

Operator's Manual

High Voltage Power Supply of the Device Class HPS, 350 W, COMPACT



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!



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1 Safety instructions

It is strongly recommended to read the operator's manual before operation.

Warning!



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!

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 residual voltages can be present for long time periods. These residual voltages can lead to severe injuries.

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!

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

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

Warning!



High voltage power supplies of the device class HPS, 350 W, COMPACT are supplied from single phase mains voltage and generate an output voltage up to 70 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 with not less than 6.3 A, with slow delay.

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

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.

An air flow rate of 70 m³/h has to be guaranteed under any circumstances. Therefore do not cover any air input or output slots.

The unit is prepared to be mounted into a 19"-cabinet with help of screws on the fastening points (thread M4, thread length 5 mm). In this case the necessary air flow conditions through the according air input and output slots have to be guaranteed.

If the unit will be used as desk top instrument then the enclosed unit bases have to be glued on the bottom in order to guarantee a certain distance to the desk.

The unit can be operated with an ambient temperature of 0°C to 50°C.

Warning!



When operating with an ambient temperature above 35°C the temperature of the mains switch and the front panel may rise above 45°C!

2 Device description

2.1 Short description

High voltage power supplies of the device class HPS, 350 W, COMPACT are supplied from single phase mains voltage and generates an output voltage up to 70 kV as well as an output current up to 350 mA.

The device can be controlled via:

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

Main characteristics:

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

2.2 Technical Data

Table 2.1: Technical data, device class

Device class HPS, 350 W, COMPACT										
Output power P_{nom} [kW]	350									
Typ	HPX ¹⁾ 10 357 351_G11	HPX ¹⁾ 20 177 351_G11	HPX ¹⁾ 30 127 361_G11	HPX ¹⁾ 50 706 351_G11	HPX ¹⁾ 80 456 361_G11	HPX ¹⁾ 100 356 351_G11	HPX ¹⁾ 150 236 351_G31	HPX ¹⁾ 200 186 361_G31	HPX ¹⁾ 250 146 351_G31	HPX ¹⁾ 300 126 361_G31
Output voltage V_{nom} [kV]	1	2	3	5	8	10	15	20	25	30
Output current I_{nom} [mA]	350	175	120	70	45	35	23	18	14	12
HV-connector	GES HB 11 T						GES HB 31 T			
Typ	HPX ¹⁾ 400 905 361_E70			HPX ¹⁾ 500 705 351_E70			HPX ¹⁾ 600 605 361_E70		HPX ¹⁾ 700 505 351_E70	
Output voltage V_{nom} [kV]	40			50			60		70	
Output current I_{nom} [mA]	9			7			6		5	
HV-connector	iseq special connector									
Polarity	¹⁾ x = n → negative or ¹⁾ x = p → positive									
Efficiency	> 90% ($V_{IN} = 230\text{ V}$, P_{NOM})									
Option capacitor charger (CLD)	Very low output voltage overshoot									
Ripple and noise (standard) (option CLD)	Voltage control: $\Delta V < 0,2\% * V_{NOM}$ ¹⁾ $\Delta V < 2,5\% * V_{NOM}$ ¹⁾									
Stability	$\Delta V < 0,05\% * V_{NOM}$ (for 8 h with constant conditions, after ½ h warmup)									
Voltage regulation (standard) (option CLD)	$\Delta V < 0,02\% * V_{NOM}$ (ΔV_{IN} , $0 \leq I_{OUT} \leq I_{NOM}$), für $5\text{ V} \leq V_{OUT} \leq V_{NOM}$ $\Delta V < 0,1\% * V_{NOM}$ (ΔV_{IN} , $0 \leq I_{OUT} \leq I_{NOM}$), für $5\text{ V} \leq V_{OUT} \leq V_{NOM}$									
Current regulation	$\Delta i < 0,2\% * I_{NOM}$ (ΔV_{IN} , $0 \leq V_{OUT} \leq V_{NOM}$), für $5\text{ V} \leq V_{OUT} \leq V_{NOM}$									
Accuracy	voltage: $< (0,5\% * V_{OUT} + 0,3\% * V_{NOM})$ for one year current: $< (0,1\% * I_{OUT} + 0,05\% * I_{NOM})$ for one year									
Temperature coefficient	$< 2 * 10^{-4} / K$ ¹⁾									
Control (local)	Front panel operation via rotary encoder and display (LCD)									

Table 2.2: Continuation: technical data, device class

Device class HPS, 350 W, COMPACT		
Remote control (all interfaces are electrically isolated)	USB	Via USB Interface
	CAN	Via CAN Interface ²⁾
	RS232	optional via RS232 Interface ²⁾
	Ethernet	optional via Ethernet Interface ²⁾
Supply	$V_{in} = 85 \text{ V} - 264 \text{ V} - \text{AC}$ (PFC up to 255 V) $I_{in} < 5 \text{ A}$ ($V_{in} = 85 \text{ V}$, P_{NOM}) Line frequency $47 \text{ Hz} < f < 63 \text{ Hz}$ Internally fused with 2 x 6,3 A with a slow characteristic Inrush current internally limited to ca. 10 A	
Cooling	Forced cooling: 2-stage with integrated fan ($\leq 70 \text{ m}^3/\text{h}$)	
Monitoring	ARC, line voltage, auxiliary voltage, over voltage, temperature, Interlock	
ARC-Management with adjustable parameters	ARC-Number, ARC-Time	
Working conditions	Temperature: 0 °C bis 50 °C Humidity: 20 % bis 90 %, no condensation	
Storage conditions	Temperature: -20 °C bis 80 °C Humidity: 20 % bis 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)	
Dimensions, Weight	254 / 107 / 280 mm, 6 kg	
Charge frequency (Standard)	$V_{nom} \leq 50 \text{ kV}$: 1 Hz $V_{nom} 60, 70 \text{ kV}$: 0,8 Hz $V_{nom} \leq 70 \text{ kV}$: 2 Hz	
(Option CLD)		

¹⁾ other values on request

²⁾ not all interfaces can be combined

2.3 Electrical wiring of the high voltage output

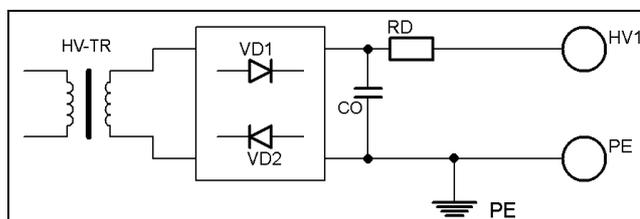


Figure 2.1: Electrical wiring of the high voltage output

2.4 Dimensions

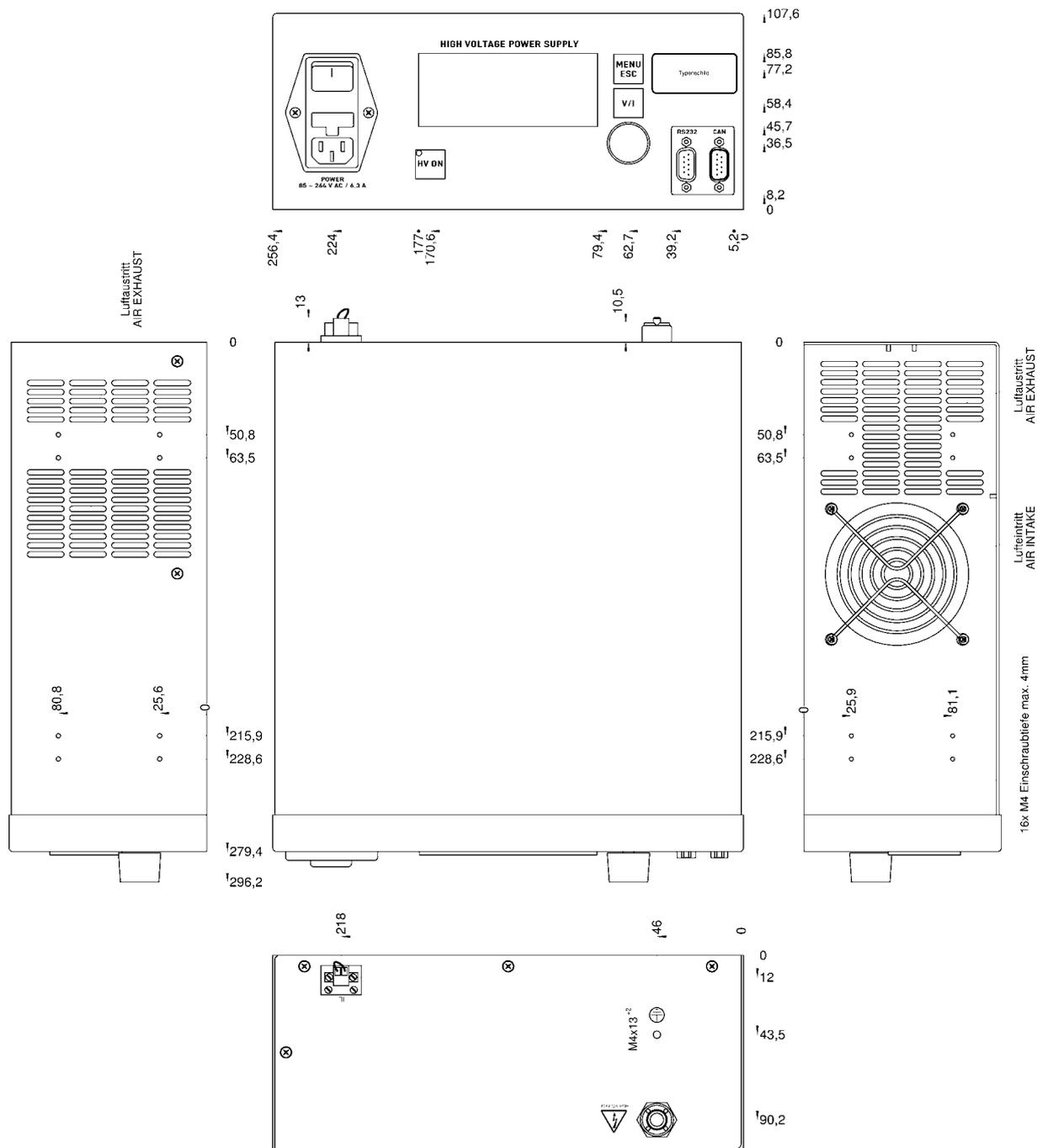


Figure 2.2: Dimensioned drawing (in mm)

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.

Attention!



If input voltage is higher than 255 V, the PFC is working as a rectifier only and power consumption is not sinusoidal in this case. If input voltage is lower than 100 V either output power or ambient temperature have to be decreased (Figure 3.2).

The PFC provides a DC link voltage, which 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.

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 adjustable parameters is installed in the power supply. The ARC-management parameters can be set via the digital interfaces or the front panel.

3.1 Operating states

Figure 2.1 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 its set value under the condition measured output current (I_{MEAS}) < set value output current (I_{SET}).

2. Constant current control CC :

Control of output current according to its set value under the condition measured output voltage (V_{MEAS}) < set value output voltage (V_{SET}).

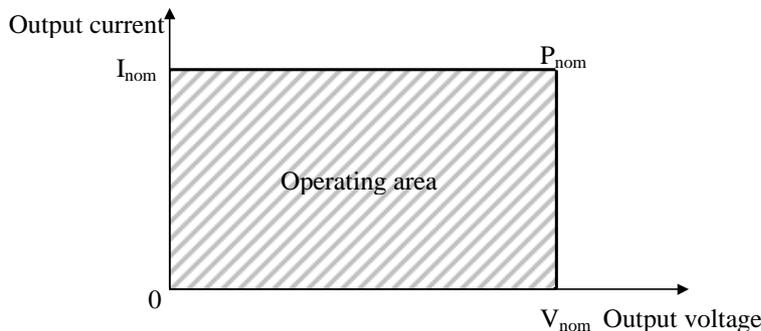


Figure 3.1: Operating area of the device

The unit has the following special operating states.

Table 3.1: Description special operating states

Function	Description
Voltage Ramp	All changes between voltage set values and turn on resp. off the high voltage are performed with the programmed 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: $0 \leq V_{SET} \leq V_{LIM} \leq V_{NOM}$ 2. If the measured voltage exceeds the limit value by two percent, the ChannelEventStatus bit EventVoltageLimit is set: $V_{MEAS} \geq 1.02 \cdot V_{LIM}$ The display shows "VLIM" in the status bar.
Current Limit ILIM	The current limit is separated into two functions: 1. Limit the current set value to the limit: $0 \leq I_{SET} \leq I_{LIM} \leq I_{NOM}$ 2. If the measured current exceeds the limit value by two percent, the ChannelEventStatus bit EventCurrentLimit is set: $I_{MEAS} \geq 1.02 \cdot I_{LIM}$ 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: $I_{MEAS} \geq I_{SET}$ 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 Operating mode

LOCAL

The device can be controlled with the buttons and the rotary encoder of the front panel. The display shows „LOC“.

REMOTE

The device switches to REMOTE mode when receiving the first command from a digital interface. The display shows the corresponding digital interface „USB“, „ETH“, „CAN“ or „232“.

3.3 Monitoring

Voltage

The dc link voltage and the auxiliary voltages are monitored. If one of these voltages is out of it's limits, the high voltage generation is stopped and an error is generated (section 9.1).

If the line voltage is smaller than $95 V_{AC}$, the output power has to be reduced, Figure 3.2, otherwise the dc link voltage will be reduced. The reduction of the dc link voltage will be handled as an error (section 9.1) and the high voltage generation is stopped.

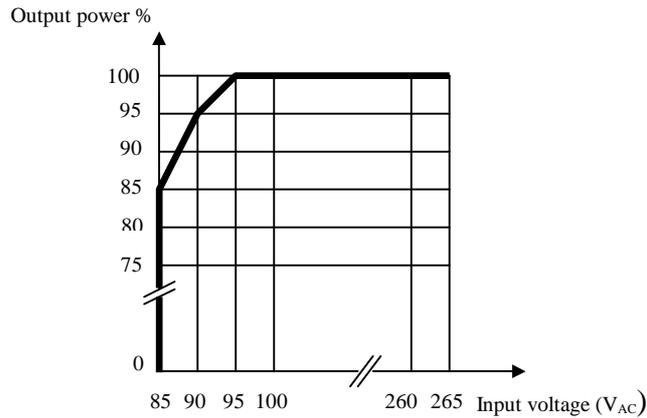


Figure 3.2: Power reduction vs. input voltage

Temperature

Temperature is monitored at several points within the unit. High voltage generation is stopped in case of external air temperature exceeds 50°C or internal temperature of several modules exceeds a predefined limiting value.

In this case an error is generated (see section 9.1).

3.4 ARC-Management

The HV power supply is equipped with an ARC Management with adjustable parameters. The ARC Management can be adjusted with the front panel or with the digital interfaces.

An ARC is defined, if the output current $I_{OUT} \geq 1.5 \cdot I_{SET}$.

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

1. KillEnable active
 - High voltage shuts down after the first ARC
2. Enable ARC counting
 - The high voltage is restored immediately after every ARC,
 - The ARCs are counted,
 - The high voltage is shut down if the allowed number of ARCs (ARC-Number) in a specific time (ARC-Time) is exceeded
 - In this case the ChannelEventStatus Bit EventArcError is set

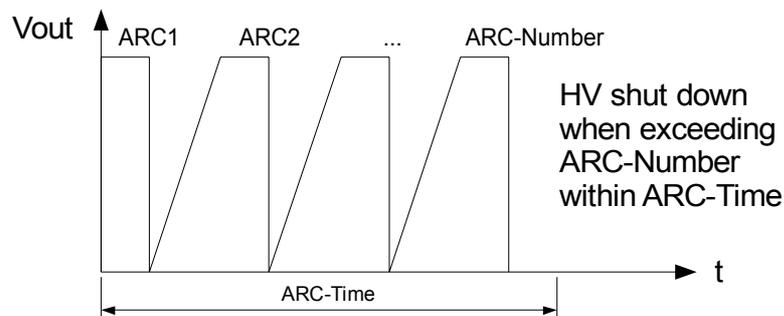


Figure 3.3: enable ARC counting

3. Disable ARC counting

- High voltage is shut down after every ARC,
- After the ARC wait time ARC-Wait high voltage is ramped to the set voltage with the ARC-Ramp,
- RC-Wait and ARC-Ramp are factory fixed to avoid damage due to permanent ARCs

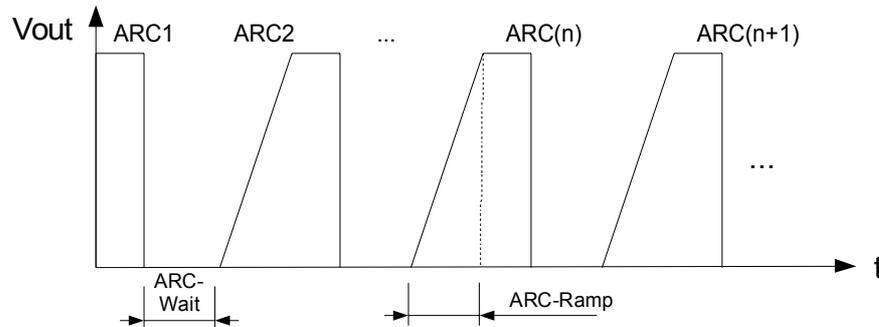


Figure 3.4: disable ARC counting

The factory settings of the ARC Management are:

Table 3.2: Factory settings of the ARC Management.

ARC counting	Disabled
ARC-Number	1
ARC-Time	Depends on the nominal output voltage (typical: < 10 s)
ARC-Wait	Depends on the nominal output voltage (typical: < 1 s)
ARC-Ramp	Depends on the nominal output voltage (typical: $5V_{nom}/s$)

3.5 Interlock

The power supply is equipped with a connector “IL” for a hardware safety loop (interlock, maximum cross section area 1.5mm²) 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. (section 9.1).

4 Pinout

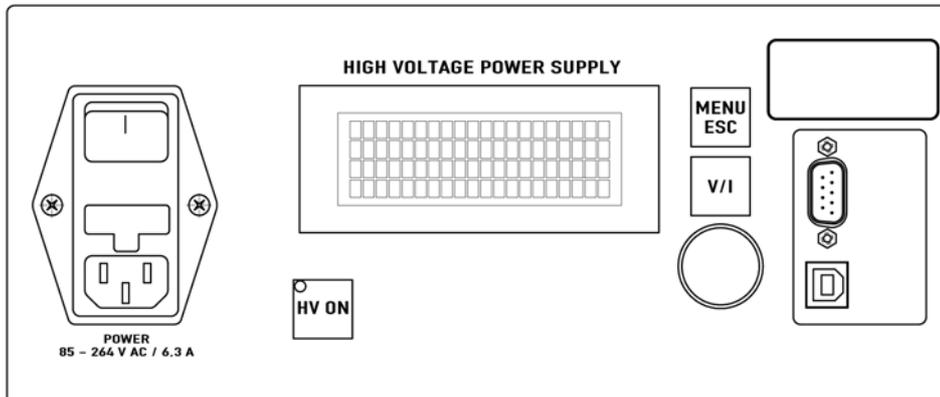


Figure 4.1: Front panel of the device

4.1 Supply

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

4.2 HV connection

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 residual voltages can be present for long time periods. These residual voltages can lead to severe injuries.

The HV connection is on the back panel of the device. The HV cable has to be connected to the load properly and isolated according to proof-voltage.

4.3 Return connection (HV ground)

The shield of the HV cable is always connected to the housing. It will be used as return. Additionally there is grounding bolt installed at the back panel of the device (M4).

4.4 USB - / RS-232 - connection

See section 6.1 Description of the RS-232- / USB

4.5 IL connection

See section 3.5 Interlock

4.6 CAN connection

see section 6.2 Description of the CAN

4.7 Ethernet connection

see section 6.3 Description of the Ethernet interface

5 Front panel operation

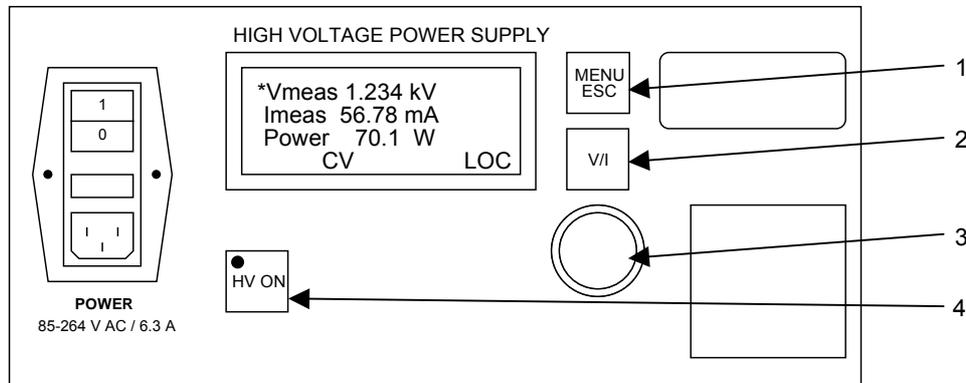


Figure 5.1: Front panel with rotary encoder and display (LCD)

After closing the mains switch the device is booting and the integrated hardware is initialised. The device is now working in LOCAL mode.

The device can be controlled with the buttons (1), (2), (4) and the rotary encoder (3). The status bar of the display shows "LOC". Button (2) V/I switches between setting of voltage and current. Standard value is voltage. The selected value is marked with * on display. The set value is changed with the rotary encoder. Button (4) HV ON is used to switch on the voltage.

Warning!



The output voltage will ramp with the specified ramp speeds (voltage, current ramp) to the selected set voltage. Factory setting for the voltage ramp speed is $0.2 \cdot V_{NOM}$ per second and $100 \cdot I_{NOM}$ per second for the current ramp speed.

By pressing the button (4) HV ON again high voltage generations is turned off. The high voltage ramps down with the specified voltage ramp speed.

5.1 Display

The unit is equipped with a four line display showing voltage, current, measured power, the operating mode and status information.

If HV is OFF, the set values VSET (voltage set) and ISET (current set) are shown. A change of these values with the rotary encoder can be seen on the display immediately. Last set values are saved and loaded after power on.

By pressing the V/I button, the star * changes between VSET and ISET. The value with the star next to it will be changed by the rotary encoder.

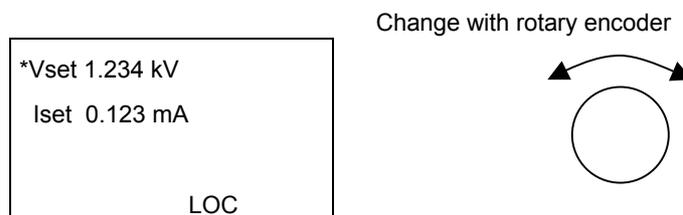


Figure 5.2: Set value of voltage and current

During high voltage generation, the measured values of voltage (V_{MEAS}) and current (I_{MEAS}) are displayed.

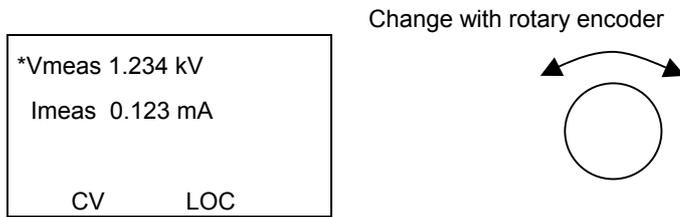


Figure 5.3: Display during high voltage generation

With a push on the rotary encoder the display switches to the set values for four seconds. If nothing is changed, the display switches to the measurement values again. It also switches back if the rotary encoder is pushed again.

If high voltage is turned off, the display shows measurement values as long as the ramping down is not finished. Four seconds after the ramp down is finished the display switches to the set values again.

5.2 Menu setting

Menu is chosen with the button Menu/ESC on front panel. Menu items are changed with the rotary encoder. The chosen item is indicated with angle brackets (e.g. >Device settings<). With a push on the rotary encoder a menu item is chosen or a set value is accepted. Every level of the menu can be left with the button MENU/ESC. If MENU/ESC is pushed in main menu, the menu will be closed.

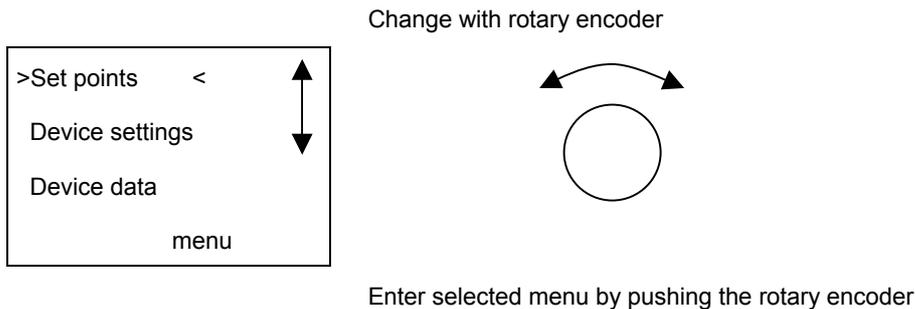


Figure 5.4: Visualization of the main menu

5.3 Menu structure

Main menu

Table 5.1: Main menu

Set points	Change of set values
Device settings	Change the unit preferences
ARC-Management	Change the ARC preferences
Device data	Display of unit data
Error List	Reserved for future use

By pressing the rotary encoder the selected submenu will be called.

Table 5.2: Submenu "Set points"

Vset	0.250 kV	Reserved for future use
Iset	100.0 mA	Reserved for future use
Vlim	4.000 kV	Change the voltage limit
Ilim	200.0 mA	Change the current limit
Vramp	0.800 kV/s	Change the voltage ramp speed
Iramp	200.0 mA/s	Change the current ramp speed
Kill	disable	Set the Kill-function enable/disable
Password		Not implemented yet

Table 5.3: Submenu "Device Settings"

CAN-Address	00	Set the devices CAN bus address 00 to 63
CAN-Bitrate	125	Set the devices CAN bus bitrate 125 or 250 kBit/s
Instruction	EDCP	Select the instruction set: EDCP (recommended), ET or SCPI
Factory Reset		Reset the device to factory settings
Password		Not implemented yet

Table 5.4: Submenu "ARC Management"

ARC Manag.	On	Enable ARC counting
ARC Number	4	Number of allowed ARCs (ARC-Number) during ARC-time (ARC-Time)
ARC Time	10000 ms	(fixed) ARC time
ARC Wait	1000 ms	(fixed) wait time ARC-Wait
ARC Ramp	500 %	(fixed), $5V_{NOM}/s$

Table 5.5: Submenu "Device Data"

Type: H600605p000...	Device type (full version by SCPI command *IDN?)
Sno.: 6500007	Device serial number
Rev.: 3.04	Device firmware version

This menu can only be left by push the button MENU/ESC.

6 Interface control

The device switches to REMOTE mode when receiving the first command from a digital interface. The display shows the corresponding digital interface „USB“, „ETH“, „CAN“ or „232“.

By pressing the MENU/ESC button the remote control is suspended and the device switches to “Local” state. The device can now be controlled via front panel. When receiving new commands via Interface, the device switches back to “Remote” state.

If the device is in “HV-ON” state via interface, high voltage can be turned off by pressing the ON/OFF button. In this case the device goes to “Local” state as well.

Warning! If local control is disabled (Local Lockout), the device can only be turned off via mains switch POWER!



While receiving or transmitting data via USB, RS-232 or Ethernet, the display shows Rx (Receiving) or Tx (Transmitting), respectively.

6.1 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 front 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 6.1.

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.

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

Table 6.1: Electrical wiring of the RS232 Interface

USB

The USB interface is realized with a female USB-B connector on the frontpanel. 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 6.2: Programming seriell interface

Befehl (mit Echo)	:VOLT 500;;VOLT ON;*OPC?<CR><LF>
Antwort	1<CR><LF>

6.2 Description of the CAN interface

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



The connector for the CAN interface (male D-SUB-9) is located at the front panel and has the following pinout:

Table 6.3: Pinout CAN interface

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

The CAN interface can be operated at the bitrates 125 or 250 kBit/s. All devices in a CAN network must be configured to the same bitrate. Furthermore, each device must be configured to a unique address in the range 0...63.

The device supports the iseg EDCP CAN command set, which is fully described in the manual

edcp_multi_channel_can.pdf.

The following software solutions for CAN control exists:

- iseg CAN Control
- iseg OPC Server
- iseg HAL (iseg Hardware Abstraction Layer)

6.3 Description of the Ethernet interface

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



The 100 MBit/s, full duplex Ethernet interface is connected via a RJ-45 socket at the front panel.

The device can be connected to a switch with a patch cable. If it shall be connected to a PC directly, a crossover cable has to be used. The configuration of the Ethernet interface is done with a web browser or the tools of Lantronix company:

<http://www.lantronix.com/support/downloads/?p=XPORT>.

Please change only the settings on the network page!

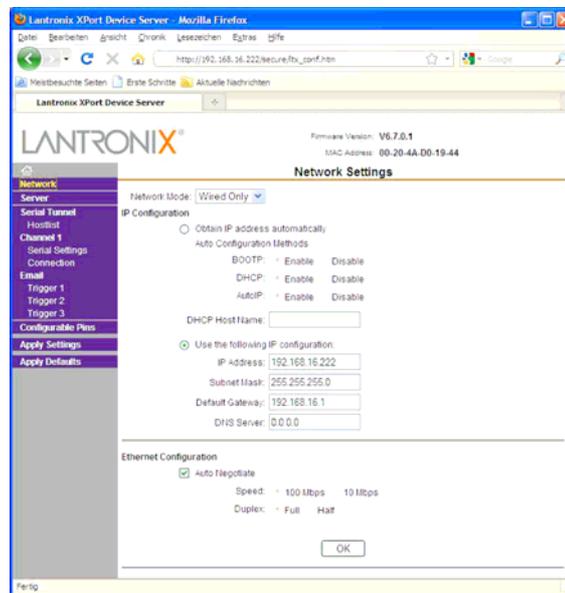


Figure 6.1: Ethernet configuration

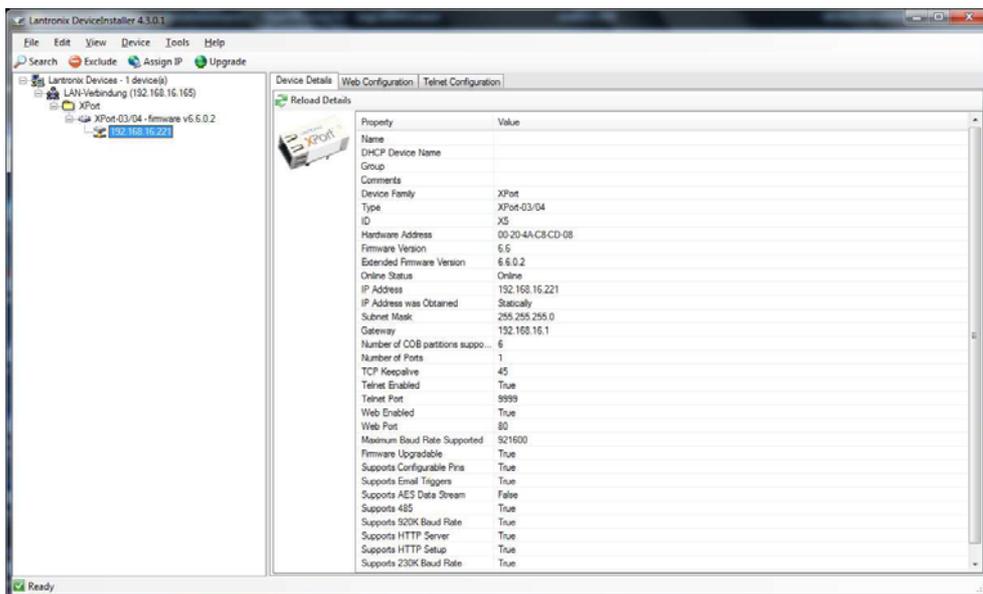


Figure 6.2: Lantronix configuration program

Factory Ethernet settings are shown in the following table:

Table 6.4: Factory Ethernet settings

IP-address	192.168.16.221
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 192.168.16.221
Ping will done for 192.168.16.221 with 32 bytes data:
Answer from 192.168.16.221: bytes=32 time=4ms TTL=128
Ping statistic for 192.168.16.221 :
Package: sent = 4, received = 4, lost = 0
Time in millisecond:
minimum = 1ms, maximum = 4ms, average = 1ms
```

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

Table 6.5: Principle sequence of communication between PC and 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[...]\r\n"
6	closesocket()	FIN, ACK	
7			FIN, ACK
8		ACK	

The first three packages establish a TCP-Connection between Computer and HV unit (three way handshake). Fourth step is the inquiry from PC to HV unit. The command 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

A simple programming example (without error handling) for communication with the HV device over Ethernet is provided. 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] = "";
    char             buf[255];
    char             *crlf;

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

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

    // bind socket to dynamic local 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 = 221;

    // 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
    do {
        retcode = recv(sock, buf, sizeof(ans), 0);
        if (retcode > 0) {
            buf[retcode] = 0;
            strcat(ans, buf);
        }
        crlf = strstr(ans, "\r\n");
    } while ( (retcode > 0) && (crlf == 0) );

    if (crlf > 0) {
        *crlf = 0;
    }

    // close socket (three way handshake) and clean up
    closesocket(sock);
    WSACleanup();
    printf("%s\n", ans);
    getchar();
    return 0;
}
```

7 SCPI command set with EDCP

7.1 Introduction

To use this command set, select "EDCP" in the menu or use the *INSTR command. (EDCP = Enhanced Device Communication Protocol). This command set is based on the iseg EDCP CAN Protocol with Status and Event handling. The Status and Event Status Fields are explained below the SCPI table.

By entering values (e.g. set voltage) it is not necessary to add the corresponding units. The response of the device always includes the unit.

Note! *Module is the description of the complete high voltage power supply. It may consist of several high voltage-channels, devices of the series HPS/LPS only have one high voltage channel.*



Table 7.1: SCPI command set with EDCP

Common Commands		
*IDN?		Query device identification
*CLS		Clear all events (module and channel)
*RST		Reset device to save values (Turn HV off with ramp, $V_{SET} = 0$, $I_{SET} = I_{NOM}$)
*LLO		Query operation complete status. Answer is "1" after all preceding commands are executed
*GTL		Local lockout (disable front panel buttons)
*INSTR?		Goto local (enable front panel buttons)
*INSTR,EDCP		Query current instruction set ("EDCP", "SCPI", "ET")
SCPI Commands		
:VOLTage		
	<Voltage>[V]	Set Channel Voltage
	:LIMit <Voltage>[V]	Set Voltage Limit
	:BOUnds <Voltage>[V]	Set Channel Voltage Bounds
	{ ON OFF }	Set Channel On / Off (with configured ramp speed)
	EMCY OFF	Shut Channel Emergency Off (without ramp) ¹
	EMCY CLR	Leave state emergency off ²
:CURRent		
	<Current>[A]	Set Channel Current
	:LIMit <Current>[A]	Set Current Limit
	:BOUnds <Current>[A]	Set Channel Current Bounds
:EVENt		
	CLEAR	Clear Channel Event Status
	:MASK <Word>	Set Channel Event Mask
:MEASure		
	:VOLTage?	Query Measured Channel Voltage (V)
	:CURRent?	Query Measured Channel Current (A)

^{1, 2} By shutting down the high voltage with :VOLT EMCY OFF, the channel stays in state emergency off. To turn on the high voltage again, the state emergency off must be leaved with :VOLT EMCY CLR. Next, the ChannelEventStatus bit EventEmergencyOff has to be cleared e. g. with *CLS.

Table 7.2: continuation command set with EDCP

:CONFigure		Set/read module configuration
:RAMP		
	:VOLTage <RampSpeed>[V/s]	Set voltage ramp speed
	:CURRent <RampSpeed>[A/s]	Set current ramp speed
:Event		
	CLEAR	Clear the ModuleEventStatus register
	:MASK	Query the ModuleEventMask register
:KILL?		Query Module Kill Status
:KILL { 0 1 }		Set Kill Disable (0) or Kill Enable (1)
:AVERage?		Query number of steps of averaging of the measured values
:AVERage { 1 16 64 256 }		Set number of steps of averaging of the measured values. this setting will be stored in the EEPROM
:SERIAL		RS-232/USB Configuration
	:BAUDrate?	Query Serial Baudrate
	:ECHO?	Query Serial Echo
	:ECHO { 0 1 }	Set Serial Echo Off (0) or Echo On (1)
:CAN		
	:ADDRess?	Query CAN Address
	:ADDRess { 0...63 }	Set new CAN Address
	:BITrate?	Query CAN Bitrate
	:BITrate {125000/250000}	Set new CAN Bitrate
:ARC		ARC Management configuration
	:CONTRol?	Query the ARC Management operation mode
	:CONTRol { 0 1 }	disable ARC counting (0) or enable ARC counting (1)
	:NUMber?	Query the number of allowed ARCs
	:NUMber { 1...n }	Set the number of allowed ARCs
	:TIME?	Query the configured ARC-Time
	:RAMP?	Query the configured ARC-Ramp
:SYStem		
	:USER	
	:CONFig <SerialNumber>	Enable configuration mode (to set CAN-Adress and –Bitrate). Only possible, if HV generation is turned off.
	:CONFig 0	Exit configuration mode
	:CONFig?	1 if configuration mode is enabled, otherwise 0

Table 7.3: continuation command set with EDCP

:READ		
	:VOLTage?	Query Set Voltage (V)
	:LIMit?	Query Voltage Limit (V)
	:NOMinal?	Query Nominal Voltage (V)
	:BOUnds?	Query Voltage Bounds (V)
	:CURRent?	Query Set Current (A)
	:LIMit?	Query Current Limit (A)
	:NOMinal?	Query Nominal Current (A)
	:BOUnds?	Query Current Bounds (A)
:RAMP		
	:VOLTage?	Query Voltage Ramp Speed (V/s)
	:CURRent?	Query Current Ramp Speed (A/s)
:MODule		
	:STATus?	Query Module Status Word (section 7.5)
	:EVENt	
	:STATus?	Query Module Event Status (section 7.6)
	:MASK?	Query Module Event Mask
	:SUPply?	Query Module Supply State (1 = good, 0 = not good)
	:TEMPerature?	Query measured Module Temperature (°C)
:CHANnel		
	:STATus?	Query Channel Status Word (section 7.3)
	:EVENt	
	:STATus?	Query Channel Event Status Word (section 7.4)
	:MASK?	Query Channel Event Status Mask
:FIRMware		
	NAME?	Query firmware name
	RELEase?	Query firmware version

7.2 Output formats for voltage and current:

Table 7.4: Output format for voltage

Vnominal	Output format for voltages
$100\text{ V} \leq V_{\text{nom}} < 1\text{ kV}$	123.456V
$1\text{ kV} \leq V_{\text{nom}} < 10\text{ kV}$	1.23456E3V
$10\text{ kV} \leq V_{\text{nom}} < 100\text{ kV}$	12.3456E3V

Table 7.5: Output format for current

Inominal	Output format for currents
$1\text{ mA} \leq I_{\text{nom}} < 10\text{ mA}$	1.23456E-3A
$10\text{ mA} \leq I_{\text{nom}} < 100\text{ mA}$	12.3456E-3A
$100\text{ mA} \leq I_{\text{nom}} < 1\text{ A}$	123.456E-3A
$1\text{ A} \leq I_{\text{nom}} < 10\text{ A}$	1.23456A

Examples:

Read Module-Identification:

```
*IDN?  
iseq Spezialelektronik GmbH,HPp 40 207,680001,5.24
```

Set Voltage to 1000.501 V:

```
:VOLT 1000.501
```

Set current to 1.58 mA:

```
:CURR 0.00158
```

Set voltage ramp speed 300 Volt per second:

```
:CONF:RAMP:VOLT 300
```

Advanced Examples:

Set and read back Voltage and Current:

```
:VOLT 2000.5; :READ:VOLT?; :CURR 0.2; :READ:CURR?  
2.00050E3V;200.000E-3A
```

Read actual measured Voltage and Current:

```
:MEAS:VOLT?; CURR?  
2.00028E3V;19.9973E-3A
```

7.3 Channel status (read access)

:READ:CHANnel:STATus?

Table 7.6: channel status register

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
isVoltageLimit	isCurrentLimit	isTrip	isExternal-Inhibit	isVoltage-Bounds	isCurrent-Bounds	isArcError	res
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
isConstant-Voltage	isConstant-Current	isEmergency-Off	isRamping	isOn	isInputError	isArc	res

The ChannelStatus register describes the actual status. Depending on the status of the channel the bits will be set or reset.

Table 7.7: Explanation of individual bits of the channel status Registers

Bit	Bit ist 1	Bit ist 0
isVoltageLimit	Voltage limit Vmax is exceeded	Voltage limit not exceeded
isCurrentLimit	Current limit Imax is exceeded	Current limit not exceeded
isTrip	High voltage has been shut down without ramp because voltage or current limit or current set has been exceeded in Kill-Enable	No Trip
isExternalInhibit	External Inhibit is active	No External Inhibit
isVoltageBounds	Voltage out of programmed bounds	Voltage is within programmed bounds
isCurrentBounds	Current out of programmed bounds	Current is within programmed bounds
isConstantVoltage	Voltage control active (evaluation is guaranteed when no ramp is running)	Voltage control not active
isConstantCurrent	Current control active (evaluation is guaranteed when no ramp is running)	Current control not active
isEmergencyOff	Emergency off without ramp	No Emergency Off
isOn	High voltage is actively generated or measured voltage is above 60 Volt	High voltage is not actively generated and measured voltage is below 60 Volt
isRamping	Ramp is running	No Ramp is running
isInputError	Input error	No Input error
res	Reserved	Reserved

7.4 ChannelEventStatus (read/write access)

:READ:CHANnel:EVent:STATus?

Table 7.8: Channel Event Status Register

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
EventVoltageLimit	EventCurrentLimit	EventTrip	EventExternalInhibit	EventVoltageBounds	EventCurrentBounds	EventArcError	res
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
EventConstantVoltage	EventConstantCurrent	EventEmergencyOff	EventEndOfRamp	EventOnToOff	EventInputError	EventArc	res

The ChannelEventStatus register describes the captured status. An event bit is set if the corresponding ChannelStatus bit is 1 or is changing to 1.

Different to the status bit an event bit isn't automatically reset. A reset has to be done by the user by writing an 1 to this event bit. All channel events can be cleared by :EVENT CLEAR. With the command *CLS the ModuleEventStatus and the ChannelEventStatus registers are cleared at once.

Table 7.9: Explanation of individual bits of the channel event status registers

Bit	Event description
EventVoltageLimit	Voltage limit has been exceeded
EventCurrentLimit	Current limit has been exceeded
EventTrip	High voltage was shut down without ramp in Kill-Enable because the voltage or current limit or current set value was exceeded
EventExternalInhibit	An external inhibit was or is active
EventVoltageBounds	Voltage bounds has been exceeded
EventCurrentBounds	Current bounds has been exceeded
EventArcError	The number of allowed ARCs was exceeded. High voltage was turned off
EventConstantVoltage	Channel was or is in constant voltage control
EventConstantCurrent	Channel was or is in constant current control
EventEmergencyOff	High voltage was shut down without ramp by emergency off
EventEndOfRamp	End of ramp
EventOnToOff	High voltage was shut down without ramp
EventInputError	An input error occurred
EventArc	At least one ARC occurred
res	Reserved

If one of the ChannelEventStatus Bits EventVoltageLimit, EventCurrentLimit, EventTrip, Event-ExternalInhibit, EventVoltageBounds, EventCurrentBounds, EventArcError or EventEmergency is set, it prevents turning on the high voltage again until the bit is cleared.

7.5 ModuleStatus (read access)

:READ:MODule:STATus?

Table 7.10: Module Status Register

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
isKillEnable	isTemperatureGood	isSupplyGood	isModuleGood	isEventActive	isSafetyLoopGood	isNoRamp	isNoSumError
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	isInputError	res	isService	isHighVoltageOn	res	res	isFineAdjust

The ModuleStatus register describes the actual status for the complete device.

Table 7.11: Explanation of the individual bits of the module status Registers

Bit	Bit ist 1	Bit ist 0
isKillEnable	Module is in state Kill enable	Module is in state Kill disable
isTemperatureGood	Module temperature is above 55 °C	Module temperature is below 55 °C
isSupplyGood	Power supply is good	Power supply is not good
isModuleGood	Module status is good	Module status bad
isEventActive	At least one masked event is active	No masked event is active
isSafetyLoopGood	Interlock (Safety loop) is closed.	High voltage can be generated
isNoRamp	Interlock (Safety loop) is open.	No high voltage generation is possible
isNoSumError	All channels are stable, no ramp is running	At least one channel is ramping
isInputError	No sum error active	Sum error active
isService	An input error occurred	No input error
isHighVoltageOn	Hardware failure detected. Contact manufacturer	No Hardware failure
isFineAdjust	High voltage is actively generated or measured voltage is above 60 Volt	High voltage is not actively generated and measured voltage is below 60 Volt
res	Adjustment is on	Adjustment is off

7.6 ModuleEventStatus (read/write access)

:READ:MODule:Event:STATus?

The ModuleEventStatus register describes the captured status for the complete device.

Depending on the status of the module the bits will be set but not reset. A reset has to be done by the user by writing an 1 to this event bit. All events in this register can be cleared by :CONFIGURE:EVENT CLEAR. With the command *CLS the ModuleEventStatus and the ChannelEventStatus registers are cleared at once.

Table 7.12: Module Event Status Register

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
res	EventTemperatureNotGood	EventSupplyNotGood	res	res	EventSafetyLoopNotGood	res	res
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	EventInputError	res	res	EventService	res	res	res

Table 7.13: Explanation of the individual bits of the module status event Registers

EventTemperatureNotGood	Temperature is or was above 55 °C
EventSupplyNotGood	At least one of the supplies is or was not good
EventSafetyLoopNotGood	Safety loop is or was open
EventService	A hardware failure of the device has been detected. Contact the manufacturer..
Reserved	res
EventInputError	An input error occurred

All events bits except input error prevents turning on the high voltage again until the bit is cleared.

8 Further Command Sets

Note! The device is compatible with further command sets (ET command set, SCPI command set old). More Information about this command sets can be requested from iseg Spezialelektronik GmbH. These command sets will not be updated, e.g. parameterization of the ARC management.



9 Error

9.1 Error acknowledgement

With the following options an error event can be reset or acknowledged:

- By pressing the button MENU/ESC at the front panel (section 5.1) or
- Via the digital interfaces with the command *CLS (section 7.1)

9.2 Error messages on the LC-Display

Table 9.1: Error messages on the LC-Display

Error messages during operation	
Display:	Explanation:
ILK	Safety loop (Interlock) is not closed. No high voltage generation possible.
TEMP	High voltage has been shut down because of over temperature
SPLY	Auxiliary voltage or DC link voltage exceeds its lower or upper threshold
VLIM	Voltage limit V_{LIM} exceeded
ILIM	Current limit I_{LIM} exceeded
ARC	Predefined number of ARCs exceeded
EMCY	High voltage has been shut down with Emergency Off
TRIP	Set current exceeded in mode Kill Enable. High voltage is shut down.

9.3 Further Errors

Table 9.2: Further Errors

Unit does not provide output voltage and the fans are not working	⇒	- Check supply voltage and connection
Unit does not provide output voltage but the fans are working.	⇒	- Check supply voltage - Check environmental temperature ($T_U \leq 50^\circ\text{C}$) - 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.

10 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.