SPHV High Voltage Regulator

Low Noise Low Impedance Bootstrap Powered Low Dropout High Voltage Regulator

FEATURES

- Output voltage from 5V to 450V
- Low noise: 1 PPM of Vout
- Small footprint—TO-220 four pins
- 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.

APPLICATIONS

- Tube/Valve preamplifiers
- Power amp input stages
- Tubed phono preamps
- Guitar amp input stages
- Anywhere a clean, fast, quiet high voltage power supply is needed

DESCRIPTION

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 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 (typ)	RMS 20Hz – 20KHz	1	PPM of Vout
Line Rejection (typ)	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		11	mA

Application Information

Superpower provides a breakthrough combination of dynamics and low noise. This sheet provides information to allow you to get the best use 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 is not destroyed by a brief output short circuit to ground. SPHV can be damaged if maximum power dissipation is exceeded.

How to set Vout

SPHV uses a single resistor Rset to set output voltage.

Output voltage Vout = (2.5mA X Rset) + 5V,
or Rset = (Vout – 5) / 0.0025. The above figure shows a 78k resistance to set Vout to 200V.

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.

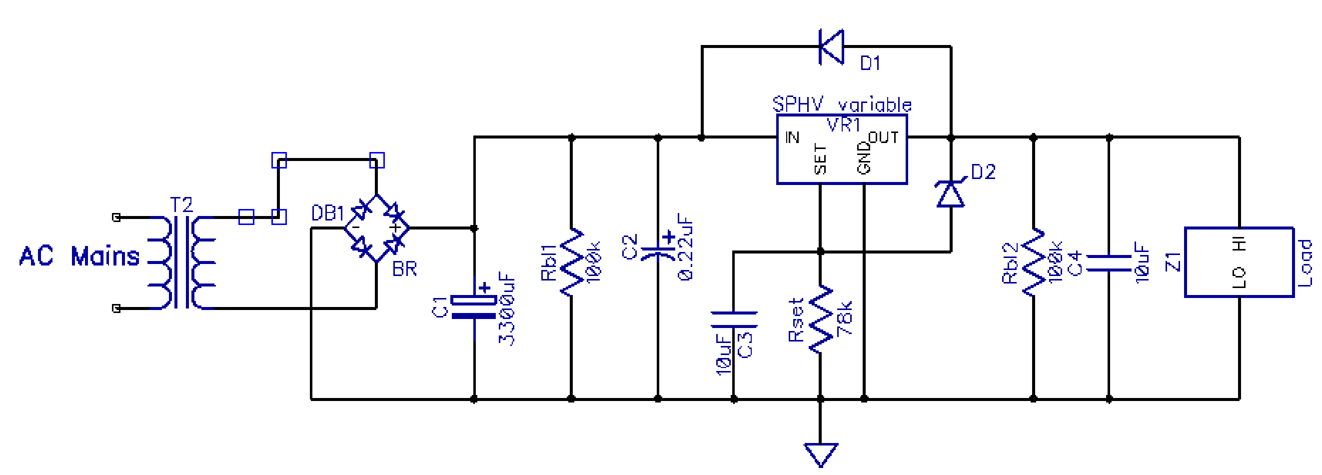


Figure 1: Example SPHV circuit including transient current protection diodes

Noise reduction

C3 in parallel with Rset reduces noise at Vout. It also increases the rise time of Vout. The current into C3 starts at 2.5mA so for C3=1µF, the circuit in figure 1 with C3=10µF 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 (100+µF) located near the input pins of Superpower provides reserve storage so Superpower can deliver that current and reduces input ripple from a rectified AC input. SPHV requires a minimum of 10µF output capacitance at Vout for stability.

Safety Precautions

The usual high voltage precautions are necessary, and the adage “keep one hand in your pocket” to prevent any slips where current goes between two hands (and through your heart) applies!

SPHV has a regulation loop that floats on the voltage across Rset. Components in this loop will be damaged if voltage between Vout and V_{Rset} goes above 12V, or if energy from a capacitor sends current backward through it during power on or off. To protect the regulator, protection diodes D1 and D2 shown in figure 1 are required for Vin > 30V. They shunt transient currents away from the regulator as Vin goes to zero and C3 or C4 are charged.

For D1 choose a standard silicon diode such as 1N4006, not a SiC high voltage diode, because a silicon diode has a lower forward voltage drop. For D2, use a high power zener diode such as 1N4737, with a zener voltage between 5V and 10V.

Thermal considerations

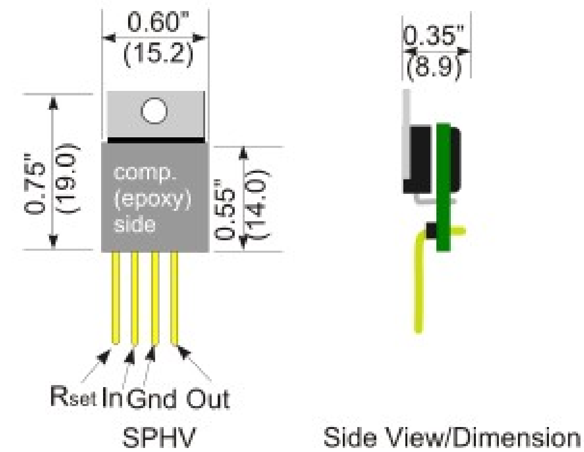
Superpower can dissipate approximately 1W without heat sinking depending on ambient temperature and air flow. Power dissipation (thus heat) depends on the input to output voltage divided by (output current + 11mA). You can minimize regulator power dissipation by taking advantage of its low drop–out voltage 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. **Use an insulating thermal pad** and, for best results, electrically connect the heat sink to a stable, quiet ground point.

Rset, as mentioned, is floating with (Vout-5V) across it, and carries 2.5mA. Thus it requires a power rating higher than 0.0025 x (Vout – 5). For the 200V example above, Rset must be rated for 0.5W dissipation. Also, wirewound resistors are more robust than metal film.

For general information on keeping your circuit cool, get the book “Hot Air Rises and Heat Sinks” by Tom Kordyban.

Mechanical Specifications



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%. Pin spacing is 0.1” (1.27mm). Pin 3 (from left) is centered on PCB.