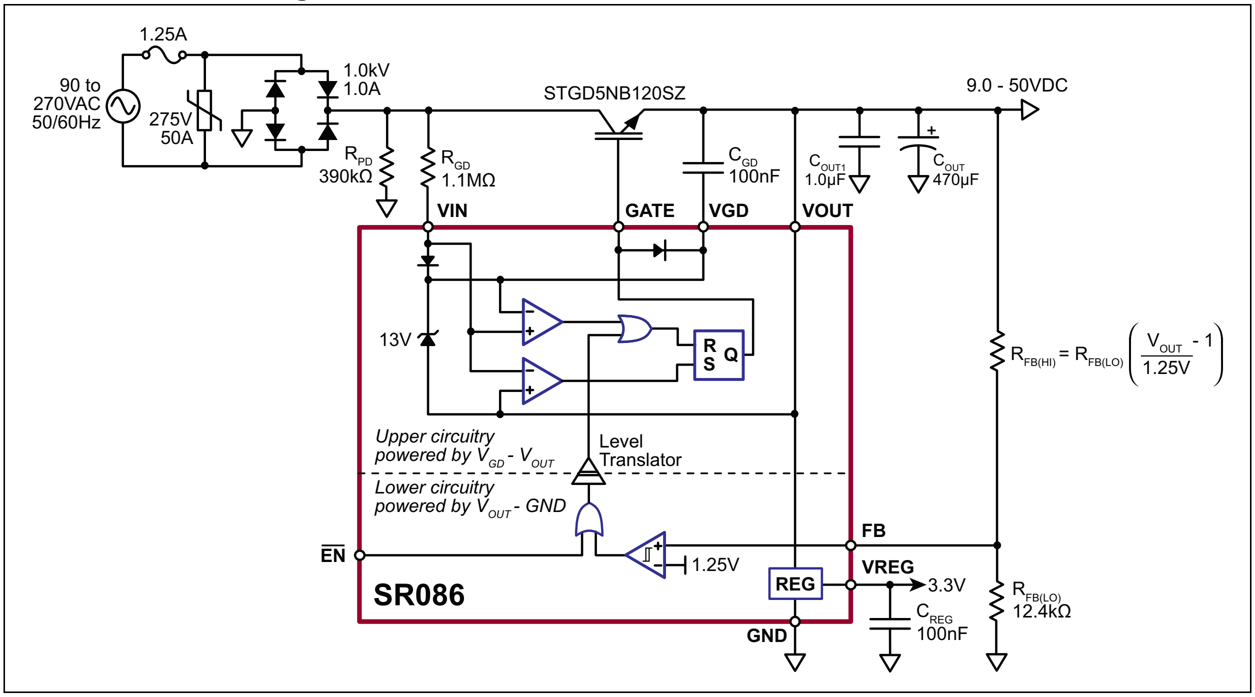
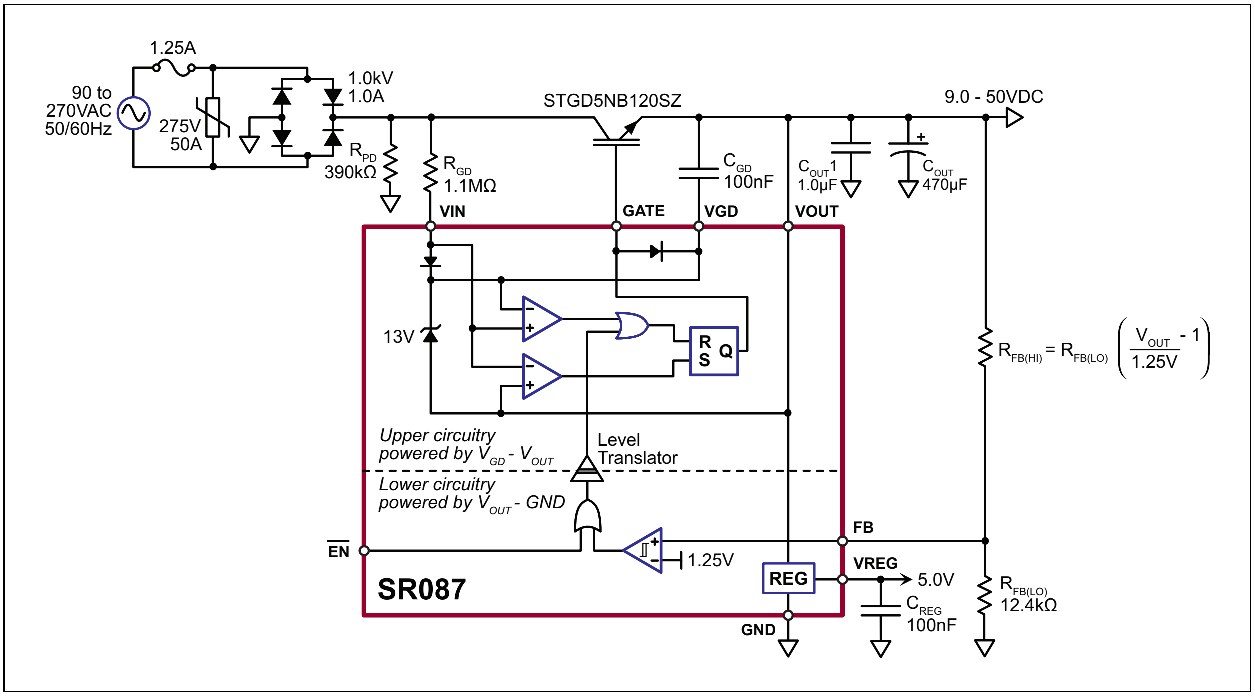
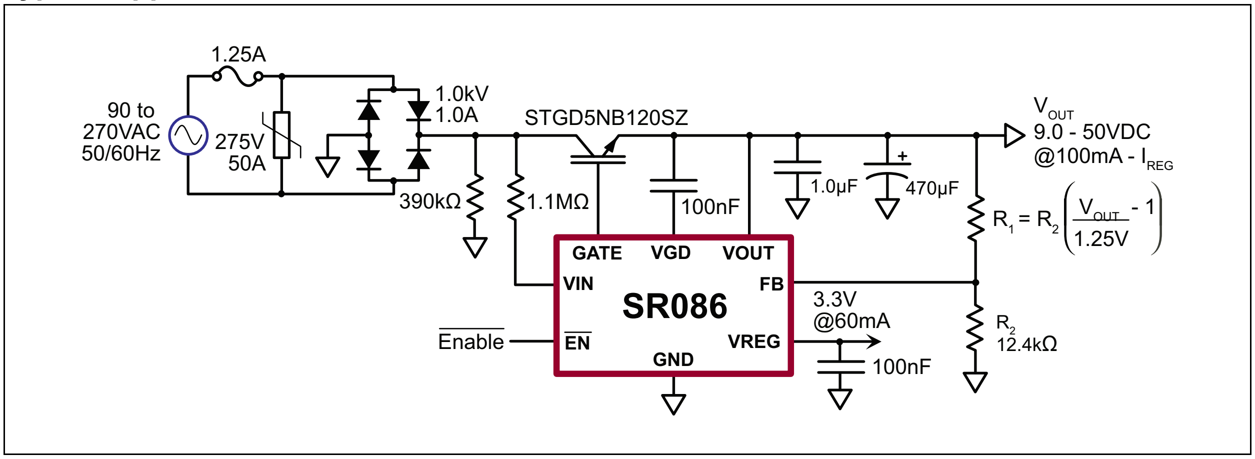
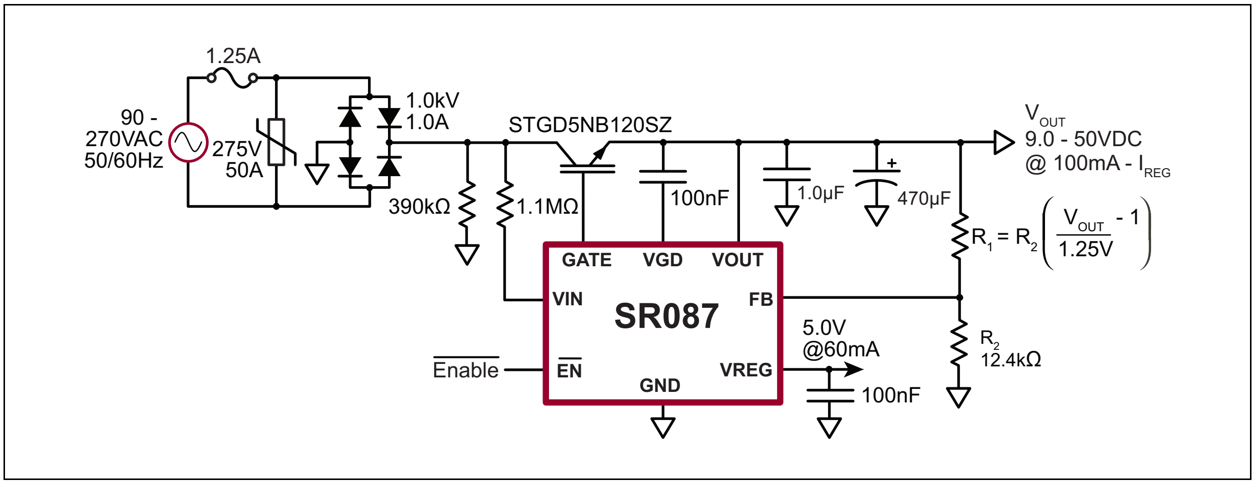
Functional Block Diagrams





Typical Application Circuits





1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

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, T_J .... –40°C to +125°C

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Output Voltage	V_{OUT}	9	—	50	V	
Load on V_{OUT}, including Feedback Divider and Load on V_{REG}	I_{OUT}	100	—	—	µA	
Headroom for Internal Linear Regulation (V_{OUT}–V_{REG})	V_{HR}	4	—	—	V	

ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise noted, T_A = –40°C to +85°C. Voltages referenced to GND pin.

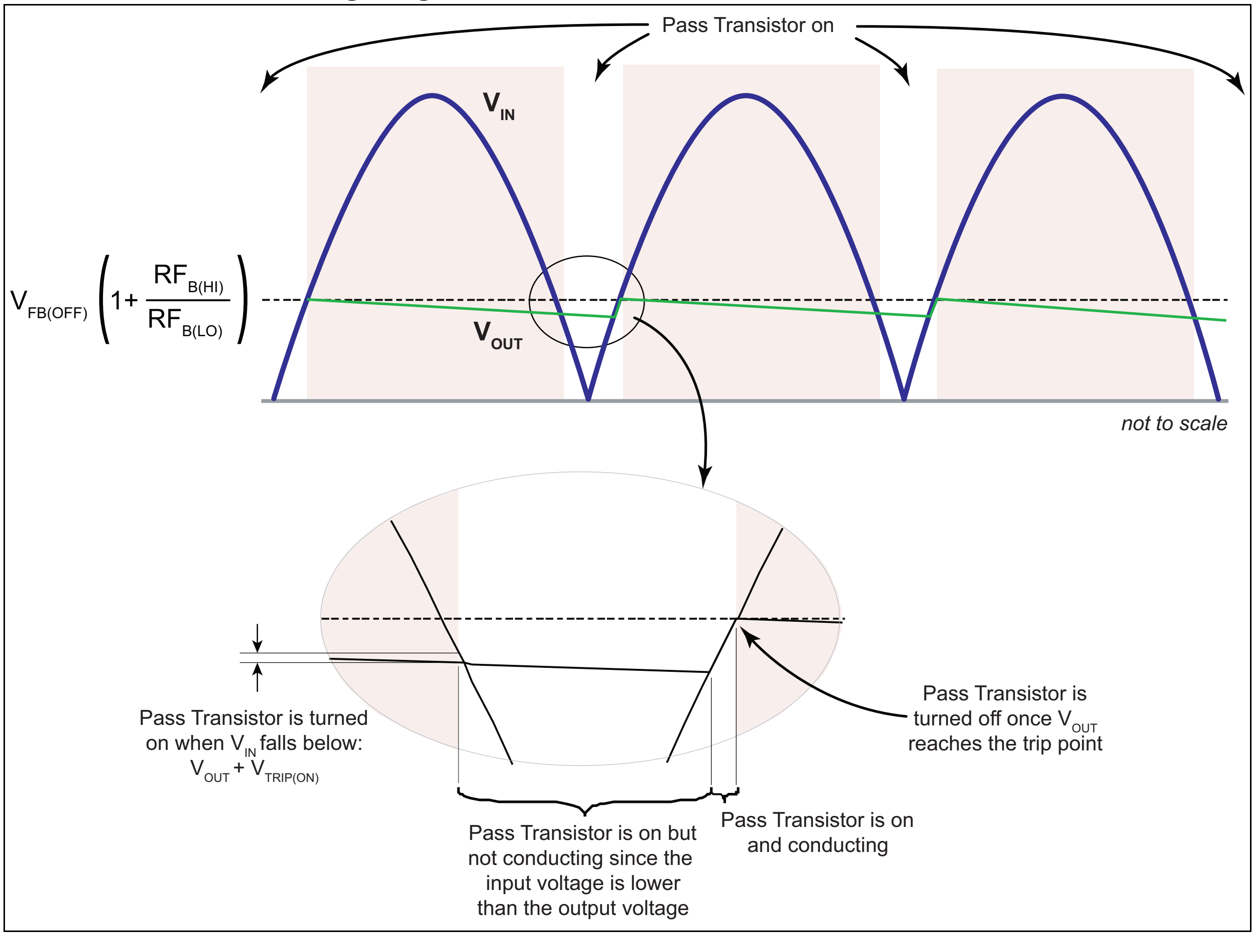
Parameter		Sym.	Min.	Typ.	Max.	Unit	Conditions
Current Consumption at V_{GD}		I_{GD}	—	—	60	µA	
Current Consumption of the Lower Circuitry		$I_{OUT(INT)}$	—	—	400	µA	V_{OUT} = 9V–50V
Gate Drive Supply Voltage		V_{GD}	11	13	15	V	Note 1
Gate Output High Voltage		$V_{GATE(HI)}$	11	—	15	V	Note 1
Gate Output Low Voltage		$V_{GATE(LO)}$	—	—	0.5	V	Note 1
Feedback Voltage (Gate Off)		$V_{FB(OFF)}$	1.18	1.25	1.31	V	
Feedback Voltage (Hysteresis)		$V_{FB(HYST)}$	—	50	—	mV	
Feedback Input Current		I_{FB}	—	—	500	nA	
V_{IN} Trip Voltage (Gate On)		$V_{TRIP(ON)}$	0	—	3	V	Note 1
V_{IN} Trip Voltage (Gate Off)		$V_{TRIP(OFF)}$	9	—	15	V	Note 1
Enable Voltage, On		$V_{EN(ON)}$	0.2	—	—	V	
Enable Voltage, Off		$V_{EN(OFF)}$	—	—	0.75	V_{REG}	
V_{IN} Gate Turn-on Delay		$t_{DIG(ON)}$	0	—	1	µs	C_{GATE} = 1 nF
V_{IN} Gate Turn-off Delay		$t_{DIG(OFF)}$	—	—	600	ns	C_{GATE} = 1 nF
Feedback Gate Turn-off Delay		$t_{DFG(OFF)}$	—	—	450	ns	C_{GATE} = 1 nF, V_{FB} = 1.5V
Regulated Output Voltage	SR086	V_{REG}	3.125	3.3	3.465	V	I_{LOAD} = 1 mA, V_{OUT} = 9V
	SR087		4.750	5	5.250	V	
V_{REG} Load Regulation		$\Delta_I V_{REG}$	–50	—	+50	mV	0 mA < I_{LOAD} < 60 mA, V_{OUT} = 9V, T_{AMB} = 25°C
Gate V_{GD} Diode Drop		V_D	—	—	1	V	I = 20 mA

Note 1: Referenced to V_{OUT}

TEMPERATURE CHARACTERISTICS

Electrical Characteristics: Unless otherwise noted, for all specifications $T_A = T_J$ = +25°C.						
Parameter	**Sym.**	**Min.**	**Typ.**	**Max.**	**Unit**	**Conditions**
TEMPERATURE RANGE						
Operating Junction Temperature	T_J	–40	—	+125	°C	
PACKAGE THERMAL RESITANCE						
8-lead SOIC (with Heat Slug)	θ_{JA}	—	84	—	°C/W	

SRO86 and SR087 Timing Diagram



2.0 PIN DESCRIPTION

The descriptions of the SR086/SR087 pins are listed on Table 2-1. Refer to **Package Type** for the location of pins.

TABLE 2-1: PIN FUNCTION TABLE

Pin Number	SR086 Pin Name	SR087 Pin Name	Description
1	VIN	VIN	Rectified AC input voltage
2	$\overline{\text{EN}}$	$\overline{\text{EN}}$	Active low enable input
3	GND	GND	Circuit ground (**Note 1**)
4	VREG	VREG	Regulated output voltage (**Note 2**)
5	FB	FB	Feedback input
6	VOUT	VOUT	Output voltage (9V–50V adj.)
7	VGD	VGD	Gate drive supply (referenced to VOUT)
8	GATE	GATE	Drives external IGBT pass transistor

Note 1: Circuit ground will be at the AC line potential.

2: Fixed 3.3V for SR086 and fixed 5V for SR087

3.0 APPLICATION INFORMATION

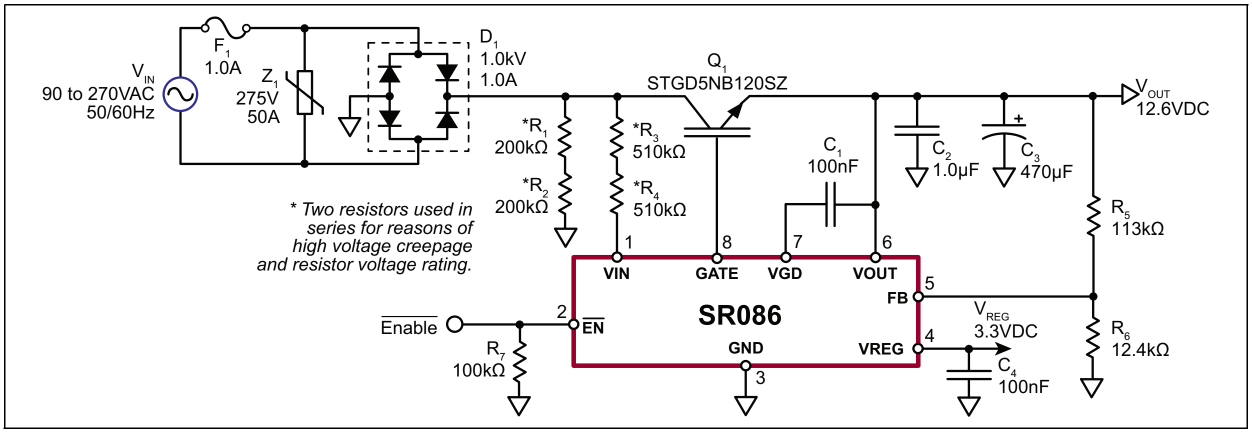


FIGURE 3-1: *SR086 Typical Application Circuit.*

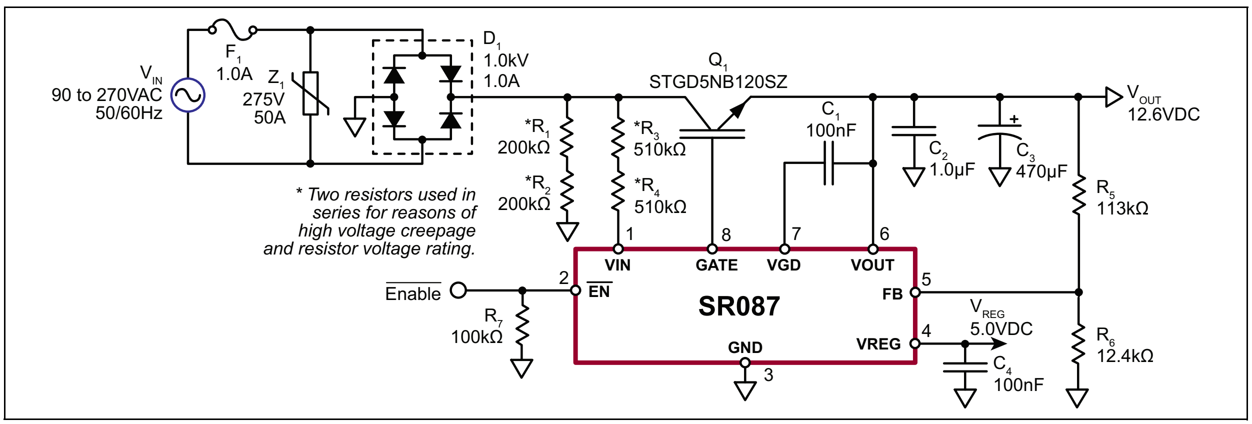


FIGURE 3-2: *SR087 Typical Application Circuit.*

3.1 Output Voltage

V_{OUT} may be adjusted in the range of 9V to 50V by changing feedback resistor R_5 based on Equation 3-1.

EQUATION 3-1:

$$R_5 = R_6[(V_{OUT}/1.25V) - 1]$$

Leave R_6 at 12.4 kΩ or less as it assures a minimum 100 µA load required for the proper operation of SR086/SR087. Change R_3 and R_4 according to Equation 3-4. Select C_2 and C_3 with appropriate voltage ratings. For C_3, use a low-ESR capacitor with an adequate ripple current rating (800 mA_{RMS}). Use ceramic for C_2.

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. Refer to Equation 3-2 for SR086 and Equation 3-3 for SR087.

EQUATION 3-2:

$$I_{REG(MAX)} = \frac{1.5W}{(V_{OUT} - 3.3V)}$$ or 60 mA, whichever is less

EQUATION 3-3:

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

3.2 Input Voltage

To reduce standby power for 230 VAC-only applications or for supply voltages less than 90 Vrms, R_3 and R_4 should be changed according to Equation 3-4. R_1+R_2 should remain at 400 kΩ or less. Two resistors in series are used to ensure adequate creepage distances for 230 VAC operation. For 120 VAC-only applications, single resistors may be used.

EQUATION 3-4: $R_3 + R_4$ EQUATION

$$(R_3 + R_4) < \frac{\sqrt{2V_{IN^2} - V_{IN^2}} - V_x \cos 1\left(\frac{V_x}{\sqrt{2} \times V_{IN}}\right)}{\Pi \times 25\mu A}$$

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.

3.3 Output Ripple

Storage capacitor C_3 was sized to provide about $2V_{P-P}$ ripple at 100 mA load ($I_{OUT} + I_{REG}$). For lighter loads, C_3 may be reduced. Conversely, C_3 may be increased for lower ripple. Use a low-ESR capacitor with an adequate ripple current rating (e.g. 800 mA_{RMS} for 100 mA 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%. See Equation 3-5.

EQUATION 3-5:

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

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

3.4 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 mH range) should not be used because it interferes with the normal operation of the SR086/SR087. This is not a concern with the normal inductance of the AC line or for AC line filters.

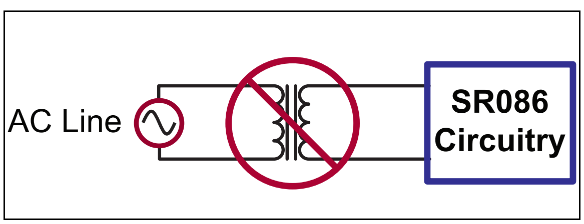


FIGURE 3-3: *Line Transformer.*

As shown in Figure 3-3, the SR086/SR087 draw 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.

3.5 Electromagnetic Interference (EMI) Capacitor

Small-value capacitors from circuit common to earth ground should not be used as they prevent the SR086/SR087 from operating. See Figure 3-4.

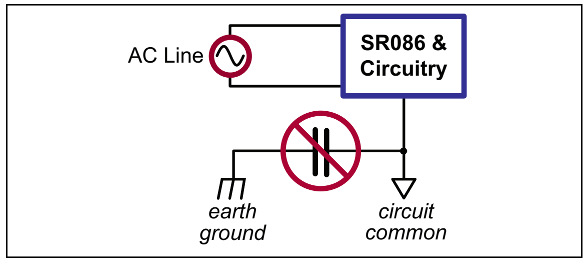


FIGURE 3-4: *EMI Capacitor.*

3.6 EMI

The SR086/SR087 circuits, as shown in the **Functional Block Diagrams**, meet FCC Class B and CISPR 14-1 (household appliances) requirements for conducted emissions for combined loads of less than 20 mA ($I_{OUT} + I_{REG}$).

3.7 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 and not the average current. For a 1W load at 120 VAC, the RMS current is 700 mA_{RMS}, while the RMS current for a 0.5W load at 230 VAC is 360 mA_{RMS}.

3.8 Load

Total load on the SR086/SR087 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 in Equation 3-6 and Equation 3-7.

EQUATION 3-6:

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

EQUATION 3-7:

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

3.9 Uninterruptible Power Supply (UPS)

The SR086/SR087 will not operate from a UPS with a square wave output. This type of output is usually referred to as "modified sine wave."

3.10 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 1.2 kV and the SR086/SR087 never see the full input voltage, the bridge rectifier becomes the limiting element when selecting an MOV. When using a 1 kV bridge, an MOV having a clamping voltage of greater than 1 kV is recommended.

An RC network on the AC line, as shown in Figure 3-5 and Figure 3-6, affords additional protection from line transients as well as reducing conducted EMI. It does, however, reduce power supply efficiency.

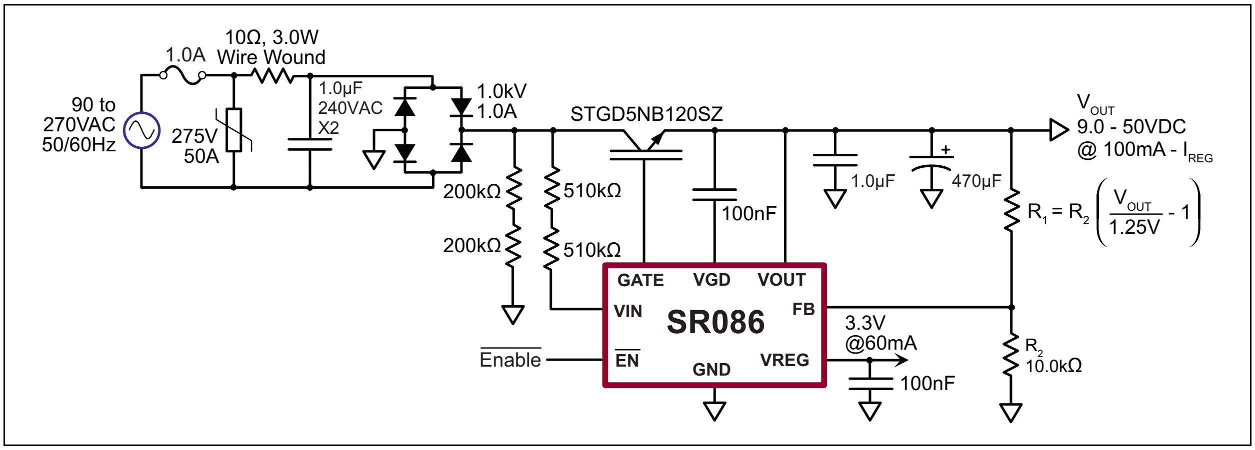


FIGURE 3-5: SR086 Additional Transient Protection.

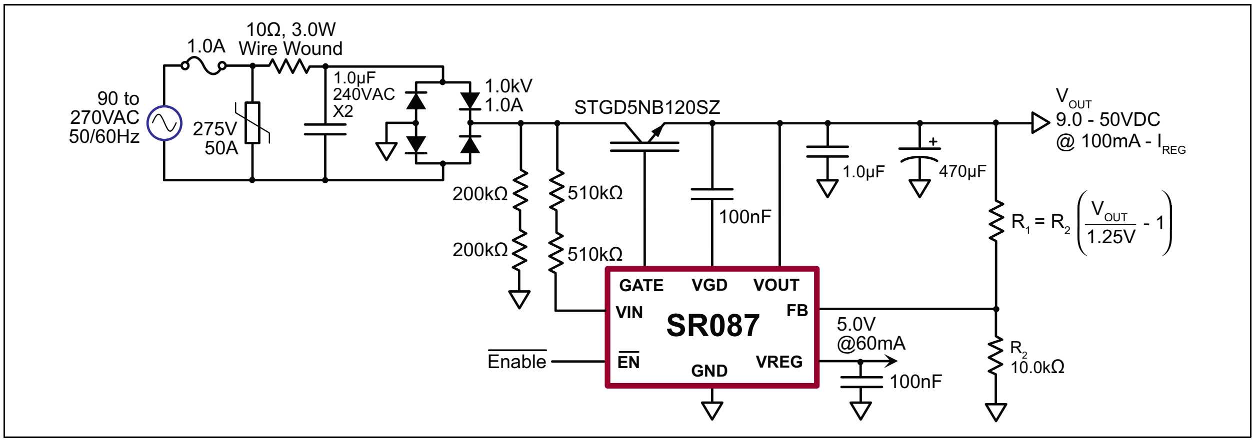
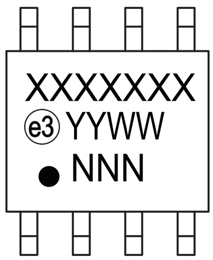


FIGURE 3-6: SR087 Additional Transient Protection.

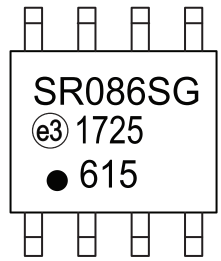
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

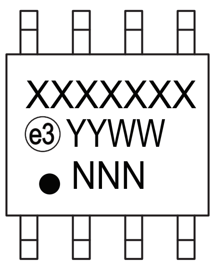
8-lead SOIC



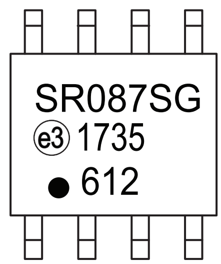
Example



8-lead SOIC



Example

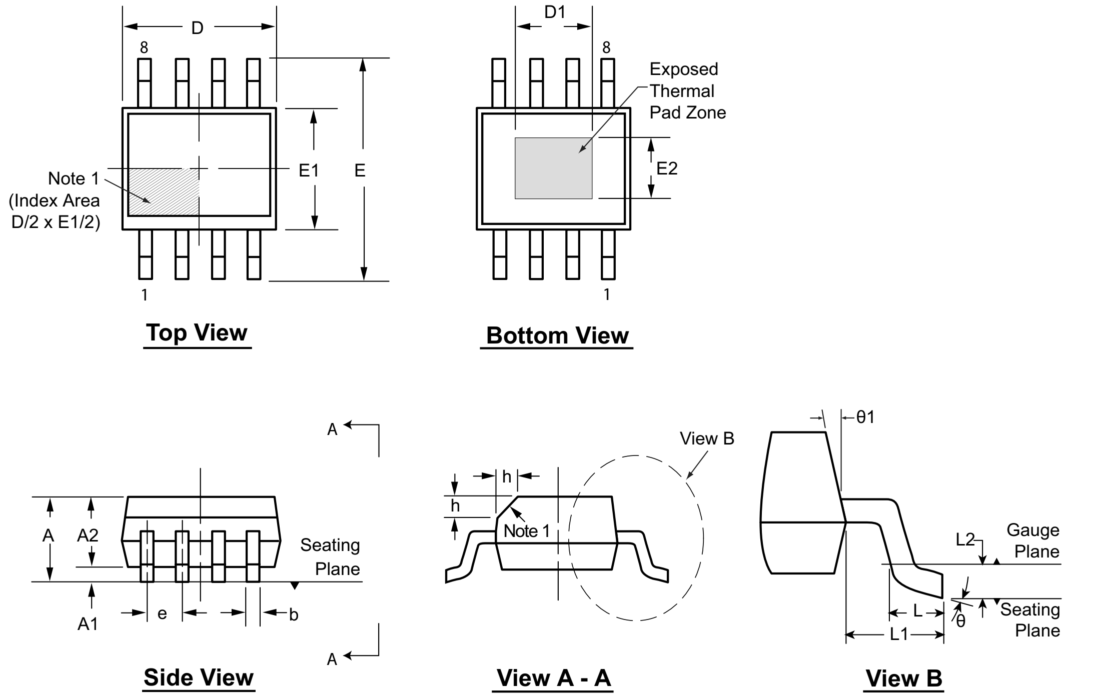


Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	e3	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for product code or customer-specific information. Package may or not include the corporate logo.

8-Lead SOIC (Narrow Body w/Heat Slug) Package Outline (SG)

4.90x3.90mm body, 1.70mm height (max), 1.27mm pitch



Note: For the most current package drawings, see the Microchip Packaging Specification at www.microchip.com/packaging.

Note:

1. *If optional chamfer feature is not present, a Pin 1 identifier must be located in the index area indicated. The Pin 1 identifier can be: a molded mark/ identifier; an embedded metal marker; or a printed indicator.*

Symbol		A	A1	A2	b	D	D1	E	E1	E2	e	h	L	L1	L2	θ	θ1
Dimension (mm)	MIN	1.25*	0.00	1.25	0.31	4.80*	3.30†	5.80*	3.80*	2.29†	1.27 BSC	0.25	0.40	1.04 REF	0.25 BSC	0°	5°
	NOM	-	-	-	-	4.90	-	6.00	3.90	-		-	-			-	-
	MAX	1.70	0.15	1.55*	0.51	5.00*	3.81†	6.20*	4.00*	2.79†		0.50	1.27			8°	15°

JEDEC Registration MS-012, Variation BA, Issue E, Sept. 2005.
** This dimension is not specified in the JEDEC drawing.*
† This dimension differs from the JEDEC drawing.
Drawings not to scale.

APPENDIX A: REVISION HISTORY

Revision A (May 2017)

- Converted and merged Supertex Doc #s DSFP-SR086 and DSFP-SR087 to Microchip DS20005544A
- Changed the package marking format
- Changed the quantity of the SG package from 3000/Reel to 3300/Reel
- Made minor text changes all throughout the document

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	XX	-	X	-	X
Device	Package Options		Environmental		Media Type

Devices:	SR086	=	Adjustable Offline Inductorless Switching Regulator with Additional 3.3V Internal Regulator
	SR087	=	Adjustable Offline Inductorless Switching Regulator with Additional 5V Internal Regulator
Package:	SG	=	8-lead SOIC (with Heat Slug)
Environmental:	G	=	Lead (Pb)-free/RoHS-compliant Package
Media Type:	(blank)	=	3300/Reel for an SG Package

Examples:

a) SR086SG-G: Adjustable Offline Inductorless Switching Regulator with Additional 3.3V Internal Regulator, 8-lead SOIC (with Heat Slug), 3300/Reel

b) SR087SG-G: Adjustable Offline Inductorless Switching Regulator with Additional 5V Internal Regulator, 8-lead SOIC (with Heat Slug), 3300/Reel

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