60V, 20mA Single Channel Constant Current LED Driver

General Description

XS4505 is a single channel LED driver with constant current regulator. XS4505 offers excellent temperature stability and output current accuracy (±3.5%) with a wide input voltage from 4.5V to 40V and temperature range. XS4505 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, XS4505 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. Thoughtfully, XS4505 also supports both high-side and low-side driving for the LED strings. XS4505 is available in the cost-effective package SOT23-3.

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

Applications

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

Ordering Information

XS4505-□□S1

S1: SOT23-3

20: IOUT= 20mA

Note: Green Product (RoHS compliant)

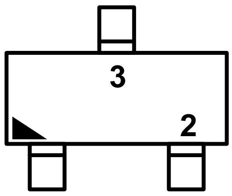
For meeting world-wide customer requirements for environmentally friendly products and government regulations, the device is available as a green product. Green products are RoHS-Compliant (i.e Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

Marking Information

A1: Product Code
DNN: Date Code

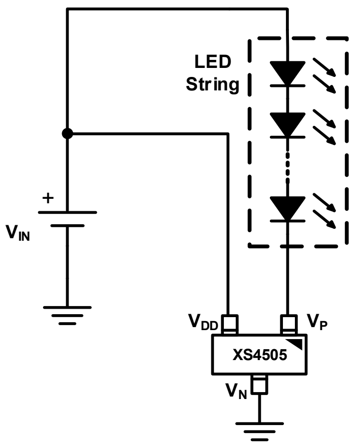
Pin Configuration

Top View



SOT-23-3

Simplified Application Circuit

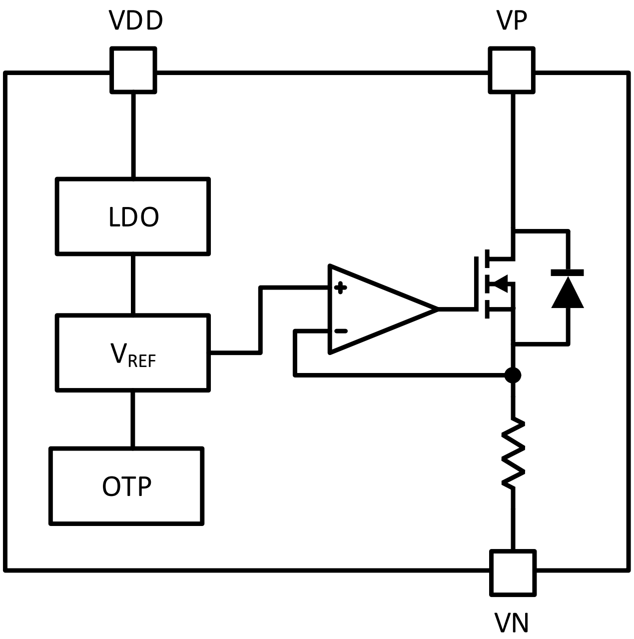


Pin Definitions and Functions

Pin	Name	I/O[(1)]	Description
1	VP	I	Output current regulated pin. Output current flows through this pin and regulated. For low-side LED string application, connect the LED cathode terminal to the "VP" terminal. For high-side LED string application, connect the LED anode terminal to the "VN" terminal.
2	VDD	I	Supply voltage
3	VN	--	Connect to anode of LED or power ground

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

Functional Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage: VDD, VP ....-0.3V to 60V
- Other Pin Voltage: VN ....-0.3V to 60V

Power Dissipation, P_D@T_A=25°C

- SOT-23-3 .... 0.41W

Package Thermal Resistance (Note 2)

- SOT-23-3, θ_{JA} .... 245°C/W
- SOT-23-3, θ_{JC} .... 33°C/W
- Lead Temperature (Soldering, 10sec.)..260°C
- Junction Temperature ....150°C
- Storage Temperature ....-65°C to 150°C

ESD Susceptibility (Note 3)

- HBM (Human Body Model)..1KV
- CDM (Charged Device Model) 500V

Recommended Operating Conditions (Note 4)

- Supply Input Voltage: VDD, VP..4.5V to 40V
- Junction Temperature Range..-40°C to 125°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.

Note 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

Note 3: Devices are ESD sensitive. Handling precautions are recommended.

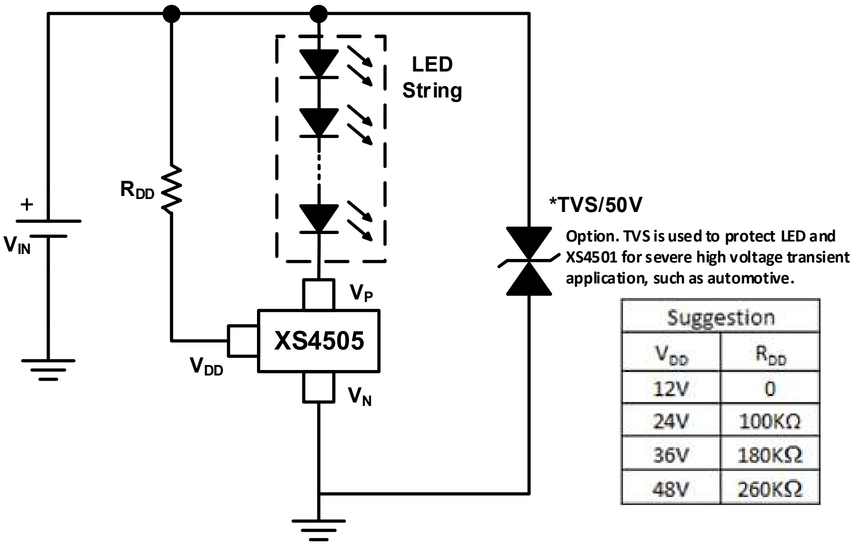
Note 4: Device function is not guaranteed if it is operated out of this range.

Electrical Characteristic

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

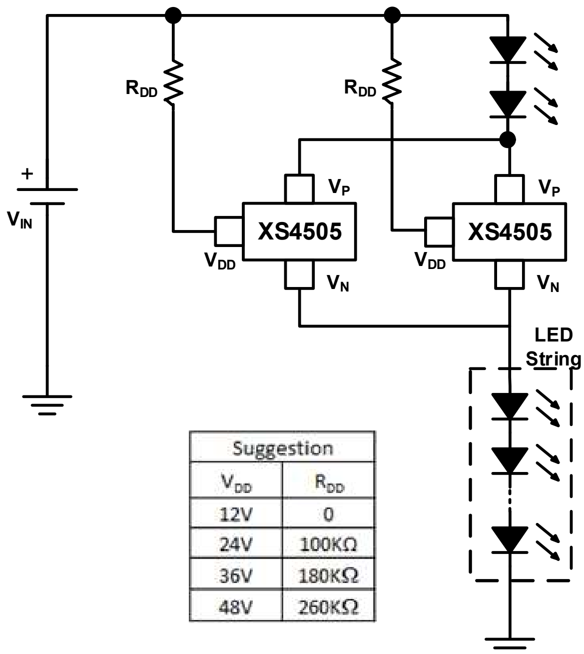
Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Supply voltage	V_{DD}	$I_{PN} \leqq$ 20mA	4.5		40	V
Supply current	I_{DD}	4.5V $\leqq V_{DD} \leqq$ 40V I_{PN}= 20mA	0.06	0.16	0.22	mA
Output current	I_S	V_{DD}= 7V		20		mA
Minimum dropout voltage	V_{PN}	V_{DD} > 7V, I_{PN}= 90%I_s			0.3	V
Output current 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~120°C	-3		3	%
Current ramp down temperature	T_{J_down}	$I_{PN} \leqq$ 90%I_S		125		°C
Shutdown temperature	T_{J_shtdn}	$I_{PN} \leqq$ 10%I_S		145		°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	%

Typical Application Circuit



Suggestion	
V_{DD}	R_{DD}
12V	0
24V	100KΩ
36V	180KΩ
48V	260KΩ

Figure 1, General DC power LED drive.



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V_{DD}	R_{DD}
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Figure 2, Parallel configuration for higher LED current requirement.

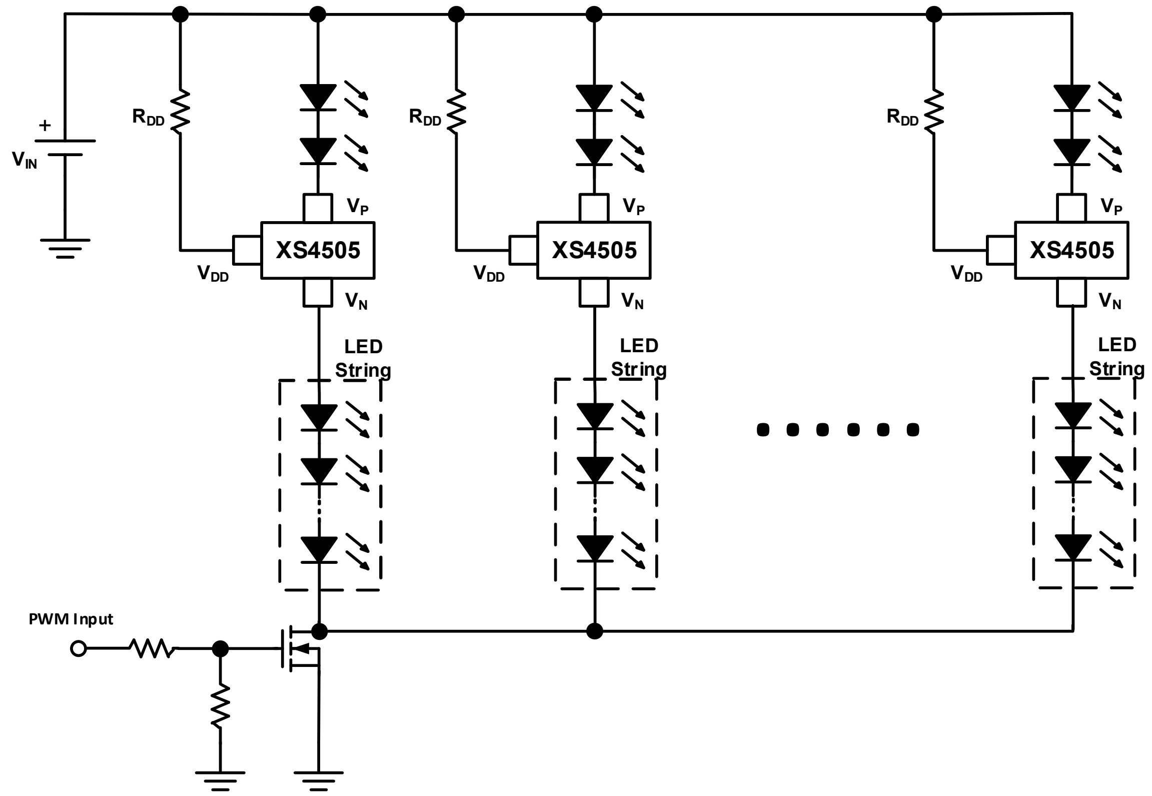


Figure 3, LED strings PWM dimming by external MOSFET

Typical Operating Characteristics

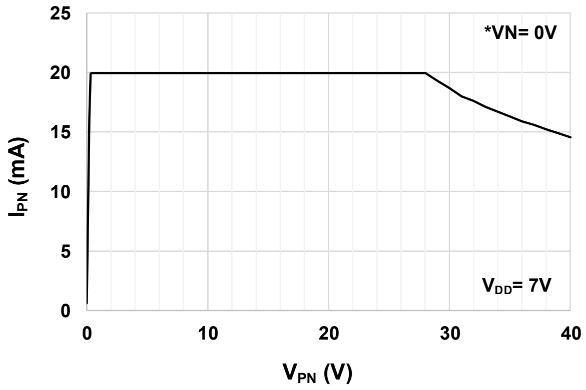


Figure 4. Line regulation, I_{PN} vs V_{PN}

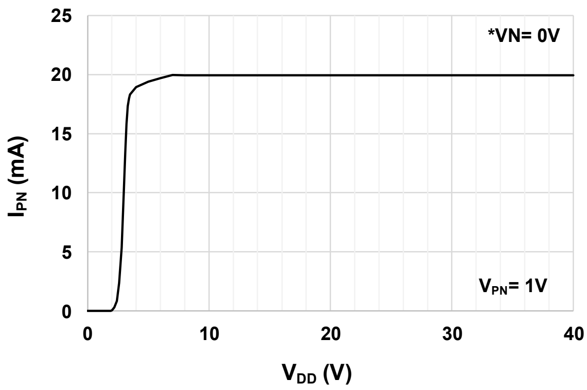


Figure 5. Line regulation, I_{PN} vs V_{DD}

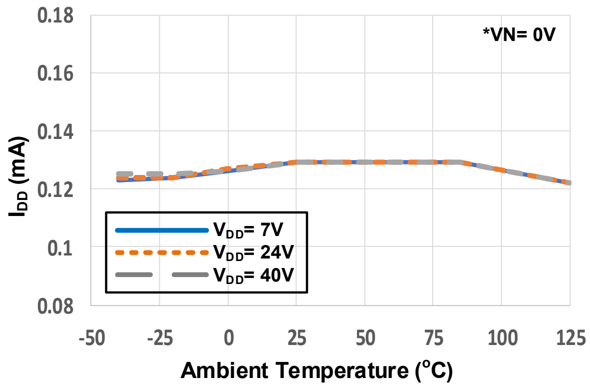


Figure 6. Supply current I_{DD} vs T_a

Application Information

The XS4505 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 XS4505 or any devices in series with it. Besides, as operating temperature rising, XS4505 features a thermal protection function to protect LEDs through reducing operating current if junction temperature of XS4505 is above 125°C.

Single LED String

XS4505 can be placed for high-side or low-side driver for LED as shown in figure 7. The number of the LEDs is limited by the voltage across the V_{PN} of XS4505. 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.

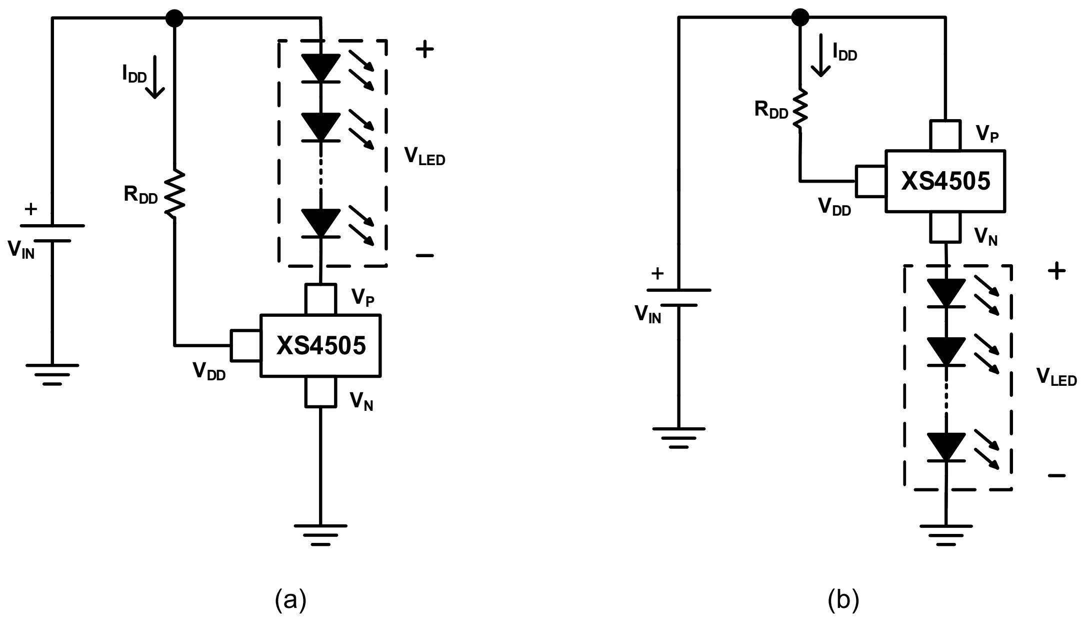


Figure 7. (a) Low-side LED Driver (b) High-side LED Driver

As XS4505 used for low-side LED driver referred to figure 7 (a), the minimum input voltage $V_{IN(min)}$ has to be larger than V_{LED}+V_{PN} or I_{DD} · R_{DD}+4.5V which depends on the LED string voltage. The equation is as follows:

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

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

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

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

For high-side LED driver referred to figure 7 (b), the minimum input voltage $V_{IN(min)}$ is as follows:

$V_{IN(\min)} = I_{DD} \cdot R_{DD} + 4.5 + V_{LED}$ .... (3)

Higher Current LED Strings

For higher LED current demand, two or more XS4505 can be connected in parallel to increase the LED current as shown in figure 8.

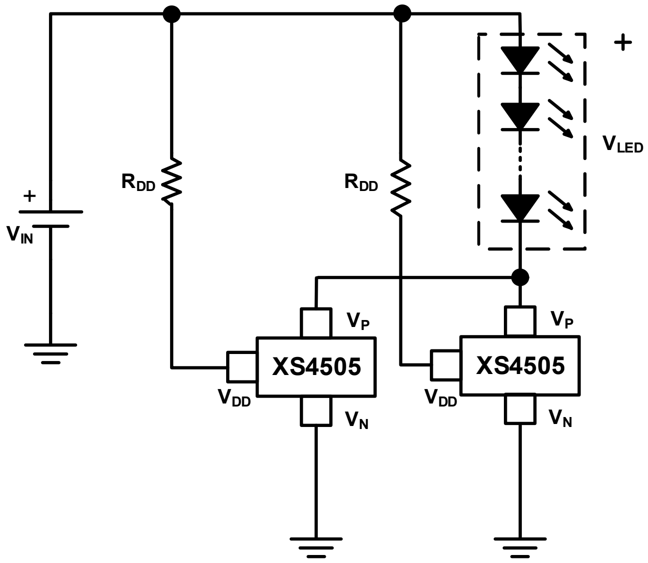


Figure 8. High current application.

Thermal Protection: LED Current Ramp Down

For protecting LED under high temperature application, LED current is decreased automatically while XS4505's junction temperature is over 125°C. Besides, if XS4505's junction temperature approaches 145°C, LED current remains around 10%. Along with temperature reducing, the LED current is recovery when junction temperature is below 125°C.

Power Dissipation

The power dissipation can be determined from the regulated current I_S multiplying the voltage across the V_{PN}.

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

Where V_{PN} is voltage deviation from V_P to V_N.

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:

$P_{D(max)} = \frac{125-T_A}{R_{\theta JA}}$, where $R_{\theta JA} = 245°C/W$ .... (5)

PWM Dimming

The LED dimming can be easily achieved by placing an external MOSFET in series with XS4505 and the dimming effect can be achieved by adjusting the PWM duty cycle, as shown in figure 9. 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 10, and figure 11 shows the current accuracy with different duty cycle.

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

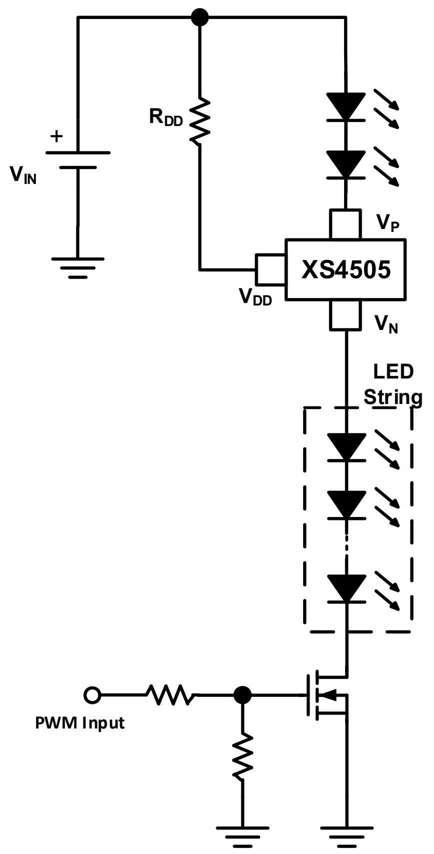


Figure 9. PWM dimming by external MOSFET

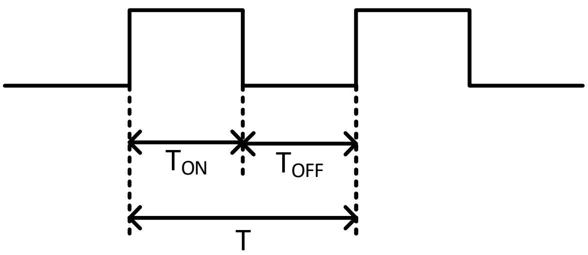


Figure 10. PWM dimming signal

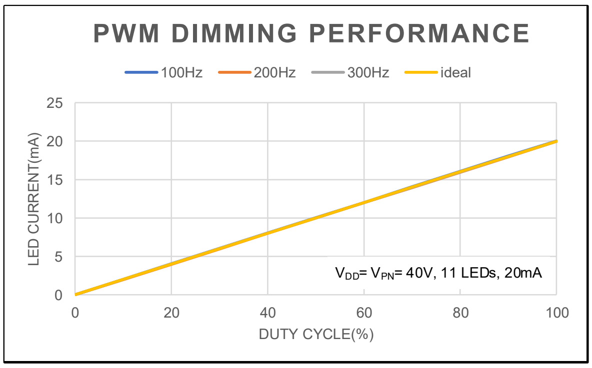
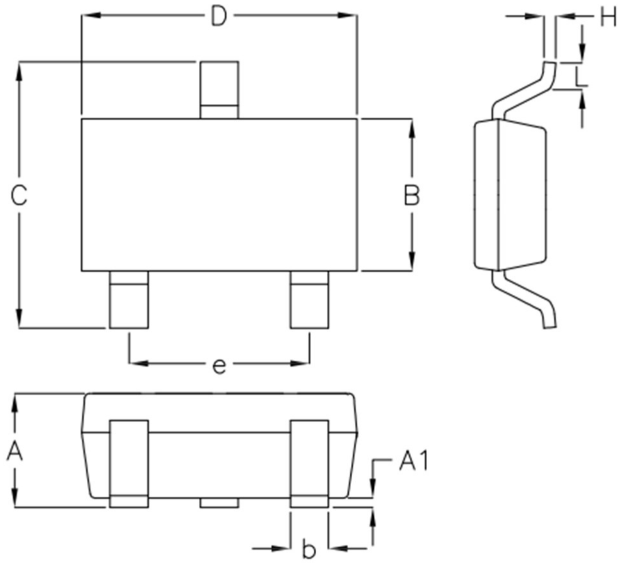


Figure 11. Current accuracy vs PWM dimming

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

Revision History

Revised on	Version	Description
2022.10.24	00	Release
2022.10.25	01	Modify accuracy SPEC