High Voltage Power Supply

VME HIGH PRECISION series

Operators Manual

Contents:

Attention!

-It is not allowed to use the unit if the covers have been removed.

-We decline all responsibility for damages and injuries caused by an improper use of the module. It is highly recommended to read the operators manual before any kind of operation.

Note

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1. General information

The HIGH PRECISION VHQ are single- or dual-channel high voltage supplies with higher stability and improved capabilities compared to the VHQ STANDARD series in 6U VME format, 164 mm deep, double width. The units offer manual control and operation via VME bus. The use of the VME interface supports extended functionality compared to manual control.
The high voltage supplies provide a high precision output voltage together with very low ripple an noise, even under full load. Separate hardware switches allow to put voltage and current limits in 10%-steps. An INHIBIT input protects sensitive devices. Additionally, a maximum output current per channel can be specified via the interface. The high voltage source is protected against overload and short circuit. The output polarity can be switched over. The HV-GND is connected to the chassis and the powering GND.

2. Technical data:

VHQ		222 M	223 M	224 L	225 L
Output voltage V_{Onom}		2 kV	3 kV	4 kV	5 kV
Output current per channel I_{Onom}		3 mA	2 mA	1 mA	1 mA
	with **option M - h**	6 mA	4 mA	3 mA	2 mA
Ripple	typ.	<1 mV_{P-P}	<1 mV_{P-P}	< 1 mV_{P-P}	< 2 mV_{P-P}
	max.	2 mV_{P-P}	2 mV_{P-P}	2 mV_{P-P}	5 mV_{P-P}
	with **option M - h** typ.	< 1 mV_{P-P}	< 1 mV_{P-P}	< 1 mV_{P-P}	< 2 mV_{P-P}
	with **option M - h** max.	2 mV_{P-P}	2 mV_{P-P}	2 mV_{P-P}	5 mV_{P-P}
Stability	ΔV_O	$< 5 * 10^{-5}$ (idle to max. load)			
	$\Delta V_O / \Delta V_{INPUT}$	$< 3 * 10^{-5}$			
Temperature coefficient		$< 3 * 10^{-5}$ /K			
Resolution of voltage setting	via interface	100 mV	, with **option VHR**: 30 mV (VHQ 222/223) 60 mV (VHQ 224) 80 mV (VHQ 226)		
	manual	1 V			
Resolution of Voltage measurement	via interface	100 mV, with **option VHR**: 10 mV (up to 4 kV)			
	display	1 V			
Resolution of current measurement		with option:	2MA		2MA0n1
	range (MR_I)	I=1: I_{Onom}	I=2: 65 µA		I=2: 6,5 µA
	via Interface	100 nA	1 nA		100 pA
	display	1 µA	10 nA		1 nA
Accuracy current measurement		± (0,1% $* I_O$ +0,05% $* MR_I$) for one year			
Accuracy voltage measurement		± (0,05% $* V_O$ +0,02% $* V_{Onom}$) for one year			
Value scope		all data are guaranteed in the range of (0,2% $* V_{Onom}) < V_O < V_{Onom}$			
Voltage control	CONTROL switch in	upper position:	10 - turn potentiometer		
		lower position (DAC):	control via interface		
Rate of change of output voltage		hardware ramp	500 V/s (on HV-ON/ -OFF)		
		software ramp:	2 . . . 255 V/s		
Protection		- separate current and voltage limit (hardware, rotary switch in 10%-steps) - INHIBIT (ext. signal TTL-level, Low = active ⇒ V_{OUT}=0) - programmable current limit (software): Current trip reaction time < 60 ms			

VHQ two channel	222 M	223 M	224 L	225 L
Power requirements V_{INPUT}	± 12 V (< 850 mA, with **option M - h < 1,6 A**) + 5 V (< 300 mA)			
Packing	VME #2 / 6U / 164 mm deep			
Connector	96-pin VME connector according to DIN 41612			
HV connector	SHV-Connector at the front panel			
INHIBIT connector	1-pin Lemo-hub			
Operating temperature	0 ... +50 °C			
Storage temperature	-20 ... +60 °C			

3. VHQ Description

T he functional principle is described in the block diagram, Appendix A.

High voltage supply

For the high voltage generation a patented highly efficient resonance converter circuit is used, which provides a sinusoidal voltage with low harmonics for the HV-transformer. For the high voltage rectification high speed HV-diodes are used. A high-voltage switch, connected to the rectifier allows the selection of the polarity. The consecutive active HV-filter damps the residual ripple and ensures low ripple and noise values as well as the stability of the output voltage. A precision voltage divider is integrated in the HV-filter to provide a feedback voltage for the output voltage control, an additional voltage divider supplies the signal for the maximum voltage monitoring. A precision control amplifier compares the feedback voltage with the set value given by the DAC (remote control) or the potentiometer (manual control). Signals for the control of the resonance converter and the stabilizer circuit are derived from the result of the comparison. The two-stage layout of the control circuit results in an output voltage, stabilized with very high precision to the set point.
Separate security circuits prevent exceeding the front-panel switch settings for the current I_{max} and voltage V_{max} limits. A monitoring circuit prevents malfunction caused by low supply voltage.
The internal error detection logic evaluates the corresponding error signals and the external INHIBIT signal and impacts the output voltage according to the setup. In addition this allows the detection of short over currents due to single flashovers.

Digital control unit

A micro controller handles the internal control, evaluation and calibration functions of both channels. The actual voltages and currents are read cyclically by an ADC with a connected multiplexer. The readings are processed and displayed on the 4 digit LCD. The current and voltage hardware limits are retrieved cyclically several times per second. A reference voltage source provides a precise voltage reference for the ADC and the control voltage for the manual operation mode of the unit.
In the computer controlled mode the set values for the corresponding channels are generated by a 18-Bit DAC.

Filter

A special feature of the unit is a tuned filtering concept, which prevents perturbation of the unit by external electromagnetic radiation, as well as the emittance of interferences by the module. A filtering network for the supply voltages is located next to their connectors, the converter circuits of the individual channels are protected by additional filters. The high-voltage filters are housed in individual metal enclosures to shield even minimal interference radiation.

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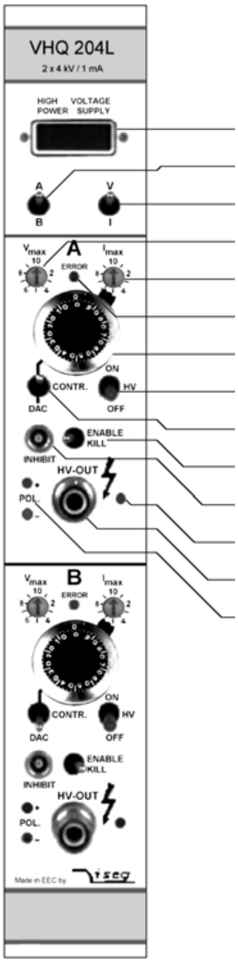
4. Front panel



[1] 4 digit LCD display
[2] Channel switch
[3] Measuring switch
[4] Rotary switch Voltage limit
[5] Rotary switch Current limit
[6] Error indicator
[7] 10 - turn potentiometer
[8] HV-ON switch
[9] CONTROL switch
[10] KILL switch
[11] INHIBIT input
[12] HV-ON indicator
[13] HV-output
[14] Polarity indicator

5. Handling

By connecting the VME-connector on the rear side the unit is set into the operating state.

Before the unit is powered the desired output polarity must be selected by the rotary switch on the cover side (see appendix B). The chosen polarity is displayed by a LED on the front panel [14] and a sign on the LCD [1].

Attention! It is not allowed to change the polarity under power!

An undefined switch setting (not at one of the end positions) will cause no output voltage.

High voltage output is switched on with HV-ON switch [8] at the front panel. The viability is signalled by the yellow LED [12].

Attention! If the CONTROL switch [9] is in upper position (manual control), high voltage is generated at the HV-output [13] on the rear side, started with a ramp speed of 500 V/s (hardware ramp) to the set voltage given by the 10-turn potentiometer [7].
This is also the case, if VME control is switched over to manual control while operating.

If the CONTROL switch [9] is in lower position (DAC), high voltage will be activated only after receiving corresponding VME commands.

The LCD [1] displays the output voltage in [V] or the output current in [µA], depending on the position of the Measuring switch [3].

For two channel units the Channel switch [2] selects whether channel (A) or channel (B) is displayed.

In the manual control mode the output voltage can be set via 10-turn potentiometer [7] in a range from 0 to the maximum voltage.

If the CONTROL switch [9] is switched over to remote control, the DAC takes over the last set output voltage of the manual control. The output voltage can be changed remotely with a programmable ramp speed (software ramp) from 2 to 255 V/s in a range from 0 to the maximum voltage.

The maximum output current for each channel (current trip) can be set via the remote interface in units of the resolution of the upper measurement range. If the output current exceeds the programmable limit, the output voltage will be shut off permanently by the software. A recovery of the voltage is possible after reading ″ Status register 2″ and then ″Start voltage change″ via interface.

The maximum output voltage and current can be selected in 10%-steps with the rotary switches V_{max} [4] and I_{max} [5] (switch dialed to 10 corresponds to 100%) independently of programmable current trip. The red error LED on the front panel [6] signals if the output voltage or current approaches the limits.

The KILL switch [10] specifies the response on exceeding limits or on the external protection signal (EXINHIBIT) at the INHIBIT input [11] as follows:

Switch to the right position: (ENABLE KILL)	When exceeding V_{max}, I_{max} or in the presence of an INHIBIT signal (Low=active) the output voltage will be shut off permanently without ramp. The output voltage is only restored after switching HV-ON [8] or KILL [10] or reading ″ Status register 2″ and then ″Start voltage change″ by DAC control.
Note:	If a capacitance is effective at the HV-output or when using a high voltage ramp speed (hardware ramp) under high loads, then the KILL function may be triggered by the capacitor charging currents. In this case smaller output voltage change rates (software ramp) should be used or ENABLE KILL should only be selected once the set voltage is reached at the output.
Switch to the left position: (DISABLE KILL)	The output voltage is limited to V_{max}, the output current to I_{max} respectively; INHIBIT shuts the output voltage off without ramp, the previous voltage setting will be restored with hard- or software ramp once INHIBIT is no longer being present.

6. VME Interface

Modus: short supervisory access (AM = 0x2D)
short nonprivileged access (AM = 0x29)

Control via VME interface

- Write function: set voltage; ramp speed; maximal output current (current trip); auto start
- Switch function: output voltage = set voltage, output voltage = 0
- Read function: set voltage; actual output voltage; ramp speed; actual output current; current trip; auto start ; hardware limits current and voltage; status

Front panel switches have priority over software control.

Manual control

While the unit is operated in manual control mode, VME read cycles are interpreted only. Commands are accepted, but do not result in a change of the output voltage.

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Command Execution Time

The command execution time is typically 2 µs.

Base Address

The base address BA is saved in a EEPROM. Setting the BA:

1. Before the module is powered up by switching on the supply voltages (± 24V; ± 6V) the following switch configuration must be set for both channels
   ⇨ switch CONTROL on MANUAL; ⇨ switch HV-ON [9] on OFF; ⇨ switch KILL on ENABLE.

2. Switch ON the supply voltages..

3. LCD display shows an ″A″ on the left side and the high byte of the base address in HEX (e.g. ″dd″) on the right side, with flashing separator in between.

4. High-order nibble can be set with channel switch, the low-order nibble with measuring switch.

5. If there is no change within 10s and a change in any other another switch, the selected base address is saved in EEPROM and the module is ready to operate.

6. Factory setting: BA = 0xDD00

Register addresses

A7	A6	A5	A4	A3	A2	A1	Read	Write
0	0	0	0	0	0	0	Status register 1	
0	0	0	0	0	1	0	Set voltage Channel A [V]	Set voltage Channel A ($V_{set} \le V_{max}$) [V]
0	0	0	0	0	1	1	Set voltage Channel A [0,1V]	Set voltage Channel A ($V_{set} \le V_{max}$) [0,1V]
0	0	0	0	1	0	0	Set voltage Channel B [V]	Set voltage Channel B ($V_{set} \le V_{max}$) [V]
0	0	0	0	1	0	1	Set voltage Channel B [0,1V]	Set voltage Channel B ($V_{set} \le V_{max}$) [0,1V]
0	0	0	0	1	1	0	Ramp speed Channel A (2... 255) [V/s]	Ramp speed Channel A (2... 255) [V/s]
0	0	0	1	0	0	0	Ramp speed Channel B (2... 255) [V/s]	Ramp speed Channel B (2... 255) [V/s]
0	0	0	1	0	1	0	Actual voltage Channel A [V]	
0	0	0	1	0	1	1	Actual voltage Channel A [0,1V]	
0	0	0	1	1	0	0	Actual voltage Channel B [V]	
0	0	0	1	1	0	1	Actual voltage Channel B [0,1V]	
0	0	0	1	1	1	0	Actual current Channel A [0,1µA]	
0	0	0	1	1	1	1	Actual current Channel A *) 2MA	
0	0	1	0	0	0	0	Actual current Channel B [0,1µA]	
0	0	1	0	0	0	1	Actual current Channel B *) 2MA	
0	0	1	0	0	1	0	Hardware limits Channel A (I_{max} , V_{max})	
0	0	1	0	0	1	1	Actual current Channel A *) 2MA0n1	
0	0	1	0	1	0	0	Hardware limits Channel B (I_{max} , V_{max})	
0	0	1	0	1	0	1	Actual current Channel A *) 2MA0n1	
0	0	1	0	1	1	0	Data ready	
0	0	1	1	0	0	0	Status register 2	
0	0	1	1	0	1	0	Start voltage change Channel A [V]	Start voltage change Channel A with data: Set voltage Channel A [V]
0	0	1	1	0	1	1	Start voltage change Channel A [0,1V]	Start voltage change Channel A with data: Set voltage Channel A [0,1V]
0	0	1	1	1	0	0	Start voltage change Channel B [V]	Start voltage change Channel B with data: Set voltage Channel B [V]
0	0	1	1	1	0	1	Start voltage change Channel B [0,1V]	Start voltage change Channel B with data: Set voltage Channel B [0,1V]

A7	A6	A5	A4	A3	A2	A1	Read	Write
0	0	1	1	1	1	0	Module identifier	
0	1	0	0	0	0	0	-	-
0	1	0	0	0	1	0	Current software limit Channel A **) [µA]	Current software limit Channel A with data **)
0	1	0	0	0	1	1	Current software limit Channel A *)	Current software limit Channel A with data *)
0	1	0	0	1	0	0	Current software limit Channel B **) [µA]	Current software limit Channel B with data **)
0	1	0	0	1	0	0	Current software limit Channel B *)	Current software limit Channel A with data *)
								current value = 0 ⇒ not a current trip

*) corresponding to resolution in the 2nd current measurement range:
option 2MA, I=2: 65 µA ⇒ [0,1µA], max. value 6553(,)4 µA
option 2MA0n1, I=2: 6,5 µA ⇒ [0,1nA], max. value 6553(,)4 nA

**) corresponding to resolution in the 1st current measurement range

Status register 1 (BA + 0x00)

Channel	Bit	Name	Description	0	1
B	D15	ERROR_2	Error on Channel B	Channel ok	Error
	D14	STATV_2	Status V_O	V_{out} stable	V_{out} in change
	D13	TRENDV_2	Ramp up / down	V_{out} falling	V_{out} rising
	D12	KILL_2	KILL switch setting	Disabled	Enabled
	D11	ON_OFF_2	HV-ON/OFF switch setting	On	Off
	D10	POL_2	Polarity V_O	Negative	Positive
	D9	IN_EX_2	CONTROL switch setting	DAC	Manual
	D8	VZ_2	$V_{Out} = 0$	V_{out}<>0	V_{out}=0
A	D7	ERROR_1	Error on Channel A	Channel ok	Error
	D6	STATV_1	Status V_O	V_{out} stable	V_{out} in change
	D5	TRENDV_1	Ramp up / down	V_{out} falling	V_{out} rising
	D4	KILL_1	KILL switch setting	Disabled	Enabled
	D3	ON_OFF_1	HV-ON/OFF switch setting	On	Off
	D2	POL_1	Polarity V_O	Negative	Positive
	D1	IN_EX_1	CONTROL switch setting	DAC	Manual
	D0	VZ_1	$V_O = 0$	V_{out}<>0	V_{out}=0

This register is representing the general status of the VHQ.

″Error“ is generated by a logical OR of REG2ER_, REG1ER_, EXTINH_, RANGE_ and ILIM_ from ″Status register 2″.

″V_{out}=0″ is generated by a logical AND of DAC output = 0 and actual voltage < 5 V.

Set voltage Channel A/B in resolution 1 V (BA + 0x04 / BA + 0x08)

Set voltage V_{set} from 0 to V_{nom} in V. If V_{set} greater then V_{max} (BA + 0x24 / BA + 0x28), V_{set} will be not changed.

With option VHR: Set voltage Channel A/B with 0,1 V resolution (BA + 0x06 / BA + 0x0A)

Set voltage V_{set} from 0 to V_{nom} in 0,1V. If V_{set} greater then V_{max} (BA + 0x24 / BA + 0x28), V_{set} will be not changed.

Ramp speed Channel A/B (BA + 0x0C / BA + 0x10)

Voltage ramp speed from 2 V/s to 255 V/s. All processor controlled changes in the output voltage are performed at this ramp speed.

Actual voltage Channel A/B (BA + 0x14 / BA + 0x18)

Output voltage $V_{out'}$ of the channel in V.

With option VHR: Actual voltage Channel A/B (BA + 0x16 / BA + 0x1A)

Output voltage $V_{out'}$ of the channel with 0,1V resolution.

Actual current Channel A/B (BA + 0x1C / BA + 0x20)

Output current I_{out} of the channel with 100nA resolution, corresponding to 1st current measurement range I_{nom}.

With option 2MA: Actual current Channel A/B (BA + 0x1E / BA + 0x22)

Output current I_{out} of the channel with 1nA resolution, corresponding to 2nd current measurement range 65µA.

With option 2MA0n1: Actual current Channel A/B (BA + 0x26 / BA + 0x2A)

Output current I_{out} of the channel with 100pA resolution, corresponding to 2nd current measurement range 6,5µA.

Hardware limits (BA + 0x24 / BA + 0x28)

D0 .. D3 Maximal output current (I_{max}) in 10 %, hardware setting on the front panel switches
D4 .. D7 Maximal output voltage (V_{max}) in 10 %, hardware setting on the front panel switches
D8 .. D15 0

Data ready (BA + 0x2C)

D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	Current B	Voltage B	Current A	Voltage A

The individual bits are set once actual measured data is available. The bits are deleted after the corresponding reading command.

Status register 2 (BA + 0x30)

	Bit	Name	Description	Remark
Channel B	D15	REG2ER_2	Quality of output voltage currently not guarantied	
	D14	REG1ER_2	I_{max} is / was exceeded	
	D13	EXTINH_2	External inhibit was / is active	
	D12	RANGE_2	V_{set} to V_{max} ratio > 1	D(BA+0x08) > V_{max}
	D11	KEY_CHANGED	A frontpanel switch position was changed	ON_OFF_2, IN_EXT_2, KILL_2
	D10	EOP_2	V_{out} has reached set value	End of process_2
	D9	ILIM_2	I_{out} was > I_{max} programmable	Current trip
	D8			
Channel A	D7	REG2ER_1	Quality of output voltage currently not guarantied	
	D6	REG1ER_1	I_{max} is / was exceeded	
	D5	EXTINH_1	External inhibit was / is active	
	D4	RANGE_1	V_{set} to V_{max} ratio > 1	A(BA+0x04) > V_{max}
	D3	KEY_CHANGED	A front panel switch position was changed	ON_OFF_1, IN_EXT_1, KILL_1
	D2	EOP_1	V_{out} has reached set value	End of process_1
	D1	ILIM_1	I_{out} was > I_{max} programmable	Current trip
	D0	TOT	Timeout error	New initialisation

The individual bits are set on the occurrence of the event. A general clear is performed after readout.

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If the Output voltage was permanently switched off by exceeding I_{max} (ENABLE KILL resp. Current trip), or INHIBIT respectively, the error bits (REG1ER_, EXTINH_, ILIM_) have to be reset by reading ″ Status register 2″ before an output voltage can be set again.

Start voltage change in Channel A/B (BA + 0x34 / Ba + 0x38)

Reading these registers will start the output voltage change to the set voltage (BA + 0x04 / BA + 0x08) with the given software ramp (BA + 0x0C / BA + 0x10). Writing a set voltage to these registers will store the data as a new set voltage (BA + 0x04 / BA + 0x08; $V_{set} \leq V_{max}$) and directly start the voltage change.

The change of output voltage is blocked, if some conditions, as described below, are not satisfied.

If hardware limits V_{max} and I_{max} have been exceeded with DISABLE KILL (limitation of the voltage/current, Error-LED on), the voltage can be lowered a single time before resetting REG1ER_ by reading status register 2 (BA + 0x30).

The command execution can be monitored by reading status register 1 (BA + 0x00). The bits D14 (channel B), D6 (channel A) respectively are set on start of voltage change. Once the set voltage is reached the bits D10, D2 of status register 2 (BA + 0x30) are set. An interruption of the voltage change (e.g. with an external INHIBIT) can be observed from these bits (status register 1: D14 / D6 = 0; status register 2: D10 / D2 = 0).

Module identifier (BA + 0x3C)

D15 .. D0 4 digit serial number, BCD coded

Current trip Channel A/B (BA + 0x44 / BA + 0x48)

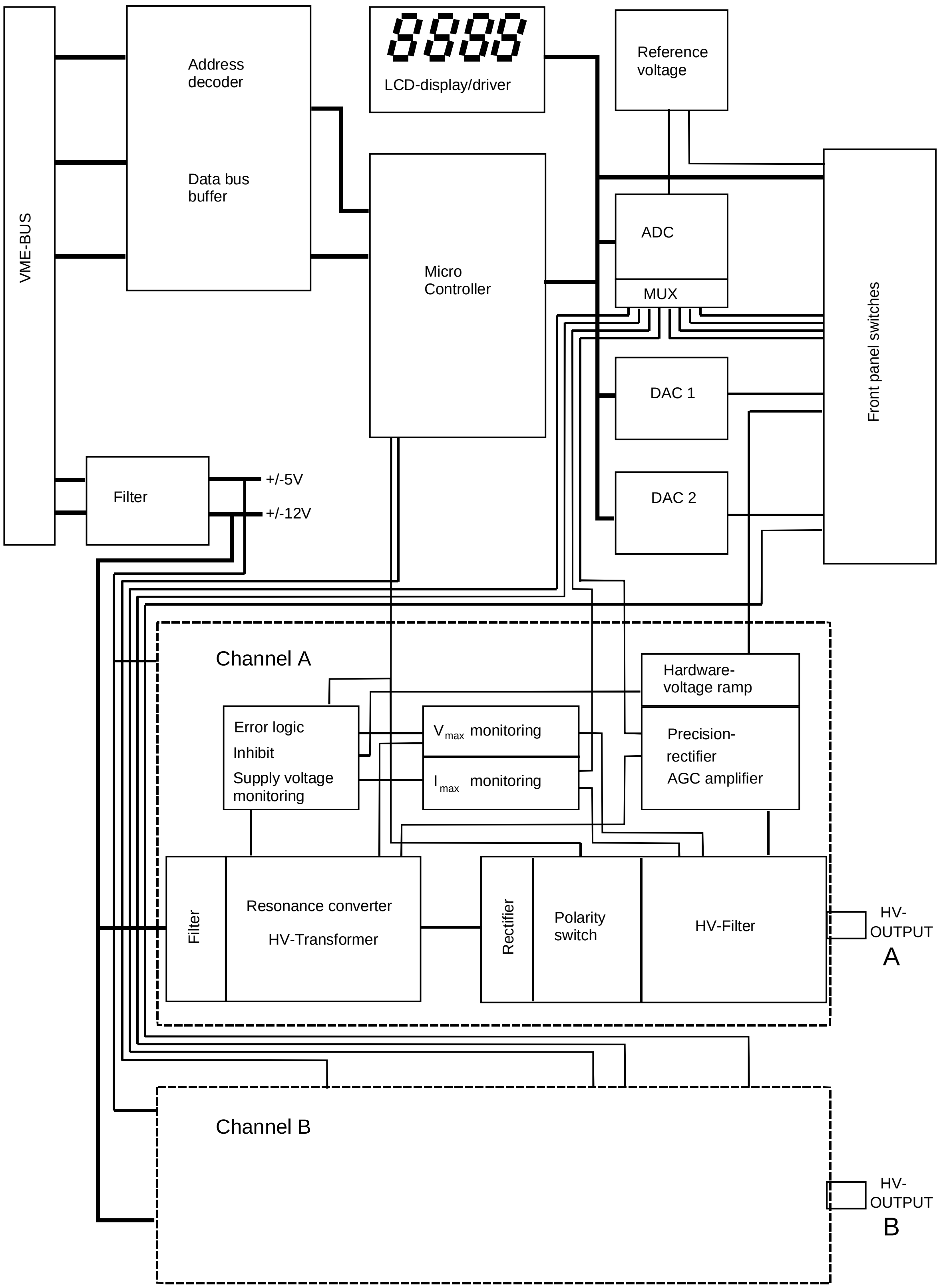
Reading these registers will return the programmed maximal output current in the corresponding current resolution. If the output current exceeds the programmable limit, the output voltage will be shut off permanently by the software (Current trip). The response time for this is between 20 and 60 ms.

A current trip is set by writing a current value in the corresponding current resolution. A current trip value of 0 will deactivate the current trip function.

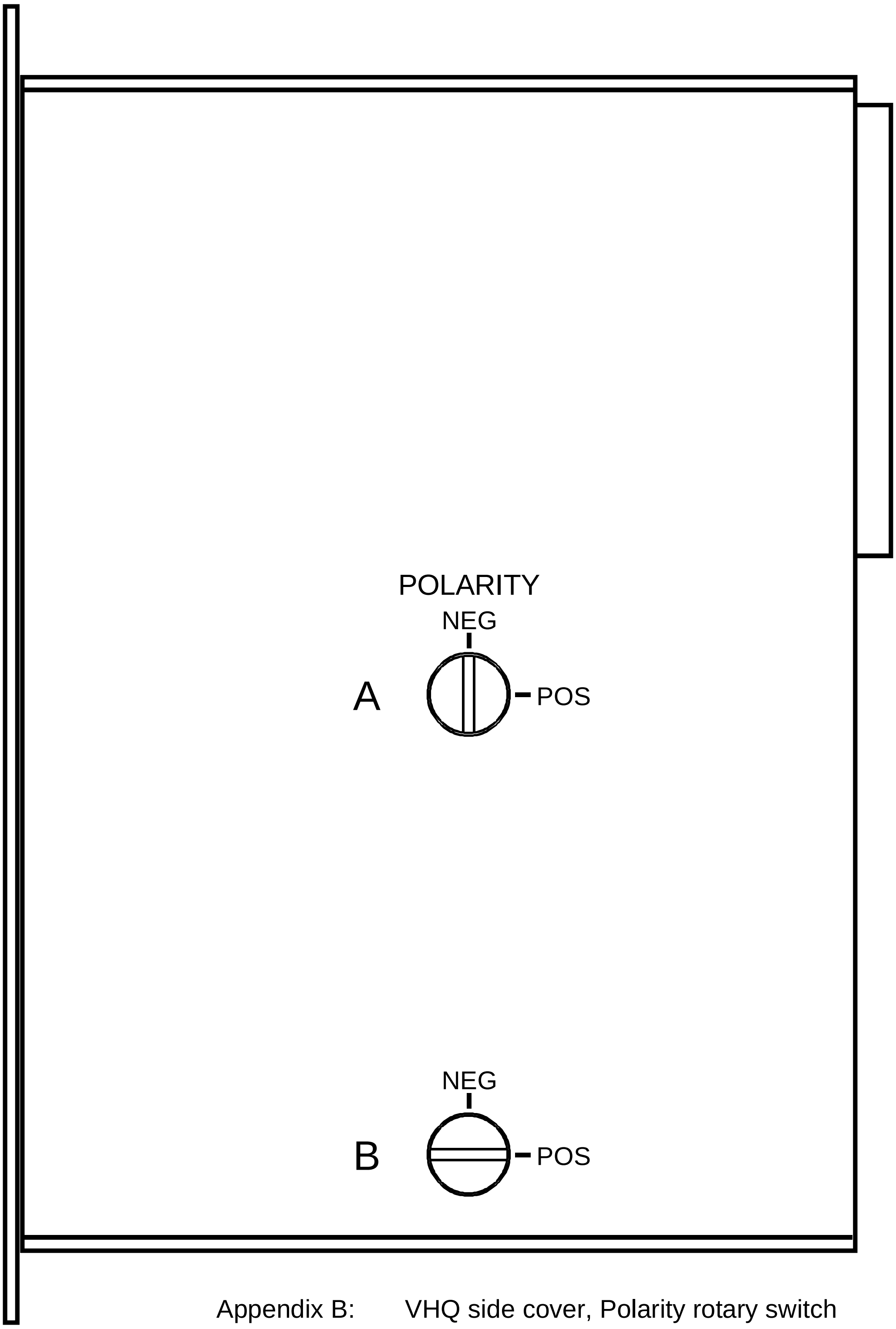
The hardware current limit (I_{max}) limits the current independently of the software trip.

With option 2MA or 2MA0n1: Current software limit (BA + 0x46 / BA + 0x4A)

The maximal output current per channel corresponding to the current resolution in the 2nd current measurement range. If the output current exceeds the programmable limit, the output voltage will be shut off permanently by the software (Current trip). The response time for this is between 20 and 60 ms.
A current trip value of 0 will deactivate the current trip function.



Appendix A: Block diagram VHQ



Appendix B: VHQ side cover, Polarity rotary switch

eg.: channel A - Polarity negative

channel B - Polarity positive