Controller for Programmable High-Voltage Power Supplies

Firmware Version 1-00

User Manual

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Technical Data

Characteristics

- control of four independent high-voltage amplifiers and a dual high-voltage switching converter
- interlock: 2 independent loops, selectable per software
- memory data space: 1 MB

Human Interface

- monochrome LCD display 128x64 pixel
  pixel size: 0.5 mm
  pixel color: yellow, background: blue
  background illumination: white LED
- keypad: 5 keys: 4x direction + 1x "enter"
- rotary encoder: 24 positions per revolution, integrated press button
- optional external shutdown button via the interlock loop

Digital Interface

- USB interface according to USB 2.0 standard
  connector: USB plug type B
  data transfer rate: up to 12 MBit/s (*Full Speed*)
  effective data transfer rate: >100 kBit/s

Human Interface

The device is equipped with a graphic liquid crystal display (LCD), a set of keys (keypad) and a rotary encoder. The keys are arranged in a circle symbolizing the key function: There are four direction keys ("left", "right", "up", and "down") and a middle key for confirmation or selection ("enter").

The keys are used for menu navigation, for selecting dialog items, or for changing various values. The function of the keypad in every device state is symbolized on the LCD immediately above the keypad. A text describes the function of the middle key, alternatively just the symbol "↵" is displayed showing that the middle key can be used. Similarly, arrows show which of the keys has an influence on the operation in the current state. When a menu is active, the vertical direction keys are used to change the current selection. The right direction key as well the middle key opens a submenu, provided it is available. The left direction key closes the submenu or the main menu if there was no opened submenu. The middle key selects the menu item and launches the corresponding action.

The rotary encoder is used to change numerical values or select items. The function of the encoder is symbolized in every device state on the LCD immediately above the encoder knob. In most situations, the encoder uses an enhanced speed control. This enables you to set precisely any desired value or rapidly make large changes, since the value steps are proportional to the rotational speed of the encoder. You can change the corresponding value in small steps when you rotate the encoder slowly or make large changes when you spin the encoder knob rapidly. To set large numbers, the encoder speed can be further increased by pressing and holding the direction key "left". If this feature is available, the left arrow is shown above the keys. In some situations, the encoder's push button is used to reset the selected value or to switch the encoder function. In such cases, the symbol "⊡" is shown on the LCD above the encoder knob.

Main Program Menu

When the device starts, the initialization takes place and the manufacturer logo is shown for couple of seconds. Then, the device enters the idle state (see Fig. 2). The lower right corner shows the uptime, i.e. the time elapsed from the last device start.

Fig. 2. Program display in device idle state.

By pressing the middle key "enter", the main menu can be accessed (see Fig. 3). You can control the device (submenu "Control", see also section "Device Control"), setup the device settings (submenu "Setup", see also section "Device Setup"), monitor the device function (submenu "Monitor", see also section "Device Monitoring"), view the device state (submenu "View", see also section "Device State"), or manage the system settings (submenu "Adjustment").

You can save the current system settings (menu item "Adjustment ► Save"), load the settings back (menu item "Adjustment ► Load"), or reset them to default values (menu item "Adjustment ► Reset"). The system settings are saved automatically to a non-volatile memory when the device powers down and are loaded back when the device starts. You may save the settings using the main menu prior to the next device shutdown if you have made changes that you wish to keep permanently. When you choose to load the settings back, the settings will be reloaded and the last saved state will be restored, i.e. the settings will be set to the state immediately before the last shutdown or after the last startup, or to the state when you saved the settings. Further, you may reset the settings to their default values. This is advisable if you wish to restore the original device state.

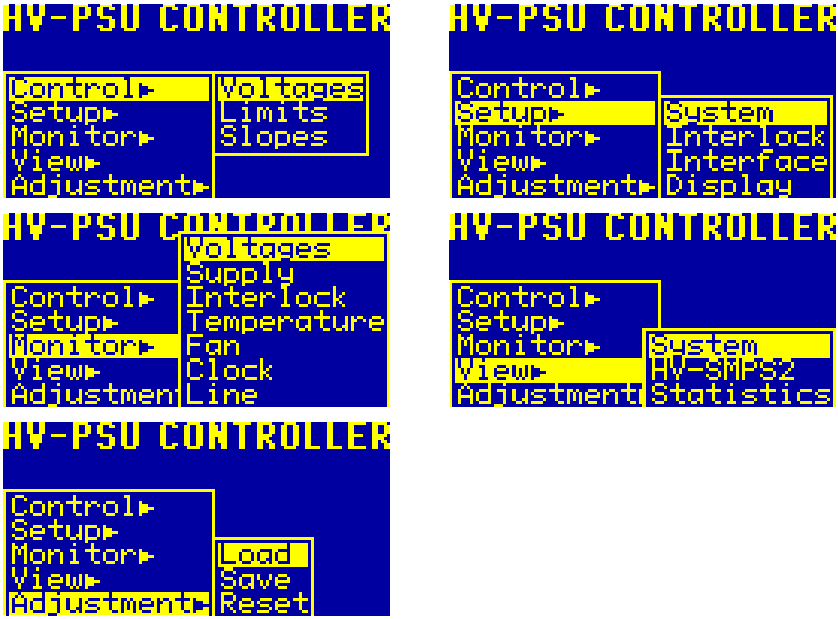

Fig. 3. Main program menu.
The figure shows the different submenus of the main program menu.

Device Control

Several dialog boxes are available to control the device.

Voltage Control

Using the dialog box "Voltage Control", you can set the output voltages and activate or deactivate the device (see Fig. 4).

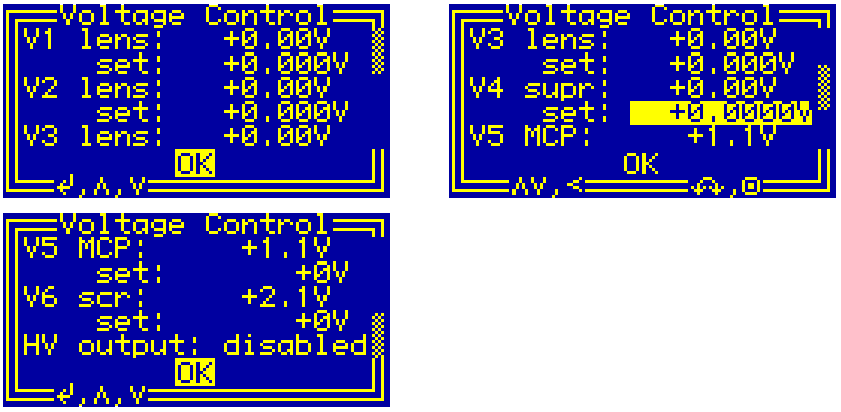

Fig. 4. Dialog box "Voltage Control".

The dialog box shows the measured values of the voltages and their set values in the second line labeled by "set". Use the vertical direction keys to change the currently selected item. The selected item is highlighted by inverting the displayed characters. By pressing the middle key "enter", the settings can by modified or the dialog box can be closed (see the selection shown at the left side of Fig. 4). The numerical values can be modified by the rotary encoder only. To be able to adjust large numbers, the voltage step may be increased by pressing and holding the direction key "left" when spinning the encoder. By pressing the encoder knob, the selected item can be reset to zero.

The item "HV output" shows the current device state (see Fig. 5). When the device is deactivated and no high-voltage can be produced, the text "disabled" is shown. When the device is activated, the high-voltages can be generated and the text "enabled" is displayed. By selecting the item "HV output" and pressing the middle key "enter", the device state can be toggled. Note that the device can be activated

only if the interlock loop is closed (see section "Interlock Setup") and no failure occurred. In this case, the device state cannot be changed and is permanently set to "disabled".

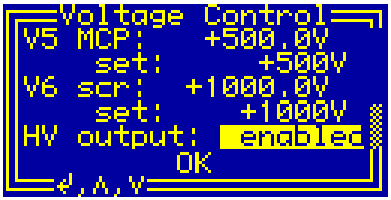

Fig. 5. Activating and deactivating the device in the dialog box "Voltage Control".

Voltage Limit Control

Using the dialog box "Limit Control", you can set the limits of the output voltages (see Fig. 6). The default values are the maximum design voltages of the respective channel. You can decrease them in order to protect the attached hardware. The settings are applied immediately and if necessary, the output voltages (see section "Voltage Control") are decreased accordingly.

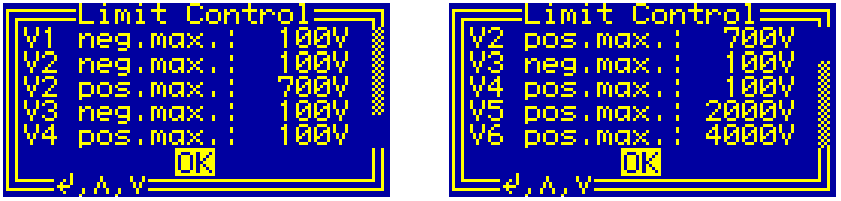

Fig. 6. Dialog box "Limit Control".

Use the vertical direction keys to change the currently selected item. The selected item is highlighted by inverting the displayed characters. By pressing the middle key "enter", the dialog box can be closed (see the selection shown in Fig. 6). The numerical values can be modified by the rotary encoder. By pressing the encoder knob, the selected item can be set to its default value.

Voltage Slope Control

Using the dialog box "Slope Control", you can set the voltage slopes (see Fig. 7). These values define the voltage ramp that is used if the output voltage is modified (see section "Voltage Control").

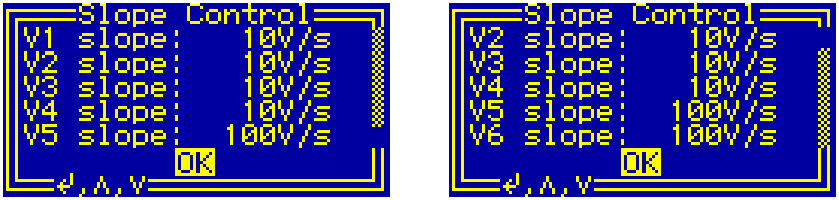

Fig. 7. Dialog box "Slope Control".

Use the vertical direction keys to change the currently selected item. The selected item is highlighted by inverting the displayed characters. By pressing the middle key "enter", the dialog box can be closed (see the selection shown in Fig. 7). The numerical values can be modified by the rotary encoder. By pressing the encoder knob, the selected item can be set to its default value.

Device Setup

System Preferences

The dialog box "System Preferences" (see Fig. 8) shows the current system settings and enables you to change them.

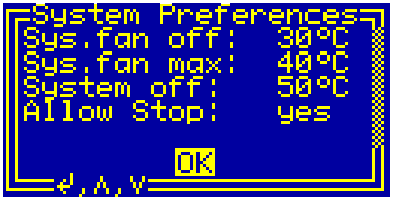

Fig. 8. Dialog box "System Preferences".

Use the vertical direction keys to change the currently selected item. The selected item is highlighted by inverting the displayed characters. By pressing the middle key "enter", the settings can by modified or the dialog box can be closed (see the selection shown in Fig. 8). The numerical values can be modified by the rotary encoder only. By pressing its knob, the selected item can be reset to its default value.

The values "Sys.fan off" and "Sys.fan max" define the temperature thresholds for the fan controller. If the temperature measured by the attached sensors is lower than the lower threshold "Sys.fan off", the fan rotates at its minimum speed. On the other hand, it rotates at its maximum speed if the measured temperature reaches the upper threshold "Sys.fan max".

The fan can be turned off if the corresponding item "Allow Stop" is set to "yes". The hysteresis is 1°C, i.e. the fan starts to rotate if the temperature exceeds the lower threshold but stops at a temperature lower by 1°C.

The function of the fan can be checked using the dialog box "Fan Monitor" (see section "Fan Monitor").

If the temperature exceeds the shutdown threshold "System off", the device is deactivated and overheating is signalized. The device can be activated again once the temperature has decreased below the shutdown threshold, the hysteresis is 1°C.

The threshold values can be changed using the rotary encoder. The minimum settable value is 20°C, the maximum is 60°C. The differences between the values must be at least 1°C.

Interlock Setup

The dialog box "Interlock Setup" (see Fig. 9) shows the current interlock settings and enables you to change them.

Fig. 9. Setting the interlock function in the dialog box "Interlock Setup".

Use the vertical direction keys to change the currently selected item. The selected item is highlighted by inverting the displayed characters. By pressing the middle key "enter", the settings can by modified or the dialog box can be closed (see the selection shown in Fig. 9).

If the selected value is enabled, the state of the corresponding interlock loop is evaluated. The interlock loop is assumed to be closed and the device can be activated, if all enabled loops are closed. The state of the interlock loop is signalized by the yellow LED "Interlock", the state of each particular loop can be displayed in the dialog box "Interlock Monitor" (see section "Interlock Monitor"). Note that if all loops are disabled, the LED "Interlock" lights permanently and the device can be enabled independently on the state of the interlock loops.

The contacts of the loops "Front BNC" and "Rear BNC" are located in the BNC sockets at the front and rear panel, respectively. The particular loop can be closed by shorting the BNC socket, i.e. by connecting its signal to ground.

Interface Setup

The dialog box "Interface Setup" (see Fig. 10) shows the current setting of the USB interface and allows you to change it.

Fig. 10. Dialog box "Interface Setup".

Use the vertical direction keys to change the currently selected item. The selected item is highlighted by inverting the displayed characters. The settings can by modified by pressing the middle key "enter". Furthermore, the dialog box can be closed using the middle key "enter" (see the selection shown in Fig. 10).

Fig. 11. Enabling the USB interface in the dialog box "Interface Setup".

The value "USB port" determines whether the USB interface is active or not (see Fig. 11). By pressing the middle key "enter", the value can be toggled between "active" or "idle" and "off". If the interface state is "off", the interface is disabled and no communication is possible. The remaining interface states indicate that the interface is enabled. If the displayed state is "active", the interface is activated and a communication can be launched. If the displayed state is "idle", the interface is activated but does not communicate, i.e. there is no connection to a remote host. If a cable connects the device with a functioning remote host, the state changes to "active".

The communication state of the USB interface is shown as the item "comm.", it indicates the state of the handshake lines of the interface.

The communication state changes between "active" and "idle" depending on the communication activity on the interface. The communication state is "idle" if you do not access the device and it changes to "active" if you start a communication software on the remote host.

Display Setup

The dialog box "Display Setup" (see Fig. 12) shows the current settings of the display controller and allows you to change them.

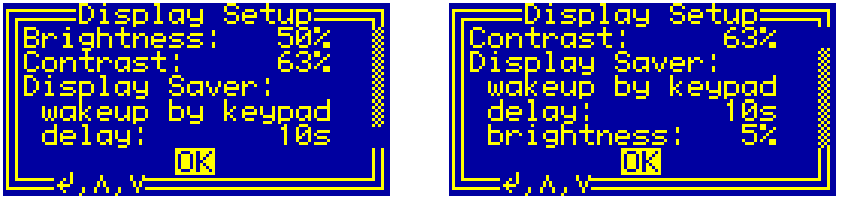

Fig. 12. Dialog box "Display Setup".

Use the vertical direction keys to change the currently selected item. The selected item is highlighted by inverting the displayed characters. The settings can by modified by pressing the middle key "enter" or by spinning the rotary encoder. Furthermore, also using the middle key "enter", the dialog box can be closed (see the selection shown in Fig. 12). The numerical values can be modified by the rotary encoder only. By pressing its knob, the selected item can be reset to its default value.

Fig. 13. Setting the brightness in the dialog box "Display Setup".

The value "Brightness" shows the luminosity of the display, it can be changed by spinning the encoder (see Fig. 13). By pressing its knob, the luminosity is reset to its default value. Note that the lifetime of the display is inversely proportional to the brightness, thus you should chose the lowest possible value that provides a sufficient luminosity.

Fig. 14. Setting the contrast in the dialog box "Display Setup".

The value "Contrast" determines the display contrast, it can be changed by spinning the encoder (see Fig. 14). By pressing its knob, the contrast is reset to its default value. By changing this value, the readability of the display for a certain view angle can be optimized.

Fig. 15. Setting the display saver in the dialog box "Display Setup".

The value "Display Saver" determines the functionality of the display saver, it can be changed by pressing the middle key "enter" (see Fig. 15). If disabled, the display is permanently lit up with the luminosity given by the value "Brightness" (see Fig. 13). In both remaining cases, the luminosity is reduced after a predefined inactivity time in order to increase the display lifetime. If "wakeup by keypad" is selected, the display saver is stopped by pressing any key or operating the encoder. The luminosity given by the value "Brightness" is restored and the device is ready for further operation. If "wakeup by all" is selected, the display saver is also stopped by pressing a virtual key using the remote controller (see Fig. 28 and the corresponding text).

Fig. 16. Setting the display saver delay in the dialog box "Display Setup".

The value "delay" defines the delay of the display saver, it can be changed by spinning the encoder (see Fig. 16). By pressing its knob, the delay is reset to its default value. The delay value is the inactivity time required to launch the display saver, the allowable values are between 3 and 9999 seconds. Be sure that you set the delay to a sufficiently high value that will not disturb normal operation. On the other hand, a too large value will completely prevent the display saver from launching, thus a compromise has be found for practical usage.

Fig. 17. Setting the display saver brightness in the dialog box "Display Setup".

The value "brightness" determines the luminosity of the display when the display saver is active, it can be changed by spinning the encoder (see Fig. 17). By pressing its knob, the brightness is reset to its default value. It should be set to lowest possible value that provides a minimum luminosity indicating that the device is still running.

Device Monitoring

To monitor the function of the device, several dialog boxes are available. You can use them to check the function of the device if you encounter any problem, for instance, if the red LED "Failure" lights.

Voltage Monitor

The dialog box "Voltage Monitor" (see Fig. 18) shows the current values of the output high voltages.

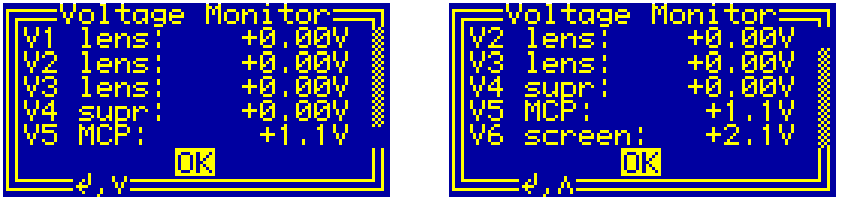

Fig. 18. Dialog box "Voltage Monitor".

Use the vertical direction keys to select the shown items. By pressing the middle key "enter", the dialog box can be closed.

Under normal conditions when the device is activated, the measured voltages should be equal to the voltage levels set by the dialog box "Voltage Control" (see section "Voltage Control"). The values V4, V5, and V6 should have positive, the voltages V1 and V3 negative values, the voltages V2 can show values of both polarities. If the device is deactivated and the high voltages are disabled, also small voltages with an opposite polarity may be shown.

If the measured voltages differ from the set values, the device may be overloaded or overheated or a hardware failure occurred. You may try to localize the failure by checking the device parameters by other monitoring dialog boxes. You may also try to disconnect the output cables and repeat the last operation in order to exclude the influence of the connected experimental setup. If the issue persists, turn off the device and contact the manufacturer.

The values are measured about 4 times per second by a 16-bit analog-to-digital converter. The resolution depends on the voltage range of the particular channel. The voltages V1, V3, and V4 have a resolu-

tion of about 5 mV, the voltage V2 only 30 mV. The high voltages V5 and V6 have a fixed resolution of 0.1 V.

If you aim to manipulate the output cables, the connectors, or the vacuum hardware, use the dialog box "Voltage Monitor" to check the high voltages. Be sure that you open the connectors or touch the vacuum hardware only if the high voltages have decreased to values that are not lethal.

Supply Monitor

The dialog box "Supply Monitor" (see Fig. 19) shows the current values of the supply voltages of the device.

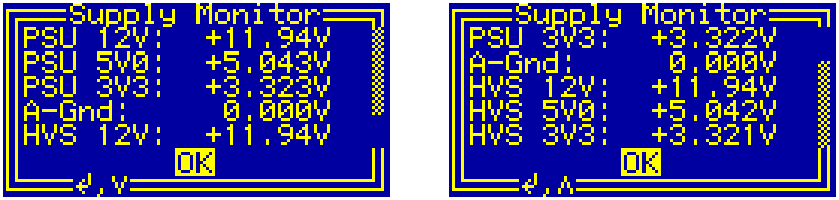

Fig. 19. Dialog box "Supply Monitor".

Use the vertical direction keys to select the shown items. By pressing the middle key "enter", the dialog box can be closed.

The value "PSU 12V" is the internal voltage supplying the fan and the high-voltage converters generating the output voltages V5 and V6. The nominal value is 12 V.

The value "PSU 5V0" is the internal voltage supplying the digital circuits of the device including the LCD. The nominal value is 5 V.

The value "PSU 3V3" is the internal voltage supplying the fast digital circuits. The nominal value is 3.3 V.

The value "A-Gnd" is the voltage at the analog ground. The analog ground should be connected to the digital ground, i.e. to the protection earth (PE) by the attached experimental setup. Due to voltage drops in the connection cables, a nonzero voltage may be indicated. However, voltages larger than 100 mV most probably indicate an issue with the cables or connectors.

The values "HVS 12V", "HVS 5V0", and "HVS 3V3" should be almost identical to their counterparts "PSU 12V", "PSU 5V0", and "PSU 3V3". They are measured by the module of the high-voltage converters HV-SMPS2. Any difference larger than several 10 mV indicates a malfunction of the device. If you observe such failure, turn off the device and contact the manufacturer.

The values are measured about 2 times per second. The microcontroller checks them continuously and deactivates the device if the voltages differ from their nominal values. This may happen when the device is overloaded, the supply voltage is shorted, or when one of the power supplies overheats.

Interlock Monitor

The dialog box "Interlock Monitor" (see Fig. 20) shows the state of the interlock loops.

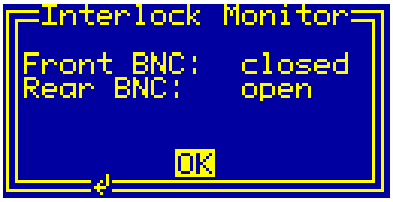

Fig. 20. Dialog box "Interlock Monitor".

For the assignments, consult the dialog box "Interlock Setup" (see section "Interlock Setup"). The possible states are "open" and "closed", they directly correspond to the state of each particular loop.

Note that the dialog box "Interlock Monitor" shows the real state of the particular loop, independently on that if it is enabled or not. If a certain interlock loop cannot be closed du to a malfunction, you may deactivate it in the dialog box "Interlock Setup" to be able to continue the experimental work.

Temperature Monitor

The dialog box "Temperature Monitor" (see Fig. 21) shows the temperatures measured in different parts of the device.

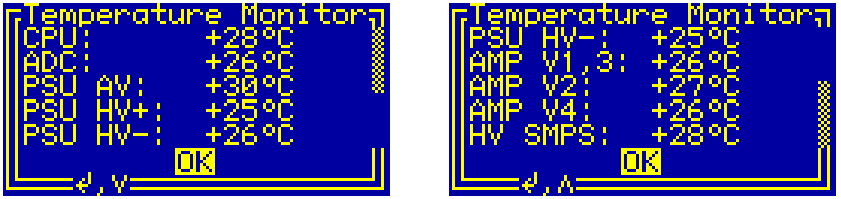

Fig. 21. Dialog box "Temperature Monitor".

Use the vertical direction keys to select the shown items. By pressing the middle key "enter", the dialog box can be closed.

The value "CPU" is the chip temperature of the controller's CPU. Under normal conditions, it approaches values between 25 and 30°C.

The value "ADC" is the chip temperature of an analog-to-digital converter (ADC) located in the controller in the proximity of the rear connector. Under normal conditions, the value stabilizes between 25 and 30°C.

The values starting with "PSU" are the heatsink temperature of the device's power supplies. The value " PSU AV" indicates the temperature of the analog power supply of ±15 V, the "PSU HV+" of the positive high-voltage power supply of about +720 V, and the " PSU HV-" of the negative high-voltage power supply of -120 V, respectively. Under normal conditions, these temperature approaches values around 30°C.

The values "AMP" are the heatsink temperature of the amplifiers producing the adjustable output voltages V1 - V5. The value "AMP V1,3" indicates the temperature of the amplifier HVA100-2ND producing the negative voltages V1 and V3. The values "AMP V2" and the "AMP V4" are the temperature of the amplifiers HVA700-1DH and HVA100-1PDH generating the voltages V2 and V4, respectively. Under normal conditions, these temperature approaches values around 30°C if the device is enabled.

The item "HV SMPS" is the chip temperature of the CPU the module of the high-voltage converters HV-SMPS2. Under normal conditions, the value stabilizes between 25 and 30°C.

The values are measured about 2 times per second. The microcontroller checks the values continuously, controls the fans, and deactivates the device if the temperature rises above the allowed values (see sections "System Preferences" and "Fan Monitor" for more details). The microcontroller is also able to discover failures such as a disconnected or shorted sensor; any failure causes an immediate deactivation of the device.

Fan Monitor

The dialog box "Fan Monitor" (see Fig. 22) shows the state of the fan mounted at the rear panel of the device.

Fig. 22. Dialog box "Fan Monitor".

The value "Rear fan" shows the rotational speed of the fan. The fan speed is shown in revolutions per minute (rpm).

The value "state" indicates the state of the fan. The values shown may be either "running" if the fan is running properly, "stopped" if the fan is halted, or "failed" if the fan has failed and does not rotate. The state "failed" may be shown for a short time after the fan start, this is a normal behavior since the fan needs several seconds to run up. If the failure persists for a longer time (about 10 s), the red LED "Failure" lights. Note that this does not prevent the device from operation but an overheating may occur sooner. You should, however, replace the defective fan as soon as possible to maintain proper device operation.

Clock Monitor

The dialog box "Clock Monitor" (see Fig. 23) shows the current frequencies of various clock signals used internally to control the device.

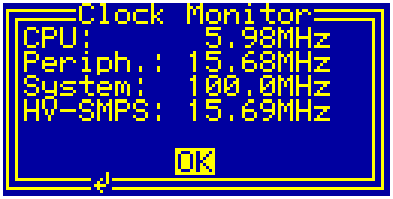

Fig. 23. Dialog box "Clock Monitor".

The value "CPU" is the clock frequency of the main microcontroller that controls the device. Since the microcontroller clock is dynamically changed according to the current load, this value may vary according to the number of active processes.

The value "Periph." is the frequency used to control the peripheral devices of the microcontroller, its clock is derived from this signal. It is regulated by the microcontroller to a value of about 15.67 MHz.

The value "System" is the frequency of the main clock controlling the FPGA (*Field Programmable Gate Array*) in the controller. It is gained by a PLL (*Phase Locking Loop*) circuitry. The PLL multiplies the frequency of a quartz oscillator and provides a clock of nominally 100 MHz. This clock is internally used to control the communication signals or generate the PWM (*Pulse-Width Modulation*) control signal for the fan.

The value "HV-SMPS" is similar to the value "Periph.", it is the frequency used to control the peripheral devices of the microcontroller in the high-voltage converters HV-SMPS2. It is regulated by this microcontroller to a value of about 15.67 MHz.

The frequencies are measured as ratios between the particular frequency and the frequency of an auxiliary quartz oscillator running at 32.768 kHz. If this oscillator fails, all measured values are subjected to systematic deviations.

Line Monitor

The dialog box "Line Monitor" (see Fig. 24) shows the current state of the line input.

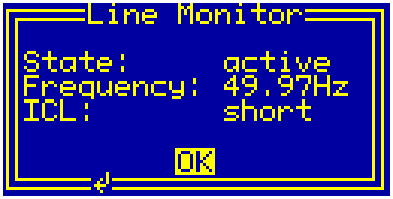

Fig. 24. Dialog box "Line Monitor".

The value "State" indicates the state of the line input. The value "active" is shown if the line voltage is present. If the line voltage is absent, the state changes to "down" but the device shuts down after a short time period.

The value "Frequency" is the line frequency measured by the device. Dependent on the location, the nominal values are 50 or 60 Hz. Due to natural deviations, the line frequency may slightly differ from the nominal values.

The value "ICL" shows the state of the inrush current limiter (ICL). The ICL is activated when the device starts and the indicated ICL state is "active". After a few seconds when the large initial charging current from the line input drops down to the nominal operational current, the ICL is deactivated, i.e. shorted and the indicated ICL state is "short".

Device State

To inspect the device state, several dialog boxes are available.

System Information

The dialog box "System Information" (see Fig. 25) summarizes general information about the device controller. The text "ID" shows the product identification, "Product No." is the unique product serial number. The entries "HW version" and "FW version" designate the hardware and the firmware versions, "FW date" is the compilation date of the firmware. In case of any trouble with the device, please use these values when contacting the manufacturer.

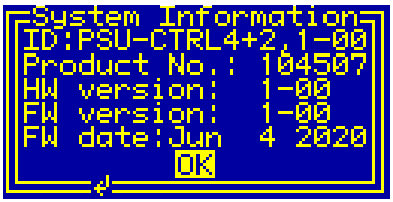

Fig. 25. Dialog box "System Information".

HV-SMPS2 Information

The dialog box "HV-SMPS2 Information" (see Fig. 25) summarizes general information about the module of the high-voltage converters HV-SMPS2. The text "ID" shows the module identification, "Product No." is the unique product serial number. The entries "HW version" and "FW version" designate the hardware and the firmware versions, "FW date" is the compilation date of the firmware. In case of any trouble with this module, please use these values when contacting the manufacturer.

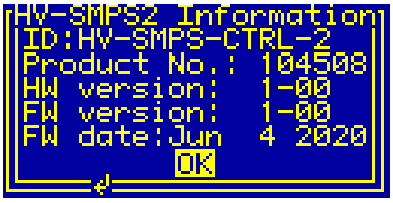

Fig. 26. Dialog box "HV-SMPS2 Information".

Statistics

The dialog box "Statistics" (see Fig. 27) shows information about the operation time of the device. The "Uptime" indicates the time elapsed since powering on the device or since the last firmware restart. The next line "total" shows the total operation time of the device.

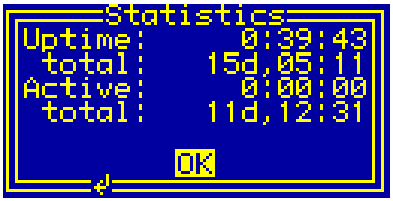

Fig. 27. Dialog box "Statistics".

The time "Active" displays the operation time of the high-voltage power supplies and the high-voltage amplifiers and converters, which has elapsed since powering on the device or since the last firmware restart. The next line "total" shows the total operation time of the device.

Tab. 1. The LCD character set.

value	char	value	char	value	char	value	char
20h	space	38h	8	50h	P	68h	h
21h	!	39h	9	51h	Q	69h	i
22h	"	3Ah	:	52h	R	6Ah	j
23h	#	3Bh	;	53h	S	6Bh	k
24h	$	3Ch	<	54h	T	6Ch	l
25h	%	3Dh	=	55h	U	6Dh	m
26h	&	3Eh	>	56h	V	6Eh	n
27h	'	3Fh	?	57h	W	6Fh	o
28h	(	40h	@	58h	X	70h	p
29h	)	41h	A	59h	Y	71h	q
2Ah	*	42h	B	5Ah	Z	72h	r
2Bh	+	43h	C	5Bh	[	73h	s
2Ch	,	44h	D	5Ch	\	74h	t
2Dh	–	45h	E	5Dh	]	75h	u
2Eh	.	46h	F	5Eh	^	76h	v
2Fh	/	47h	G	5Fh	_	77h	w
30h	0	48h	H	60h	`	78h	x
31h	1	49h	I	61h	a	79h	y
32h	2	4Ah	J	62h	b	7Ah	z
33h	3	4Bh	K	63h	c	7Bh	{
34h	4	4Ch	L	64h	d	7Ch	|
35h	5	4Dh	M	65h	e	7Dh	}
36h	6	4Eh	N	66h	f	7Eh	~
37h	7	4Fh	O	67h	g	7Fh	©

Software Utilities

The software utilities can be found in the directory "Program" of the enclosed software package. Before using them, the virtual USB port driver must be installed (see section "Driver Installation"). The utilities do not require any additional installation, you need only to copy them to a suitable directory on your computer. Before starting the utilities, you need to obtain the virtual port number, as described in the section "Driver Installation".

Utility HVPSU6-Controller

The HVPSU6-Controller is a simple Windows™ program that runs in text mode. It enables you to control and monitor the voltage controller. Launching the utility `HVPSU6-Controller.exe` without any parameters or with the parameter `-?` displays a simple help:

```
HVPSU6-Controller -?
```

To start the program without any error message, at least the number of the COM port must be given:

```
HVPSU6-Controller 6
```

This command starts the utility HVPSU6-Controller and assumes that the device is connected to the port COM6. On success, the utility reports the following message:

```
Press '?' for help
```

and waits for command input.

In case of any problem, check whether the port number matches the system settings (see section "Driver Installation") and the connected device is powered on and working properly (see section "Interface Setup"). If an error occurs, please consult the section "Error Codes". The tables 7 and 8 explain the possible error messages; they should help you to localize the reason for the software failure.

To check the communication, press the key 'p' to obtain the product identification text. The device should respond as follows:

```
Product identification: PSU-CTRL4+2,1-00
```

Tab. 2. Command line parameters of the program HVPSU6-Controller - General commands.

Parameter	Explanation
`-b, -B`	get the device buffer status
`-z, -Z`	purge the communication
`-t, -T`	terminate the program
`-q, -Q`	quiet mode
`-g`	debug mode
`-G`	debug mode with output into `Debug.txt`
`-#`	restart the device
`-?`	show the online help

If the device responds properly, you may try other program commands. Press '?' to obtain the help listing of all available commands[‡].

In practice, you may prefer to use the command line mode instead of the interactive mode. The former mode allows you, for instance, to save the complete commands in batch files for repeated usage.

General commands

Table 2 summarizes general command line parameters of the program HVPSU6-Controller. The parameters are processed from left to right. If an error in the command line is encountered, the program stops with an error text showing the allowed values of the parameters.

If the parameter `-t` is found, the program stops without processing any following parameter. If you do not specify the parameter `-t` at all, the program does not stop and enters the interactive mode after having processed the complete command line.

The quiet program mode is turned on by the parameter `-q`. If specified, the program text output is reduced. In contrary to that, the debug mode (parameters `-g` or `-G`) provides a detailed output for error analysis. It is intended to be used in case of communication problems.

[‡] Note that keyboard layouts different to the US one may cause issues when evaluating several characters. We recommend to switch to the US layout when using the utility HVPSU6-Controller in the interactive mode.

Tab. 3. Command line parameters of the program HVPSU6-Controller - Getting device parameters.

Parameter	Explanation
`-V`	get the device firmware version
`-v`	get the device hardware version
`-d, -D`	get the device firmware date
`-p, -P`	get the product identification text
`-n, -N`	get the product number

The parameter `-G` creates additionally the file `Debug.txt` in the current directory, the file contains a detailed logging of the communication. In case of communication issues, turn on the debug mode by this parameter and sent the file to the manufacturer if you cannot resolve the problems.

The parameters `-z` or `-b` can be used if the communication does not work properly. The parameters `-z` or `-Z` clear the communication buffers and restarts the communication. The commands `-b` or `-B` show the device buffer status, it should be empty since the device should process all commands immediately.

Getting device parameters

The command line parameters for obtaining the device parameters are listed in Tab. 3. You can use them to identify the device and check the firmware version. For more details, see section "Device State". To collect a complete set of device information, consult section "Device testing".

Device monitoring

Table 4 shows command line parameters for monitoring the device. They are useful in case of a malfunction when you are searching for the reason unwanted issues. For more details, see section "Device Monitoring". To measure a complete set of device data, consult section "Device testing".

Tab. 4. Command line parameters of the program HVPSU6-Controller - Device monitoring.

Parameter	Explanation
`-u`	get the device uptime
`-U`	get the device uptime periodically
`-c`	get CPU data
`-C`	get CPU data periodically
`-f`	get HV-SMPS2 CPU data
`-F`	get HV-SMPS2 CPU data periodically
`-h`	get device housekeeping data
`-H`	get device housekeeping data periodically
`-k`	get HV-SMPS2 housekeeping data
`-K`	get HV-SMPS2 housekeeping data periodically
`-s`	get device state
`-S`	get device state periodically
`-j`	get measured temperatures
`-J`	get measured temperatures periodically
`-r`	get measured voltages
`-R`	get measured voltages periodically

Device control

The command line parameters for controlling the device are shown in Tab. 5. You can use them to activate the device or control the output voltages. For more details, see section "Device Control".

The device can be activated by the parameter `-A` and deactivated by the parameter `-a`. After issuing this command, the utility scans the device state periodically. You can check the device state and determine whether the activating was successful.

Tab. 5. Command line parameters of the program HVPSU6-Controller - Device control.

Parameter	Explanation
`-a`	turn the HV off
`-A`	turn the HV on
`-mn`	get the voltage limit of the channel number n
`-Mn Limit`	set the voltage limit of the channel number n to the value `Limit`
`-on`	get the voltage slope of the channel number n
`-On Slope`	set the voltage slope of the channel number n to the value `Slope`
`-ln`	get the voltage of the channel number n
`-Ln Voltage`	set the voltage of the channel number n to the value `Voltage`

To obtain the currently set voltage limit, the parameter `-m` can be used. The parameter requires a numerical value n that specifies the channel. Since the channel V2 has two limits (one for the negative and second for the positive voltages), the channel assignment is as follows: 0 = V1, 1 = V2 negative, 2 = V2 positive, 3 = V3, .., 6 = V6. Using the parameter `-M`, the voltage limits can be set. Beside the numerical value n specifying the channel, the parameter requires the new value of the voltage limit given in volts.

To view the currently set the voltage slope, the parameter `-o` can be used. The parameter requires a numerical value n that specifies the channel. The channel assignment is as follows: 0 = V1, 1 = V2, .., 5 = V6. By the parameter `-O`, the voltage slopes can be set. Beside the numerical value n specifying the channel, the parameter requires the new value of the voltage slope given in volts per second.

The output voltages can be shown by the parameter `-l`. The numerical value n specifies the channel, the assignment is identical to the previous command: 0 = V1, 1 = V2, .., 5 = V6. To set the output volt-

Tab. 6. Command line parameters of the program HVPSU6-Controller - Device testing.

Parameter	Explanation
`-i FileName`	save device data to a text file with the name `FileName`
`-I FileName`	log device data to a text file with the name `FileName`
`-x FileName` `-X FileName`	create test protocol to a text file with the name `FileName`
`-e FileName n s p d t` `-E FileName n s p d t`	scan SMPS voltages and save them to a text file with the name `FileName`. `n` is the channel number, `s` the starting voltage, `p` the final voltage, `d` the voltage step, and `t` the measurement delay

ages, use the parameter `-L`. The second numerical value that must be specified is the voltage given in volts.

Device testing

Table 6 summarizes command line parameters of the program HVPSU6-Controller for testing the device. They can be used to create log files or measurement protocols automatically.

Note: If you wish to specify a name parameter containing spaces or special characters, use the conventions valid for your operating system. In Windows™ systems, for instance, enclose the name in quotation marks.

Using the parameter `-i`, a summary of device data can be stored in a specified text file. By the parameter `-I`, a log file with all measured device values is created. The values are obtained 2 times per second and stored in a tab-separated text file. The file can be opened in any text editor and easily copied in any table-calculation program.

The parameters `-x` or `-X` can be used to create a test protocol of the device. You can start this function in order to test the device and compare the resulting protocol with that one that was created by the manufacturer.

Utility FlashLoader

The FlashLoader is a simple Windows™ program running in text mode. It enables you to upgrade the firmware of the voltage controller. You should perform the upgrade if you have received or downloaded a new firmware file from the device manufacturer. Launching the utility `FlashLoader.exe` without any parameters displays a simple help text with the expected syntax of the command line.

Before upgrading the firmware, you should first test the device and the communication by verifying the current firmware version. To do so, start the following command:

```
FlashLoader 6 Firmware.txt -v
```

where `Firmware.txt` is the file containing the current firmware and the number 6 indicates the port COM6 to which the device is connected. The program should produce the following output:

```
Code file R:Final.txt from 11/04/2019, 12:00:00
Flash Loader 1.12
Verifying code file Final.txt
Verifying finished at Tue, 11/05/2019, 15:00:00
100495 (1888Fh) bytes processed, 99584 (18500h)
bytes verified
Resetting the target
Program finished ok
```

During the verify procedure, a message box is displayed at the device display informing the user that the flash loader has been activated. When the verify finishes without any error, the device is restarted.

Note that the utility `FlashLoader.exe` cannot communicate with the device if it is not in the idle state (see Fig. 2).

! **Attention:** To be sure that the device cannot apply high voltages to the attached experimental setup when the FlashLoader is active, disconnect the output cables. Note that the utility stops all processes running at the microcontroller, thus the monitoring is not available and the device would not be deactivated if a critical situation arises.

If any error occurs, do not proceed with the firmware upgrade. If you cannot resolve the issues, contact the manufacturer. Note that even if the verify fails and the flash loader at the device remains active, it is

safe to power the device off to restart it. However, a more safe and comfortable alternative to that is to execute the following command:

```
FlashLoader 6 -i -f
```

This prevents the utility at the host computer from initializing the flash loader utility at the microcontroller again and sends the reset command to the device.

If the verify has succeeded, you may start the firmware upgrade by entering the command:

```
FlashLoader 6 Firmware.txt
```

where `Firmware.txt` is the file with the new firmware. The program should produce the following output:

```
Code file R:Final.txt from 11/04/2019, 12:00:00
Flash Loader 1.12
Programming code file Final.txt
Programming finished at Tue, 11/05/2019, 15:00:00
100495 (1888Fh) bytes processed, 99584 (18500h)
bytes programmed
Resetting the target
Program finished ok
```

During the programming procedure, a message box is displayed at the device display. When the programming finishes, the device is restarted with the new firmware.

If an error occurs, the flash loader utility at the microcontroller may remain active. This is the case if the message box at the device display is still present and the device did not restart. In this case, you may retry the action with the command line parameter '-i':

```
FlashLoader 6 Firmware.txt -i
```

This will prevent the utility at the host computer from initializing the flash loader utility at the microcontroller again and it will just try to reprogram the file `Firmware.txt`. If the error persists, contact the manufacturer.

! **Attention:** You must not power down the device if the firmware upgrade did not succeed. Otherwise, the device will not operate properly or might even not restart at all. Did this happen, it would be necessary to reprogram the device in the factory.

If the current firmware is damaged so that the device is inoperable, you may try to start the flash loader utility at the microcontroller manually. Press the horizontal direction keys (left and right) simultaneously and power on the device. If this small part of the firmware is still working, the device's flash loader will start. Then, try to launch the utility FlashLoader with the command line parameter '-s':

```
FlashLoader 6 Firmware.txt -s
```

This does not start the flash loader utility at the microcontroller but will only try to reprogram the file `Firmware.txt`. If an error occurs that you cannot solve, contact the manufacturer.

Utility RemoteControl

The RemoteControl is a Windows™ GUI program that enables you to control the voltage controller remotely and obtain a hardcopy of the current LCD content.

To launching the utility, start the following command:

```
RemoteControl 6
```

The number 6 indicates the port COM6 to which the device is connected.

The program opens a dialog box that shows the current content of the device's LCD (see Fig. 28). The direction keys and the encoder can be simulated by clicking the corresponding buttons or using the keyboard shortcuts. For the detailed description of them, see the online help.

The right side of the program window shows the status of the device LEDs. This allows you to observe the LEDs without the necessity of a direct visual contact to the front panel of the device.

You may obtain a hardcopy at any time by selecting the menu item File ► Save Hardcopy. The program opens a dialog box to select the destination bitmap file. The hardcopy is performed immediately without waiting for any confirmation.

Note that the utility RemoteControl continuously transfers display data over the USB. Compared to the idle state, this leads to a higher load

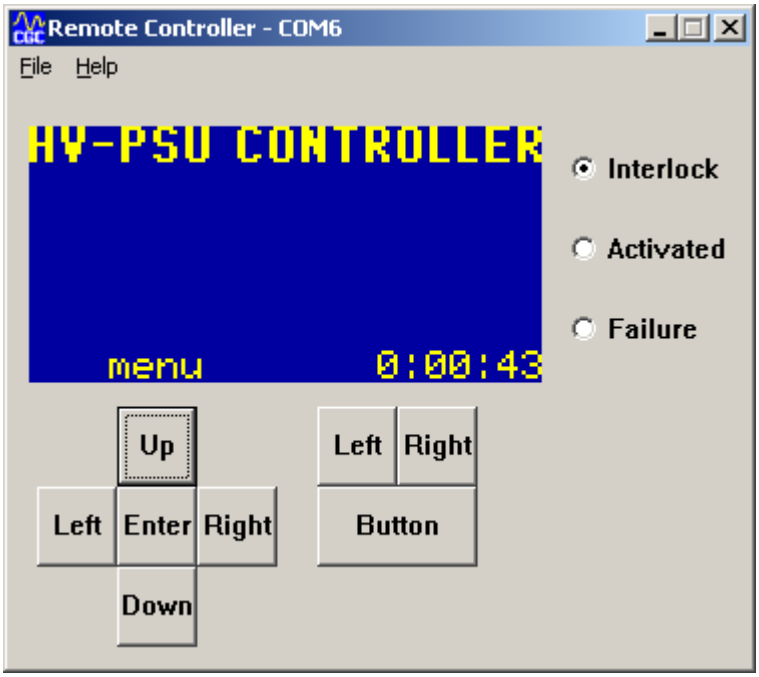

Fig. 28. Utility RemoteControl.

of the microcontroller controlling the device. Further, the utility prevents any other program from accessing the device via USB.

Error Codes

Tab. 7. Return values of the interface functions

Return value	Error message	Description
0	No error	The data transfer finished successfully.
-2	Error opening the port	The port could not be opened. For the possible reasons, see Tab. 8.
-3	Error closing the port	The port could not be closed. For the possible reasons, see Tab. 8.
-4	Error purging the port	The port buffers could not be cleared.
-5	Error setting the port control lines	The port control lines could not be set.
-6	Error reading the port status lines	The port status lines could not be read.
-7	Error sending command	The data transfer to the device failed. For the possible reasons, see Tab. 8.
-8	Error sending data	
-9	Error sending termination character	
-10	Error receiving command	The data transfer from the device failed. For the possible reasons, see Tab. 8.
-11	Error receiving data	
-12	Error receiving termination character	
-13	Wrong command received	The device sent an unexpected response.
-14	Wrong argument received	
-15	Wrong argument passed to the function	One of the arguments passed to the function was out of the allowable range.

Return value	Error message	Description
-100	Device not connected	The port status lines indicate that the device is not connected.
-101	Device not ready	The port status lines indicate that the device is not ready. The communication with the device is possible only if it does not execute any process. Terminate all dialog boxes and menus at the device and retry the operation.
-102	Device state could not be set to not ready	The device did not react properly. Try to reset the communication or restart the device by powering it off and on.
-400	Error opening the file for debugging output	The file for debugging output cannot be opened for writing. Check if you have permissions to perform this action or if the file exists and is opened by another application.
-401	Error closing the file for debugging output	The file for debugging output cannot be closed. Check if the access to the file is still possible.

Tab. 8. I/O errors

Return value	Error message	Description
0	No error	The data transfer finished successfully.
1	Port has not been opened yet	You attempted to use the communication channel before having opened it.
2	Cannot open the port	The specified port could not be opened. Either the port does not exist or it is being currently used by another program.
3	Cannot get the state of the port	The system could not get the state of the port.
4	Cannot set the state of the port	The system could not set the state of the port.
5	Cannot set the timeouts for the port	The system could not set the timeouts for the port.
6	Cannot clear the port	The system could not clear the port buffers.
7	Error reading data from the port	The system could not read data from the port. Most probably, no data is available because the device is either disconnected or does not respond.
8	Error writing data to the port	The system could not write data to the port.
9	Wrong data amount written to the port	The system could not write the proper data amount to the port.
10	Error setting the control lines of the port	The system could not set the state of the port control lines.
11	Error reading the status lines of the port	The system could not get the state of the port status lines.
12	Device is busy	The system could not access the device since menus or dialog boxes are active.

Driver Installation

Installation of the Virtual Port for the USB Interface

The virtual port driver is required for the operation of the device with a USB interface. If you use the operating system Windows™, please note the following:

- Please use the update function of the operating system at the host computer or download the most recent driver from the homepage of the manufacturer of the USB adapter. The drivers are located at the following address: http://www.ftdichip.com/Drivers/VCP.htm. Please choose the correct driver version according to your operating system.
- To install the driver, administrative rights are required.
- The installation is described in detail in the "Installation Guides" available at the abovementioned address. Please read this description carefully before starting the installation.
- After the installation, the number of the virtual port can be set. You can change the settings in the device manager by opening the settings of the device *USB Serial Port (COMx)*. To modify the settings, administrative rights are required. The settings are applied immediately, you do not need to reboot the PC to activate them.

The software can also be used at computers running the Linux operating system. You can run them using the Windows™ emulator wine (see http://www.winehq.org/).

Starting with Linux Kernel 3.0.0-19, all FTDI devices are already supported without the necessity of compiling additional kernel modules. For more details, consult the homepage of the manufacturer of the USB adapter: http://www.ftdichip.com/Drivers/VCP.htm.

The system has to be configured an the following way:

- Use, for instance, the program 'dmesg' to find out to which USB port the device is attached: Look for a line similar to "FTDI USB Serial Device converter now attached to ttyUSB0"
- Link the Linux device to the virtual COM port of wine:
  `ln -s /dev/ttyUSB0 ~ /.wine/dosdevices/com3`
  This assumes that the device is attached to ttyUSB0 and will be linked with COM3