Belleson

SUPERPOWER

SPLV low voltage
SPM miniature low current
SP standard
SPJ high current
SPHP high power
SPHV high voltage

Low Noise, Low Impedance,
Bootstrap Powered
Low Dropout Regulator

FEATURES

- Wide Vout range from 1.2V to 400V
- Very low noise
- Exceptionally fast transient response
- Output currents of 225mA, 500mA, 2A, 10A
- Very low output impedance
- Self powered bootstrapped reference
- Low drop-out voltage
- Available as positive or negative output
- LM78xx, LM79xx and LM317 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 any output voltage from 1.2V (SPLV) to 30V (SPM, SP and SPJ), 100V (SPHP), 400V (SPHV) 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/SPHV). 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.

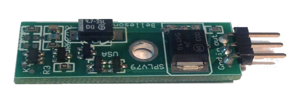
With a footprint to match industry standard TO-220 monolithic regulators, Superpower can be easily retrofit into existing systems or designed into new systems for maximum performance. The design can also be licensed and built into your own products.

Contact Belleson for more information.

SPM

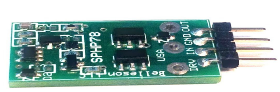
SP

SPLV

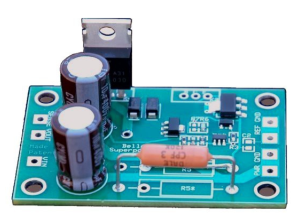


SPJ

SPHP



SPHV

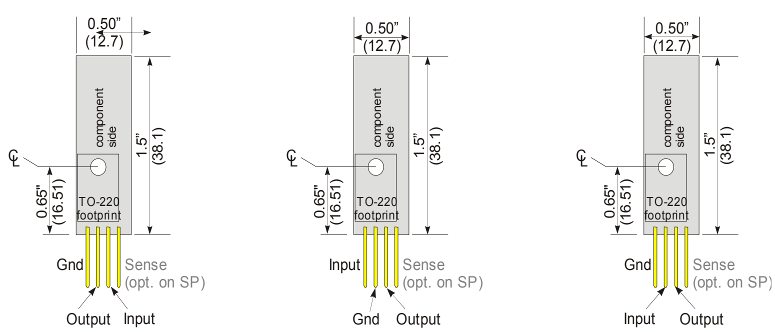


Absolute Maximum Ratings

Parameter	Conditions	Value	Units
Input voltage maximum	**SPLV** **SP, SPJ, SPM** **SPL** **SPHP** **SPHV**	12 35 70 105 450	V
Maximum continuous current	**SPLV** **SPM** **SP** **SPJ** **SPL** **SPHP** **SPHV**	2 0.225 0.7 8.0 2.0 12.0 2.0	A
Total power dissipation	**SPM** at TA = 25°C Derate above 25°C	0.330 1.8	W mW/°C
Total power dissipation	**SP** at TA = 25°C (requires heat sink) Derate above 25°C	2.5 25	W mW/°C
Total power dissipation	**SPJ, SPL** at TA = 25°C (requires heat sink) Derate above 25°C	60 480	W mW/°C
Thermal Resistance	**SP** $R_{\theta JA}$,Junction−to−Ambient	83	°C/W
Thermal Resistance	**SPJ, SPL** $R_{\theta JA}$,Junction−to−Ambient no heat sink	63	°C/W

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

Example Pin Connections



SP17, SPLV17   SP78, SPLV78   SP79, SPLV79

Typical Performance Characteristics

SPLV Low Voltage 2A Output

Parameter	Conditions	Value	Units
Input voltage maximum		12	V
Output voltage positive	Standard values (1*)	1.2, 1.5, 2.0, 2.5	V
Output voltage negative	Standard values (1*)	-1.2, -1.5, -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	Load Current 0.5A 1A 2A	 2.1 2.4 2.7	V

SPM Standard Voltage Low Current 225mA

Parameter	Conditions	Value	Units
Input voltage maximum		35	V
Output voltage positive	Standard values (1*)	3.3, 5, 6.25, 9, 10, 12, 15, 18, 24, 30	V
Output voltage negative	Standard values (1*)	-5, -6.25, -9, -10, -12, -15, -18, -24, -30	V
Output Noise	RMS 20Hz – 20KHz (5*)	<1	PPM of Vout
Line Rejection	60Hz, 1Vpp	110	dB
Continuous current	within power dissipation limit	225	mA
Maximum power dissipation (2*)		330	mW
Drop–out voltage	Load Current 50mA 225mA	 1.0 1.0	V

SP Standard Voltage Medium Current 500mA

Parameter	Conditions	Value	Units
Input voltage maximum		35	V
Output voltage positive	Standard values (1*)	3.3, 5, 6.25, 9, 10, 12, 15, 18, 24, 30	V
Output voltage negative	Standard values (1*)	-5, -6.25, -9, -10, -12, -15, -18, -24, -30	V
Output Noise	RMS 20Hz – 20KHz (5*)	<1	PPM of Vout
Line Rejection	60Hz, 1Vpp	110	dB
Continuous current	within power dissipation limit	0.5	A
Maximum power dissipation (2*)	no heat sink sufficient heat sink	1 2	W
Drop–out voltage	Load Current 50mA 250mA 500mA	 0.5 1 2	V

SPJ Standard Voltage High Current 2A

Parameter	Conditions	Value	Units
Input voltage maximum		35	V
Output voltage positive	Standard values (1*)	3.3, 5, 6.25, 9, 10, 12, 15, 18, 24, 30	V
Output voltage negative	Standard values (1*)	-5, -6.25, -9, -10, -12, -15, -18, -24, -30	V
Output Noise	RMS 20Hz – 20KHz (5*)	<1	PPM of Vout
Line Rejection	60Hz, 1Vpp	110	dB
Continuous current	within power dissipation limit	2	A
Maximum power dissipation (2*)	no heat sink sufficient heat sink	2 60	W
Drop–out voltage	Load Current 0.5A 1A 2A	 0.6 0.8 1	V

SPHP 10A High Power ***NOTE: SPECIFICATIONS ARE PRELIMINARY***

Parameter	Conditions	Value	Units
Input voltage maximum		150	V
Output voltage positive		5 to 100	V
Output voltage negative		-5 to -100	V
Output Noise	RMS 20Hz – 20KHz (5*)	<5	PPM of Vout
Line Rejection	60Hz, 1Vpp	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 (max)	20Hz – 20KHz	10	mΩ

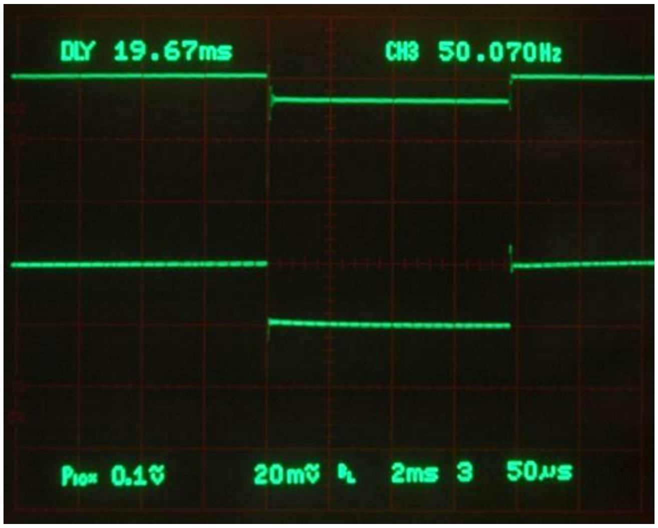
SPHV High Voltage

Parameter	Conditions	Value	Units
Input voltage maximum		450	V
Output voltage maximum	Built to order	400	V
Output Noise (typ)	RMS 20Hz – 20KHz	<10	PPM of Vout
Line Rejection (typ)	60Hz	110	dB
Maximum continuous current	typical, within power dissipation limit	1	A
Maximum current	<10mV output shift typical (depends on circuit connection)	400	mA
Maximum power dissipation (2*)	no heat sink sufficient heat sink	2 50	W
Drop–out voltage	load current 50mA 500mA 1A	0.5 1 2	V
Output Impedance	20Hz – 20KHz	10	mΩ

Notes

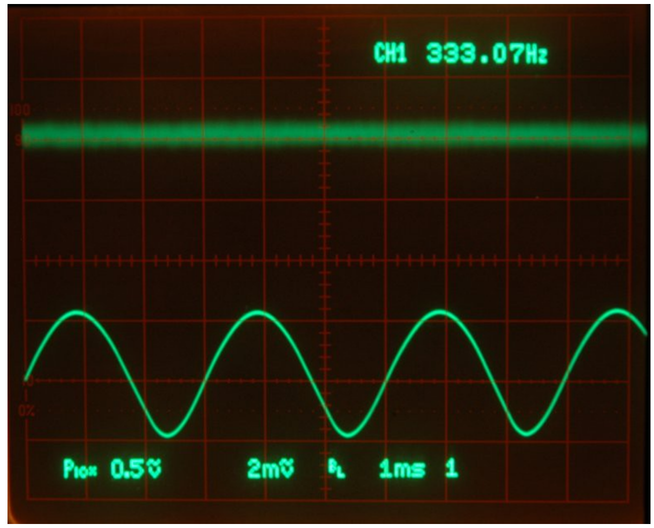
(*1) Other values available, contact us.
(*2) Maximum at 25°C ambient air temperature
(*3) SPL has no thermal protection, which yields an instantaneous power dissipation limit of 36W-sec.
(*4) At 2A, SPL begins to limit Vout so drop-out voltage is not applicable.
(*5) The 3.3V output Superpower have ≈4µV noise.

Transient Step Response



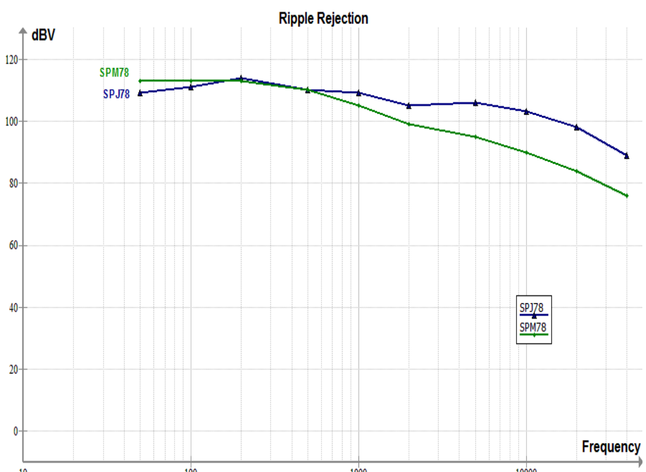
Transient peaks for 1A load change over 50mA static load
Top: ΔVout, 20mV/div, Vout=12Vdc
Bottom: Output current through ½Ω, 1A/div
Time axis = 50μsec/div

Ripple Rejection Oscillogram



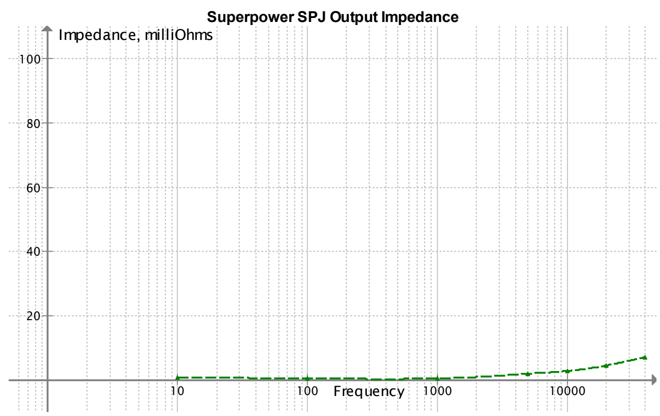
Line Regulation, 333Hz
Top: Vout, 2mV/div
Bottom: Vin, 12VDC ±0.5VppAC

Ripple Rejection vs. Frequency



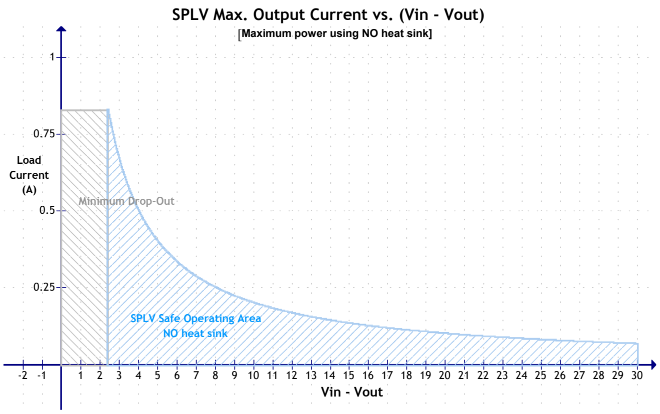
Ripple rejection, SPJ78 and SPM78
Vout=12V, Vin=15Vdc+1Vac

Output Impedance

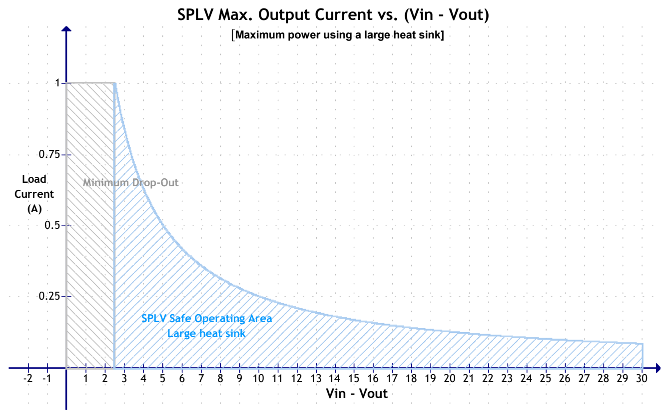


Vin=11.5V, Vout=5V
Voltage across 50Ω load = (5VDC - 5Vpp)

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

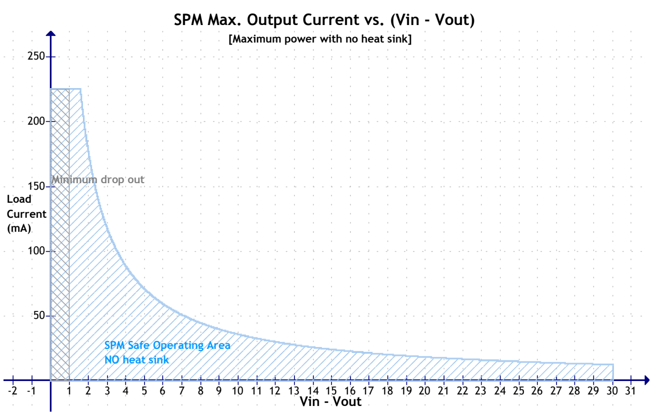


Max power dissipation with no heat sink



Max power dissipation with large heat sink

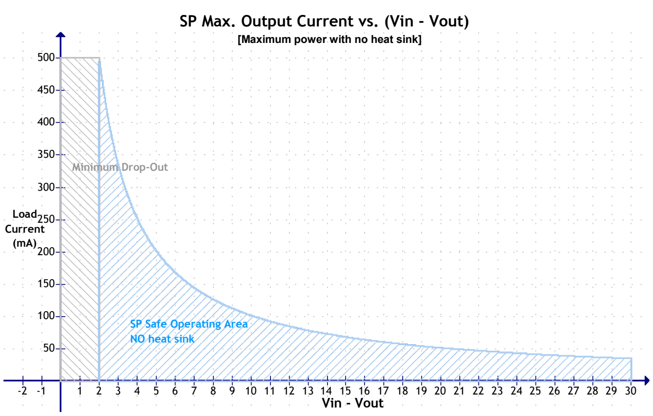
SPM Max. Load Current vs. (Vin-Vout)



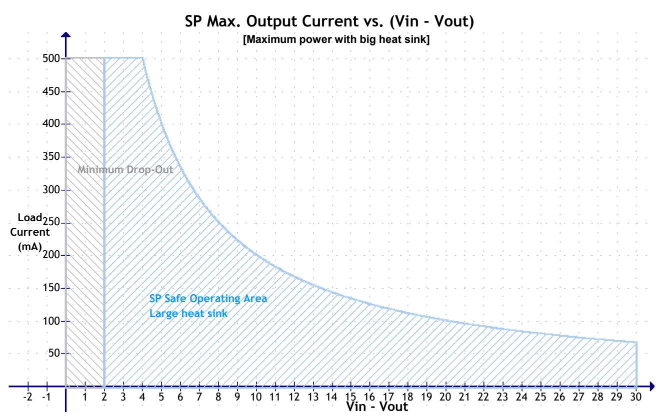
Max power dissipation with no heat sink

No way to heat sink SPM

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

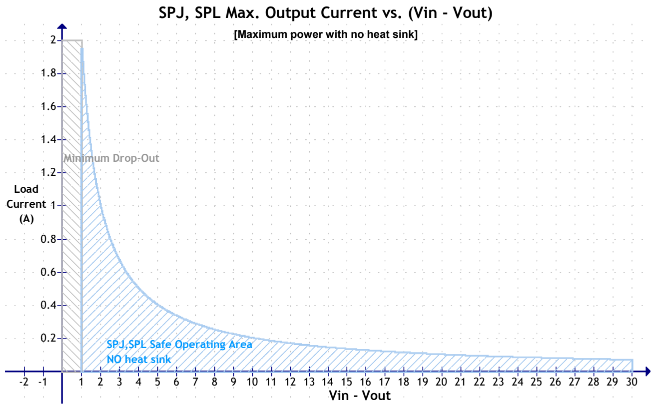


Max power dissipation with no heat sink

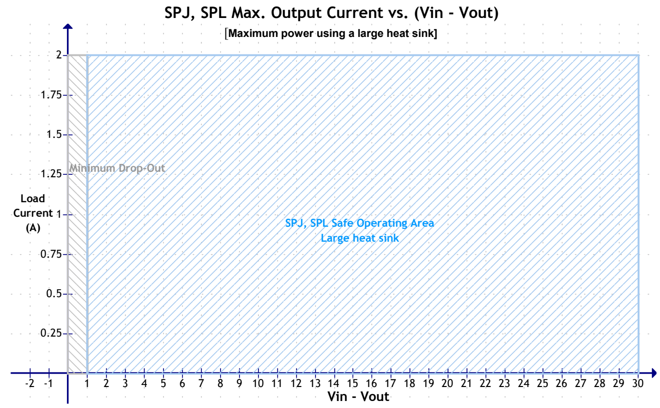


Max power dissipation with large heat sink

SPJ, SPL Max. Load Current vs. (Vin-Vout)

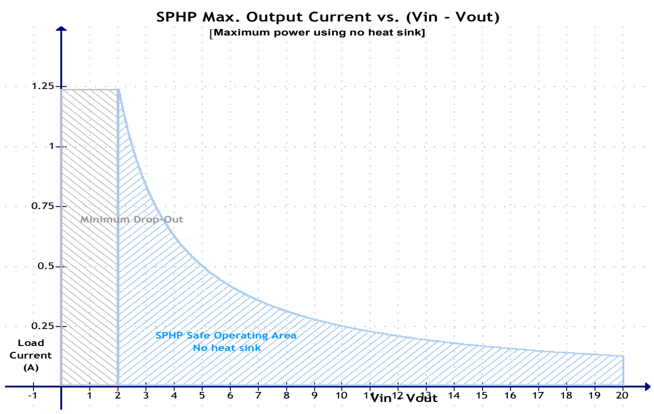


Max power dissipation with no heat sink

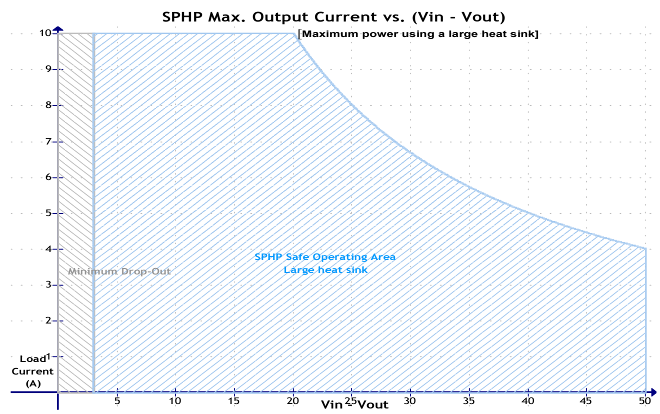


Max power dissipation with large heat sink

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

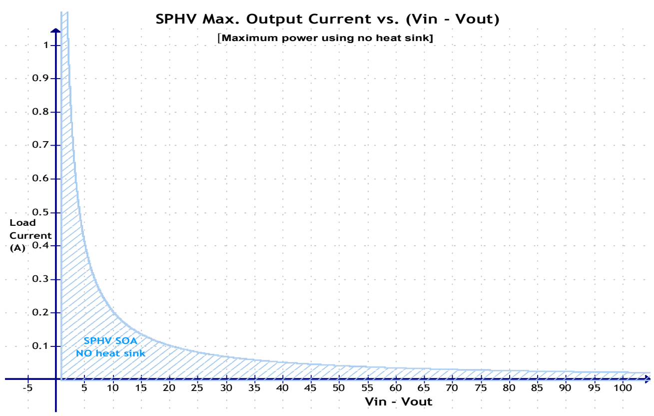


Max power dissipation with no heat sink

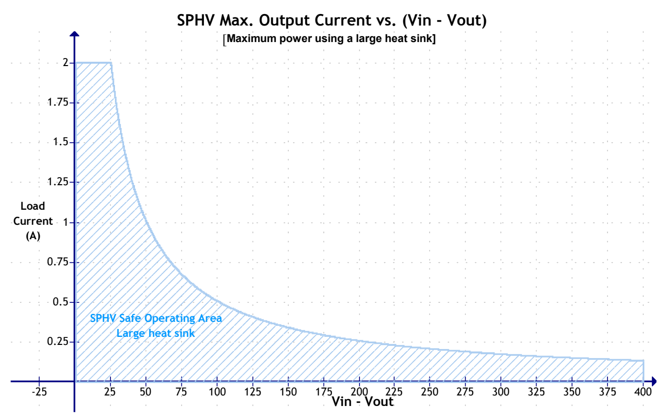


Max power dissipation with large heat sink

SPHV 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, SP and SPJ circuits have no output current limit. Any short circuit of the output to common may destroy the output device and render the circuit useless.

SPL regulators are designed with a special output current limit that does not affect output impedance but does increase drop–out voltage. See the above SPL specifications. SPL is more durable than SPJ but *can be damaged or destroyed with a long duration short to ground*. Caution during installation is required.

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+µF) located near the input pins of Superpower provides reserve storage so Superpower can deliver that current. An input capacitor also decreases output noise.

SPJ and SP have a 4.7µF output capacitor on board, but adding an external capacitor near the load may improve dynamic response.

If multi-MHz oscillation is observed, a 0.1µF or higher ceramic or film capacitor soldered directly across the IN to GND pins is likely to cure it.

Sense Connection

The sense connection is the 4th (rightmost) pin on the board. It allows the voltage at the *load* to be sensed rather than the voltage at the Superpower output pin. With no sense connection, when load current changes dramatically (e.g. in a circuit with large dynamic range) the voltage drop between the regulator and the load can change as the load current changes—the regulator output will remain constant while the load voltage changes due to IR losses. Use of the sense connection keeps the load voltage more constant.

The sense pin is internally connected via a 1Ω resistor. To use the sense connection, make a connection from the sense pin/pad directly to the load. The connection resistance to the load is in parallel with the internal 1Ω, so keep the sense connection below 0.1Ω, the lower the better. If the sense connection is longer than 10-15 centimeters, check stability as inductance may influence circuit behavior.

Sense connection is most useful for a single load; for a distributed load, find either a central point or a point where the most load current flows.

SPLV does not have a sense connection.

SPHV Vout Sense and Ground Ref

This applies only to SPHV high voltage regulator.

Vout sense and Ref Ground connections are labeled on the board. They allow the voltage at the *load* to be sensed rather than the voltage at the Superpower output pin. With no sense connection, when load current changes dramatically (e. g. in a circuit with large dynamic range) the voltage drop between the regulator and the load will change as the load current changes — the regulator output will remain constant while the load voltage changes due to IR losses. Use of the sense connection keeps the load voltage more constant.

The Vout and Vout sense terminals must be connected together at either the PCB or at the load. For typical low current applications (<50mA), a jumper on the PCB is fine. If the sense connection is longer than 10-15 centimeters, check stability as inductance may influence circuit behavior.

Ref Gnd and Pwr Gnd terminals must be connected together at either the PCB or at the star ground point of the system. For low current applications (<50mA), connection at the PCB is fine. Connecting them individually to system star ground prevents load current from affecting the Superpower's reference voltage.

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

$$\frac{V_{in} - V_{out}}{I_{load} + 10\text{mA}}$$

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. See our transformer calculator web page at http://www.belleson.com/xfcalc.php.

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 power dissipation vs. ambient temperature curves for more information.

If you have any concerns about power dissipation we recommend you use SPJ or SPL 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

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

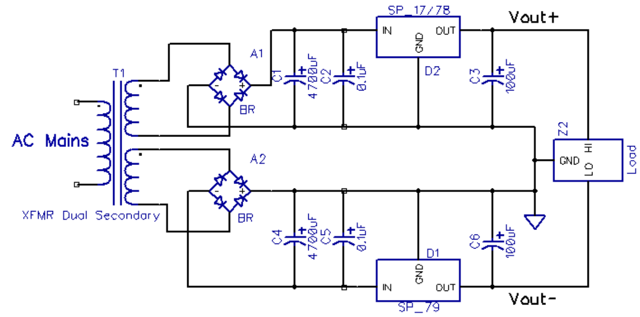


Figure 1: Typical regulated power supply with recommended Cout (C3 and C6)

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

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

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 peak of at least 5.7V to deliver 5V out.

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

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

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. But keep in mind that lost power is due to a constant DC value plus the RMS value of ripple magnitude.

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 160W of power anywhere between100V at 1.6A or 16V at 10A. Vout is available from 5V to 100V.

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

Also notice the "OUT" pin of the SPHP—with the output transistor mounted off–board, this is not really OUT any more, but instead 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.

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 Regulators

SP78, SP79, SPJ78 and SPJ79 regulators are direct 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 100µF capacitor directly at the Superpower input to ground and another at the load.

IMPORTANT! SPJ and SPL Power Transistor Tab

The power transistor heat sink tab on SPJ/SPL is electrically connected to regulator Vin, unlike the LM78x/LM79x regulators. When using a heat sink, *this tab must be insulated from the heat sink or chassis* by using a thermal pad and shoulder washer.

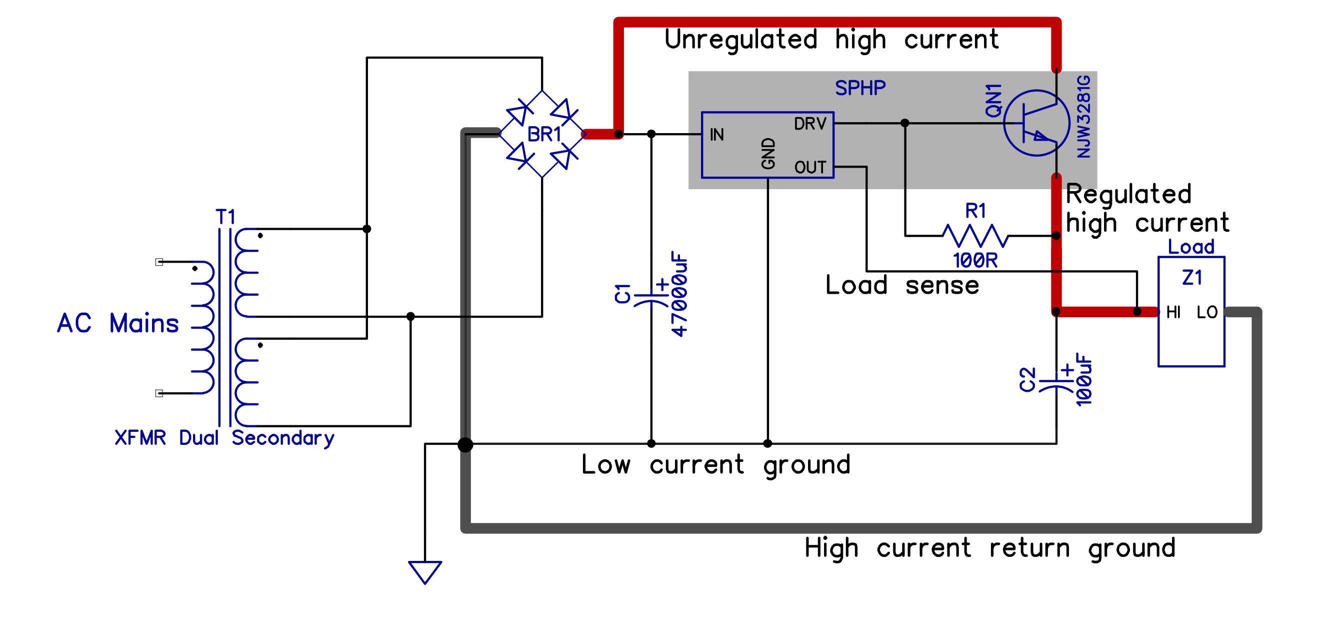


Figure 2: SPHP connections for optimum performance.

LM317 and LM337 Regulators

Refer to figures 3 and 4 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 10 for capacitor C1 value. C2 should be a high quality 100uF capacitor such as Nichicon UVR1H101MPD.

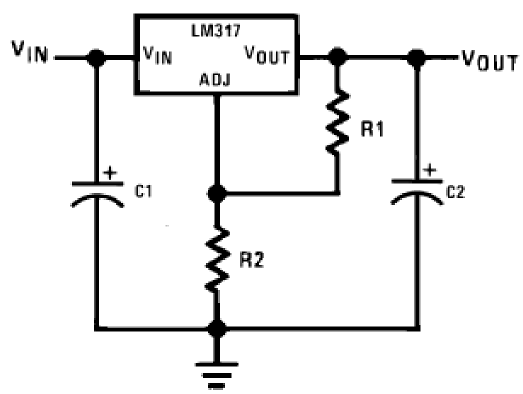


Figure 3: Standard LM317 connections. Remove R1, replace R2 with wire.

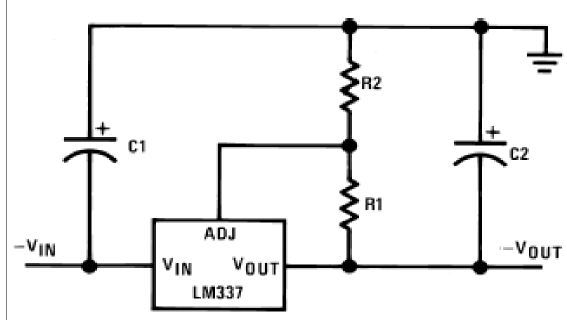
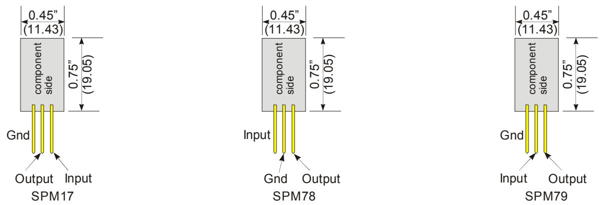
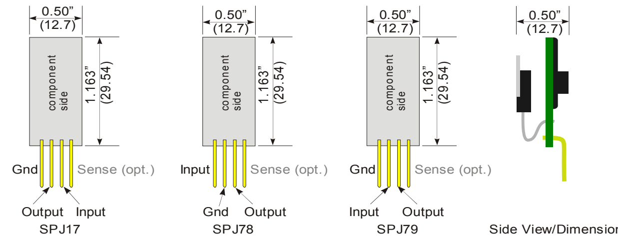


Figure 4: Standard LM337 connections. Remove R1, replace R2 with wire.

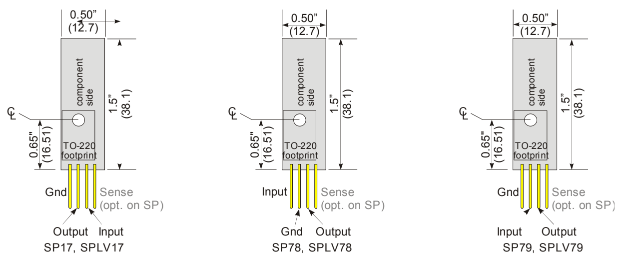
MECHANICAL SPECIFICATIONS



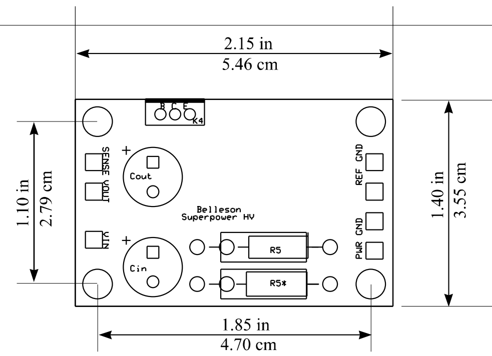
SPM pin out and dimensions
inches" and (mm)



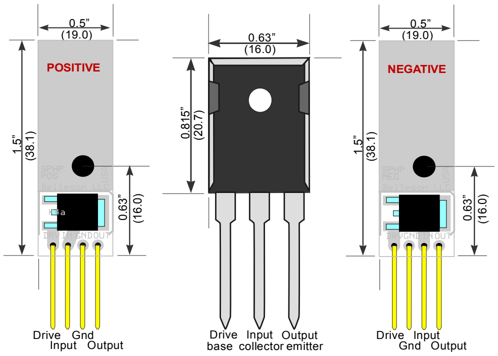
SPJ pin out and dimensions
inches" and (mm)



SP and SPLV pin out and dimensions
inches" and (mm)



SPHV height is 1.0 in / 2.54 cm, mounting holes are
0.15 in / 0.38 cm diameter.



SPHP with separate power transistor
inches" and (mm).

External dimensions may vary by ±2%, mounting hole dimensions by ±0.5%.

Legal Information

By using Belleson Superpower regulators, you agree that SPLV, SPM, SP, SPJ and SPHV devices have no output protection and a short circuit of the output to ground can damage or destroy the regulator. SPL devices have a current limit but not a power limit and can be damaged or destroyed by a short circuit to ground when the specified maximum time duration of a short circuit is exceeded. 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.

Belleson products are not authorized for use as critical components in life support devices or systems.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.

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.

You read this far? Great! Call us with any questions— 864-444-9981.

Illustration 1: You know what to do.