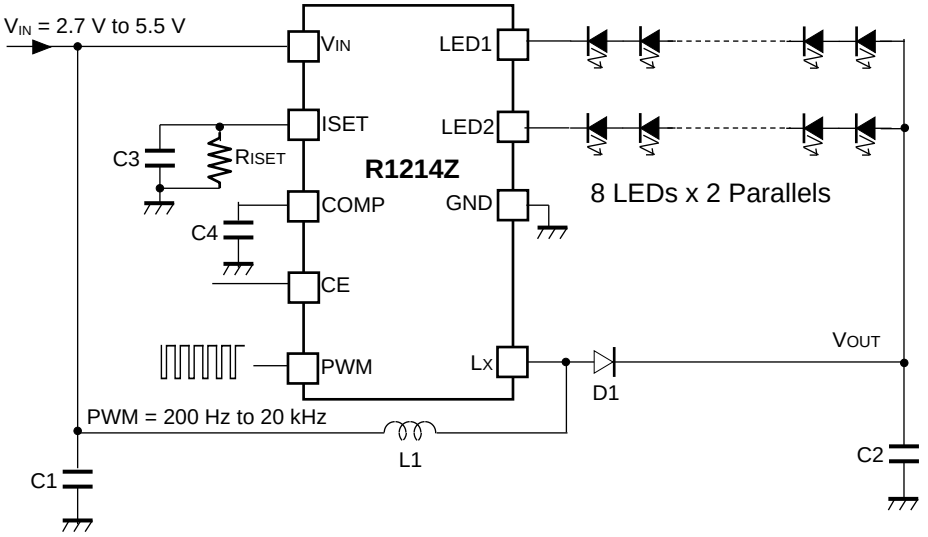
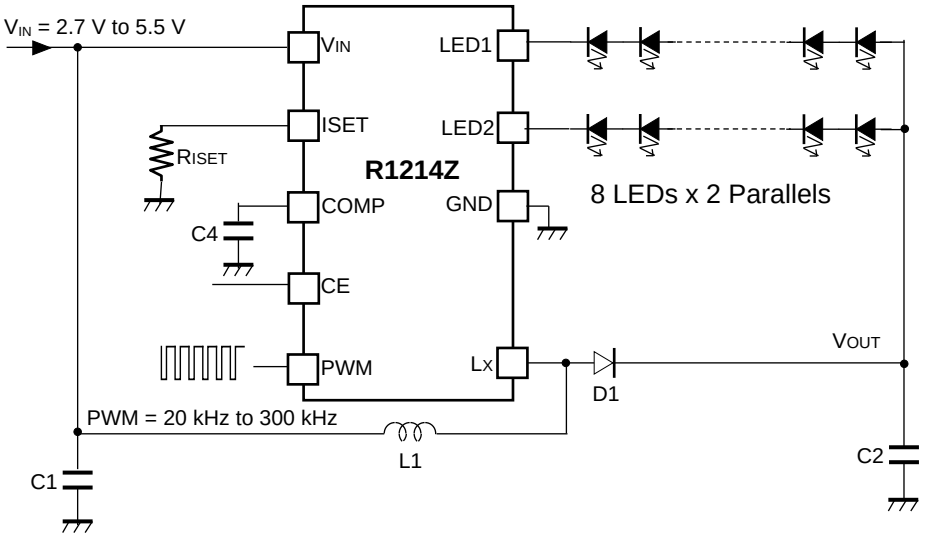
DESIGN GUIDE

NO.ED-327-151015

TYPICAL APPLICATION



Typical Application: 8 LEDs in series x 2 parallels, 200 Hz to 20 kHz PWM signal



Typical Application: 8 LEDs in series x 2 parallels, 20 kHz to 300 kHz PWM signal

RECOMMENDED COMPONENTS

Recommended Inductors

L1 (µH)	Product Name	Rated Current (mA)	Inductor Size (mm)	Components No.
10	R1214Z221x (750 kHz)	550	2.5 x 2.0 x 1.0	VLS252010ET-100M
10		620	3.0 x 2.5 x 1.2	VLF302512MT-100M
10		900	4.0 x 3.2 x 1.2	VLF403212MT-100M
10		1320	5.0 x 4.0 x 1.2	VLF504012MT-100M
22	R1214Z211x (450 kHz)	430	3.0 x 2.5 x 1.2	VLF302512MT-220M
22		540	4.0 x 3.2 x 1.2	VLF403212MT-220M
22		890	5.0 x 4.0 x 1.2	VLF504012MT-220M

Recommended Components

Symbol	Description	Rated Voltage (V)	Value	Components No.
C1 (C_{IN})	Ceramic Capacitor	6.3	4.7 µF or more	C1608JB0J475K
C2 (C_{OUT})	Ceramic Capacitor	50	2.2 µF or more R1214Z211x	C2012X5R1H225K
			1.0 µF or more R1214Z221x	C2012X5R1H105K
C3	Ceramic Capacitor	6.3	2.2 µF or more	-
C4	Ceramic Capacitor	6.3	0.1 µF to 1µF	-
D1	Diode	60	-	CRS12
		60	-	RB060M-60

BOARD LAYOUT CONSIDERATIONS

The performance of a power source circuit using this device is highly dependent on a peripheral circuit. A peripheral component or the device mounted on PCB should not exceed a rated voltage, a rated current or a rated power. When designing a peripheral circuit, please be fully aware of the following points.

Soft-Start

During start-up, soft-start increases the output voltage (V_{OUT}) by forcibly switching the L_X pin and gradually increasing the L_X current limit (I_{LXLIM}). If the preset LED current is 1.5 mA or more, soft-start gradually increases the LED current (I_{LED}) until it reaches the preset LED current. If the preset LED current is less than 1.5 mA, soft-start increases I_{LED} until it reaches 1.5 mA, then reduces it to the preset LED current. To minimize the overshoot of I_{LED}, a 1-µF capacitor (C4) can be used.

White LED Current Setting

The LED current for each LED string when a PWM signal applied to the PWM pin is Duty = 100% (I_{LEDSET}) can be determined by the value of feedback resistor (R_{ISET}). I_{LEDSET} can be calculated as follows:

$$I_{LEDSET} = 0.0466 \times R_{ISET} / (40\ k + R_{ISET})$$

Note: R_{ISET} should be set to 19 kΩ or more. If R_{ISET} with 30.1 kΩ is placed between the ISET and GND pins, I_{LEDSET} will be set to 20 mA.

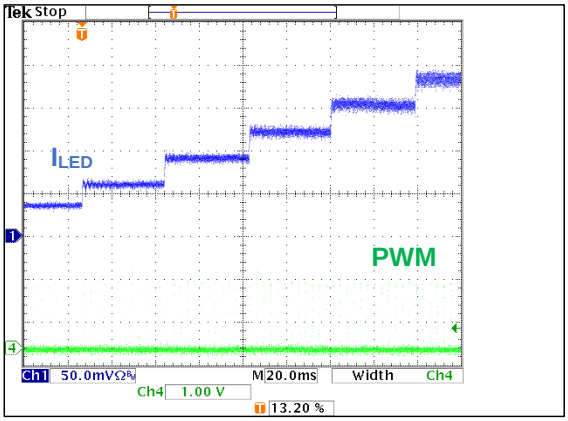
LED Dimming Control

The brightness of the LEDs can be adjusted by applying a PWM signal to the PWM pin. The LED current (I_{LED}) can be controlled by the duty of a PWM signal for the PWM pin. The duty range of a PWM signal can be set in a range of 0.4% to 100% when using a 1-µF capacitor (C4) and a 30.1-kΩ feedback resistor (R_{ISET}). The relation between the high-duty of the PWM pin (Hduty) and I_{LED} can be calculated as follows:

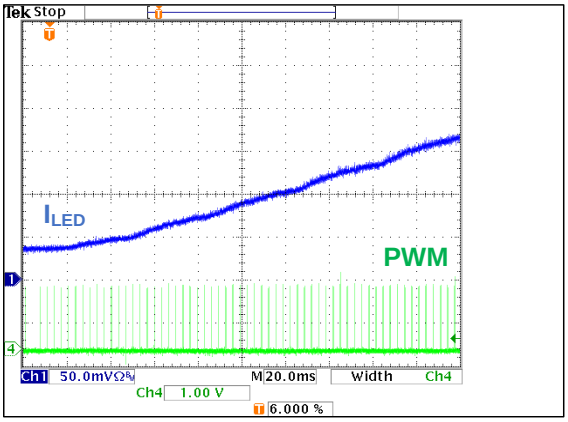
$$I_{LED} = Hduty \times I_{LEDSET}$$

The frequency of a PWM signal for dimming the LEDs can be set within the range of 200 Hz to 300 kHz; however, it is recommended that a 20-kHz to 100-kHz frequency be used. In the case of using a less than 20-kHz PWM signal, an increase or decrease in an inductor current (IL) may generate noise in the audible band. To avoid this, connect a 2.2-µF or more capacitor (C3) between the ISET pin and GND pin. In the case of using a 20-kHz or more PWM signal, C3 is not required. Note that if a PWM signal is changed stepwise, a change in the LED luminance level can be visible as shown in Figure 3. To reduce the visible change in the LED luminance level, C3 can also be used.

Figure 3. Reducing the visible change in LED luminance level by using C3



C3 = 0 µF



C3 = 2.2 µF

Unused LED Current Source

Unused LED pin should be connected to GND.

Selection of Inductor

The peak current of the inductor (ILmax) under steady operation can be calculated as follows:

$$ILmax = 1.25 \times I_{LED} \times V_{OUT} / V_{IN} + 0.5 \times V_{IN} \times (V_{OUT} - V_{IN}) / (L \times V_{OUT} \times fosc)$$

When starting up the device or adjusting the brightness of LED lights using the PWM pin, a large transient current may flow into an inductor (L1). ILmax should be equal or smaller than the Lx current limit (I_{LXLIM}) of the device. It is recommended that a 10 µH to 22 µH inductor be used.

Selection of Capacitor

Set a 4.7 µF or more input capacitor (C1) between the V_{IN} and GND pins as close as possible to the pins.
Set a 2.2 µF or more output capacitor (C2) between the V_{OUT} and GND pins for R1214Zx1xx.
Set a 1 µF or more output capacitor (C2) between the V_{OUT} and GND pins for R1214Zx2xx.
If a PWM input signal is within the range of 200 Hz to 10 kHz, set a 2.2 µF or more capacitor (C3) between the ISET and GND pins. If a PWM input signal is within the range of 10 kHz to 300 kHz, a capacitor (C3) is not required.
Set a capacitor (C4) 0.1 µF between the COMP and GND pins.

Selection of SBD (Schottky Barrier Diode)

Choose a diode that has low forward voltage (V_F), low reverse current (I_R), and low parasitic capacitance.
SBD is an ideal type of diode for R1214Z since it has low V_F, low I_R, and low parasitic capacitance.

Current Paths on PCB

Figure 1 and Figure 2 show the current pathways of application circuits when MOSFET is turned ON or when MOSFET is turned OFF, respectively. As shown in Figure 1 and Figure 2, the currents flow in the directions of blue or green arrows. The parasitic components, such as impedance, inductance or capacitance, formed in the pathways indicated by the red arrows affect the stability of the system and become the cause of noise. Reduce the parasitic components as much as possible. The current pathways should be made by short and thick wirings.

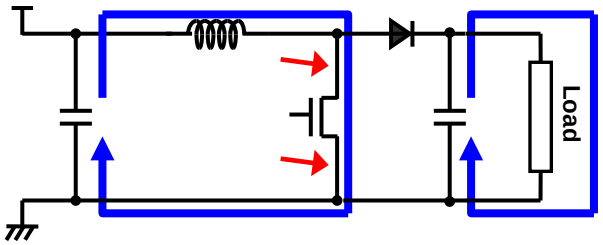


Figure 1. MOSFET-ON

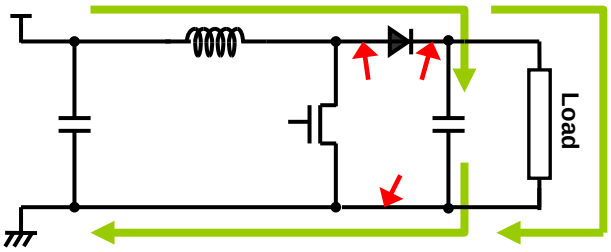
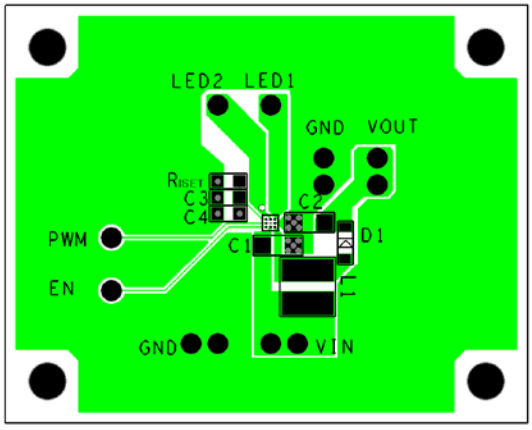
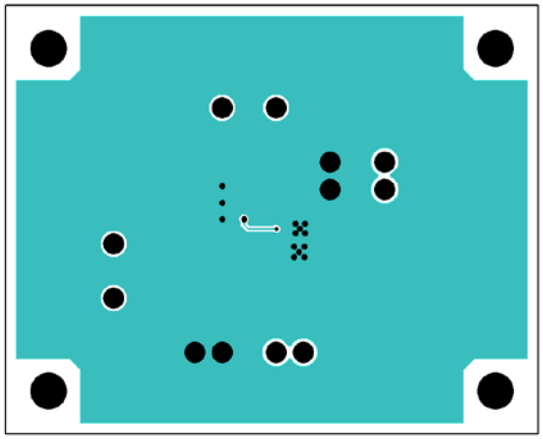


Figure 2. MOSFET-OFF

PCB Layout Recommendation

- Place an input capacitor (C1) between the V_{IN} pin and the GND pin as close as possible. Also, connect the GND pin to the wider plane.
- Make the L_X land pattern as small as possible.
- Make the wirings between the L_X pin, the inductor and the diode as short as possible. Also, connect an output capacitor (C2) as close as possible to the cathode of the diode.
- Place C2 as close as possible to the GND pin.

TYPICAL BOARD LAYOUT

Top View	Bottom View
	
WLCSP-9-P1 Typical Board Layout	

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