HAR12S

12 Channel High Voltage Amplifier Mainframe

HA05B2

High Voltage Amplifier ±500V

HAR2

2 Channel High Voltage Amplifier Mainframe
(discontinued)

Operating Manual

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1 Warnings

Caution! This device produces dangerous voltage above 500V.

Due to capacitive charging, dangerous voltages can still be present in the set-up even after the amplifier has been switched off!

Please respect the following rules before every activation 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.
- 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.
- Before switching the unit on, the experiment setup must be checked, and safety should be assured. High voltage areas have to be blocked 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.
- The safety ground must always be connected! The grounding nut on the rear panel must be connected to the grounding point of the setup and to protective earth. Local regulations about grounding should be taken into account.
- The output connectors must only be operated when the unit is switched off.
- 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!
- No wires or similar objects may project into the device through the ventilation slots
- Fuses have to be replaced by types as rated on the nameplate on the rear of the unit.

Personal safety must be given the highest priority!

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1 Warnhinweise

Achtung! Dieses Gerät erzeugt gefährliche Spannungen über 500V.

Vor jeder Inbetriebnahme des Hochspannungsverstärkers sind u. a. folgende Regeln zu beachten:

- Die Inbetriebnahme darf nur von einer Elektrofachkraft im Sinne der Berufsgenossenschaft der Feinmechanik und Elektrotechnik vorgenommen werden.
- Vor der Inbetriebnahme muss die Bedienungsanleitung gelesen und verstanden worden sein.
- Es sind die einschlägigen Bestimmungen und Vorschriften des Gesetzgebers, der Berufsgenossenschaft und des VDE zu beachten, insbesondere
  - DIN-VDE 104 "Errichten und Betreiben elektrischer Prüfanlagen" (s. auch BGI 891 "Errichten und Betreiben von elektrischen Prüfanlagen")
  - Unfallverhütungsvorschrift DGUV Vorschrift 3 / BGV A3 "Elektrische Anlagen und Betriebsmittel"
- Das Gerät darf nur als Bestandteil eines im Ganzen den Vorschriften für den Umgang mit Hochspannung genügenden Gesamtaufbaus betrieben werden!
- Vor jedem Einschalten des Geräts ist der Versuchsaufbau zu überprüfen und sicherzustellen, dass es zu keiner Gefährdung kommen kann. Die Hochspannung führenden Bereiche müssen vorschriftengerecht abgesperrt oder anderweitig gesichert sein!
- Sollte der Verdacht bestehen, dass das Gerät beschädigt ist oder Fehlfunktionen zeigt, ist es umgehend außer Betrieb zu setzen und gegen beabsichtigten oder unbeabsichtigten Betrieb zu sichern.
- Der Erdbolzen auf der Rückplatte des Geräts muss mit dem Zentralen Erdpunkt des Versuchsaufbaus und dem Schutzleiter verbunden werden. Die örtlichen Vorschriften über Erdung sind zu beachten.
- Die Ausgangssteckverbinder dürfen nur bei spannungsfrei geschaltetem Gerät betätigt werden!
- Bei Arbeiten am Versuchsaufbau oder bei Berühren der Ausgangsanschlüsse ist das Gerät zuvor von der Spannungsversorgung zu trennen.
- Vor dem Öffnen des Geräts ist das Gerät von der Spannungsversorgung zu trennen.
- Es dürfen keine Objekte – wie Drähte o. ä. durch die Lüftungsschlitze in das Gerät Hereinragen.
- Im angeschlossenen Versuchsaufbau können evtl. vorhandene Kapazitäten auf Hochspannung aufgeladen werden. Diese können auch nach Abschalten des Geräts noch gefährliche Spannungen führen.
- Sollte ein Ersatz der Netzsicherungen erforderlich sein, so ist sicherzustellen, dass nur Sicherungen der angegebenen Nennstromstärke und Nennspannung als Ersatz verwendet werden.

Der Personensicherheit ist höchste Priorität einzuräumen!

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2 Overview

This manual covers the following models:

- **HA05B2** single channel high voltage amplifier module family
- **HAR12S** 12-channel high voltage amplifier mainframe (SHV output connectors)
- **HAR2** 2-channel high voltage amplifier mainframe (SHV output connectors) table top unit (**discontinued**)
- **HAR2-W** 2-channel high voltage amplifier mainframe (SHV output connectors) wall mount unit (**discontinued**)

3 Description

The high voltage amplifier channel module **HA05B2** with bipolar output voltage is designed to drive capacitive and resistive-capacitive loads.
The amplifier channels are characterized by high accuracy, very high stability and very low noise. High precision electrostatic deflection or multi channel high voltage reference source are typical applications.

A version with extended bandwidth is available: **HA05B2_BA**.

Output voltages of -500V to +500V at load currents of up to ±2mA are provided. The signal gain is 50, the input voltage range is -10V...+10V.
The output voltages of each channel can be controlled by a control voltage (IN) or by a 10-turn potentiometer (SETPOINT). Each channel is equipped with a precision high-speed voltage monitor output, current monitor output and an inhibit input.
The amplifier outputs are protected against overload, short circuit, and transient overvoltage.

The **HA05B2** is a 3U plug-in card intended to be mounted in a suitable subrack.

The **HAR2/HAR2-W** mainframes (discontinued) accommodate up to 2 amplifier channel modules **HA05B2**.
HAR2 is a table top unit, **HAR2-W** is a wall-mount type.

The 19"/3U **HAR12** mainframe accommodates up to 12 amplifier channel modules **HA05B2**.
It features internal power supplies, cooling fans and a common Interlock input for all channels.

All mainframes contain two DVMs and the high voltage converters to feed the **HA05B2** amplifier channel modules.
Both the output voltage and the load current of each channel can be displayed on the DVMs.
A switch (CHANNEL) is provided for selection of the channel to be measured.

The **HAR12** is supplied by mains voltage. The **HAR2** models are supplied by an external $24V_{DC}$.

Customized and full custom models are available on request.

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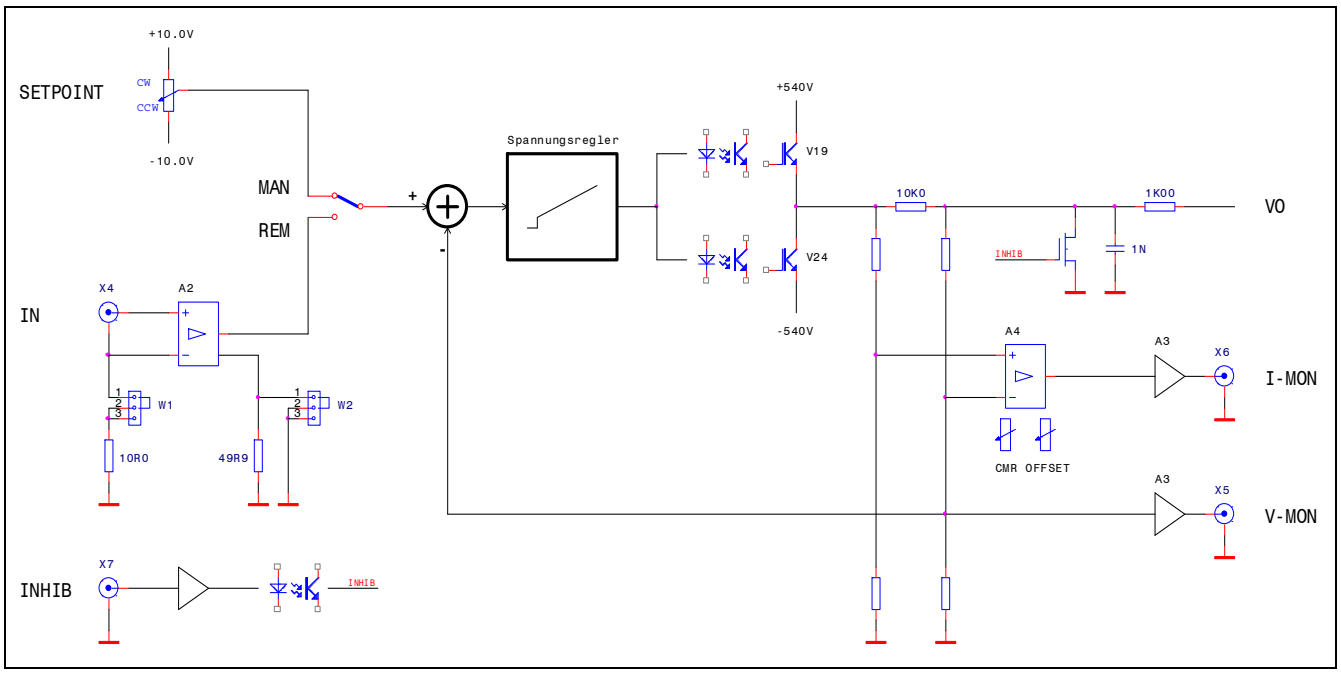
3.1 Block Diagram



The block diagram shows one amplifier channel.

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3.2 Control Voltage Input

The control voltage input (IN) is connected to a differential amplifier to suppress common mode voltages between the external signal source and the amplifier. Two jumpers (W1, W2) are provided on each amplifier module HA05B2 in order to adapt the control voltage input to the signal source.
W1 connects the input signal reference via 10Ω to the amplifier signal ground. W2 adjusts the amplifier gain to the output impedance of the signal source.

W1

1-2	Floating signal source Common mode voltage <1V_{RMS}	Default
2-3	Grounded signal source (connected to PE) Common mode voltage <5V_{RMS}	

W2

1-2	Output impedance of signal source <1Ω	Default
2-3	Output impedance of signal source 50Ω	

Alternatively, the control voltage can be generated by means of a 10-turn potentiometer (SETPOINT). The potentiometer supplies –10 V at the CCW end position (0) and +10 V at the CW end position (10). Zero position is at 5. Switching between internal and external control voltage is achieved by a front panel switch (MAN / REM).

3.3 Monitor Outputs

Two BNC monitor outputs (**V-MON / I-MON**) provide actual values of output voltage and output current, both of which are normalized to ±10 V.
The monitor outputs receive their signal through a compensated voltage divider. Current measurement takes place differentially across a sense resistor in the output line. Due to differential measurement, a certain drift of the measured output current over temperature and output voltage is inevitable (refer to technical specifications).
The frequency response of **V-MON** is linear up to well above the upper cut-off frequency of the amplifiers.

The monitor outputs are buffered and short-circuit-proof. They are able to drive capacitive loads (coaxial cables), but are not designed to drive cables with a low-impedance termination.

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3.4 INHIBIT

Each high voltage amplifier channel can be remotely switched off through the **INHIB** input. The input is TTL-compatible. A LOW-signal turns on the amplifier. In case of open input or HIGH-signal, the amplifier is turned off. For manual operation, a 50Ω BNC-termination resistor can be used to statically turn the amplifier channel on.
The Inhibit signal drives a semiconductor switch, short-circuiting the output (approx. 100Ω) within microseconds. The switch conducts independently of the internal supply voltage, even after the device is switched-off.
The **INHIB** input is not suitable to achieve a safe state at the amplifier output. It must not be used for safety relevant purposes.

3.5 Loading Conditions

The amplifiers are designed to drive any combination of resistive and capacitive loads.
Full output voltage is available for resistive loads ≥ 250kΩ. When driving capacitive loads the reactive current must be taken into consideration. This current into the load capacitance depends on the capacitance value and the slew-rate: $\mathbf{i_{CL} = C_L * dv / dt}$.
The effective load capacitance consists of the connected load capacitance, the capacitance of the output cable, and the capacitance internal to the amplifier. If the output current exceeds the peak current capability of the amplifier module (refer to the specifications), the output voltage will become distorted.
In case of larger load capacitances overshoot of the output may occur.

The achievable large-signal bandwidth strongly depends on the capacitance of the connected load.

Particularly with regard to the high speed versions of the amplifier modules, the cable capacitance may become the dominant part of load capacitance. One meter of typical coaxial cable has a capacitance of about 100pF.

Large capacitive loads driven by high frequency signals may result in a DC-offset superimposed on the output voltage. This occurs if the final value of the desired output voltage can not be reached periodically.

No damage to the amplifier modules will result from the different conditions mentioned.

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3.6 Interlock

The **HAR12** mainframe incorporate an interlock circuit by which the supply voltage of the high voltage sources is switched.
The interlock circuit is **not** provided on the **HAR2** mainframes (discontinued).
The interlock signal is available via the rear connector **INTERLOCK** on the subrack. It is a closed circuit (break contacts). Its source voltage is 24V$_{DC}$. The source voltage is provided on the **INTERLOCK** connector. The voltage source is protected against overload or short circuit.
To enable the high voltage generators, signal **+24V_IL (INTERLOCK.2)** and **IL (INTERLOCK.3)** must be connected by a jumper or a contact. The contact can be part of an external interlock circuit. The quiescent current is 12mA typ.
When the interlock circuit is closed, the high voltage sources are switched on.

The device must be disconnected from the power supply before carrying out any operations on the test setup or before touching the output terminals.

3.7 Connector INTERLOCK

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

Pin	Signal	Direction	Function
1	-		
2	+24V_IL	O	24V output for interlock circuit; protected against overload
3	IL	I	Interlock / bridge to **+24V_IL**
4	-		
5	GND	-	Supply voltage GND

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4 Technical Data

Mainframe HAR12S – equipped with 12x HA05B2

Parameter	Conditions	
Mains voltage		95 – 265VAC
Mains frequency		47 – 63Hz
Input current	V_{Line}=115V_{AC}, full load	1.0A_{RMS}
	V_{Line}=230V_{AC}, full load	0.5A_{RMS}
Mains fuses	F1, F2	T3.15A, 250V, IEC127-2/V
External fusing		16A
Protection category		I

- Fuses F1, F2 are located within the mains connector unit on the rear.
- Signal ground and high voltage ground are connected to chassis ground / protective earth and the earth connector (M4 bolt).
- The appliance conforms to protection category I. It must only be used on mains power sockets with a ground connection.

Mainframe HAR2 / HAR2-W (discontinued) – equipped with 2x HA05B2

Parameter	Conditions	
Supply voltage		22.8 – 25.2V_{DC}
Input current	V_{IN}=24V_{DC}, full load	0.6A_{DC}

Amplifier modules HA05B2 / HA05B2_BA

Parameter	Conditions	
Supply voltage, +V_S		+24V_{DC} ±10%
Supply current, I_S	+V_S = 24V	< 80mA
Supply voltage, +VHV		+525 - +550V_{DC}
Supply current, I_{+VHV} - HA05B2 - HA05B2_BA	+VHV = +540V	 < 3mA < 10mA peak
Supply voltage, -VHV		-525 - -550V_{DC}
Supply current, I_{-VHV} - HA05B2 - HA05B2_BA	-VHV = -540V	 < 3mA < 10mA peak
Input voltage range IN	Control input	-10.0V – +10.0V
Max. input voltage IN	Control input	±18V
Input resistance IN		50kΩ typ.
DC Gain		50 ±0.2%
Output voltage range		-500V – +500V
DC load current range	static	-2mA – +2mA
Peak output current - HA05B2 - HA05B2_BA	dynamic, t < 1ms	 > ±2mA > ±8mA
Short circuit output current		< ±4mA

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Power bandwidth - HA05B2 - HA05B2_BA	R_L = 500kΩ, C_L = 100pF,	 DC – ≥ 500Hz DC – ≥ 15000Hz
Internal output capacitance - HA05B2 - HA05B2_BA		 1200pF typ. 100pF typ.
Ripple, Noise - HA05B2 - HA05B2_BA	R_L = 500kΩ, C_L = 100pF,	 ⩽ 10mV_{PP} / ⩽ 1mV_{RMS} ⩽ 30mV_{PP} / ⩽ 3mV_{RMS}
Output voltage stability	R_L = 500kΩ, control value via IN, ΔTamb < ±10K, Δt = 24h	< ±100ppm f.s.
Load regulation	I_L = 0 -> 100%	< 50ppm
Temperature coefficient Output voltage	R_L = 500kΩ, 10.00V via IN, ΔTamb < ±10K	typ. 5ppm/K
Output offset voltage - HA05B2 - HA05B2_BA		 < ±20mV < ±30mV
Scaling monitor output V-MON		10V ≙ 500V ±0.2% f.s.
Scaling monitor output I-MON		10V ≙ 2mA ±0.2% f.s.
Zero point stability I-MON	V_O = -500V - +500V, ΔTamb < ±10K	< ±0.2% f.s.
Accuracy DVM (V/I)		< ±0.2% f.s.
Zero point stability DVM (I)	V_O = -500V - +500V, ΔTamb < ±10K	< ±0.2% f.s.
Input voltage INHIB	INHIB = LOW INHIB = HIGH	-15 - +1.5V -2.4 - +15V
max. Input voltage INHIB		30V_{RMS} / ±30V_{DC}
Response time INHIB=>HIGH	V_O<50V, C_L = 100pF	< 10µs
Response time INHIB=>LOW	V_O<50V, C_L = 100pF	ca. 2.5ms

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

4.1 Ambient Conditions

Parameter	**Conditions**	**Min.**	**Max.**	**Unit**
Ambient temperature - Operation - Storage and Transportation		 0 -25	 +0 +70	 °C °C
Relative humidity - Operation - Storage and Transportation	Not condensing	 5 5	 80 95	 % %

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4.2 Mechanical Specifications

Mainframe HAR12S

Parameter		Unit
Depth overall	423	mm
Depth case	376	mm
Width overall	483	mm
Width case	449	mm
Height	133	mm
Weight without amplifier modules	5.8	kg
Weight fully equipped	9.0	kg

Mainframe HAR2 / HAR2-W (discontinued)

Parameter		Unit
Depth overall	263	mm
Depth case	239	mm
Width overall (**HAR2-W**)	178	mm
Width case (**HAR2**)	140	mm
Height	134	mm
Weight without amplifier modules	1.4	kg

Amplifier module HA05B2 / HA05B2_BA

Parameter		Unit
Depth overall	200	mm
Width	129	mm
Height	30	mm
Weight	0.27	kg

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5 Operation

5.1 Initial Check

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.

5.2 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 setup 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 setup must be fully wired and protected against any contact before the device is put into operation.
- The test setup 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 insulation of the wires is not damaged.
- The high-voltage areas must be blocked in accordance with regulations or secured by other means.
- Once the test setup is connected, any existing capacitances can be charged to high voltage. They may carry dangerous voltages even after the device is switched off.
- The ground bolt on the rear panel of the device must be connected to the central grounding point of the test setup and to protective earth. Local regulations on grounding must be observed.
- No wires or similar objects may project into the device through the ventilation slots
- If it is suspected that safe operation is no longer possible, the device has to be taken out of operation and secured against unintentional operation.

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

5.3 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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5.4 Power Supply

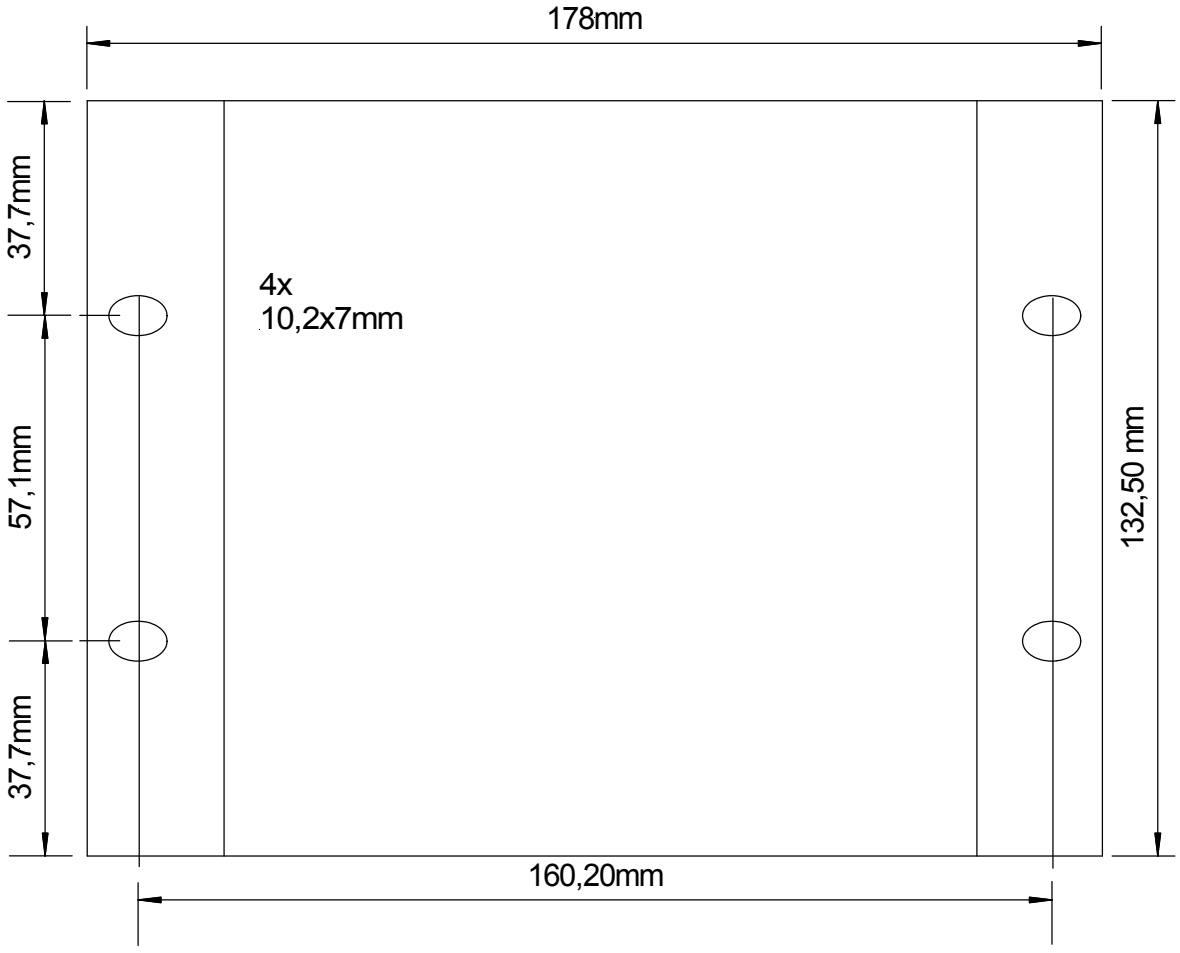
The **HAR12S** mainframe is fed by mains voltage.
The **HAR2** mainframe (discontinued) is fed by an external 24V_{DC} / ±10% power supply. The power supply should be able to source 1A output current minimum.

5.5 Ventilation

The **HAR12S** amplifier subrack may be used in rack mounted or bench top applications. In either case, sufficient space must be allowed for cooling air to reach the ventilation inputs on the front panels and for the fan exhaust air to exit from the rear of the unit.

The **HAR2** (discontinued) may not be covered when in use. The unit must not be used without the provided rubber-feet mounted to the bottom side.
Sufficient space for ventilation must be kept below and above the unit when the **HAR2-W** is mounted.

5.6 Wall Mounting HAR2-W (discontinued)



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5.7 Rack Mounting HAR12

The HAR12 Amplifier Subrack is designed to fit in a standard 19" equipment rack. Use the rack mount brackets at both sides of the front panel to install the unit into a 19" rack.

5.8 Functional Test

Before the device is finally put into operation in a setup, a short functional test is to be carried out.
It is necessary that the interlock circuit is closed (**HAR12S**).

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 **+24V_IL (INTERLOCK.2)** and **IL (INTERLOCK.3)** by means of a wire link.
4. Set all of the SETPOINT potentiometers to 10.0.
5. Set all input selector switches to REM.
6. Connect the unit to a grounded power outlet and turn the unit on (**HAR12S**);
   for **HAR2** (discontinued) connect the unit to a $24V_{DC}$ power supply.
7. Connect a 50Ω BNC-termination to the INHIB input at channel 1.
8. Select channel 1 (CHANNEL).
9. The voltage DVM should display about 0000 ±10;
   the current DVM should display about 0000 ±10.
10. Set the input selector switch to MAN.
11. The voltage DVM should display about 500.0;
    the current DVM should display about 0000 ±20.
12. Turn the SETPOINT-potentiometer to 0.
13. The output voltage changes from about +500V to about -500V.
14. Repeat the test with all the other channels.
15. Turn off the supply voltage.

5.9 Output connections

The outputs of the device supply a voltage of higher than 500V via SHV connectors. Connections to the load should be provided only using connectors and cables with appropriate voltage rating.
Do not mate or unmate the output connector unless the device is switched off!

5.10 Output Connectors

Connector type: SHV

Connections to the loads should only be made using connectors and cables with appropriate voltage rating.

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

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5.11 External Connectors

Signals:	BNC
HV Outputs:	SHV
Power line:	IEC320-1 (HAR12S)
Earth:	Bolt M4 (HAR12S)
Power supply:	2 pole Phoenix Combicon Connector (HAR2, HAR2-W - discontinued)
Mating connector:	2 pole Phoenix Combicon Plug MSTB 2.5/2-ST-5.08

5.12 Internal Connectors

Internal connectors for HA05B2 plug-in modules (DIN41612, Type F)

Pins			**Signal**
D2	B2	Z2	+VHV (+540V)
D4	B4	Z4	GND
D6	B6	Z6	VO (Amplifier output)
D8	B8	Z8	GND
D10	B10	Z10	-VHV (-540V)
D12	B12	Z12	GND
D14	B14	Z14	n.c.
D16	B16	Z16	n.c.
D18	B18	Z18	Internal connection, do not connect
D20	B20	Z20	Internal connection, do not connect
D22	B22	Z22	Internal connection, do not connect
D24	B24	Z24	Internal connection, do not connect
D26	B26	Z26	Internal connection, do not connect
D28	B28	Z28	Internal connection, do not connect
D30	B30	Z30	+VS (+24V)
D32	B32	Z32	GND

5.13 Grounding

The M4 ground bolt on the back panel of the device must be connected to the central grounding point of the test setup and to protective earth (**HAR12S**).

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5.14 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.

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 return the device to the manufacturer after consultation.

Symptom	**Possible causes**
Device will not turn on; DVM displays will not light up	- No supply voltage present - Fuses F1, F2 in the IEC inlet defective (**HAR12S**)
Output signal is distorted	- Load capacitance too large for the desired slew rate (see section 3.5 for load conditions)
Power supply and input signal present but no output signal	- Examine the level of **INHIB** input signals

5.15 Maintenance

Depending on the cleanliness of the ambient air dust may accumulate within the unit possibly blocking the airflow. In that case the accumulated dust has to be removed by taking out the amplifier modules and blowing out the unit and the modules cautiously.
The manufacturer specified lifetime of the **HAR12S** fans is >50000h. After about 6 years of continuous operation the fans might be replaced.
Type: Sunon **MF60252V21000UA99**

Caution: disconnect the unit from the power supply before removing any modules or opening any covers.

Further regular maintenance is not required.

5.16 Cleaning

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

As of 11/2023

Document History:

Version	Date	Name	Changes
1.0	10/2016	WM	created
1.1	2020-07-16	WM	updated layout and content
1.2	2022-09-26	AR	mechanical specifications and photographs HAR12S
1.3	2023-11-30	AR	HAR2, HAR2-W discontinued

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6 Declaration of Conformity

We declare under sole responsibility that the products

Device:	**High Voltage Amplifiers**
Series:	**HA05B2**
Subrack:	**HAR12S, HAR2, HAR2-W**

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

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