# Linear LED driver with BCR431U

## Low-voltage-drop LED driver board up to 36.5 mA

## About this document

### Scope and purpose

This document presents an evaluation board design for a linear and low-voltage-drop LED driver based on an Infineon BCR431U driver IC. It is an engineering report on features and performance for a 24 V/36.5 mA (max. LED current) solution, with explanations covering circuit and layout design.

BCR431U is a linear LED driver IC in a small PG-SOT23-6 package regulating the LED current in standalone operation without any external power transistor.

### Intended audience

This document is intended for design engineers, application engineers and students, for example, who need to design low-cost, highly reliable linear LED drivers for:

- LED strips
- LED displays and channel letters
- Architectural and landscape lighting
- Retail lighting

## Table of contents

# 1 Introduction

This is an engineering report for a 24 V, 36.5 mA linear LED driver evaluation board. This document contains the technical specification for the LED driver, a description of the main features, and circuit and layout descriptions, as well as the measurement results.

In this application, an Infineon BCR431U is used as an LED driver IC. It regulates the LED current in standalone operation without any external power transistor. The LED current level can be adjusted up to 36.5 mA by connecting a high-ohmic resistor Rset to pin RS. The default LED current is set to 15 mA with an Rset of 60.4 kΩ. The voltage drop at the integrated LED driver stage can typically go down to 80 mV (refer to LED current vs. voltage on LED pin), improving the overall system efficiency and providing extra voltage headroom to compensate for tolerances of LED forward voltage or supply voltage. A smart over-temperature protection function reduces the LED current when the junction temperature of BCR431U is very high.

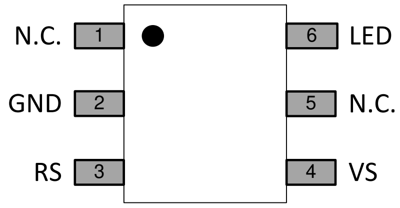


**Figure 1 BCR431U pin definition**

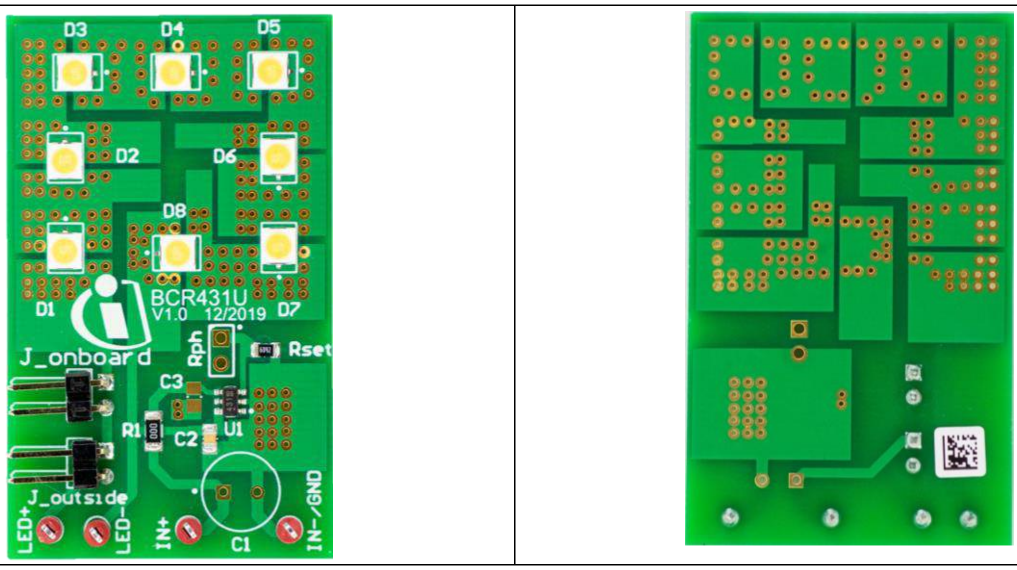


**Figure 2 Top and bottom side of the reference design board (55.1 mm x 33.7 mm)**

# 2 Technical specification

**Table 1 Technical specification**

| | |
|---|---|
| Input voltage | 24 V |
| Default Rset | 60.4 kΩ |
| Default LED current | 15 mA |
| Rset range | 114 kΩ to 24.9 kΩ |
| LED current range | 8 mA to 36.5 mA |
| On-board LED number | 8 LEDs in series |
| Device dimensions | 55.1 mm x 33.7 mm (L x W) |

# 3 List of product features

**Table 2 List of IC features**

| |
|---|
| Supply voltage from 6 V to 42 V |
| Controls up to 36.5 mA LED current |
| Typical 80 mV saturation voltage at 15 mA |
| LED current precision ±10 percent |
| Smart over-temperature protection function vs. junction temperature |

# 4 Circuit description

## 4.1 Circuit diagram

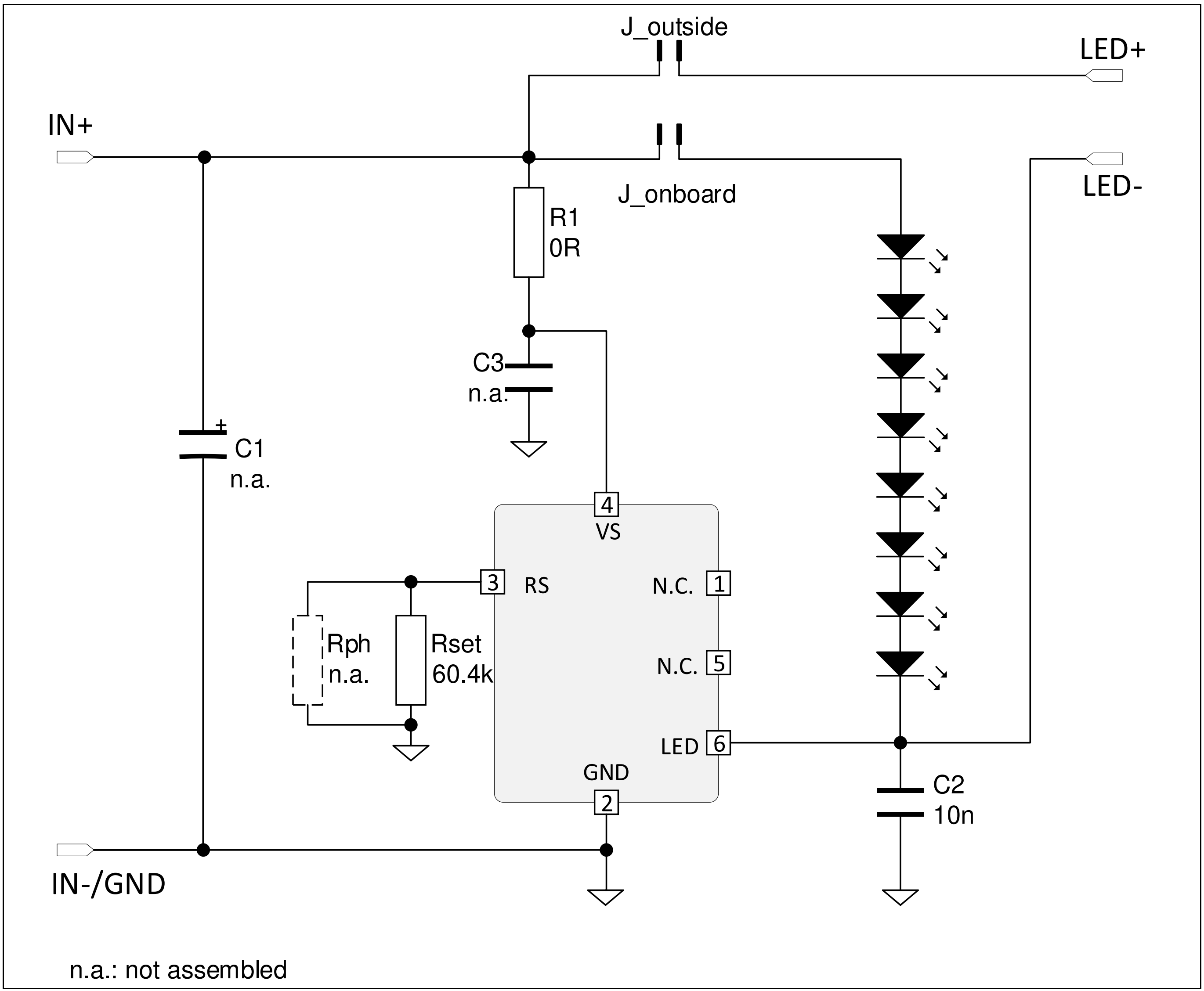


**Figure 3 Schematic diagram of 24 V/15 mA linear LED driver**

C1, C3 and Rph are not assembled.

C1 is a "placeholder" of an electrolytic capacitor. In case of power-supply output voltage ripple, an electrolytic capacitor can be assembled to suppress the ripple.

R1 and C3 can be assembled as high-frequency noise filters if needed for power-supply connection.

A 10 nF bypass capacitor C2 connected between LED pin 6 and GND reduces the risk of oscillation at the LED pin. C2 needs to be placed close to LED pin 6.

R1 can be replaced by a multimeter connection in order to measure the IC current $I_S$. Rph is a "placeholder" for a two-pin through-hole footprint of 2.54 mm. It allows for the option of soldering a variable resistor, a header or a through-hole resistor to the board.

## 4.2 Configuration

24 V DC source is supplied to ports IN+ and IN-/GND. By default, a jumper is placed on header J_onboard, so that the on-board LED string is used as the load. If an external LED load is desired, it can be connected to ports LED+ and LED-, and it can be selected as the load by removing the jump from header J_onboard and placing a jump on header J_outside.

By default, Rset is 60.4 kΩ, which configures the LED current to be 15 mA. The LED current level can be adjusted by placing different Rset resistances (please refer to the BCR431U datasheet for more detail).

# 5 PCB layout

The PCB is double-sided and is manufactured with the standard 1.5 mm thickness and 1 oz. copper. It measures 33.7 mm x 55.1 mm.

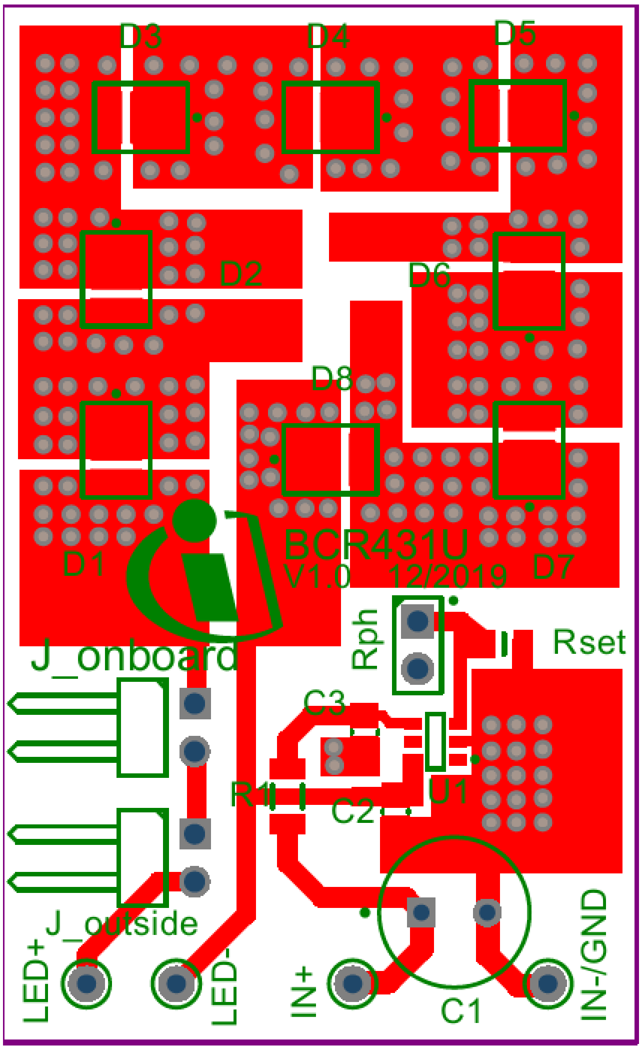


**Figure 4 Layout top**

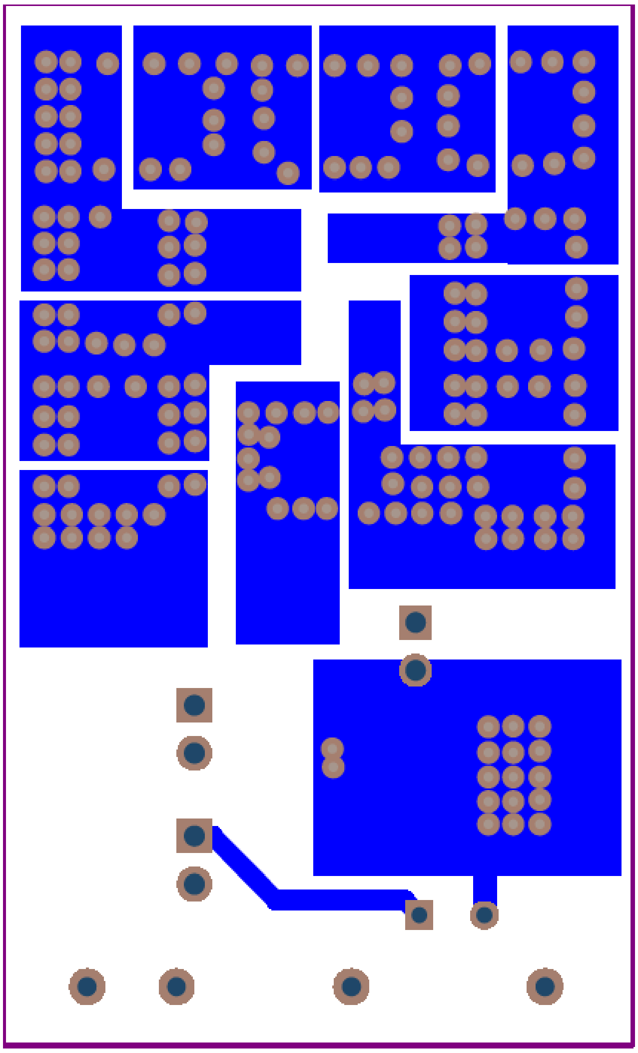

**Figure 5 Layout bottom**

For heat dissipation on BCR431U, it is recommended to connect copper areas that act as heat spreaders to the GND pin. LEDs also require large copper areas and vias for heat dissipation.

# 6 Bill of Materials (BOM)

**Table 3 BOM**

| Component designator | Description | Manufacturer | Manufacturer part number |
|---|---|---|---|
| C2 | Ceramic capacitor, 10 nF, 50 V, X7R | | Standard capacitor |
| D1, D2, D3, D4, D5, D6, D7, D8 | White LEDs with $V_F$ approx. 2.8 V at 50 mA at $T_j$ = 25°C | Lumileds | MXA9-PW65-H001 |
| J_onboard, J_outside | Through-hole header, 2.54 mm pitch, two pins, right angle | Würth Elektronik | 61300211021 |
| J_jump | Jumper sockets, placed on top of J_onboard | 3M | 969102-0000-DA |
| R1 | Resistor, 0 Ω, 1 percent, 1206 | | Standard resistor |
| Rset | Resistor, 60.4 kΩ, 1 percent, 0805 | | Standard resistor |
| U1 | BCR431U, SOT23-6 | Infineon | SP005351261 |

# 7 Test results

## 7.1 Ambient temperature ($T_A$) from -40°C to 125°C

Smart over-temperature protection is implemented inside BCR431U, which reduces the LED current at high junction temperatures in order to prevent a "thermal runaway". In this section, voltages at pins RS and LED and LED current are measured at different temperatures.

Test procedure:

1. Rset = 60.4 kΩ.
2. Place the board inside the temperature chamber.
3. Set the chamber temperature to -40°C, and ramp up to 125°C.
4. Measure the voltages on the RS pin ($V_{RS}$) and LED pin ($V_{LED}$), and LED current ($I_{LED}$).

*Note: Due to its temperature coefficient, the Rset resistance value changes with respect to temperature.*

### 7.1.1 On-board LEDs as the load

A key advantage of BCR431U is the low driver saturation voltage ($V_{LED,sat}$), which provides extra headroom for tolerances of supply voltage and LED forward voltage and also results in a small power dissipation inside BCR431U. In this measurement input voltage $V_{IN}$ is reduced to 21.5 V in order to drive the voltage at the LED pin at -40°C, close to the saturation voltage of BCR431U (**Figure 7** and **Figure 8**).

*Note: The on-board LEDs are not specified for 125°C ambient temperature.*

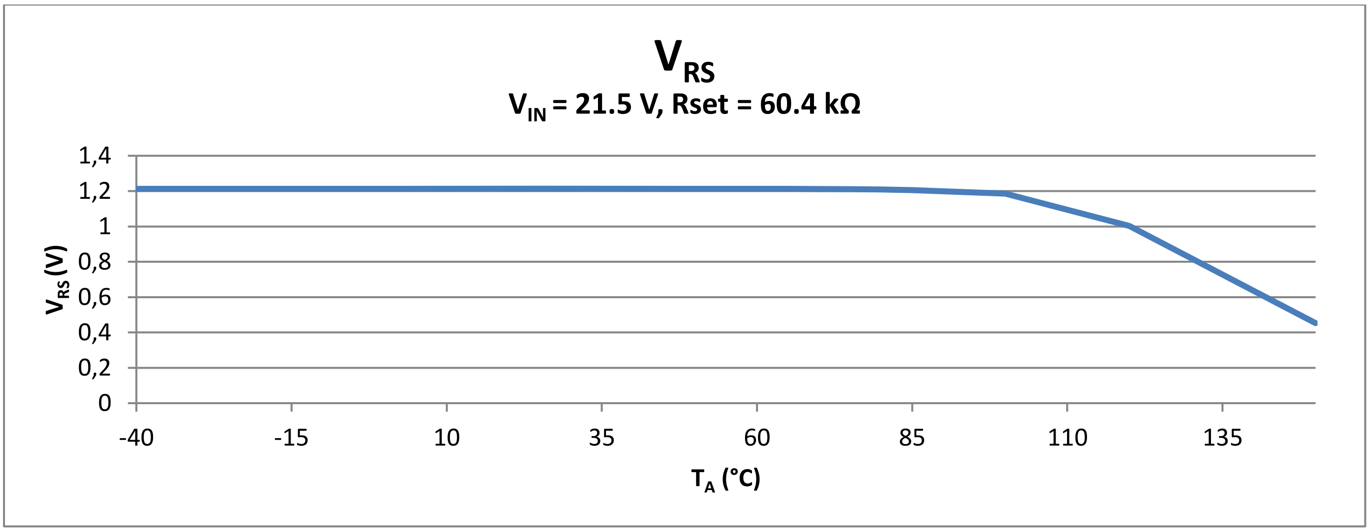


**Figure 6 Voltage on the RS pin vs. $T_A$**

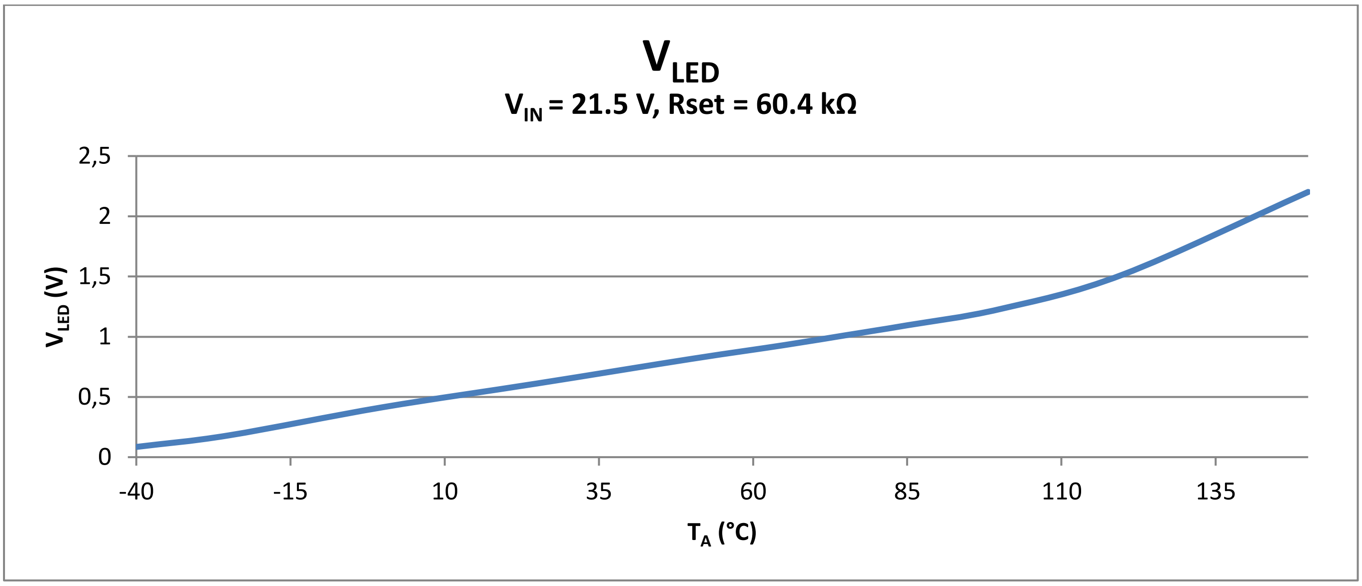


Figure 7 Voltage on the LED pin vs. $T_A$

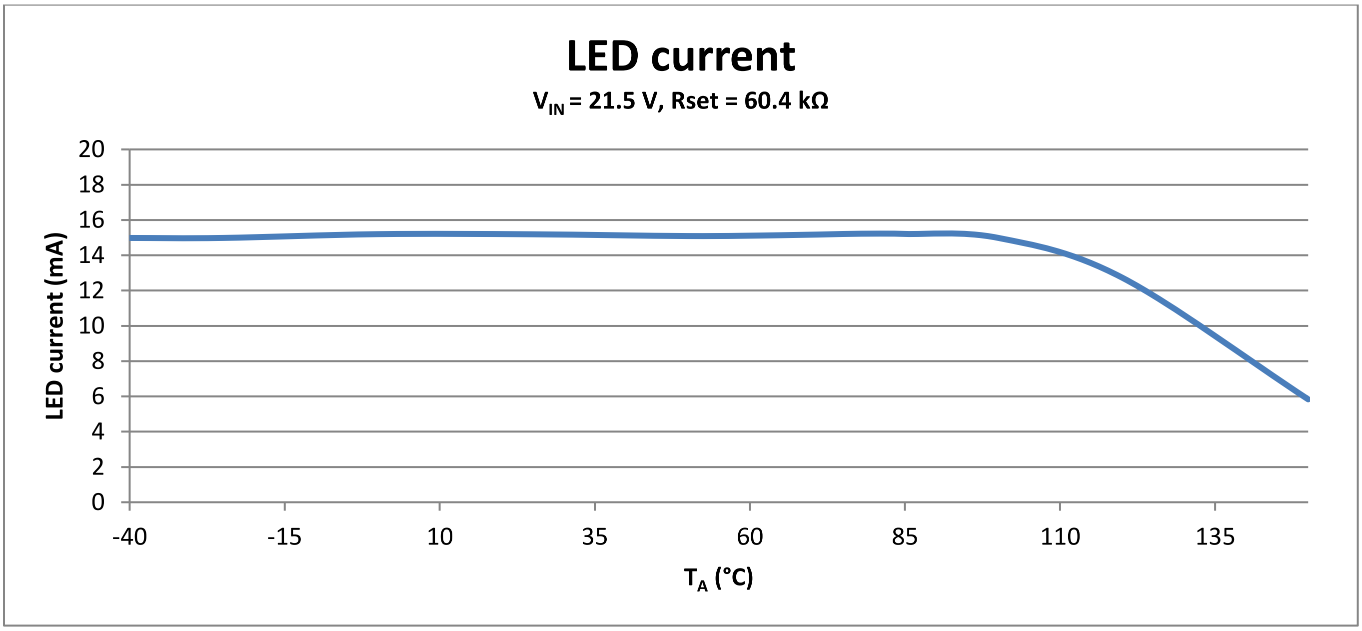


Figure 8 LED current vs. $T_A$

It can be seen from **Figure 6** and **Figure 8** that when the ambient temperature rises above 100°C, the over-temperature protection function starts, reducing the LED current.

## 7.2 More measurements

The following measurements are done at room temperature (unless otherwise specified). The data is recorded when the board runs for 30 minutes and reaches thermal stability, except **Figure 10**.

**Figure 9** shows the LED current measured at 0 (i.e. immediately LEDs are on), 10, 20 and 30 minutes. In the beginning, the IC is at room temperature. Over time the IC temperature increases until it reaches thermal stability. Due to the positive temperature coefficient of the LED current below activation of the over-temperature protection (refer to **Figure 9**), the LED current increases slightly until the IC reaches thermal stability.

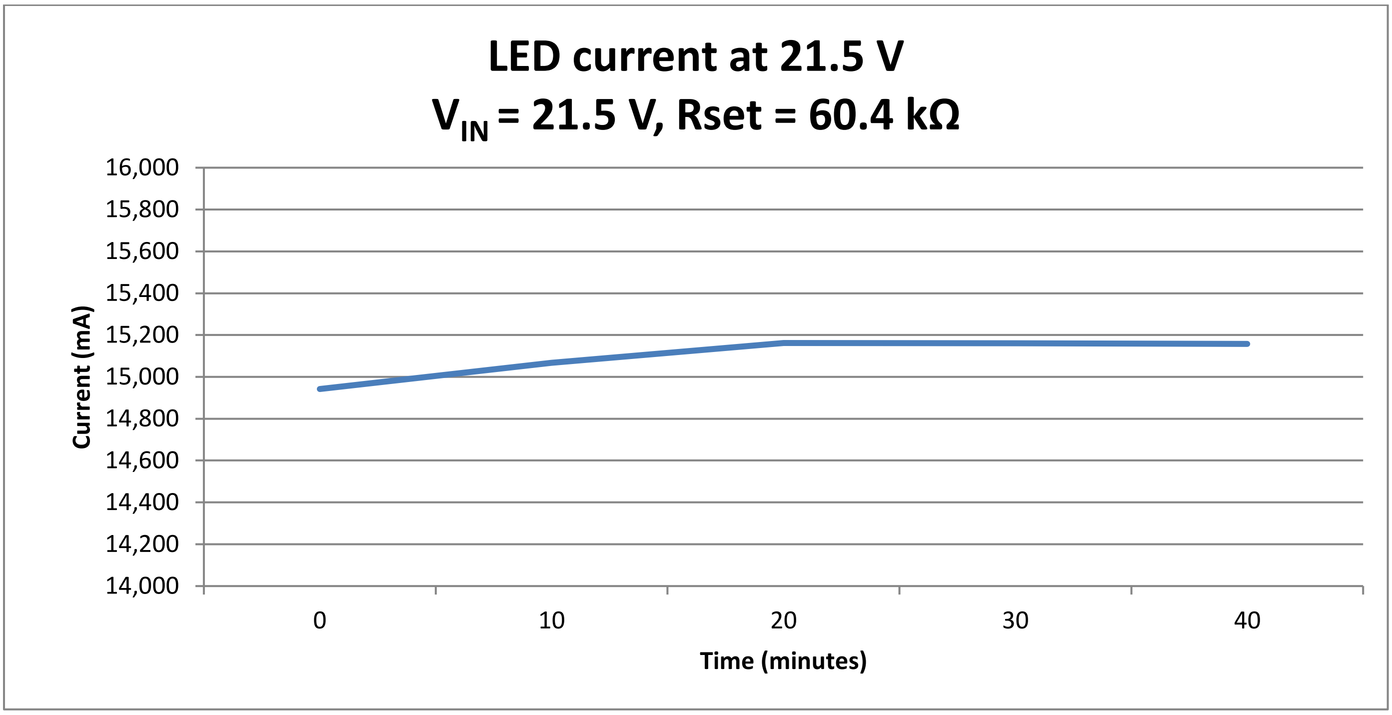


**Figure 9 LED current vs. running time**

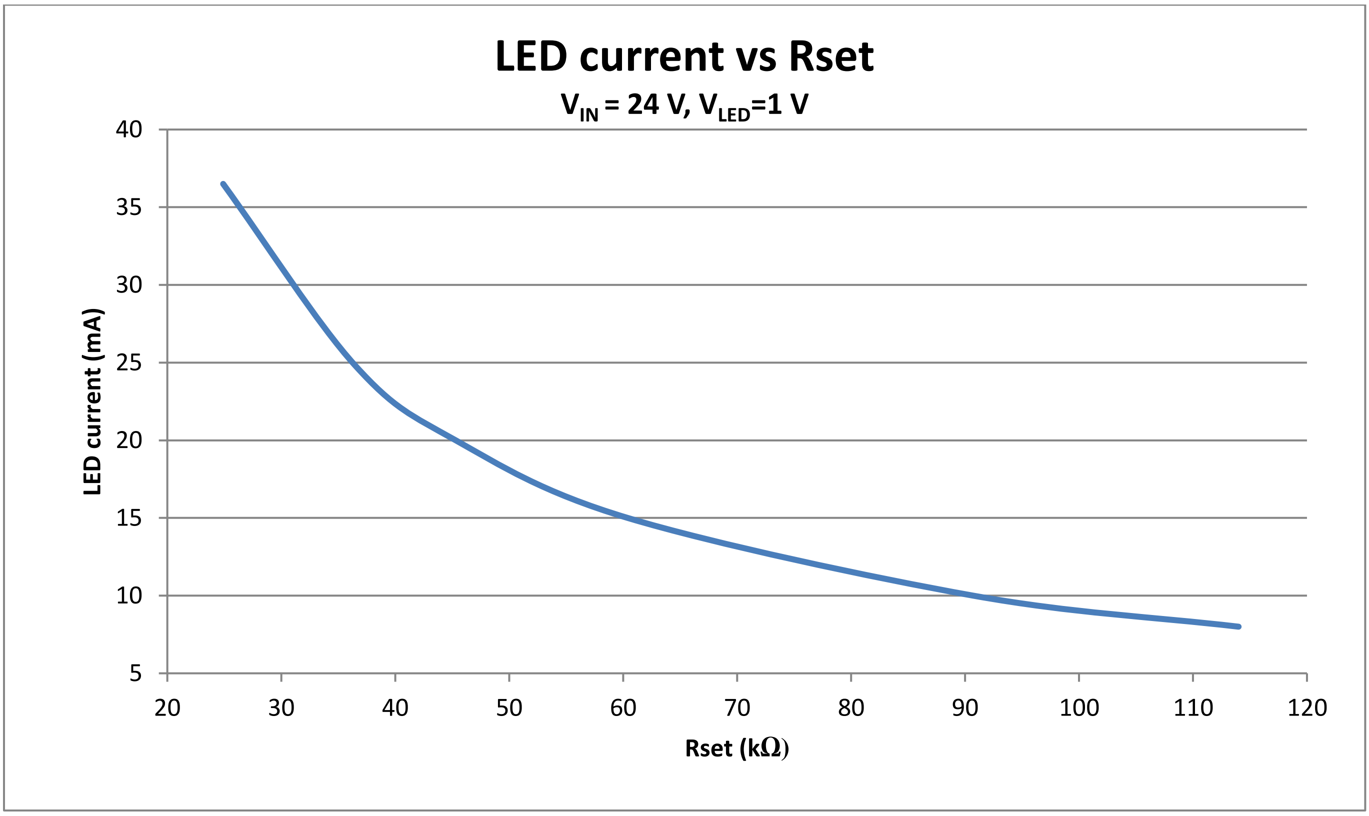


**Figure 10 LED current dependency on Rset**

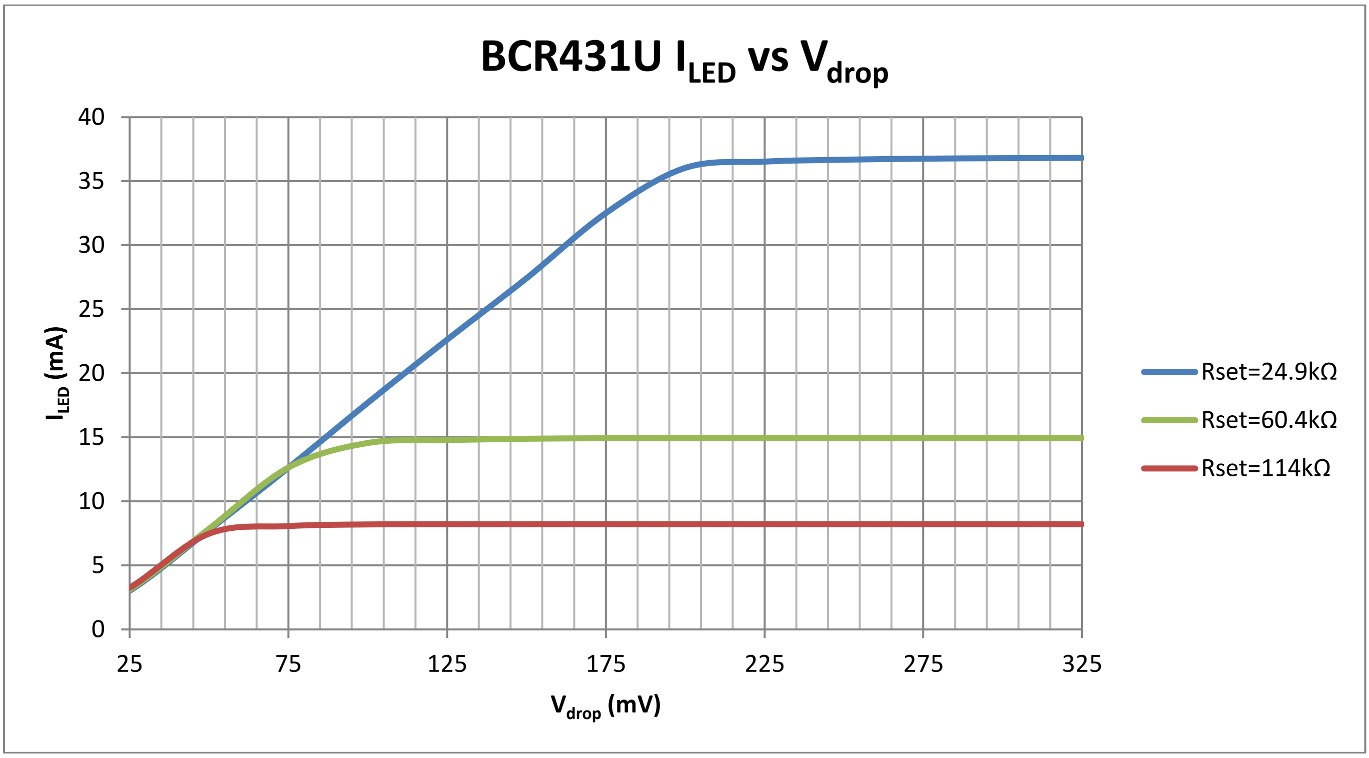


**Figure 11** LED current vs. voltage on LED pin (pin 6)

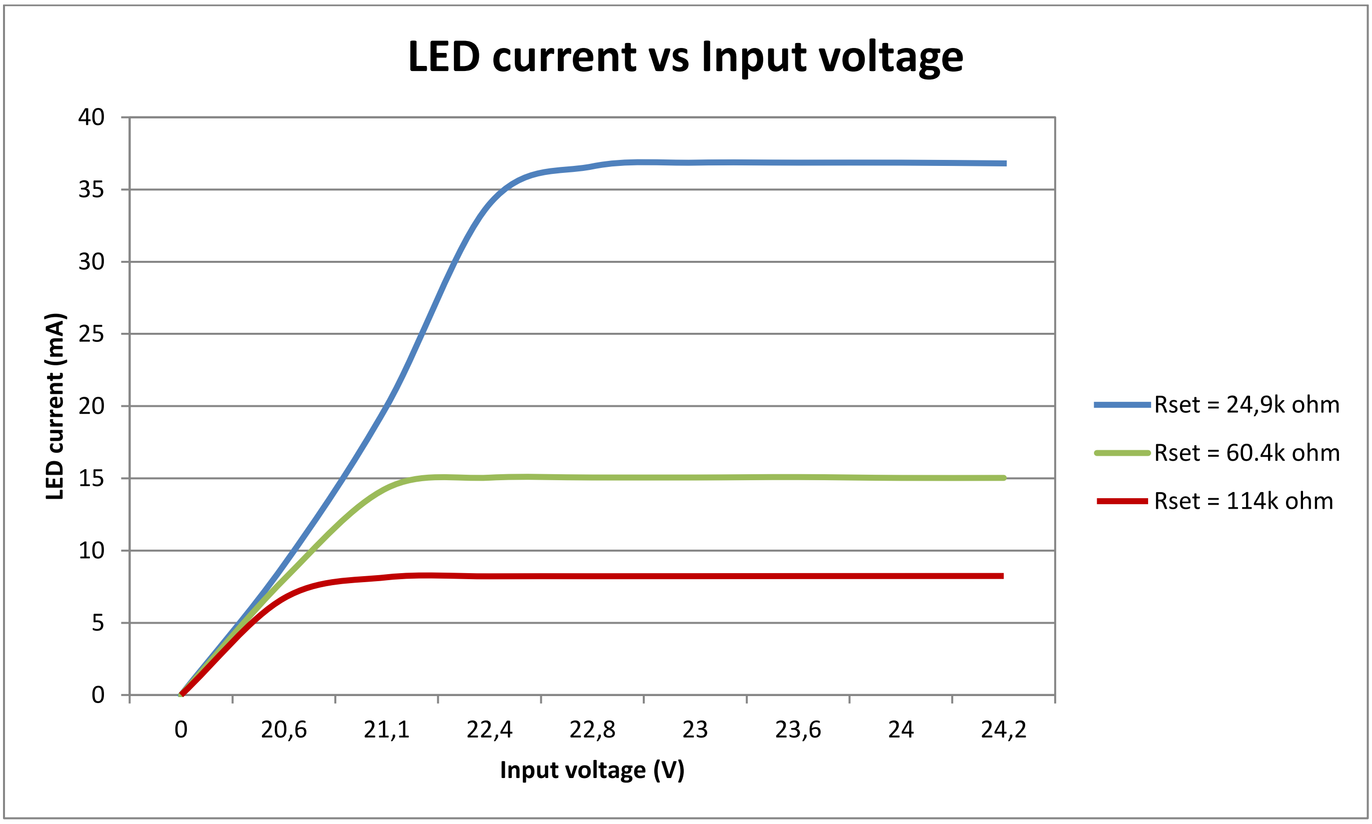


**Figure 12** LED current vs. input voltage (at room temperature)

Figure 11 shows the relationship between LED current $I_{LED}$ and the voltage $V_{LED}$ at pin 6 for three different values of resistor Rset.

**Figure 12** shows the relationship between LED current $I_{LED}$ and the evaluation board input voltage $V_{IN}$ for three different values of resistor Rset. Due to the increase in the LED forward voltage with increasing LED current, the $V_{IN}$ voltage sweep is wider than in Figure 11 until a constant LED current is reached.

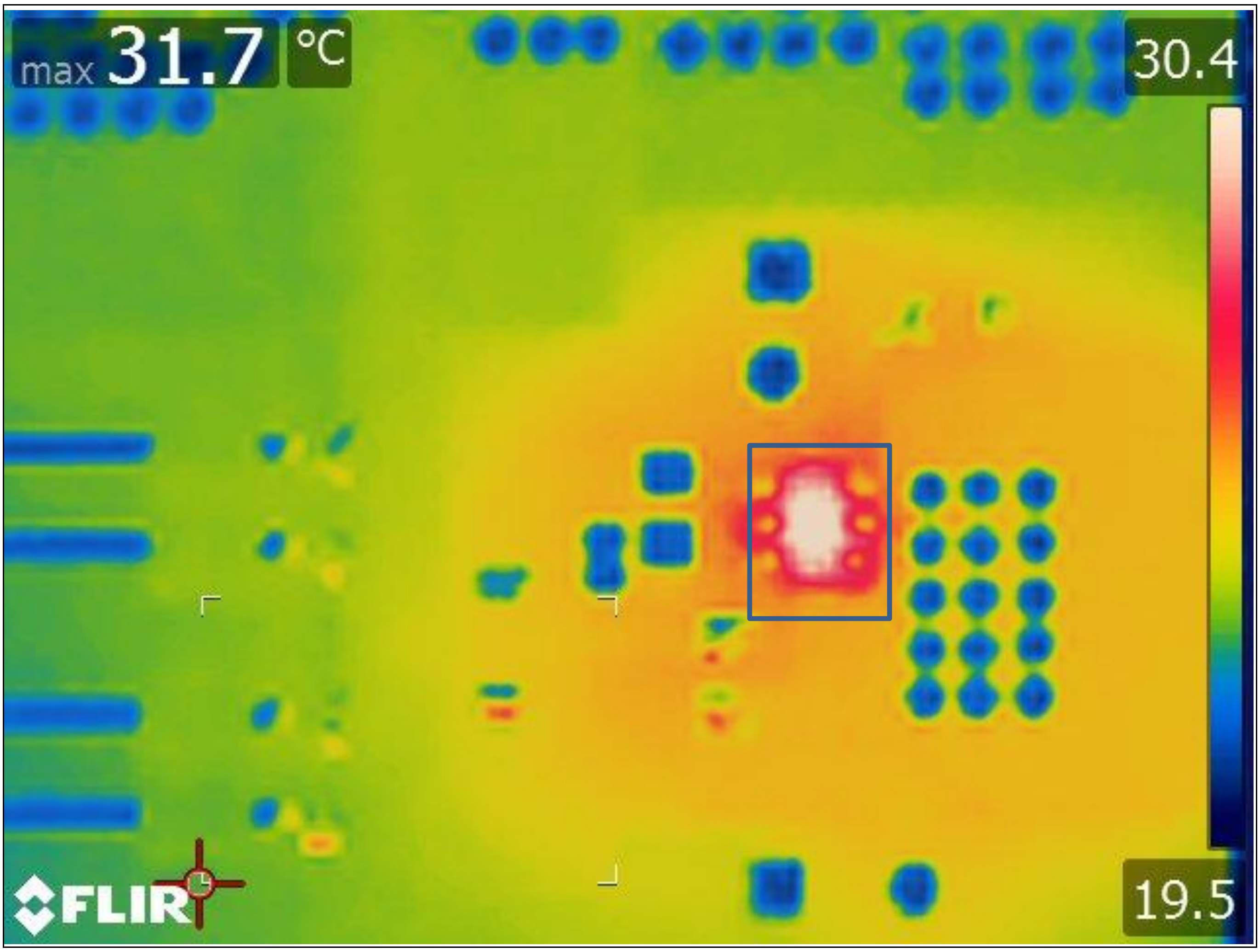


**Figure 13 Thermal photo ($V_{IN}$ = 24 V, Rset = 60.4 kΩ, $I_{LED}$ = 15 mA, $T_A$ = 25°C)**

**Figure 13** shows the thermal photo of the board (portion). BCR431U is located in the rectangle, with a case temperature of 31.7°C.

# 8 Revision history

| Document version | Date of release | Description of changes |
|---|---|---|
| V 1.0 | 2020-03-20 | First release |
| | | |
| | | |

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