Small Package, High Performance, Asynchronous Boost LED Driver

General Description

The RT4526 is a high frequency, asynchronous Boost converter. The internal MOSFET can support up to 10 white LEDs for backlighting and OLED power applications, and the internal soft-start function can reduce the inrush current. The device operates with 1MHz fixed switching frequency to allow small external components and to simplify possible EMI problems. For the protection, the RT4526 provides 37V OVP to allow inexpensive and small-output capacitors with lower voltage ratings. The LED current is initially set with the external sense resistor R_{SET}. The RT4526 is available in the tiny TSOT-23-6 package to provide the best solution for PCB space saving and total BOM cost.

Ordering Information

RT4526□□

- Package Type
  J6 : TSOT-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.

Features

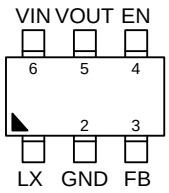
- **VIN Operating Range : 2.5V to 5.5V**
- **Internal Power N-MOSFET Switch**
- **Wide Range for PWM Dimming (100Hz to200kHz)**
- **Minimize the External Component Counts**
- **Internal Soft-Start**
- **Internal Compensation**
- **Under-Voltage Protection**
- **Over-Voltage Protection**
- **Over-Temperature Protection**
- **RoHS Compliant and Halogen Free**

Applications

- Cellular Phones
- Digital Cameras
- PDAs and Smart Phones and MP3 and OLED.
- Portable Instruments

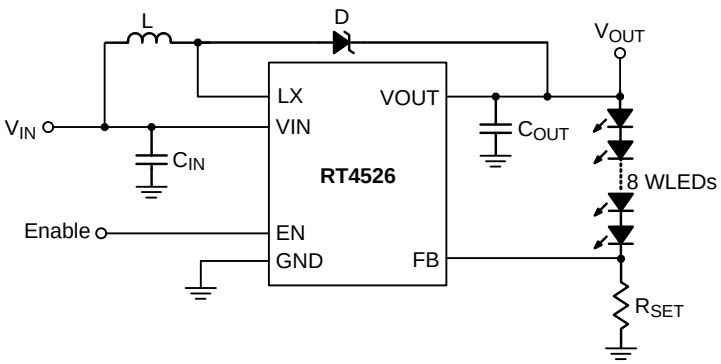
Pin Configurations

(TOP VIEW)



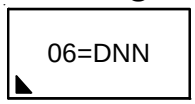
TSOT-23-6

Simplified Application Circuit



Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Marking Information



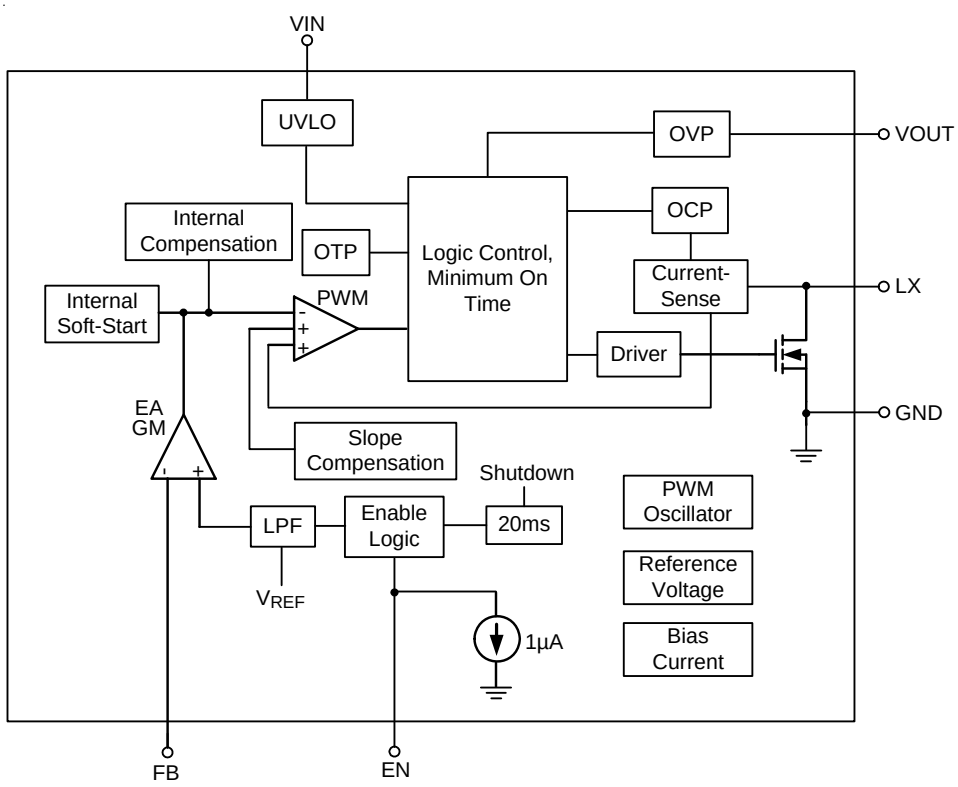
06= : Product Code

DNN : Date Code

Functional Pin Description

Pin No.	Pin Name	Pin Function
1	LX	Switch Node. Open-drain output of the internal N-MOSFET. Connect this pin to external inductor and diode.
2	GND	Ground.
3	FB	Feedback Voltage Input. Connect a resistor to GND to set output current.
4	EN	Enable Control Input (Active High).
5	VOUT	Output Voltage. (For OVP detect function)
6	VIN	Supply Input.

Function Block Diagram



Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Operation

The RT4526 is an asynchronous step-up converter that can support input voltage from 2.5V to 5.5V.

When the power plugs in and EN = H, V_{OUT} is soft-started (20m sec) to avoid the inrush current of V_{IN}. Normally, the low-side MOSFET is turned on by logic control which drives the gate driver block when V_{FB} is lower than the internal reference voltage. The low-side MOSFET will be turned on by minimum on-time. When the low-side MOSFET is turned off, the current of inductor provide the power to VOUT until V_{FB} is lower than the internal reference voltage. Then, the low-side MOSFET is turned on. When the current of low-side MOSFET is over the rating current, the low-side MOSFET is turned off. When the temperature is over the rating temperature, the low-side MOSFET is turned off until the temperature is dropped by the OTP block. When V_{IN} is lower than 2.1V, the low-side MOSFET is turned off by the UVLO block. When VOUT is higher than rating voltage, the low-side MOSFET is turned off by the OVP block. Internal clock is proved by the PWM Oscillator block. Internal reference voltage is provided by the Reference Voltage block. Internal current bias is provided by the Bias Current block. the EN pin is pulled low by 1μA current source.

Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, V_{IN} ---------- –0.3V to 6V
- Switching Pin, LX ---------- –0.3V to 50V
- VOUT ---------- –0.3V to 46V
- Other Pins ---------- –0.3V to 6V
- Power Dissipation, P_D @ T_A = 25°C
  TSOT-23-6 ---------- 0.5W
- Package Thermal Resistance (Note 2)
  TSOT-23-6, θ_{JA} ---------- 197.4°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)

- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{IN} = 3.7V, C_{IN} = 2.2µF, C_{OUT} = 0.47µF, I_{OUT} = 20mA, L = 22µH, T_A = 25°C, unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage		V_{IN}		2.5	--	5.5	V
Under-Voltage Lockout		V_{UVLO}		2	2.2	2.45	V
UVLO Hysteresis				--	0.1	--	V
Quiescent Current		I_Q	FB = 1.5V, No Switching	--	400	600	µA
Supply Current		I_{IN}	FB = 0V, Switching	--	1	2	mA
Shutdown Current		I_{SHDN}	V_{EN} < 0.4V	--	1	4	µA
Line Regulation			V_{IN} = 3V to 4.3V	--	1	--	%
Load Regulation			1mA to 20mA	--	1	--	%
Operation Frequency		f_{OSC}		0.75	1	1.25	MHz
Maximum Duty Cycle				90	92	--	%
Clock Rate				0.1	--	200	kHz
Feedback Reference Voltage		V_{REF}		285	300	315	mV
On Resistance		$R_{DS(ON)}$		--	0.7	1.2	Ω
EN Threshold Voltage	Logic-High	V_{IH}		1.4	--	--	V
	Logic-Low	V_{IL}		--	--	0.5	
EN Sink Current		I_{IH}		--	1	--	µA
EN Hysteresis				--	0.1	--	V
Over Voltage Threshold		V_{OVP}		35	37	39	V
Over Current Threshold		I_{OCP}		1	1.2	--	A

Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
OTP	T_{OTP}		--	160	--	°C
OTP Hysteresis			--	30	--	°C
Shutdown Delay	T_{SHDN}		--	20	--	ms

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.

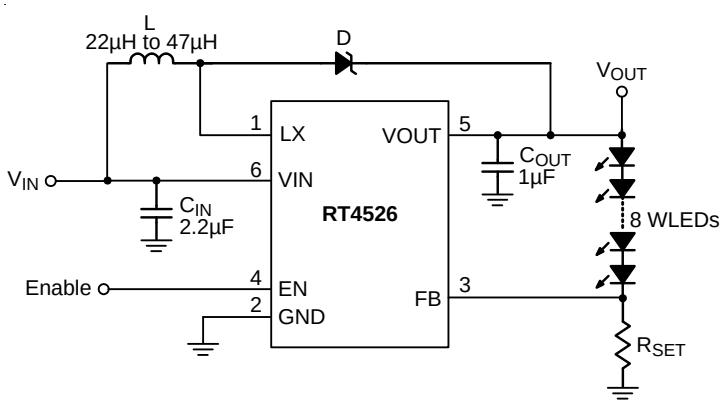
Note 2. θ_{JA} is measured at T_A = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7.

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

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

Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Typical Application Circuit

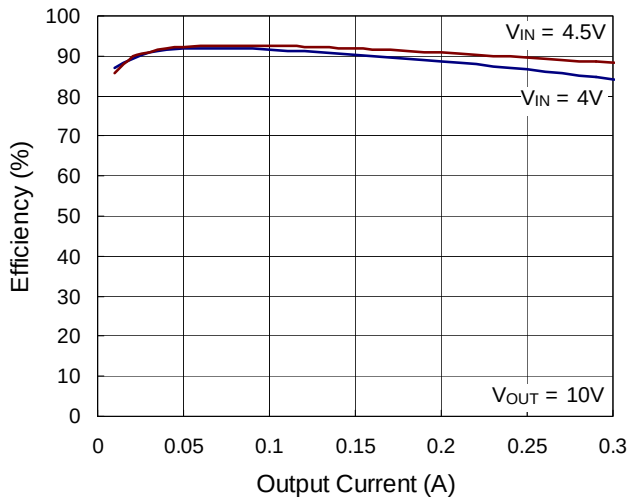


Note : The IC is not suitable for unstable supply applications which caused by the external components of VIN.

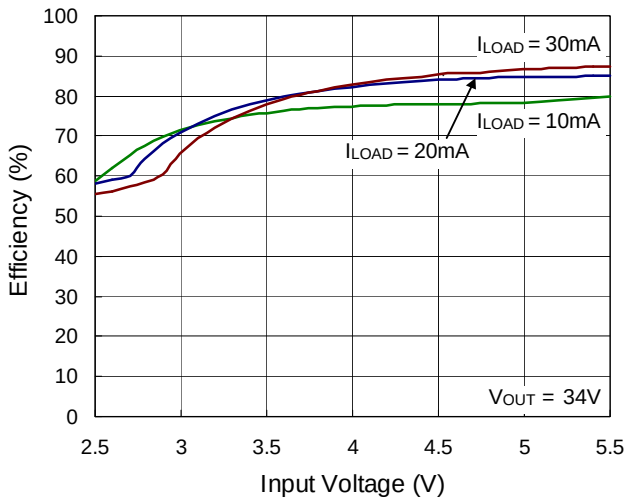
Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Typical Operating Characteristics

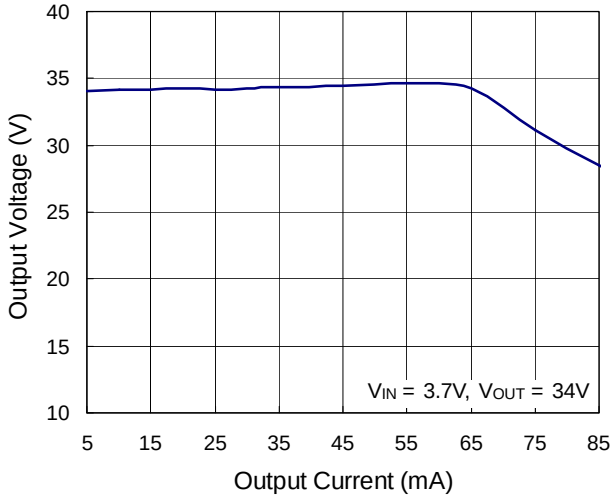
Efficiency vs. Output Current



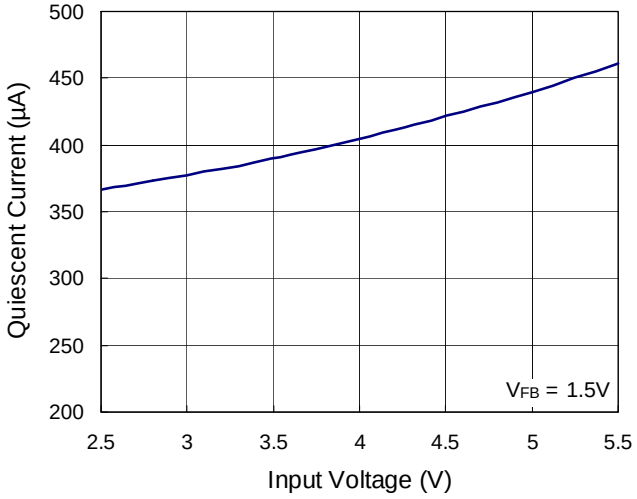
Efficiency vs. Input Voltage



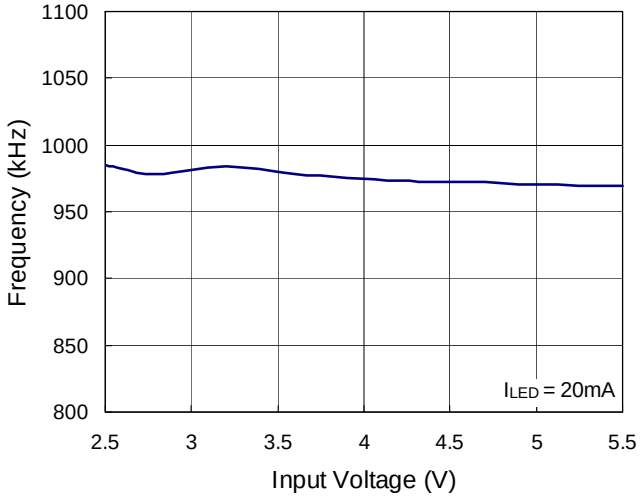
Output Voltage vs. Output Current



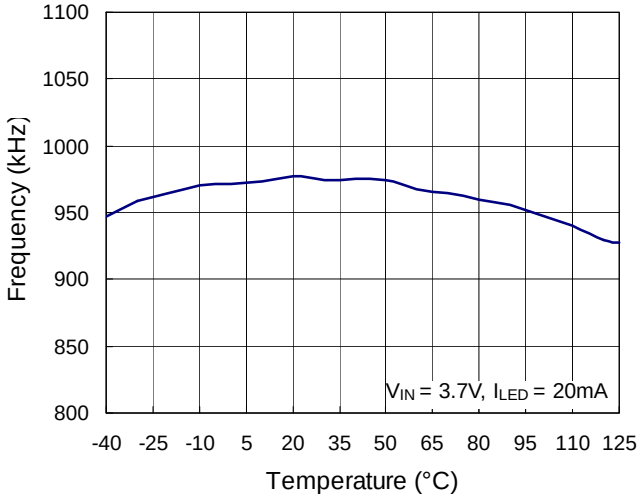
Quiescent Current vs. Input Voltage



Frequency vs. Input Voltage

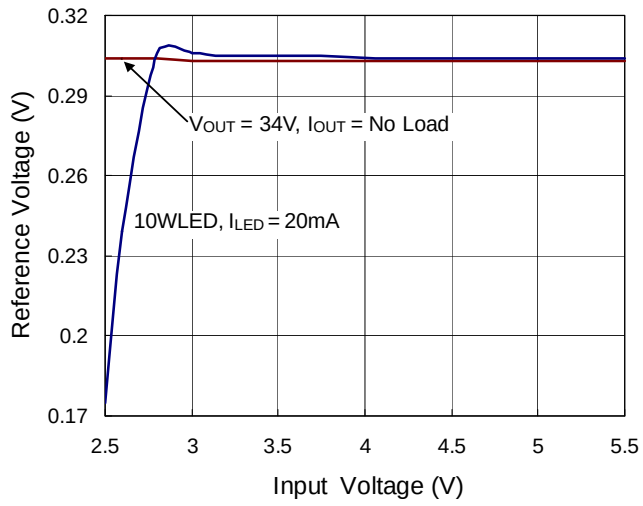


Frequency vs. Temperature

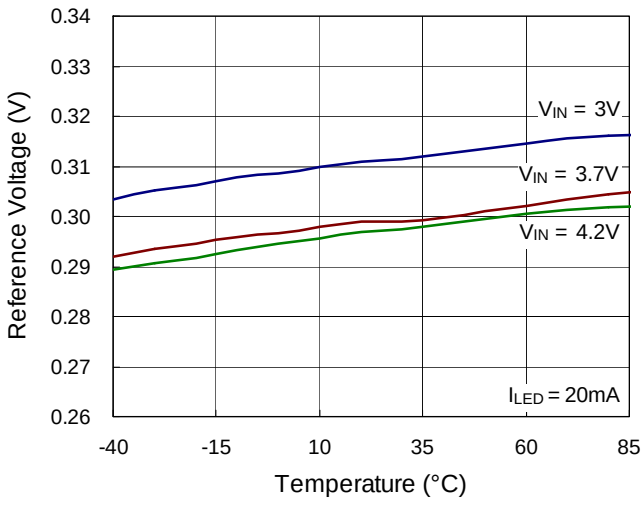


Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

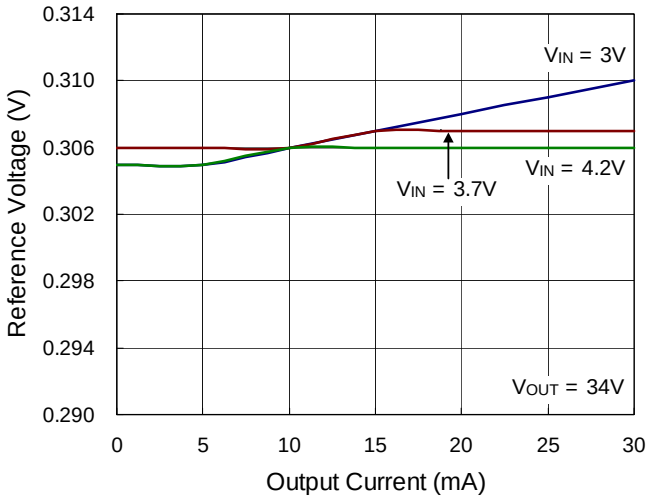
Reference Voltage vs. Input Voltage



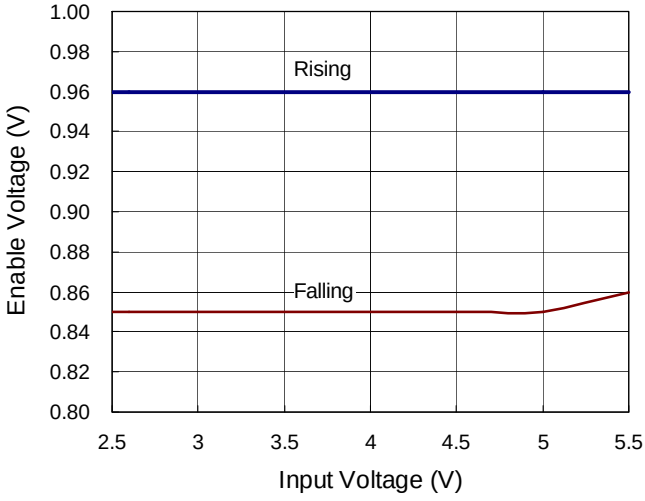
Reference Voltage vs. Temperature



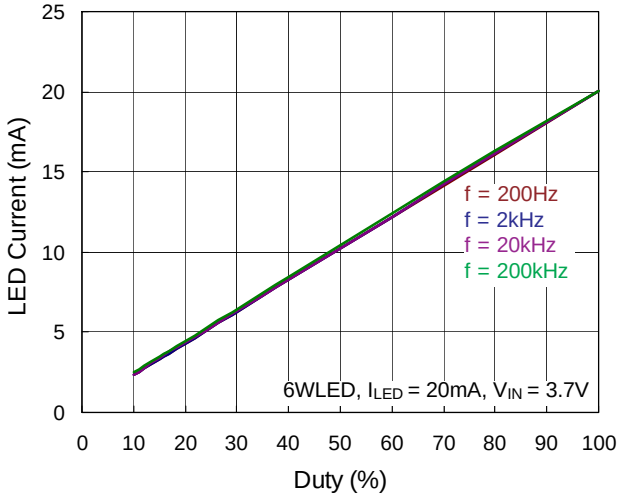
Reference Voltage vs. Output Current



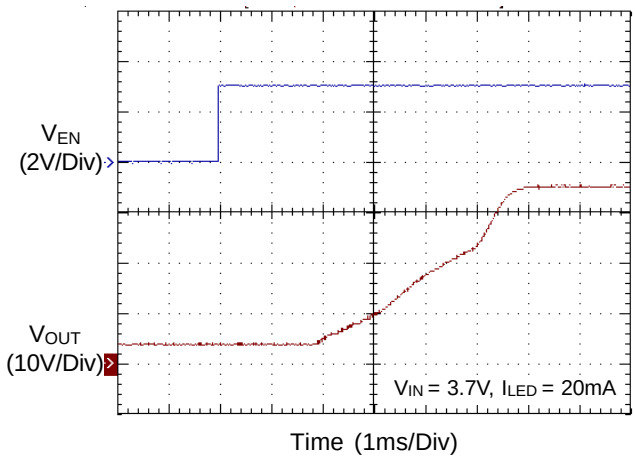
Enable Threshold vs. Input Voltage



LED Current vs. Duty

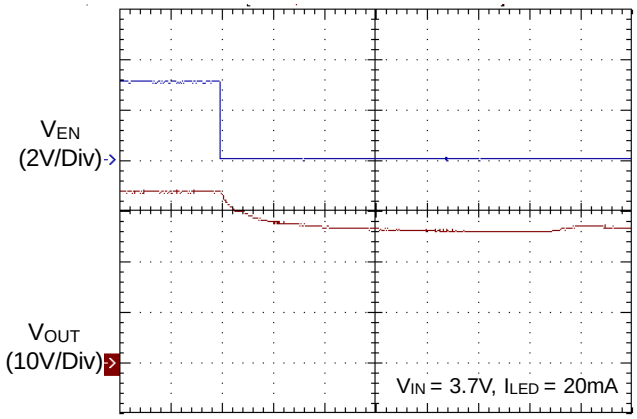


Power On from EN

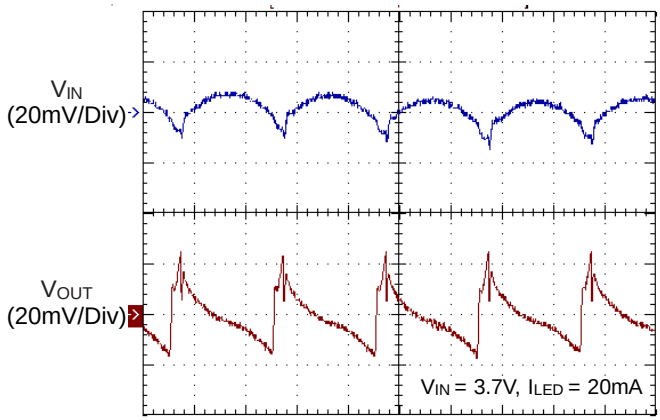


Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

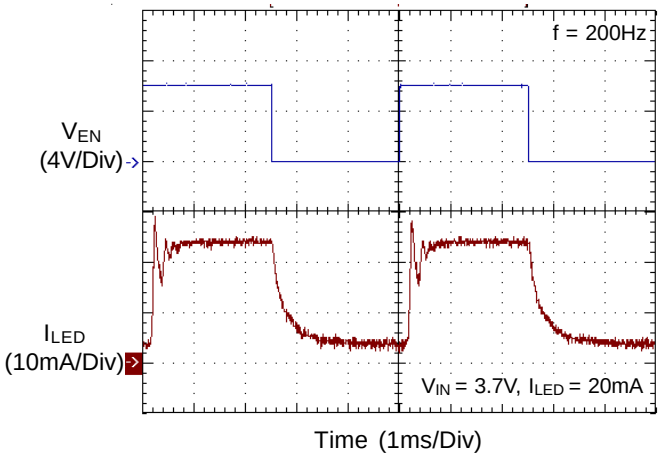
Power Off from EN



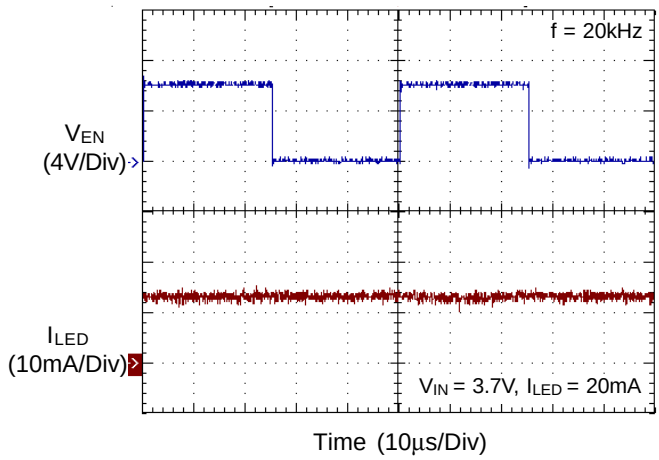
Ripple Voltage



PWM Dimming from EN



PWM Dimming from EN



Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Applications Information

LED Current Setting

The loop of Boost structure will keep the FB pin voltage equal to the reference voltage V_{REF}. Therefore, when R_{SET} connects the FB pin and GND, the current flows from V_{OUT} through LED and R_{SET} to GND will be decided by the current on R_{SET}, which is equal to following equation :

$$I_{LED} = \frac{V_{REF}}{R_{SET}}$$

Dimming Control

a. Using a PWM Signal to EN Pin

For the brightness dimming control of the RT4526, the IC provides typically 300mV feedback voltage when the EN pin is pulled constantly high. However, the EN pin allows a PWM signal to reduce this regulation voltage by changing the PWM duty cycle to achieve LED brightness dimming control. The relationship between the duty cycle and FB voltage can be calculated as the following equation :

V_{FB} = Duty x 300mV

Where

Duty = duty cycle of the PWM signal

300mV = internal reference voltage

As shown in Figure 1, the duty cycle of the PWM signal is used to cut the internal 300mV reference voltage. An internal low pass filter is used to filter the pulse signal, and then the reference voltage can be made by connecting the output of the filter to the error amplifier for the FB pin voltage regulation.

However, the internal low pass filter 3db frequency is 500Hz. When the dimming frequency is lower than 500Hz, V_A is also a PWM signal and the LED current is controlled directly by this signal. When the frequency is higher than 500Hz, PWM is filtered by the internal low pass filter and the V_A approaches a DC signal. The LED current is a DC current which eliminates the audio noise. Two figures of PWM Dimming from EN are shown in Typical Operating Characteristics section and the PWM dimming frequency is 200Hz and 20kHz, respectively.

For the RT4526, the minimum duty vs. frequency is listed in following table.

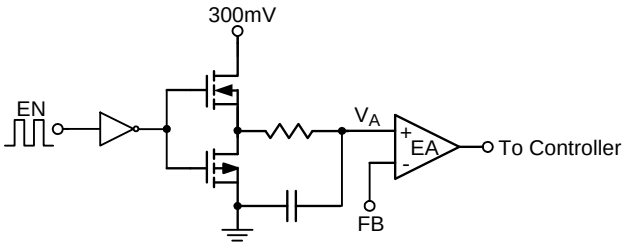


Figure 1. Block Diagram of Programmable FB Voltage Using PWM Signal

	PWM Minimum Duty
Dimming frequency < 500Hz	4%
Dimming frequency > 500Hz	10%

b. Using a DC Voltage

Using a variable DC voltage to adjust the brightness is a popular method in some applications. The dimming control using a DC voltage circuit which is shown in Figure 2. As the DC voltage increases, the current flows through R3 increasingly and the voltage drop on R3 increases, i.e. the LED current decreases. For example, if the VDC range is from 0V to 2.8V and assume the RT4526 is selected which V_{REF} is equal to 0.3V, the selection of resistors in Figure 2 sets the LED current from 21mA to 0mA. The LED current can be calculated by the following equation.

$$I_{LED} = \frac{V_{REF} - \frac{R3 \times (V_{DC} - V_{REF})}{R4}}{R_{SET}}$$

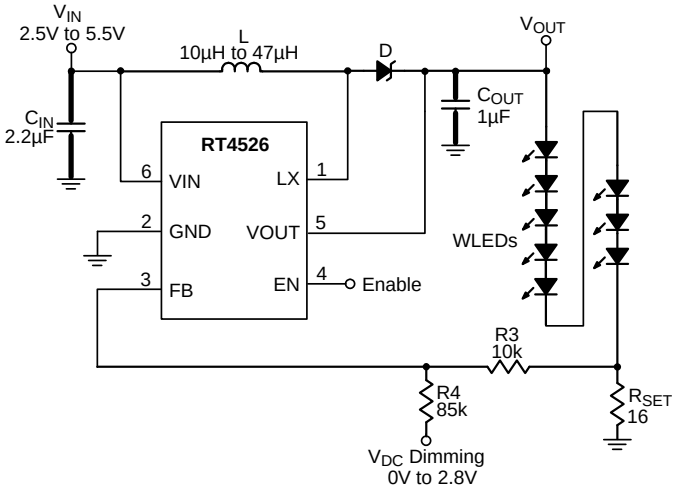


Figure 2. Dimming Control Using a DC Voltage

Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

c. Using a Filtered PWM signal

Another common application is using a filtered PWM signal as an adjustable DC voltage for LED dimming control. A filtered PWM signal acts as the DC voltage to regulate the output current. The recommended application circuit is shown as Figure 3. In this circuit, the output ripple depends on the frequency of PWM signal. For smaller output voltage ripple (<100mV), the recommended frequency of 2.8V PWM signal should be above 2kHz. To fix the frequency of PWM signal and change the duty cycle of PWM signal can get different output current. The LED current can be calculated by the following equation :

$$I_{LED} = \frac{V_{REF} - \frac{R3 \times (V_{PWM} \times Duty - V_{REF})}{R4 + R_{DC}}}{R_{SET}}$$

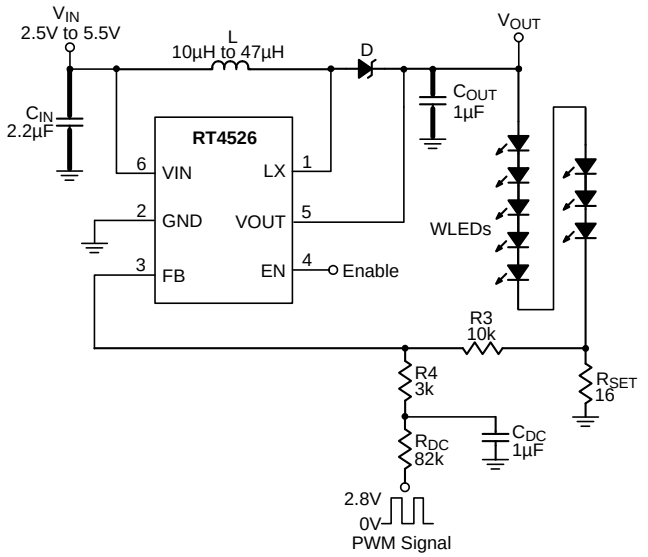


Figure 3. Dimming Control Using a Filtered PWM Signal

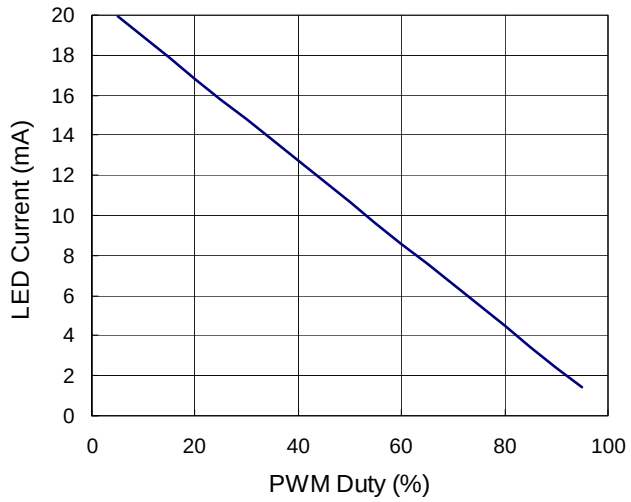


Figure 4. PWM Duty Cycle vs. LED Current

By the above equation and the application circuit shown in Figure 3, and assume the RT4526 is selected which V_{REF} is equal to 0.3V. Figure 4 shows the relationship between the LED current and PWM duty cycle. For example, when the PWM duty is equal to 60%, the LED current will be equal to 8.6mA. When the PWM duty is equal to 40%, the LED current will be equal to 12.7mA.

Constant Output Voltage Control

The output voltage of the R4526 can be adjusted by the divider circuit on the FB pin. Figure 5 shows the application circuit for the constant output voltage. The output voltage can be calculated by the following equations :

$$V_{OUT} = V_{REF} \times \frac{R1+R2}{R2} \; ; \; R2 > 10k$$

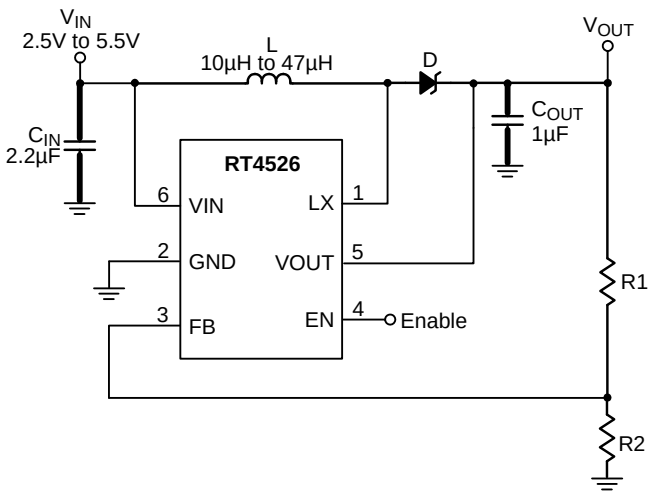


Figure 5. Constant Output Voltage Application

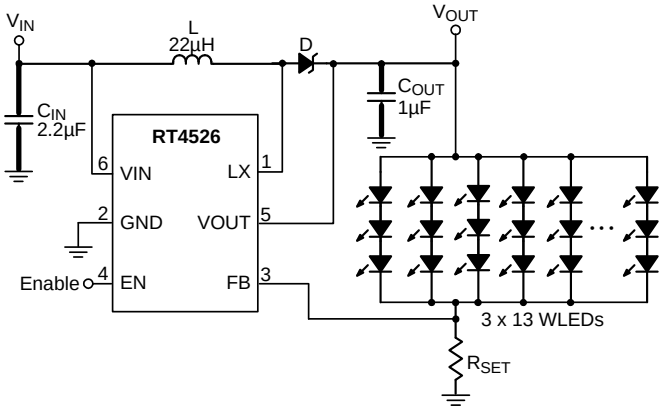


Figure 6. Application for Driving 3 X 13 WLEDs

Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Application for Driving 3 x 13 WLEDs

The RT4526 can drive different WLEDs topology. For example, the Figure 6 shows the 3x13 WLEDs and total current is equal to 260mA. The total WLEDs current can be set by the R_{SET} which is equal to the following equation.

$$I_{Total} = \frac{V_{REF}}{R_{SET}}$$

Power Sequence

In order to assure the normal soft-start function for suppressing the inrush current, the input voltage should be ready before EN pulls high.

Soft-Start

The function of soft-start is made for suppressing the inrush current to an acceptable value at the beginning of power-on. The RT4526 provides a built-in soft-start function by clamping the output voltage of error amplifier so that the duty cycle of the PWM will be increased gradually in the soft-start period.

Current Limiting

The current flows through inductor during charging period is detected by a current sensing circuit. As the value comes across the current limiting threshold, the N-MOSFET will be turned off so that the inductor will be forced to leave charging stage and enter discharging stage. Therefore, the inductor current will not increase over the current limiting threshold.

OVP/UVLO/OTP

The Over-Voltage Protection (OVP) is detected by a junction breakdown detecting circuit. Once V_{OUT} goes over the detecting voltage, the LX pin stops switching and the power N-MOSFET will be turned off. Then, the V_{OUT} will be clamped to be near V_{OVP}. As the output voltage is higher than a specified value or input voltage is lower than a specified value, the chip will enter protection mode to prevent abnormal function. As the die temperature is higher then 160°C, the chip will also enter protection mode. The power MOSFET will be turned off during protection mode to prevent abnormal operation.

Inductor Selection

The recommended value of inductor for 10 WLEDs applications is from 10μH to 47μH. Small size and better efficiency are the major concerns for portable devices, such as the RT4526 used for mobile phone. The inductor should have low core loss at 1MHz and low DCR for better efficiency. The inductor saturation current rating should be considered to cover the inductor peak current.

Capacitor Selection

A 2.2μF input ceramic capacitor and a 1μF output ceramic capacitor are recommended for the RT4526 applications for driving 10 series WLEDs. For better voltage filtering, ceramic capacitors with low ESR are recommended. X5R and X7R types are suitable because of their wider voltage and temperature ranges.

Thermal Considerations

For continuous operation, do not exceed absolute maximum operation junction temperature. The maximum power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of surroundings airflow and temperature difference between junction to ambient. The maximum power dissipation can be calculated by following formula :

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

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

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

For the recommended operating conditions specification of RT4526, the maximum junction temperature of the die is 125°C. The junction to ambient thermal resistance θ_{JA} is layout dependent. For TSOT-23-6 package, the thermal resistance, θ_{JA}, is 197.4°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 following formula :

$P_{D(MAX)}$ = (125°C – 25°C) / (197.4°C/W) = 0.5W for TSOT-23-6 package

Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curve in Figure 7 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

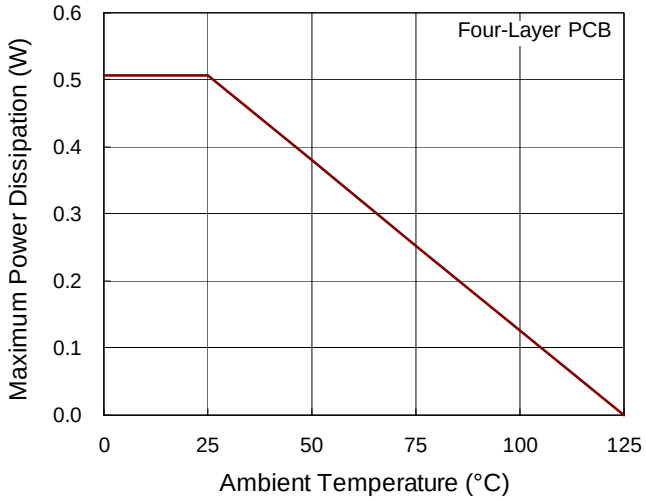


Figure 7. Derating Curve of Maximum Power Dissipation

Layout Consideration

For best performance of the RT4526, the following guidelines must be strictly followed.

- Input and Output capacitors should be placed close to the IC and connected to ground plane to reduce noise coupling.
- The GND should be connected to a strong ground plane for heat sinking and noise protection.
- Keep the main current traces as short and wide as possible .
- LX node of DC/DC converter is with high frequency voltage swing. It should be kept at a small area.
- Place the feedback components as close as possible to the IC and keep away from the noisy devices.

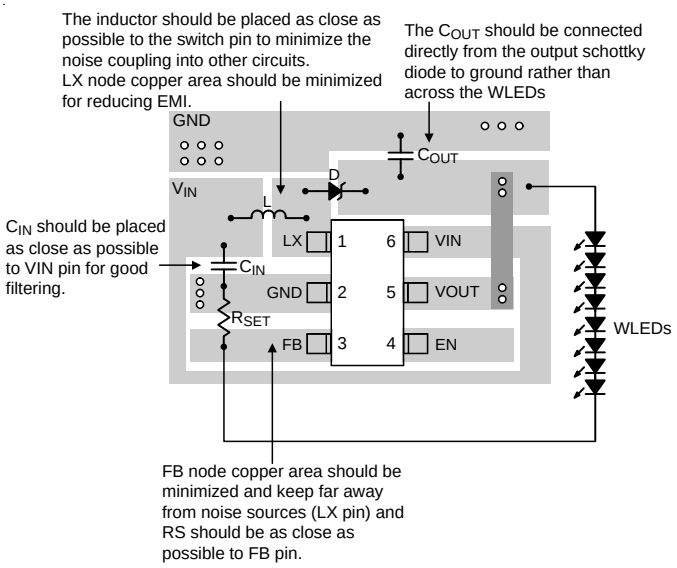


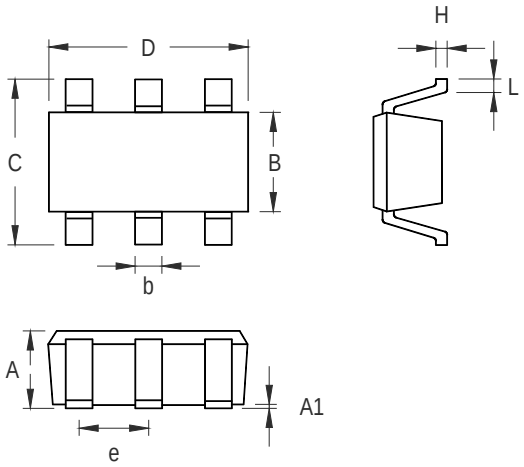
Figure 8. PCB Layout Guide

Table 1. Recommended Components for Typical Application Circuit

Reference	Qty	Part Number	Description	Manufacture
D	1	SR26	Schottky Diode	PANJIT
C_{IN}	1	EMK107BJ225MA-T	Capacitor, Ceramic, 2.2μF/16V X5R	Taiyo Yuden
C_{OUT}	1	GMK107BJ105KA	Capacitor, Ceramic, 1μF/50V X5R	Taiyo Yuden
R_{SET}	1	RC0603FR	Resistor 15Ω, 1%	YAGEO
L	1	NR4018T220M	Inductor, 22μH	Taiyo Yuden

Copyright ©2015 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

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-23-6 Surface Mount Package

Richtek Technology Corporation

14F, No. 8, Tai Yuen 1st Street, Chupei City

Hsinchu, Taiwan, R.O.C.

Tel: (8863)5526789

Richtek products are sold by description only. Richtek reserves the right to change the circuitry and/or specifications without notice at any time. Customers should obtain the latest relevant information and data sheets before placing orders and should verify that such information is current and complete. Richtek cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Richtek product. Information furnished by Richtek is believed to be accurate and reliable. However, no responsibility is assumed by Richtek or its subsidiaries for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of Richtek or its subsidiaries.