

## Description

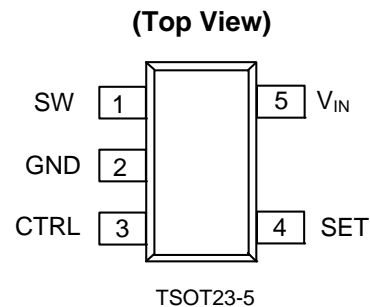
The AP8800A is a step-down DC/DC converter designed to drive LEDs with a constant current. The device can drive up to 7 LEDs, depending on the forward voltage of the LEDs, in series from a voltage source of 8V to 28V. Series connection of the LEDs provides identical LED currents resulting in uniform brightness and eliminating the need for ballast resistors. The AP8800A switches at frequency up to 600kHz. This allows the use of small size external components, hence minimizing the PCB area needed.

Maximum output current of AP8800A is set via an external resistor connected between the  $V_{IN}$  and SET input pins. Dimming is achieved by applying either a DC voltage or a PWM signal at the CTRL input pin. An input voltage of 0.2V or lower at CTRL switches off the output MOSFET simplifying PWM dimming.

## Features

- LED driving current up to 370mA
- Better than 5% accuracy
- High efficiency up to 95%
- Operating input voltage from 8V to 28V
- Simple, versatile solution requiring only 4 components
- PWM/DC input for dimming control
- Built-in output open-circuit protection
- TSOT23-5: Available in "Green" Molding Compound (No Br, Sb) with lead Free Finish/ RoHS Compliant (Note 1)

## Pin Assignments

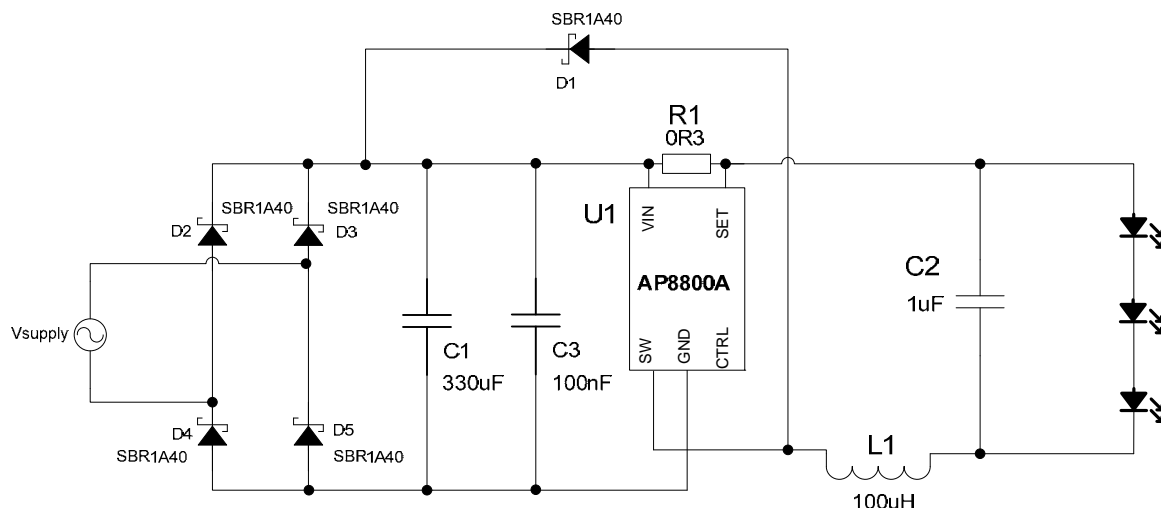


## Applications

- MR16 lamps
- General illumination lamps

Notes: 1. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied. Please visit our website at [http://www.diodes.com/products/lead\\_free.html](http://www.diodes.com/products/lead_free.html).

## Typical Application Circuit



## Pin Descriptions

Pin Name	Pin Number	Descriptions
SW	1	Switch Pin. Connect inductor/freewheeling diode here, minimizing track length at this pin to reduce EMI.
GND	2	GND Pin
CTRL	3	Dimming and On/Off Control Input. <ul style="list-style-type: none"> <li>Input voltage of 0.2V or lower forces the device into low current standby mode and shuts off the output. An open-drain/collector PWM signal allows the output current to be adjusted below the level set by the resistor connected to SET input pin.</li> <li>The input impedance is about 50kΩ, and if the pin is left open <math>V_{CTRL} = V_{REF}</math>.</li> <li>Drive with DC voltage (<math>0.3V &lt; V_{CTRL} &lt; 2.5V</math>) to adjust output current from 24% to 200% of <math>I_{OUTnom}</math></li> </ul>
SET	4	Set Nominal Output Current Pin. Configures the output current of the device.
$V_{IN}$	5	Input Supply Pin. Must be locally decoupled to GND with $\geq 2.2\mu F$ X7R ceramic capacitor – see applications section for more information.

## Absolute Maximum Ratings

Symbol	Parameter	Ratings	Unit
$V_{IN}$	Continuous $V_{IN}$ pin voltage relative to GND	-0.3~30	V
$V_{SET}$	Set voltage relative to $V_{IN}$	$V_{IN} - 5 \sim V_{IN} + 0.3$	V
$V_{SW}$	SW voltage relative to GND	-0.3~30	V
$V_{CTRL}$	CTRL pin input voltage	-0.3 ~ 5	V
$I_{SW}$	Switch current	0.45	A
$T_J$	Junction Temperature	105	°C
$T_{LEAD}$	Lead Temperature Soldering	300	°C
$T_{ST}$	Storage Temperature Range	-55 to +150	°C

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any condition.  
 Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

## Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
$V_{IN}$	Operating Input Voltage relative to GND	8.0	28	V
$V_{CTRLDC}$	Voltage range for 24% to 200% DC dimming relative to GND	0.3	2.5	V
$V_{CTRLLL}$	Voltage Low for PWM dimming relative to GND		0.2	V
$I_{SW}$	Continuous average switch current (Note 2)		370	mA
$D_{PWM}$	Duty cycle range applied to CTRL ( $f < 500Hz$ )	0.01	1	
$f_{SW}$	Switching frequency		600	kHz
$T_A$	Ambient Temperature Range	-40	105	°C

Notes: 2. Refer to figure 4 for the device derating curve.

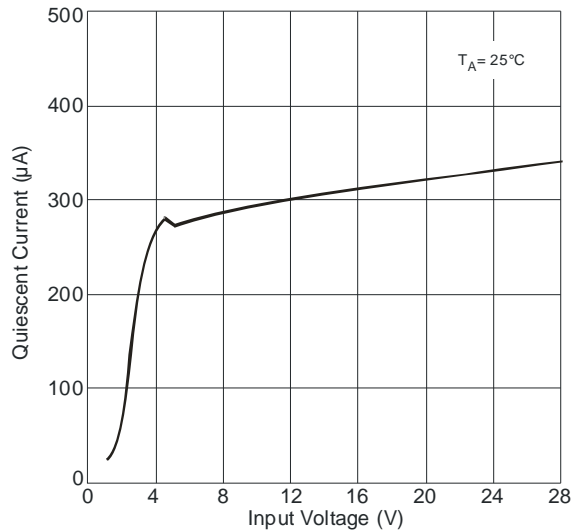
## Electrical Characteristics

$V_{IN} = 12V$ ,  $T_A = 25^\circ C$ , unless otherwise specified.

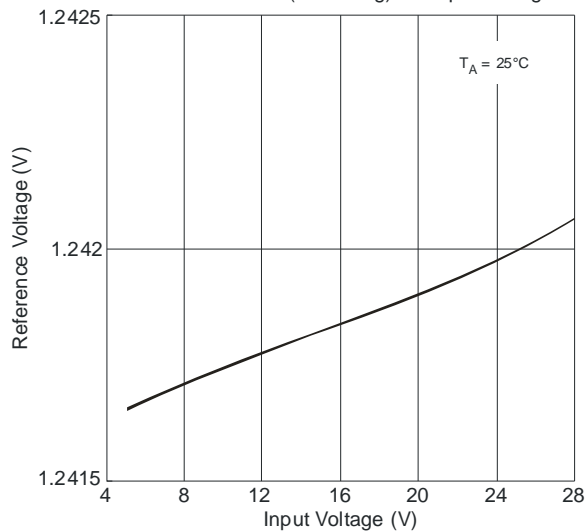
Symbol	Parameter	Conditions	Min	Typ.	Max	Unit
$I_Q$	Quiescent Current	$V_{CTRL} = 1.25V$ , $f_{SW} = 250kHz$		300	650	$\mu A$
$I_{SD}$	Shutdown current	$V_{CTRL} = 0V$		20	30	$\mu A$
$V_{THD}$	Internal Threshold Voltage		95	100	105	mV
$V_{REF}$	Internal Reference Voltage			1.25		V
$I_{SET}$	SET pin input current	$V_{SET} = V_{IN} - 0.1$		1.3		$\mu A$
$R_{DS(ON)}$	On Resistance of MOSFET			1.5	2.2	$\Omega$
$I_{SW-LKG}$	Switch leakage current				5	$\mu A$
$f_{SW}$	Switching frequency with $L = 100\mu H$	ADJ pin floating $L = 100H$ $I_{OUT} = 350mA$ @ 1 LED ( $V_{LED} = 3.4V$ )		250		kHz
$t_{SS}$	Soft start time	Time taken for output current to reach 90% of final value after $V_{CTRL} = 0.3V$		500		$\mu s$
$t_{PD}$	Internal comparator propagation delay			55		ns
$\theta_{JA}$	Thermal Resistance Junction-to-Ambient	TSOT23-5 (Note 3)		200		$^\circ C/W$

Notes: 3. Test condition for TSOT23-5: Device mounted on FR-4 PCB (25mm x 25mm 1oz copper, minimum recommended pad layout on top layer and thermal vias to bottom layer ground plane. For better thermal performance, larger copper pad for heat-sink is needed.

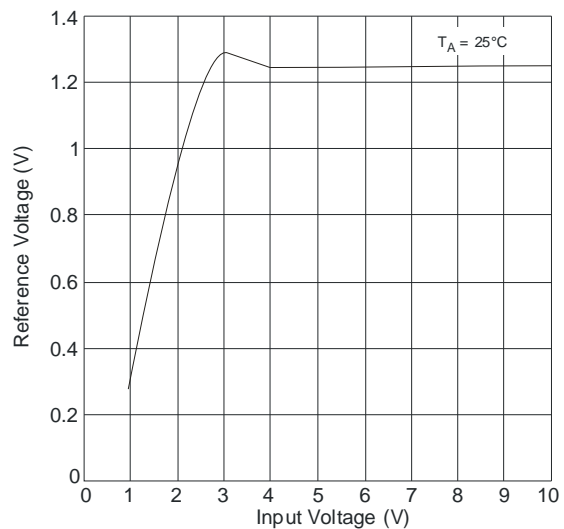
## Typical Characteristics



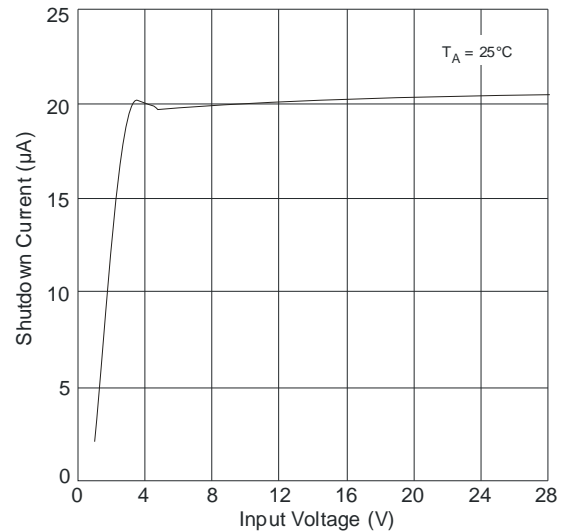
Quiescent Current (Switching) vs. Input Voltage



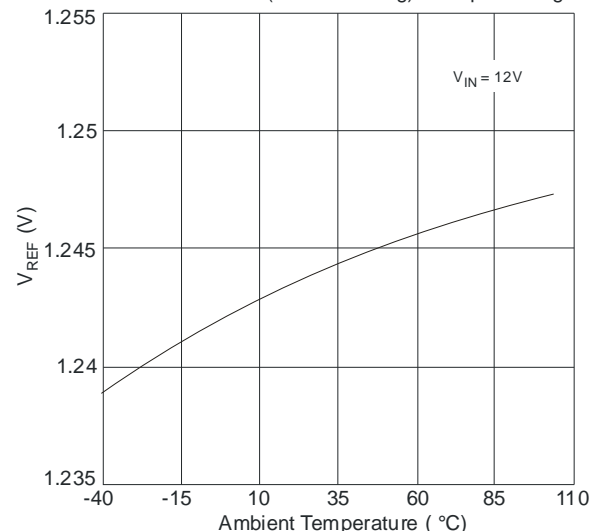
Reference Voltage vs. Input Voltage



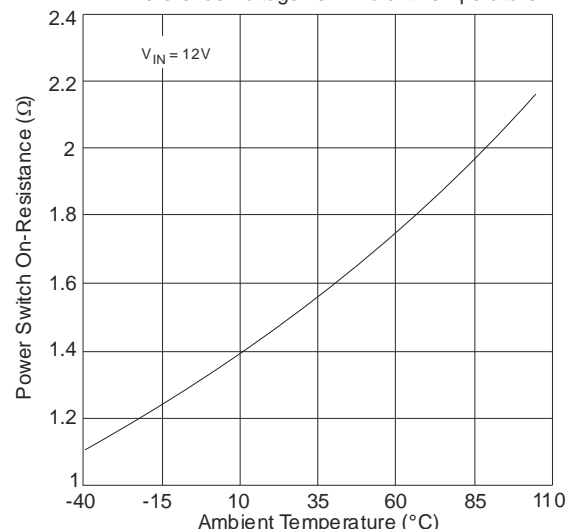
Reference Voltage vs. Input Voltage (Low Voltage)



Shutdown Current (Non-Switching) vs. Input Voltage

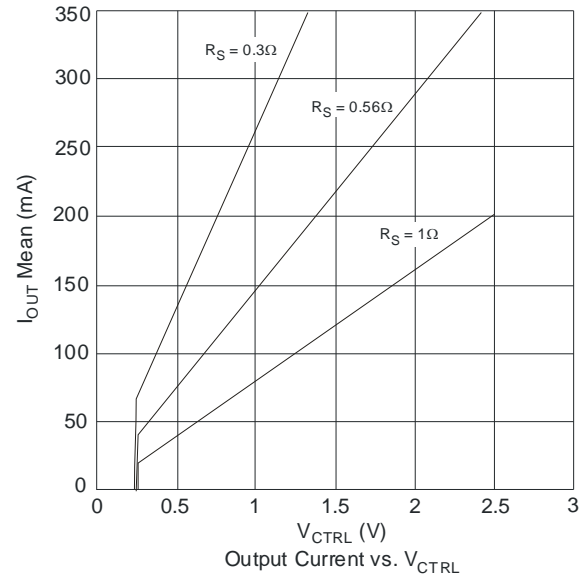
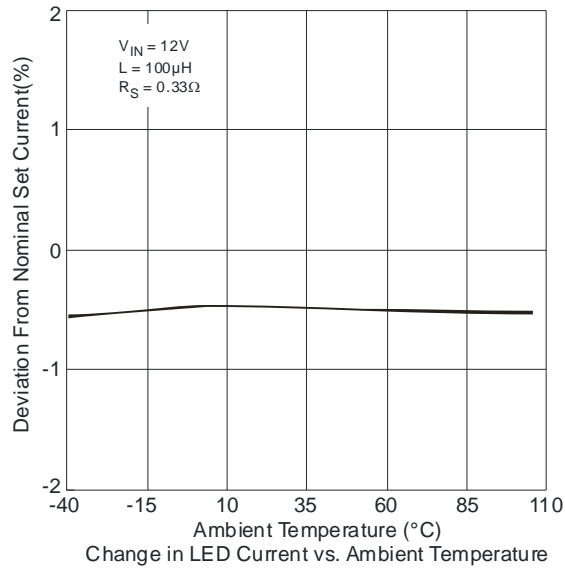


Reference Voltage vs. Ambient Temperature



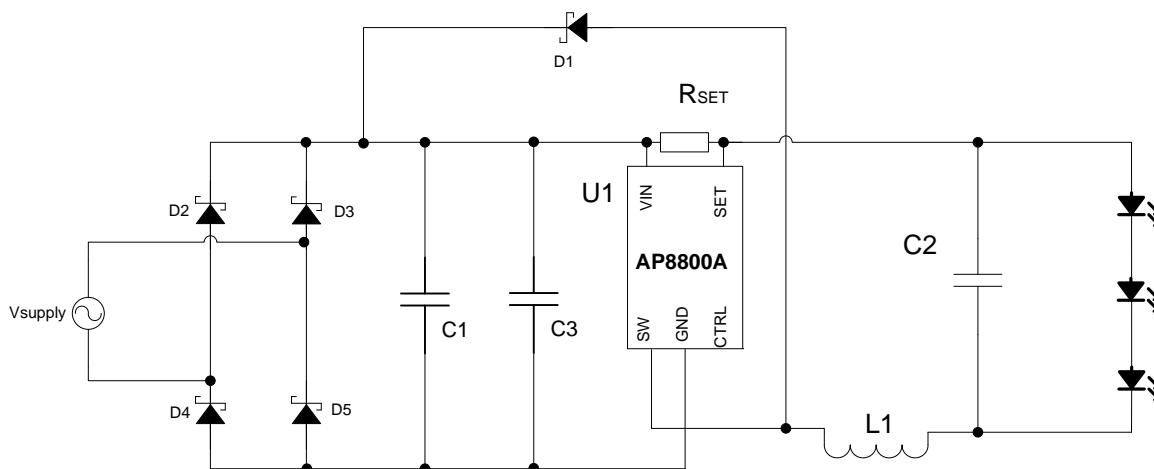
Power Switch On-Resistance vs. Ambient Temperature

## Typical Characteristics (Continued)



**Applications Information** ( $T_A = 25^\circ\text{C}$  unless otherwise stated)

**LED Current Control**



**Figure 1. MR16 Typical configuration**

The LED current is controlled by the resistor  $R_{SET}$  in Figure 1.

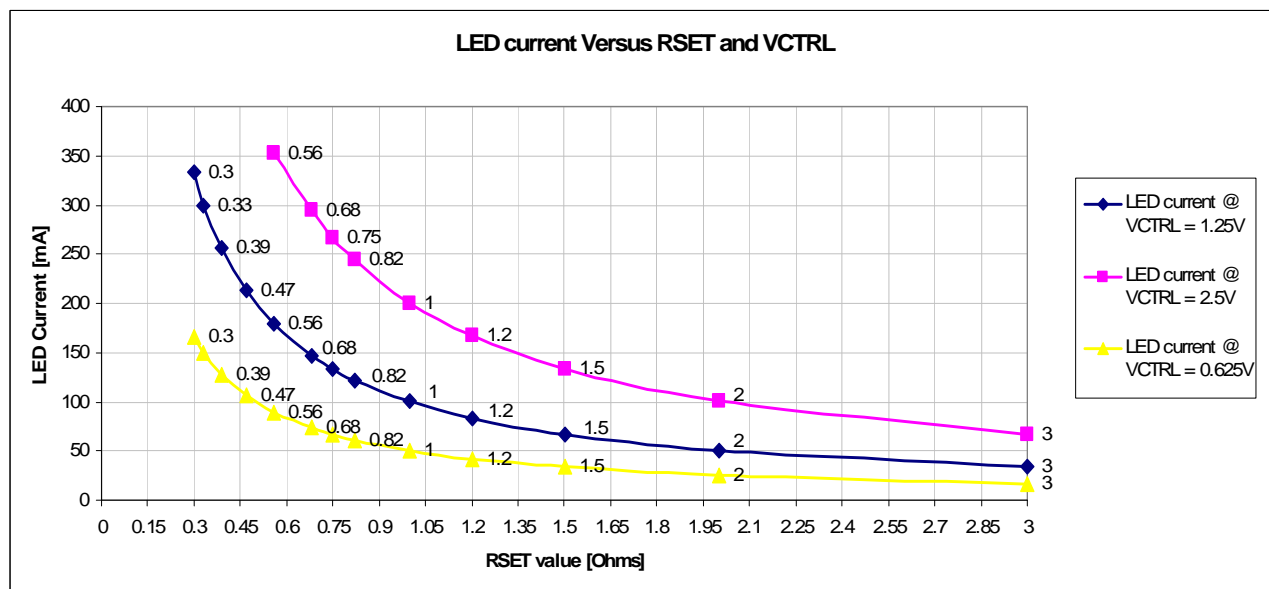
With the CTRL pin left floating and the external current sense resistor,  $R_{SET}$  (greater than  $0.3\ \Omega$ ) is connected between  $V_{IN}$  and SET, the nominal average output current in the LEDs is:

$$I_{LED} = \frac{V_{THD}}{R_{SET}} \quad \text{where } V_{THD} \text{ is nominally } 1.25\text{V}$$

If the CTRL pin is driven by an external voltage (lower than 2.5V), the average LED current in this case is:

$$I_{LED} = \frac{V_{CTRL}}{V_{REF}} \frac{V_{THD}}{R_{SET}}$$

The graph in figure 2 gives values of nominal average output current for several values of current setting resistor ( $R_{SET}$ ) in the typical application circuit shown on Figure 1, for different voltages applied on the CTRL pin.

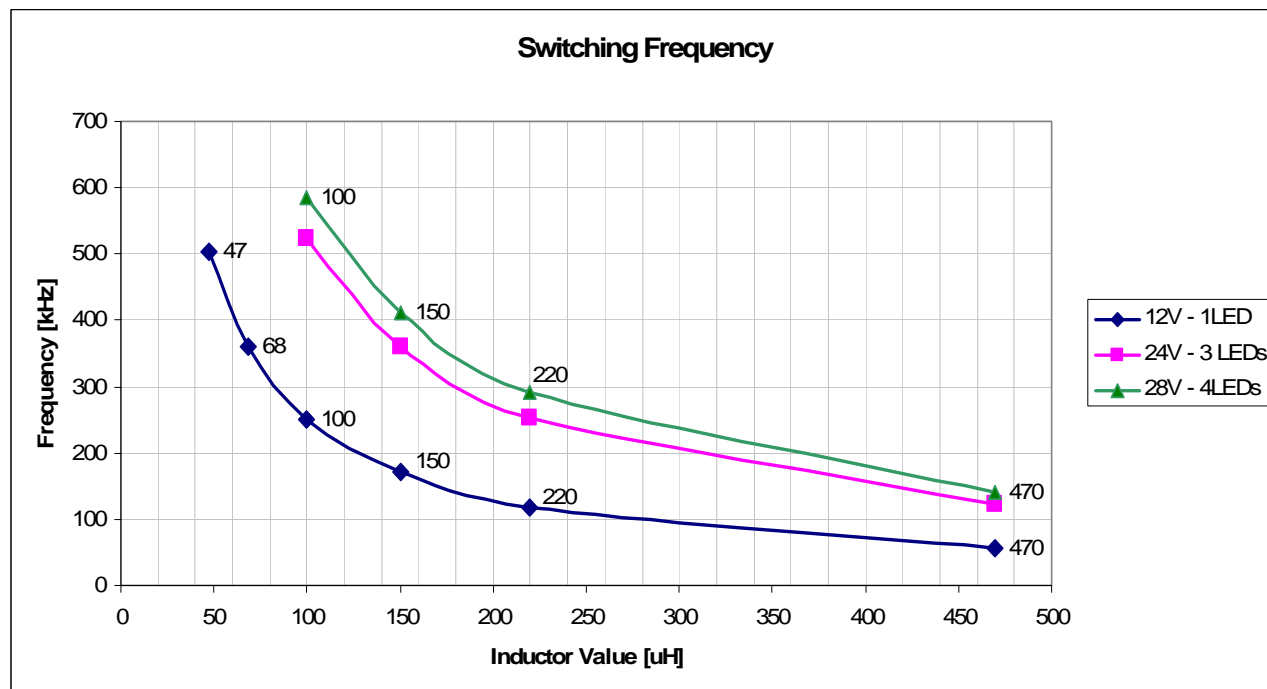


**Figure 2. LED Current setting Vs  $R_{SET}$  and  $V_{CTRL}$**

**Applications Information (Continued) ( $T_A = 25^\circ\text{C}$  unless otherwise stated)**
**Inductor Selection**

A 68 $\mu\text{H}$  inductor or higher, is recommended for most AP8800A applications with input voltage at 12V.

Figure 3 displays the resulting switching frequency with various main circuit parameters: Supply voltage, Inductor value and number of LEDs to be driven.



**Figure 3. Switching Frequency Vs Supply voltage, Inductor, and number of LEDs**

**Capacitor Selection**

A low ESR capacitor should be used for input decoupling, as the ESR of this capacitor appears in series with the supply source impedance and lowers overall efficiency. This capacitor has to supply the relatively high peak current to the coil and smooth the current ripple on the input supply. A minimum value of 1 $\mu\text{F}$  is acceptable if the DC input source is close to the device, but higher values will improve performance at lower input voltages, especially when the source impedance is high. The input capacitor should be placed as close as possible to the IC.

For AC input sources a bigger capacitor ( 300 $\mu\text{F}$  in the case of 12C AC) to guarantee the accuracy of the LED current.

For maximum stability over temperature and voltage, capacitors with X7R, X5R, or better dielectric are recommended. Capacitors with Y5V dielectric are not suitable for decoupling in this application and should **NOT** be used.

**Diode Selection**

For maximum efficiency and performance, the rectifier (D1) should be a fast low capacitance SBR diode with low reverse leakage at the maximum operating voltage and temperature. The recommended diode for use with this part is the SBR1A40, with a current rating above the peak coil current and a continuous current rating higher than the maximum output load current. It is very important to consider the reverse leakage of the diode when operating above 85 $^\circ\text{C}$ . Excess leakage will increase the power dissipation in the device.

## Applications Information (Continued) ( $T_A = 25^\circ \text{C}$ unless otherwise stated)

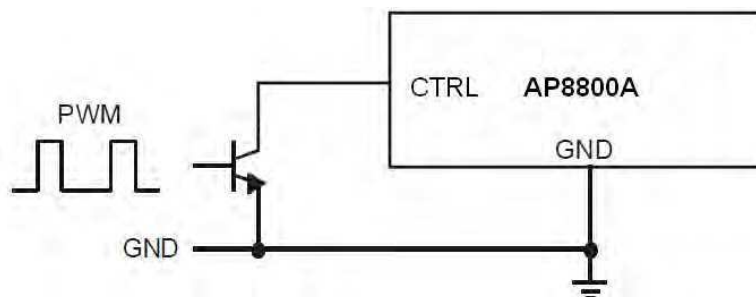
### LED Current Dimming

The LED current can be dimmed in two ways; either by applying a dc signal to the CTRL pin or by applying a Pulse Width Modulated (PWM) signal to the CTRL pin.

A dc signal from 0.3V to 2.5V applied to the CTRL pin will vary the LED current from 24% to 200% of nominal LED current. This gives an approximate 8:1 dimming range; care, however, should be exercised when overdriving the CTRL pin to 200% LED current not to exceed the power dissipation of the package.

A PWM signal with a max resolution of 8bit can be applied to CTRL regulate the output current to a value below the nominal average value set by resistor  $R_{SET}$ . PWM dimming gives a wider average LED current variation and is more accurate at lower average LED currents than by applying dc voltage to the CTRL pin to achieve average LED current dimming.

The recommended method of driving the CTRL pin and controlling the amplitude of the PWM waveform is to use a small NPN switching transistor as shown below:

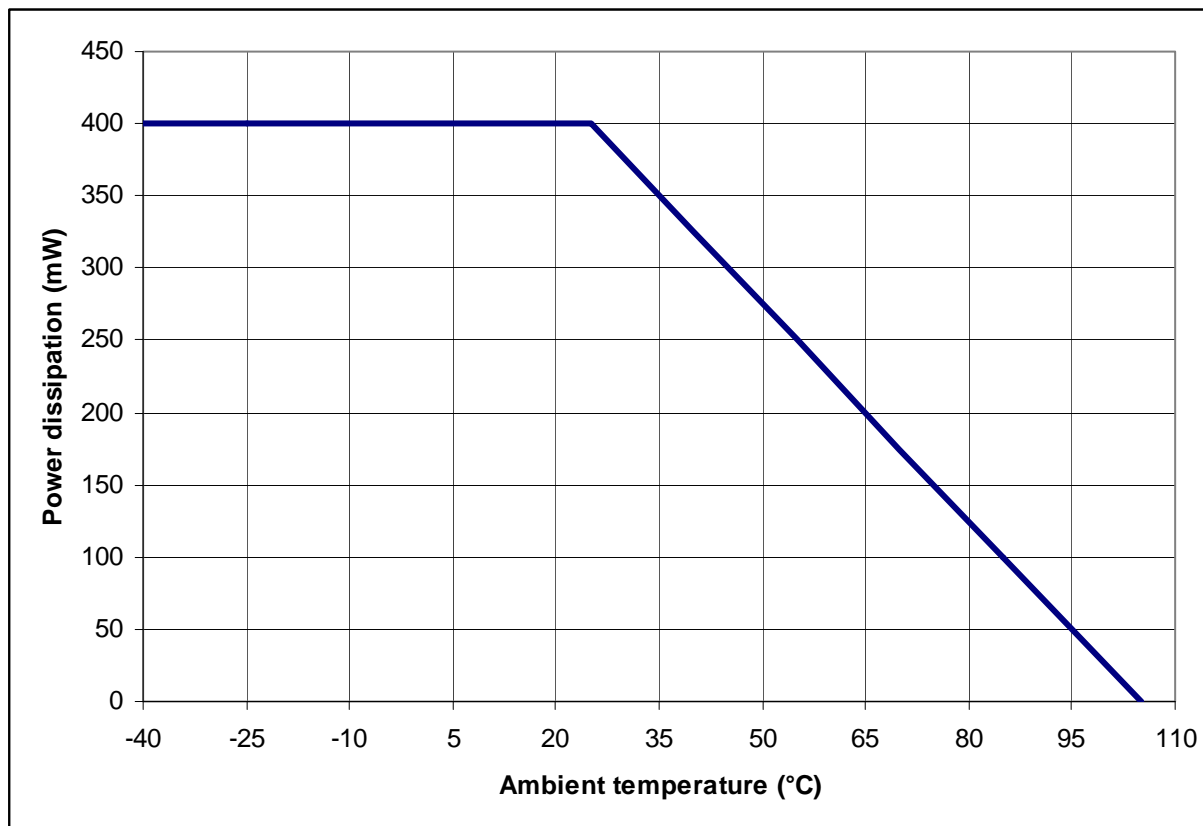


This scheme uses the 50k resistor between the ADJ pin and the internal voltage reference as a pull-up resistor for the external transistor eg MMBT3904.



**Applications Information (Continued) ( $T_A = 25^\circ\text{C}$  unless otherwise stated)**
**Thermal Considerations**

The graph below in figure 4, gives details for the power derating of the AP8800AWT. This assumes the device to be mounted on a 25x25mm PCB with 1oz copper standing in still air.



**Figure 4. Derating Curve**

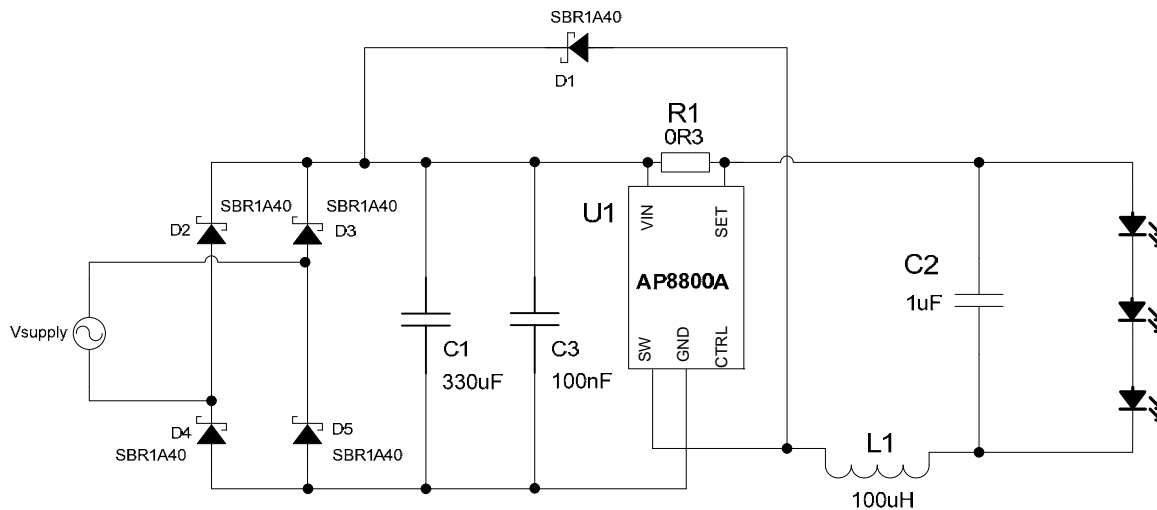
**Soft-start**

An external capacitor from the CTRL pin to ground will provide soft-start delay, by increasing the time taken for the voltage on this pin to rise to the turn-on threshold and by slowing down the rate of rise of the control voltage at the input of the comparator. The soft-start time is 0.5ms/nF.

## Applications Information (Continued)

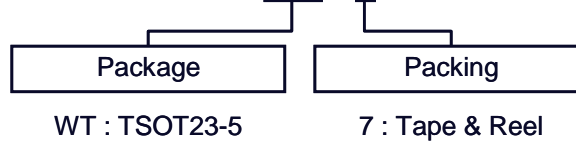
### Application example

The typical application for the AP8800A is the MR16 application driving 1W rated LEDs from a 12V ac supply.



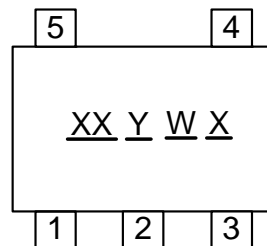
### AP8800A Component list

QUANTITY	PCB IDENT	VALUE	DESCRIPTION	SUGGESTED SOURCE
1	U1	AP8800A	LED Driver IC	Diodes Inc.
1	D1, D2, D3, D4, D5	SBR1A40	Input bridge & freewheeling diode	Diodes Inc.
1	R1	0R15	Resistor, 0805, +/-1% <+/-300ppm KOA SR732ATTDR150F	Kemet
1	C1	330uF 20v	Electrolytic capacitor	Kemet
1	C2	1uF >=25v	X7R 1206 Generic Kemet C1206105K5RAC7800 (50v) NIC NMC1206X7R105K50F (50v)	Kemet NIC Components
1	C3	100nF >=25v	X7R 0805 Generic Kemet C0805C104K5RAC (50v) NIC NMC0805X7R104K50TRPF (50v)	Kemet NIC Components
1	L1	100uH	LPS6235 - series	Coilcraft

**Ordering Information (Continued)**
**AP8800A WT - 7**


Device	Package Code	Packaging (Note 4)	7" Tape and Reel	
			Quantity	Part Number Suffix
AP8800AWT-7	WT	TSOT23-5	3000/Tape & Reel	-7

Notes: 4. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>.

**Marking Information**
**(1) TSOT23-5**
**(Top View)**


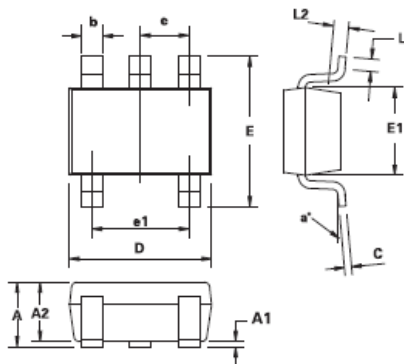
XX : Identification code

Y : Year 0~9

W : Week : A~Z : 1~26 week;  
a~z : 27~52 week; z represents  
52 and 53 week

X : A~Z : Internal code

Part Number	Package	Identification Code
AP8800AWT-7	TSOT23-5	AZ

**Package Outline Dimensions (All Dimensions in mm)**
**(1) Package Type: TSOT23-5**


DIM	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	-	1.00	-	0.0393
A1	0.01	0.10	0.0003	0.0039
A2	0.84	0.90	0.0330	0.0354
b	0.30	0.45	0.0118	0.0177
c	0.12	0.20	0.0047	0.0078
D	2.90 BSC		0.114 BSC	
E	2.80 BSC		0.110 BSC	
E1	1.60 BSC		0.062 BSC	
e	0.95 BSC		0.0374 BSC	
e1	1.90 BSC		0.0748 BSC	
L	0.30	0.50	0.0118	0.0196
L2	0.25 BSC		0.010 BSC	
a°	4°		12°	

Note: Controlling dimensions are in millimeters. Approximate dimensions are provided in inches

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