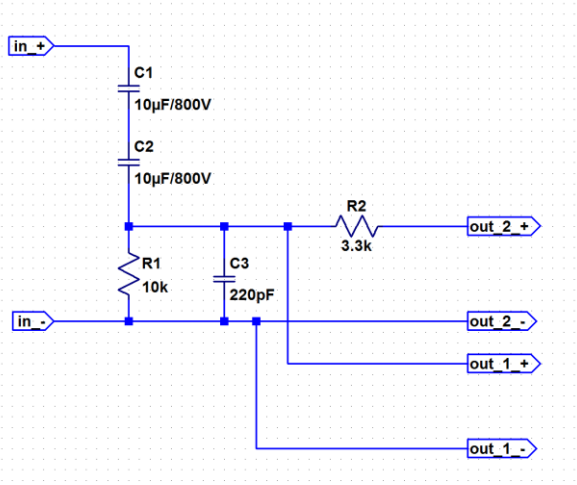


previous know circuit and also the same circuit with some added leakage component how are contribute to the output noise.

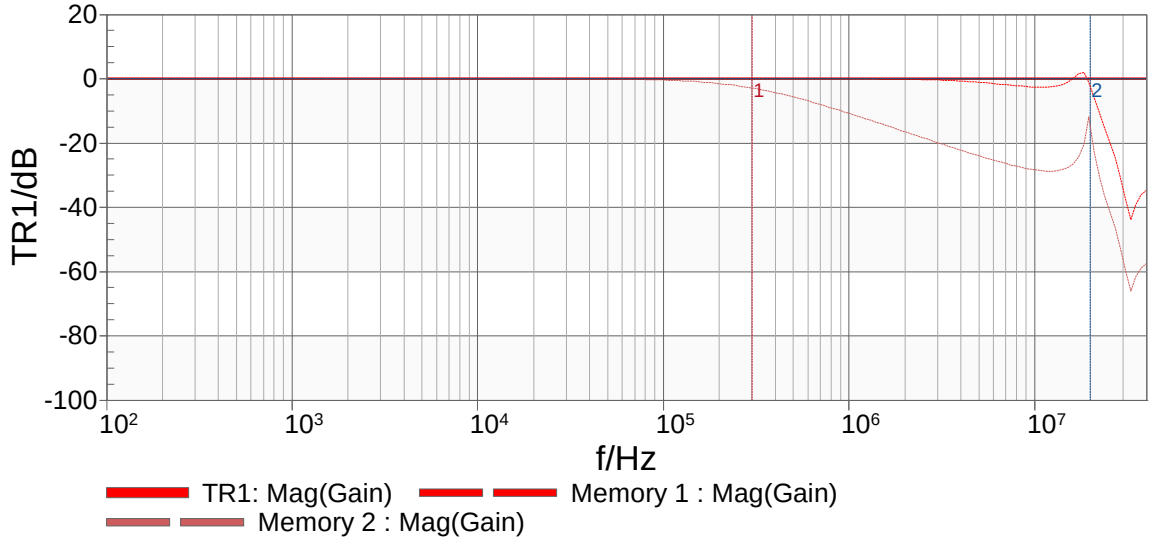
This example show that the measurement bandwidth do influence the spikes or noise measurement.

24.2 Pratical Rippel Measurment.

ET-System measured the ripple with the test setup how is show at picture 5. Tow high voltage capacitor in serie with a 10k Ohm resistor is use to measured only the AC-Component of the output voltage of the power supply. The circuit have tow output. Output 1 have a measurment bandwith of 20MHz and output 2 have a bandwith of 300kHz. This rippel circuit was build at the labortory and was tuned by using a frequency analyser (Bode 100). Also the used 1:1 Oscilloscope probe was during the tuning procedure connectet to the rippel measurment setup to elemenate the influence of the probe to the measurment bandwith.



Picture 6 show the result of frequency analyses of the tuning measurement. Point 1 shows the 3dB point of the 300kHz output. Point 2 show the 20MHz point.



The bode plot show that the transfer function of this circuit is very linear. This allowed making a clean and real measurement of the output ripple of a power supply also at high voltage devices.

25 NOTES