Demo Kit Available

Inductorless, Dual Output Off-Line Regulators

Features

- ❑ Accepts peak input voltages up to 700V
- ❑ Operates directly off of rectified 120V AC or 240V AC
- ❑ Integrated linear regulator
- ❑ Minimal power dissipation
- ❑ No high voltage capacitors required
- ❑ No transformers or inductors required

Applications

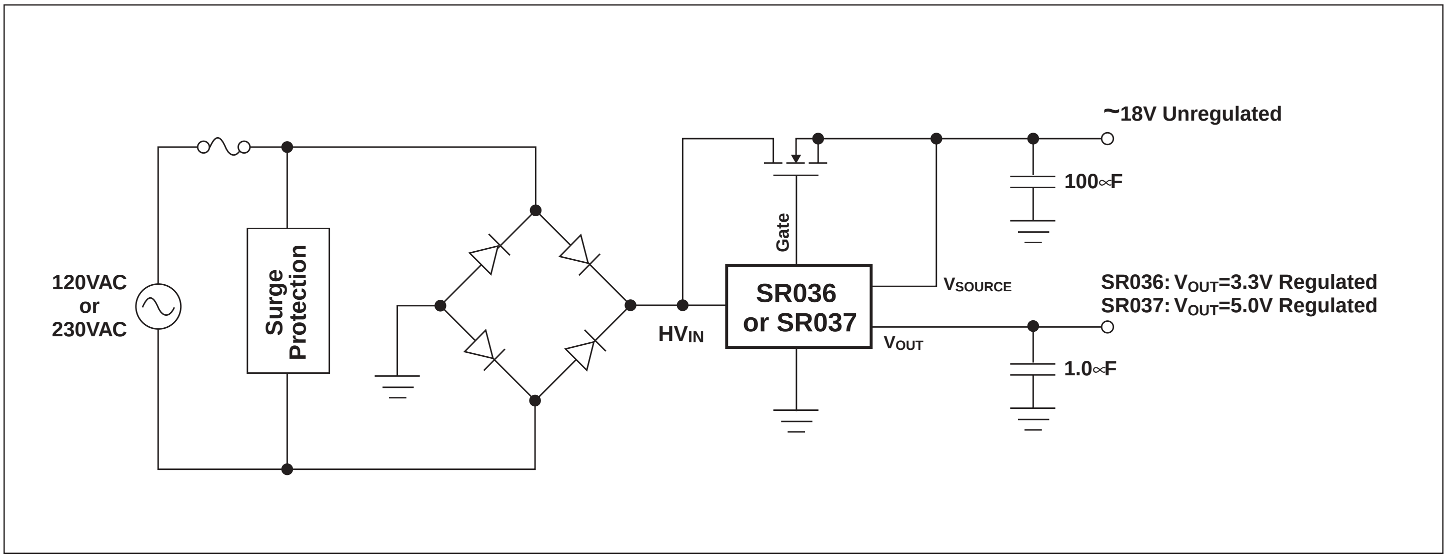
- ❑ 3.3V or 5.0V power supplies
- ❑ SMPS house keeping power supplies
- ❑ White goods
- ❑ Appliances
- ❑ Small off-line low voltage power supplies
- ❑ Lighting controls

General Description

The Supertex SR036 and SR037 are inductorless, dual output off-line controllers. They do not require any transformers, inductors, or high voltage input capacitors. The input voltage, HV_{IN}, is designed to operate from an unfiltered full wave rectified 120V or 230V AC line. It is designed to control an external N-channel MOSFET. When HV_{IN} is between $V_{GS(th)}$ to 40V, where $V_{GS(th)}$ is the threshold voltage of the external MOSFET, the external N-channel MOSFET is turned on allowing it to charge an external capacitor connected to V_{SOURCE}. An unregulated DC voltage will develop on V_{SOURCE}. Once HV_{IN} is above 45V, the N-channel MOSFET is turned off. The maximum gate voltage for the external MOSFET is 24V. The unregulated voltage is approximately 18V. The SR036 also provides a regulated 3.3V whereas the SR037 provides a regulated 5.0V.

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

SR03x Typical Application Circuit



Ordering Information

V_{OUT}	Package Options	
	MSOP-8	SO-8 w/ Heat Slug
3.3V	SR036MG*	SR036SG
5.0V	SR037MG*	SR037SG

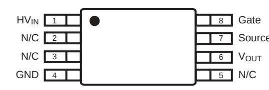
** Product supplied on 2500 piece carrier tape reel.*

Absolute Maximum Ratings*

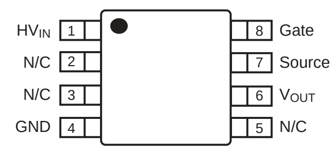
V_{IN}, High Voltage Input	+700V
V_{OUT}, Low Voltage Output	+6.0V
Storage Temperature	-65°C to +150°C
Soldering Temperature	+300°C
Power Dissipation, MSOP-8	300mW
Power Dissipation, SO-8 slug	1.50W

* All voltages are referenced to GND.

Pin Configuration



MSOP-8
(top view)



SO-8 Slug
Make no electrical connections to Backside Plate
(top view)

Electrical Characteristics

(Over operating supply voltages unless otherwise specified, T_A=0°C to +125°C)

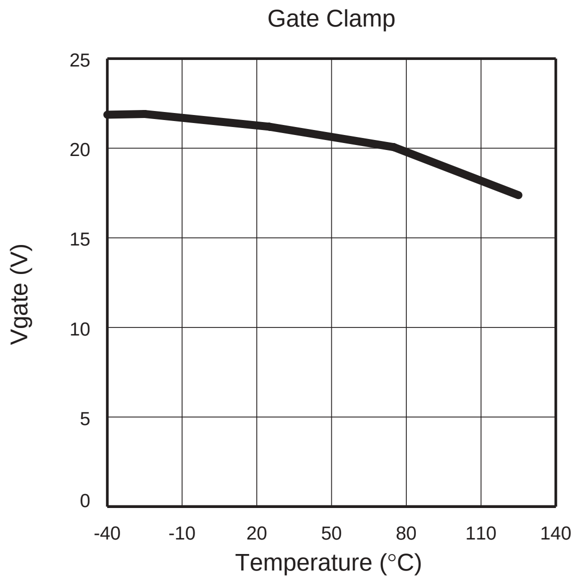
Symbol	Parameter		Min	Typ	Max	Units	Conditions
HV_{IN}	Input voltage				700	V	Peak transient voltage
					407		Peak rectified AC voltage
V_{TH}	HV_{IN} voltage when Gate is pulled to ground		40	45	50	V	
V_{GS}	Gate to source clamp voltage		±10	±15	±20	V	I_{GS} = ±100µA
V_{GATE}	Gate to ground clamp voltage		18	20	24	V	
V_{OUT}	Regulated output voltage for the SO-8 with heat slug	SR036	2.97	3.30	3.63	V	V_{SOURCE} = 10V
		SR037	4.5	5.00	5.50		V_{SOURCE} = 10V
ΔV_{OUT}	V_{OUT} load regulation			20	120	mV	V_{SOURCE} = 10V, I_{Load} = 0 to 50mA (1)
Freq	Input AC frequency		40		100	Hz	

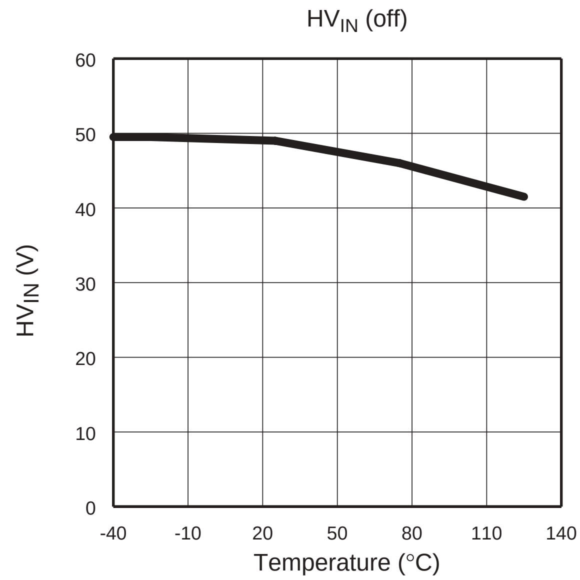
(1) Load current on the regulated output must not cause SR03 power dissipation to exceed max ratings. Worst case power dissipation is given by:

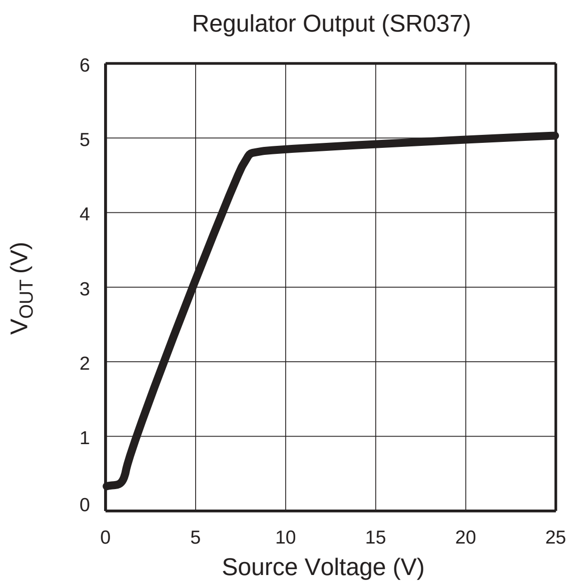
$$P \approx \frac{V_{IN}^{2}}{200k\Omega} + (16V - V_{OUT}) \times I_{OUT}$$

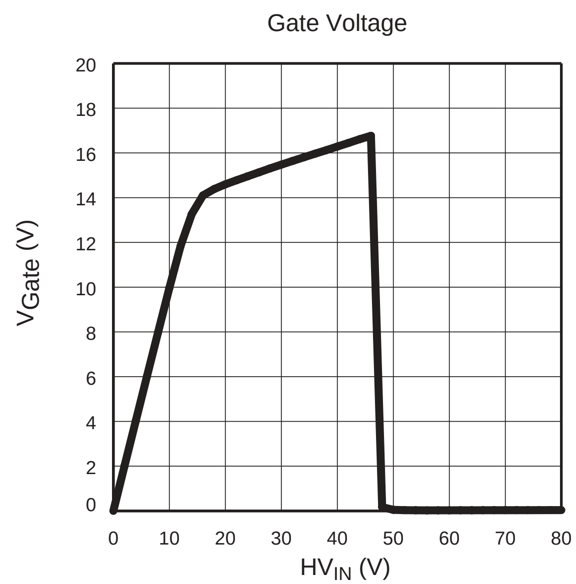
Where I_{OUT} is the load on the regulated output

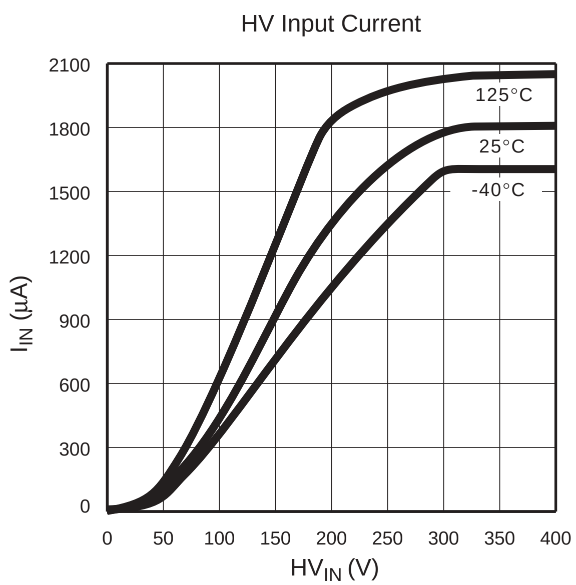
Typical Performance Curves

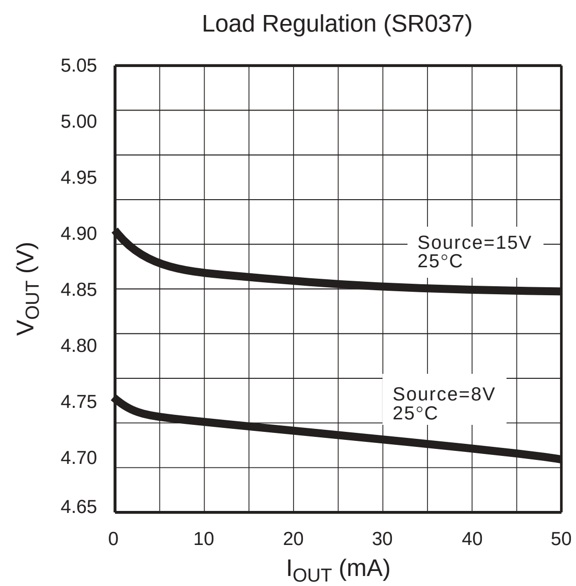










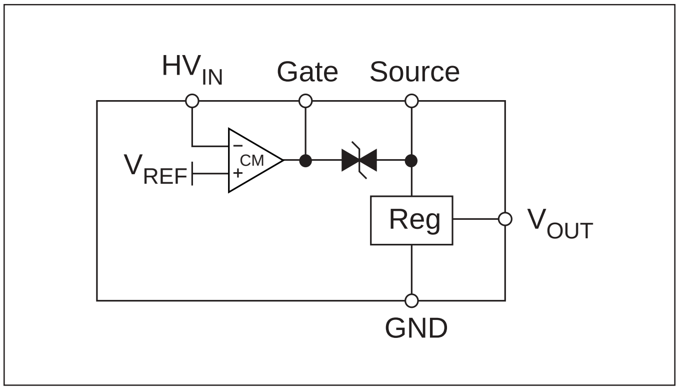


Applications Information

Operating Principle

The SR03x operates by controlling the conduction angle of the external MOSFET as shown in Figure 1. When the rectified AC voltage is below the V_{TH} threshold, the pass transistor is turned on. The pass transistor is turned off when the rectified AC is above $HV_{IN(off)}$. Output voltage (Vunreg) decays during the periods when the switch is off and when the rectified AC is below the output voltage. The amount of decay is determined by the load and the value of C1. Since the switch only conducts with low voltages across it, power dissipation is minimized.

Functional Block Diagram



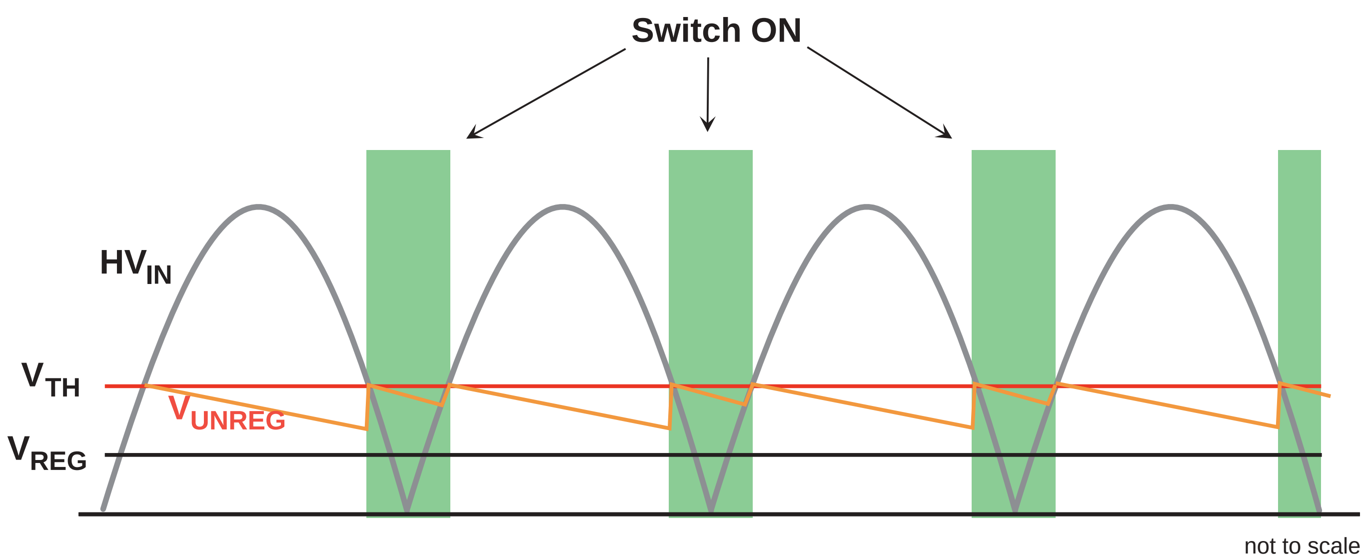


Figure 1: Typical Waveforms

Applications Information, continued

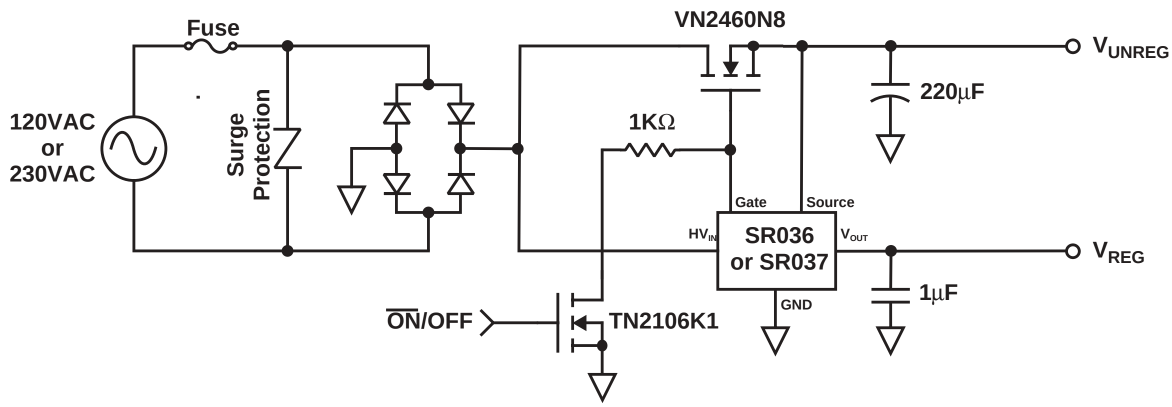


Figure 2: Example Circuit with Enable Control

Figure 2 is an example circuit using the SR036 or SR037 along with a Supertex VN2460N8 MOSFET to generate an unregulated voltage of approximately 18V and a regulated voltage of 3.3V for the SR036 or 5.0V for the SR037. The combined total output current is typically 50mA. The TN2106K1 in series with a 1KΩ resistor can be added for applications requiring an enable control.

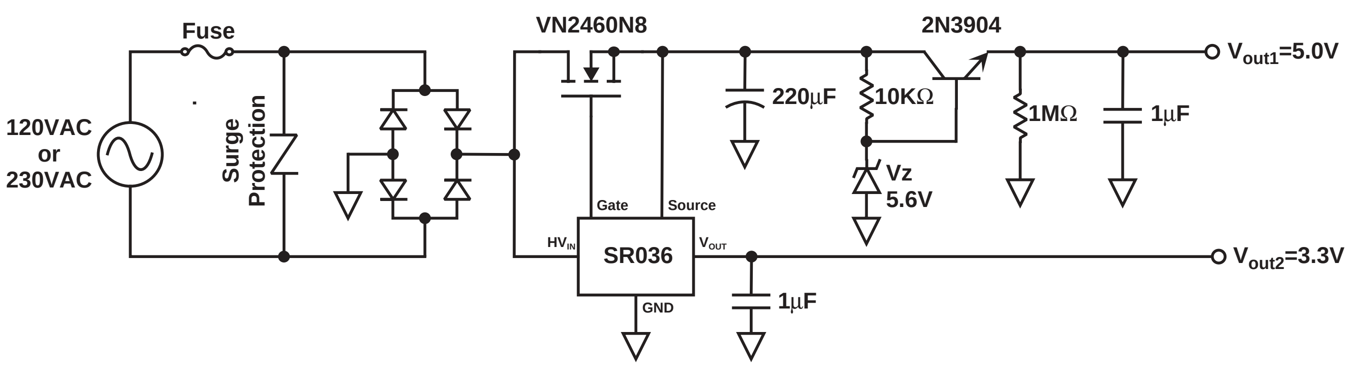


Figure 3: Generating Two Regulated Voltages

For applications requiring two regulated voltages, an inexpensive discrete linear regulator can be added to regulate the unregulated output as show in Figure 3. The discrete linear regulator consists of a Zener diode, a resistor and a bipolar transistor. The regulated voltage, Vout1, is determined by the Zener diode voltage minus the base-to-emitter voltage drop of 0.6V. Figure 3 uses a 5.6V Zener diode to obtain a 5.0V output. Different Zener diode voltages can be used to obtain different regulated output voltages.

Applications Information, continued

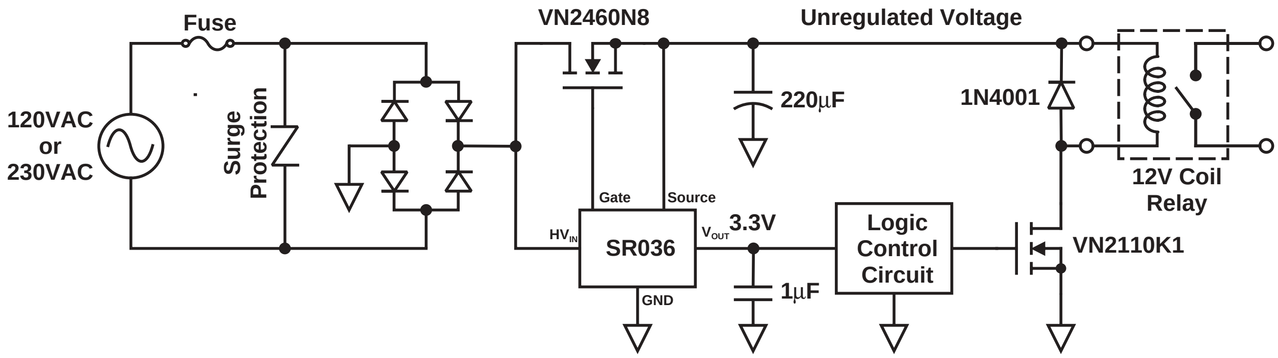


Figure 4: Driving 12V Relay Coils

The circuit shown in Figure 4 uses the SR036 to supply a regulated 3.3V for the logic control circuitry while the unregulated voltage is used to drive a 12V relay coil. The operating voltage for a 12V relay coil is typically very wide and can therefore operate directly from the unregulated line.

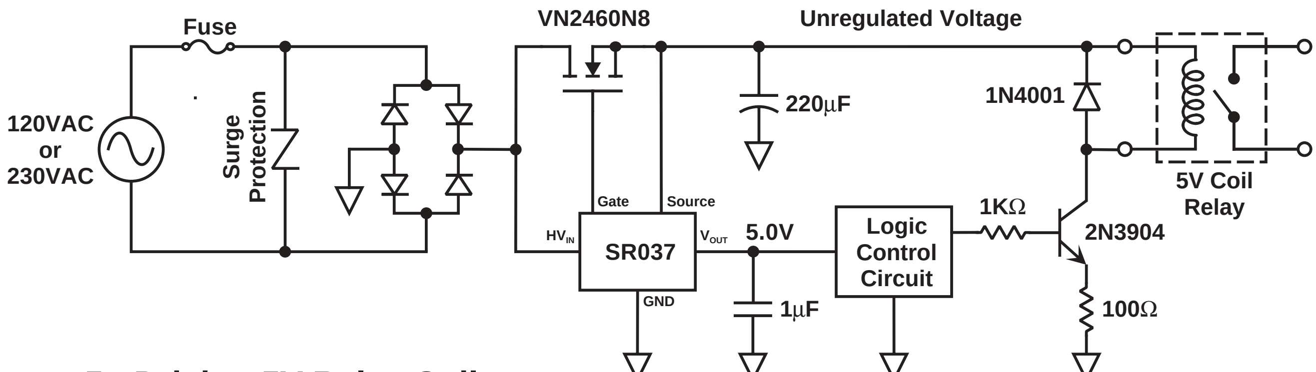


Figure 5: Driving 5V Relay Coils

The circuit shown in Figure 5 uses the SR037 to supply a regulated 5.0V for the logic control circuitry while the unregulated voltage is used to drive a 5.0V coil relay. To overcome the voltage variation of the unregulated line, a bipolar transistor is used to drive the coil with a constant current. The resistor value from the emitter to ground sets the desired coil current. For an arbitrary coil current of 40mA, the resistor value can be calculated as:

$$R = \frac{5.0V - \frac{40mA}{\beta} 1K\Omega - V_{be}}{40mA}, \text{ where } V_{be} = 0.6V \text{ and } \beta = 100$$

$$= 100\Omega$$

Applications Information, continued

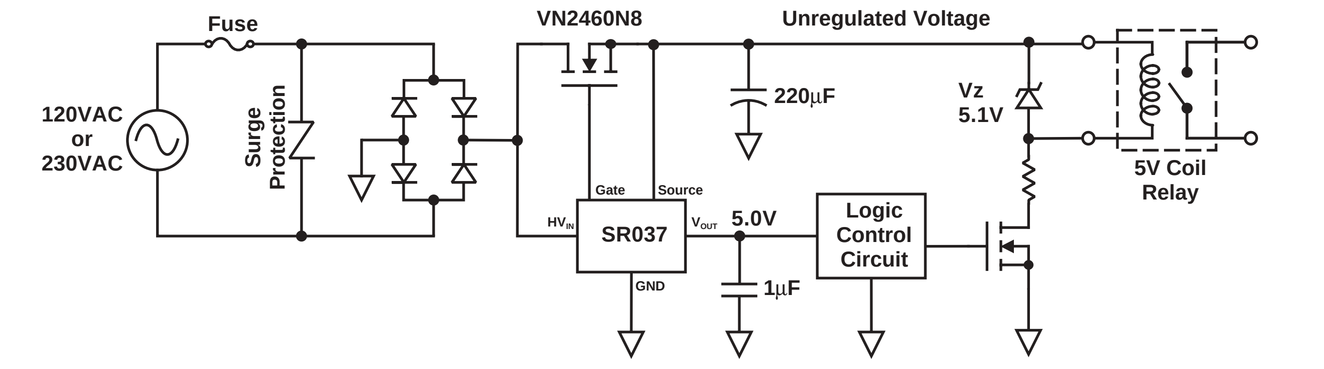


Figure 6: Driving 5V Relay Coils with Zener Diode Clamp

The circuit shown in Figure 6 uses the SR037 to supply a regulated 5.0V for the logic control circuitry. A 5.1V Zener diode is used in parallel with the 5.0V relay coil to ensure that the relay coil's maximum operating voltage is not exceeded. The Zener diode also acts as the catch diode when the coil is switched to the off state. An external series resistor is used to limit the amount of Zener current.

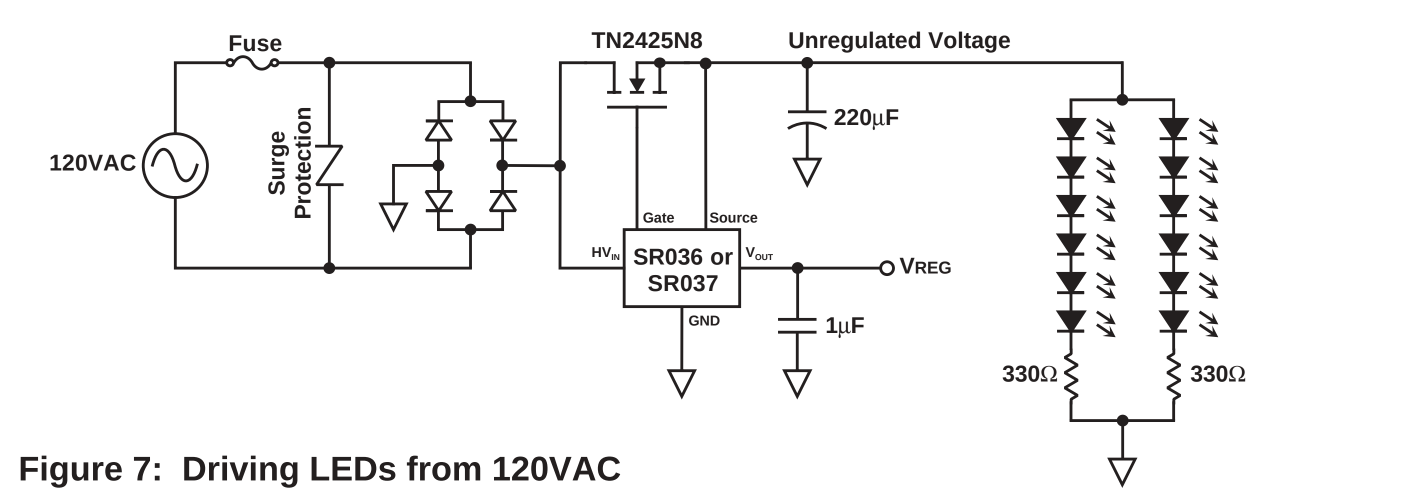


Figure 7: Driving LEDs from 120VAC

The circuit shown in Figure 7 uses the SR036 or SR037 to drive 12 high efficient red LEDs from a 120V AC line. The average LED current is approximately 20mA.

Applications Information, continued

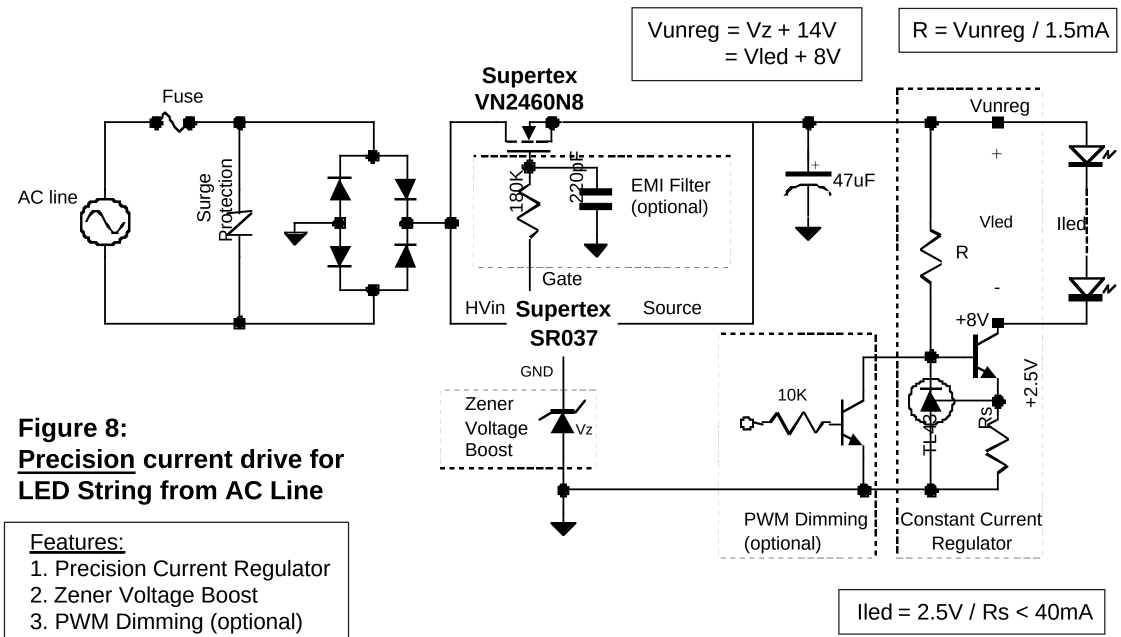


Figure 8:
<u>Precision</u> current drive for LED String from AC Line

<u>Features:</u>
1. Precision Current Regulator
2. Zener Voltage Boost
3. PWM Dimming (optional)
4. EMI Filter (optional)

The circuit uses the SR037or SR036 and VN2460 to drive a string of LEDs from AC power line.
The LED current is regulated at up to 40mA.
The LED string voltage can be up to AC line voltage (120V for 120Vac / 230V for 230VAC).

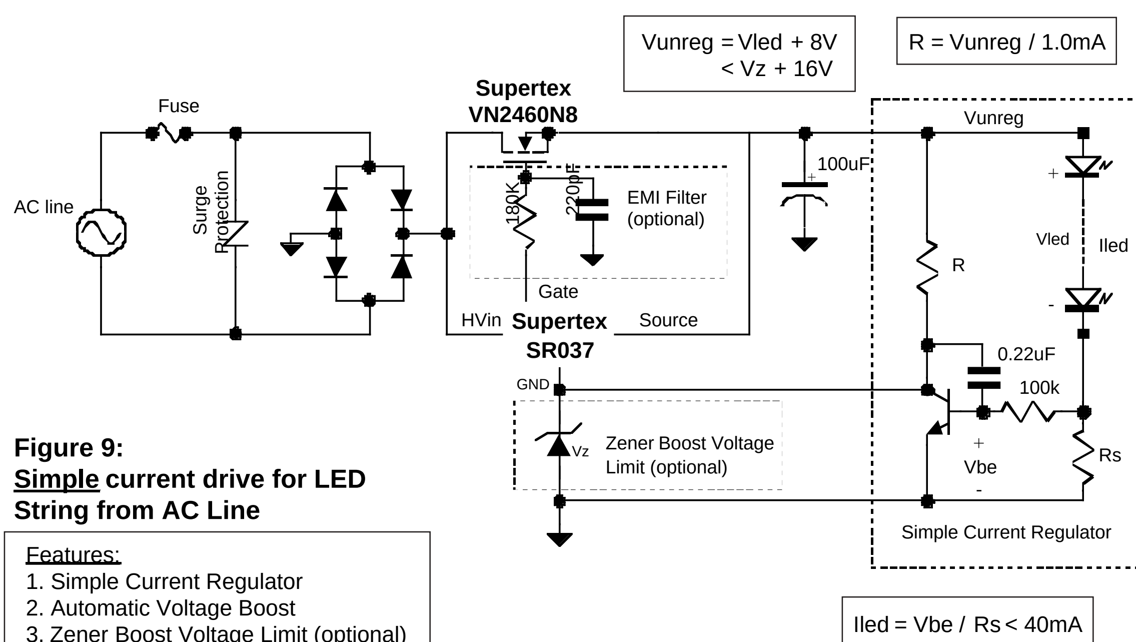


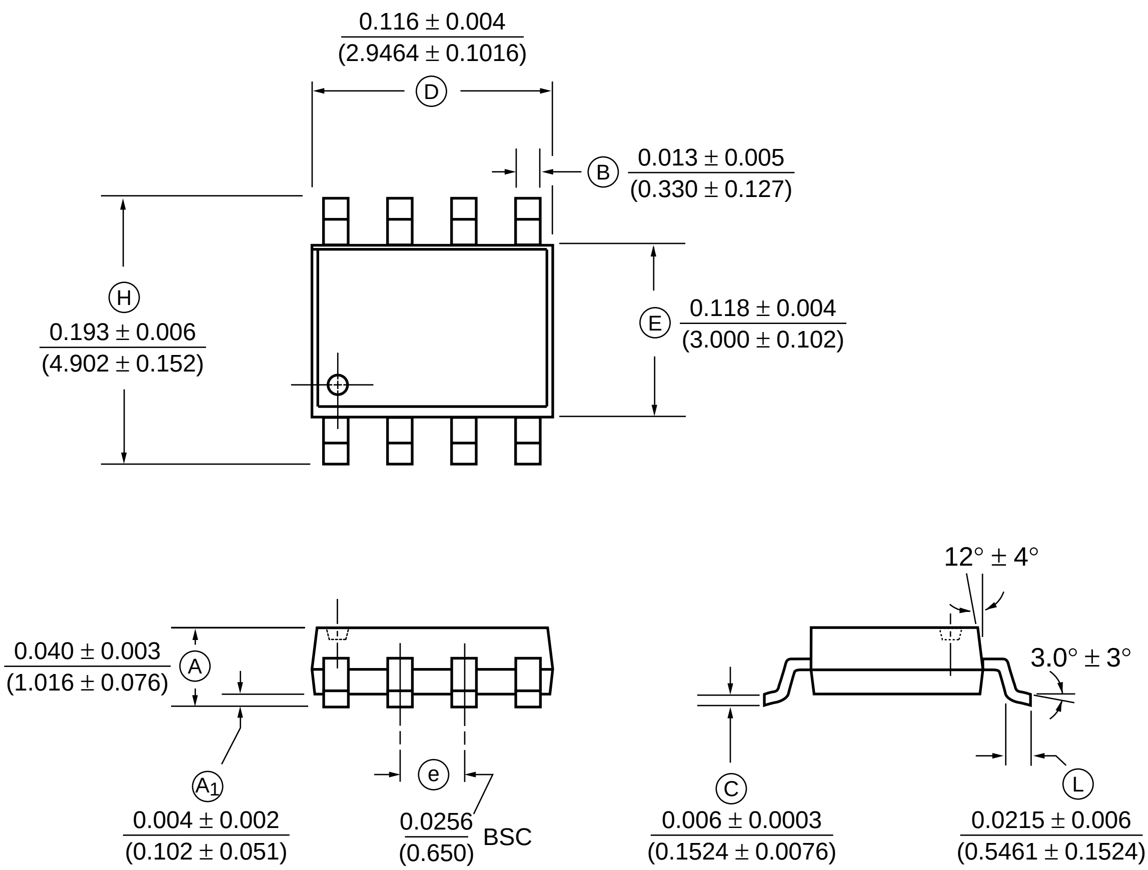
Figure 9:
<u>Simple</u> current drive for LED String from AC Line

<u>Features:</u>
1. Simple Current Regulator
2. Automatic Voltage Boost
3. Zener Boost Voltage Limit (optional)
4. EMI Filter (optional)

The circuit uses the SR037 or SR036 and VN2460 to drive a string of LEDs from AC power line.
The LED current is regulated at up to 40mA.
The LED string voltage can be up to AC line voltage (120V for 120Vac / 230V for 230VAC).

Package Outlines

8-LEAD MSOP PACKAGE OUTLINE (MG)

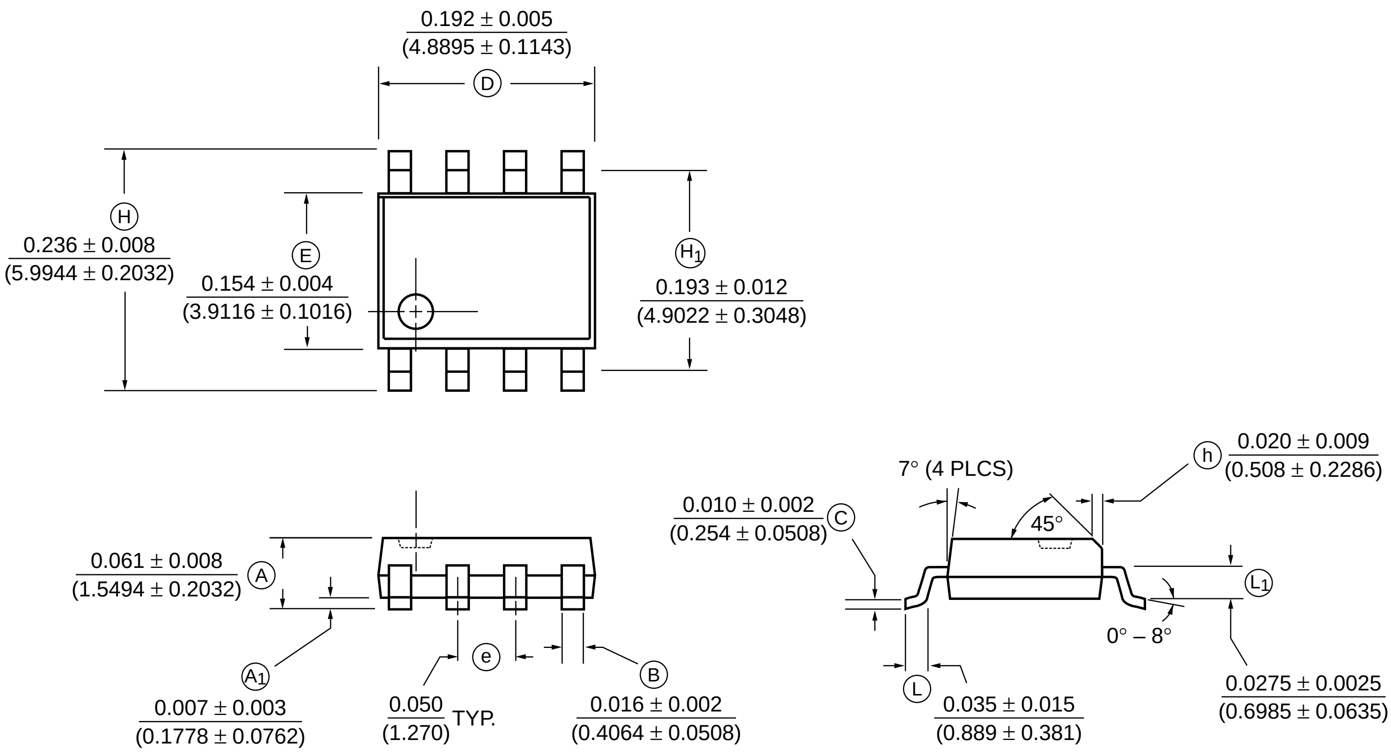


Note: Circle (e.g. Ⓑ) indicates JEDEC Reference.

Measurement Legend = Dimensions in Inches / (Dimensions in Millimeters)

Package Outlines

8-LEAD SMALL OUTLINE PACKAGE WITH HEAT SLUG (SG)



Note: Circle (e.g. (B)) indicates JEDEC Reference.

Measurement Legend = Dimensions in Inches / (Dimensions in Millimeters)

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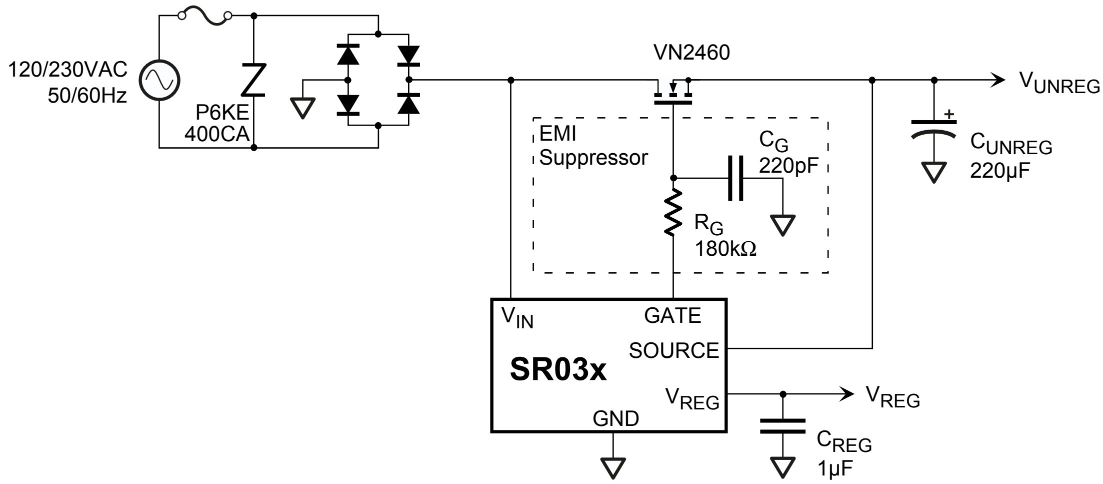
SR03x EMI Reduction

SR03-based power supplies may create conducted EMI into the AC power line that exceeds FCC and CISPR requirements. This bulletin describes one technique to reduce EMI, allowing SR03-based supplies to comply with applicable requirements.

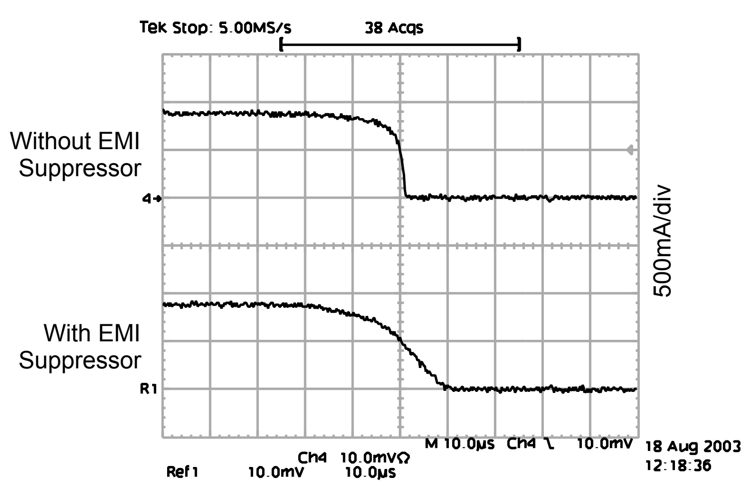
Conducted EMI is largely due to the short, high-current pulse imposed on the AC line when the pass MOSFET turns on. Smoothing out this current pulse reduces the harmonic content of the current drawn from the AC line, thus reducing conducted EMI. Placing a simple RC filter before the MOSFET gate smoothes out the pulse.

EMI Supressor Circuit



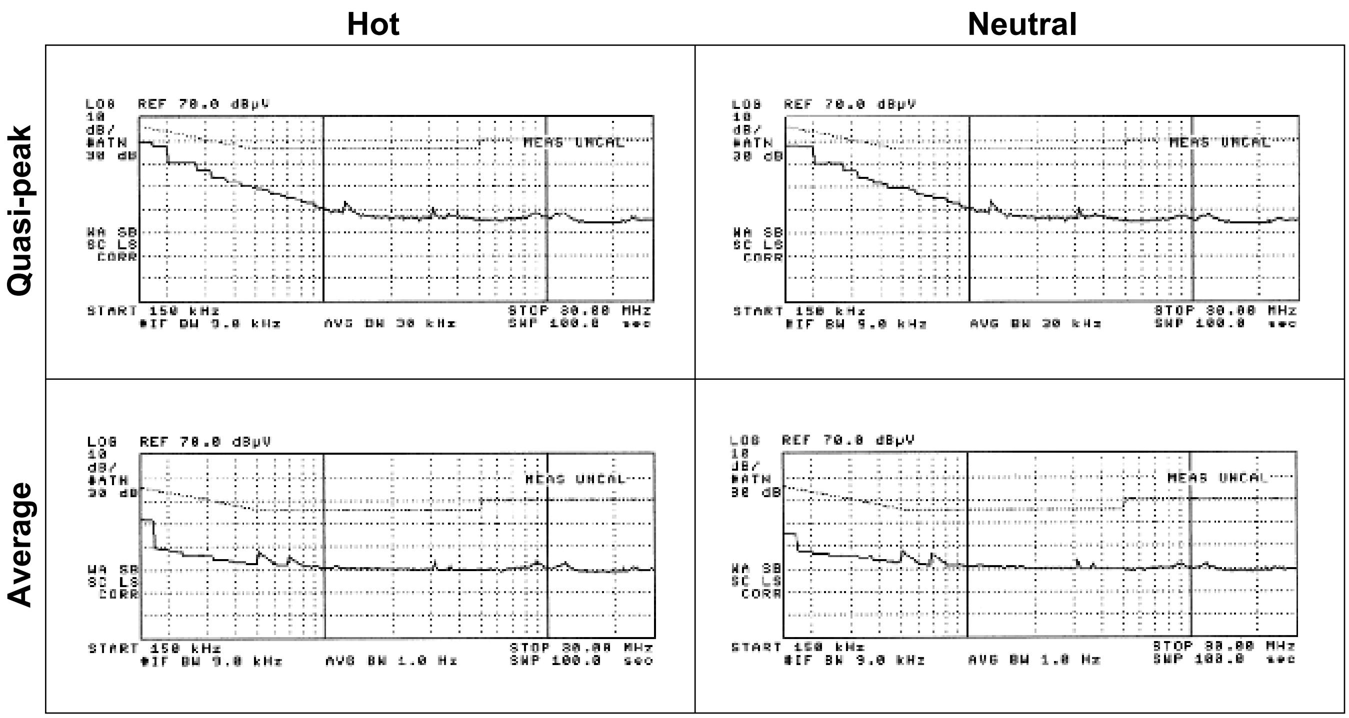
The values for R_G and C_G may need adjustment depending on the characteristics of the chosen MOSFET and the value of C_{UNREG}. (Higher values of C_{UNREG} generally produce higher EMI as capacitor recharge times are shorter.) The idea is to select values of R and C to soften the edges of the current pulse, as shown below. It may be tempting to forego C_G, relying instead on the MOSFETs' input capacitance. However, high dV/dt when first plugged in may cause the MOSFET to turn on due to C_{RSS}, damaging the FET. C_G protects against this possibility. Note that extending the turn-off time increases the voltage drop across the FET, decreasing efficiency somewhat.

AC Line Current – Turn-off Edge



The following spectrums show the effect of the EMI suppression technique.

120VAC/60Hz Limits per 47CFR15.107 for Class B devices. 45mA total load.



208VAC/60Hz (230VAC/50Hz not available) Limits per CISPR 14-1 for household appliances. 20mA total load.