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
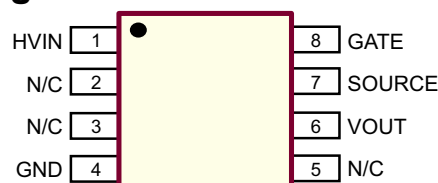
Typical Application Circuit
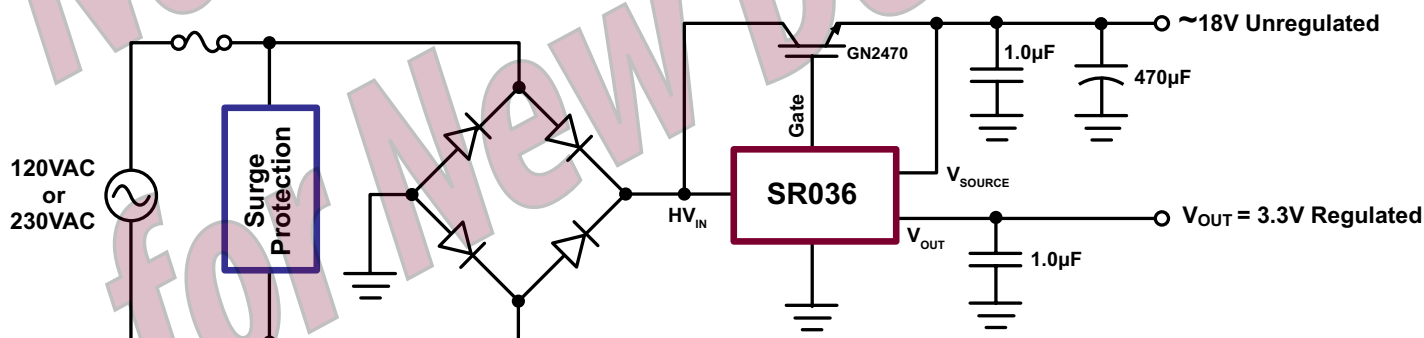
Ordering Information

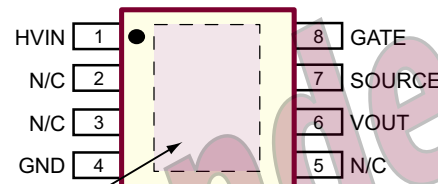| Device	8-Lead MSOP *3.00x3.00mm body* *1.10mm height (max)* *0.65mm pitch*	8-Lead SOIC w/ Heat Slug *4.90x3.90mm body* *1.70mm height (max)* *1.27mm pitch*
SR036	SR036MG-G	SR036SG-G

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

Pin Configuration

8-Lead MSOP (MG)

Heat Slug

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[1]

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.

1.   *When underside plate soldered to 2cm² of exposed copper.*

Product Marking

Top Marking

S036
LLLL

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

Bottom Marking

YYWW

8-Lead MSOP (MG)

YYWW
SR036
LLLL

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

8-Lead SOIC w/ Heat Slug (SG)

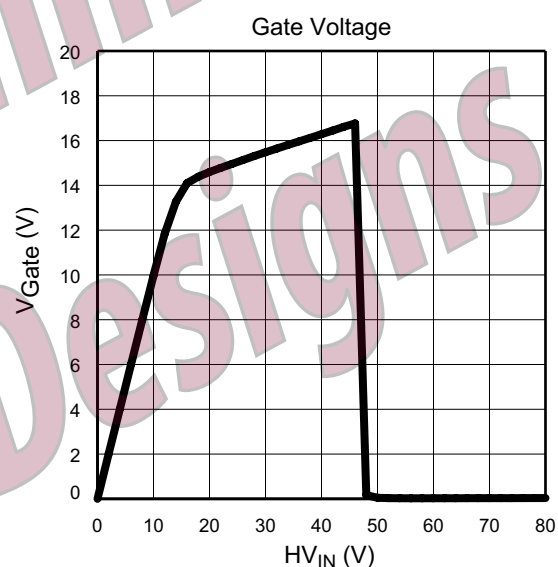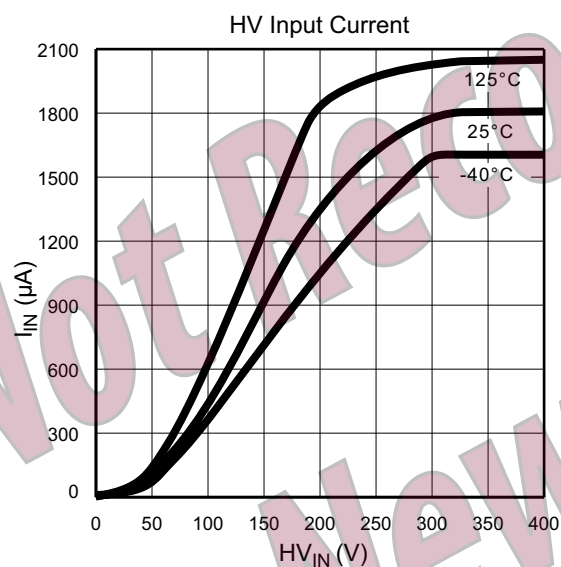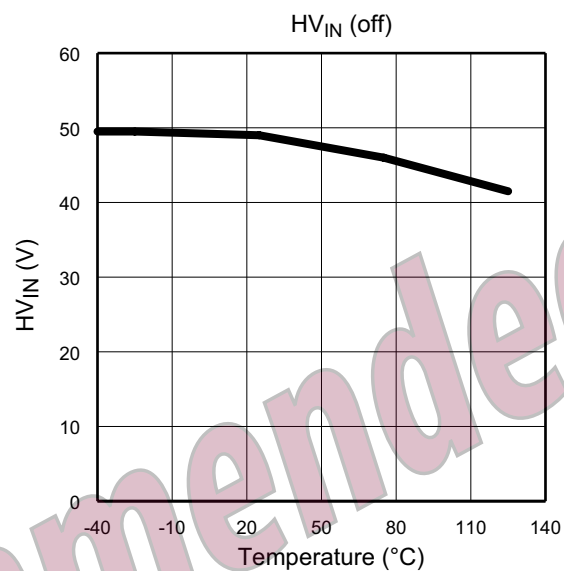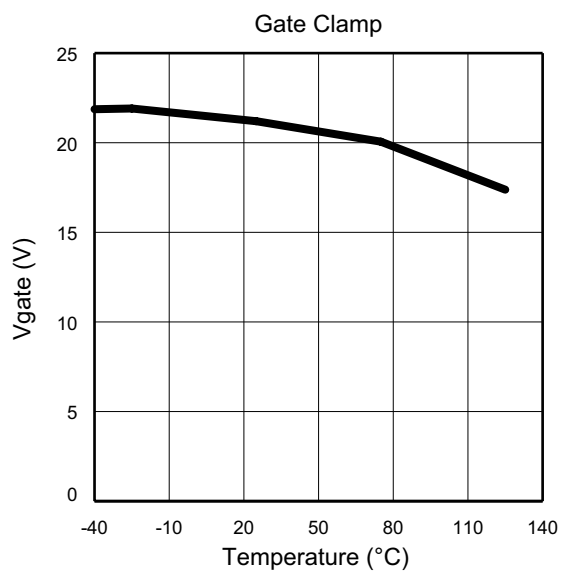## Electrical Specifications *(Over operating supply voltages unless otherwise noted, T_A = 0°C to +125°C)*

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} = ±100µA
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} = 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 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.

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Typical Performance Curves

Gate Clamp

HV_IN (off)

HV Input Current

Gate Voltage

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.
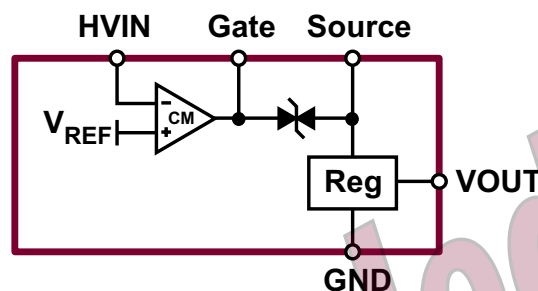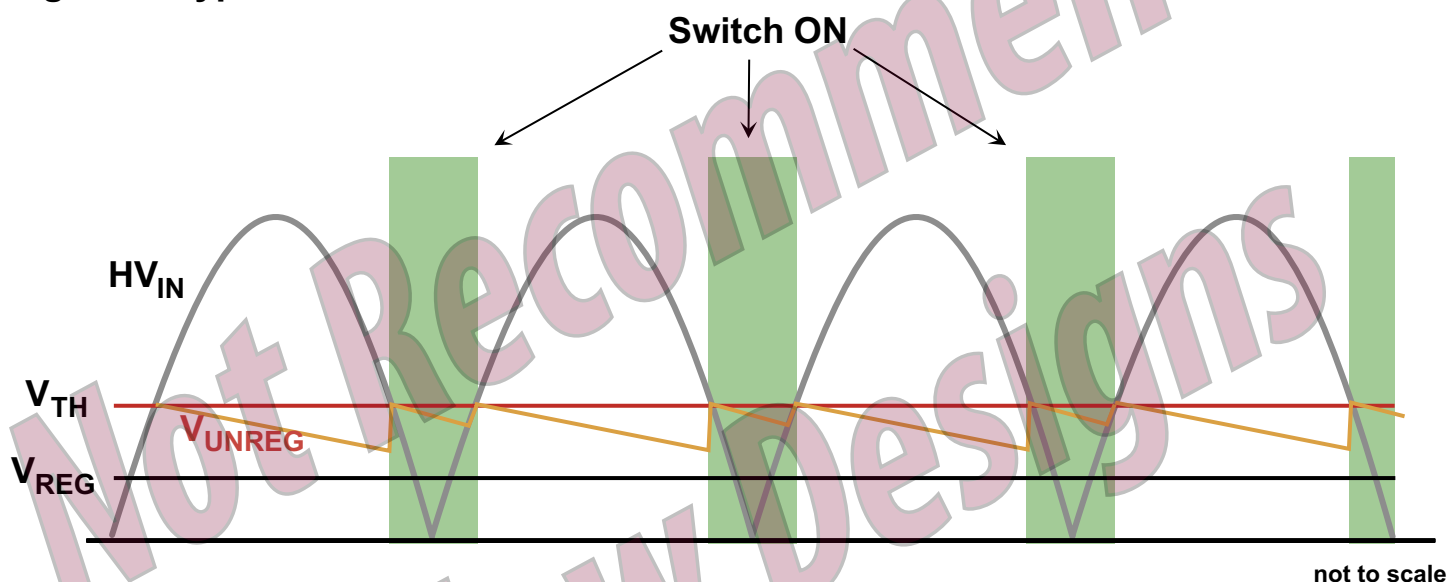
Functional Block Diagram

Figure 1. Typical Waveforms

Switch ON

HV_{IN}

V_{TH}

V_{UNREG}

V_{REG}

not to scale

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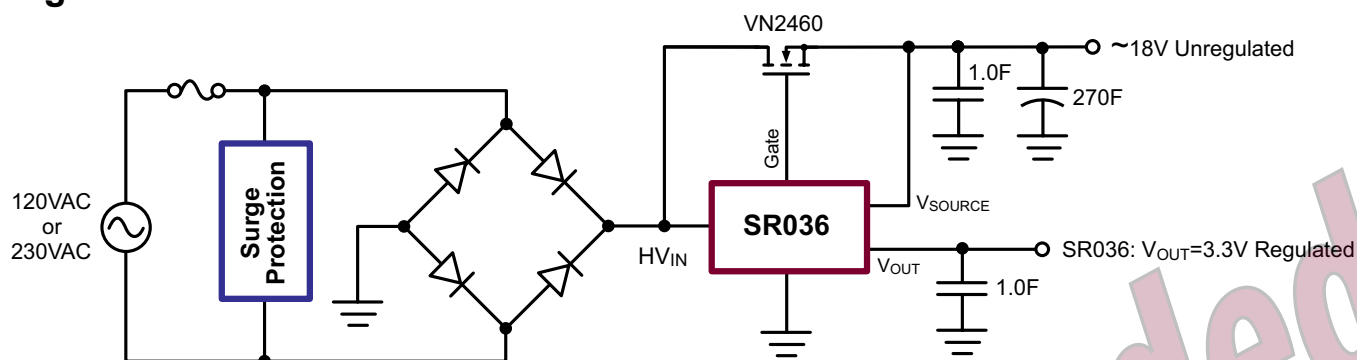
Power is also dissipated by the pass transistor. Power dissipated by the transistor will be $(16V * I_{TOTAL}) * (1/Eff -1)$ where I_{TOTAL} is the sum of the load currents on the regulated and unregulated outputs and Eff is the converter efficiency (0.30 to be conservative). The transistor should be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

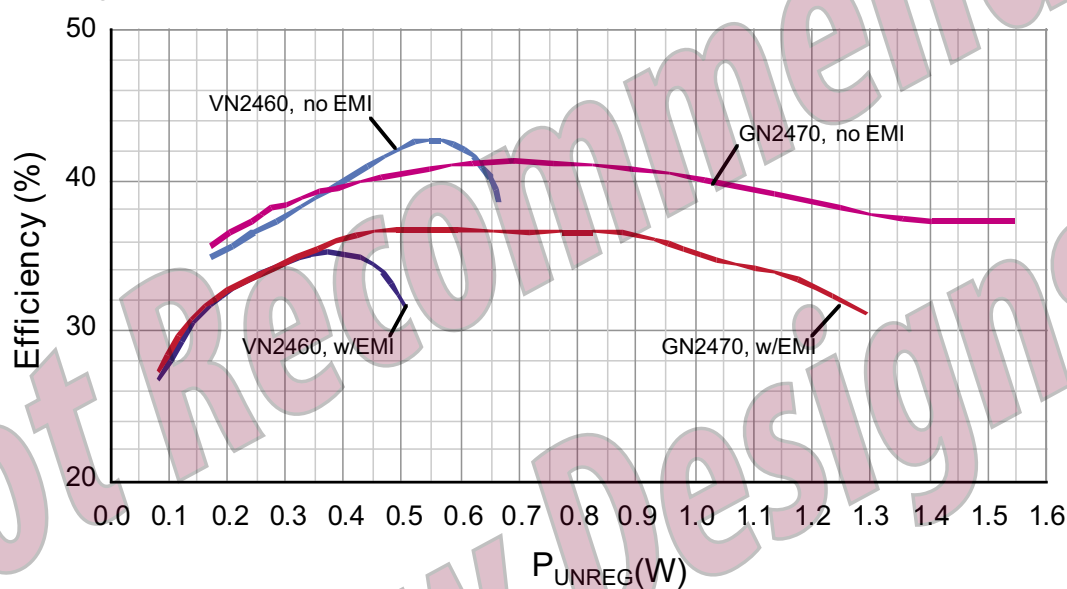## Transformers

AC Line   **SR036**

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.
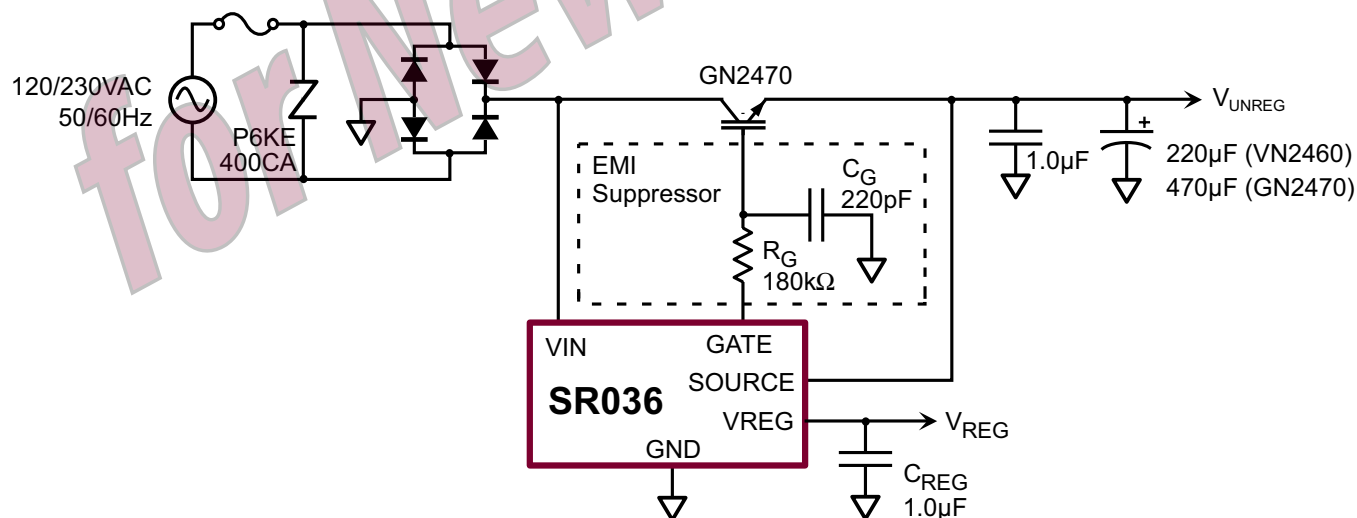
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Using a MOSFET in Place Of an IGBT

VN2460

120VAC or 230VAC

Surge Protection

HV$_{IN}$

SR036

Gate

V$_{SOURCE}$

V$_{OUT}$

1.0F

270F

~18V Unregulated

1.0F

SR036: V$_{OUT}$=3.3V Regulated

SR036 Efficiency

VN2460, no EMI

GN2470, no EMI

VN2460, w/EMI

GN2470, w/EMI

Efficiency (%)

P$_{UNREG}$(W)

Efficiency and EMI Test Circuit

120/230VAC 50/60Hz

P6KE 400CA

GN2470

EMI Suppressor

C$_G$ 220pF

R$_G$ 180kΩ

VIN

SR036

GATE

SOURCE

VREG

GND

V$_{UNREG}$

1.0µF

220µF (VN2460)
470µF (GN2470)

+

V$_{REG}$

C$_{REG}$ 1.0µF

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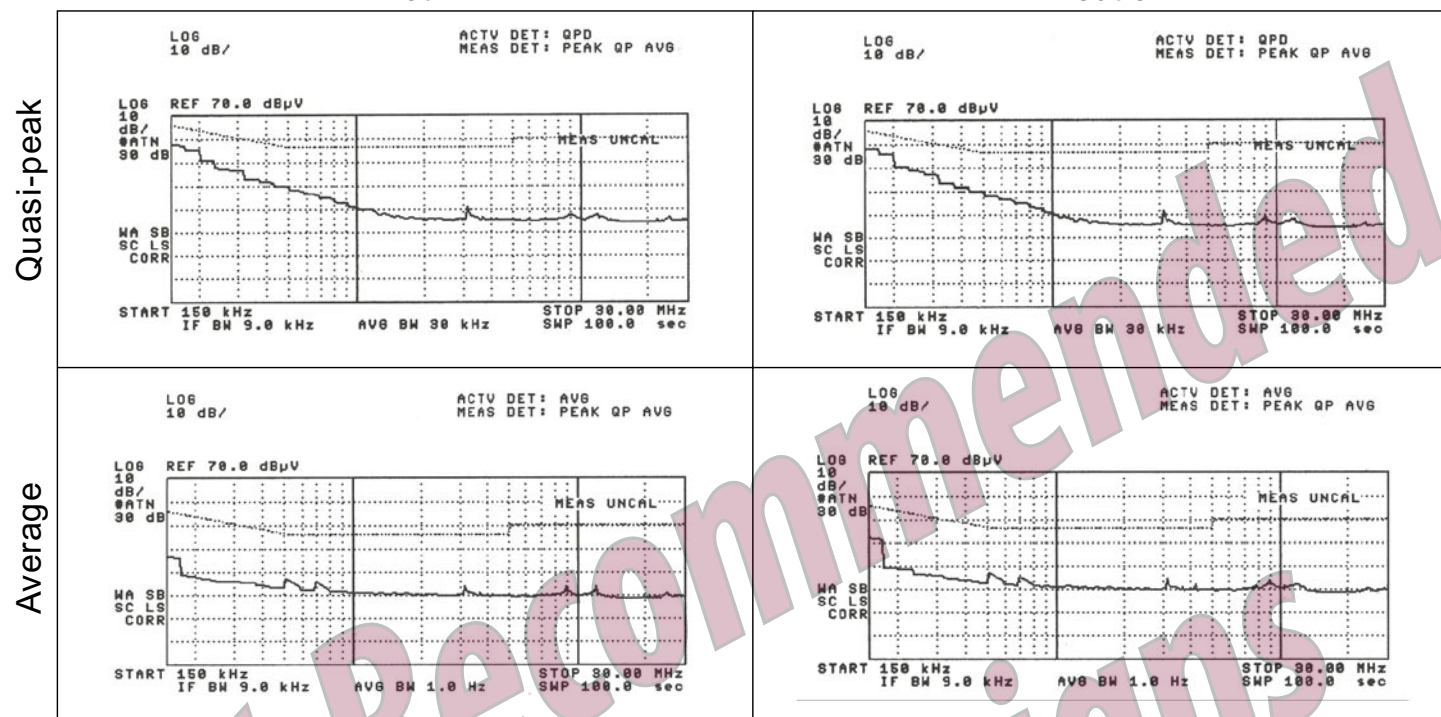
5

SR036 Circuit Using VN2460 (with EMI Supression Circuit)

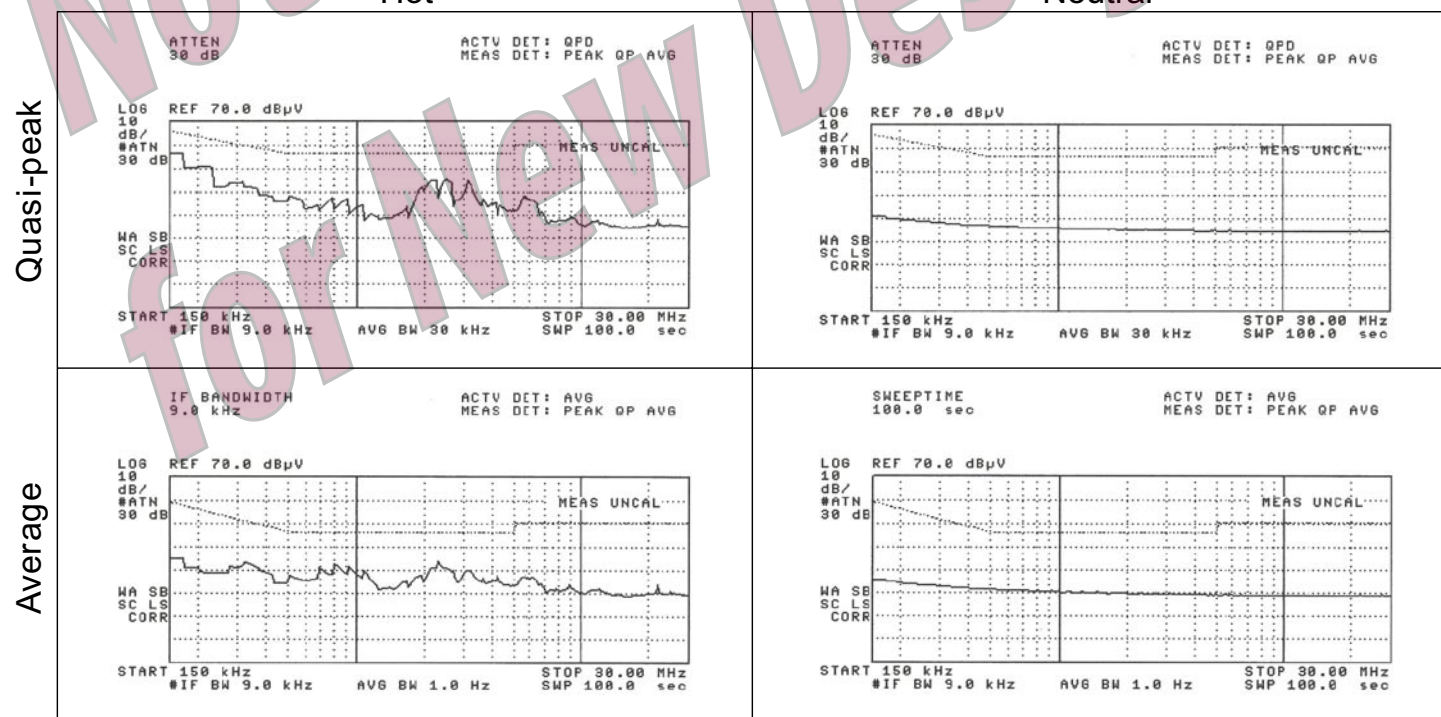**120VAC/60Hz -** Limits per 47CFR15.107 for Class B devices. 45mA total load.

Hot   Neutral

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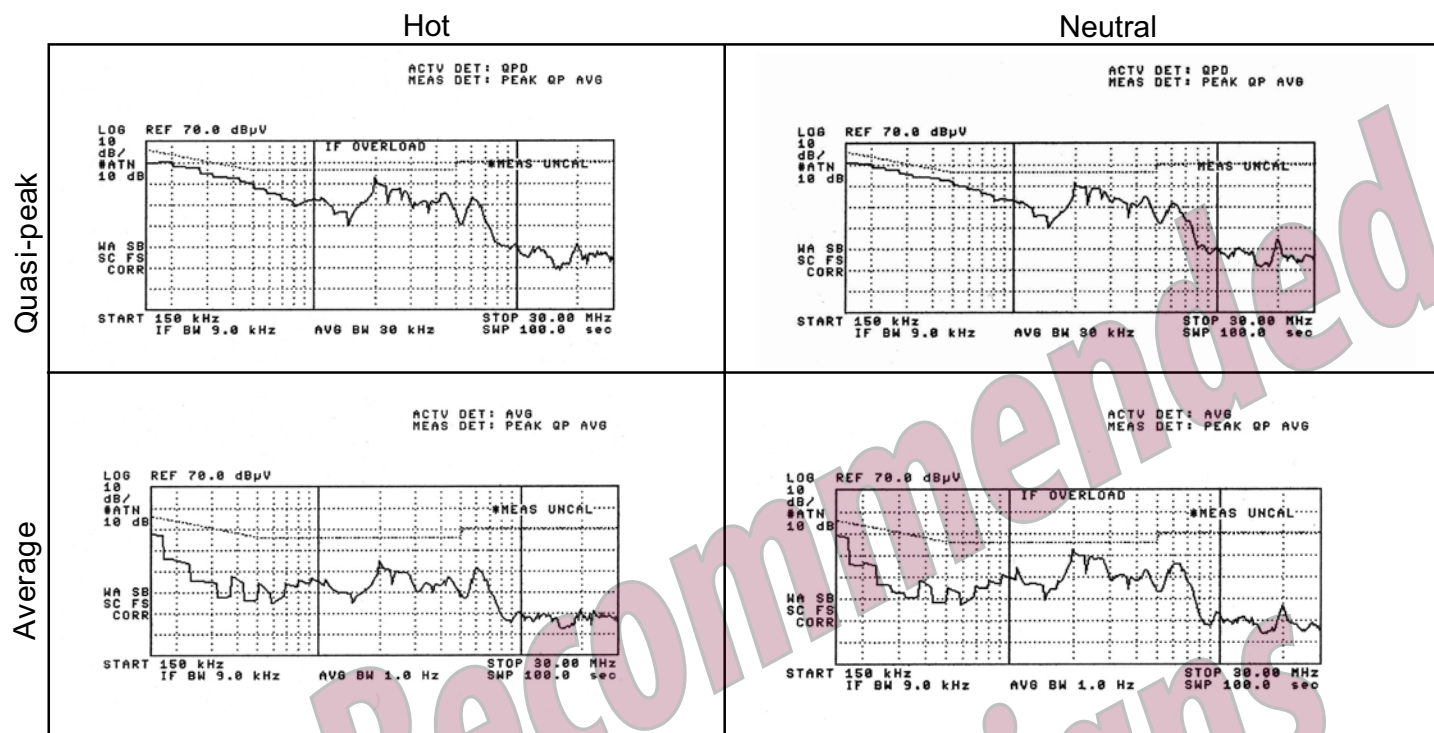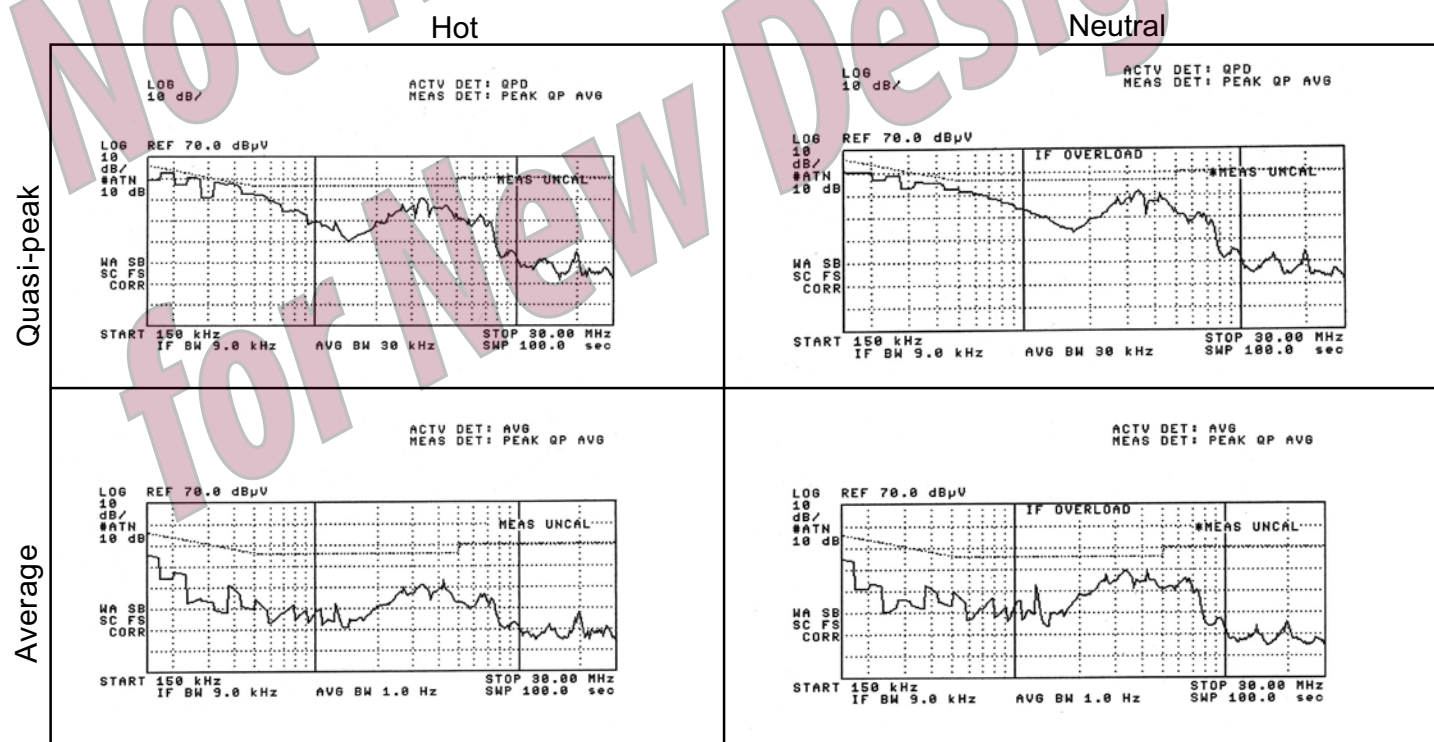
Hot   Neutral

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SR036 Circuit Using GN2470 (no EMI Supressor)

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

Hot   Neutral

Quasi-peak

Average

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

Hot   Neutral

Quasi-peak

Average

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SR036 Circuit Using GN2470 (no EMI Supressor)

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

Hot	Neutral
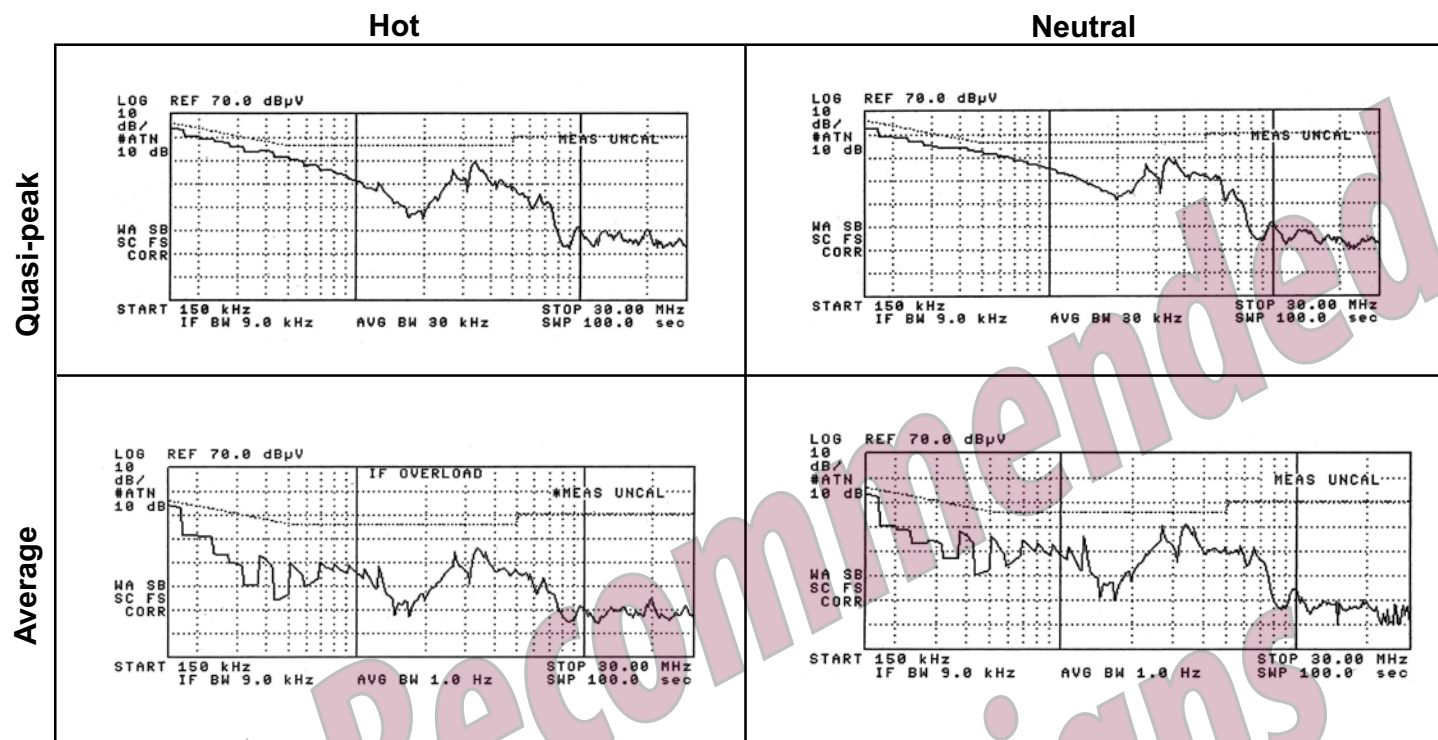
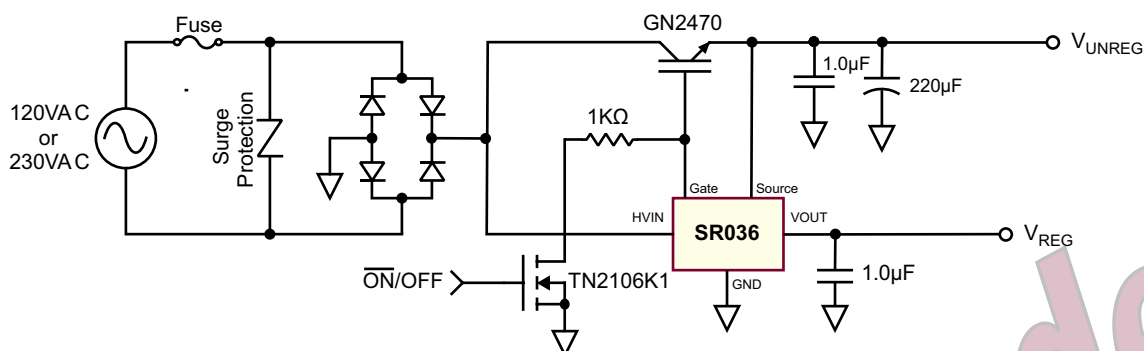## Application Information *(cont.)*

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.
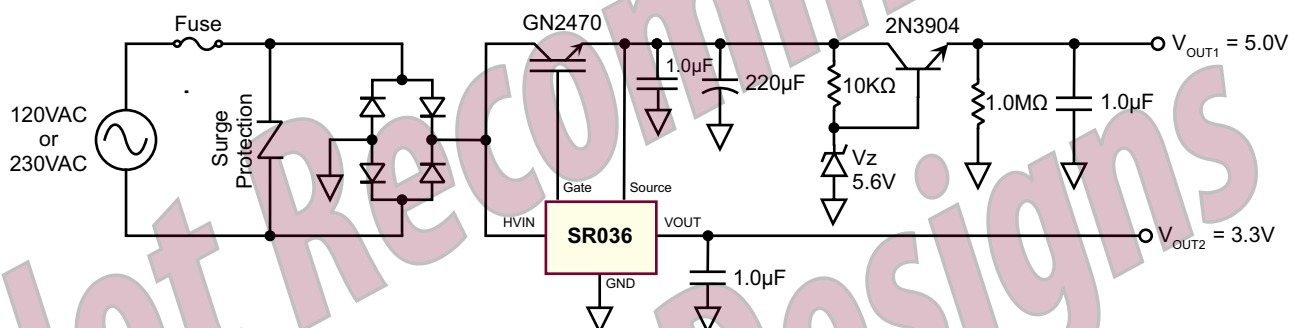

Figure 3: Generating Two Regulated Voltages

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, $V_{OUT}1$, 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.
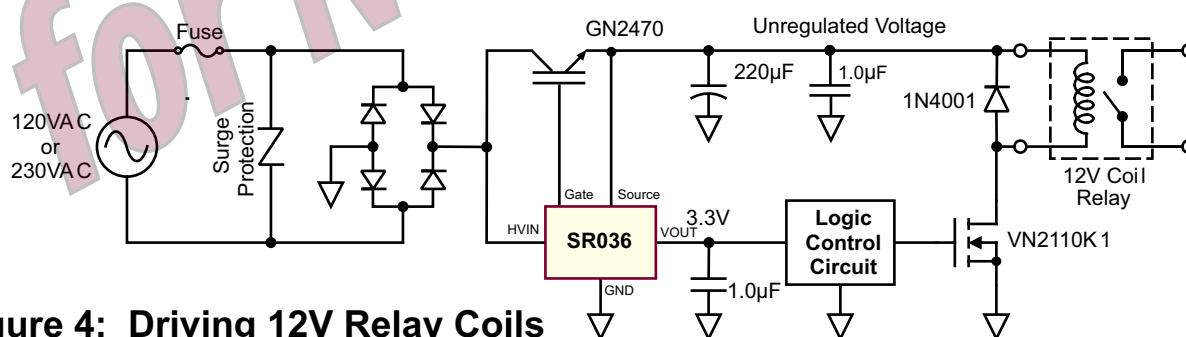

Figure 4: Driving 12V Relay Coils

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

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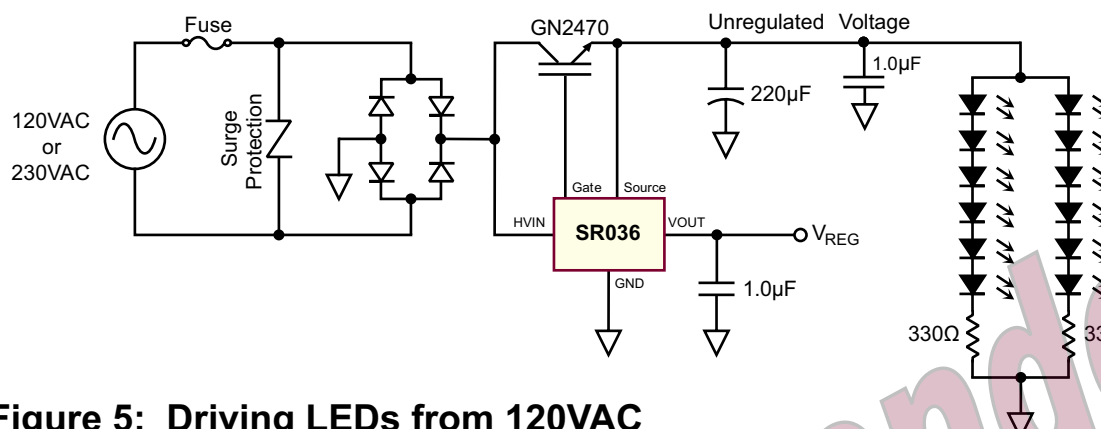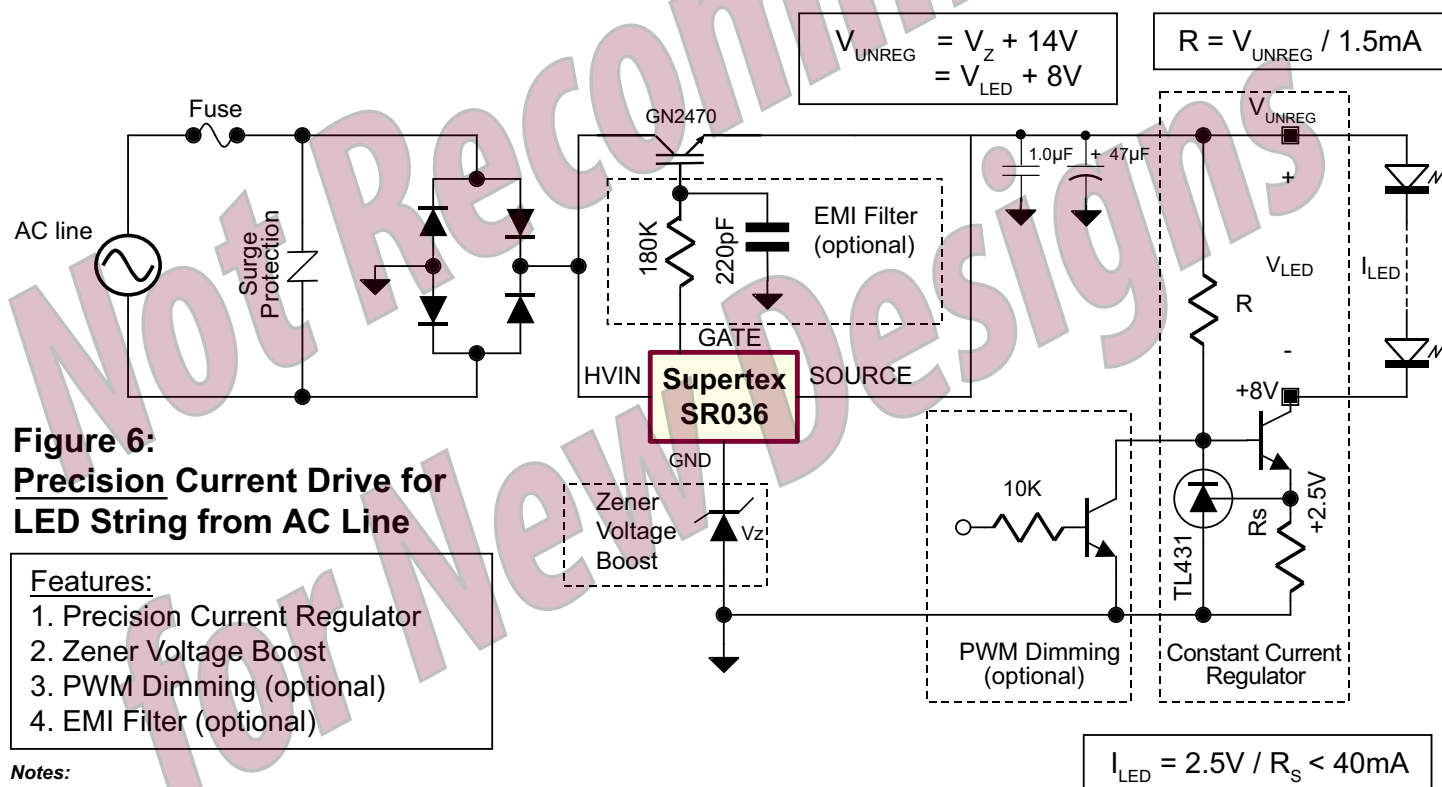
9

Application Information *(cont.)*

Figure 5: Driving LEDs from 120VAC

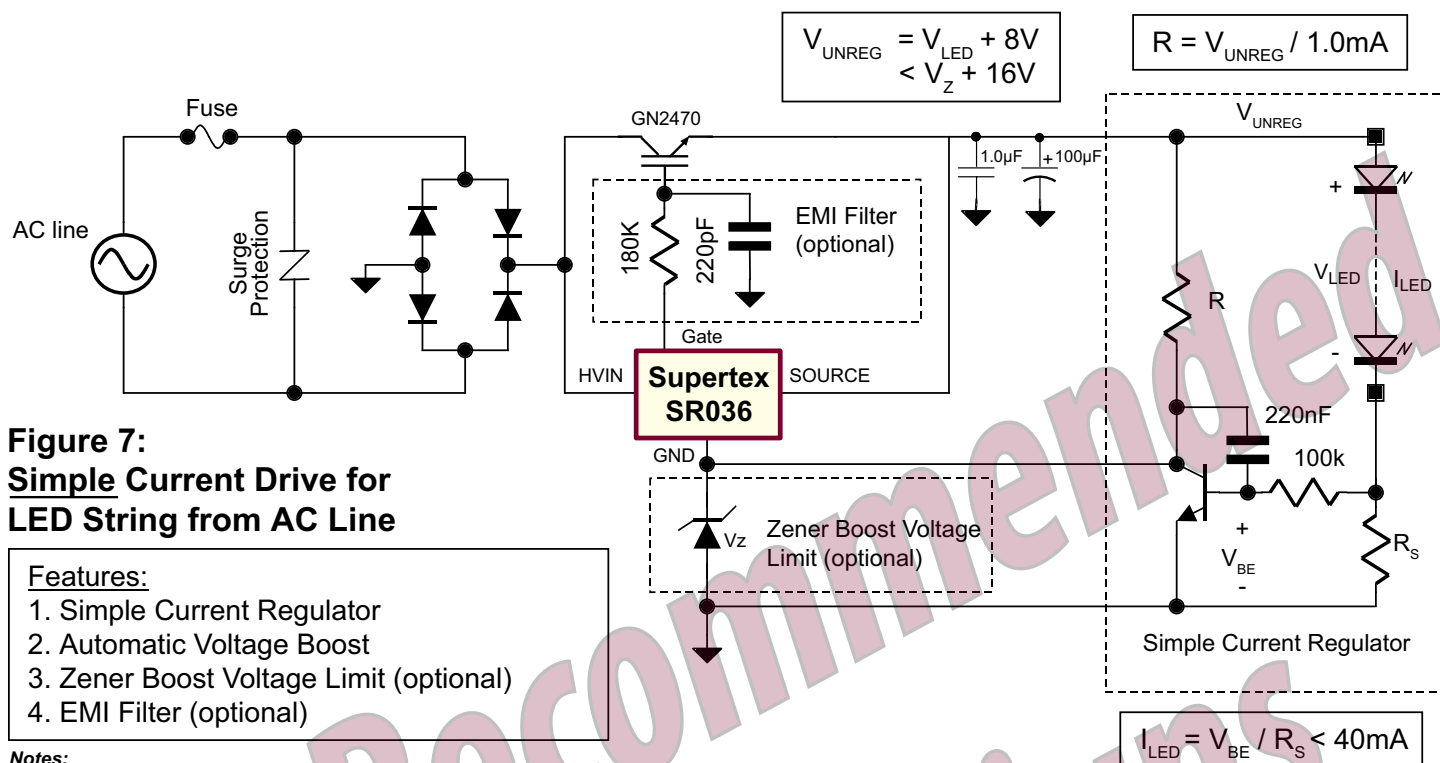The circuit shown in Figure 5 uses the SR036 to drive 12 high efficiency red LEDs from an AC line. The average LED current is approximately 20mA.

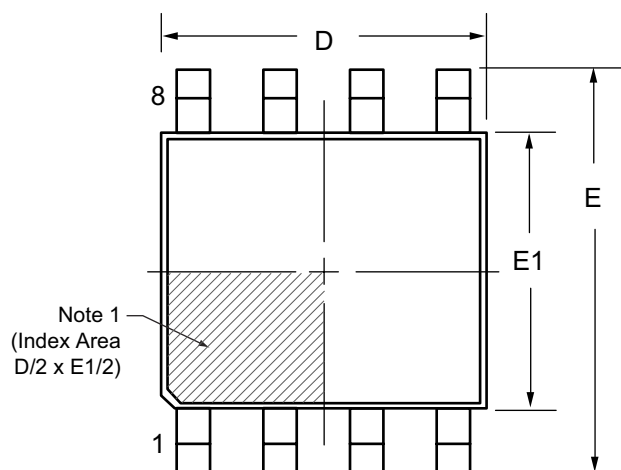$$V_{UNREG} = V_Z + 14V$$
$$= V_{LED} + 8V$$

$$R = V_{UNREG} / 1.5mA$$

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)

$$I_{LED} = 2.5V / R_S < 40mA$$

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).
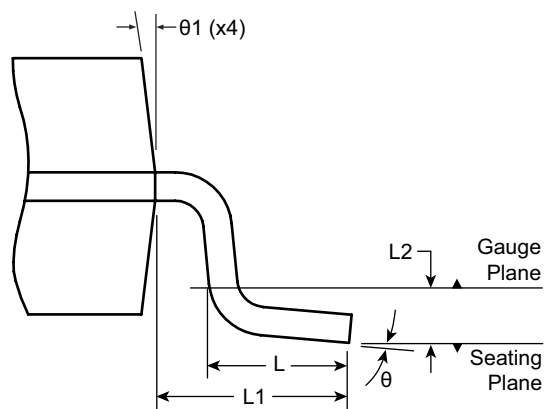
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Application Information *(cont.)*

$$V_{UNREG} = V_{LED} + 8V$$
$$< V_Z + 16V$$

$$R = V_{UNREG} / 1.0mA$$

Figure 7:
<u>Simple</u> 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)

$$I_{LED} = V_{BE} / R_S < 40mA$$

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).*

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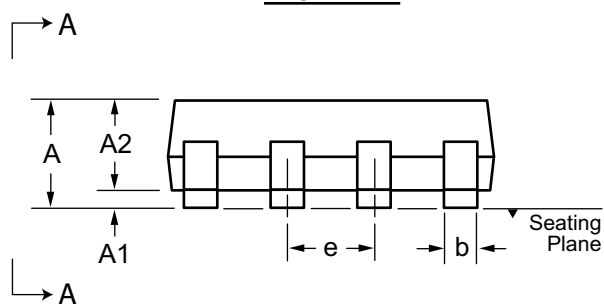# 8-Lead MSOP Package Outline (MG)
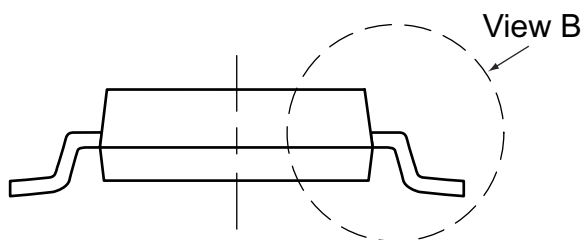*3.00x3.00mm body, 1.10mm height (max), 0.65mm pitch*

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.
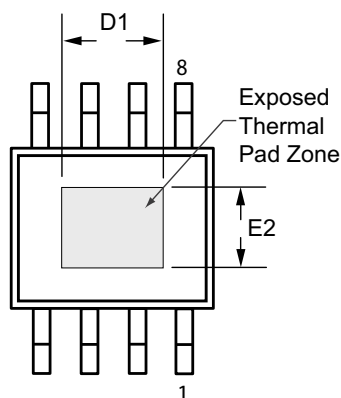***Drawings are not to scale.***
***Supertex Doc. #:** DSPD-8MSOPMG, Version G101008.*

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8-Lead SOIC (Narrow Body w/Heat Slug) Package Outline (SG)
4.90x3.90mm body, 1.70mm height (max), 1.27mm pitch
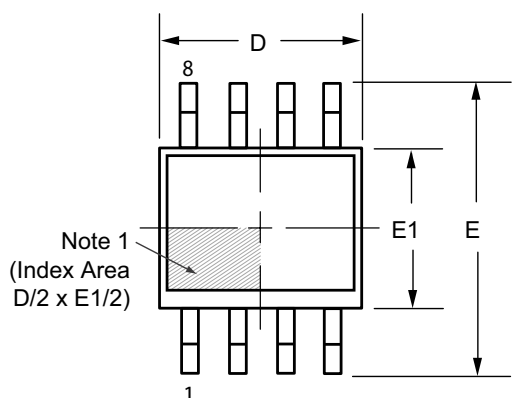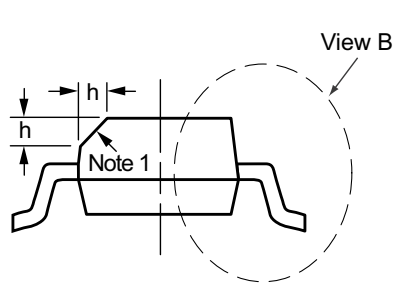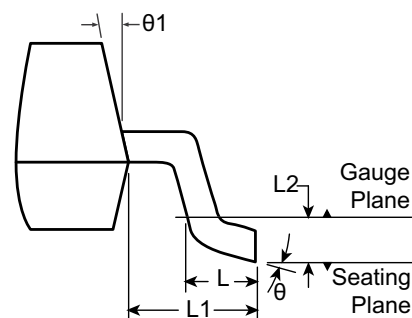

Top View

Bottom View
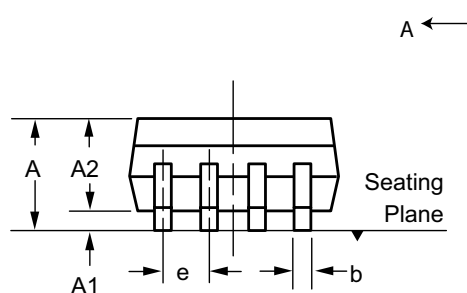
Side View

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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