

### General Description

The **XR46701** is a current controller which integrates a PWM dimming function which can be controlled by a 1V to 4V control signal. Current is regulated through an external N-channel power MOSFET which allows one to scale current and spread heat dissipation.

The XR46701 is generally configured to be the last step in an LED AC direct step drive solution which provides excellent Power Factor and THD without the need for bulk capacitance or inductors. The DC dimming control signal applied to the DIM pin is converted to a Pulse Width Modulation signal to adjust the LED brightness.

The XR46701 also includes thermal foldback and power line regulation to avoid excessive power loss and over heating which can significantly reduce the life of LEDs. The Over Voltage Protection (OVP) and Over Temperature Protection (OTP) provide a failsafe in the worst operating conditions. The OVP can also be used to enable unique dual range AC direct drive solutions.

#### FEATURES

- 4V to 40V supply voltage range
- Power line regulation
- 1V to 4V DC to PWM dimming control range
- 400 to 2000 Hz adjustable internal PWM oscillator
- $V_{IN}$  supply clamp eliminates external zener
- Dual Mode over temperature protection
  - Thermal current foldback
  - Thermal shutdown
- Over voltage protection enables dual range lighting solutions
- >600V Native Surge protection extends MOV life
- 5V 1mA output

#### APPLICATIONS

- AC direct drive LED lighting
- High bay lighting
- Dual range light engines
- Downlights
- Smart lighting

### Typical Application

Ordering Information - [Back Page](#)

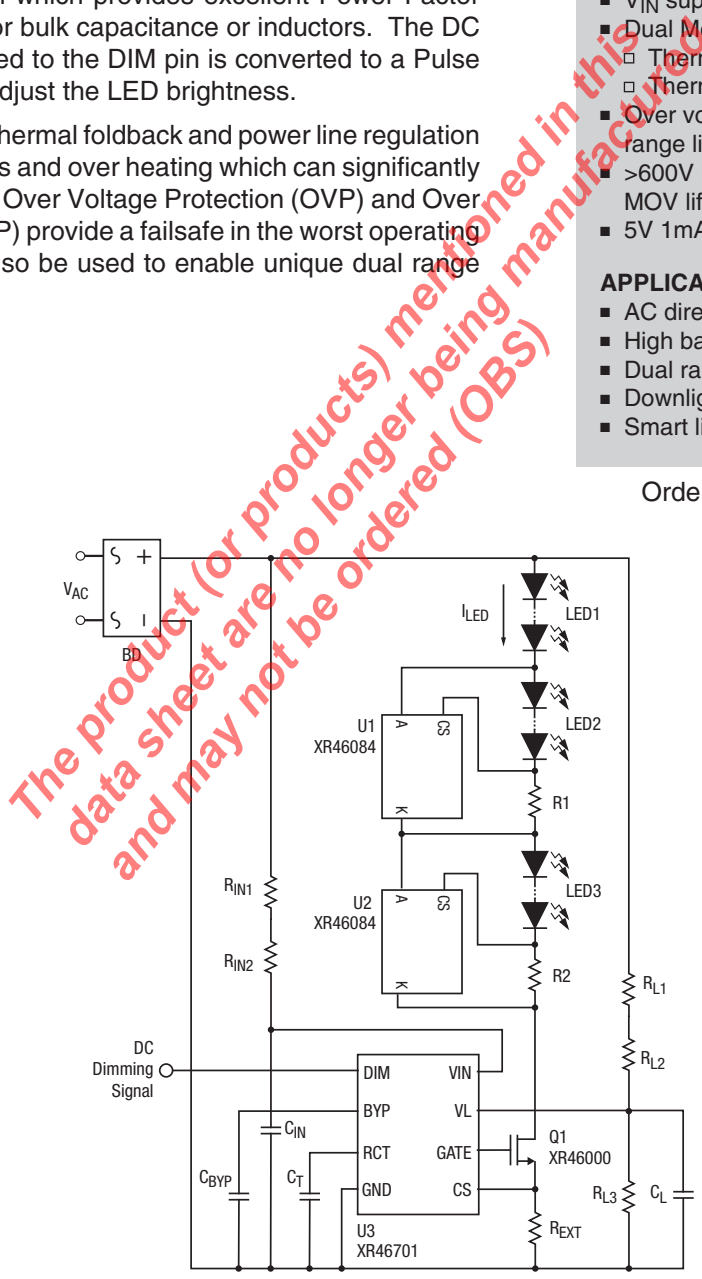


Figure 1: Typical Application

## Absolute Maximum Ratings

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

### Sustaining voltage

$V_{IN}$  pin.....-0.3V to 45V

Other pins.....-0.3V to 7V

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

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

### 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:  $T_J = T_C = T_A$ .

## Operating Conditions

Input voltage,  $V_{IN}$ .....4V to 42V

DC dimming signal,  $V_{DIM}$ .....0V to 5V

VL line regulation control signal,  $V_{VL}$ .....0V to 5V

Internal PWM dimming frequency,  $f_{RCT}$  ..... 1200Hz, typical

Operating junction temperature,  $T_J$  ..... -40°C to 125°C

Maximum operating junction temperature,  $T_J$ ..... 150°C

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

## Electrical Characteristics

Specifications are for Operating Junction Temperature of  $T_J = 25^\circ\text{C}$  only; limits applying over the full Operating Junction Temperature range are denoted by a “•”. Typical values represent the most likely parametric norm at  $T_J = 25^\circ\text{C}$ , and are provided for reference purposes only. Unless otherwise noted, values are at  $T_A = 25^\circ\text{C}$ .

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$I_{IN}$	$V_{IN}$ supply current	$V_{IN} = 5.5\text{V to }36\text{V}$ , DIM = 0V and 5V	0.3	0.6	1.0	mA
$V_{IN,CLAMP}$	$V_{IN}$ over voltage clamp	When $V_{IN} > V_{IN,CLAMP}$ , $I_{IN}$ will increase to $>1\text{mA}$ to clamp $V_{IN}$ at $V_{IN,CLAMP}$ .	36	40	42	V
$V_{BYP}$	BYP voltage	$6\text{V} \leq V_{IN} \leq 40\text{V}$ , $I_{BYP} = 0$ to $2\text{mA}$	4.6	5.1	5.6	V
$I_{BYP}$	BYP pin output current		1			mA
$V_{CS}$	CS pin voltage	$V_{IN} = 15\text{V}$ , $V_{VL} = 2.7\text{V}$	0.264	0.270	0.276	V
			• 0.260		0.285	
$\Delta V_{LR}$	CS voltage line regulation vs. $V_{IN}^{(1)}$	$V_{IN} = 15\text{V}$ , $V_{VL} = 2.7\text{V to }3.3\text{V}$	-18	-20	-22	%
			-0.08		-0.09	
$V_{L,OVP}$	VL over voltage protection	$V_{VL}$ increasing		3.40		V
$V_{L,OVPR}$	VL over voltage protection recovery to normal <sup>(2)</sup>	$V_{VL}$ falling	2.95	3.06	3.15	V
$V_{CS,OVP}$	VL over voltage protection mode $V_{CS}$	$V_{VL} > V_{L,OVP}$		0		%
$V_{L,UVP}$	VL under voltage protection			2.2		V
$V_{CS,UVP}$	VL Under voltage protection mode $V_{CS}$	$V_{VL} = 2.0\text{V}$		112		%
				302		mV
$I_{SOURCE}$	GATE source current	$V_{GATE} - V_{CS} = 3\text{V}$		5		mA
$I_{SINK}$	GATE sink current	$V_{GATE} - V_{CS} = 3\text{V}$		5		mA
$i_{DOWN}$	Internal pull-high current	DIM pins		1		uA
$V_{IH}$	DIM pin DC dimming voltage level	"H" level	PWM duty = 100%	4		V
$V_{IL}$		"L" level	PWM duty = 2% (minimum duty)	0.5	1	
$V_{OFF}$		Off	PWM duty = 0% (shutdown).	0	0.5	
$V_{HYS}$			Hysteresis		44	
$D_{MIN}$	PWM dimming minimum duty	$V_{DIM} = 0.5$ to $1\text{V}$ , $f_{RCT} = 1\text{kHz}$		2		%
$f_{RCT}$	Internal PWM dimming frequency	RCT pin, $C_{RCT} = 2.2\text{nF}$		1.0		kHz
$i_{CHARGE}$	RCT charge current	Source by RCT pin		300		uA
$i_{DISCHARGE}$	RCT discharge current	Sink by RCT pin		8		uA

## Electrical Characteristics

Specifications are for Operating Junction Temperature of  $T_J = 25^\circ\text{C}$  only; limits applying over the full Operating Junction Temperature range are denoted by a “•”. Typical values represent the most likely parametric norm at  $T_J = 25^\circ\text{C}$ , and are provided for reference purposes only. Unless otherwise noted, values are at  $T_A = 25^\circ\text{C}$ .

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$T_{TP1}$	Primary thermal protection trip temperature <sup>(3),(4)</sup>	When $T_J$ is higher than $T_{TP1}$ , $V_{CS}$ decreases linearly at the slope of $-1\%/^\circ\text{C}$ .	120	135		$^\circ\text{C}$
$T_{TP2}$	Secondary thermal protection trip temperature <sup>(3),(5)</sup>	When $T_J$ is higher than $T_{TP2}$ , $V_{CS}$ decreases to $V_{CS,TP2}$ directly. ( $T_{TP2} - T_{TP1} = 25^\circ\text{C}$ )		150		$^\circ\text{C}$
$V_{CS,TP2}/V_{CS}$	Secondary thermal protection mode $V_{CS}$ voltage	$T_J > T_{TP2}$		20		%
$T_{SD,HYS}$	Secondary thermal protection hysteresis <sup>(3)</sup>			40		$^\circ\text{C}$

### NOTES:

1. The CS voltage line regulation is defined as:

$$\Delta V_{LR} = \frac{\Delta V_{CS}}{\Delta V_{VL}} = \frac{V_{CS}(V_{VL} = 3.3V) - V_{CS}(V_{VL} = 2.7V)}{3.3V - 2.7V}$$

2. VL Under Voltage Protection Mode  $V_{CS}$ :

$$\% = \frac{V_{CS}(V_{VL} = 2.0V)}{V_{CS}(V_{VL} = 2.7V)}$$

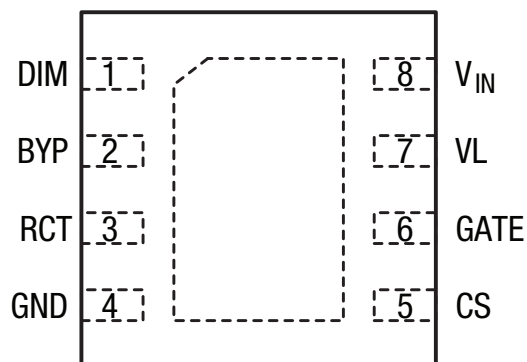
3. Guarantee by design, not by production test.

4. When  $T_J > T_{TP1}$ , the  $V_{CS}$  voltage decreases linearly at the slope of  $-1\%/^\circ\text{C}$ .

5. When  $T_J > T_{TP2}$ , the  $V_{CS}$  voltage drops to 20%.

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

## Pin Configuration



DFN-8 3mm x 3mm, Top View



MSOP-8, Top View

## Pin Functions

Pin Number	Pin Name	Description
1	DIM	PWM Dimming Control Input pin. A DC control signal from 1V to 4V sets the PWM duty cycle where the frequency is set by RCT pin. An input to the DIM pin higher than 4V results in 100% duty cycle. When the DIM pin is between 0.5V and 1V, the duty is fixed at the minimum of 2%. When the DIM pin is lower than 0.5V, the duty cycle is 0% (off)
2	BYP	Bypass pin of the internal regulator. Connect a de-coupling capacitor to ground.
3	RCT	PWM dimming frequency set pin. Connecting a 2.2nF capacitor between the RCT pin and GND will result in approximately 1.2kHz operation.
4	GND	Ground pin.
5	CS	Current Sense pin. Connect a sense resistor, R <sub>EXT</sub> , between this pin and the GND pin. The current is set by: $I_{OUT} = \frac{V_{CS}}{R_{EXT}}$
6	GATE	External MOSFET gate drive pin.
7	VL	VAC power line regulation compensation control pin. The VL voltage level is used to control the VCS voltage to provide power line regulation compensation and trigger the over voltage protection circuit.
8	VIN	Power supply pin. This pin is clamped with an internal 40V clamp.

## Functional Block Diagram

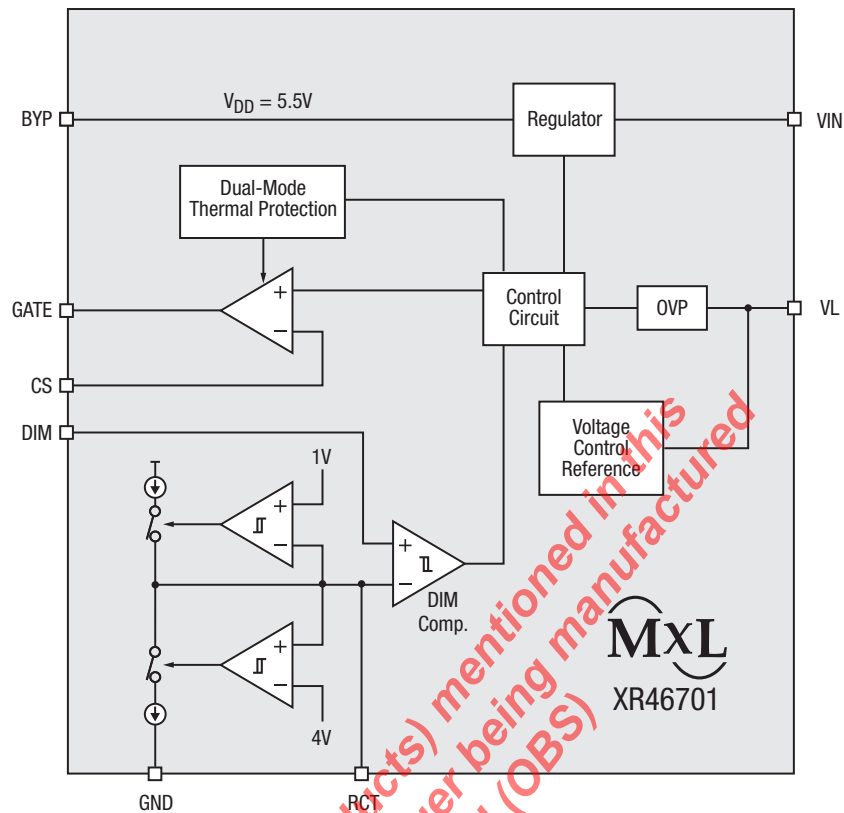


Figure 2: Functional Block Diagram

## Applications Information

### Dual-Mode Thermal Protection

When the junction temperature  $T_J$  reaches  $T_{TP1}$ , the  $V_{CS}$  voltage starts to decrease linearly at the slope of  $-1\%/^{\circ}\text{C}$ . 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 XR46701 chip becomes lower so the  $T_J$  will stop increasing when thermal balance is reached. If  $T_J$  keeps increasing to reach  $T_{TP2}$ , the  $V_{CS}$  voltage drops to 20% directly.

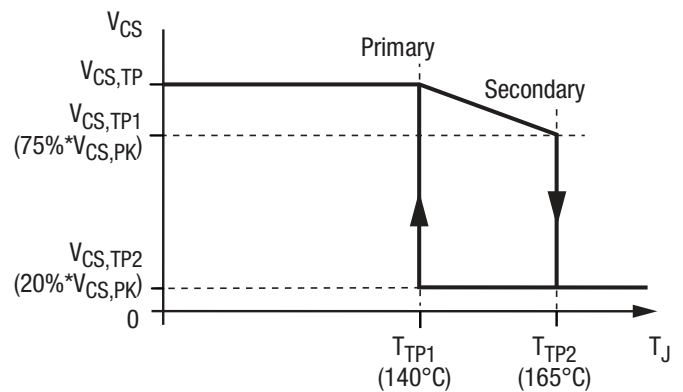


Figure 3: Dual-Mode Thermal Protection

### Applications Information (Continued)

#### Line Regulation Compensation & Over Voltage Protection

When there is variation in  $V_{AC}$  source, the power of the lamp will also change if the LED driving current is kept unchanged. In order to provide good line regulation when  $V_{AC}$  varies in  $\pm 20\%$  range, the average of the rectified  $V_{AC}$  is sensed by the VL pin to provide compensation in order to keep the power of the lamp in the same level.

The LED driving current is adjusted as the voltage level  $V_{VL}$  at the VL pin changes. Based on the design, the LED driving current will be lower when  $V_{AC}$  is higher than the nominal value, while the LED driving current will be higher when  $V_{AC}$  is lower than the nominal value. The system power can then be maintained at almost the same level.

The typical  $V_{CS}$  voltage is defined at  $V_{VL}=2.7V$  (100%). When  $V_{VL}$  reaches 3.4V, the Over Voltage Protection (OVP) function will be enabled so that the  $V_{CS}$  voltage will drop to zero.

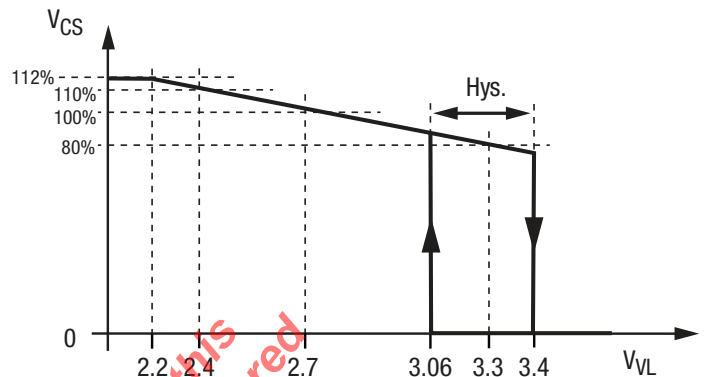


Figure 4: Line Regulation and OVP

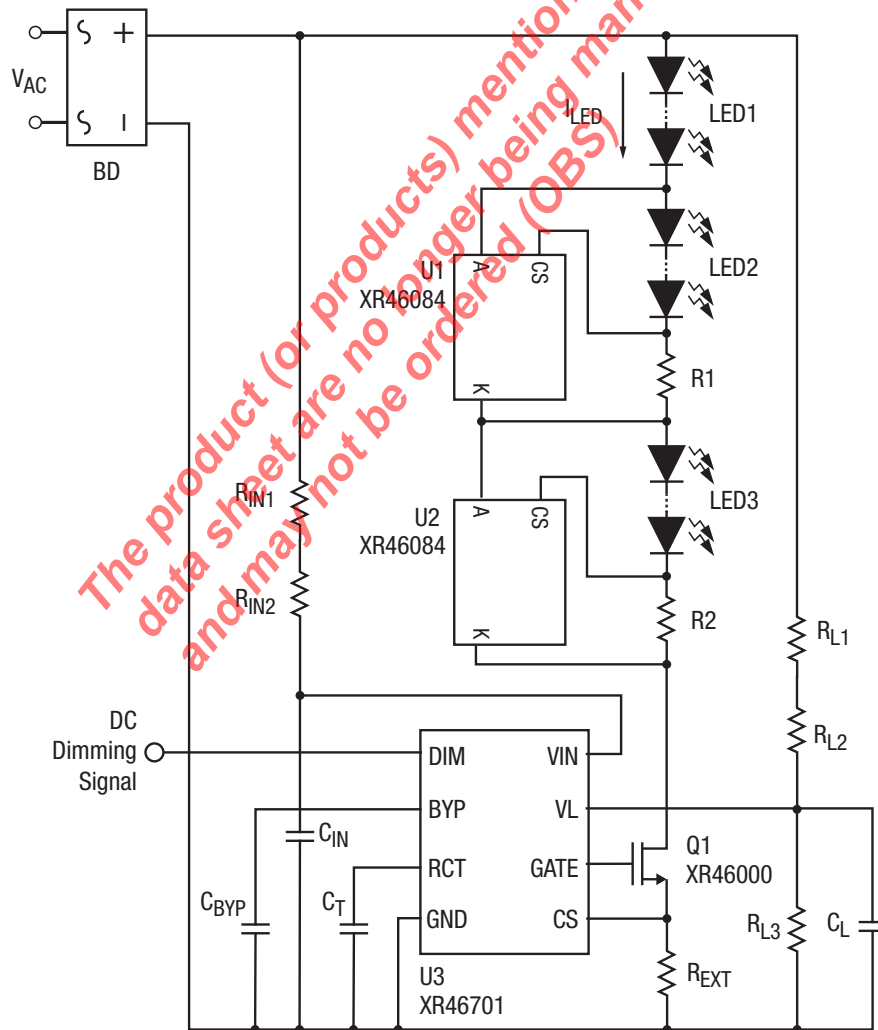


Figure 5: DC to PWM Dimming

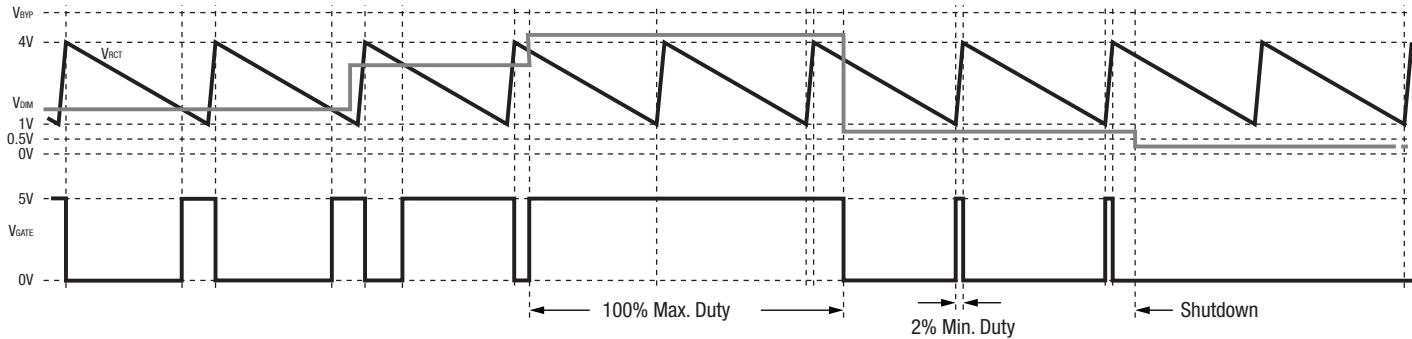


Figure 6: PWM Dimming Timing

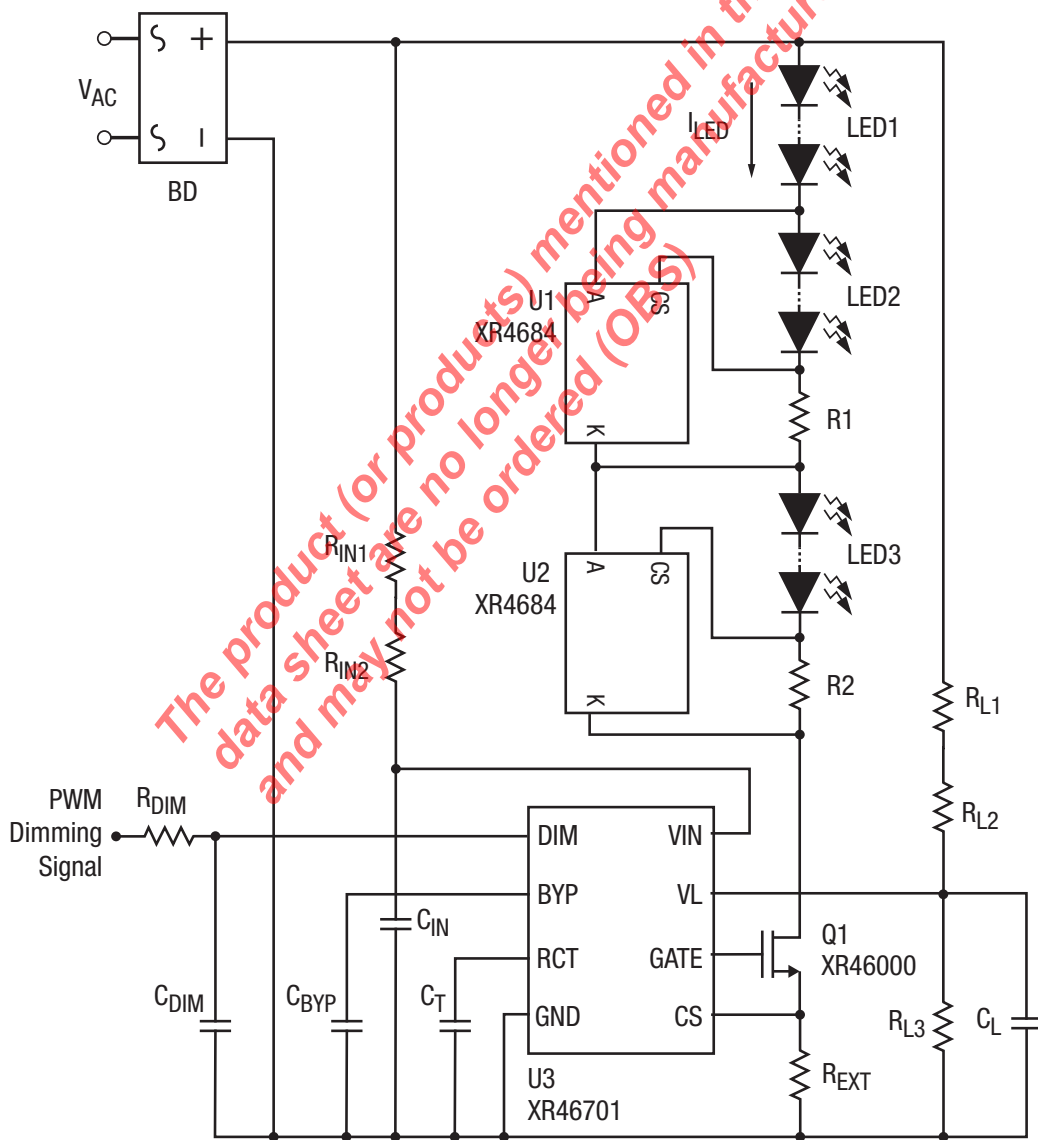
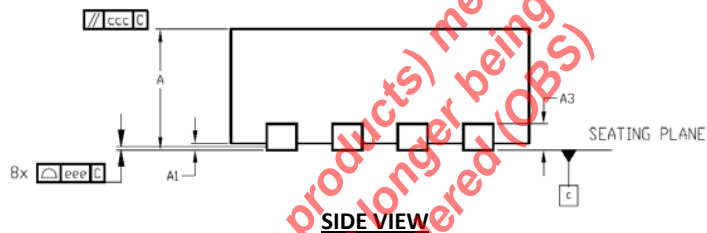
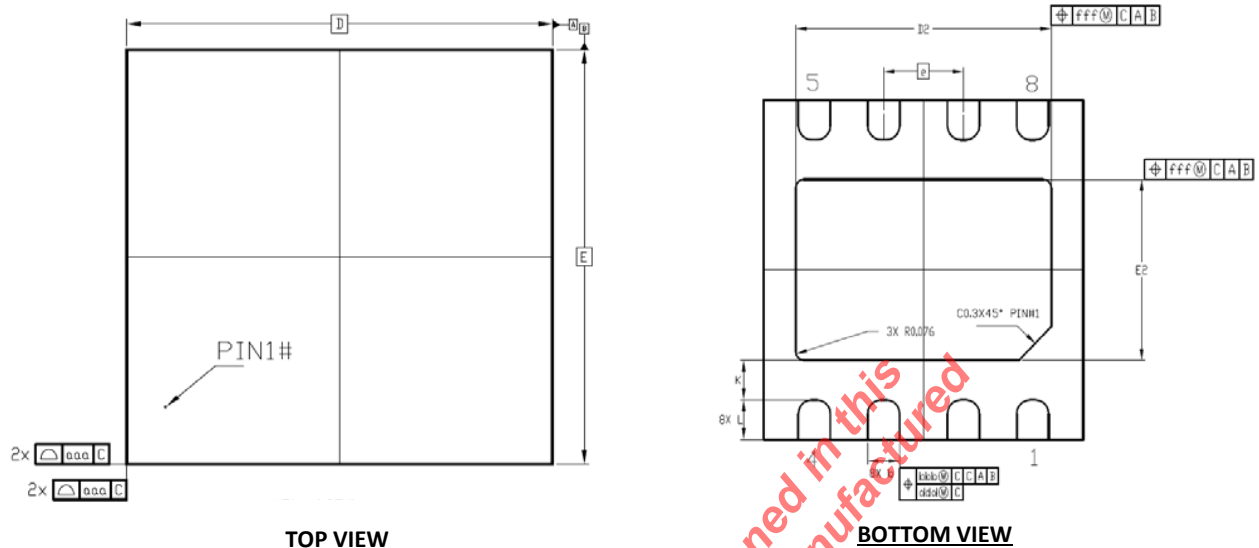


Figure 7: PWM Dimming



Mechanical Dimensions

TDFN-8



DM SYMBOL	Min	Nom	Max
A	0.7	0.75	0.8
A1	0	0.02	0.05
A3	0.2Ref		
b	0.18	0.25	0.3
D	3.00 BSC		
E	3.00 BSC		
D2	2.2	2.4	2.6
E2	1.4	1.6	1.8
e	0.65 BSC		
L	0.25	0.40	0.55
K	0.20		
aaa	0.15		
bbb	0.10		
ccc	0.10		
ddd	0.05		
eee	0.08		
fff	0.10		

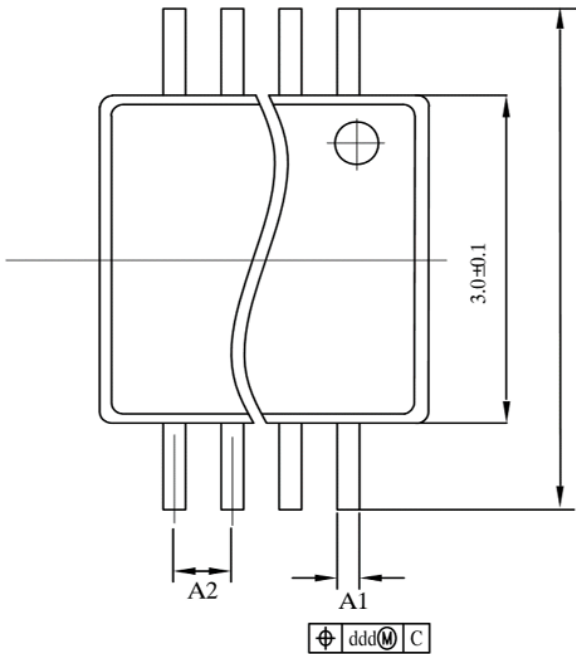
TERMINAL DETAILS

1. All dimensions are in Millimeters
2. Dimensions and tolerance per Jeduc MO-220

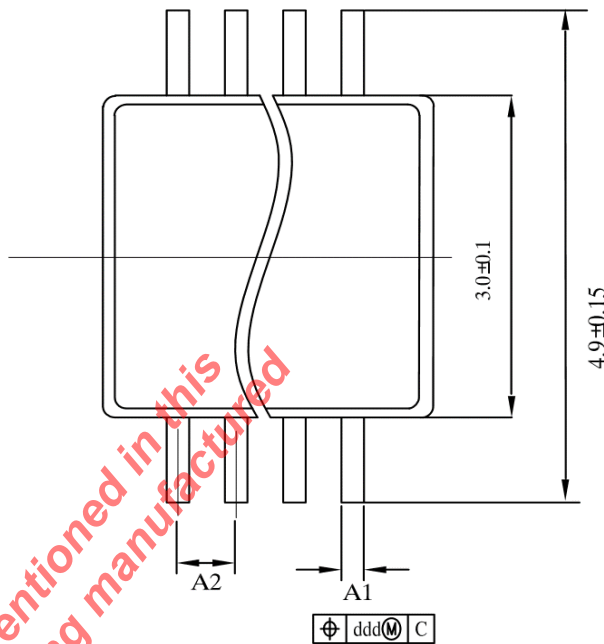
Drawing No. : POD - 0000088

Mechanical Dimensions (Continued)

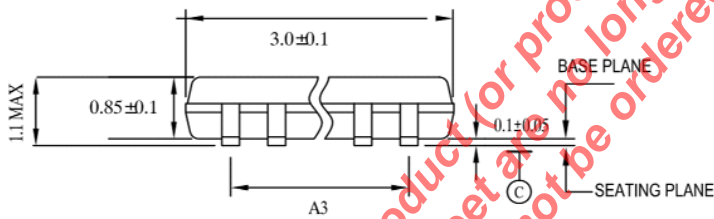
MSOP-8



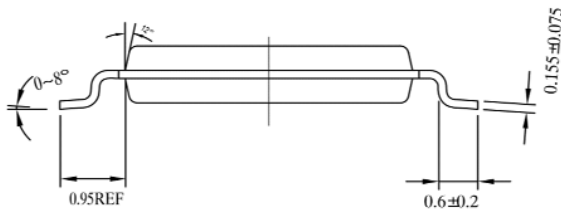
TOP VIEW



BOTTOM VIEW



SIDE VIEW



LEAD	A1		A2	A3	ddd
	MIN	MAX			
8LD	0.22	0.38	0.65 BSC	1.95 BSC	0.13

TERMINAL DETAILS

1. All dimensions are in Millimeters
2. Dimensions and tolerance per Jeduc MO-187F

Drawing No. : POD - 0000127

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

Part Number	Operating Temperature Range	Lead-Free	Package	Packaging Method
XR46701IHBTR	$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$	Yes <sup>(2)</sup>	DFN-8	Tape and reel
XR46701IRBTR	$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$		MSOP-8	Tape and reel

## NOTE:

1. Refer to [www.exar.com/XR46701](http://www.exar.com/XR46701) 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
1A	September 2017	Initial release.

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:**  
 48720 Kato Road  
 Fremont, CA 94538  
 Tel.: +1 (510) 668-7000  
 Fax: +1 (510) 668-7001  
 Email: [LEDtechsupport@exar.com](mailto:LEDtechsupport@exar.com)  
[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.