40V, 120mA Single Channel Linear LED Driver

Features

- Adjustable output current LED driver
- Support digital and analog dimming control
- Maximum 120mA output current regulator
- Wide supply voltage ranges from 4.5V to 40V
- ±4% output current accuracy
- Low quiescent current
- Thermal protect: Current ramp down 3.3%/℃
- RoHS Compliant and Halogen Free

General Description

PS4508 is a single channel LED driver with adjustable output current. The output current typically ranges from 10mA to 120mA through external current setting resistor (REXT pin). To achieve no flick feature with analog dimming control, the set output current is linearly controlled by dimming control (PDIM pin) ranging from 0.25V to 3V. However, digital dimming control is obtained by giving PWM signal to dimming control (PDIM pin).

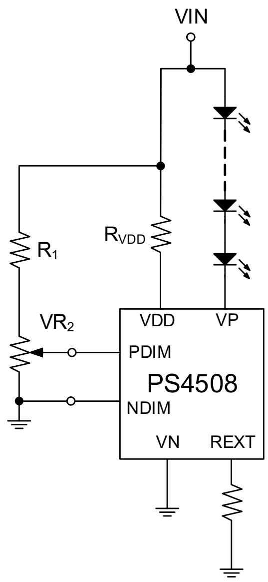
PS4508 offers excellent output current accuracy with supply voltage (VDD pin) from 4.5V to 40V and output voltage (V_{PN}) up to 40V. PS4508 is featured a thermal protection by output current ramp down (3.3%/℃) as junction temperature is located from 130℃ to 150℃. Moreover, taking reliability into consideration, the absolute maximum voltage rating (AMR) on VDD and OUT is designed as 45V ability to handle high voltage pulse suddenly.

PS4508 is available in the cost-effective package SOT-23-6.

Applications

- Bus/Train walk way lighting
- Indoor healthy lighting
- Class room lighting
- RGB pixel light bar

Basic Application Circuit



Contents

1 Ordering Information

Part no.	Package	Description	Pin1 Orientation Follow EIA-481-D	Product code
PS4508S3	S3: SOT-23-6	40V, 120mA Single Channel High Power Linear LED Driver	_1: Quadrant 3	A2

2 Marking Information

SOT-23-6

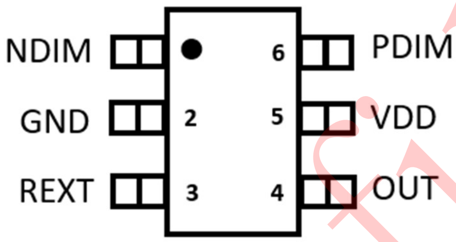
A2: Product Code
DNN: Date Code

3 Device Information

3.1 Pinout

Top View

SOT-23-6



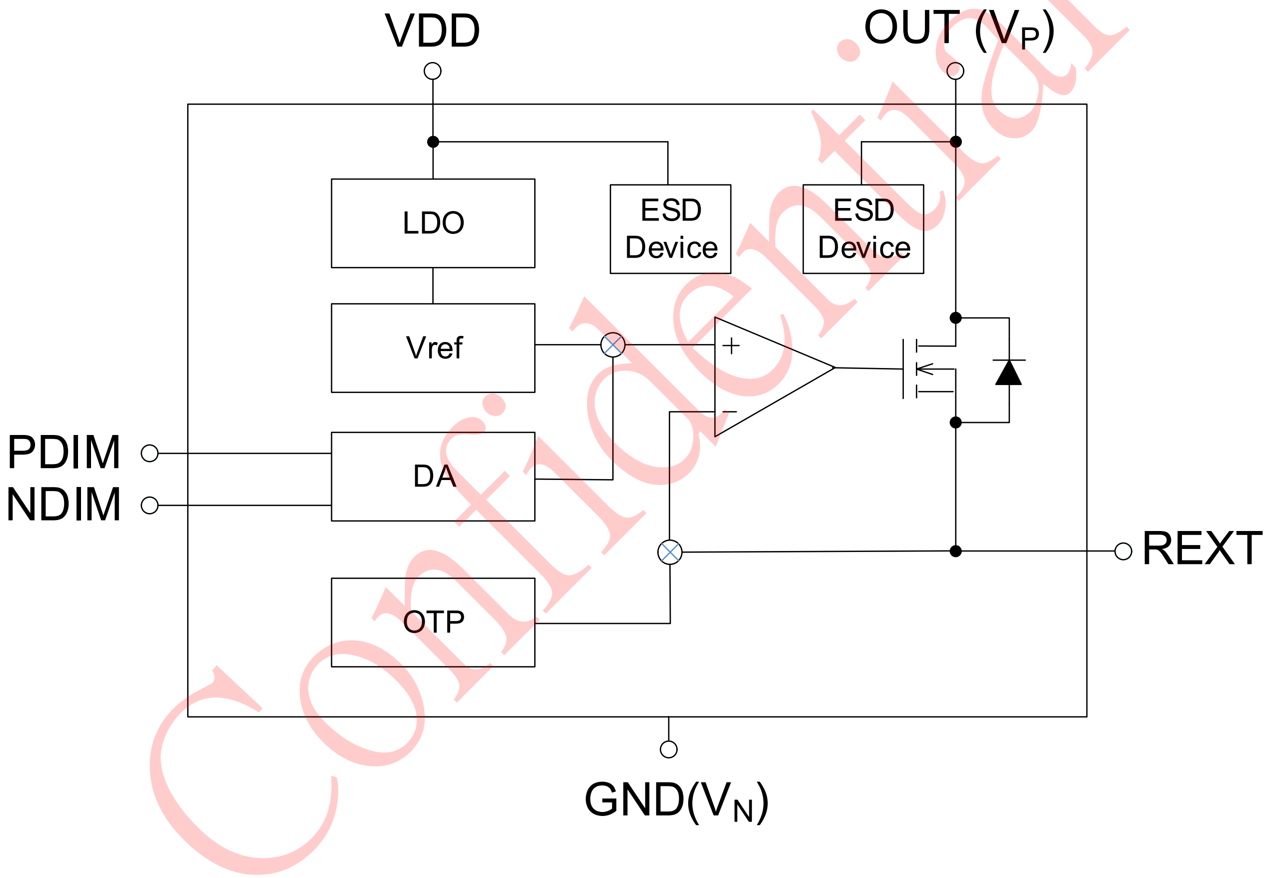
3.2 Pin Definitions and Functions

Pin	Name	I/O [(1)]	Descriptions
1	NDIM	I	Negative dimming control input pin. This pin is internally connected to negative terminal of differential amplifier for dimming control. Generally, connect this pin to the GND(V_N) pin.
2	GND(V_N)	--	Negative dimming current pin. This pin is also called power ground pin. For more accurate current regulation, connect this pin to negative terminal of current sense resistor with independent trace.
3	REXT	O	External current sense resistor output pin. This pin is internally connected to the source terminal of MOSFET and negative terminal of an operational amplifier. The voltage between REXT pin and GND(V_N) pin is controlled to 0.2V for full-scale output current. An external current setting resistor set this full-scale current. The distance between external current setting resistor and PS4508 should be as short as possible.
4	OUT(V_P)	O	Regulated current sink pin. Dimming current flows into this pin and is regulated by V_{CMD}.
5	VDD	I	Supply voltage input. V_{DD} is recommended from 4.5V to 40V.

6	PDIM	I	Positive dimming control input pin. This pin is initial pull-high as V_{DD} is ready. The voltage on PDIM pin presents 3V for full-scale dimming current if PDIM pin keeps floating. Moreover, the PDIM pin is internally connected to the positive terminal of differential amplifier for dimming control. The dimming command (V_{CMD}) is the voltage difference between PDIM pin and NDIM pin. V_{CMD} typically ranges from 0.2V to 3V for increasing dimming current from 6.7% to 100% full-scale current. V_{CMD} below 0.1V will shut down the output current.

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

3.3 Functional Block Diagram



4 Specifications

4.1 Absolute Maximum Ratings [1]

Condition	MIN	MAX	Unit
V_{DD}	-0.2	45	V
V_{PN}	-0.2	45	
P_{DIM}	-5	7	
N_{DIM}	-5	7	
REXT	-0.5	0.5	
Operating Junction Temperature	-40	150	ºC
Storage Temperature Range	-65	150	

4.2 Thermal Information [2]

Package Thermal Resistance		Unit
Junction to board thermal resistance (θ_{JA})	245	ºC/W
Junction to case thermal resistance (θ_{JC})	33	

4.3 Power Dissipation

Item	Value	Unit
P_D@TA=25ºC (SOT23-6)	0.41	W

4.4 Recommended Operating Conditions [3]

Item	Value	Unit
V_{DD}	4.5 to 40	V
V_{PN}	P_{D_MAX} / I_S	V
Operating Junction Temperature	-40 to 125	ºC

(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 with the component mounted on minimum pad PCB, 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.

4.5 Electrical Characteristic

T_A=25℃, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
SUPPLY VOLTAGE & CURRENT						
Supply voltage	V_{DD}	I_{PN} ≦ 120mA, no reverse protects	4.5	--	40	V
Supply current	I_{DD}	4.5V ≦ V_{DD} ≦ 40V, I_{PN}= 120mA	0.1	0.2	0.4	mA
OUTPUT VOLTAGE & CURRENT & ACCURACY & LEAKAGE						
Output voltage	V_{PN}(1)	V_{DD} ≧ 4.5V, I_{PN} = 120mA	1	--	20	V
Output leakage	I_{LEAK}	V_{DD} = 0V, V_{PN} = 36V	--	0	5	μA
Output Current Sense Voltage	V_{REXT}	V_{DD} ≧ 4.5V, I_{PN}=I_S	0.192	0.2	0.208	V
Output current accuracy	I_{ACY}	V_{DD} ≧ 4.5V, V_{CMD} ≧ 1V	-4	--	4	%
Output current vs V_{DD} regulation	I_{ACY_VDD}	V_{PN}= 1.1V, V_{DD}= 4.5V~40V	-2	--	2	%
Output current vs V_{PN} regulation	I_{ACY_VPN}(2)	V_{DD}= 4.5V, V_{PN}= 1.1V~36V, R_{EXT} = 10Ω	-1	--	1	%
Maximum output current	I_{S_MAX}(3)	V_{DD} ≧ 4.5V, R_{EXT} = 0.167Ω	115.2	120	124.8	mA
DROPOUT VOLTAGE						
Minimum dropout voltage	V_T	I_{PN} > 95% I_{S_MAX}(3), V_{DD} ≧ 4.5V	--	0.8	1	V
DIMMING COMMAND VOLTAGE						
Dimming command voltage	V_{CMD}	V_{CMD} = V_{PDIM} - V_{NDIM}	0	--	5	V
Max. input reference voltage	V_{NDIM_MAX}	I_{ACY} ≦ ±4%	-2	--	2	V
Input voltage (V_{CMD}) logic high	V_{IH}	-2V ≦ V_{NDIM} ≦ 2V	2.85	3	3.15	V
Input voltage (V_{CMD}) logic low	V_{IL}	-0.3V ≦ V_{NDIM} ≦ 0.3V	0.1	0.15	0.25	V
PDIM pull high current	I_{PDIM_H}	V_{DD} ≧ 4.5V, V_{PDIM} = 0V	5	13	20	μA
THERMAL PROTECT						
OTP start temperature	T_{OTP}	I_{PN} ≧ 90%I_S	--	130	--	°C
OTP output decreasing rate	T_{OTDR}	T_J ≧ T_{OTP}	--	3.3	--	%/°C

(1) V_{PN} tested in pulse mode.

(2) I_{ACY_VPN} tested in pulse mode.

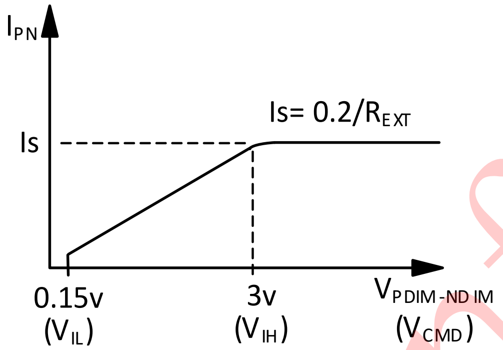
(3) I_{S_MAX} is 120mA. $\mathbf{I_S}$ is defined as the full-scale output current, ranging from 10mA to 120mA, set by the REXT pin resistance. I_{PN} is actual output current, ranging from 0 to 100% I_S, regulated by V_{CMD}.

4.6 Switching Characteristic

T_A=25℃, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
V_{DD} power on delay	$t_{PrOnDly}$	V_{PN} = 2V, V_{DD} = 0V → 7V P_{DIM} floating, N_{DIM} = 0V R_{EXT} = 0.167Ω, I_{PN} ≧ 90%I_S	--	3	5	μs
V_{DD} power on rising	$t_{PrOnRise}$		--	4	7	
V_{DD} power off delay	$t_{PrOffDly}$	V_{PN} = 2V, V_{DD}= 7V → 0V P_{DIM} floating, N_{DIM} = 0V R_{EXT}=0.167Ω, I_{PN} ≦ 10%I_S	--	--	100	ns
V_{DD} power off falling	$t_{PrOffFall}$		--	--	400	
P_{DIM} switch on delay	$t_{OEOnDly}$	V_{PN} = 2V, V_{DD}= 7V V_{CMD} = 0V → 3.5V R_{EXT} = 0.167Ω, I_{PN} ≧ 90%I_S	--	3	5	μs
P_{DIM} switch on rising	$t_{OEOnRise}$		--	4	7	
P_{DIM} switch off delay	$t_{OEOffDly}$	V_{PN} = 2V, V_{DD} = 7V V_{CMD} = 3.5V → 0V R_{EXT} = 0.167Ω, I_{PN} ≦ 10%I_S	--	--	1000	ns
P_{DIM} switch off falling	$t_{OEOffFall}$		--	--	400	

4.7 Output Current Calculation



$$I_S = \frac{0.2}{R_{EXT}}$$

$I_{PN} = I_S$, while V_{CMD} ≧ V_{IH} (V_{CMD}=V_{PDIM}-V_{NDIM})

$I_{PN} = I_S \times \frac{V_{CMD}}{V_{IH}}$, while V_{IL}<V_{CMD}<V_{IH}

$I_{PN} = 0$, while V_{CMD} ≦ V_{IL}

Figure 1. V_{CMD} VS. I_{OUT} Curve.

4.8 Input Pin Equivalent Circuit

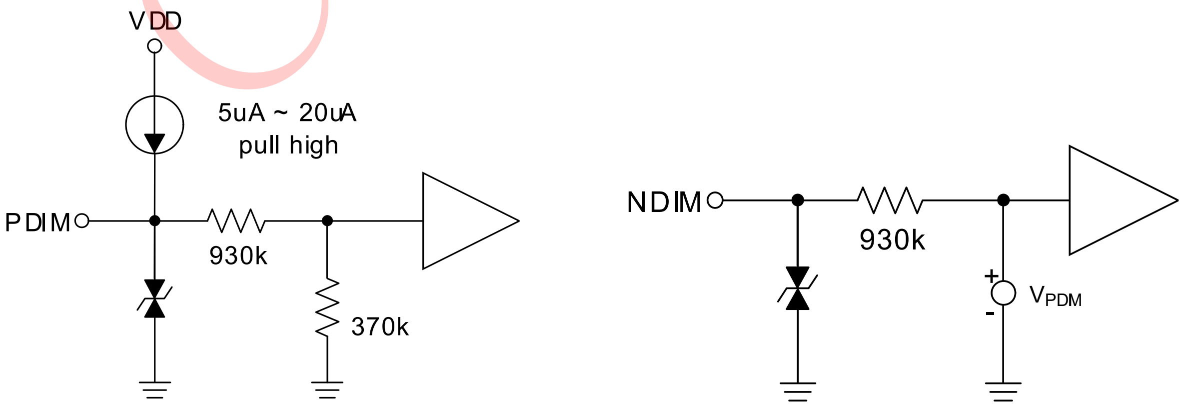


Figure 2. Input Pin Equivalent Circuit.

4.9 Temperature VS. I_{PN} Characteristic

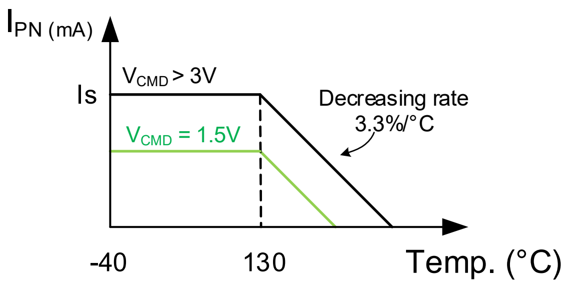


Figure 3. OTP Characteristic.

5 Typical Characteristics

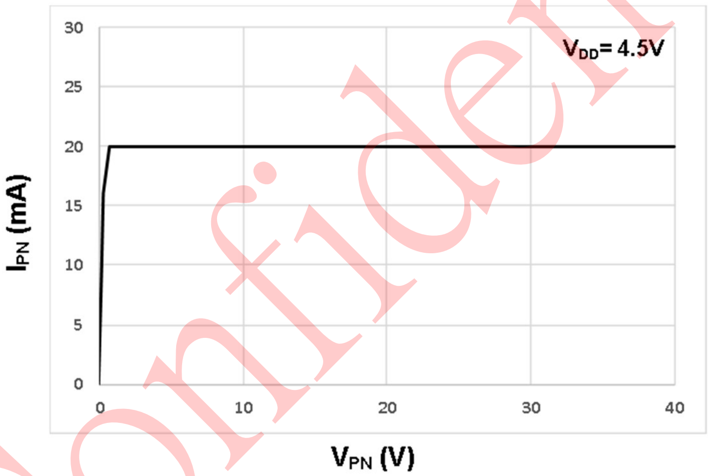


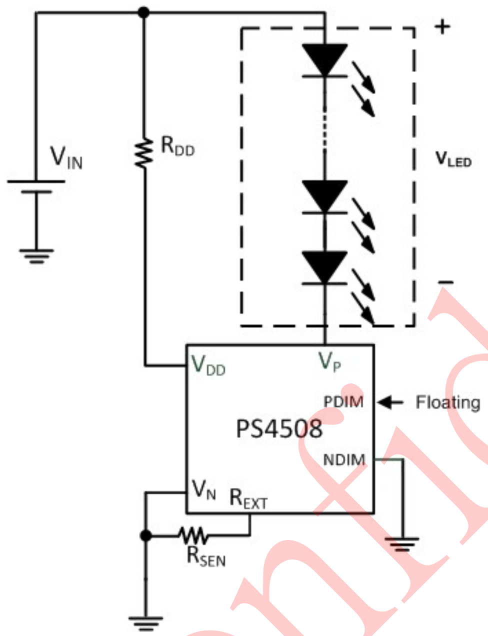
Figure 4. Load Regulation, I_{PN} vs V_{PN}

6 Application Information

The PS4508 is a Constant Current Regulator (CCR) for LED driver. It is achieved by adjusting the internal self-biased transistor to regulate the current through PS4508 or any devices in series with it. Besides, as operating temperature rising, PS4508 features a thermal protection function to protect LEDs through reducing operating current if junction temperature of PS4508 is above 130°C.

6.1 Single LED String

PS4508 can be placed in a series of LEDs string, as shown in Figure 5. The number of the LEDs is limited by the voltage across the V_{PN} of PS4508 and V_{IN} supply voltage. Hence, the design must estimate the voltage across the LEDs and PS4508 by taking the minimum input voltage greater than the sum of maximum voltage across the LED string and minimum V_{PN} drop out.



Recommended component table		
V_{IN}	R_{DD}	LEDs (EA)
12V	20kΩ	3
24V	82kΩ	7
36V	150kΩ	11

Figure 5. General 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 $I_{DD} \cdot R_{DD}$+4.5V. 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:

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

$$R_{DD} \leq \frac{V_{IN}-4.5V}{I_{DD(max)}} \quad (2)$$

Figure 6 shows another way to driving LEDs. In this way, the self-bias V_{DD} voltage of PS4508 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 4.5V. Generally, 1 white LEDs or 2 red LEDs between V_{DD} and V_P pin are sufficient for this application.

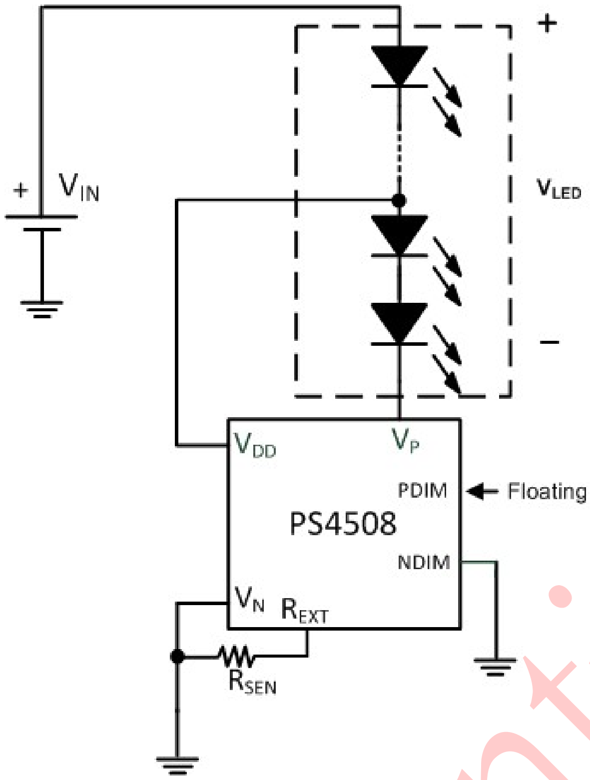


Figure 6. Self-bias LED driving application

6.2 Higher Current LED Strings

For higher LED current demand, two or more PS4508 can be connected in parallel to increase the LED current as shown in Figure 7.

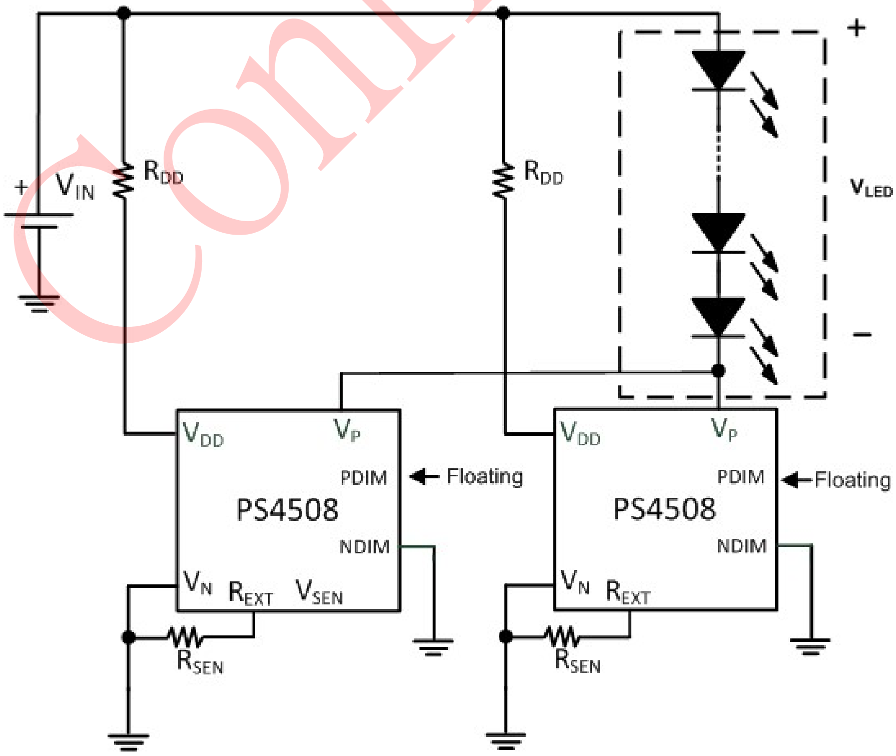


Figure 7. High current application.

6.3 PWM Dimming

Figure 8 is the best PWM dimming application circuit. To achieve LED dimming in an LED driving circuit with the PS4508, 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 PS4508 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.

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

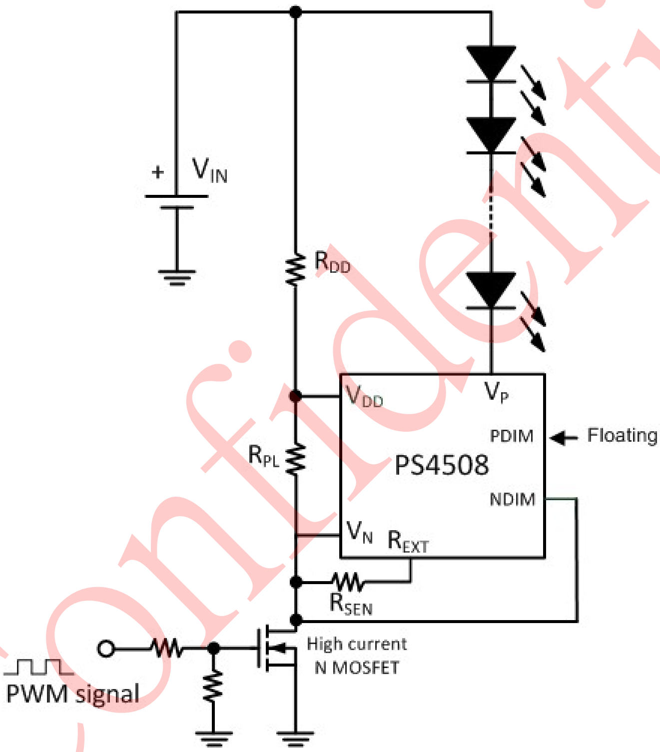


Figure 8. PWM dimming by external MOSFET

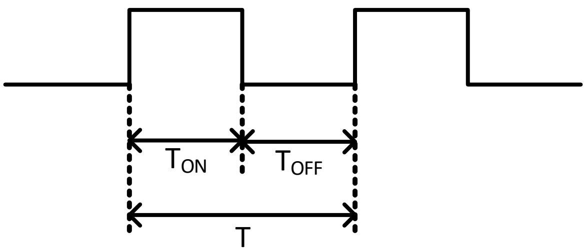


Figure 9. PWM dimming signal

Figure 10. Current accuracy vs PWM dimming

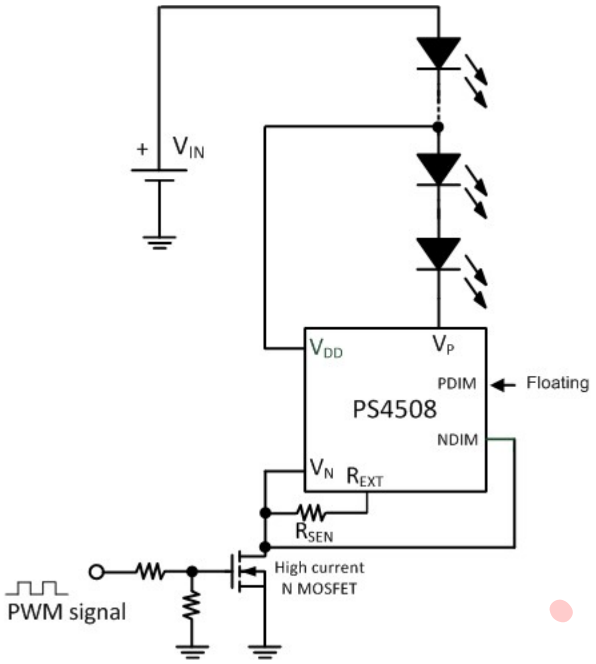


Figure 11. Simplified dimming circuit.

Figure 11 shows the self-bias dimming circuit. The advantage is no need of resister for PS4508 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. If a simpler PWM dimming method is used, the MCU can send a PWM signal (0~5V) through the GPIO pin to control the VDD ON-OFF time to achieve dimming purposes (Figure 12). Or the dimming function can be realized by sending a differential voltage signal of 0~3V through the PDIM and NDIM pins (see Figure 13).

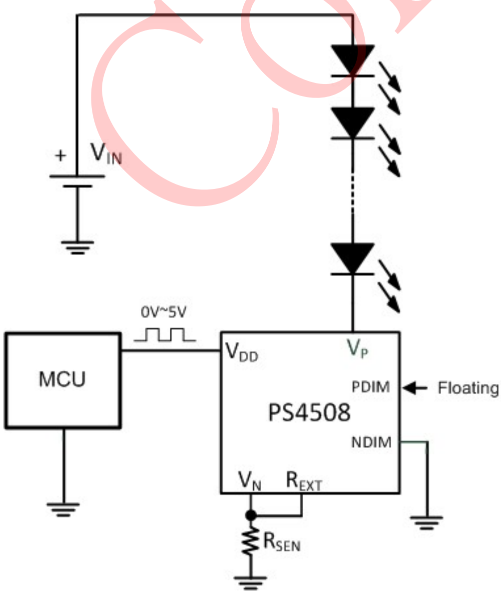


Figure 12. PWM dimming by MCU

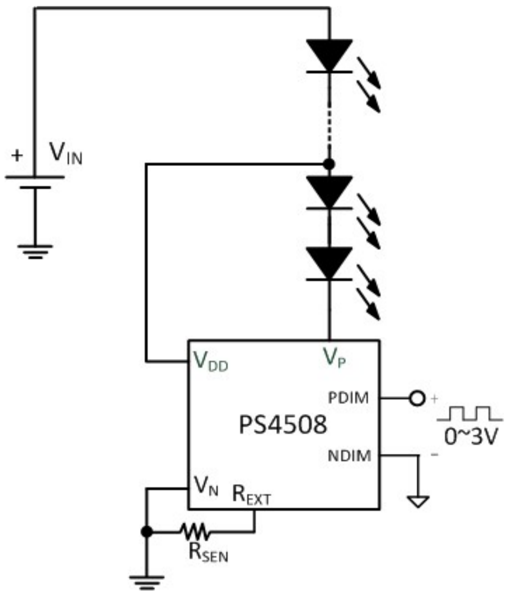


Figure 13. PWM dimming by PDIM and NDIM

6.4 Thermal Protection: LED Current Ramp Down

For protecting LED under high temperature application, LED current is decreased automatically while PS4508's junction temperature is over 130^{o}C. Besides, if PS4508's junction temperature approaches 145^{o}C, LED current remains around 10%. Along with temperature reducing, the LED current is recovery when junction temperature is below 130^{o}C.

6.5 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}.

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

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

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:

$$P_{D(max)} = \frac{130 - T_A}{R_{\theta JA}}, \text{ where } R_{\theta JA} = 245°C/W \quad (5)$$

7 Typical Application Circuit

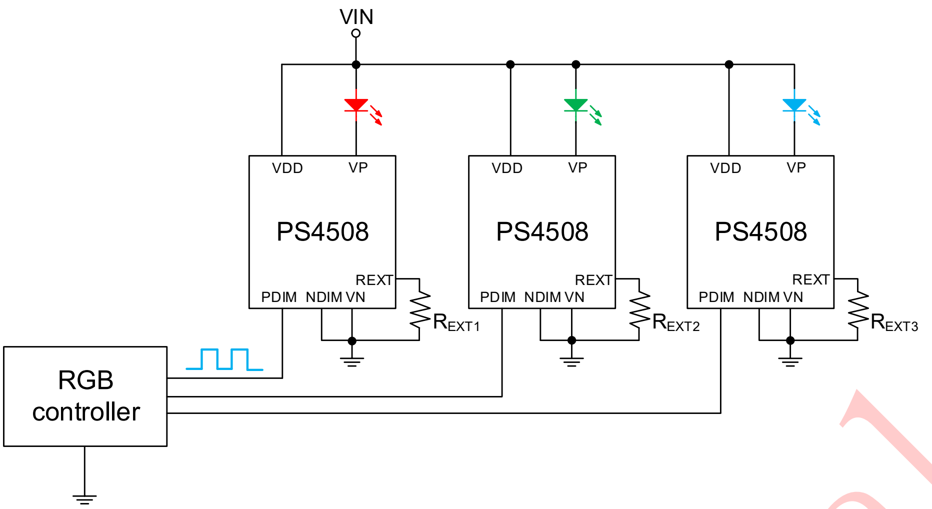


Figure 14.Controller Driving Current Expansion for Decoration Lighting Application.

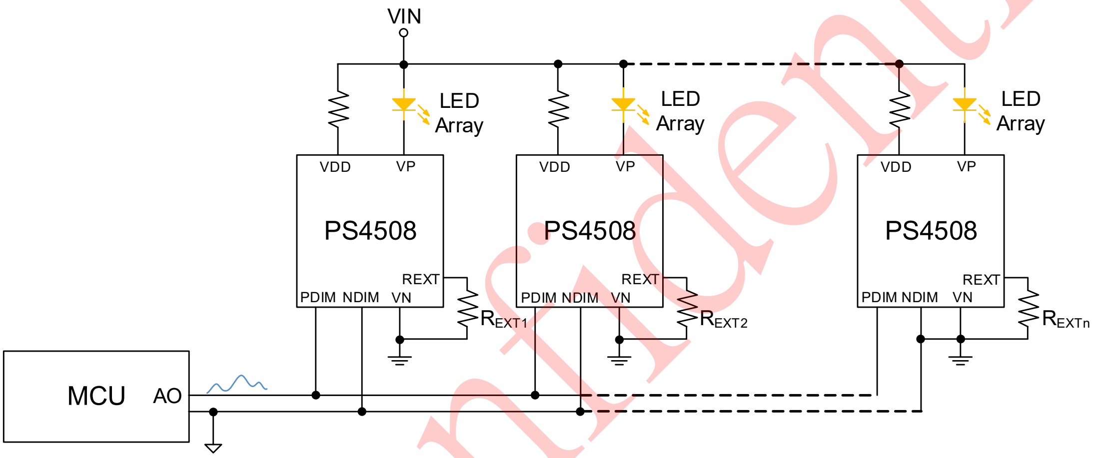
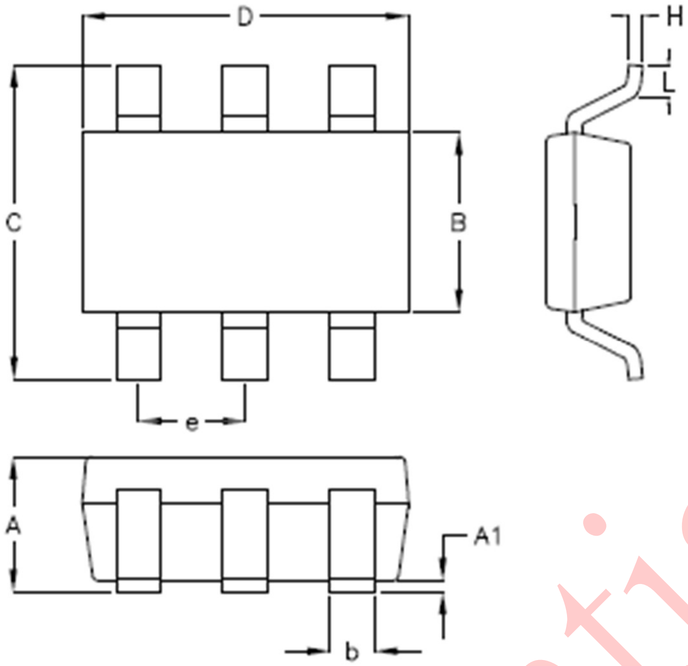


Figure 15.Driving Current Expansion for Wide Area zero Flicker Lighting Application.

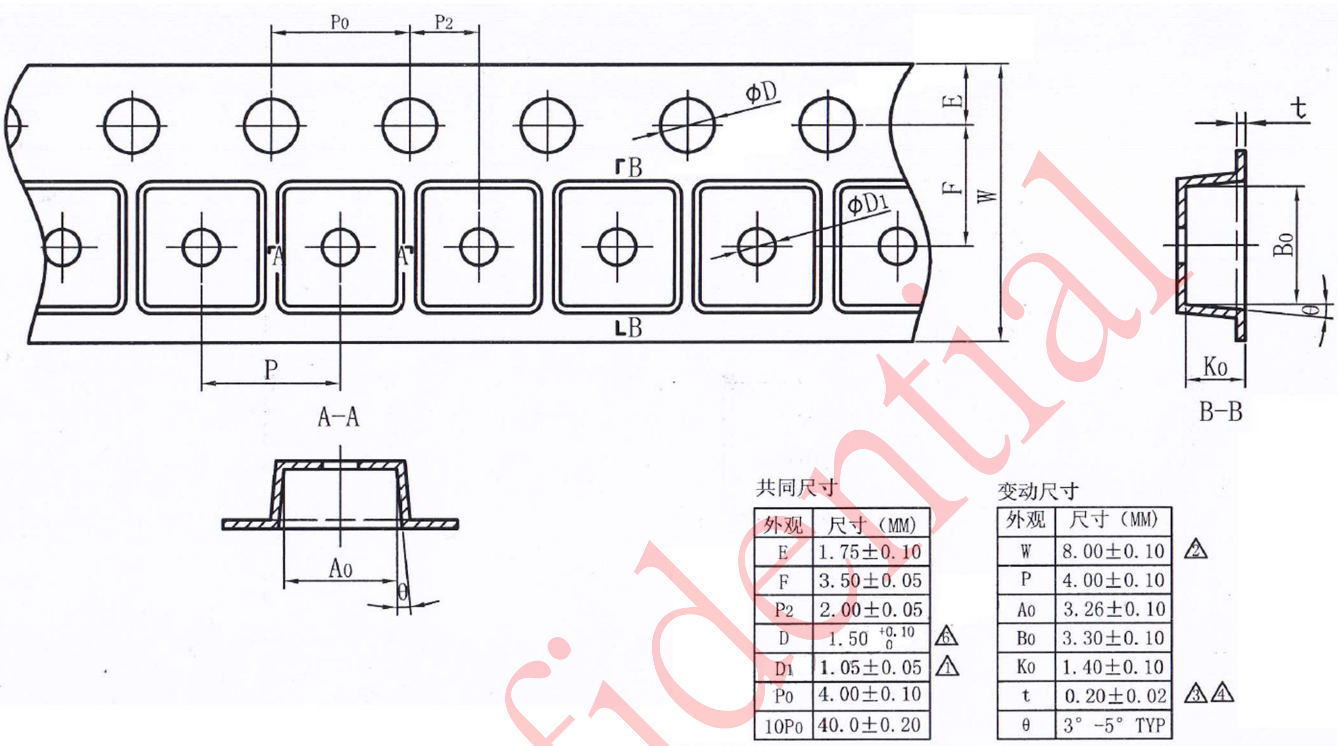
8 Outline Dimension & Land Pattern



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min	Nom	Max	Min	Nom	Max
A	0.889	1.092	1.295	0.035	0.043	0.051
A1	0.000	0.076	0.152	0.000	0.003	0.006
B	1.397	1.600	1.803	0.055	0.063	0.071
b	0.250	0.405	0.560	0.010	0.016	0.022
C	2.591	2.794	2.997	0.102	0.110	0.118
D	2.692	2.896	3.099	0.106	0.114	0.122
e	0.838	0.940	1.041	0.033	0.037	0.041
H	0.080	0.167	0.254	0.003	0.007	0.010
L	0.300	0.455	0.610	0.012	0.018	0.024

9 Tape & Reel Drawing

封裝型態 Package type	軸片直徑 Reel Diameter(inch)	承載帶寬 Carrier width(mm)	承載帶間距 Carrier Pitch(mm)	極性方向 Pin1 Orientation	每捲數量 Units Per Reel	每內盒總數量 TTL QTY Per Inner Box	每外箱總數量 TTL QTY Per Carton
SOT23 series	7	8	4	User direction	3,000	3,000	84,000
Note: greater than 16cm on the trailer and greater than 60cm on the leader.							



共同尺寸

外观	尺寸（MM）
E	1.75±0.10
F	3.50±0.05
P2	2.00±0.05
D	1.50 $^{+0.10}_{0}$
D1	1.05±0.05
P0	4.00±0.10
10P0	40.0±0.20

变动尺寸

外观	尺寸（MM）
W	8.00±0.10
P	4.00±0.10
A0	3.26±0.10
B0	3.30±0.10
K0	1.40±0.10
t	0.20±0.02
θ	3° -5° TYP

10 Restrictions On Product Use

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