

Inductorless Switching Power Supply Demoboard

Introduction:

The Supertex SR10 is an inductorless switching power supply controller intended for operation directly from a rectified 120/240VAC line. Due to the capacitor-coupled, switched shunt topology (CCSS), it exhibits low standby power and good efficiency while employing no magnetics nor high voltage electrolytic capacitors.

To meet a wide variety of applications, the SR10DB1 is highly configurable. Many components are socketed. Half or full-wave rectification is jumper-selectable. Output voltage is jumper-selectable to 3 fixed voltages or may be set anywhere in the range of 6 - 28V using an on-board feedback divider.

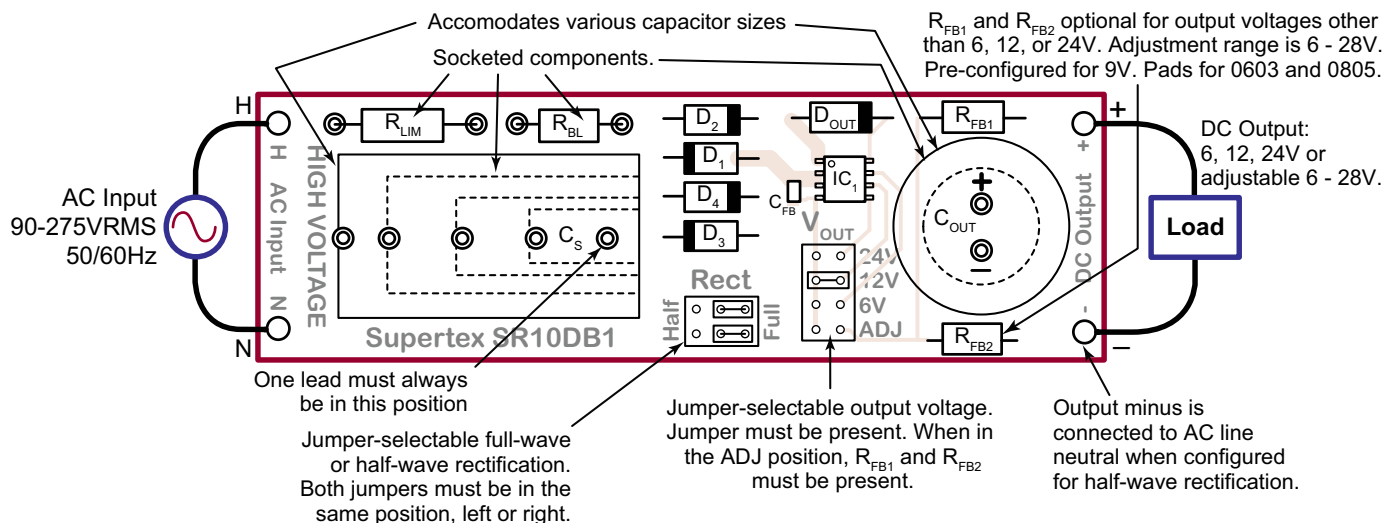
Specifications

Parameter	Value
AC Input	90VAC to 275VAC 50Hz to 60Hz
Output voltage	6V, 12V, 24V $\pm 10\%$ or 6-28V using divider
Output current ¹	up to 50mA
No-load input power ¹	as low as 20mW
Efficiency ¹	up to 75%
Actual board size	88mm x 28mm

Notes:

1. Dependent upon configuration and degree of transient protection.

Board Layout and Connection Diagram



AC Input (H and N)

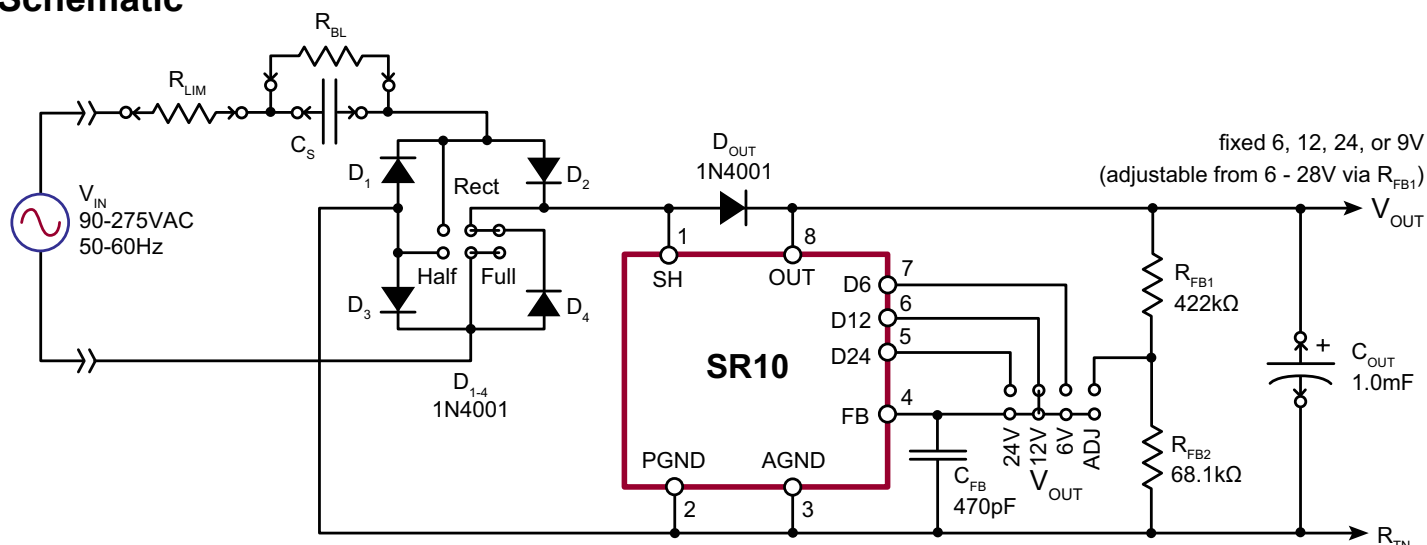
Connect to the AC line. The 'H' terminal should be connected to the AC line hot conductor. The 'N' terminal should be connected to the AC line neutral conductor. When configured for half-wave rectification, the N terminal is connected to the DC output minus (-) terminal.

DC Output (+ and -)

Connect the load to these terminals. Do not connect earth-grounded loads or test equipment without using an isolation transformer on the AC line.

Output voltage is jumper-selectable at 6, 12, or 24V, or it may be set in the range of 6 - 28V using the R_{FB} feedback divider and setting the jumper to ADJ.

Schematic



Bill of Materials

Designation	Description	Value	Rating	Mfg	PN
R _{LIM}	Resistor, fusible	22Ω	2W	any	—
R _{BL}	Resistor	4.7MΩ	1/4W	any	—
R _{FB1}	Resistor	422kΩ	1/4W	any	—
R _{FB2}	Resistor	68.1kΩ	1/4W	any	—
C _S	Capacitor, film	220nF to 2.2μF	275VAC,X2	any	—
C _{OUT}	Capacitor, alum	220μF min	35V	any	—
C _{FB}	Capacitor, ceramic NPO	470pF	6V	any	—
D ₁₋₄	Rectifier	—	1A, 50V	any	1N4001
D _{OUT}	Rectifier	—	1A, 50V	any	1N4001
IC ₁	CCSS regulator	—	—	Supertex	SR10

Socketed Components

The SR10DB1 is provided with all components pre-installed. Other components may be substituted for the on-board components to meet other requirements.

Refer to the above schematic and BOM, and the drawing and photo on page 1 to determine the proper locations for the components.

Output Voltage

Fixed output voltages of 6V, 12V, or 24V may be selected by setting the appropriate jumper on the V_{OUT} header.

For other output voltages, the on-board resistive feedback divider may be used to provide any voltage in the range of 6 - 28V. To maintain a minimum 15μA through the feedback divider, only R_{FB1} should be changed.

$$R_{FB1} = R_{FB2} \left(\frac{V_{OUT}}{V_{FB}} - 1 \right) = 68.1k\Omega \left(\frac{V_{OUT}}{1.25V} - 1 \right)$$

Output Current (C_S selection)

Output current is primarily dependent on input voltage, C_S value, and rectification (full or half). Given the minimum input voltage and choice of rectification, the minimum value of C_S

is given by the following equations. Don't forget to take tolerances into account. The SR10 is powered by V_{OUT} , so the available output current is reduced by the SR10's operating current (150 μ A nom, 200 μ A max). Current may also be reduced ~5% due to losses.

For standard capacitance values, see the table on page 4.

Full-wave:

$$C_S \geq \frac{I_{OUT}}{4f_{IN}(V_{IN}\sqrt{2} - V_{OUT} - 3V_D)}$$

Half-wave:

$$C_S \geq \frac{I_{OUT}}{f_{IN} (2V_{IN} \sqrt{2} - V_{OUT} - 2V_D)}$$

where: I_{OUT} is the maximum output current
 f_{IN} is the AC line frequency
 C_S is the series cap on the AC line
 V_{IN} is the RMS AC line voltage
 V_{OUT} is the DC output voltage
 V_D is the diode forward voltage ($\sim 700\text{mV}$)

Limiting Resistor (R_{lim})

The limiting resistor in series with the AC line is to protect against transients on the AC line. For safety reasons it is fusible and is the most upstream component on the AC line. Higher values provide greater protection but at the expense of higher losses.

$$P_{LIM} \approx (V_{IN} \cdot 2\pi f_{IN} \cdot C_S)^2 \cdot R_{LIM}$$

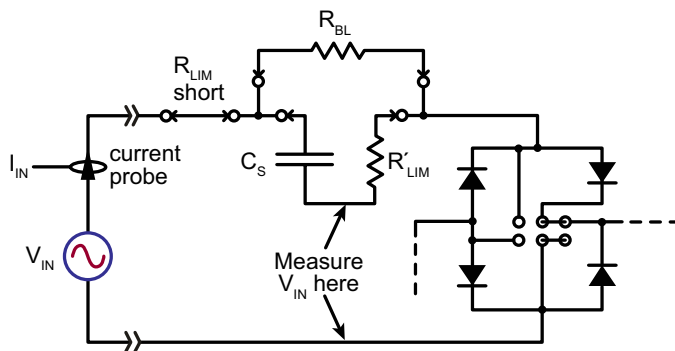
Output Capacitor (C_{OUT})

The output capacitor serves 2 functions - it supplies the load when the shunt is on, and helps absorb transients on the AC line. The supplied value may be lowered but at the expense of higher ripple voltage and increased output voltage during a transient.

Input Power Measurements

The high ratio between the imaginary and real power components makes power measurements difficult. To make accurate measurements of real power, the imaginary component may be eliminated by measuring input voltage after C_s . This excludes C_s losses, but AC rated film capacitors exhibit very low losses, so the error is minimal.

Since the PCB is laid out with R_{LIM} upstream of C_S for safety reasons, it must be relocated after C_S if R_{LIM} losses are to be included.



Do not connect earth-grounded instruments when operating off the AC line! Use either battery-powered equipment, high voltage differential probes, or an isolation transformer on the AC line. Note that many Variacs (variable transformers) do not provide isolation.

Ideally, R_{BL} should be removed. Its contribution to loss is approximately V_{IN}^2 / R_{BL}

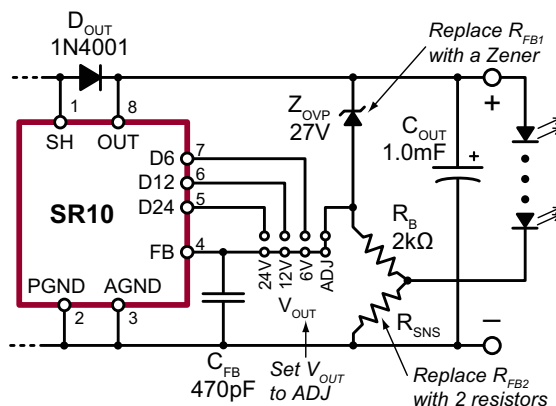
Since the input current is not a perfect sine wave, real power cannot be obtained by simply multiplying RMS input current by RMS input voltage. One way to make correct measurements is by multiplying instantaneous current by instantaneous voltage on a time-point basis and taking the average over an integer number of 50/60Hz cycles. At low load currents the shunt turns off only occasionally, requiring a long time window for accurate power measurements.

This measurement technique may be performed on most digital oscilloscopes. When taking the average, be sure to window the average over an integer number of cycles.

Driving LEDs

The SR10 can be configured to provide a constant-current output to drive LEDs. A current sense resistor (R_{SNS}) is used to convert LED current to the 1.25V feedback voltage required by the SR10.

$$I_{LED} = \frac{1.2V}{R_{SNS}}$$



Driving LEDs

When operated over a wide supply voltage range, a small C_{OUT} can result in overcharging at higher line voltages. It may take several cycles for the voltage to drop back down to the regulation threshold. This may cause visible flicker. The remedy is to increase C_{OUT} .

To protect against open LEDs, an overvoltage protection (OVP) circuit is employed. The OVP level is set by the value of the OVP Zener. R_B limits the current thru the Zener.

$$V_{OVP} = V_Z + 1.2V$$

C_s Table

The following table is based on the previously provided equations for C_s . Actual output current may be less due to losses (~5% less). AC line voltage is assumed to be 90 - 135VRMS @ 60Hz or 190 - 275VRMS @ 50Hz. Slashed cells exceed recommended operating conditions for peak shunt current at 85°C.

For universal 120V and 240V operation choose C_s based on 120VAC and make sure that operation at 240VAC does not fall in a slashed cell. The relevant cells are adjacent to each other. For example, if 50mA at 12V is needed and full rectification used, a C_s capacitor of $2.2\mu F \pm 10\%$ provides 53.8mA at 120VAC (90VAC low line). But at 240VAC, the cell to the right (240VAC column) is slashed, and universal operation is not possible. This assumes 120VAC low line is 90VAC and 240VAC high line is 275VAC. For other high/low voltages use the equations.

Output current capability (mA)

C_s	C_s Tol	6V Output				12V Output				24V Output			
		Half		Full		Half		Full		Half		Full	
		120V 60Hz	240V 50Hz	120V 60Hz	240V 50Hz	120V 60Hz	240V 50Hz	120V 60Hz	240V 50Hz	120V 60Hz	240V 50Hz	120V 60Hz	240V 50Hz
220nF	10%	2.9	5.2	5.7	10.3	2.9	5.2	5.4	10.1	2.7	5.1	4.8	9.6
	20%	2.6	4.7	5.0	9.2	2.5	4.6	4.8	9.0	2.4	4.5	4.3	8.5
330nF	10%	4.4	7.9	8.5	15.5	4.3	7.8	8.1	15.1	4.1	7.6	7.2	14.4
	20%	3.9	7.0	7.6	13.8	3.8	6.9	7.2	13.4	3.6	6.8	6.4	12.8
470nF	10%	6.3	11.2	12.1	22.0	6.1	11.1	11.5	21.5	5.8	10.8	10.3	20.5
	20%	5.6	10.0	10.8	19.6	5.4	9.9	10.2	19.1	5.2	9.6	9.1	18.2
680nF	10%	9.1	16.2	17.5	31.9	8.9	16.0	16.6	31.2	8.4	15.7	14.9	29.7
	20%	8.1	14.4	15.6	28.4	7.9	14.3	14.8	27.7	7.5	13.9	13.2	26.4
1.0μF	10%	13.3	23.9	25.7	46.9	13.0	23.6	24.4	45.8	12.4	23.0	21.9	43.7
	20%	11.9	21.2	22.9	41.7	11.6	21.0	21.7	40.7	11.0	20.5	19.4	38.8
1.5μF	10%	20.0	35.8	38.6	70.4	19.5	35.4	36.7	68.7	18.6	34.6	32.8	65.5
	20%	17.8	31.8	34.3	62.5	17.4	31.4	32.6	61.1	16.5	30.7	29.1	58.2
2.2μF	10%	29.4	52.5	56.6	103.2	28.6	51.9	53.8	100.8	27.2	50.7	48.1	96.1
	20%	26.1	46.6	50.3	91.7	25.5	46.1	47.8	89.6	24.2	45.1	42.7	85.4

 = Exceeds Recommended Operating Limits

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