# Detectors & Nuclear Instrumentation

**Where a 2 kW or 3 kW digitally regulated supply belongs in a detector laboratory: ion-source and accelerator electrodes, bulk bias buses behind local filtering, electron guns, and high-voltage test. The bias of a single photomultiplier or silicon photomultiplier belongs to a low-current source, and the numbers below say why.**

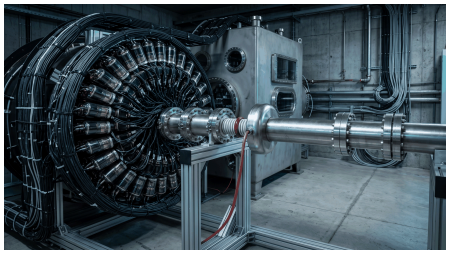


Illustration: a photomultiplier array beside an accelerator beam pipe, with a high-voltage feedthrough on the pipe and a vacuum chamber behind. No real facility or product is depicted.

APPLICATION BRIEF · BNC HVX-SERIES DIGITALLY REGULATED DC HIGH VOLTAGE · dc-62022201

## Detectors & Nuclear Instrumentation



A detector laboratory runs on more than one kind of high voltage. A photomultiplier draws a fraction of a milliampere through its divider at 1 to 2 kV. A silicon photomultiplier draws microamps at 25 to 70 V. An ion-source extraction gap carries the beam current it launches, milliamps to hundreds of milliamps at kilovolts. An electron gun or an electrostatic accelerator column carries its beam at tens of kilovolts. A feedthrough, cable or divider under test has to be held at voltage while its leakage is read. These loads differ in current by five orders of magnitude or more, and no single supply class serves all of them.

The deciding numbers are a supply's floors rather than its ceilings: the smallest current its current loop regulates, the smallest voltage step it sets, and the ripple it leaves on the output. The Berkeley Nucleonics HVX-Series is a 2U supply in 500 W, 2 kW and 3 kW classes with microcontroller and FPGA regulation, and each of its floors scales with the nominal rating of the model. Table 1 works them out from the datasheet: ripple is specified at 0.01 percent of nominal voltage plus 100 mV peak to peak, the setting range as 0.01 to 100 percent of nominal, and setting resolution as 16 bits.

**Table 1.**

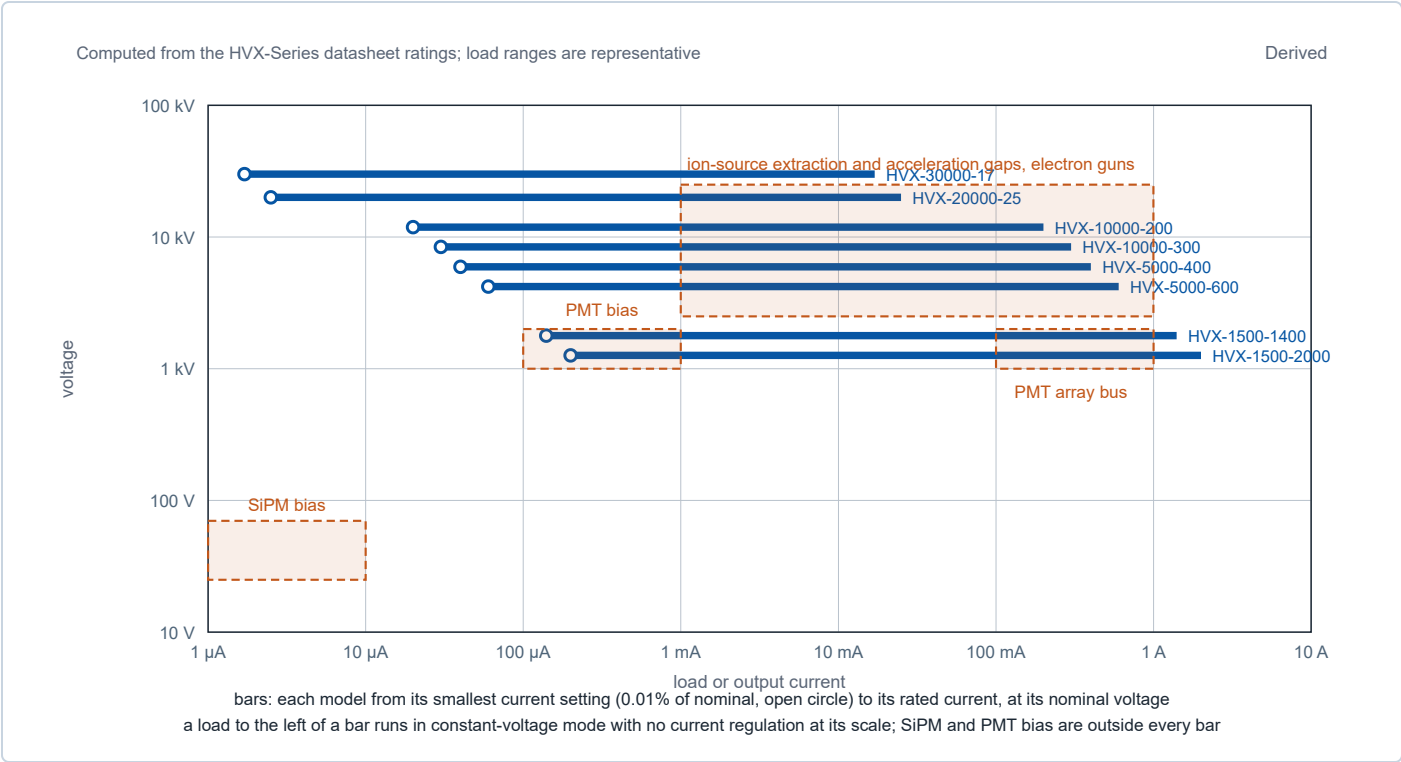
**Table 1. The floors of each HVX-Series model, computed from the datasheet ratings (16 bits taken across the nominal range).**

| Model (class) | Nominal | Voltage step | Ripple floor, p-p | Smallest current setting |
|---|---|---|---|---|
| **HVX-1500-1400 (2 kW)** | 1.5 kV, 1.4 A | 23 mV | 0.25 V | 140 µA |
| **HVX-1500-2000 (3 kW)** | 1.5 kV, 2 A | 23 mV | 0.25 V | 200 µA |
| **HVX-5000-400 (2 kW)** | 5 kV, 400 mA | 76 mV | 0.6 V | 40 µA |
| **HVX-5000-600 (3 kW)** | 5 kV, 600 mA | 76 mV | 0.6 V | 60 µA |
| **HVX-10000-200 (2 kW)** | 10 kV, 200 mA | 153 mV | 1.1 V | 20 µA |

| Model (class) | Nominal | Voltage step | Ripple floor, p-p | Smallest current setting |
|---|---|---|---|---|
| **HVX-10000-300 (3 kW)** | 10 kV, 300 mA | 153 mV | 1.1 V | 30 µA |
| **HVX-20000-25 (500 W)** | 20 kV, 25 mA | 305 mV | 2.1 V | 2.5 µA |
| **HVX-30000-17 (500 W)** | 30 kV, 17 mA | 458 mV | 3.1 V | 1.7 µA |

Read against a silicon photomultiplier, those floors rule the HVX-Series out. A device with a 28 V breakdown run at 3 V of overvoltage is biased at 31 V. Its gain is proportional to the overvoltage, so the 0.25 V ripple floor of a 1.5 kV model modulates the gain by 8 percent peak to peak, and the 23 mV voltage step is 0.8 percent of the overvoltage. The microamp bias current is below the 140 µA at which the current loop begins to act. The right source is the bias generator built into the ScintIQ silicon-photomultiplier detectors and readout modules, which runs from a 5 to 16 V supply and corrects the bias for temperature.

A photomultiplier is a closer call and still the wrong fit. At 1,500 V the ripple floor is 170 ppm of the bias, and for a ten-stage tube whose dynode gain varies as the 0.7 power of voltage that moves the gain by about 0.1 percent peak to peak, which is small against the energy resolution of any scintillator. The mismatch is in current and in scale: a tube's divider draws 0.1 to 1 mA, below the 140 to 200 µA at which the current loop of a 1.5 kV model engages, and a 2 kW supply on a 1 W load has none of its range in use. For a single tube the ScintIQ bMCA carries its own 0 to 1,500 V supply in 4,096 steps; a counting room full of tubes is served by a multichannel detector bias supply built for microamp loads. Figure 1 places those loads against the HVX-Series bars.




**DERIVED** **Figure 1.** Figure 1. Each HVX-Series model drawn from its smallest current setting (0.01 percent of nominal) to its rated current at its nominal voltage, against representative detector-laboratory loads. Ion-source gaps, electron guns and an array bias bus fall inside the bars; photomultiplier and silicon-photomultiplier bias fall outside every bar. Computed from the datasheet ratings; the load ranges are representative.

## Where the HVX-Series belongs

Loads at the other end of the current scale are where the HVX-Series works at its ratings, with Arc Detection and Ramp Control doing the work those loads ask for.

**Ion-source extraction and acceleration gaps.** The electrode carries the beam current it launches plus the drain of the gap. A 10 kV extraction passing 100 mA of beam is a 1 kW load, within an HVX-10000-200 at half its current. A source that sparks during conditioning is what Arc Detection is for: it reports the flashover and can switch the output off, and Ramp Control brings the gap back up at a set gradient, from 1 V/s upward, rather than as a step. The external interlock input on the I/O terminal ties the output to the source enclosure.

**Electron guns and electrostatic columns at 20 to 30 kV.** The HVX-20000-25 and HVX-30000-17 deliver 500 W in fixed positive or negative polarity: a 20 kV gun at 15 mA is 300 W on the HVX-20000-25. Line regulation is better than 0.01 percent of nominal for a 10 percent mains change, and stability is 0.01 percent of nominal over 8 hours, which holds a 20 kV gun within 2 V over a shift.

**A bulk bias bus for a large photomultiplier array.** Four hundred tubes at 1,500 V and 1 mA each draw 0.4 A, 600 W, from one HVX-1500-1400, provided each tube's divider is fed through its own series resistor and capacitor so the bus ripple is filtered locally. A 10 kohm and 1 µF stage has a 16 Hz corner and attenuates a 20 kHz component by 62 dB, taking 0.25 V to 0.2 mV, at the cost of 10 V of drop at 1 mA and a per-tube trim where the tubes need one. The arithmetic depends on the ripple frequency, so measure the bus before sizing the filter.

**High-voltage test of detector hardware.** Feedthroughs, cables, dividers and insulators are held at 10 to 30 kV with the current limit set to protect the item under test and the actual current shown on the display, and the event log time-tags every trip. Discharge at no load takes 60 s typical and up to 120 s, which is the wait before the item is handled.

**The DC source behind a high-voltage pulser.** The DEI PVM-1001, which gates photomultipliers and microchannel plates with 0 to 950 V pulses into 50 ohm, takes an external supply of up to 975 V; a 1.5 kV HVX-Series model in the matching polarity supplies it.

## Which HVX-Series models and options fit

Table 2 places each need against the model whose ratings and floors fit it, and names the right tool where that is not an HVX-Series supply.

**Table 2.**

**Table 2. Model selection for detector and nuclear instrumentation loads.**

| Need | Recommended | Rating |
|---|---|---|
| **Ion-source extraction and acceleration to 10 kV at up to 200 or 300 mA** | HVX-10000-200 or HVX-10000-300 | 10 kV, 2 kW or 3 kW, polarity reversible |
| **Electrodes and deflection plates to 5 kV that carry current** | HVX-5000-400 or HVX-5000-600 | 5 kV, 2 kW or 3 kW, polarity reversible |
| **Bulk bias bus for a detector array at 1.5 kV, filtered per channel** | HVX-1500-1400 or HVX-1500-2000 | 1.5 kV, 1.4 A or 2 A; FLO variants for a bus referenced away from earth |
| **Electron guns and electrostatic columns to 20 or 30 kV** | HVX-20000-25 or HVX-30000-17 | 500 W, positive or negative |
| **Single photomultiplier at 0.1 to 1 mA** | ScintIQ bMCA on-board supply, not an HVX-Series model | 0 to 1,500 V in 4,096 steps |

| Need | Recommended | Rating |
|---|---|---|
| **Silicon photomultiplier at 25 to 70 V, microamps** | ScintIQ bias generator module, not an HVX-Series model | Runs from 5 to 16 V, temperature compensated |

Two options matter for these loads. **Arc Detection** detects a flashover in the output, reports it and can switch the output off. **Ramp Control** sets the gradient of every rise and fall from 1 V/s to ten times the nominal voltage per second. Both are field-retrofittable. Polarity on the 1.5 kV to 10 kV models is positive, negative or electrically reversible; the 20 kV and 30 kV models are ordered positive or negative. Ethernet and RS232 with SCPI, the external interlock and the time-tagged event log are standard.

## Recommended configuration

For an ion-source or beamline electrode bench, an **HVX-10000-200** with **Arc Detection** and **Ramp Control**, the interlock wired to the enclosure, and the supply driven over Ethernet with SCPI so the set voltage, the actual current and every arc event are logged with the run. For an array bias bus, an **HVX-1500-1400** with per-channel filtering as above. For guns and columns above 10 kV, the **HVX-20000-25** or **HVX-30000-17** in the polarity the gun needs. For a single photomultiplier or any silicon photomultiplier, use the ScintIQ readout's own bias source.

Limitations. The smallest current the HVX-Series regulates is 0.01 percent of nominal, 140 µA on the 1.5 kV, 1.4 A model, so a load below that runs in constant-voltage mode with no current regulation. The ripple floor is 0.25 V to 3.1 V peak to peak by model and is filtered at the load where a quieter rail is needed. The datasheet does not state how far the FLO models may be referenced away from earth; confirm that figure for a stacked installation before ordering.

## Talk to an application engineer

Berkeley Nucleonics can help you match an HVX-Series model and option set to the loads in your detector or accelerator laboratory. Call **800-234-7858** or email info@berkeleynucleonics.com. Specifications: HVX-Series datasheet, ScintIQ bMCA datasheet, ScintIQ SiPM readout datasheet.

For a quick question, chat with an engineer at berkeleynucleonics.com.

**Ask now →** Chat with our assistant and get an answer in seconds.