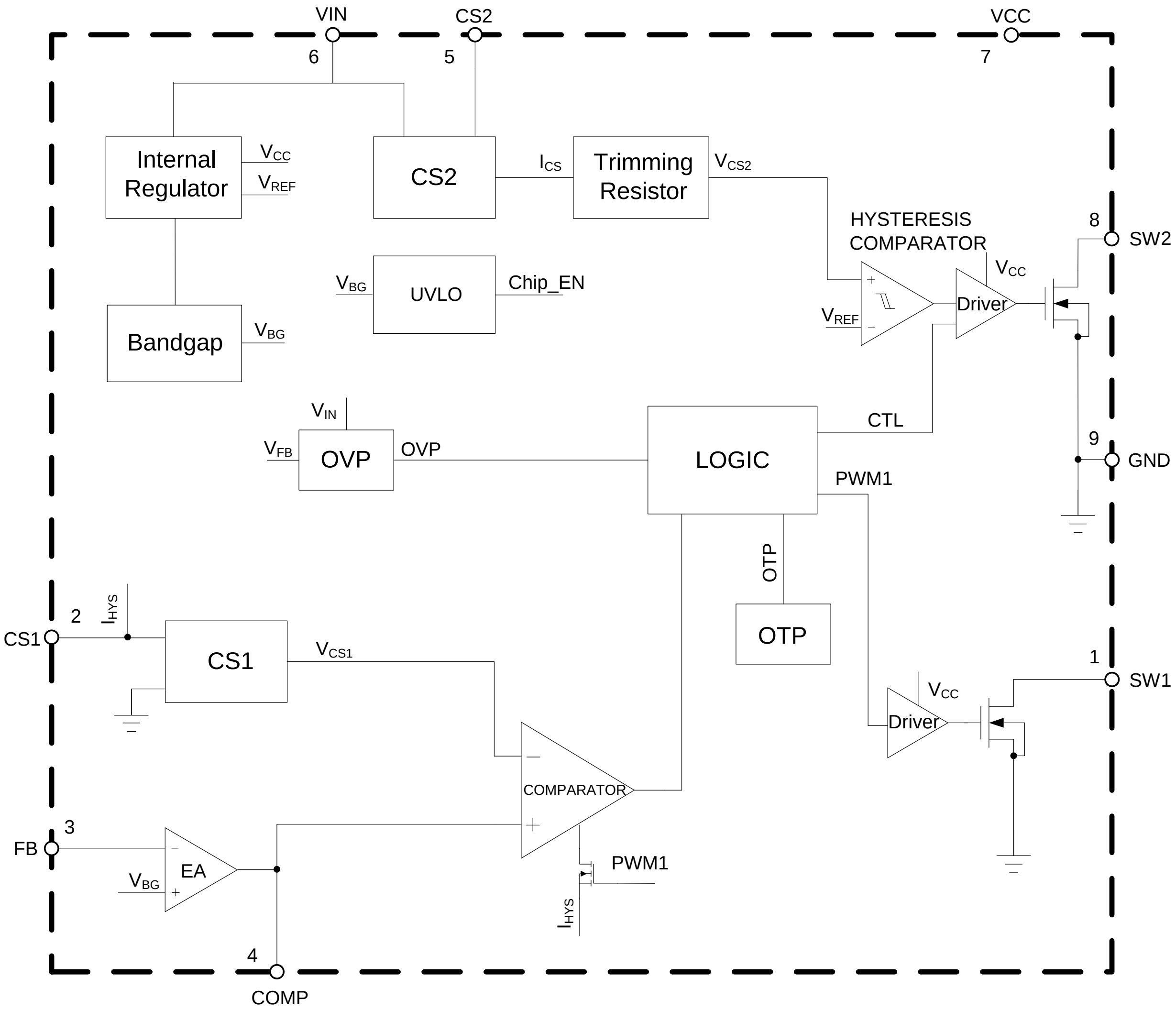
Pin Descriptions

Pin Number	Pin Name	Function
1	SW1	Integrated Boost MOS Drain
2	CS1	Boost Input Current Sense Pin
3	FB	Boost Output Voltage Feedback Pin
4	COMP	Soft-start and Boost Control Loop Compensation
5	CS2	Buck Output Current Sense Pin
6	VIN	IC Input Voltage, Adding from Boost Output Voltage
7	VCC	Supply Voltage For Internal Circuit
8	SW2	Integrated Buck MOS Drain
9	Exposed Pad	Connected To Ground

Functional Block Diagram



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

Parameter	Symbol	Value	Unit
VIN Pin Voltage	V_{IN}	-0.3 to 40	V
SW1 Pin Voltage	V_{SW1}	-0.3 to 40	V
SW2 Pin Voltage	V_{SW2}	-0.3 to 40	V
COMP Pin Voltage	V_{COMP}	-0.3 to 6	V
CS1 Pin Voltage	V_{CS1}	-0.3 to 6	V
CS2 Pin Voltage	V_{CS2}	-0.3 to 40	V
FB Pin Voltage	V_{FB}	-0.3 to 6	V
VCC Pin Voltage	V_{CC}	-0.3 to 6	V
Operating Junction Temperature	T_J	+150	ºC
Storage Temperature	T_{STG}	-65 to +150	ºC
Thermal Resistance (Junction To Ambient) (Note 5)	θ_{JA}	66	°C/W
Lead Temperature (Soldering, 10sec)	T_{LEAD}	+300	ºC
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	-40	+105	°C

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

Parameters	Symbol	Conditions	Min	Typ	Max	Unit
Input Supply						
VIN Pin Voltage	V_{IN}	–	5	–	36	V
Quiescent Current	I_Q	No Switching	–	1	–	mA
Under-Voltage Lockout Voltage	V_{UVLO}	V_{IN} Rising	–	4.2	–	V
UVLO Hysteresis	V_{HYS}	–	–	500	–	mV
VCC Regulator						
VCC Pin Voltage	V_{CC}	–	4.5	5	5.5	V
Source Current Capability	–	V_{CC} = 5V	10	–	–	mA
Load Regulation	–	–	–	4	–	%
Integrated NMOS_BUCK						
MOS Voltage Stress (Note 6)	V_{DS1}	–	–	40	–	V
MOS Current Stress (Note 6)	I_{DS1}	–	–	2	–	A
MOS R_{DSON}	R_{DSON1}	–	–	250	–	mΩ
Integrated NMOS_BOOST						
MOS Voltage Stress (Note 6)	V_{DS2}	–	–	40	–	V
MOS Current Stress (Note 6)	I_{DS2}	–	–	2	–	A
MOS R_{DSON}	R_{DSON2}	–	–	250	–	mΩ
Compensation and Soft Start (COMP Pin)						
Error Amplifier Trans-conductance	GEA	–	–	1000	–	µA/V
Sourcing Current	I_{O_H}	V_{COMP} = 0.5V	–	68	–	µA
Sinking Current	I_{O_L}	V_{COMP} = 4.5V	–	68	–	µA
FB Pin Voltage	V_{FB}	–	1.18	1.22	1.26	V
FB OVP Voltage	V_{OVP}	–	1.59	1.66	1.75	V
FB OVP Voltage Hysteresis	V_{OVP_HYS}	–	0.15	0.2	0.25	V
Hysteresis Competitor (Boost)						
Boost Sense Voltage Low Level	V_{CS1_MIN}	V_{COMP} = 0V	–	-90	–	mV
Hysteresis Current	I_{HYS}	–	85	100	115	µA
Hysteresis Competitor (Buck)						
Buck Sense Voltage High Level	V_{CSH}	–	–	115	–	mV
Buck Sense Voltage Low Level	V_{CSL}	–	–	85	–	mV
Buck Sense Voltage Average Level	V_{CS2_AVE}	–	95	100	105	mV
Over-Temperature Protection						
Thermal Shutdown (Note 6)	T_{OTSD}	–	+140	+160	–	ºC
Thermal Shutdown Hysteresis (Note 6)	T_{HYS}	–	–	+40	–	ºC

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

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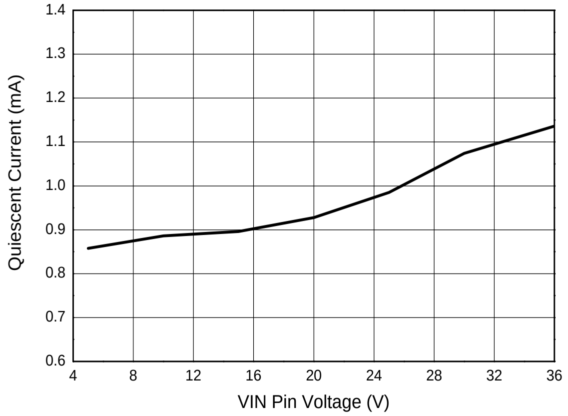
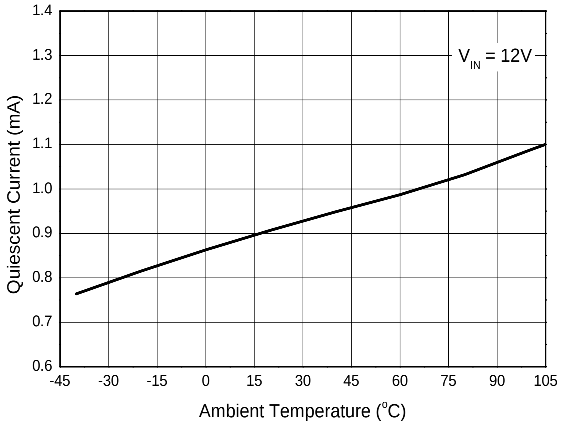
Performance Characteristics

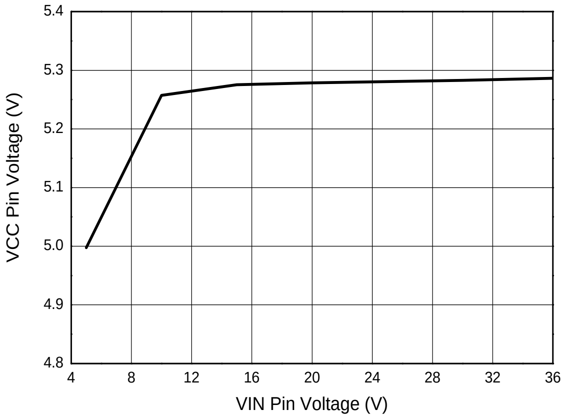
Quiescent Current vs. VIN Pin Voltage



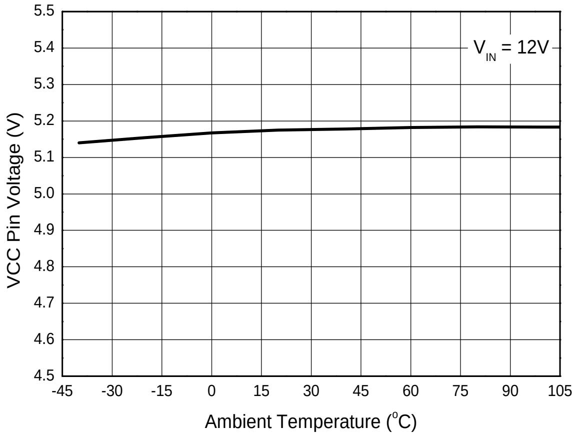
Quiescent Current vs. Ambient Temperature



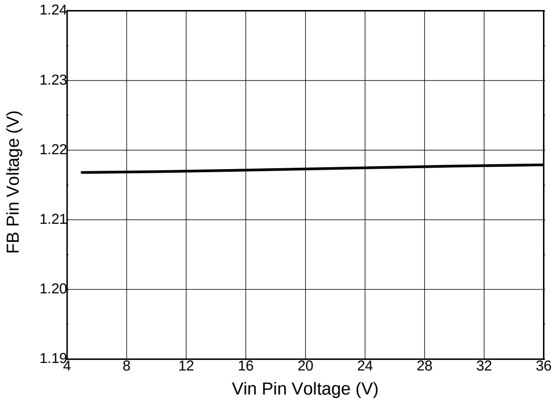
VCC Pin Voltage vs. VIN Pin Voltage



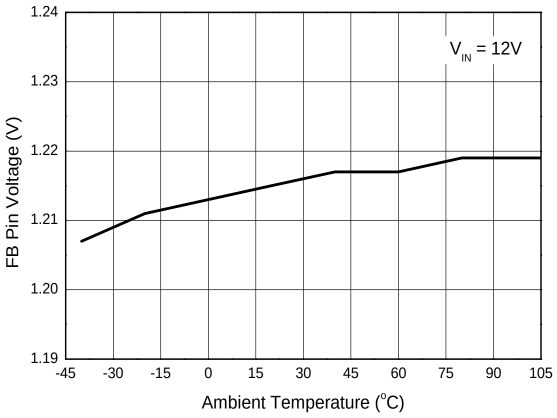
VCC Pin Voltage vs. Ambient Temperature



FB Pin Voltage vs.VIN Pin Voltage



FB Pin Voltage vs. Ambient Temperature



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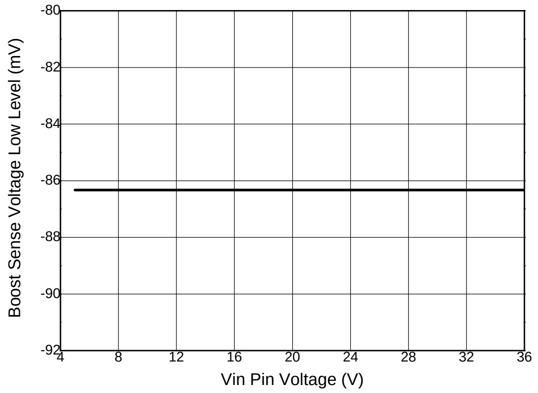
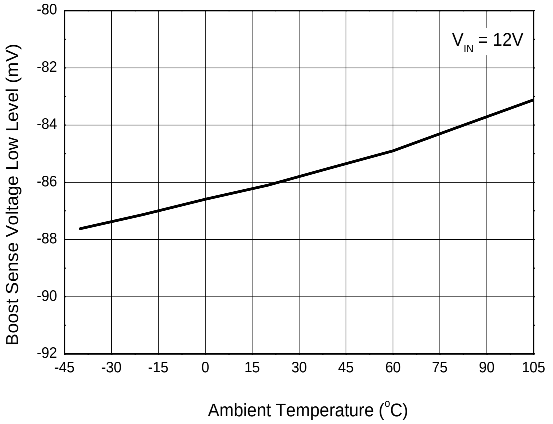
Performance Characteristics (Cont.)

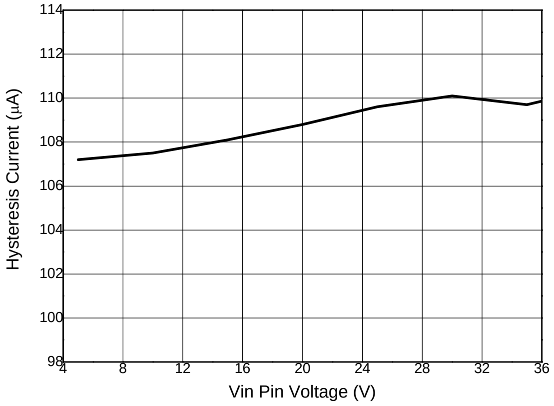
Boost Sense Voltage Low Level vs. VIN Pin Voltage



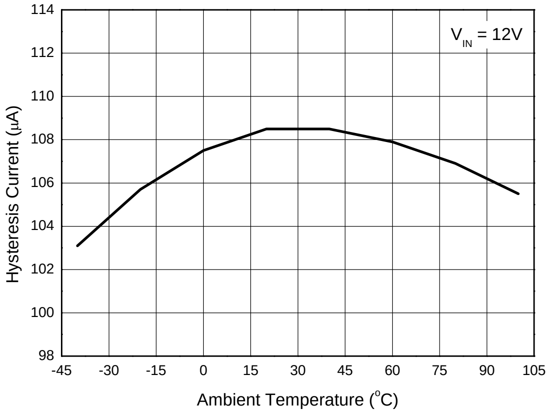
Boost Sense Voltage Low Level vs. Ambient Temperature



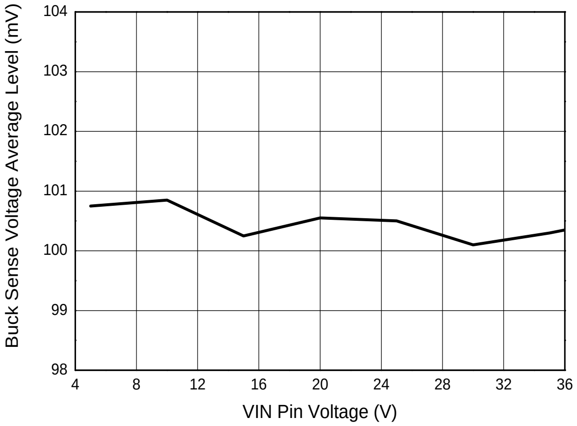
Hysteresis Current vs. VIN Pin Voltage



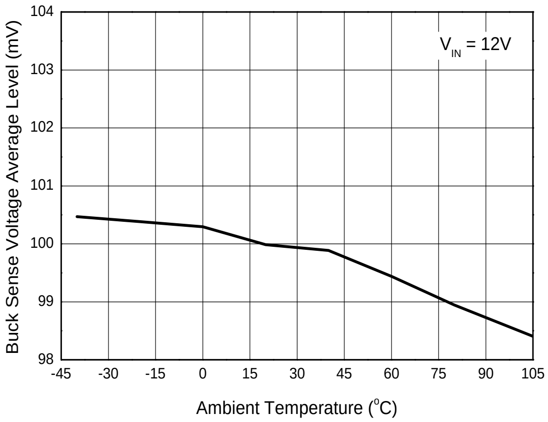
Hysteresis Current vs. Ambient Temperature



Buck Sense Voltage Average Level vs. VIN Pin Voltage



Buck Sense Voltage Average Level vs. Ambient Temperature



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Application Information

AL8820 Operation

The device integrates two DC/DC regulators. This two stage design offers superior performance for MR16/AR111 applications. The first stage is a boost PFC stage which improves PF, reduces EMI and conditions the input to be compatible with many of the most commonly used Electronic Transformers (ET). This input stage also provides power for the second stage buck converter which provides regulated constant output current for the LEDs.

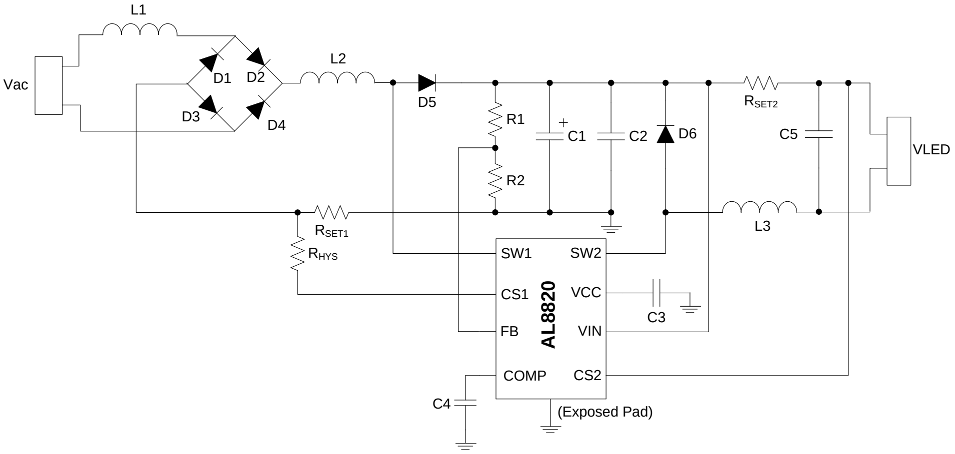

Figure 1. Typical Application Circuit

V_{IN} Voltage Setting

V_{IN} Voltage is the output voltage of boost section and is also the input voltage of the buck section. Therefore V_{IN} must be set sufficiently higher than the output voltage of buck section. For the Boost application, the output voltage can be defined as:

$$V_{IN} = 1.22V \times \frac{R1 + R2}{R2}$$

R_{SET1} and R_{HYS} Setting

The Boost converter of the AL8820 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.

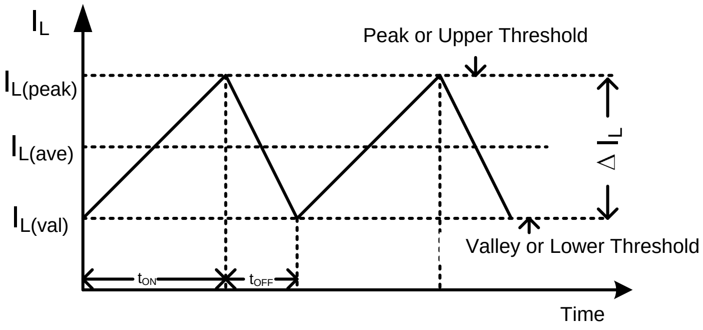

Figure 2. Inductor Current

When switch SW1 is turned on, the inductor current flows through R_{SET1} and ramps up linearly. The rising current produces a voltage ramp across R_{SET1}. When the voltage across R_{SET1} reaches the upper threshold, switch SW1 is turned off. The inductor current continues to flow through R_{SET1} but decays. The decaying current produces a falling voltage at R_{SET1}. When the voltage across R_{SET1} falls to the lower threshold, switch SW1 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.)

$$V_{LT} = \begin{cases} \dfrac{(V_{COMP} - 1.5) \times 0.6 + 1.4}{16} mV, 1.5V \le V_{COMP} \le 5V \\ 88mV, 0V \le V_{COMP} \le 1.5V \end{cases}$$

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.

$$I_{L(val)} = \frac{V_{LT}}{R_{SET1}}$$

$$\Delta I_L = \frac{V_{HYS}}{R_{SET1}}$$

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 boost converter and total efficiency η. So the average current $I_{L(ave)}$ can be obtained by the below equation.

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

Where:

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Application Information (Cont.)

V_{LED} is the output voltage of Buck converter.

I_{LED} is the output current of Buck converter.

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

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

R_{SET1} and R_{HYS} can be obtained from above equations:

$$R_{SET1} = \begin{cases} \dfrac{((V_{COMP} - 1.5) \times 0.6 + 1.4) \times (2 - K) \times \eta \times V_{IN1} \times 10^{-3}}{32 \times V_{LED} \times I_{LED} \times (1\text{-}K)} 1.5V \le V_{COMP} \le 5V \\ \dfrac{44 \times (2 - K) \times \eta \times V_{IN1} \times 10^{-3}}{V_{LED} \times I_{LED} \times (1 - K)}, 0V \le V_{COMP} \le 1.5V \end{cases}$$

$$R_{HYS} = \frac{2 \times V_{LED} \times I_{LED} \times K \times R_{SET1} \times 10^{4}}{\eta \times V_{IN1} \times (2 - K)}$$

When the value of K, η and V_{COMP} are provided, the value of resister R_{SET1} 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.

Step-Up Converter 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 by using the following equation:

$$L2 = \frac{[V_{IN1} - (R_{SET1} + R_L + R_{DSON1}) \times I_{L(ave)}] \times [V_{IN} - V_{IN1} - V_F - (R_L + R_{SET1}) \times I_{L(ave)}]}{\Delta I_L [V_{IN} - V_F - (2R_{SET1} + 2R_L - R_{DSON1}) \times I_{L(ave)}] \times f_{SW1}}$$

Where:

L2 is the coil inductance.

R_L is the coil resistance.

R_{SET1} is the current sense resistance.

R_{DSON1} is the switch SW1 resistance.

V_{IN1} is the rated input voltage of the boost converter.

V_{IN} is the output voltage of boost converter.

V_F is the diode forward voltage at the required load current.

f_{SW1} is the desired switching frequency.

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Application Information (Cont.)

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 L2 @ Vac = 12Vac, V_{IN} = 22V, V_{OUT} = 10V, I_{OUT} = 650mA	Operation Frequency of SW1 at Peak Voltage of Vac
10µH	637kHz
15µH	500kHz
27µH	373kHz

Table 1

LED Current Control

The LED current is controlled by the resistor R_{SET2} in Figure 1.

Connected between VIN pin and CS2 pin, the nominal average output current in the LED(s) is defined as:

$$I_{LED} = \frac{100mV}{R_{SET2}}$$

Buck Converter Inductor Selection

The inductance L3 in Buck converter is determined by the following factors: inductor ripple current, switching frequency, V_{LED}/V_{IN} ratio, internal FET, and component parameter. The inductance L3 is calculated according to the following equation:

$$L3 \geq \frac{V_{IN} - V_{LED} - (R_{SET2} + R_{DSON2} + R_{COIL}) \times I_{LED}}{\Delta I_{LED}} \times \frac{V_{LED}}{V_{IN}} \times \frac{1}{f_{SW2}}$$

Where:

V_{IN} is the output voltage of Boost converter.

V_{LED} is the output voltage of Buck converter.

R_{SET2} is the current sense resistance.

R_{DSON2} is the switch resistance (=0.25Ω).

R_{COIL} is the coil resistance of inductor L3.

ΔI_{LED} is the coil peak-peak ripple current, internally set to 0.25 x I_{LED}.

f_{SW2} is the switching frequency.

The low switching frequency f_{SW2} is recommended in order to minimize errors due to switching delays which will result in increased ripple and lower efficiency. Higher switching frequency can choose smaller inductor value that has smaller size in order to meet the saturation current but will increase the switching loss. For example, the relationship between switching frequency and inductor value is shown as below Table 2 in the same application system. Considering these factors, about 300kHz switching frequency is recommended in typical application.

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Application Information (Cont.)

Inductance Value of L3 @ V_{IN} = 22Vac, V_{OUT} = 10V, I_{OUT} = 650mA	Operation Frequency of SW2
33µH	756kHz
47µH	568kHz
68µH	397kHz
100µH	257kHz

Table 2

VIN OVP Protection

The AL8820 has two kinds of Over-voltage (OVP) protection both of which turn off the power switch SW1. When the voltage at the FB pin exceeds threshold approximately 1.66V, the power switch of step-up stage is turned off. The power switch of boost section can be turned on again once the voltage at the FB pin drops below 1.46V.

The AL8820 additionally has an internal over voltage protection to protect the AL8820 from excessive input voltage. When the voltage applied at VIN pin exceeds 39V, it will turn off the power switch SW1. The power switch will turn on once the voltage at V_{IN} drops below 34V.

VCC Regulator

The VCC pin requires a capacitor 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 between the VCC pin and the exposed pad.

An internal current limit on the VCC output protects against 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 AL8820, the extra loads should be limited to less than 8mA.

Output Capacitor C1 and C2 of Boost

The capacitor C1 is used to hold the bus voltage when the electronic transformer has no output. For most applications, it is recommended to use an aluminum electrolytic capacitor with greater than 220µF capacitance.

The output capacitor C2 is selected to handle the output ripple noise requirements. For the best performance, it is recommended to use X7R or better grade ceramic capacitor greater than 1µF 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 Boost regulator.

Output Capacitor C5 of Buck

Higher LED current ripple will shorten the LED life time and increase heat accumulation of LED. To reduce the LED current ripple, an output capacitor in parallel with the LED should be added. Lower ripple can be achieved with higher capacitor values. For most applications, a value of 4.7µF is recommended.

Diode Selection

For maximum efficiency and performance, the rectifiers (D5, D6) 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

A over temperature protection feature is to protect the AL8820 from excessive internal temperature. When the junction temperature exceeds +160ºC, the internal FETs will be turned off. When junction temperature drops below +120ºC, IC will turn on both FETs and return to normal operation.

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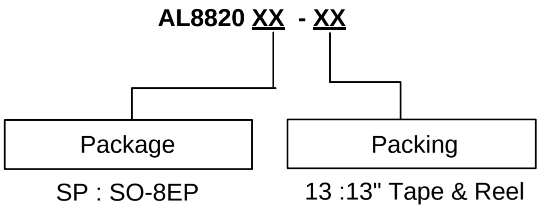
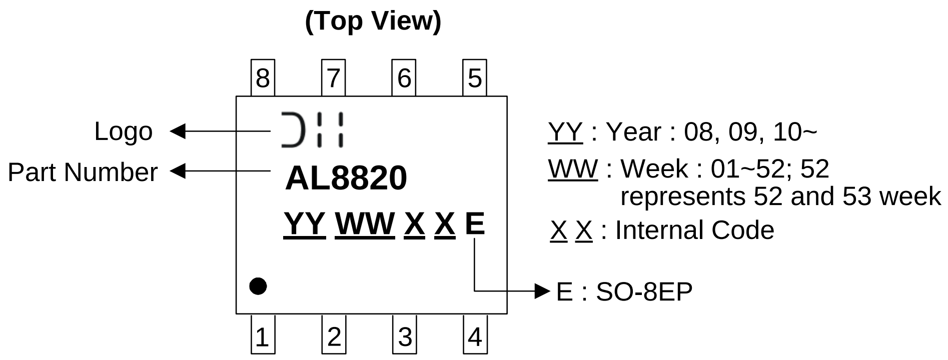
NEW PRODUCT

Ordering Information



Part Number	Package Code	Package	13" Tape and Reel	
			Quantity	Part Number Suffix
AL8820SP-13	SP	SO-8EP	2500/Tape & Reel	-13

Marking Information



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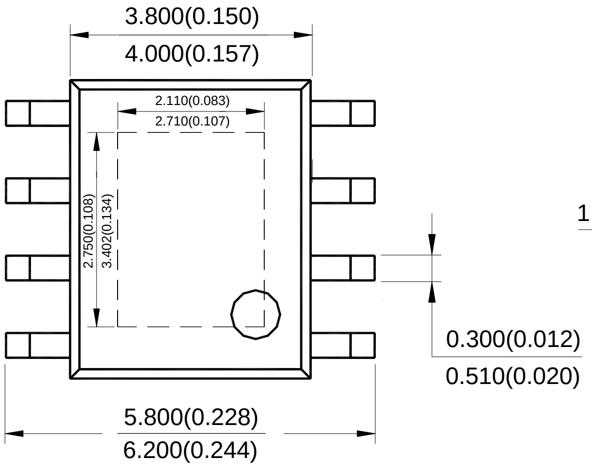
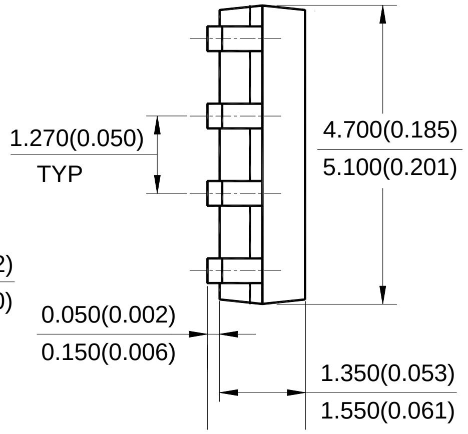
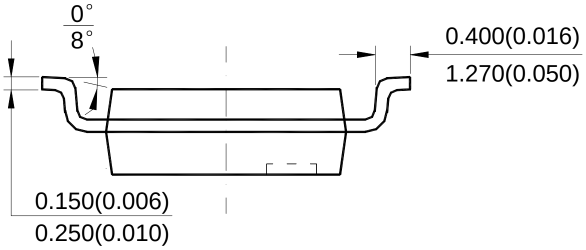
NEW PRODUCT

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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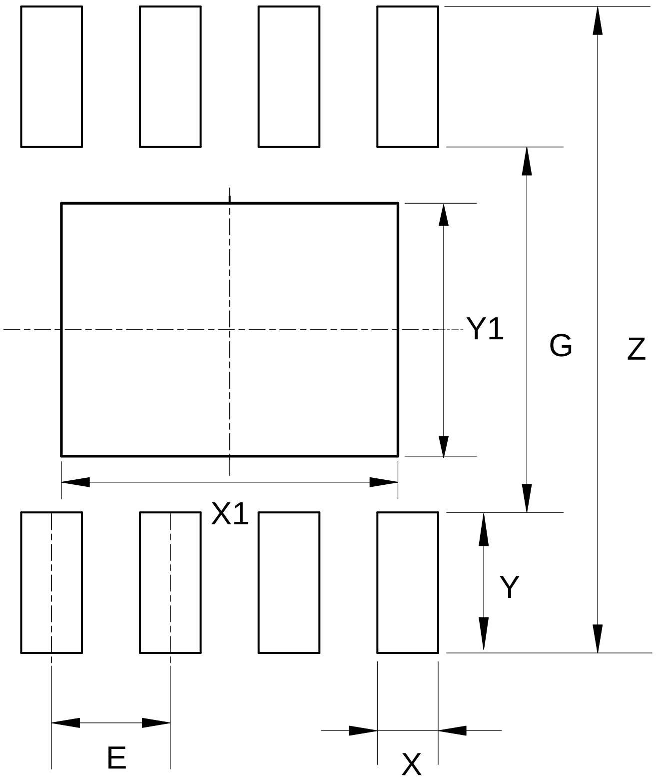
Suggested Pad Layout

(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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