

High Performance, OLED + LED Driver for Dual Panel Mobile Phone

General Description

The RT9273 is a high efficiency step-up DC-DC converter specifically designed for dual panel mobile phone applications.

According to SP status, RT9273 can either regulates output current flowing through series-connected LEDs or regulate output voltage applying to OLED with a common output LC filter. This along with compact VDFN-10L 3x3 package and high switching frequency allows less part count and smaller external components for space and cost saving.

Pulling low EN pin shuts down the chip and reduces the supply current to less than 1µA. The EN pin also accepts PWM signal for LED brightness dimming control. The averaged LED current is well proportional to the duty cycle of the PWM signal. The internal soft start reduces inrush current during EN turning on or PWM dimming control.

Other features include OVP, OCP and OTP. OVP prevents the damages in case of feedback loop open.

Ordering Information

RT9273 □ □

- Package Type
QV : VDFN-10L 3x3 (V-Type)
- 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.

Features

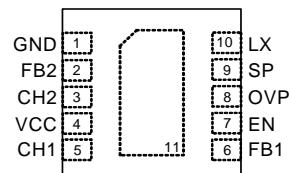
- Lion-Battery operating Range : 2.7V to 4.5V
- Maximum Output Voltage Up to 16V
- Share One Set of Inductor and Schottky Diode for 2 Channels
- Programmable Dimming Function by EN pin with 200Hz to 1kHz
- Internal Soft-Start Function to Avoid PWM Dimming Noise.
- Zero Shut Down Supply Current
- Complete Protection : OVP, OCP, OTP and SS
- RoHS Compliant and 100% Lead (Pb)-Free

Applications

- Dual panel mobile phone, with LED backlight

Pin ConFigurations

(TOP VIEW)



VDFN-10L 3x3

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.

Typical Application Circuit

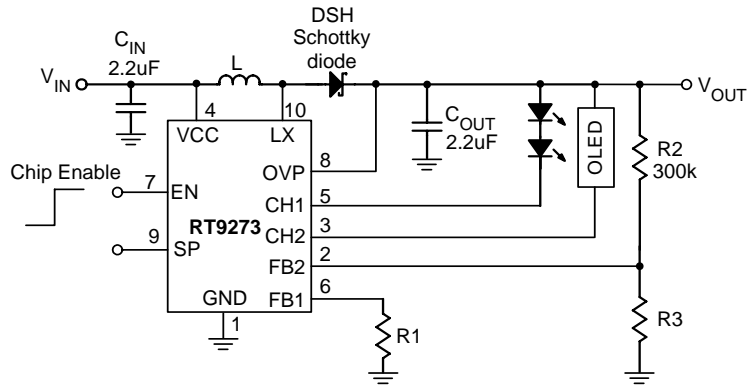


Figure 1. Dual panel 2LEDs + OLED mobile phone power solution

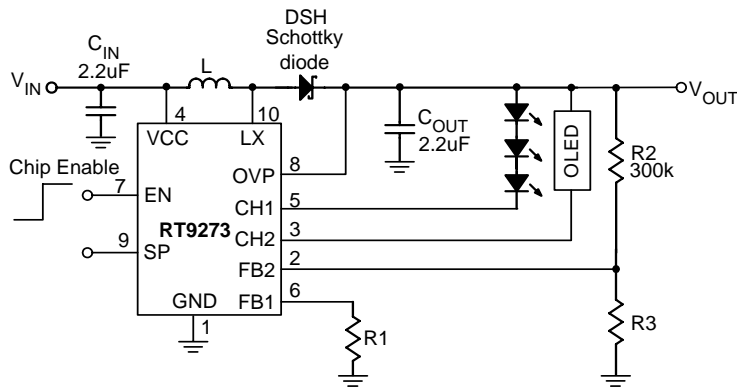


Figure 2. Dual panel 3LEDs + OLED mobile phone power solution

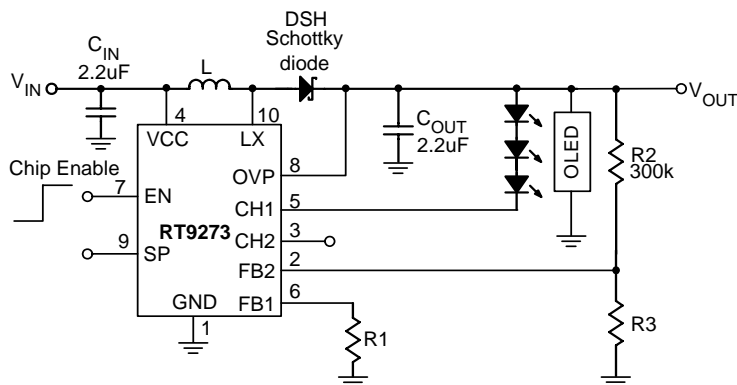


Figure 3. Dual panel 3LEDs + OLED mobile phone power solution. OLED is controlled by its driver to turn on/off.

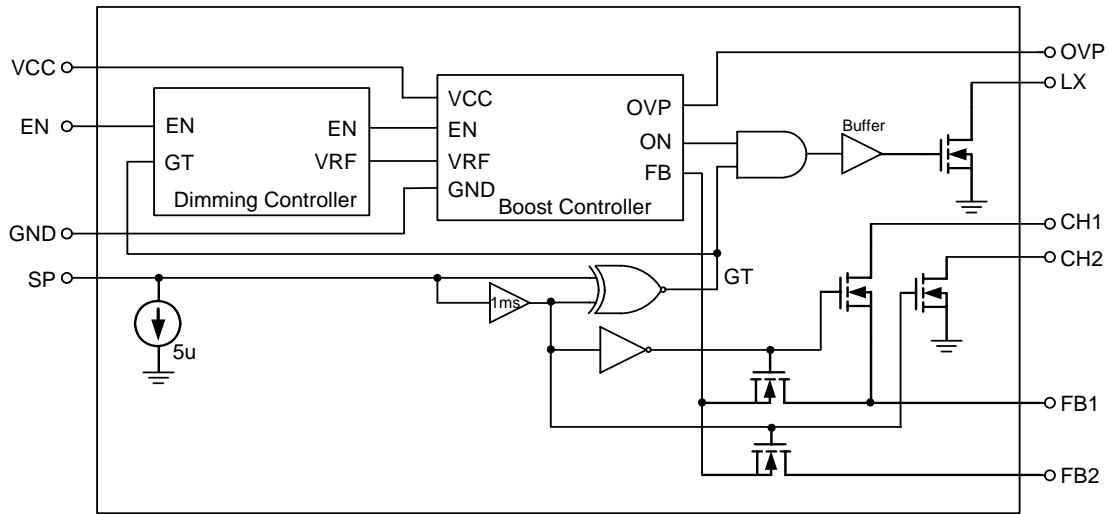
Note:

1. Figure 1 is for PMOLED power ground connected to CH2 but not for OLED driver digital ground.
2. R3 = 7.68k for V_{OUT} = 12V & 9.31k for V_{OUT} = 10V
3. L: Measured by Murate LQH32C series 4.7μH with DCR = 0.15Ω
4. a. OLED turns on procedure: Firstly, EN pin pulls high and then SP pin pulls High. Finally set the OLED display to turn ON.
 b. OLED turns off procedure: Firstly set OLED display to turn OFF. And then SP pin pulls low but at the same time LED will turn on. Or keep the SP status and finally let the EN pin pull low.

Functional Pin Description

Pin No.	Pin Name	Pin Function
1	GND	Ground.
2	FB2	Feedback 2. Switching regulator feedback input. The feedback set point is 0.36V. Connect to a resistive divider between the switching regulator output and GND to adjust the output voltage as SP pin pull high.
3	CH2	Channel 2. Internal FB loop. Connect the cathode of OLED to this pin.
4	VCC	Voltage Input Pin. Bypass a 2.2uF capacitor to GND to reduce the input noise.
5	CH1	Channel 1. Internal FB loop. Connect the cathode of LED to this pin.
6	FB1	Feedback 1. Internal feedback voltage to set FB current of CH1 as SP pin pull low.
7	EN	Chip Enable Pin. Pull low or floating this pin to disable the system. Using a PWM signal on EN pin can achieve the dimming control.
8	OVP	Over Voltage Protection. Detect over voltage condition and latch up the system until SP, EN or UVLO reset. Connect directly to the output capacitor.
9	SP	Selection Pin. Internal MOSFET selection. Pull low to turn on the internal CH1. Pull high to turn on CH2. As SP input signal changes, internal MOSFET of LX pin will turn off 1ms to prevent the over voltage damage by the output voltage instant change.
10	LX	Switch Pin. Connect this pin to inductor and schottky diode. Minimize the track area to reduce EMI.
Exposed Pad (11)	NC	No Internal Connection.

Function Block Diagram



Operation

RT9273 operates at a wide input voltage range suitable for Li-On battery and has a constant high frequency for smaller inductor and capacitors. The block diagram refers the operation circuit. The scheme is divided into three parts: dimming controller, boost controller and the logic selection function. By SP pin, it can choose the different channel to turn on CH1 or CH2. As the input signal change, internal MOSFET of LX pin will turn off 1ms to prevent the over voltage damage by the output voltage instant change.

- The Dimming Controller:

RT9273 uses the PWM signal on EN pin to achieve dimming control. If the period of EN is less than 3ms in 50% duty, EN is always pulled high. Then EN signal is sent to the next boost controller to enable the function. This action is to differentiate between shut down and dimming control. V_{RF} offers the reference voltage to error amplifier of next function. The internal soft start is designed for enable control and dimming control to avoid the inrush current.

- The Boost Controller:

RT9273 uses current mode control scheme to provide better performance of line and load regulation. The boost controller includes of error amplifier, summing comparator, logic control and protection function. The difference between the feedback voltage and the reference voltage is send to the negative input of comparator. The comparator also senses the sensing current from inductor and slope compensation. To keep the output in regulation, the output of summing comparator is sent to the logic function, and then to control the duty ratio of the MOSFET switch. If the error amplifier's output increases, the duty of the switch will be larger to deliver more current to the output.

Absolute Maximum Ratings (Note 1)

- Input Supply Voltage ----- -0.3V to 6V
- LX ----- -0.3V to 18V
- CH1, CH2, and OVP ----- -0.3V to 18V
- The Other Pins ----- -0.3V to 6V
- Power Dissipation, P_D @ $T_A = 25^\circ\text{C}$, $T_J = 125^\circ\text{C}$
 VDFN-10L 3x3 ----- 2.083W
- Package Thermal Resistance (Note 2)
 VDFN-10L 3x3, θ_{JA} ----- 48°C/W
- Operating Junction Temperature Range ----- -40°C to 85°C
- Junction Temperature Range ----- -40°C to 125°C
- Storage Temperature Range ----- -65°C to 150°C
- Lead Temperature (Soldering, 10 sec.) ----- 260°C

Recommended Operating Conditions (Note 3)

- Input Supply Voltage ----- 2.7V to 4.5V
- Output Voltage ----- Under 16V
- Output Current ----- Under 80mA
- Maximum Output Power ----- Under 1.28W

Electrical Characteristics

($V_{CC} = 3.7\text{V}$, $T_A = 25^\circ\text{C}$, Unless Otherwise specification)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
System Supply						
Supply Current	I_{CC}	$V_{CC}=3.7\text{V}$, Switching, $V_{FB}=0\text{V}$	--	--	2	mA
Shut Down Current	I_{CC}	$V_{CC}=3.7\text{V}$, $V_{EN}<0.4\text{V}$	--	--	1	uA
Maximum Duty Cycle			85	90	--	%
Reference Voltage						
Feedback Voltage 1	V_{FB1}		0.285	0.300	0.315	V
Feedback Voltage 2	V_{FB2}		0.285	0.300	0.315	V
Power Switch MOSFET						
On Resistance of MOSFET	$R_{DS(ON)}$		--	0.5	1	Ω
Current Limitation	I_{MAX}	Normal Operation	--	1.5	--	A
Internal MOSFET Selection						
On Resistance of CH1 MOSFET	$R_{DS(ON)}$		--	6	9	Ω
On Resistance of CH2 MOSFET	$R_{DS(ON)}$		--	4.0	6	Ω
SP Low Level Voltage	V_{SP}		--	--	0.4	V
SP High Level Voltage	V_{SP}		1.5	--	--	V
SP signal change delay time	$R_{DS(ON)}$	LX off time as SP change	--	0.5	1	ms
Protection						
OVP Threshold	OVP		16	17	19	V
Over Temperature Protection	OTP		--	170	--	°C
Shut Down Voltage	V_{EN}		--	--	0.4	V
Enable Voltage	V_{EN}		1.5	--	--	V

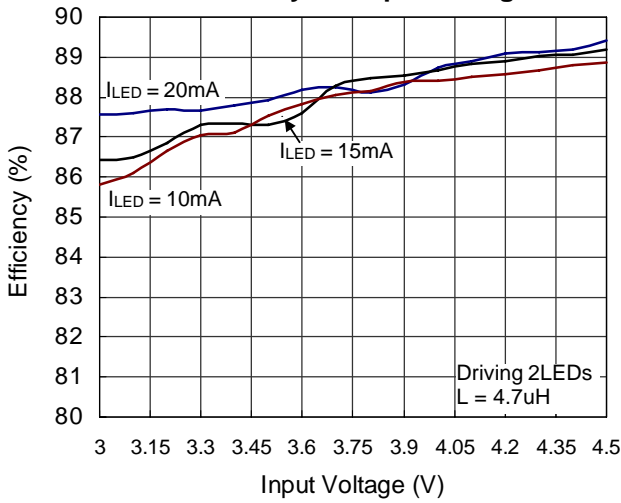
Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. θ_{JA} is measured in the natural convection at $T_A = 25^\circ\text{C}$ on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

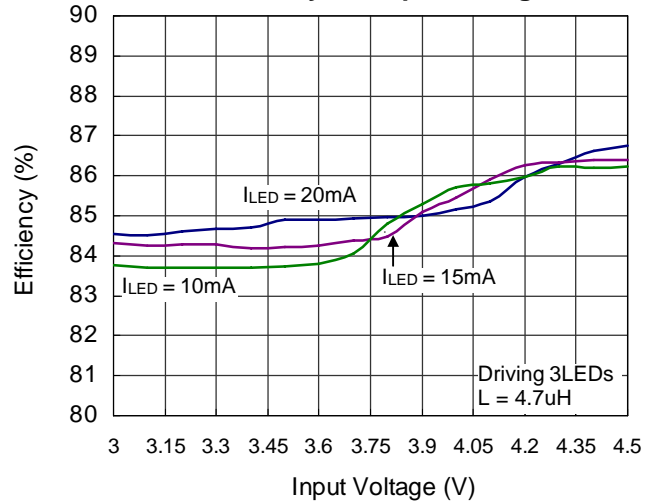
Note 3. The device is not guaranteed to function outside its operating conditions.

Typical Operating Characteristics

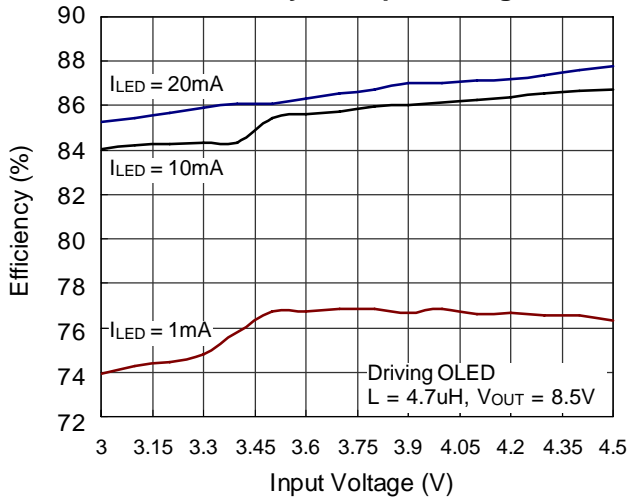
Efficiency vs. Input Voltage



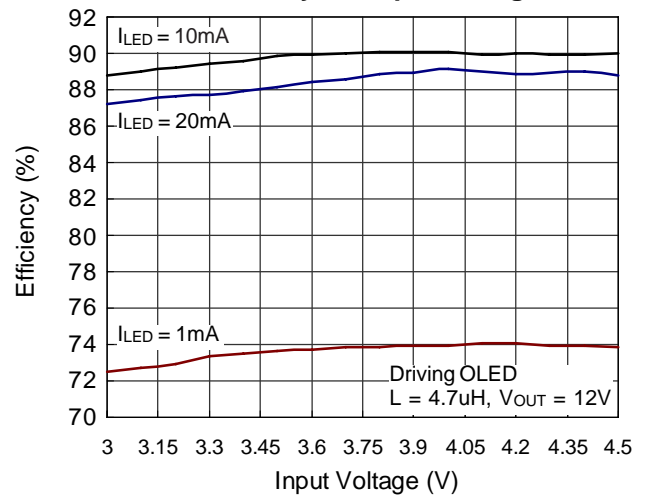
Efficiency vs. Input Voltage



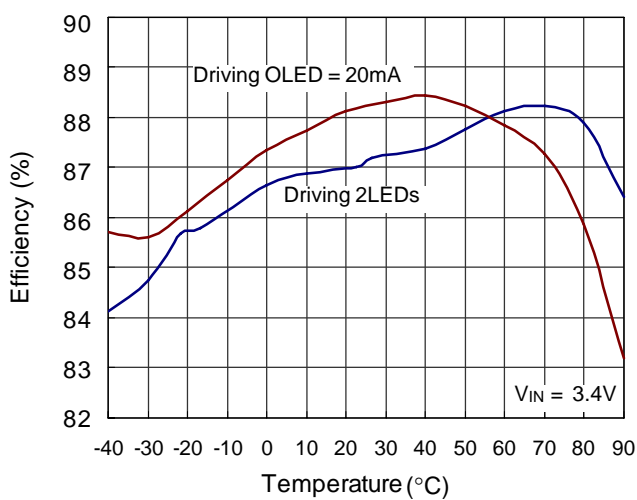
Efficiency vs. Input Voltage



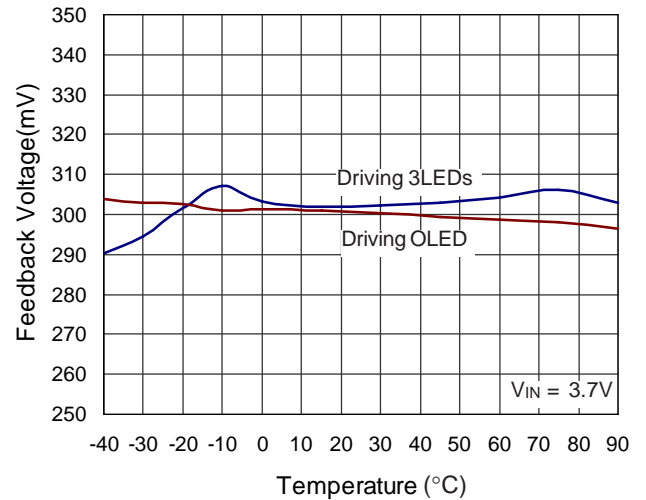
Efficiency vs. Input Voltage

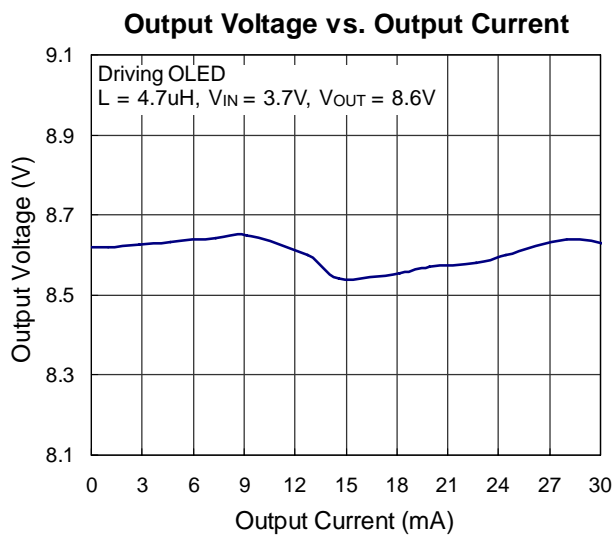
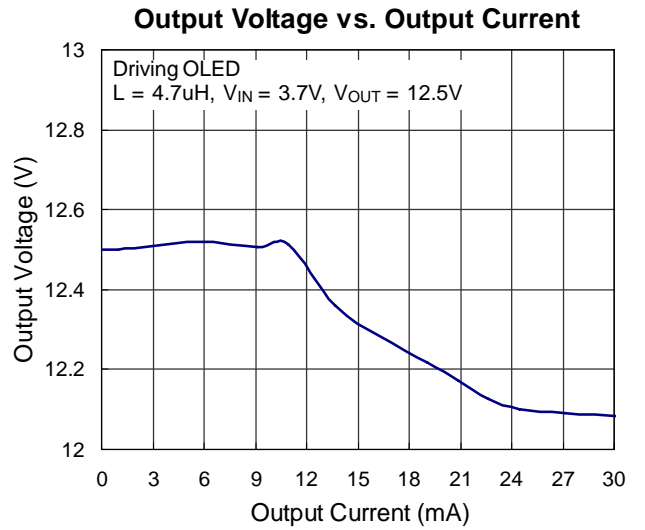
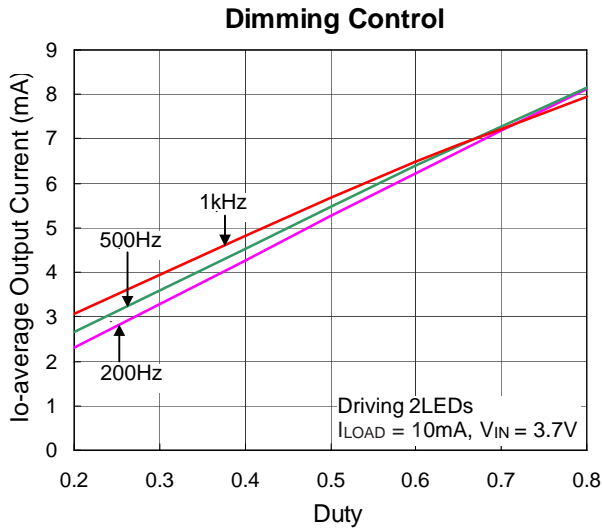
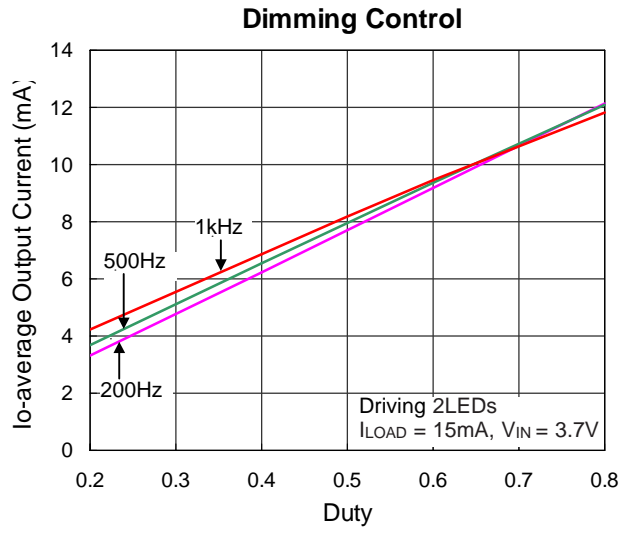
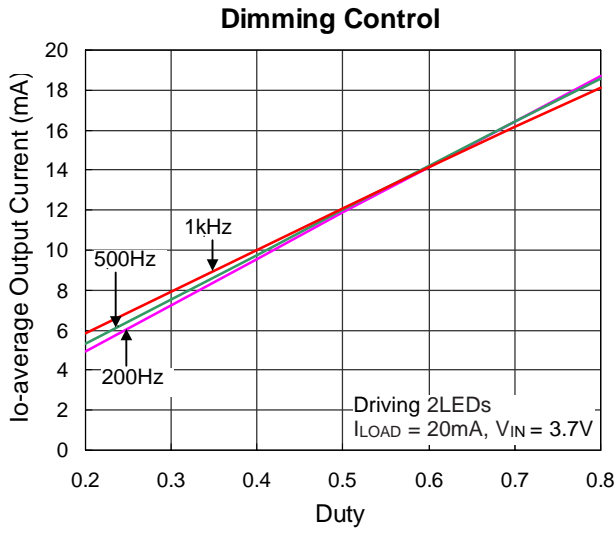


Efficiency vs. Temperature



Feedback Voltage vs. Temperature





Application Information

Inductor Selection

The recommended value of inductor for RT9273 applications is 4.7uH. Small size and better efficiency are the major concerns for portable device, such as RT9273 used for dual panel mobile phone. The inductor should have low DCR for better efficiency. To avoid inductor saturation, current rating should be at least 600mA for 3LEDs application in the input range 2.7V to 4.5V.

Capacitor Selection

2.2uF input output ceramic capacitors are recommended for RT9273 applications. 2.2uF input capacitor can reduce input ripple effectively. For better voltage stability, to increase the input capacitor value or using LC filter is feasible, especially in the Li-ion battery application. 1uF output capacitor is sufficient to reduce output voltage ripple. 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.

Diode Selection

Schottky diode is a good choice for RT9273 because of its lower forward voltage drop and faster reverse recovery. Using schottky diode can get better efficiency. The high-speed rectification is also a good characteristic of schottky diode for high switching frequency. Current rating of the diode must meet the root mean square of the peak current and output average current multiplication as following:

$$I_{\text{diode(RMS)}} \cong (\sqrt{I_{\text{OUT}} \times I_{\text{PEAK}}})$$

The diode's reverse breakdown voltage should be larger than the output voltage. SS0520 is recommended schottky diode for rectifier.

LED Current Control

Current control is to change different brightness of LEDs. To regulate the output resistor can get different currents of LEDs as following formula. The table for the selection of feedback resistor is shown below.

$$\text{LEDs Feedback_resistor} = \frac{0.3V}{I_{\text{LED}}}$$

I _{LED} (mA)	LEDs feedback resistor (Ω)
5	59
10	30.1
12	24.9
15	20
20	15

OLED output voltage control

The output voltage can be set using a resistor-divider as Figure 2. To regulate the output resistor-divider (R2/R3) can get different output voltage of OLED as following formula.

$$V_{\text{OUT}} = V_{\text{FB}} \left(1 + \frac{R_2}{R_3}\right)$$

Dimming Control

Dimming control is the current programming method when output resistor fixes the brightness of LEDs. Using a PWM signal on EN pin can achieve the dimming control. RT9273 is turned on or off by the PWM signal applied to EN pin. The brightness of LEDs is depended on PWM duty cycle. The average LED current increases proportionally as the duty cycle added. The average LED current is linear in different duty cycle. It should be notice that the magnitude of PWM signal should be higher than the minimum EN voltage. The recommended dimming frequency is 200Hz to 1kHz.

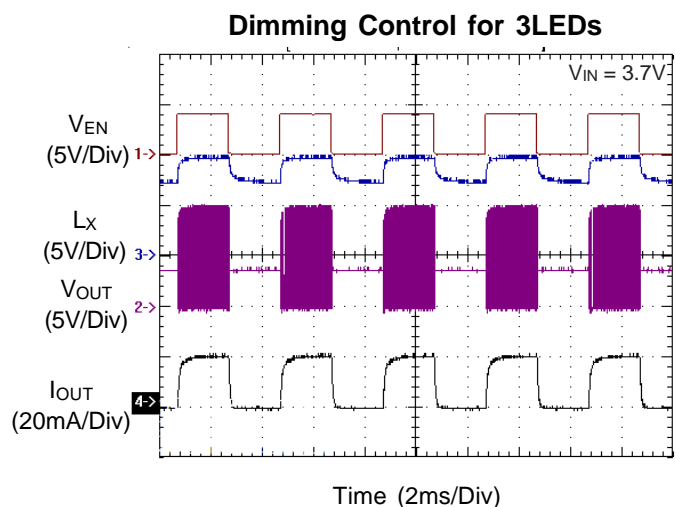


Figure 4

Channel Selection

There is one set of LC filter for RT9273 to share two channels power requirement. Each time turning on only one channel can save the power dissipation and easily extend the standby time. Selection pin is internal logic controller. SP pin is pulled low to turn on the internal channel 1 (for LED) and pulling high to turn on channel 2 (for OLED). As the input signal change, internal MOSFET of LX pin will turn off 1ms to prevent the over voltage damage by the output voltage instant change.

Logic control and application circuit for LEDs and OLED turning on simultaneously + 2 modes dimming control

To achieve LEDs and OLED turning on simultaneously, the following application circuit (Figure 5) provides the complete solution by simple logic control (Table 1).

Formula:

$$V_{OUTH} = \frac{R2 + (R8//R7)}{(R8//R7)} \times V_{FB2} ; V_{OUTL} = \frac{R2 + R7}{R7} \times V_{FB2}$$

$$I_{LEDH} = \frac{V_{FB1}}{(R5//R6)} ; I_{LEDL} = \frac{V_{FB1}}{R5}$$

$$R3 = \frac{V_{OUT} - 3V_{F(LED)}}{I_{LED}}$$

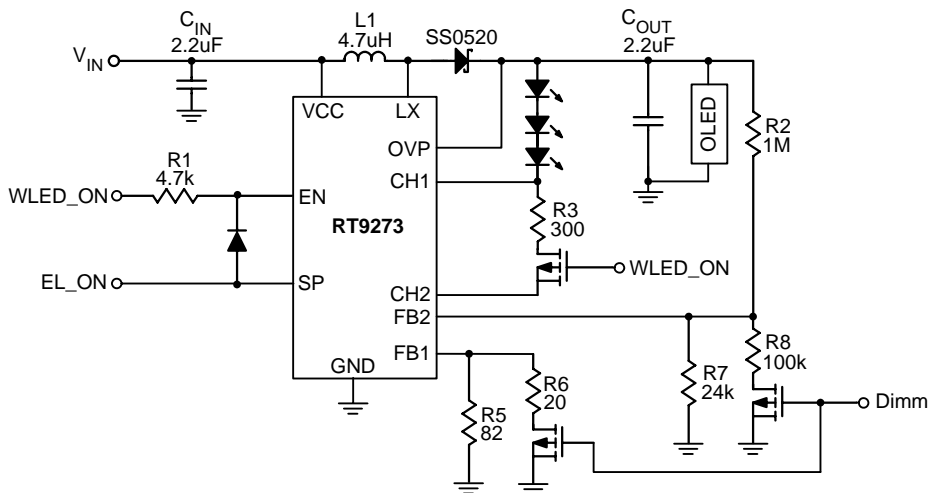


Figure 5. Application circuit for LED and OLED turning on simultaneously

Table 1. Truth table for Figure 5

	WLED_ON	EL_ON	DIMM	Function
M & S turn on simultaneously Normal	H	H	H	$V_{OUT} = 16V,$ $I_{LED} = [V_{OUT} - 3V_{F(LED)}]/R3$ mA
M & S turn on simultaneously Dimming	--	--	--	--
Main ONLY Normal	H	L	H	$V_{OUT} = 9.5V, I_{LED} = 18.5$ mA
Main ONLY Dimming	H	L	L	$V_{OUT} = 9.5V, I_{LED} = 3.6$ mA
Sub ONLY Normal	L	H	H	$V_{OUT} = 13V, I_{LED} = 0$ mA
Sub ONLY Dimming	L	H	L	$V_{OUT} = 16V, I_{LED} = 0$ mA
SHUT DOWN	L	L	Don't care	$V_{OUT} = 0V, I_{LED} = 0$ mA

Logic control and application circuit for LED and OLED turning on simultaneously + PWM dimming control for LED

To achieve LEDs and OLED turning on simultaneously, the following application circuit (Figure 6) provides another solution by simple logic control (Table 2).

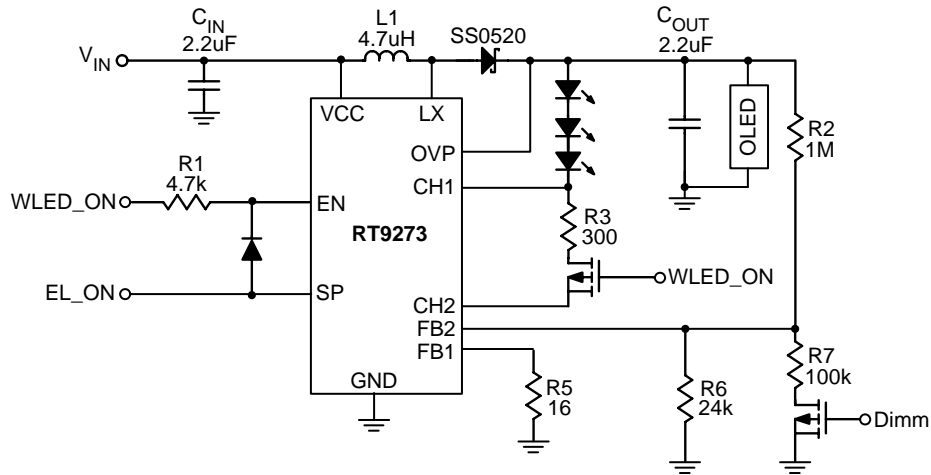


Figure 6. Application circuit for LED and OLED turning on simultaneously

Table 2. Truth table for Figure 6

	WLED_ON	EL_ON	DIMM	Function
M & S turn on simultaneously Normal	H	H	H	$V_{OUT} = 16V$, $I_{LED} = [V_{OUT} - 3V_{F(LED)}]/R3$ mA
M & S turn on simultaneously Dimming	--	--	--	--
Main ONLY Normal	H	L	H	$V_{OUT} = 9.5V$, $I_{LED} = 18.5$ mA
Main ONLY Dimming	PWM	L	H	$V_{OUT} = 9.5V$, $I_{LED} =$ depends on PWM
Sub ONLY Normal	L	H	H	$V_{OUT} = 13V$, $I_{LED} = 0$ mA
Sub ONLY Dimming	L	H	L	$V_{OUT} = 16V$, $I_{LED} = 0$ mA
SHUT DOWN	L	L	Don't care	$V_{OUT} = 0V$, $I_{LED} = 0$ mA

Logic control and application circuit for LED and OLED 2 level dimming control

Besides using a PWM signal on EN pin, using logic control can also achieve LEDs and OLED 2 modes dimming control function. The following application circuit (Figure 7) provides another solution by simple logic control (Table 3).

Formula:

$$I_{LED(MIN)} = \frac{V_{FB1}}{R4} = \frac{0.3V (typ.)}{R4}$$

$$I_{LED(MAX)} = \frac{V_{FB1}}{R4//R5} = \frac{0.3V (typ.)}{R4//R5}$$

$$V_{OLED} = \frac{R1+(R2//R3)}{(R2//R3)} \times (V_{FB} - \frac{R1//R2}{R3+(R1//R2)} Vd)$$

$V_{FB} = 0.3 (typ.)$,

If $Vd_{low} = 0V$, $Vd_{high} = 2.8V$, $V_{OLED_high} = 16.3V$, $V_{OLED_low} = 13V$.

Firstly to set $R1=100k\Omega$, and then get

$R2 = 1.92k\Omega$, $R3 = 84.85k\Omega$

Note: The recommended $R1$ value is $100k\Omega$. Choosing $R1$'s value $\leq 100k\Omega$ is proper to the application circuit.

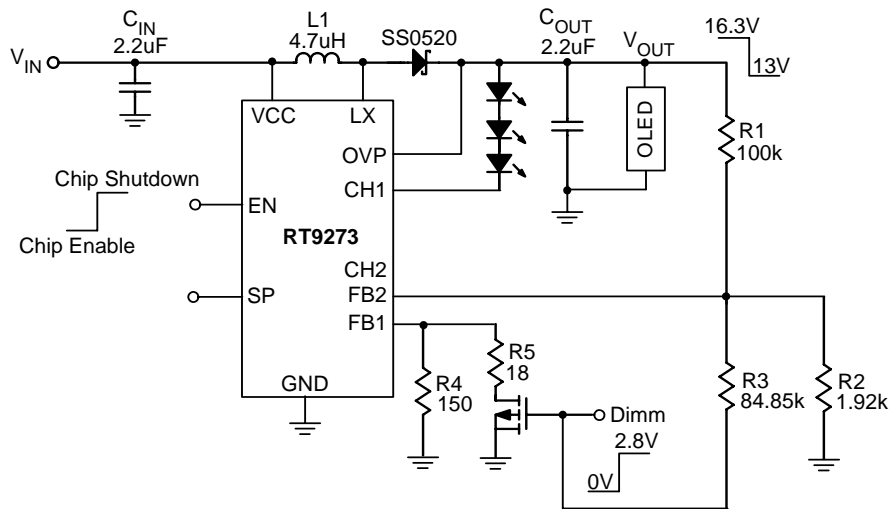


Figure 7. Application circuit for LED and OLED 2 level dimming control respective

Table 3. Truth table for Figure 7

	EN	SP	DIMM H_2.8V/ L_0V	Function
Main ONLY NORMAL	H	L	H	$I_{LED} = 18mA$
Main ONLY DIMMING	H	L	L	$I_{LED} = 2mA$
Sub ONLY NORMAL	H	H	L	$V_{OUT} = 16.3V$, $I_{LED} = 0mA$
Sub ONLY DIMMING	H	H	H	$V_{OUT} = 13V$, $I_{LED} = 0mA$
SHUT DOWN	L	Don't care	Don't care	--

Layout Guide

- A full GND plane without gap break.
- The input capacitor should be placed as close as possible to the input for good filtering.
- The switching path should be shorter to prevent EMI problems.
- The inductor and diode must be placed closely to the switch pin.
- The feedback path should be away from the inductor.
- The feedback resistor should be connected directly to the GND.

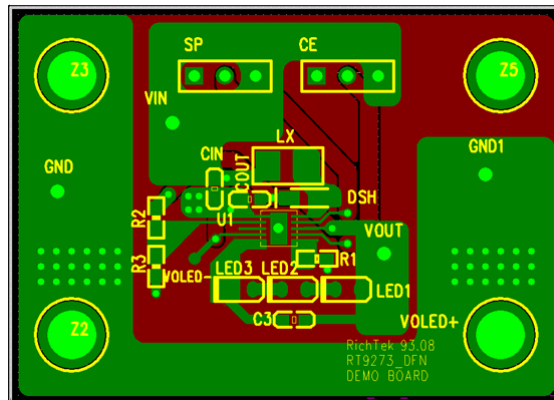


Figure 8. Top Layer

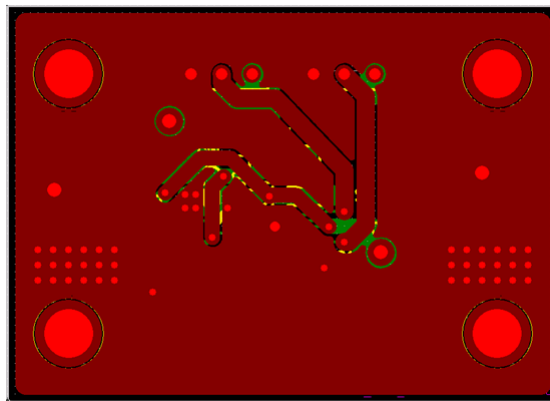
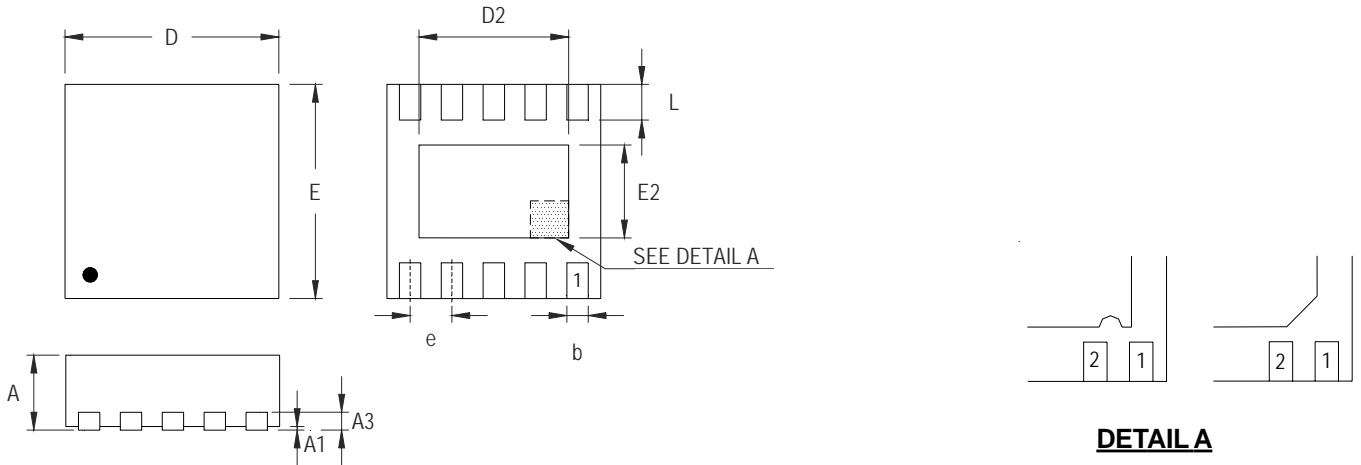


Figure 9. Bottom Layer

Outline Dimension



DETAIL A

Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.000	0.031	0.039
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.180	0.300	0.007	0.012
D	2.950	3.050	0.116	0.120
D2	2.300	2.650	0.091	0.104
E	2.950	3.050	0.116	0.120
E2	1.500	1.750	0.059	0.069
e	0.500		0.020	
L	0.350	0.450	0.014	0.018

V-Type 10L DFN 3x3 Package

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