60V/20mA~300mA Single Channel Constant Current LED Driver

Features

- 20mA~300mA constant current LED regulator
- Wide input voltage range
  - Output<80mA: 4.5V to 40V
  - Output>80mA: 7V to 40V
- 60V breakdown voltage
- ±4.5% LED current accuracy
- Thermal protection: Current ramp down at 125°C
- RoHS Compliant and Halogen Free

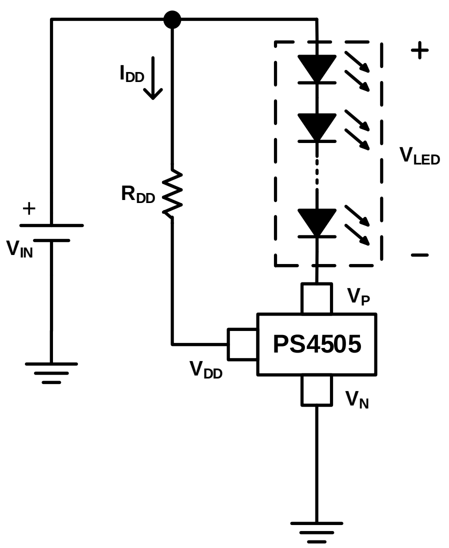
General Description

PS4505 is a single channel LED driver with constant current sink function. PS4505 has excellent temperature stability and output current accuracy (±4.5%) over a wide input voltage from 4.5V to 40V. PS4505 implements various fixed output current versions without the need for external current setting resistors, creating a simple solution for driving LEDs. Besides, for the thermal management in LED, PS4505 is featured a current ramp down function from 125°C to 145°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. PS4505 is available in the cost-effective packages SOT-23-3 or SOT-89-3.

Applications

- General LED lighting
- Constant current COB light engine
- Plant and animal growth lighting

Simplified Application Circuit

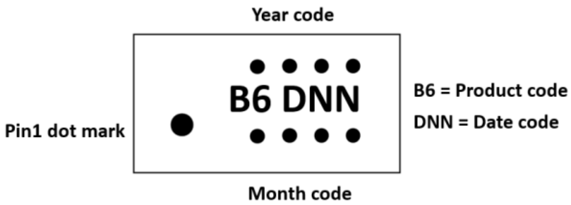


Contents

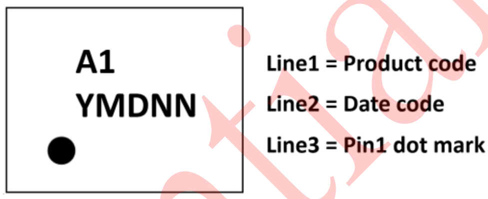
1 Ordering Information

Part Number	Package	Output current	Product Code
PS4505-020S1	SOT-23-3	20mA	A1
PS4505-120S5	SOT-89-3	120mA	A1
PS4505-150S5	SOT-89-3	150mA	B1
PS4505-200S5	SOT-89-3	200mA	B3
PS4505-220S5	SOT-89-3	220mA	B4
PS4505-250S5	SOT-89-3	250mA	B5
PS4505-300S5	SOT-89-3	300mA	B2

2 Marking Information



SOT-23-3



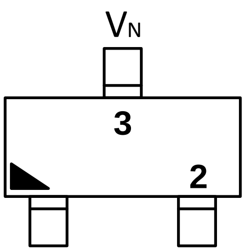
SOT-89-3

3 Pinout and Functions

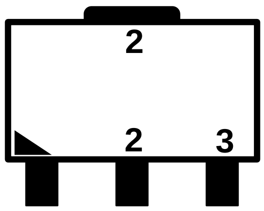
PIN			I/O[1]	Description
SOT-23-3	SOT-89-3	NAME		
1	1	VP	I	Output current regulated pin. Output current flows through this pin and regulated.
2	3	VDD	I	Supply voltage.
3	2	VN	--	Chip ground pin.

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

Top View

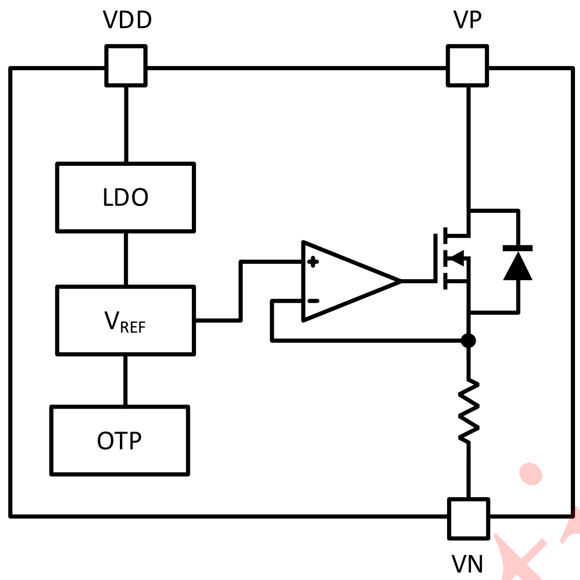


SOT-23-3



SOT-89-3

4 Functional Block Diagram



5 Absolute Maximum Ratings (1)

Condition	MIN	MAX	Unit
VDD to VN	-0.3	60	V
VP to VN	-0.3	60	
Operating Junction Temperature	-40	150	°C
Storage Temperature Range	-65	150	

6 Thermal Information (2)

SOT-23-3 Package Thermal Resistance		Unit
Junction to board thermal resistance (θ_{JA})	245	°C/W
Junction to case thermal resistance (θ_{JC})	33	

SOT-89-3 Package Thermal Resistance		Unit
Junction to board thermal resistance (θ_{JA})	168	°C/W
Junction to case thermal resistance (θ_{JC})	20	

7 Power Dissipation

Item	Value	Unit
P_D@TA=25°C (SOT-23-3)	0.41	W
P_D@TA=25°C (SOT-89-3)	0.60	W

8 Recommended Operating Conditions (3)

Item	Value	Unit
VDD	4.5/7 to 40	V
VP	4.5/7 to 40	V
Operating Junction Temperature	-40 to 125	°C

(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.

(2) θ_{JA} is measured under natural convection (still air) at T_A = 25°C with the component mounted on a high effective-thermal conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard. θ_{JC} is measured at the exposed pad of the package.

(3) Device function is not guaranteed if it is operated out of this recommended range.

9 Electrical Characteristic

(V_{DD}= 7V, V_N= 0V, T_A= 25°C unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
SUPPLY VOLTAGE & CURRENT						
Supply voltage	V_{DD}	I_{PN} < 80mA	4.5	--	40	V
		I_{PN} > 80mA	7	--	40	
Supply current	I_{DD}	4.5V ≦ V_{DD} ≦ 40V, I_S ≦ 250mA	0.06	0.16	0.22	mA
		7V ≦ V_{DD} ≦ 40V, I_S>250mA	0.12	0.32	0.44	
OUTPUT VOLTAGE & CURRENT & ACCURACY & LEAKAGE						
Output current accuracy	I_{ACY}	T_A= 25°C, V_{DD}= 7V	-4.5	--	4.5	%
Output current accuracy vs temperature	$I_{ACY,T}$	T_J= -40°C~120°C	-3	--	3	%
Output current accuracy vs VDD	$I_{ACY,VDD}$	V_{DD}= 7V to 40V, V_{PN}= 1V	-1.5	--	1.5	%
Output current accuracy vs VPN	$I_{ACY,VPN}$	V_{PN}= 0.3V to 40V, V_{DD}= 7V	-1.5	--	1.5	%
Output current	I_S	V_{DD}= 7V	20	--	300	mA
DROPOUT VOLTAGE						
Minimum dropout voltage	V_{PN_Min}	V_{DD} > 7V, I_S=20mA, I_{PN}= 90%I_S	--	0.25	0.3	V
		V_{DD} > 7V, I_S≧80mA, I_{PN}= 90%I_S	--	0.8	1	
CURRENT CRAMP DOWN & THERMAL PROTECT						
Current ramp down temperature	T_{J_down}	I_{PN} ≦ 90%I_S	--	125	--	°C
Shutdown temperature	T_{J_shtdn}	I_{PN} ≦ 10%I_S	--	145	--	°C

10 Typical Application Circuit

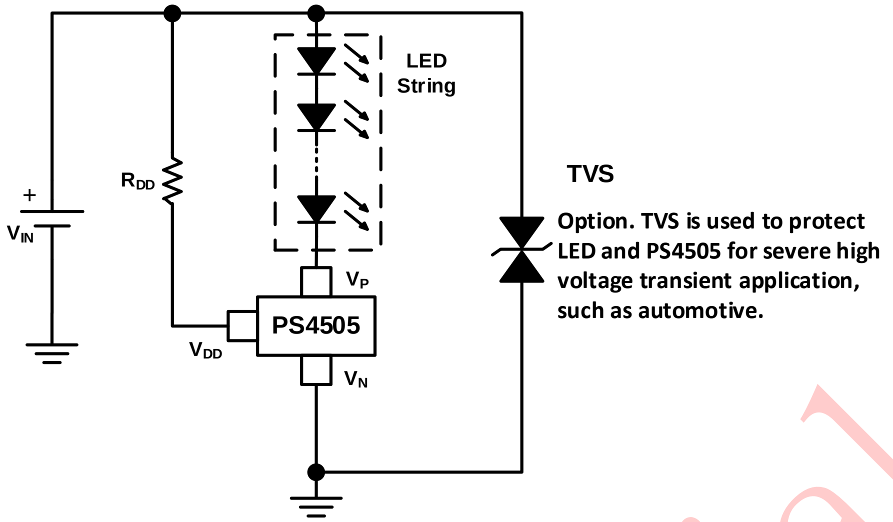


Figure 1. General DC power LED drive (Option 1).

R_{DD} suggestion table

V_{IN}	LEDs (EA)	R_{DD} (I_{PN} < 300mA)	R_{DD} (I_{PN} ≧ 300mA)
12V	3	24kΩ	12kΩ
24V	7	100kΩ	47kΩ
36V	11	180kΩ	91kΩ
48V	15	270kΩ	130kΩ

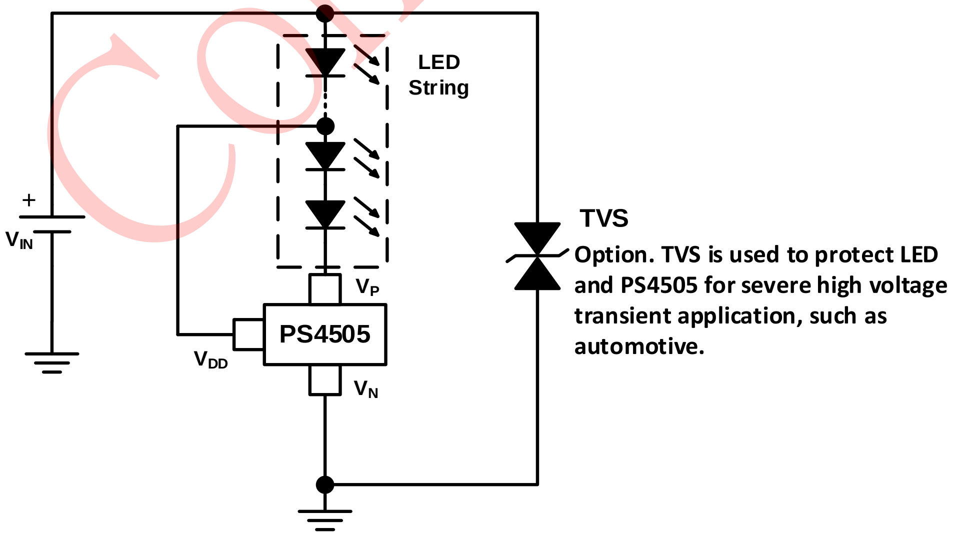


Figure 2. General DC power LED drive (Option 2).

11 Typical Characteristics

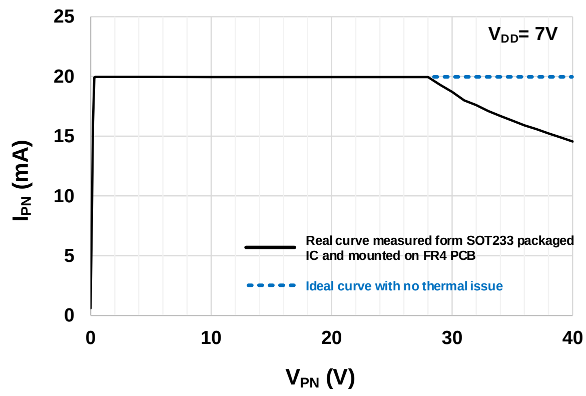


Figure 3. Load regulation, I_{PN} vs V_{PN}

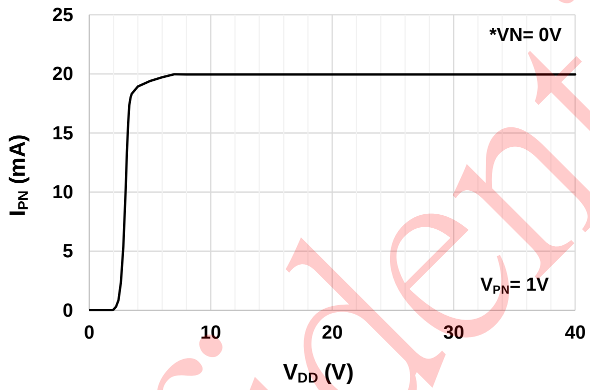


Figure 4. Line regulation, I_{PN} vs V_{DD}

12 Application Information

The PS4505 is a Constant Current Regulator (CCR) for LED driver. It is achieved by adjusting the internal self-biased transistor to regulate the current through PS4505 or any devices in series with it. Besides, as operating temperature rising, PS4505 features a thermal protection function to protect LEDs through reducing operating current if junction temperature of PS4505 is above 125°C.

12.1 Single LED String

PS4505 can be placed in a series of LEDs string, as shown in figure 5. The number of the LEDs is limited by the V_{IN} supply voltage and V_{PN} voltage across the PS4505. Hence, the design must estimate the voltage across the LEDs and PS4505 by taking the minimum input voltage greater than the sum of maximum voltage across the LED string and minimum V_{PN} drop out.

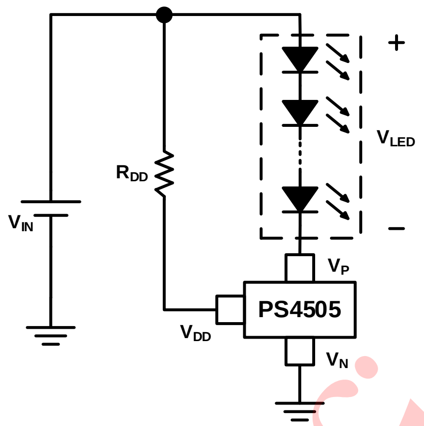


Figure 5. General LED driving application

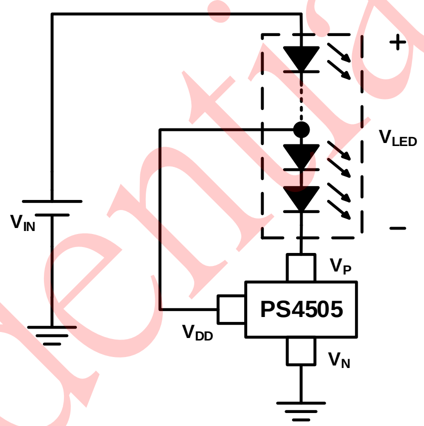


Figure 6. Self-bias LED driving application

Figure 5 is a general LED driving method. the minimum input voltage $V_{IN(min)}$ has to be higher than V_{LED}+V_{PN} or $I_{DD} \cdot R_{DD}$+7V. Resistor R_{DD} is used to protect the V_{DD} pin from damage due to fast V_{IN} transitions, such as hot plug of V_{IN} power or unexpected high spikes from power line. The equation is as follows:

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

$$R_{DD} \leq \frac{V_{IN}-7V}{I_{DD(max)}} \quad (2)$$

Figure 6 shows another way to driving LEDs. In this way, the self-bias V_{DD} voltage of PS4505 is equal to the total V_F voltage of LEDs between V_{DD} and V_P pin plus $V_{PN(min)}$ voltage. This V_{DD} voltage should be approximately above 7V. Generally, 2 white LEDs or 3 red LEDs between V_{DD} and V_P pin are sufficient for this application.

Note: If output current I_S is lower than 80mA, the V_{DD_Min} is 4.5V. If output current I_S is greater than 80mA, V_{DD_Min} is 7V.

12.2 Higher Current LED Strings

For higher LED current demand, two or more PS4505 can be connected in parallel to increase the LED current as shown in figure 7.

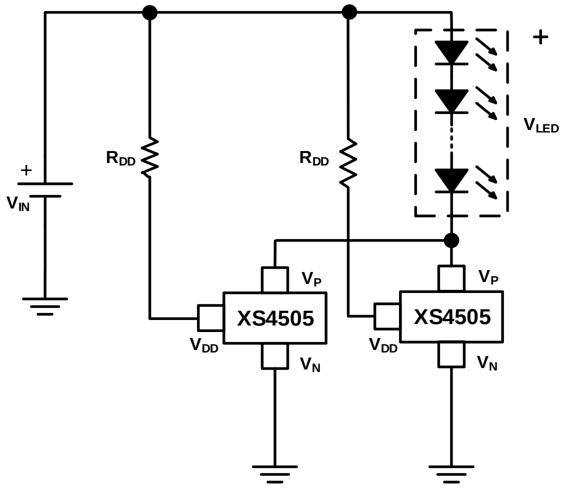


Figure 7. High current application.

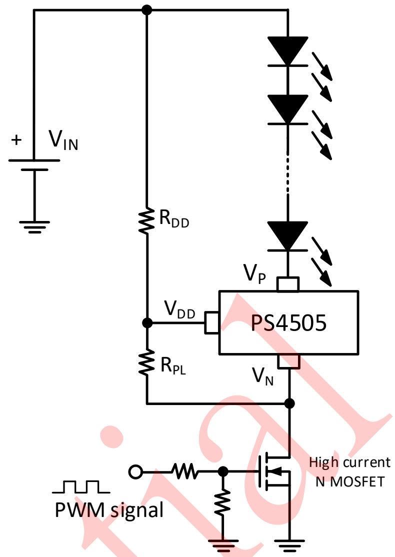


Figure 8.PWM dimming by external MOSFET

12.3 PWM Dimming

Figure 8 is the best PWM dimming application circuit. To achieve LED dimming in an LED driving circuit with the PS4505, you can use a MOSFET to switch the power supply. The brightness is controlled by the duty cycle of a PWM (Pulse Width Modulation) signal. Resistor R_{DD} and R_{PL} act as a voltage divider to generate the proper V_{DD} voltage for PS4505 and discharge the residual charge on power line while the switch MOSFET is off. To discharge the residual charge is important because it will cause instability in dimming control, resulting in flickering or inconsistent brightness. The duty cycle of the PWM signal is defined as the ratio of the LED on time (T_{ON}) to the entire cycle time (T). The duty cycle of the PWM signal is shown in figure 9. Figure 10 shows the current accuracy with different duty cycle.

$$Duty = \frac{T_{ON}}{T_{ON}+T_{OFF}} = \frac{T_{ON}}{T} \quad \text{......} \quad (3)$$

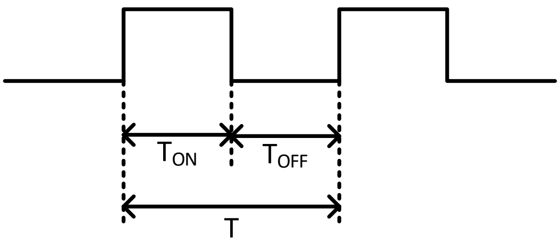


Figure 9. PWM dimming signal

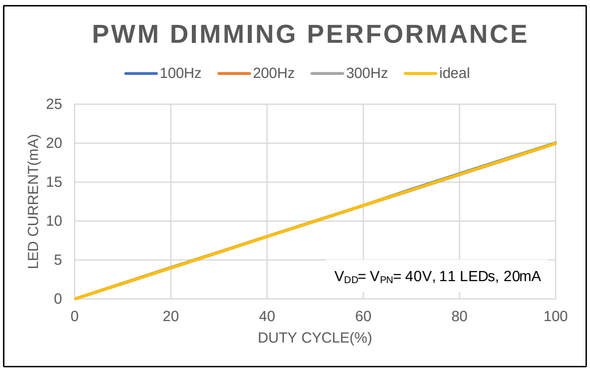


Figure 10. Current accuracy vs PWM dimming

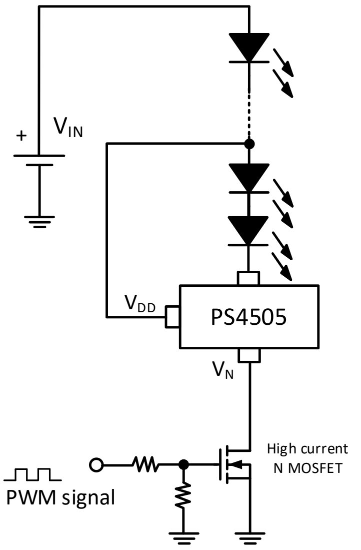


Figure 11. High current application.

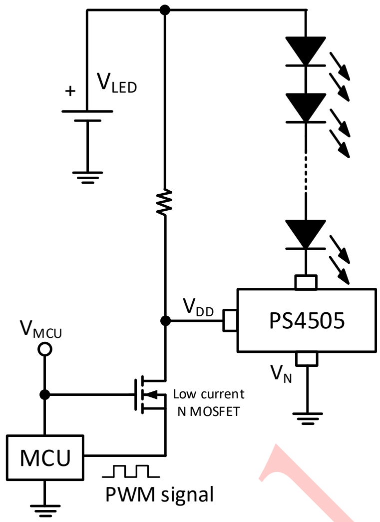


Figure 12.PWM dimming by external MOSFET

Figure 11 shows the self-bias dimming circuit. The advantage is no need of resister for PS4505 biasing. In many compact LED applications this will mostly reduce the procedure of production. The disadvantage is the PWM dimming frequency should be lower. It is suggested the frequency should be lower than 1KHz to get better dimming control. Both switch N MOSFETs in figure 8 and figure 11 are to switch the total power of LED loads, so it should have lower R_{DS} resistance and lager power dissipation capability to minimize the power lost and heat generation. In contrast to those two circuits, figure 12 provides alternative way to control the V_{DD} of PS4505 by using a small, low power N MOSFET. This MOS can resist the higher PS4505 V_{DD} voltage from V_{LED} or cut off this voltage while MCU outputs a low voltage.

12.4 Thermal Protection: LED Current Ramp Down

For protecting LED under high temperature application, LED current is decreased automatically while PS4505's junction temperature is over 125°C. If PS4505's junction temperature approaches 145°C, LED current remains below 10%. As the temperature decreases, the LED current will recover when the junction temperature is below 125°C.

12.5 Power Dissipation Considerations

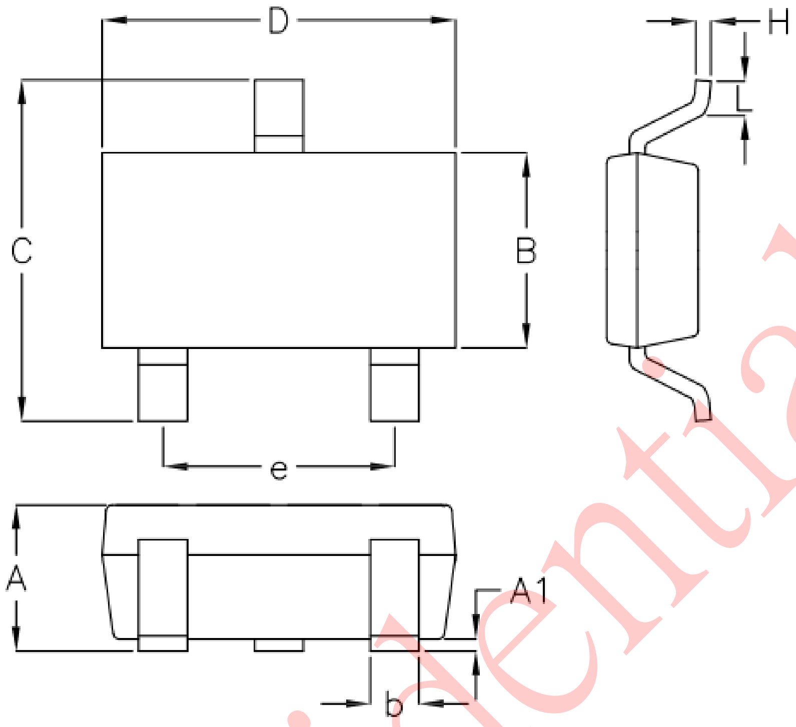
PS4505 is indeed a linear constant current driver, and managing the heat it generates is important for ensuring its reliability and performance. The power consumption of PS4505 can be calculated using the formula:

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

$$P_D = I_{PN} \times V_{PN} \quad (4)$$

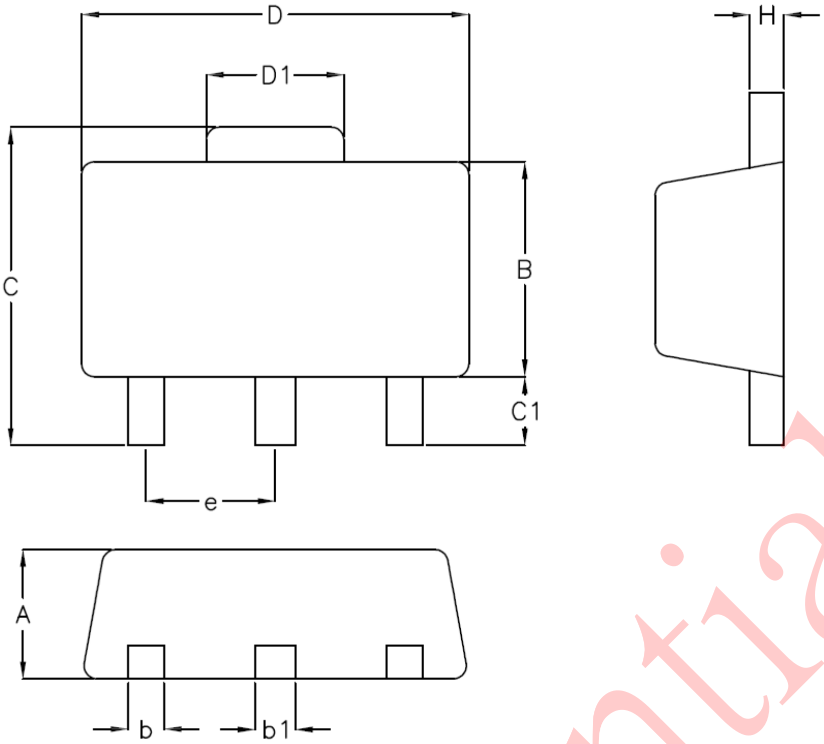
Where I_{PN} is the regulated current, V_{PN} is the voltage across the device. From circuit design perspective, first, optimizing the voltage across the device is crucial for improving system efficiency and reducing heat generation. Such as selecting LEDs with a forward voltage that best matches supply voltage, or carefully selecting or designing the power supply to provide a voltage that matches the LED string's needs without excessive headroom. Secondly, for higher current applications, using multiple low current drivers in parallel can spread the heat generation and avoid OTP protection. Third, implement proper thermal management, such as heat sinks or improved airflow.

13 Package Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.356	0.508	0.014	0.020
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	1.803	2.007	0.071	0.079
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

SOT-23-3 Surface Mount Package



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.397	1.600	0.055	0.063
b	0.356	0.483	0.014	0.019
B	2.388	2.591	0.094	0.102
b1	0.406	0.533	0.016	0.021
C	3.937	4.242	0.155	0.167
C1	0.787	1.194	0.031	0.047
D	4.394	4.597	0.173	0.181
D1	1.397	1.753	0.055	0.069
e	1.448	1.549	0.057	0.061
H	0.356	0.432	0.014	0.017

SOT-89-3 Surface Mount Package

14 Restrictions on product use

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