Via Acquanera, 29 22100 COMO
tel. 031.526.566 (r.a.) fax 031.507.984
info@calpower.it www.calpower.it

high voltage iseg Spezialelektronik GmbH

# Operator's Manual

## High Voltage Power Supply of the Device Class

## HPS, 350 W, COMPACT

iseg Spezialelektronik GmbH
Bautzner Landstr. 23
D - 01454 Radeberg/ Rossendorf

Email: sales@iseg-hv.de
http://www.iseg-hv.com

Tel ++ 49 (0)351 / 26 996 - 0
Fax ++ 49 (0)351 / 26 996 - 21

## 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.**

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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 residiual voltages can be present for long time periods. These residiual 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 | iseg special connector | | | | | | | | | |
| Polarity | $^{)1}$x = n → negative or $^{)1}$x = p → positive | | | | | | | | | |
| Efficiency | > 90% ($V_{IN}$ = 230 V, $P_{NOM}$) | | | | | | | | | |
| Option capacitor chargerr (CLD) | Very low output voltage overshoot | | | | | | | | | |
| Ripple and noise (standard)<br>(option CLD) | Voltage control: $\Delta v < 0{,}2\ \% * V_{NOM}$ [1)]<br>$\Delta v < 2.5\ \% * V_{NOM}$ [1)] | | | | | | | | | |
| Stability | $\Delta v < 0{,}05\% * V_{NOM}$ (for 8 h with constant conditions, after ½ h warmup) | | | | | | | | | |
| Voltage regulation (standard)<br>(option CLD) | $\Delta v < 0{,}02\ \% * V_{NOM}$ ($\Delta v_{IN}$, $0 \le I_{OUT} \le I\ V_{NOM}$), für $5\ V \le V_{OUT} \le V_{NOM}$<br>$\Delta v < 0{,}1\ \% * V_{NOM}$ ($\Delta v_{IN}$, $0 \le I_{OUT} \le I_{NOM}$), für $5\ V \le V_{OUT} \le V_{NOM}$ | | | | | | | | | |
| Current regulation | $\Delta i < 0{,}2\ \% * I_{NOM}$ ($\Delta v_{IN}$, $0 \le V_{OUT} \le V_{NOM}$) , für $5\ V \le V_{OUT} \le V_{NOM}$ | | | | | | | | | |
| Accuracy | voltage: < (0.5 % ∗ $V_{OUT}$ + 0.3 % ∗ $V_{NOM}$) for one year<br>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 V - 264 V – AC (PFC up to 255 V)<br>$I_{in}$ < 5 A ($V_{in}$ = 85 V, $P_{NOM}$)<br>Line frequency 47 Hz < f < 63 Hz<br>Internally fused with 2 x 6,3 A with a slow characteristic<br>Inrush current internally limited to ca. 10 A |
| Cooling | | Forced cooling: 2-stage with integrated fan (≤ 70 m³/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<br>Humidity: 20 % bis 90 %, no condensation |
| Storage conditions | | Temperature: -20 °C bis 80 °C<br>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)<br>(Option CLD) | | $V_{nom}$ ≤ 50 kV: 1 Hz<br>$V_{nom}$ 60, 70 kV: 0,8 Hz<br>$V_{nom}$ ≤ 70 kV: 2 Hz |

[1)] other values on request

[2)] not all interfaces can be combined

## 2.3 Electrical wiring of the high voltage output

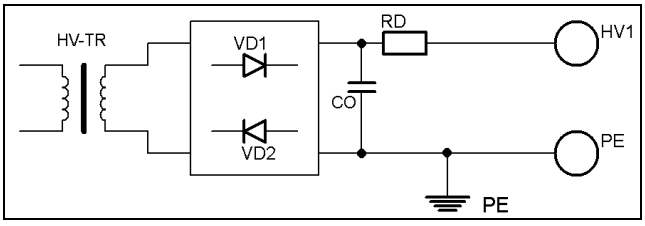


Figure 2.1: Electrical wiring of the high voltage output

## 2.4 Dimensions

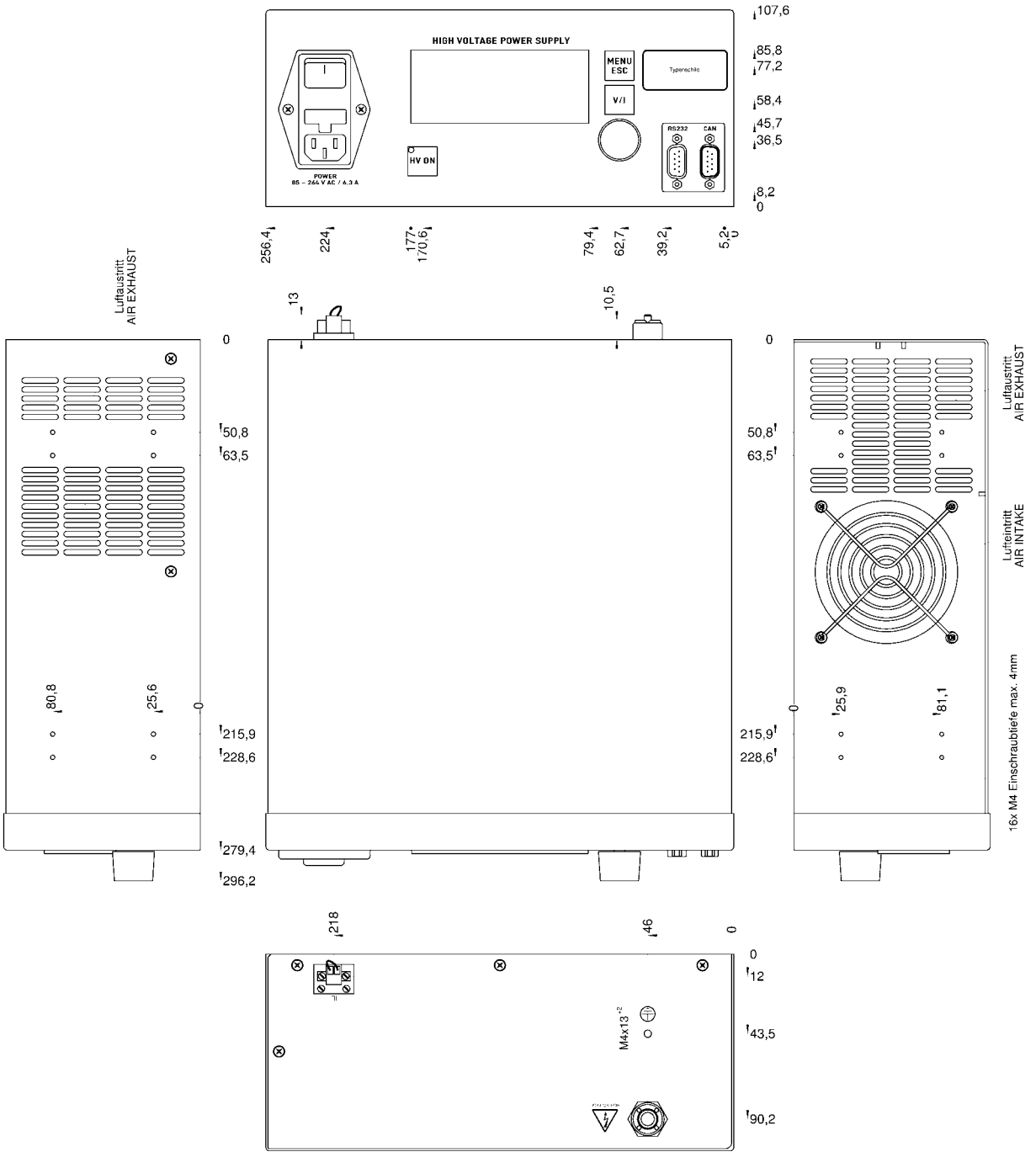


Figure 2.2: Dimensioned drawing (in mm)

# 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.

**Atention!** **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 ($V_{SET}$).

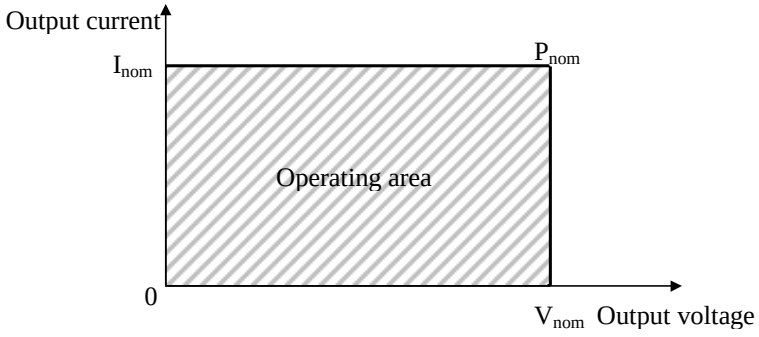


Figure 3.1: Operating area of the device

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:<br>1. Limit the voltage set value to the limit value: $0 \le V_{SET} \le V_{LIM} \le V_{NOM}$<br>2. If the measured voltage exceeds the limit value by two percent, the ChannelEventStatus bit EventVoltageLimit is set: $V_{MEAS} \ge 1.02 \cdot V_{LIM}$<br>The display shows "VLIM" in the status bar. |
| Current Limit $I_{LIM}$ | The current limit is separated into two functions:<br>1. Limit the current set value to the limit: $0 \le I_{SET} \le I_{LIM} \le I_{NOM}$<br>2. If the measured current exceeds the limit value by two percent, the ChannelEventStatus bit EventCurrentLimit is set: $I_{MEAS} \ge 1.02 \cdot I_{LIM}$<br>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.<br>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: $I_{MEAS} \ge I_{SET}$<br>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.<br>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 ouptut 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.

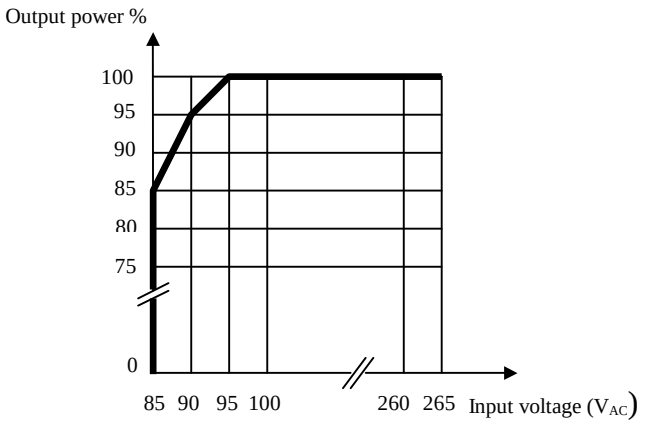


Figure 3.2: Power reduction vs. input voltage

**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

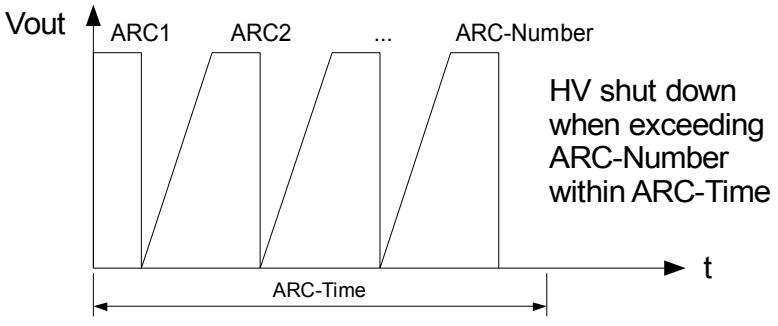


Figure 3.3: enable ARC counting

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

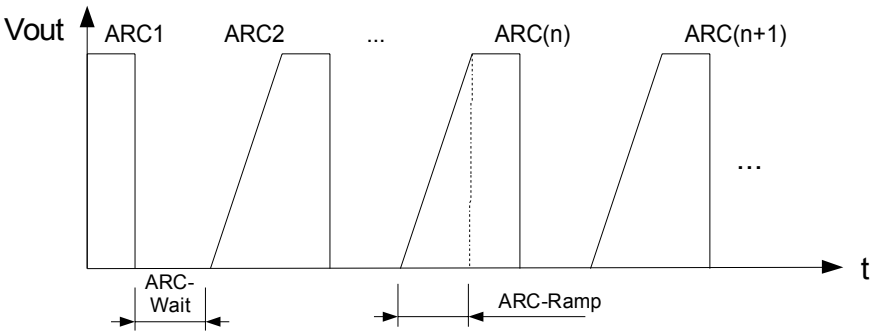


Figure 3.4: disable ARC counting

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: 5·$V_{nom}$/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

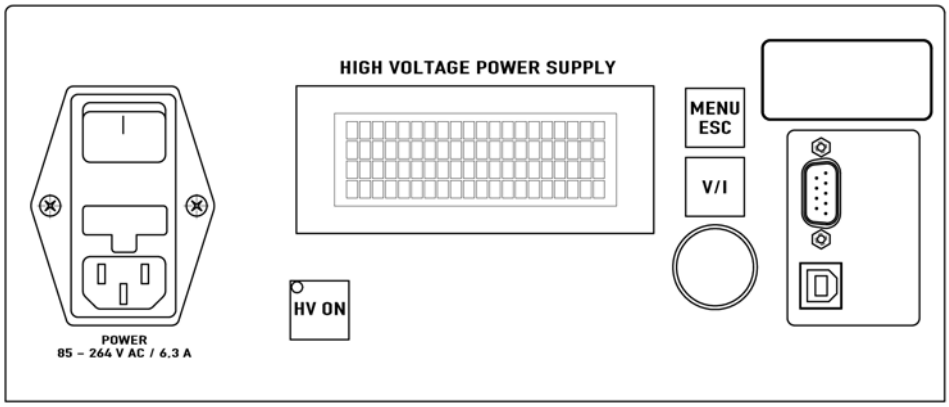


Figure 4.1: Front panel of the device

## 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 residiual voltages can be present for long time periods. These residiual 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

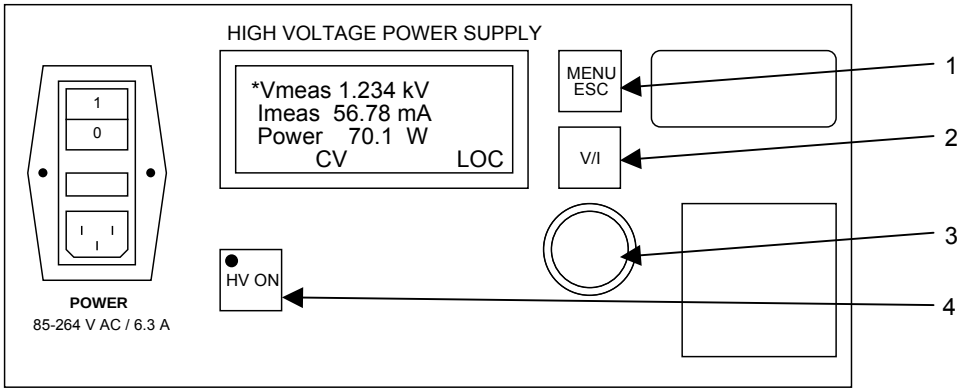


Figure 5.1: Front panel with rotary encoder and display (LCD)

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) U/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 • $V_{NOM}$ per second and 100 • $I_{NOM}$ 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.

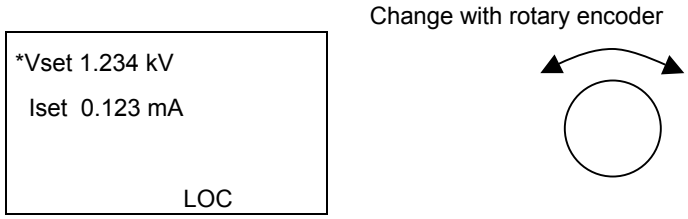


Figure 5.2: Set value of voltage and current

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

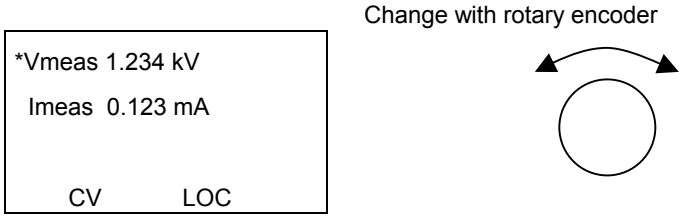


Figure 5.3: Display during high voltage generation

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.

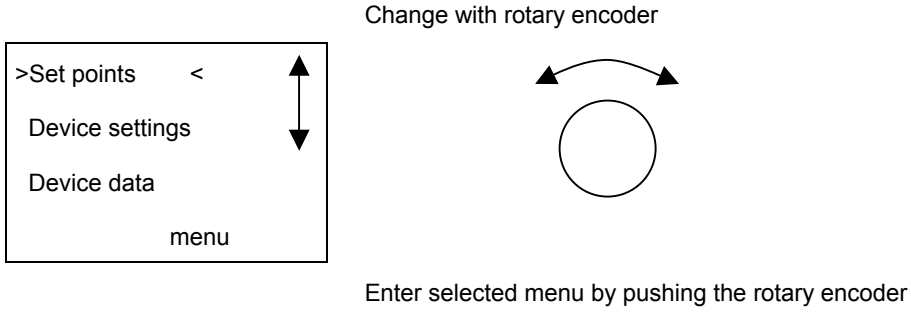


Figure 5.4: Visualization of the main menu

## 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), 5·$V_{NOM}$/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!

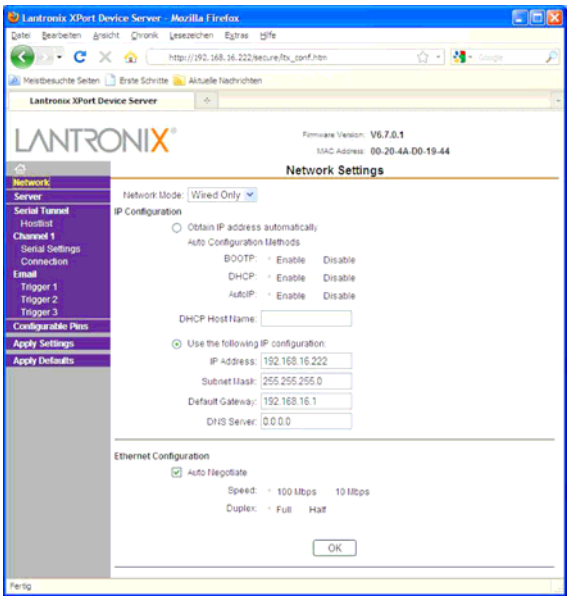


Figure 6.1: Ethernet configuration

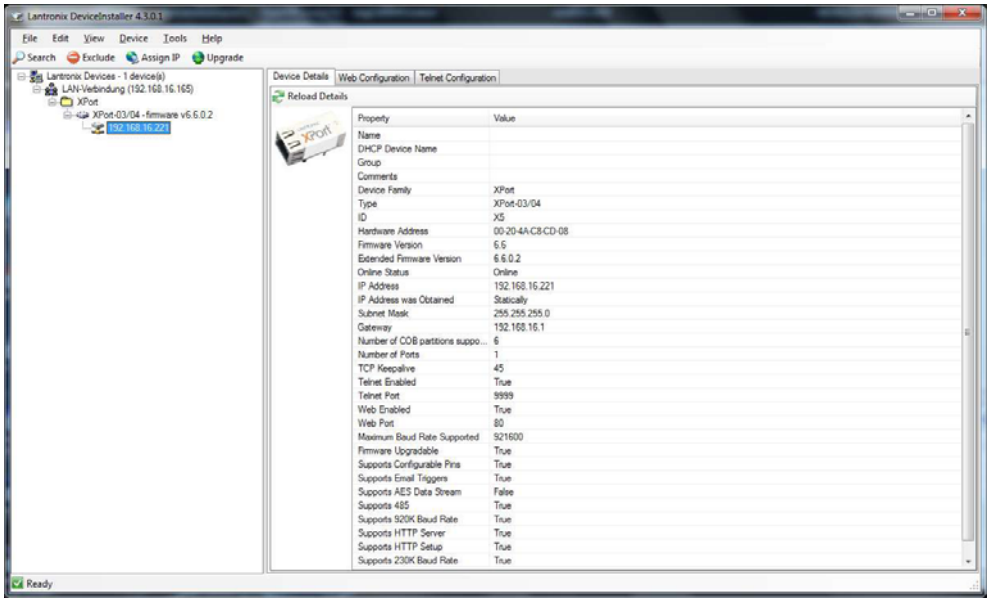


Figure 6.2: Lantronix configuration program


iseg Spezialelektronik GmbH
Bautzner Landstr. 23
D - 01454 Radeberg/ Rossendorf
Email: sales@iseg-hv.de
http://www.iseg-hv.com
Tel ++ 49 (0)351 / 26 996 - 0
Fax ++ 49 (0)351 / 26 996 - 21

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*
*Answer from 192.168.16.221: bytes=32 time=4ms TTL=128*
*Answer from 192.168.16.221: bytes=32 time=4ms TTL=128*
*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)
        WSAStartup(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<br>(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.<br>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<br>(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 V ≤ $V_{nom}$ < 1 kV | 123.456V |
| 1 kV ≤ $V_{nom}$ < 10 kV | 1.23456E3V |
| 10 kV ≤ $V_{nom}$ < 100 kV | 12.3456E3V |

Table 7.5: Output format for current

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

**Examples:**

*Read Module-Identification:*

```
*IDN?
iseg 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 | IsExtenal -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 cannel 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: Channal Event Status Register

| Bit15 | Bit14 | Bit13 | Bit12 | Bit11 | Bit10 | Bit9 | Bit8 |
|---|---|---|---|---|---|---|---|
| EventVoltage-Limit | EventCurent-Limit | EventTrip | EventExternal Inhibit | EventVolage-Bounds | EventCurent-Bounds | EventArcError | res |
| Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
| EventCostant-Voltage | EventCostant-Current | Event EmergencyOff | EventEnd-OfRamp | EventOnToOff | EventIput-Error | 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 cannel 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 | isTem-peratureGood | isSupplyGood | isModuleGood | isEventActive | isSafetyLoop-Good | isNoRamp | isNoSumError |
| Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
| res | isInputError | res | isService | isHigh-VoltageOn | 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 manufac-turer | 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 | EventTempera-tureNotGood | EventSupply NotGood | res | res | EventSafety-LoopNotGood | 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<br>- Check environmental temperature ($T_U \leq 50°C$)<br>- Check safety loop |
| External fuses trip during switch on. | ⇒ | - Use fuses with slow characteristic<br>(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.