Linear LED Constant Current Regulator in SOT26

Description

This Linear LED driver is designed to meet the stringent requirements of automotive applications.

The BCR421U monolithically integrates transistors, diodes and resistors to function as a Constant Current Regulators (CCR) for linear LED driving. The device regulates with a preset 10mA nominal that can be adjusted with an external resistor up to 350mA. It is designed for driving LEDs in strings and will reduce current at increasing temperatures to self-protect. Operating as a series linear CCR for LED string current control, it can be used in multiple applications, as long as the maximum supply voltage to the device is < 40V.

With the low-side control, the BCR421U has an Enable (EN) pin which can be pulse-width modulated (PWM) up to 10 kHz by a micro-controller for LED dimming.

With no need for additional external components, this CCR is fully integrated into an SOT26 minimizing PCB area and component count.

Features

- LED Constant Current Regulator using NPN Emitter-Follower with Emitter Resistor to Current Limit
- I_{OUT} – 10mA ± 10% Constant Current (Preset)
- I_{OUT} up to 350mA Adjustable with an External Resistor
- V_{OUT} – 40V Supply Voltage
- P_D up to 1W in SOT26 (SC-74)
- Low-Side Control Enabling PWM Input < 10kHz
- Negative Temperature Coefficient (NTC) Reduces I_{OUT} with Increasing Temperature
- Parallel Devices to Increase Regulated Current
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **Qualified to AEC-Q101 Standards for High Reliability**
- **PPAP Capable (Note 4)**

Applications

Constant Current Regulation (CCR) in:

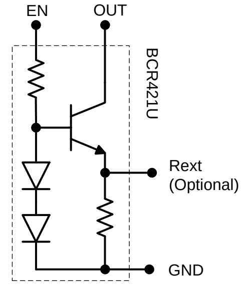
- Automotive Interior Lighting
- Mood and Decorative Lighting

Mechanical Data

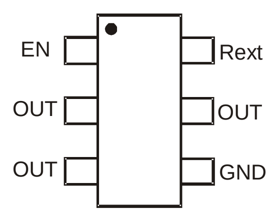
- Case: SOT26 (SC-74)
- Case Material: Molded Plastic. "Green" Molding Compound. UL Flammability Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish - Matte Tin Plated Leads. Solderable per MIL-STD-202, Method 208 e3
- Weight: 0.018 grams (Approximate)

SOT26 (SC-74)

Top View



Internal Device Schematic



Top View
Pin-Out

Pin Name	Pin Function
OUT	Regulated Output Current
EN	Enable for Biasing Transistor
R_{EXT}	External Resistor for Adjusting Output Current
GND	Power Ground

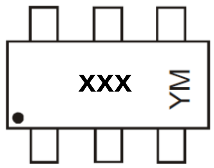
Ordering Information (Note 5)

Product	Compliance	Marking	Reel Size (inches)	Tape Width (mm)	Quantity per Reel
BCR421UW6Q-7	Automotive	421	7	8	3,000

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.
4. Automotive products are AEC-Q101 qualified and are PPAP capable. Refer to http://www.diodes.com/quality/product_compliance_definitions/.
5. For packaging details, go to our website at http://www.diodes.com/products/packages.html.

Marking Information

SOT26 (SC-74)



xxx = Part Marking (See Ordering Information)
YM = Date Code Marking
Y = Year (ex: C = 2015)
M = Month (ex: 9 = September)

Date Code Key

Year	2015	2016	2017	2018	2019	2020	2021
Code	C	D	E	F	G	H	I

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Code	1	2	3	4	5	6	7	8	9	O	N	D

Absolute Maximum Ratings (Voltage relative to GND, @T_A = +25°C, unless otherwise specified.)

Characteristic	Symbol	Value	Unit
Enable Voltage	V_{EN}	18	V
Output Current	I_{OUT}	500	mA
Output Voltage	V_{OUT}	40	V
Reverse Voltage Between All Terminals	V_R	0.5	V

Thermal Characteristics (@T_A = +25°C, unless otherwise specified.)

Characteristic		Symbol	Value	Unit
Power Dissipation	(Note 6)	P_D	1,190	mW
	(Note 7)		912	
Thermal Resistance, Junction to Ambient	(Note 6)	$R_{θJA}$	105	°C/W
	(Note 7)		137	
Thermal Resistance, Junction to Lead	(Note 8)	$R_{θJL}$	50	
Recommended Operating Junction Temperature Range		T_J	-55 to +150	°C
Maximum Operating Junction and Storage Temperature Range		T_J , T_{STG}	-65 to +150	

ESD Ratings (Note 9)

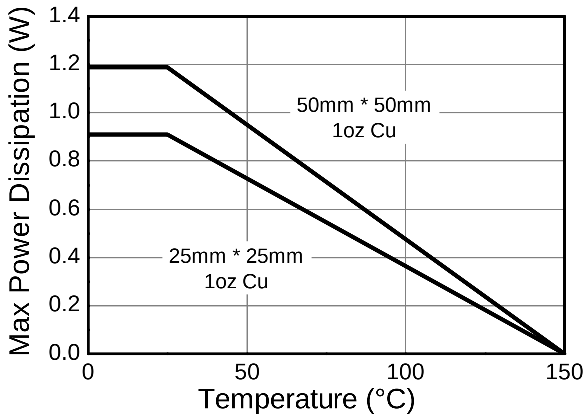
Characteristics	Symbols	Value	Unit	JEDEC Class
Electrostatic Discharge – Human Body Model	HBM	1,000	V	1C
Electrostatic Discharge – Machine Model	MM	400	V	C

Notes:
6. For a device mounted with the OUT leads on 50mm x 50mm 1oz copper that is on a single-sided 1.6mm FR4 PCB; device is measured under still air conditions while operating in steady-state.
7. Same as Note 5, except mounted on 25mm x 25mm 1oz copper.
8. $R_{θJL}$ = Thermal resistance from junction to solder-point (at the end of the OUT leads).
9. Refer to JEDEC specification JESD22-A114 and JESD22-A115.

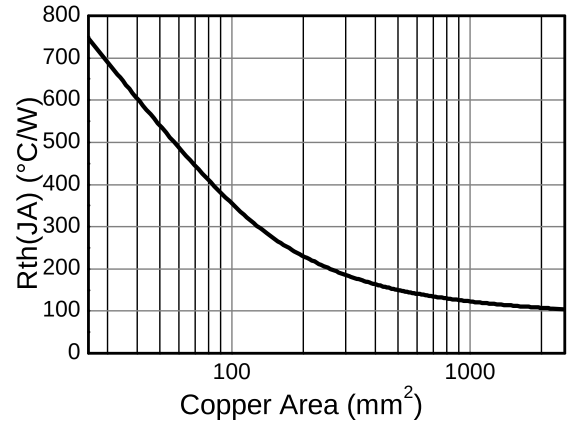
Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

Characteristic	Symbol	Min	Typ	Max	Unit	Test Condition
Collector-Emitter Breakdown Voltage	BV_{CEO}	40	—	—	V	I_C = 1mA
Enable Current	I_{EN}	—	1.2	—	mA	V_{EN} = 3.3V
DC Current Gain	h_{FE}	200	350	500	—	I_C = 50mA; V_{CE} = 1V
Internal Resistor	R_{INT}	85	95	105	Ω	I_{RINT} = 10mA
Bias Resistor	R_B	—	1.5	—	kΩ	—
Output Current	I_{OUT}	9	10	11	mA	V_{OUT} = 1.4V; V_{EN} = 3.3V
Output Current at R_{EXT} = 5.1Ω	I_{OUT}	—	150	—	mA	V_{OUT} > 2.0V; V_{EN} = 3.3V
Voltage Drop (V_{REXT})	V_{DROP}	0.85	0.95	1.05	V	I_{OUT} = 10mA
Minimum Output Voltage	$V_{OUT(MIN)}$	—	1.4	—	V	I_{OUT} > 18mA
Output Current Change vs. Temperature	$\Delta I_{OUT}/I_{OUT}$	—	-0.2	—	%/°C	V_{OUT} > 2.0V; V_{EN} = 3.3V
Output Current Change vs. Supply Voltage	$\Delta I_{OUT}/I_{OUT}$	—	1	—	%/V	V_{OUT} > 2.0V; V_{EN} = 3.3V

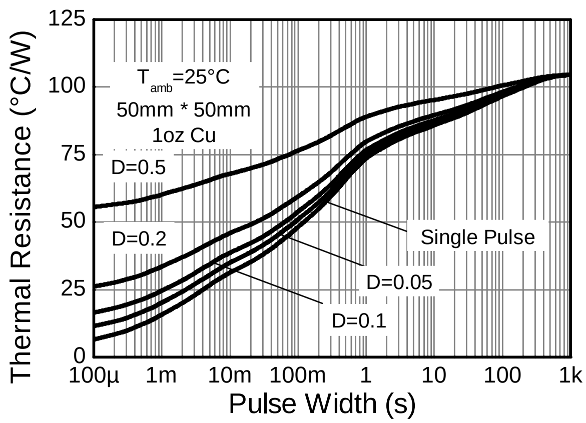
Typical Thermal Characteristics (@T_A = +25°C, unless otherwise specified.)



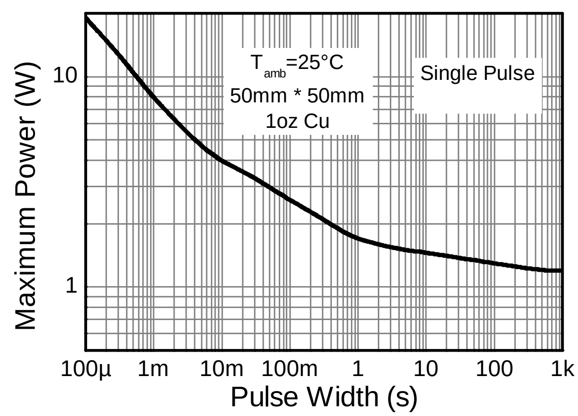
Derating Curve



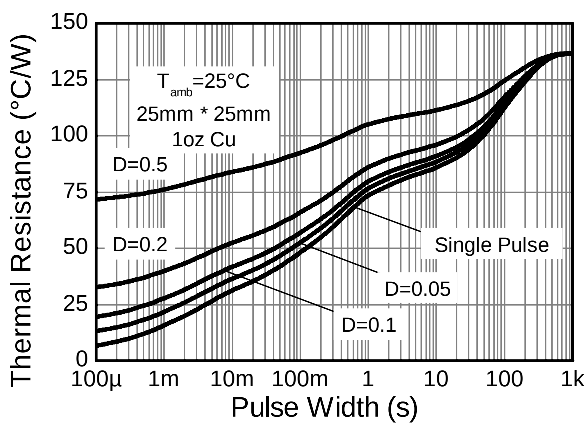
Rth(JA) VS Cu Area



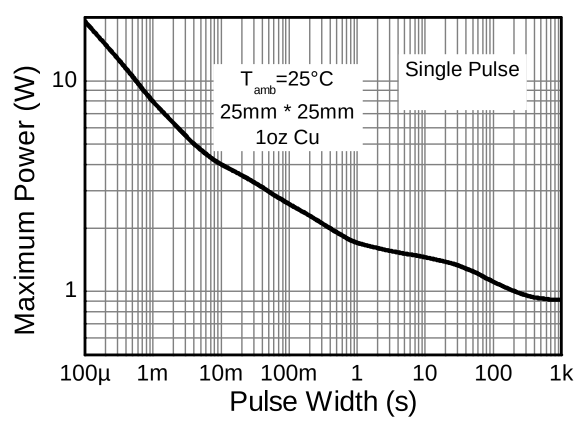
Transient Thermal Impedance



Pulse Power Dissipation

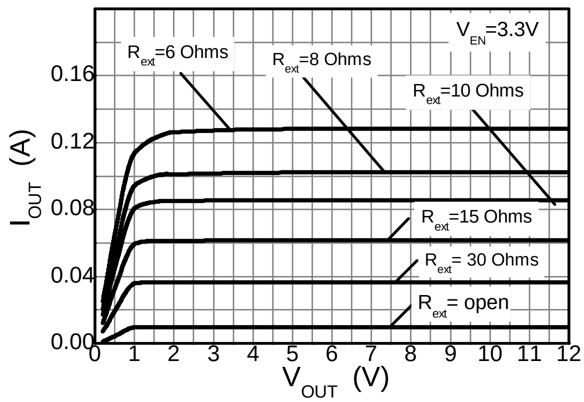


Transient Thermal Impedance

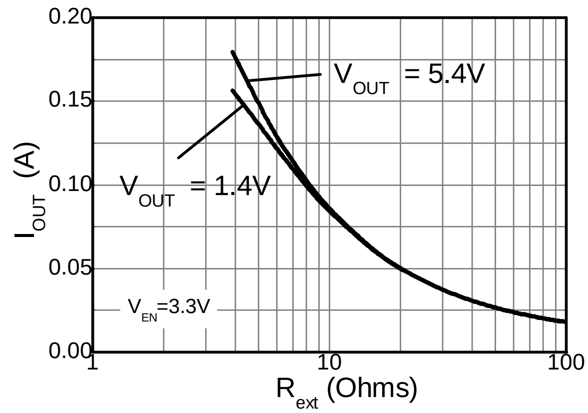


Pulse Power Dissipation

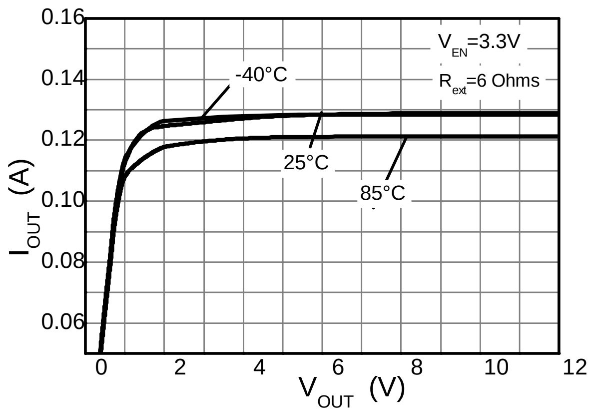
Typical Electrical Characteristics (Continued) (@T_A = +25°C, unless otherwise specified.)



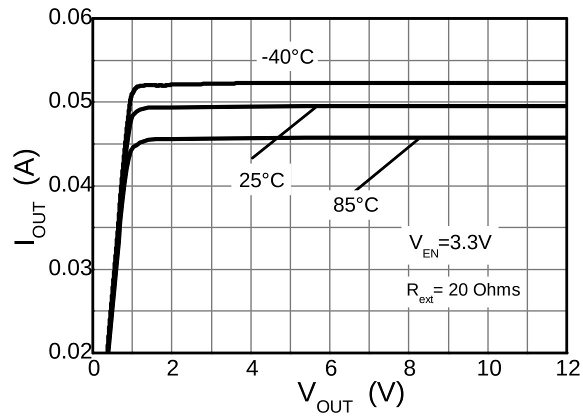
V_{OUT} vs I_{OUT}



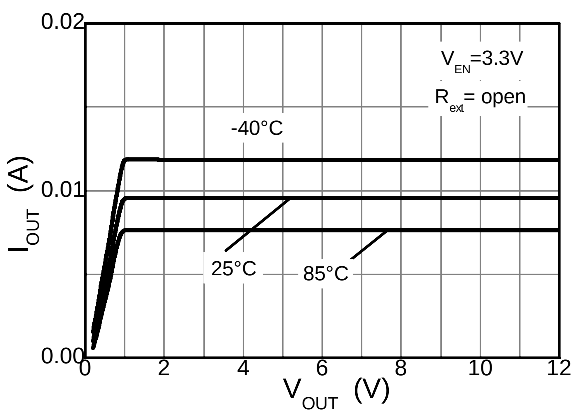
R_{ext} (Ohms)vs I_{OUT}



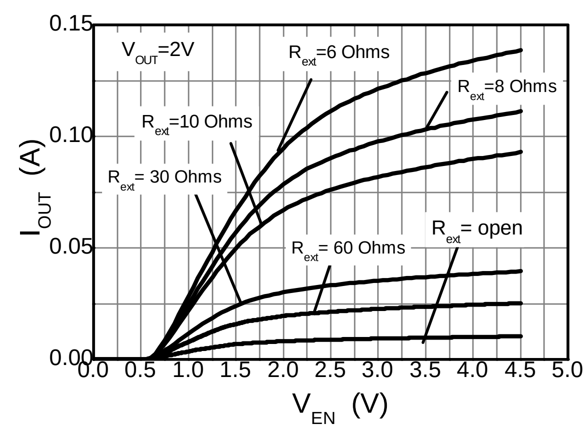
V_{OUT} vs I_{OUT}



V_{OUT} vs I_{OUT}

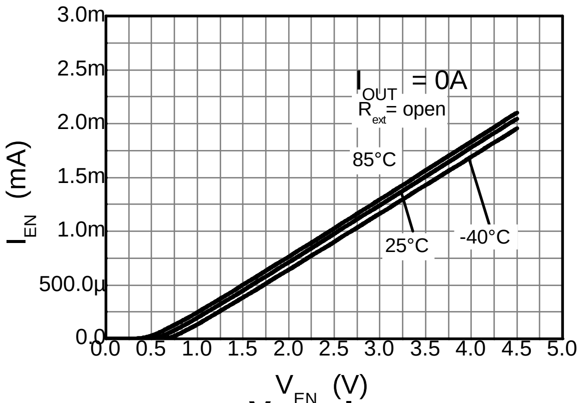


V_{OUT} vs I_{OUT}

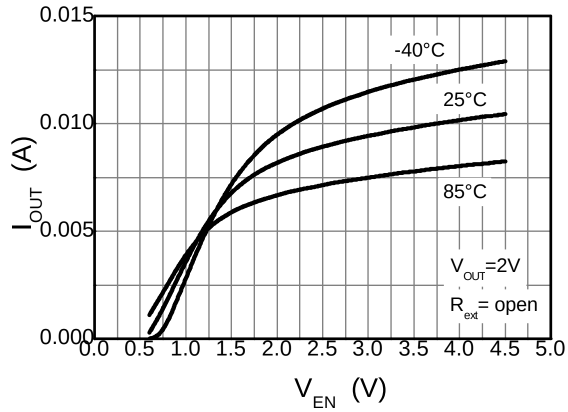


V_{EN} vs I_{OUT}

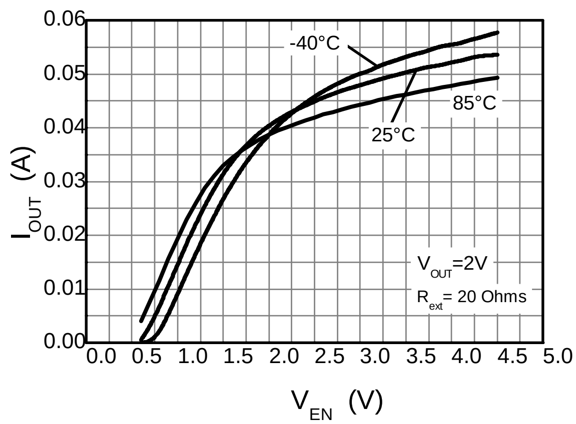
Typical Electrical Characteristics (Cont.) (@T_A = +25°C, unless otherwise specified.)



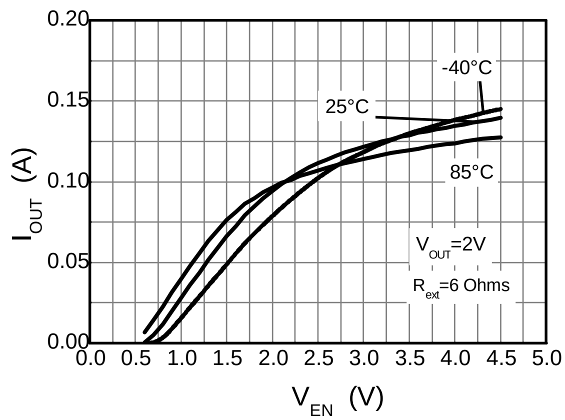
V_{EN} vs I_{EN}



V_{EN} vs I_{OUT}



V_{EN} vs I_{OUT}



V_{EN} vs I_{OUT}

Application Information

The BCR421 is designed for driving low current LEDs with typical LED currents of 10mA to 350mA. They provide a cost-effective way for driving low current LEDs compared with more complex switching regulator solutions. Furthermore, they reduce the PCB board area of the solution as there is no need for external components like inductors, capacitors and switching diodes.

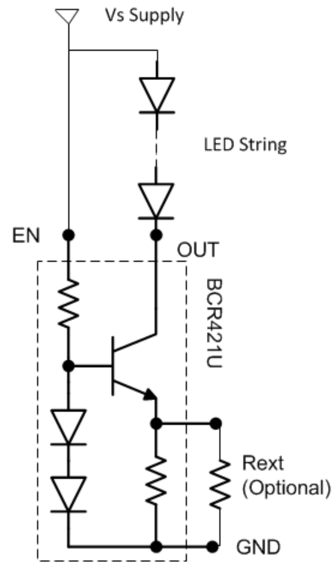


Figure 1 Typical Application Circuit for Linear Mode Current Sink LED Driver

Figure 1 shows a typical application circuit diagram for driving an LED or string of LEDs. The device comes with an internal resistor (R_{INT}) of typically 95Ω, which in the absence of an external resistor, sets an LED current of 10mA (typical) from a V_{EN} = 3.3V and V_{OUT} = 1.4V for BCR421. LED current can be increased to a desired value by choosing an appropriate external resistor, R_{EXT}.

The R_{EXT} Vs I_{OUT} graphs should be used to select the appropriate resistor. Choosing a low tolerance R_{EXT} will improve the overall accuracy of the current sense formed by the parallel connection of R_{INT} and R_{EXT}.

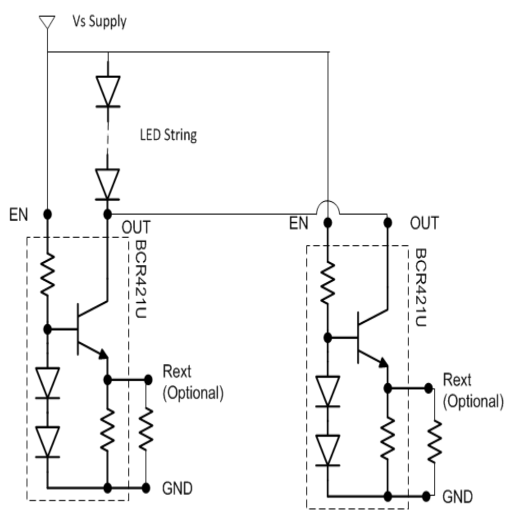


Figure 2 Application Circuit for Increasing LED Current

Two or more BCR421s can be connected in parallel to construct higher current LED strings as shown in Figure 2. Consideration of the expected linear mode power dissipation must be factored into the design, with respect to the BCR421's thermal resistance. The maximum voltage across the device can be calculated by taking the maximum supply voltage and subtracting the voltage across the LED string.

$V_{OUT} = V_S – V_{LED}$
$P_D = (V_{OUT} \times I_{LED}) + (V_{EN} \times I_{EN})$

As the output current of BCR421 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:

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

Refer to the thermal characteristic graphs on Page 4 for selecting the appropriate PCB copper area.

Application Information (Continued)

PWM dimming can be achieved by driving the EN pin. 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; typical circuit is shown in Figure 3. Figure 4 is a typical response of LED current vs. PWM duty cycle on the EN pin.

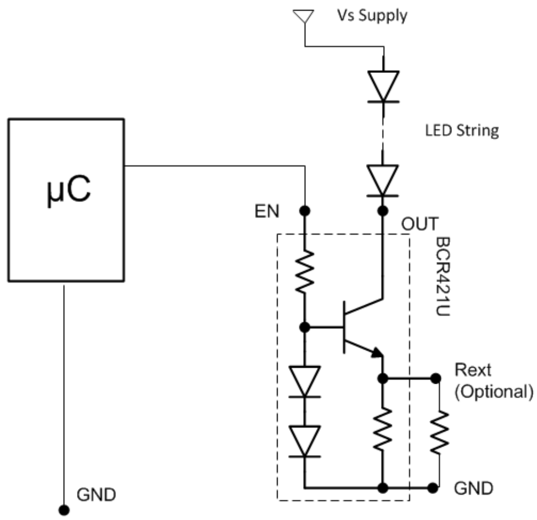


Figure 3 Application Circuits for LED Driver with PWM Dimming Functionality

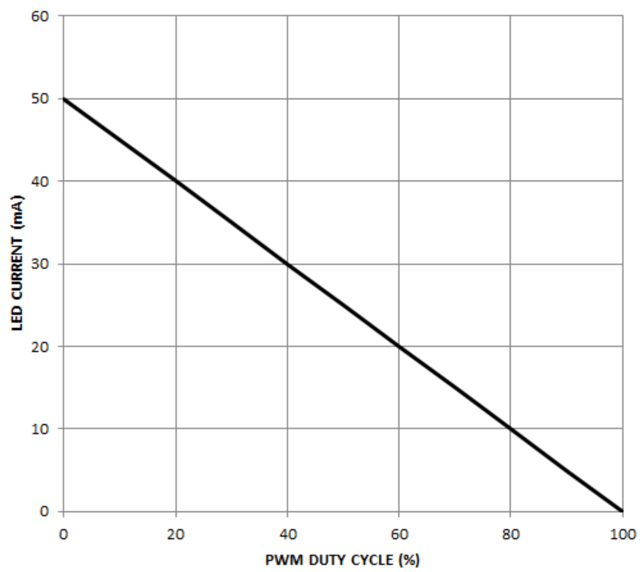


Figure 4 Typical LED Current Response vs. PWM Duty Cycle for 400Hz PWM Frequency

Application Information (Cont.)

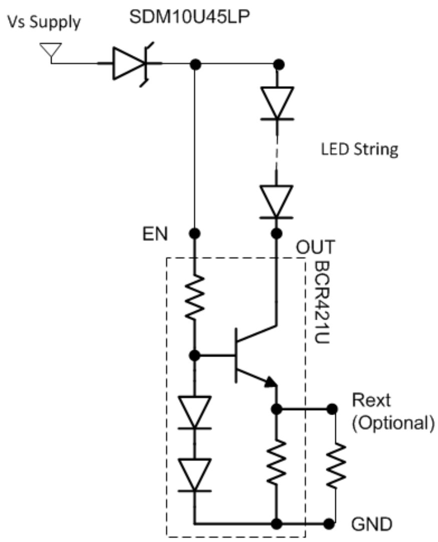


Figure 5 Application Circuit for LED Driver with Reverse Polarity Protection

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 5 which protects the light engine although it will not function until the problem is diagnosed and corrected. An SDM10U45LP (0.1A/45V) is shown, providing exceptionally low V_F for its package size of 1mm x 0.6mm. Other reverse voltage ratings are available from Diodes Incorporated's website such as the SBR02U100LP (0.2A/100V) or SBR0220LP (0.2A/20V).

While automotive applications commonly use this method for reverse battery protection, an alternative approach shown in Figure 6, provides reverse polarity protection and corrects the reversed polarity, allowing the light engine to function.

The BAS40BRW incorporates four low V_F Schottky diodes in a single package, reducing the power dissipated and maximizes the voltage across the LED stack.

Figure 7 shows an example configuration for 350mA operation. In such higher current configurations adequate enable current is provided by increasing the enable voltage.

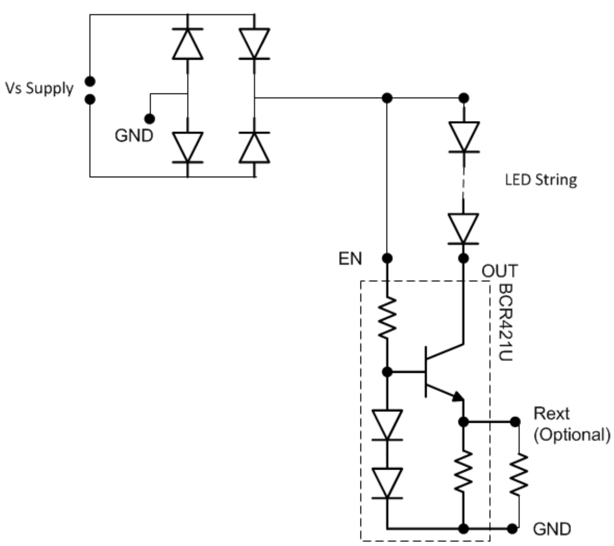


Figure 6 Application Circuit for LED Driver with Assured Operation Regardless of Polarity

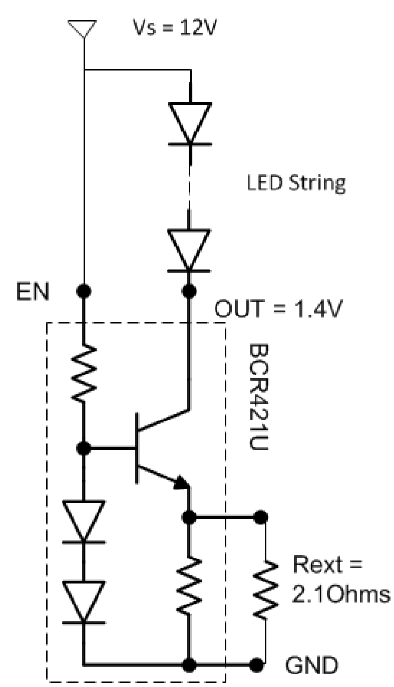
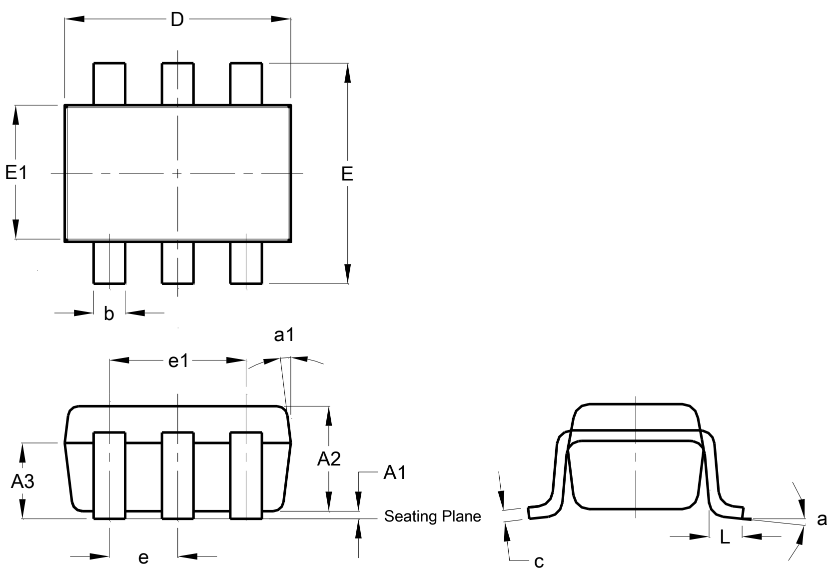


Figure 7 Example for 350mA operation

Package Outline Dimensions

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

SOT26 (SC74R)

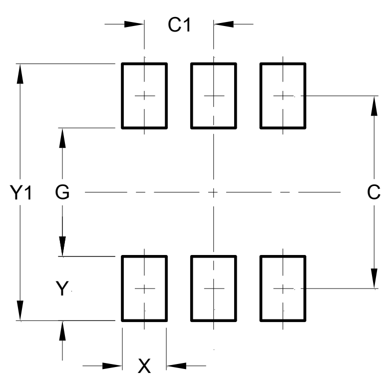


SOT26 (SC74R)			
Dim	**Min**	**Max**	**Typ**
A1	0.013	0.10	0.05
A2	1.00	1.30	1.10
A3	0.70	0.80	0.75
b	0.35	0.50	0.38
c	0.10	0.20	0.15
D	2.90	3.10	3.00
e	-	-	0.95
e1	-	-	1.90
E	2.70	3.00	2.80
E1	1.50	1.70	1.60
L	0.35	0.55	0.40
a	-	-	8°
a1	-	-	7°
All Dimensions in mm			

Suggested Pad Layout

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

SOT26 (SC74R)



Dimensions	Value (in mm)
C	2.40
C1	0.95
G	1.60
X	0.55
Y	0.80
Y1	3.20

IMPORTANT NOTICE

LIFE SUPPORT