

Adjustable Off-Line Inductorless Switching Regulators

Features

- ▶ Efficient operation without magnetics
- ▶ No high voltage capacitors
- ▶ Adjustable main output voltage (9V to 50V)
- ▶ Additional 3.3V or 5V internal regulator
- ▶ Up to 100mA combined output current
- ▶ Single BOM for 120VAC/230VAC
- ▶ Built-in soft start
- ▶ Less than 200mW standby power

Applications

- ▶ White goods
- ▶ Household appliances
- ▶ Lighting controls
- ▶ Circuit breakers
- ▶ Keep-alive supplies

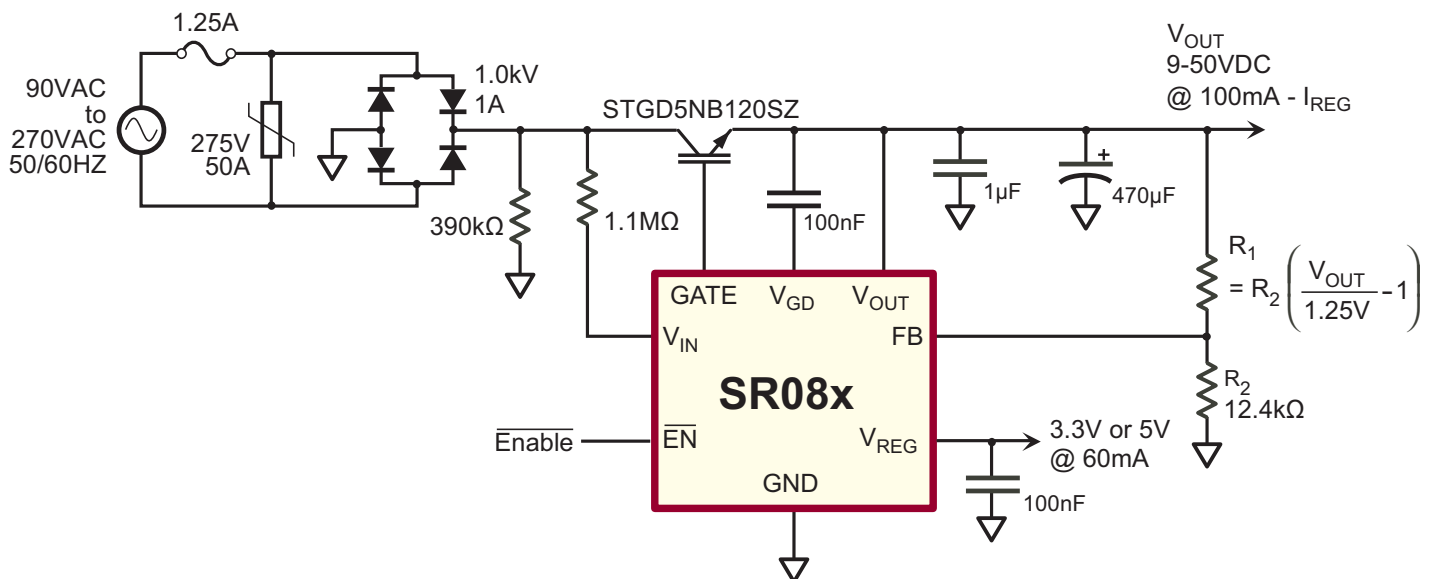
General Description

The Supertex SR086 and SR087 are inductorless switching regulators designed to operate directly from a rectified AC line. The operating principle is to turn on a pass transistor when the rectified AC is below the output voltage, and to turn it off when the output voltage reaches a specific level. A linear regulator supplied by V_{OUT} provides an additional fixed 3.3V output (SR086) or 5V output (SR087). Efficiencies of around 55% may be realized for loads up to 1W in 120VAC applications, with around 50% efficiencies for loads up to 800mW in 230VAC applications.

A logic-level enable input allows the SR086 and SR087 to be disabled – useful when they are employed as a keep-alive power supply.

WARNING! Galvanic isolation is not provided. Dangerous voltages are present when connected to the AC line. It is the responsibility of the designer employing the SR08x to ensure adequate safeguards are in place to protect the end user from electrical shock.

Typical Application Circuit



Ordering Options

Device (V_{REG})	Package Options
	8-Lead SOIC
SR086 (3.3V)	SR086SG-G
SR087 (5.0V)	SR087SG-G

-G indicates package is RoHS compliant ('Green')

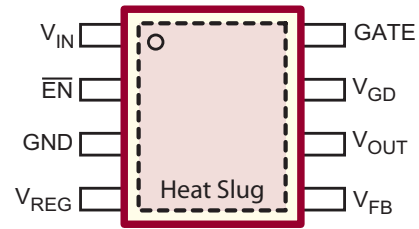


Absolute Maximum Ratings

Parameter	Value
Output Voltage (V_{OUT})	-0.3V to 56V
Feedback Voltage (V_{FB})	-0.3V to 6.5V
Enable Voltage (V_{EN})	-0.3V to 6.5V
Operating Junction Temperature	-40°C to +125°C

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied. Continuous operation of the device at the absolute rating level may affect device reliability. All voltages are referenced to device ground.

Pinout



SO-8

Backside on the SO-8 package is at ground potential and may be connected to ground or left unconnected.

Pin Description

Name	Pin #	Description
V_{IN}	1	Rectified AC input voltage
\overline{EN}	2	Active low enable input
GND	3	Circuit ground <i>Note: circuit ground will be at the AC line potential</i>
V_{REG}	4	Regulated output voltage, fixed 3.3V or 5.0V
FB	5	Feedback input
V_{OUT}	6	Output voltage (9.0V - 50V adj.)
V_{GD}	7	Gate drive supply (referenced to V_{OUT})
GATE	8	Drives external IGBT pass transistor

Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Units	Conditions
V_{OUT}	Output voltage	9	-	50	V	---
I_{OUT}	Load on V_{OUT} including feedback divider and load on V_{REG}	100	-	-	μA	---

Specifications

(Unless otherwise noted, $T_A = -40^\circ C$ to $+85^\circ C$, Voltages referenced to GND pin)

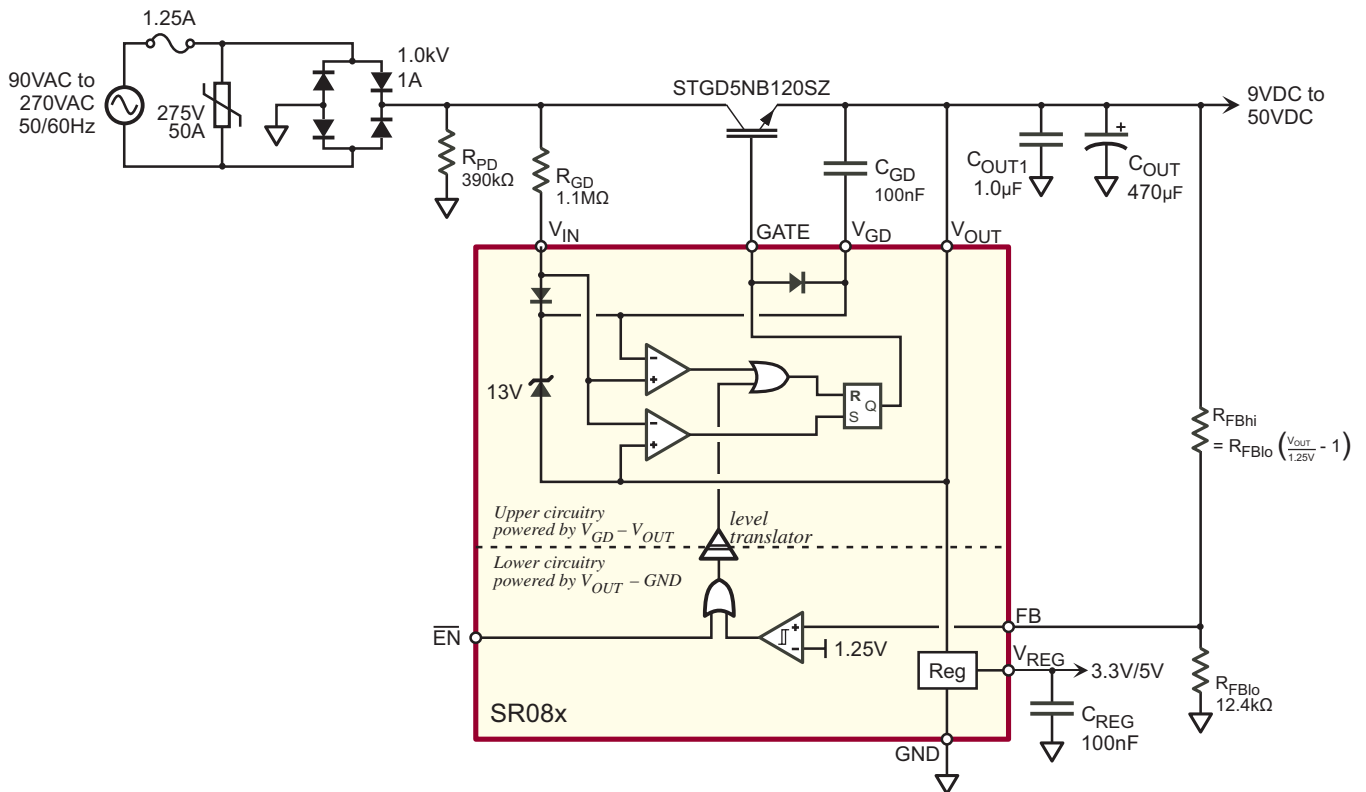
Symbol	Parameter	Min	Typ	Max	Units	Conditions
I_{GD}	Current consumption at V_{GD}	-	-	60	μA	---
$I_{OUT(int)}$	Current consumption of the lower circuitry	-	-	400	μA	$V_{OUT} = 9-50V$
V_{GD}	Gate drive supply voltage ¹	11	13	15	V	---
$V_{GATE(hi)}$	GATE output high voltage ¹	11	-	15	V	---
$V_{GATE(lo)}$	GATE output low voltage ¹	-	-	0.5	V	---
$V_{FB(off)}$	Feedback voltage (GATE off)	1.18	1.25	1.31	V	---
$V_{FB(hys)}$	Feedback voltage hysteresis	-	50	-	mV	---

Specifications (cont.)

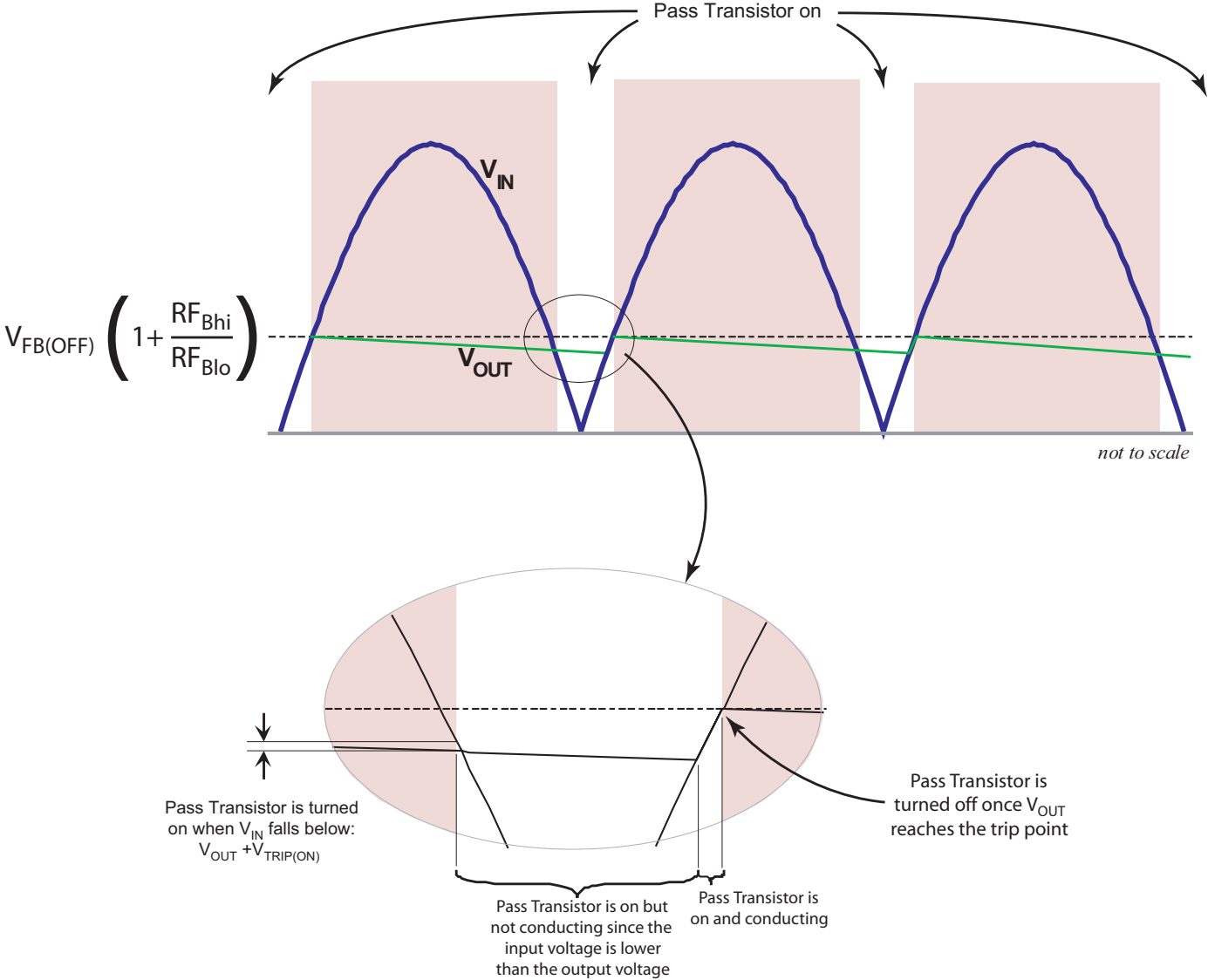
Symbol	Parameter	Min	Typ	Max	Units	Conditions
I_{FB}	FB input current	-	-	500	nA	---
$V_{TRIP(on)}$	V_{IN} trip voltage, GATE on ¹	0	-	3	V	---
$V_{TRIP(off)}$	V_{IN} trip voltage, GATE off ¹	9	-	15	V	---
$V_{EN(on)}$	Enable voltage, on	0.2	-	-	V	---
$V_{EN(off)}$	Enable voltage, off	-	-	0.75	V_{REG}	---
$t_{DIG(on)}$	V_{IN} – GATE turn-on delay	0	-	1.0	μ s	$C_{GATE} = 1nF$
$t_{DIG(off)}$	V_{IN} – GATE turn-off delay	-	-	600	ns	$C_{GATE} = 1nF$
$t_{DFG(off)}$	FB – GATE turn-off delay	-	-	450	ns	$C_{GATE} = 1nF$ $V_{FB} = 1.5V$
V_{REG}	Regulated output voltage SR086 SR087	3.125 4.750	3.300 5.000	3.465 5.250	V	$I_{LOAD} = 1mA$, $V_{OUT} = 9V$
$\Delta V_{I,REG}$	V_{REG} load regulation	-50	-	+50	mV	$0mA < I_{LOAD} < 60mA$, $V_{OUT} = 9V$, $T_{Amb} = 25^{\circ}C$
V_D	GATE – V_{GD} diode drop	-	-	800	mV	$I = 20mA$

¹ Referenced to V_{OUT} .

Block Diagram

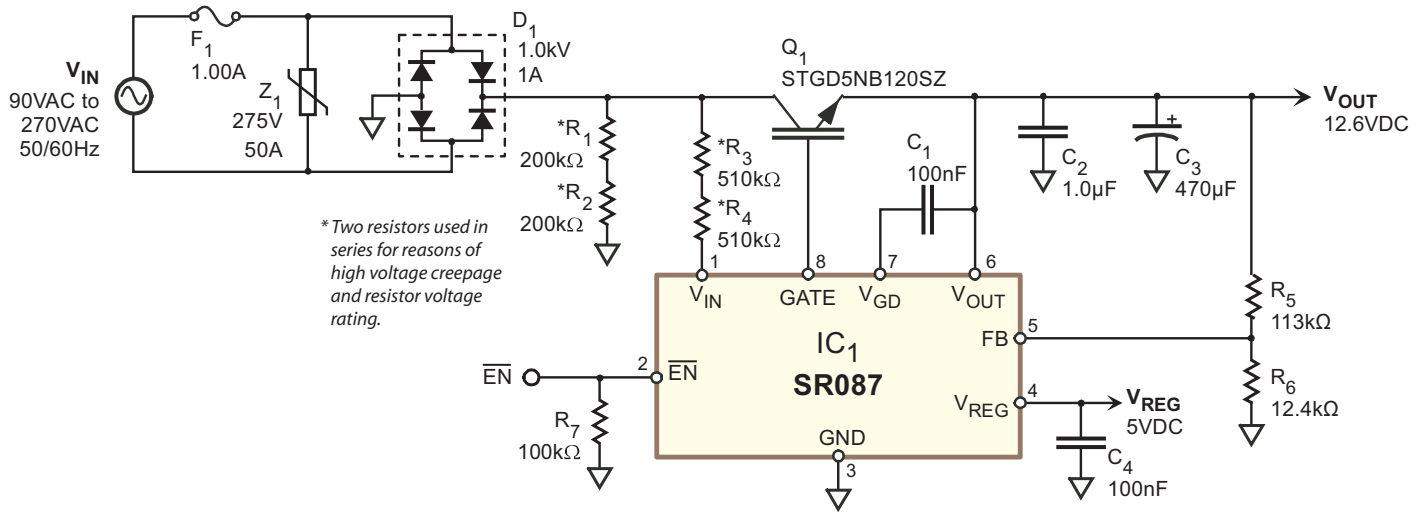


SR08x Timing



Data Sheet Application Section:

Typical Application Circuit



Output Voltage*

V_{OUT} may be adjusted in the range of 9V to 50V*, by changing feedback resistor R₅ according to the following equation.

$$R_5 = R_6 \left(\frac{V_{OUT}}{1.25V} - 1 \right)$$

Leave R₆ at 12.4kΩ or less - it assures a minimum 100µA load required for the proper operation of the SR087. Change R₃ and R₄ according to the R₃+R₄ equation below. Select C₂ and C₃ with appropriate voltage ratings. For C₃, use a low ESR capacitor with an adequate ripple current rating (800mA_{RMS}). Use ceramic for C₂.

Since V_{REG} is a linear regulator supplied from V_{OUT}, the maximum current available from V_{REG} is reduced as V_{OUT} is increased due to power considerations.

$$I_{REG(max)} = \frac{1.5W}{V_{OUT} - 5V} \quad \text{or } 60mA, \text{ whichever is less.}$$

Input Voltage

To reduce standby power for 230VAC-only applications, or for supply voltages less than 90Vrms, R₃ and R₄ should be changed according to the R₃+R₄ equation below. R₁+R₂ should remain at 400kΩ or less. Two resistors in series are employed to ensure adequate creepage distances for 230VAC operation. For 120VAC-only applications, single resistors may be employed.

Output Ripple*

Storage capacitor C₃ was sized to provide about 2V_{P-P} ripple at 100mA load (I_{OUT} + I_{REG}). For lighter loads, C₃ may be reduced. Conversely, C₃ may be increased for lower ripple. Use a low ESR capacitor with an adequate ripple current rating (800mA_{RMS} for 100mA loads). Efficiency and output current capability may drop with increased capacitance because of a smaller conduction angle associated with lower ripple. Due to feedback hysteresis, ripple cannot be reduced below 4%.

$$V_{RIPPLE(P-P)} \approx \frac{I_{OUT} + I_{REG}}{2f_{IN}C_3}$$

*V_{REG} requires at least 4V of headroom. Therefore, V_{OUT} including ripple, must not fall below 9V for the SR087, or below 7.3V for the SR086.

R₃ + R₄ Equation:

$$(R_3 + R_4) < \frac{\sqrt{2V_{IN}^2 - V_X^2} - V_X \cos^{-1}\left(\frac{V_X}{\sqrt{2}V_{IN}}\right)}{\pi \cdot 25\mu A} \quad \text{where } V_X = V_{OUT} + 15V$$

Use the minimum anticipated RMS value for V_{IN}. Take resistor tolerance into account, selecting the next lower standard value. Choosing a lower value has no effect other than higher standby power.

Line Transformer

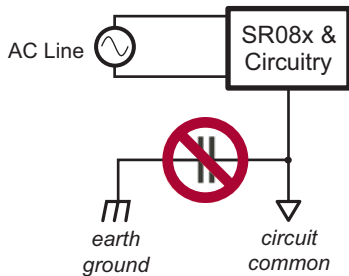
During initial testing it is tempting to use an isolation transformer or a variable transformer on the AC line. However, the high inductance of the transformer (frequently in the mH's) interferes with the normal operation of the SR08x and should not be used. This is not a concern with the normal inductance of the AC line or for AC line filters.



The SR08x draws current from the AC line in short, high current pulses. The transformer's high inductance tends to limit the current pulse. Furthermore, inductive kickback on the falling edge of the current pulse can create high voltage spikes which must be absorbed by the transient protector.

EMI Capacitor

The use of a small-value capacitor from circuit common to earth ground prevents the SR08x from operating and should not be employed.



EMI

The SR08x circuit as depicted on Page 1, (Typical Application Circuit), meets FCC Class B and CISPR 14-1 (household appliances) requirements for conducted emissions, for combined loads of less than 20mA ($I_{OUT} + I_{REG}$).

Fuse

Although the average current drawn from the AC line is low, the RMS current is fairly high due to the current being drawn in short, high-current pulses. Since a fuse is basically a resistor with a power dissipation given by $I_{RMS}^2 R$, the fuse must be sized for the RMS current, not the average current. For a 1W load and 120VAC the RMS current is $700mA_{RMS}$, and for a 0.5W load at 230VAC it is $360mA_{RMS}$.

Transient Protection

The transient protector must be located before the bridge rectifier. The reason for this is to minimize capacitance to allow the rectified AC to fall below V_{OUT} .

Since there is no capacitor to absorb AC line transients, complete transient protection must be provided by the TVS or MOV device. Since the recommended IGBT is rated at 1.2kV and the SR08x never sees the full input voltage, the bridge rectifier becomes the limiting element when selection an MOV. If using a 1.0kV bridge, an MOV having a clamping voltage of < 1.0kV is recommended.

Load

Total load on the SR08x is the total load current drawn from V_{OUT} (I_{OUT}) and, since the linear regulator is supplied from V_{OUT} , it also includes the current drawn from V_{REG} (I_{REG}). Total load is calculated as follows:

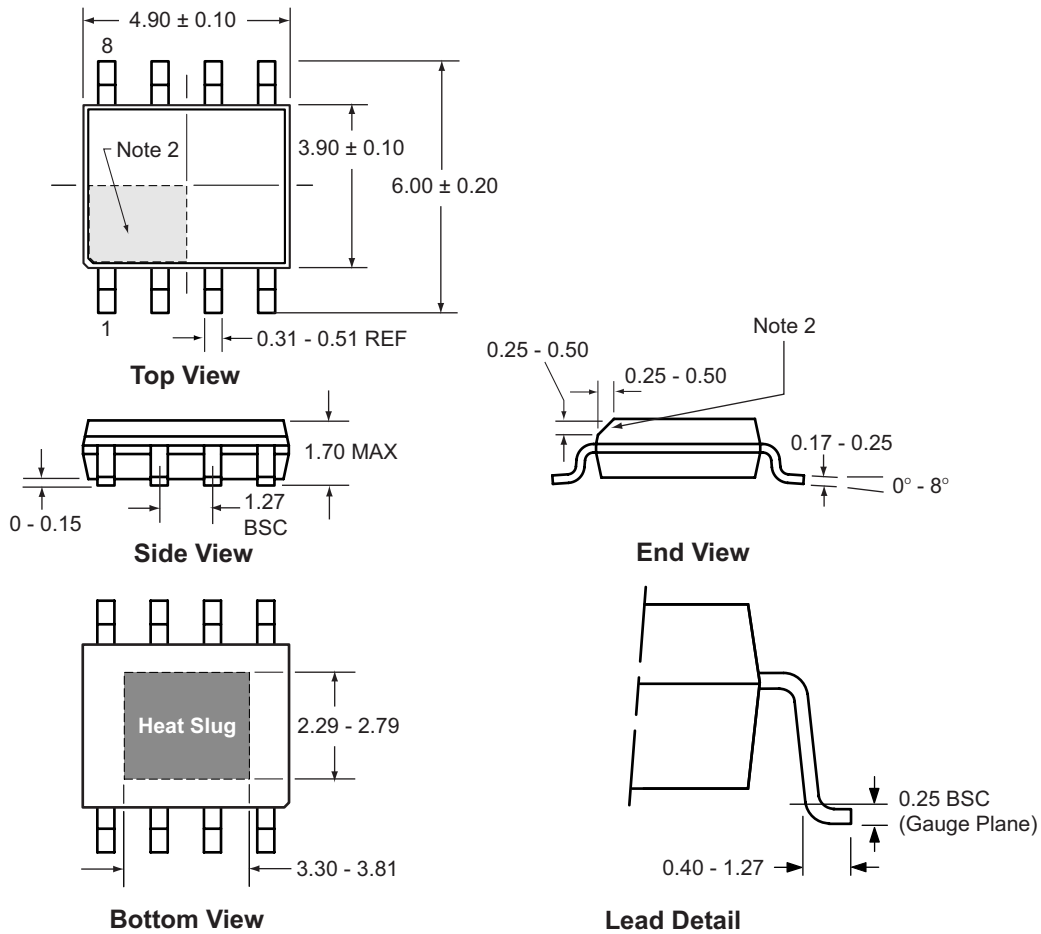
$$I_{LOAD} = I_{OUT} + I_{REG}$$

$$P_{LOAD} = V_{OUT} (I_{OUT} + I_{REG})$$

UPS

The SR08x will not operate from uninterruptable power supplies having a square wave output. This type of output is usually referred to as 'modified sine wave'

8-Lead SOIC (with heat slug) Package Outline (SG)



Notes:

1. All dimensions in millimeters; angles in degrees
2. Pin 1 identifier must be located within the indicated area

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to <http://www.supertex.com/packaging.html>.)

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