

### Description

The XR46050 is a two-step LED current controller for bulb application powered by an alternative current (AC) voltage source directly. It can drive an external N-channel power MOSFET to regulate the current flowing through a High Voltage (HV) LED string.

The XR46050 works as a constant current regulator to control two-step current levels for AC step driver with simplest structure. It also provides linear type Over Temperature Protection (OTP).

The PCB design can be very compact to meet various shape requirements. It is especially suitable for replacing A-series LED light bulbs and candelabra LED bulbs.

### FEATURES

- Device
  - 6V to 76V chip supply voltage range
  - Over temperature protection
  - Single board LED lighting solution available
  - 2mm x 2mm TDFN-6 package
- System
  - All solid state components
  - No electrolytic capacitor required
  - Fewer component counts and simple solution for LED lighting
  - Scalable architecture allows optimization of performance vs. cost
  - Driver-on-board and chip-on-board design solution available which minimize process flow and assembly cost
  - High PF and Low THD performance
  - Flexible PCB layout options

### APPLICATIONS

- A series LED bulbs
- Candelabra LED bulbs
- AC LED lighting engines

### Typical Application

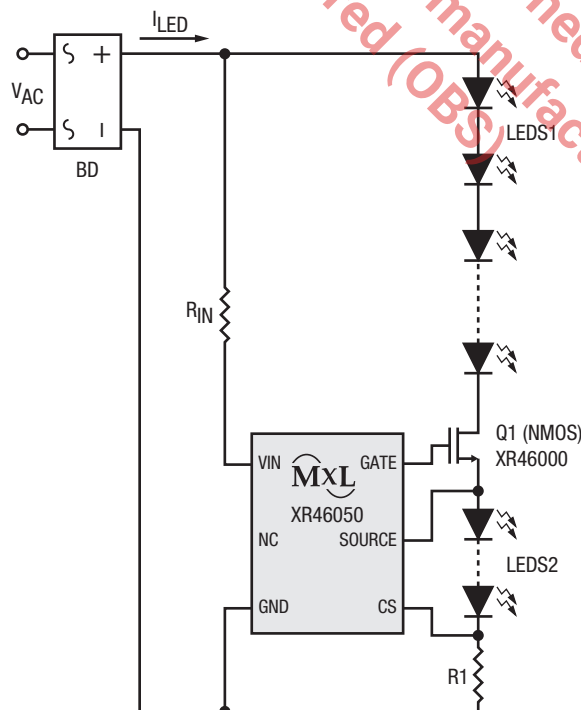


Figure 1. Typical Application

## Absolute Maximum Ratings

Stresses beyond the limits listed below may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

### Sustaining Voltage

V<sub>IN</sub>, GATE, SOURCE to GND ..... -0.3V to 85V

GATE to SOURCE ..... -0.3V to 7V

SOURCE to CS ..... -0.3V to 70V

CS to GND ..... -0.3V to 1V

V<sub>IN</sub> input current ..... 3mA

SOURCE to CS current ..... 180mA

Maximum operating junction temperature, T<sub>J</sub> ..... 150°C

Operating temperature, T<sub>OPR</sub> ..... -40°C to 85°C

Storage temperature range ..... -55°C to 150°C

Lead temperature (soldering, 10 seconds) ..... 260°C

## Operating Conditions

Input Voltage, V<sub>IN</sub> ..... 6V ~ 76V

Peak level current ..... 180 mA

### NOTES:

1. All voltages are with respect to ground. Currents are positive into, negative out of the specified terminal.
2. All parameters having min/max specifications are guaranteed. Typical values are for reference purpose only.
3. Unless otherwise noted, all tests are pulsed tests at the specified temperature, therefore: T<sub>J</sub> = T<sub>C</sub> = T<sub>A</sub>.

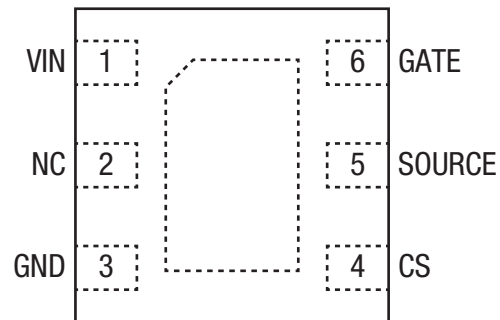
## Electrical Characteristics

| Symbol                                   | Parameter   | Conditions   | Min | Typ  | Max | Units |
|--|---|--|-----|------|-----|-------|
| V <sub>INMIN</sub>                       | Minimum V <sub>IN</sub> supply voltage                                  |  | 6   |      |     | V     |
| I <sub>IN</sub>                          | V <sub>IN</sub> supply current  | V <sub>IN</sub> = 6V to 73V  |     | 0.3  | 0.5 | mA    |
| V <sub>INCLAMP</sub>                     | V <sub>IN</sub> over voltage clamp                                      | When V <sub>IN</sub> > V <sub>INCLAMP</sub> , I <sub>IN</sub> will increase to >1mA to clamp V <sub>IN</sub> at V <sub>INCLAMP</sub> | 74  | 76   | 80  | V     |
| V <sub>CS</sub>                          | CS voltage  | V <sub>IN</sub> = 15V and 75V  | 310 | 323  | 336 | mV    |
| V <sub>REF1</sub> /<br>V <sub>REF0</sub> | Reference voltage ratio   |  | 85  | 90   | 95  | %     |
| V <sub>GATE</sub>                        | GATE voltage  | Gate to SOURCE   |     | 5.4  |     | V     |
| I <sub>SOURCE</sub>                      | GATE source current <sup>(1)</sup>                                      | V <sub>GATE</sub> - V <sub>CS</sub> = 3V   |     | 30   |     | μA    |
| I <sub>SINK</sub>                        | GATE sink current <sup>(1)</sup>  | V <sub>GATE</sub> - V <sub>CS</sub> = 3V   |     | 500  |     | μA    |
| T <sub>TP</sub>                          | Thermal protection trip temperature                                     | When T <sub>J</sub> is higher than T <sub>TP</sub> , V <sub>CS</sub> decreases linearly  | 135 | 145  |     | °C    |
| ΔV <sub>CS</sub> /ΔT <sub>J</sub>        | Thermal protection mode V <sub>CS</sub> decreasing slope <sup>(1)</sup> | T <sub>J</sub> > T <sub>TP</sub>   |     | -1.1 |     | %/°C  |

### NOTE:

1. Guarantee by design, not by production test.

## Pin Configuration



2mm x 2mm TDFN-6

## Pin Functions

| Pin Number               | Pin Name | Description   |
|--------------------------|----------|---|
| 1                        | VIN      | Power supply pin.   |
| 2                        | NC       | No connection.  |
| 3                        | GND      | Ground pin.   |
| 4                        | CS       | Current sense pin. Connect a sense resistor, $R_{CS}$ , between this pin and the GND pin. The peak current is set by $I_{OUT} = V_{CS}/R_{CS}$ .  |
| 5                        | SOURCE   | External HV NMOS SOURCE pin. The $V_F$ of the LED segment connected between the source pin and the CS pin should not be higher than 70V.  |
| 6                        | GATE     | External HV NMOS gate driving pin. Limited to 5.5V maximum.   |
| Exposed thermal pad (EP) |          | Exposed thermal pad of the chip. Use this pad to enhance the power dissipation capability. The thermal conductivity will be improved if a copper foil on PCB is soldered with the thermal pad. It is recommended to connect the exposed thermal pad to the GND pin. |

## Functional Block Diagram

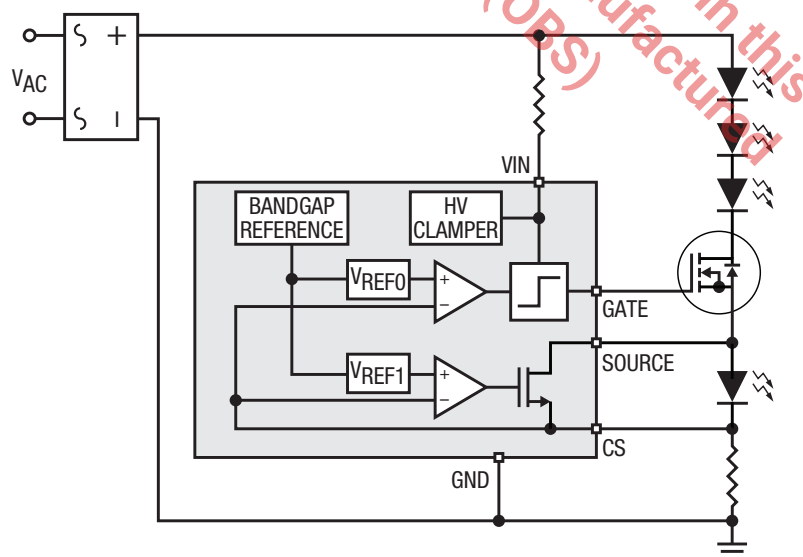


Figure 2. Functional Block Diagram

Applications Information

Typical Application

For a typical two-step driving scheme with one XR46050, the electrical performance is good enough to meet most of the requirement: the Power Factor (PF) is higher than 0.92 and the Total Harmonic Distortion (THD) is around 30%. If higher PF or lower THD is required, one more XR46083 or XR46084 can be added to make the lighting system becoming a three-step driving scheme, as shown in below. The three-step system can provide better electrical performance of PF > 0.96 and THD = ~ 20%.

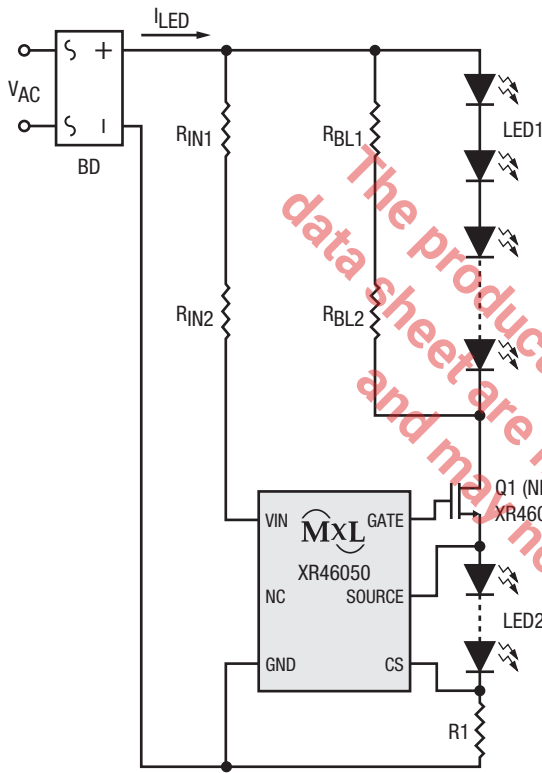


Figure 3. 2-Step (PF > 0.92, THD = ~ 30%)

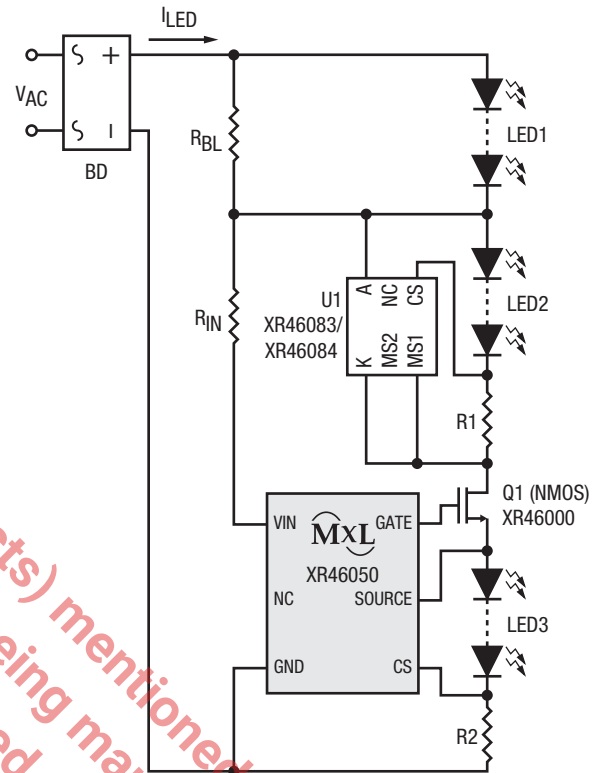


Figure 4. 3-Step (PF > 0.96, THD = ~ 20%)

## Applications Information (Continued)

### Linear Type Thermal Protection

When the junction temperature  $T_J$  rises up to the Thermal Protection Trip temperature  $T_{TP}$  (145°C in typical), the current sense voltage  $V_{CS}$  starts to decrease linearly at a slope of  $-1.1\%/^{\circ}\text{C}$ . The LED driving current decreases accordingly. The system can still work normally under the thermal protection mode with lower driving current. The power dissipation on the XR46050 chip becomes lower so the  $T_J$  will stop increasing when thermal balance is reached.

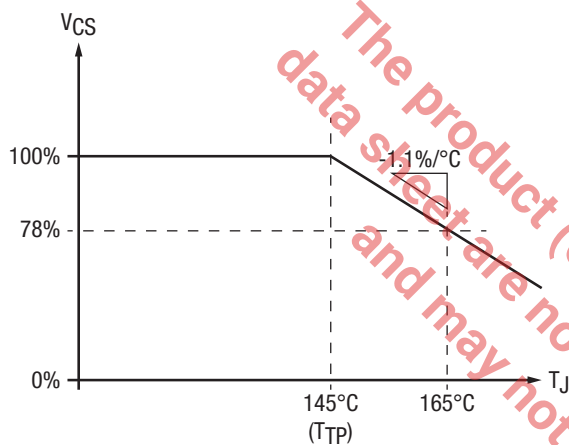


Figure 5.  $V_{CS}$  vs.  $T_J$

### Layout Suggestion

The exposed thermal pad under the chip is used to enhance the power dissipation capability. The thermal conductivity will be improved if a copper foil on PCB soldered with the thermal pad can be as large as possible. It is strongly recommended to connect the GND pin to the exposed thermal pad.

The external HV NMOS is recommended to be placed close to the chip. The pull-high resistor for the  $V_{IN}$  pin should be placed close to the chip too. The current sense resistor connected between the CS pin and GND pin should be placed as close as to the CS pin and GND pin, as the example in below.

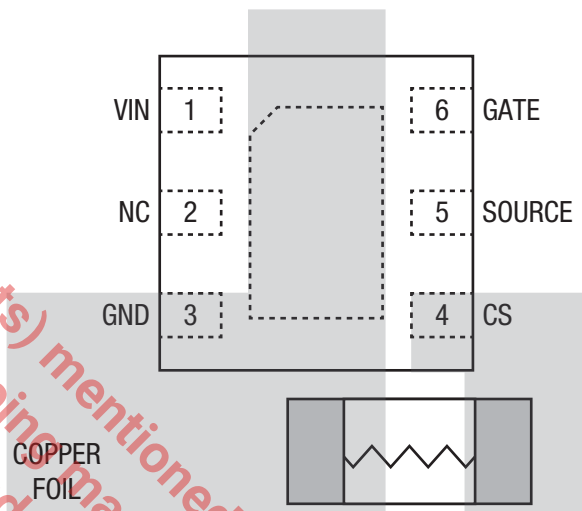
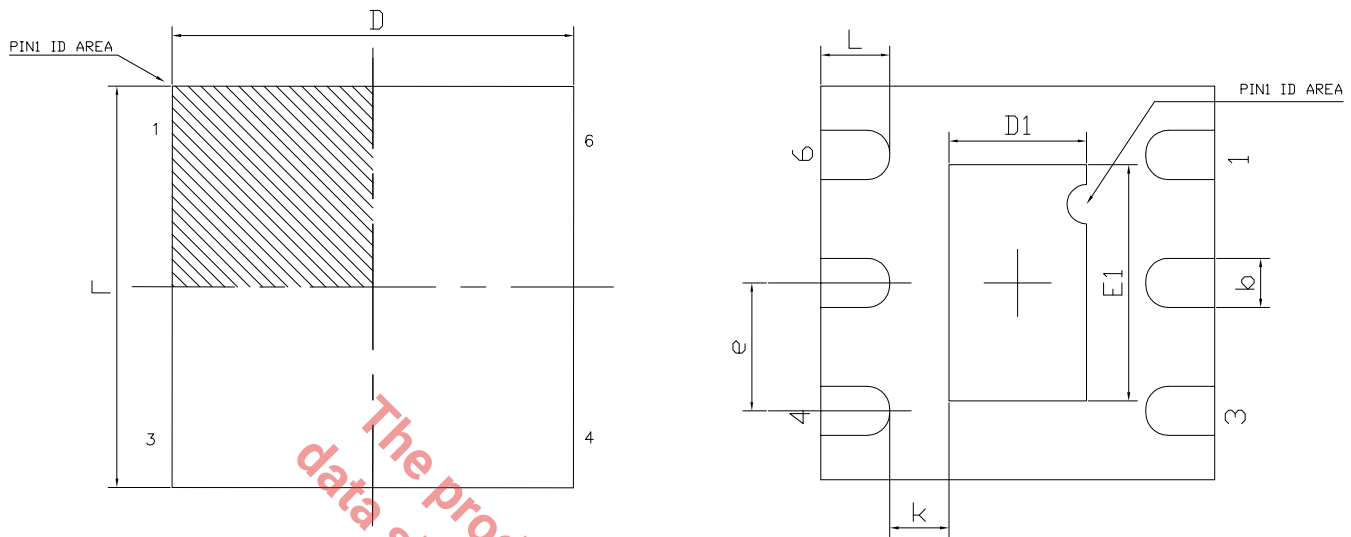


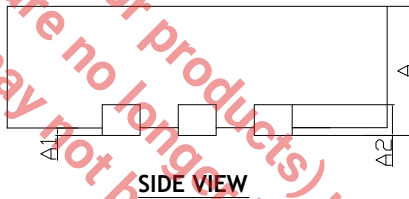
Figure 6. Foil

## Mechanical Dimensions



TOP VIEW

BOTTOM VIEW



SIDE VIEW

| DIM SYMBOL | MIN       | NOM   | MAX   |
|------------|-----------|-------|-------|
| A          | 0.700     | 0.750 | 0.800 |
| A1         | 0.000     | —     | 0.050 |
| A2         | 0.203Ref  |       |       |
| b          | 0.200     | 0.250 | 0.300 |
| D          | 2.00 BSC  |       |       |
| E          | 2.00 BSC  |       |       |
| e          | 0.650 BSC |       |       |
| D1         | 0.600     | 0.700 | 0.800 |
| E1         | 1.100     | 1.200 | 1.300 |
| L          | 0.274     | 0.350 | 0.426 |
| K          | 0.200     | —     | —     |
| N          | 6         |       |       |

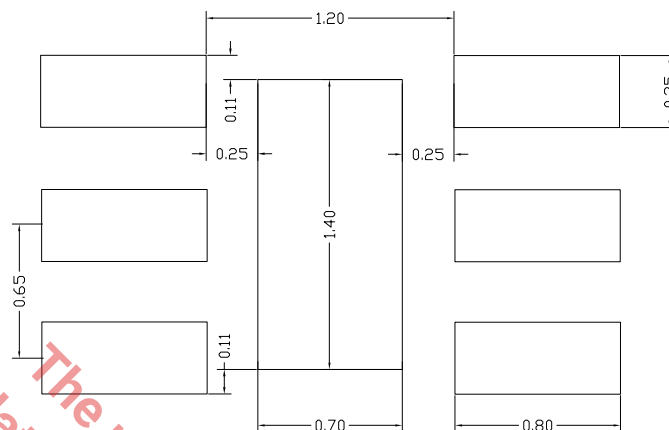
## TERMINAL DETAILS

- ALL DIMENSIONS ARE IN MILLIMETERS, ANGLES ARE IN DEGREES.
- DIMENSIONS AND TOLERANCE PER JEDEC MO-229.

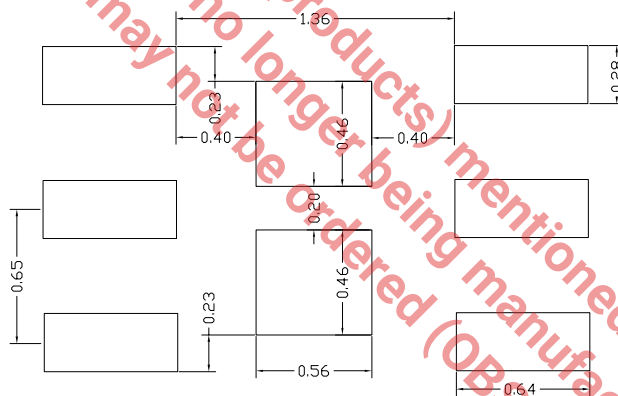
Drawing No.: POD-00000072

Revision: B

Recommended Land Pattern and Stencil



TYPICAL RECOMMENDED LAND PATTERN



TYPICAL RECOMMENDED STENCIL

The product (or products) mentioned in this data sheet are no longer being manufactured and may not be ordered (OBS)

Drawing No.: POD-0000072

Revision: B

Ordering Information<sup>(1)</sup>

| Part Number  | Operating Temperature Range | Lead-Free          | Package   | Packaging Method |
|--------------|-----------------------------|--------------------|-----------|------------------|
| XR46050IHBTR | -40°C to 85°C               | Yes <sup>(2)</sup> | TDFN6 2x2 | Tape and reel    |

**NOTE:**

1. Refer to [www.exar.com/XR46050](http://www.exar.com/XR46050) for most up-to-date Ordering Information.
2. Visit [www.exar.com](http://www.exar.com) for additional information on Environmental Rating.

## Revision History

| Revision | Date     | Description   |
|----------|----------|---|
| 1.0      | Aug 2015 | Initial release.  |
| 1A       | Oct 2016 | New datasheet format, update Typical Application and update Package Description.              |
| 1B       | May 2018 | Update to MaxLinear logo. Update format. Change Package Description to Mechanical Dimensions. |

The product (or products) mentioned in this data sheet are no longer being manufactured and may not be ordered (OBS)



**Corporate Headquarters:**  
 5966 La Place Court  
 Suite 100  
 Carlsbad, CA 92008  
 Tel.: +1 (760) 692-0711  
 Fax: +1 (760) 444-8598  
[www.maxlinear.com](http://www.maxlinear.com)

**High Performance Analog:**  
 1060 Rincon Circle  
 San Jose, CA 95131  
 Tel.: +1 (669) 265-6100  
 Fax: +1 (669) 265-6101  
[www.exar.com](http://www.exar.com)

The content of this document is furnished for informational use only, is subject to change without notice, and should not be construed as a commitment by MaxLinear, Inc.. MaxLinear, Inc. assumes no responsibility or liability for any errors or inaccuracies that may appear in the informational content contained in this guide. Complying with all applicable copyright laws is the responsibility of the user. Without limiting the rights under copyright, no part of this document may be reproduced into, stored in, or introduced into a retrieval system, or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), or for any purpose, without the express written permission of MaxLinear, Inc.

MaxLinear, Inc. does not recommend the use of any of its products in life support applications where the failure or malfunction of the product can reasonably be expected to cause failure of the life support system or to significantly affect its safety or effectiveness. Products are not authorized for use in such applications unless MaxLinear, Inc. receives, in writing, assurances to its satisfaction that: (a) the risk of injury or damage has been minimized; (b) the user assumes all such risks; (c) potential liability of MaxLinear, Inc. is adequately protected under the circumstances.

MaxLinear, Inc. may have patents, patent applications, trademarks, copyrights, or other intellectual property rights covering subject matter in this document. Except as expressly provided in any written license agreement from MaxLinear, Inc., the furnishing of this document does not give you any license to these patents, trademarks, copyrights, or other intellectual property.

Company and product names may be registered trademarks or trademarks of the respective owners with which they are associated.