60V/20mA Single Channel Constant Current LED Driver

Features

- 20mA constant current LED regulator
- Wide input voltage range from 4.5V to 40V
- 60V breakdown voltage
- ±3.5% LED current accuracy
- Thermal protection: Current ramp down at **65°C**

General Description

PS4500 is a single channel LED driver with constant current regulator. PS4500 offers excellent temperature stability and output current accuracy (±3.5%) with wide input voltage from 4.5V to 40V and temperature range. PS4500 implements various fixed output current versions without external current setting resistors and thus creates a simple solution for constant current LED driver. Besides, for the thermal management in LED, PS4500 is featured a current ramp down function from 65°C to 85°C of junction temperature. Moreover, taking reliability into consideration, the maximum voltage rating on VDD, VP and VN is designed as 60V ability to handle high voltage pulse suddenly. Thoughtfully, PS4500 also supports both high-side and low-side driving for the LED strings. PS4500 is bare die and die size is 426um x 745um, which is available for COB (chip on board) LED lighting application, etc.

Applications

- Constant current LED (CCLED)
- Constant current COB light engine

Simplified Application Circuit

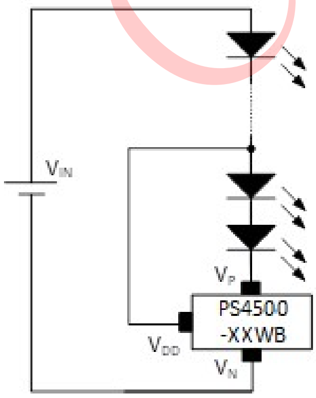
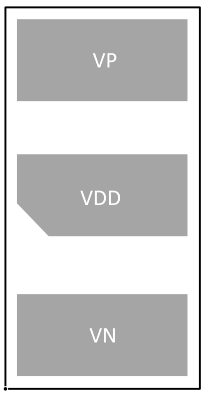


Figure 1. Single channel LED driver

Wafer and Dice Information



Wafer thickness: 29mil / 6 inches

Die size: 426um x 745um

Scribe line: 80um

Substrate: P-Sub

Substrate potential: Same as VN pin or floating

Main material of solder/bond pad: Ag

Pad structure: Circuit under pad

Figure 2. Bare chip top view

Contents

1 Ordering Information

PS4500-□□WB

WB: Wafer Business

20: IOUT= 20mA

Note: Green Product (RoHS compliant)

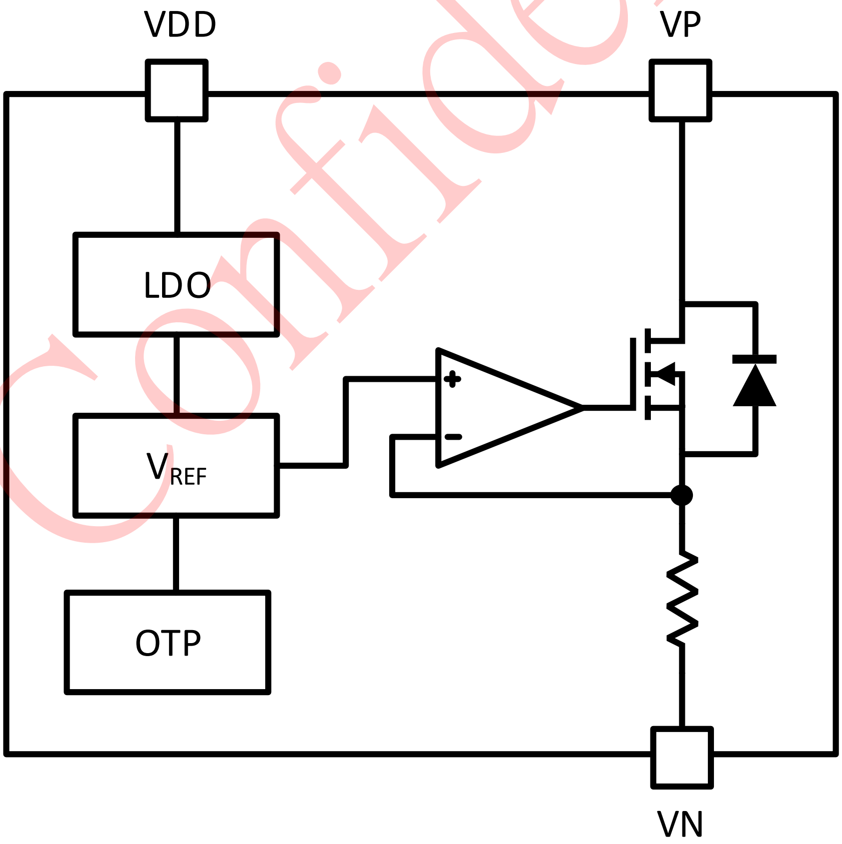
For meeting the world-wide customer requirements for environmentally friendly products and government regulations, the device is available as a green product. Green products are RoHS-Compliant
(i.e Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020)

2 Pin Definitions and Functions

Pin	Name	I/O(1)	Description
1	VP	I	Output current regulated pin. Output current flows through this pin and regulated.
2	VDD	I	Supply voltage.
3	VN	--	Chip ground.

(1) I= Input, O= Output, --= Other

3 Functional Block Diagram



4 Absolute Maximum Ratings (Note 1)

Condition	Value	Unit
VDD	-0.3 to 60	V
VP	-0.3 to 60	V
VN	-0.3 to 60	V
Junction Temperature	150	°C

Note 1: Stresses above the ones listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

5 Recommended Operating Conditions (Note 2)

Item	Value	Unit
VDD, VP	4.5 to 40	V
Junction Temperature Range	-40 to 65	°C

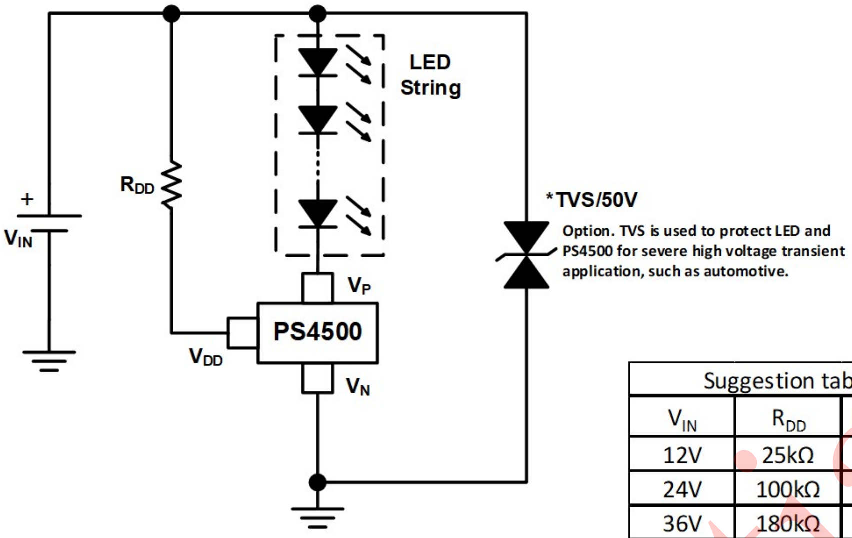
Note 2: Device function is not guaranteed if it is operated out of this range.

6 Electrical Characteristic

(V_{DD}= 7V, T_A = 25°C unless otherwise specified)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Supply voltage	V_{DD}	$I_{PN} \leqq$ 20mA	4.5	--	40	V
Supply current	I_{DD}	4.5V $\leqq V_{DD} \leqq$ 40V I_{PN}= 20mA	0.06	0.16	0.22	mA
Minimum dropout voltage	V_{PNmin}	V_{DD} > 7V, I_{PN}= 90%I_S	0.15	--	0.3	V
Output current	I_S	V_{DD}= 7V	--	20	--	mA
Output current accuracy	I_{Skew}	T_A= 25°C, V_{DD}= 7V	-3.5	--	3.5	%
Output current accuracy vs temperature	$I_{Skew,T}$	T_J= -40°C~60°C	-3	--	3	%
Current ramp down temperature	T_{J_down}	$I_{PN} \leqq$ 90%I_S	--	65	--	°C
Shutdown temperature	T_{J_shtdn}	$I_{PN} \leqq$ 10%I_S	--	85	--	°C
Output current accuracy vs VDD	$I_{Skew,VDD}$	V_{DD}= 7V to 40V, V_{PN}= 1V	-1.5	--	1.5	%
Output current accuracy vs VPN	$I_{Skew,VPN}$	V_{PN}= 0.3V to 40V V_{DD}= 7V	-1	--	1	%

7 Typical Application Circuit



Suggestion table		
V_{IN}	R_{DD}	LEDs (EA)
12V	25kΩ	3
24V	100kΩ	7
36V	180kΩ	11
48V	260kΩ	15

Figure 3. General DC power LED drive (Option 1).

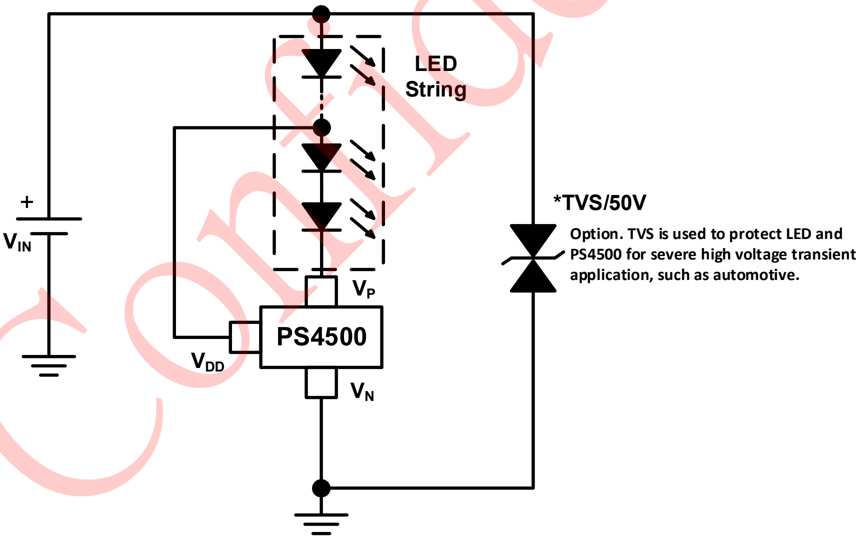
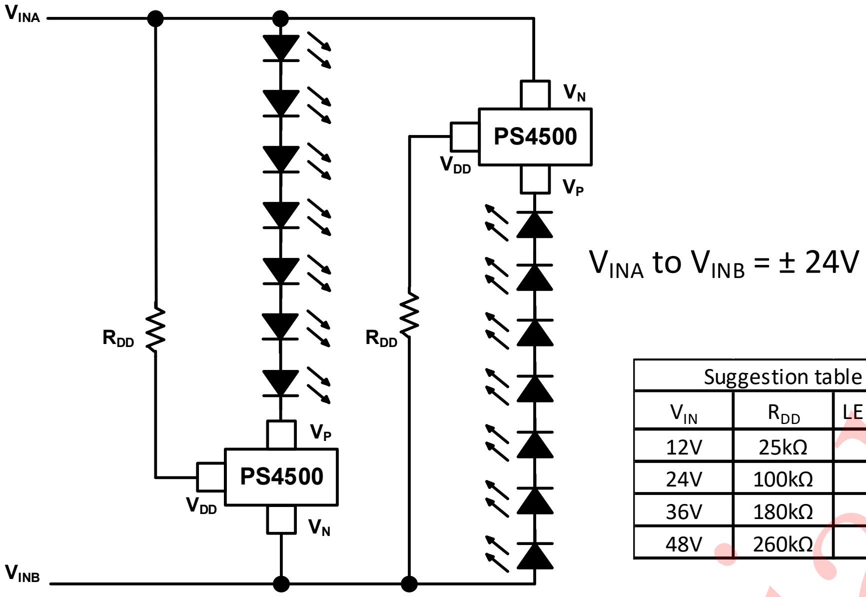


Figure 4. General DC power LED drive (Option 2).



Suggestion table		
V_{IN}	R_{DD}	LEDs (EA)
12V	25kΩ	3
24V	100kΩ	7
36V	180kΩ	11
48V	260kΩ	15

Figure 5. Dual color lighting application (Bi-direction power supply Option 1).

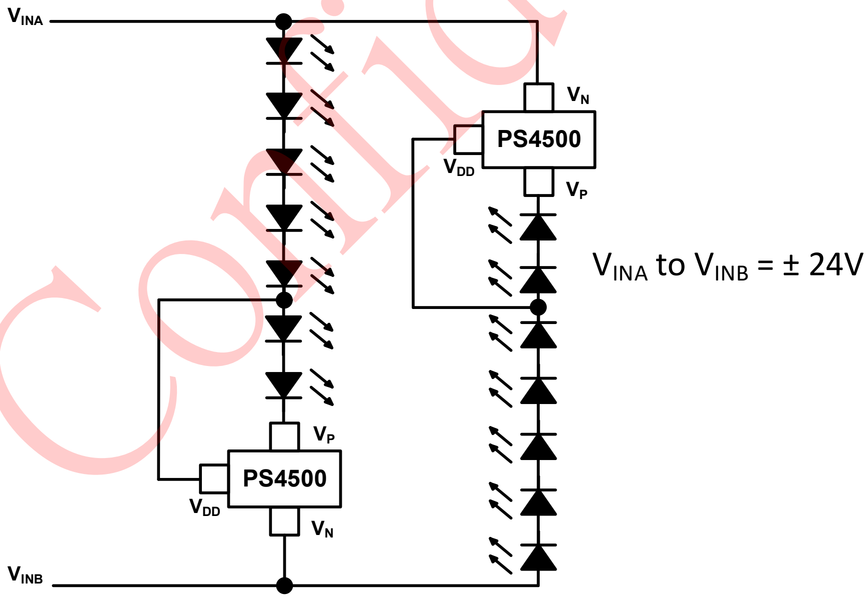


Figure 6. Dual color lighting application (Bi-direction power supply Option 2).

8 Typical Operating Characteristics

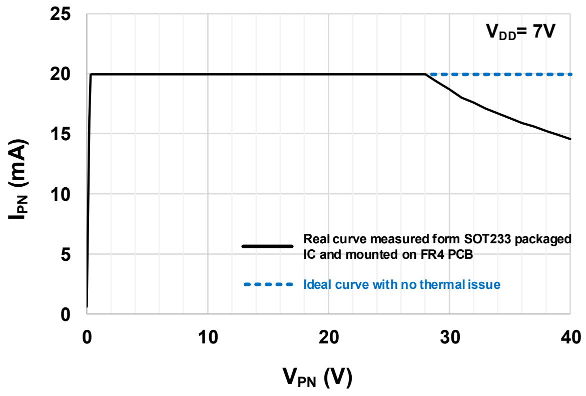


Figure 7. Load regulation, I_{PN} vs V_{PN}

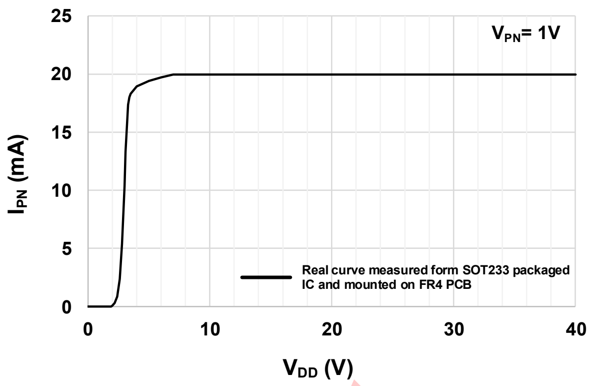


Figure 8. Line regulation, I_{PN} vs V_{DD}

9 Application Information

The PS4500 is a Constant Current Regulator (CCR) for LED driver and provides two kinds of driving method for LED, high-side driver and low-side driver. CCR is achieved by adjusting the internal self-biased transistor to regulate the current through PS4500 or any devices in series with it. Besides, as operating temperature rising, PS4500 features a thermal protection function to protect LEDs through reducing operating current if junction temperature of PS4500 is above 65°C.

9.1 Single LED String

PS4500 can be placed for high-side or low-side driver for LED as shown in Figure 9. The number of the LEDs is limited by the voltage across the V_{PN} of PS4500. Hence, the designed must estimate the maximum and minimum voltage across the V_{PN} by taking the maximum input voltage less the voltage across the LED string.

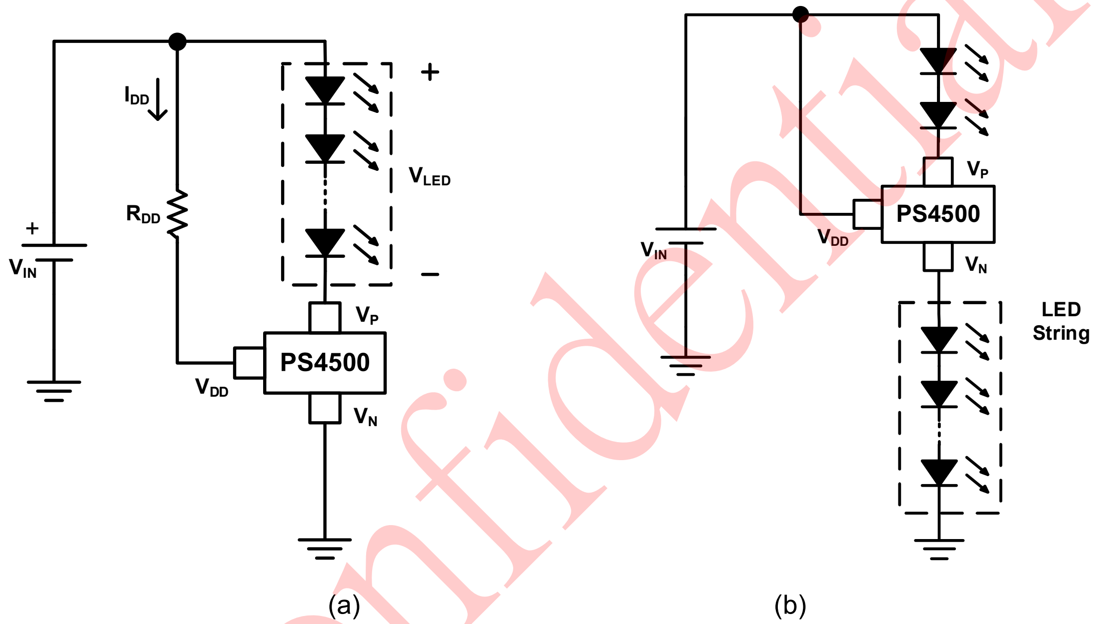


Figure 9. (a) Low-side LED Driver (b) High-side LED Driver

As PS4500 used for low-side LED driver referred to Figure 9 (a), the minimum input voltage $V_{IN(min)}$ has to be larger than $V_{LED}+V_{PNmin}$ or $I_{DD} \cdot R_{DD}$+4.5V which depends on the LED string voltage. The equation is as follows:

If $V_{LED} > I_{DD} \cdot R_{DD} + 4.5 - V_{PNmin}$

$$V_{IN(\min)} = V_{LED} + V_{PNmin} \quad (1)$$

If $V_{LED} < I_{DD} \cdot R_{DD} + 4.5 - V_{PNmin}$

$$V_{IN(\min)} = I_{DD} \cdot R_{DD} + 4.5 \quad (2)$$

For high-side LED driver referred to Figure 9 (b), the minimum input voltage $V_{IN(min)}$ is as follows:

$$V_{IN(\min)} = V_{PNmin} + V_{LED} \quad (3)$$

9.2 Higher Current LED Strings

For higher LED current demand, two or more PS4500 can be connected in parallel to increase the LED current as shown in Figure 10.

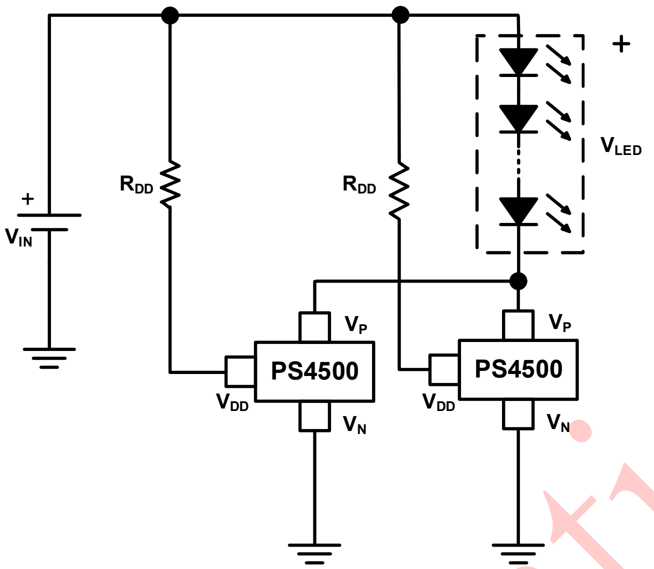


Figure 10. High current application.

9.3 Thermal Protection: LED Current Ramp Down

For protecting LED under high temperature application, LED current is decreased automatically while PS4500's junction temperature is over 65°C. Besides, if PS4500's junction temperature approaches 85°C, LED current remains around 10%. Along with temperature reducing, the LED current is recovery when junction temperature is below 65°C.

9.4 Power Dissipation

The power dissipation can be determined from the regulated current I_S multiplying the voltage across the V_{PN} that is the supply voltage on V_P to substrate the voltage across the LED string V_{LED}.

$V_{PN} = V_{IN} - V_{LED}$ .... (3)

$P_D = I_S \times V_{PN}$ .... (4)

As the power requirement of LED is increased, the power dissipation should be considered for thermal relief. The maximum power dissipation supported by the device is dependent on PCB layout design, PCB material and operating ambient temperature. Further, the maximum power dissipation before current ramp down function triggering is given by:

$P_{D(max)} = \frac{60-T_A}{R_{\theta JA}}$, where $R_{\theta JA} = 245°C/W$ .... (5)

9.5 PWM Dimming

The LED dimming can be easily achieved by placing an external MOSFET in series with PS4500 and the dimming effect can be achieved by adjusting the PWM duty cycle, as shown in Figure 11. Besides, duty cycle is expressed as below and that is a ration of LED turn-on time (T_{ON}) dividing the total time of an on/off cycle (T) which is shown in Figure 12, and Figure 13 shows the current accuracy with different duty cycle.

$$D = \frac{T_{ON}}{T_{ON}+T_{OFF}} = \frac{T_{ON}}{T} \quad (6)$$

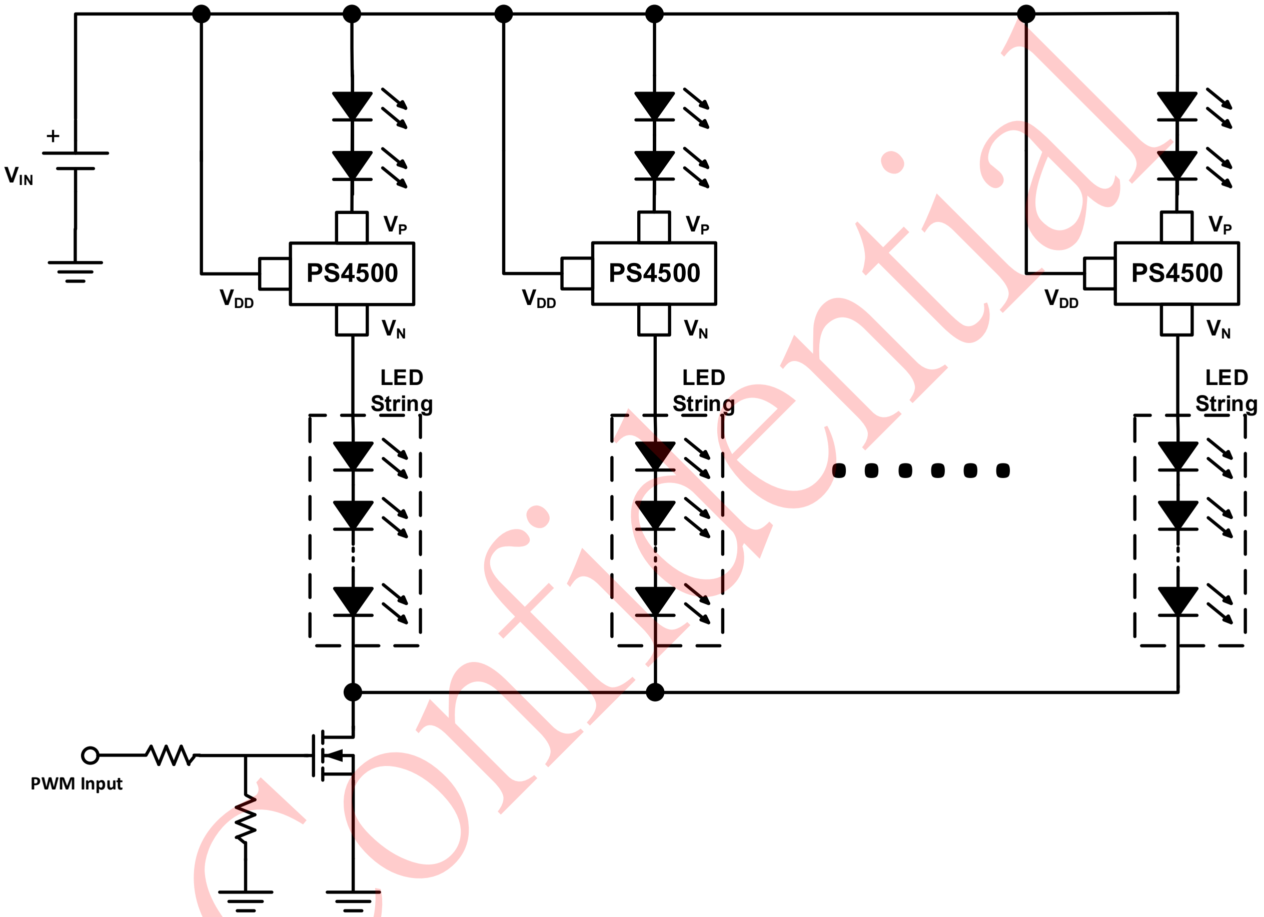


Figure 11. LED strings PWM dimming by external MOSFET

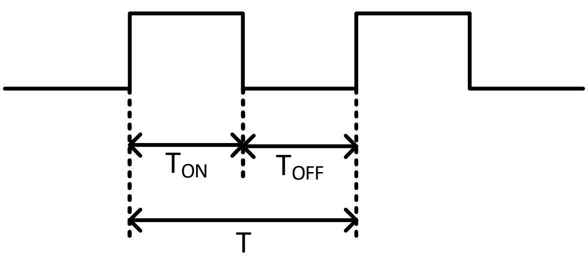


Figure 12. PWM dimming signal

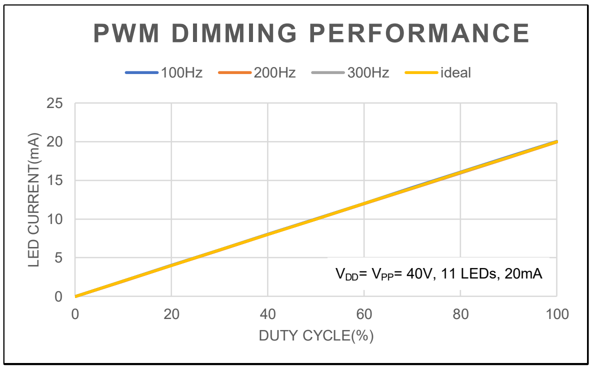


Figure 13. Current accuracy vs PWM dimming

9.6 PCB design considerations for flip chip application

When integrating the PS4500 as a flip chip application, the major ingredient of the three pads on the PS4500 surface is silver. These silver pads can be soldered to the copper paths on the PCB using tin (solder). Figure 14 shows the cross-section of how the PS4500 is soldered to the PCB.

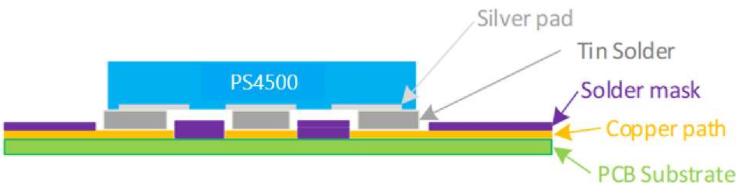


Figure 14. Cross section of PS4500 on PCB.

Figure 15 (a) shows the recommend foot print design of PS4500. Figure 15 (c) shows the flipped PS4500 dice. Figure 15 (b) shows the flipped PS4500 which is placed on PCB. For good thermal management, the larger VP and VN copper path area, the better heat dissipation capability.

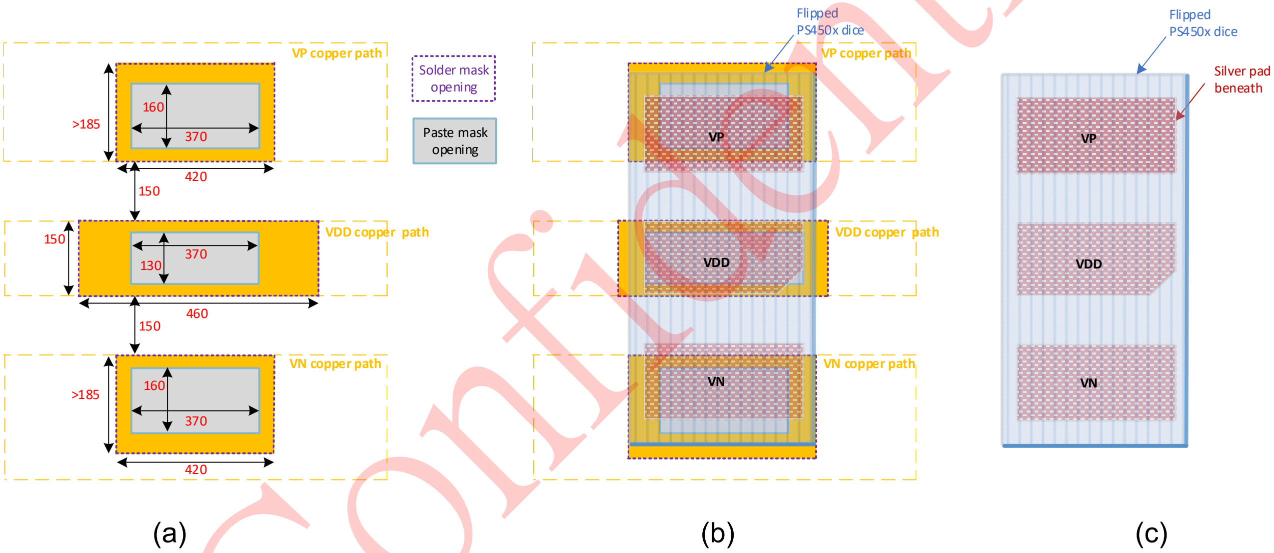
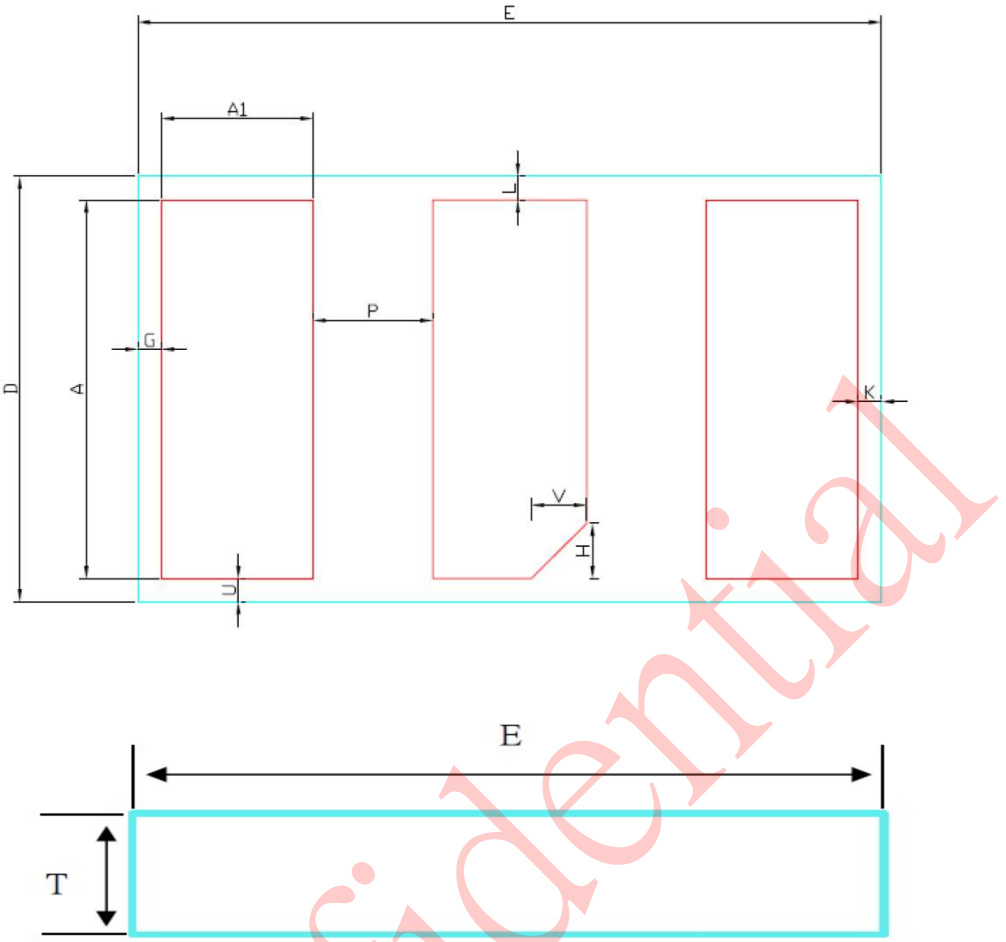


Figure 15. PS4500 foot print for flip chip applications

10 Outline Dimension



Note3: Die thickness(T)

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.389	0.409	0.0153	0.0161
A1	0.157	0.177	0.0062	0.0070
D	0.456	0.476	0.0180	0.0187
E	0.775	0.795	0.0305	0.0313
P	0.102	0.122	0.0040	0.0048
G	0.0235	0.0435	0.0009	0.0017
U	0.0235	0.0435	0.0009	0.0017
K	0.0235	0.0435	0.0009	0.0017
L	0.0235	0.0435	0.0009	0.0017
H	0.06	0.08	0.0024	0.0031
V	0.06	0.08	0.0024	0.0031
T	0.19	0.21	0.0075	0.0083

11 Flip chip application notice

1. The recommended dice thickness is 200um. (Wafer back side grinding thickness: 200um)
2. Step cut in wafer dicing process. It is recommended that the width of the first saw blade is 40um, sawing depth is about 1/2 wafer thickness and sawing speed is about 10 to 15 mm/sec. The second saw blade is 30um wide, and saw it off.
3. The recommended solder thickness is about 50um to 60um and the solder mask opening area is about 70% of the pad area.
4. When the PS4500 bare die is exposed to bright light, the driving current may drift. It works better if the bare die is covered with an opaque material or mechanical structure to keep light out.

12 Restrictions on product use

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