# LINEAR LED CONSTANT CURRENT REGULATOR IN SOT26

## Description

The BCR420UW6 and BCR421UW6 monolithically integrate transistors, diodes, and resistors to function as a Constant Current Regulator (CCR) for linear LED driving. Each 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 low-side control, the BCR421U has an Enable (EN) pin which can be pulse-width modulated (PWM) up to 25kHz by a micro-controller for LED dimming.

With no need for additional external components, this CCR is fully integrated into the SOT26 package, 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 (BCR421U)
- $V_{OUT}$ – 40V Supply Voltage
- $P_D$ up to 1W in SOT26
- Low-Side Control Enabling PWM Input < 25kHz (BCR421U)
- 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)**
- **Automotive-compliant parts are available under separate datasheet (BCR420UW6Q/BCR421UW6Q)**

## Applications

Constant Current Regulation (CCR) in:

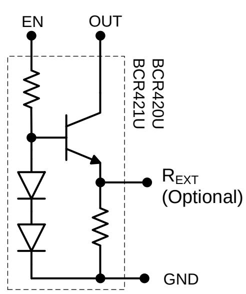
- Automotive interior lighting
- Emergency lighting
- Signage, advertising, and decorative/architectural lighting
- Retail lighting in fridges, freezer cases, and vending machines

## Mechanical Data

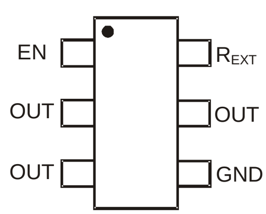
- Package: SOT26
- Package Material: Molded Plastic. “Green” Molding Compound. UL Flammability Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish - Matte Tin Plated Leads. Solderable per MIL-STD-202, Method 208 (e3)
- Weight: 0.018 grams (Approximate)

SOT26

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 |

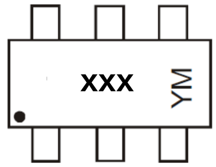
## Ordering Information (Note 4)

| Orderable Part Number | Marking | Reel Size (inches) | Tape Width (mm) | Packing | |
|---|---|---|---|---|---|
| | | | | Quantity | Carrier |
| BCR420UW6-7 | 420 | 7 | 8 | 3,000 | Reel |
| BCR421UW6-7 | 421 | 7 | 8 | 3,000 | Reel |

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ 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 https://www.diodes.com/design/support/packaging/diodes-packaging/.

## Marking Information

SOT26




xxx = Part Marking (See Ordering Information)
YM = Date Code Marking
Y = Year (ex: J = 2022)
M = Month (ex: 3 = March)

Date Code Key

| Year | 2016 | …… | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | D | …… | I | J | K | L | M | N | P | R | S | T |

| 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 | BCR420U | $V_{EN}$ | 40 | V |
| | BCR421U | | 18 | |
| 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 5) | $P_D$ | 1,190 | mW |
| | (Note 6) | | 912 | |
| Thermal Resistance, Junction to Ambient | (Note 5) | $R_{\theta JA}$ | 105 | °C/W |
| | (Note 6) | | 140 | |
| Thermal Resistance, Junction to Lead | (Note 7) | $R_{\theta JL}$ | 50 | |
| Thermal Resistance, Junction to Case | (Note 6) | $R_{\theta JC}$ | 31 | |
| 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 8)

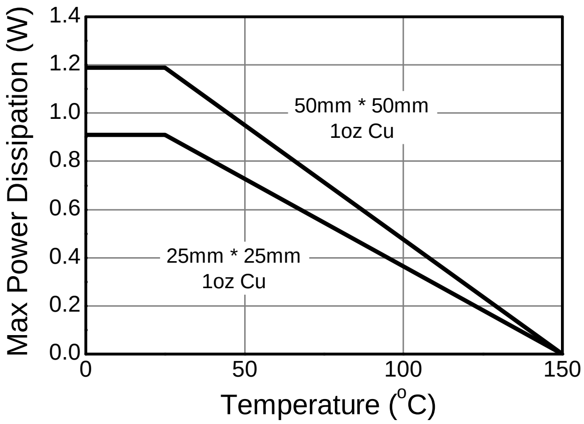
| Characteristics | | Symbols | Value | Unit | JEDEC Class |
|---|---|---|---|---|---|
| Electrostatic Discharge – Human Body Model | BCR420U | HBM | 500 | V | 1B |
| | BCR421U | | 1,000 | V | 1C |
| Electrostatic Discharge – Machine Model | BCR420U | MM | 300 | V | B |
| | BCR421U | | 400 | V | C |
| Electrostatic Discharge – Charged Device Model | BCR420U | CDM | 1,000 | V | C6 |
| | BCR421U | | 1,000 | V | C6 |

Notes:
5. 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.
6. Same as Note 5, except mounted on 25mm x 25mm 1oz copper.
7. $R_{\theta JL}$ = Thermal resistance from junction to solder-point (at the end of the OUT leads).
8. Refer to JEDEC specification JESD22-A114 and JESD22-A115.

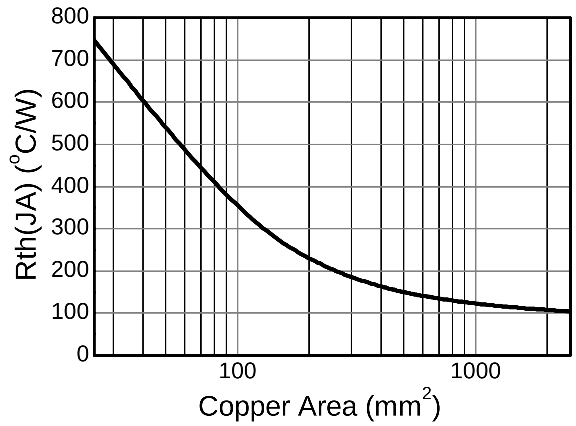
## Electrical Characteristics (@ $T_A$ = +25°C, unless otherwise specified.)

| Characteristic | | Symbol | Min | Typ | Max | Unit | Test Condition |
|---|---|---|---|---|---|---|---|
| Collector-Emitter Breakdown Voltage | | $BV_{CEO}$ | 40 | — | — | V | $I_C$ = 1mA |
| Enable Current | BCR420U | $I_{EN}$ | — | 1.2 | — | mA | $V_{EN}$ = 24V |
| | BCR421U | | — | 1.2 | — | | $V_{EN}$ = 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 | BCR420U | $R_B$ | — | 20 | — | kΩ | — |
| | BCR421U | | — | 1.5 | — | | — |
| Output Current | BCR420U | $I_{OUT}$ | 9 | 10 | 11 | mA | $V_{OUT}$ = 1.4V; $V_{EN}$ = 24V |
| | BCR421U | | 9 | 10 | 11 | mA | $V_{OUT}$ = 1.4V; $V_{EN}$ = 3.3V |
| Output Current at $R_{EXT}$ = 4.9Ω | BCR420U | $I_{OUT}$ | — | 150 | — | mA | $V_{OUT}$ > 2.0V; $V_{EN}$ = 24V |
| | BCR421U | | — | 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 | BCR420U | $\Delta I_{OUT}/I_{OUT}$ | — | -0.2 | — | %/°C | $V_{OUT}$ > 2.0V; $V_{EN}$ = 24V |
| | BCR421U | | — | -0.2 | — | | $V_{OUT}$ > 2.0V; $V_{EN}$ = 3.3V |
| Output Current Change vs. Supply Voltage | BCR420U | $\Delta I_{OUT}/I_{OUT}$ | — | 1 | — | %/V | $V_{OUT}$ > 2.0V; $V_{EN}$ = 24V |
| | BCR421U | | — | 1 | — | | $V_{OUT}$ > 2.0V; $V_{EN}$ = 3.3V |

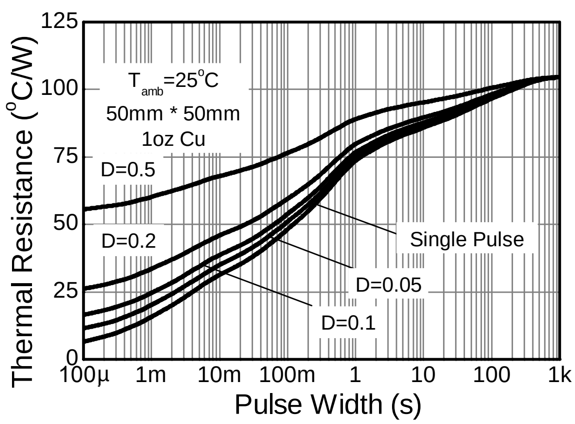
## Typical Thermal Characteristics BCR420/1U (@ $T_A$ = +25°C, unless otherwise specified.)



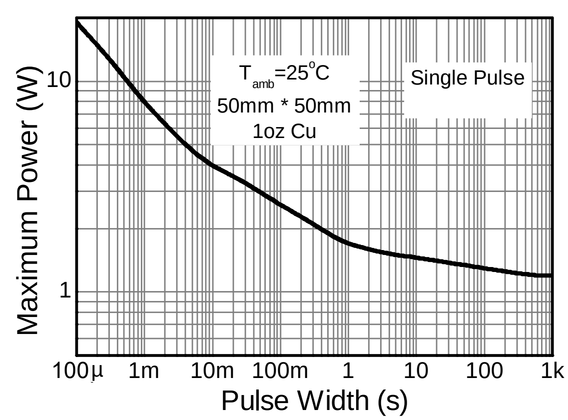

**Derating Curve**



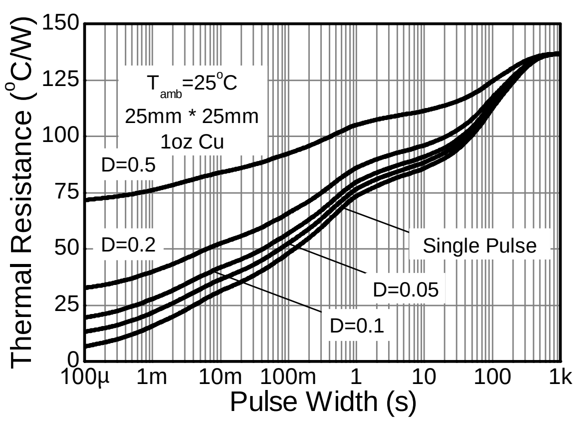

**Rth(JA) VS Cu Area**



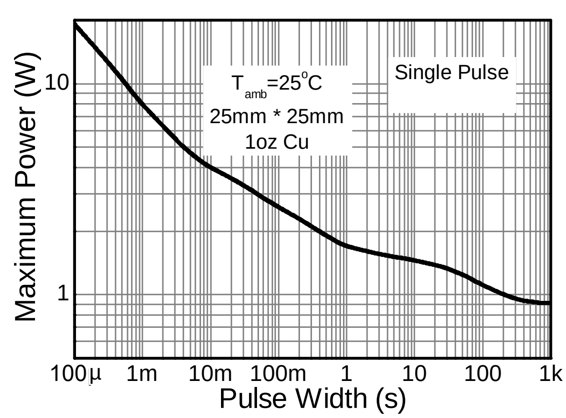

**Transient Thermal Impedance**




**Pulse Power Dissipation**

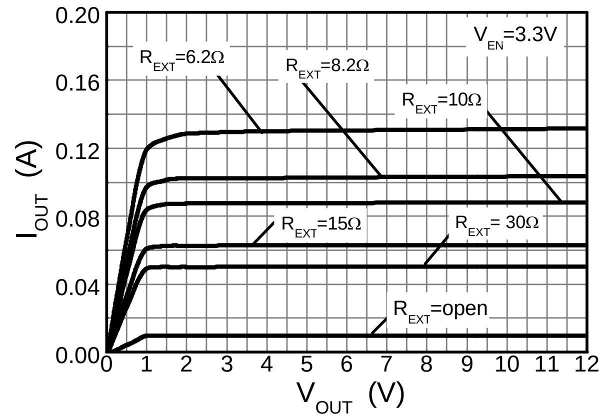



**Transient Thermal Impedance**

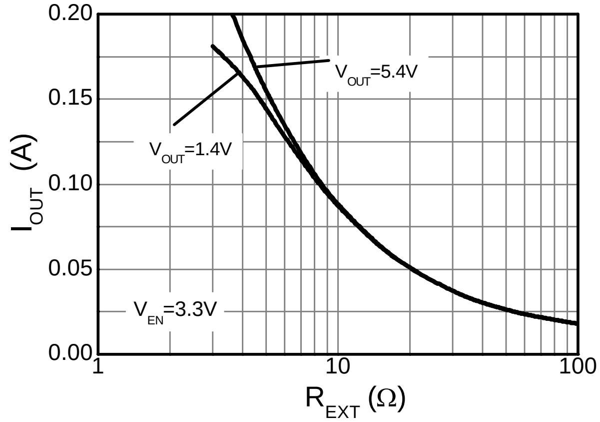



**Pulse Power Dissipation**

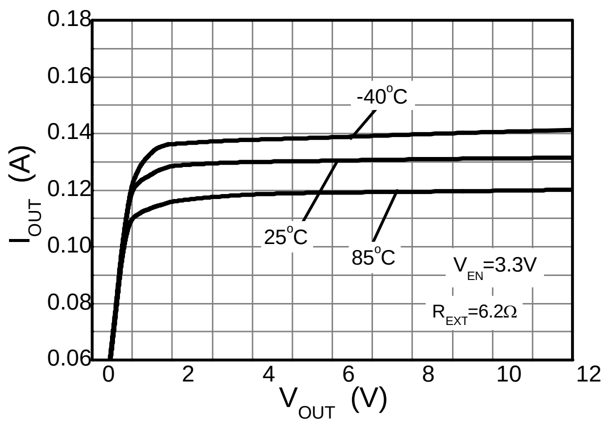
## Typical Electrical Characteristics BCR421U (@ $T_A$ = +25°C, unless otherwise specified.)



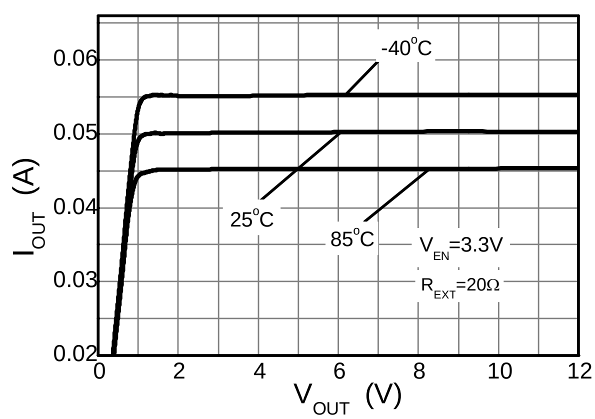

**$V_{OUT}$ vs $I_{OUT}$**



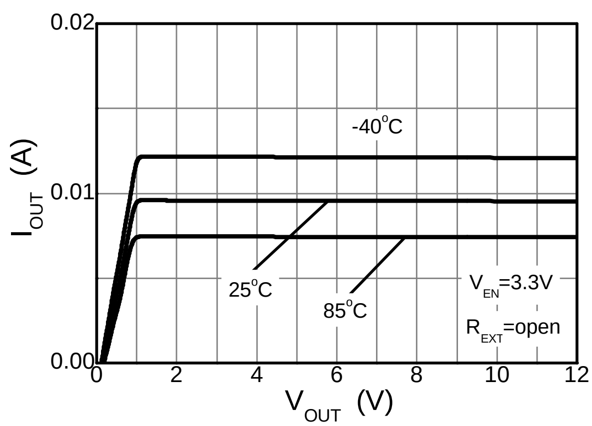

**$R_{EXT}$ (Ω) vs $I_{OUT}$**



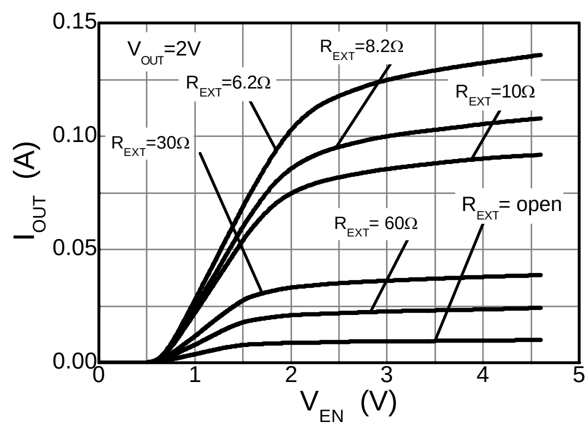

**$V_{OUT}$ vs $I_{OUT}$**




**$V_{OUT}$ vs $I_{OUT}$**

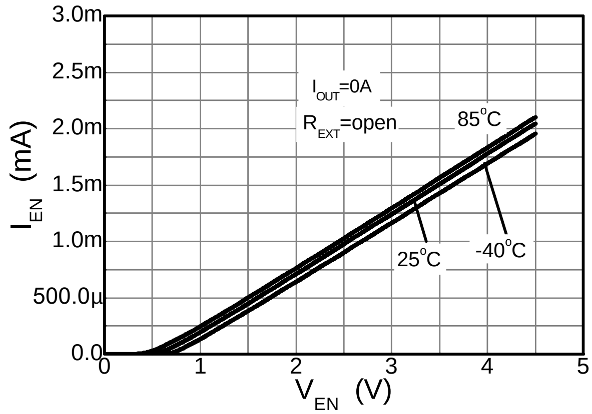



**$V_{OUT}$ vs $I_{OUT}$**

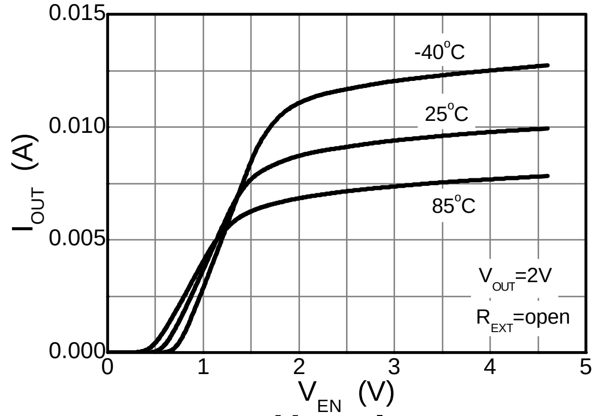



**$V_{EN}$ vs $I_{OUT}$**

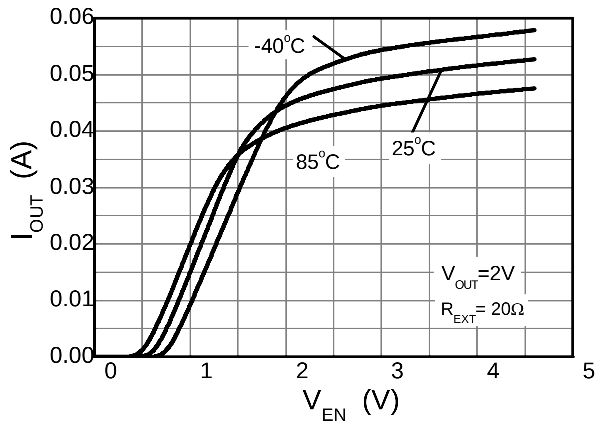
## Typical Electrical Characteristics BCR421U (@ $T_A$ = +25°C, unless otherwise specified.) (continued)



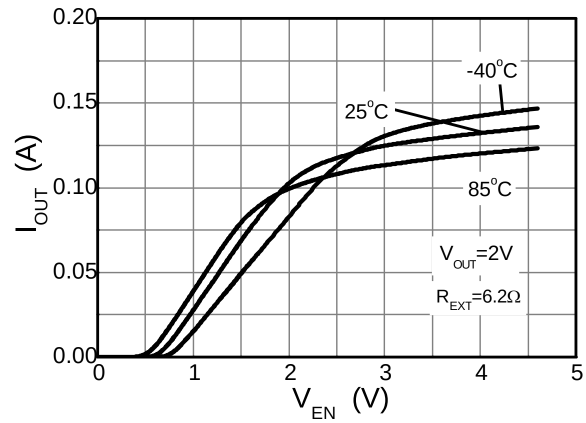

$V_{EN}$ vs $I_{EN}$




$V_{EN}$ vs $I_{OUT}$

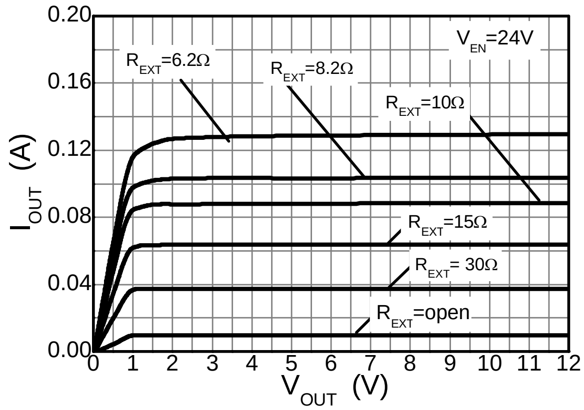



$V_{EN}$ vs $I_{OUT}$

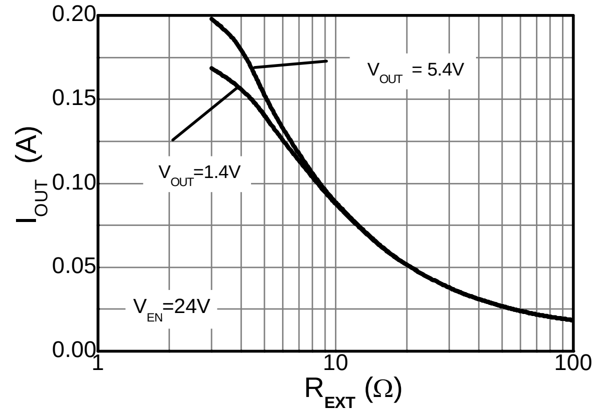



$V_{EN}$ vs $I_{OUT}$

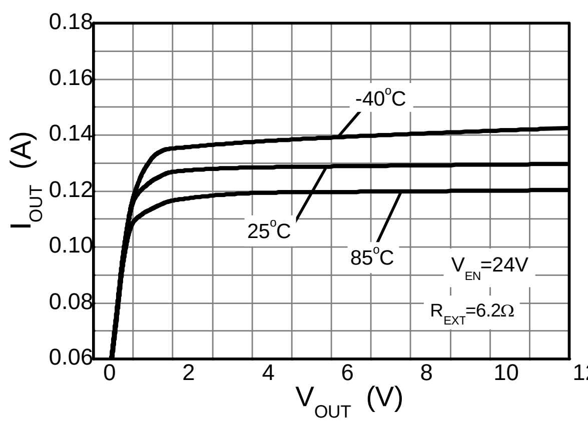
## Typical Electrical Characteristics BCR420U (@ $T_A$ = +25°C, unless otherwise specified.)



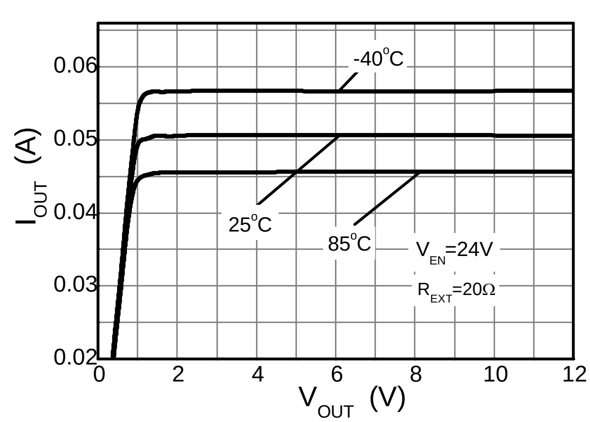

$V_{OUT}$ vs $I_{OUT}$



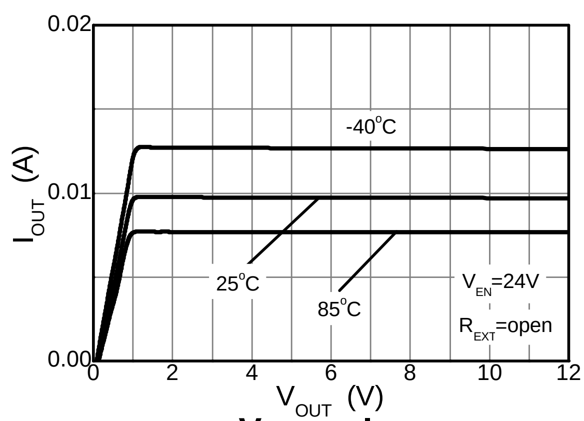

$R_{EXT}$ (Ω)vs $I_{OUT}$



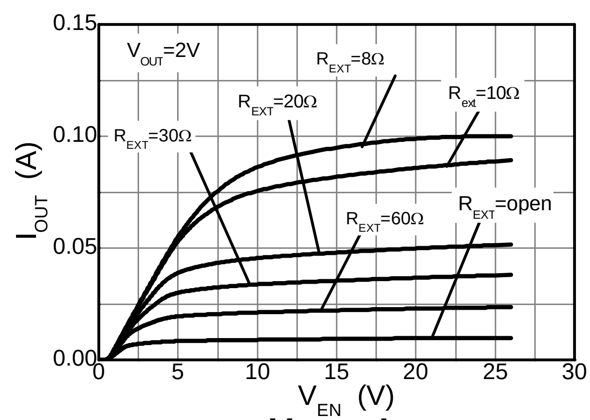

$V_{OUT}$ vs $I_{OUT}$




$V_{OUT}$ vs $I_{OUT}$

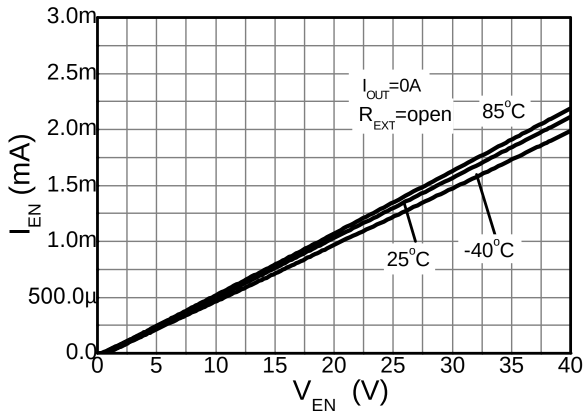



$V_{OUT}$ vs $I_{OUT}$

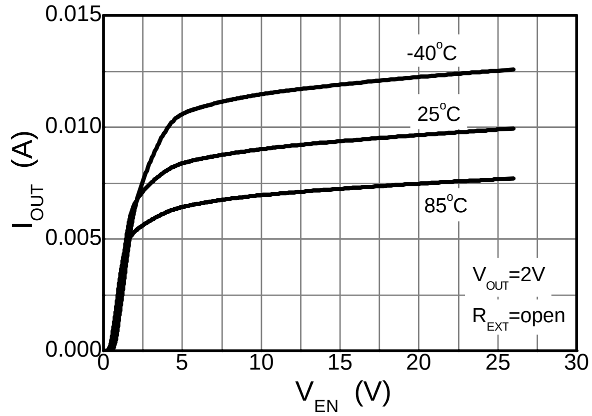



$V_{EN}$ vs $I_{OUT}$

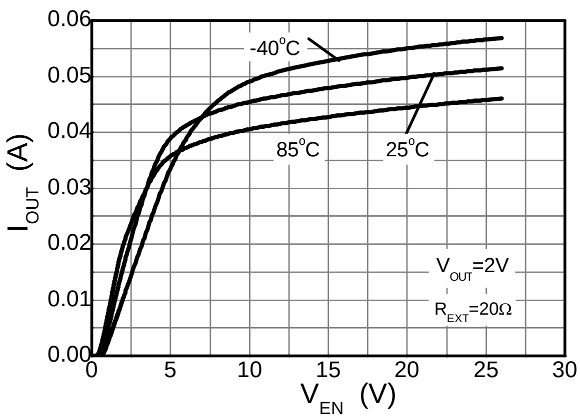
## Typical Electrical Characteristics BCR420U (@ $T_A$ = +25°C, unless otherwise specified.) (continued)



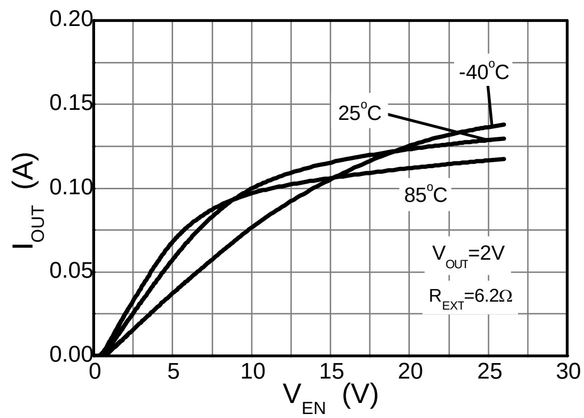

**$V_{EN}$ vs $I_{EN}$**




**$V_{EN}$ vs $I_{OUT}$**




**$V_{EN}$ vs $I_{OUT}$**




**$V_{EN}$ vs $I_{OUT}$**

## Application Information

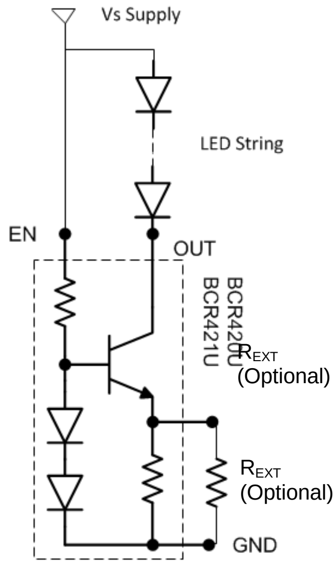



Figure 1 Typical Application Circuit for Linear Mode Current Sink LED Driver

The BCR420/1 are 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 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; or $V_{EN}$ = 24V and $V_{OUT}$ = 1.4V for BCR420. 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 $R_{EXT}$.

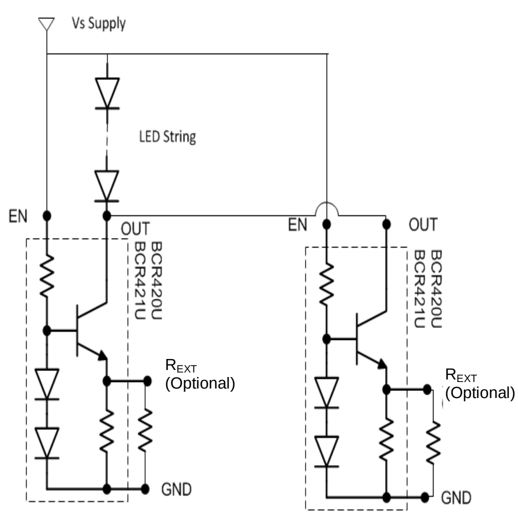



Figure 2 Application Circuit for Increasing LED Current

Two or more BCR420/1s 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 BCR420/1'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 BCR420/1 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. PWM up to 25kHz with duty cycle of 0.5% (dimming range 200:1). This is above the audio band minimizing audible power supply noise.

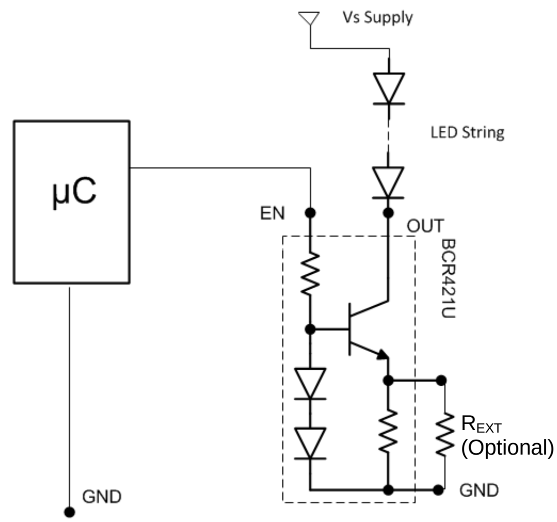



Figure 3 Application Circuits for LED Driver with PWM Dimming Functionality using BCR421U

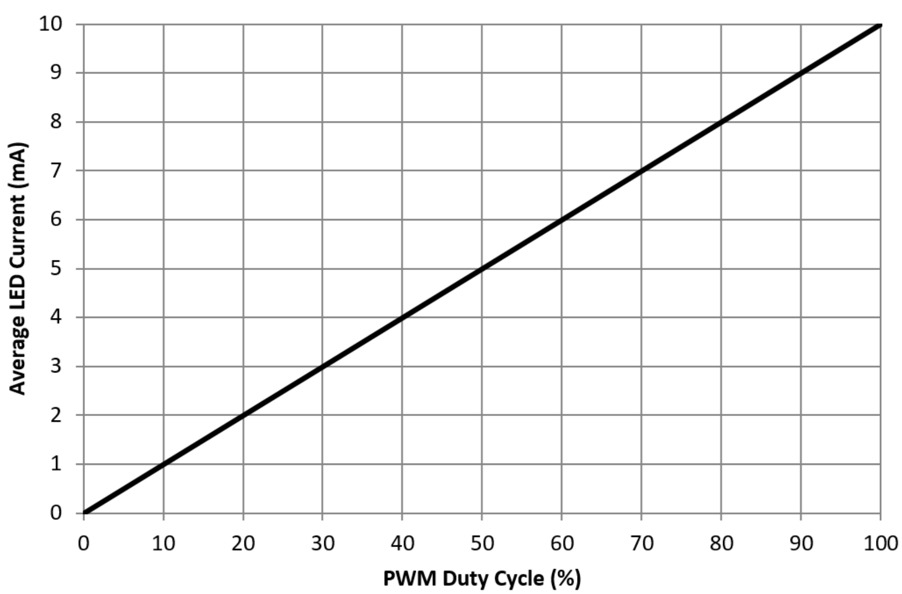



Figure 4 Typical LED Current Response vs. PWM Duty Cycle for
25kHz PWM Frequency (Dimming Range 200:1)

## Application Information (continued)

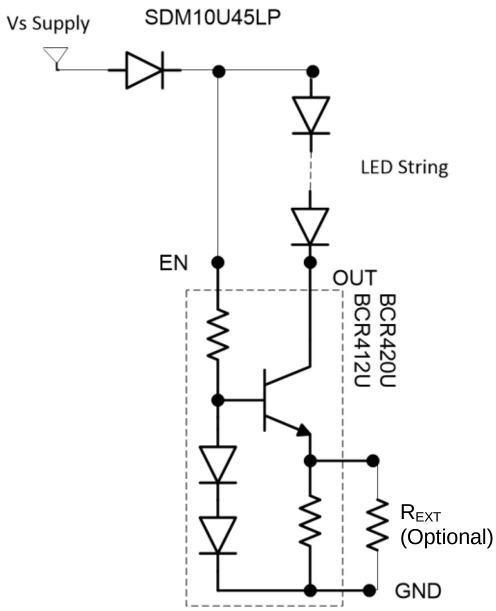



Figure 5 Application Circuit for LED Driver with Reverse Polarity Protection

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 using BCR421U. In such higher current configurations adequate enable current is provided by increasing the enable voltage.

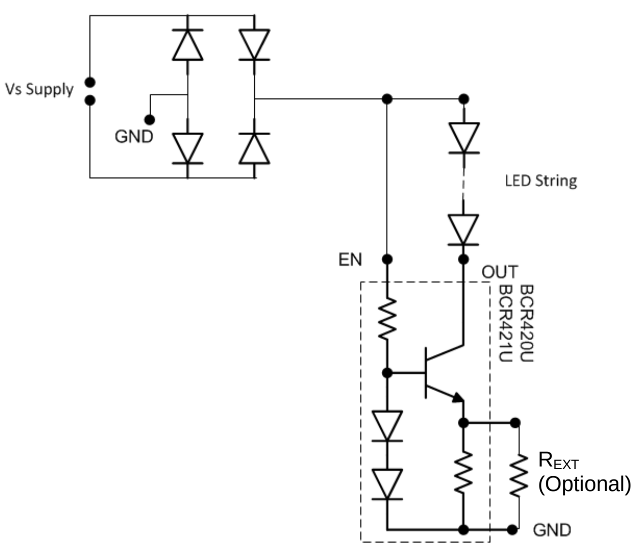



Figure 6 Application Circuit for LED Driver with Assured Operation Regardless Of Polarity

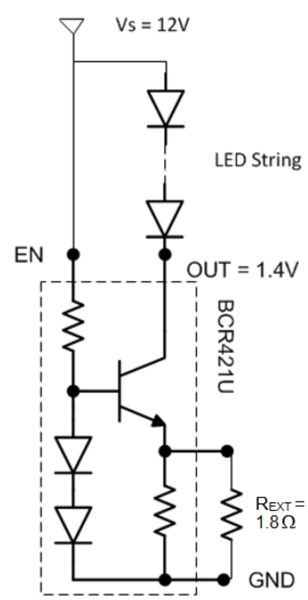
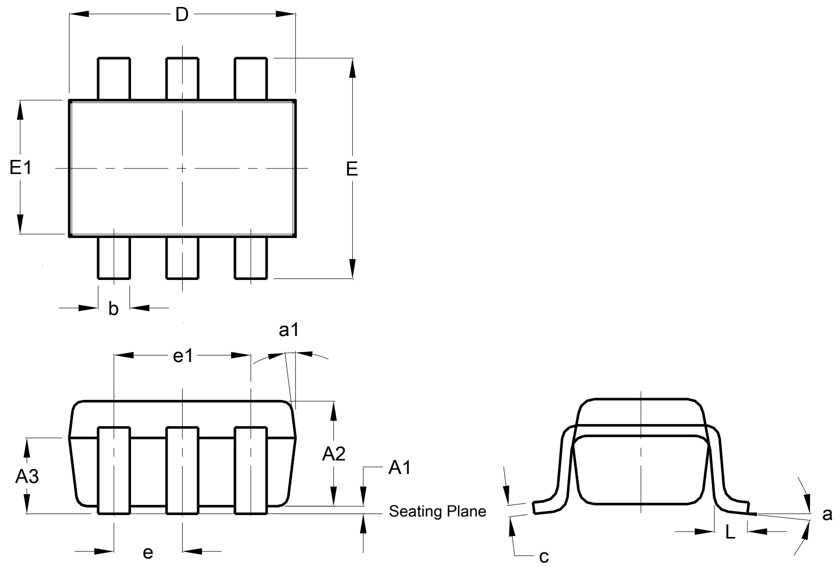



Figure 7 Example for 350mA Operation using BCR421U

## Package Outline Dimensions

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

**SOT26**

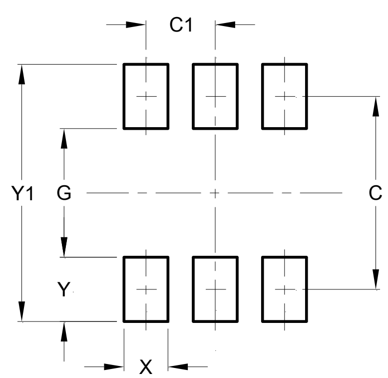



| SOT26 | | | |
|---|---|---|---|
| **Dim** | **Min** | **Max** | **Typ** |
| **A1** | 0.013 | 0.10 | 0.05 |
| **A2** | 1.00 | 1.30 | 1.10 |
| **A3** | 0.70 | 0.80 | 0.75 |
| **b** | 0.35 | 0.50 | 0.38 |
| **c** | 0.10 | 0.20 | 0.15 |
| **D** | 2.90 | 3.10 | 3.00 |
| **e** | - | - | 0.95 |
| **e1** | - | - | 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 http://www.diodes.com/package-outlines.html for the latest version.

**SOT26**




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

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