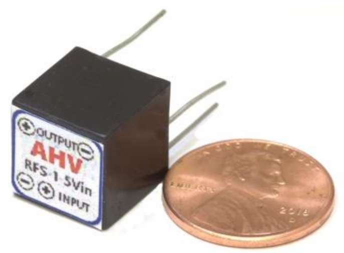
RFS Series
Micro High Voltage Power Supply

General Description

The RFS Series high voltage power supplies are a line of very small DC to DC converters. They provide isolated outputs of up to 2kVDC and 0.5 Watts in power. The output voltage of the RFS power supply is directly proportional to the input DC voltage. The two output leads are floating and fully isolated from the input power leads by over 1T Ohm (@ 25 deg C) with less than 15 pF of coupling capacitance. This permits the RFS unit to be floated upon a DC potential with isolation up to 5kVDC. All RFS units are short circuit protected. Output ripple voltage is kept below 0.5% at full load. Load regulation is approximately 30% NL – FL.

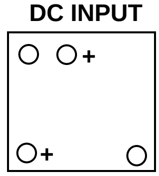
Features

- Output proportional to Input
- Encapsulated
- 100 VDC to 2,000 VDC available
- 0.5 Watts
- Input voltage 0 – 5V



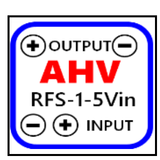
Connection Diagram

DC INPUT



DC OUTPUT

Bottom View



Top View

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Electrical Characteristics

(at 25 degrees C unless otherwise specified)

Parameter	Conditions		Value Min	Value Typical	Value Max	Units
Supply Voltage*:	5 Vin model:		0.7	5	8	VDC
Input Current:	No Load (5Vin model): Full Load (5Vin model):		50 190	55 160	60 165	mA mA
Load Regulation:	No Load to Full Load Half Load to Full Load		25% 10%	30% 15%	35% 20%	VNL/VL VNL/VL
Output Linearity	No Load			1%		ΔVOUT / ΔVOUT (ideal)
Output Linearity	Full Load (all models):			1%		ΔVOUT / ΔVOUT (Ideal)
Short Circuit Current:				100	300	mA
Power Efficiency:	Full Load		60%	65	70%	POUT / PIN
Temperature Drift:	No Load Full Load				1,000 1,000	ppm/ º C ppm/ º C
Thermal Rise:	No Load (case) Full Load (case)				5 10	º C º C
Slew Rate (10% - 90%)	No Load Full Load				10 12	mS mS
Slew Rate (90% - 10%)	No Load Full Load				50 20	mS mS
Drain Out Time	No Load (5 TC)				50	mS

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

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Physical Characteristics

(at 25 degrees C unless otherwise specified)

Parameter	Conditions	Value	Units
Dimensions	MKS English	12.7 W x 12.7 L x 12.7 H 0.5 W x 0.5 L x 0.5 H	mm inches
Volume:	MKS English	2.04 0.125	cm^3 $inch^3$
Mass:	MKS English	12 0.42	grams oz
Packaging:	Solid Epoxy Thermosetting		
Finish	Smooth Dial-Phthalate Case		
Terminations:	#24 Tin coated buss-wire	diameter: 0.020 diameter: 0.51	inches mm

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 May 21, 2019):

(Vin = 0 – 5 VDC)

Model	Output Voltage Range	Power	Ripple
RFS-1-5Vin	0 – 100 VDC	0.5 Watts	0.2 Vpp
RFS-2-5Vin	0 – 200 VDC	0.5 Watts	0.4 Vpp
RFS-5-5Vin	0 – 500 VDC	0.5 Watts	1.0 Vpp
RFS-10-5Vin	0-1,000 VDC	0.5 Watts	10 Vpp

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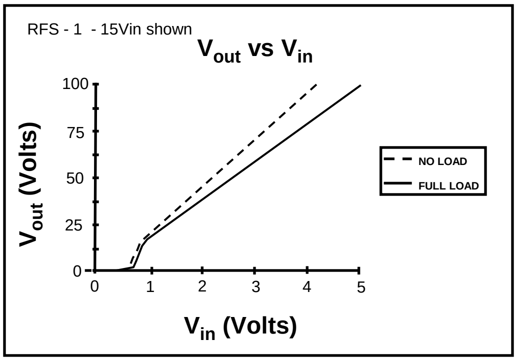
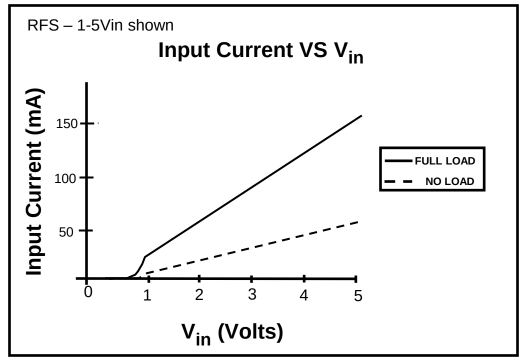
RFS Series Performance Charts (5Vin model)

(at 25 degrees C unless otherwise specified)



Output VS Input Voltage



Input Current VS Input Voltage

RFS Series Application Notes

The RFS Series high voltage power supplies come in two varieties. The input voltage is 0 – 5VDC. The input current and output voltage as a function of input voltage is shown in the above graphs. There are NO internal connections between the input and output pins. As can be seen from the above chart, the output voltage is approximately linear with respect to input voltage except near the lower input voltage region. Typically the absolute minimum input voltage needed for reliable starting is approximately 0.7 VDC. As shown in Figure 1 below, the simple connection of an RFS 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.

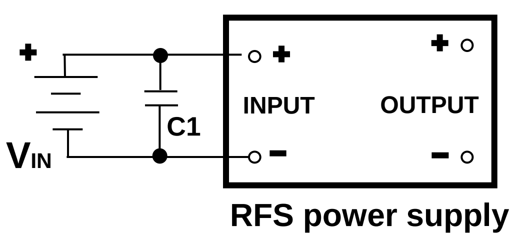


Figure 1: Basic RFS hookup schematic

The output voltage of the RFS 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's value is determined by power considerations. Practical values limit its dissipation to 0.05 Watts. This allows a 10% preload on the RFS converter since the maximum power output of the RFS is limited to 0.5 Watts by internal circuitry. Incorporating too high a feedback resistance value may seem desirous from an energy standpoint but excessive values may cause loop instability and greater drift over temperature. 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 usually 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. In addition, capacitor C4 must also be rated for the proper voltage. It serves to lower output ripple and 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 ratio with R5, providing a 2.5 volt feedback at full output voltage. For maximum temperature stability, R1 should be identical in value to R6..

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RFS Series Application Notes (continued)

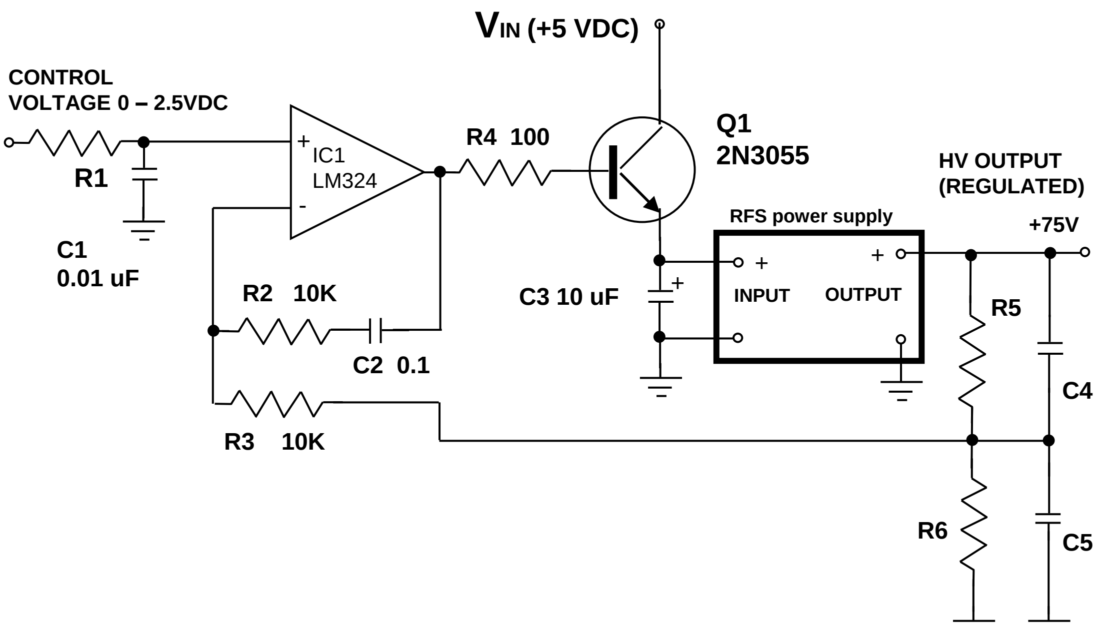

Figure 2: Positive 75 Volt Regulator

Resistor R2 and capacitor C2 provide frequency compensation for the amplifier IC1 an LM324 bipolar opampl 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 a positive 75 volt bias supply are as follows:

TC:	RFS – 1 – 5Vin
R1:	24.9K Ohm
R5:	1 Megohm (Slimox 102 – Ohmite)
R6:	24.9K Ohm
C4:	0.01 uF 1kV disc
C5:	0.1 uF 50 V ceramic
IC1:	LM324
Q1:	Power NPN such as 2N3055, D44H11 or equivalent

Typical voltages seen during operation are as follows:

Voltage at junction of R5 and R6:	2.5V
Voltage at opamp output:	1.5V
Voltage into + supply RFS:	4.2V (depends on output load)
Voltage of base of Q1:	4.8 V

The power supply feeding the opamp is not shown however it may be connected to the +5V 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 2.5V, the high voltage output of the RFS power supply may be regulated. Line and load regulation as good as 0.01% are both achievable depending upon physical layout and quality of feedback resistor. To lower the output ripple further, an capacitor may be inserted in the output line.

RFS Series Application Notes (continued)

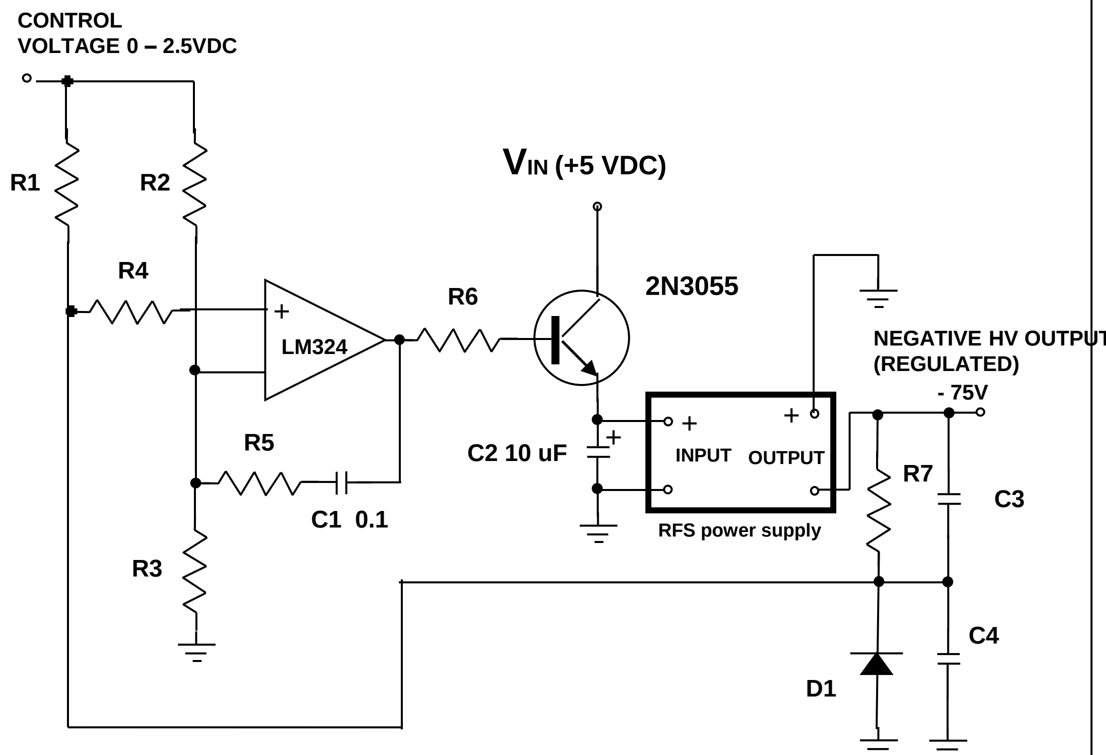

Figure 3: Negative 75 Volt Regulator

A regulated negative high voltage output is easily obtained using the floating output feature of the RFS unit. Figure 3 utilizes much of the same topology as the positive regulator except that a summing junction is made for the 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 0.1 Watts. 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 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 75 volt bias supply are as follows:

Power Supply:	RFS – 1 – 5Vin
R1:	16.7K Ohm
R7:	1 Megohms (Slimox 102 – Ohmite)
R2:	33,1K Ohm
R3:	33.1K Ohm
R5:	10K
C3:	0.01 uF 1kV disc
C4:	0.1 uF 50 V ceramic
IC1:	LM324
Q1:	Power NPN such as D44H11, 2N3055 or equivalent
D1:	1N4148

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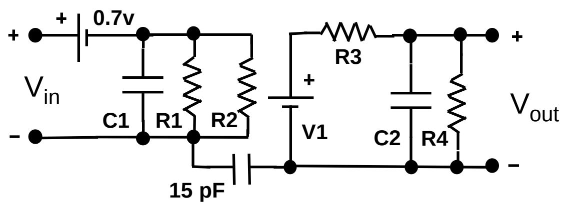
Equivalent RFS Circuit Model (5Vin model)



Equivalent RFS HVPS Circuit Model

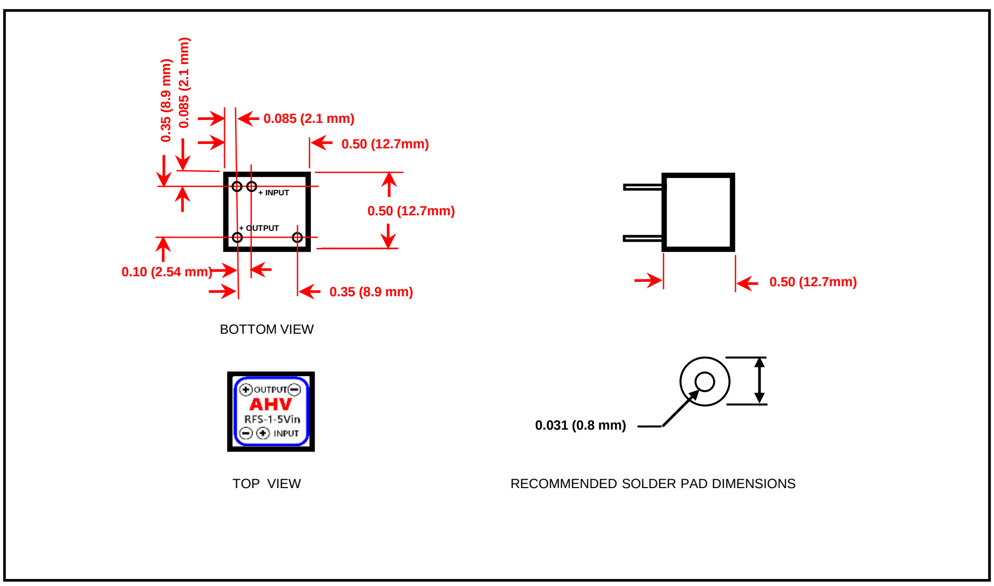
From this information:

R1 = (83) *Ohms*
R2 = (50 / Pout) *Ohms (load dependent)*
R3 = (0.3 x $Vout_{max}$ / $Iout_{max}$) *Ohms (depends on RFS model)*
R4 = (20 x $Vout_{max}^2$) *Ohms (depends on RFS model)*

C1 = (10 x 10^{-6}) *Farads*
C2 = (0.01 x $Iout_{max}$ / $Vout_{max}$) *Farads (depends on RFS model*
V1 = voltage dependent source (V_{R2} x $Vout_{max}$ / 5) *Volts (depends on RFS model*

For example, for an RFS - 1 Vout **max** = 100 V
Iout **max** = 0.005 A
R2 = 100 Ohms at full load
R3 = 6,000 Ohms
R4 = 200K OHms
C2 = 0.5 uF

Outline Drawing: (inches (millimeters))



Ordering Information:

RFS – XX - 5Vin **XX = maximum output voltage divided by 100**

Example:

RFS – 5 – 5Vin: Maximum output = 500 V @ Maximum input 5VDC