18V Multi-Topology LED Driver with Dimming Control

General Description

The RT8498 is a current-mode LED driver supporting wide input voltage range from 3V to 18V and output voltage up to 18V. With internal 350kHz operating frequency, the size of the external PWM inductor and input/output capacitors can be minimized. High efficiency is achieved by a 100mV current sensing control. LED dimming control can be done from either analog or PWM signal. The RT8498 provides an internal soft-start function to avoid inrush current and thermal shutdown to prevent the device from overheat.

The RT8498 is available in the SOT-23-6 package.

Ordering Information

RT8498□□

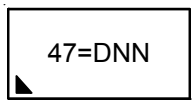
- Package Type
  E : SOT-23-6
- Lead Plating System
  G : Green (Halogen Free and Pb Free)

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



47= : Product Code

DNN : Date Code

Features

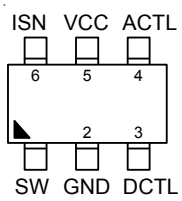
- **High Voltage : VIN Up to 18V, VOUT Up to 18V**
- **Built-In 2A Power Switch**
- **Current-Mode PWM Control**
- **350kHz Fixed Switching Frequency**
- **Analog, PWM Digital or PWM Converting to Analog with One External Capacitor**
- **Internal Soft-Start to Avoid Inrush Current**
- **Under-Voltage Lockout**
- **Internal Over Voltage Protection to Limit Output Voltage**
- **Cycle-by Cycle Current Limit**
- **Thermal Shutdown**

Applications

- GPS, Portable DVD Backlight
- Display Cabinet Lamp and Room Lighting
- IP Camera

Pin Configuration

(TOP VIEW)



SOT-23-6

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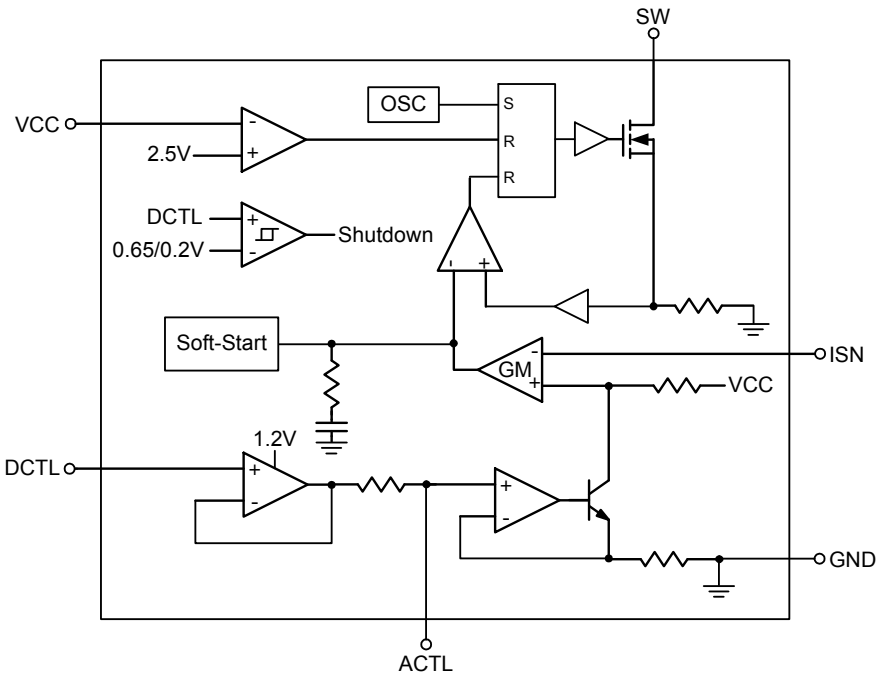
Functional Pin Description

Pin No.	Pin Name	Pin Function
1	SW	Switch node of the PWM converter.
2	GND	Ground.
3	DCTL	Digital dimming control input.
4	ACTL	Analog dimming control input. Effective programming range is 0.65V to 1.2V.
5	VCC	Supply voltage input. For good bypass, connect a low ESR capacitor between this pin and GND.
6	ISN	Current sense input. Voltage threshold between VCC and ISN is 100mV.

Functional Block Diagram



Operation

The RT8498 is specifically designed to be operated in Buck, Boot and Buck-Boost converter applications. This device uses a fixed frequency, current-mode control scheme to provide excellent line and load regulation. The maximum duty ratio of RT8498 is 100% (typ.), and the minimum on time is 150ns (typ.)

The current through the sense resistor is set by the programmed voltage and the sense resistance. The voltage across the sense resistor can be programmed by the analog or digital signal at the ACTL pin. By adding a 0.47μF filtering capacitor on the ACTL pin, the PWM dimming signal on DCTL pin will be averaged and converted into analog dimming signal on the ACTL pin. V_{ACTL} = 0.65V + 0.55 x PWM dimming duty ratio. The RT8498 provides protection functions which include over- temperature, and switch current limit to prevent abnormal situations.

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Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, VCC ---------- –0.3V to 21V
- SW Pin Voltage at Switching Off, ISN ---------- –0.3V to 21V
- DCTL, ACTL Pin Voltage ---------- –0.3V to 21V
- Power Dissipation, P_D @ T_A = 25°C
  SOT-23-6 ---------- 0.48W
- Package Thermal Resistance (Note 2)
  SOT-23-6, θ_{JA} ---------- 208.2°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

Recommended Operating Conditions (Note 4)

- Supply Input Voltage, VCC ---------- 3V to 18V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{CC} = 12V, No Load on any Output, T_A = 25°C, unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Overall							
Supply Current		I_{VCC}		--	--	3	mA
VIN Under Voltage Lockout Threshold		V_{UVLO}	V_{IN} Rising	2.1	2.55	3	V
			V_{IN} Falling	1.8	2.2	2.6	
Shutdown Current		I_{SHDN}	V_{DCTL} < 0.1V	--	--	10	μA
Enable Voltage	Logic-High	V_{DCTL_H}		0.65	--	--	V
	Logic-Low	V_{DCTL_L}		--	--	0.2	
Current Sense Amplifier							
Input Threshold (V_{VCC} – V_{ISN})			V_{ACTL} ≥ 1.25V	96	100	104	mV
Input Current		I_{ISN}	V_{ISN} = 12V	--	20	--	μA
LED Dimming							
Analog Dimming ACTL Pin Input Current		I_{ACTL}	0.65 ≤ V_{ACTL} ≤ 3V	–2	--	--	μA
LED Maximum Current on Threshold at ACTL		V_{ACTL_ON}	(V_{VCC} – V_{ISN}) = 100mV	--	1.33	1.4	V
LED Current Off Threshold at ACTL		V_{ACTL_OFF}		0.57	0.65	0.72	V
DCTL Input Current		I_{DCTL}	0.3V ≤ V_{DCTL} ≤ 5V	--	0.5	--	μA

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Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
DCTL Input Voltage	Logic-High	V_{DCTL_H}		2	--	--	V
	Logic-Low	V_{DCTL_L}		--	--	0.1	
PWM Boost Converter							
Switching Frequency		f_{SW}		--	350	--	kHz
SW $R_{DS(ON)}$				--	0.1	--	Ω
SW Current Limit		I_{LIM_SW}		2	2.5	--	A
Over Voltage Protection		V_{CC_OVP}		18.3	19.6	20.9	V
Over Voltage Hysteresis				--	0.6	--	V
Temperature Protection							
Thermal Shutdown Temperature		T_{SD}		--	150	--	°C
Thermal Shutdown Hysteresis		ΔT_{SD}		--	10	--	°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 high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard.

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

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

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Typical Application Circuit

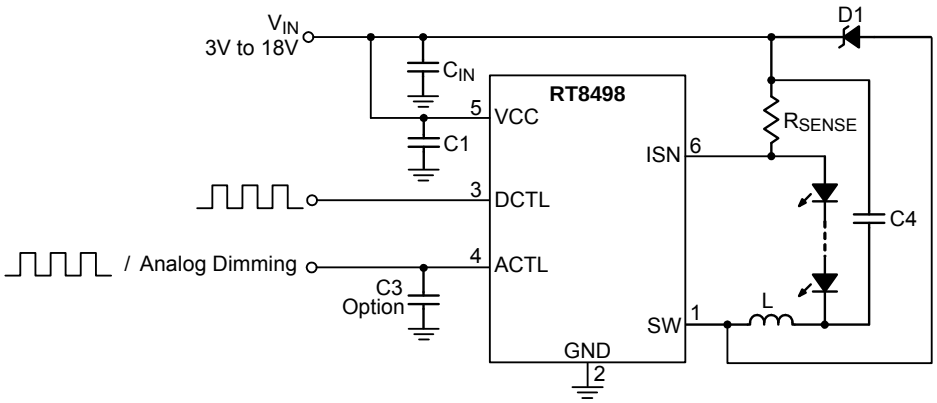

Figure 1. Buck Configuration

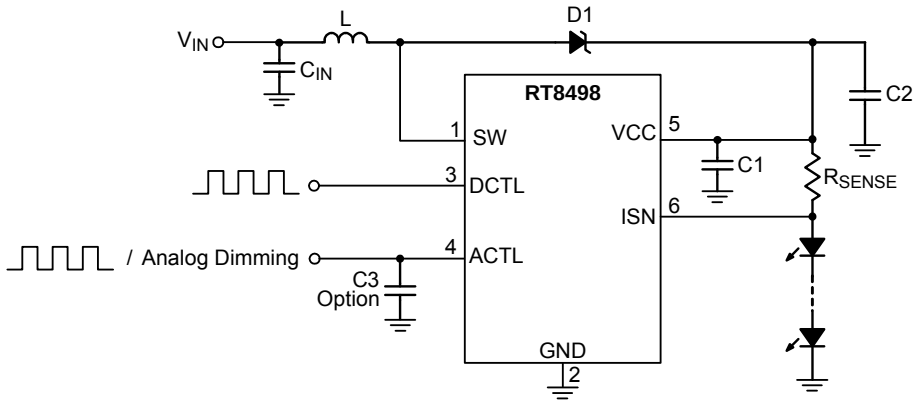

Figure 2. Boost Configuration

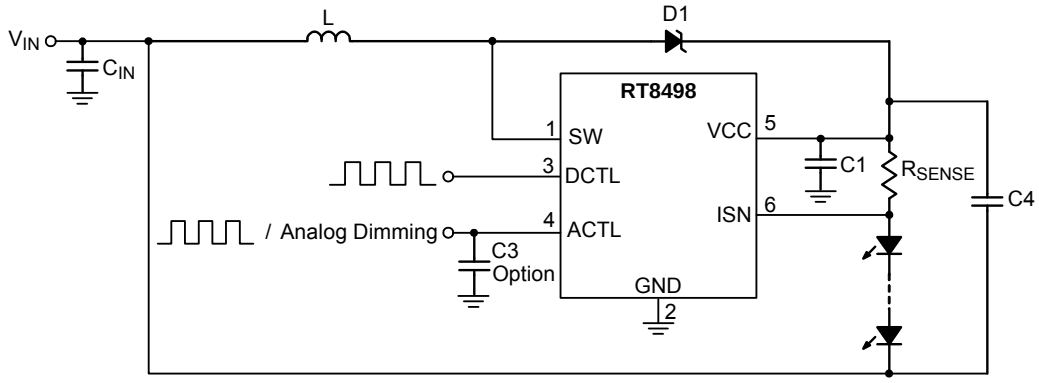

Figure 3. Buck-Boost Configuration

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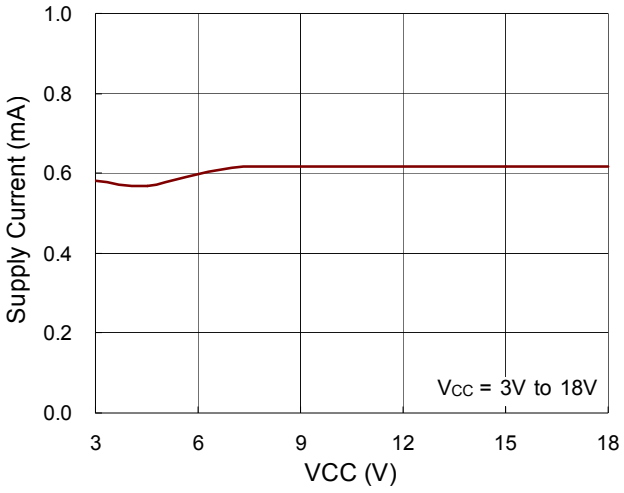
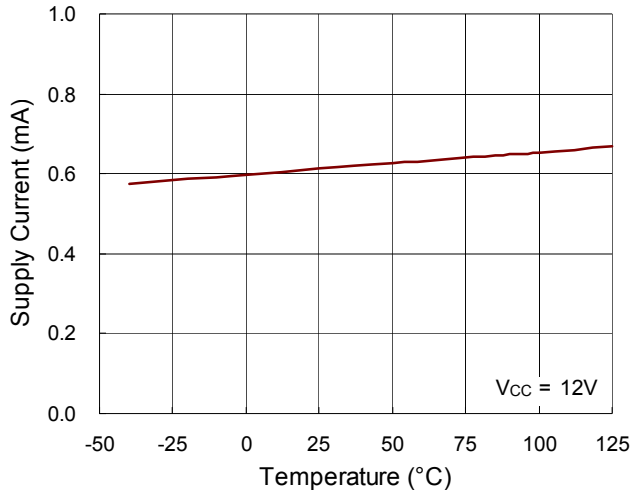
Typical Operating Characteristics

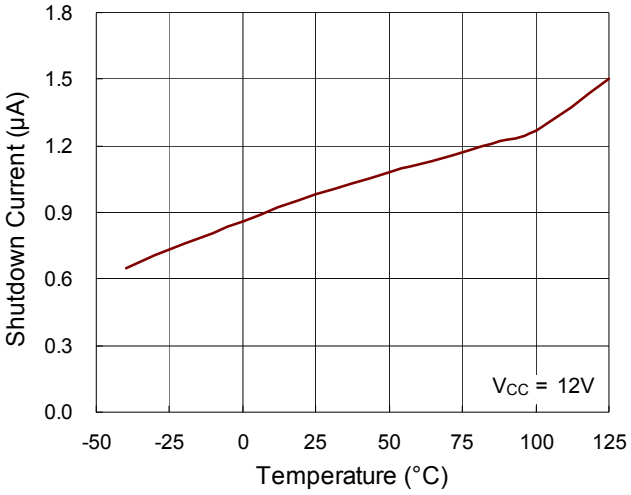
Supply Current vs. VCC



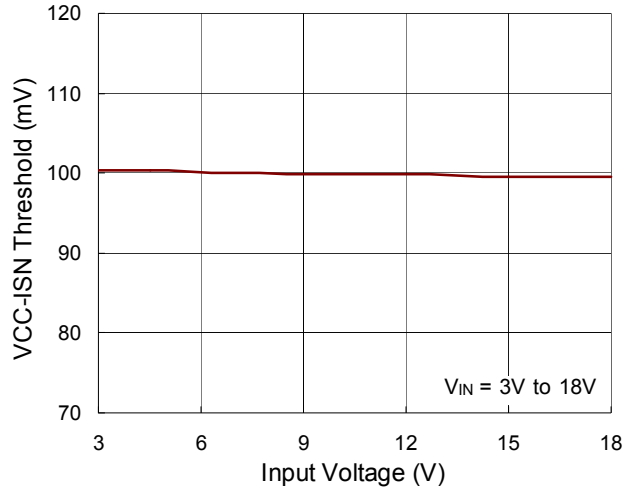
Supply Current vs. Temperature



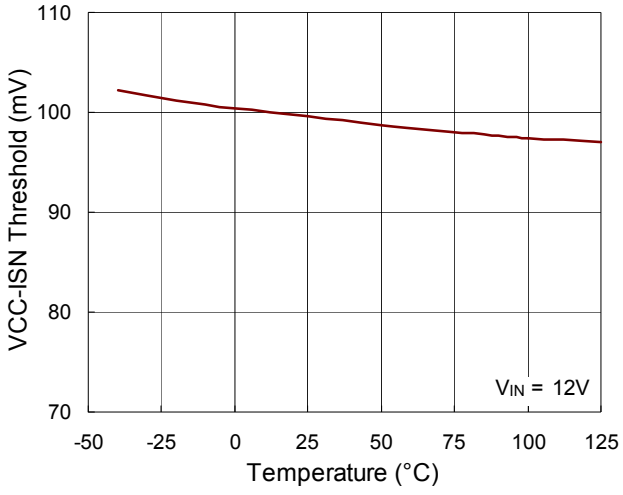
Shutdown Current vs. Temperature



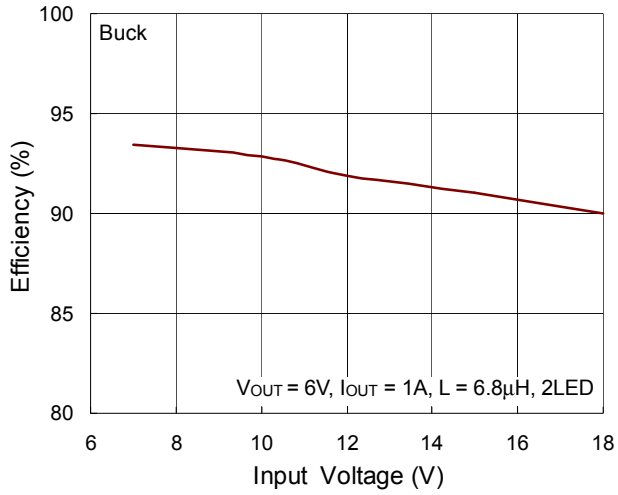
VCC-ISN Threshold vs. Input Voltage



VCC-ISN Threshold vs. Temperature



Efficiency vs. Input Voltage



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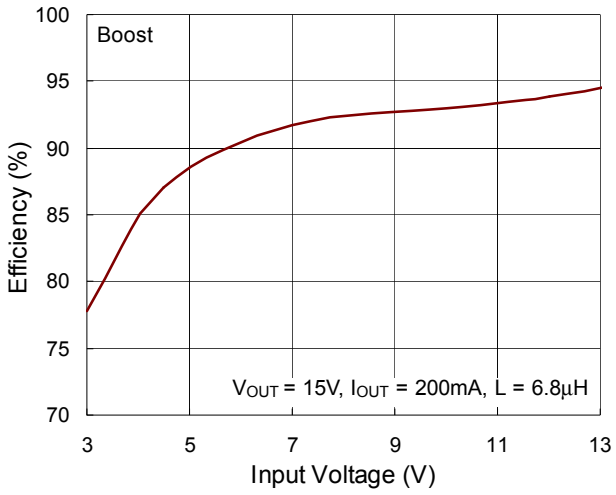
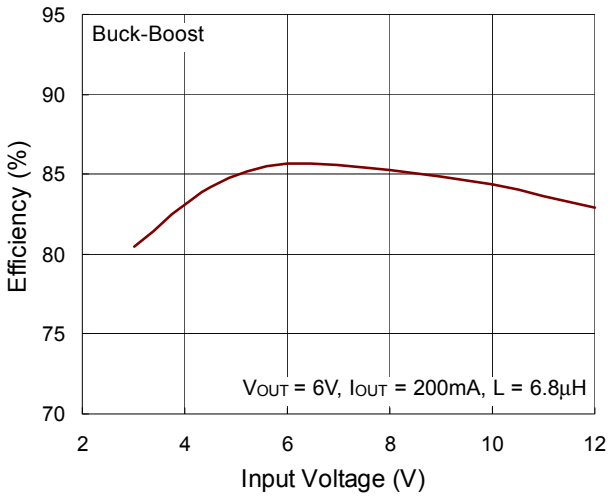
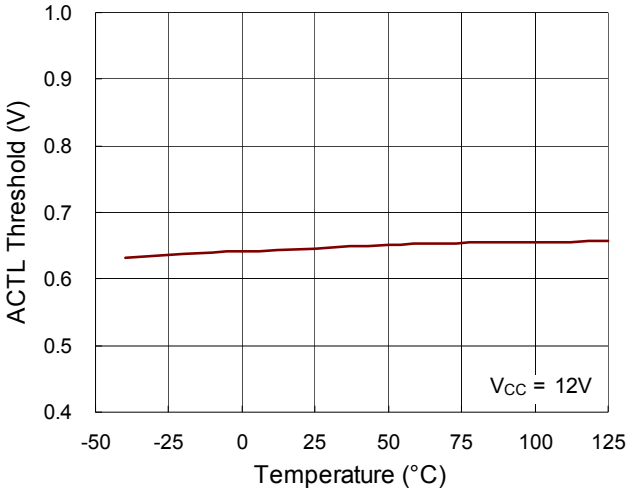
Efficiency vs. Input Voltage



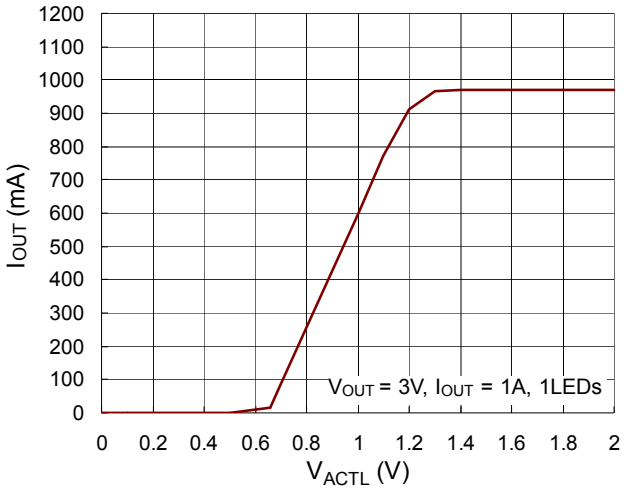
Efficiency vs. Input Voltage



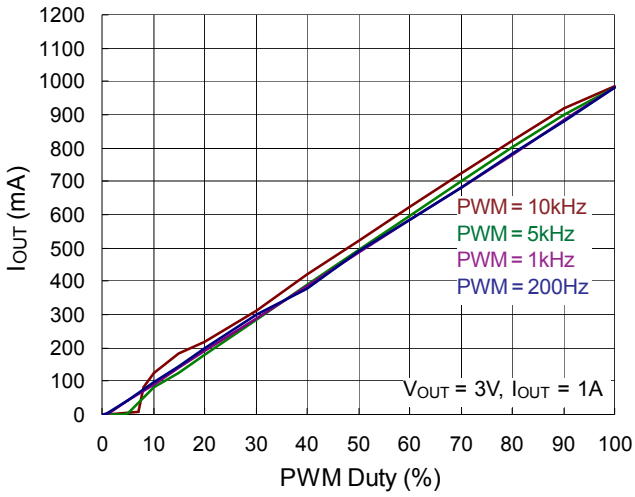
ACTL Threshold vs. Temperature



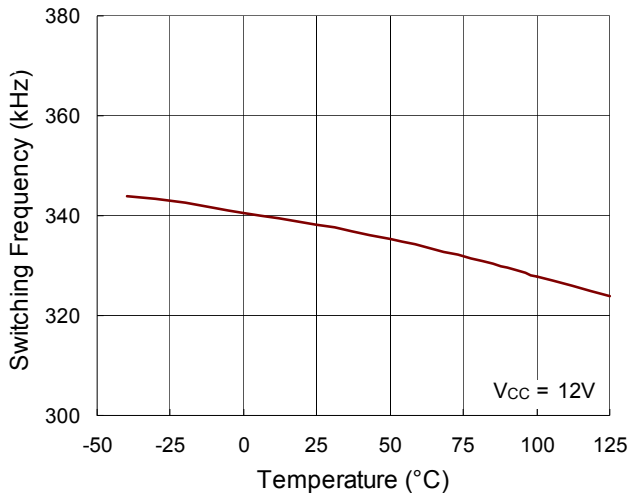
I_{OUT} vs. V_{ACTL}



I_{OUT} vs. PWM Duty



Switching Frequency vs. Temperature



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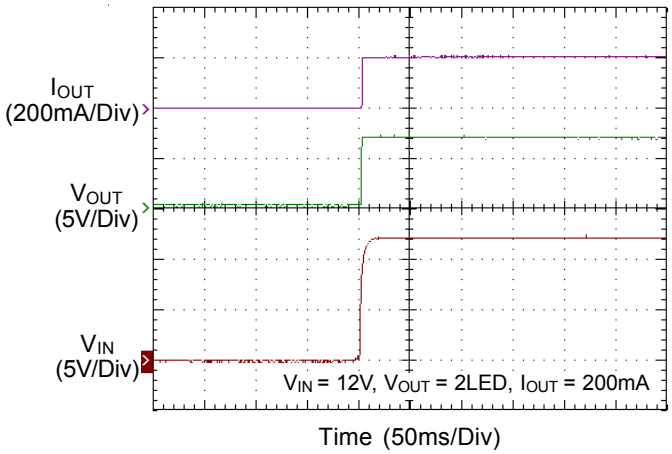
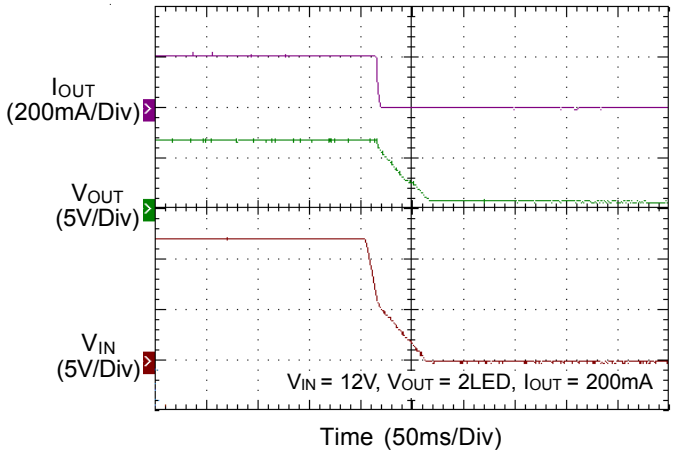
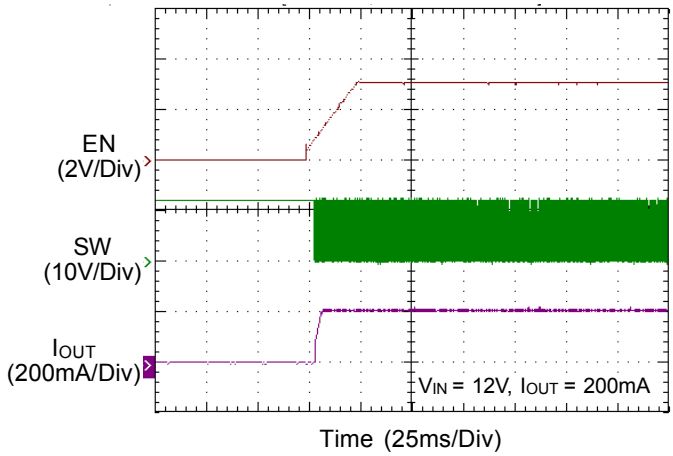
Power On from VIN



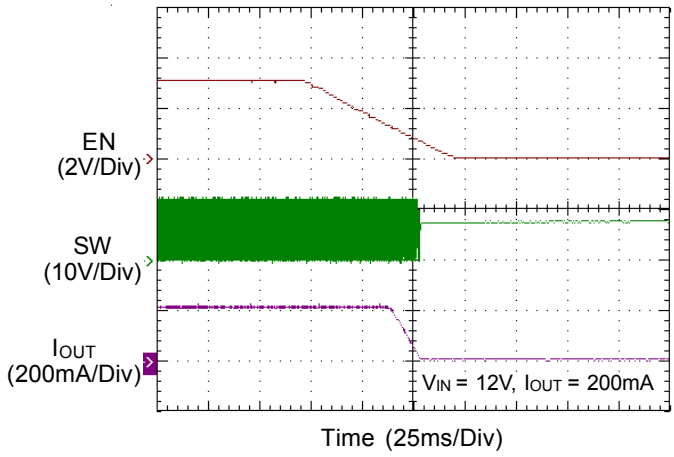
Power Off from VIN



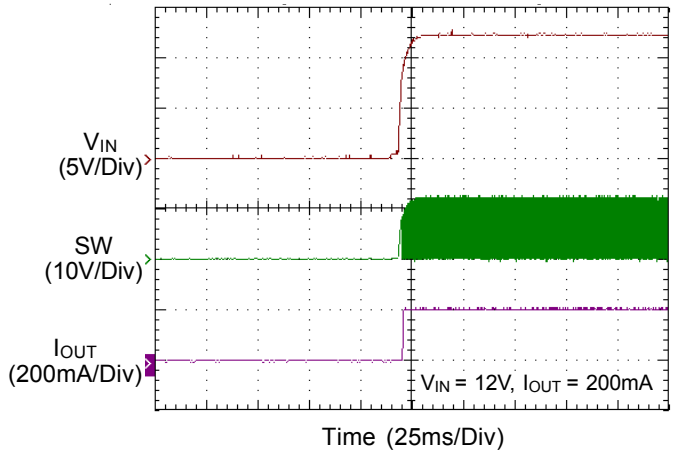
Power On from EN



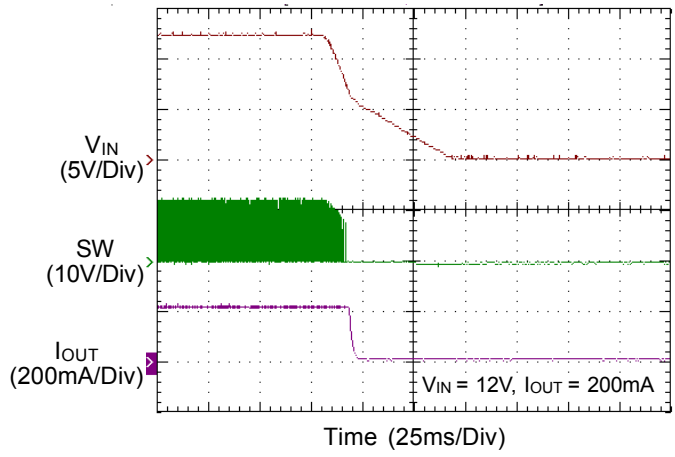
Power Off from EN



Start Up



Shutdown



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Application Information

The RT8498 is specifically designed to be operated in Buck converter applications. This device uses a fixed frequency, current-mode control scheme to provide excellent line and load regulation.

LED Current Setting

The LED current can be calculated by the following equation :

$$I_{LED(MAX)} = \frac{(V_{VCC} - V_{ISN})}{R_{SENSE}}$$

where ($V_{VCC} - V_{ISN}$) is the voltage between the VCC and ISN pins (100mV typ. if ACTL dimming is not applied) and the R_{SENSE} is the resister between the VCC and ISN pins.

Current Limit

The RT8498 can limit the peak switch current with its internal over-current protection feature. In normal operation, the power switch is turned off when the switch current hits the loop-set value. The over-current protection function will turn off the power switch independent of the loop control when the peak switch current reaches around 2.5A (type.).

Over-Temperature Protection

The RT8498 has over-temperature protection (OTP) function to prevent the excessive power dissipation from overheating. The OTP function will shut down switching operation when the die junction temperature exceeds 150°C. The chip will automatically start to switch again when the die junction temperature cools off.

Inductor Selection

Choose an inductor that can handle the necessary peak current without saturating and ensure that the inductor has a low DCR (copper-wire resistance) to minimize I^2R power losses. Inductor manufacturers specify the maximum current rating as the current where the inductance falls to certain percentage of its nominal value, typically 65%. In Multiple-Topology application where the transition between discontinuous and continuous modes occurs, the value of the required output inductor, L, can be approximated by the following equation :

For Buck application :

$$L = \left[\frac{V_{OUT}}{f \times \Delta I_L}\right] \times \left[1 - \frac{V_{OUT}}{V_{IN(MAX)}}\right]$$

The ripple current ΔI_L and peak current I_{PEAK} can be calculated :

$$\Delta I_L = \left[\frac{V_{OUT}}{f \times L}\right] \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right]$$

$$I_{PEAK} = I_{OUT} + \frac{\Delta I_L}{2}$$

For Boost application :

$$L = \left[\frac{V_{IN}}{f \times \Delta I_L}\right] \times \left[1 - \frac{V_{IN}}{V_{OUT}}\right]$$

The ripple current ΔI_L and peak current I_{PEAK} can be calculated :

$$\Delta I_L = \left[\frac{V_{IN}}{f \times L}\right] \times \left[1 - \frac{V_{IN}}{V_{OUT}}\right]$$

$$I_{PEAK} = \left[\frac{I_{OUT} \times V_{OUT}}{\eta \times V_{IN}}\right] + \frac{\Delta I_L}{2}$$

For Buck-Boost application :

$$L = \left[\frac{V_{OUT}}{\Delta I_L \times f}\right] \times \left[1 - \frac{V_{OUT}}{V_{IN} + V_{OUT}}\right]$$

The ripple current ΔI_L and peak current I_{PEAK} can be calculated :

$$\Delta I_L = \left[\frac{V_{OUT}}{L \times f}\right] \times \left[1 - \frac{V_{OUT}}{V_{IN} + V_{OUT}}\right]$$

$$I_{PEAK} = \left[\frac{(V_{IN} + V_{OUT}) \times I_{OUT}}{\eta \times V_{IN}}\right] + \frac{\Delta I_L}{2}$$

where,

V_{OUT} = output voltage.

V_{IN} = input voltage.

I_{OUT} = LED current.

f = switching frequency.

η = efficiency

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Schottky Diode Selection

The Schottky diode, with their low forward voltage drop and fast switching speed, is necessary for RT8498 applications. In addition, power dissipation, reverse voltage rating and pulsating peak current are important parameters of the Schottky diode that must be considered. The diode's average current rating must exceed the average output current. The diode conducts current only when the power switch is turned off (typically less than 50% duty cycle).

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 SOT-23-6 package, the thermal resistance, θ_{JA}, is 208.2°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. The maximum power dissipation at T_A = 25°C can be calculated as below :

$P_{D(MAX)}$ = (125°C – 25°C) / (208.2°C/W) = 0.48W for a SOT-23-6 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 4 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

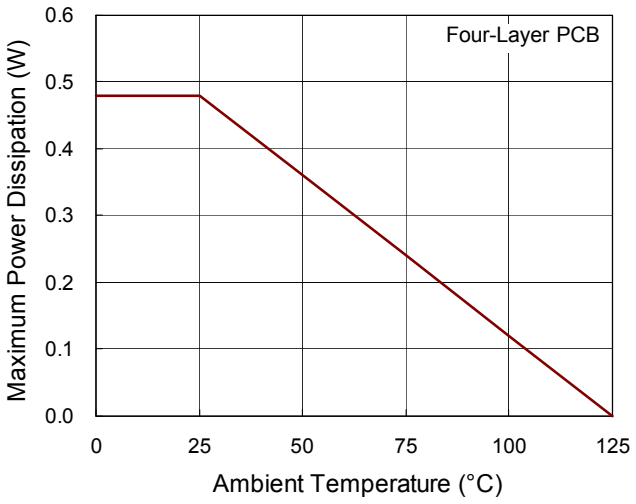

Figure 4. Derating Curve of Maximum Power Dissipation

Layout Considerations

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

- The power components L, D1 and C4 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.
- The input capacitor C1 must be placed as close to the VCC pin as possible.

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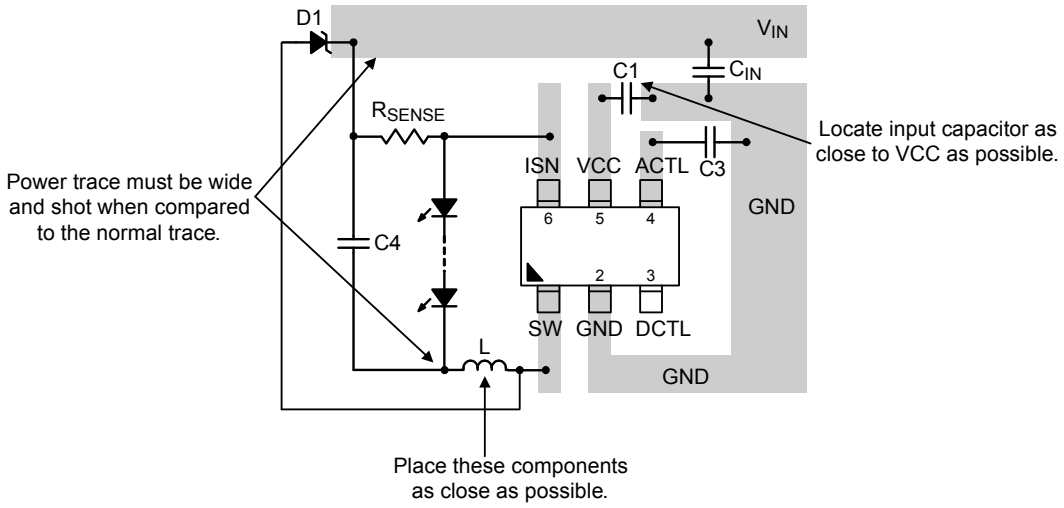

Figure 5. PCB Layout Guide

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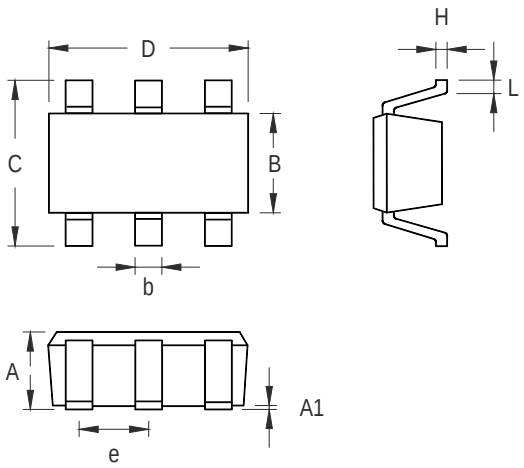
Outline Dimension



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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