LED DRIVER, 30V, LINEAR, ADJUSTABLE, CURRENT SINK

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 REXT pin (2) to GND pin (3), and the internal high gain transistor develops approximately 0.6V across the external resistor.

The AL5802LP open-collector output can operate from 0.8V to 30V enabling it to operate from 5V to 24V power supplies without additional components.

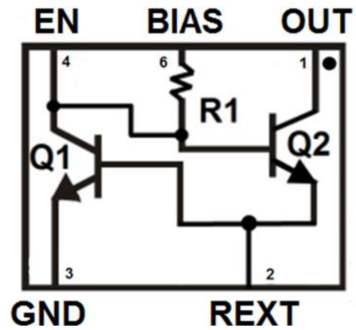
PWM dimming of the LED current can be achieved by either driving the BIAS pin (6) with a low impedance voltage source, or driving the EN pin (4) with an external open-collector NPN transistor or open-drain N-Channel MOSFET.

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

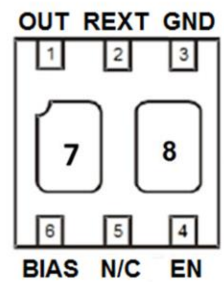
Features

- Reference Voltage VRSET = 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 Package with Exposed Pads
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Pin Assignments



Internal Schematic (Top View)



(Bottom View)

Package: U-DFN1616-6

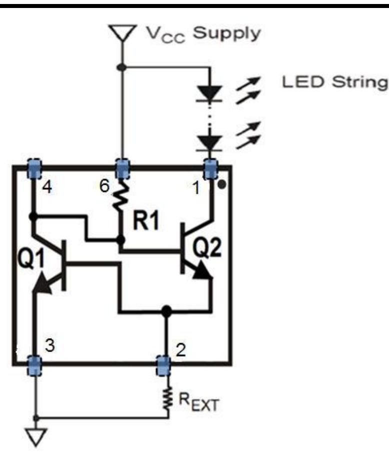
- **The collector of Q2 is connected to pin 1 and pad 7 which is on the underside of the package**
- **Pad 8 is electrically tied to the collector of Q1 and to the base of Q2, i.e. it is common with terminal 4**

Mechanical Data

- Case: U-DFN1616-6
- 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 208 (e4)
- Weight: 0.005 grams (Approximate)

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.

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

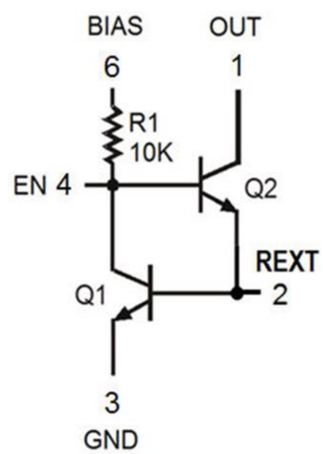


Figure 1 Block Diagram

Absolute Maximum Ratings

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	150	mA
T_{OP}	Operating Temperature	-40 to +150	°C
T_{STG}	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 of time may reduce device reliability.

Package Thermal Data

Characteristic	Symbol	Value	Unit
Power Dissipation (Note 4) @ T_A = +25°C	P_D	0.50	W
Thermal Resistance, Junction to Ambient Air (Note 4) @ T_A = +25°C	$R_{\theta JA}$	250	°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	120	mA
T_A	Operating Ambient Temperature Range	-40	+125	°C

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 (Notes 6 & 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 Cut-Off Current (Note 7)	V_{CE} = 30V, $V_{EB(OFF)}$ = 3.0V	—	—	50	nA
I_{BL}	Base Cut-Off Current (Note 7)	V_{CE} = 30V, $V_{EB(OFF)}$ = 3.0V	—	—	50	nA
h_{FE}	DC Current Gain	I_C = 100µA, V_{CE} = 1.0V I_C = 1.0mA, V_{CE} = 1.0V I_C = 10mA, V_{CE} = 1.0V	40 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} = 1.50V, 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 Cut-Off Current	V_{CB} = 30V, I_E = 0	—	—	0.5	µA
I_{EBO}	Emitter Cut-Off 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

Note:
4. Device mounted on FR-4 PCB, single-sided, 2oz copper trace weight with minimum recommended pad layout.
5. Subject to ambient temperature, power dissipation and PCB substrate material selection.
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 goods level due to the testability of the device changed after packaging multiple dies to form an application circuit.

Thermal Characteristics

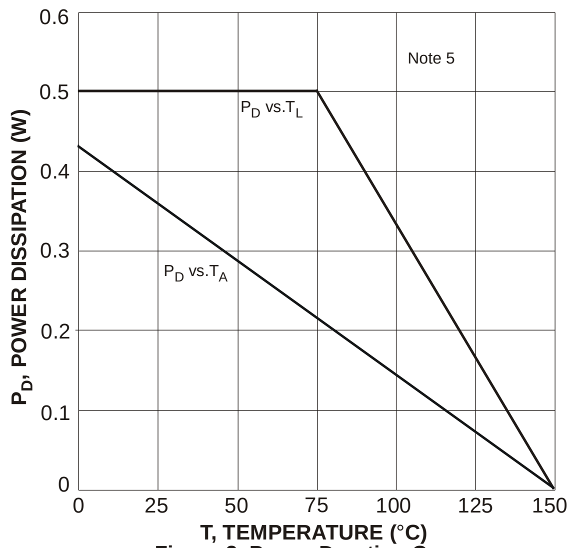


Figure 2 Power Derating Curve

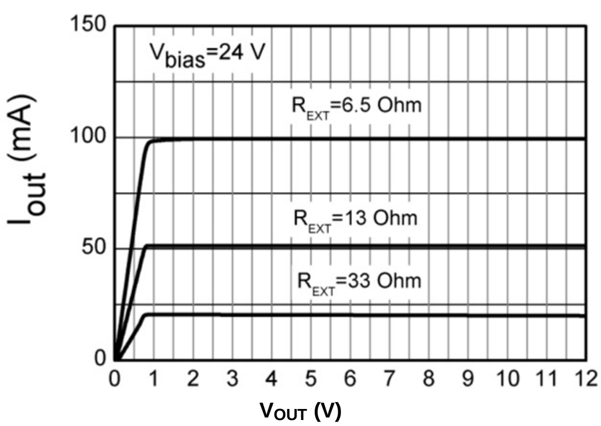


Figure 3 Output Current vs. V_{OUT}

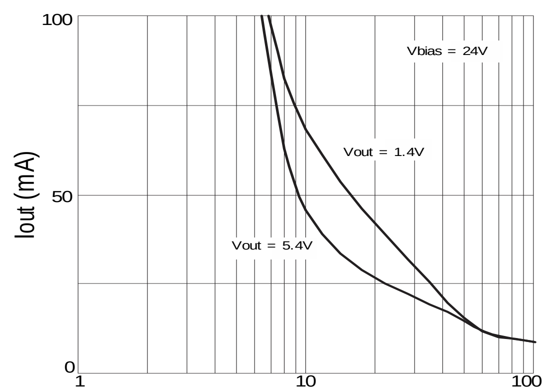


Figure 4 Output Current vs. Rext

Rext (Ω)

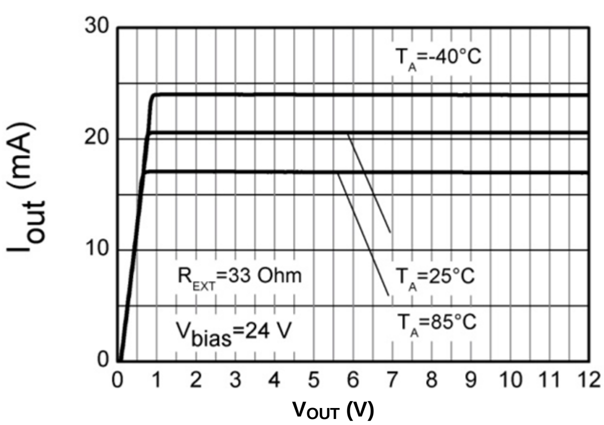


Figure 5 Output Current vs. V_{OUT}

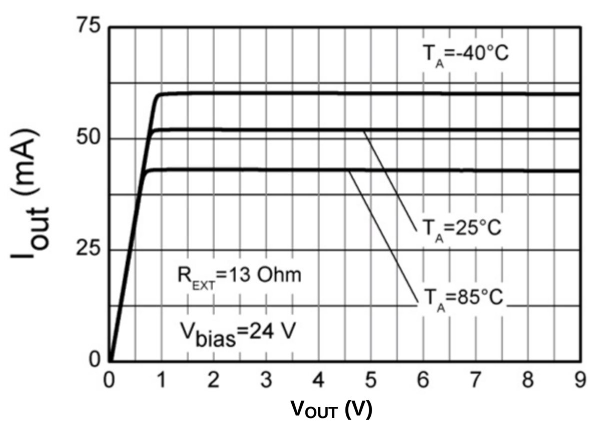


Figure 6 Output Current vs. V_{OUT}

Typical Performance Characteristics (cont.)

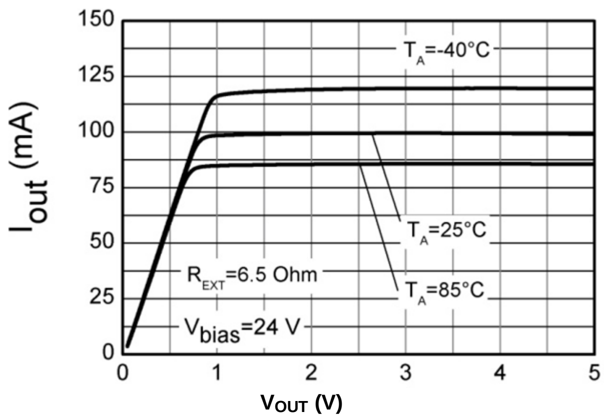


Figure 7 Output Current vs. V_{OUT}

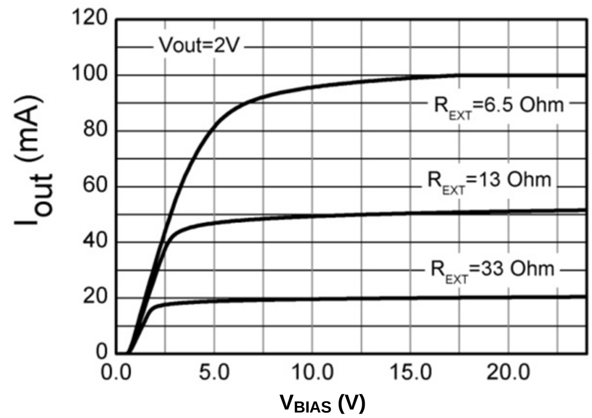


Figure 8 Output Current vs. V_{BIAS}

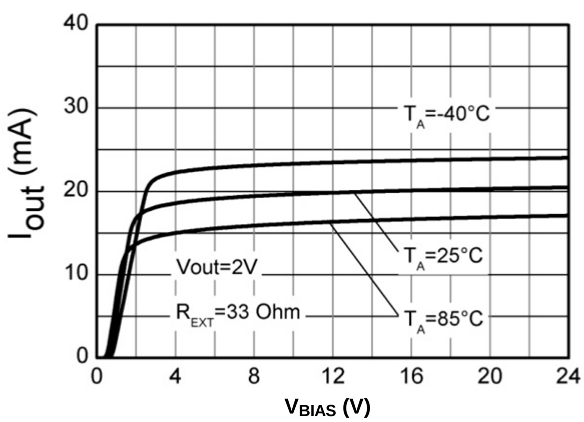


Figure 9 Output Current vs. V_{BIAS}

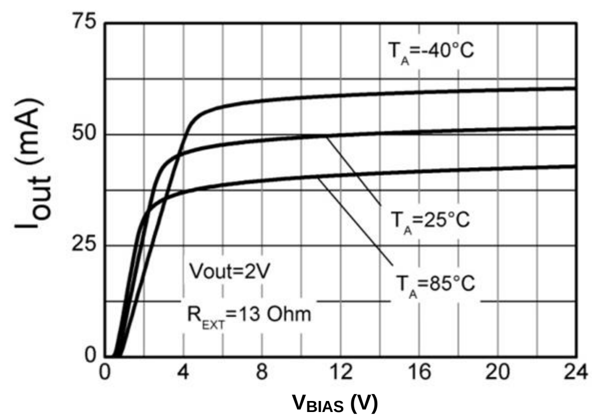


Figure 10 Output Current vs. V_{BIAS}

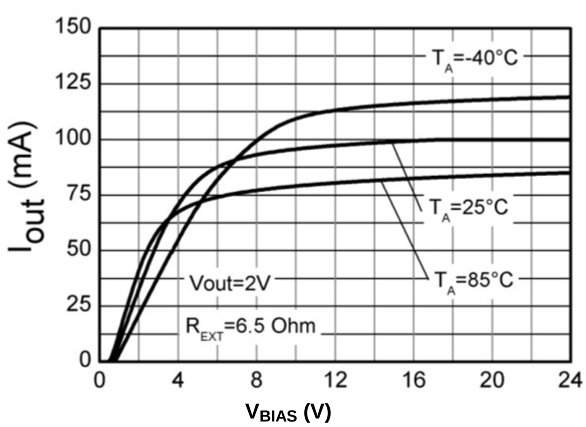


Figure 11 Output Current vs. V_{BIAS}

Application Information

The AL5802LP is designed for driving low current LEDs with typical LED current 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 R_{EXT}. Q1 uses its V_{BE} as a 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 expressed as follows:

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

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

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

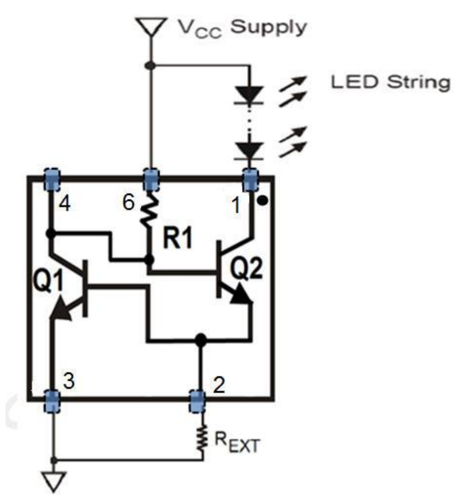


Figure 12 Typical Application Circuit for Linear Mode Current Sink LED Driver

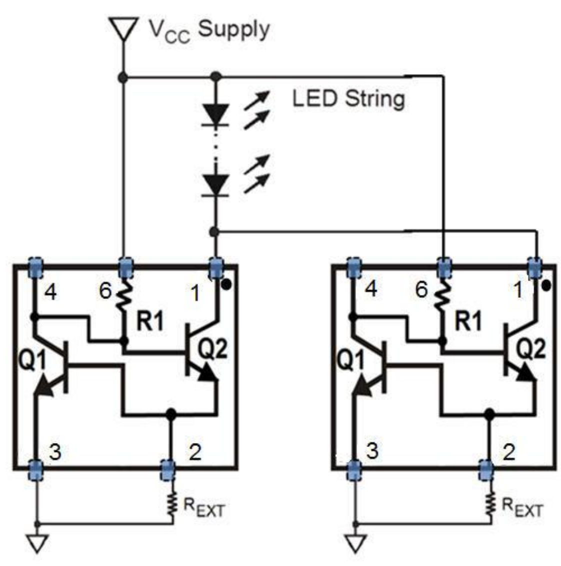


Figure 13 Application Circuit for Increasing LED Current

Application Information (cont.)

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.

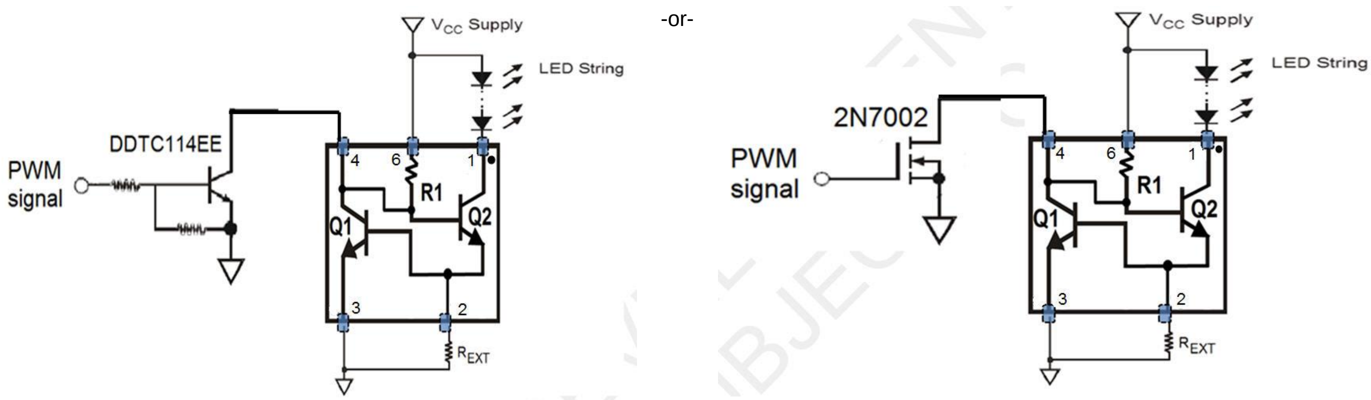


Figure 14 Application Circuits for LED Driver with PWM Dimming Functionality

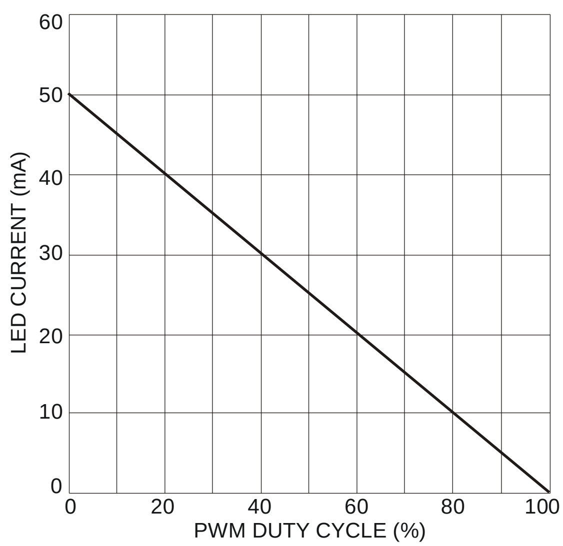


Figure 15 Typical LED Current Response vs. PWM Duty Cycle for R_{EXT} = 13Ω at 400Hz PWM Frequency

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 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® (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 in Diodes' website such as the SBR02U100LP (0.2A/100V) or SBR0220LP (0.2A/20V).

Automotive applications commonly use this method for reverse battery protection.

SBR is a registered trademark of Diodes Incorporated

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 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.

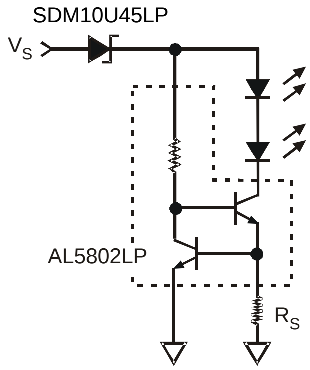


Figure 16 Application Circuit for LED Driver with Reverse Polarity Protection

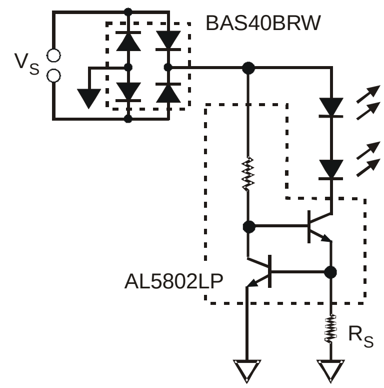


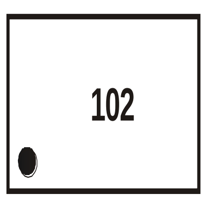
Figure 17 Application Circuit for LED Driver with Assured Operation Regardless of Polarity

Ordering Information (Note 8)

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

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

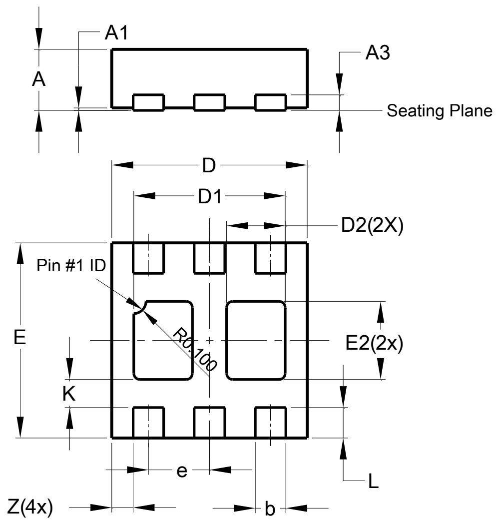
Marking Information



102 = Product Type Marking Code

Package Outline Dimensions

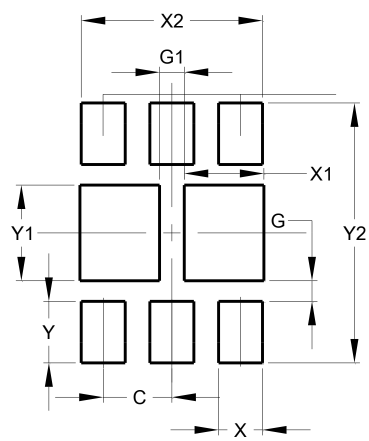
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.



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



Dimensions	Value (in mm)
C	0.50
G	0.15
G1	0.18
X	0.32
X1	0.58
X2	1.32
Y	0.45
Y1	0.70
Y	1.90

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