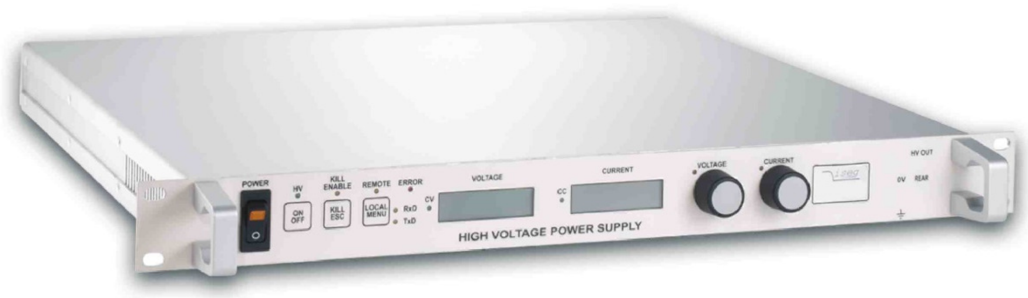
Manual

High Voltage Power Supply
of the Device Classes
HPS 300 W, HPS 800 W



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Attention

It is strongly recommended to read the manual before operation!

To avoid the possibility of lethal shock to the operator, the unit must not be operated with the cover removed.

There are no user maintainable parts inside the power supply!

The mains connector is equipped with basic insulation and a protective earth conductor. The unit may only be operated with protective earth conductor connected.

We decline all responsibility for damages and injuries caused by an improper use of the device. It is strongly recommended to read the manual before operation!

All information in this document is subject to change without notice. We take no responsibility for any error in this document. We reserve the right to make changes in the product design without any notification to the users.

Warning! **notes in the text call attention to hazards in operation of these units that could lead to possible injury or death.**

Caution! **notes in the text indicate procedures to be followed to avoid possible damage to equipment.**

Note! **notes in the text point to special features.**

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1 Safety instructions

Following instructions are made for the personal safety of the operator, the safe use of this product and the connected devices.

Warning! **Before operations at the load or the high voltage output of the power supply are started, the device has to be switched off, the discharge of residual voltage has to be finished and the high voltage output of the power supply must be properly grounded. Depending on application residiual voltages can be present for long time periods. These residiual voltages can lead to severe injuries.**

This High Voltage Power Supply has to be installed by trained and qualified personnel only.

Warning! **High voltage power supplies of the device class HPS 300 W, 800 W are supplied from single phase mains voltage and generate an output voltage up to 30 kV. The disregard of this voltage condition can cause death, heavy injuries or material damage.**

Before connecting to the local mains it must be made sure that the nominal line voltage of this unit matches to the local mains.

The power input has to be fused (see technical data).

After system assembly the connections with the protective ground have to be checked for proper connection!

Warning! **For devices equipped with a LEMO-HV connector, the high voltage must not be switched on until the corresponding counterpart has been contacted.**

The HV cable has to be connected to the load properly and isolated according to proof-voltage.

The shield of the HV cable is always connected to the housing. It can be used as return.

The factory installed short-circuit bridge must be mounted between the connections "0V" and "X". If this short-circuit bridge is not installed, an additional conductor with a cross-section of at least 1.5 mm² must be used as the return conductor. This conductor must be connected to the "0V" connection. The "0V" terminal can accept a voltage related to the earth potential.

Warning! **The user has to ensure that no danger will occur because of the voltage between the return conductor and the protective ground!**

A specified air flow rate (see technical details) has to be guaranteed under any circumstances. Therefore do not cover any air input or output slots.

If the device is used as a desk top instrument, the enclosed distance pieces have to be installed at the bottom side of the device.

2 Device description

High voltage power supplies of the device class HPS 300 W and 800 W are supplied from single phase mains voltage and generates an output voltage up to 30 kV as well as an output current up to 800 mA.

The device can be controlled via:

- front panel operation with rotary encoder and display,
- digital interfaces or
- analogue interface.

Main characteristics:

- best control characteristics
- ARC management
- very low ripple and noise, very low EMI
- multiple interface options
- front panel control with LCD
- optional capacitor charger (CLD)

2.1 Technical data device class HPS, 300 W

Table 2.1: Technical data HPS 300W

Device class HPS, 300 W			
Output power P_{nom} [W]		300	
Polarity		Factory fixed, n → negative or p → positive	
Efficiency		> 80% (V_{in} = 230 V)	
Option capacitor charger (CLD)		Very low output voltage overshoot	
Ripple and noise	Standard	$\Delta v_{out} < 0.01\% * V_{nom}$ (> 10 Hz), $V_{out} \le 8$ kV	$\Delta v_{out} < 0.05\% * V_{nom}$ (> 10 Hz) $V_{out} > 8$ kV
	Option CLD	$\Delta v_{out} < 1.5\% * V_{nom}$ (> 10 Hz)	
Stability		$\Delta v_{out} < 0.05\% * V_{nom}$ (for 8 h with constant conditions, after ½ h warmup)	
Voltage regulation		$\Delta v_{out} < 0.01\% * V_{nom}$ (Δv_{in}, $0 \le I_{out} \le I_{nom}$, $5 V \le V_{out} \le V_{nom}$)	
Current regulation		$\Delta I_{out} < 0.2\% * I_{nom}$ (Δv_{in}, $5 V \le V_{out} \le V_{nom}$)	
Accuracy		Voltage: $< 0.5\% \cdot V_{OUT} + 0.3\% \cdot V_{NOM}$ for one year Current: $< 0.1\% \cdot I_{OUT} + 0.05\% \cdot I_{NOM}$ for one year	
Temperature coefficient		$< 2 * 10^{-4}$ /K	
Front panel control		Front panel operation via rotary encoders and displays (LCD)	
Remote control	Option AIO	Analogue signals	Level 0 V – 5 V
		Digital signals	Low level 0 V – 1 V High level 3.5 V – 5 V or open
	Digital interface	USB, CAN, Option: RS232 (RS2), Ethernet (ETH), IEEE 488 (IEE)	
Supply		V_{in} = 85 V – 264 V AC (PFC) I_{in} = 1.7 A (V_{in} = 230 V, P_{nom}); I_{in} = 3.5 A (V_{in} = 115 V, P_{nom}) Line frequency 47 Hz < f_l < 63 Hz Internally fused with 2 x 6.3 A with slow characteristic Inrush current approx. 25 A	
External fuse		6.3 A, with slow characteristic	
Cooling		Forced cooling with integrated fans (≤ 10 m³/h)	
Monitoring		Single phase mains voltage, auxiliary voltage, over voltage, temperature	
Working conditions		Temperature: 0°C to 35 °C Humidity: 20% to 90%, no condensation	
Storage conditions		Temperature: -25°C to 80 °C Humidity: 20% to 90%, no condensation	
Electromagnetic compatibility	Emission	EN 55011 (curve B)	
	Immunity	EN 61000 4-2, EN 61000 4-3, EN 61000 4-4, EN 61000 4-8	
Safety standard		EN 61010-1 (VDE 0411)	
Maximum complete discharges (ARC) per time ARC Management		See 3.3 ARC Management	
Voltage ramp, (fastest voltage ramp, slower ramp speeds can be programmed)	Standard	3000 V/s; $V_{nom} \le 15$ kV; $0.2 * V_{nom}$/ s; $V_{nom} > 15$ kV	
	Option CLD	$> 10 * V_{nom}$/ s	
Electrically isolated return of the high voltage		Potential difference between return conductor and protective ground up to ± 400 V	

Table 2.2: Additional technical data HPS 300W

Type	V_{nom}	I_{nom}	HV connector	Dimension, weight	Options
HPx 10 307	1 kV	300 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 20 157	2 kV	150 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 30 107	3 kV	100 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 40 756	4 kV	75 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 60 506	6 kV	50 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 80 356	8 kV	35 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 150 256	12 kV	25 mA	LEMO ERA1Y660.0750-1 or GES HB21T	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 200 206	15 kV	20 mA	LEMO ERA1Y660.0750-1 or GES HB21T	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 250 156	20 kV	15 mA	LEMO ERA3Y 660.0750-1 or GES HB21T	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 300 106	30 kV	10 mA	LEMO ERA3Y 660.0750-1 or GES HB31T	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE

Note: Not all interfaces can be combined

2.2 Technical data device class HPS, 800 W

Table 2.3: Technical data HPS 800W

Device class HPS, 800 W			
Output power P_{nom} [W]		800	
Polarity		Factory fixed, n → negative or p → positive	
Efficiency		> 85% (V_{in} = 230 V)	
Option capacitor charger (CLD)		Very low output voltage overshoot	
Ripple and noise	Standard	$\Delta v_{out} < 0.01\% * V_{nom}$ (> 10 Hz), $V_{out} \leq 8$ kV	$\Delta v_{out} < 0.05\% * V_{nom}$ (> 10 Hz) $V_{out} > 8$ kV
	Option CLD	$\Delta v_{out} < 1.5\% * V_{nom}$ (> 10 Hz)	
Stability		$\Delta v_{out} < 0.05\% * V_{nom}$ (for 8 h with constant conditions, after ½ h warmup)	
Voltage regulation		$\Delta v_{out} < 0.01\% * V_{nom}$ (Δv_{in}, $0 \leq I_{out} \leq I_{nom}$, $5 V \leq V_{out} \leq V_{nom}$)	
Current regulation		$\Delta I_{out} < 0.2\% * I_{nom}$ (Δv_{in}, $5 V \leq V_{out} \leq V_{nom}$)	
Accuracy		Voltage: $< 0.5\% \cdot V_{OUT} + 0.3\% \cdot V_{NOM}$ for one year Current: $< 0.1\% \cdot I_{OUT} + 0.05\% \cdot I_{NOM}$ for one year	
Temperature coefficient		$< 2 * 10^{-4}$ /K	
Front panel control		Front panel operation via rotary encoders and displays (LCD)	
Remote control	Option AIO	Analogue signals	Level 0 V – 5 V
		Digital signals	Low level 0 V – 1 V High level 3.5 V – 5 V or open
	Digital interface	USB, CAN, Option: RS232 (RS2), Ethernet (ETH), IEEE 488 (IEE)	
Supply		V_{in} = 85 V – 264 V AC (PFC) I_{in} = 4.5 A (V_{in} = 230 V, P_{nom}); I_{in} = 9 A (V_{in} = 115 V, P_{nom}) Line frequency 47 Hz < f_l < 63 Hz Internally fused with 2 x 10 A with slow characteristic Inrush current approx. 25 A	
External fuse		10 A, with slow characteristic	
Cooling		Forced cooling with integrated fans (≤ 20 m^3/h)	
Monitoring		Single phase mains voltage, auxiliary voltage, over voltage, temperature	
Working conditions		Temperature: 0°C to 35 °C Humidity: 20% to 90%, no condensation	
Storage conditions		Temperature: -25°C to 80 °C Humidity: 20% to 90%, no condensation	
Electromagnetic compatibility	Emission	EN 55011 (curve B)	
	Immunity	EN 61000 4-2, EN 61000 4-3, EN 61000 4-4, EN 61000 4-8	
Safety standard		EN 61010-1 (VDE 0411)	
Maximum complete discharges (ARC) per time ARC Management		See 3.3 ARC Management	
Voltage ramp, (fastest voltage ramp, slower ramp speeds can be programmed)	Standard	3000 V/s	
	Option CLD	$> 10 * V_{nom}$/ s	
Electrically isolated return of the high voltage		Potential difference between return conductor and protective ground up to ± 400 V	

Table 2.4: Additional technical data HPS 800W

Type	V_{nom}	I_{nom}	HV connector	Dimension, weight	Options
HPx 10 807	1 kV	800 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 20 407	2 kV	400 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 30 257	3 kV	250 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 40 207	4 kV	200 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 60 137	6 kV	130 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 80 107	8 kV	100 mA	SHV	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 150 656	12 kV	65 mA	LEMO ERA1Y660.0750-1 GES HB21T	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE
HPx 200 506	15 kV	50 mA	LEMO ERA1Y660.0750-1 GES HB21T	1U, 19“, 410 mm, 5 kg	CLD, RS2, ETH, IEE

Note: Not all interfaces can be combined

2.3 Electrical wiring of the high voltage output

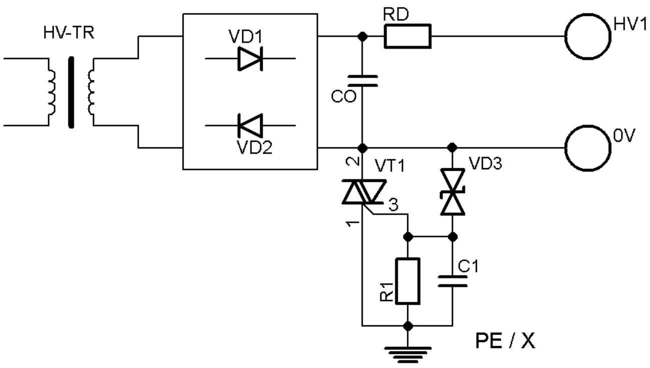

Figure 2.1: Electrical wiring of the high voltage output

2.4 Dimensions

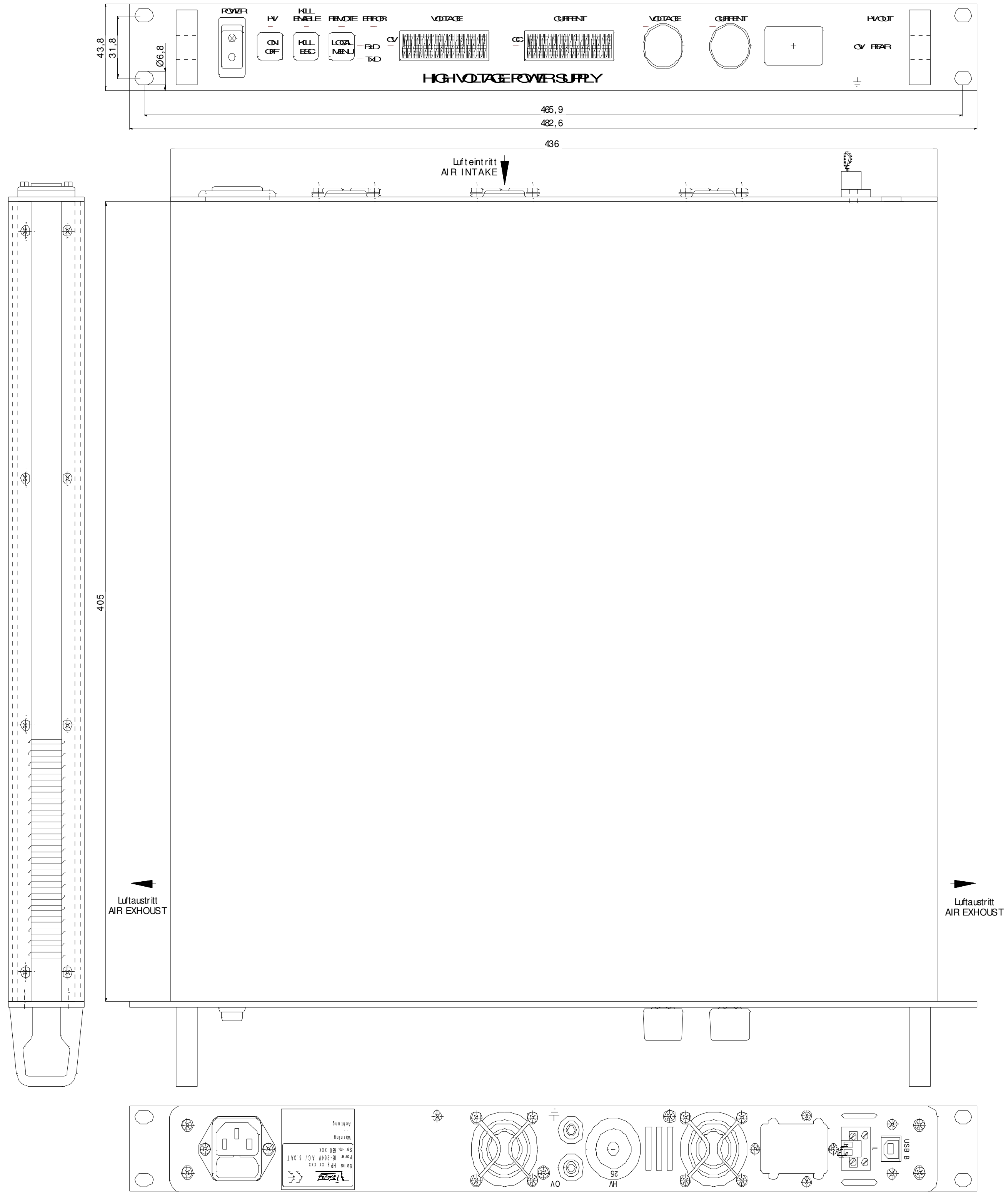

Figure 2.2: Dimensioned drawing, in mm

3 Functional description

In the following, the working principle of the power supply will be described:

Next to the mains there is a EMI/RFI filter, which feeds the power factor correction unit (PFC) and the inrush current limitation circuit. The PFC draws sinusoidal currents from the mains, which are in phase with the supply voltage.

Caution! **With an input voltage greater than 255 V, the PFC only functions as a rectifier and the current consumption is no longer sinusoidal. In the input voltage range below 100 V, either the output power or the ambient temperature must be reduced (Figure 4.2).**

Furthermore the PFC provides a DC link voltage, that is buffered by an electrolytic capacitor battery. An inverter with a connected resonance circuit transforms the DC-Link voltage into a controllable sinusoidal voltage. The HV transformer and HV rectifier provide an output voltage corresponding to the external set voltage. Output voltage and current are measured by high precision voltage dividers and a shunt and are fed back to the control circuit. A damping resistor connected to the output capacitance limits the output current during a load change or ARC.

High voltage power supplies of this class work with a fixed switching frequency. The output parameters are controlled via a pulse width modulation (PWM).

The control circuit controls and limits the output voltage and current corresponding to the set values. Normalized monitor voltages for voltage and current are provided for read back. The control circuit is also monitoring the input voltages, auxiliary voltages and the temperatures of cooling air and single components.

The power supply is turned ON/OFF with a switch installed at the front panel of the power supply. An ARC-management with fixed parameters is installed in the power supply.

3.1 Operation states

Figure 3.1 shows the operating area of the device. There are two modes for high voltage generation:

1. Constant voltage control CV:
   Control of output voltage according to set value V_{set_v} ($V_{mon\_i} < V_{set\_i}$).
2. Constant current control CC:
   Control of output current according to set value V_{set_i} ($V_{mon\_v} < V_{set\_v}$).

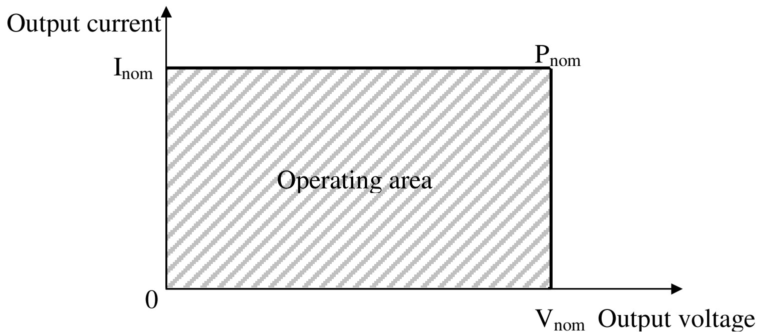

Figure 3.1: Operating area of the device.

The device has the following special operating states

Table 3.1: Operating states

Function	Description
Voltage Ramp	The change of the output voltage between the set values and after switching the high voltage on or off are performed with the set voltage ramp.
Current Ramp	All changes between current set values are performed with the programmed current ramp.
Voltage Limit VLIM	The voltage limit is separated into two functions: 1. Limit the voltage set value to the limit value: $0 \le V_{SET} \le V_{LIM} \le V_{NOM}$ 2. If the measured voltage exceeds the limit value by two percent, the ChannelEventStatus bit EventVolt-ageLimit is set: $V_{MEAS} \ge 1.02 \cdot V_{LIM}$ The display shows "VLIM" in the status bar.
Current Limit I_{LIM}	The current limit is separated into two functions: 1. Limit the current set value to the limit: $0 \le I_{SET} \le I_{LIM} \le I_{NOM}$ 2. If the measured current exceeds the limit value by two percent, the ChannelEventStatus bit EventCur-rentLimit is set: $I_{MEAS} \ge 1.02 \cdot I_{LIM}$ The display shows "ILIM" in the status bar.
Kill-Enable	The following events shut down the high voltage without ramp in mode Kill-Enable: EventConstantCurrent, EventArc, EventVoltageLimit, EventCurrentLimit. The display shows “KILL” in the status bar.
Current Trip	In mode Kill-Enable the high voltage will be shut down without a ramp, if the measured current is greater than the set current: $I_{MEAS} \ge I_{SET}$ The display shows "TRIP" in the status bar..
Emergency Off	The function emergency off shut down the high voltage without ramp. To turn the high voltage on again, the state emergency off has to be leaved and the ChannelEventStatus bit EventEmergencyOff must be cleared afterwards. The display shows “EMCY” in the status bar.

3.2 Monitoring

Voltage

The single phase mains voltage and the internal auxiliary voltages are monitored. If one of these voltages is out of its limits, the high voltage generation is stopped.

Warning! **High voltage generation is reactivated immediately if the limit values are no longer exceeded or fallen below.**

For devices of the class GPS with option CLD, the maximum voltage value is monitored by the OVP-comparator. The threshold is set to approx. 110 percent of nominal voltage at the factory. If this threshold is reached (e.g. through an internal defect), high voltage generation is stopped.

The output power of the unit will be reduced, if the input voltage is smaller than 95 V_{AC} (see Figure 3.2).

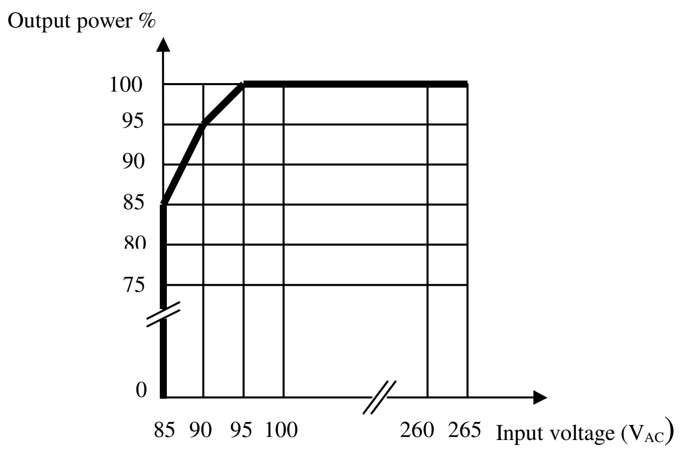

Figure 3.2: Power reduction vs. input voltage

Temperature

Temperature is monitored at several points within the unit. High voltage generation is stopped in case the external air temperature exceeds 35°C (or 50°C for the device class GPS, 350 W, COMPACT) or internal temperature of several modules exceeds a predefined limiting value.

Warning! **The high voltage generation is reactivated immediately when the limit values are no longer exceeded.**

3.3 Interlock

The power supply is equipped with a connector "IL" for a hardware safety loop (interlock, maximum cross section area $1.5 mm^2$) at the back side.

If the loop is closed an internal current source (open circuit voltage 15 V / short circuit current max. 40 mA) will drive a current of ca. 12 mA through a built-in mechanical relays (certified in accordance with IEC/EN 60950 and UL 60950, fulfils the Telcordia requirements according GR 1089 and FCC part 68).

The impedance of the closed loop must be less than 300 Ohm.

If the safety loop is open (Impedance > 100 kOhm), the relays will open. The high voltage generation is stopped only by the opened relay contacts. The relay locks the gate pulses of the semiconductors of the inverter.

Warning! **The internal and external capacitances must be discharge by the load before the output will be voltage-free. The internal discharge resistors have a high resistance, so a very long discharging time is possible according to the connected load.**

The unit is not equipped with an active discharging circuit! Before operations at the load or the high voltage output of the power supply are started, the high voltage output of the power supply must be properly grounded.

It is not possible to switch on the high voltage generation if the safety loop is open.

The state of the opened safety loop is handled as an error. For releasing the high voltage generation the closed safety loop has to be approved.

3.4 ARC Management

The HV power supply is equipped with an ARC Management. An ARC is an almost complete discharge per time unit

An output current greater than $1.5 \cdot I_{nom}$. is evaluated as an ARC.

The functionality of the ARC Management can be divided in two operating states:

1. KillEnable active
   - High voltage shuts down after the first ARC
2. KillEnable not active
   - High voltage is restored immediately after the first ARC
   - If an second ARC occur during the time period of 1 second, the control signals of the inverter are blocked within some µ-seconds for the blanking time (ARC-Wait).
   - At the same time, the internal set value for the output voltage is set to 0. High voltage generation is released after the time ARC-Wait and the output voltage increases with the adjustable voltage ramp.

The parameters of the ARC-Management are shown in Table 3.2.

Table 3.2: Parameters of the ARC Management

	HPS
ARC-Number / second	1
ARC-Wait	1 s
ARC-Ramp	Adjustable voltage ramp

3.5 KillEnable

If KillEnable is active, the device switches off the high voltage at the following events without voltage ramp:

- when an ARC is detected (ARC),
- output voltage $V_{OUT} \geq$ voltage limit V_{LIM},
- output current $I_{OUT} \geq$ current limit I_{LIM},
- when the device is switched to the constant current source CC operating mode

The display shows "KILL" in the status line.

4 Pinout

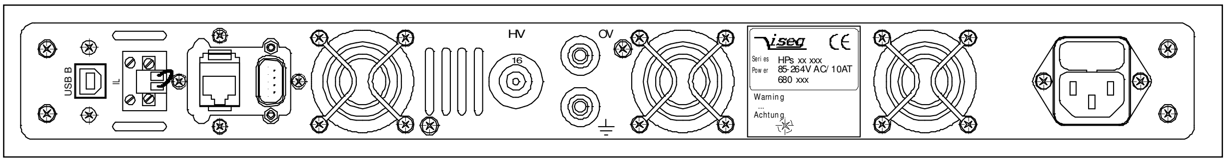

Figure 4.1: Back panel of the device

4.1 Supply

The unit is connected to mains net using the power connector on the back panel.

4.2 HV connection

The unit has one HV output. The HV cable has to be connected to the load properly and isolated according to proof-voltage.

The shield of the HV cable is always connected to the housing. It can be used as return if the connectors “0V” and “PE” are short circuited.

4.3 OV connection

If the short circuit between the connectors “0V” and “PE” is removed, as return an additional wire has to be used. This wire has to connected with “0V”. The potential between the connector “0V“ and the protective ground can be ± 400 V.

Warning! **The user has to ensure that no danger will occur because of the voltage between the connectors ”0V“ and ”PE“!**

If the potential between the return conductor and the protective ground will be larger than |400| V then the connectors will be short circuited via an electronically protection circuit to avoid damages of the power supply.

4.4 IL connection

See section 3.3 Interlock

4.5 Interface connection

See section USB, RS232 interface, CAN interface, IEEE interface, Ethernet interface and AIO interface.

5 Operation

5.1 Operating mode

LOCAL

The device can be controlled with the buttons and the rotary encoders of the front panel. The led “REMOTE” is not illuminated.

REMOTE

For remote control, the corresponding interface (USB, CAN, RS-232, USB, IEEE-488, Ethernet, AIO) must be specified first via the menu item “F07 Set Interfce”. The device switches to REMOTE mode when receiving the first command from a digital interface. The led “REMOTE” is not illuminated.

5.2 Front panel operation

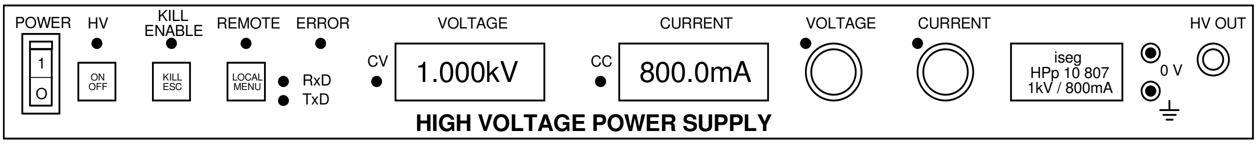

Figure 5.1: Front panel (HV connector at the front)

After pushing the POWER button the device is booting. During boot, the integrated hardware is initialized. After start-up the device is working in LOCAL mode and the KILL function is “disable”.

In LOCAL mode, the set values for voltage and current can be adjusted with the rotary encoders VOLTAGE for VSET and CURRENT for ISET. The yellow LEDs VOLTAGE and CURRENT are lighting. When trying to set VSET or ISET beyond the adjusted limit, the corresponding LED is flashing for one second.

Generation of high voltages starts by pushing the ON/OFF button. While generating high voltage, the green LED “HV” is lighting.

Caution! **The high voltage which has been selected with the rotary encoders is going to ramp to the chosen voltage with the programmed ramp speed!**

By pressing ON/OFF again, the high voltage generation is turned off, the green LED “HV” turns off. The high voltage is ramped down with the programmed ramp speed.

5.2.1 Displays

The device has two eight digit displays for voltage and current as well as for Menu control.

In HV-OFF state, the set values are shown on display for easy changes with the rotary encoders VOLTAGE and CURRENT. These set values are stored in processor’s EEPROM and reloaded at next start-up.

While displaying the set values for voltage and current, a small ’s’ is flashing at the left display side:

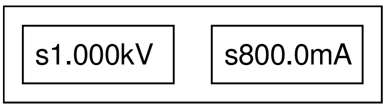

Figure 5.2: Set values the display in HV OFF state

In HV-ON state the measured values of voltage and current are displayed:

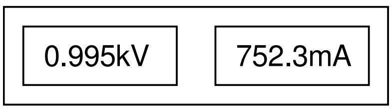

Figure 5.3: Set values the display in HV ON state

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By pressing the rotary encoder VOLTAGE or CURRENT in HV ON state, the corresponding set value is displayed for a short time to allow exact adjustment.

If the set values aren't changed, the device shows the measured values again after four seconds. By pressing the corresponding rotary encoder again, this delay can be shortened.

After turning high voltage off, the displays show the measured values while ramping down. After four seconds with a measured voltage lower than 60 V, the device shows the set values again.

5.2.2 Menu

In HV-OFF mode the device menu is activated by pressing the button MENU.

If no button is pressed, the display switch back to HV-OFF mode after 30 seconds. The menu can also be closed without changing any value by pressing the button ESC.

By turning the rotary encoder VOLTAGE you can scroll through the menu. By pressing the rotary en-coder VOLTAGE the displayed menu point is selected. The setting can be changed by the active rotary encoder (shown by yellow LED). By pressing the active rotary encoder the changes are stored and the main menu is displayed again.

Display	Description
F01 Set Limit V	Adjust the Software voltage limit V_{OUTmax} in the range of 0.02 • $V_{NOM} \le V_{OUTmax} \le V_{NOM}$ with rotary encoder VOLTAGE. V_{SET} will be limited to this value. If the Limit gets smaller than the actual value of V_{SET}, V_{SET} will be decreased to V_{OUTmax} automatically.
F02 Set Limit I	Adjust the Software current limit I_{OUTmax} in the range of 0.02 • $I_{NOM} \le I_{OUTmax} \le I_{NOM}$ with rotary encoder CURRENT. I_{SET} will be limited to this value. If the Limit gets smaller than the actual value of I_{SET}, I_{SET} will be decreased to I_{OUTmax} automatically.
F03 Set Ramp V	Adjust voltage ramp speed with rotary encoder VOLTAGE in the range of 1…3000 V/s or 0.2 • V_{NOM}/s) (factory setting is 0.2 • V_{NOM}/s). At devices with option CLD, the software voltage ramp can be disabled. In this case, the device changes its output voltage as fast as possible. The software ramp can be disabled be setting the ramp speed greater than 3000 V/s: “max.” will be displayed..
F04 Set Ramp I	Adjust current ramp speed with rotary encoder CURRENT with the given values in the range of 0.02 • I_{NOM}/s up to I_{NOM}/s (factory setting is 1 • I_{NOM}/s)
F05 Auto Start	Not implemented yet.
F06 Auto AIF	AIF ON: Turn on HV by pushing the ON/OFF button or with INHIBIT Low to High on analogue I/O AIF OFF Turn on HV by pushing the ON/OFF button only The INHIBIT signal on analogue I/O has priority in both cases! INHIBIT High to Low: turn off HV Low to High: turn on HV (KILL disable) Low static: HV = 0
F07 Set Interfce	Select external Interface with rotary encoder VOLTAGE: “CAN” control via CAN-Interface “RS-232” control via RS232-Interface “USB“ control via USB-Interface “IEEE 488” control via IEEE (GPIB)-Interface “Ethernet“ control via Ethernet-Interface “AIF” control via Analogue I/O
F08 Set Instruct	Select instruction type for RS-232/USB/IEEE-488/Ethernet control with rotary encoder VOLTAGE: ”EDCP” SCPI command set with EDCP (recommended) “SCPI” old SCPI command set “ET” old ET command set
F09 Addr IEEE	Select IEEE address with rotary encoder VOLTAGE: 01 to 30. Factory setting is 17.
F10 Addr CAN	Select CAN address with rotary encoder VOLTAGE: 00 to 63. Factory setting is 0.
F11 Set Echo	Select Echo state for RS-232/USB control with rotary encoder VOLTAGE: “on” ⇒ “off” ⇒ “on”
F12 Set Password	Block menu access using a four-digit number sequence. "0000" deactivates the password function, any other number sequence activates it. The digits of the password must be entered separately using the VOLTAGE rotary encoder.
F13 Show Power	Display of the measured power instead of the measuring current (on/off)
F14 Quit Menu	Closes the menu

5.2.3 Software limits

The device uses two software limits for voltage and current.

These limits consists of two functions:

1. Limitation of the set values to the set limits: limit V_{SET} to V_{OUTmax} resp. I_{SET} to I_{OUTmax}.
2. Set the limit bits in Channel Status and Channel Event Status, if the measured values exceed the limits:
   - isVLIM and EVLIM if $V_{OUT} \ge V_{OUTmax} + 0.02 \bullet V_{NOM}$
   - isCLIM and ECLIM if $I_{OUT} \ge I_{OUTmax} + 0.02 \bullet I_{NOM}$

In kill mode "Enable" the bits "EVLIM" or "ECLIM" cause the high voltage to be switched off without a ramp.

5.2.4 Error states

The following Events cause the High Voltage to shut down without ramp and have to be cleared with Button KILL/ESC or a remote command (e. g. *CLS) before turning it on again.

Event Bit	Display	Description
EEMCY	EMERGENCY OFF	Emergency off via remote control
ETRIP	CURRENT TRIP	Current trip ($I_{OUT} \geq I_{SET}$) in mode Kill enable
EVLIM	VOLTAGE LIMIT	Voltage limit exceeded in mode Kill enable
ECLIM	CURRENT LIMIT	Current limit exceeded in mode Kill enable
ESFLPngd	SAFETYLOOP	Safety loop was or is open
ETEMPngd	OVERTEMPATURE	Maximum allowed temperature was or is exceeded

5.3 Interface control

For remote control, the corresponding interface (USB, CAN, RS-232, USB, IEEE-488, Ethernet, AIO) must be specified first via the menu item "F07 Set Interfce". The device switches to "REMOTE" mode when receiving the first command from the selected interface. The yellow LED "REMOTE" is illuminated.

By pressing the "LOCAL/MENU" button the remote control is suspended. The device can now be controlled from the front panel. When receiving new commands via Interface, the device switches back to "REMOTE" mode.

If "HV-ON" is activated while the device is controlled via a remote interface, high voltage can be turned off by pressing the "ON/OFF" button. In this case the device switches to "LOCAL" mode.

Warning! **If local control is disabled (Local Lockout, see section** Fehler! Verweisquelle konnte nicht gefunden werden.**), the device can only be turned off via mains switch!**

5.3.1 Description of the RS-232- / USB interface

Warning! **Turn off the device with mains switch before connecting/disconnecting the interface cable.**

Caution! **If the device is equipped with RS-232 and USB Interface, only one of them must be connected to the HPS.**

RS-232

The RS-232 interface is located at a D Sub 9 connector on the back panel.

The electric transfer is performed via RxD and TxD, which are related to floating GND of the Interface. The D-Sub 9 pin assignment is given in Table 5.1.

The cable connection to the computer is 1:1 (no zero modem-cable!). If no 9-pin cable is available, connections must be set up as shown in the table.

For remote control, "RS-232" must be selected in Menu "F07 Set Interfce". The device switches to the "REMOTE" state when receiving the first command via interface.

Table 5.1: Electrical wiring of the RS232 Interface

Signal	HV-PS		PC	Connection	Signal
RS-232	D-SUB-9	Internal	D-SUB-9	RS-232	D-SUB-9
RxD	2		2	RxD	2
TxD	3		3	TxD	3
GND	5		5	GND	5
	4	┐	4		4
	6	┤	6		6
	8	┘	8		8

USB

The USB interface is realized with a female USB-B connector on the back panel. Internally, the USB is implemented by a USB-serial converter FTDI FT232R.

This device operates as a virtual serial port in a PC, and can be used with every program that supports a serial port, e. g. a terminal program or LabVIEW.

Programming

The following description applies to both, RS-232 and USB interface.

The (virtual) serial interface is set to 9600 Bit/s, 8 Bit/character, no parity, 1 Stop-Bit.

The data transfer is character oriented, while the synchronization in the direction "Computer to HV PS unit" (Input direction) is established by echoes. The transfer direction “HV-PS to computer“ (Output direction) is free running.

The command transfer uses ASCII characters. Commands are terminated by <CR><LF> ($0D $0A or 13 10).

A new command may be sent immediately after the last answer was completely received (including <CR><LF>). For commands that don't return an answer, the simplest thing is to add *OPC? in EDCP instruction set:

Table 5.2: Programming serial interface

Instruction (with Echo)	:VOLT 500;:VOLT ON;*OPC?<CR><LF>
Answer	1<CR><LF>

5.3.2 Description of the CAN interface

Warning! Turn off the device with mains switch before connecting/disconnecting the interface cable.

The connector (SUB D 9) for the CAN interface is located at the back panel of the module and has the following pinout:

Table 5.3: Pinout CAN connector

PIN	Signal
2	CAN_L (CAN Low)
3	CAN_GND
5	CAN_Shield
7	CAN_H (CAN High)

The operating and the command set is equivalent to the EDCP protocol, which is described in the manuals

CAN-Interface

Multi-Channel High Voltage Power Supply Module

EHS xxx and EDS xxx.

To control the device, the programs “IsegCANHVControl” or “iseg OPC Server” can be used.

5.3.3 Description of the IEEE-488 Interface (GPIB)

Warning! **Turn off the device with mains switch before connecting/disconnecting the interface cable.**

IEEE-488 interface

The IEEE-488 bus interface was implemented with a NEC 7210 compatible IEEE controller. The following interface functions according to IEC 625 are available:

SH1	Source Handshake:	all functions (no polling)
AH1	Acceptor Handshake:	all functions (no polling)
T6	Talker:	Standard equipment
L4	Listener:	Standard equipment

To connect the device to the IEEE bus, a Micro-D25 male connector is located on the back panel. An adapter cable with a 24 pin connector following IEEE-488.2 standard is available as an option.

At devices with a Front panel, “IEEE” must be selected at menu “F09 Set Interfce“ for remote control. At devices without a Front panel, the interface is active after start up.

The IEEE address (1…30) can be specified in the menu “F11 Addr IEEE“. The factory setting for the IEEE address is 17. The IEEE address can also be changed with the SCPI command :CONFIGURE:GPIB:ADDRESS. When receiving control commands over IEEE, the device switches to “REMOTE” state.

Programming

The command transfer uses ASCII codes. Commands are terminated by <CR><LF> ($0D $0A or 13 10). Alternatively, the control line EOI (End or Identify) can be set together with the command’s last character. On input side, no leading zeros are required. The output is in a fixed format without leading zeros.

A minimum time delay of 5 ms between two IEEE commands is needed.

5.3.4 Ethernet Interface

Warning! **Turn off the device with mains switch before connecting/disconnecting the interface cable.**

The Ethernet Interface with 10-MBit/s, Full-Duplex, is connected via RJ-45 socket on the device rear.

The device can be connected to a switch via patch cable. If it shall be connected to a PC directly, a crossover cable has to be used.

“Ethernet” has to be set in menu “F07 Set Interfce“. The additional settings (IP address, net-mask, default gateway) have to be made with the SCPI Instruction set with EDCP. This can be done over Ethernet or RS-232. Ex works settings are as follows:

IP-address:	192.168.16.13
Net mask:	255.255.255.0
Default Gateway:	192.168.16.1
Command port:	10001 (fixed)

The connection can be tested with the ping command (Start → programs → accessories → command).

```
C:\>ping 192.168.16.13

Ping will done for 192.168.16.13 with 32 bytes data:

Answer from 192.168.16.13: bytes=32 time=4ms TTL=128
Answer from 192.168.16.13: bytes=32 time=4ms TTL=128
Answer from 192.168.16.13: bytes=32 time=4ms TTL=128
Answer from 192.168.16.13: bytes=32 time=4ms TTL=128

Ping statistic for 192.168.16.13:
Package: sent = 4, received = 4, lost = 0
Time in millisecond:
minimum = 1ms, maximum = 4ms, average = 1ms
```

During communication the HV unit act as server, the control PC act as client. The following table shows the principle sequence of communication PC to HV unit.

Step	Function call	Computer → HV-Unit	HV-Unit → Computer
1.	connect()	SYN	
2.			SYN, ACK
3.		ACK	
4.	send()	"*IDN?\r\n"	
5.	recv()		"iseg Spezialelektronik GmbH [...]"
6.	closesocket()	FIN, ACK	
7.			FIN, ACK
8.		ACK	

The first three packages are for the establishing of a TCP-Connection (three way handshake). Fourth step is the inquiry from PC to HV unit. The order is ASCII coded in data field of the TCP packet. The answer is also ASCII coded send to the PC in step 5. Package No. 6 confirms the receipt of the packet and sends a FIN for termination of connection. Step 7 and 8 are the confirmation of termination of connection from HV unit and PC.

The communication can be monitored with a network sniffer (e. g. Wireshark). Control is done with the instruction sets described later. The preferred command set for Ethernet is “SCPI with EDCP”, as you can build longer Frames which reduces Ethernet Overhead.

Programming

Simple programming example (without error handling) for communication with the HV device over Ethernet. This program was compiled and tested with Microsoft Visual C++ 6.0 on Windows XP.

```c
#include <stdio.h>
#include <winsock.h>

int main(int argc, char *argv[])
{
	WSADATA     wsadata;
	SOCKET      sock;
	SOCKADDR_IN sockaddr_in;
	int         retcode;
	char        cmd[255] = "*IDN?\r\n";
	char        ans[255];

	// init sockets (Berkeley style, UNIX compatible)
	WSAStartup(2, &wsadata);

	// create TCP socket
	sock = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);

	// bind socket to dynamic port
	memset(&sockaddr_in, 0, sizeof(sockaddr_in));
	sockaddr_in.sin_family = AF_INET;            // UDP, TCP
	sockaddr_in.sin_port   = htons(10001);       // Remote Port
	sockaddr_in.sin_addr.S_un.S_un_b.s_b1 = 192; // IP address
	sockaddr_in.sin_addr.S_un.S_un_b.s_b2 = 168;
	sockaddr_in.sin_addr.S_un.S_un_b.s_b3 =  16;
	sockaddr_in.sin_addr.S_un.S_un_b.s_b4 =  13;

	// connect to server (three way handshake)
	connect(sock, (SOCKADDR *)&sockaddr_in, sizeof(SOCKADDR_IN));

	// send command to server
	send(sock, cmd, strlen(cmd), 0);

	// read answer from server
	retcode = recv(sock, ans, sizeof(ans), 0);

	// close socket (three way handshake) and clean up
	closesocket(sock);
	WSACleanup();

	// print answer to screen
	printf("%s\n", ans);

	return 0;
}
```

Programming

Simple programming example (without error handling) for communication with the HV device over Ethernet. This program was compiled and tested with Microsoft Visual C++ 6.0 on Windows XP.

```
#include <stdio.h>
#include <winsock.h>

int main(int argc, char *argv[])
{
	WSADATA      wsadata;
	SOCKET       sock;
	SOCKADDR_IN  sockaddr_in;
	int          retcode;
	char         cmd[255] = "*IDN?\r\n";
	char         ans[255];

	// init sockets (Berkeley style, UNIX compatible)
	WSAStartup(2, &wsadata);

	// create TCP socket
	sock = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);

	// bind socket to dynamic port
	memset(&sockaddr_in, 0, sizeof(sockaddr_in));
	sockaddr_in.sin_family = AF_INET;            // UDP, TCP
	sockaddr_in.sin_port   = htons(10001);       // Remote Port
	sockaddr_in.sin_addr.S_un.S_un_b.s_b1 = 192; // IP address
	sockaddr_in.sin_addr.S_un.S_un_b.s_b2 = 168;
	sockaddr_in.sin_addr.S_un.S_un_b.s_b3 =  16;
	sockaddr_in.sin_addr.S_un.S_un_b.s_b4 =  13;

	// connect to server (three way handshake)
	connect(sock, (SOCKADDR *)&sockaddr_in, sizeof(SOCKADDR_IN));

	// send command to server
	send(sock, cmd, strlen(cmd), 0);

	// read answer from server
	retcode = recv(sock, ans, sizeof(ans), 0);

	// close socket (three way handshake) and clean up
	closesocket(sock);
	WSACleanup();

	// print answer to screen
	printf("%s\n", ans);

	return 0;
}
```

5.4 Description of the Analogue I/O interface (AIO)

Warning! **Turn off the device with mains switch before connecting/disconnecting the interface cable.**

All analogue and digital inputs and outputs are electrically isolated from the protective ground. The user is responsible that no danger will occur due to a voltage between the AIO and the protective ground!

"AIF" has to be set in menu "F07 Set Interfce".

All control inputs and outputs are located at the male D Sub 9 connector labelled "AIO" on the back side of the device. The pin assignment of this connector is described in the following table.

Table 5.4: Pin assignment male D Sub 9 connector

AIO, male D Sub 9 connector			
Pin 1	GND		Return of pins 2-9
Pin 2	V_{mon_I}	(0 .. 5 V)	Monitor output current
Pin 3	INHIBIT		Digital input signal
Pin 4	V_{set_i}	(0 .. 5 V)	Set value output current
Pin 5	CC		Digital output signal
Pin 6	GND		Return of pins 2-9
Pin 7	V_{mon_v}	(0 .. 5 V)	Monitor output voltage
Pin 8	V_{set_v}	(0 .. 5 V)	Set value output voltage
Pin 9	V_{ref}	5 V	Reference (1 mA)

5.4.1 Set values

A voltage between 0 - 5 V at Pin 8 (reference potential Pin 6) of the connector "AIO" controls the output voltage between 0 – V_{nom}. Similarly, at Pin 4 the output current is controlled between 0 - I_{nom}.

5.4.2 Monitor voltages

Monitor voltages (0 - 5 V) proportional to the output voltage and output current are available at Pin 7 and Pin 2 of the connector "AIO", respectively (reference potential Pin 6).

5.4.3 INHIBIT

By applying a low level signal at pin 3 of the connector "AIO", the high voltage generation will be shut off immediately and will be blocked. High voltage generation is activated with a high level signal or open contact at pin 3 of the connector "AIO".

Warning! **Do not use the INHIBIT function as a safety loop.**

5.4.4 CC

A low level signal at pin 5 of the connector "AIO" indicates, that the device operates in the mode constant current control CC.

On the contrary, a high level signal at this pin indicates, that the device operates in the mode constant voltage control CV.

5.4.5 Function "Auto AIF"

If the interface "AIF" is selected in the menu "F07 Set Interfce", the automatic function "Auto AIF" in the menu „F06 Auto AIF" can be enabled. Now the generation of high voltage will start with a rising edge of the INHIBIT function. (without pushing the button "HV ON").

If another interface is chosen, the function "Auto AIF" will be disabled automatically.

Figure 5.4 shows the electrical wiring of the analogue and digital in- and outputs.

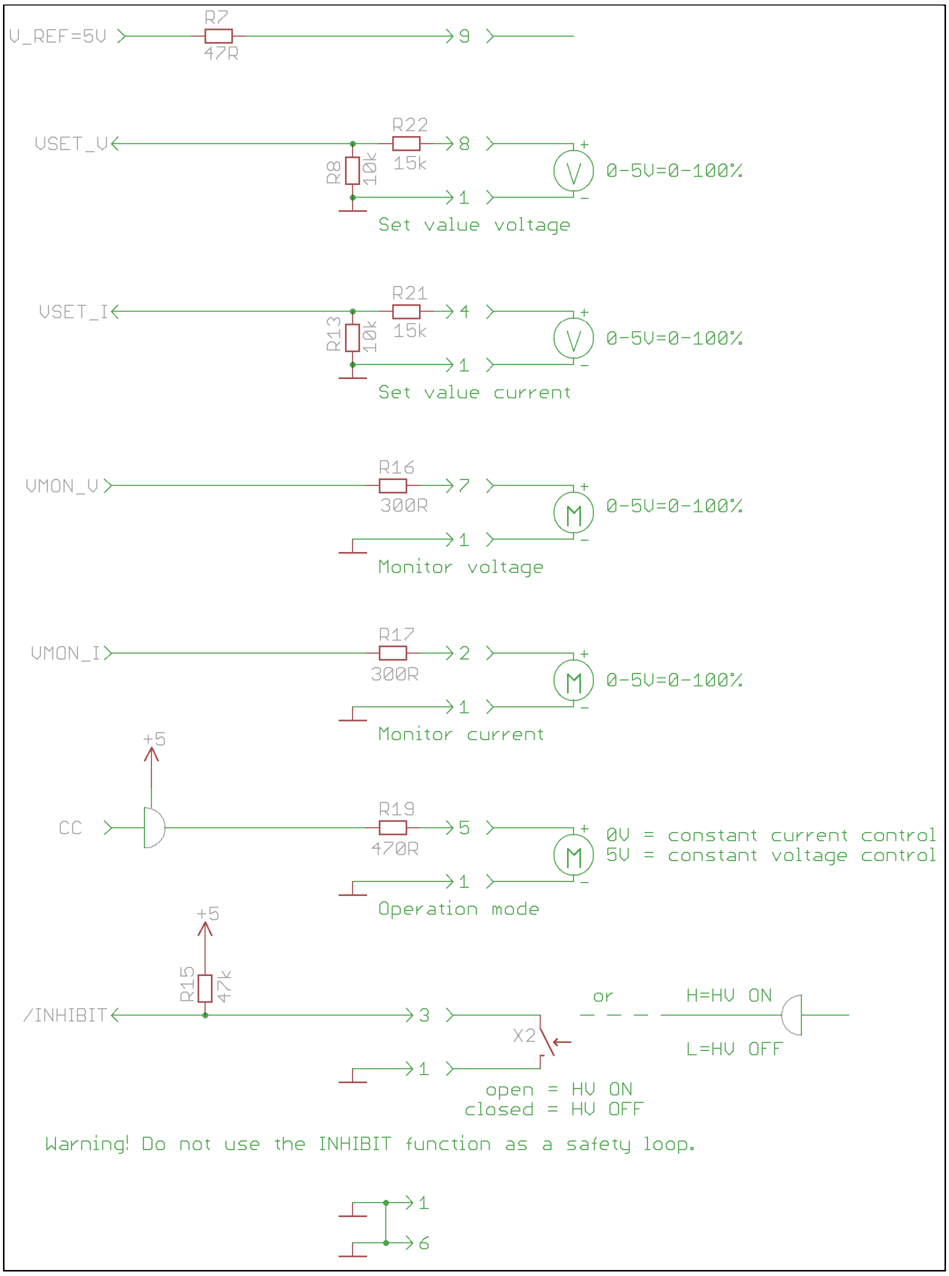

Figure 5.4: Electrical wiring of the analogue and digital in- and outputs

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6 Troubleshooting

6.1 Error messages on Displays

Error messages during operation	
Display:	**Meaning:**
SAFETYLOOP	Safety loop (Interlock) is not closed.
EXTERNAL INHIBIT	High voltage cannot be generated because of external inhibit (analogue I/O).
EMERGENCY	High voltage has been shut down without ramp due to Emergency Off.
CURRENT TRIP	Current set value reached during Kill enable. High voltage has been shut down without ramp.
VOLTAGE LIMIT	Voltage Limit V_{max} has been exceeded. In mode Kill enable, the high voltage is shut down without ramp.
CURRENT LIMIT	Current Limit I_{max} has been exceeded. In mode Kill enable, the high voltage is shut down without ramp.
OVERTEMPERATURE	High voltage has been shut down because of over temperature. Let device cool down.
ERROR SUPPLY	Internal voltage supply faulty. Device must be shipped to service.
ERROR SERVICE	Internal failure. Device must be shipped to service.
Error messages during boot	
Display:	**Meaning:**
ERROR RTC	Real time clock battery is low. Contact service.
CONTACT SERVICE	Device must be shipped to the factory for service.
ERROR AIF	Analogue interface (optional) is not working. Contact service.
ERROR IEEE	IEEE interface (optional) is not working. Contact service.

6.2 Further Errors

Table 6.1: Further Errors

Unit does not provide output voltage, and the displays are not lightning	⇒	- Check supply voltage and connection
Unit does not provide output voltage but the displays are lightning	⇒	- Check environmental temperature ($T_U \leq 35$°C) - Check control - Check INHIBIT function - Check safety loop
External fuses trip during switch on.	⇒	- Use fuses with slow characteristic (inrush current 25 A)

If these instructions do not lead to a good result, this unit must be checked by an authorised agent or shipped to the factory.

7 Maintenance

For compliance of the specified accuracy of set and monitor signals, the unit has to be recalibrated once a year.

Repair and maintenance may only be performed by trained and authorized personnel.