AND9425/D

LED Boost Driver, Dual channel, PWM, 1-Wire Dimming, using the LV52207NXB

ON Semiconductor®

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APPLICATION NOTE

Overview

The LV52207NXB is a high voltage boost driver for LED drive with 2 channels adjustable constant current sources.

Features

- Operating Voltage from 2.7V to 5.5V
- Integrated 40V MOSFET
- 1-Wire 255 level digital and PWM dimming
- Supports CABC
- 600kHz Switching Frequency
- 37.5V Over Voltage Protection (OVP) Threshold

Typical Applications

LED Display Backlight Control

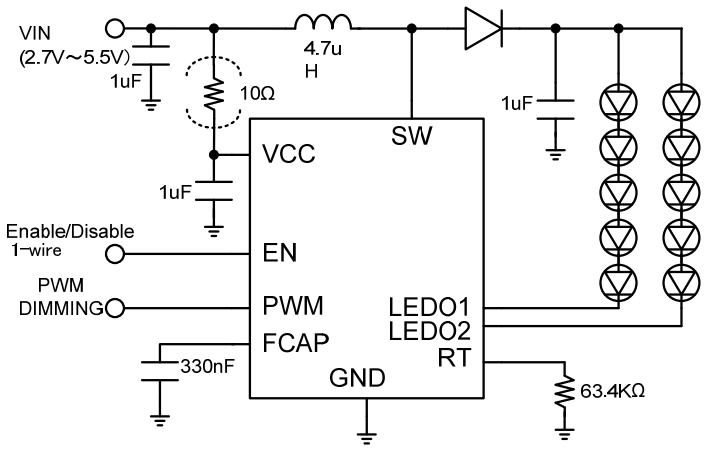
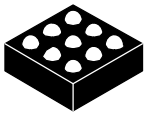


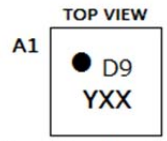
Fig1. 5x2 LED Application

PACKAGE PICTURE



WLP9J, 1.31x1.31, 0.4mm pitch
(1.31mm x 1.31mm, Amax=0.65 mm)

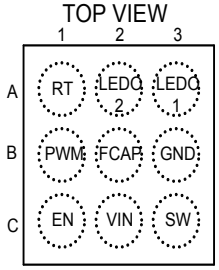
MARKING DIAGRAM



D9 = Device Code
YXX = Assembly Lot Code

OPTION:BACKSIDE COATING

PIN CONNECTION



< Overall composition >

LV52207NXB is a Boost type DC-DC convertor for White LED drive. It integrated a MOSFET which can tolerate 40V. The maximum LED current is set by resistance connected to RT terminal. Case of 63.4KΩ, it is 20mA.

We can set 256 steps of current values by using 1-wire control. (Digital mode) We can adjust dimming for LED currents by PWM signal. (PWM mode) Change of LED current do not synchronize the PWM signal. It is converted to DC current by LPF of FCAP PIN.

The switching frequency of LV52207NXB is 600kHz to improve efficiency (The switching frequency of LV52207XA is 1200kHz)

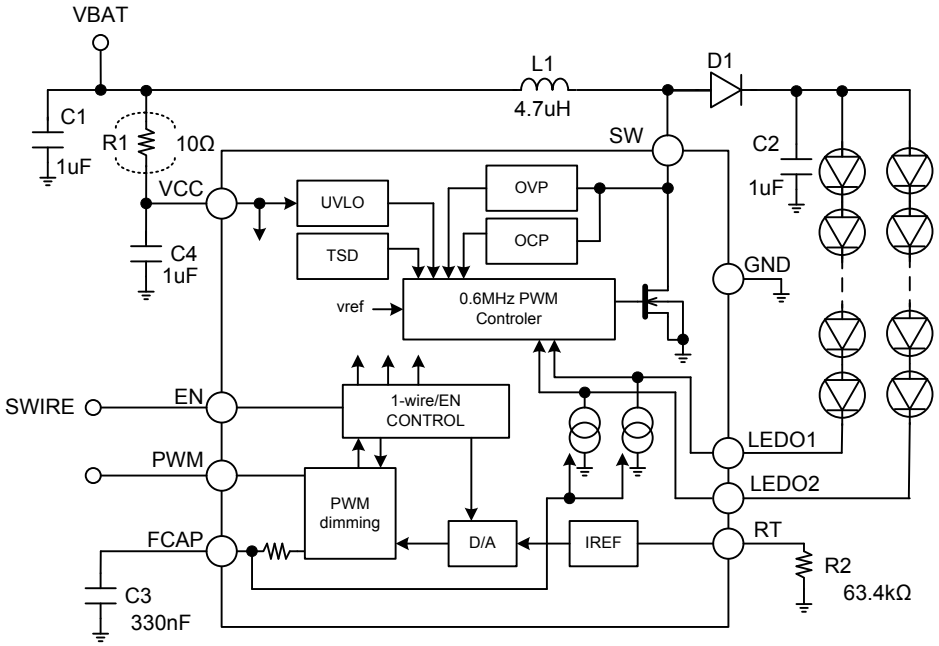
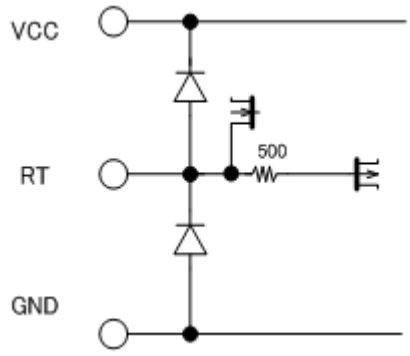
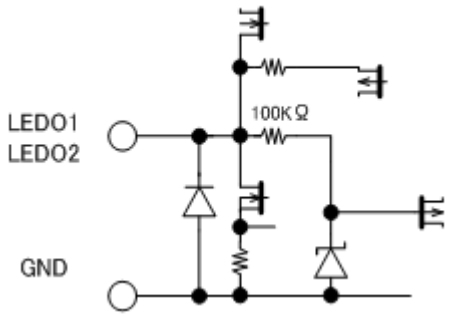
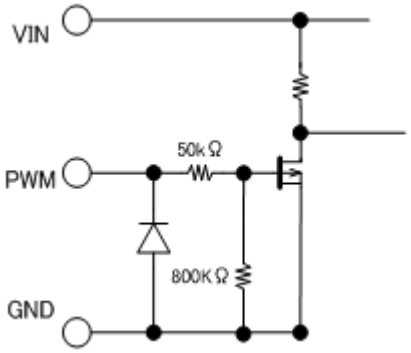


Fig.2 Block Diagram

< Explanation of the terminal >

PIN No.	PIN Sign	Equivalent circuit	Explanations
A1	RT		Resistance connect PIN for maximum LED current setting ; Resistance to set the maximum LED current is connected to this terminal between GND. Case of 63.4KΩ, the maximum LED current is set 20mA to LEDO1 and LEDO2.
A2 A3	LEDO2 LEDO1		Sink Pin of the LED current ; This PIN connect to the cathodal of the LED and pulls a set current. The voltage is used for the feedback control of DC-DC converter.
B1	PWM		Input PIN of PWM control signal ; This PIN is used for dimming of the LED.

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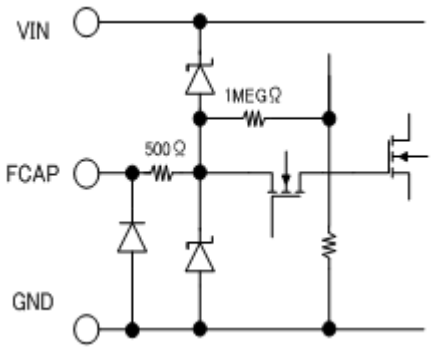
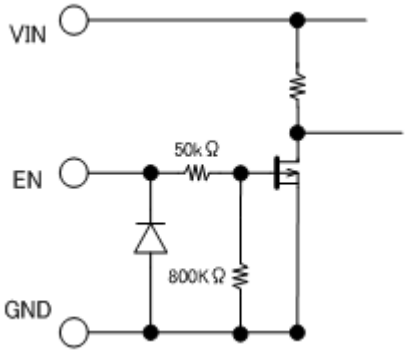
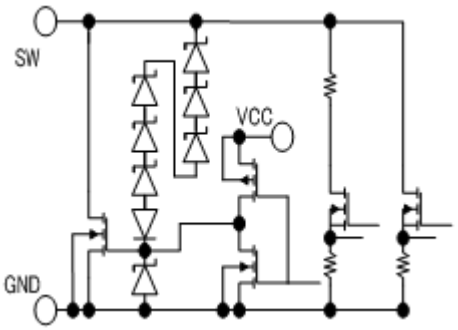
PIN No.	PIN Sign	Equivalent circuit	Explanations
B2	FCAP		Filter PIN for input PWM signals ; A capacitor to convert PWM signal into DC is connected to this PIN.
B3	GND		GND PIN
C1	EN		Input PIN of EN and 1-wire control signal ; This PIN is used for enabling and dimming (1-wire control) of the LED.
C2	VIN		Power supply PIN (2.7V-5.5V)
C3	SW		Switching PIN ; SW is output PIN of DC-DC convertor. It is used for overvoltage detection at the time of the LED opening.

< LED Current setting and Select of control mode >

The LED current is set in the IC inside.
The maximum LED current is 20mA, when you select 63.4KΩ to RT resistor.

LED Current Setting (max sink current)

LED_full current is set by an external resistor connected between the RT pin and ground.
I(LED_full)= 2113 x (V(RT)/R(RT_res))
V(RT) : RT_pin DC Voltage typ=0.6V
R(RT_res) : RT_pin resistor

RT_res=63.4kΩ : I(LED_full)=20mA

LED Current setting Address=00 RT resistor = 63.4KΩ
LED current = I (maximum LED current) x code / 255 = LEDO1current = LEDO2current.
Table.1 Conversion list of LEDI Setting v.s. LED Current

code	D8	D7	D6	D5	D4	D3	D2	D1	LED Current (mA)
0	0	0	0	0	0	0	0	0	0 Unavailable
1	0	0	0	0	0	0	0	1	0.22
2	0	0	0	0	0	0	1	0	0.3
3	0	0	0	0	0	0	1	1	0.38
4	0	0	0	0	0	1	0	0	0.47
5	0	0	0	0	0	1	0	1	0.55
6	0	0	0	0	0	1	1	0	0.63
7	0	0	0	0	0	1	1	1	0.7
8	0	0	0	0	1	0	0	0	0.78
9	0	0	0	0	1	0	0	1	0.86
10	0	0	0	0	1	0	1	0	0.94
.	.								.
.	.								.
.	.								.
246	1	1	1	1	0	1	1	0	19.3
247	1	1	1	1	0	1	1	1	19.38
248	1	1	1	1	1	0	0	0	19.46
249	1	1	1	1	1	0	0	1	19.54
250	1	1	1	1	1	0	1	0	19.61
251	1	1	1	1	1	0	1	1	19.69
252	1	1	1	1	1	1	0	0	19.77
253	1	1	1	1	1	1	0	1	19.84
254	1	1	1	1	1	1	1	0	19.93
255	1	1	1	1	1	1	1	1	20

Default code=255

Fig.3 shows the control curve by the digital mode.

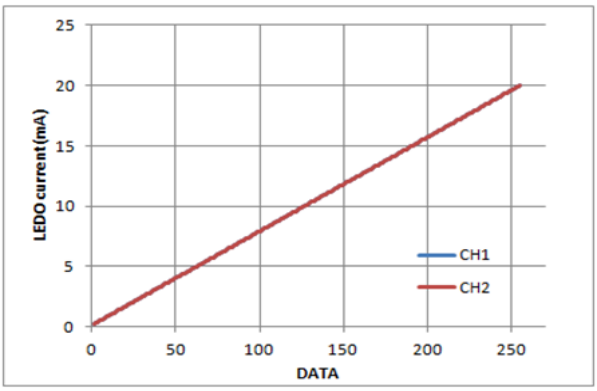


Fig.3 Digital Mode

Fig.4 shows the control curve by the PWM mode. By the PWM mode, the LED current is decided with input signal DUTY.

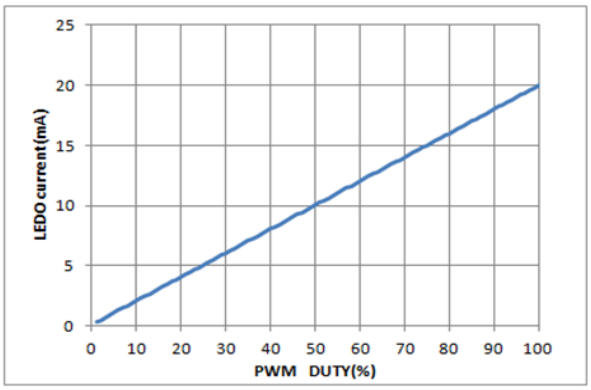


Fig.4 PWM Mode

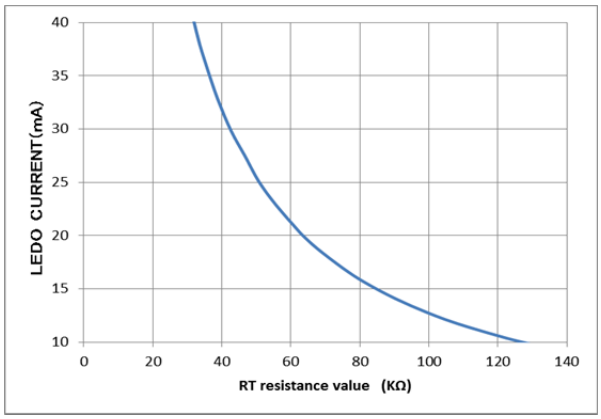


Fig.5 RT resistance value VS LED CURRENT

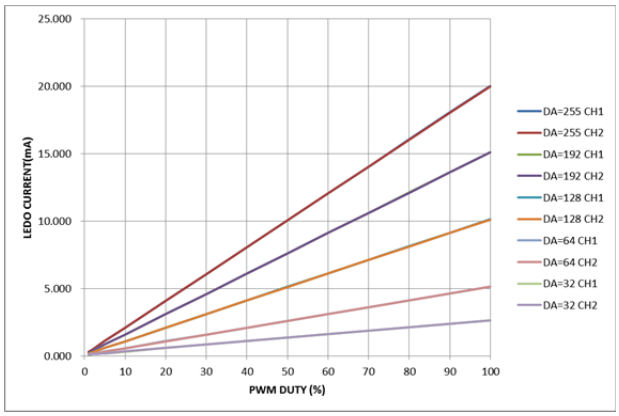


Fig.6 CABC DIMMING
PWM DIMMING + 1-wire DIMMING

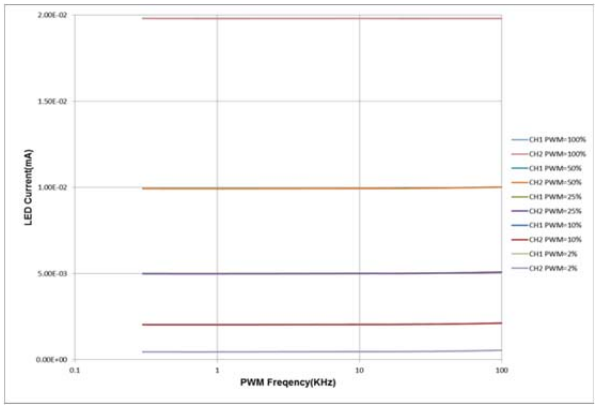
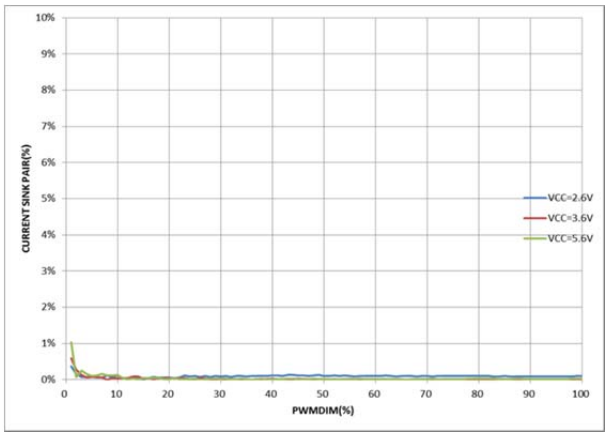


Fig.7 PWM frequency VS LED CURRENT

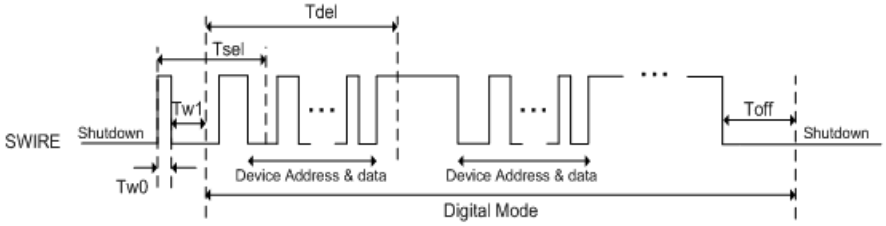


PAIR=(Imax-Iaverage)/Iaverage
Iaverage=(LEDO1current+LEDO2current)/2
Fig.8 Output Current Matching

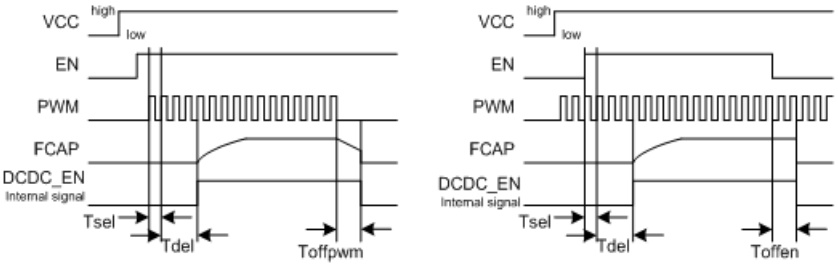
< Start/Shut Down sequences >

1. Please set PWM PIN "High", when you use only 1-wire control for dimming.
   IC will start by 1-wire signal input.
2. Please set EN PIN "High", when you use only PWM control for dimming.
   IC will start by PWM signal input.
3. When you perform dimming with 1-wire and PWM, the next condition is necessary for IC start.
   During Tw0 period of 1-wire, PWM must be set "High".
   Because Tw0 must be more than 100uS, please use frequency of more than 10KHz for PWM signal.
   In the case of less than 10kHz PWM frequency, after starting IC with PWM PIN "High", please input PWM signal and then transmit 1-wire data.
4. It will shut down when EN PIN is set "Low" for longer than Toffen(2.5ms) period or
   PWM PIN is set "Low" for longer than Toffpwm(20ms) period.
   The Data register will get initialized when IC is shut down.

1-wire timing



PWM timing



1-wire + PWM timing

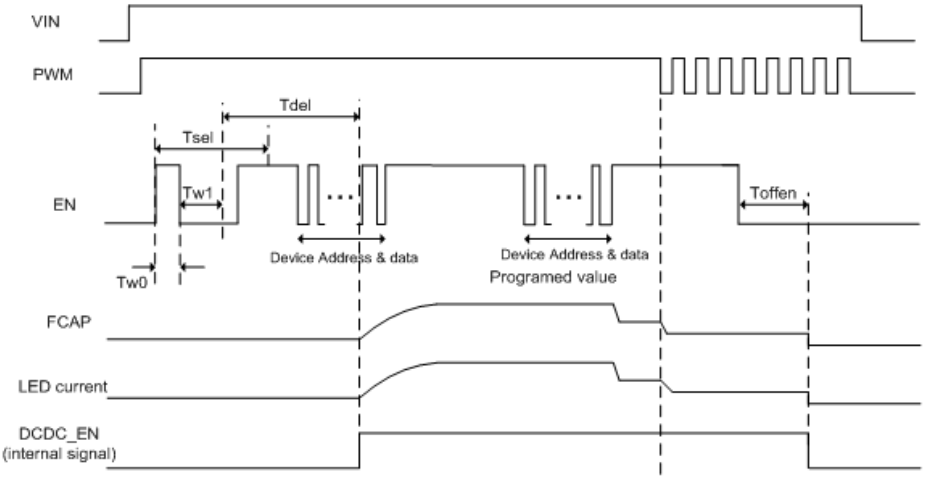
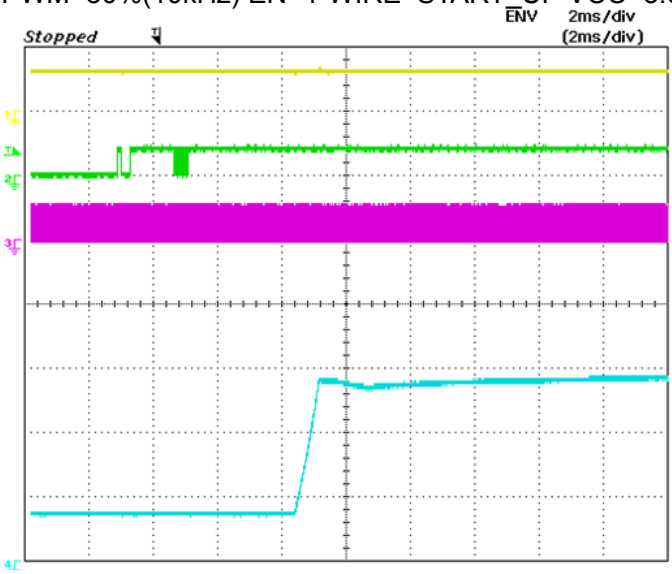


Fig.9 SWIRE Timing Diagram

PWM=50%(10kHz) EN=1-WIRE START_UP VCC=3.6V



CH1(Yellow):VCC(5V/DIV)
CH2(Green):EN(5V/DIV)
CH3(Red):PWM(5V/DIV)
CH4(Blue):VOUT(5V/DIV)

Note: When starting up at 1-wire(EN)+PWM , PWM freq.>10KHz is required
Fig.10 1-wire(EN)+PWM START_UP (CABC)

Table.2 BITMAP of the LED Control

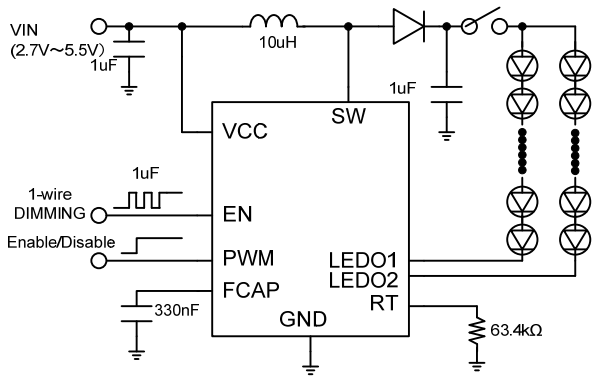
R/W	DATA							
	D9	D8	D7	D6	D5	D4	D3	D2
W	LEDI [7:0]							
	1	1	1	1	1	1	1	1

Upper column : Register name Lower column : Default value

LED OPEN/SHORT

< When both LED strings become open.>

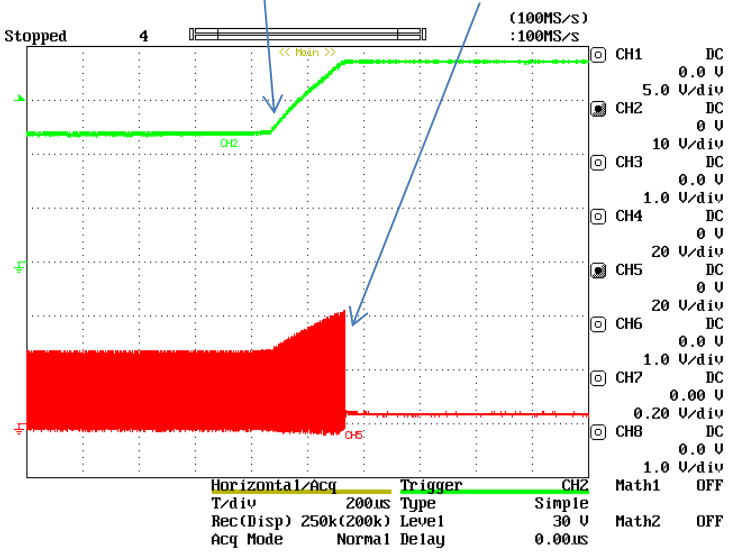
If both LED strings are open, LEDO1 pin voltage and LEDO2 pin voltage is about ground, and the boost output voltage is increased When SW pin voltage is reached the SW OVP threshold the LV52207NXB's switching converter stops switching.



LED 7s2p LED current=20mA setting

VOUT SW SHORT >> OPEN

SW_OVP: DCDC LATCH OFF



CH2(GREEN):DCDCOUT(10V/DIV)
CH5(RED):SW_PIN(20V/DIV)

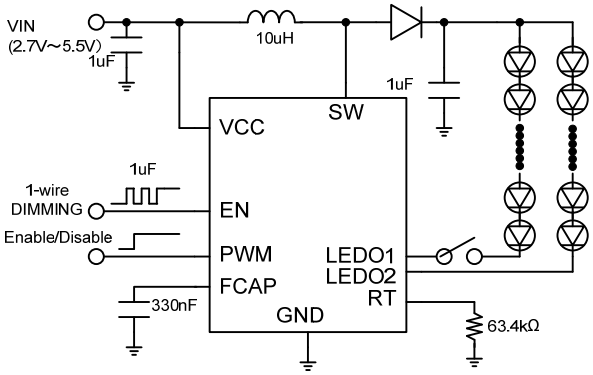
Fig.11 BOTH STRING OPEN

< When one LED string becomes open.>

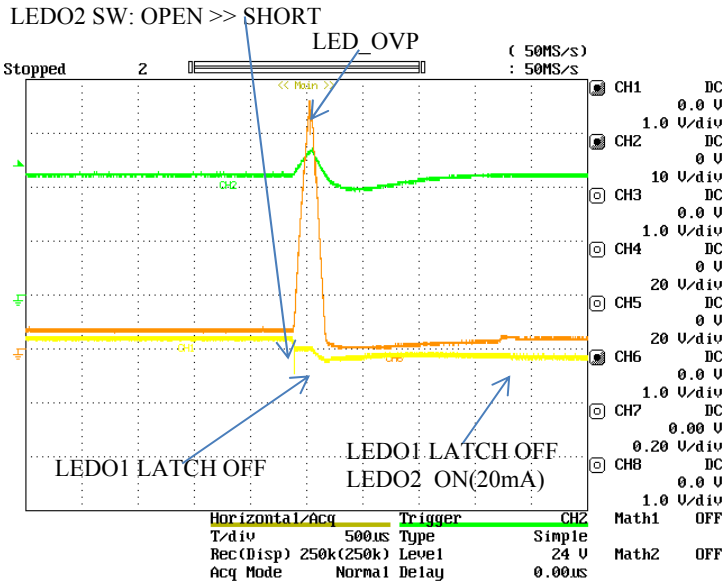
If one LED string is open, open channel voltage is about ground, the boost output voltage is increased and other LEDO channel voltage is increased. When SW pin voltage is reached the SW OVP threshold the LV52207NXB's switching converter stops switching.

When other LEDO pin voltage is reached the LEDO OVP threshold, the LV52207NXB's switching converter stops switching.

Open channel is latch-off.



LED 7s2p LED current=20mA setting

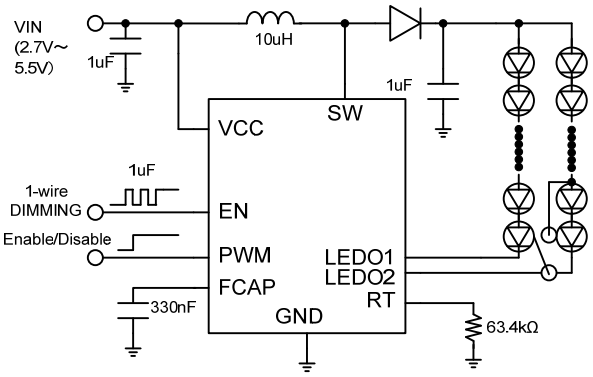


CH1(YELLOW):LEDO1 (1V/DIV)
CH2(GREEN):DCDCOUT(10V/DIV)
CH6(ORANGE):LEDO2 (1V/DIV)

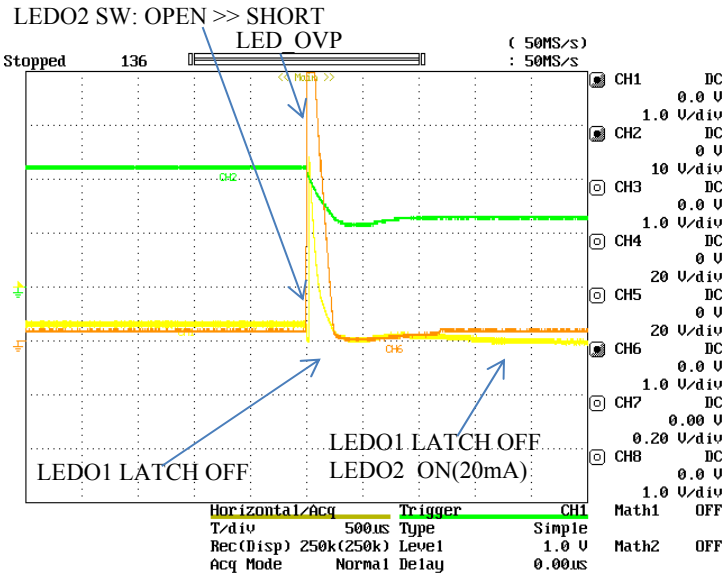
Fig.12 ONE LED SHORT

< When 2 LED SHORT>

LEDO pin over-voltage protection is set at 4.5V(rise) 3.5V(fall). This IC monitors the Voltage at LEDO1 pin and LEDO2 pin. When the voltage exceed LEDO OVP threshold, the switching converter stops switching. No short channel is latch-off.



LED 7s2p LED current=20mA setting



CH1(YELLOW):LEDO1 (1V/DIV)
CH2(GREEN):DCDCOUT(10V/DIV)
CH6(ORANGE):LEDO2 (1V/DIV)

Fig.13 TWO LED SHORT

< Board Layout >

The traces that carry the high-frequency switching current have to be carefully designed on the boradin order to minimize EMI, ripple and noise in general. The loop shown on Fig.14 corresponds to the current path when LV52207N internal switch is closed.
The thicker lines show the switching current path. All these traces have to be short and wide enough to minimize parasitic inductance and resistance. Fig.15 shows the current loop, when LV52207N switch is open. Both loop areas should be as small as possible.
Capacitor C1(VBAT-GND) has to be placed as close as possible to the VBAT pin and GND pin.
The connection between SW pin to the inductor and schottky diode should be kept as short and wide as possible.
The trace between schottky diode and the output capacitor C2 should also be as short and wide as possible.
Capacitor C2(VOUT-GND) has to be placed as close as possible to the GND pin.
Resistor R1(FB-GND) has to be placed as close as possible to the RT pin.
Capacitor C3(FCAP-GND) has to be placed as close as possible to the FCAP pin.

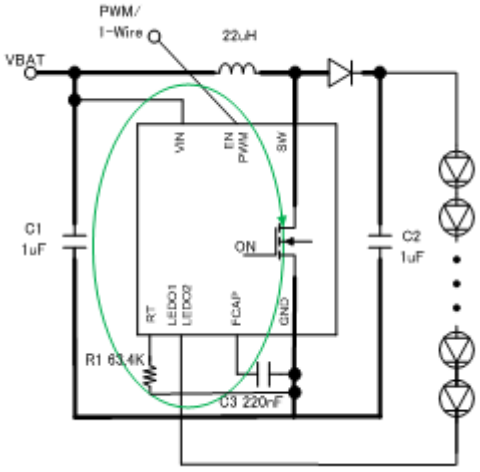


Fig.14 Closed-switch Current Loop

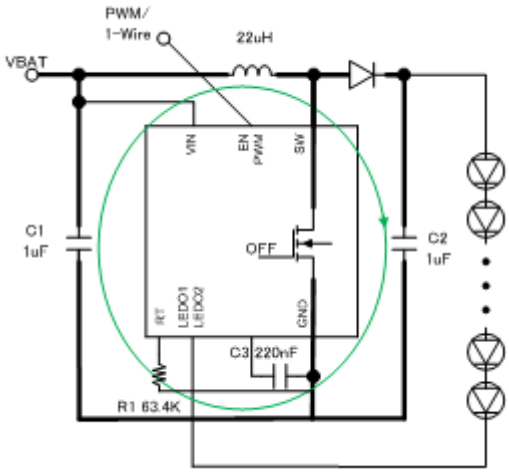


Fig.15 Open-switch Current Loop

< External Part Selection >

< Capacitor >

The ceramic capacitor from 1uF to 4.7uF is recommended as input capacitor C1.
A ceramic capacitor requires attention which capacitance value decreases to by applying rating DC voltage.
The ceramic capacitor from 1uF to 2.2uF is recommended as output capacitor C2.
When LED become OPEN, because the OVP voltage is applied to each parts, please use parts which can endure 50V.

< Schottky diode >

To get the optimum efficiency, LV52207NXB demands a low forward voltage, high-speed and low capacitance schottky diode . Ensure that the diode average and peak current rating exceeds the average output current and peak inductor current.
In addition, the diode's reverse breakdown voltage must exceed the open LED protection voltage.

< Inductor >

Three different electrical parameters need to be considered when selecting an inductor, the value of the inductor, the saturation current and the DCR.
Calculation formula of the peak current

$$\mathrm{Ipeak_p} = \frac{Iout}{\{n \times (1-D)\}} + \frac{Vin \times D}{2 \times L1 \times Fosc}$$

$$\mathrm{D} = \frac{\{(Vout + Vf) - Vin\}}{Vout + Vf}$$

VIN:battery voltage, IOUT:load current, L:inductor value, Fosc: OSC frequency,
D:duty cycle, n:converter efficiency varies with load current.
Vout:output voltage, Vf:forward voltage of Schottky diode.

It is important to ensure that the inductor current rating is high enough such that it not saturate.
As the inductor size is reduced, the peak current for a given set of conditions increases along with higher current ripple so it is not possible to deliver maximum output power at lower inductor values.
DCR should be small to make efficiency better.

The inductor value from 4.7uH to 10uH is recommended.