Description

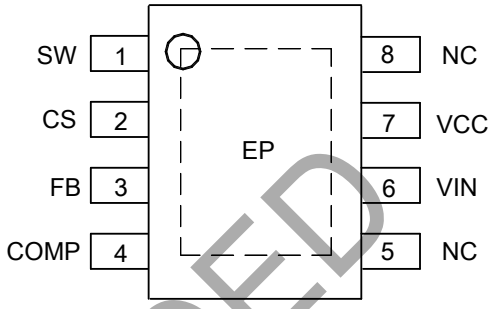
The DIODES™ AL8821 is a boost converter that delivers an accurate constant current for MR16 and similar LED lamps. With proprietary control scheme, the LED driver is compatible with many commonly used electronic transformers and provides designs with High Power Factor (PF) and low Total Harmonic Distortion (THD) for these applications. The operation frequency is up to 1MHz that allows the use of small size inductor. With the package of SO-8EP, the AL8821 has small thermal resistance and can be used for wide range of output power. The driver can be used for dimmable MR16 application and can be compatible with leading-edge dimmer and trailing-edge dimmer.

Features

- Wide Input Voltage Range: 5V to 36V
- Internal 50V NDMOS Switches
- Continuous Conduction Mode (CCM) Operation
- Up to 1MHz Switching Frequency
- High PF > 0.9 and Low THD < 30% and Low Ripple < 20%
- Compatible with Leading-Edge Dimmer and Trailing-Edge Dimmer
- Internal Protections
  - Under Voltage Lock Out (UVLO)
  - Output Open
  - Over Temperature Protection (OTP)
- Pb-free SO-8EP
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

Pin Assignments

(Top View)



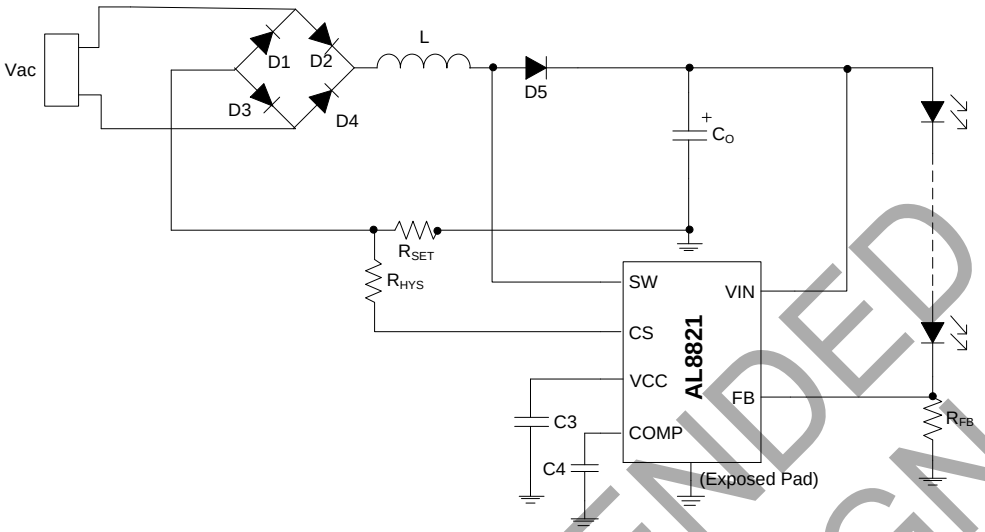
SO-8EP

Applications

- Non-dimmable MR16 lamps
- Dimmable MR16 lamps
- General illumination lamps

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

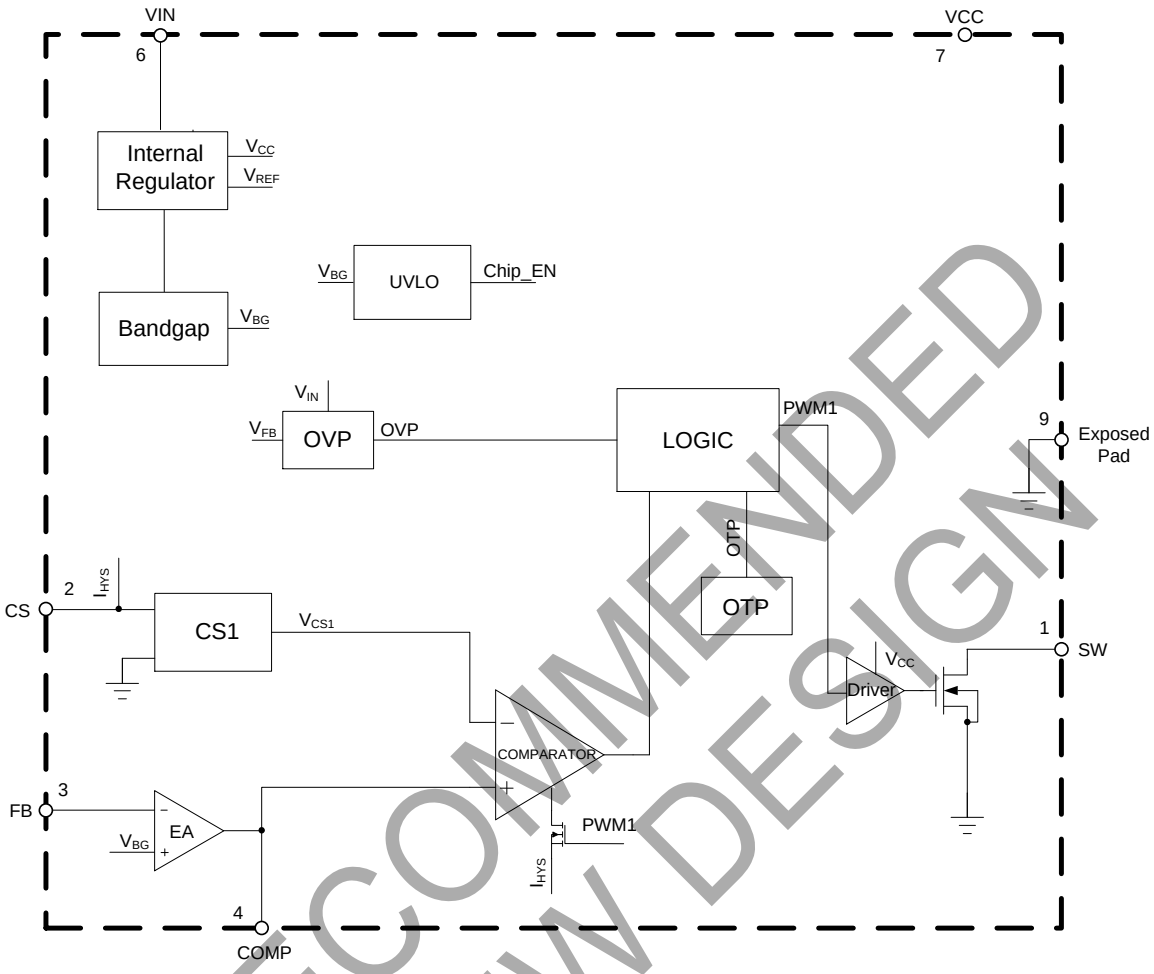
Typical Applications Circuit



Pin Descriptions

Pin Number	Pin Name	Function
1	SW	Integrated MOS Drain
2	CS	Input Current Sense Pin
3	FB	LED Output Current Feedback Pin
4	COMP	Control Loop Compensation Pin
5	NC	Not Connected
6	VIN	IC Input Voltage, Adding from Boost Output Voltage
7	VCC	Supply Voltage for Internal Circuit
8	NC	Not Connected
EP	Exposed Pad	Connected to Ground

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.) (Note 4)

Symbol	Parameter	Rating	Unit
V_{IN}	VIN Pin Voltage	-0.3 to 40	V
V_{SW}	SW Pin Voltage	-0.3 to 50	V
V_{COMP}	COMP Pin Voltage	-0.3 to 6	V
V_{CS}	CS Pin Voltage	-0.3 to 6	V
V_{FB}	FB Pin Voltage	-0.3 to 6	V
V_{CC}	VCC Pin Voltage	-0.3 to 6	V
T_J	Operating Junction Temperature	+150	°C
T_{STG}	Storage Temperature	-65 to +150	°C
θ_{JA}	Thermal Resistance (Junction to Ambient) (Note 5)	66	°C/W
T_{LEAD}	Lead Temperature (Soldering, 10sec)	+300	°C
—	ESD (Machine Model)	200	V
—	ESD (Human Body Model)	2000	V

Notes: 4. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.

5. Device mounted on FR-4 PCB (51mm x 51mm) 2oz 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.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{IN}	VIN Pin Voltage	5	36	V
T_A	Ambient Temperature	-40	+105	°C

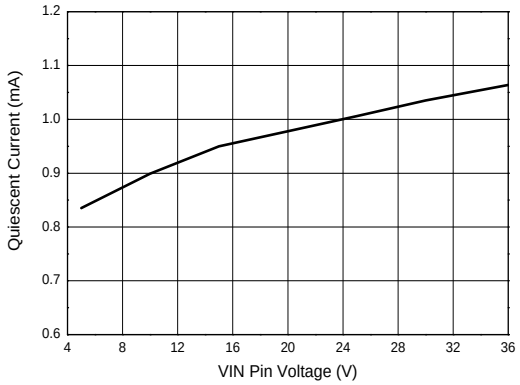
Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
Input Supply						
V_{IN}	VIN Pin Voltage	—	5	—	36	V
I_Q	Quiescent Current	No Switching	—	1	—	mA
V_{UVLO}	Under-Voltage Lockout Voltage	V_{IN} Rising	—	4.2	—	V
V_{HYS}	UVLO Hysteresis	—	—	500	—	mV
VCC Regulator						
V_{CC}	VCC Pin Voltage	—	4.5	5	5.5	V
—	Source Current Capability	V_{CC} = 5V	10	—	—	mA
—	Load Regulation	—	—	4	—	%
Integrated NMOS_BOOST						
V_{DS}	MOS Voltage Stress (Note 6)	—	—	50	—	V
I_{DS}	MOS Current Stress (Note 6)	—	—	2	—	A
R_{DSON}	MOS R_{DSON}	—	—	250	—	mΩ
Compensation and Soft Start (COMP Pin)						
GEA	Error Amplifier Trans-Conductance	—	—	1000	—	μA/V
I_{O-H}	Sourcing Current	V_{COMP} = 0.5V	—	68	—	μA
I_{O-L}	Sinking Current	V_{COMP} = 4.5V	—	68	—	μA
V_{FB}	FB Pin Voltage	—	—	444	—	mV
Hysteresis Competitor						
V_{CS_MIN}	Boost Sense Voltage Low Level	V_{COMP} = 0V	—	-90	—	mV
I_{HYS}	Hysteresis Current	—	85	100	115	μA
Over-Temperature Protection						
T_{OTSD}	Thermal Shutdown (Note 6)	—	—	+160	—	°C
T_{HYS}	Thermal Shutdown Hysteresis (Note 6)	—	—	+40	—	°C

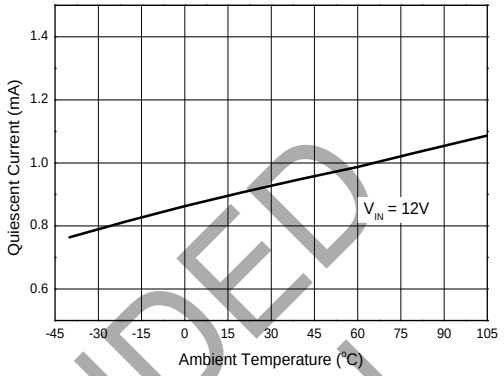
Note: 6. These parameters, although guaranteed by design, are not 100% tested in production.

Performance Characteristics

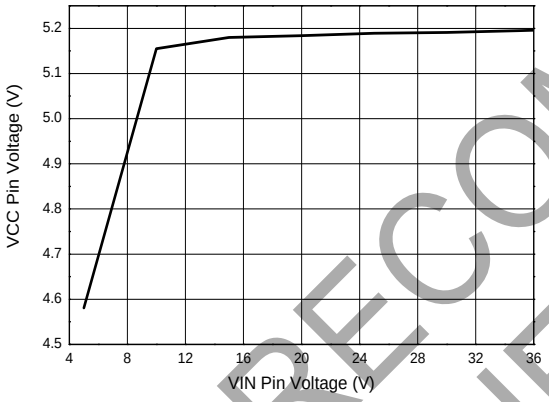
Quiescent Current vs. VIN Pin Voltage



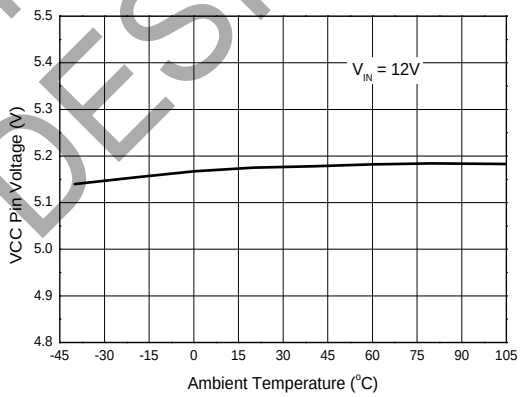
Quiescent Current vs. Ambient Temperature



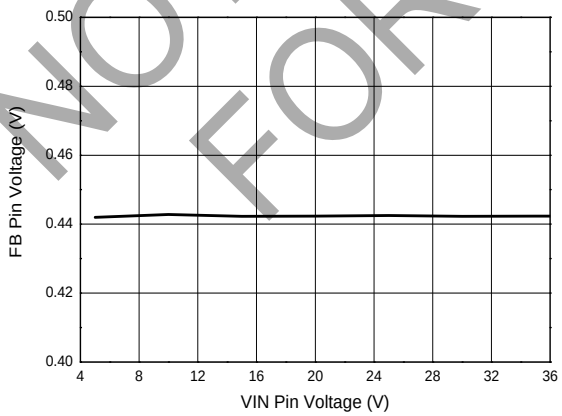
VCC Pin Voltage vs. VIN Pin Voltage



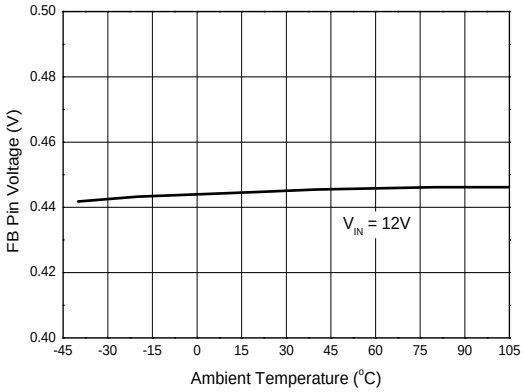
VCC Pin Voltage vs. Ambient Temperature



FB Pin Voltage vs. VIN Pin Voltage

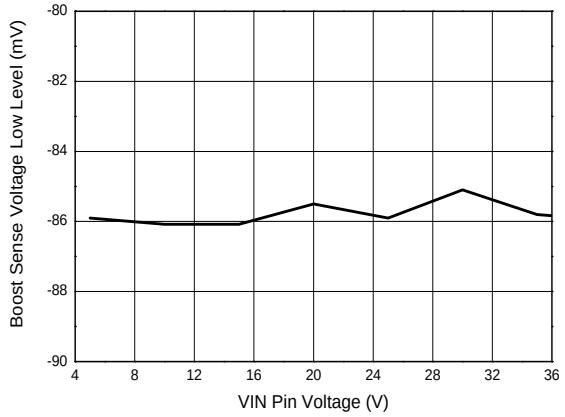


FB Pin Voltage vs. Ambient Temperature

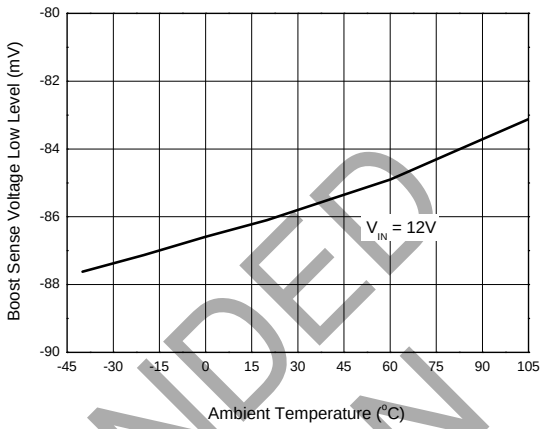


Performance Characteristics (continued)

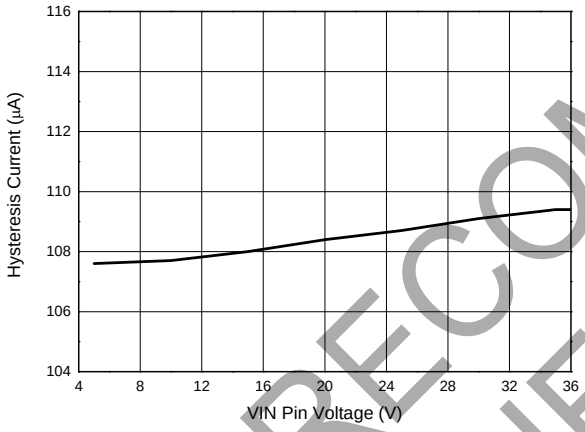
Boost Sense Voltage Low Level vs. VIN Pin Voltage



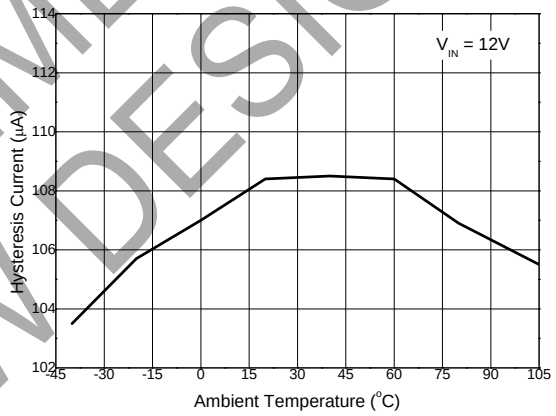
Boost Sense Voltage Low Level vs. Ambient Temperature



Hysteresis Current vs. VIN Pin Voltage



Hysteresis Current vs. Ambient Temperature



Application Information

AL8821 Operation

The AL8821 is a boost converter that delivers an accurate constant current for driving LEDs. With hysteretic control scheme, the LED driver is compatible with most of commonly used electronic transformers. The driver can be compatible with leading-edge dimmer and trailing-edge dimmer.

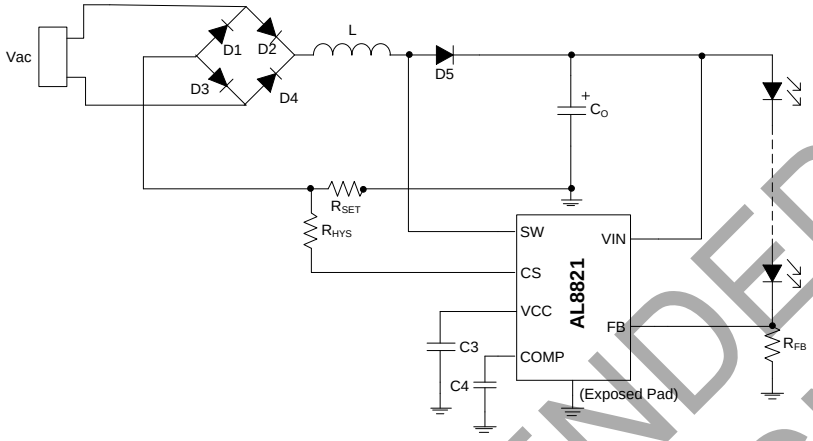


Figure 1. Typical Application Circuit

LED Current Control

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

Connected between FB pin and Ground, the nominal average output current in the LED(s) is defined as:

$$I_{LED} = \frac{0.444V}{R_{FB}}$$

R_{SET} and R_{HYS} Setting

The Boost converter of the AL8821 operates at continuous conduction mode and is based on hysteresis schematic which has lower threshold and upper threshold. Refer to Figure 2 depicting the inductor current waveform.

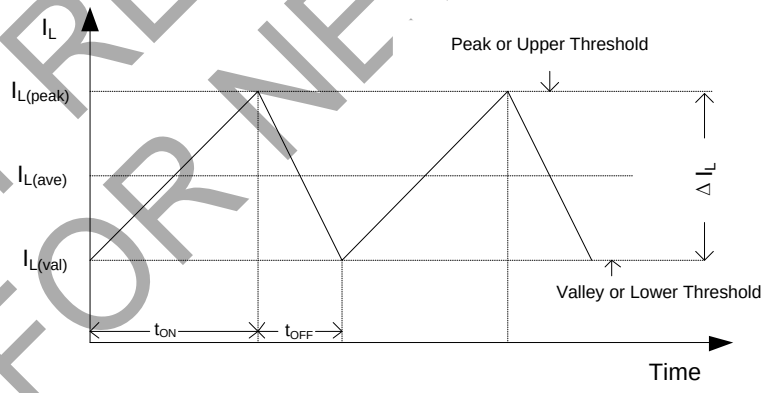


Figure 2. Inductor Current

When switch SW is turned on, the inductor current flows through R_{SET} and ramps up linearly. The rising current produces a voltage ramp across R_{SET}. When the voltage across R_{SET} reaches the upper threshold, switch SW is turned off. The inductor current continues to flow through R_{SET} but decays. The decaying current produces a falling voltage at R_{SET}. When the voltage across R_{SET} falls to the lower threshold, switch SW is turned on again.

The lower threshold voltage V_{LT} depends on the voltage V_{COMP} at COMP pin that varies with the input voltage and output load. The equation is shown as below.

Application Information (continued)

$$V_{LT}=\begin{cases}\dfrac{(V_{COMP}-1.5)\times 0.6+1.4}{16}V, 1.5V\le V_{COMP}\le 5V\\ 0.088V, 0V\le V_{COMP}\le 1.5V\end{cases}$$

The range of V_{COMP} is from 0V to 5V.

The upper threshold depends on the lower threshold and the hysteresis value. The hysteresis value is set by external resister R_{HYS}. It is defined as below.

$$V_{HYS}=R_{HYS}\times 100\mu A$$

According to the operation principle, the peak to peak current ΔI_L and the valley current $I_{L(val)}$ can be obtained by the below equations.

$$I_{L(val)}=\frac{V_{LT}}{R_{SET}}$$

$$\Delta I_L=\frac{V_{HYS}}{R_{SET}}$$

Where:

ΔI_L is the peak to peak current of inductor.

$I_{L(val)}$ is the valley current of inductor.

From the Figure 2, the relationship between $I_{L(peak)}$, $I_{L(val)}$, $I_{L(ave)}$ and ΔI_L can be obtained as below.

$$I_{L(peak)}=I_{L(val)}+\Delta I_L$$

$$I_{L(ave)}=I_{L(val)}+\frac{1}{2}\times\Delta I_L$$

Where:

$I_{L(peak)}$ is the peak current of inductor.

$I_{L(ave)}$ is the average current of inductor.

As we know the average current $I_{L(ave)}$ depends on the output power, rated input voltage V_{IN1} of step-up converter and total efficiency η. So the average current $I_{L(ave)}$ can be obtained by the following equation.

$$I_{L(ave)}=\frac{(V_{LED}+0.444)\times I_{LED}}{\eta\times V_{IN1}}$$

Where:

V_{LED} is the voltage in LEDs.

Set ratio of ΔI_L to $I_{L(peak)}$ as K.

Application Information (continued)

$$K = \frac{\Delta I_L}{I_{L(peak)}}$$

R_{SET} and R_{HYS} can be obtained from above equations:

$$R_{SET} = \begin{cases} \dfrac{((V_{COMP} - 1.5) \times 0.6 + 1.4) \times (2 - K) \times \eta \times V_{IN1}}{32 \times (V_{LED} + 0.444) \times I_{LED} \times (1\text{-}K)}, 1.5V \le V_{COMP} \le 5V \\ \dfrac{0.044 \times (2 - K) \times \eta \times V_{IN1}}{(V_{LED} + 0.444) \times I_{LED} \times (1\text{-}K)}, 0V \le V_{COMP} \le 1.5V \end{cases}$$

$$R_{HYS} = \frac{2 \times (V_{LED} + 0.444) \times I_{LED} \times K \times R_{SET} \times 10^4}{\eta \times V_{IN1} \times (2 - K)}$$

When the value of K, η and V_{COMP} are provided, the value of resister R_{SET} and R_{HYS} can be calculated according to these above equations. In order to get appropriate efficiency and Electronic Transformer (ET) compatibility, generally K is set between 0.4 and 0.8. Due to the range of V_{COMP} is from 0V to 5V, in order to get output voltage regulation, generally V_{COMP} is set as 3V at rated input voltage.

Inductor Selection

Because of the using of the hysteretic control scheme, the switching frequency in a boost configuration can be adjusted in accordance to the value of the inductor being used. The value of the inductor can be determined on the desired switching frequency by using the following equation:

$$L = \frac{[V_{IN1} - (R_{SET} + R_L + R_{DSON}) \times I_{L(ave)}] \times [V_{LED} + 0.444 + V_F + (R_L + R_{SET}) \times I_{L(ave)} - V_{IN1}]}{\Delta I_L \left(V_{LED} + 0.444 + V_F - R_{DSON} \times I_{L(ave)}\right) \times f_{SW}}$$

Where:

L is the coil inductance.

R_L is the coil resistance.

R_{DSON} is the switch SW resistance.

V_{IN1} is the rated input voltage.

V_F is the diode forward voltage.

f_{SW} is the desired switching frequency. Generally 500kHz to 800kHz switching frequency is suggested. Low switching frequency can decrease the switching loss but need to choose higher inductor values that will result in larger size in order to meet the saturation current. For example the relationship between switching frequency and inductor value is shown as below Table 1 in the same application system. Considering these factors, 500kHz switching frequency is recommended in typical application.

Inductance Value of L @ Vac = 12Vac, V_{IN} = 22V V_{LED} = 28V, I_{LED} = 180mA	Operation Frequency of SW at Peak Voltage Of Vac
10μH	840kHz
15μH	800kHz
22μH	680kHz
33μH	465kHZ

Table 1

Application Information (continued)

VIN OVP Protection

AL8821 has an internal over voltage protection to protect IC from excessive input voltage. When the voltage applied at VIN pin exceeds 39V, it will turn off the power switch SW. The power switch SW will be turned on again once the voltage at V_{IN} drops below 34V.

VCC Regulator

The VCC pin requires a capacitor C3 for stable operation and to store the charge for the large GATE switching currents. Choose a 10V rated low ESR, X7R or X5R, ceramic capacitor for best performance. A 4.7µF capacitor will be adequate for many applications. Place the capacitor close to the IC to minimize the trace length to the VCC pin and to the IC ground.

An internal current limit on the VCC output protects the excessive on-chip power dissipation. The VCC pin has set the output to 5V (typ.) to protect the internal FETs from excessive power dissipation caused by not being fully enhanced. If the VCC pin is used to drive extra circuits beside the AL8821, the extra loads should be limited to less than 8mA.

Output Capacitor C_O

The capacitor C_O is used to hold the bus voltage and reduce the ripple of LED current when the electronic transformer has no output. For most applications, it is recommended to use an aluminum electrolytic capacitor with greater than 220µF capacitance.

Compensation Capacitor C4

In applications powered by electronic transformer, the input voltage can change roughly in one cycle of AC power frequency. A 1µF ceramic capacitor C4 connected from COMP pin to ground helps to stabilize the control loop of the regulator.

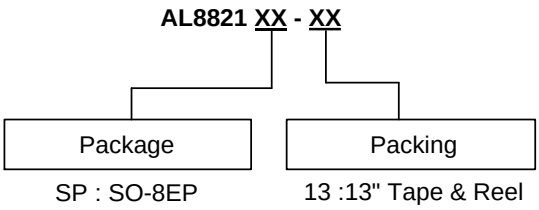
Diode Selection

For maximum efficiency and performance, the rectifiers (D5) should be fast low capacitance Schottky diodes with low reverse leakage at maximum operating voltage and temperature. With its low power dissipation, the Schottky diode outperforms other silicon diodes and increases overall efficiency.

Over Temperature Protection

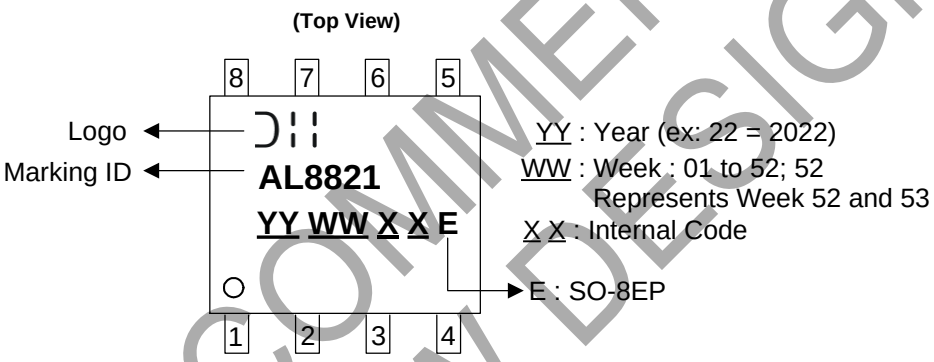
An over temperature protection feature is to protect the AL8821 from excessive heat damage. When the junction temperature exceeds +160°C, the internal FET will be turned off. When junction temperature drops below +120°C, IC will turn on both FETs and return to normal operation.

Ordering Information



Part Number	Part Number Suffix	Package Code	Package	Packing	
				Qty.	Carrier
AL8821SP-13	-13	SP	SO-8EP	2500	Tape & Reel

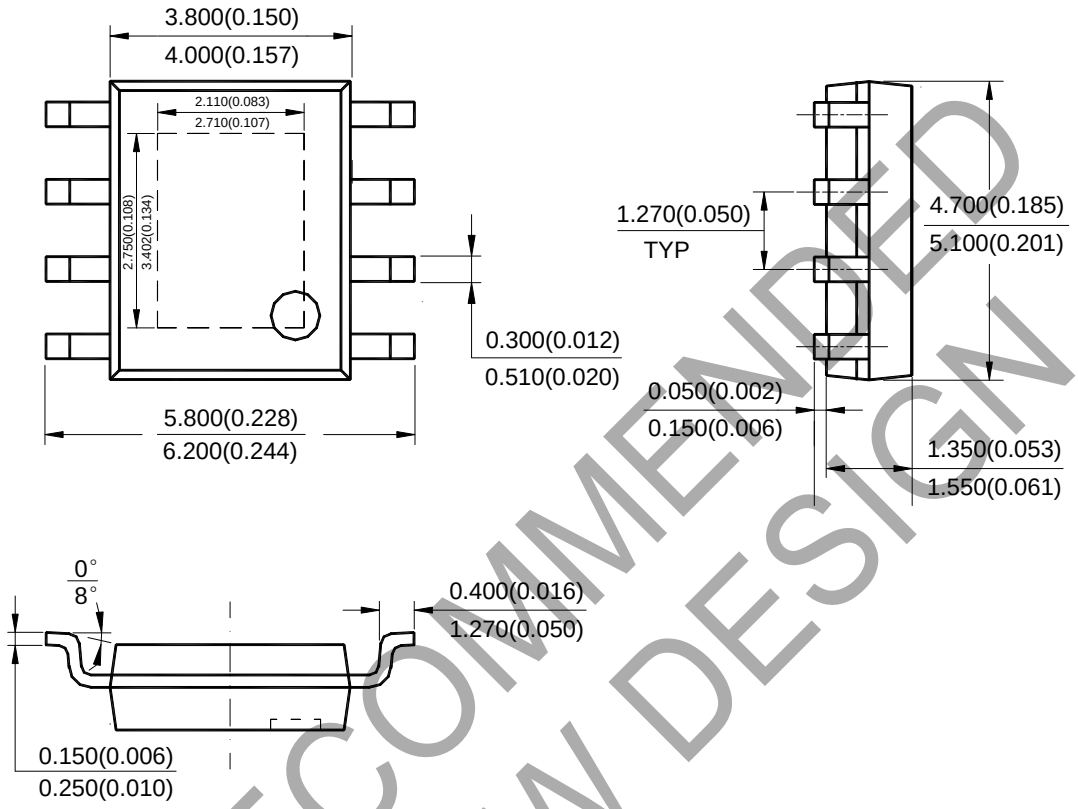
Marking Information



Package Outline Dimensions (All dimensions in mm(inch).)

Please see http://www.diodes.com/package-outlines.html for the latest version.

Package Type: SO-8EP

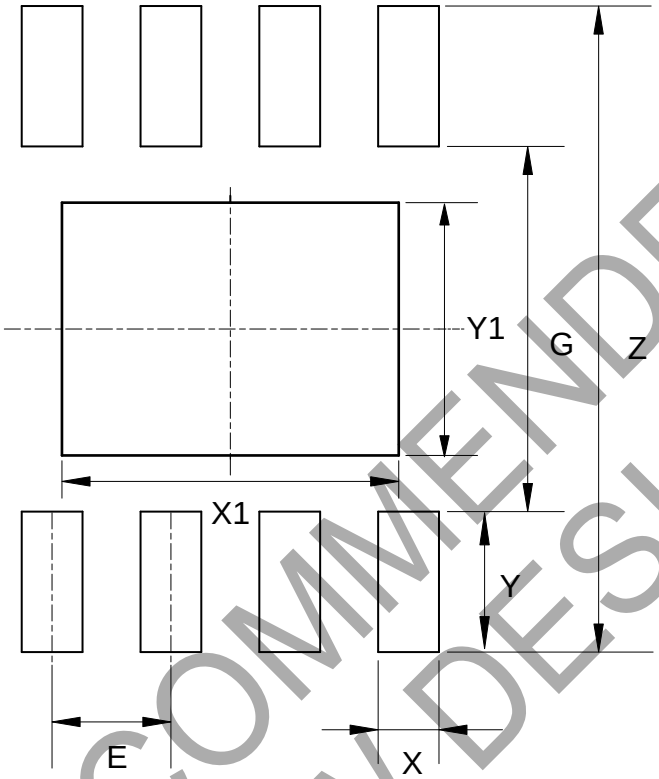


Note: Eject hole, oriented hole and mold mark is optional.

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

Package Type: SO-8EP



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	X1 (mm)/(inch)	Y1 (mm)/(inch)	E (mm)/(inch)
Value	6.900/0.272	3.900/0.154	0.650/0.026	1.500/0.059	3.600/0.142	2.700/0.106	1.270/0.050

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