White LED Step-Up Converter in Tiny Package

General Description

The RT9271 is a step-up DC/DC converter specifically designed to drive white LEDs with a constant current. The device can drive one to three LEDs in series from a Li-Ion cell. Series connection of the LEDs provides identical LED currents resulting in uniform brightness and eliminating the need for ballast resistors. The RT9271 switches at 1.1 MHz, allowing the use of tiny external components. The input and output capacitor can be as small as 1uF, saving space and cost versus alternative solutions. A low 0.25V feedback voltage minimizes power loss in the current setting resistor for better efficiency.

The RT9271 is available in low profile SOT-23-6 package.

Ordering Information

RT9271□□

- Package Type
  - B : SOT-23-5
  - E : SOT-23-6
- Operating Temperature Range
  - P : Pb Free with Commercial Standard
  - G : Green (Halogen Free with Commercial Standard)

Note :

RichTek Pb-free and 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.
- 100% matte tin (Sn) plating.

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

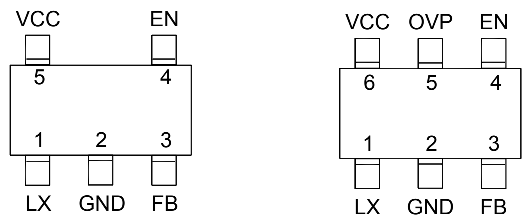
- **Inherently Matched LED Current**
- **Up to 80mA Output Current @ V_{OUT} < 12V**
- **High Efficiency : 85% Typical**
- **Drives Up to Three LEDs from 2.8V Supply**
- **20V Internal Switch**
- **Fast 1.1 MHz Switching Frequency**
- **Uses Tiny 1 mm Height Inductors**
- **Requires Only 1uF Output Capacitor**
- **Low Profile SOT-23-6 Package**
- **Optional 15V Over Voltage Protection**
- **RoHS Compliant and 100% Lead (Pb)-Free**

Applications

- Mobile Phone
- Digital Still Camera
- PDAs, Handheld Computers
- MP3 Players
- GPS Receivers

Pin Configurations

(TOP VIEW)



SOT-23-5 SOT-23-6

Note : There is no pin1 indicator on top mark for SOT-23-6 type, and pin1 will be lower left pin when reading top mark from left to right.

Typical Application Circuit

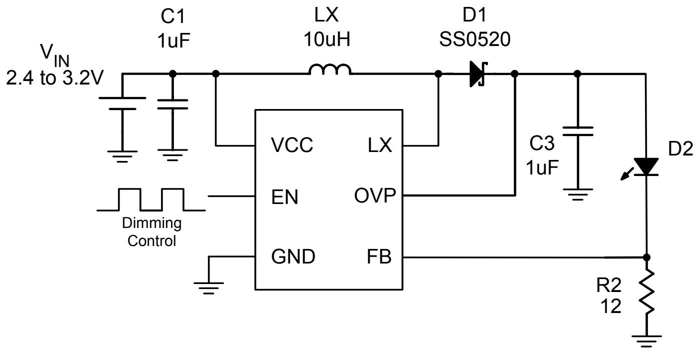


Figure 1. RT9271 Drivers 1 WLED Application Circuit

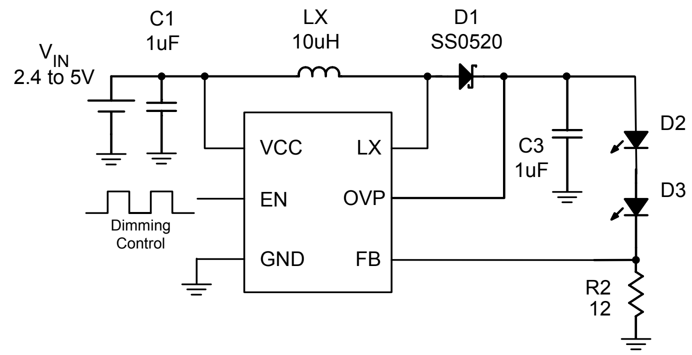


Figure 2. RT9271 Drivers 2 Series WLEDs Application Circuit

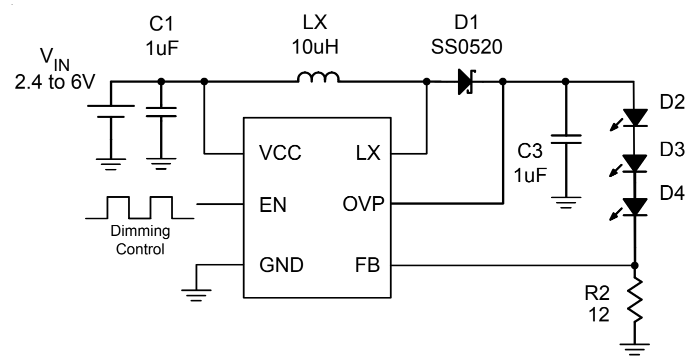


Figure 3. RT9271 Drivers 3 Series WLEDs Application Circuit

Note : 1. D1 is Schottky diode (SS0520).
2. D2 ~ D4 are the WLED (HT-S91CW-DT) of HARVATEK.
3. LX is the SH4018 series of ABC TAIWAN ELECTRONICS CORP.

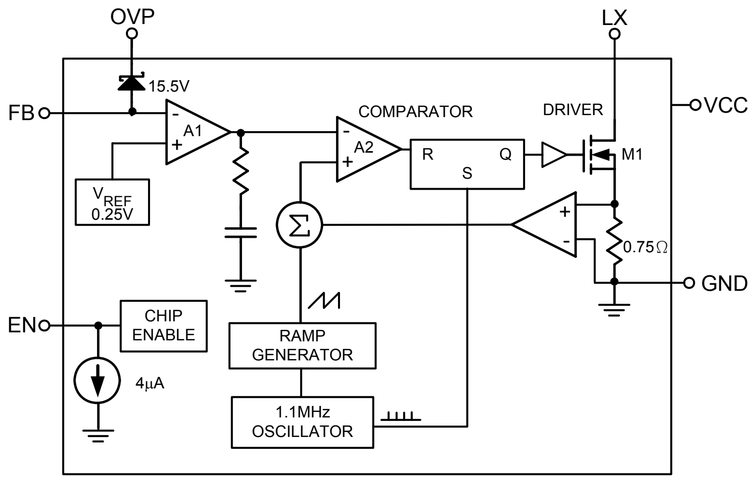
Recommended Circuits for Driving LEDs

Figure 1 to Figure 3 illustrates the recommended application circuits for driving white LEDs. The series connected LEDs are driven with identical current to emit uniform luminescence, and the 250mV low reference voltage can minimize the efficiency loss across the current-sensing resistor. The recommended current setting for driving white LEDs is 10mA to 20mA, and the dimming control can be implemented by toggling EN pin with 60Hz to 1kHz PWM clock. Please refer to application notes for guidance of component selection and board layout.

Functional Pin Description

Pin No. –XB	Pin No. –XE	Pin Name	Pin Function
1	1	LX	Switch Pin. Connect inductor/diode here. Minimize trace area at this pin to reduce EMI.
2	2	GND	Ground Pin. Connect directly to local ground plane.
3	3	FB	Feedback Pin. Reference voltage is 0.25V. Connect cathode of lowest LED and resistor here. Calculate resistor value according to the formula: $R_{FB} = 0.25/I_{LED}$
4	4	EN	Chip Enable Pin. Connect to 1.4V or higher to enable device, 0.4V or less to disable device.
–	5	OVP	Over Voltage Protection Pin. Voltage sensing input to trigger the function of over voltage protection, the trip point is 15.5V. Leave it unconnected to disable this function.
5	6	VCC	Input Voltage Pin. Must be locally bypass with 1uF capacitor to GND.

Function Block Diagram



Operation

The RT9271 is a constant frequency step-up converter with an internal switch. For excellent line and load regulation, the current mode control is adopted. The operations of RT9271 can be understood from block diagram clearly. The oscillator triggers the SET input of SR latch to turn on the power switch M1 at the start of each cycle. A current sense voltage sum with a stabilizing ramp is connected to the positive terminal of the PWM comparator A2. When this voltage exceeds the output voltage of the error amplifier A1, the SR latch is reset to turn off the power switch till next cycle starts. The output voltage of the error amplifier A1 is amplified from the difference between the reference voltage 0.25V and the feedback voltage. In this manner, if the error amplifiers voltage increases, more current is delivered to the output; if it decreases, less current is delivered. A 15.5V Zener diode connects from OVP pin to FB pin internally to provide an optional protection function which prevents LX pin from over-voltage damage. Especially when the case of the feedback loop broken due to component wear-out or improper connection occurs. The behavior of OVP is to clamp the output voltage to 15.5V typically. This function is suitable for the applications while driving white LEDs less than 4 in series.

Absolute Maximum Ratings (Note 1)

- Supply Voltage, V_{CC} ---------- –0.3V to 7V
- LX, OVP ---------- –0.3V to 21V
- The Other Pins ---------- –0.3V to 7V
- Power Dissipation, P_D @ T_A = 25°C
  SOT-23-6 ---------- 0.4W
- Package Thermal Resistance (Note 4)
  SOT-23-6, θ_{JA} ---------- 250°C/W
- Maximum Junction Temperature ---------- 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 Voltage, V_{CC} ---------- 2.4V to 6V
- Junction Temperature Range ---------- –40°C to 125°C

Electrical Characteristics

(V_{CC} = 3.6V, T_A = 25°C, unless otherwise specified.)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
System Supply Input						
Under Voltage Lock Out	UVLO		1.8	2.2	2.3	V
Maximum Output Voltage			--	--	20	V
Supply Current	I_{CC1}	V_{CC}=6V, Continuously Switching	--	--	2	mA
Quiescent Current	I_{CC2}	V_{CC}=6V, FB=1.3V, No Switching	50	90	120	μA
Shut Down Current	I_{CC3}	V_{CC}=6V, V_{EN}<0.4V	--	0.1	1	μA
Oscillator						
Operation Frequency	F_{OSC}		0.9	1.1	1.3	MHz
Maximum Duty Cycle	Dmax		85	90	--	%
Reference Voltage						
Feedback Voltage	V_{FB}		0.237	0.25	0.263	V
MOSFET						
On Resistance of MOSFET	Rds(on)		0.5	0.75	1.0	Ω
Current Limit	I_{max1}	Normal Operation	800	900	1000	mA
Current Limit	I_{max2}	Start up Condition	500	625	750	mA
Control and Protection						
Shut Down Voltage	V_{EN1}		0.4	0.8	--	V
Enable Voltage	V_{EN2}		--	0.8	1.4	V
EN Pin Pull Low Current	I_{EN}		--	4	6	μA
OVP Threshold (Note 5)	OVP		14.5	15.5	20.0	V

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.

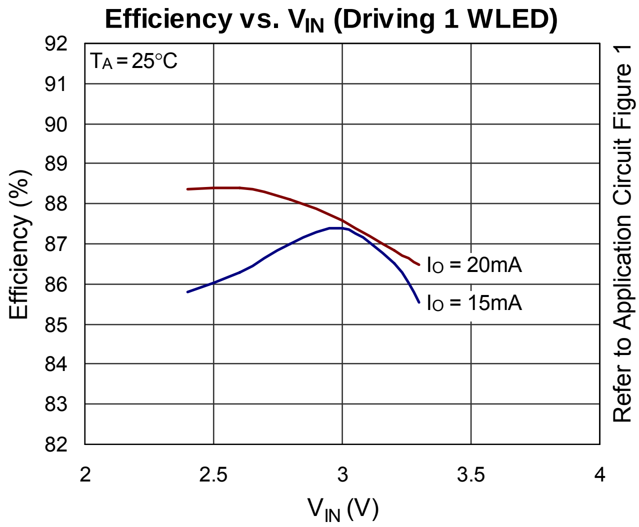
Note 2. Devices are ESD sensitive. Handling precaution recommended.

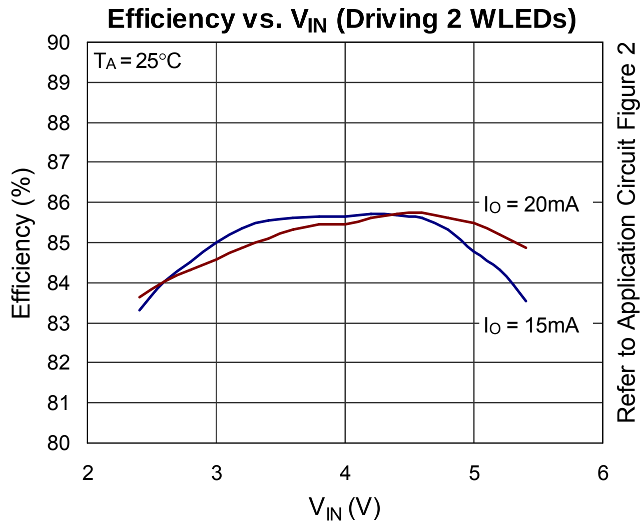
Note 3. The device is not guaranteed to function outside its operating conditions.

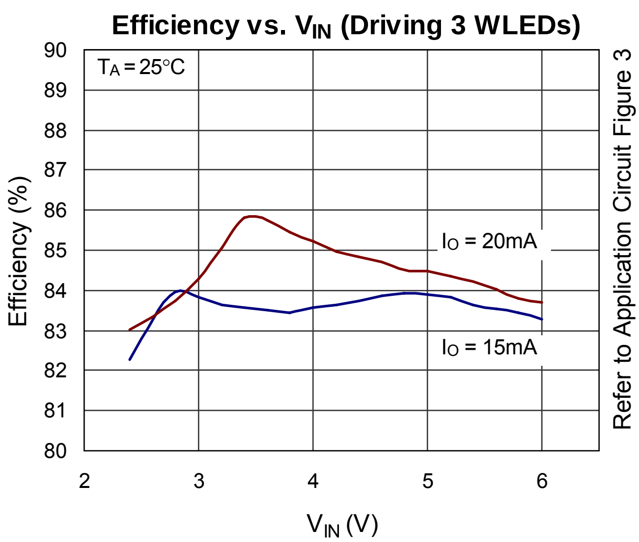
Note 4. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

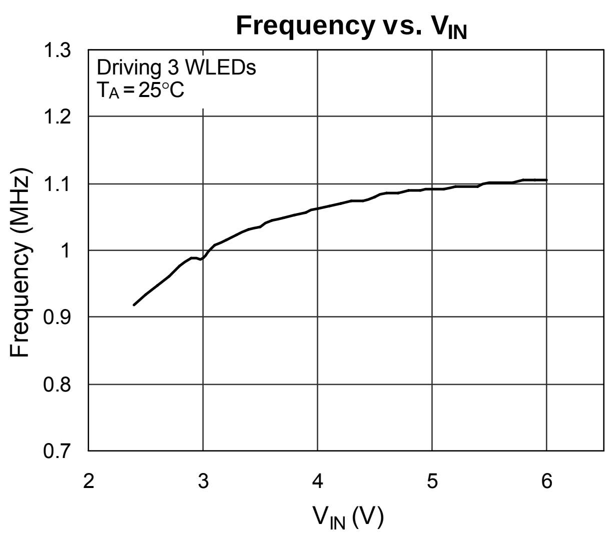
Note 5. Floating the OVP pin to disable OVP function.

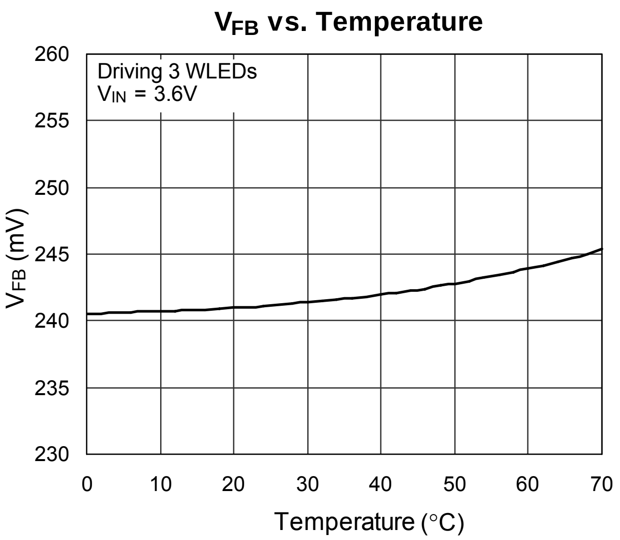
Typical Operating Characteristics

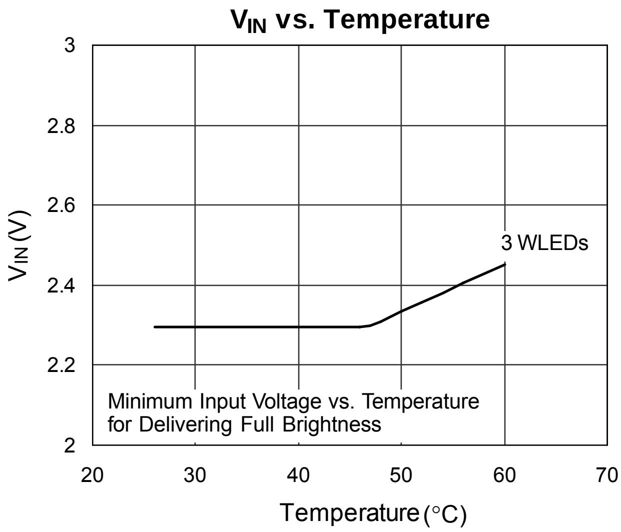




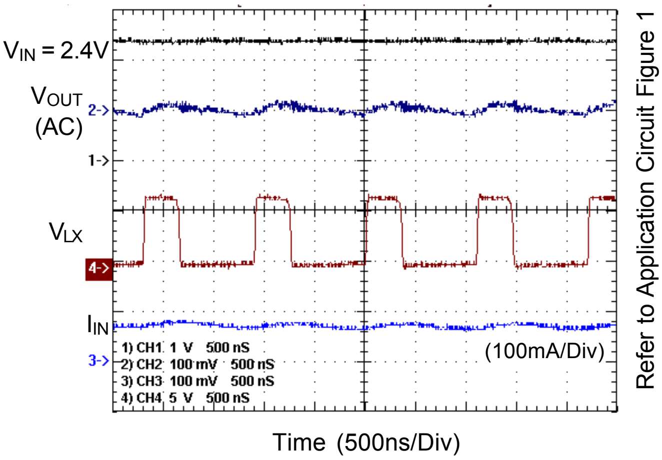




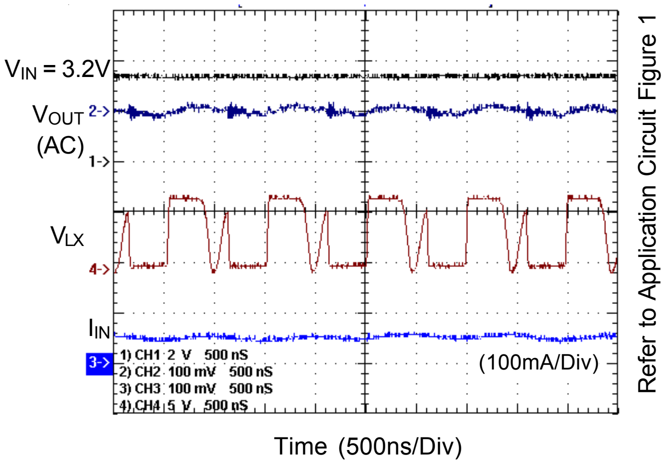




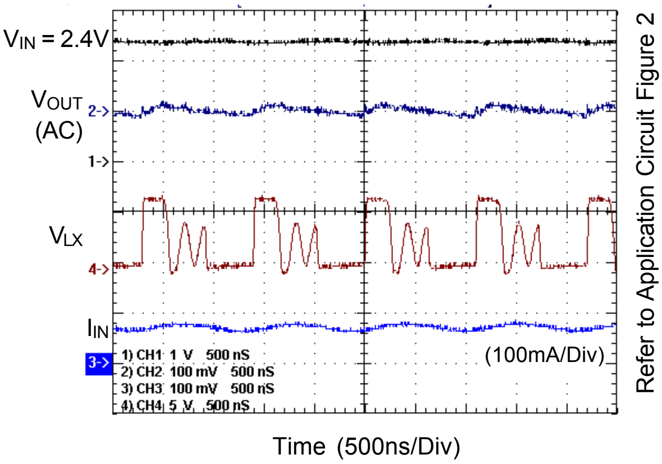
Stability for Driving 1 WLED



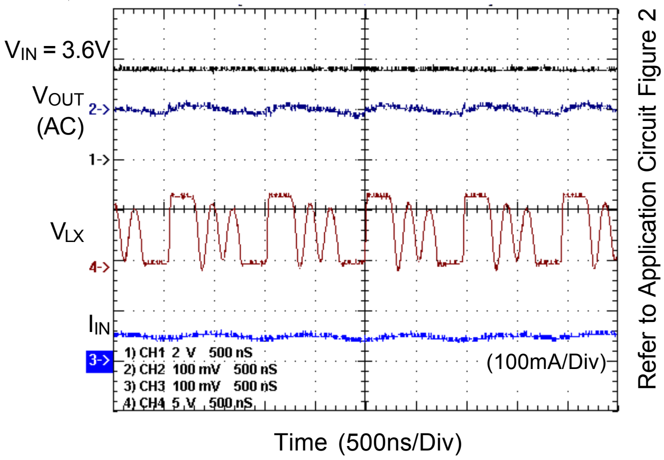
Stability for Driving 1 WLED



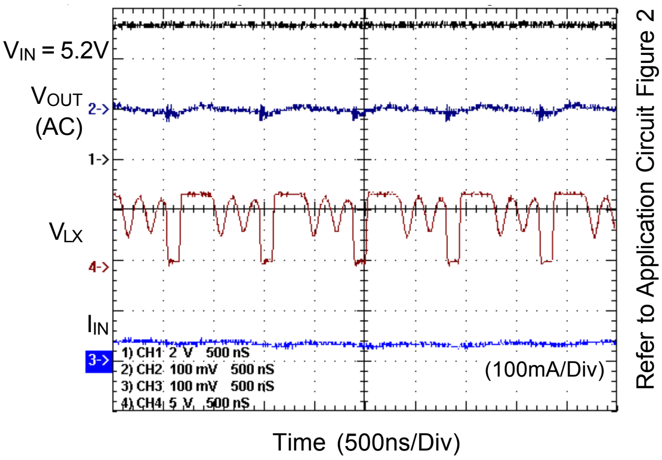
Stability for Driving 2 WLEDs



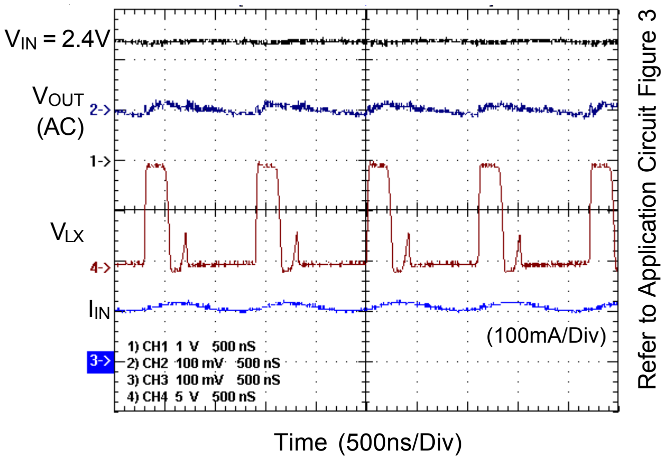
Stability for Driving 2 WLEDs



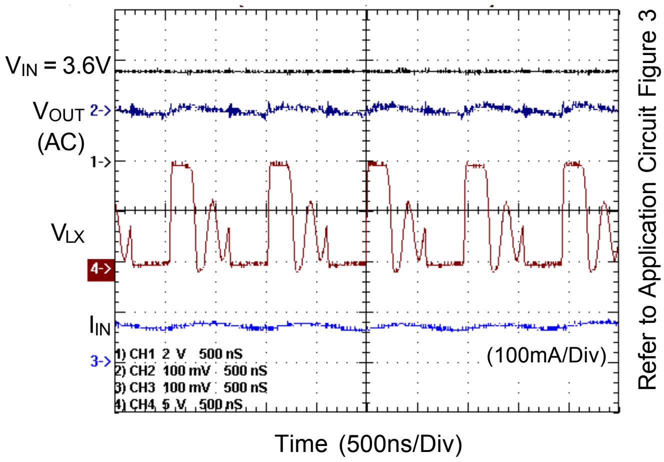
Stability for Driving 2 WLEDs



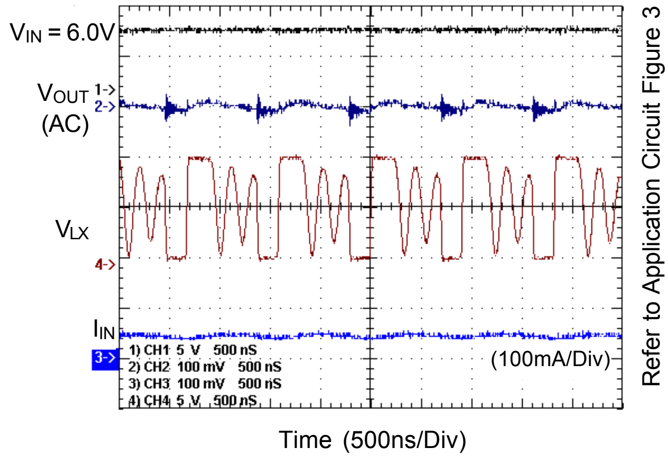
Stability for Driving 3 WLEDs



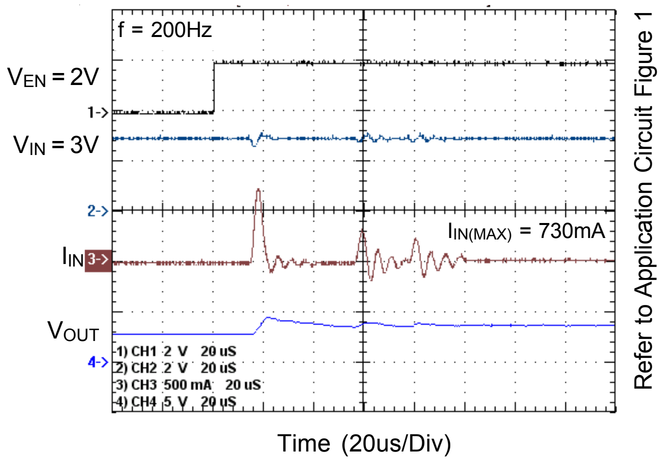
Stability for Driving 3 WLEDs



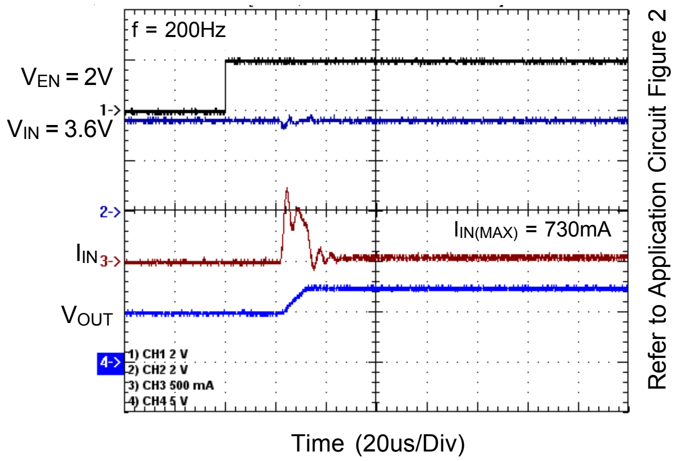
Stability for Driving 3 WLEDs



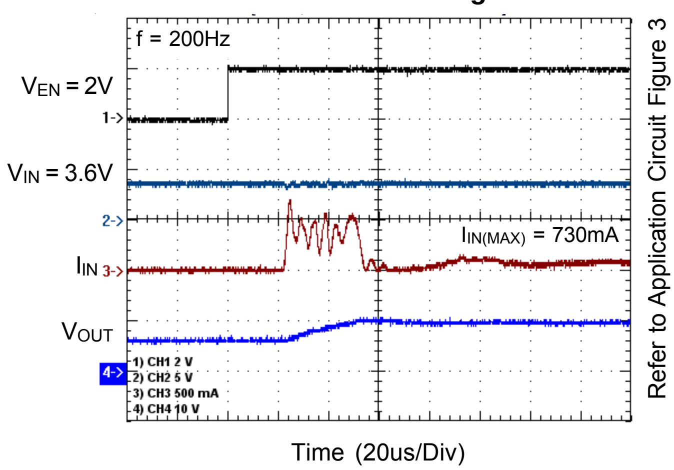
Inrush Current for Driving 1 WLED



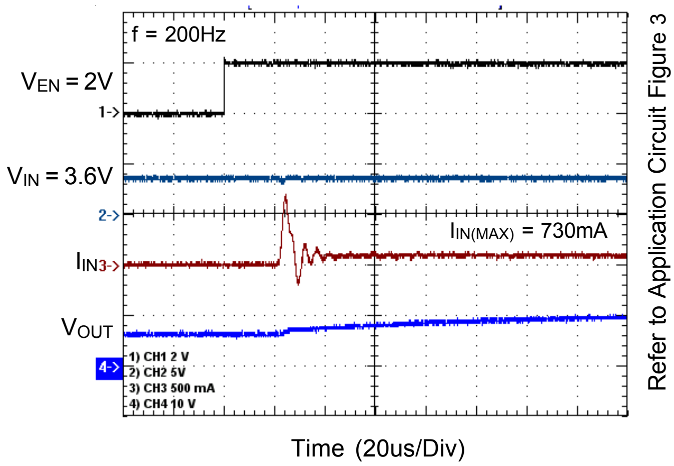
Inrush Current for Driving 2 WLEDs



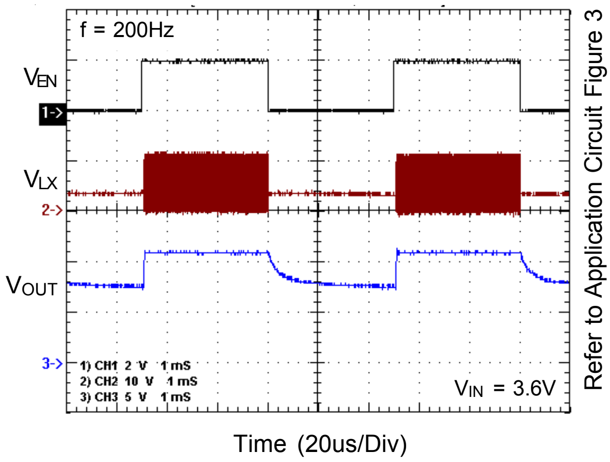
Inrush Current for Driving 3 WLEDs



Inrush Current for Driving 3 WLEDs with soft-start



Dimming Control for Driving 3



Application Information

LED Current Control

The RT9271 regulates the LED current by setting the current sense resistor (R2) connecting to feedback and ground. The internal feedback reference voltage is 0.25V. The LED current can be set from following equation easily.

$$R2 = 0.25V / I_{LED}$$

In order to have an accurate LED current, precision resistors are preferred (1% is recommended). The table for R2 selection is shown below.

R2 Resistor Value Selection

I_{LED} (mA)	R2 (Ω)
5	49.9
10	24.9
12	21
15	16.5
20	12.4

Recommended Inductance and Rectifier (for Li-Ion cell)

Condition	Inductance (H)	Schottky Diode
2 WLEDs	4.7u~10u	SS0520
3 WLEDs	4.7u~10u	SS0520

Dimming Control

a. Using a PWM Signal to EN Pin

For controlling the LED brightness, the RT9271 can perform the dimming control by applying a PWM signal to EN pin. The average LED current is proportional to the PWM signal duty cycle. The magnitude of the PWM signal should be higher than the maximum enable voltage of EN pin, in order to let the dimming control perform correctly.

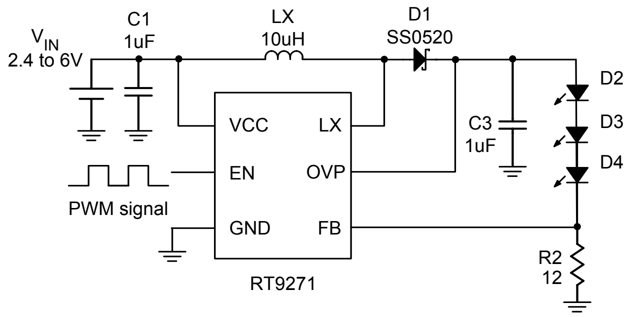


Figure 4. PWM Dimming Control Using the EN Pin

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 is shown in Figure 5. According to the Superposition Theorem, as the DC voltage increases, the voltage contributed to V_{FB} increases and the voltage drop on R2 decreases, i.e. the LED current decreases. For example, if the V_{DC} range is from 0V to 2.8V, the selection of resistors in Figure 5 sets dimming control of LED current from 20mA to 0mA.

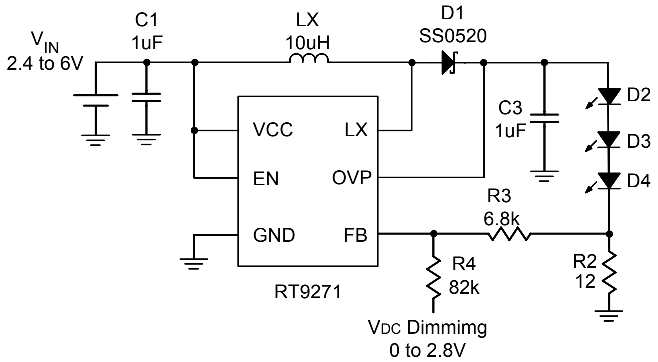


Figure 5. Dimming Control Using a DC Voltage

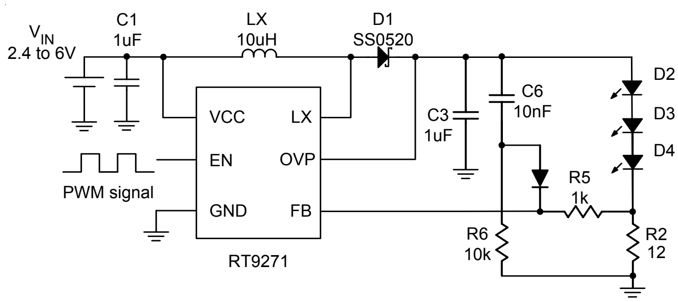


Figure 6. Recommended Soft-Start Circuit

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 in the Figure 7. 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 as Figure 8. According to the application circuit of Figure 7, output current is from 20.5mA to 5.5mA by adjusting the PWM duty cycle from 10% to 90%.

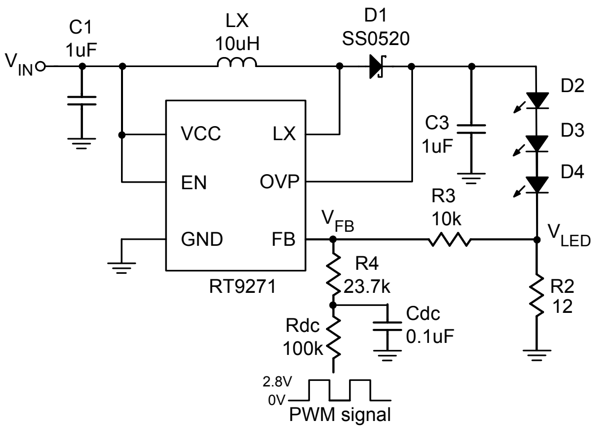


Figure 7. Filtered PWM Signal for LED Dimming Control

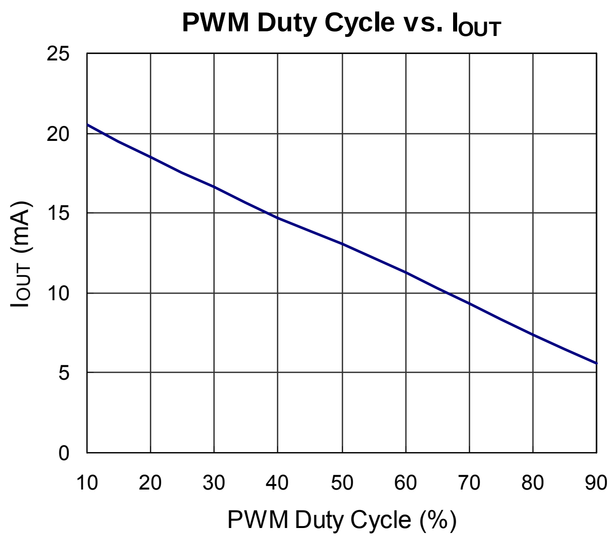


Figure 8

Constant Output Voltage for Backlight of Main Panel and Flashlight:

Figure 9 is an application of RT9271 for backlight of main panel and flashlight. Setting the divider-resistors (R1 & R2) is to get a constant output voltage that depends on the forward voltage and the numbers of series-LEDs. There are three kinds of mode controlled by the switches - backlight mode /flashlight mode /backlight + flashlight mode. It can turn on backlight or flashlight at one time or both at the same time. Applying different duty cycle of PWM signal above 22kHz to backlight's switch can also control the brightness. The following formula (1)(2) can determine R3 and R4.

$$R3 = \frac{V_{OUT} - 3VFb - V_{DS}}{Ib} \quad (1)$$

$$R4 = \frac{V_{OUT} - 3VFf - V_{DS}}{If} \quad (2)$$

$$V_{DS} = Ib \times R_{DS(ON)} \quad (3)$$

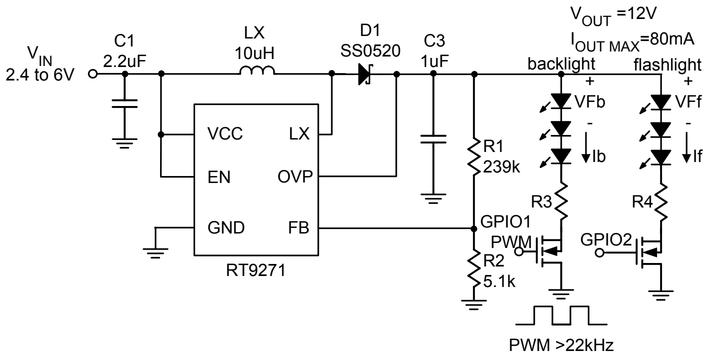


Figure 9. Constant output voltage for backlight and flashlight

Constant output voltage for backlight of main panel and keypad:

Figure 10 is another application of RT9271 for backlight and keypad. Setting the divider-resistors (R1 & R2) is to get a constant output voltage that depends on the forward voltage and the numbers of series-LEDs. It can turn on backlight of main panel and keypad at the same time. Applying different duty cycle of PWM signal above 22kHz to the backlight's switch can also control the brightness of main panel's backlight. The keypad's backlight will keep the same brightness during the dimming control of main panel. Otherwise the brightness of keypad's s backlight can also change during the dimming control of main panel by using the application circuit as figure 5. The following formula (4)(5) can determine the resistors of Figure 10.

$$R3 = \frac{V_{OUT} - 3VFb - V_{DS}}{Ib} \quad (4)$$

$$R4 = R5 = R6 = \frac{V_{OUT} - 3VFk}{Ik} \quad (5)$$

$$V_{DS} = Ib \times R_{DS(ON)} \quad (6)$$

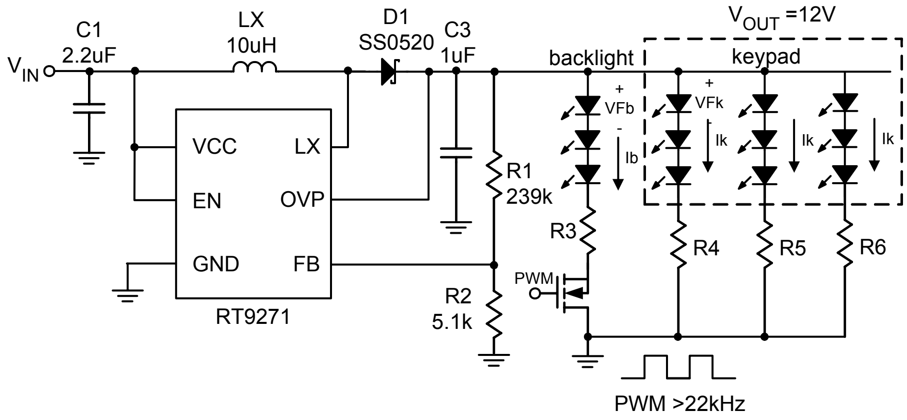


Figure 10. Constant output voltage for backlight and keypad

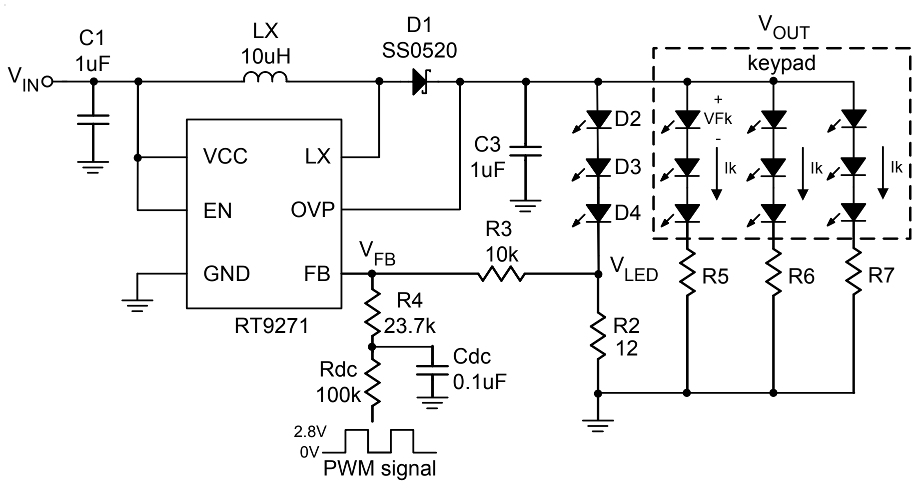
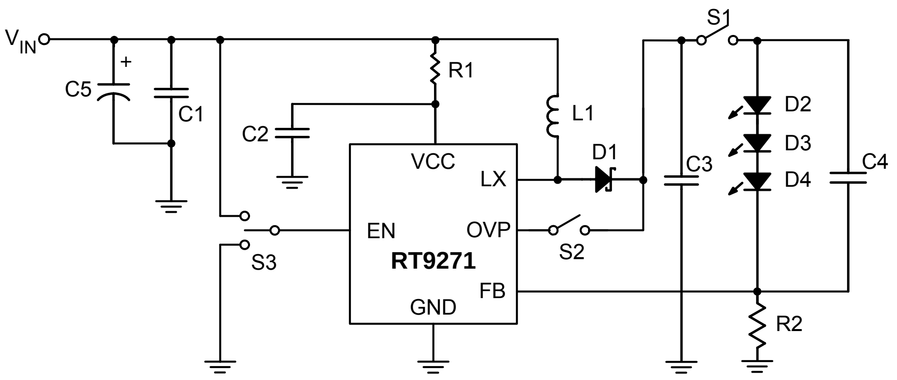


Figure 11. Constant output current for backlight and keypad

Layout Guide

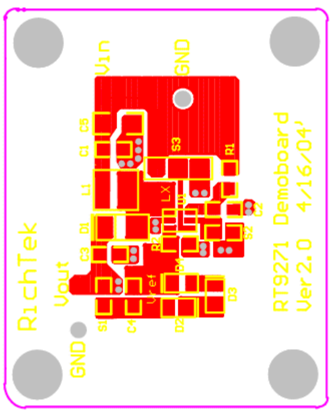
- A full GND plane without gap break.
- V_{CC} to GND noise bypass – Short and wide connection for the 1μF MLCC capacitor between Pin6 and Pin2.
- Minimized LX node copper area to reduce EMI.
- Minimized FB node copper area and keep far away from noise sources.



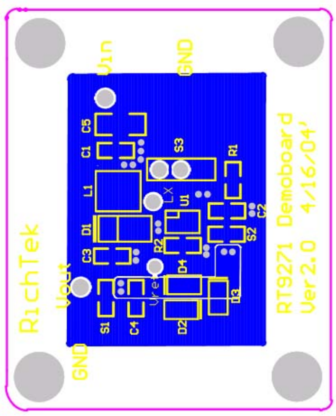
EVB Circuit

Board Layout Example (2-Layer EVB Board)

(Refer to EVB Circuit)

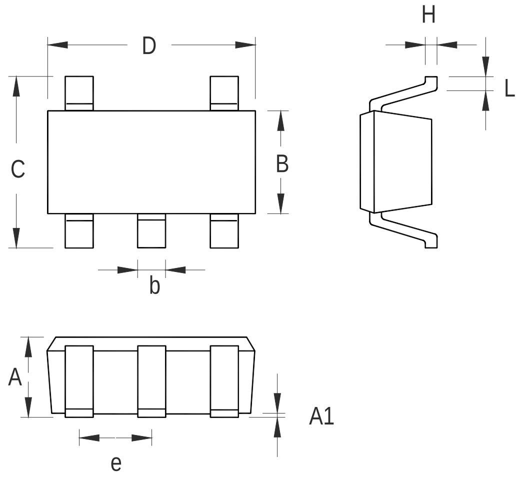


- Top Layer -



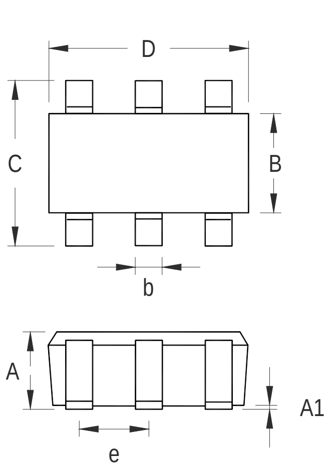
- Bottom Layer -

Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.356	0.559	0.014	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-23-5 Surface Mount Package



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

Richtek Technology Corporation
Headquarter
5F, No. 20, Taiyuen Street, Chupei City
Hsinchu, Taiwan, R.O.C.
Tel: (8863)5526789 Fax: (8863)5526611

Richtek Technology Corporation
Taipei Office (Marketing)
8F, No. 137, Lane 235, Paochiao Road, Hsintien City
Taipei County, Taiwan, R.O.C.
Tel: (8862)89191466 Fax: (8862)89191465
Email: marketing@richtek.com