30V, ADJUSTABLE CURRENT SINK LINEAR LED DRIVER

Description

The AL5802LP4 combines a high-gain NPN transistor with a pre-biased NPN transistor to make a simple small footprint LED driver.

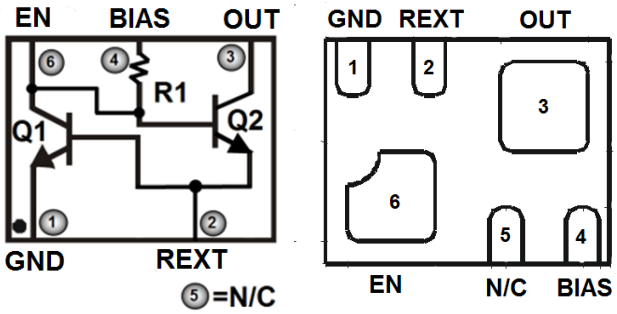
The LED current is set by an external resistor connected from R_{EXT} Pin (2) to GND Pin (1). The internal high-gain transistor develops approximately 0.6V across the external resistor.

The AL5802LP4's open-collector output can operate from 0.8V to 30V making it suitable for industry standard 5V to 24V power supplies without additional components.

PWM dimming of the LED current can be achieved by either driving the BIAS Pin (4) with a low impedance voltage source, or driving the EN Pin (6) with an external open-collector NPN transistor or open-drain N-Channel MOSFET.

The AL5802LP4 is available in a X2-DFN1310-6 package and is ideal for driving up to 120mA current.

Pin Assignments



Internal Schematic (Top View)

(Bottom View)

Mechanical Data

- Case: X2-DFN1310-6
- Case Material: Molded Plastic, "Green" Molding Compound. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: NiPdAu (Lead-Free) Plating. Solderable per MIL-STD-202, Method 208 e4
- Weight: 0.0013 grams

Features

- Reference Voltage V_{REXT} = 0.65V
- -40 to +125°C Temperature Range
- 0.8V to 30V Open-Collector Output
- Negative Temperature Co-Efficient – Automatically Reduces the LED Current at High Temperatures
- Low Thermal Impedance, Small Footprint X2-DFN1310-6 Package with Exposed Pads
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Applications

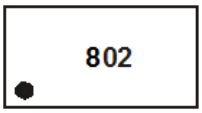
- Linear LED Driver
- LED Signs
- Offline LED Luminaries

Ordering Information (Note 8)

Device	Qualification	Packaging	Tape and Reel	
			Quantity	Part Number Suffix
AL5802LP4	Commercial	X2-DFN1310-6	3,000/Tape & Reel	-7

Note: 8. For packaging details, go to our website at http://www.diodes.com/products/packages.html.

Marking Information

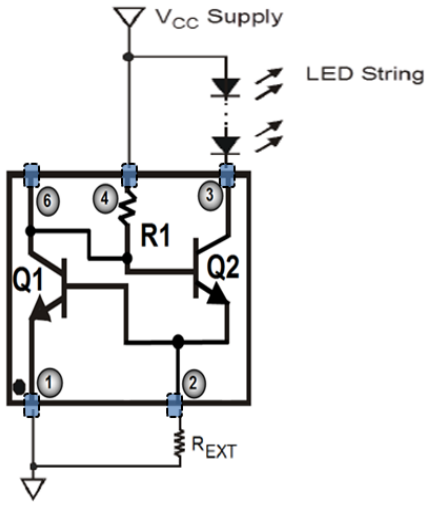


802 = Product Type Marking Code

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

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Typical Application Circuit



Pin Descriptions

Pin Number	Name	Function
1	GND	Ground Reference Point for Setting LED Current
2	R_{EXT}	Current Sense Pin LED current sensing resistor should be connected from here to GND
3	OUT	Open-Collector LED Driver Output
4	BIAS	Biases the Open Collector Output Transistor
5	N/C	No Connection
6	EN	Enable Pin for PWM Dimming Provides access to the base of Q2 and collector of Q1

Functional Block Diagram

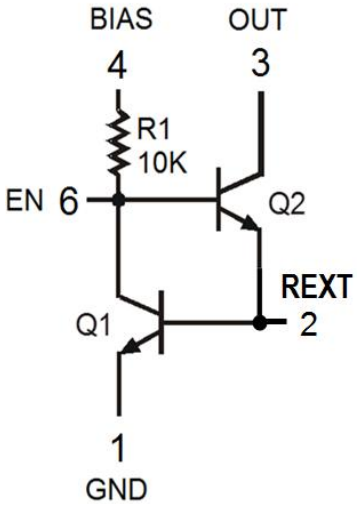


Figure 1 Block Diagram

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Absolute Maximum Ratings

Symbol	Characteristics	Values	Unit
V_{OUT}	Output Voltage Relative to GND	30	V
V_{BIAS}	BIAS Voltage Relative to GND	30	V
V_{FB}	LED Voltage Relative to GND	6	V
V_{EN}	EN Voltage Relative to GND	6	V
V_{REXT}	REXT Voltage Relative to GND	6	V
I_{OUT}	Output Current	120	mA
T_J	Operating Junction Temperature	-40 to +150	°C
T_{ST}	Storage Temperature	-55 to +150	°C

These are stress ratings only. Operation outside the absolute maximum ratings may cause device failure. Operation at the absolute maximum rating for extended periods may reduce device reliability.

Package Thermal Data

Characteristic	Symbol	Value	Unit
Power Dissipation (Note 4) @T_A = +25°C	P_D	0.36	W
Thermal Resistance, Junction to Ambient Air (Note 4) @T_A = +25°C	$R_{\theta JA}$	347	°C/W

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{BIAS}	Supply Voltage Range	4.5	30	V
V_{OUT}	OUT Voltage Range	0.8	30	
I_{LED}	LED Pin Current (Note 5)	10	100	mA
T_A	Operating Ambient Temperature Range	-40	+125	°C

Notes: 4. Device mounted on FR-4 PCB, 2oz with minimum recommended pad layout.
5. Subject to ambient temperature, power dissipation and PCB.

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Electrical Characteristics: NPN Transistor – Q1 (@T_A = +25°C, unless otherwise specified.)

Symbol	Characteristic	Test Condition	Min	Typ	Max	Unit
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage (Note 6) (Note 7)	I_C = 1.0mA, I_B = 0	40	—	—	V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10μA, I_C = 0	6.0	—	—	V
I_{CEX}	Collector Cutoff Current (Note 7)	V_{CE} = 30V, $V_{EB(OFF)}$ = 3.0V	—	—	50	nA
I_{BL}	Base Cutoff Current (Note 7)	V_{CE} = 30V, $V_{EB(OFF)}$ = 3.0V	—	—	50	nA
h_{FE}	DC Current Gain	I_C = 1.0mA, V_{CE} = 1.0V I_C = 10mA, V_{CE} = 1.0V	70 100	— —	— 300	—
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage (Note 6)	I_C = 10mA, I_B = 1.0mA	—	—	0.20	V
$V_{BE(SAT)}$	Base-Emitter Saturation Voltage	I_C = 10mA, I_B = 1.0mA	0.65	—	0.85	V
$V_{BE(ON)}$	Base-Emitter Turn-On Voltage	V_{CE} = 1.20V, I_C = 2.0mA	0.30		1.10	V

Electrical Characteristics: NPN Pre-biased Transistor – Q2 (@T_A = +25°C, unless otherwise specified.)

Symbol	Characteristic	Test Condition	Min	Typ	Max	Unit
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 50μA, I_E = 0	30	—	—	V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage (Note 6)	I_C = 1mA, I_B = 0	30	—	—	V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage (Note 7)	I_E = 50μA, I_C = 0	5.0	—	—	V
I_{CBO}	Collector Cutoff Current	V_{CB} = 30V, I_E = 0	—	—	0.5	μA
I_{EBO}	Emitter Cutoff Current (Note 7)	V_{EB} = 4V, I_C = 0	—	—	0.5	μA
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage (Note 6)	I_C = 10mA, I_B = 1mA	—	—	0.3	V
$V_{BE(ON)}$	Base-Emitter Turn-On Voltage	V_{CE} = 5.0V, I_C = 2.0mA	0.30		1.10	V
h_{FE}	DC Current Gain (Note 6)	V_{CE} = 5V, I_C = 150mA	100	—	—	—
R_1	Input Resistance	—	7	10	13	kΩ

*Characteristics of transistor only.

Notes: 6. Short duration pulse test used to minimize self-heating effect.

7. Guaranteed by design and tested only at the wafer level for single die. These parameters cannot be tested at the finished good level due to test conditions changed after packaging multi-dies to form an application circuit.

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Thermal Characteristics

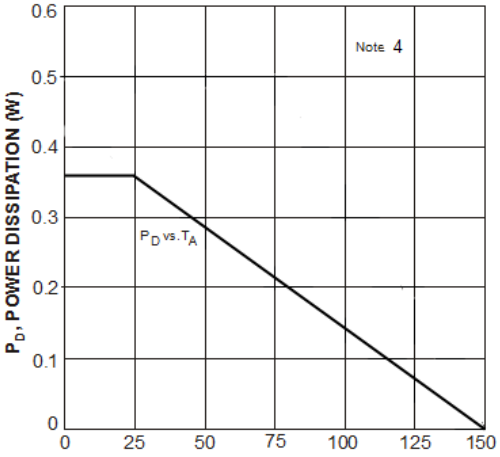


Figure 2 Power Derating Curve

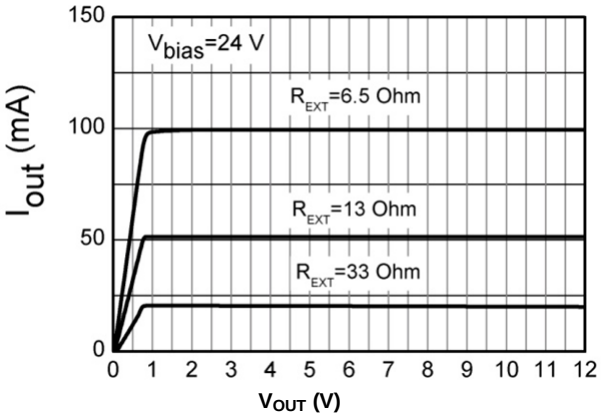


Figure 3 Output Current vs. V_{OUT}

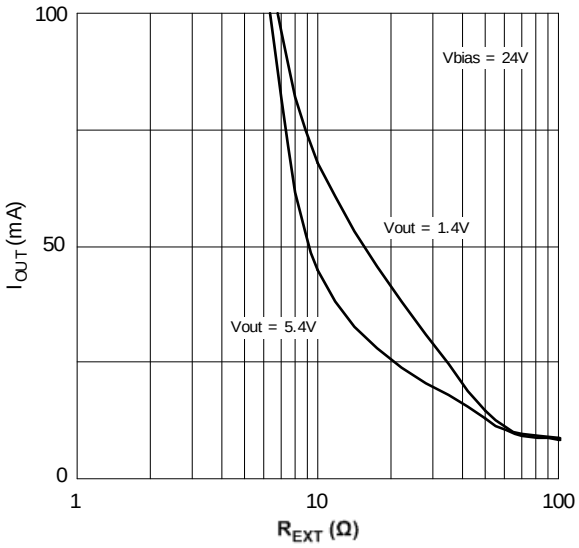


Figure 4 Output Current vs. R_{EXT}

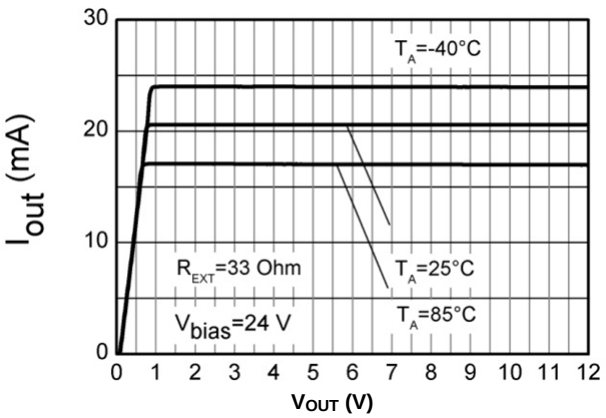


Figure 5 Output Current vs. V_{OUT}

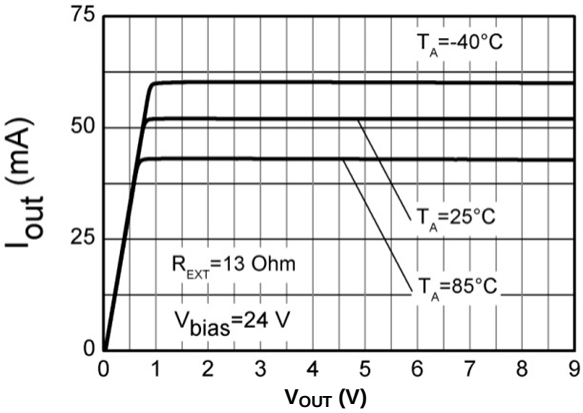


Figure 6 Output Current vs. V_{OUT}

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Typical Performance Characteristics (Continued)

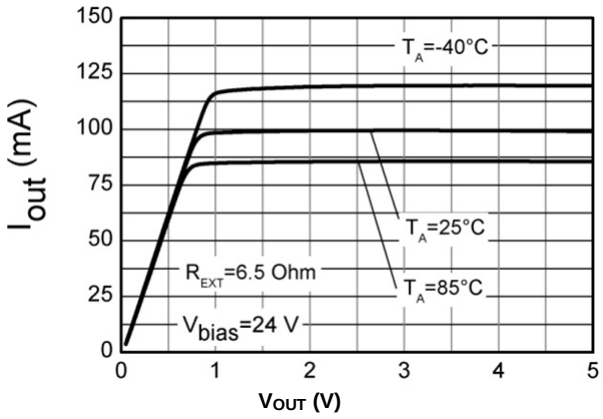


Figure 7 Output Current vs. V_{OUT}

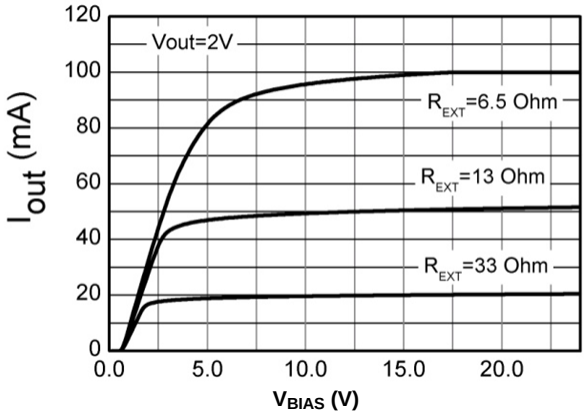


Figure 8 Output Current vs. V_{BIAS}

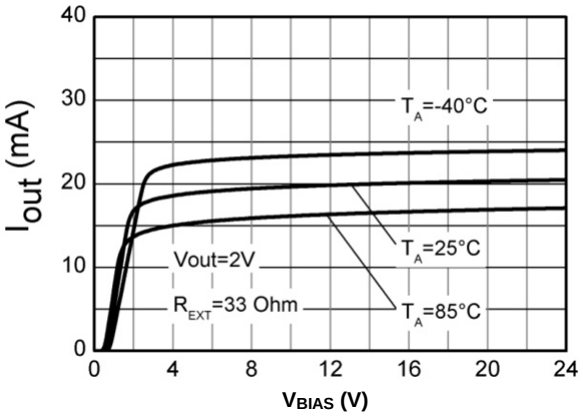


Figure 9 Output Current vs. V_{BIAS}

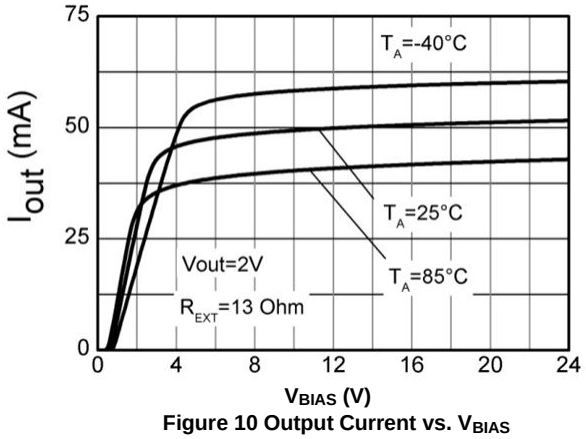


Figure 10 Output Current vs. V_{BIAS}

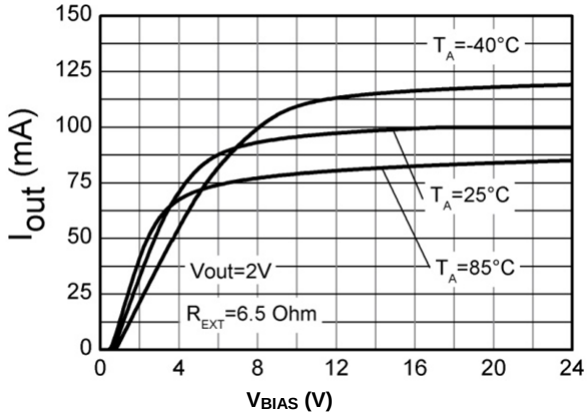


Figure 11 Output Current vs. V_{BIAS}

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Application Information

The AL5802LP4 is designed for driving low current LEDs with typical LED currents of 10mA to 100mA. It provides a cost effective way of driving low current LEDs compared with more complex switching regulator solutions. Furthermore, it reduces the PCB board area of the solution as there is no need for external components like inductors, capacitors and switching diodes.

Figure 12 shows a typical application circuit diagram for driving an LED or string of LEDs. The NPN transistor Q1 measures the LED current by sensing the voltage across an external resistor R_{EXT}. Q1 uses its V_{BE} as reference to set the voltage across R_{EXT} and controls the base current into Q2. Q2 operates in linear mode to regulate the LED current. The LED current is:

$$I_{LED} = V_{BE(Q1)} / R_{EXT}$$

From this, for any required LED current the necessary external resistor R_{EXT} can be calculated from:

$$R_{EXT} = V_{BE(Q1)} / I_{LED}$$

Two or more AL5802LP4 can be connected in parallel to construct higher current LED strings as shown in Figure 13.

Consideration of the expected linear mode power dissipation must be factored into the design, with respect to the AL5802LP4's thermal resistance.

The maximum voltage across the device can be calculated by taking the maximum supply voltage less the voltage across the LED string.

$$V_{CE(Q2)} = V_{CC} – V_{LED} – V_{BE(Q1)}$$

$$P_D = V_{CE(Q2)} * I_{LED} + (V_{CC} – V_{BE(Q2)} – V_{BE(Q1)})^2 / R_1$$

As the output current of AL5802LP4 increases, it is necessary to provide appropriate thermal relief to the device. The power dissipation supported by the device is dependent upon the PCB board material, the copper area and the ambient temperature. The maximum dissipation the device can handle is given by:

$$P_D = (T_{J(MAX)} - T_A) /R_{\theta JA}$$

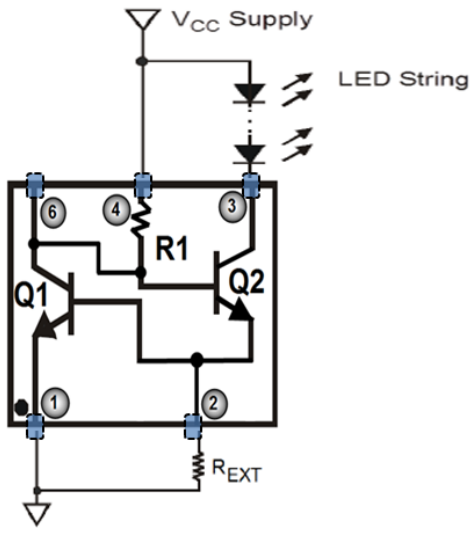


Figure 12 Typical Application Circuit for Linear Mode Current Sink LED Driver

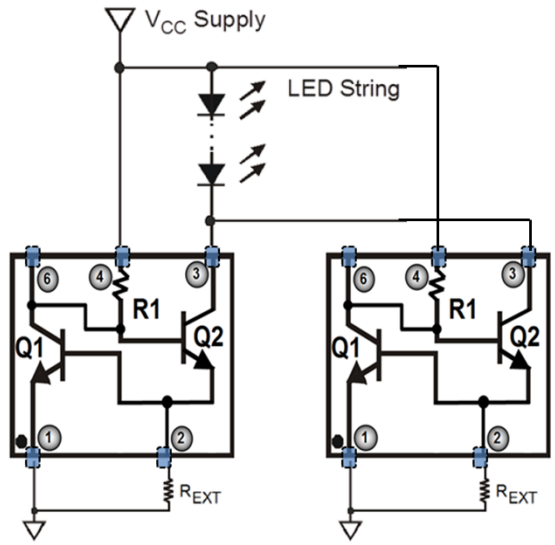


Figure 13 Application Circuit for Increasing LED Current

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Application Information (Continued)

PWM dimming can be achieved by driving the EN Pin. An external open-collector NPN transistor or open-drain N-Channel MOSFET can be used to drive the EN Pin as shown in Figure 14. Dimming is achieved by turning the LEDs ON and OFF for a portion of a single cycle. The PWM signal can be provided by a micro-controller or analog circuitry. Figure 16 is a typical response of LED current vs. PWM duty cycle on the EN Pin.

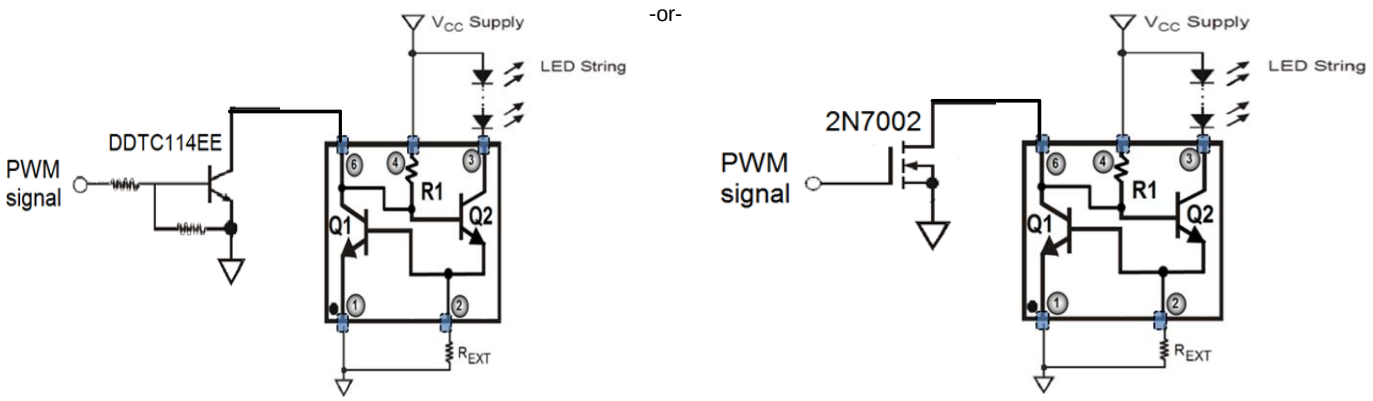


Figure 14 Application Circuits for LED Driver with PWM Dimming Functionality

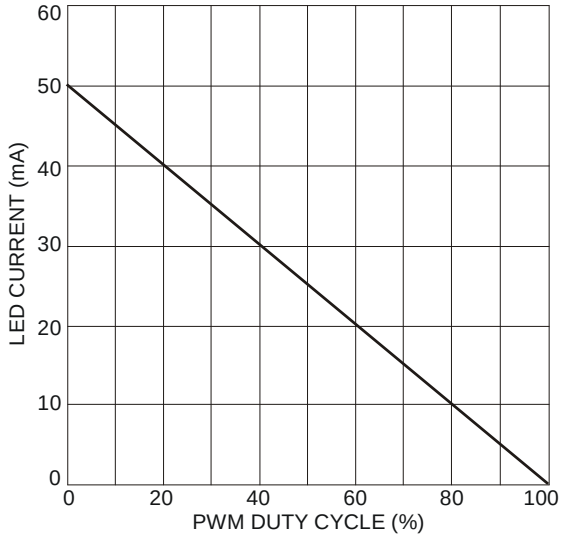


Figure 15 Typical LED Current Response vs. PWM Duty Cycle for R_{EXT} = 13Ω at 400Hz PWM Frequency

To remove the potential of incorrect connection of the power supply damaging the lamp's LEDs, many systems use some form of reverse polarity protection.

One solution for reverse input polarity protection is to simply use a diode with a low V_F in-line with the driver/LED combination. The low V_F increases the available voltage to the LED stack and dissipates less power. A circuit example is presented in Figure 16 using Diodes Incorporated's SBR (Super Barrier Rectifier) technology. An SDM10U45LP (0.1A/45V) is shown, providing exceptionally low V_F for its package size of 1mm x 0.6mm, equivalent to an 0402 chip style package. Other reverse voltage ratings are available on Diodes' website, such as the SBR02U100LP (0.2A/100V) or SBR0220LP (0.2A/20V).

Automotive applications commonly use this method for reverse battery protection.

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Application Information (cont.)

A second approach, shown in Figure 17, improves upon the method shown in Figure 16. Whereas the method in Figure 16 protects the light engine, it will not function until the problem is diagnosed and corrected.

The method shown in Figure 17 not only provides reverse polarity protection, it also corrects the reversed polarity, allowing the light engine to function.

The BAS40BRW incorporates four low V_F, Schottky diodes into a single package and allows more voltage to be available for the LED stack and dissipates less power than standard rectifier bridges.

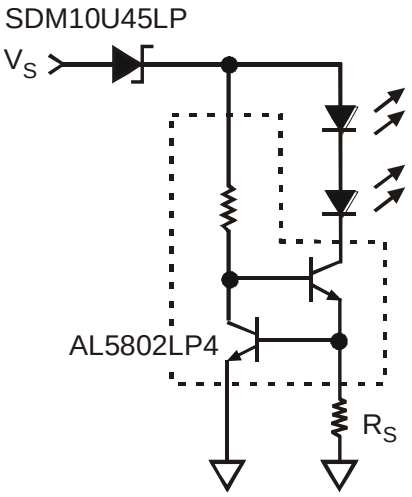


Figure 16 Application Circuit for LED Driver with Reverse Polarity Protection

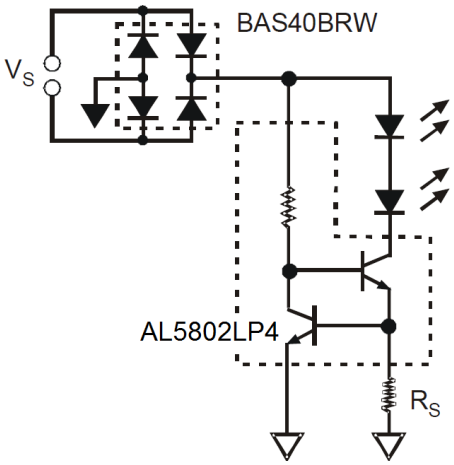
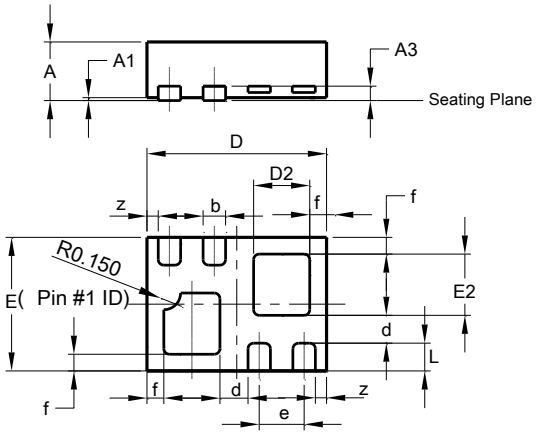


Figure 17 Application Circuit for LED Driver with Assured Operation Regardless of Polarity

Package Outline Dimensions

Please see AP02001 at http://www.diodes.com/_files/datasheets/ap02001.pdf for the latest version.

X2-DFN1310-6



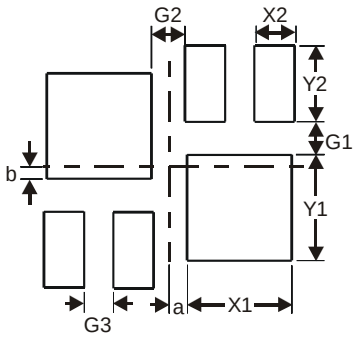
X2-DFN1310-6			
Dim	**Min**	**Max**	**Typ**
A	—	0.40	—
A1	0	0.05	0.02
A3	—	—	0.13
b	0.10	0.20	0.15
D	1.25	1.38	1.30
d	—	—	0.25
D2	0.30	0.50	0.40
E	0.95	1.075	1.00
e	—	—	0.35
E2	0.30	0.50	0.40
f	—	—	0.10
L	0.20	0.30	0.25
Z	—	—	0.05
All Dimensions in mm			

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Suggested Pad Layout

Please see AP02001 at http://www.diodes.com/_files/datasheets/ap02001.pdf for the latest version.

X2-DFN1310-6



Dimensions	Value (in mm)
G1	0.16
G2	0.17
G3	0.15
X1	0.52
X2	0.20
Y1	0.52
Y2	0.375
a	0.09
b	0.06

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