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

General Description

The RT8470 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 7V to 30V and employs hysteretic control with a high-side current sense resistor to set the constant output current.

The RT8470 includes the 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.

Ordering Information

RT8470□□

Package Type
J5 : TSOT-23-5

Operating Temperature Range
G : Green (Halogen Free with Commercial Standard)

Note :

Richtek Green 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.

Marking Information

For marking information, contact our sales representative directly or through a Richtek distributor located in your area, otherwise visit our website for detail.

Features

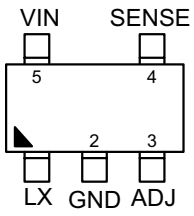
- **7V to 30V Input Voltage Range**
- **Hysteretic Control with High-side Current Sensing**
- **Internal N-MOSFETs**
- **1A Output Current**
- **Up to 95% Efficiency**
- **Typical ±5% LED Current Accuracy**
- **Analog or PWM Control Signal for PWM Dimming**
- **300Hz On-Board Ramp Generator**
- **Input Under Voltage Lockout**
- **Thermal Shutdown Protection**

Applications

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

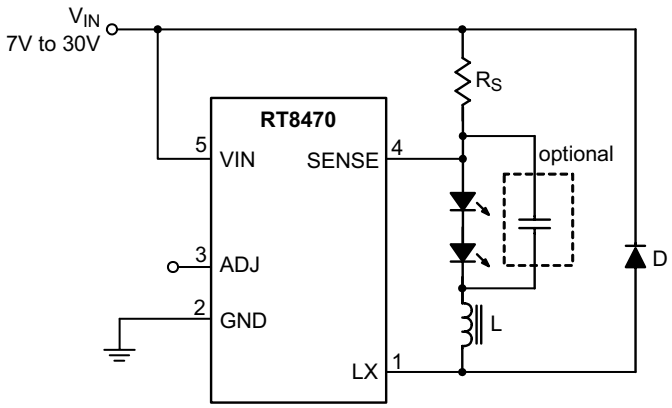
Pin Configurations

(TOP VIEW)



TSOT-23-5

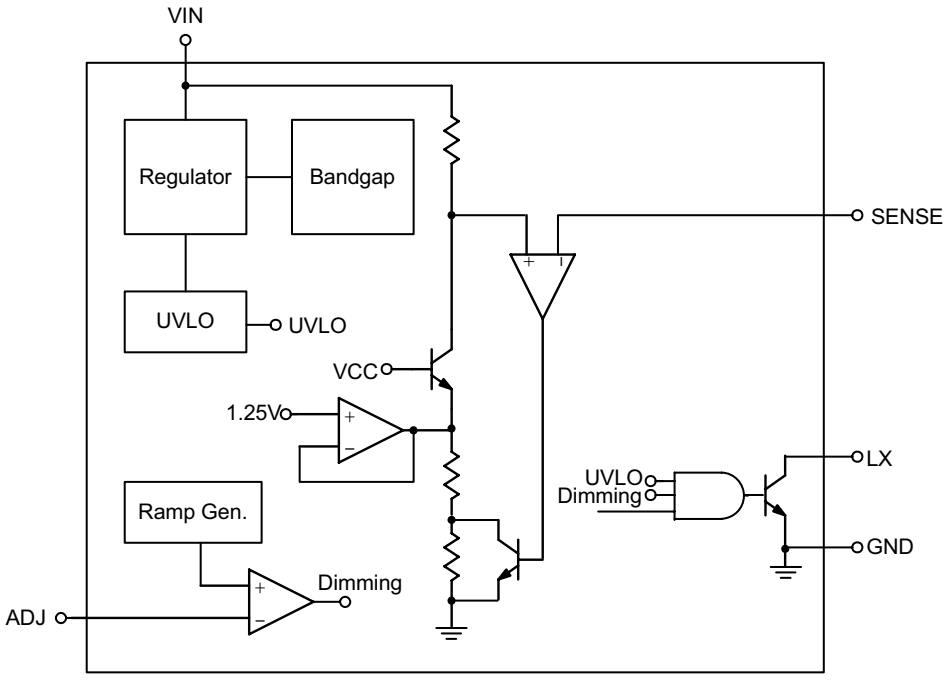
Typical Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	LX	Switch Output Terminal. Drain of internal N-MOSFETs.
2	GND	Ground.
3	ADJ	Dimming Control Input: --- Analog signal input for analog control of PWM dimming. --- PWM signal input for digital PWM dimming.
4	SENSE	Output Current Sense Terminal. Sense LED string current.
5	VIN	Input Supply Voltage, 7V to 30V.

Function Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, V_{IN} ---------- –0.3V to 30V
- 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) ---------- 0.392W
  TSOT-23-5 (Four-layer PCB) ---------- 0.625W
- Package Thermal Resistance (Note 4)
  TSOT-23-5, θ_{JA} (Single-layer PCB) ---------- 255°C/W
  TSOT-23-5, θ_{JA} (Four-layer PCB) ---------- 160°C/W
- Junction Temperature ---------- 150°C
- Ambient Temperature Range ---------- –40°C to 125°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 2)
  HBM (Human Body Mode) ---------- 2kV
  MM (Machine Mode) ---------- 200V

Recommended Operating Conditions (Note 3)

- Supply Input Voltage, V_{IN} ---------- 7V 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 Condition	Min	Typ	Max	Units
Mean Current Sense Threshold Voltage	V_{SENSE}	Measure on SENSE pin with respect to V_{IN}. V_{ADJ} is floating.	95	100	105	mV
Sense Threshold Hysteresis	$V_{SENSEHYS}$		--	±15	--	%
Low-Side Switch On -Resistance	$R_{DS(ON)}$		--	450	--	mΩ
Low-Side Switch Leakage Current		V_{EN} = 0V, V_{LX} = 5V	--	0	10	μA
Under Voltage Lockout Threshold Rising			--	5.8	--	V
Under Voltage Lockout Threshold Hysteresis			--	700	--	mV
Ramp Frequency	f_{RAMP}		--	300	--	Hz
ADJ Pin “H” Level	$V_{ADJ, H}$		1.4	--	--	V
ADJ Pin “L” Level	$V_{ADJ, L}$		--	--	0.2	V
Analog Dimming Linear Range			0.4	--	1.2	V
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 floating, f = 250kHz	--	850	--	μA
Internal Propagation Delay	t_{PD}		--	25	--	ns
Sense Pin Input Current	I_{SENSE}	V_{SENSE} = V_{IN} – 0.1V	--	300	--	nA
Thermal Shutdown			--	150	--	°C

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. 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 for extended periods may remain possibility to affect device reliability.

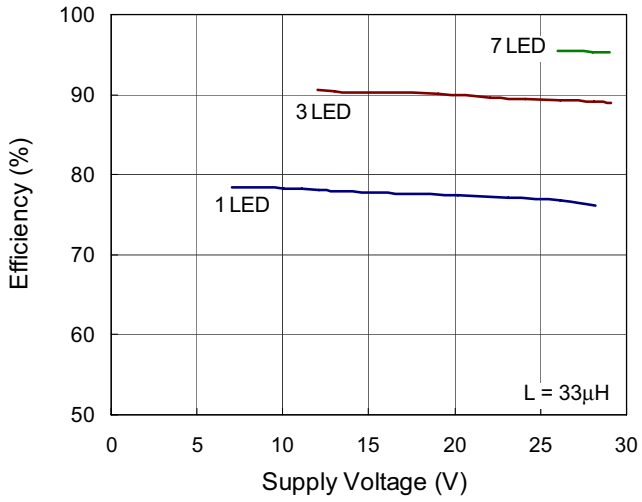
Note 2. Devices are ESD sensitive. Handling precaution is recommended.

Note 3. The device is not guaranteed to function outside its operating conditions.

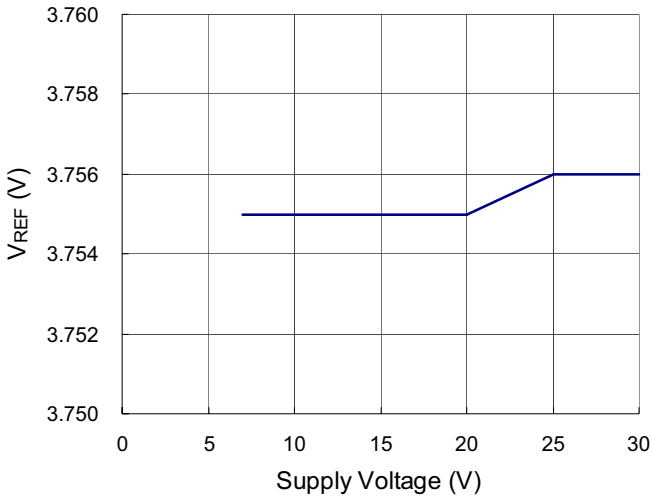
Note 4. θ_{JA} is measured in natural convection at T_A = 25°C on a single-layer and four-layer test board of JEDEC 51 thermal measurement standard.

Typical Operating Characteristics

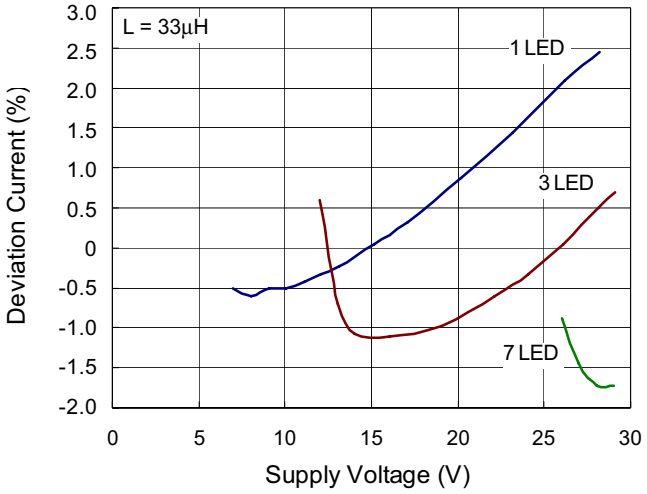
Efficiency vs. LEDs



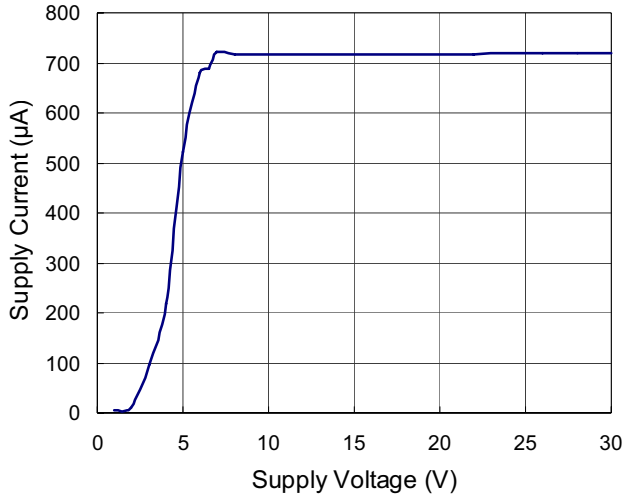
V_{REF} vs. Supply Voltage



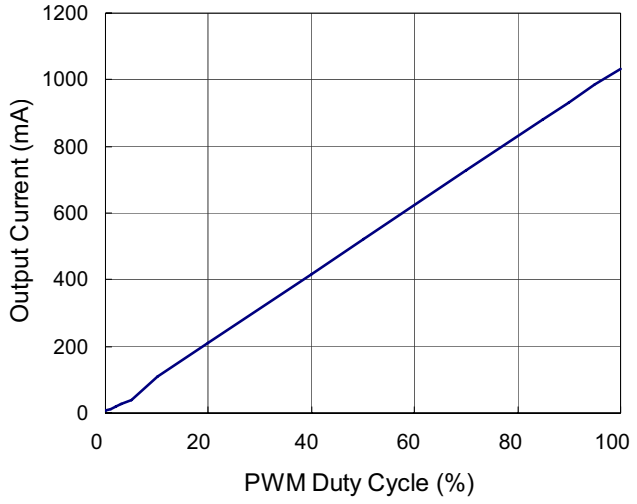
Deviation Current vs. Supply Voltage



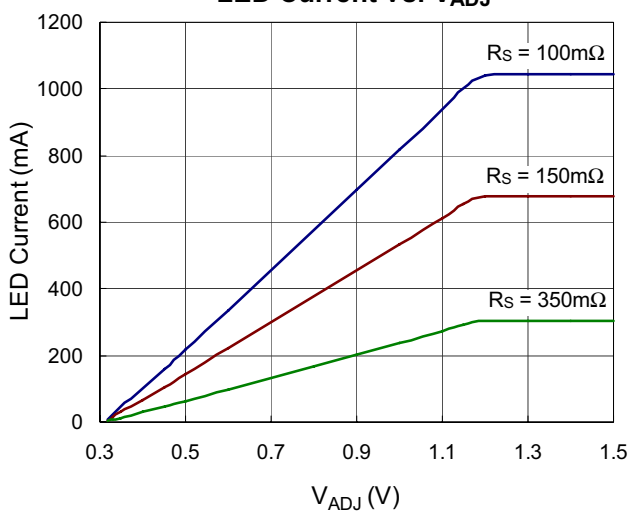
Supply Current vs. Supply Voltage



Output Current vs. PWM Duty Cycle



LED Current vs. V_{ADJ}



Applications Information

The RT8470 is a simple high-efficiency, continuous mode inductive step-down converter. The device operates with an input voltage range from 7V 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 on-board current-setting circuitry minimize the number of external components required while delivering LED current with ±3% accuracy, using a 1% sense resistor.

Undervoltage Lockout (UVLO)

The RT8470 includes an UVLO feature with 500mV hysteresis. The internal MOSFET turns off when VIN falls below 5.8V (typ.).

Dimming Control

The RT8470 features a PWM signal at the ADJ pin. A logic level below 0.2V at ADJ forces the RT8470 output low, hence turning off the LED current. To turn the LED current back on, the logic level at the ADJ pin must be greater than 1.4V.

Setting Average Output Current

The RT8470 output current which flows through the LEDs is set by an external resistor (R_S), which is connected between the VIN and SENSE terminal. The relationship between output current (I_{OUT}) and R_S is shown below :

$$I_{OUTavg} = \frac{0.1V}{R_S}$$

The value of the output current is 1A at 0.1Ω. This is the calculated output current when the ADJ terminal is floating.

Output Current Adjustment

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 :

$$I_{OUTavg} = \left(\frac{0.1V}{R_S}\right) \times \frac{V_{ADJ} - 0.2}{1.2}$$

The voltage range for V_{ADJ} to adjust the output current is from 0.2V to 1.4V. When V_{ADJ} is large than 1.4V, the output current value will just be set by the external resistor (R_S).

A Pulse Width Modulated (PWM) signal 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 zero at the ADJ terminal. It's recommended to maintain the PWM Dimming at low frequency (ex. 500Hz) in order to obtain linear dimming curve.

Thermal Protection

A thermal protection feature is included to protect the RT8470 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 RT8470 will turn back on the LX terminal 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 of the RT8470, the maximum junction temperature is 125°C and T_A is the ambient temperature. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For TSOT-23-5 packages, the thermal resistance, θ_{JA}, is 255°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) / (255°C/W) = 0.392W for single-layer PCB

$P_{D(MAX)}$ = (125°C – 25°C) / (160°C/W) = 0.625W for four-layer PCB

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. For the RT8470 package, the derating curves in Figure 1 allow the designer to see the effect of rising ambient temperature on the maximum power dissipation.

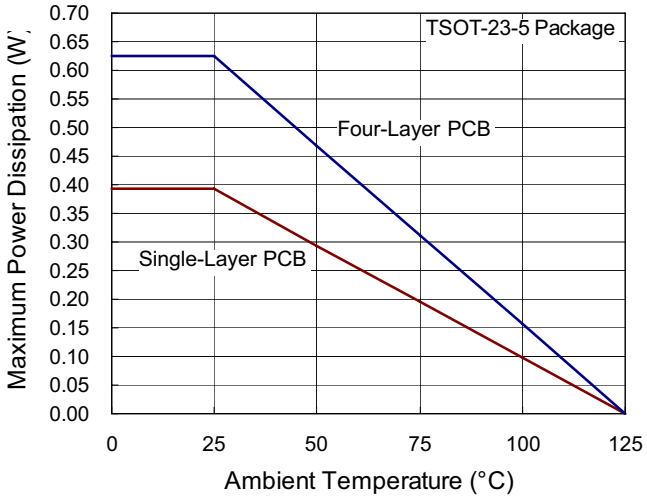


Figure 1. Derating Curve for Packages

Layout Consideration

For best performance of RT8470, please abide the following layout guide.

- The capacitor C_1 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 as possible and wide.
- The inductor (L1) should be mounted as close to the device with low resistance connections.
- The ADJ pin trace need to far away from LX terminal.

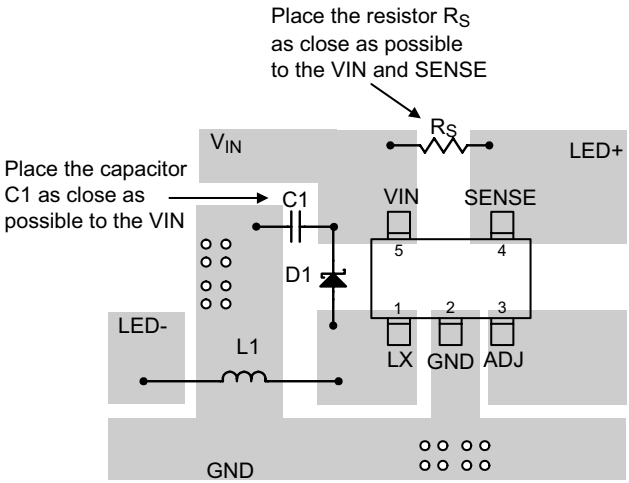
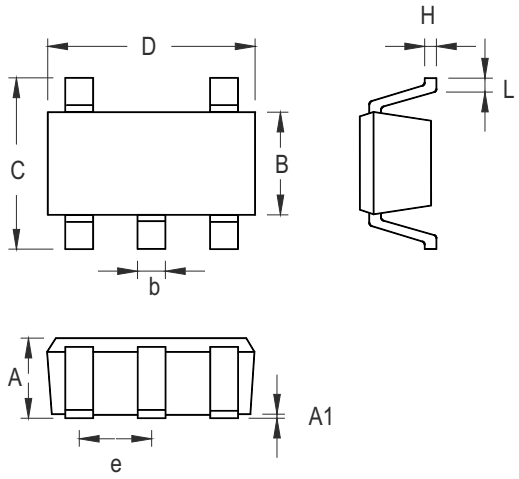


Figure 2. PCB Layout Guide



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

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