Power Supply Manual

BIASET3
HV2/4, HV2/6, HV2/8, HV2/10
SPS2 (mini)
BA3, HVZ and HVT/HVT4
USB-I/O1

(Version 11.0.2102.1)
The HV2/4 and HV2/6 were developed by

iseg
Spezialelektronik GmbH

for

RoentDek
Handels GmbH

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5 The RoentDek High Voltage Supplies

Safe and high-performance operation of RoentDek detectors requires adequate high voltage supplies and auxiliary passive bias units. In the following the standard units are described. If you have received a different model, please refer to the respective manual.

5.1 The HV2/4 (/6 /8 /10) dual High Voltage supply module

The RoentDek 2×4kV High Voltage power supply is especially designed for biasing multi-channel-plate detectors, featuring low ripple and regulated current limitation and protection. It is usually powered by a NIM crate or via the RoentDek SPS2(mini) mains adapter (through the 9-pin socket on the rear side panel). Special versions of this module for up to 6, 8 and 10 kV (HV2/6, HV2/8, …) are available, also for “pseudo-floating” operation mode (see Chapter 5.2).

The switches on the side panel will set the respective channels A and B to negative or positive output polarity (not for HV2/10, which has factory-fixed polarities). The polarity is indicated by an LED on the front panel. Only change polarity when mains power is off.

If a channel of the power supply is switched on (indicated by an LED), and the “DAC” switch is set to the upward position, the 10-turn potentiometers on the front panel can be used for manual setting of the output potential $U_o$, 10 turns corresponding to $U_{\text{max}}$ (e.g. 4 kV in case of the HV2/4) with linear progression. The voltages can also be set externally via an analog voltage input to the LEMO-sockets on the rear panel (0-10 V positive input corresponds to 0-4 kV voltage output for HV2/4 (1:400) or 1 kV progression for every 1 V analog input for HV2/6, HV2/8 and HB2/10 (1:1000) with linear progression). For this the “DAC” switch must be set to “DAC”. Please contact RoentDek for adequate DC level remote controls (e.g. the USB-IO1, see Chapter 5.10).

The A/B switch will allocate the display to channel A or B, the V/I switch will enable voltage or current reading of the respective channel. The accuracy of the reading is within a few volts and a few $\mu$A (typically 1 $\mu$A), respectively.

If a channel is turned on, the “Inhibit” input can be used for enabling / disabling the voltage output with a TTL level. Specified operation modes are:

a) Input open (resistance to ground > 10 k$\Omega$) or level > +2.5 V: high voltage output is enabled

b) Input shorted (resistance to ground < 1 k$\Omega$) or level < +1 V: high voltage output is disabled

Do not use input voltages outside of the range from 0 V to +6 V.

The “Inhibit” input can be used for remote safe-guarding or actively enabling/disabling the voltage output by applying a TTL level as described above. Notice: if the “Enable” switch is on “Kill” position, high voltage output must be resumed manually.

The maximum current $I_{\text{max}}$ delivered is 3 mA for the HV2/4 (1 mA for HV2/6 and /8, and 0.5 mA for HV2/10). Both $I_{\text{max}}$ and $U_{\text{max}}$ can be restricted in 10 % steps (e.g. from 0.3 mA/400 V to 3 mA/4 kV for the HV2/4, the latter corresponding to 100 %). Usually the current limiter should set to 10 %, i.e. 0.3 mA when using it with a RoentDek MCP detector (exception: biasing via an HVT device).

If a pre-set limit is exceeded (e.g. too high current) a red “Error” LED on the front flashes once and the high voltage “trips”: it turns off when the “Enable” switch on the front table is in the “Kill” position (see Figure 5.1, on channel B). Re-engagement must be manually prompted by turning the channel off and on again via the red main switch.

If the “Enable” switch is not in “Kill” position (see Figure 5.1, on channel A) the unit will automatically try to resume the set value. The latter is NOT a favorable operation condition if the tripping is caused by detector sparks and may cause damage if prolonged. We strongly advise to operate the power supply only in “Kill Enable” mode. In case of an “Error”, turn off the voltage to 0 Volts and switch the module off. Do not turn it on again before a proper state for safe operation has been verified.

Figure 5.1: 2x4kV Power Supply (front panel)
Important: The safest operation mode for MCPs is the “Enable Kill” position. If the current limitation is set low and the switch is on this position it can happen that an error is indicated when starting to increase the voltage on a certain detector part, although no problem of the hardware actually exists. This is due to the loading current of capacitors in the power supply itself or in the signal decoupling circuits. In that case set the switch to the other direction when starting to increase voltage. You may switch to the “Enable Kill” position later after the voltage setting is finished.

The hardware ramp speed is 500 V/s. (power switch or inhibit turned on/off.)

For standard modules the 9-pin socket located on the rear panel can be used to alternatively receive power via a SPS2(mini) mains adapter (in absence of a NIM crate. Pin assignments are

Pin1/2: ground
Pin6: -24 V, Pin7 +24 V for N24 modules (see Figure 5.9) and
Pin5: -6 V, Pin8: +6 V additionally for 6 V modules (not with N24 label)*

Further specifications:

Operation/storing temperature: 0 ... +50 °C / -20 ... +60 °C
Ripple (peak-to-peak)  < 50 mVpp for all frequencies (HV2/4 and /6)
HV2/8 and /10: for < 1 kHz up to 200 mVpp
Display reading precision ±0.1% plus 1 digit
Stability ΔUa < 2 × 10⁻⁴ or 5 × 10⁻⁵ of ΔUe
Temperature coefficient < 1 × 10⁻⁴/°C

Changing the Polarity:
To change the polarity of either channel A or B, locate the corresponding “red knobs” on the left side-panel (see Figure 5.2, here: negative polarity is selected for both channels). Only if the mains power is off adjust the slit of the “red knob” to the desired polarity using either an adequate screwdriver or a coin. Do not press on the knob! Do not use force! The channel is adjusted if you hear and feel the lock click into place.

Figure 5.2 (left side): 2x4kV Power Supply

Warning: the HV output of this power supply can be hazardous if not properly operated. Never operate the module with open housing. RoentDek denies any responsibility for accidents with their products and is protected by German laws. If you need special instructions how to handle high voltage power supplies please contact RoentDek.

Notice: HV2/4 and similar units may need an adequate pull-up preventer circuit like the RoentDek HVT when operating two channels at the same polarity supplying resistive-coupled contacts such as the two sides of an MCP stack (see Chapter 5.5).

For optimal stability of the set values is recommended to operate the RoentDek high voltage power supplies mainly between 2% and 100% of Umax, e.g. between 80 V and 4000 V for the HV2/4. Lower voltage settings are possible but specs are not guaranteed below 1% of Umax. If you want to achieve stable voltage outputs well below 100 V with a HV2/4, RoentDek can provide a voltage divider based on the RoentDek HVT+ passive voltage dividing unit (see Chapter 5.9).

* Modules with 6 V operation (as displayed in Figure 5.3) can be used for routing voltages from a NIM bin to the 9-pin socket which acts then as a DC-output for ±6 V, ±24 V, +12 V (pin4) and -12 V (pin9) in order to bias other modules like the DLATR6 and ATR19-2. Please observe the label next to the socket.
Module versions with the “KIB” label (see Figure 5.4) have an internal jumper switch that allows linking the “Enable Kill” function of both channels: If one of the channels experiences a current drain at the $I_{\text{max}}$ set value (a “trip”), both channels will be turned off (only when both channels are set to “Enable Kill”). The “kill both” (KIB) setting is of advantage when tripping of one channel alone will result in a problematic bias situation while the other channel maintains its set potential. This is especially relevant for high voltage units with higher than 4 kV output.

Unless otherwise indicated the factory setting of the jumper position does NOT support the “kill both” functionality (see in Figure 5.5). The jumper for enabling the “kill both” functionality can be accessed after opening the side panel with the polarity switches (before opening the case switch off both channels and then remove all cable connections to the module, otherwise there is risk of electro-hazard. Only touch the inside at the jumper position!). To enable the “kill both” functionality set the jumper to the position as shown in Figure 5.5, lower picture).

Figure 5.4: Label on the side panel indicating availability of the “kill both” functionality:

![Figure 5.4](image)

Figure 5.5: Photos of the internal circuit board (after opening the side panel) with standard setting (“kill both” disabled, see blue jumper setting above) and jumper setting for enabling the “kill both” functionality.

![Figure 5.5](image)

* Such a potentially damaging bias scheme can for example occur when both channels bias an MCP stack on same polarities. Tripping of only one channel can then result in a situation that the other channel in function produces an excessive voltage across the MCP stack or between an intermediate MCP stack contact and front/back side.
5.2 The Pseudo-Floating power supply options PF+ and PF-

For some applications it is beneficial to operate a high voltage supply for detector bias in the so-called “Pseudo-Floating” mode. While the function of channel A corresponds to the standard high voltage supply version, channel B output is determined not only by the setting of channel B (via the corresponding dial or remote control) but also by the setting of channel A:

\[ B' = B + A \quad \text{and} \quad A' = A \]  

(for PF+, same polarity)

A' and B' are the actual output potentials \( U_o \), from the corresponding SHV sockets on rear panel, A and B are the set values, controlled by the dials or remote control inputs. If both channels are set to same polarity, A defines the “float potential” while the B setting defines the potential difference between the outputs (A' and B'). For detector operation, the A' output is used for MCP front or the anode bias while B biases the opposing detector end. B then determines voltage across the detector while A defines the “float” potential of the respective detector part relative to ground: Changing A setting only will not affect the detector function, e.g. in terms of gain.

It is to note, however, that B' can never exceed the maximum rating \( U_{\text{max}} \) of the specific high voltage supply (4, 6, 8 or 10 kV), e.g. B' is always \(< 4 \text{ kV}\) for HV2/4PF+ even if \((B + A)\) would mathematically yield a higher value.

It is also possible to operate the two channels of a PF+ high voltage power supply at alternating polarities. In this case, however, the voltage difference \( B' = B + A \) between the SHV output does not stay constant when A is varied due to the sign change.

For this reason a the HV2/4 version can be supplied as PF- version, internally set to

\[ B' = B - A \quad \text{and} \quad A' = A \quad \text{with} \quad B > A \]  

(for PF-, different polarities)

correspondences between set values and outputs. This allows for an equivalent pseudo-floating operation scheme when the potentials at the detector ends have different sign.

For the PF- version the minimum value of B' is 0, i.e. the polarity of the output cannot change if \((B - A)\) would mathematically yield a negative value. The versions PF- or PF+ are factory-fixed and cannot be changed

It is to note that the high voltage outputs of the PF high voltage supply versions are not physically floating, only the function of a floating power supply channel as simulated by special voltage control circuits inside the units. Therefore, it is not possible to reverse the output polarity of B' by changing set values from \( A < B \) to \( A > B \).

The following table shows some examples. Channel B is set to the MCP voltage (here: 2700 Volts), while channel A can be varied.

<table>
<thead>
<tr>
<th>Examples for HV2/4PF+/¬</th>
<th>pol. B</th>
<th>B set (diff.)</th>
<th>pol. A</th>
<th>A set range and output</th>
<th>output on lower SHV socket</th>
</tr>
</thead>
<tbody>
<tr>
<td>electron mode</td>
<td>+</td>
<td>2700 V</td>
<td>+</td>
<td>0 V to 1300 V (front)</td>
<td>+2700 V to +4000 V (back)</td>
</tr>
<tr>
<td>pos. ion mode</td>
<td>-</td>
<td>2700 V</td>
<td>-</td>
<td>1300 V to 0 V (back)</td>
<td>- 4000 V to -2700 V (front)</td>
</tr>
<tr>
<td>alternate mode</td>
<td>+</td>
<td>2700 V</td>
<td>-</td>
<td>2700 V to 0 V (front)</td>
<td>0 V to +2700 V (back)</td>
</tr>
</tbody>
</table>

Note that also the operation the pseudo-floating HV2/4 and similar units may need an adequate pull-up preventer circuit like the RoentDek HVT when operating two channels at the same polarity supplying resistive-coupled contacts such as the two sides of an MCP stack (see Chapter 5.5).
5.3 The BIASET3 with SPS2(mini)

The BIASET3 consists of the 90-250 VAC main power supply SPS2 or SPS2mini and 1 to 4 units of HV2/4 (or HV2/6, HV2/8 and HV2/10) modules (see Chapter 5.1) as a standalone power supply solution without the need for a NIM bin. It can also incorporate single channel high voltage (HV) modules like the HV1/4 or any of the EHQ 1xxx series earlier BIASET2 product. The BIASET3 includes a stand for up to 4 HV modules. The HV modules and the SPS2mini are interconnected via 9-pin sub-D cables (included) on the rear panels.

Figure 5.7: BIASET3 with SPS2 and one HV2/4 module (corresponds to BIASET3-2). Alternative mountings include adapter frames for placing several HV2/4 units in 6HU 19" rack or sideways in 3HU racks.

The SPS2 mains adapter provides power via standard 9-pin sub-D cables for up to two HV modules or via twin-9-pin sub-D cables for up to four HV modules. It measures about 130×130 mm with a depth of approximately 250 mm (extra 100 mm free depth are needed for the cables on the rear panel).

The SPS2 can be mounted to a 3-HU 19" rack (occupies 24 width units) or can be used as a table-top unit. The unit requires sufficient airflow and an ambient temperature < 40 °C. A spare main fuse (250 V 4 A, slow) is supplied within the AC-input socket. Separate fuses inside the housing (0.63 A “slow”) secure the 6 V DC output lines. Lit LEDS on the rear panel indicate normal operation.

Always turn off the unit when connecting/disconnecting the mains power cable or the cables to the HV modules. Always turn off the unit AND remove the power cable when opening the case or changing fuses.

* The output from the SPS2mini cannot supply operation voltages for the (N)DLATR or FAMP/CFD modules.
High voltage modules of the type “N24” and EHQ 1xxx (e.g. HV1/4) can alternatively be supplied via the SPS2mini mains adapter which delivers only ±24 V. If you want to purchase a mains adapter for an existing HV2/4 module, verify of which type it is. The “N24” units can be recognized by the respective label on the front panel or equivalent side-panel labelling:

The SPS2mini comes with an external mains adapter, to be connected to the “DC input” socket. Remove the mains power plug from the AC socket when connecting/disconnecting cables on DC input or output sockets of the SPS2mini.

### 5.4 BA3 battery unit

The BA3 battery unit is one of several specific “passive” units for biasing RoentDek detectors as an add-on device to a HV2/4 or similar high voltage supply unit. Its typical application is to simplify helical wire delay-line anode bias but it can also be used whenever a floating battery device is needed for certain biasing schemes. Several BA3 units can be cascaded and combined with other devices.
Usually it is sufficient to operate a helical wire delay-line anode with a voltage difference of 20 to 50 V between the “reference” and the “signal” wires (for details please refer to the RoentDek Delay-line manual. To supply this constant voltage offset between the wires a battery can be used. The RoentDek BA3 battery pack provides this offset with values between 35 and 40 V (nominally 36 V, without load 38-39 V).

For using the BA3 to supply wire potentials you need to connect the SHV output “HV +36 V” to the U_{sig} input of the FT12/16-TP plug and the other SHV output “HV” to the U_{ref} input. The desired potential for the reference wire (U_{ref}) must be supplied to the SHV input. “HV input” of the BA3’s opposite side. The maximum potential for U_{ref} is specified as 4 kV, on demand units with up to 6 kV rating can be provided.

Please note that the battery is not discharged during normal operation as no current is flowing between U_{ref} and U_{in}. Even in the presence of a short on the delay-line anode, there is still a 10 kΩ resistance between the poles of the internal battery pack (this is only valid for BA3 bought in or after 2014). The lifetime of the battery pack is therefore very long (several years). The individual batteries are standard 12 V cells which can be found for example in camera shops. If you need help in replacing the battery, please contact RoentDek. Before opening the case, make sure to turn off, discharge and disconnect the high voltage. Only open the side where the “HV Input” socket is located. The BA3 circuits is also used as part of the HVZ10 voltage dividing unit, see Chapter 5.4.

![Figure 5.10: RoentDek BA3 battery box. The voltage input is on the left side, the output connectors (here as reserve SHV) on the right side. The input voltage is routed to the upper voltage output (for U_{ref}) and produces with the internal battery pack the signal voltage U_{sig} = U_{ref} + 36 V (nominally) on the lower output connector. Newer versions of the BA3 have SHV sockets as outputs (instead of plugs shown here) and in-line 10 kΩ resistors.](image)

### 5.5 HVT and HVT4(+) High Voltage Terminators

If a micro-channel plate stack or similar device semi-conducting device with resistance in the MΩ to several GΩ range shall be biased with same polarity on both sides (e.g. positive, for electron detection), standard high voltage power supplies’ control circuits cannot stabilize the lower bias setting below a certain minimum voltage ΔU. The reason is that any biased device can be described as a “load resistance” R_L which forms a resistor chain to ground with an internal resistance R_HV inside the high voltage supply: While the far end of R_L is biased to a certain voltage U by another power supply channel (with same polarity *) the other end of R_L will be pulled up to a certain potential ΔU, even if the dial setting of the connected high voltage supply channel is set to zero or a lower output potential, see Figure 5.11. This effect prevails even if this channel is connected indirectly to an MCP side via a resistor/diode chain (e.g. through an HVZ, see Chapter 5.5.1).

\[
\Delta U/U = R_{HV}/(R_{HV} + R_{L})
\]

Figure 5.11: Scheme of effective biasing circuit when both ends of a resistor load (e.g. an MCP stack) shall be set to same-polarity potentials U_F < U_B. U_F is pulled to minimum potential ΔU determined by the resistor ratio R_{HV}/R_{L}.

For the RoentDek high voltage supplies R_{HV} is on the order of 100 MΩ. To prevent pull-up when biasing devices having R_L of same order a smaller “terminating” resistor R_{HVT} must be placed to ground, i.e. parallel to R_{HV}, thus reducing ΔU. This can for example be achieved by a passive pull-up preventer circuit, the RoentDek High Voltage Terminator box (HVT). On the

* If the ends of R_L are biased at different polarity there is no such effect as described here.
RoentDek HV2/4 and similar units ΔU can directly be observed on the voltage display (when the respective set voltage is zero or low enough).

The standard HVT contains a 1 MΩ resistor to “ground” and is optimized for electron detection purposes with MCP front potential near +200 V or higher. For typical MCP stack resistances (> 20 MΩ) MCP front voltage due to the “pull-away” effect will be < 200 V and can actively be raised up to 1000 V with a high voltage supply (1400 V maximum rating). If ΔU is still too high even in presence of an HVT, a parallel resistor can be placed inside the unit to reduce the effective $R_{HVT}$. Note, that the current drawn from the low-voltage power supply channel is determined by $R_{HVT}$ and may limit the maximum voltage that can be reached in presence of an HVT (especially if current limiter settings are engaged). In this case $R_{HVT}$ may be increased by adding an in-line resistor inside the HVT. For higher potentials it is necessary to supplement another resistor in series with 1 MΩ resistor inside the HVT. Only use resistors with sufficient voltage and power rating. Contact RoentDek if you need extra instruction how to change $R_{HVT}$ and for supply of adequate resistors.

It is important to note that the effective MCP front potential may still differ from the set voltage in case of a non-negligible value of $R_{Df}$. Please refer to the RoentDek Delay-line manual for determining this effect.

The latest FT12TP(z) decoupling plugs can be equipped with an internal on-board HVT circuit, please refer to Chapter 5.8.

The HVT4 version of the High Voltage Terminator contains a 10 MΩ resistor rated for up to 4 kV. It is typically used for applications with MCP front at a high negative potential up to -6 kV via an SHV feedthrough and MCP back side thus being at a negative potential well beyond -1 kV (exceeding the standard HVT rating). In this case the MCP back side voltage may be pulled away unless connected through High Voltage Terminator (see Figure 5.13).

**Electron detection** ($0 \text{ V} < U_{MCP \text{ front}} < +1000 \text{ V}$)

- MCP front $\overset{\leftarrow}{\text{HVT}}$ $\overset{\rightarrow}{\text{HV supply (+)}}$
- MCP back $\overset{\leftarrow}{\text{HV supply (++)}}$

**Heavy positive ion detection** ($U_{MCP \text{ back}}$ with negative bias)

- MCP front $\overset{\rightarrow}{\text{HV supply (-)}}$
- MCP back $\overset{\leftarrow}{\text{HVT4}}$ $\overset{\rightarrow}{\text{HV supply (-) or via HVZ}}$
- MCP back $\overset{\leftarrow}{\text{HVT4}}$ (for operation with FT12TPz)

**Figure 5.13:** Typical voltage settings requiring an in-line HVT or HVT4 for pull-up prevention. When detecting negative ions (if having low kinetic energy) the MCP front potential must be increased to at least +2000V and an HVT4 is to be used in the left diagram. In this operation mode the necessary MCP back/anode voltages are beyond the rating of the standard feedthroughs typically used for delay-line detectors (see Chapter 5.7).

It is also possible changing the internal resistor to a customized value so that the desired voltage on MCP front (or back) is generated only by applying the bias on the other MCP side (passive HVT use).

If you need help in determining $R_{HVT}$ for passive HVT use or finding adequate resistors, please contact RoentDek. For applications with demands for slow heavy ion or negative ion detection please contact RoentDek for special detector mounting, signal decoupling and high voltage supplies rated up to 10 kV.
5.5.1 The HVT4+ matched mode

For MCP stacks with intermediate connection via a shim ring placed in between two MCPs, RoentDek offers a modified HVT4+ unit. It alternatively (or additionally) contains an in-line matching resistor (R_M) inserted for forcing a matched MCP stack operation (R_HVT is usually removed when the HVT4+ is used in matching mode).

In this “matching mode” the resistor value R_M is selected so that it reduces the effective resistance on one side of the stack by placing R_M in parallel to the MCP with higher resistance. The HVT4+ unit in combination with an SHV-T plug (also available from RoentDek) completes the necessary biasing scheme. The HVT4+ unit connects between the corresponding high voltage inputs for the intermediate connection, e.g. “X” in case of an FT12TP plug, or any other SHV/MHV feedthrough connected to the shim ring (as in case of FT4TP/FT16TP) and either the MCP front SHV input or the MCP back SHV input (usually via FT12TP or HFSD/HFST), see Figure 5.15.

Figure 5.14: HVT4+ showing the circuit with resistors R_M (and optionally R_HVT), R_M internally formed by two serial resistors (red arrows), their sum equalling the value of R_M. A specific block diagram on the top panel of each unit indicates the installed circuits on delivery. R_HVT can also be added later, to be soldered between the pads indicated by blue arrows (right picture). R_M must always be connected parallel to the MCP with higher resistance.

For an MCP stack containing individual MCP with resistances R_1 and R_2 the ratio between the voltages U_1 and U_2 across the respective MCP follow Kirchhoff's law as \( \frac{U_1}{U_2} = \frac{R_1}{R_2} \), with a total voltage across the MCP stack of \( U = U_1 + U_2 \). Blocking resistors in the signal decouplers can slightly change the effective potential on the MCPs so that \( V_A - V_B \) is not exactly equal to \( U \). For a matched chevron MCP set \( R_1/R_2 \) is selected to be near unity and the individual MCPs the same voltage. If MCPs have different resistances a matching resistor R_M can be placed in parallel to the MCP with higher resistance (assumed to be R_1 in the following considerations).

\[
\begin{align*}
V_A & \quad \frac{U_1}{U_2} = \frac{R_M}{R_1 + R_M} \frac{R_1}{R_2} & \text{Equation 5.1} \\
V_B & \quad \frac{U_1}{U_2} = 1: \quad R_M = \frac{R_1 R_2}{R_1 - R_2} \left( \frac{R_1 + R_{D1}}{R_1} \right) & \text{Equation 5.2}
\end{align*}
\]

Figure 5.15: Connection scheme for the HVT4+ operated in matching mode and equations for determining R_M. The dashed vertical line indicates the vacuum wall with feedthroughs. The MCPs, separated by a shim ring with contact lug, have resistances of R_1 and R_2, respectively, with R_1 > R_2. If the resistance of the front MCP is larger than of the rear MCP (which is then R_2 in above equations), V_A denominates the front MCP stack bias (and V_B the rear bias). If the resistance of the front MCP is smaller than of the rear MCP (which is then R_1) V_A denominates the rear bias (and V_B the front bias). R_D1 and R_D2 denote blocking resistors in the signal decouplers/terminators (inside HFSD, HFST or FT12TP) which can usually be neglected (term in parentheses) when determining R_M.

The same considerations hold for triple stack assemblies in which case the sum-resistance of the two unseparated MCPs enter Equation 5.1 as R_1 or R_2. Note, that in this (and in selected other) cases the targeted value of \( U_1/U_2 \) may differ from 1 so that the equation to determine R_M must be modified accordingly. In case you need help to find the ideal value of R_M and/or physically a resistor with desired properties please contact RoentDek. It is mandatory to choose resistors with sufficient voltage and power ratings.

For connecting the HVT4+ in the biasing scheme for matching mode an additional SHV-T plug is required at the position of the blue oval in Figure 5.15. Note again that the HVT4+ is always placed in parallel to the MCP stack stage that needs resistance reduction*. Typical connection schemes, also in combination with other passive voltage dividing boxes such as the HVZ (see Chapter 5.6) can be found on the RoentDek web site.

* When using a FT12TP plug with internal HVZ voltage divider circuit (see Chapter 5.8) the plastic stopper on the MCP back SHV needs to be removed if the rear MCP is the one with higher resistance.
If you have received a non-matched MCP set and HVT4+ from RoentDek, the HVT4+ will usually be equipped with a resistor set that produces an effective $R_m$ close to the desired value. The choice of the resistor set was then based on estimations about the MCP resistances from specifications values obtained from the manufacturer(s).

However, this does NOT guarantee sufficient matching since the real resistance values can significantly deviate from the specified numbers. Therefore, it is mandatory to verify MCP's resistances (e.g. by a method described in an Appendix of the detector manual) and then modify the resistance in the HVT4+ accordingly.

An HVT4+ unit operated in matching mode can only simultaneously be used as bias pull-up preventer on the MCP side with the larger resistance, otherwise $R_{HVT}$ must be located in a separate HVT connected to the other MCP bias input. Please contact RoentDek for advice in case you are unsure about the proper connection scheme for combining both $R_{HVT}$ and $R_m$ for a certain MCP stack. If an HVT4+ shall be operated only in the standard HVT terminating mode (with $R_{HVT}$ in place), $R_m$ must be set to zero, i.e. short-circuit with a bypass cable.

If you need help in modifying the HVT4+ to improve matching conditions (i.e. by adding/exchanging resistors) please contact RoentDek.

The HVT4+ unit can alternatively be used to place $R_m$ as “backup resistor” parallel to the whole MCP stack. This can increase operation safety in application with biasing schemes beyond 4 kV detector potential and stabilize MCP bias when a resistor chain is applied for supplying detector voltages. Two SHV-T plugs are required for this biasing scheme.

### 5.6 HVZ voltage divider unit

The RoentDek HVZ is a passive voltage distributing box generating intermediate potentials in steps of 28 V or 56 V ($\pm$10 %) for all delay-line anode contacts and MCP back side of RoentDek delay-line detectors (and a BA3-equivalent voltage between the reference and signal wire). This is achieved by a chain of special diodes which are serially placed between the contact junctions to the respective detector parts.

The HVZ has one high voltage input socket (SHV) labeled “HV In” and four SHV output sockets for providing bias to the MCP back side ($U_{MCP\ back}$), “Holder” ($U_H$) and the delay-line anode wires ($U_{ref}/U_{sig}$). Thus, only two potentials are to be provided from high voltage supplies for biasing all detector contacts: $U_{sig}$ (via the “HV In” socket) and $U_{MCP\ front}$, i.e. the MCP front potential. The latter may be produced by “terminating” MCP front via a RoentDek HVT (see Chapter 5.5). Other detectors like the RoentDek DET40/75 can also be biased in this way using the HVZ-T.

The maximum potential for “HV In” is specified as 4 kV, units with up to 6 kV rating can be provided on demand. For operation of detectors at even higher voltage (“XHV”) a special HVZ10 can be provided (see Chapter 5.7).

Using the HVZ for detector bias distribution is equivalent to applying a resistor divider chain for this purpose. The HVZ using Z-diodes has the advantage that the relative voltages set between MCP back, Holder and delay-line wires do not depend on the absolute detector bias with respect to ground (i.e. are independent from the choice of MCP front potential). This ensures the proper voltage difference between the MCP back side and the anode (wires) and provides near-optimal voltage setting for the DLD’s or Hex “Holder” bias: The voltage drop is generated as soon as a minimum current of few $\mu$A is flowing in the proper direction. The intermediate potential of the Holder can be selected in steps of about 28 V or 56 V (for older versions) by jumper settings. A battery box is not needed when using the HVZ, however, optional jumper positions also allow bias settings for the wires through a separate BA3 or other floating battery units. The BA3 can also be used in combination with the HVZ for further increasing the voltage difference between anode wires and MCP back.

![Figure 5.16: HVZ with the SHV connector sockets.](image)
Inside the HVZ a total voltage drop of up to a maximum set value (nominally about 260 V) is generated as soon as appropriate electrical current flows through the unit from the input SHV socket labeled “HV In” to the “Back” socket. This current can only flow if there is an according potential difference maintained between the sockets and if the current is drained by a resistor load connected to the “Back” socket. During detector operation this resistor is formed by the microchannel plate stack. For this the HVZ “Back” socket must be physically connected to the MCP stack’s rear side input and must always be at the same or more positive potential than the MCP stack’s front side, which is connected to the MCP front high voltage supply. Please insure that U_{MCP\, \text{front}} < “HV In” at all times, i.e. during increases of the voltages toward normal detector operation and also when voltages are turned down from termination detector operation. **If the potential on the MCP back socket should become more positive than the potential on “HV In” the HVZ may be damaged!**

Never supply a separate potential to any other HVZ socket than the “HV In” socket. Never directly ground any socket in order to force this potential to zero. This may cause irrecoverable damage to the HVZ circuit.

It is important to note that the relation between the current through the MCP stack and the voltage between “HV In” and MCP front potentials is not linear as long as it is lower than the HVZ’ set value. For calculating the nominal MCP back potential (i.e. on the voltage input of a signal decoupler on MCP back contact) the set voltage needs to be subtracted from the nominal “HV In” bias. This is important to note when considering the effective voltage across the MCP stack and when calculating the MCP resistance from the current flowing through the stack.

It is important to ensure that the voltage across the HVZ is never inversed and that “HV In” > “Back” > MCP front bias according to normal detector operation. The use of the HVZ requires the “Back” output always being connected to the MCP back side when applying voltage.

For operation in the standard configuration (as shipped) with all outputs sockets “Ref”, “Sig”, “Holder” and “Back” connected to the detector (e.g. via the RoentDek FT12TP or FT16TP decoupling circuits) the bias applied to “HV In” is directly connected with the “Sig” output socket, i.e. supplying the signal wire potential (U_{sig}). “Ref” output provides a 39 V more negative U_{ref} potential (i.e. with the same potential difference as obtained by a RoentDek BA3 unit).

As described above the “Back” output provides the bias for U_{MCP\, \text{back}} which is nominally 260 V more negative than “HV In”. However, the effective bias on MCP back side may be lower (more negative) due to the voltage drop across the blocking resistor in the signal decoupling circuit (typically 1 MΩ, please refer to the delay-line detector manual for determining this additional bias shift).

The bias pickup from the HVZ for the Holder potential (U_H) can be adjusted between U_{ref} and U_{MCP\, \text{back}} in steps of 56 V or 28 V by selecting a jumper position (default: U_H = U_{MCP\, \text{back}} + 56 V). * Before opening the HVZ, make sure to reduce all voltages to zero and then disconnect all cables from the HVZ. When removing the cables while still on high potential, there might still be hazardous voltages stored within the HVZ’s capacitors.

There are two different versions of the HVZ: the older version (with printed circuit board showing ‘Rev. 1.0’, ‘Rev. 1.1’ or ‘Rev 1.2’ labels) and the newer version (‘Rev. 1.3’ or higher). Their basic functionality is the same – the new versions just offers additional jumper settings (e.g. with 28 V steps) which might be helpful for special requirements. Please verify which version you own and follow the corresponding setting instructions below:

The latest FT12TP decoupling plugs can be equipped with an internal on-board HVZ circuit, please refer to Chapter 5.8.

For DET detectors a special HVZ-T version is available which also contains a separate HVT(4) circuit (see in the respective detector manual).

* Note that the detector’s Holder potential is not necessarily to be supplied through the HVZ. It can also be drawn from an independent high voltage supply if linearity near the MCP edge needs further optimization.
5.6.1 HVZ Revisions 1.3 and newer

![HVZ Revisions 1.3 and newer with jumper options.](image)

The standard setting (as shown in Figure 5.17) sets \( U_{\text{ref}} = U_{\text{MCP back}} + 224 \, \text{V} \) and \( U_H = U_{\text{MCP back}} + 56 \, \text{V} \). For this, jumpers are set on positions J3 and J11. You may change \( U_H \) (without modifying \( U_{\text{ref}} \)) as following:

- **J1 to J7**: jumper positions determining "Holder" potential. Only one jumper shall be set on J1 to J7.
  - Jumper at J1: Holder and Back outputs provide the same potential \( U_H = U_{\text{MCP back}} \)
  - Jumper at J2: \( U_H = U_{\text{MCP back}} + 28 \, \text{V} \)
  - Jumper at J3: default \( U_H = U_{\text{MCP back}} + 56 \, \text{V} \)
  - Jumper at J4: \( U_H = U_{\text{MCP back}} + 112 \, \text{V} \)
  - Jumper at J5: \( U_H = U_{\text{MCP back}} + 168 \, \text{V} \)
  - Jumper at J6: \( U_H = U_{\text{MCP back}} + 224 \, \text{V} = U_{\text{ref}} \)
  - Jumper at J7: \( U_H = U_{\text{MCP back}} + 224 \, \text{V} = U_{\text{ref}} \)

Changing this jumper position from the default setting can be beneficial for modified detector geometry (MCP holding plate at a non-standard position) or if the effective MCP back potential is significantly shifted (use J1 position). There are a numerous different settings possible, listed by the value of \( U_{\text{ref}} \):

- **\( U_{\text{ref}} = U_{\text{MCP back}} + 280 \, \text{V} \)** - remove J11 and then follow this table instead of the one above:
  - J1 to J7: jumper positions determining "Holder" potential. Only one jumper shall be set on J1 to J7.
    - Jumper at J1: Holder and Back outputs provide the same potential \( U_H = U_{\text{MCP back}} \)
    - Jumper at J2: \( U_H = U_{\text{MCP back}} + 28 \, \text{V} \)
    - Jumper at J3: default \( U_H = U_{\text{MCP back}} + 56 \, \text{V} \)
    - Jumper at J4: \( U_H = U_{\text{MCP back}} + 112 \, \text{V} \)
    - Jumper at J5: \( U_H = U_{\text{MCP back}} + 168 \, \text{V} \)
    - Jumper at J6: \( U_H = U_{\text{MCP back}} + 224 \, \text{V} = U_{\text{ref}} \)
    - Jumper at J7: \( U_H = U_{\text{MCP back}} + 252 \, \text{V} = U_{\text{ref}} \)

- **\( U_{\text{ref}} = U_{\text{MCP back}} + 252 \, \text{V} \)** - remove J11 and set J8. Then follow this table instead of the one above:
  - J1 to J7: jumper positions determining "Holder" potential. Only one jumper shall be set on J1 to J7.
    - Jumper at J1: Holder and Back outputs provide the same potential \( U_H = U_{\text{MCP back}} \)
    - Jumper at J2: \( U_H = U_{\text{MCP back}} + 28 \, \text{V} \)
    - Jumper at J3: Holder and Back outputs provide the same potential \( U_H = U_{\text{MCP back}} + 84 \, \text{V} \)
    - Jumper at J4: \( U_H = U_{\text{MCP back}} + 140 \, \text{V} \)
    - Jumper at J5: \( U_H = U_{\text{MCP back}} + 196 \, \text{V} \)
    - Jumper at J6: \( U_H = U_{\text{MCP back}} + 252 \, \text{V} = U_{\text{ref}} \)
$U_{\text{ref}} = U_{\text{MCP\ back}} + 196$ V - set J11, J10 and J8. Then follow this table instead of the one above:

J1 to J7: jumper positions determining “Holder” potential. Only one jumper shall be set on J1 to J7.

- jumper at J1: Holder and Back outputs provide the same potential
  - $U_H = U_{\text{MCP\ back}}$
- jumper at J2: Holder and Back outputs provide the same potential
  - $U_H = U_{\text{MCP\ back}}$
- jumper at J3: default
  - $U_H = U_{\text{MCP\ back}} + 28$ V
- jumper at J4: default
  - $U_H = U_{\text{MCP\ back}} + 84$ V
- jumper at J5: default
  - $U_H = U_{\text{MCP\ back}} + 140$ V
- jumper at J6: default
  - $U_H = U_{\text{MCP\ back}} + 196$ V ($= U_{\text{ref}}$)
- jumper at J7: default
  - $U_H = U_{\text{MCP\ back}} + 196$ V ($= U_{\text{ref}}$)

$U_{\text{ref}} = U_{\text{MCP\ back}} + 168$ V - set J11 and J10. Then follow this table instead of the one above:

J1 to J7: jumper positions determining “Holder” potential. Only one jumper shall be set on J1 to J7.

- jumper at J1: Holder and Back outputs provide the same potential
  - $U_H = U_{\text{MCP\ back}}$
- jumper at J2: default
  - $U_H = U_{\text{MCP\ back}} + 28$ V
- jumper at J3: default
  - $U_H = U_{\text{MCP\ back}} + 56$ V
- jumper at J4: default
  - $U_H = U_{\text{MCP\ back}} + 112$ V
- jumper at J5: default
  - $U_H = U_{\text{MCP\ back}} + 168$ V ($= U_{\text{ref}}$)
- jumper at J6: default
  - $U_H = U_{\text{MCP\ back}} + 168$ V ($= U_{\text{ref}}$)
- jumper at J7: default
  - $U_H = U_{\text{MCP\ back}} + 168$ V ($= U_{\text{ref}}$)

$U_{\text{ref}} = U_{\text{MCP\ back}} + 140$ V - set J11, J10 and J9. Then follow this table instead of the one above:

J1 to J7: jumper positions determining “Holder” potential. Only one jumper shall be set on J1 to J7.

- jumper at J1: Holder and Back outputs provide the same potential
  - $U_H = U_{\text{MCP\ back}}$
- jumper at J2: default
  - $U_H = U_{\text{MCP\ back}} + 28$ V
- jumper at J3: default
  - $U_H = U_{\text{MCP\ back}} + 84$ V
- jumper at J4: default
  - $U_H = U_{\text{MCP\ back}} + 140$ V ($= U_{\text{ref}}$)
- jumper at J5: default
  - $U_H = U_{\text{MCP\ back}} + 140$ V ($= U_{\text{ref}}$)
- jumper at J6: default
  - $U_H = U_{\text{MCP\ back}} + 140$ V ($= U_{\text{ref}}$)
- jumper at J7: default
  - $U_H = U_{\text{MCP\ back}} + 140$ V ($= U_{\text{ref}}$)

$U_{\text{ref}} = U_{\text{MCP\ back}} + 112$ V - set J11, J10, J9 and J8. Then follow this table instead of the one above:

J1 to J7: jumper positions determining “Holder” potential. Only one jumper shall be set on J1 to J7.

- jumper at J1: Holder and Back outputs provide the same potential
  - $U_H = U_{\text{MCP\ back}}$
- jumper at J2: default
  - $U_H = U_{\text{MCP\ back}} + 28$ V
- jumper at J3: default
  - $U_H = U_{\text{MCP\ back}} + 56$ V
- jumper at J4: default
  - $U_H = U_{\text{MCP\ back}} + 112$ V ($= U_{\text{ref}}$)
- jumper at J5: default
  - $U_H = U_{\text{MCP\ back}} + 112$ V ($= U_{\text{ref}}$)
- jumper at J6: default
  - $U_H = U_{\text{MCP\ back}} + 112$ V ($= U_{\text{ref}}$)
- jumper at J7: default
  - $U_H = U_{\text{MCP\ back}} + 112$ V ($= U_{\text{ref}}$)

These options can be beneficial if the effective MCP back potential is strongly shifted, or a lower anode voltage shall be used for some reason (i.e. different anode type). If a larger voltage drop (beyond 280 V between $U_{\text{ref}}$ and $U_{\text{MCP\ back}}$) is required it is possible placing two HVZ units in series or combining a HVZ with a BA3.

**For all HVZ revisions and settings above the following is valid:**

J12: no jumper: $U_{\text{sig}} = U_{\text{ref}} + 36$ V (default)

This option allows using a BA3 or other floating battery device for producing the voltage difference between “Ref” and “Sig” for a delay-line anode.

If you use an HVZ with an older board (revision 1.2 or earlier) please contact RoentDek for information on jumper settings/functions.

### 5.7 HVZ10 voltage divider unit for XHV operation

For the XHV option (i.e. RoentDek delay-line detectors that can operate beyond the standard high voltage ratings) the HVZ10 unit is available. It contains a flexible high voltage dividing circuitry in a box with (typically) four output lines rated to 10 kV and up to two input voltages.
Figure 5.19: Left picture: HVZ10 box with four-fold high voltage output cable which will be connected to an XHV feedthrough. Right picture: high voltage inputs on rear panel. Here, two SHV10 socket are provided for supplying two independent voltages. Other versions are available which operate with just one input voltage (MCP front or \(U_{ref}\)) and/or use other input socket standards.

In the following, the basic HVZ10 version is described. You may have received a separate add-on manual if your unit differs remarkably from the standard version. You will in any case receive specific information about the circuitry and tables for output voltages as function of input voltage(s) and MCP resistance. The HVZ10 must be operated in combination with RoentDek-approved high voltage supplies and feedthroughs. It is important to verify whether the high voltage supply can deliver sufficient current for the HVZ10 circuit as it is laid out.

**Before using, please verify for which maximum input/output voltages and polarity your HVZ10 version is rated and never exceed this voltage or invert the polarity.**

The HVZ10 contains an exchangeable upper board to allow for different operational modes, e.g. the detector’s initial startup procedure at low voltages and the final operation at high voltages. The boards can simply be interchanged after opening the case. Resistor values on the boards may have to be adjusted when the MCPs need replacement. RoentDek provides specific information, voltage tables (and adequate resistors, if needed) for this procedure or can completely service a board.

**Only apply high voltage to the HVZ10 when the case is closed. Before opening the case, make sure to fully discharge your high voltage power supply and then disconnect it or disable it and secure it against being switched on again.**

Once you have received the detector system it is recommended to first install the MCP dummy disc made from insulating material in place of the MCP stack for verifying the high voltage soundness of the whole assembly at first. For this test, the board for normal high-voltage operation should be installed in the HVZ10, as it is the case when you receive the setup. Although no MCP stack is installed the voltage should be increased very slowly to the design values (the vacuum within the chamber should be better than \(10^{-5}\) mbar). Minor arcing incidents are not uncommon during this procedure. Once the setup sustains operation at the design potential without discharge, the MCP stack can be installed to the detector. At this point, the top-side board should be exchanged for the PCB designated for the initial startup procedure of the detector. The startup procedure itself is defined in the manual (see Chapter 2).

The PCB for the initial startup procedure will set one detector potential (MCP front or \(U_{ref}\), depending on the polarity of the high voltage supply) to ground potential or near that, while the detector function is verified by raising the MCP bias to operational values as described in the initial startup procedure. General detector performance can thus be fully verified.
Figure 5.20: Open HVZ10 case with exposed top-side voltage divider PCB which can be reconfigured to allow for different biasing schemes. A BA3 circuit (not visible) is placed on the intermediate PCB plane and produces the differential delay-line wire potentials from $U_{\text{ref}}$. The values of the resistors within the chain are specifically selected for detector operation near the targeted MCP front voltage (here: -10 kV, operated with only one high voltage supply channel) and for the given MCP resistance. PCBs for operation at positive MCP potentials look very similar. After that, the PCB for high voltage operation may be re-installed and voltage can be raised to the design potential. As a general safety precaution, raising voltages very slowly should be standard practice.

For replacing the PCB, turn off and fully discharge the high voltage and open the case. Then remove the plastic screws that secure the board onto the back plane PCB. Retract the top-sided PCB and replace it by the desired one. Make sure that all connection posts are well met and then secure the board with plastic screws. Close the case before applying high voltage.

The safest operation mode for a detector biased to XHV voltages employs only one high voltage channel, which is either connected to “MCP Front” input (positive ion detection, negative polarity) or with positive polarity to the “Ref” input (i.e. the anode), for negative ion or electron detection on the positively biased MCP.

In case of operational problems (power failure, vacuum breakdown, etc.) a controlled voltage shut down may be maintained and guarantee safe regulation detector voltages at all times, preventing damage from erroneous settings. In this biasing scheme, the counter-side of the detector must be bridged to ground potential via a “terminating resistor” of adequate resistance that may be formed as a chain of resistors (R1 to R4, see Figure 5.21, right picture).

The disadvantage of this scheme is that an optimal MCP bias cannot be set independently from the floating potential value. The terminating resistor bridge and the MCP stack resistance with its parallel resistor (R9) form a voltage dividing chain. The bias across the MCP stack and thus the gain will depend both on the resistor ratio and the floating voltage on MCP front.

Thus, the ideal bias voltage for the MCP stack must be determined before, e.g. during the startup procedure. Bias adjustment for the MCP stack requires changing of resistors R1 to R4 so that the chain yields the right resistance ratio to the parallel array of R9 and the MCP stack resistance. Operation at a different floating voltage will again require adjustments if the ideal MCP bias shall be maintained. Likewise, MCP replacement may also require resistor adjustments.
Figure 5.21: PCB for initial start-up procedure (left) for operation with negative polarity on “MCP front” input via HVZ10. U_{ref} potential is set to ground. As the voltage is raised to about -2500 V the detector operates in (positive) ion detection mode. Right picture: PCB for operation at high negative MCP potential using one high voltage power supply which provides U_{ref} plus a floating high voltage power supply that generates the voltage across the MCP stack. In both cases a Z-diode maintains a voltage drop of nominally 230 Volts between U_{ref} and U_{back}.

If two independent high voltage supplies are used, floating voltage and MCP bias can be independently adjusted. However, it is strongly recommended to ensure that during voltage increase/decrease and also in case of voltage tripping both high voltage channels are always ramped in a coordinated and synchronized way so that no excessive potential differences can occur across the detector which will lead to uncontrolled discharge and damage.

RoentDek can provide approved high voltage power supplies for all operation modes, such as the HV2/10PF+ and HV2/8PF+ units.

It must also be noted that there are different types of high voltage supplies. Floating power supplies usually do not impose any problems. But when using two fully independent high voltage supplies it must be checked whether they are based on a diode cascade voltage multiplier. If this is the case, an additional resistor from the lower potential to ground must be implemented in order to prevent that the power supplies influence each other. When you plan to replace your power supplies by different ones, please contact RoentDek for advice.

5.8 HVZ voltage divider circuit and internal HVT inside the FT12TPz

The latest version of the FT12TP plug for DLD can be upgraded to internally contain HVZ and/or HVT circuits by replacing PCBs inside the housing. If an FT12TPz is ordered, the according PCB set is included and may already be factory-mounted (then noted on a label found on the top lid of the housing).
Before opening the FT12TP, make sure to first reduce applied voltages to zero and only then disconnect all SHV cables. When removing the cables while still on high potential, there might still be hazardous voltages stored within the FT12TP's capacitors.

If an internal HVZ board is in place only the (MCP) “Front” and the “Sig” (and optionally the “X”) SHV sockets are used to provide voltage to the detector. Here, the “Sig” socket input corresponds to the “HV in” socket in the standard HVZ box, see Chapter 5.6 and also refer to the operation and safety instructions given there. The white plastic stoppers on the SHV sockets “Back”, “Holder” and “Ref” prevent some common mistakes when connecting the high voltage cables. These plastic stoppers may be temporarily removed for connection testing purposes with an Ω-meter, or when a HVT4(+) unit is connected on “Back”. While in the HVZ operation mode (actively biasing all detector contacts) only via “HV in” and “Front” sockets). Neither of “Back”, “Holder” and “Ref” sockets should be independently biased or grounded. MCP front bias must always be more negative than the signal bias. Otherwise the internal HVZ circuits can be damaged. Note generally that MCP front bias must always be more negative than the signal bias.

In case you achieved an upgrade from a standard FT12TP to an FT12TPz by exchanging the PCB board #3 to #4 by yourself you should add the supplied label and insert the white stoppers to the SHV sockets for preventing common mistakes when connecting the high voltage cables. Likewise, if you place the internal HVT you should add the corresponding sticker supplied with it. The presence of an HVT bridge inside the plug can be verified by measuring the resistance between pin 2 and any screw on the plug’s case: If 1 MΩ is measured the HVT is installed, otherwise there is infinite resistance (>10 MΩ).

* Only MCP back socket may be terminated via an appropriate R_{HVT} (inside an HVT4 box, one of its SHV sockets then remains unconnected), or connected to an intermediate MCP contact via an HVT4+ box, see Figure 5.13 and Chapter 5.5.1.
The optional combinations of jumper settings for J1-J11 on the (internal) HVZ board as shown in Figure 5.23 (version 1.7 and newer) result in exactly the same bias output functionalities as described for the (external) HVZ box boards (for version 1.3 as described in Chapter 5.6.1). The factory-set jumper positions are noted on the case of the FT12TPz. It is advisable to keep track of any modification at any time.

Since the internal HVZ board of the FT12TPz is directly supplying the voltages to its decoupling circuits, J12 on the external HVZ unit had to be replaced by a combination of jumpers J13-J15 (default: J13 and J15 are set) in order to maintain flexibility for alternative biasing schemes, e.g. during trouble shooting or verification procedures.

These (non-standard) options are summarized as followed:

**J14 jumper is set instead of J13:**

U_{ref} is separately biased through the “Ref” SHV socket.

**None of jumpers J1-J7 being set:**

Holder bias (U_H) is separately biased via the “Holder” SHV socket.

**Jumpers from J1-J7, J13 and J15, are all removed (only J14 jumper must be set):**

All voltages are supplied through the SHV sockets.

Thus, the HVZ function of the internal board can be stepwise reduced to the “standard” FT12TP plug (e.g. equipped with internal board #3) bias input scheme through the separate SHV sockets. Obviously, for this the white stoppers on the SHV sockets must be at least partially removed, only temporarily, i.e. as long as these non-standard settings are operated. Please put the stoppers back in place as soon as you reactivate the corresponding HVZ functions.

Further biasing options are enabled by changes on the base board (#2):

### 5.8.1 Internal HVT board and additional bias options of the latest FT12TP plugs for DLD

In the course of ongoing FT12TP upgrades further options have been implemented on the base board (#2) to allow for additional biasing functions after internal modifications by the user. These settings are independent from the piggy-back board selection #3 (standard bias through the SHV sockets), #4 (HVZ) or else. FT12TP(z) units with serial numbers of 360 and higher allow the following options:

**Internal HVT functions:** A special bridge circuit which can be obtained from RoentDek (see Figure 5.23) contains a RHVT resistor and terminates MCP front input to ground via a 1 MΩ, exactly like the external HVT box as described in Chapter 5.5. However, there are no options defined of changing this resistor value or of connecting the internal RHVT to any other bias contact.

If you are not sure (while the FT12TP plug case is closed) whether an HVT resistor bridge is placed on the internal base board (#2) or not you can verify its presence/absence with an Ω meter by checking the resistance to ground (i.e. the FT12TP case) of the “Front” SHV socket. This should take place while the FT12TP plug is removed from the feedthrough. Then you should either measure the 1 MΩ HVT resistance (i.e.: bridge in place) or find a near-infinity resistance (no bridge connected).

**Internally connecting MCP back to Holder potential:** by changing the jumper position J2B from its default position “down” (as shown in Figure 5.23, middle picture) to its upper position, the bias input to MCP back from the corresponding SHV socket (or HVZ circuit) is suspended. The “Holder” bias input (coming either through the corresponding SHV socket or the HVZ circuit) is then routed both to MCP back and “Holder”, being on nearly the same potential. **For this setting it is important that the “Back” SHV socket connected to a high voltage supply or grounded.**

Setting MCP back and Holder on a detector to the same potential cannot always be achieved simply by biasing the corresponding SHV sockets with the same nominal potential (i.e. by short-connecting the sockets “Holder” and “Back” via a SHV-T or by placing a jumper at J1 in case of operation with a HVZ circuit):

As soon as the MCP front side is set to a more negative bias during operation, the presence of the blocking resistor R{sub}B (usually 1 MΩ, see Chapter 5.5) in the MCP back connection line will change the effective MCP back bias on the detector. This can only be avoided if the jumper J2B in Figure 5.24 is changed to the “up” position.

* If you have received an earlier board version, please refer to the descriptions obtained with the unit.
Figure 5.24: Connection circuits for the two J2B jumper settings, left scheme: the standard “down” setting (as in Figure 5.23), right scheme for the alternative “up” setting. The 10 kΩ resistance separating “Detector” and MCP back is low enough to not impose a remarkable voltage shift of MCP back compared to “Holder” even when MCP front is set to operational values. Note, that there is the 1 MΩ blocking resistor in the line to the MCP back (and “Holder”) causing a corresponding (common) bias shift, as described earlier.

For detector assemblies without intermediate MCP carrier plate (e.g. DLD120, HEX100 and DLD40SL) the Holder bias setting is not affecting the imaging properties on the outer diameter. For these detectors the factory-setting for the Holder potential (i.e. near MCP back potential) can be kept.

5.9 HVT+ and custom-designed voltage dividing circuit boxes

Based on the HVT RoentDek provides the passive voltage divider HVT+ for increasing the operation range of the RoentDek high voltage supplies (e.g. the HV2/4) to voltages well below 100 V. Depending on the internal jumper position the output voltage is nominally reduced by a factor of 10 (jumper at J1 position, see Figure 5.26) or by a factor of 100 (jumper at J2 position). These scaling factors are only accurate within a few % due to resistor tolerances. The presence of an external resistor load (e.g. formed by a series of resistor-coupled spectrometer plates to ground) will alter the scaling factor systematically, see below. With maximum specified input voltage of 1000 V this allows to set stable output voltages between 1 V and 100 V with a HV2/4, e.g. for biasing spectrometers, meshes or lens elements.

![HVT+ with 100:10:1 resistor chain](image)

Figure 5.25: HVT+ with 100:10:1 resistor chain. Depending on the jumper the nominal scaling factor between output and input voltage is 1:10 (J1 set) or 1:100 (J2 set). The maximum input voltage is 1000 V. On demand the HVT+ can also come as a version equipped with a third jumper position J3 which enables the standard HVT functionality (see Chapter 5.5) with RHVT having a nominal value of 1111kΩ.

Precision voltage setting via HVT+ requires measuring the actual output voltage with an adequate instrument (while the output is connected to the resistor load Rl, if any). However, as long as Rl > 10 MΩ, the voltage reading on the HV2/4 gives a fairly precise indication of the output voltage, taking into account the nominal scaling factor (depending on jumper setting). For smaller Rl the scaling factor deviates from the nominal values. It can be approximated for Rl > 100 kΩ by:

\[
\frac{U_o}{U_{\text{eff}}} = 10 + \frac{1 \Omega}{R_l} \quad (\text{J1 set}) \quad \text{or} \quad \frac{U_o}{U_{\text{eff}}} = 100 + 1.1 \frac{\Omega}{R_l} \quad (\text{J2 set})
\]

It is to note that the current drawn from the high voltage supply will be dominated by the “blind” current through the internal resistors to ground inside the HVT+. The effect of an external resistor load on this current can hardly be measured via the current display of the HV2/4.
For special biasing schemes of detectors RoentDek can provide custom-designed voltage dividing boxes. The following figures show a (not-complete) selection of circuits that have been provided to customers.

**Figure 5.26**: Set of voltage divider boxes for DET operated at high negative bias (MCP front up to -4800 V) with a mesh biased 200 V more negative than MCP front (lower box) and a resistor divider chain for biasing MCP back and Anode at adequate potential for single particle counting (upper box). The voltage drop between MCP back and Anode is 1/6 of the MCP back potential, here (can be altered by changing the 2 MΩ resistor, see Kirchhoff’s laws).

**Figure 5.27**: Voltage divider for DET operation with MCP front at +300 V (or ground), with MCP back and Anode at any set potentials between MCP front and +5 kV.
5.10 Remote Control of the RoentDek HV supply via USA-IO1

The voltage setting of the HV2/4 (6/8/10) units can be operated via the RoentDek USB-IO1 DA/AD controller. If the control switches on a HV2/4 (6/8/10) unit is set to “DAC” (as upper channel in Figure 5.1), its high voltage output is proportional to the voltage input (0 -4 V or 0 -10 V) on the corresponding input socket on the rear panel. A USB-IO1 can provide two individual voltage outputs up to 10 V for this purpose, controlled by software via USB, see Figure 5.28.

Control of the USB outputs is provided by LabView, CoboldPC and the Iseg_control_USB_IO1.exe GUI-program. Please contact RoentDek for details of advanced operation with LabView or CoboldPC.

For simple tasks of remote voltage setting the GUI program (see Figure 5.29) is usually sufficient, its operation self-explaining for most applications (otherwise please contact RoentDek).

The program interface has two sections for two independent output channels. Setting options for channel 2 (output from out2 socket) are kept minimal while channel 1 (output from out1 socket) control provides options to ramp the voltage automatically with selectable speed (in 10 V steps) or to change voltage settings after selectable delays (2 steps). Do not enter any set voltage above the maximum range of the connected high voltage supply.

**It is very important** to first enter the correct conversion factor which is independently selectable for the two channels. This value will determine the correspondence between set voltage and output voltage and depends on the used high voltage unit. For HV2/4 the conversion is 4000 for HV2/6 (8/10) it has to be set to 10000.

False conversion factor setting will result in false output voltages which can cause damage to connected devices.

It is therefore recommended to verify proper output response on the HV2/4 (6/8/10) display before connecting any SHV socket.

Minor deviation between set voltage and real output voltage is possible and may be corrected by “fine-tuning” of the conversion factor, e.g. setting it to 3997 instead of 4000 for HV2/4.
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operates in (positive) ion detection mode. Right picture: PCB for operation at high negative MCP potential using one high voltage power supply which provides $U_{\text{REF}}$ plus a floating high voltage power supply that generates the voltage across the MCP stack. In both cases a Z-diode maintains a voltage drop of nominally 230 Volts between $U_{\text{REF}}$ and $U_{\text{BACK}}$.

**Figure 5.22:** FT12TPz with internal HVZ board (#4) which is accessible after removing the bottom side of the case (loosen the four screws indicated by the red arrows).

**Figure 5.23:** Inside view of a FT12TP plug with installed standard board #3 (no HVZ function, left picture) and with exposed base board (#2) when the upper board (#3, #4, or custom board) is removed (for that loosen the two plastic screws and retract the board). The red arrows in the middle picture indicate a bank pair where the optional HVT resistor board $\text{HVTM}_{\text{MINI}}$ can be placed, see in the right picture on a similar #2 board (description in Chapter 5.8.1). Also described there is the function of the J2B jumper bank (indicated by the yellow rectangle).

**Figure 5.24:** Connection circuits for the two J2B jumper settings, left scheme: the standard “down” setting (as in Figure 5.23), right scheme for the alternative “up” setting. The 10 k$\Omega$ resistance separating “holder” and MCP back is low enough to not impose a remarkable voltage shift of MCP back compared to “holder” even when MCP front is set to operational values. Note, that there is the 1 M$\Omega$ blocking resistor in the line to the MCP back (and “holder”) causing a corresponding (common) bias shift, as described earlier.

**Figure 5.25:** HVT+ with 100:10:1 resistor chain. Depending on the jumper the nominal scaling factor between output and input voltage is 1:10 (J1 set) or 1:100 (J2 set). The maximum input voltage is 1000 V. On demand the HVT+ can also come as a version equipped with a third jumper position J3 which enables the standard HVT functionality (see Chapter 5.5) with $R_{\text{HV}}$ having a nominal value of 1111 k$\Omega$.

**Figure 5.26:** Set of voltage divider boxes for DET operated at high negative bias (MCP front up to -4800 V) with a mesh biased 200 V more negative than MCP front (lower box) and a resistor divider chain for biasing MCP back and anode at adequate potential for single particle counting (upper box). The voltage drop between MCP back and anode is 1/6 of the MCP back potential, here (can be altered by changing the 2 M$\Omega$ resistor, see Kirchhoff’s laws).

**Figure 5.27:** Voltage divider for DET operation with MCP front at +300 V (or ground), with MCP back and anode at any set potentials between MCP front and +5 kV.

**Figure 5.28:** Front and rear panels of the USB-I01 device with USB-port for the PC-connection and the two LEMO analogue OUT2 and OUT1 output sockets, suitable for remote-controlling the HV2/4 (6/8/10) units.

**Figure 5.29:** Input options of the GUI-program.

**List of Equations**

- Equation 5.1
- Equation 5.2