

## Description

The AL5802LP 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<sub>EXT</sub> pin (2) to GND pin (3), and the internal high-gain transistor develops approximately 0.6V across the external resistor.

The AL5802LP'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.

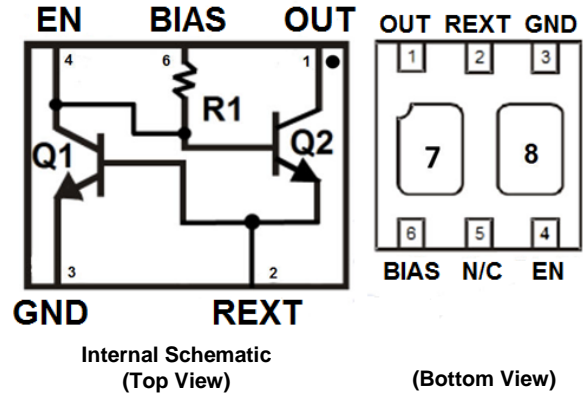
PWM dimming of the LED current can be achieved by either driving the BIAS pin (6) with a low impedance voltage source, or driving the EN pin (4) with an external open-collector NPN transistor or open-drain N-Channel MOSFET.

The AL5802LP is available in a U-DFN1616-6 (Type F) package and is ideal for driving 10mA to 120mA LED currents.

## Features

- Reference Voltage  $V_{REXT} = 0.65V$
- -40 to +125°C Operating Temperature Range
- 0.8V to 30V Open-Collector Output
- Negative Temperature Coefficient – Automatically Reduces the LED Current at High Temperatures
- Low Thermal Impedance, Small Footprint DFN1616-6 Package with Exposed Pads
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

## Pin Assignments



Package: U-DFN1616-6 (Type F)

- The collector of Q2 is connected to pin 1 and pad 7 which is on the underside of the package
- Pad 8 is electrically tied to the collector of Q1 and to the base of Q2, i.e. it is common with terminal 4

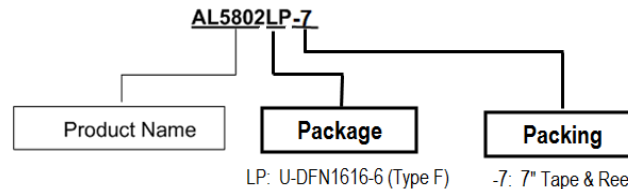
## Mechanical Data

- Case: U-DFN1616-6 (Type F)
- Case Material: Molded Plastic, "Green" Molding Compound; UL Flammability Classification Rating 94-V-0.
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – NiPdAu over Copper Leadframe; Solderable per MIL-STD-202, Method 208④
- Weight: 0.005 grams (Approximate)

## Applications

- Linear LED Driver
- LED Signs
- Offline LED Luminaries

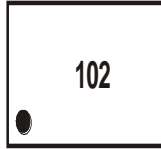
## Ordering Information (Note 4)



Device	Qualification	Packaging	Tape and Reel	
			Quantity	Part Number Suffix
AL5802LP	Commercial	U-DFN1616-6 (Type F)	3,000/Tape & Reel	-7

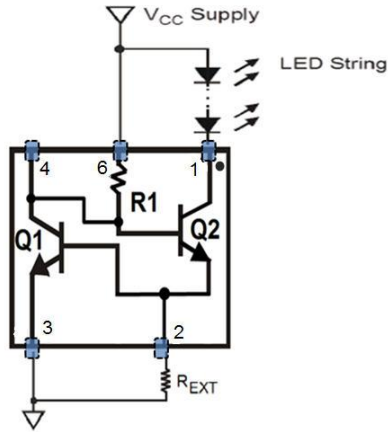
- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
  2. See [http://www.diodes.com/quality/lead\\_free.html](http://www.diodes.com/quality/lead_free.html) for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "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.
  4. For packaging details, go to our website at <http://www.diodes.com/products/packages.html>.

**Marking Information**



102 = Product Type Marking Code

**Typical Application Circuit**



**Pin Descriptions**

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

**Functional Block Diagram**

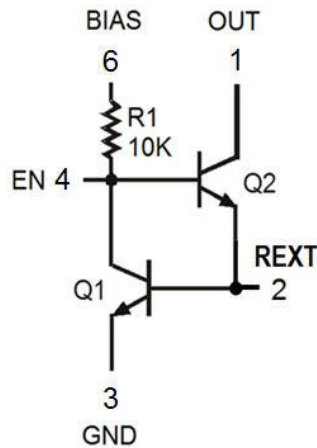


Figure 1 Block Diagram

### Absolute Maximum Ratings (Note 5)

Symbol	Characteristics	Values	Unit
V <sub>OUT</sub>	Output Voltage Relative to GND	30	V
V <sub>BIAS</sub>	BIAS Voltage Relative to GND	30	V
V <sub>FB</sub>	LED Voltage Relative to GND	6	V
V <sub>EN</sub>	EN Voltage Relative to GND	6	V
V <sub>REXT</sub>	REXT Voltage Relative to GND	6	V
I <sub>OUT</sub>	Output Current	150	mA
T <sub>OP</sub>	Operating Temperature	-40 to +150	°C
T <sub>STG</sub>	Storage Temperature	-55 to +150	°C

Notes: 5. These are stress ratings only. Operation outside the absolute maximum ratings may cause device failure. Operation at the absolute maximum rating for extended periods of time may reduce device reliability.

### Package Thermal Data

Characteristic	Symbol	Value	Unit
Power Dissipation (Note 6) @ T <sub>A</sub> = +25°C	P <sub>D</sub>	0.44	W
Thermal Resistance, Junction to Ambient Air (Note 6) @ T <sub>A</sub> = +25°C	R <sub>θJA</sub>	284	°C/W

### Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V <sub>BIAS</sub>	Supply Voltage Range	4.5	30	V
V <sub>OUT</sub>	OUT Voltage Range	0.8	30	
I <sub>LED</sub>	LED Pin Current (Note 7)	10	120	mA
T <sub>A</sub>	Operating Ambient Temperature Range	-40	+125	°C

Notes: 6. Device mounted on FR-4 PCB, single-sided, 2oz copper trace weight with minimum recommended pad layout.  
7. Subject to ambient temperature, power dissipation and PCB substrate material selection.

### Electrical Characteristics – NPN Transistor – Q1 (@T<sub>A</sub> = +25°C, unless otherwise specified.)

Symbol	Characteristic	Test Condition	Min	Typ	Max	Unit
V <sub>(BR)CEO</sub>	Collector-Emitter Breakdown Voltage (Notes 8 & 9)	I <sub>C</sub> = 1.0mA, I <sub>B</sub> = 0	40	—	—	V
V <sub>(BR)EBO</sub>	Emitter-Base Breakdown Voltage	I <sub>E</sub> = 10μA, I <sub>C</sub> = 0	6.0	—	—	V
I <sub>CEX</sub>	Collector Cut-Off Current (Note 9)	V <sub>CE</sub> = 30V, V <sub>EB(OFF)</sub> = 3.0V	—	—	50	nA
I <sub>BL</sub>	Base Cut-Off Current (Note 9)	V <sub>CE</sub> = 30V, V <sub>EB(OFF)</sub> = 3.0V	—	—	50	nA
h <sub>FE</sub>	DC Current Gain	I <sub>C</sub> = 100μA, V <sub>CE</sub> = 1.0V	40	—	—	—
		I <sub>C</sub> = 1.0mA, V <sub>CE</sub> = 1.0V	70	—	—	
		I <sub>C</sub> = 10mA, V <sub>CE</sub> = 1.0V	100	—	300	
V <sub>CE(SAT)</sub>	Collector-Emitter Saturation Voltage (Note 8)	I <sub>C</sub> = 10mA, I <sub>B</sub> = 1.0mA	—	—	0.20	V
V <sub>BE(SAT)</sub>	Base-Emitter Saturation Voltage	I <sub>C</sub> = 10mA, I <sub>B</sub> = 1.0mA	0.65	—	0.85	V
V <sub>BE(ON)</sub>	Base-Emitter Turn-On Voltage	V <sub>CE</sub> = 1.50V, I <sub>C</sub> = 2.0mA	0.30	—	1.10	V

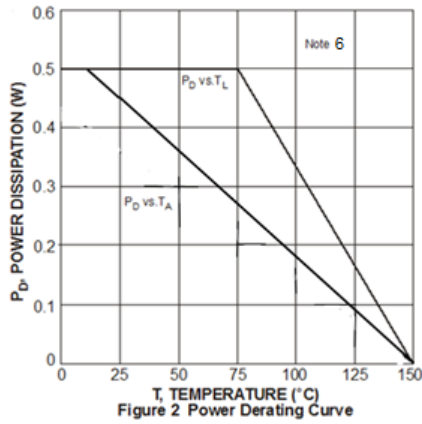
Notes: 8. Short duration pulse test used to minimize self-heating effect.  
9. Guaranteed by design and tested only at the wafer level for single die. These parameters cannot be tested at the finished goods level due to the testability of the device changed after packaging multiple dies to form an application circuit.

**Electrical Characteristics – NPN Pre-biased Transistor – Q2** (@ $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

Symbol	Characteristic	Test Condition	Min	Typ	Max	Unit
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 50\mu\text{A}, I_E = 0$	30	—	—	V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage (Note 8)	$I_C = 1\text{mA}, I_B = 0$	30	—	—	V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage (Note 9)	$I_E = 50\mu\text{A}, I_C = 0$	5.0	—	—	V
$I_{CBO}$	Collector Cut-Off Current	$V_{CB} = 30\text{V}, I_E = 0$	—	—	0.5	$\mu\text{A}$
$I_{EBO}$	Emitter Cut-Off Current (Note 9)	$V_{EB} = 4\text{V}, I_C = 0$	—	—	0.5	$\mu\text{A}$
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage (Note 8)	$I_C = 10\text{mA}, I_B = 1\text{mA}$	—	—	0.3	V
$V_{BE(ON)}$	Base-Emitter Turn-On Voltage	$V_{CE} = 5.0\text{V}, I_C = 2.0\text{mA}$	0.30	—	1.10	V
$h_{FE}$	DC Current Gain (Note 8)	$V_{CE} = 5\text{V}, I_C = 150\text{mA}$	100	—	—	—
$R_1$	Input Resistance	—	7	10	13	k $\Omega$

Notes: 8. Short duration pulse test used to minimize self-heating effect.  
 9. Guaranteed by design and tested only at the wafer level for single die. These parameters cannot be tested at the finished goods level due to the testability of the device changed after packaging multiple dies to form an application circuit.

**Thermal Characteristics**



**Typical Performance Characteristics**

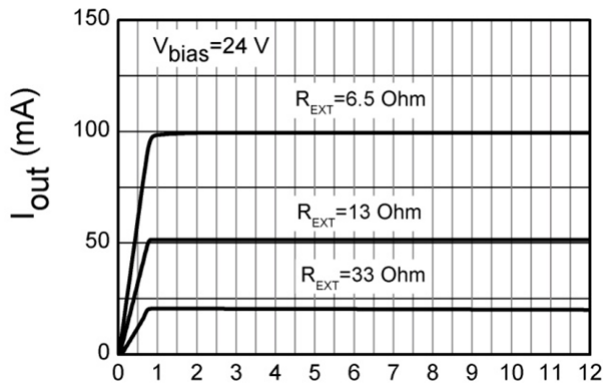


Figure 3 Output Current vs.  $V_{OUT}$

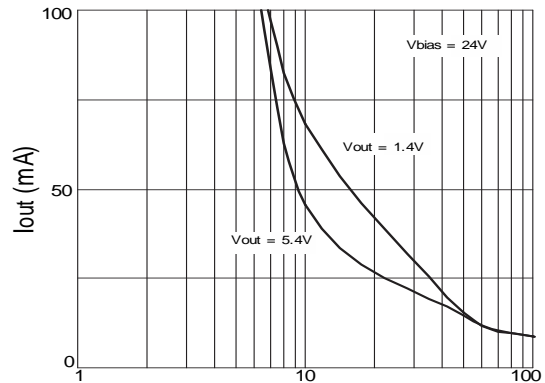
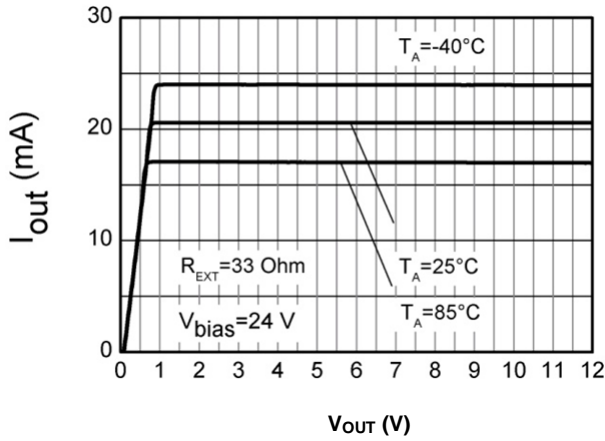
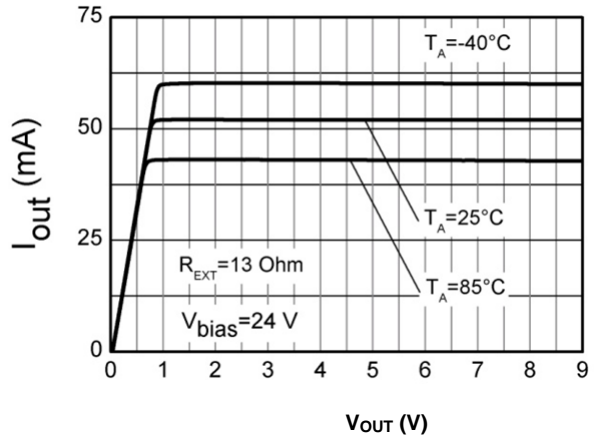


Figure 4 Output Current vs.  $R_{ext}$

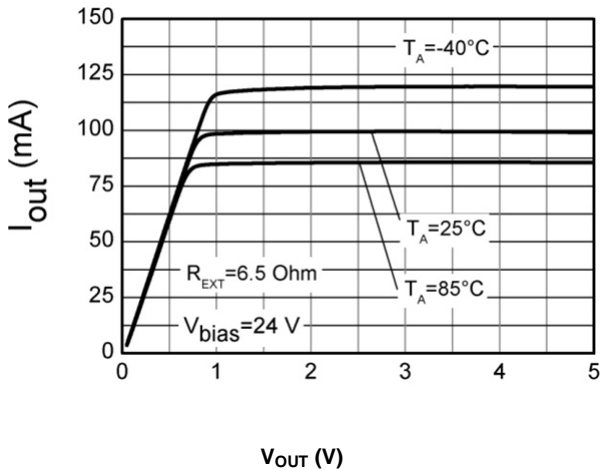
**Typical Performance Characteristics** (continued)



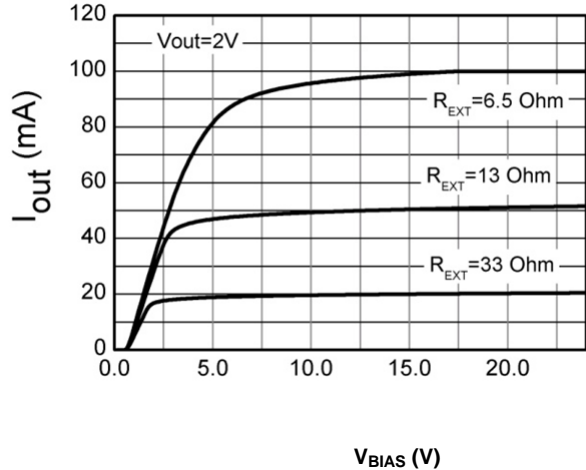
**Figure 5 Output Current vs. Vout**



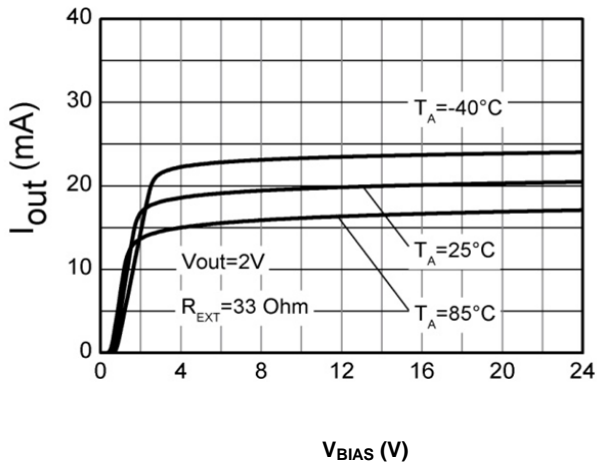
**Figure 6 Output Current vs. Vout**



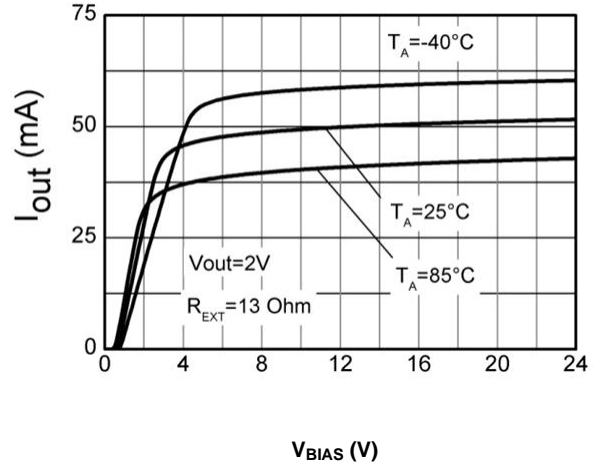
**Figure 7 Output Current vs. Vout**



**Figure 8 Output Current vs. VBIAS**



**Figure 9 Output Current vs. VBIAS**



**Figure 10 Output Current vs. VBIAS**

**Typical Performance Characteristics** (cont.)

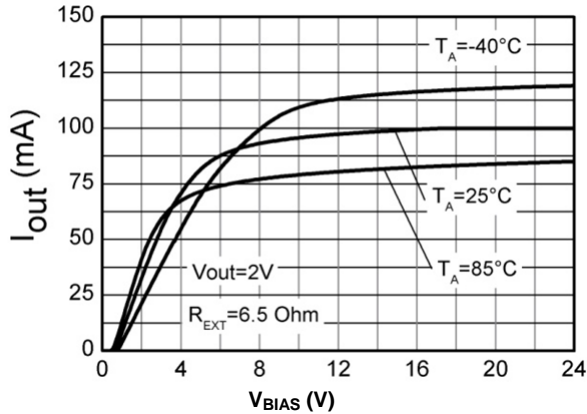


Figure 11 Output Current vs. VBIAS

**Application Information**

The AL5802LP is designed for driving low current LEDs with typical LED current range of 10mA to 100mA. It provides a cost-effective way for 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 REXT. Q1 uses its VBE as a reference to set the voltage across REXT and controls the base current into Q2. Q2 operates in linear mode to regulate the LED current. The LED current is expressed as follows:

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

From this, for any required LED current, the necessary external resistor REXT can be calculated as follows:

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

Two or more AL5802LP devices 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 AL5802LP'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.

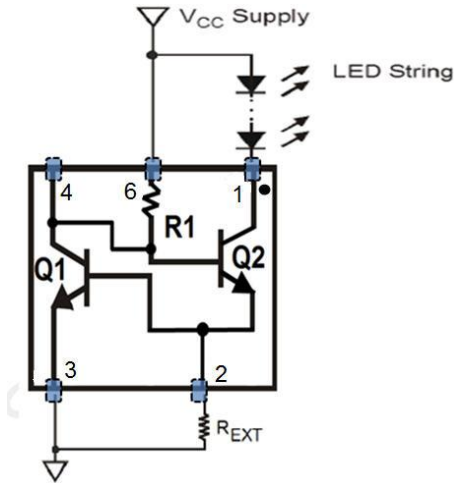
$$V_{CE(Q2)} = V_{CC} - V_{LED} - V_{BE(Q1)}$$

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

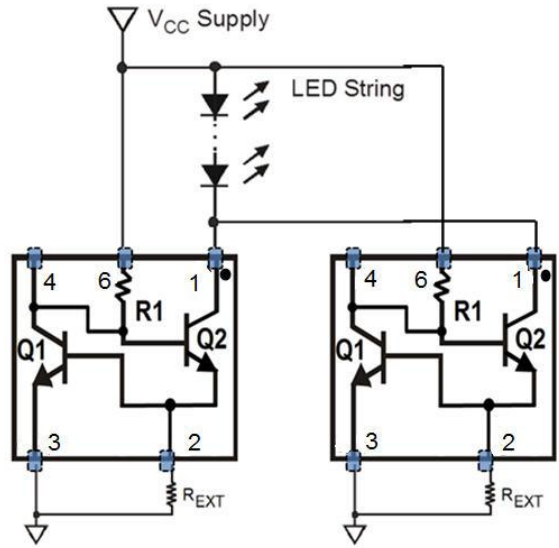
As the output current of AL5802LP increases, it is necessary to provide appropriate thermal relief to the device. The power dissipation supported by the device is dependent upon the properties of the PCB board material, the copper pad areas and the ambient temperature. The maximum dissipation the device can handle is given as follows:

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

**Application Information** (continued)

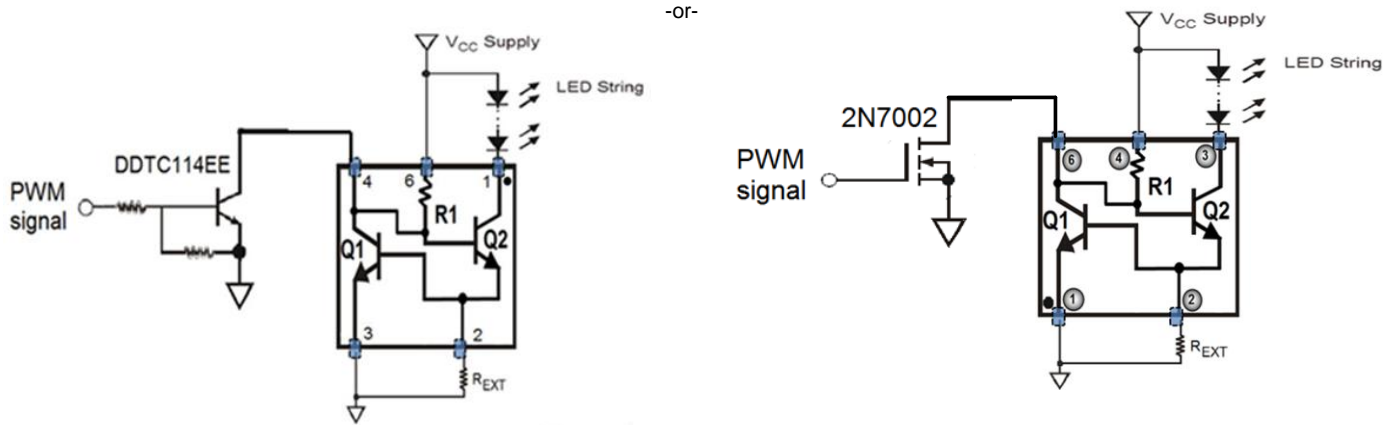


**Figure 12 Typical Application Circuit for Linear Mode Current Sink LED Driver**



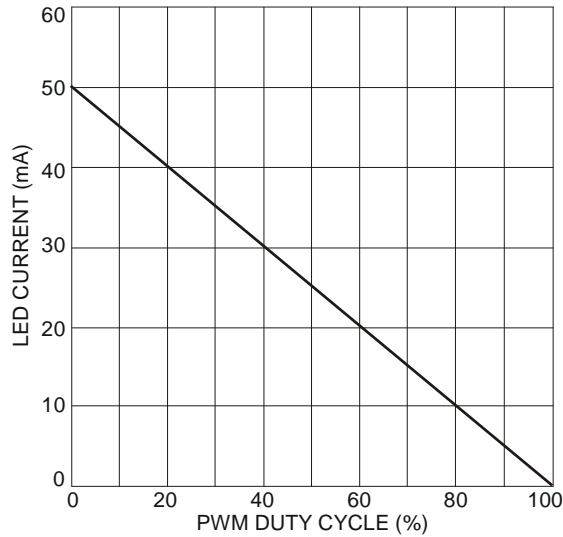
**Figure 13 Application Circuit for Increasing LED Current**

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 15 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**

**Application Information** (cont.)



**Figure 15 Typical LED Current Response vs. PWM Duty Cycle for  $R_{EXT} = 13\Omega$  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.

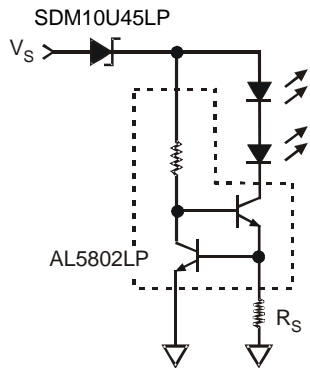
One solution for reverse input polarity protection is to simply use a diode with a low  $V_F$  in-line with the driver/LED combination. The low  $V_F$  of the series connected diode increases the available voltage to the LED stack and dissipates less power. A circuit example is presented in Figure 16 using Diodes Inc. SBR<sup>®</sup> (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 also available on Diodes Inc.'s website such as the SBR02U100LP (0.2A/100V) or SBR0220LP (0.2A/20V).

Automotive applications commonly use this method for reverse battery protection.

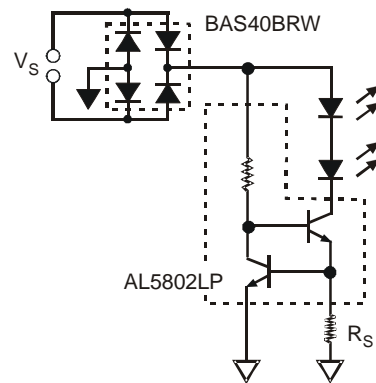
A second approach, shown in Figure 17, improves upon the method shown in Figure 16. Whereas the method in Figure 16 protects the light engine, it will not function until the problem has been diagnosed and corrected.

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 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**

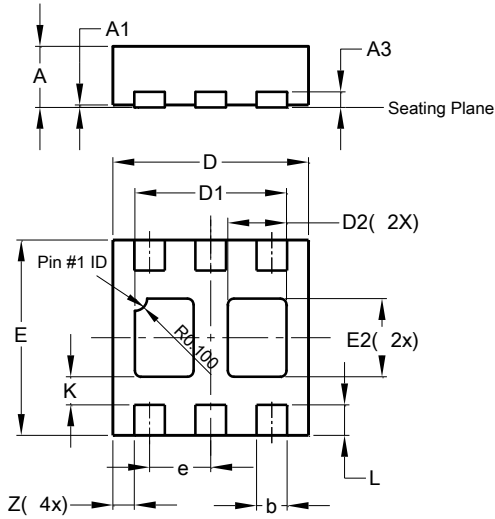
SBR is a registered trademark of Diodes Incorporated



**Package Outline Dimensions**

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

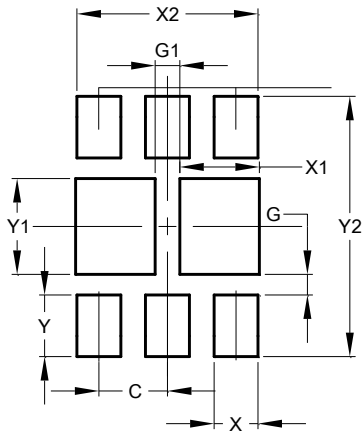
**U-DFN1616-6 (Type F)**



U-DFN1616-6 (Type F)			
Dim	Min	Max	Typ
A	0.45	0.55	0.50
A1	0	0.05	0.02
A3	—	—	0.127
b	0.20	0.30	0.25
D	1.55	1.65	1.60
D1	1.14	1.34	1.24
D2	0.38	0.58	0.48
E	1.55	1.65	1.60
E2	0.54	0.74	0.64
e	—	—	0.50
K	—	—	0.23
L	0.15	0.35	0.25
Z	—	—	0.175
All Dimensions in mm			

**Suggested Pad Layout**

Please see <http://www.diodes.com/package-outlines.html> for the latest version.



Dimensions	Value (in mm)
C	0.500
G	0.150
G1	0.180
X	0.320
X1	0.580
X2	1.320
Y	0.450
Y1	0.700
Y	1.900

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