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Lead-free Green

# AL8822

**50V, 2A BOOST LED DRIVER**

## Description

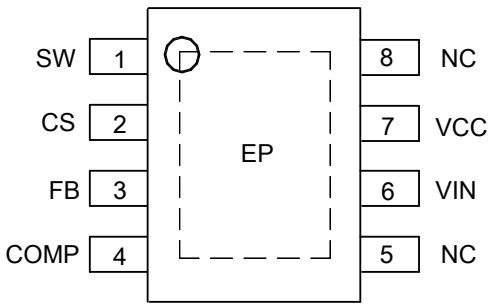
The AL8822 is a boost converter that delivers an accurate constant current for MR16 and similar LED Lamps. With proprietary control scheme, the LED driver is compatible with many commonly used electronic transformers and provides designs with High Power Factor (PF) and low Total Harmonic Distortion (THD) for these applications. The operation frequency is up to 1MHz that allows the use of a small size inductor. With the package of SO-8EP, the AL8822 has small package size, 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 Protection
  - 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**)

## 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.

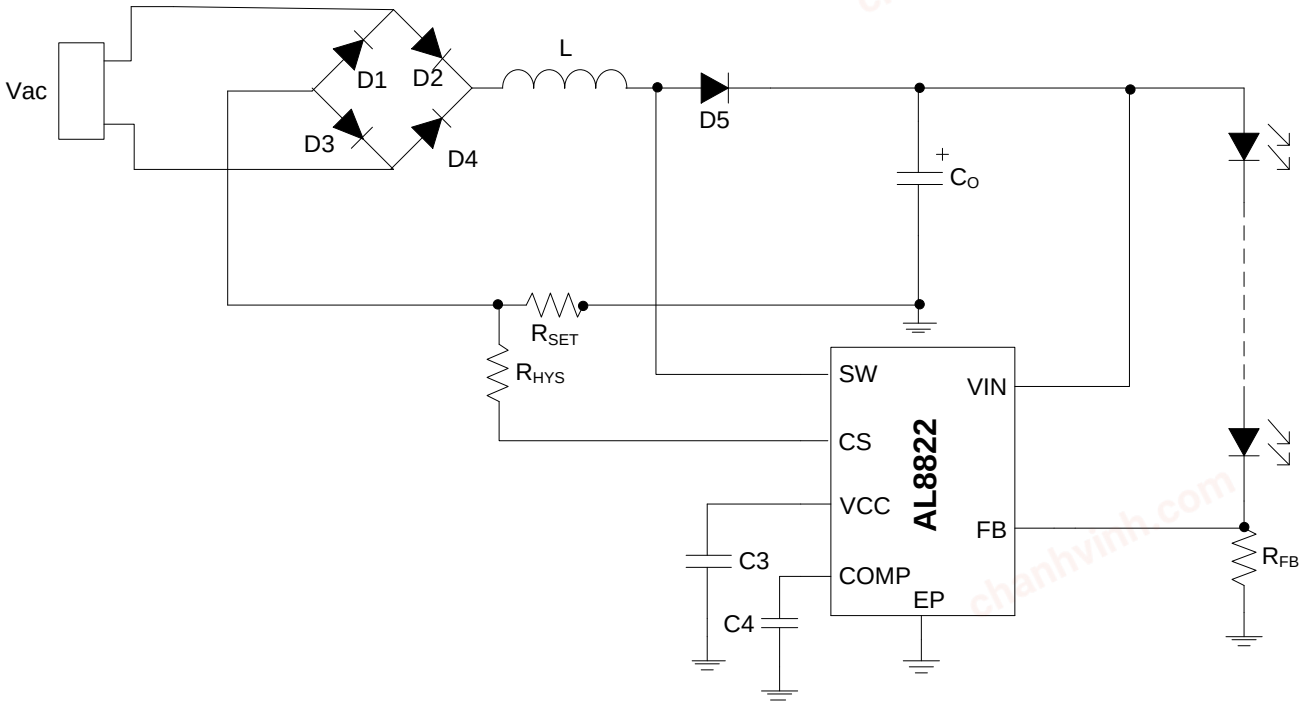

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## Typical Applications Circuit




The AL8822 Boost Application 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 |
| 9 | EP | Exposed pad that connect to GND. |

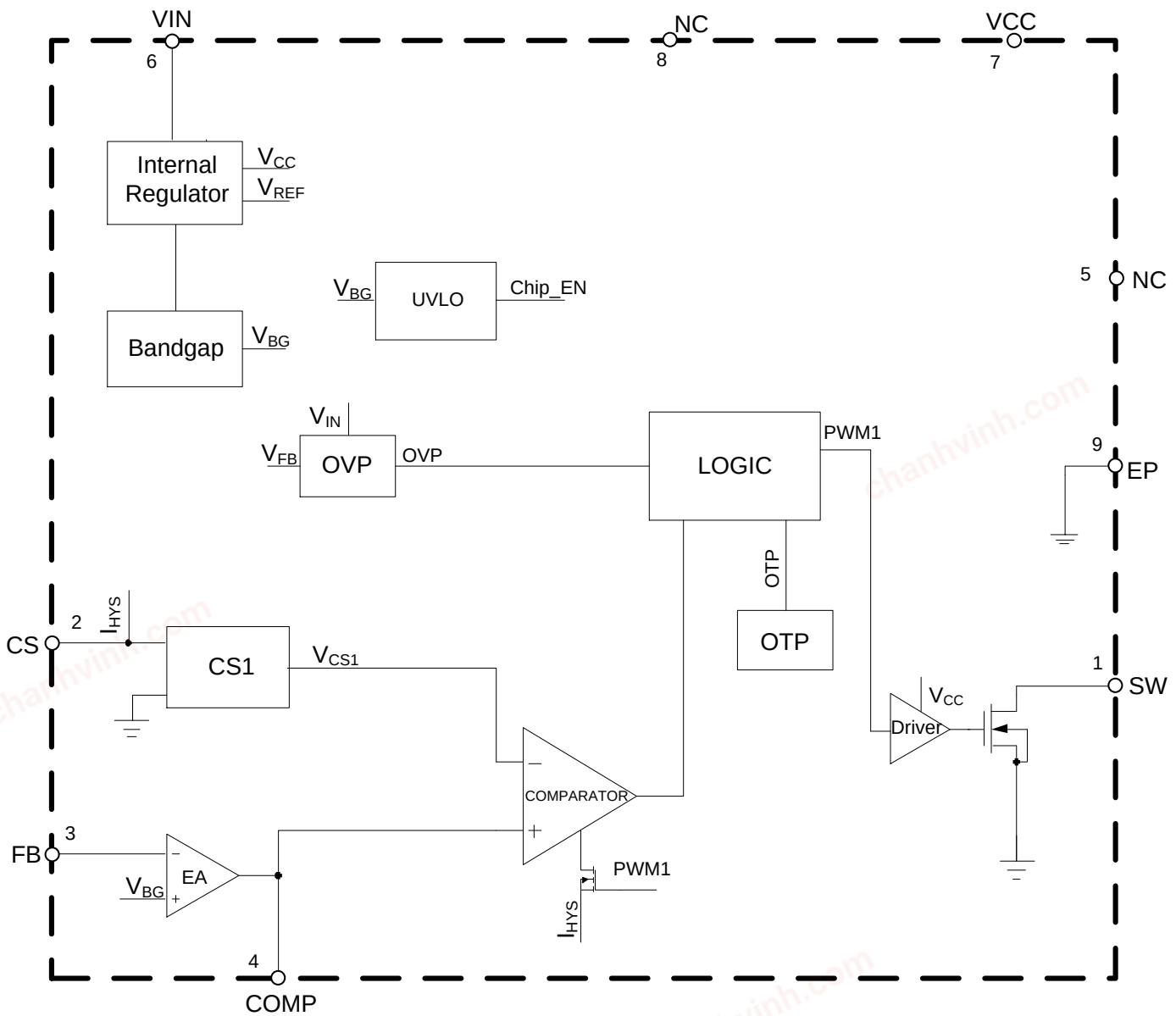

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## Functional Block Diagram




AL8822 Block Diagram


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## 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 |
| $\theta_{JA}$ | Thermal Resistance (Junction to Ambient) (Note 5) | 66 | °C/W |
| $T_{LEAD}$ | Lead Temperature (Soldering, 10s) | +300 | °C |
| – | ESD (Machine Model) | 200 | V |
| – | ESD (Human Body Model) | 2000 | V |

Notes: 4. Stresses greater than those listed under “Absolute Maximum Ratings” may 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 may 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 (Note 6) | -40 | +105 | °C |

Note: 6. The device may operate normally at +125°C ambient temperature under the condition not trigger temperature protection.


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

| Symbol | Parameter | Condition | 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 7) | – | 50 | – | – | V |
| $I_{DS}$ | MOS Current Stress (Note 7) | – | – | 2 | – | A |
| $R_{DSON}$ | MOS $R_{DSON}$ | – | – | 250 | 500 | mΩ |
| **Compensation and Soft Start (COMP Pin)** | | | | | | |
| $G_{EA}$ | 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 | – | 430 | 444 | 458 | mV |
| **Hysteresis Comparator** | | | | | | |
| $V_{CS_MIN}$ | 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 7) | – | – | +160 | – | °C |
| $T_{HYS}$ | Thermal Shutdown Hysteresis (Note 7) | – | – | +40 | – | °C |

Note: 7. Guaranteed by design, not tested in production.


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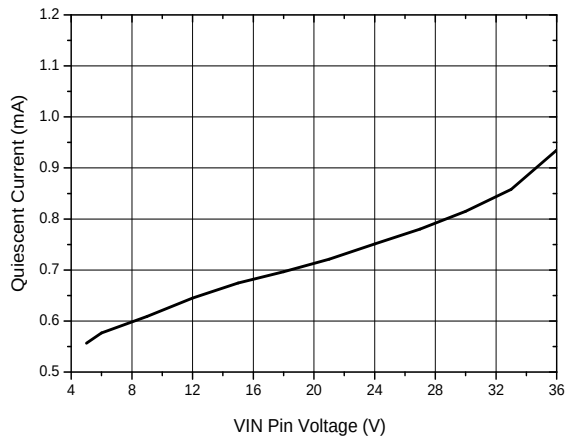
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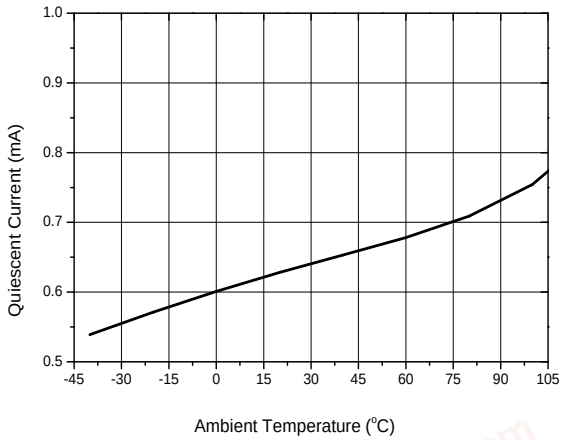
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## Performance Characteristics

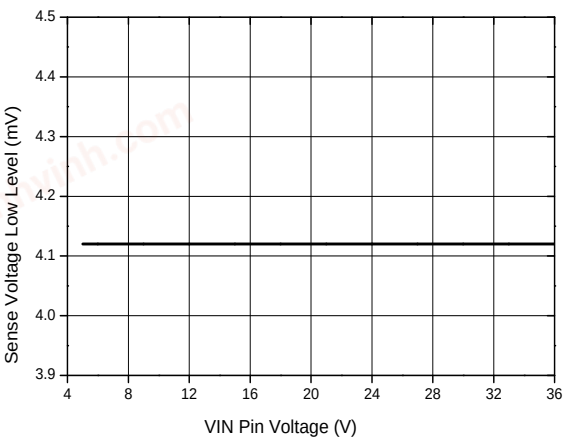
### Quiescent Current vs. VIN Pin Voltage



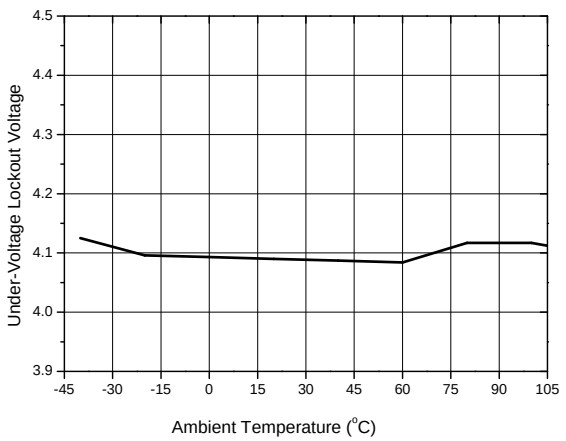

### Quiescent Current vs. Ambient Temperature



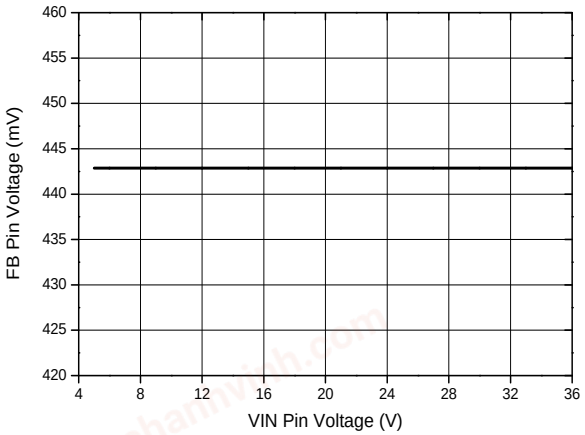

### Under-Voltage Lockout Voltage vs. VIN Pin Voltage



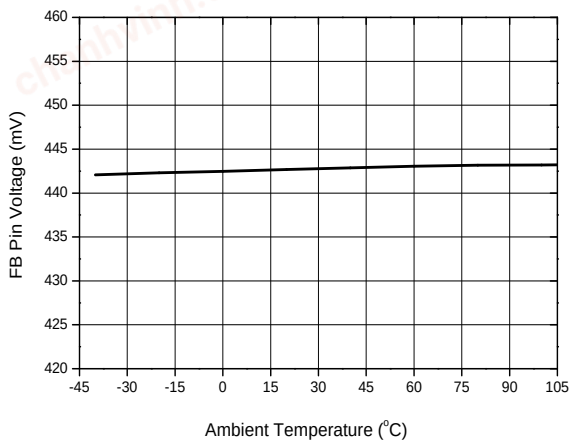

### Under-Voltage Lockout Voltage vs. Ambient Temperature




### FB Pin Voltage vs.VIN Pin Voltage




### FB Pin Voltage vs. Ambient Temperature





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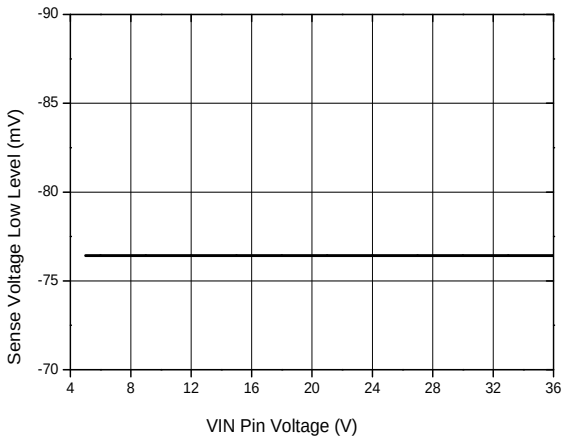
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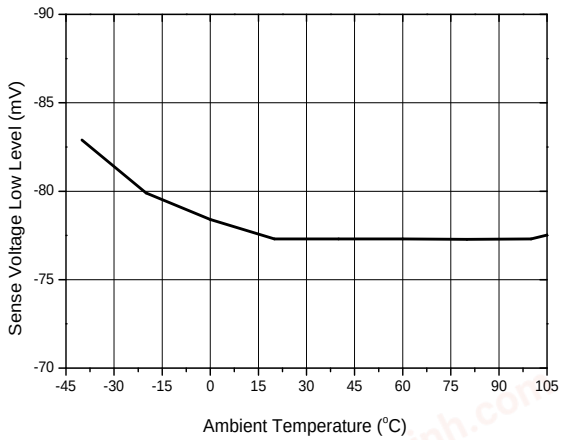
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## Performance Characteristics (Cont.)

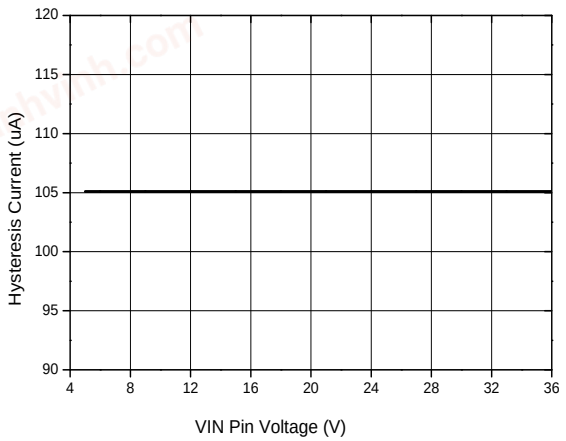
**Boost Sense Voltage Low Level vs. VIN Pin Voltage**



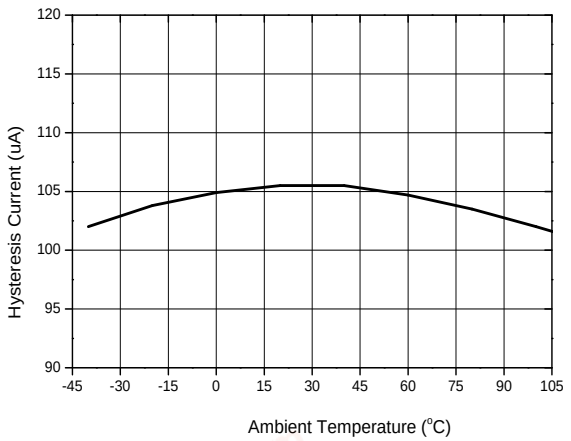

**Boost Sense Voltage Low Level vs. Ambient Temperature**




**Hysteresis Current vs. VIN Pin Voltage**




**Hysteresis Current vs. Ambient Temperature**





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## Application Information

### Operation

The AL8822 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.

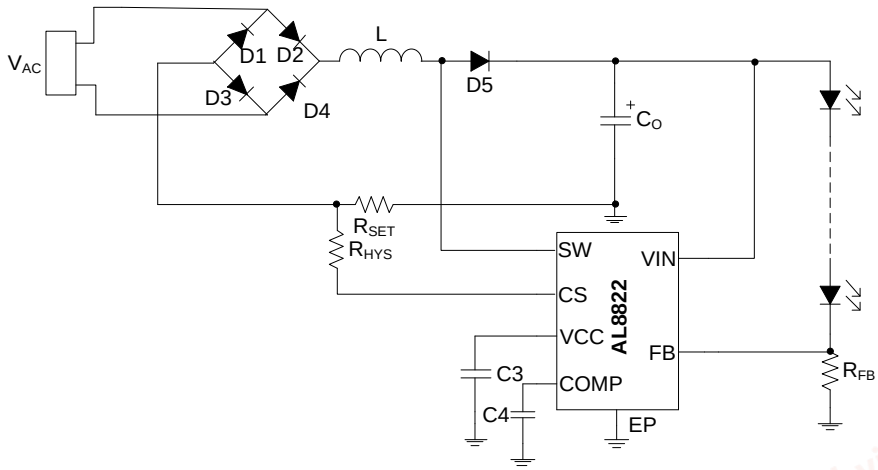



Figure 1. Typical Application Circuit

### 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:

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

### $R_{SET}$ and $R_{HYS}$ Setting

The Boost converter of the AL8822 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.

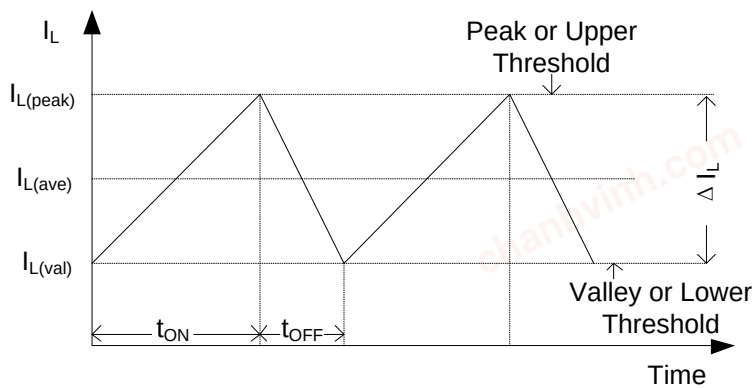



Figure 2. Inductor Current

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.


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## Application Information (Cont.)

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

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 $\Delta I_L$ 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:

$\Delta I_L$ 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 $\Delta I_L$ 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 $\Delta I_L$ to $I_{L(peak)}$ as K.


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## Application Information (Cont.)

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

$R_{SET}$ 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 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 on 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 recommend in typical application.

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

Table 1


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## Application Information (Cont.)

**VIN OVP Protection**

AL8822 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 , 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 help to stabilize the control loop of the regulator.

**Diode Selection**

For maximum efficiency and performance, the rectifier (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 AL8822 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.

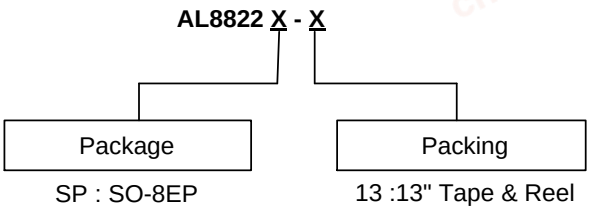

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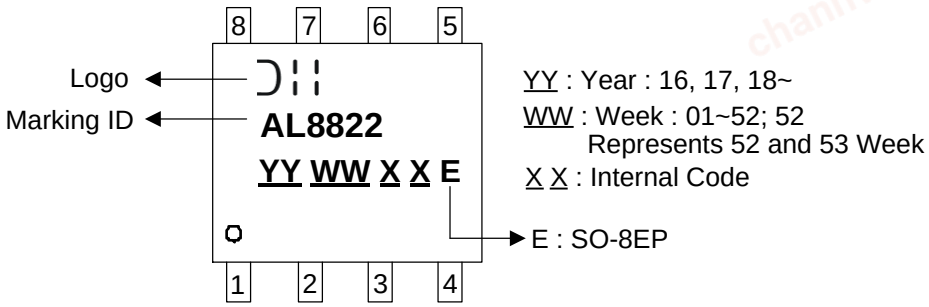
## Ordering Information




| Part Number | Package Code | Package | 13" Tape and Reel | |
|---|---|---|---|---|
| | | | Quantity | Part Number Suffix |
| AL8822SP-13 | SP | SO-8EP | 2500/Tape & Reel | -13 |

## Marking Information

(Top View)





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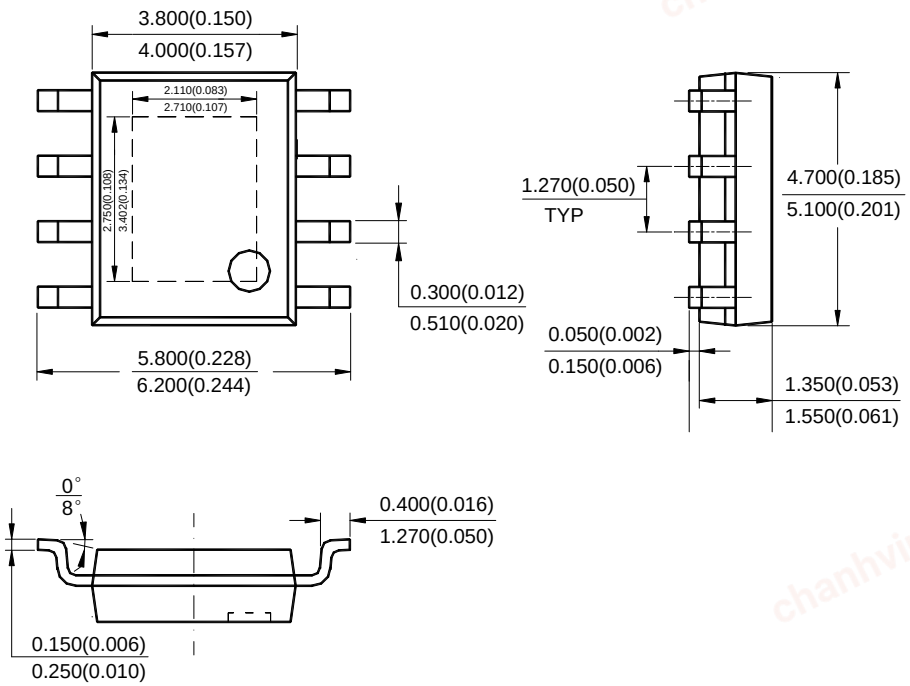
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## Package Outline Dimensions (All dimensions in mm(inch).)

**(1) Package Type: SO-8EP**




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


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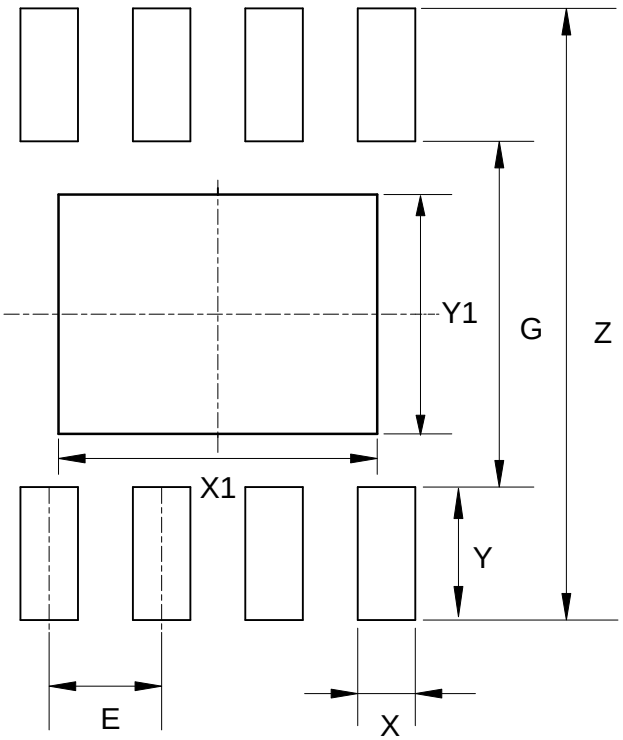
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## Suggested Pad Layout

**(1)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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2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

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