1A, Hysteretic, High Brightness LED Driver with Internal Switch
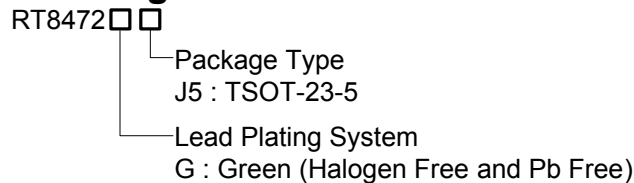
General Description

The RT8472 is a high efficiency, continuous mode inductive step-down converter, designed for driving single or multiple series connected LEDs from a voltage source higher than the LED voltage. It operates from an input voltage of 5V to 30V and employs hysteretic control with a high side current sense resistor to set the constant output current.

The RT8472 includes an output switch and a high side output current sensing circuit, which uses an external resistor to set the nominal average output current. LED brightness control is achieved with PWM dimming from an analog or PWM input signal.

The RT8472 is available in a small TSOT-23-5 package.
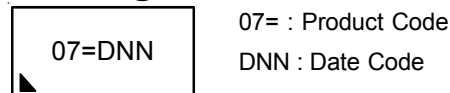
Ordering Information

RT8472☐☐

└─ Package Type
    J5 : TSOT-23-5

└─ Lead Plating System
    G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

▸ RoHS compliant and compatible with the current require-
   ments of IPC/JEDEC J-STD-020.

▸ Suitable for use in SnPb or Pb-free soldering processes.

Marking Information

07=DNN

07= : Product Code
DNN : Date Code

Features

- **5V to 30V Input Voltage Range**
- **Hysteretic Control with High Side Current Sensing**
- **Internal N-MOSFET with 350mΩ Low $R_{DS(ON)}$**
- **1A Output Current**
- **Up to 97% Efficiency**
- **Typical ±5% LED Current Accuracy**
- **Analog or PWM Control Signal for LED Dimming**
- **300Hz On-Board Ramp Generator**
- **Input Under Voltage Lockout**
- **Thermal Shutdown Protection**
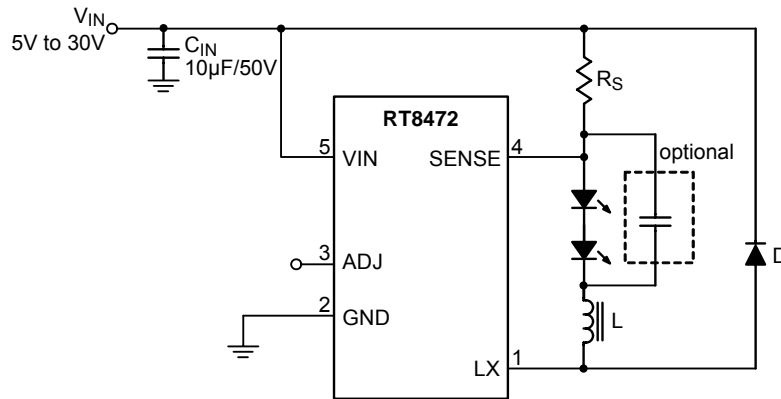- **RoHS Compliant and Halogen Free**

Applications

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

Pin Configurations

(TOP VIEW)

TSOT-23-5
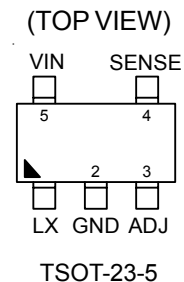
Typical Application Circuit

Functional Pin Description

Pin No.	Pin Name	Pin Function
1	LX	Switching Node. Open drain output of internal N-MOSFET.
2	GND	Ground.
3	ADJ	Dimming Control Input : --- Analog signal input for analog PWM dimming. --- PWM signal input for digital PWM dimming.
4	SENSE	Output Current Sense Terminal. Sense LED string current.
5	VIN	Supply Input Voltage.

Function Block Diagram
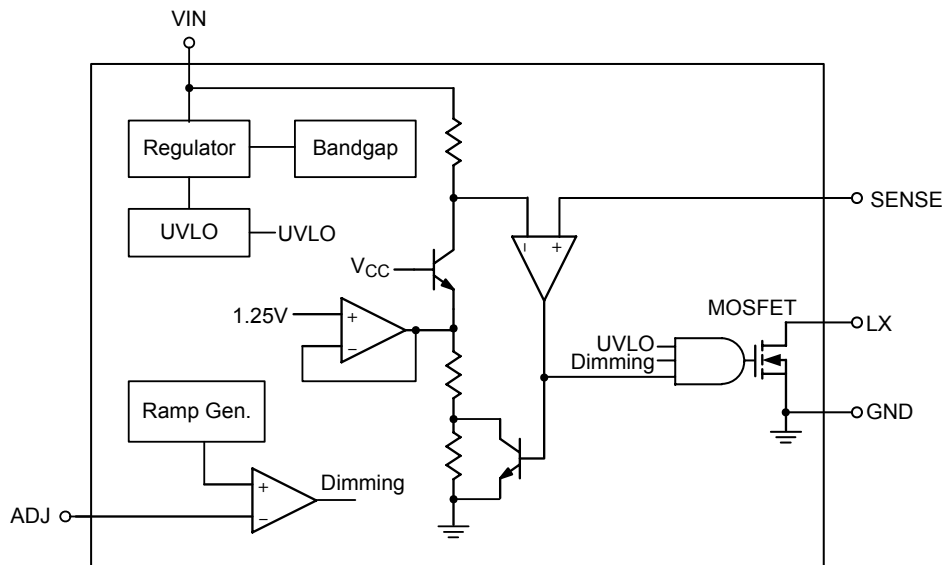
Absolute Maximum Ratings   (Note 1)

- Supply Input Voltage, VIN --- −0.3V to 33V
- Switch Voltage, LX --- −0.3V to (V_{IN} + 0.7V)
- Sense Voltage, SENSE --- (V_{IN} − 5V) to (V_{IN} + 0.3V)
- All Other Pins -- −0.3V to 6V
- Power Dissipation, P_D @ T_A = 25°C
    TSOT-23-5 (Single-layer PCB) -- 0.400W
    TSOT-23-5 (Four-layer PCB) -- 0.625W
- Package Thermal Resistance   (Note 2)
    TSOT-23-5, θ_{JA} (Single-layer PCB) --- 250°C/W
    TSOT-23-5, θ_{JC} (Single-layer PCB) --- 130°C/W
    TSOT-23-5, θ_{JA} (Four-layer PCB) --- 160°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

Recommended Operating Conditions   (Note 4)

- Supply Input Voltage, VIN --- 5V to 30V
- Junction Temperature Range --- −40°C to 125°C

Electrical Characteristics

(V_{IN} = 12V, T_A = 25°C, unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Mean Current Sense Threshold Voltage		V_{SENSE}	Measure on SENSE Pin with Respect to V_{IN}. ADJ pin is Floating.	95	100	105	mV
Sense Threshold Hysteresis		$V_{SENSEHYS}$		--	±15	--	%
MOSFET On-Resistance		$R_{DS(ON)}$		--	350	--	mΩ
MOSFET Leakage Current			V_{LX} = 5V	--	0.01	10	μA
Under Voltage Lockout Threshold		V_{UVLO}	V_{IN} Rising	--	4	--	V
Under Voltage Lockout Threshold Hysteresis		ΔV_{UVLO}		--	200	--	mV
Ramp Frequency		f_{RAMP}		--	300	--	Hz
ADJ Input Threshold Voltage	Logic-High	V_{ADJ_H}		1.4	--	5.5	V
	Logic-Low	V_{ADJ_L}		--	--	0.2	
Analog Dimming Range				0.4	--	1.2	V
Minimum Switch On Time		$t_{ON(MIN)}$	LX Switch On	--	210	--	ns
Minimum Switch Off Time		$t_{OFF(MIN)}$	LX Switch Off	--	170	--	ns

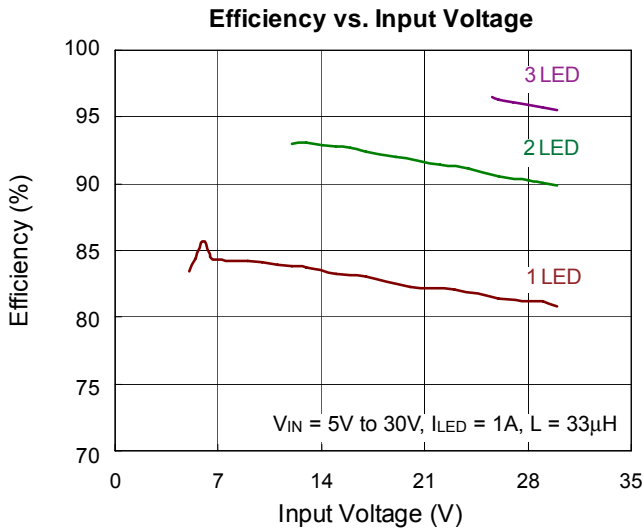| Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Quiescent Supply Current with Output Off	I_{VIN_Off}	$V_{ADJ} = 0V$	--	450	--	μA
Quiescent Supply Current with Output Switching	I_{VIN_On}	ADJ Pin is Floating, $f_{SW} = 250kHz$, $V_{IN} = 8V$	--	1000	--	μA
Internal Propagation Delay	t_{PD}		--	25	--	ns
Sense Pin Input Current	I_{SENSE}	$V_{SENSE} = V_{IN} - 0.1V$	--	300	--	nA
Thermal Shutdown	T_{SD}		--	150	--	°C
Thermal Shutdown Hysteresis	ΔT_{SD}		--	30	--	°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.
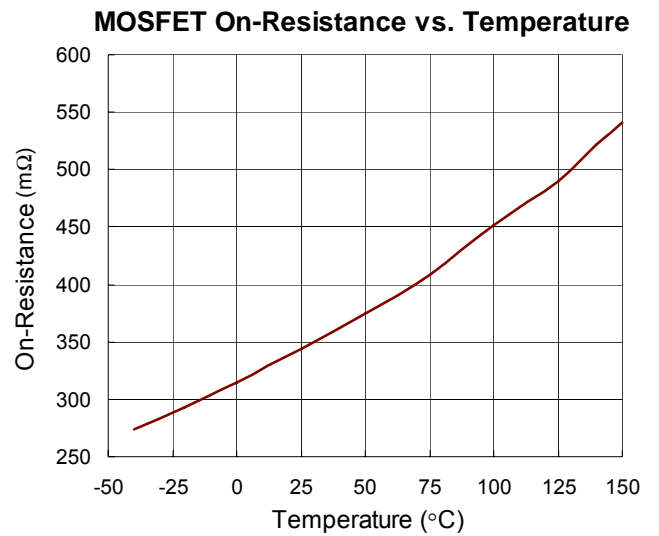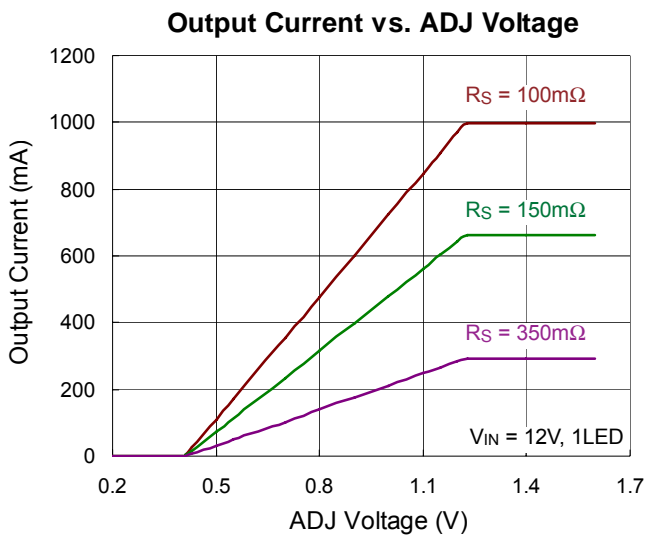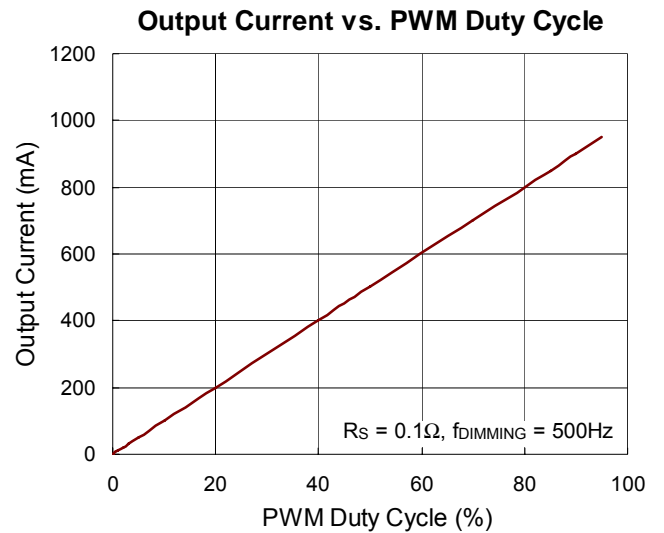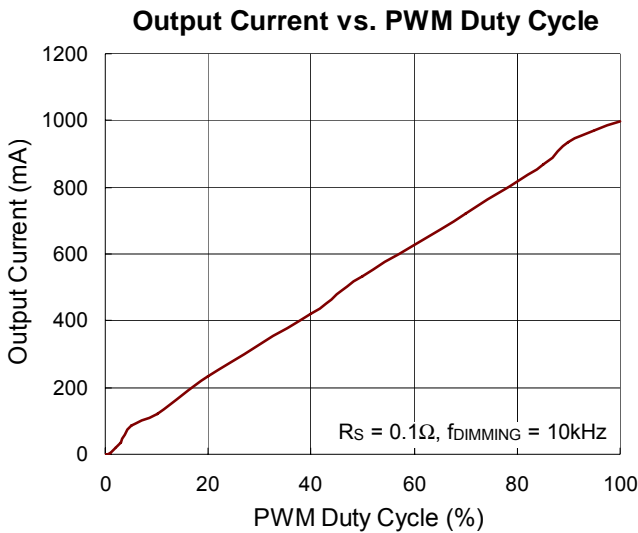
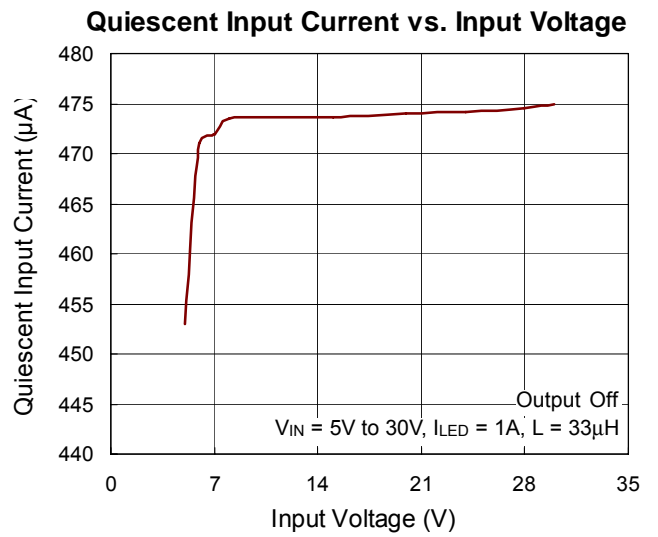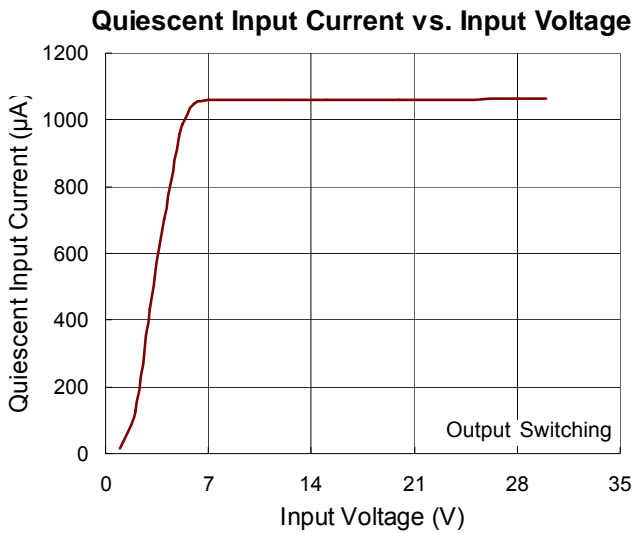**Note 2.** θ_{JA} is measured at $T_A = 25°C$ on a single-layer and four-layer test board of JEDEC 51. The measurement case position of θ_{JC} is on the lead of the package.

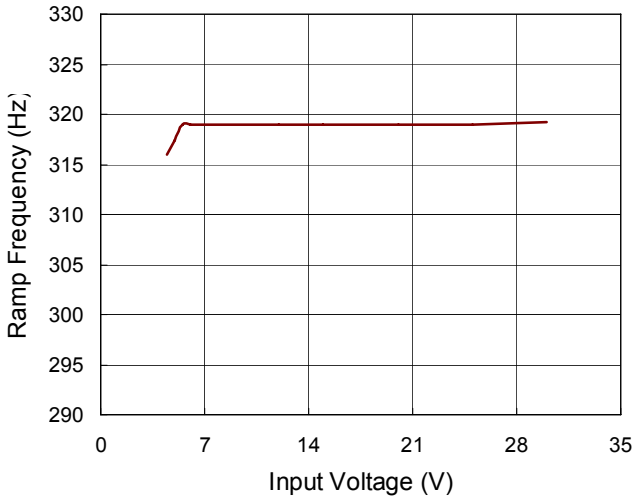**Note 3.** Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.
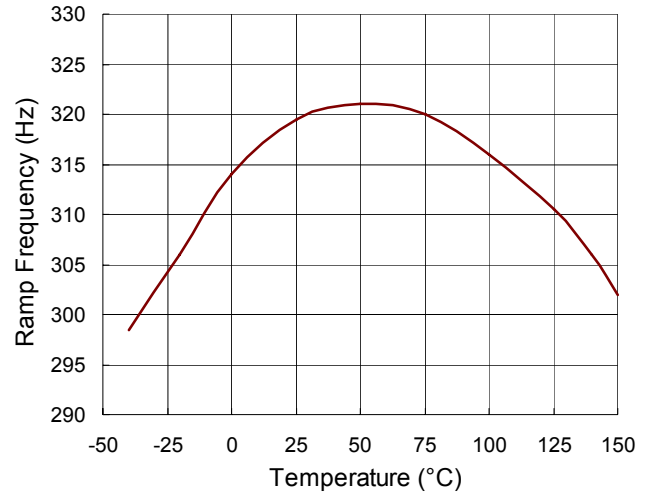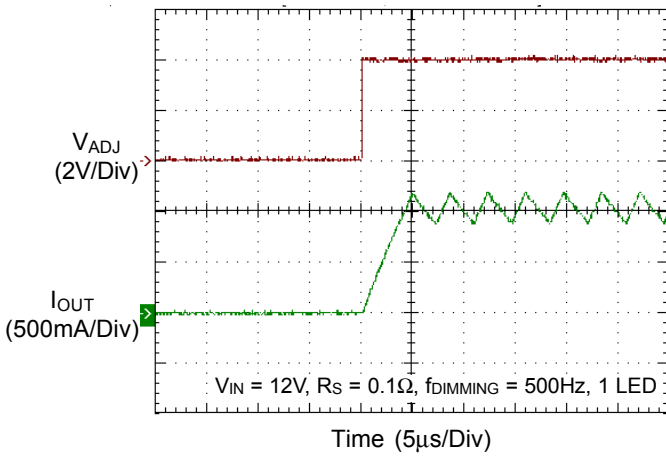
Typical Operating Characteristics
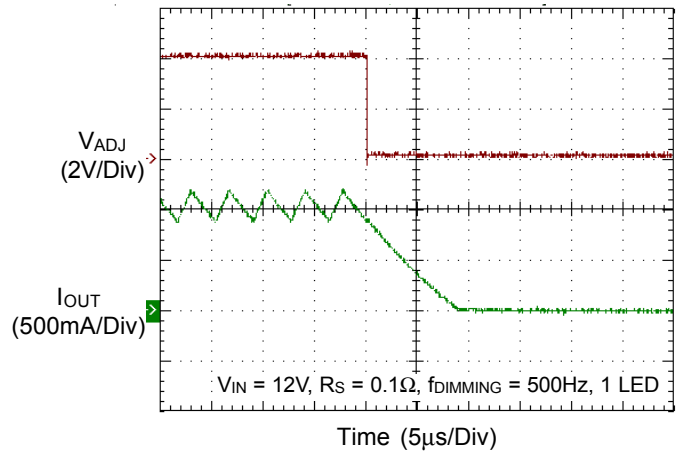
Efficiency vs. Input Voltage

Y-axis: Efficiency (%), 70 to 100
X-axis: Input Voltage (V), 0 to 35

3 LED
2 LED
1 LED

V_{IN} = 5V to 30V, I_{LED} = 1A, L = 33μH

Output Current Deviation vs. Input Voltage

Y-axis: Output Current Deviation (%), -6 to 6
X-axis: Input Voltage (V), 0 to 35

3 LED
2 LED
1 LED

V_{IN} = 5V to 30V, I_{LED} = 1A, L = 33μH

Output Current vs. Input Voltage

Y-axis: Output Current (A), 0.96 to 1.04
X-axis: Input Voltage (V), 0 to 35

1 LED
2 LED
3 LED
4 LED
5 LED
6 LED
7 LED
8 LED

V_{IN} = 5V to 30V, I_{LED} = 1A, L = 33μH

Output Current Deviation vs. Input Voltage

Y-axis: Output Current Deviation (%), -4 to 4
X-axis: Input Voltage (V), 0 to 35

1 LED
2 LED
3 LED
4 LED
5 LED
6 LED
7 LED
8 LED

V_{IN} = 5V to 30V, I_{LED} = 1A, L = 33μH

Switching Frequency vs. Input Voltage

Y-axis: Switching Frequency (kHz), 50 to 850
X-axis: Input Voltage (V), 0 to 35

1 LED
2 LED
3 LED
4 LED
5 LED
6 LED
7 LED
8 LED

V_{IN} = 5V to 30V, I_{LED} = 1A, L = 33μH

Duty Cycle vs. Input Voltage

Y-axis: Duty cycle (%), 0 to 100
X-axis: Input Voltage (V), 0 to 35

1 LED
2 LED
3 LED
4 LED
5 LED
6 LED
7 LED
8 LED

V_{IN} = 5V to 30V, I_{LED} = 1A, L = 33μH

Quiescent Input Current vs. Input Voltage

Output Switching

Quiescent Input Current vs. Input Voltage

Output Off

V_{IN} = 5V to 30V, I_{LED} = 1A, L = 33μH

Output Current vs. PWM Duty Cycle

R_S = 0.1Ω, $f_{DIMMING}$ = 10kHz

Output Current vs. PWM Duty Cycle

R_S = 0.1Ω, $f_{DIMMING}$ = 500Hz

Output Current vs. ADJ Voltage

R_S = 100mΩ

R_S = 150mΩ

R_S = 350mΩ

V_{IN} = 12V, 1LED

MOSFET On-Resistance vs. Temperature

Ramp Frequency vs. Input Voltage

Ramp Frequency vs. Temperature

Digital Dimming from ADJ On

V_{IN} = 12V, R_S = 0.1Ω, $f_{DIMMING}$ = 500Hz, 1 LED

Digital Dimming from ADJ Off

V_{IN} = 12V, R_S = 0.1Ω, $f_{DIMMING}$ = 500Hz, 1 LED

Power On from VIN

R_S = 0.1Ω, 1 LED

Power Off from VIN

R_S = 0.1Ω, 1 LED
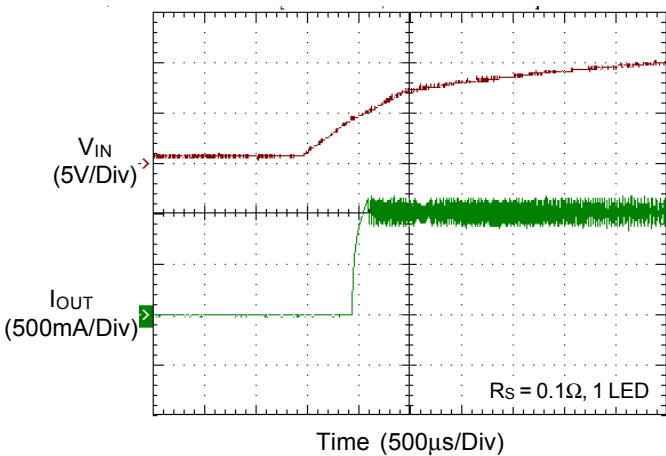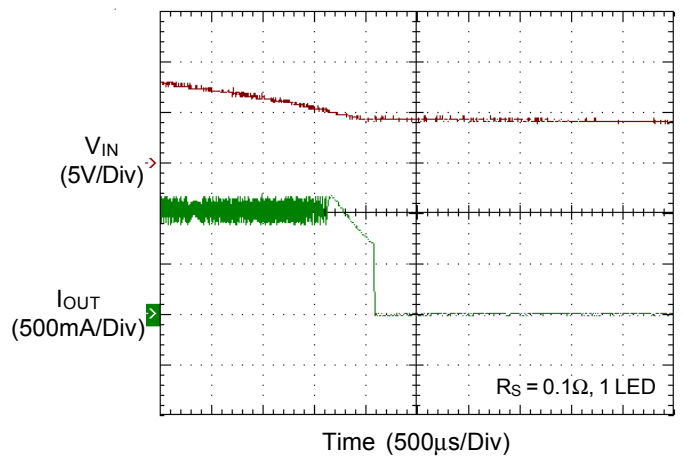
Application Information

The RT8472 is a simple high efficiency, continuous mode inductive step-down converter. The device operates with an input voltage range from 5V to 30V and delivers up to 1A of output current. A high side current sense resistor sets the output current and a dedicated PWM dimming input enables pulsed LED dimming over a wide range of brightness levels. A high side current sensing scheme and an onboard current setting circuitry minimize the number of external components. A 1% sense resistor performs a ±3% LED current accuracy for the best performance.

Under Voltage Lockout (UVLO)

The RT8472 includes a UVLO feature with 200mV hysteresis. The internal MOSFET turns off when V_{IN} falls below 3.8V (typ.).

Setting Average Output Current

The RT8472 output current which flows through the LEDs is set by an external resistor (R_S) connected between the VIN and SENSE terminal. The relationship between output current (I_{OUT}) and R_S is shown as below :

$$I_{OUTavg} = \frac{0.1V}{R_S} \; (\,A\,)$$

Analog Dimming Control

The ADJ terminal can be driven by an external voltage (V_{ADJ}) to adjust the output current to an average value set by R_S. The average output current is given by :

$$I_{OUTavg} = \left(\frac{0.1V}{R_S} \right) \times \frac{V_{ADJ} - 0.4}{0.8}$$

where V_{ADJ} is ranged from 0.4V to 1.2V. When V_{ADJ} is larger than 1.2V, the output current value will just be set by the external resistor (R_S).

Digital Dimming Control

A Pulse Width Modulated (PWM) signal can drive the ADJ terminal directly. Notice that the PWM signal logic high level must be above 1.4V and the logic low level must be below 0.2V at the ADJ terminal. It's recommended to maintain the PWM dimming at low frequency (ex. 500Hz) in order to obtain a linear dimming curve.

PWM Soft-Start Behavior

The RT8472 features an optional PWM soft-start behavior that allows for gradual brightness transition. This is achieved by simply connecting an external capacitor between the ADJ pin and GND. An internal current source will then charge this capacitor for soft-start behavior, resulting in steady LED current increase and decrease during power on and power off, as shown in Figure 1.
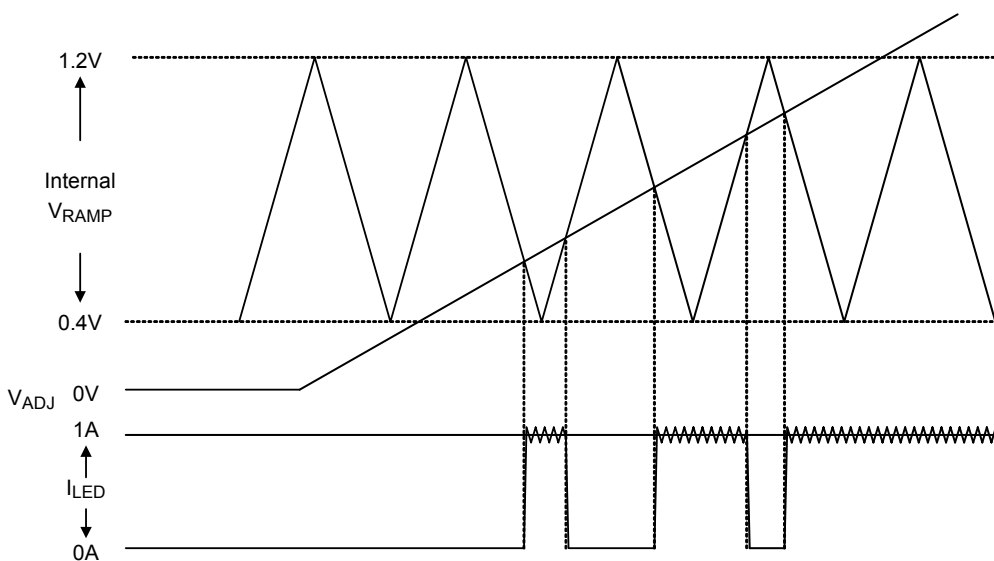

Figure 1. PWM Soft-Start Behavior Mechanism

The capacitor can be selected according to below equation :

$$C = 1.5 \times 10^{-6} \times t_{SS}$$

where t_{SS} is the soft-start period.

LED Current Ripple Reduction

Higher LED current ripple will shorten the LED life time and increase heat accumulation of LED. By adding an output capacitor in parallel with the LED. This will then allow the use of a smaller inductor.

Inductor Selection

The inductance is determined by inductor current ripple, switching frequency, duty ratio, circuit specifications and component parameters, as expressed in the following equation :

$$L > \left[V_{IN} - V_{OUT} - V_{SEN} - \left(R_{DS(ON)} \times I_{OUT} \right) \right] \times \frac{D}{f_{SW} \times \Delta I_L}$$

where

f_{SW} is the switching frequency (Hz)

$R_{DS(ON)}$ is the on-resistance of internal MOSFET ($= 0.35\Omega$ typical)

D is the duty cycle determined by V_{OUT}/V_{IN}

I_{OUT} is the required LED current (A)

ΔI_L is the inductor peak-peak ripple current (internally set to 0.3 x I_{OUT})

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

V_{OUT} is the total LED forward voltage (V)

Besides, the selected inductance has also to satisfy the limit of the minimum switch on/off time. The calculated on time must be greater than 210ns of the minimum on time, and the off time must be greater than 170ns of the minimum off time. The following equation can be used to verify the suitability of the inductor value.

$$t_{ON} = \frac{L \times \Delta I_L}{V_{IN} - V_{OUT} - I_{OUT} \left(R_{SEN} + R_L + R_{DS(ON)} \right)}$$

$$> t_{ON(MIN)} (210ns \text{ typ.})$$

$$t_{OFF} =$$

$$\frac{L \times \Delta I_L}{V_{OUT} + V_D + V_{SEN} + \left(I_{OUT} \times R_L \right)} > t_{OFF(MIN)} (170ns \text{ typ.})$$

where

V_D is the rectifier diode forward voltage (V)

V_{SEN} is the voltage cross current sense resistor (V)

R_L is the inductor DC resistance (Ω)

L is the inductance (H)

The saturation current of the selected inductor must be higher than the peak output LED current, and the continuous current rating must be above the average output LED current. In general, the inductor saturation current should be 1.5 times the LED current. In order to reduce the output current ripple, a higher inductance is recommended at higher supply voltages. However, it could also cause a higher line resistance and result in a lower efficiency.

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 increase overall efficiency.

Input Capacitor selection

Input capacitor has to supply peak current to the inductor and flatten the current ripple on the input. The low ESR condition is required to avoid increasing power loss. The ceramic capacitor is recommended due to its excellent high frequency characteristic and low ESR, which are suitable for the RT8472. For maximum stability over the entire operating temperature range, capacitors with better dielectric are suggested.

Thermal Protection

A thermal protection feature is included to protect the RT8472 from excessive heat damage. When the junction temperature exceeds a threshold of 150°C, the thermal protection will turn off the LX terminal. When the junction temperature drops below 125°C, the RT8472 will turn back on the LX terminal and return to normal operations.

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by 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 recommended operating condition specifications, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For TSOT-23-5 package, the thermal resistance, θ_{JA}, is 250°C/W on a standard JEDEC 51-3 single-layer thermal test board and 160°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formulas :

$P_{D(MAX)}$ = (125°C − 25°C) / (250°C/W) = 0.4W for

TSOT-23-5 package (single-layer PCB)

$P_{D(MAX)}$ = (125°C − 25°C) / (160°C/W) = 0.625W for

TSOT-23-5 package (four-layer PCB)

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curves in Figure 2 allow the designer to see the effect of rising ambient temperature on the maximum power dissipation.
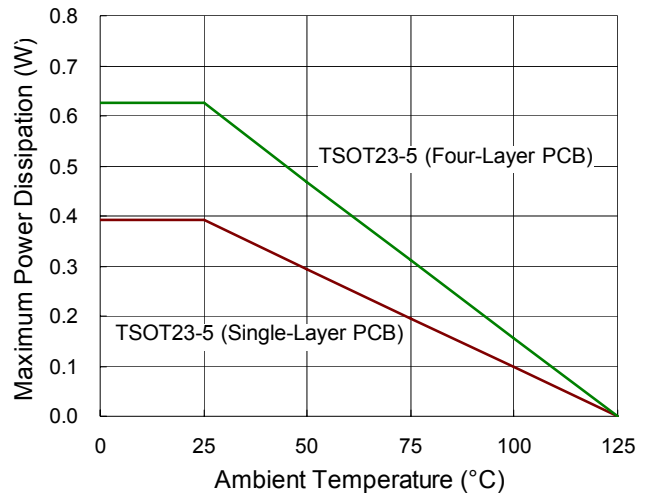

Figure 2. Derating Curve of Maximum Power Dissipation

Layout Considerations

For best performance of the RT8472, please abide the following layout guide.

▸ The capacitor C_{IN}, C_{ADJ} and external resistor, R_S, must be placed as close as possible to the VIN and SENSE pins of the device respectively.

▸ The GND should be connected to a strong ground plane.

▸ Keep the main current traces as short and wide as possible.

▸ The inductor (L) should be mounted as close to the device with low resistance connections.

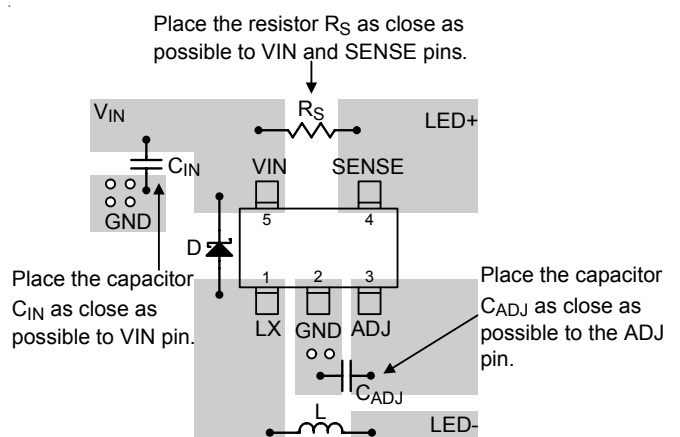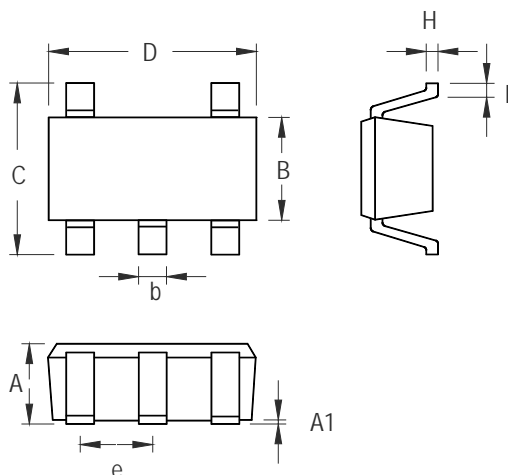▸ The ADJ pin trace need to be kept far away from LX terminal.

Figure 3. PCB Layout Guide

Outline Dimension

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	1.000	0.028	0.039
A1	0.000	0.100	0.000	0.004
B	1.397	1.803	0.055	0.071
b	0.300	0.559	0.012	0.022
C	2.591	3.000	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

TSOT-23-5 Surface Mount Package

Richtek Technology Corporation

5F, No. 20, Taiyuen Street, Chupei City

Hsinchu, Taiwan, R.O.C.

Tel: (8863)5526789

单击下面可查看定价，库存，交付和生命周期等信息

>>Richtek(台湾立锜)