

## Isolated Secondary Side LED Lighting Current Controller

### General Description

The RT8456 is an isolated secondary LED current controller designed specifically for lighting fixtures such as E27, GU10, T5 and T8. The IC is suitable for applications that require power line isolation for safety and reliability, high conversion efficiency, as well as high LED current accuracy.

The RT8456 contains 1) a constant current regulating amplifier with 59mV threshold used to program the LED string current with a simple resistor to within 5% LED current accuracy; 2) an over voltage comparator to protect the output when LED string is open or broken; 3) and an opto-coupler driver to control the primary side of the transformer to complete the system loop.

The RT8456 is offered in a small SOT-23-6 package.

### Ordering Information

RT8456□□

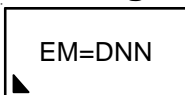
- Package Type  
E : SOT-23-6
- Lead Plating System  
G : Green (Halogen Free and Pb Free)

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.

### Marking Information



EM= : Product Code  
DNN : Date Code

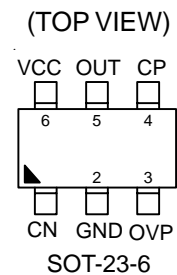
### Features

- Secondary Side LED Current Regulation
- 4.75V to 48V Operation Range
- High Accuracy 59mV LED Current Threshold Control
- 0.6mA Operating Current
- Programmable LED Current
- Output Over Voltage Protection
- Small SOT-23-6 Package
- RoHS Compliant and Halogen Free

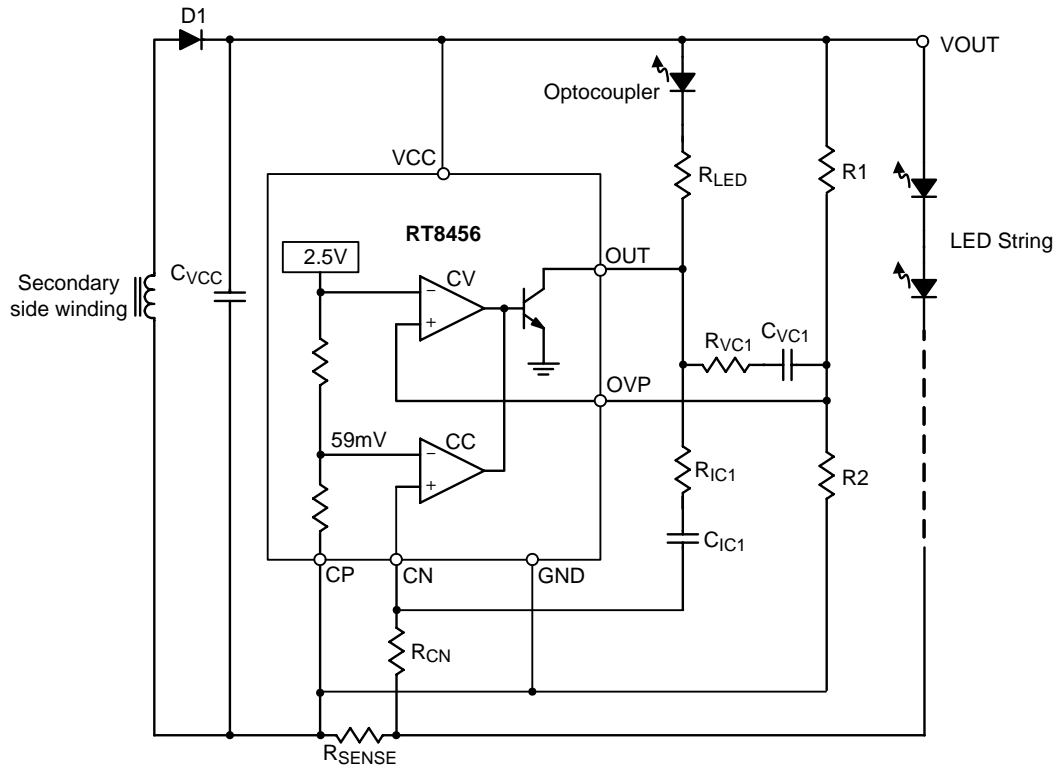
### Applications

- Isolated LED Lighting Fixtures
- E27/GU10/T5/T8

### Pin Configurations



Function Block and Typical Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	CN	Non-inverting Input of the CC Regulating Amp. It has a 59mV offset from the CP pin. The CN pin should be connected to the "Current In" node of the current sensing resistor, R <sub>SENSE</sub> .
2	GND	Ground of the RT8456 and secondary side.
3	OVP	Output Over Voltage Protection Pin with Threshold of 2.5V.
4	CP	Inverting Input of the CC Regulating Amp. It has a -59mV offset from CN pin. CP pin connects to a resistor to set LED current.
5	OUT	Open-collector Output. Connects this pin to an opto-coupler with a current limiting resistor.
6	VCC	Supply Voltage Input. A 0.1μF bypass capacitor should be connected between VCC and GND.

**Absolute Maximum Ratings** (Note 1)

- Supply Input Voltage, VCC ----- -0.3V to 52V
- CP ----- -0.6V to 1V
- CN ----- -0.3V to 1V
- OUT ----- -0.3V to 52V
- Power Dissipation, P<sub>D</sub> @ T<sub>A</sub> = 25°C  
   SOT-23-6 ----- 0.4W
- Package Thermal Resistance (Note 2)  
   SOT-23-6, θ<sub>JA</sub> ----- 250°C/W
- Lead Temperature (Soldering, 10 sec.) ----- 260°C
- Junction Temperature ----- 150°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, VCC (Note5) ----- 4.75V to 48V
- Junction Temperature Range ----- -40°C to 125°C

**Electrical Characteristics**

(V<sub>CC</sub> = 12V, T<sub>A</sub> = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Quiescent Current	I <sub>CC</sub>	V <sub>CN</sub> = V <sub>CP</sub> = 0V	--	550	--	μA
GND Pin Current	I <sub>GND</sub>	V <sub>CN</sub> = V <sub>CP</sub> = 0V, GND = 0V	--	530	--	μA
OVP Voltage	V <sub>OVP</sub>	V <sub>CN</sub> = V <sub>CP</sub> = 0V	2.46	2.5	2.54	V
		V <sub>CN</sub> = V <sub>CP</sub> = 0V, T <sub>A</sub> = -25°C to 105°C	2.45	--	2.55	
OVP Input Bias Current	I <sub>OVP</sub>	V <sub>OVP</sub> = 2.4 to 2.6V	--	--	100	nA
LED Current Sensing Amplifier Threshold	V <sub>CN-CP</sub>	V <sub>OVP</sub> = 2.4V	56	59	62	mV
		V <sub>OVP</sub> = 2.4V, T <sub>A</sub> = -25°C to 105°C	55	--	63	
CN Input Bias Current	I <sub>CN</sub>		--	--	200	nA
OUT Maximum Pin Sink Current	I <sub>OUTH</sub>	V <sub>OUT</sub> = 1.5V	--	8	--	mA

**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<sub>JA</sub> is measured at T<sub>A</sub> = 25°C on a low effective thermal conductivity single-layer test board per JEDEC 51-3.

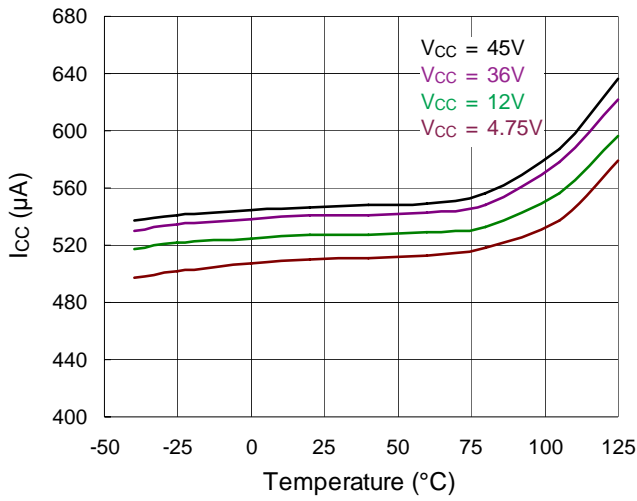
**Note 3.** Devices are ESD sensitive. Handling precaution is recommended.

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

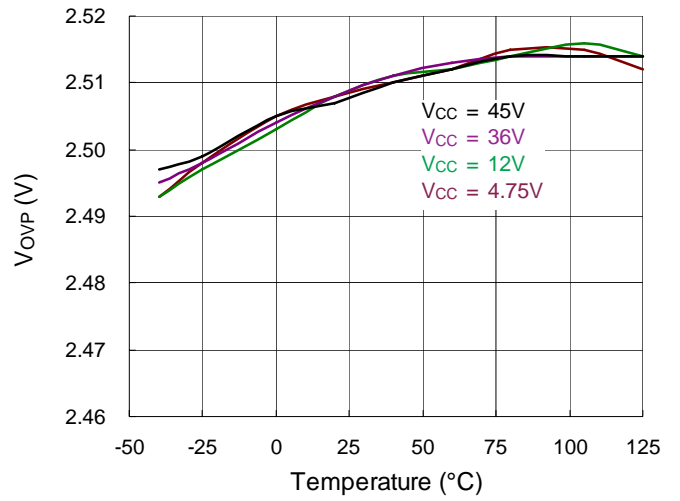
**Note 5.** RT8456 starts regulation at V<sub>CC</sub> ≥ 4.5V, and meets all parameter specs at V<sub>CC</sub> ≥ 4.75V.

Typical Operating Characteristics

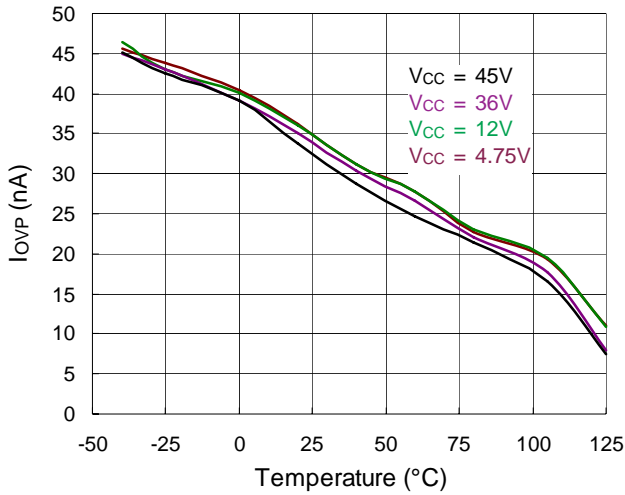
I<sub>CC</sub> vs. Temperature



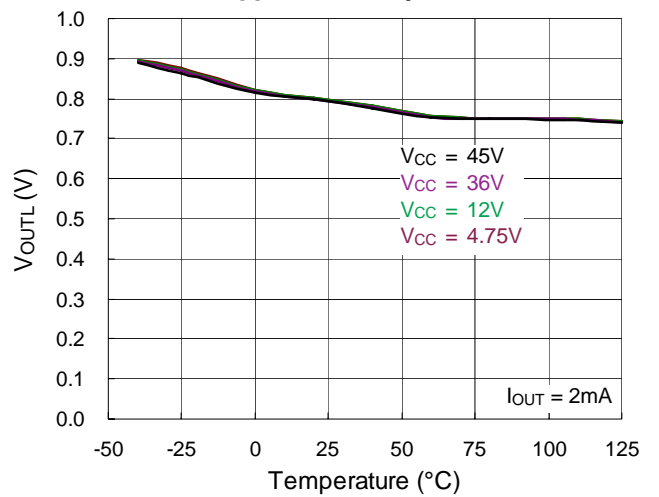
V<sub>OVP</sub> vs. Temperature



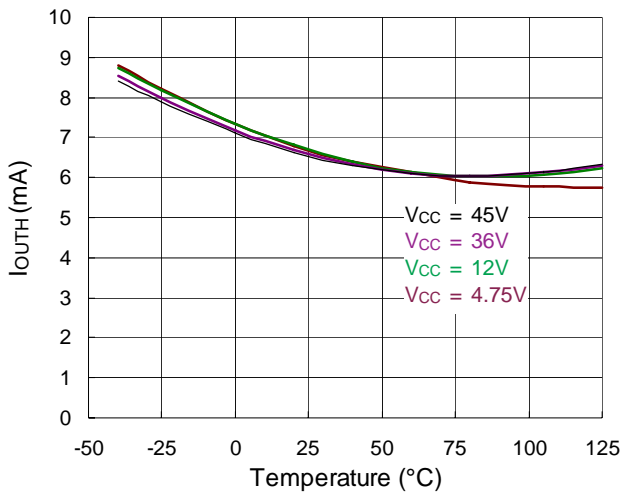
I<sub>OVP</sub> vs. Temperature



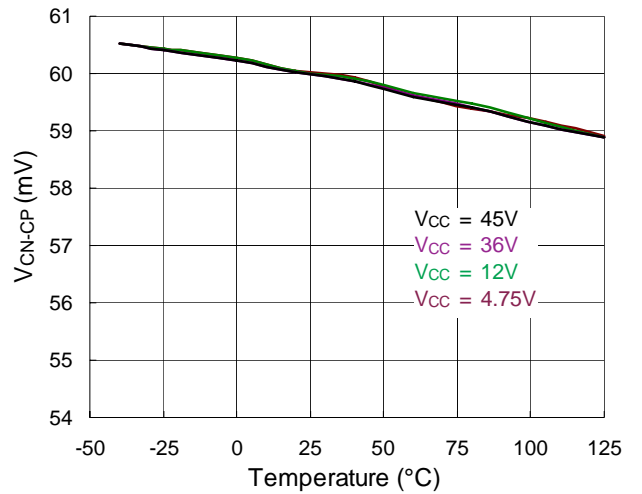
V<sub>OUTL</sub> vs. Temperature



I<sub>OUTH</sub> vs. Temperature



V<sub>CN-CP</sub> vs. Temperature



## Application Information

### Output Voltage Setting

The voltage control loop is controlled via the first trans-conductance operational amplifier. An optocoupler which is directly connected to the output and an external resistor bridge is connected between the output positive line and the ground reference. The middle point is to be connected to the OVP pin of the RT8456, where R2 is the upper resistor and R1 the lower resistor of the bridge. The relationship between R2 and R1 is shown below

$$V_{OUT} = V_{OVP} \times \frac{(R1 + R2)}{R2}$$

$$R1 = R2 \times \frac{(V_{OUT} - V_{OVP})}{V_{OVP}}$$

where  $V_{OUT}$  is the desired maximum output voltage. To avoid discharge of the load, the resistor bridge R1, R2, should be highly resistive. For this type of application a total value of 100k $\Omega$  (or more) would be appropriate for the resistors R1 and R2.

As an example, with R1 = 80k $\Omega$  and R2 = 20k $\Omega$ ,  $V_{OUT} = 12.5V$

### Output Current Setting

The current control loop is controlled via the second transconductance operational amplifier. An optocoupler and the sense resistor,  $R_{SENSE}$ , is placed in series on the output negative line.  $V_{CN-CP}$  threshold is achieved externally by a resistor bridge tied to the reference voltage,  $V_{REF}$ . Its middle point is tied to the positive input of the current control operational amplifier and its foot is connected to the lower potential point of the sense resistor. The resistors of the bridge are matched to provide the best precision. With  $V_{CN-CP}$  and  $R_{SENSE}$ , the expected output current,  $I_{OUT}$ , can be obtained as below equation :

$$I_{OUT} = \frac{V_{CN-CP}}{R_{SENSE}}$$

where  $I_{OUT}$  is the desired maximum output current, and  $V_{CN-CP}$  the threshold voltage for the current control loop. Note that the sense resistor,  $R_{SENSE}$ , should be chosen taking into account its maximum power dissipation ( $P_{LIM}$ ) during full load operation.

### Compensation

Both the voltage control trans conductance amplifier and the current control trans-conductance amplifier can be fully compensated. The output and negative inputs are directly accessible for external compensation components, as shown in the Typical Application Circuit.

The typical component values for the compensation network of voltage control loop is  $C_{VC1} = 2.2nF$  and  $R_{VC1} = 22k\Omega$ . The typical component values for the compensation network of current control loop is  $C_{IC1} = 2.2nF$ ,  $R_{IC1} = 22k\Omega$  and  $R_{CN} = 1k\Omega$ . However, in many application conditions, the current control loop can be stable without compensation network ( $R_{CN} = 0$ , no  $C_{IC1}$  nor  $R_{IC1}$ ).

When the voltage control loop is used as the voltage limit protection or the current control loop is used as the current limit protection, no compensation network is needed for the protecting control loop.

A resistor,  $R_{OPT}$ , must be connected in series with the opto-coupler since it is part of the compensation network. Although the value of  $R_{OPT}$  is not critical, it's recommended to be in the range from 0.33k $\Omega$  to  $(V_{OUT} - 2) / (0.005)\Omega$ .

### 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  $\theta_{JA}$  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,  $\theta_{JA}$ , is layout dependent. For SOT-23-6 packages, the thermal resistance,  $\theta_{JA}$ , is 250°C/W on a standard JEDEC 51-3 single-layer thermal test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated by the following formula :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (250^\circ\text{C/W}) = 0.4\text{W for SOT-23-6 package}$$

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

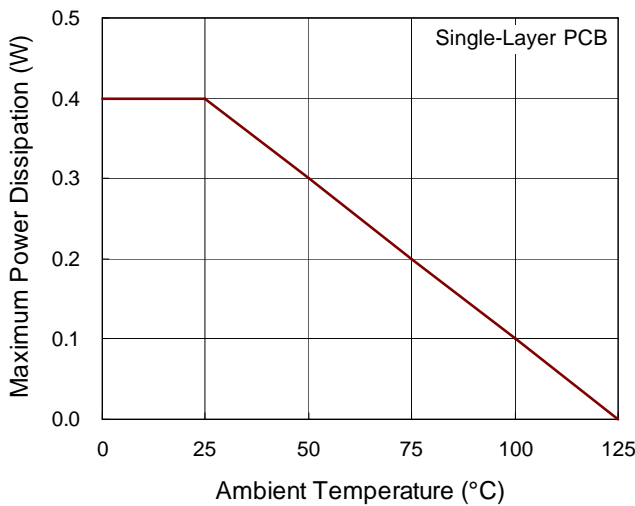


Figure 1. Derating Curve of Maximum Power Dissipation

### Layout Consideration

For the best performance of the RT8456, the following PCB Layout guidelines must be strictly followed.

- ▶ Place the  $R_{SENSE}$  resistor as close to the IC as possible.
- ▶ Keep the input/output traces as wide and short as possible.

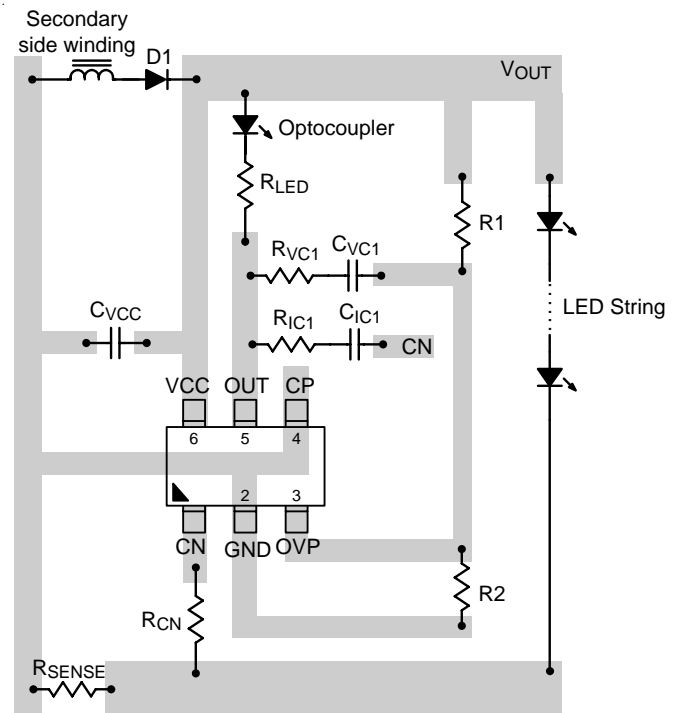
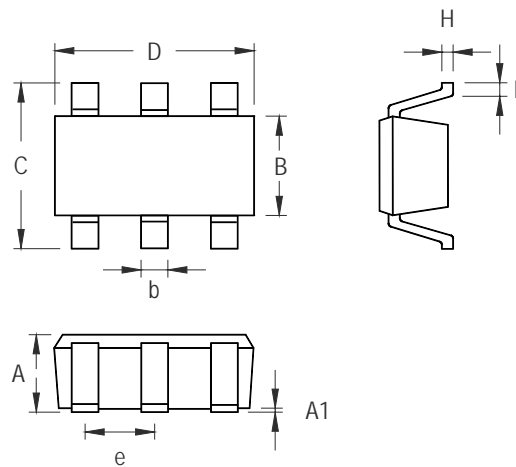


Figure 2. PCB Layout Guide

**Outline Dimension**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.889	1.295	0.031	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.250	0.560	0.010	0.022
C	2.591	2.997	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

**SOT-23-6 Surface Mount Package**

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