

## Inductorless, Dual Output Off-Line Regulators

### Features

- ▶ Accepts peak input voltages up to 700V
- ▶ Operates directly off of rectified 120 or 230VAC
- ▶ Integrated linear regulator
- ▶ Minimal power dissipation
- ▶ No high voltage capacitors required
- ▶ No transformers or inductors required
- ▶ Up to 1.0W output power

### Applications

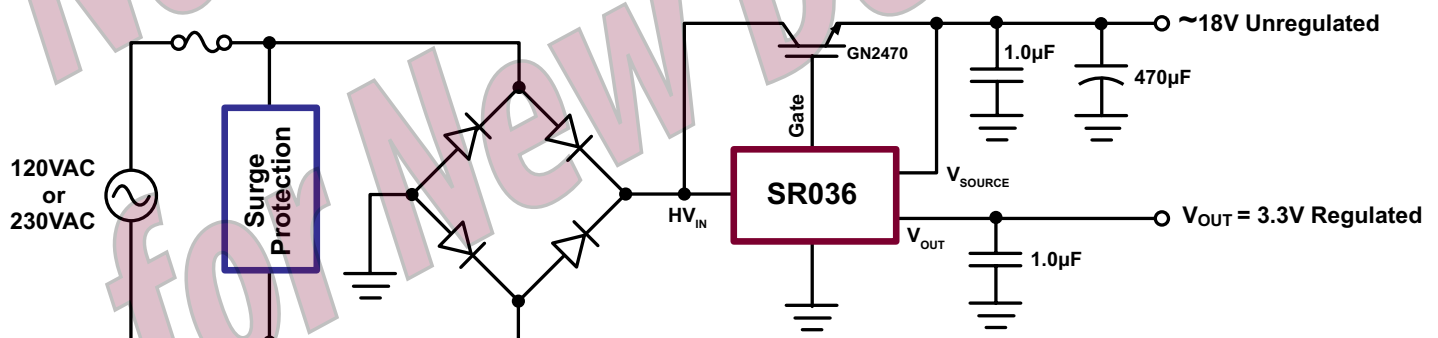
- ▶ 3.3V power supplies
- ▶ SMPS house keeping power supplies
- ▶ White goods
- ▶ Appliances
- ▶ Small off-line low voltage power supplies
- ▶ Lighting controls

### General Description

The Supertex SR036 is an inductorless, dual output off-line controller providing up to 1.0W of output power. It does 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 or IGBT. When  $HV_{IN}$  is less than 45V, the external transistor 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 transistor is turned off. The maximum gate voltage for the external transistor is 24V. The unregulated voltage is approximately 18V. The SR036 also provides a regulated 3.3V.

***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***

### Typical Application Circuit



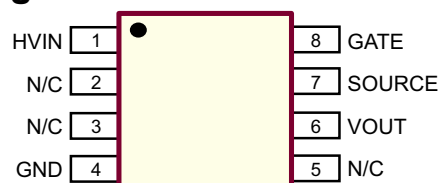
## Ordering Information

| Device | 8-Lead MSOP<br>3.00x3.00mm body<br>1.10mm height (max)<br>0.65mm pitch | 8-Lead SOIC<br>w/ Heat Slug<br>4.90x3.90mm body<br>1.70mm height (max)<br>1.27mm pitch |
|--------|--|--|
| SR036  | SR036MG-G  | SR036SG-G  |

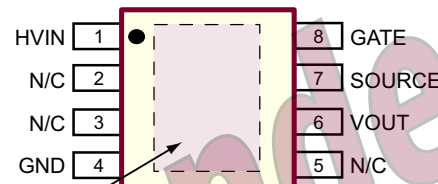
-G indicates package is RoHS compliant ('Green')



## Pin Configuration



8-Lead MSOP (MG)



8-Lead SOIC w/ Heat Slug (SG)

(top view)

Make NO electrical connections to backside plate!

## Absolute Maximum Ratings

| Parameter                      | Value             |
|--------------------------------|-------------------|
| $V_{IN}$ , High voltage input  | +700V             |
| $V_{OUT}$ , Low voltage output | +6.0V             |
| Storage temperature            | -65°C to +150°C   |
| Soldering temperature          | +300°C            |
| Power dissipation, 8-Lead MSOP | 300mW             |
| Power dissipation, 8-Lead SOIC | 1.5W <sup>1</sup> |

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.

- When underside plate soldered to 2cm<sup>2</sup> of exposed copper.

## Product Marking

Top Marking

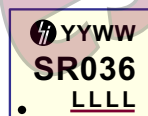


L = Lot Number  
YY = Year Sealed  
WW = Week Sealed  
— = "Green" Packaging

Bottom Marking



8-Lead MSOP (MG)



YY = Year Sealed  
WW = Week Sealed  
L = Lot Number  
— = "Green" Packaging

8-Lead SOIC w/ Heat Slug (SG)

## Electrical Specifications (Over operating supply voltages unless otherwise noted, $T_A = 0^\circ\text{C}$ to +125°C)

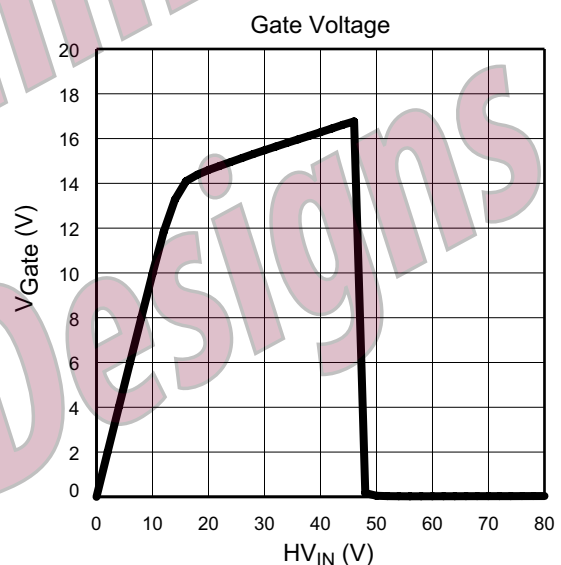
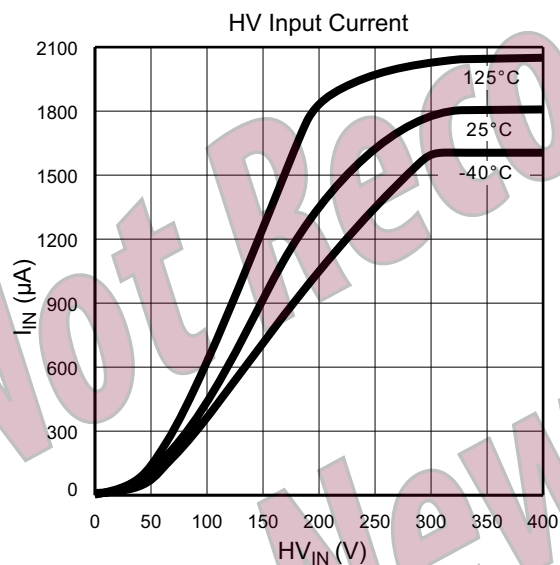
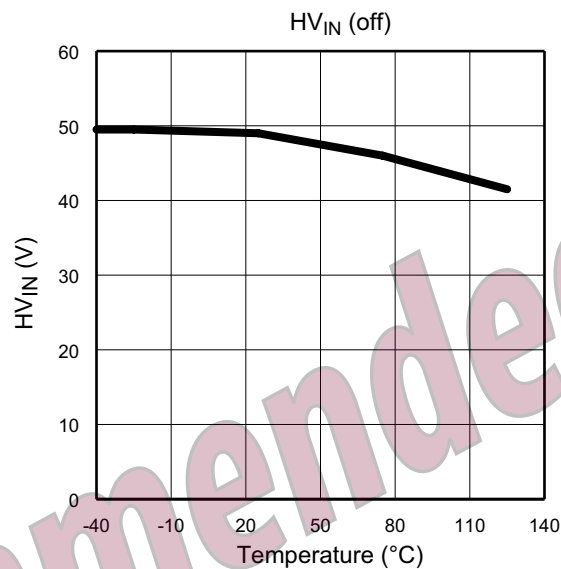
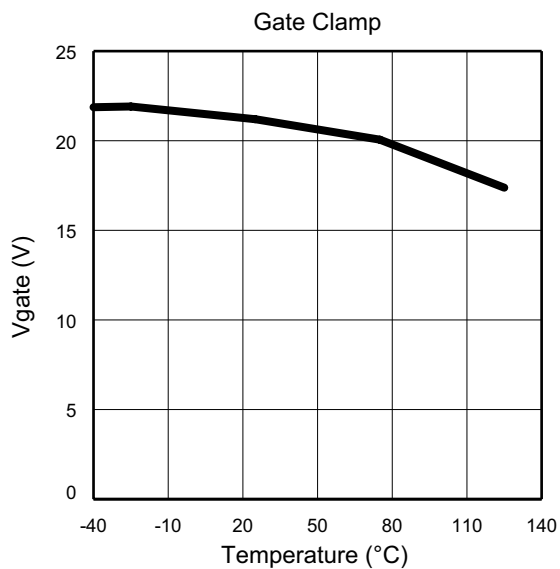
| Sym              | Parameter                                       | Min  | Typ  | Max  | Units | Conditions   |
|------------------|---|------|------|------|-------|--|
| $HV_{IN}$        | Input voltage                                   | -    | -    | 700  | V     | Peak transient voltage                                       |
|                  |   | -    | -    | 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     | $I_{GS} = \pm 100\mu\text{A}$                                |
| $V_{GATE}$       | Gate to ground clamp voltage                    | 18   | 20   | 24   | V     | ---  |
| $V_{OUT}$        | Regulated output voltage for the 8-Lead SOIC    | 2.97 | 3.30 | 3.63 | V     | $V_{SOURCE} = 10\text{V}$                                    |
| $\Delta V_{OUT}$ | $V_{OUT}$ load regulation                       | -    | 20   | 120  | mV    | $V_{SOURCE} = 10\text{V}, I_{LOAD} = 0$ to 50mA <sup>1</sup> |
| Freq             | Input AC frequency                              | 40   | -    | 100  | Hz    | ---  |

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

$$P \approx \frac{V_{IN}^2}{185k\Omega} + (16V - V_{OUT}) \cdot I_{OUT}$$

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

Typical Performance Curves



## Application Information

### Operating Principle

The SR036 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 ( $V_{UNREG}$ ) 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

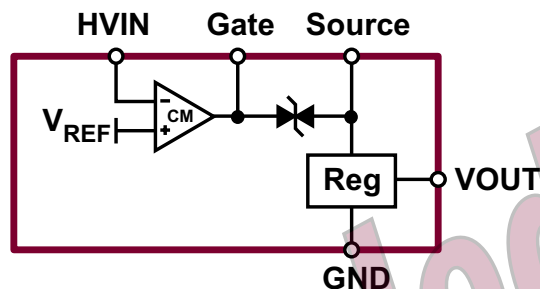
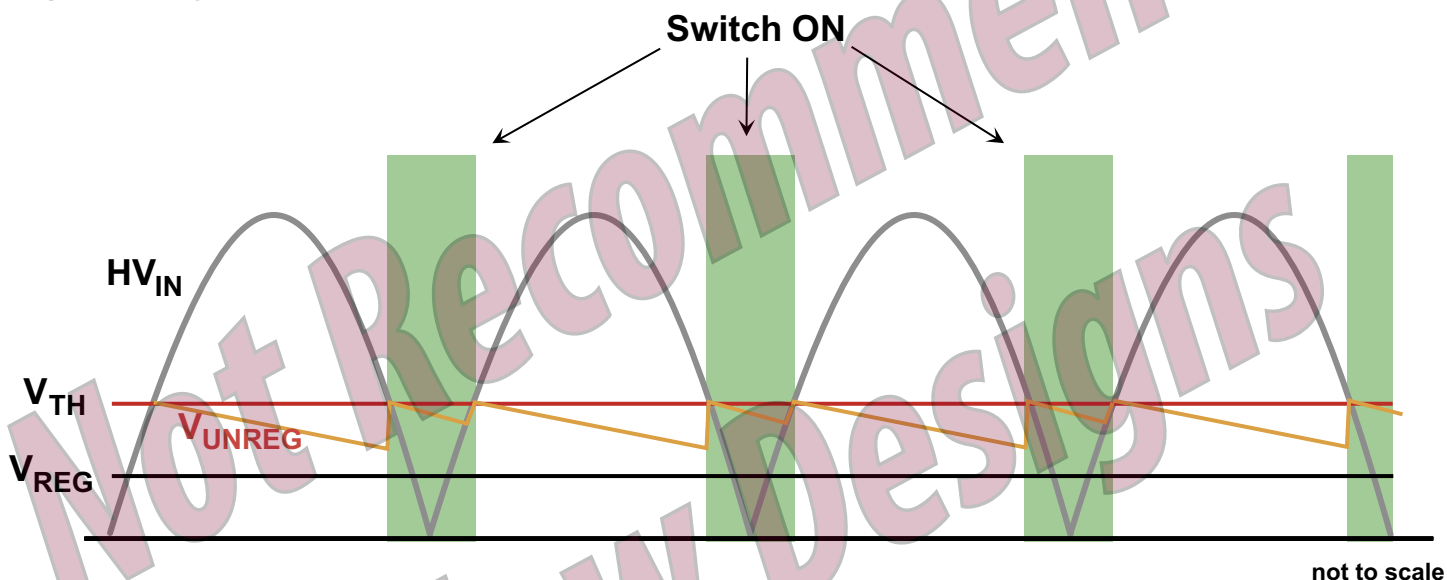


Figure 1. Typical Waveforms



### Power dissipation

Power dissipation in the SR036 is from 2 sources. The first is due to the bias current (or overhead) required to operate the device. This may be calculated from  $P_{BIAS} = V_{IN}^2 / 185k\Omega$ , where  $V_{IN}$  is the input voltage in  $V_{RMS}$ . The second source of power dissipation is the 3.3V linear regulator and may be calculated from  $P_{REG} = (16V - V_{OUT}) * I_{REG}$ , where  $V_{OUT}$  is 3.3V, and  $I_{REG}$  is the load current on the 3.3V output. The total power dissipated by the SR036 is the sum of these two:  $P_{BIAS} + P_{REG}$ . (These equations are conservative – actual dissipation may be less.)

To adequately dissipate the power, the underside plate of the SR036SG should be soldered to at least 2.0cm<sup>2</sup> of exposed copper area on the PCB.

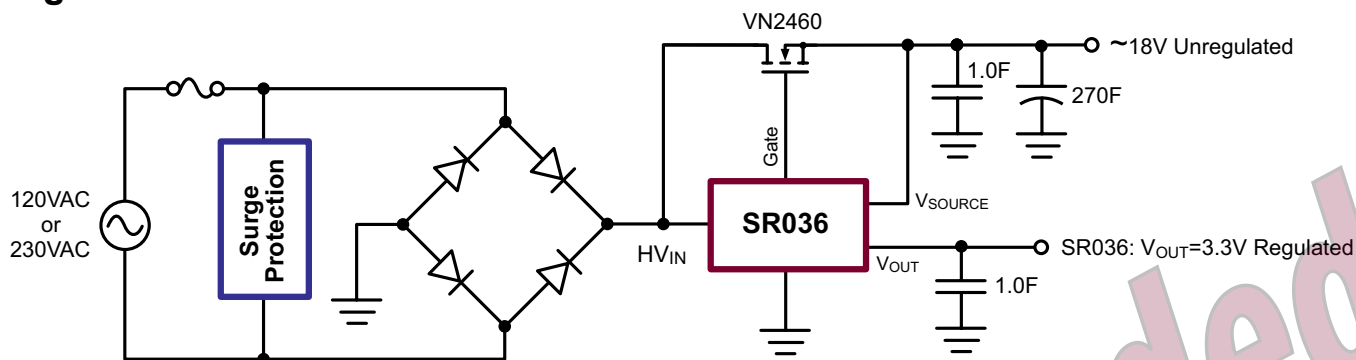
Power is also dissipated by the pass transistor. Power dissipated by the transistor will be  $(16V * I_{TOTAL}) * (1/Eff - 1)$  where  $I_{TOTAL}$  is the sum of the load currents on the regulated and unregulated outputs and Eff is the converter efficiency (0.30 to be conservative). The transistor should be soldered to at least 5.0cm<sup>2</sup> of exposed copper area on the PCB for heat-sinking.

### Transformers

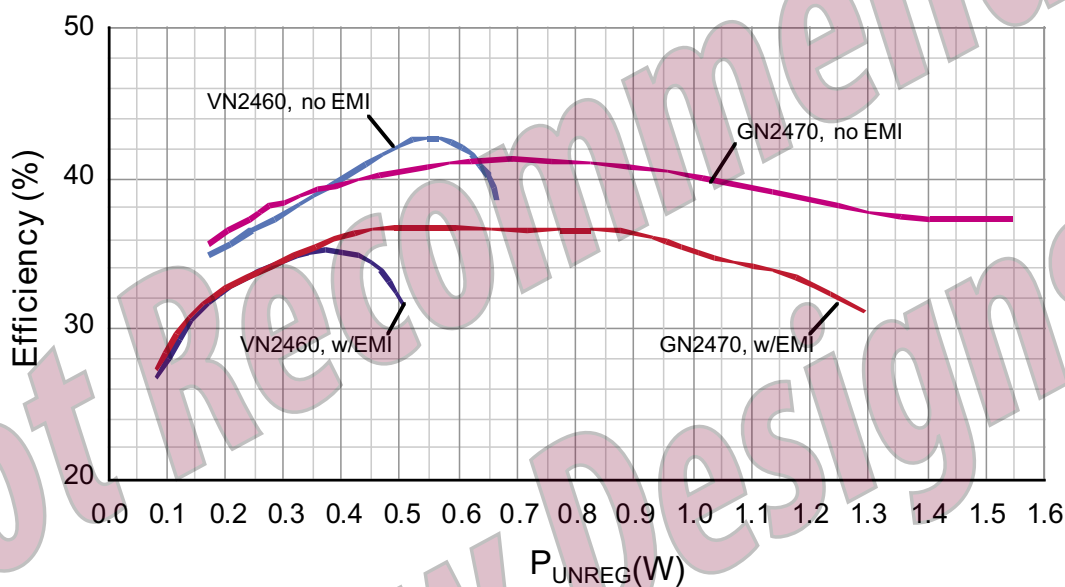


*Do not use a transformer - either fixed or variable - on the AC line. The inductance of the transformer interferes with the normal operation of the SR036.*

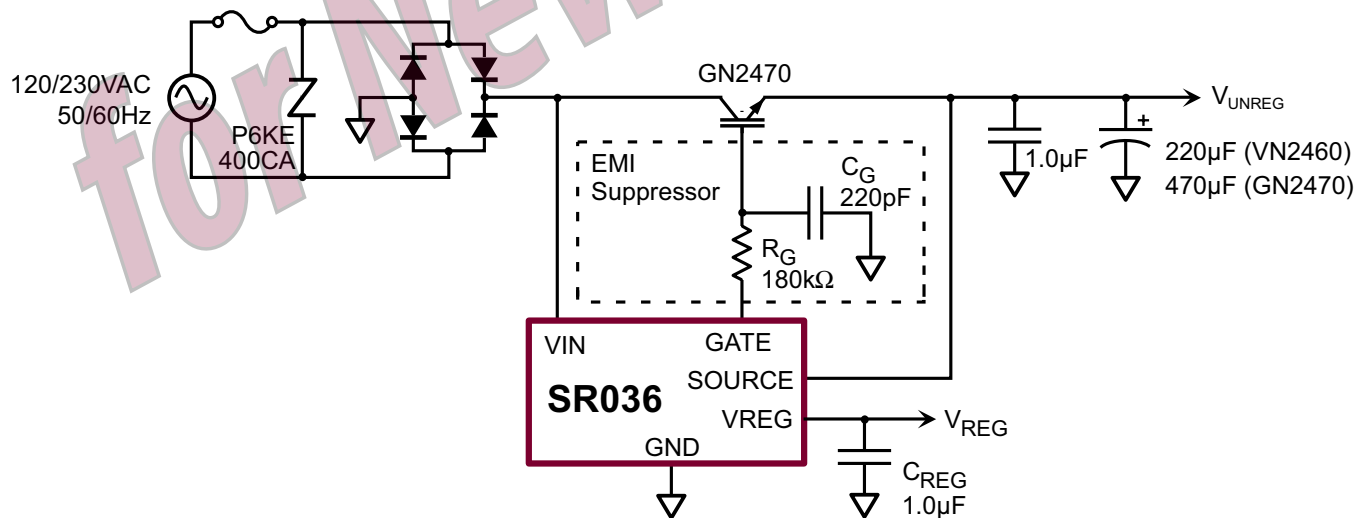
Using a MOSFET in Place Of an IGBT



SR036 Efficiency



Efficiency and EMI Test Circuit



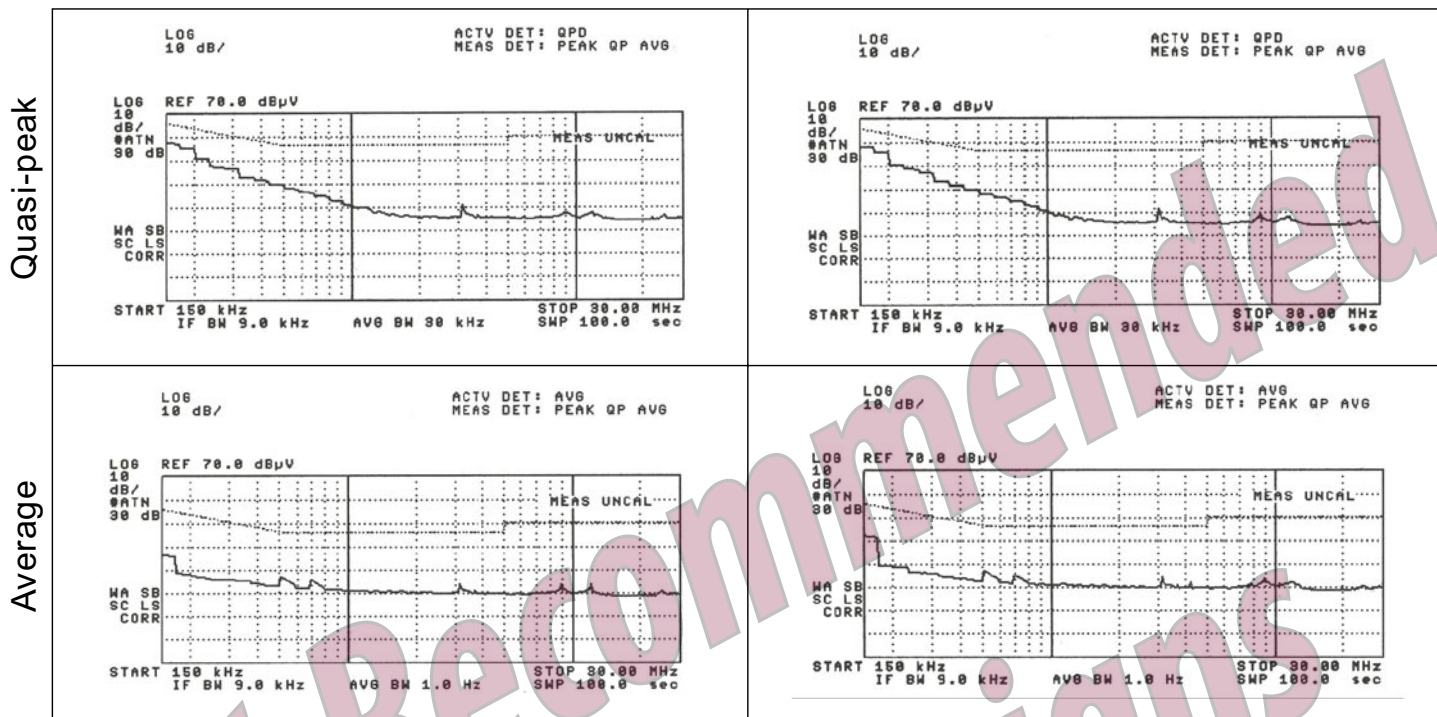


SR036 Circuit Using VN2460 (with EMI Supression Circuit)

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

Hot

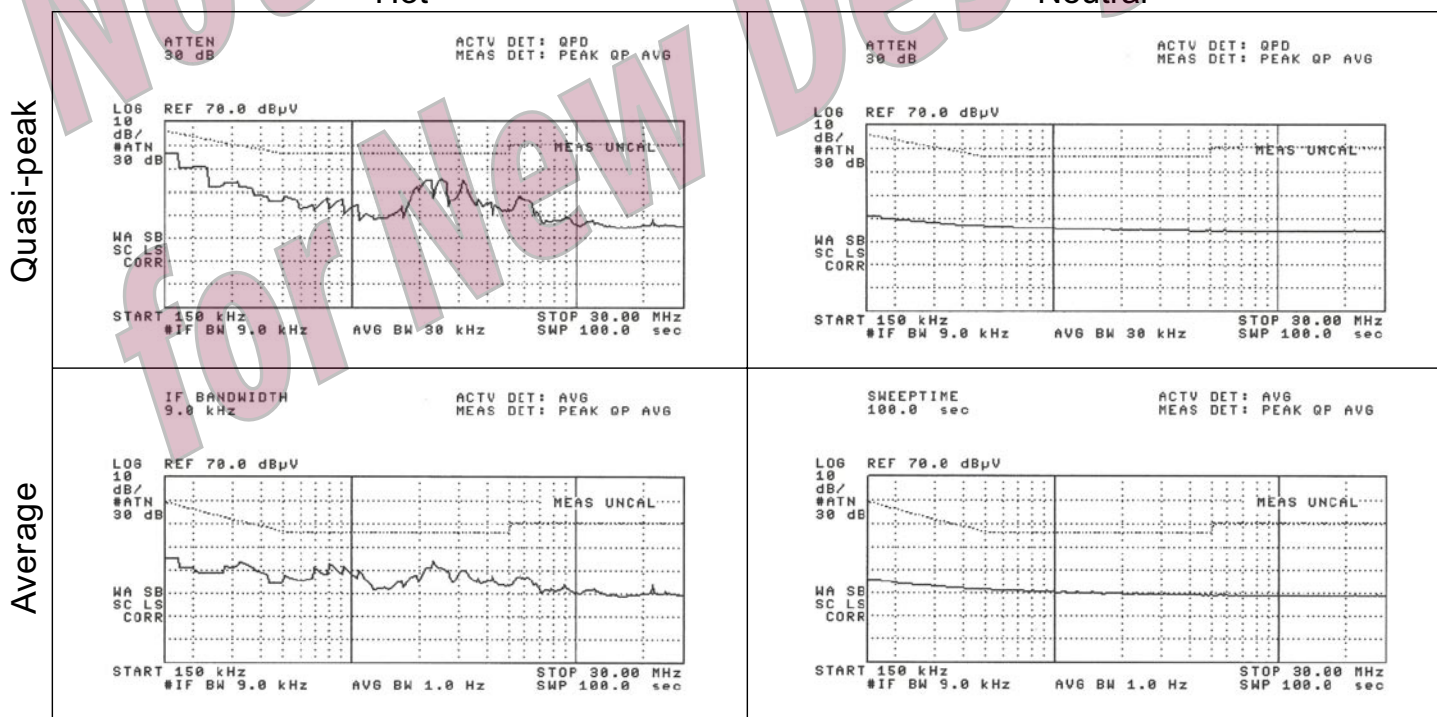
Neutral



208VAC/60Hz (230VAC/50Hz not available) - Limits per CISPR 14-1 for household appliances. 23mA total load.

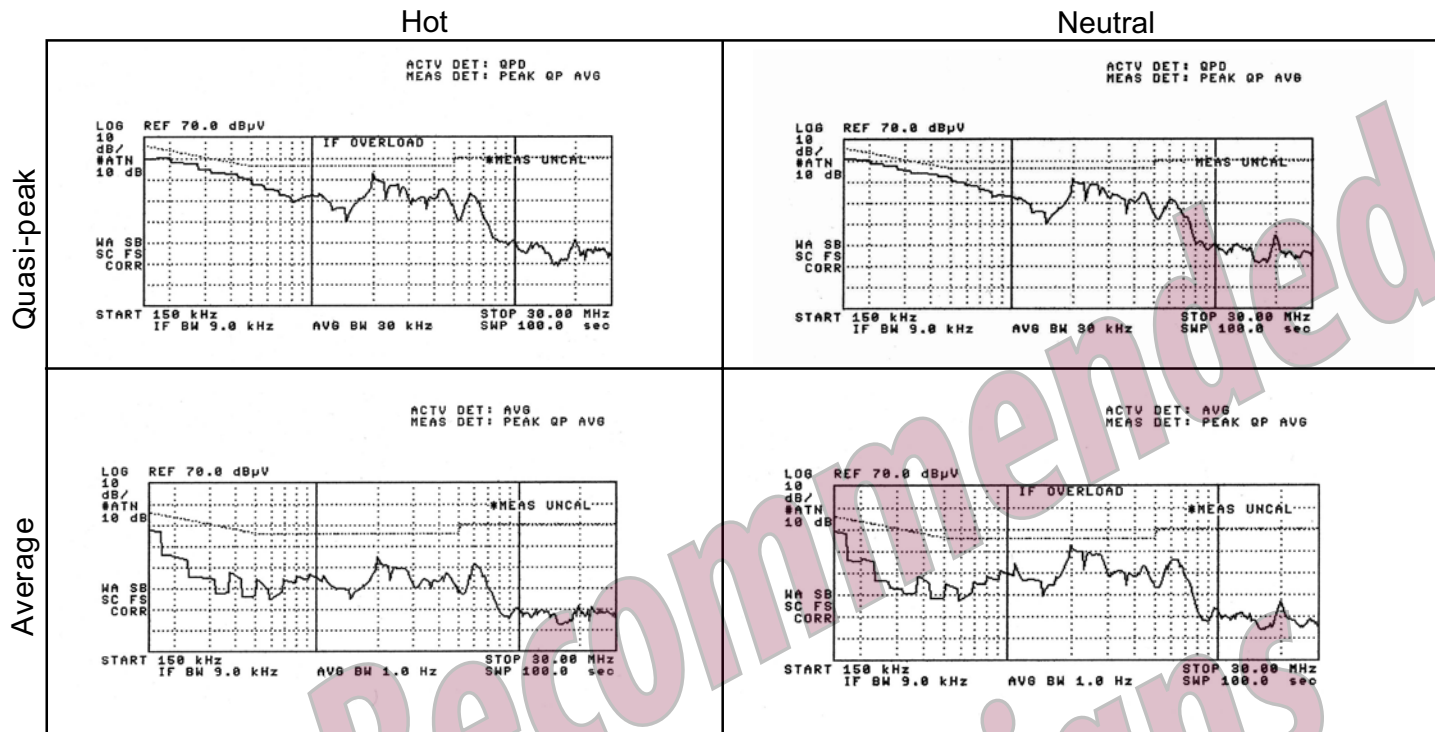
Hot

Neutral

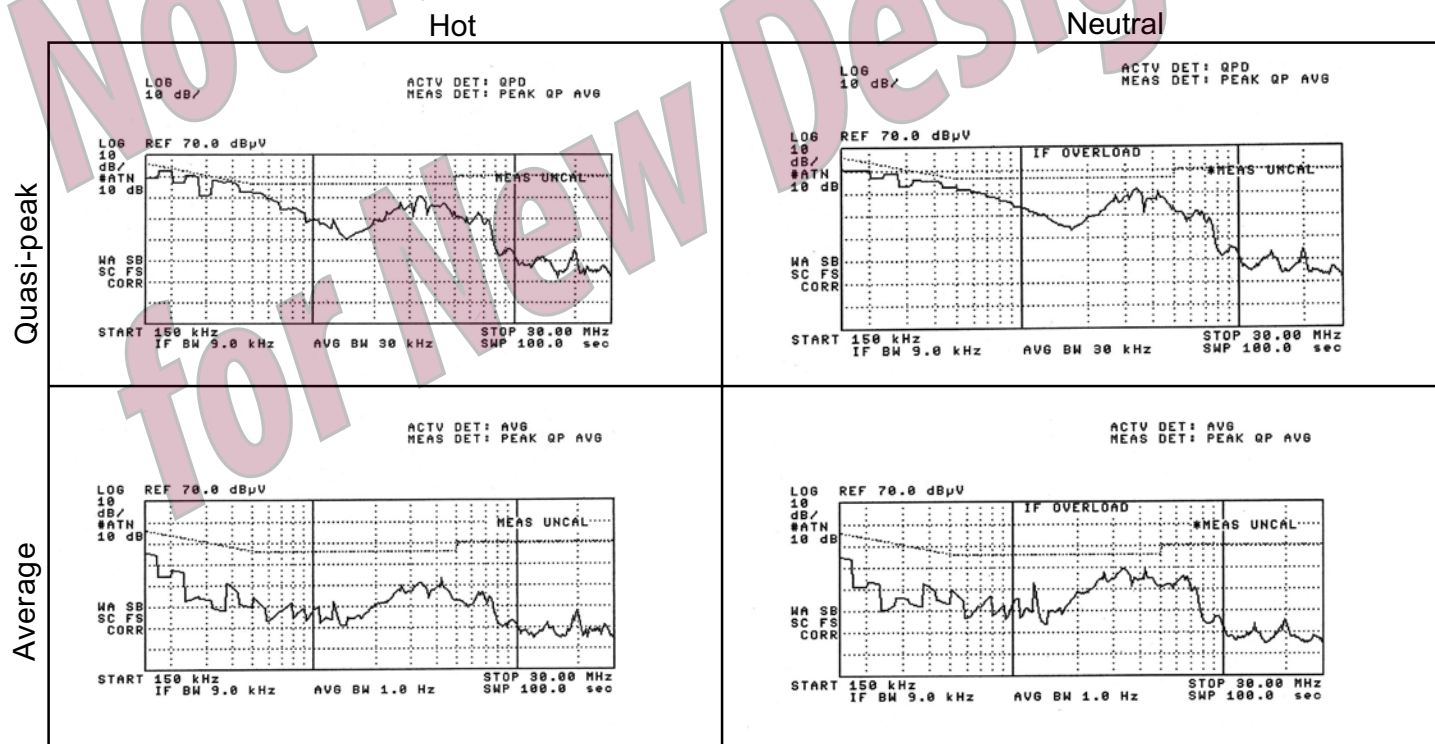


SR036 Circuit Using GN2470 (no EMI Suppressor)

120VAC/60Hz - Limits per 47CFR15.107 for Class B devices. 50mA total load.

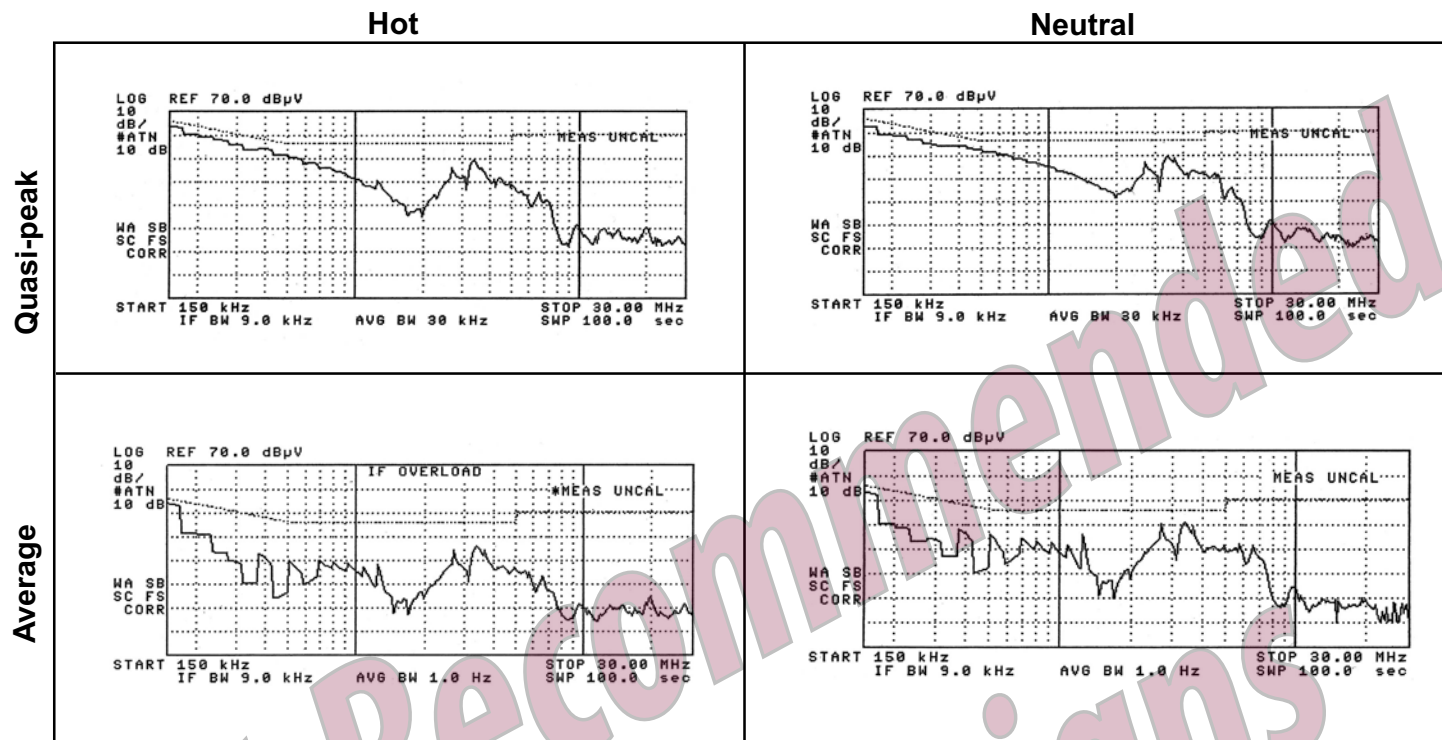


208VAC/60Hz - (230VAC/50Hz not available). Limits per CISPR 14-1 for household appliances. 25mA total load.



SR036 Circuit Using GN2470 (no EMI Suppressor)

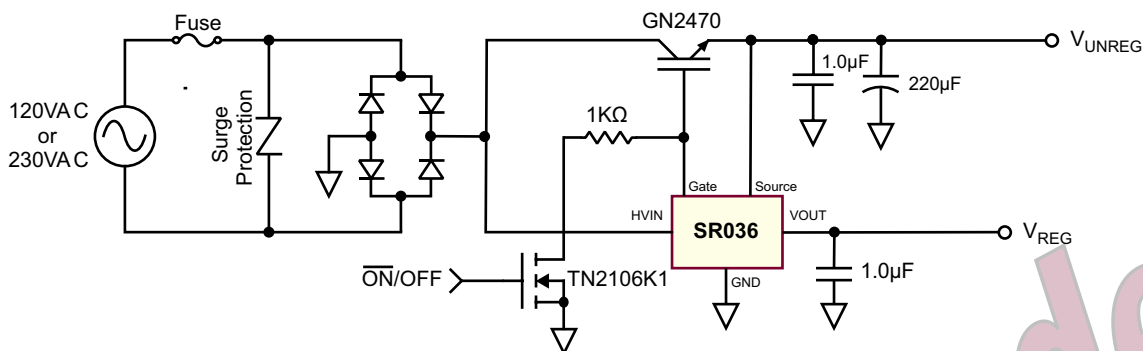
120VAC/60Hz - Limits per 47CFR15.107 for Class B devices. 100mA total load.



Not Recommended for New Designs



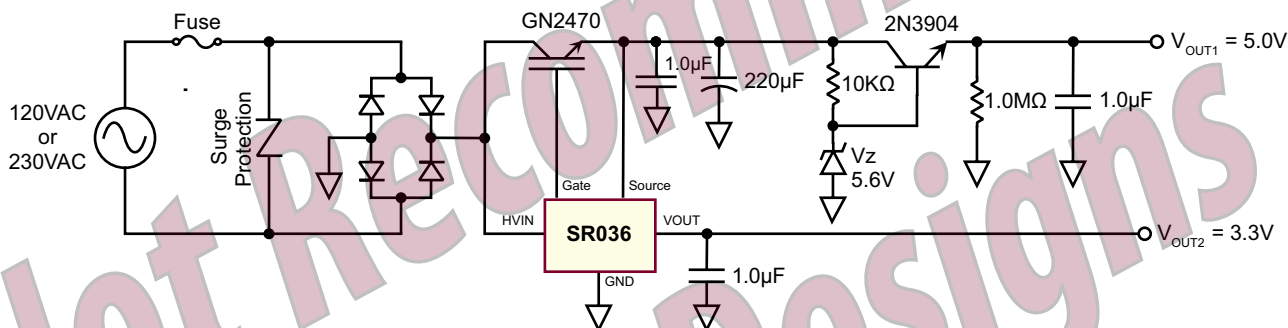
Application Information (cont.)



**Figure 2: Example Circuit with Enable Control**

Figure 2 is an example circuit using the SR036 along with a Supertex GN2470 IGBT to generate an unregulated voltage of approximately 18V and a regulated voltage of 3.3V.

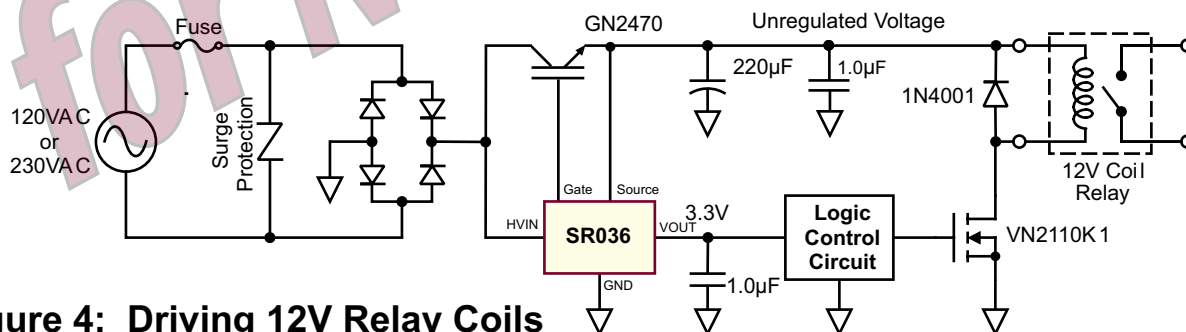
The combined total output current is typically 50mA. The TN2106K1 in series with a 1.0KΩ resistor can be added for applications requiring an enable control.



**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,  $V_{OUT1}$ , 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.



**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 operat-

ing voltage for a 12V relay coil is typically very wide and can therefore operate directly from the unregulated line.

Application Information (cont.)

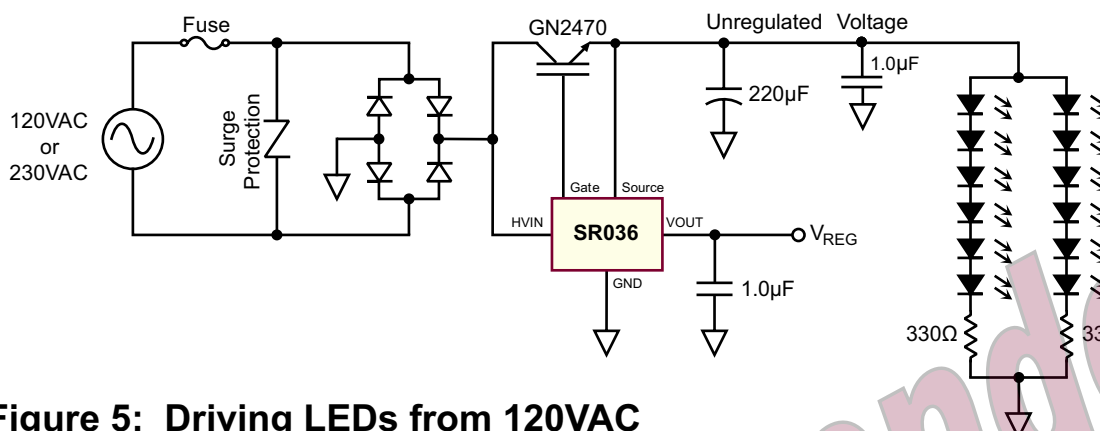


Figure 5: Driving LEDs from 120VAC

The circuit shown in Figure 5 uses the SR036 to drive 12 high efficiency red LEDs from an AC line. The average LED current is approximately 20mA.

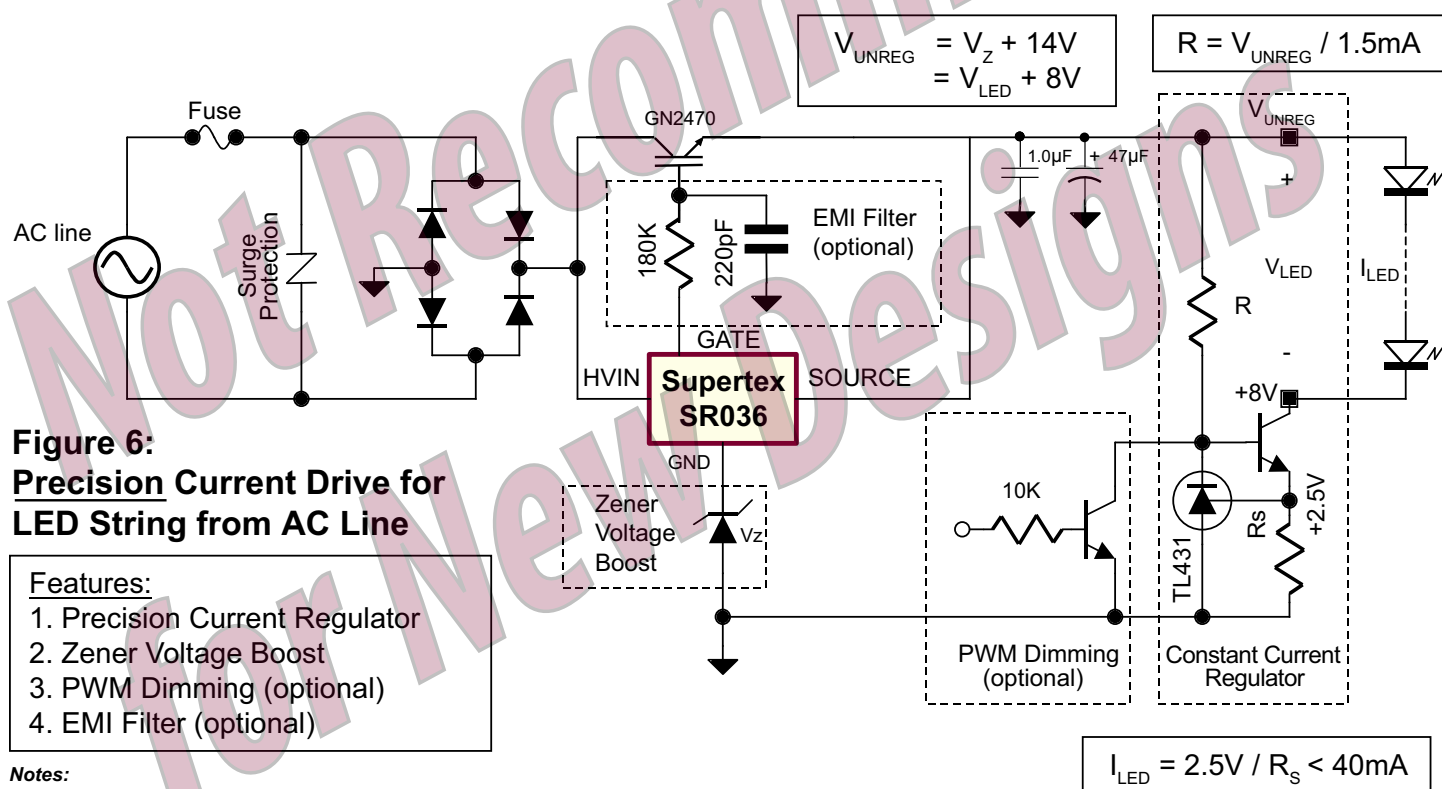


Figure 6: Precision Current Drive for LED String from AC Line

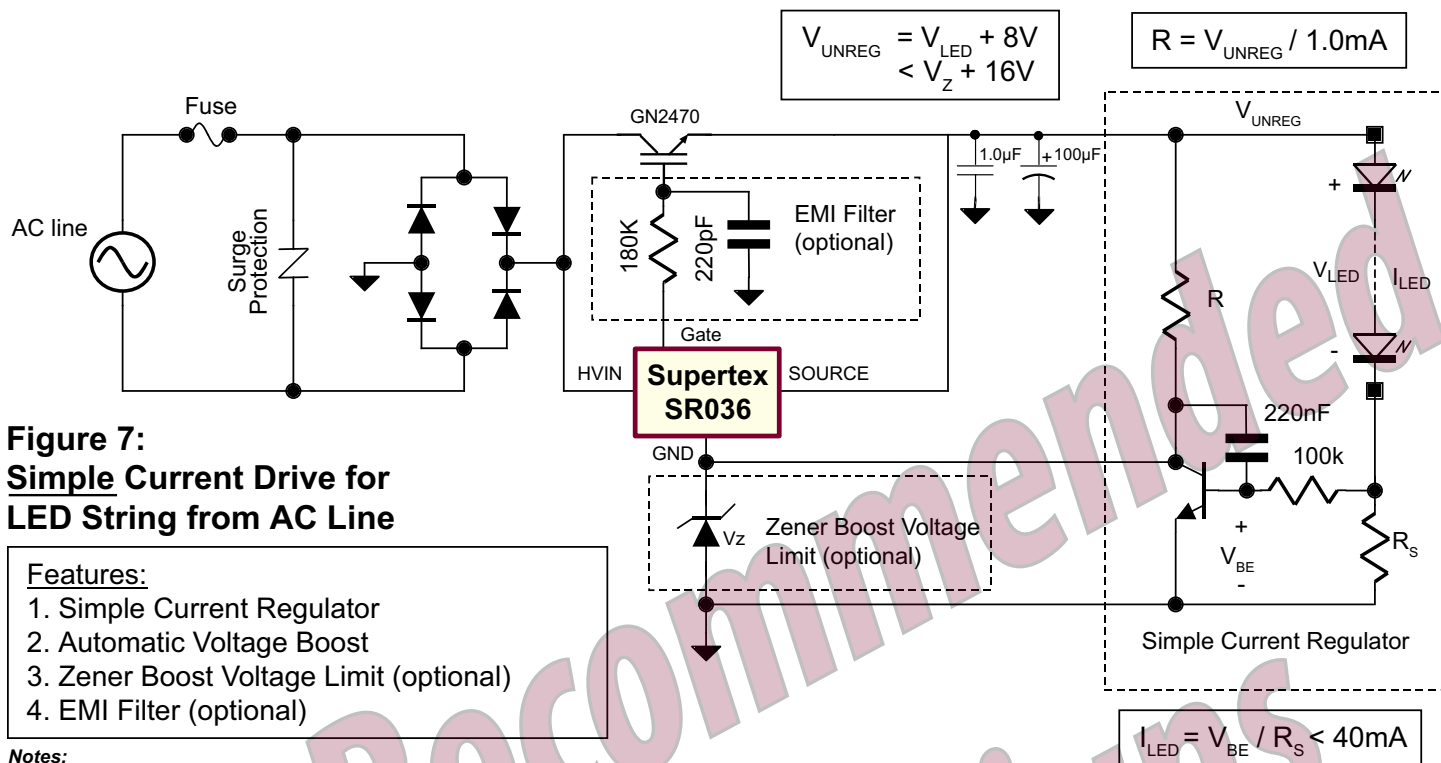
Features:

1. Precision Current Regulator
2. Zener Voltage Boost
3. PWM Dimming (optional)
4. EMI Filter (optional)

Notes:

1. The circuit uses the SR036 and GN2470 to drive a string of LEDs from AC power line.
2. The LED current is regulated at up to 40mA.
3. The LED string voltage can be up to AC line voltage (120V for 120VAC / 230V for 230VAC).

Application Information (cont.)



**Figure 7:**  
**Simple Current Drive for LED String from AC Line**

**Features:**

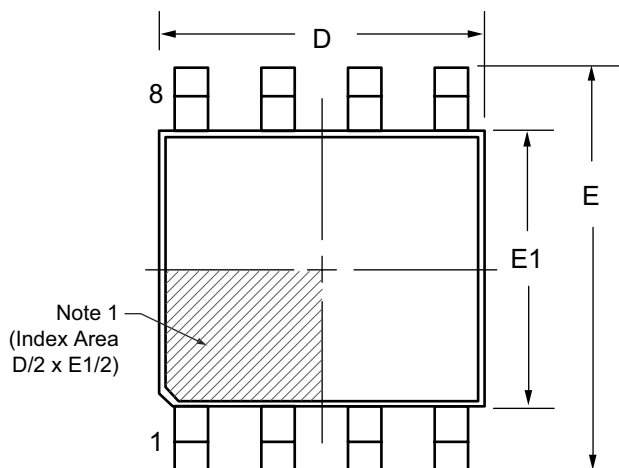
1. Simple Current Regulator
2. Automatic Voltage Boost
3. Zener Boost Voltage Limit (optional)
4. EMI Filter (optional)

**Notes:**

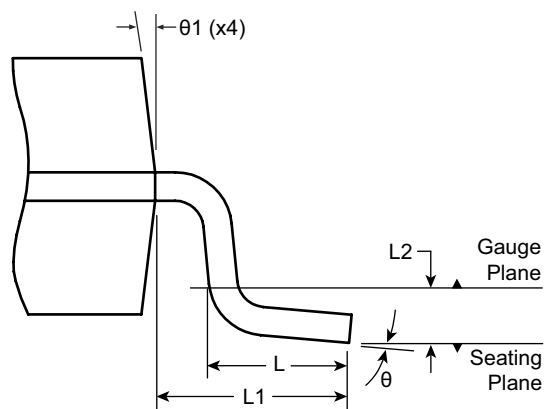
1. The circuit uses the SR036 and GN2470 to drive a string of LEDs from AC power line.
2. The LED current is regulated at up to 40mA.
3. The LED string voltage can be up to AC line voltage (120V for 120VAC / 230V for 230VAC).

# 8-Lead MSOP Package Outline (MG)

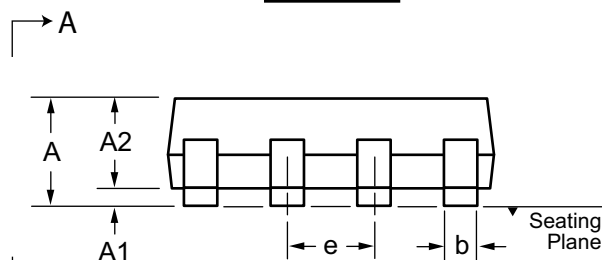
3.00x3.00mm body, 1.10mm height (max), 0.65mm pitch



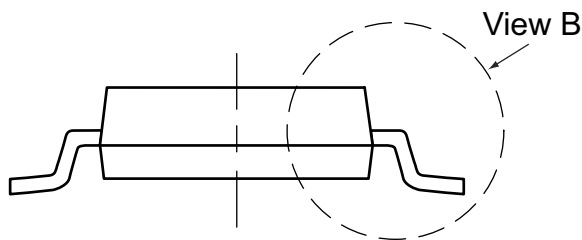
**Top View**



**View B**



**Side View**



**View A-A**

**Note:**  
1. 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.

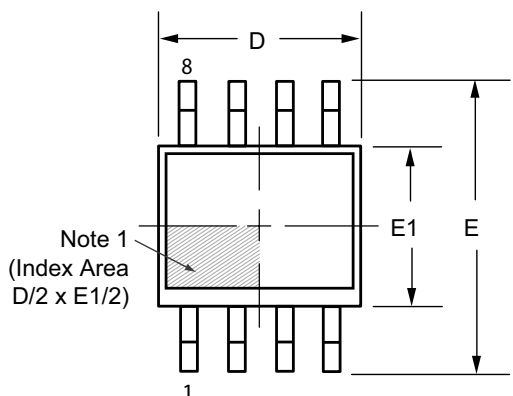
| Symbol         | A   | A1    | A2   | b    | D    | E     | E1    | e     | L        | L1   | L2       | θ        | θ1 |     |
|----------------|-----|-------|------|------|------|-------|-------|-------|----------|------|----------|----------|----|-----|
| Dimension (mm) | MIN | 0.75* | 0.00 | 0.75 | 0.22 | 2.80* | 4.65* | 2.80* | 0.65 BSC | 0.40 | 0.95 REF | 0.25 BSC | 0° | 5°  |
|                | NOM | -     | -    | 0.85 | -    | 3.00  | 4.90  | 3.00  |          | 0.60 |          |          | -  | -   |
|                | MAX | 1.10  | 0.15 | 0.95 | 0.38 | 3.20* | 5.15* | 3.20* |          | 0.80 |          |          | 8° | 15° |

JEDEC Registration MO-187, Variation AA, Issue E, Dec. 2004.  
\* This dimension is not specified in the original JEDEC drawing. The value listed is for reference only.  
**Drawings are not to scale.**  
**Supertex Doc. #: DSPD-8MSOPMG, Version G101008.**

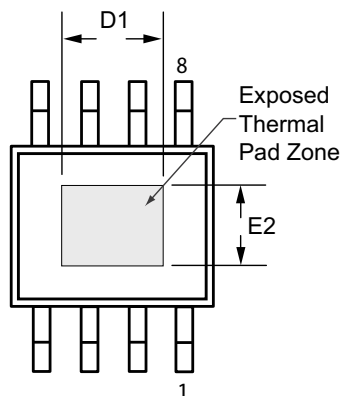


# 8-Lead SOIC (Narrow Body w/Heat Slug) Package Outline (SG)

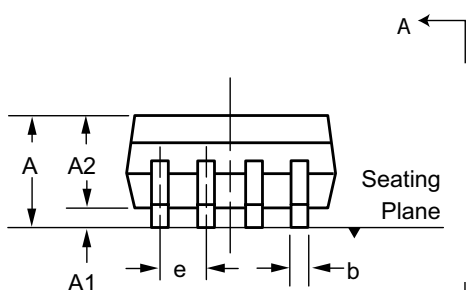
4.90x3.90mm body, 1.70mm height (max), 1.27mm pitch



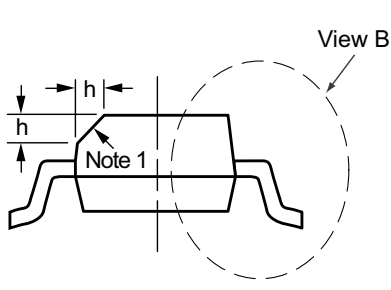
**Top View**



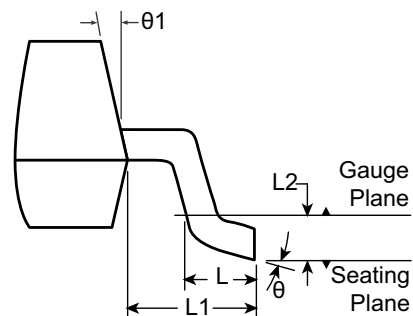
**Bottom View**



**Side View**



**View A - A**



**View B**

**Notes:**

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 original JEDEC drawing. The value listed is for reference only.

† This dimension is a non-JEDEC dimension.

**Drawings not to scale.**

Supertex Doc. #: DSPD-8SOSG, Version C090408.

(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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