HA51U-3B2

High Voltage Amplifier ±3000V

Operating Manual

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1 Warnings

Attention! This device produces dangerous voltage above 3000V.

Due to capacitive charging, it can still be present even after the device has been switched off!

Please respect the following rules before every start-up of the high voltage amplifier:

- The device should be operated only by skilled personnel, in accordance with the local regulations and the instructions given in this manual.
- Before switching the unit on, the experiment set-up should be checked out, and safety should be assured. High voltage areas have to be sealed off and secured.
- In case of suspected damage or malfunction, the device should immediately be put out of service, and it should be secured against unintentional or accidental operation.
- To provide protection for personnel in case of unit failure, the safety ground must always be connected! Local regulations about grounding should be taken into account.
- High voltages may still exist even after the switch-off of the device due to capacitive charge! Capacitances connected to the outputs of the device can possibly remain charged to dangerous voltages, even after switching off the device
- Before removing any covers disconnect the unit from the power supply!
- Before touching the output or working on the experimental setup, disconnect the unit from the power supply!
- The device may only be operated as a component of an overall structure that fully complies with the regulations for working with high voltage systems.

Personal safety must be given the highest priority!

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2 Description

The single-channel high voltage amplifier HA51U-3B2 with bipolar output voltage is designed to drive capacitive and ohmic-capacitive loads.
The amplifier is characterized by high speed, good stability and low noise. Piezo elements, electroactive polymers, electrorheological fluids, electrostatic deflecting electrodes and many other loads can be driven by this amplifier easily.
Output voltages of -3000V to +3000V at load currents of up to ±2.5mA and >5mA$_P$ are provided. The signal gain is 300, the input voltage range is -10V...+10V.
The output voltage can be monitored by a high-speed voltage monitor; a current monitor provides a representation of the output current.

The amplifier's output is protected against overload, short circuit, overtemperature, transient overvoltage and high voltage flashover. The LEDs on the front panel indicate operation and error statuses.

An isolated USB interface is provided, allowing the user to control the amplifier via a simple command interface (output voltage setting, voltage and current back reading, readout of temperatures and other operating parameters, amplifier configuration, I/O lines setting and readout, ...).
Alternatively, the internal microcontroller can be utilized to allow the user to run his own application programs. For example, to generate simple, arbitrary waveforms. It is also possible to run more complex applications. For this purpose, additional free I/O lines and a separate analog input are provided.
The internal microcontroller can be programmed via the free Arduino IDE. The entire application software of the amplifier is available as open source.

The HA51U is housed in a sturdy aluminium case. It can be operated as a tabletop unit or be built in a device housing.

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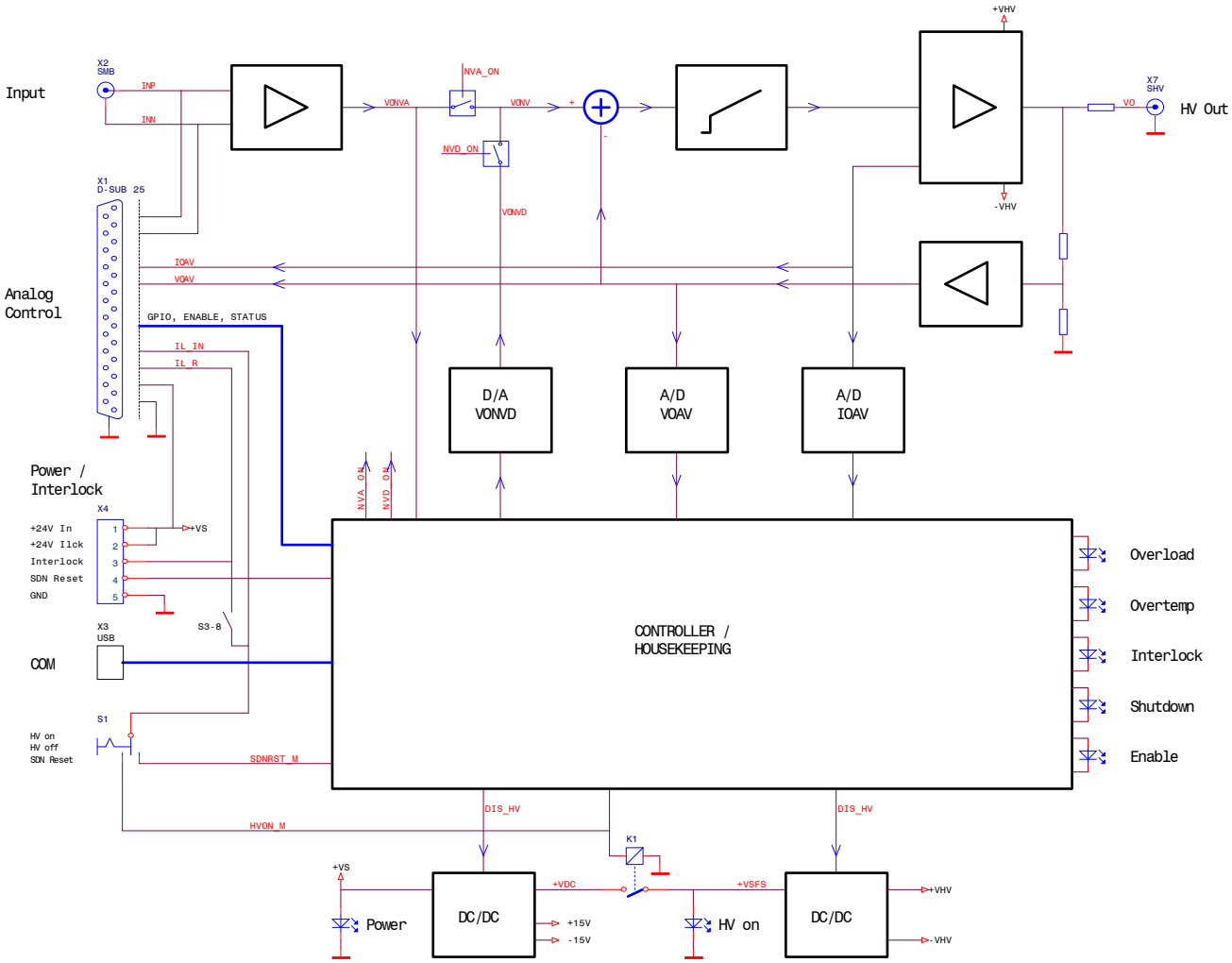
2.1 Block Diagram



2.2 Amplifier

The device incorporates the high voltage amplifier itself, high voltage supplies for the output stage, measuring functions, a microcontroller with a communication interface as well as monitoring and protective functions.
The signal input is connected to a differential amplifier to avoid interference from ground loops. It is available on SMB connector **X2** and on **X1** (Analog Control). It provides the analog setpoint VONVA. Alternatively, the digitally generated setpoint VONVD can be used (command **$ SV**).

The amplifier has one voltage monitor output and one current monitor output. The VOAV voltage monitor receives its signal via a compensated voltage divider and provides a scaled image of the output voltages (10V ≙ 3000V). The frequency response is linear up to well above the upper cut-off frequency of the amplifiers. The frequency response of the IOAV current monitor output is limited to 2kHz in order to filter out the ripple of high voltage sources.
The buffered monitor outputs are connected to **X1** (output impedance: 10kΩ). They are able to drive capacitive loads (coaxial cables), but are not designed to drive cables with a low-impedance termination. They are short-circuit proof.
The monitor values can also be read using the commands **$ RC**, **$ RP**, **$ RV**.

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During operation, the internal auxiliary supplies, overload of the high voltage sources, overtemperature and interlock are monitored. In the event of a fault, the high voltage supplies are switched off and the shutdown state is saved without interference. A shutdown state can only be exited by means of a shutdown reset (**S1** push button function **SDN Reset**, **X1 SDNRST_D**, **X4 SDN Reset** or command **$ SR**).

LED	**Function**
Power	on: 24V supply voltage
Overload	on: overload blink: shutdown due to overload
Overtemp	on: overtemperature blink: shutdown due to overtemperature
Interlock	on: shutdown: interlock circuit open blink: shutdown after interlock
Shutdown	on: OFF state due to shutdown
Enable	on: output stage is enabled by signal X1.ENABLE or command **$ EN1**
HV on	on: HV sources on

2.3 Loading Conditions

The amplifier channels are designed to drive capacitive and ohmic-capacitive loads. The output is stable even with large capacitive loads

The slew rate that can be achieved for output voltage depends on the load capacitance. The effective load capacitance C_L consists of the amplifier's internal output capacitance (ca. 300pF), capacitance of the output line (a typical coaxial cable: ca. 100pF/m) and capacitance of the connected load. The output stage can provide peak currents (I_{OP}) of > ±5mA$_P$ for ca. 1ms. The maximum static output current is +2.5mA and -2.5mA.
Achievable slew rate: **$SR = I_O / C_L$ [V/s]**.

If the average positive or negative output current exceeds +2.5mA or -2.5mA, the amplifier shuts down with **Overload**.

If the maximum slew rate is exceeded, distortions occur in the output signals. In principle, the amplifier should thus only be controlled by input signals, that satisfy the achievable slew rate for a given load. However, dynamic override of the inputs (e.g. control by square wave signals) is harmless. The edges of the output waveform are nearly linear then with a slight overshoot.

Ohmic loads of ≥ 1200kΩ can be driven to the maximum output voltage.

At certain operating points (higher frequency at larger amplitude, higher load capacitance), the amplifier temperature can rise to such an extent that the amplifier will switch off with **Overtemp**.
It is important to ensure that the amplifier is well ventilated. The internal temperatures can be observed using the command **$ RT**. The switch-off threshold is around 80°C.

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2.4 Interlock

The device incorporates an interlock circuit through which the supply voltage of the high voltage sources is switched. It is a closed circuit with three switching points (break contacts). Its source voltage is 24 V (carried out via **+24V Ilck**), quiescent current is 10mA. The switching points are:

1. Connector **X4 Power / Interlock**:
   with terminals **+24V Ilck** and **Interlock**, the device can be looped into an interlock circuit (potential-free break contact); these terminals must be connected together in order to allow the high voltage sources in the device to be switched on;
2. Connector **X1**:
   with **IL_IN (X1.3)** and **IL_R (X1.16)** the device can be looped into an interlock circuit (potential-free break contact); if these pins are not used, they can be bridged using the DIP switch in the device;
3. Lever key **HV on / HV off** on the front panel.

Only if all three contacts are closed, the supply voltage of the high voltage sources will be switched on. The device will then still be in the **Interlock** shutdown state. The high voltage generation is not functionally activated till the **Interlock** shutdown state is finished by **Shutdown Reset**.
The **HV on** display indicates that the supply voltage of the high voltage sources is switched on.

The device must be disconnected from its power supply before carrying out any works on the test set-up or before touching the output terminals.

3 Technical Data

Parameter	**Conditions**	
Supply voltage, V_S		$24V_{DC}$ ±10%
Supply current, I_S	V_S = 24V	<1.6A_{DC}
Input voltage range	Control input	-10.0V – +10.0V
Max. input voltage		±18V
Input resistance		50kΩ
Gain		300 ±1%
Offset		≤ 200mV
Output voltage range		-3000V – +3000V
Load current range	static	-2.5mA – +2.5mA
Load current range	dynamic, t < 1ms	-5mA – +5mA
Power bandwidth	C_L = 100pF, VO = 6000V_{PP}, THD ≤ 1%	DC – ≥ 1kHz
Bandwidth	C_L = 100pF, VO = 600V_{PP} -3dB	DC – ≥ 10kHz
Slew-Rate	C_L = 100pF	≥ 15V/µs
Internal output capacitance		< 300pF
Ripple, Noise	C_L = 100pF; 1Hz – 20kHz	≤ 150mV_{RMS}
Scaling monitor output V		10V ≙ 3000V ±1%
Bandwidth monitor output V		DC – ≥ 20kHz
Scaling monitor output I		10V ≙ 10mA ±1%
Bandwidth monitor output I		DC – ≥ 2kHz

- Signal ground and high voltage ground are connected to the chassis ground / earth terminal.

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3.1 Ambient Conditions

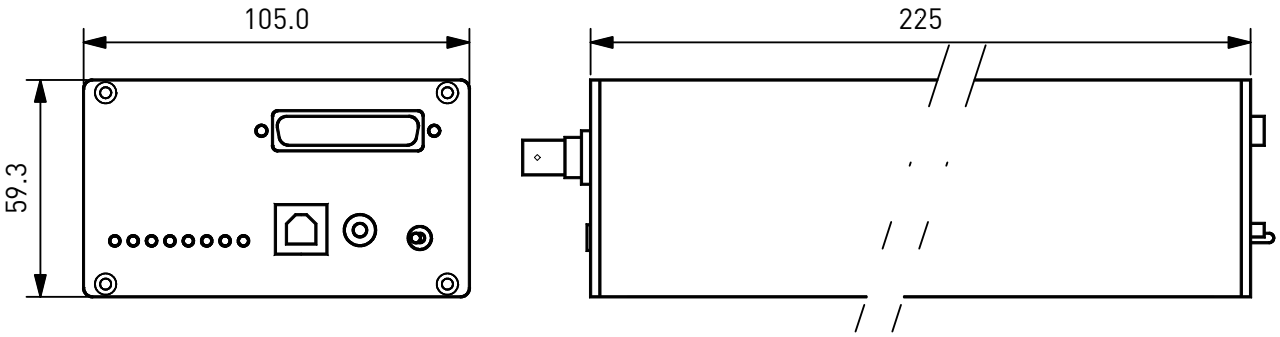
Parameter	Conditions	Min.	Max.	Unit
Ambient temperature				
- Operation		-20	+50	°C
- Storage and Transportation		-25	+70	°C
Relative humidity	Not condensing			
- Operation		5	80	%
- Storage and Transportation		5	95	%

- Depending on the ambient temperature, modulation amplitude and load capacitance, the maximum power may need to be derated.

3.2 Mechanical Specifications

Parameter	Typ.	Unit
Depth overall *	250	mm
Depth case	225	mm
Width	105	mm
Height	59.3	mm
Weight	1.2	kg

* Depth overall without connection cables plugged in.



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4 Operation

4.1 Check After Delivery

Once the product is delivered, please check the packaging and the device for possible transport damage. Please check the device taken out of the packaging for any mechanical defects before the unit is put into operation.
If the device has any signs of damage caused by transport, please immediately inform the shipping company so that damages can be claimed.

4.2 Warning Notices

- For safe operation of this device, it should be put into operation by a qualified electrician according to this Operating Manual.
- The device may only be operated as a component of an overall structure that fully complies with the regulations for working with high voltage systems.
- Output connectors may only be touched when the device is disconnected from the power supply! Otherwise, there is a risk of electric shock.
- The test set-up must be fully wired and protected against any contact before the device is put into operation.
- The test set-up must be checked each time before the device is put into operation to ensure that it is not potentially dangerous. It should be checked that the high voltage connections are faultless and the wire insulation is not damaged.
- The high-voltage areas must be blocked in accordance with regulations or otherwise secured.
- Once the test set-up is connected, any existing capacitances can be charged to high voltage. They may carry dangerous voltages even after the device is switched off.
- The earth bolt on the back panel of the device must be connected to the central earthing point of the test set-up and to protective earth. Local regulations on earthing must be observed.
- If it is suspected that safe operation is no longer possible, the device is to be taken out of operation and secured against unintentional operation.

This symbol on the output terminals warns of the risk of electric shock.

This symbol on the case warns of potentially hot surfaces.

4.3 Temperature Compensation

To avoid condensation within the device, it should be allowed to reach the room temperature. Please unpack the product at least two hours prior to power-up.

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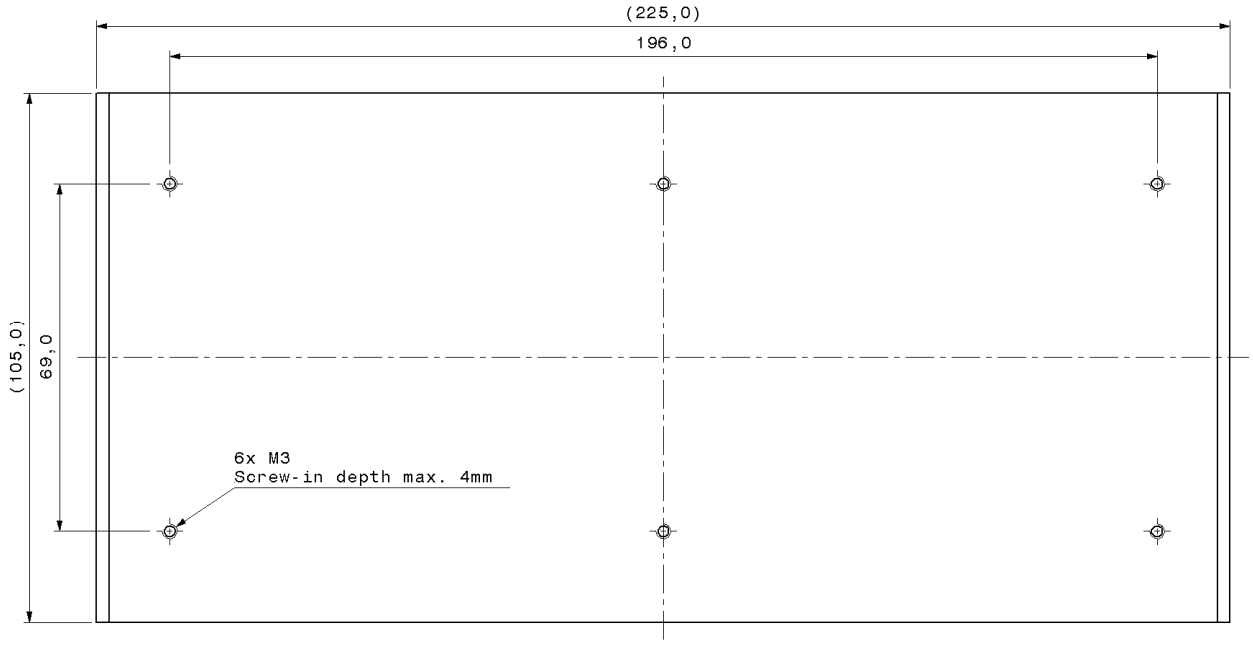
4.4 Installation

The device can be used as a tabletop unit or installed in a device housing.
At the bottom of the housing there are six M3 threaded holes for the in-housing installation. The maximum screw-in depth is **4mm!** When installing the device, please remove the rubber feet.



4.5 Power Supply

The device requires an external DC voltage source of 24V_{DC} / min. 1.6A as the power supply. The connection is made via the **X4 Power / Interlock** connector at the **+24V In** and **GND** pins.

Caution: Before you turn on the voltage source, please check its output voltage. Admissible range: +24V_{DC} ±10%. If the amplifier is operated with wrong supply voltage, it could become damaged.

4.6 Ventilation

Sufficient ventilation is required to remove the heat dissipated inside the case during operation (P_D of up to 36W). For tabletop operation, free flow of air is required. Active ventilation could be useful, depending on the working point and ambient temperature.
If built into a device housing, the thermal losses can be removed through the structure of the housing, if its design allows for this. Otherwise, active ventilation is required.

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4.7 Functional Test

Before the device is finally put into operation in a test set-up, a short functional test is to be carried out. For this purpose, it is necessary that the interlock circuit is closed.

1. Make sure that the supply voltage is disconnected.
2. Remove all input signal cables and the output cable from the device.
3. Connect the terminals **X4 +24V Ilck** and **Interlock** with the aid of a wire link.
4. Connect the supply voltage.
5. The **Power**, **Shutdown** and **Enable** LEDs will light up.
6. Activate the **SDN Reset** push button of the **S1** switch and set the switch to **HV on**.
7. The **Power**, **Enable** and **HV on** LEDs will light up, the other LEDs will not.
8. Set the switch to **HV off**.
9. The **HV on** LED will turn off.
10. Disconnect the supply voltage.
11. Open the interlock bridge at **X4**.
12. Connect the supply voltage again.
13. The **Interlock** LED will light up.
14. Press the **SDN Reset** push button.
15. The interlock status remains unchanged and the high voltage cannot be switched on.
16. Turn off the supply voltage.

4.8 Input Connection

The amplifier features a differential signal input. If the signal generator has single-ended outputs, the reference signal shall be grounded on the generator side.
The analog control signal can be fed via the SMB connector **X2** or the D-Sub connector **X1**.

The input differential amplifier can be adapted to signal sources with 50Ω output impedance or low output impedance. The characteristic can be changed using the command **$ SS**.

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4.9 Analog Control X1

Connector type: D-Sub 25-pin female connector
Screwlock: UNC 4-40

Pin	Signal	Direction	Function
1	+VS_IN	I	Supply voltage +24V_{DC}
2	+VS_IN	I	Supply voltage +24V_{DC}
3	IL_IN	I	Interlock / bridge to X1.IL_R
4	SDNRST_D	I	Control signal: TTL-H for 0.5s => Shutdown Reset; Caution: This reactivates the HV output after a shutdown!
5	STAT1	O	Status output; 5V level; R_O = 1kΩ; H == no shutdown
6	INP	I	Differential analog input; positive
7	VOAV	O	Analog output: voltage monitor
8	IOAV	O	Analog output: current monitor
9	GPI1	I	Digital input; TTL level
10	GPI2	I	Digital input; TTL level
11	GPI3	I	Digital input; TTL level
12	GPI4	I	Digital input; TTL level
13	+5VX	O	Auxiliary voltage output +5V; max. 10mA
14	GND	-	Supply voltage GND
15	GND	-	Supply voltage GND
16	IL_R	O	Interlock / bridge to X1.IL_IN
17	ENABLE	I	Control signal: TTL-H => enables HV sources and output stages *; Caution: This activates the HV output!
18			n. c.
19	INN	I	Differential analog input; negative
20	GND	-	Signal ground
21	X1_CTLn	I	Control signal: 5V level; L => function X1.ENABLE active; internal pullup 10kΩ
22	GPO1	O	Digital output; 5V level; R_O = 1kΩ
23	GPO2	O	Digital output; 5V level; R_O = 1kΩ
24	GPO3	O	Digital output; 5V level; R_O = 1kΩ
25	GPO4	O	Digital output; 5V level; R_O = 1kΩ

* The **ENABLE** signal is only effective when the input **X1_CTLn** is set to L.
Switching the output off via the **ENABLE** control input must not be used as a safety-relevant function!
ENABLE OFF -> **ENABLE ON** may not be switched faster than 5 s in each level, otherwise shutdown will be triggered.

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4.10 USB / COM X3

Connector type: USB B

The USB port **COM** is electrically isolated from GND to prevent ground loops (functional isolation).

When the USB cable is plugged in or unplugged during operation, or when the virtual COM port is initialized by the operating system (for example, when being assigned to another application), a reset is initiated and the device changes to the shutdown state. If this is disruptive, the reset signal coming from the COM port can be interrupted via a DIP switch (S3-6). In this configuration, however, no software download (internal program update) is possible.

4.11 Power / Interlock X4

Connector type: Mini-Combicon, 5-pin
Mating connector: Phoenix Mini-Combicon, 5-pin, FK-MCP1.5_ 5-ST-3.81

Pin	Signal	Direction	Function
1	+24V In	I	Supply voltage +24V_{DC}
2	+24V Ilck	O	24V output for interlock circuit; protected against overload
3	Interlock	I	Interlock / bridge to X4.+24V Ilck
4	SDN Reset	I	Control signal: 24V for 0.5s => Shutdown Reset; Caution: This reactivates the HV output after a shutdown!
5	GND	-	Supply voltage GND

4.12 Output Connector X7

Connector type: SHV

The high voltage connector may only be mated or unmated when the supply voltage is switched off! Otherwise, there is a risk of electric shock.

4.13 Earthing

The M4 earth bolt on the back panel of the device must be connected to the central earthing point of the test set-up and to protective earth.

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4.14 DIP Switch S3

Switch	Function	Default
S3-1	Free: Controller PD4	
S3-2	Free: Controller PD5	
S3-3	Free: Controller PD6	
S3-4	Free: Controller PD7	
S3-5	Free: Controller PG0	
S3-6	Enable COM-Reset; ON => Enable	ON
S3-7	**Must always be OFF!**	OFF
S3-8	Disable X1 Interlock; ON => Disable	ON

4.15 LEDs

LED	Function
Power	on: 24V supply voltage
Overload	on: overload blink: shutdown due to overload
Overtemp	on: overtemperature blink: shutdown due to overtemperature
Interlock	on: shutdown: interlock circuit open blink: shutdown after interlock
Shutdown	on: OFF state due to shutdown
[NN]	free LED to be controlled by user software; Arduino standard LED, Arduino "Pin 13"
Enable	on: output stage is enabled by signal X1.ENABLE or command **$ EN1**
HV on	on: HV sources on

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5 Handling / Maintenance

5.1 Configuration

The device can be operated in different configurations:

- As a pure analog amplifier:
  The interlock circuit must be closed and an analog setpoint must be supplied via **X1** or **X2**.
  High voltage is switched on and shutdown states are reset by **S1**.
  Control and monitor signals are available at **X1** for functional extension.
- As an analog amplifier with digital control and measuring functions:
  The interlock circuit must be closed and an analog setpoint must be supplied via **X1** or **X2**.
  High voltage is released by **S1**.
  Configuration, control, shutdown states reset and measuring functions run through the command interface.
  Control and monitor signals are available at **X1** for functional extension.
- As an amplifier with digitally generated set value and digital control and measuring functions:
  The interlock circuit must be closed. High voltage is released by **S1**.
  Configuration, control, set value generation, shutdown states reset and measuring functions run through the command interface.
  Control and monitor signals are available at **X1** for functional extension. The analog set value input can be used as a universal analog input.

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5.2 Command Interface

A simple command interface with recognizable ASCII commands using a request-response structure has been implemented to control and monitor the amplifier. Each command is followed by a response.

Coding format:

Request: $<id><com>[pars]<cr>[<lf>]
Response: $<err><id>[pars]<cr><lf>

$		Start character: "$"
id	1AN	Sequence Id: a free alphanumeric character (not "$"); the id is returned with the response for identification of the command sequence
com	2A	Command: two alpha characters
pars	AN	Parameter: [par[;par[;...]]]; optional, depending on the command. Number format: [-]1234.56; leading zeros, decimal point and decimal places optional. Parameter separator: ";"
err	1N	Error number
<cr>		End of record: Carriage Return
<lf>		End of record: Line Feed (optional)

Examples:

Request:	$1SR<cr>	Shutdown Reset; id=1
Response:	$01<cr><lf>	no error; id=1
Request:	$2SV-2577.23<cr>	Set Output Voltage: -2577.23V; id=2
Response:	$02<cr><lf>	no error; id=1
Request:	$ GI<cr>	Read General Purpose Inputs; id=" "
Response:	$0 12<cr><lf>	no error; id=" "; Input Pattern: 12 (0x0c)
Request:	$5rt<cr>	Read Temperatures; id=5
Response:	$05357;423;615<cr><lf>	no error; id=5; 35,7°C (PA1), 42,3°C (PA2), 61,5°C (DC)
Request:	$1XY<cr>	invalid command; id=1
Response:	$91<cr><lf>	unknown command; id=1

Error numbers:

9	unknown command
8	wrong number format
7	parameter too high
6	parameter too low
0	no error

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Command list:

Cmd	Request Param.	Response Parameter	Function
EN	0,1		Enable HV and Amplifier 0: disable: HV sources functional off 1: enable (default): HV sources active
ES	0,1		Enable Amplifier Setpoint 0: disable: amplifier setpoint VONV = 0 1: enable (default): amplifier setpoint enabled
GI	-	0...15	Read X1 General Purpose Inputs Bit 0: GPI1 Bit 1: GPI2 Bit 2: GPI3 Bit 3: GPI4
GO	0...15	-	Write X1 General Purpose Outputs Bit 0: GPO1 Bit 1: GPO2 Bit 2: GPO3 Bit 3: GPO4
ID	-	<Model> <Version>	Get Model ID / SW-Version
RA	-	 0...3000; 0...-3000; 0...10000; 0...-10000; 0...20000; 0...10000; 0...-20000; 0...20000; -10000...10000; 0...100; 0...100; 0...100	Read Aux Values VHVPAV [V]: Actual value of positive HV supply voltage VHVNAV [V]: Actual value of negative HV supply voltage IHVPAV [µA]: Actual value of positive HV supply current IHVNAV [µA]: Actual value of negative HV supply current +VDC [mV]: Actual value of supply HV DC/DC converter +5V [mV]: Actual value of +5.2V supply -15V [mV]: Actual value of -15V supply +15V [mV]: Actual value of +15V supply VONVA [mV]: Actual value of analog setpoint VT_PA1 [0,1°C]: Temperature of output stage pos. branch VT_PA2 [0.1°C]: Temperature of output stage neg. branch VT_DC [0.1°C]: Temperature of DC/DC converter
RC	-	-10000...10000	Read Output Current IOAV [µA]: Actual value of output current
RH	-	 0...3000; 0...-3000; 0...10000; 0...-10000	Read HV Source Values VHVPAV [V]: Actual value of positive HV supply voltage VHVNAV [V]: Actual value of negative HV supply voltage IHVPAV [µA]: Actual value of positive HV supply current IHVNAV [µA]: Actual value of negative HV supply current
RN	-	-10000...10000	Read Analog Input VONVA [mV]: Actual value of analog input signal (INP, INN)
RP	-	 3000...3000; -10000...10000	Read Output Voltage and Output Current VOAV [V]: Actual value of output voltage IOAV [µA]: Actual value of output current

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RS	-	0...32767	Read Status Status word (see below)
RT	-	0...100; 0...100; 0...100	Read Temperatures VT_PA1 [0.1°C]: Temperature of output stage pos. branch VT_PA2 [0.1°C]: Temperature of output stage neg. branch VT_DC [0.1°C]: Temperature of DC/DC converter
RV	-	-3000...3000	Read Output Voltage VOAV [V]: Actual value of output voltage
SD	0,1	-	Select Setpoint Source 0: analog setpoint VONVA (default) 1: digital setpoint VONVD
SQ	-	-	Shutdown Request Set Shutdown Latch
SR	-	-	Shutdown Reset Reset Shutdown Latch
SS	0,1	-	Select Analog Input Source Resistance 0: 0Ω signal source output impedance 1: 50Ω signal source output impedance (default)
SV	-3000... 3000		Set Output Voltage Setpoint VONVD [10mV]: digital setpoint; resolution 10mV

Status word:

Bit #	Status bit	Function
0	AXPWFAIL	Aux Power Fail: Failure of auxiliary supplies +15V, -15V, +5.2V
1	IL	Interlock loop open
2	IHV_OVR	Overload Shutdown activated
3	T_OVR	Overtemp Shutdown activated
4	SUM_SDN	SUM Shutdown: Shutdown latch set
5	SDN_RST	SUM Shutdown Reset signal active
6	DIS_SDNL	Shutdown Latch deactivated
7	HV_ON	High voltage active
8	HV_ON_M	HV-ON switch S1 active
9	NVASL	Analog Input (Setpoint) selected
10	NVEN	Setpoint enabled
11	U4_ERR	Pos HV Error
12	U5_ERR	Neg HV Error

The status bits AXPWFAIL, IL, IHV_OVR, T_OVR, SUM_SDN, U4_ERR, U5_ERR are set when the corresponding shutdown condition is present or has led to the shutdown.

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5.3 COM Port

Communication takes place via a virtual COM port on the USB port **COM**. A USB-to-UART module FTDI FT231X is used in the device for the conversion.
To communicate with an application (terminal program or application software) a hardware driver and a driver for the virtual COM port is required. Using Windows, the drivers are normally installed automatically. If this is not initiated automatically, you can also download the drivers from http://www.ftdichip.com/Drivers/VCP.htm and install them manually.
In the Device Manager, entries are displayed under “USB Controller:USB Serial Converter” and under “Ports (COM&LPT):USB Serial Port (COMxx)”.

The baud rate is set to 115 kBd. It cannot be changed.
Format: no parity bit, 8 data bits, 1 stop bit (N,8,1). End of line: <cr> or <cr><lf>.

The device can be directly controlled via the COM port using a terminal program or can be integrated into a more complex application.

5.4 Programming

The device is controlled by an ATMEGA2560 microcontroller which operates at 16 MHz clock frequency. The controller can be fully programmed by the user. The free Arduino IDE software is suitable for this purpose. The entire application software of the amplifier is available for free usage.

The amplifier’s protection functions are independent of the controller and of the operation of the application program.

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5.5 Troubleshooting

If the device behaves unusual or erratic, please switch off the supply voltage and check the wiring of the load and that of the control and monitoring signals. Check the connected load and the signal source. Check the interlock circuit.

During operation various parameters are monitored and analyzed. In case of a fault the error is reported via error LEDs on the front panel of the amplifier module. Press the **SDN Reset** to reset the error condition.

Do not attempt to locate any faults within the device. This can be dangerous to life due to the high voltage used in the device. In such a case, please send the device to the manufacturer after consultation.

Symptom	**Possible causes**
Device will not turn on; **Power** LED will not light up	- No supply voltage present
HV on display will not light up	- **S1** switch is in **HV off** position - Interlock circuit is open - **X1.ENABLE** signal not set to H - Enabling by command **$ EN** is switched off
Output signal is distorted	- Load capacitance too large for the desired slew rate (see section 2.3 for load conditions)
Amplifier switches off, the **OVERLOAD** indicator lights up	- Dynamic load current exceeded (see section 2.3 for load conditions) - Static load current exceeded (see section 2.3 for load conditions)
Amplifier switches off, the **OVERTEMP** indicator lights up	- Poor ventilation - Total load too large (see section 2.3 for load conditions)

5.6 Maintenance

Regular maintenance is not required.

5.7 Cleaning

If necessary, wipe the device with a slightly damp cloth. Do not use abrasive detergents or solvents.

As of 10/2016

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1.0	2016-10-04	WM	created
1.0	2016-10-11	WM	corrections
1.0	2016-12-08	AR	english version

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6 Declaration of Conformity

We declare under sole responsibility that the products

Device: **High Voltage Amplifiers**

Series: **HA51U**

are in accordance with the following European directives:

Low Voltage Directive	2014/35/EU
EMC Directive	2014/30/EU

and comply with the following European standards:

EN 61010-1:2010	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements
EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements Classification: Group 1, Class B

Manufacturer:

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2016-10-04

Wulf Müller
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