



superpower

SPX max performance
SPHP high power
SPLV low voltage

Low Noise, Low Impedance,
Bootstrap Powered
Low Dropout Regulator

FEATURES

- Wide Vout range from 1.2V to 100V
- Very low noise
- Exceptionally fast transient response
- Output currents from 1A to 10A
- Very low output impedance
- Low drop-out voltage
- Available as positive or negative output
- LM78xx, LM79xx, LM317, LM337 pin out
- No pre-regulator needed

APPLICATIONS

- High resolution D/A and A/D converters
- Audio DACs, preamps, mixers, microphone amps
- Phono preamps
- Power amps
- Turntable motors
- Tube/Valve preamplifiers
- Microphone amps
- Precision high power sources
- Precision measurement systems
- Any system that needs clean, quiet, fast power!

DESCRIPTION

The Superpower regulator is a high performance voltage regulator with a novel circuit design (U.S. Patent 8,294,440) to internally power its reference circuit with its own regulated output. A floating reference allows output voltage from 1.2V (SPLV) to 30V (SPX) and 100V (SPHP) with low noise, low output impedance, high current (10A with SPHP) and fast transient response in a compact circuit that fits a standard IC footprint (except SPHP). Optimum load transient response is obtained with a 100µF or more capacitor connected to Vout.

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 increases overall drop out requirements and may limit the dynamic current available to the load.

With a footprint to match industry standard TO-220 monolithic regulators, Superpower can be easily retrofit into existing systems or designed into new systems for maximum performance. A custom PCB design can be built into your own products.

For higher voltage output, see our SPHV with up to 450V output at 500mA.

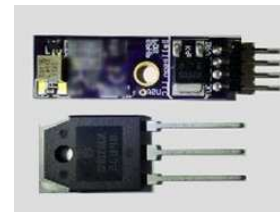
[Contact Belleson](#) for more information.



SPX



SPLV



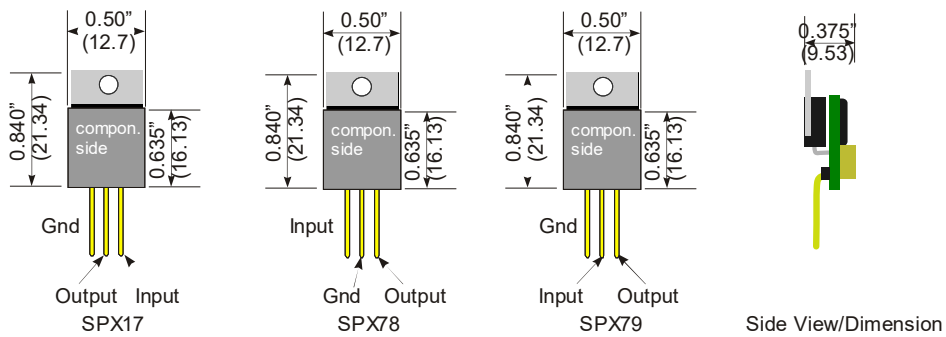
SPHP

Absolute Maximum Ratings

Parameter	Conditions	Value	Units
Input voltage maximum	SPLV	12	V
	SPX	35	
	SPHP	105	
Peak current	SPLV	1.0	A
	SPX	8.0	
	SPHP	12.0	
Total power dissipation	SPX at $T_A = 25^\circ\text{C}$ (requires heat sink) Derate above 25°C	36 288	W mW/ $^\circ\text{C}$
	SPHP at $T_A = 25^\circ\text{C}$ (requires heat sink) Derate above 25°C	200 1400	
Thermal Resistance	SPX $R_{\theta JA}$, Junction-to-Ambient no heat sink	63	$^\circ\text{C}/\text{W}$

Operation at these limits is not guaranteed. Operation beyond these limits may result in irreversible damage.

Example Pin Connections

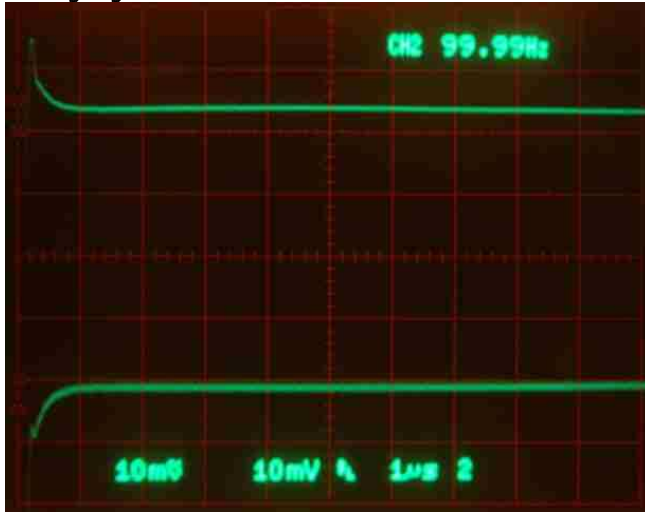


Typical Performance Characteristics, SPX

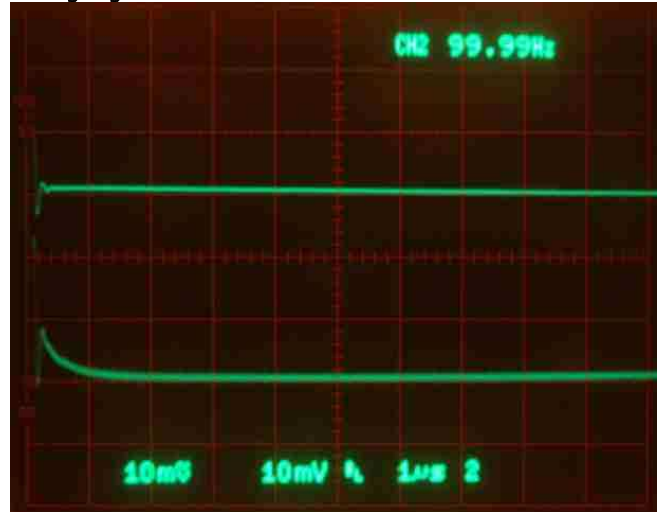
SPX Transient Step Response, 250mA

DC load: 500Ω (24mA)
 Output capacitance: 100μF
 Top: ΔOutput current, 200mA/div (one up from centerline is 0mA)
 Bottom: ΔVout, 20mV/div
 Horizontal: 1μsec/div

Leading Edge

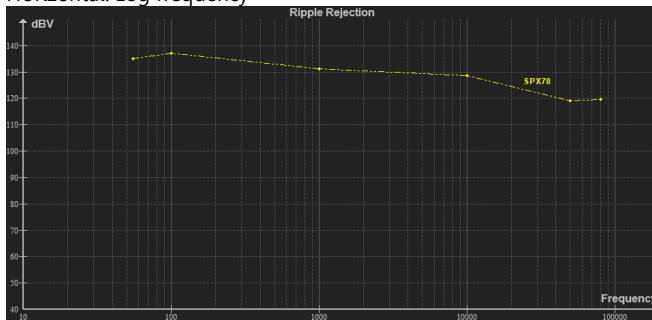


Trailing Edge



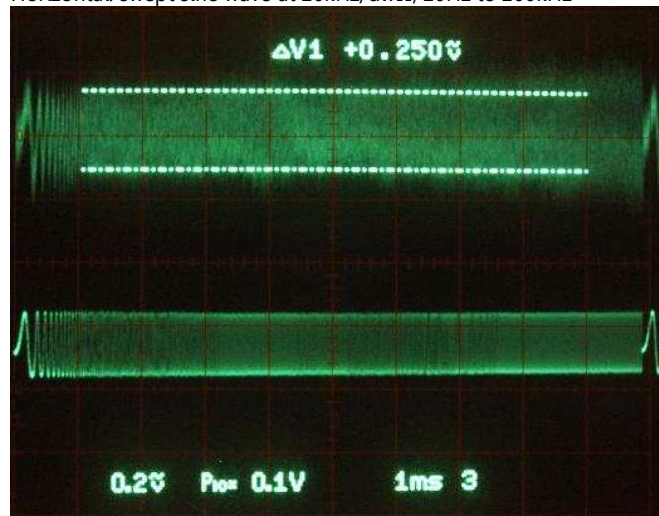
SPX Ripple Rejection vs. Frequency

Vin: 15VDC ±0.5VppAC
 Vertical: 10dBV/div
 Horizontal: Log frequency



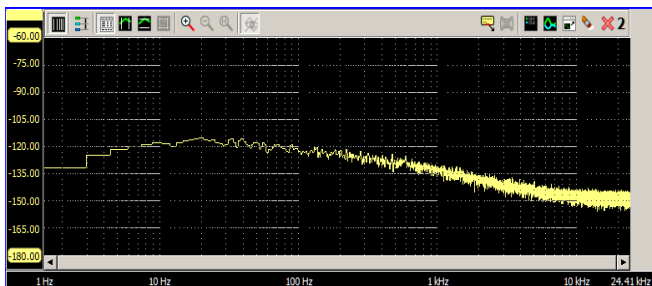
SPX Output Impedance

Top: Vout at 200μV/div (via 1000x amplifier)
 Bottom: Iout = 10mAac/div swept sine wave at 20kHz/div
 Horizontal: swept sine wave at 20kHz/div, 20Hz to 200kHz



Impedance: 0.25mV/10mA = 25mΩ including test apparatus
 resistance, flat across 200kHz bandwidth

SPX Noise Spectrum



SPLV Low Voltage 1A Output

Parameter	Conditions	Value	Units
Input voltage maximum		12	V
Output voltage positive	Standard values (1*)	1.2, 1.5, 1.8, 2.0, 2.5	V
Output voltage negative	Standard values (1*)	-1.2, -1.5, -1.8, -2.0, -2.5	V
Output Noise	RMS 20Hz – 20KHz	5	μV
Line Rejection	60Hz, 5V in +1Vpp	115	dB
Continuous current	within power dissipation limit	1	A
Maximum power dissipation (2*)	no heat sink sufficient heat sink	2 2.5	W
Drop-out voltage	<u>Load Current</u> 0.5A 1A	2.1 2.4	V

SPX, Maximum Performance

Parameter	Conditions	Value	Units
Input voltage maximum		35	V
Output voltage positive	variable (4*)	+3.3 to +30	V
Output voltage negative	variable	-5 to -30	V
Output Noise	RMS 20Hz – 20KHz (3*)	<1	PPM of Vout
Line Rejection	60Hz, 1Vpp 80kHz, 1Vpp	135 119	dB
Continuous current	Positive (SPX78, SPX17) Negative (SPX79) within power dissipation limit	3 -3	A
Maximum power dissipation (2*)	no heat sink sufficient heat sink	1 36	W
Drop-out voltage	<u>Load Current</u> 0.5A 1A 2A 3A	0.6 0.8 1 1.5	V
Output Impedance	20Hz – 20KHz	25	mΩ

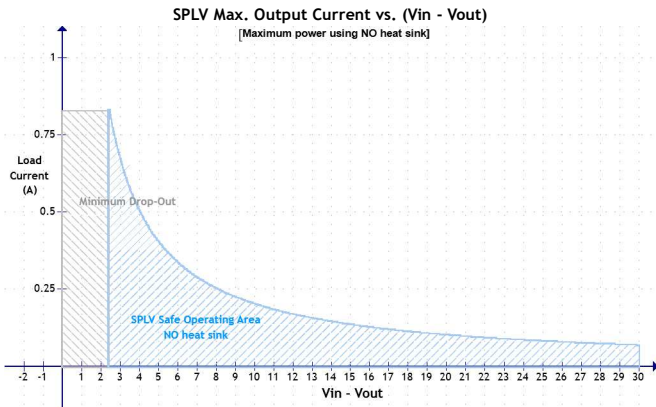
SPHP 10A High Power

Parameter	Conditions	Value	Units
Input voltage maximum		120	V
Output voltage positive	Adjustable or fixed output	5 to 100	V
Output voltage negative	Adjustable or fixed output	-5 to -100	V
Output Noise	RMS 20Hz – 20KHz (3*)	<1	PPM of Vout
Line Rejection	60Hz, 1Vpk	110	dB
Continuous current	Within power dissipation limits drop-out voltage 3V 5V	10 14	A
Maximum power dissipation (2*)	no heat sink sufficient heat sink	30 160	W
Drop-out voltage (typical)	load current 0 to 1.5A 2A to 4A 4A to 10A	2.0 2.5 3.0	V
Output Impedance	20Hz – 20KHz	50	mΩ

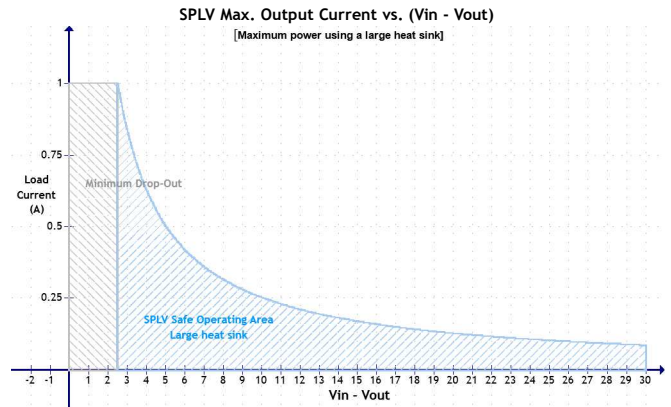
Notes

- (*1) Custom output values available, [see our web site](#).
- (*2) Maximum *regulator* (not load) dissipation at 25°C ambient air temperature,
- (*3) No load.
- (*4) 3.3V output is fixed, variable goes from 5V to 30V

SPLV Max. Load Current vs. (Vin-Vout)

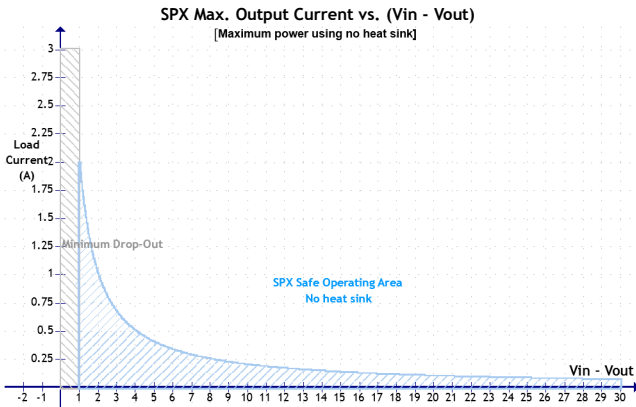


Max power dissipation with no heat sink

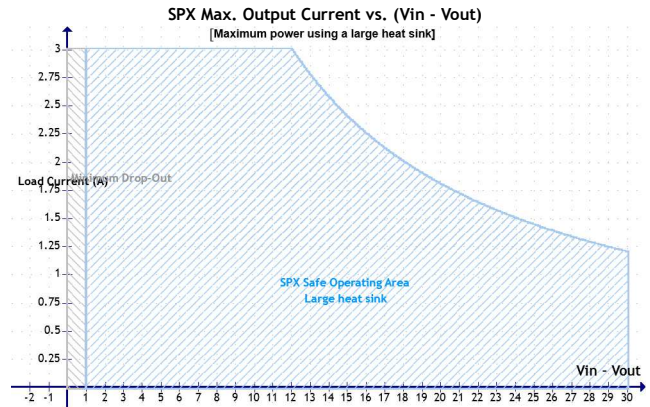


Max power dissipation with large heat sink

SPX Max. Load Current vs. (Vin-Vout)

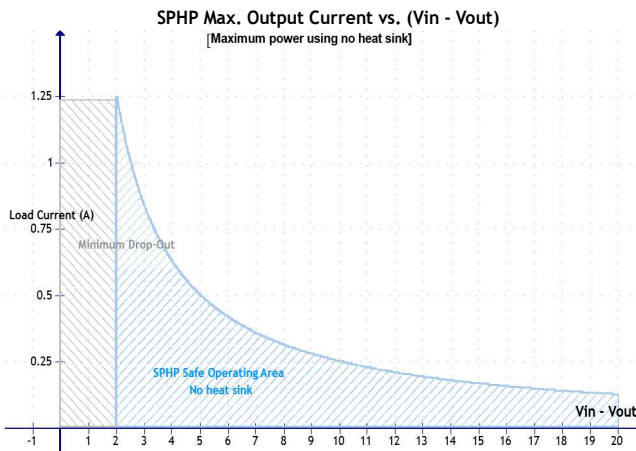


Max power dissipation with no heat sink

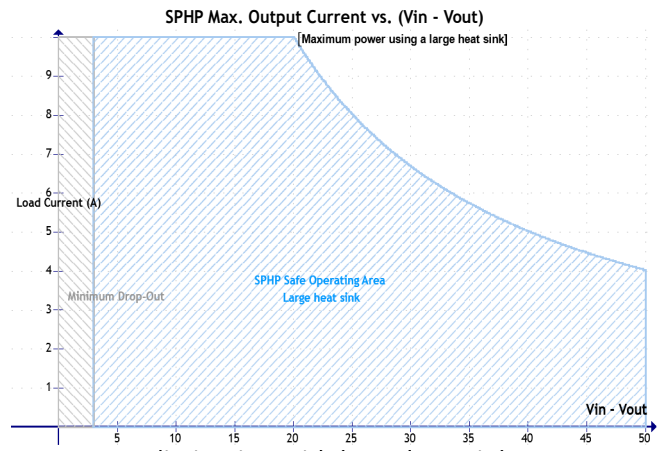


Max power dissipation with large heat sink

SPHP Max. Load Current vs. (Vin-Vout)



Max power dissipation with no heat sink



Max power dissipation with large heat sink

Application Information

Superpower provides a breakthrough combination of dynamics and low noise. This provides information to allow you to get the best use from your Superpower.

No Output Protection

To deliver maximum current with least drop out voltage, Superpower regulators have no output current limit. Any short circuit of the output to common may destroy the output device and render the circuit useless.

Input Voltage Pre-regulation

Use of a pre-regulator may adversely affect the dynamic response of Superpower by limiting delivery of current. Best performance is obtained by taking Superpower's input directly from a raw rectified and filtered power supply. If you do use a pre-regulator, use a Superpower, that's what we have to use for testing.

Dynamics and Capacitance

Good dynamic response means supplying a lot of current very quickly. A large capacitor (100+ μ F) located near the input pins of Superpower provides reserve storage so Superpower can deliver that current. An input capacitor also decreases output noise. See the discussion of Line Rejection and Drop Out Voltage on page 8 for minimum input capacitance requirements.

SPX has a 10 μ F output capacitor on board, but adding a 100 μ F external capacitor near the load may improve dynamic response.

If low level multi-MHz oscillation is observed at Vout, a 0.1 μ F or higher ceramic or film capacitor soldered directly across the IN to GND pins may cure it.

SPHP Sense Connection

SPHP sense is done via the OUT connection, see the discussion of SPHP on page 6.

SPX Output Voltage Set

SPX is available as variable Vout. As shipped, Vout is set at 30V and decreased by soldering a small ¼ Watt resistor between the two PCB holes near the pins:



We suggest soldering on the rear side of the PCB.

Calculate Rset in k Ω as

$$R_{set} (kOhms) = \frac{(10 \times V_{out}) - 50}{30 - V_{out}}$$

Typical values are

Vout	Rset	Nearest 1% value (Ohms)	Nominal Vout
5	0	0	5
6.3	548.52	549	6.3
7	869.57	866	6.99
8	1363.64	1370	8.01
9	1904.76	1910	9.01
10	2500	2490	9.98
12	3888.89	3900	12.01
12.6	4367.82	4320	12.54
15	6666.67	6650	14.98
16	7857.14	7870	16.01
18	10833.33	10700	17.92
20	15000	15000	20
24	31666.67	31600	23.99
30	none	none	30

Heat Sinks and Power Dissipation

This discussion pertains to the power dissipation in the regulator itself, not power delivered from a regulator to a load. This is calculated as

$$\frac{V_{in} - V_{out}}{I_{load} + 5mA}$$

Superpower can dissipate 1 or 2 Watts without heat sinking depending on ambient temperature and air flow. You can minimize regulator power dissipation by taking advantage of the low drop-out voltage, i. e. setting input voltage slightly higher than output voltage + drop-out.

To dissipate more than 1W, attach Superpower to a heat sink or a heat conductive chassis. Use an insulating thermal pad or mica insulator with thermal paste and, for best results, electrically connect the heat sink to a stable, quiet ground point.

SP and SPLV regulators use surface mounted output transistors and their power dissipation is limited by the thermal resistance of the PCB, through which heat must pass to get to a heat sink. Power dissipation for SP should not exceed 2.5W at room temperature (25°C) and for SPLV should not exceed 3.2W at 25°C. See (Vin-Vout) vs. Load Current curves on page 6 for more information.

If you have any concerns about power dissipation we recommend you use SPX with output device that can be mounted directly to a heat sink.

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

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

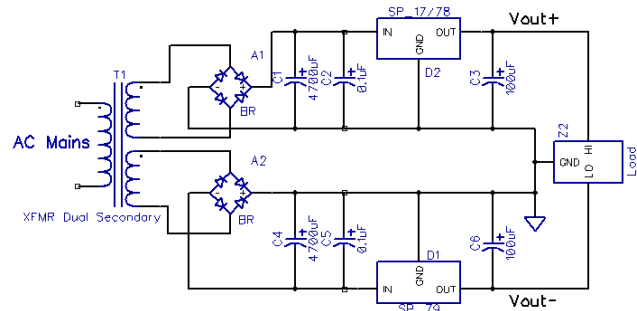


Figure 1: Typical regulated power supply with recommended Cout (C3 and C6)

For example, consider a 5V regulator circuit as seen in Figure 1 using a 100µF filter capacitor. At 400mA, the ripple for a 60Hz AC input =

$$\frac{0.4}{2 \times 60 \times (100 \times 10^{-6})} = 33V (!)$$

Clearly 100µF is not enough capacitance for this circuit.

The same calculation with 4700µF results in a more tolerable 0.7V ripple. If the minimum point of the rectified voltage must be 5V, the DC + ripple at Cin must have a minimum low peak of 5.7V or higher to deliver 5V out.

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

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

However, this does not consider the regulator drop out voltage—the voltage to operate a standard SP Superpower is almost 2V of drop out "head-room" at 400mA. The minimum point of ripple must then be 5V Vout + 2V drop out and Vin must peak at least 0.7V above that. So the absolute minimum voltage supplied by the rectifier at full load must be 7.7V(DC + ripple) to get 5V out and meet the SP specification for line regulation. It is best to allow for other factors and supply something higher than minimum, for example 9V for this circuit. Use an SPJ for lower drop out voltage of 1V at 2A.

The required trade off is increased power dissipation in the regulator.

Replacing Existing Regulators

Superpower regulators are designed to make it easy to replace lesser regulators in your equipment. They are built as a direct replacement for some pin outs or can be externally mounted or chassis mounted and wired into PC boards where there is not enough space or where you are replacing a surface mount regulator.

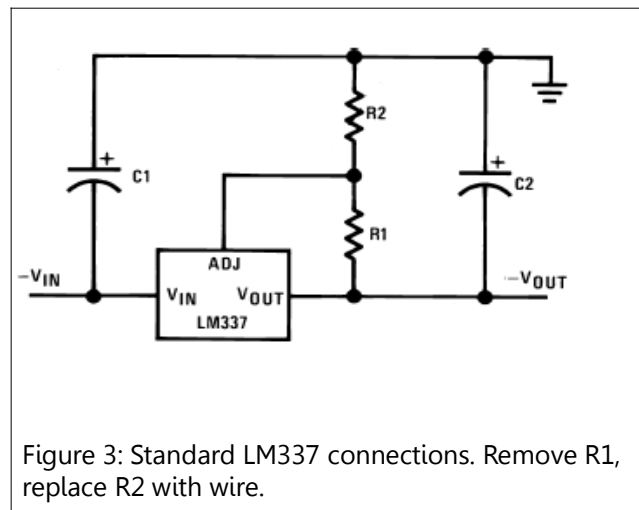
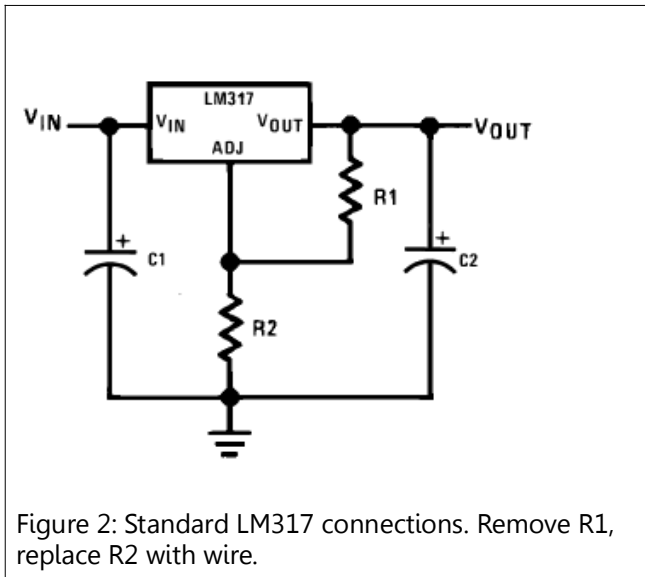
LM78x and LM79x and similar regulators

SPX78 and SPX79 regulators are drop-in replacements for TO-220 packaged LM78x and LM79x type regulators. Unsolder and remove the existing regulator, insert and resolder the same voltage Superpower. You can keep or remove any existing input and/or output capacitors. For best performance, use a 100 μ F capacitor directly at the Superpower input to ground and another at the load.

LM317, LM1117, LM337 and similar regulators

Refer to figures 2 and 3 for this discussion. Superpower regulators are fixed output, LM317 and LM337 regulators are adjustable. To replace the adjustable regulators, circuit modifications must be made. To replace LM317/LM337/LM1117 (variable), etc., make the following circuit changes:

1. Replace R2 (goes from ADJ to ground) with a wire or short R2 to ground.
2. Remove R1 (goes from Vout to ADJ) because now it has the full Vout across it (instead of 1.2V) and will overheat.
3. If there is a capacitor at the ADJ adjustment pin, it can stay or be removed as it now has both ends grounded.
4. See Line Rejection and Drop Out Voltage section on page 8 for capacitor C1 value. C2 should be a high quality 100 μ F capacitor such as Nichicon UVR1H101MPD.



Connecting the SPHP

SPHP is a high voltage, high current regulator shipped in two pieces, a controller circuit and a power output transistor. Together they are capable of providing up to 1000W of power, or 100V at 10A. Vout is available from 5V to 100V, or 3.3V via special order. The power transistor (NJW3281G or J4313-O) is rated to 250W with adequate heat sink. At 10A we recommend Vin-Vout between 4V and 6V to keep power dissipation low in the power transistor. See [our web site](#) for a detailed discussion of regulator drop-out.

The circuit is designed so all load current flows through the power transistor and not through the controller. This removes IR losses and thermal transients from the controller circuit and allows for better regulation.

Care must be used in designing high current circuits, where PC traces are short and wide enough for delivering large currents with low resistance and inductance.

Notice in figure 4 the high current path: bridge->QN1 collector->QN1 emitter->Load->bridge. Use heavy PCB traces for this connection path. The maximum current in the control PCB is QN1 base current from DRV which has a maximum of about 250mA for output current of 10A.

Also notice the "OUT" pin of the SPHP—with the output transistor mounted off-board, this is not really OUT, it is the output sense for the control loop of the Superpower. It's a low current line (about 1mA) that should be connected near the load if possible and isolated from any digital or other noisy traces.

R1 (100Ω 1/4 Watt) is recommended between the base and emitter of QN1 for best dynamic step response.

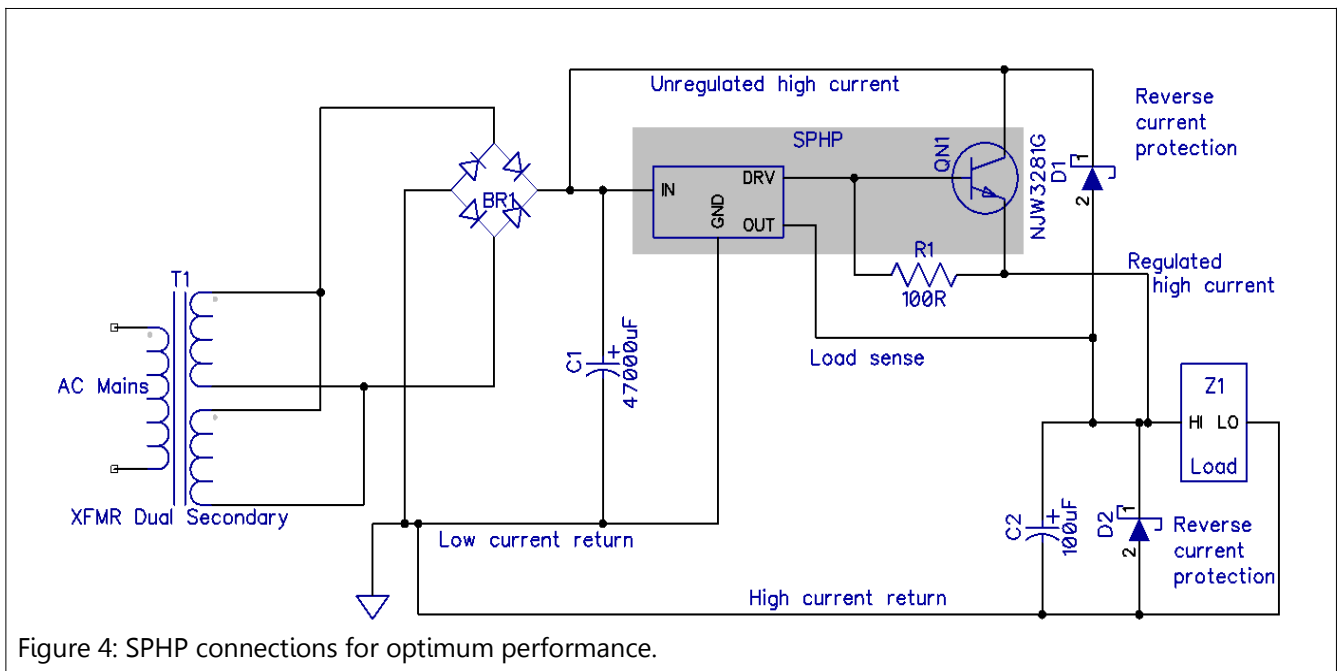
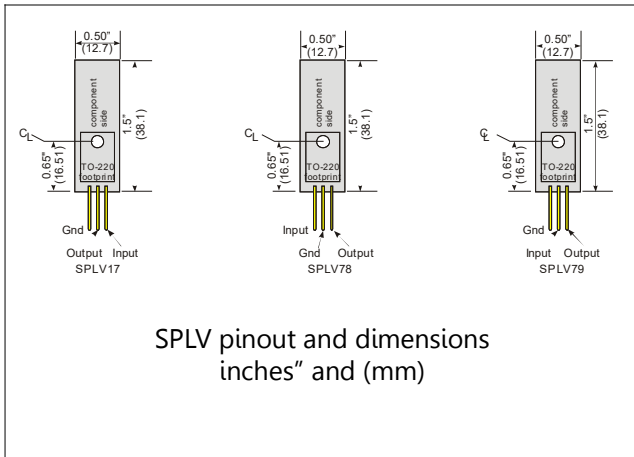
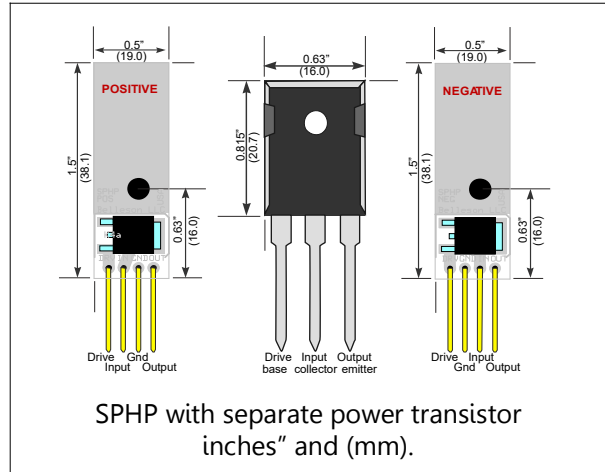
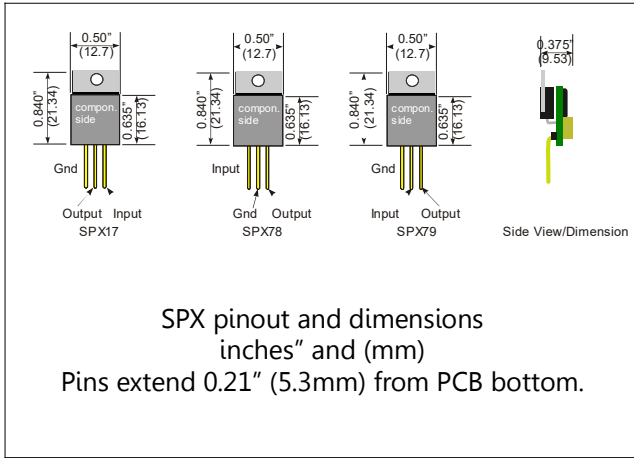


Figure 4: SPHP connections for optimum performance.

Mechanical Specifications



External dimensions may vary by $\pm 2\%$, mounting hole dimensions by $\pm 0.5\%$.

Legal Information

By using Belleson Superpower regulators, you agree that SPLV, SPHV, SPX, SPHP and all Belleson products that have no output protection a short circuit of the output to ground can damage or destroy the regulator. All devices are tested prior to shipment and damaged devices will not be replaced.

You also agree that misuse or misapplication of Belleson products may cause damage where attempted use or application occurs and you as user of the product(s) accept all responsibility for all consequences of use or application of Belleson product(s) and will not hold Belleson responsible for any damage nor injury as a result of use or attempted use of Belleson products.

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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Illustration 1: You know what to do.