

Boost LED Current Driver

General Description

The RT8405 is a simple boost LED current driver by well inductor current control with a built-in power MOSFET. The high efficiency can be achieved by the low current sense threshold typ. around 250mV. When used in specific MR16/AR111 LED lighting applications, the RT8405 performs high compatibility with various Electronic Transformers (ET) with extremely high Power Factor.

The RT8405 is available in the SOP-8 (Exposed Pad) package. The whole system board can be made very small and compact.

Ordering Information

- RT8405 □ □
- Package Type
SP : SOP-8 (Exposed Pad-Option 2)
 - Lead Plating System
G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

- ▶ RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- ▶ Suitable for use in SnPb or Pb-free soldering processes.

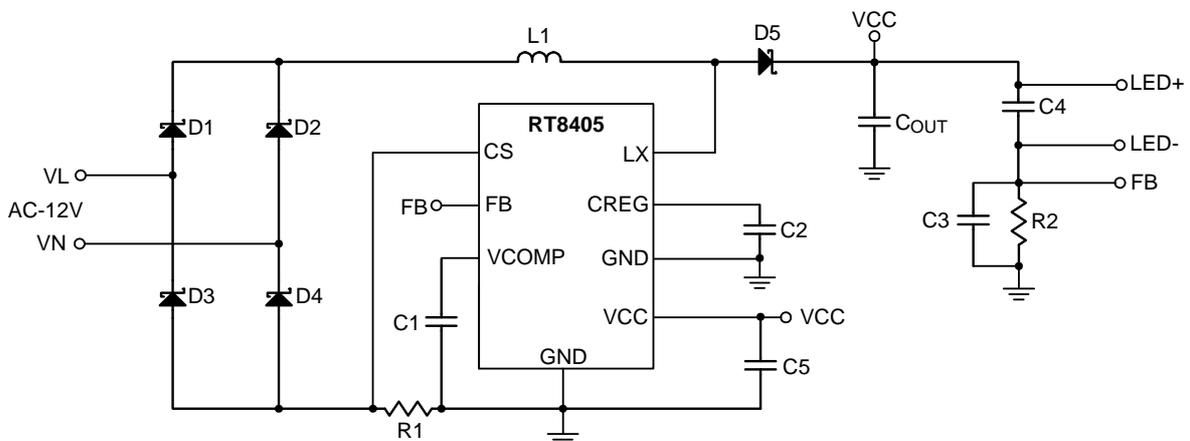
Features

- Boost Topology
- Power MOSFET Inside
- Wide Input Voltage Range : 4.5V to 35V
- Excellent Power Factor
- Programmable LED Current with $\pm 5\%$ LED Current Accuracy
- Input Under Voltage Lockout Detection
- Boost Output Over Voltage Protection
- Thermal Shutdown Protection
- SOP-8 (Exposed Pad) Package
- RoHS Compliant and Halogen Free

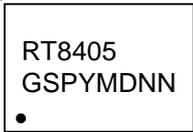
Applications

- MR16 Lighting
- Signage and Decorative LED Lighting
- Architectural Lighting
- High Power LED Lighting
- Low Voltage Industrial Lighting
- Indicator and Emergency Lighting
- Automotive LED Lighting

Simplified Application Circuit



Marking Information

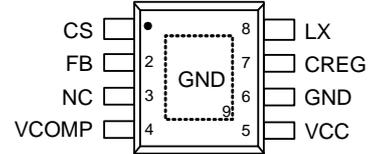


RT8405GSP : Product Number

YMDNN : Date Code

Pin Configuration

(TOP VIEW)

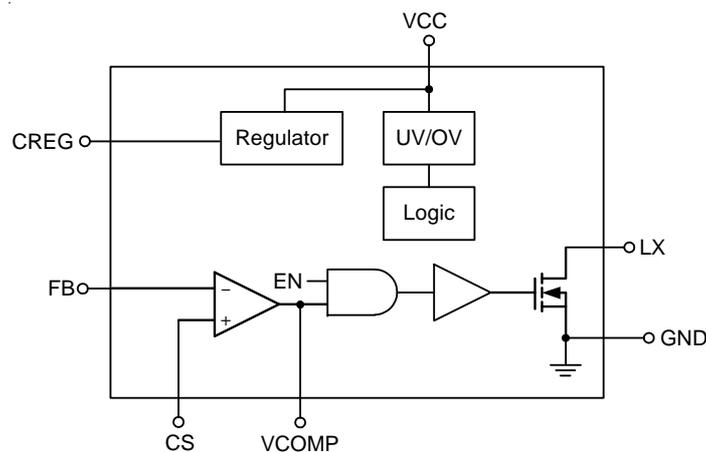


SOP-8 (Exposed Pad)

Functional Pin Description

Pin No.	Pin Name	Pin Function
1	CS	Current sense input.
2	FB	Average LED output current sensing input.
3	NC	No internal connection.
4	VCOMP	Compensation node. A compensation network between VCOMP and GND is needed.
5	VCC	Power supply. For good bypass, place a ceramic capacitor near the VCC pin.
6	GND	Ground. Connected to Pin 9 directly.
7	CREG	Internal regulator output. Place a Capacitor between CREG and GND pins.
8	LX	Internal MOSFET drain. Switch of the boost topology.
9 (Exposed Pad)	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.

Functional Block Diagram



Operation

The RT8405 is a simple boost LED current driver by well inductor current control with a built-in power MOSFET. The high efficiency can be achieved by the low current sense threshold typ. around 250mV. When used in specific MR16/AR111 LED lighting applications, the RT8405 performs high compatibility with various Electronic Transformers (ET) with extremely high Power Factor.

The RT8405 is available in the SOP-8 (Exposed Pad) package. The whole system board can be made very small and compact.

Absolute Maximum Ratings (Note 1)

- Supply Voltage, VCC to GND ----- -0.3V to 40V
- CREG, FB, VCOMP, CS to GND ----- -0.3V to 6V
- LX to GND ----- -0.3V to 40V
- Power Dissipation, P_D @ T_A = 25°C
 - SOP-8 (Exposed Pad) ----- 2.46W
- Package Thermal Resistance (Note 2)
 - SOP-8 (Exposed Pad), θ_{JA} ----- 40.6°C/W
 - SOP-8 (Exposed Pad), θ_{JC} ----- 2°C/W
- Junction Temperature ----- 150°C
- Lead Temperature (Soldering, 10 sec.) ----- 260°C
- Storage Temperature Range ----- -65°C to 150°C
- ESD Susceptibility (Note 3)
 - HBM (Human Body Model) ----- 2kV
 - MM (Machine Model) ----- 200V
 - CDM (Charge Device Model) ----- 1kV

Recommended Operating Conditions (Note 4)

- Supply Input Voltage, VCC ----- 4.5V to 35V
- Junction Temperature Range ----- -40°C to 125°C
- Ambient Temperature Range ----- -40°C to 85°C

Electrical Characteristics

(V_{CC} = 20V_{DC}, No Load, C_{LOAD} = 1nF, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Voltage						
CREG UVLO_ON	V _{UVLO_ON}	V _{FB} = 0V	--	4.2	--	V
CREG UVLO_OFF	V _{UVLO_OFF}	V _{FB} = 0V	--	3.9	--	V
Supply Current						
VCC Shutdown Current	I _{SHDN}	V _{CC} = 2V	--	10	--	μA
VCC Quiescent Current	I _Q	V _{FB} = 5V	--	2	--	mA
VCC OVP Trigger Level	V _{CC_OVP}		--	38	--	V
VCC OVP Recovery Level	V _{CC_OVP_R}		--	24	--	V
Internal Reference Voltage	V _{CREG}		--	5	--	V
Internal Reference Voltage (I _{CREG} = -20mA)		I _{CREG} = 20mA	--	4.9	--	V
CS Input Impedence		CS = -0.2V	--	50	--	kΩ
FB OVP	High Level	VOVP_H	--	1.88	--	V
	Low Level	VOVP_L	--	1.57	--	V
FB Sense Threshold			237.5	250	262.5	mV

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VCOMP Source			--	-10	--	μA
VCOMP Sink			--	10	--	μA
LX Internal Switch R _{DS(ON)}	R _{DS(ON)}	Sink = 100mA	--	200	--	mΩ
Thermal Shutdown	T _{SD}		--	150	--	°C

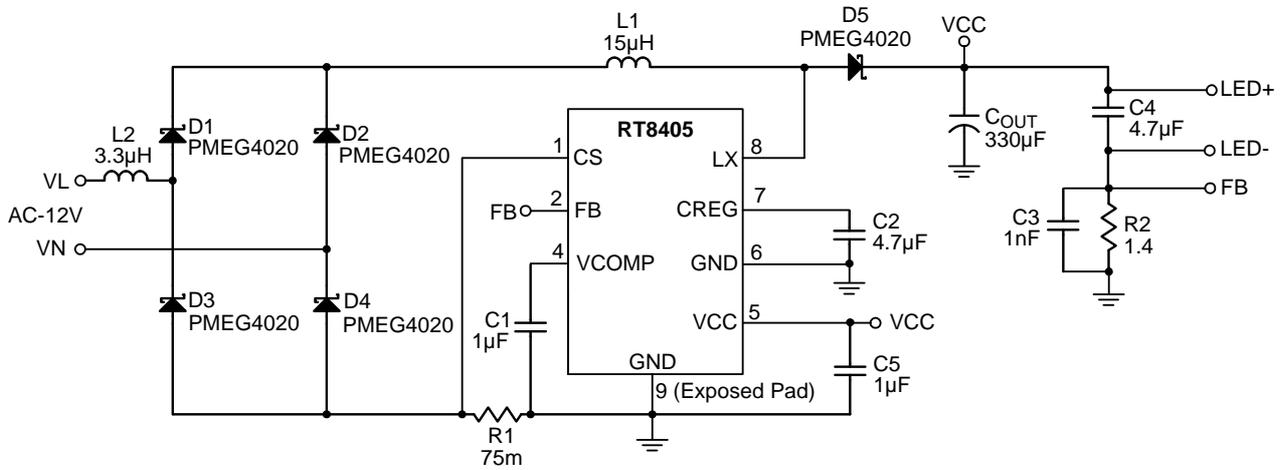
Note 1. Stresses beyond those listed “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured under natural convection (still air) at T_A = 25°C with the component mounted on a low effective-thermal-conductivity two-layer test board on a JEDEC thermal measurement standard. θ_{JC} is measured at the exposed pad of the package.

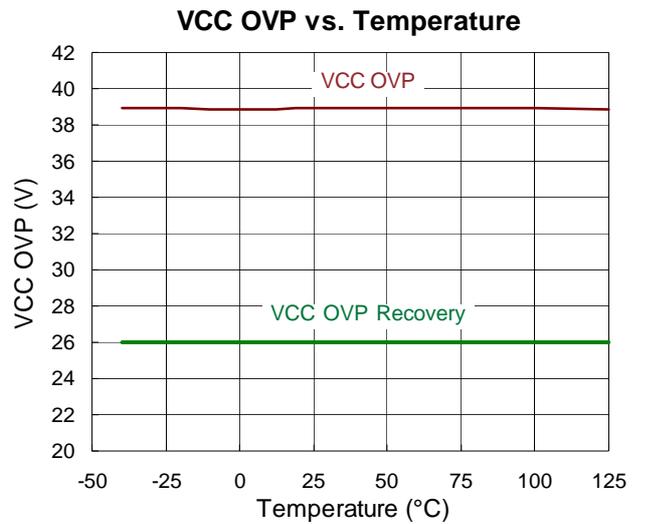
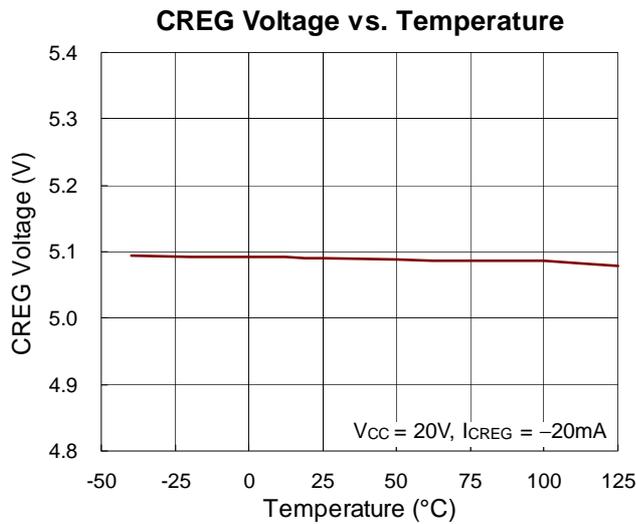
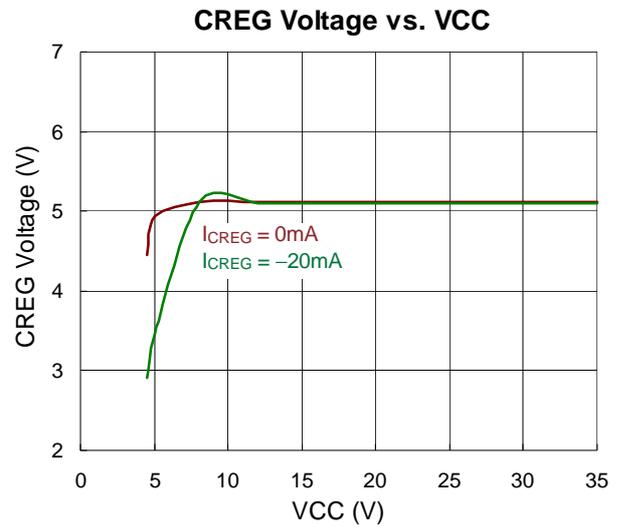
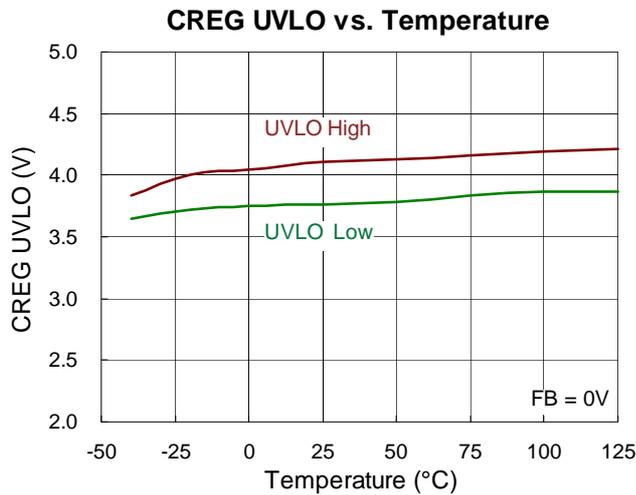
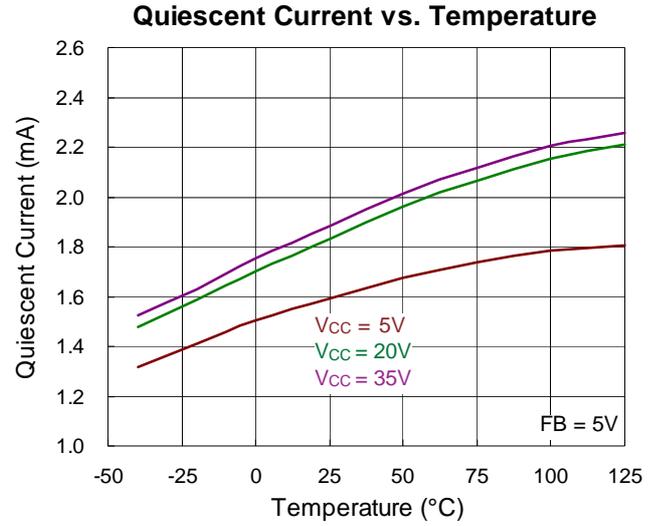
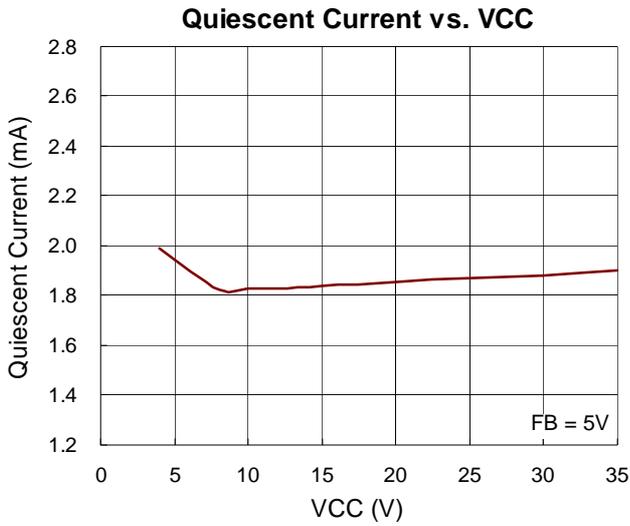
Note 3. Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

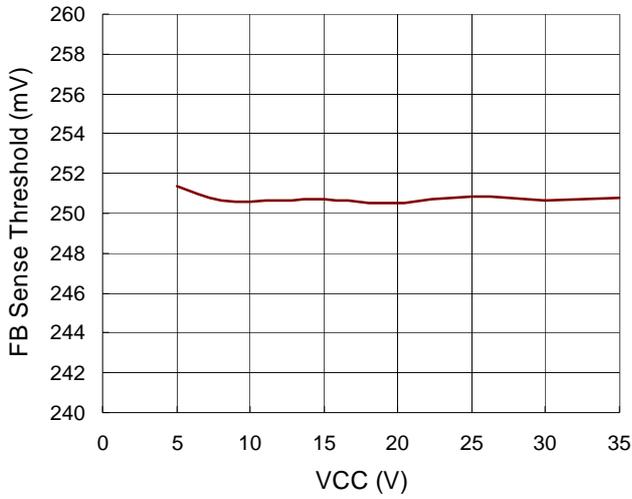
Typical Application Circuit



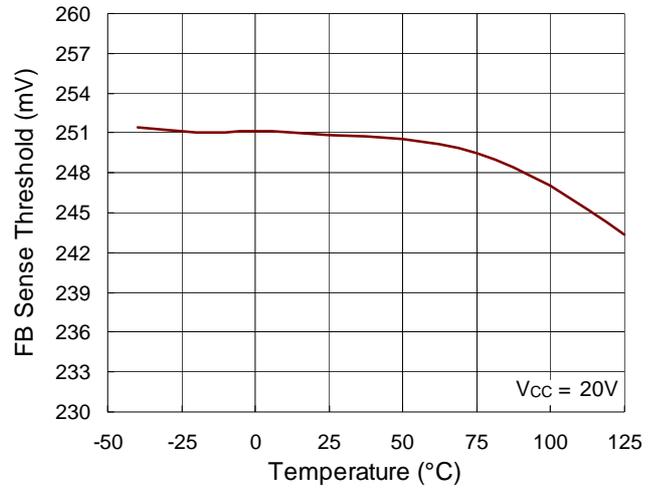
Typical Operating Characteristics



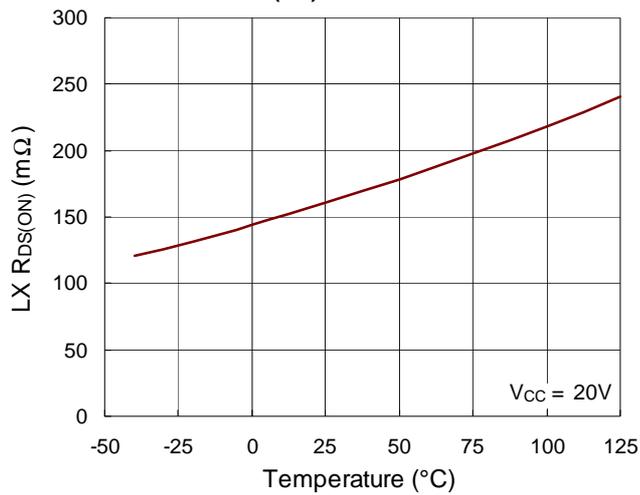
FB Sense Threshold vs. VCC



FB Sense Threshold vs. Temperature



LX R_{DS(ON)} vs. Temperature



Application Information

The RT8405 is a specifically design to be operated in Boost converter applications. The Boost controller is based on a peak current, well PFC control architecture, and designed to operate up to 1MHz to use a very small inductor for space constrained applications.

Under-Voltage Lockout (UVLO)

The RT8405 includes an under-voltage lockout function with 300mV hysteresis. The internal MOSFET turns off when VCC falls below 3.9V (typ.).

CREG Regulator

The CREG 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 to the CREG pin and to the IC ground. An internal current limit on the CREG output protects the RT8415 from excessive on-chip power dissipation. The CREG pin has set the output to 4.2V (typ.) to protect the internal FETs from excessive power dissipation caused by not being fully enhanced. If the CREG pin is used to drive extra circuits beside the RT8405, the extra loads should be limited to less than 10mA.

LED Current Setting

The loop of Boost structure will keep the FB pin voltage equal to the reference voltage V_{FB} . Therefore, when R2 connects FB pin and GND, the relationship between output current, I_{OUT} , and R_{SENSE} is shown below :

$$I_{OUT} = \frac{250mV}{R2}$$

VCC Voltage Setting

The VCC voltage setting is equipped with an over-voltage protection (OVP) function. When the voltage at the VCC pin exceeds threshold approximately 38V, the power switch is turned off. The power switch can be turned on again once the voltage at the VCC pin drops below 24V.

Inductor Selection

The RT8405 uses a continuous mode and well inductor control to provide wide electronic transformer compatibility step-up converter.

Following the continuous mode mechanism, the inductance L1 is calculated according to the following equation :

$$L1 \geq \left[V_{IN} - V_{FBR} - (R_{DS(ON)_LX} \times I_{L1}) - (R1 \times I_{L1}) \right] \times \frac{D}{(f_{SW} \times \Delta I_{L1})}$$

The limit current of first inductor is calculated according to the following equation :

$$I_{L1_LIMIT} = \frac{V_{CL}}{R1}$$

where

f_{SW} is the switching frequency of Boost controller (Hz).

$R_{DS(ON)_LX}$ is the switch on-resistance of internal MOSFET.

D is the duty cycle = $(V_{CC} - V_{IN}) / V_{CC}$.

I_{L1} is the input current. The typical value is 2A for MR16 application.

ΔI_{L1} is the inductor peak-peak ripple current (typically set to $0.055 / R4$).

V_{FBR} is the bridge rectifier forward voltage (V).

V_{IN} is the supply input voltage (V).

V_{CC} is the Boost output voltage (V).

V_{CL} is the current limit threshold (0.125V, typ.).

L1 is the inductance (H).

R1 is the CS resistance (Ω).

The selected inductor must have saturation current higher than the limit current of inductance L1. In general, the inductor saturation current should be 1.2 times the limit current of inductance L1. A 10μH to 33μH inductor will meet the demand of most of the the RT8405 applications.

Current Sense Resistor Selection

The resistor, R1, between the CS and GND should be selected to provide adequate switch current to drive the application without exceeding the current limit threshold set by the CS pin sense threshold of the RT8405. The

Sense resistor value can be calculated according to the following equation :

$$R1 = \frac{V_{CL}}{I_{L1_LIMIT}}$$

Where

V_{CL} is the current limit threshold (0.125V, typ.).

I_{L1_LIMIT} is the limit current of first inductor.

Schottky Diode Selection

To obtain better efficiency, the Schottky diode is recommended for its low reverse leakage current, low recovery time and low forward voltage. With its low power dissipation, the Schottky diode outperforms other silicon diodes and increases overall efficiency.

Thermal Protection

A thermal protection feature is to protect the RT8405 from excessive heat damage. When the junction temperature exceeds 150°C, the thermal protection will turn off the LX terminal. When the junction temperature drops below 125°C, the RT8405 will turn on the LX terminal and return to normal operation.

Thermal Considerations

The junction temperature should never exceed the absolute maximum junction temperature $T_{J(MAX)}$, listed under Absolute Maximum Ratings, to avoid permanent damage to the device. The maximum allowable power dissipation depends on the thermal resistance of the IC package, the PCB layout, the rate of surrounding airflow, and the difference between the junction and ambient temperatures. The maximum power dissipation can be calculated using the following formula :

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction-to-ambient thermal resistance.

For continuous operation, the maximum operating junction temperature indicated under Recommended Operating Conditions is 125°C. The junction-to-ambient thermal resistance, θ_{JA} , is highly package dependent. For a SOP-8 (Exposed Pad) package, the thermal resistance, θ_{JA} , is 40.6°C/W on a standard JEDEC low effective-

thermal-conductivity two-layer test board. The maximum power dissipation at $T_A = 25^\circ\text{C}$ can be calculated as below :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (40.6^\circ\text{C/W}) = 2.46\text{W for a SOP-8 (Exposed Pad) package.}$$

The maximum power dissipation depends on the operating ambient temperature for the fixed $T_{J(MAX)}$ and the thermal resistance, θ_{JA} . The derating curves in Figure 1 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

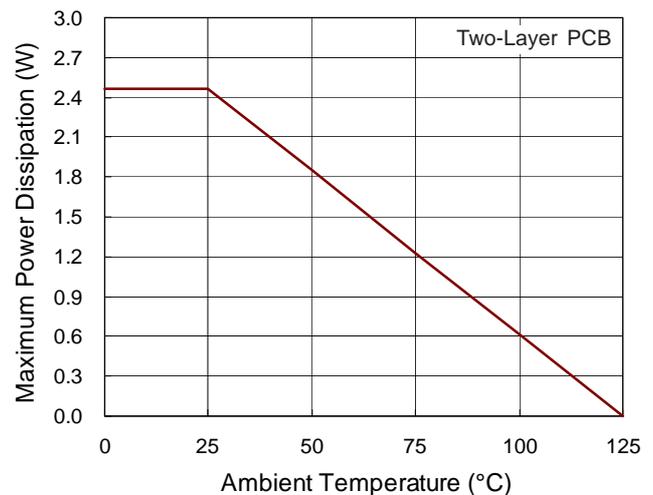


Figure 1. Derating Curve of Maximum Power Dissipation

Layout Consideration

PCB layout is very important when designing power switching converter circuits. Some recommended layout guide lines are as follows :

- ▶ The power components L1, LX Pin, C_{OUT} and D5 must be placed as close to each other as possible to reduce the ac current loop area. The PCB trace between power components must be as short and wide as possible due to large current flow through these traces during operation.
- ▶ Place the compensation components to the VC pin as close as possible to avoid noise pickup.
- ▶ The capacitor C_{OUT} and C5 must be placed as close as possible to the VCC pin.
- ▶ The CREG capacitor C2 must be placed as close as possible to the CREG pin.
- ▶ The GND should be connected to a strong ground plane.

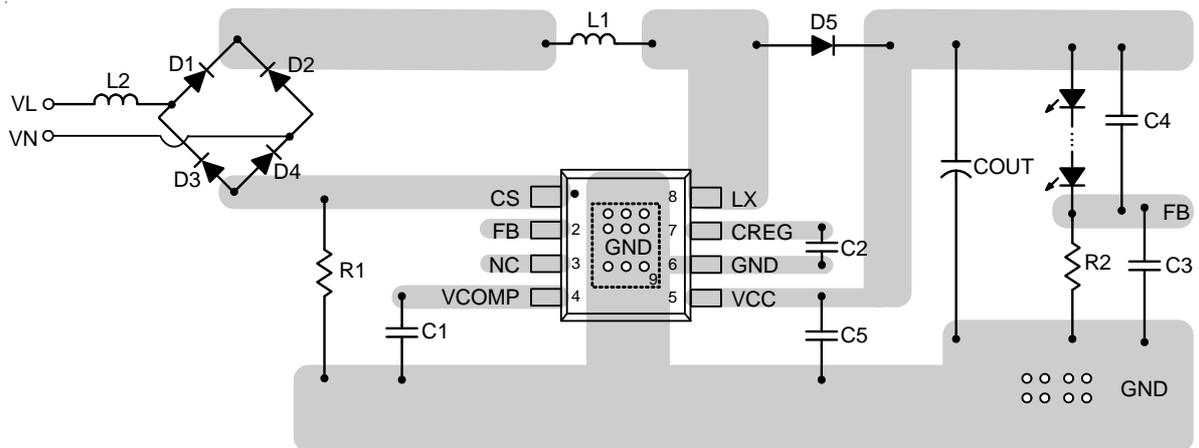
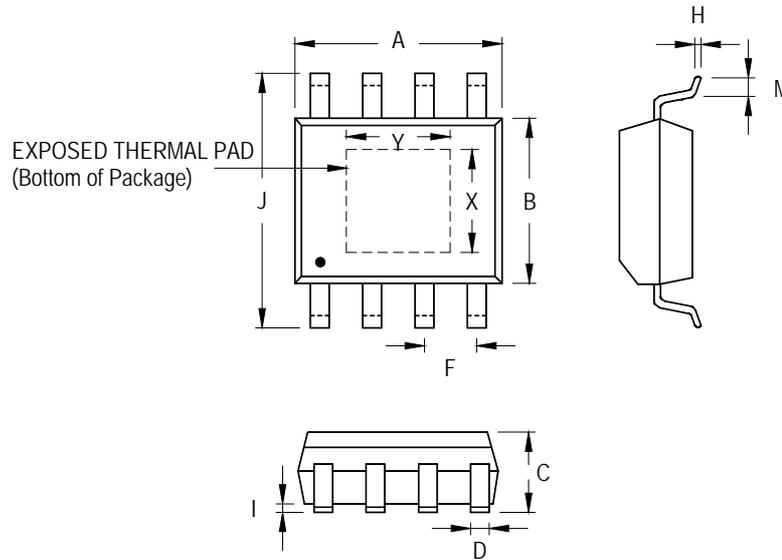


Figure 2. PCB Layout Guide

Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches		
	Min	Max	Min	Max	
A	4.801	5.004	0.189	0.197	
B	3.810	4.000	0.150	0.157	
C	1.346	1.753	0.053	0.069	
D	0.330	0.510	0.013	0.020	
F	1.194	1.346	0.047	0.053	
H	0.170	0.254	0.007	0.010	
I	0.000	0.152	0.000	0.006	
J	5.791	6.200	0.228	0.244	
M	0.406	1.270	0.016	0.050	
Option 1	X	2.000	2.300	0.079	0.091
	Y	2.000	2.300	0.079	0.091
Option 2	X	2.100	2.500	0.083	0.098
	Y	3.000	3.500	0.118	0.138

8-Lead SOP (Exposed Pad) Plastic Package

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