SQ Series
High Efficiency High Voltage Power Supply

General Description

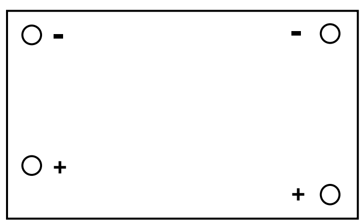
The SQ Series high voltage power supplies are very high efficiency power supplies. They are well suited for battery operated systems and provide isolated outputs of up 3kV. The output voltage of the SQ power supply is directly proportional to the input voltage and the output ripple is typically less than 1% at full power. The two output leads are floating and fully isolated from the input power leads by over 1T Ohm (@ 25 deg C) with less than 50 pF of coupling capacitance. This permits either positive or negative polarity operation. All SQ's are reverse polarity and short circuit protected.

Features

- Output proportional to Input
- Encapsulated
- 500 VDC to 3,000 VDC available
- 1.5 Watt power
- Efficiency to 80%

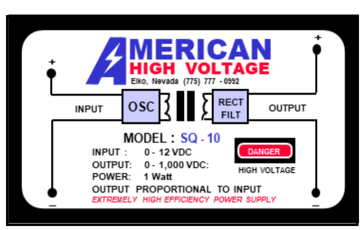
Connection Diagram

INPUT



OUTPUT

Bottom View



Top View

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Electrical Characteristics

(at 25 degrees C unless otherwise specified)

Parameter	Conditions		Value			Units
			Min	Typical	Max	
Supply Voltage*:	(all models)		1 VDC	12VDC	18 VDC	VDC
Input Current:	No Load:		20	30	40	mA
	Full Load (1.5W):		130	140	150	mA
Output Ripple:	No Load (all models): Full Load (all models):		0.7% 0.8%	0.7% 0.8%	1% 1%	Vpp Vpp
Load Regulation:	No Load to Full Load Half Load to Full Load		25% 20%	25% 20%	30% 30%	V_{NL}/V_L VNL/VL
Output Linearity	No Load			1%		ΔVOUT ----------- ΔVOUT (ideal)
Output Linearity	Full Load (all models):			1%		ΔVOUT ------------ ΔVOUT (Ideal)
Short Circuit Current:				100	200	mA
Power Efficiency:	Full Load		75%	80%	85%	POUT -------- PIN
Reverse Input Polarity	Protected to 20 VDC					
Temperature Drift:	No Load Full Load				1,000 1,000	ppm/DegC ppm/Deg C
Thermal Rise:	No Load (case) Full Load (case)				5 15	degrees C degrees C
Slew Rate (10% - 90%)	No Load Full Load				100 120	mS mS
Slew Rate (90% - 10%)	No Load Full Load				200 100	mS mS
Drain Out Time	No Load (5 τ)				150	mS

* Other input voltages available: 5VDC, 15VDC, 24VDC, 28VDC and 48VDC

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SQ Series

Physical Characteristics
(at 25 degrees C unless otherwise specified)

Parameter	Conditions	Value	Units
Dimensions	MKS English	38.1 W x 63.5 L x 19 H 1.5 W x 2.5 L x 0.75 H	mm inches
Volume:	MKS English	46 2.8	cm^3 $inch^3$
Mass:	MKS English	120 4.3	grams oz
Packaging:	Solid Epoxy Thermosetting		
Finish	Smooth Dial-Phthalate Case		
Terminations:	Gold Plated Brass pins (4)		

Environmental Characteristics
(at 25 degrees C unless otherwise specified)

Parameter	Conditions	Value	Units
Temperature Range	case temperature case temperature	-40 degrees to + 71 degrees -40 degrees to + 160 degrees	Celsius Fahrenheit
Shock:	MIL-STD-810 Method 516	40 g's	Proc IV
Altitude:	pins sealed against corona pins sealed against corona	-350 to + 16,700 -1,000 to +55,000	meters feet
Vibrations:	MIL-STD-810 Method 514	20 g's	Curve E
Thermal Shock	MIL-STD-810 Method 504	-40 deg C to + 71 deg C	Class 2

Models Available (as of July 2019):

(Vin = 0 – 12 VDC)

Model	Output Voltage Range	Power	Ripple (max)
SQ-1	0 – 100 VDC	1 Watt	1 Vpp
SQ-2	0 – 200 VDC	1 Watt	2 Vpp
SQ-3	0 – 300 VDC	1 Watt	3 Vpp
SQ-5	0 – 500 VDC	1 Watt	5 Vpp
SQ-10	0 – 1,000 VDC	1 Watt	10 Vpp
SQ-15	0 – 1,500 VDC	1 Watt	15 Vpp
SQ-30	0 – 3,000 VDC	1 Watt	30 Vpp

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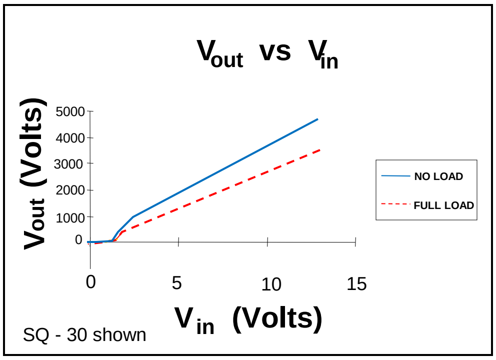
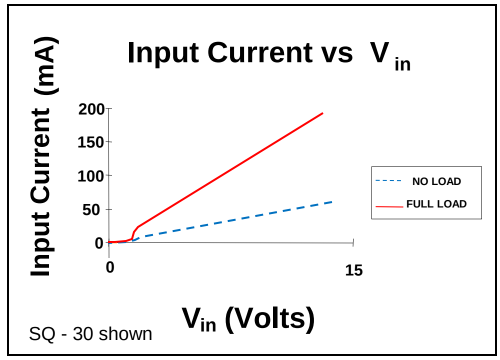
SQ Series Performance Charts





SQ Series Application Notes

The SQ Series high voltage power supplies are driven by an input voltage of from 1 to 12 VDC. The input current and output voltage as a function of input is shown in the above graphs. There are NO internal connections between the input and output pins. As can be seen from the above, the output voltage is approximately linear with respect to input except near the lower input voltage region. Here, the output drops off rapidly as the input voltage approaches zero with the absolute minimum input voltage needed for reliable starting being 0.9 VDC. As shown in Figure 1 below, the simple connection of a SQ unit to a DC source of voltage will provide a high voltage stepped-up output. The input AC bypass capacitor C1 is optional and is utilized to prevent switching spikes from riding back on the input power lines. Values of 0.1 uF to 10 uF are commonly used.

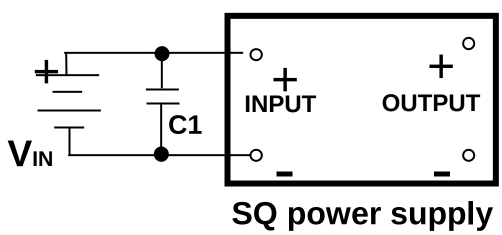


Figure 1: Basic SC hookup schematic **(top view of SQ shown)**

The output voltage of the SQ unit may be regulated by incorporating a simple op-amp circuit and linear control device such as an NPN transistor. Here, the output voltage is sensed and compared against an external reference control voltage. For single supply operation, the circuit of Figure 2 may be used for positive output regulation. A high voltage divider is made up of R5 and R6 to divide down the output to a value comparable with the control voltage. The resistor R5 is value is determined by power considerations. A good rule of thumb is to be 10% of the full output load. Too high a value may lead to output drift problems due to operational amplifier input bias current drift. The resistor R5 must be rated for the voltage that it is to step down. Simple high value carbon film resistors are usually avoided because their maximum voltage is limited to 300 VDC. Precision metal film resistors are more stable but also have limiting maximum voltages. It is possible to series several metal film resistors to build up the voltage rating of R5. Capacitor C4 likewise must be rated for the proper voltage. It serves to lower output ripple provide a feed-forward pole in the feedback loop for stability. Capacitor C5, the ground mirror capacitor serves as a lower end of the AC divider formed with C4 and prevents excessive voltage from being fed to the operational amplifier in the case of a shorted output. R6 is selected by calculating the resistance divider ration with R5, providing a 5 volt feedback at full output voltage. The input reference bypass capacitor C1 is used to remove any noise feeding to the non-inverting signal pin of the operational amplifier. For maximum temperature stability, R1 should be identical in value to R6.

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SQ Series Application Notes (continued)

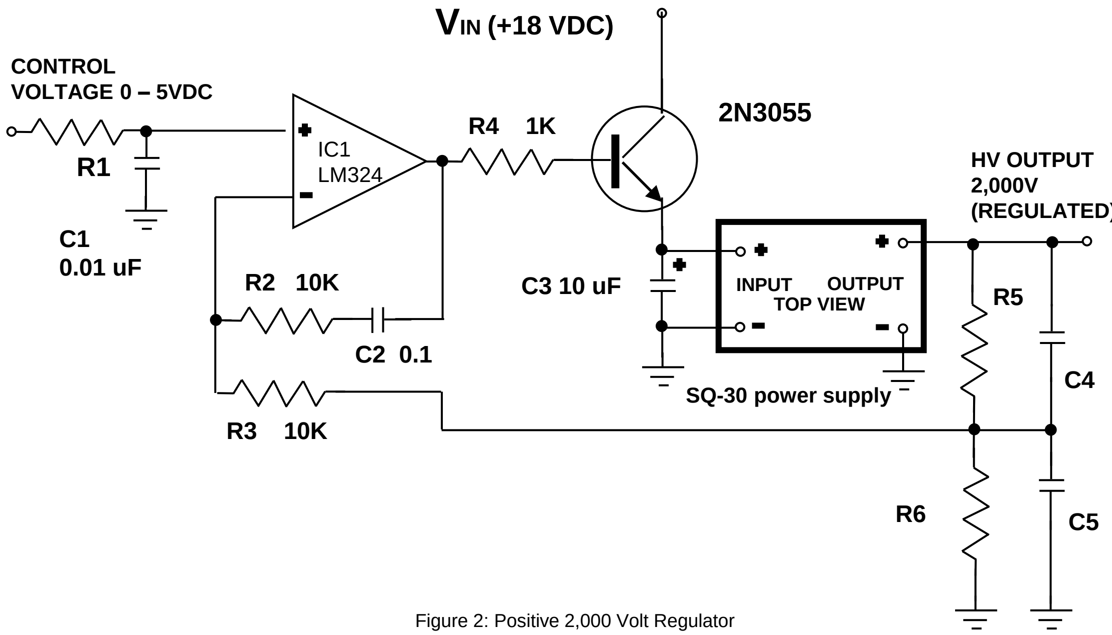

Figure 2: Positive 2,000 Volt Regulator

Resistor R2 and capacitor C2 provide frequency compensation for the amplifier IC1 a common bipolar amplifier is used since its outputs and signal inputs can reach almost to ground. R3 provides protection to the signal inverting input of the opamp in case of a short circuit or arcing condition exists on the HV output. R4 protects the output of the opamp in case of a shorted NPN transistor. Typical values for an 2,000 volt Microchannel Plate power supply are as follows:

TC:	TC-10
R1:	62.9K Ohm
R5:	400 Megohms (Slimox 102 – Ohmite)
R6:	1 Megohm 1%
C4:	2200 pF 3kV disc
C5:	0.1 uF 50 V ceramic
IC1:	LM324
Q1:	Power NPN such as D44H11 or equivalent

Typical voltages seen during operation are as follows:

Voltage at junction of R5 and R6:	5V
Voltage at opamp output:	11.3V
Voltage into + supply TC:	10V (depends somewhat on output load)
Voltage of base of Q1:	10.7 V

The power supply feeding the opamp is not shown however it may be connected to the +15V supply and ground. It is a good idea to bypass the input power pins of the opamp with a 0.1 uF capacitor to reduce the EMI that may damage the opamp if an output arcing condition is suddenly encountered. By varying the control voltage from 1 to 5V, the high voltage output of the SQ power supply may be regulated. Line and load regulation as good as 0.01% are achievable depending upon physical layout and quality of feedback resistor. To lower the output ripple further, an resistor (carbon composition type) of a high value may be inserted in series with the HV output of the SQ unit before it continues on in the circuit. A value of 100K Ohm will drop the output ripple to less than 0.2 Vpp . Here the 100 K Ohm resistor works as a filter in conjunction with C4. Higher ripple reduction is achievable with a capacitor added directly to the output pin a d ground.

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SQ Series Application Notes (continued)

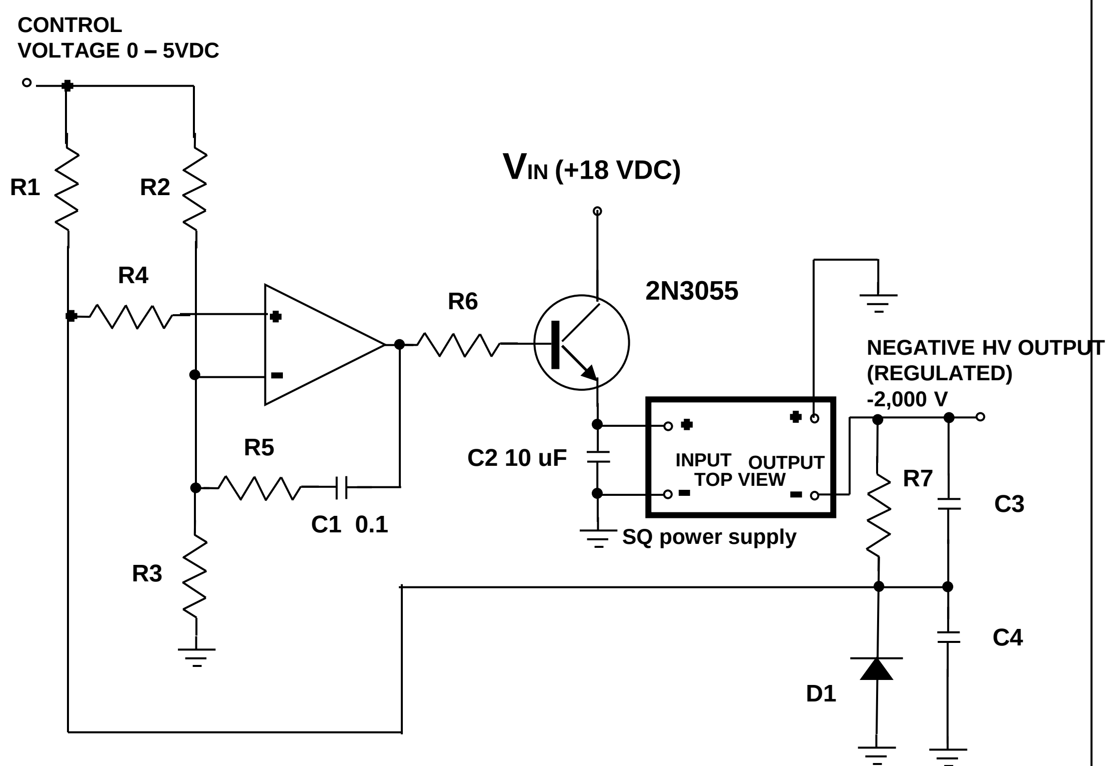

Figure 3: Negative 2,000 Volt Regulator

A regulated negative High Voltage output is easily obtained using the floating output feature of the SQ unit. Figure 3 utilizes much of the same topology as the positive regulator except that a summing junction is made for operational amplifier IC1. Again, the values of R7 and C3 are selected with respect to the proper HV output parameters. Dissipation in R7 should be limited to less than 1% full load. C3 must be a high voltage capacitor, capable of working at the full output voltage. Diode D1 provides a return path in cast the output is suddenly shorted, protecting IC1 from huge positive spikes on the signal input. Resistors R2 and R3 form a simple divider, their values should be equal. The voltage drop in R1 should be such that at full output voltage the signal at the non-inverting input of IC1 should be exactly half the control voltage. R4 is a simple 10K Ohm limiter. The values of R2 and R3 should be twice that of R1 for good thermal stability. Typical values for a negative 2,000 volts ionization counter are as follows:

TC:	TC-10
R1:	499K Ohm 1%
R7:	400 Megohms (Slimox 102 – Ohmite)
R2:	1 Megohm Ohm 1%
R3:	1 Megohm Ohm 1%
R5:	10K
C3:	2200 pF 3kV disc
C4:	0.1 uF 50 V ceramic
IC1:	LM324
Q1:	Power NPN such as 2N3055 or D44H11 or equivalent
D1:	1N4148

Typical voltages seen during operation are as follows: Voltage at junction of R7 and D1: 2.5V

AHV
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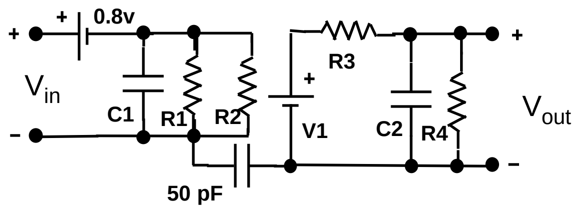
Equivalent SQ Circuit Model

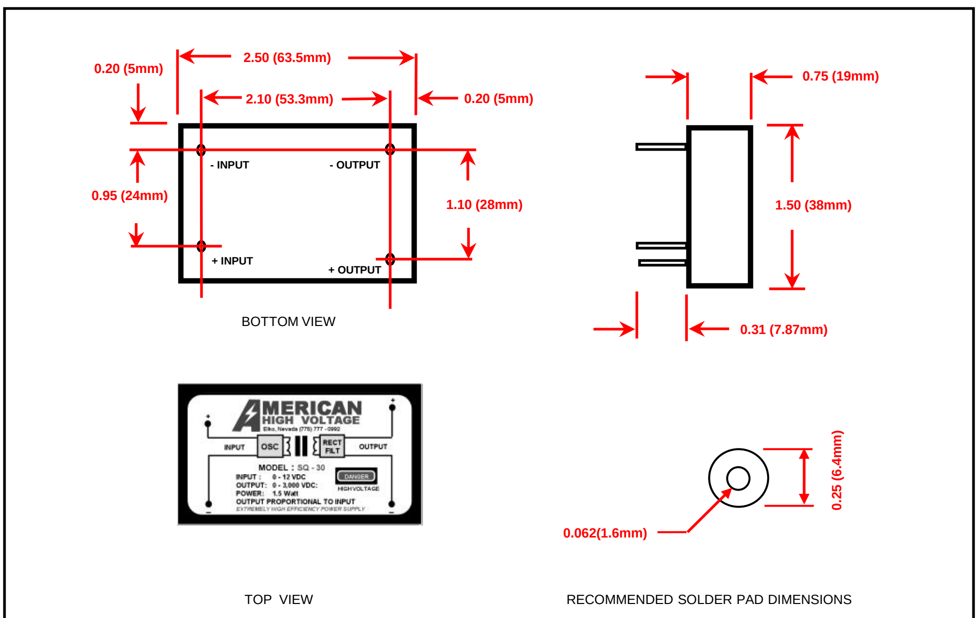


Equivalent SC HVPS Circuit Model

R1 = 400 *Ohms*
R2 = (150 / Pout) *Ohms*
R3 = (0.1 x $Vout_{max}$ / $Iout_{max}$) *Ohms*
R4 = (55 x $Vout_{max}^{2}$) *Ohms*
C1 = (10 x 10^{-6}) *Farads*
C2 = (0.005 x $Iout_{max}$ / $Vout_{max}$) *Farads*
V1 = (V_{R2} x $Vout_{max}$ / 12) *Volts*

For example, for an SQ - 30 5W:
Vout**max** = 3,000 V
Pout**max** = 1.5 W
Iout**max** = 0.0005 A
R1 = 400 Ohms
R2 = 100 Ohms
R3 = 600K Ohms
R4 = 500 Megohm
C1 = 10 uF
C2 = 1,000 pF

Outline Drawing: (inches (millimeters))



Ordering Information:

SQ – XX

XX = 5: SQ-5 500v max
XX = 15: SQ-15 1,500v max
XX = 30: SQ-30 3,000v max