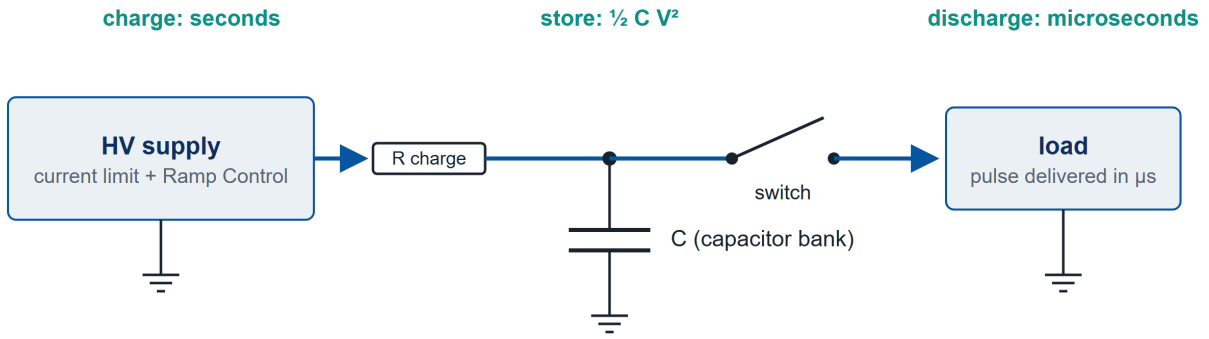
Capacitor Charging & Pulsed Power

Controlled capacitor charging with programmable ramp rates, arc detection, repeatable set points, and up to 3 kW of power for pulsed-power and energy-storage setups.

APPLICATION BRIEF · HVX-SERIES HIGH VOLTAGE POWER SUPPLIES · dc-62022201

Derived

Capacitor charging: the supply charges at its current limit, the bank stores the energy, the switch delivers it



Worked example (computed from the stated values, not measured):

C = 10 µF charged to V = 10 kV at the current limit I = 300 mA (HVX-10000-300)

charge time t = C · V / I = 10 µF × 10 kV / 0.3 A = 0.33 s stored energy E = ½ C V² = 0.5 × 10 µF × (10 kV)² = 500 J

at 200 mA (HVX-10000-200) the same charge takes 0.5 s; shot-to-shot energy repeats to 0.2% when the voltage repeats to 0.1%

Derived: the charging chain (supply, charge resistor, capacitor bank, switch, load) with the charge time and stored energy computed for a 10 uF bank at 10 kV and 300 mA: 0.33 s and 500 J. Computed from the stated values, not measured.

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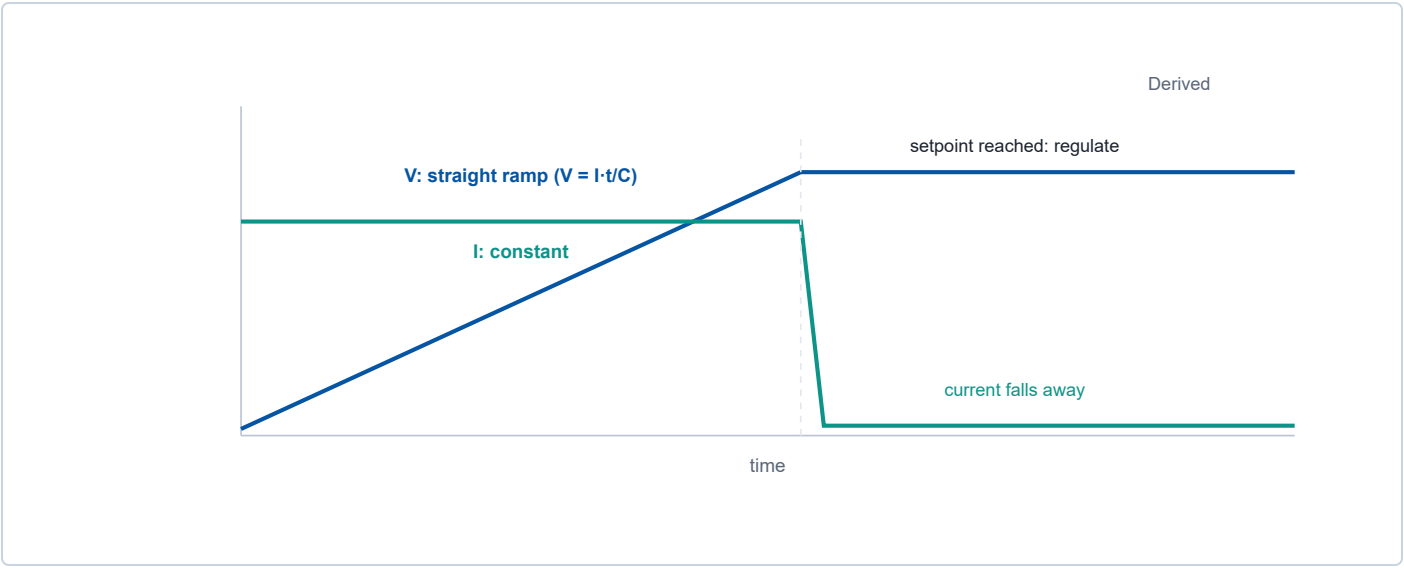
Pulsed-power systems store energy slowly and release it fast. A capacitor or capacitor bank charges over seconds, then dumps its energy into a load in microseconds. The charging supply is the front of that chain, and its behavior shapes everything downstream: how quickly the system can cycle, how repeatable each shot is, and how safely the bank handles the inevitable fault.



Charging a capacitor is not the same as driving a resistive load. At the start of a charge the capacitor looks like a short circuit, so the supply slams into its current limit and stays there until the voltage builds. A supply that cannot

regulate cleanly through that constant-current phase, or that overshoots as the capacitor approaches its setpoint, makes the shot-to-shot energy unpredictable. Repeatability in pulsed power starts with a charge that lands on the same voltage every time.

The other defining feature of these setups is fault energy. A charged bank holds real stored energy, and a flashover or an unexpected load short has to be caught fast. Without quick detection and the ability to remove the source, a single arc can damage the bank, the switch, or the experiment. The charging supply is the first line of protection.



DERIVED **Figure 1.** From capacitor physics: at constant charging current the bank voltage is a straight ramp, V = I·t/C, followed by a clean handoff to regulation at the setpoint. A programmable ramp and a repeatable set point hold the stored energy constant from shot to shot: with the voltage reproducible to 0.1 percent, the energy, which goes as the square of the voltage, repeats to 0.2 percent.

How the BNC HVX-Series line solves it

The Berkeley Nucleonics HVX-Series is a fully digitally regulated DC high-voltage supply with a microcontroller and FPGA control core, and that fast digital loop is what makes it a good capacitor charger. The supply charges at its current limit until the bank reaches the set voltage, then holds it, and the set point repeats to within 0.1 percent of nominal, so the stored energy repeats to within 0.2 percent shot after shot.

The retrofittable ramp-control option is built for this work. It sets a defined gradient from 1 V/s up to ten times nominal volts per second, which lets an operator program a controlled rate of rise rather than charging at the bare current limit. A controlled ramp protects the dielectric, makes inrush predictable, and gives a repeatable charge profile that automated pulsed-power sequences depend on.

Arc detection is the safety half of the equation. The option detects and reports a flashover and can shut the output off, removing the source before a fault escalates. Combined with the time-tagged event log, that gives an operator both protection during the run and a record afterward. For throughput, the higher power classes reach up to 3 kW, so a bank charges quickly and the system cycles at a useful repetition rate. On-board Ethernet and RS232 with a SCPI command set let the supply run inside an automated shot sequence, and the single-phase 230 V input (187 V to 253 V on the 2 kW models) with active power-factor correction runs from a 230 V branch circuit.

Which HVX-Series models and options fit

For charging duty the model is chosen by the bank voltage and the charge rate the system needs. Charge time follows from the current limit: a 10 µF bank charged to 10 kV at 300 mA takes t = CV/I = 10 µF × 10 kV / 0.3 A = 0.33 s and stores ½CV² = 500 J; at 200 mA the same charge takes 0.5 s. Higher current shortens charge time and raises the achievable repetition rate, so the 3 kW class is the starting point where throughput matters.

Table 1.

Charging profile	Recommended HVX-Series model	Output
Low-voltage bank, fast cycle	HVX-1500-2000	1.5 kV, 2000 mA, 3 kW
Mid-voltage bank, high throughput	HVX-5000-600	5 kV, 600 mA, 3 kW
High-voltage bank, high throughput	HVX-10000-300	10 kV, 300 mA, 3 kW
High-voltage bank, standard rate	HVX-10000-200	10 kV, 200 mA, 2 kW

The two options to specify for this application are **Ramp Control** and **Arc Detection**, both retrofittable so a bench can add them later as a program grows. The 1.5 kV to 10 kV models are available in positive, negative or reversible-polarity versions, so a reversible HVX-5000-600 covers both polarities in one chassis. For charging work a fixed polarity matching the bank is usually all that is needed, which keeps the order straightforward.

Recommended configuration

A capable default for capacitor charging is the **HVX-10000-300** fitted with the ramp-control and arc-detection options. At 10 kV and 300 mA it charges a 10 µF bank to full voltage in a third of a second, the 0.1 percent reproducibility keeps shot-to-shot energy repeatable to 0.2 percent, the programmable ramp protects the dielectric, and Arc Detection removes the source on a flashover. Drive it over Ethernet with SCPI so the charge cycle runs inside your pulsed-power sequence and every shot is logged.

Where the bank runs at lower voltage but needs fast cycling, the **HVX-1500-2000** delivers the same 3 kW with the same options at 1.5 kV. Both mount in a standard 19-inch rack at 2U or run on the bench with the integrated adapter, and both ship with a 3 m high-voltage cable and plug. Confirm your bank's working voltage, capacitance, and target charge time with an applications engineer so the power class and ramp rate match the duty cycle.

> **Working with stored energy**
> A charged capacitor bank holds energy that can injure. Specify Arc Detection, follow safe discharge practice, and confirm interlocks with your safety team before commissioning.

> **Building a pulsed-power or charging setup?**
> Berkeley Nucleonics applications engineers can size a HVX-Series charger to your bank voltage, charge time, and protection needs. Call 800-234-7858 or write info@berkeleynucleonics.com to scope a configuration.

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