LV52207NXA Application Notes

Typical Applications

. LED Display Backlight Control
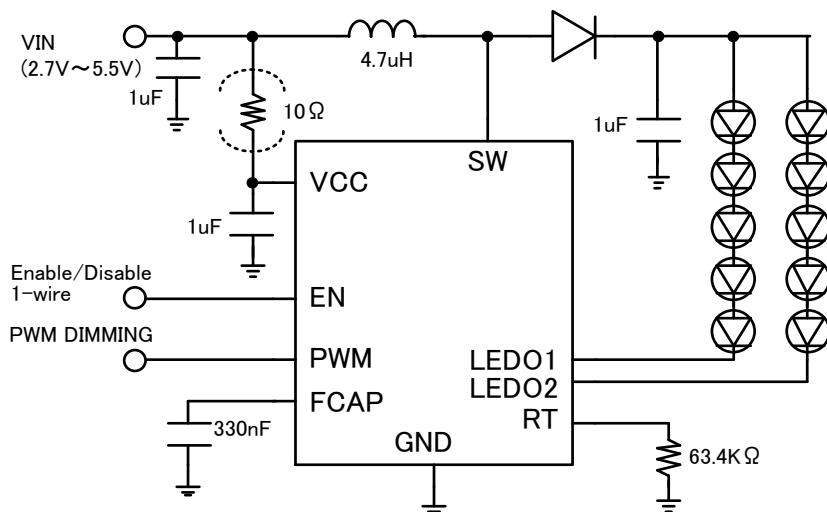
PACKAGE
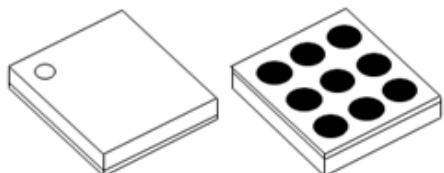
WLP9 - 0.4mm pitch
(1.31mm * 1.31mm, Amax=0.625mm)

MARKING DIAGRAM

TOP VIEW

A1

D7
YXX
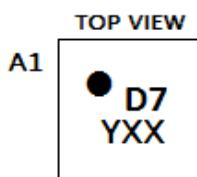
D7 = Device Code
YXX = Assembly Lot Code

PIN CONNECTIONS

TOP VIEW
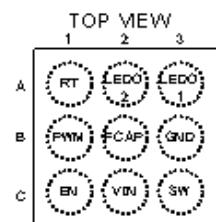
< Overall composition >

LV52207NXA 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 63.4Kohm, 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 LV52207NXA is 600kHz to improve efficiency
(The switching frequency of LV52207NXA is 1200kHz)

Fig.1 Block Diagram
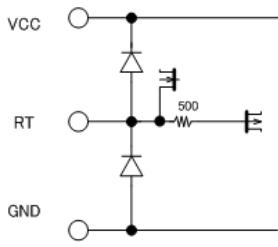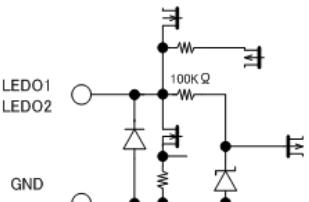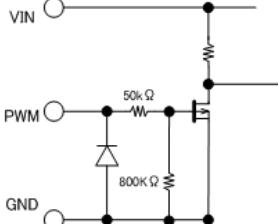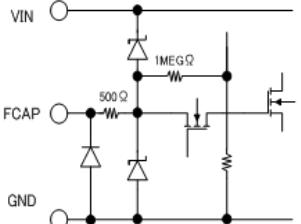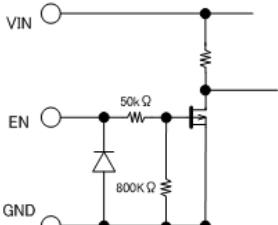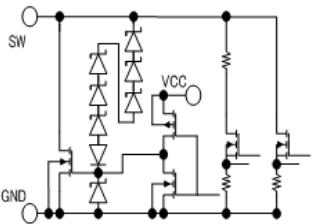
< Explanation of the terminal >
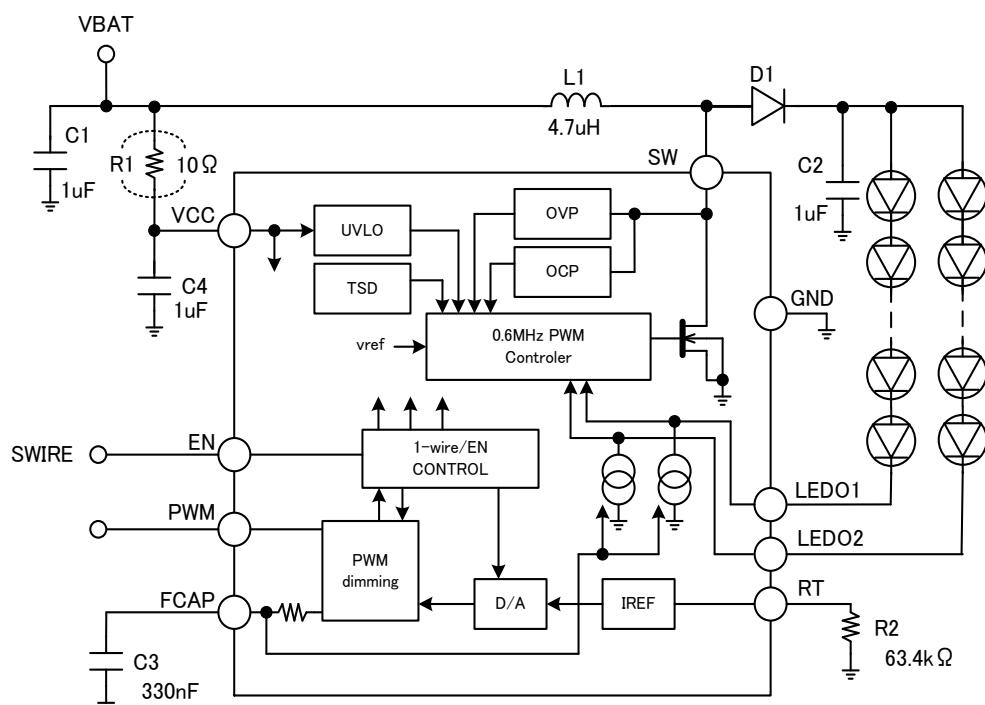
PIN No.	PIN Sign	Equivalent circuit	Explanations
A1	RT	VCC / RT 500 / GND	Resistance connect PIN for maximum LED current setting ; Resistance to set the maximum LED current is connected to this terminal between GND. Case of 63.4Kohm, the maximum LED current is set 20mA to LEDO1 and LEDO2.
A2 A3	LEDO2 LEDO1	LEDO1 LEDO2 100KΩ / GND	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	VIN / PWM 50kΩ / 800KΩ / GND	Input PIN of PWM control signal ; This PIN is used for dimming of the LED.
B2	FCAP	VIN / 1MEGΩ / FCAP 500Ω / GND	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	VIN / EN 50kΩ / 800KΩ / GND	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	SW / VCC / GND	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 63.4Kohm 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.
    $I(LED\_full) = 2113 \times (V(RT)/R(RT\_res))$

    $V(RT)$: RT_pin DC Voltage typ=0.6V
    $R(RT\_res)$: RT_pin resistor
    RT_res=63.4kohm：I(LED_full)=20mA

LED Current setting   Address=00   RT resistor = 63.4Kohm

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

Fig.2 shows the control curve by the digital mode.
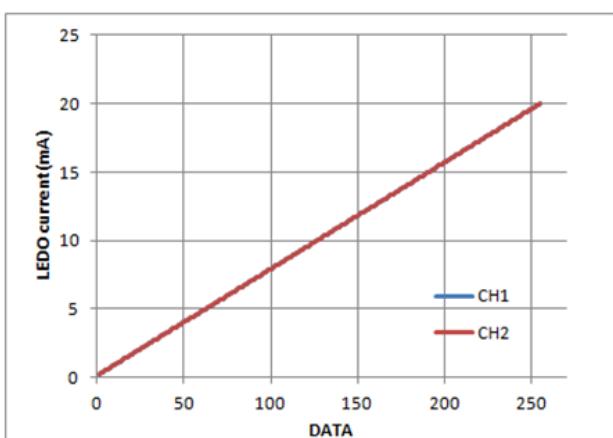
Fig.3 shows the control curve by the PWM mode. By the PWM mode, the LED current is decided with input signal DUTY.



Fig.2 Digital Mode
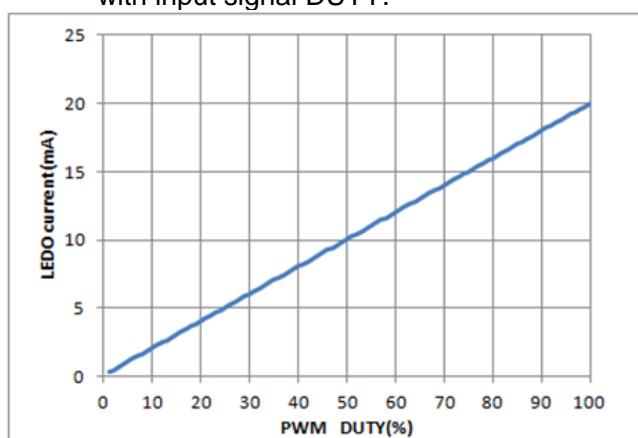
Fig.3 PWM Mode
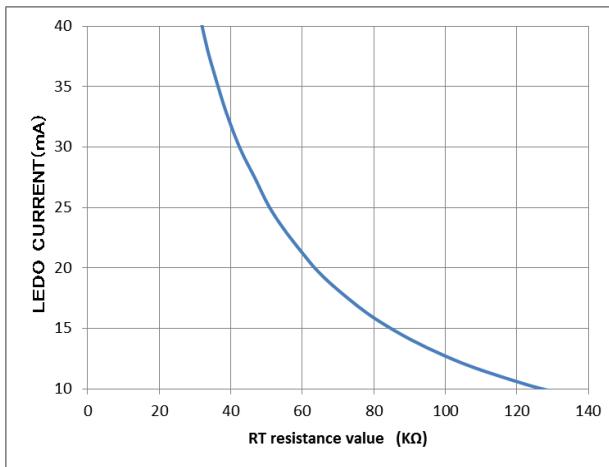
Fig.7 RT resistance value VS LED CURRENT
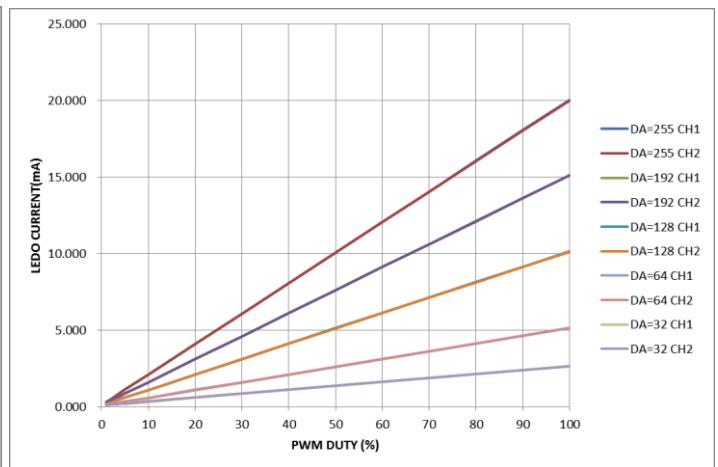

Fig.8 CABC DIMMING
PWM DIMMING + 1-wire DIMMING
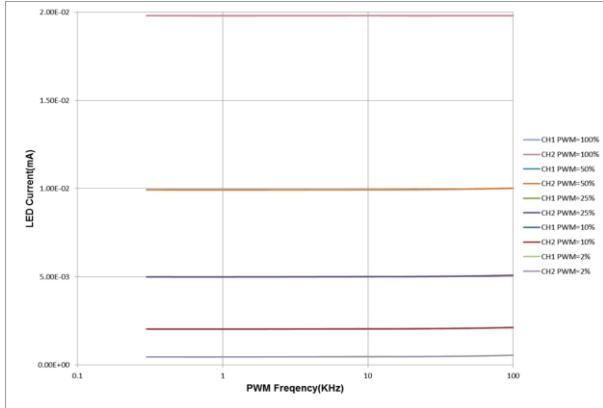
Fig.9 PWM frequency VS LED CURRENT
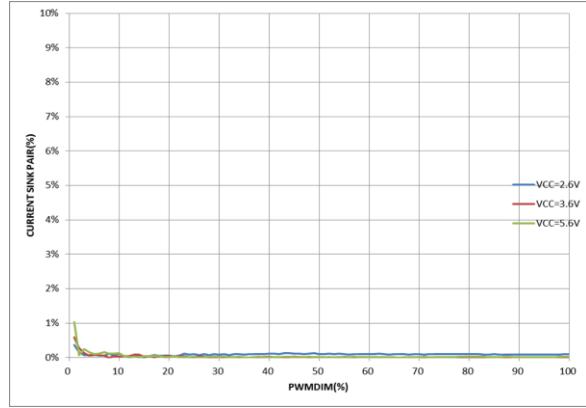
PAIR=(Imax-Iaverage)/Iaverage   Iaverage=(LEDO1current+LEDO2current)/2

Fig.10 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 signa
   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
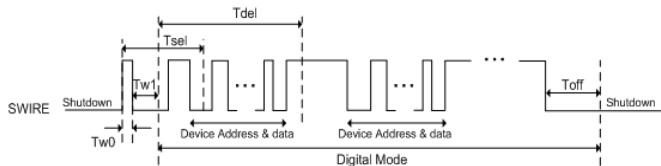
PWM timing
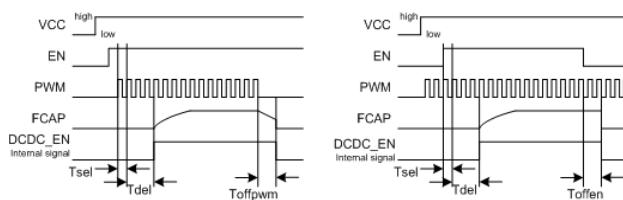

1-wire + PWM timing
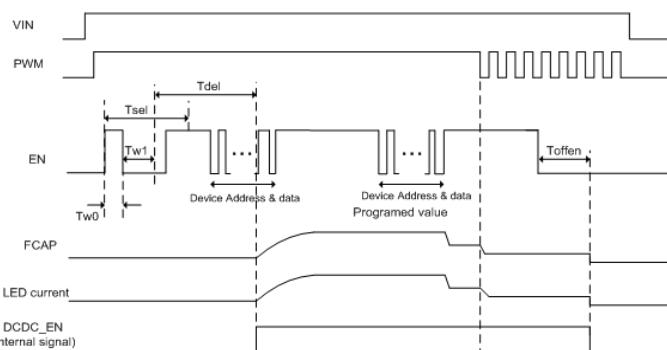
Fig.4 SWIRE Timing Diagram

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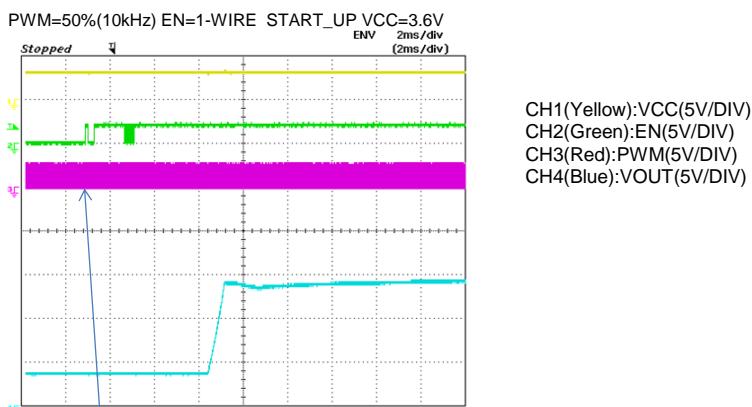
Note: When starting up at 1-wire(EN)+PWM , PWM freq.>10KHz is required

Fig.15 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 LV52207NXA's switching converter stops switching.
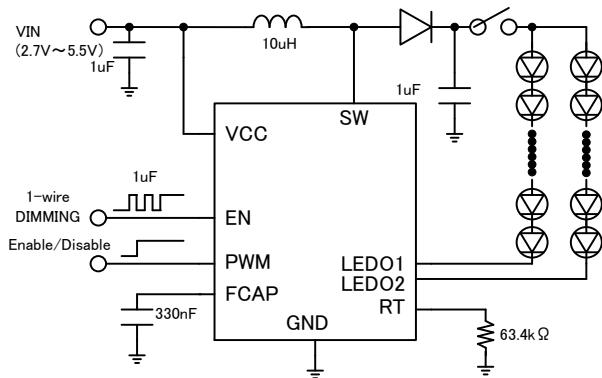
LED 7s2p   LED current=20mA setting

VOUT SW   SHORT >> OPEN
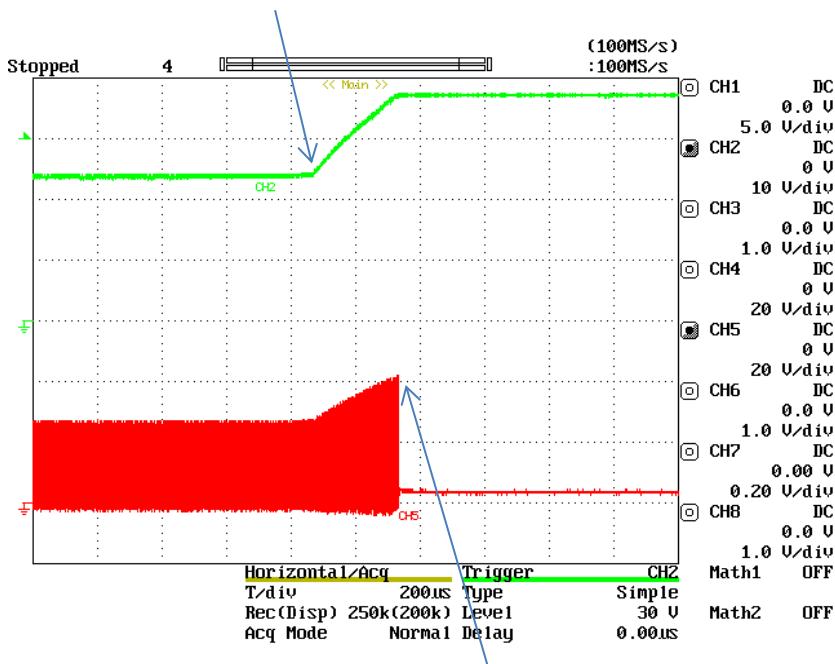
SW_OVP
DCDC LATCH OFF

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 LV52207NXA's switching converter stops switching.
When other LEDO pin voltage is reached the LEDO OVP threshold,
the LV52207NXA's switching converter stops switching.
Open channel is latch-off.
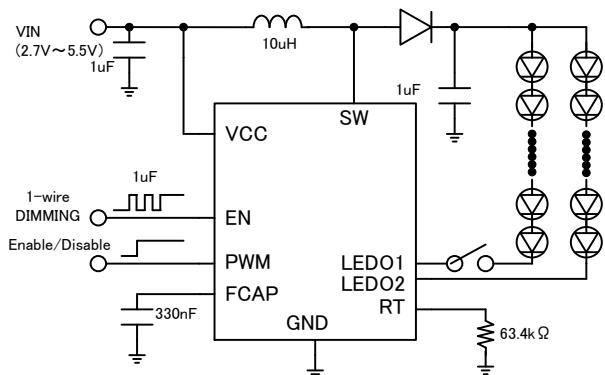
LED 7s2p   LED current=20mA setting

LEDO2 SW   OPEN >> SHORT

LED_OVP   LEDO1 LATCH OFF LEDO1 OFF
                                LEDO2 ON(20mA)
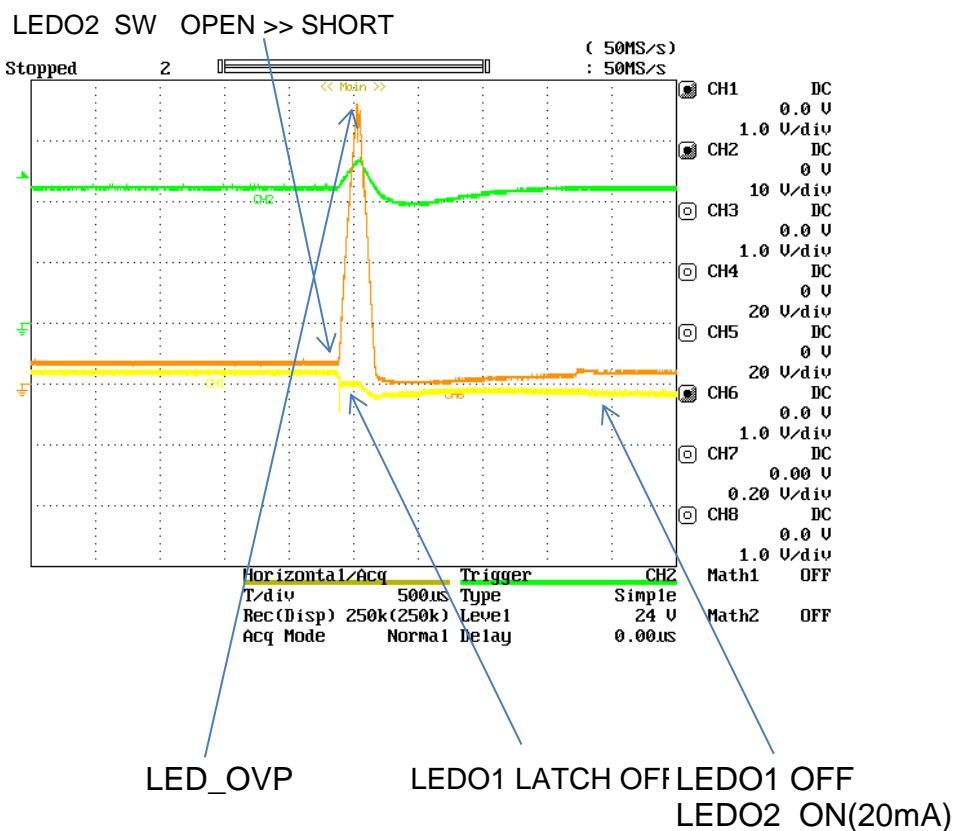
CH2(GREEN):DCDCOUT(10V/DIV)   CH1(YELLOW):LEDO1 (1V/DIV)
CH6(ORANGE):LEDO2 (1V/DIV)

Fig12 ONE STRING OPEN

< When one LED SHORT>

When the higher LEDO pin voltage does not reach the VLED_OVP threshold , LEDO1,LEDO2 current is normal
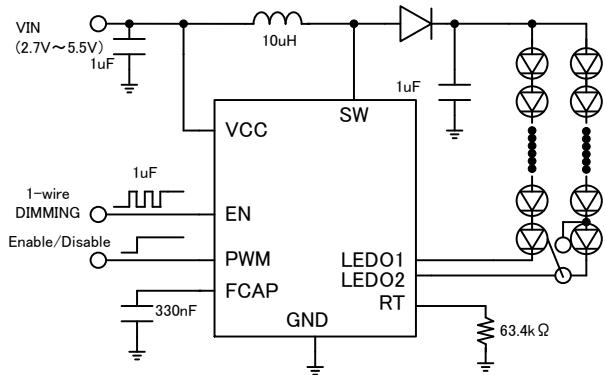
LED 7s2p   LED current=20mA setting

LEDO2 SW   OPEN >> SHORT

LEDO1 ON(20mA)
LEDO2 ON(20mA)
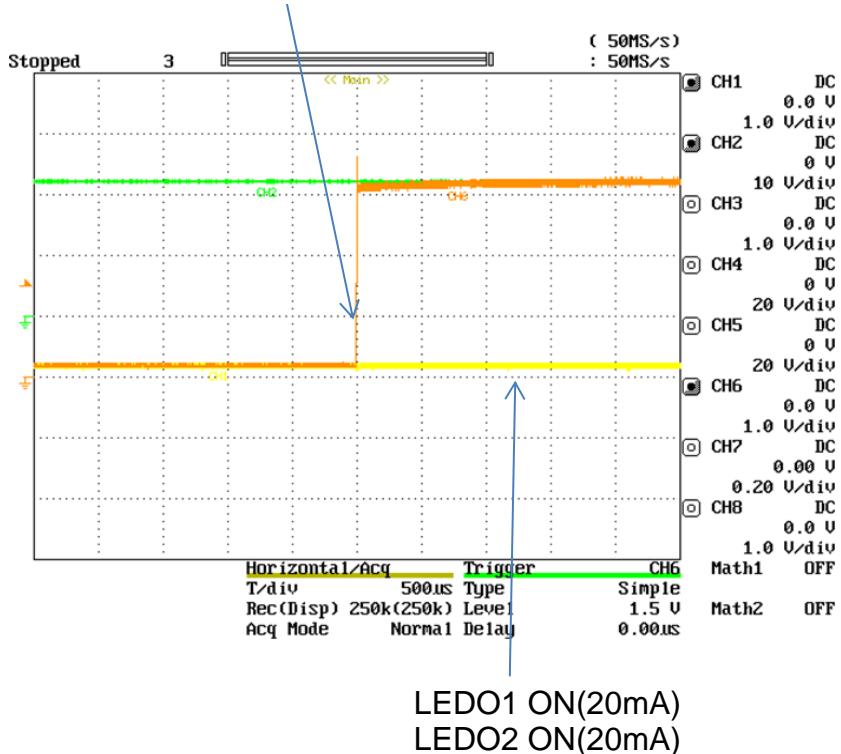
CH2(GREEN):DCDCOUT(10V/DIV)   CH1(YELLOW):LEDO1 (1V/DIV)
CH6(ORANGE):LEDO2 (1V/DIV)

Fig13 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.
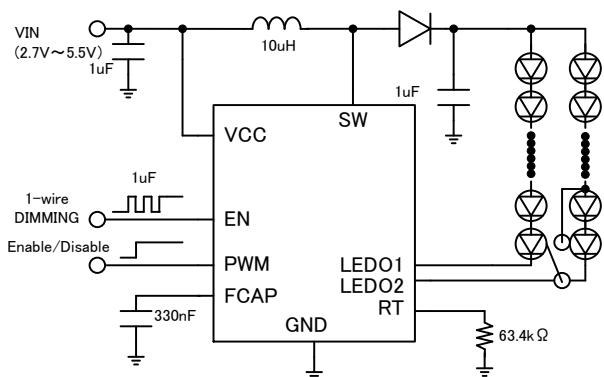
VIN
(2.7V～5.5V)
1uF
10uH
1uF
VCC
SW
1-wire
DIMMING
1uF
EN
Enable/Disable
PWM
LEDO1
LEDO2
FCAP
RT
330nF
GND
63.4kΩ

LED 7s2p   LED current=20mA setting

LEDO2 SW   OPEN >> SHORT

(50MS/s)
: 50MS/s

Stopped   136   << Main >>

CH1   DC
0.0 V
1.0 V/div
CH2   DC
0 V
10 V/div
CH3   DC
0.0 V
1.0 V/div
CH4   DC
0 V
20 V/div
CH5   DC
0 V
20 V/div
CH6   DC
0.0 V
1.0 V/div
CH7   DC
0.00 V
0.20 V/div
CH8   DC
0.0 V
1.0 V/div

Horizontal/Acq		Trigger	CH1	Math1	OFF
T/div	500us	Type	Simple		
Rec(Disp) 250k(250k)		Level	1.0 V	Math2	OFF
Acq Mode	Normal	Delay	0.00us		

LED_OVP

LEDO1 LATCH OFF

LEDO1 OFF

LEDO2 ON(20mA)

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

Fig14 2 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.5 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.6 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.
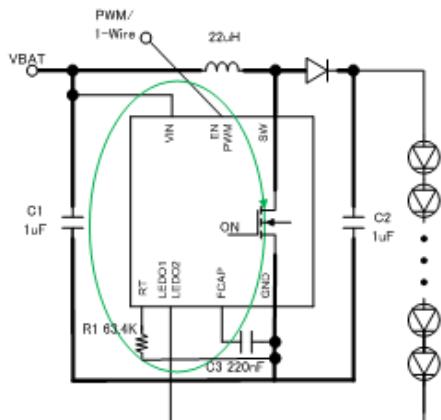
Fig5. Closed-switch Current Loop   Fig.6 Open-switch Current Loop
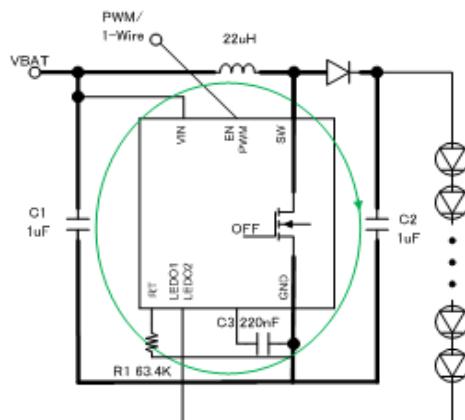
< External Part Selection >

< 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, LV52207NXA 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

$$Ipeak\_p = Iout / (n \times (1- D)) + (VIN \times D) / (2 \times L1 \times Fosc)$$

VIN:battery voltage, IOUT:load current, L:inductor value, Fosc: OSC frequency,
D:duty cycle, n:converter efficiency varies with load current.

$$D = ((Vout + Vf) - VIN) / (Vout + Vf)$$

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 satura
As the inductor size is reduced, the peak current for a given set of conditions increases alor
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.