LINEAR LED CONSTANT CURRENT REGULATOR IN U-DFN2020-6

Description

These Linear LED drivers are designed to meet the stringent requirements of automotive applications.

The BCR420UFDQ and BCR421UFDQ monolithically integrate transistors, diodes and resistors to function as a Constant Current Regulator (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 BCR421UFDQ 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 a 2mm x 2mm x 0.6mm package (U-DFN2020-6) minimizing PCB area, off-board height, 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 (BCR421UFDQ)
- V_{OUT} – 40V Supply Voltage
- P_D up to 1.7W in U-DFN2020-6 Package
- 0.6mm Height for Low-Profile Edge Lighting
- Low-Side Control Enabling PWM Input < 25kHz (BCR421UFDQ)
- 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)**
- **The BCR420UFDQ and BCR421UFDQ are suitable for automotive applications requiring specific change control; these parts are AEC-Q101 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities.** **https://www.diodes.com/quality/product-definitions/**

Applications

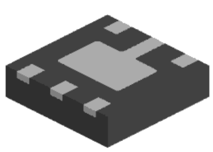
Constant Current Regulation (CCR) in automotive LED lighting:

- Interior and exterior automotive LED lighting
- Dome and mood lighting
- Puddle lighting
- Side marker lights
- Edge lighting strips

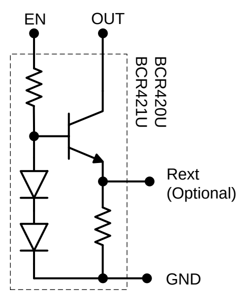
Mechanical Data

- Package: U-DFN2020-6
- Package Material: Molded Plastic. "Green" Molding Compound. UL Flammability Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish - NiPdAu, Solderable per MIL-STD-202, Method 208 e4
- Weight: 0.007 grams (Approximate)

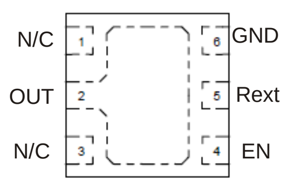
U-DFN2020-6



Bottom View



Internal Device Schematic



Top View Pinout

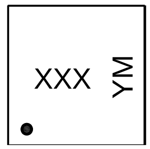
Pin Name	Pin Function
OUT	Regulated Output Current
EN	Enable for Biasing Transistor
Rext	External Resistor for Adjusting Output Current
GND	Power Ground
N/C	Not Connected Internally

Ordering Information (Note 4)

Orderable Part Number	Package	Marking	Reel Size (inches)	Tape Width (mm)	Packing	
					Qty	Carrier
BCR420UFDQ-7	U-DFN2020-6	420	7	8	3000	Reel
BCR421UFDQ-7	U-DFN2020-6	421	7	8	3000	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



XXX = Product Type Marking Code (See *Ordering Information*)
Y = Year (ex: M = 2025)
M = Month (ex: 9 = September)

Date Code Key

Year	2017	-	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Code	E	-	M	N	P	R	S	T	U	V	W	X

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	BCR420UFDQ	V_{EN}	40	V
	BCR421UFDQ		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	1.7	W
	(Note 6)		1.3	
Thermal Resistance, Junction to Ambient	(Note 5)	$R_{\theta JA}$	75	°C/W
	(Note 6)		100	
Thermal Resistance, Junction to Lead	(Note 7)	$R_{\theta JL}$	35	°C/W
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)

Characteristic		Symbol	Value	Unit	JEDEC Class
Electrostatic Discharge – Human Body Model	BCR420UFDQ	HBM	700	V	1B
	BCR421UFDQ		1000	V	1C
Electrostatic Discharge – Machine Model	BCR420UFDQ	MM	300	V	B
	BCR421UFDQ		400	V	C

Notes:
5. For a device mounted with the OUT leads on 50mm x 50mm 1oz copper that is on a single-sided 1.6mm FR-4 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	BCR420UFDQ	I_{EN}	—	1.2	—	mA	V_{EN} = 24V
	BCR421UFDQ		—	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	BCR420UFDQ	R_B	—	20	—	kΩ	—
	BCR421UFDQ		—	1.5	—		—
Output Current	BCR420UFDQ	I_{OUT}	9	10	11	mA	V_{OUT} = 1.4V; V_{EN} = 24V
	BCR421UFDQ		9	10	11	mA	V_{OUT} = 1.4V; V_{EN} = 3.3V
Output Current at R_{EXT} = 5.1Ω	BCR420UFDQ	I_{OUT}	—	150	—	mA	V_{OUT} > 2.0V; V_{EN} = 24V
	BCR421UFDQ		—	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	BCR420UFDQ	$\Delta I_{OUT}/I_{OUT}$	—	-0.2	—	%/°C	V_{OUT} > 2.0V; V_{EN} = 24V
	BCR421UFDQ		—	-0.2	—		V_{OUT} > 2.0V; V_{EN} = 3.3V
Output Current Change vs. Supply Voltage	BCR420UFDQ	$\Delta I_{OUT}/I_{OUT}$	—	1	—	%/V	V_{OUT} > 2.0V; V_{EN} = 24V
	BCR421UFDQ		—	1	—		V_{OUT} > 2.0V; V_{EN} = 3.3V

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

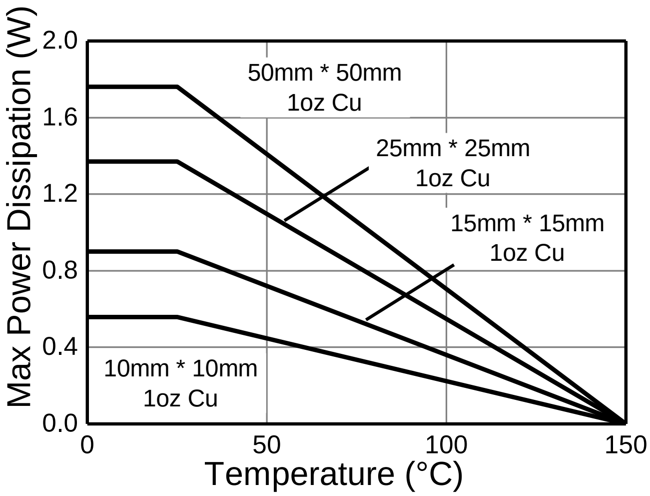


Fig.1 Derating Curve

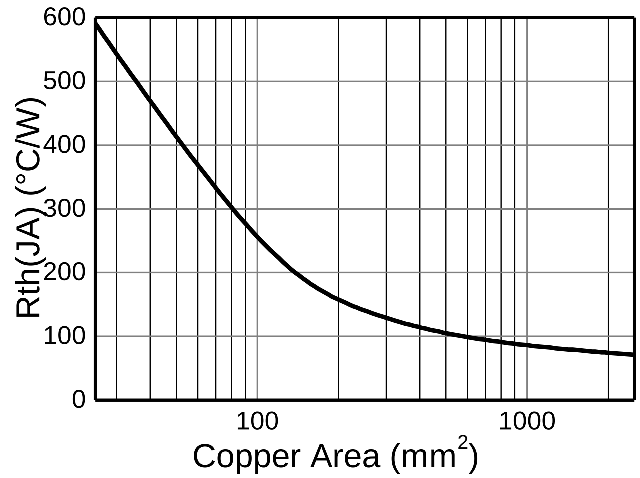


Fig.2 Rth(JA) VS 1 oz Cu Area

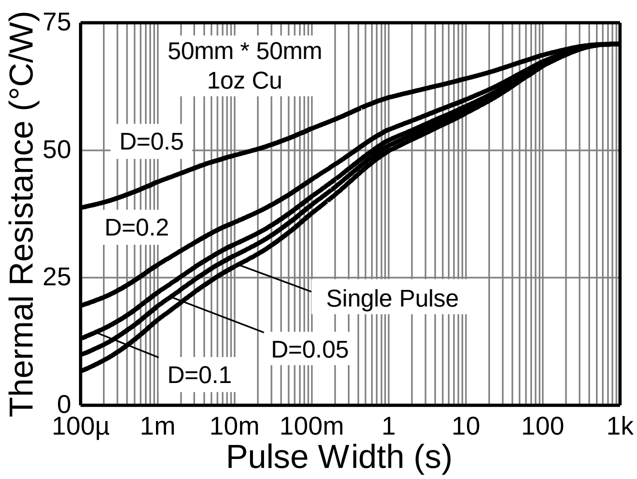


Fig.3 Transient Thermal Impedance

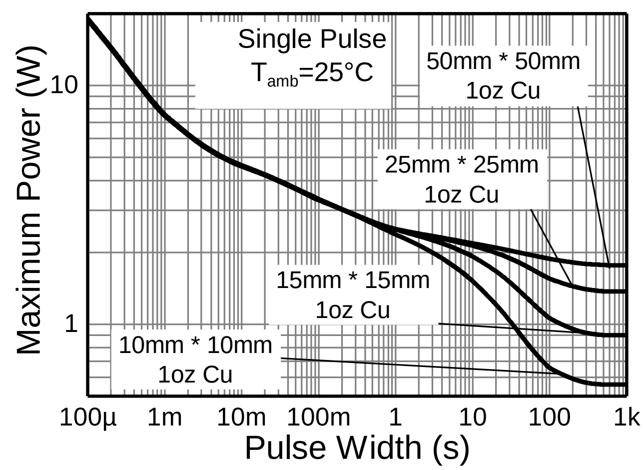


Fig.4 Pulse Power Dissipation

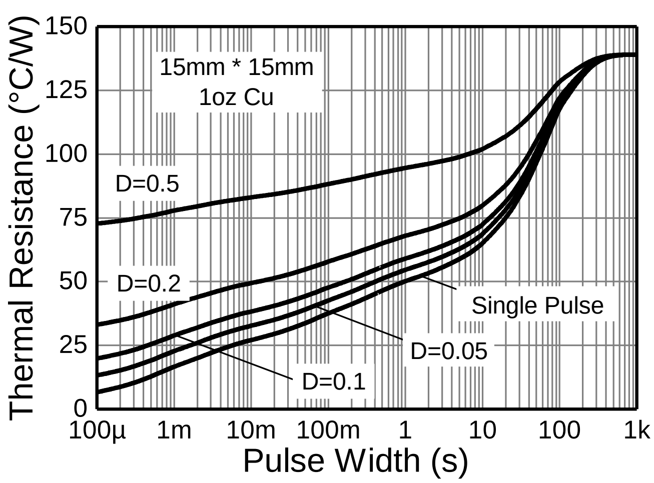


Fig.5 Transient Thermal Impedance

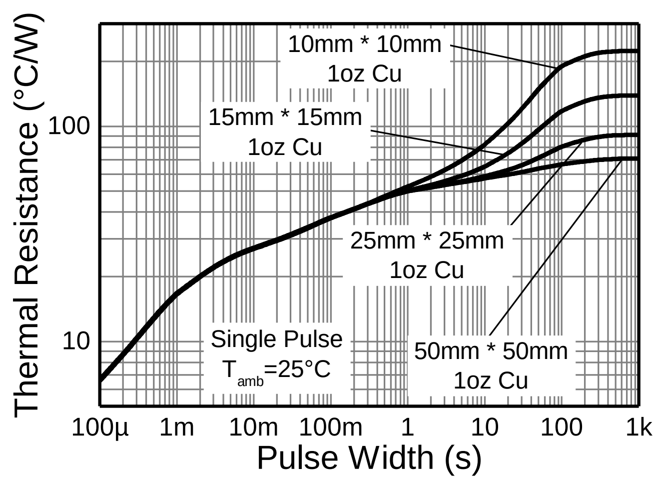


Fig.6 Pulse Power Dissipation

Typical Electrical Characteristics BCR421UFDQ (@T_A = +25°C, unless otherwise specified.)

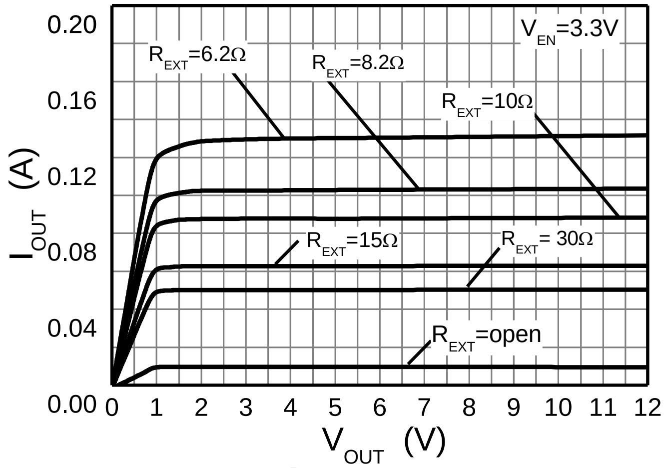


Fig.7 V_{OUT} v I_{OUT}

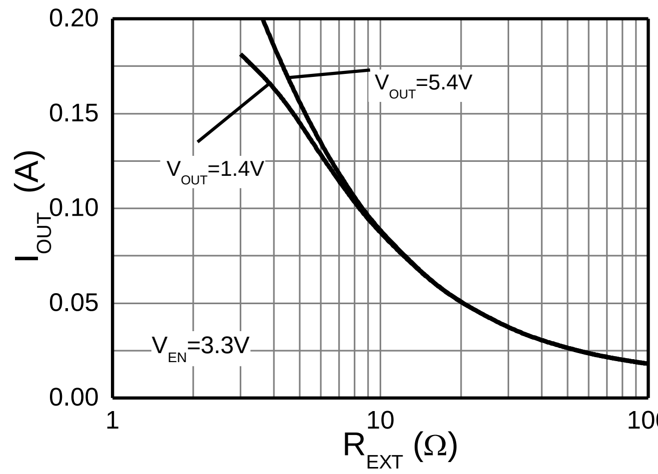


Fig.8 R_{EXT} (Ω) v I_{OUT}

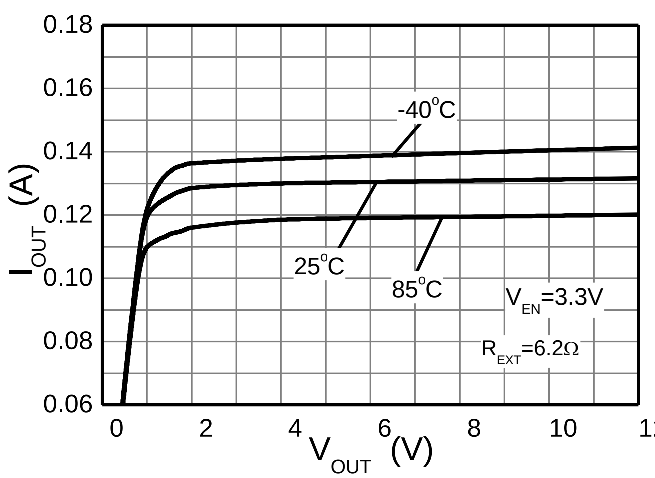


Fig.9 V_{OUT} v I_{OUT}

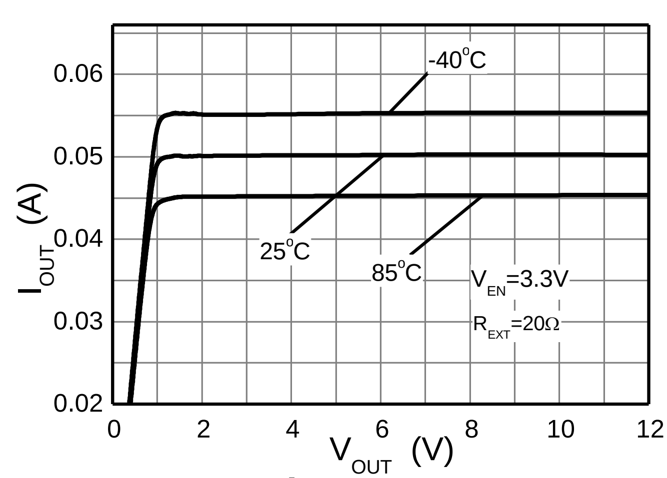


Fig.10 V_{OUT} v I_{OUT}

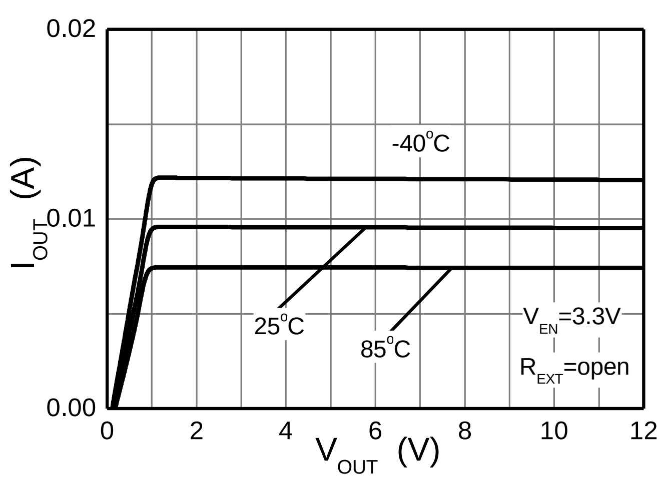


Fig.11 V_{OUT} v I_{OUT}

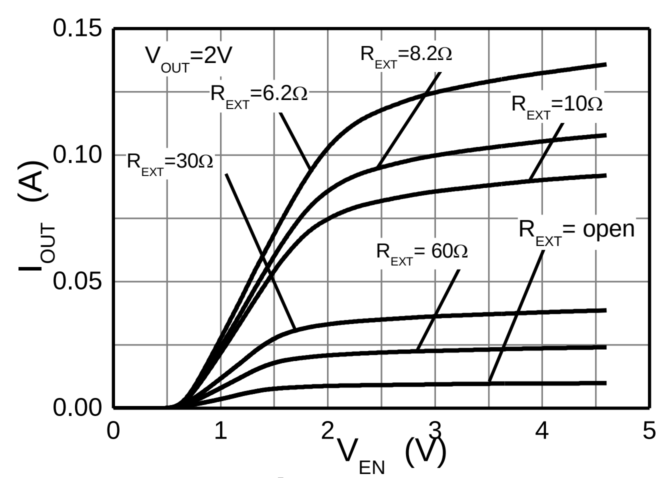


Fig.12 V_{EN} v I_{OUT}

Typical Electrical Characteristics BCR421UFDQ (continued) (@T_A = +25°C, unless otherwise specified.)

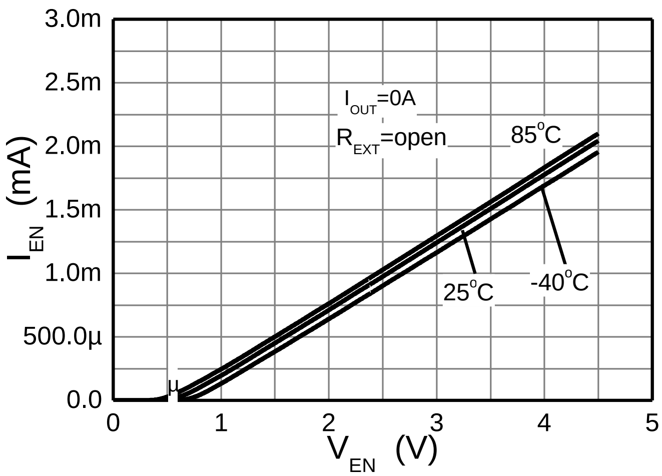


Fig. 13 V_{EN} v I_{EN}

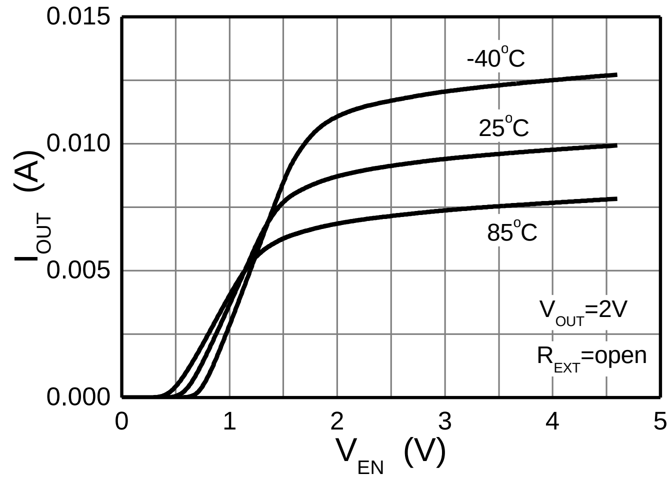


Fig.14 V_{EN} v I_{OUT}

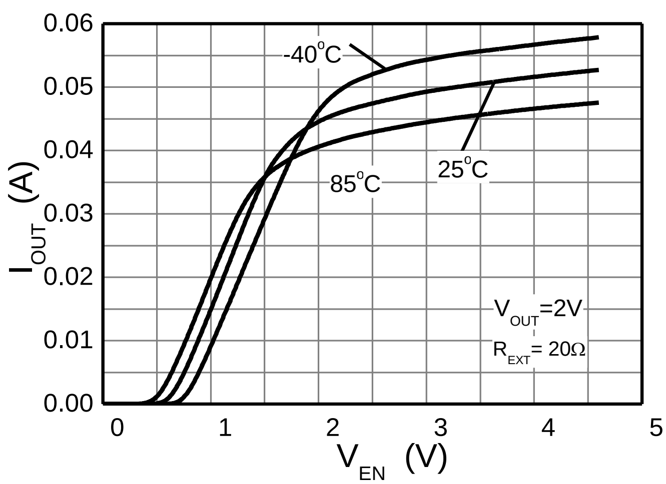


Fig.15 V_{EN} v I_{OUT}

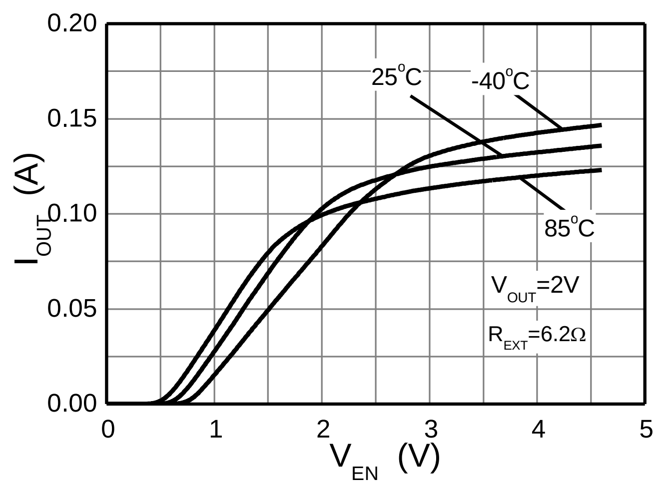


Fig.16 V_{EN} v I_{OUT}

Typical Electrical Characteristics BCR420UFDQ (@T_A = +25°C, unless otherwise specified.)

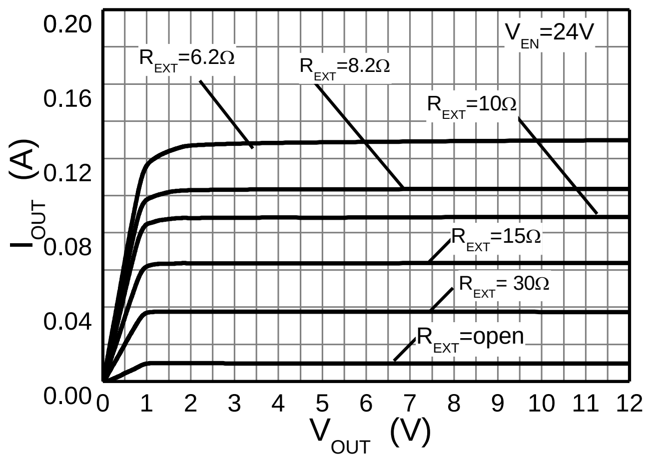


Fig.17 V_{OUT} vs I_{OUT}

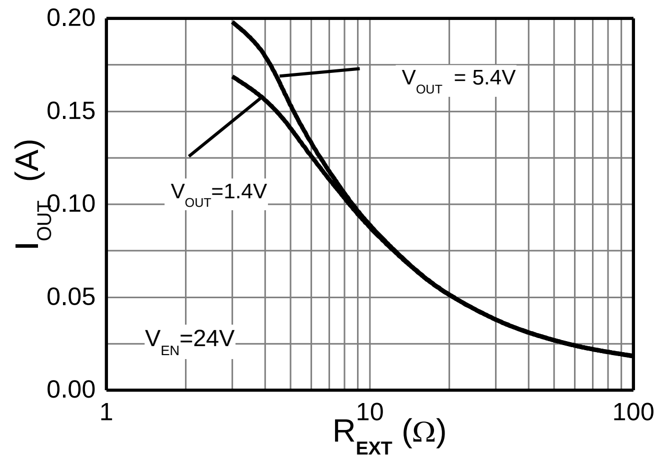


Fig.18 R_{EXT} (Ω)vs I_{OUT}

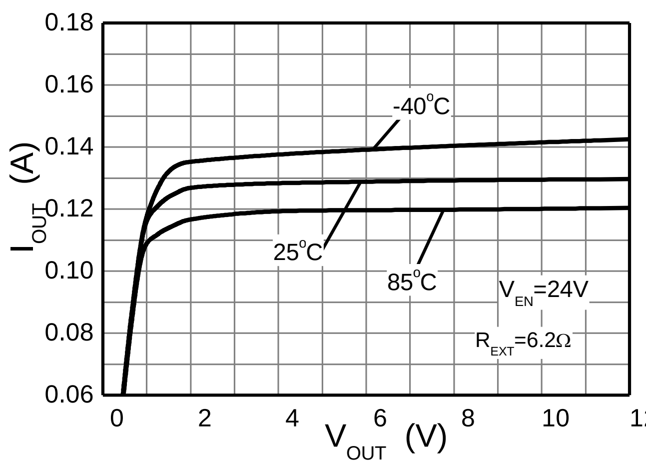


Fig.19 V_{OUT} v I_{OUT}

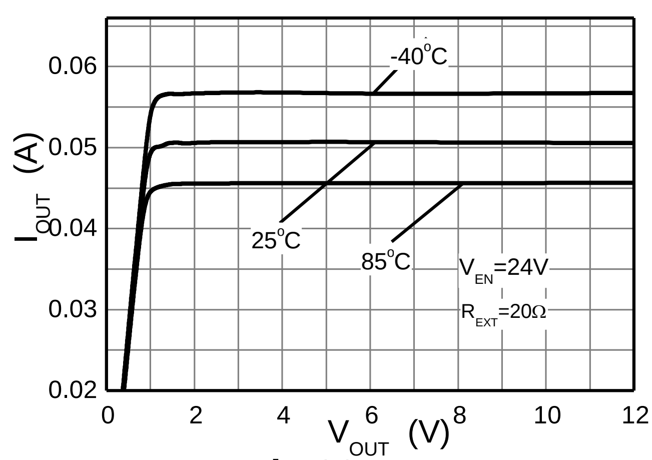


Fig.20 V_{OUT} v I_{OUT}

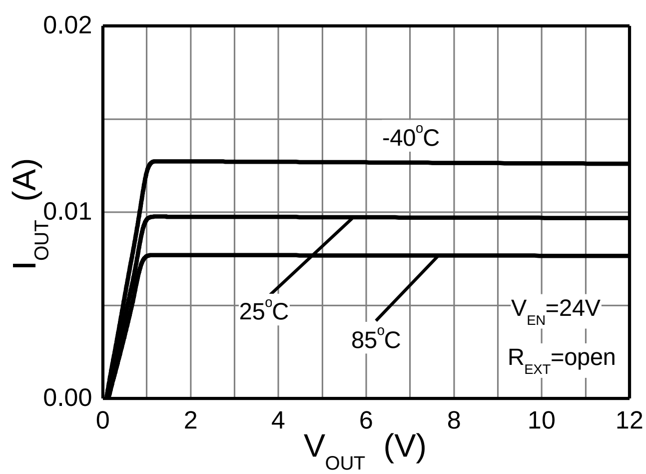


Fig.21 V_{OUT} v I_{OUT}

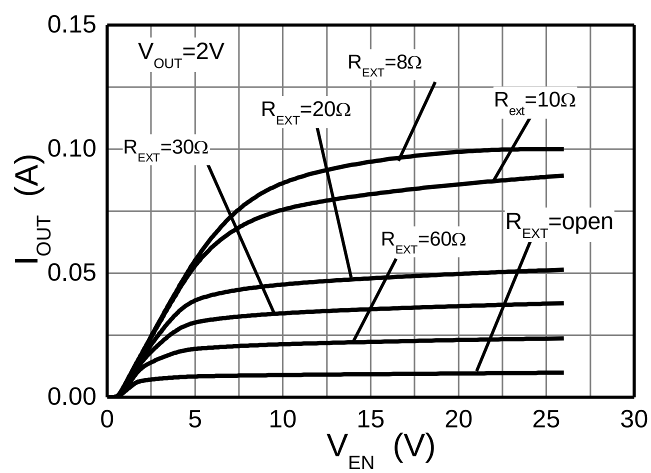


Fig.22 V_{EN} v I_{OUT}

Typical Electrical Characteristics BCR420UFDQ (continued) (@T_A = +25°C, unless otherwise specified.)

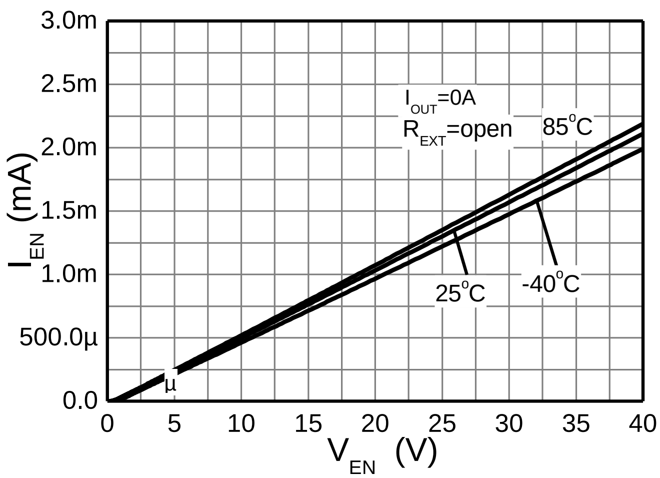


Fig.23 V_{EN} v I_{EN}

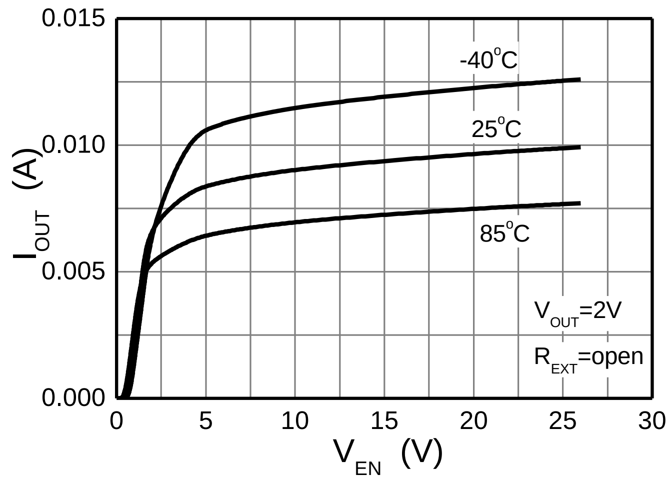


Fig.24 V_{EN} v I_{OUT}

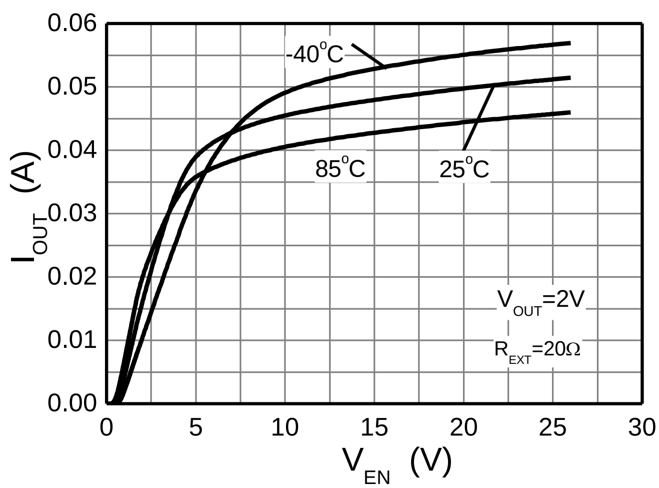


Fig.25 V_{EN} v I_{OUT}

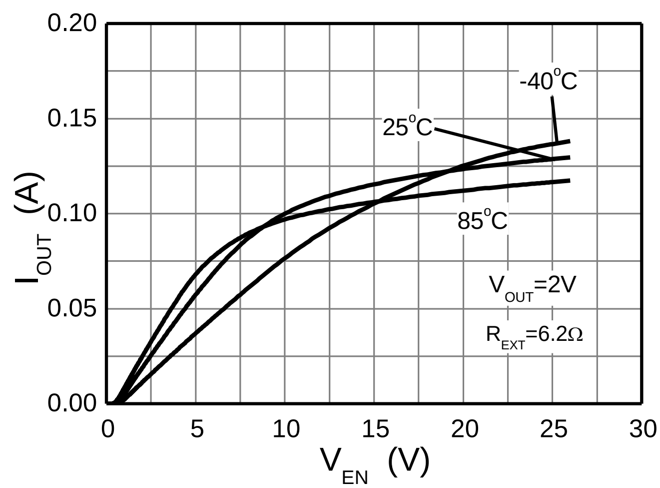


Fig.26 V_{EN} v I_{OUT}

Application Information

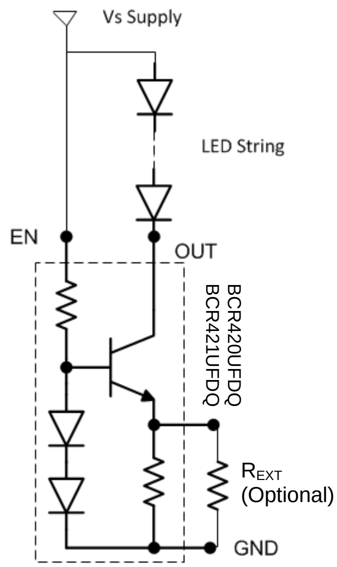


Fig. 27 Typical Application Circuit for Linear Mode Current Sink LED Driver

The BCR420/1UFDQ 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.

Fig. 27 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 BCR421UFDQ; or V_{EN} = 24V and V_{OUT} = 1.4V for BCR420UFDQ. 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}.

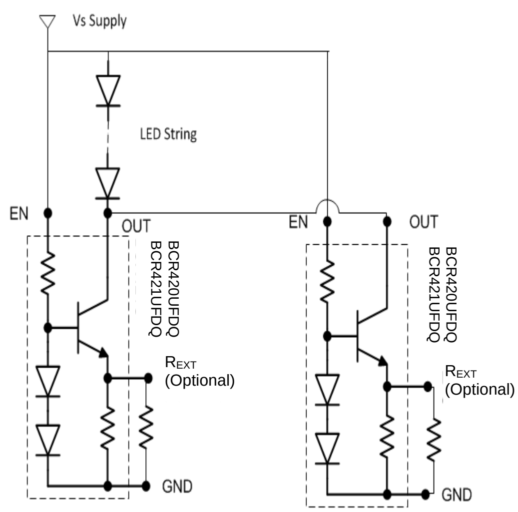


Fig. 28 Application Circuit for Increasing LED Current

Two or more BCR420/1UFDQs can be connected in parallel to construct higher current LED strings as shown in Fig. 28. Consideration of the expected linear mode power dissipation must be factored into the design, with respect to the BCR420/1UFDQ'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 BCR420/1UFDQ 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 Fig. 29. Fig. 30 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.

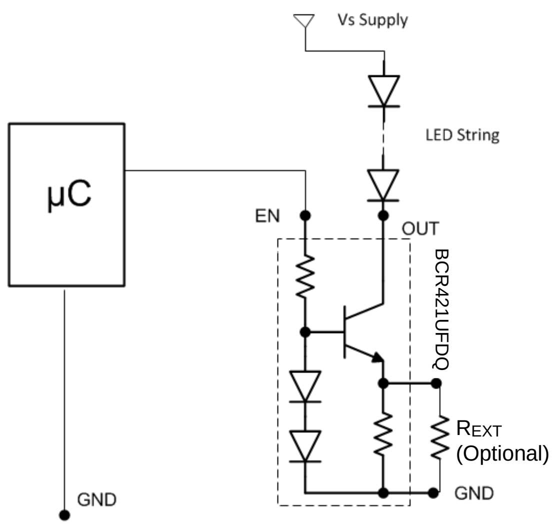


Fig. 29 Application Circuits for LED Driver with PWM Dimming Functionality Using BCR421UFDQ

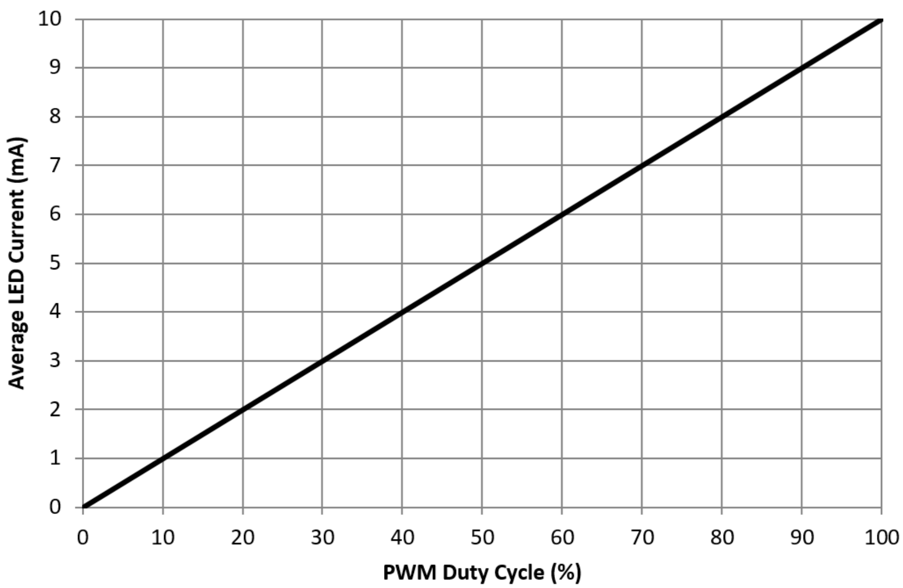


Fig. 30 Typical LED Current Response vs. PWM Duty Cycle for 25kHz PWM Frequency (Dimming Range 200:1)

Application Information (continued)

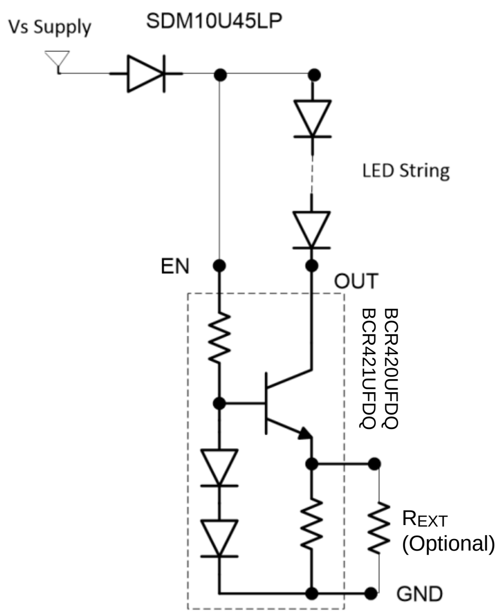


Fig. 31 Application Circuit for LED Driver with Reverse-Polarity Protection

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 Fig. 31 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 Fig. 32, 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.

Fig. 33 shows an example configuration for 350mA operation using BCR421UFDQ. In such higher current configurations, adequate enable current is provided by increasing the enable voltage.

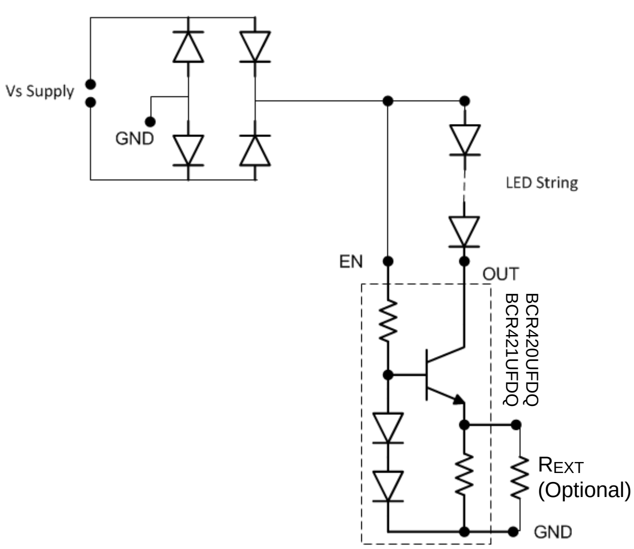


Fig. 32 Application Circuit for LED Driver with Assured Operation Regardless of Polarity

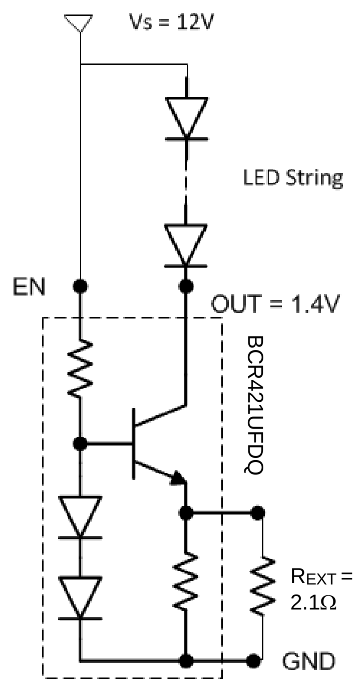
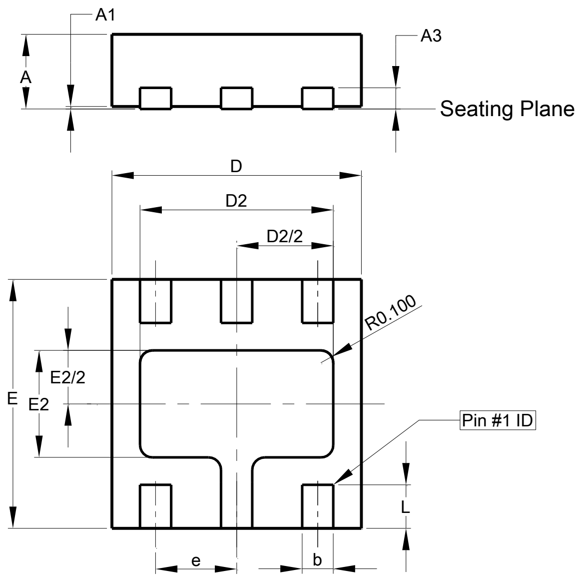


Fig. 33 Example for 350mA Operation using BCR421UFDQ

Package Outline Dimensions

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

U-DFN2020-6

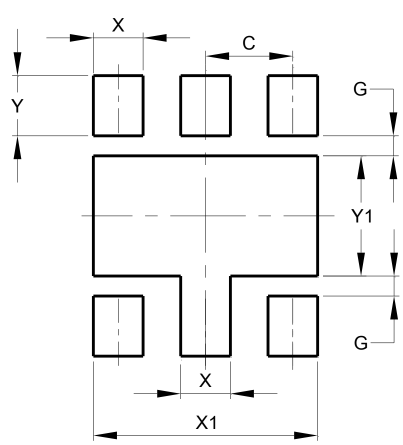


U-DFN2020-6			
Dim	**Min**	**Max**	**Typ**
A	0.57	0.63	0.60
A1	0	0.05	0.03
A3	-	-	0.15
b	0.20	0.30	0.25
D	1.95	2.075	2.00
D2	1.45	1.65	1.55
e	-	-	0.65
E	1.95	2.075	2.00
E2	0.76	0.96	0.86
L	0.30	0.40	0.35
All Dimensions in mm			

Suggested Pad Layout

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

U-DFN2020-6



Dimensions	Value (in mm)
C	0.65
G	0.15
X	0.37
X1	1.67
Y	0.45
Y1	0.90

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