SPHV High Voltage Regulator

Low Noise Low Impedance Bootstrap Powered Low Dropout High Voltage Regulator

- Output voltage from 5V to 450V
- Low noise: 1 PPM of Vout
- Small footprint—standard TO-220
- Fast dynamic output response
- Very low output impedance
- Self powered reference
- Low drop-out voltage
- No pre-regulator needed
- Output voltage set with a single resistance.

- Tube/Valve preamplifiers and mixers
- Power amplifiers
- Tubed phono preamps
- Guitar amplifiers
- Anywhere a clean, fast, quiet high voltage power supply is needed

The Superpower regulator is a high performance voltage regulator with a novel circuit design (US patent 8294440) to internally power its reference circuit with its own regulated output. A floating reference allows SPHV to deliver output voltage from 5V to 450V with low noise, low output impedance, high current and fast dynamic performance in a compact circuit that fits a standard IC footprint.

Superpower delivers current to a load with a clean dynamic waveform with minimum ringing or overshoot and settles quickly. Superpower works best without a pre-regulator, because a pre-regulator can limit the dynamic current available to the load.

Contact Belleson for more information.

Parameter	Conditions	Value	Units
Input voltage maximum	(1*)	500	V
Output voltage	Variable based on requirements	maximum 450	V
Output Noise (typical)	RMS 20Hz – 20KHz	1	PPM of Vout
Line Rejection (typical)	60Hz	110	dB
Maximum continuous current	typical, within power dissipation limit	500	mA
Maximum regulator (not load) power dissipation	no heat sink sufficient heat sink	2 >50	W
Drop–out voltage	Load Current 50mA 500mA	 0.25 0.5	V
Output Impedance	20Hz – 20KHz	10	mΩ
No-load ground current		1	mA

SPHV provides a breakthrough combination of high voltage, dynamic current delivery and low noise. This is information to allow you to get the best performance from your Superpower.

No Output Protection

To deliver the lowest possible output impedance, this circuit has no output protection circuitry. However, it uses a FET output device and thus has a built-in output current limit and may not destroyed by a brief output short circuit to ground. SPHV can be damaged if maximum power dissipation is exceeded.

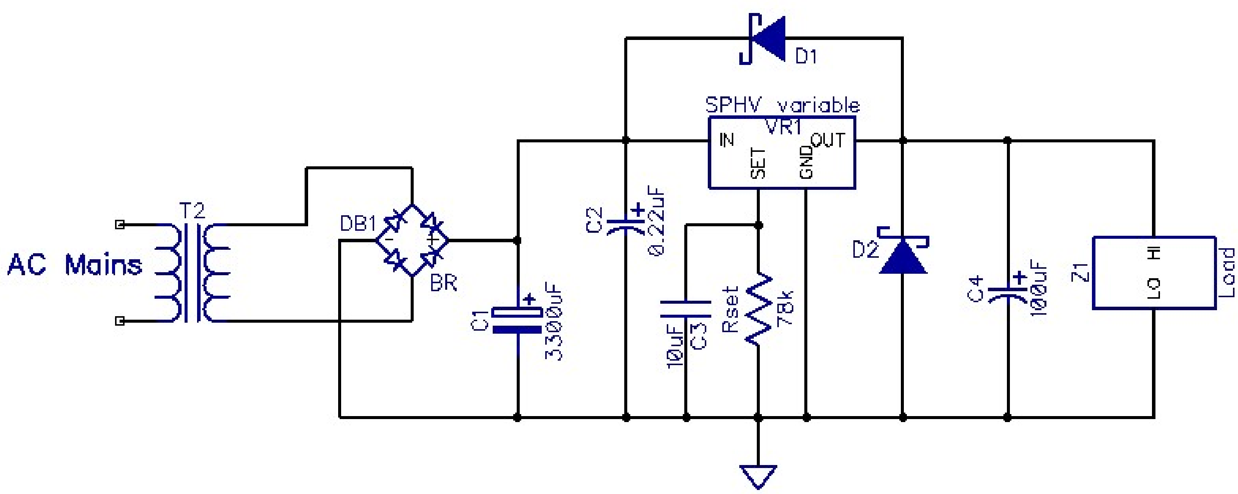


Figure 1: Typical schematic for 200V regulated output

How to set Vout and choose Rset

SPHV uses a single resistor *Rset* to set output voltage.

Vout = (2.5mA X *Rset*) + 5V

or

Rset = (*Vout* – 5) / 0.0025

The above figure 1 shows a 78k resistance to set Vout to 200V.

Power dissipation in *Rset* depends on *Vout* as

PD = (*Vout* – 5) x 2.5mA

The example in figure 1 thus requires a ½ W resistor.

Rset=0 gives *Vout*=5V, providing an easy way to do a basic test using, for example, a 9V battery.

Output Capacitor and Regulator Stability

A capacitor of at least 10μF must be connected between *Vout* and *GND* to prevent regulator oscillation. Typically 100μF is enough, more capacitance provides diminishing benefit. Also at high voltage ratings, larger value capacitors are also physically large. The regulator itself provides low output impedance across a wide bandwidth due to its internal gain+feedback loop.

Line Rejection and Drop Out Voltage

(This section does not apply when Vin is supplied by a switched mode power supply, only to a linear rectified power supply.)

As current increases, the minimum value of input ripple goes down and the regulator drop-out voltage goes up. If they meet or overlap, line regulation degrades rapidly. Ripple on the output of a full wave rectifier is calculated as

$Vr = \frac{Idc}{2fC}$ where *Vr* is the peak to peak ripple voltage.

For example, consider a 200V regulator circuit as seen in the figure. With 3300μF ripple is about 200mV.

To calculate the capacitance required for a given ripple voltage and output current, use

$$C=\frac{Idc}{2fVr}.$$

More capacitance gives less ripple, which in turn reduces the amount of input voltage “overhead” and thus the power dissipation in the regulator.

Noise reduction

C3 in parallel with *Rset* reduces noise at Vout. It also increases the rise time of Vout at initial power–up. The current into *C3* starts at 2.5mA so for *C3*=1μF, the above circuit takes 0.5sec, and for C3=10μF it takes almost 5 seconds to reach 199+ volts. In a tube circuit it's generally beneficial for B+ to rise slowly, and the noise contribution of Rset is reduced to a negligible level.

Dynamics

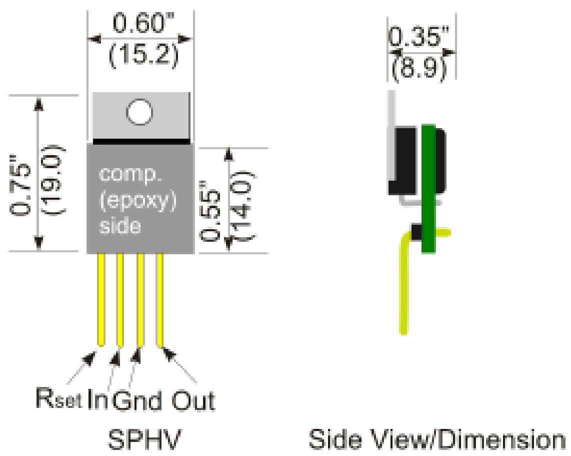
Good dynamic response means supplying a lot of current very quickly. A large capacitor (100μF or more) located near the input pins of Superpower provides reserve storage so Superpower can deliver that current. An input capacitor also decreases output noise. SPHV requires a minimum of 10μF output capacitance added to its output for stability, Additional capacitance near the load of 100μF or more improves dynamic response.

Thermal considerations

SPHV can dissipate approximately 1W without heat sinking depending on ambient temperature and air flow. Power dissipation (thus heat) depends on the input to output voltage divided by (output current + 1mA). You can minimize regulator power dissipation by taking advantage of its low drop–out voltage of ½ to 2V (depending on load), i. e. setting the input voltage to 1 or 2 volts higher than the output voltage.

To dissipate more than 1W, bolt the TO-220 power output transistor to a heat sink or a heat conductive chassis. **The power tab on this transistor is electrically connected to V_{IN} so use an insulating thermal pad** and, for best results, electrically connect the heat sink to a stable, quiet ground point.

Always be careful around high voltage and “keep one hand in your pocket”!



Superpower HV pinout and mechanical dimensions. Mounting holes are 0.15” (3.8mm) diameter. External dimensions may vary by ±5%, mounting hole dimensions by ±0.5%.