XR46701

Current Controller with Dimming Function

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

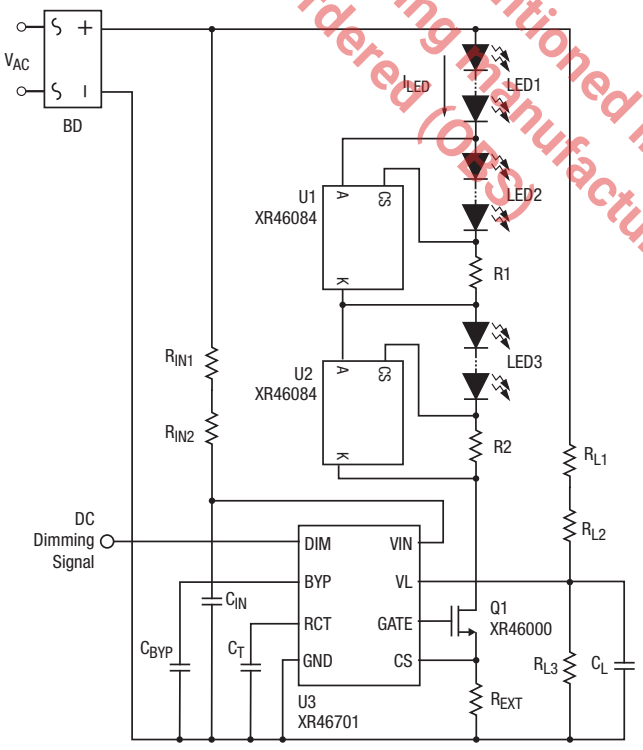


Figure 1: Typical Application

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 to125°C

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

Electrical Characteristics

Specifications are for Operating Junction Temperature of T_J = 25°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°C, and are provided for reference purposes only. Unless otherwise noted, values are at T_A = 25°C.

Symbol	Parameter		Conditions		Min	Typ	Max	Units
I_{IN}	V_{IN} supply current		V_{IN} = 5.5V to 36V, 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 >1mA to clamp V_{IN} at $V_{IN,CLAMP}$.		36	40	42	V
V_{BYP}	BYP voltage		6V ≤ V_{IN} ≤ 40V, I_{BYP} = 0 to 2mA		4.6	5.1	5.6	V
I_{BYP}	BYP pin output current				1			mA
V_{CS}	CS pin voltage		V_{IN} = 15V, V_{VL} = 2.7V		0.264	0.270	0.276	V
				•	0.260		0.285	
ΔV_{LR}	CS voltage line regulation vs. V_{IN}[1]		V_{IN} = 15V, V_{VL} = 2.7V to 3.3V		-18	-20	-22	%
					-0.08	-0.09	-0.10	mV/mV
$V_{L,OVP}$	VL over voltage protection		V_{VL} increasing			3.40		V
$V_{L,OVPR}$	VL over voltage protection recovery to normal[2]		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} = 2.0V			112		%
						302		mV
I_{SOURCE}	GATE source current		V_{GATE} - V_{CS} = 3V			5		mA
I_{SINK}	GATE sink current		V_{GATE} - V_{CS} = 3V			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_{BYP}	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		mV
D_{MIN}	PWM dimming minimum duty		V_{DIM} = 0.5 to 1V, f_{RCT} = 1kHz			2		%
f_{RCT}	Internal PWM dimming frequency		RCT pin, C_{RCT} = 2.2nF			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°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°C, and are provided for reference purposes only. Unless otherwise noted, values are at T_A = 25°C.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
T_{TP1}	Primary thermal protection trip temperature(3),(4)	When T_J is higher than T_{TP1}, V_{CS} decreases linearly at the slope of -1%/°C.		120	135		°C
T_{TP2}	Secondary thermal protection trip temperature(3),(5)	When T_J is higher than T_{TP2}, V_{CS} decreases to $V_{CS,TP2}$ directly. (T_{TP2} - T_{TP1} = 25°C)			150		°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(3)				40		°C

NOTES:

1. The CS voltage line regulation is defined as:

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

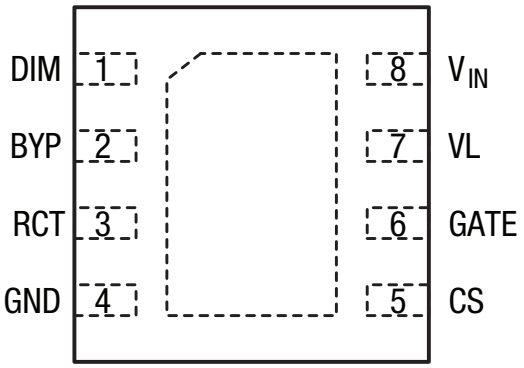
"

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

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, REXT, 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

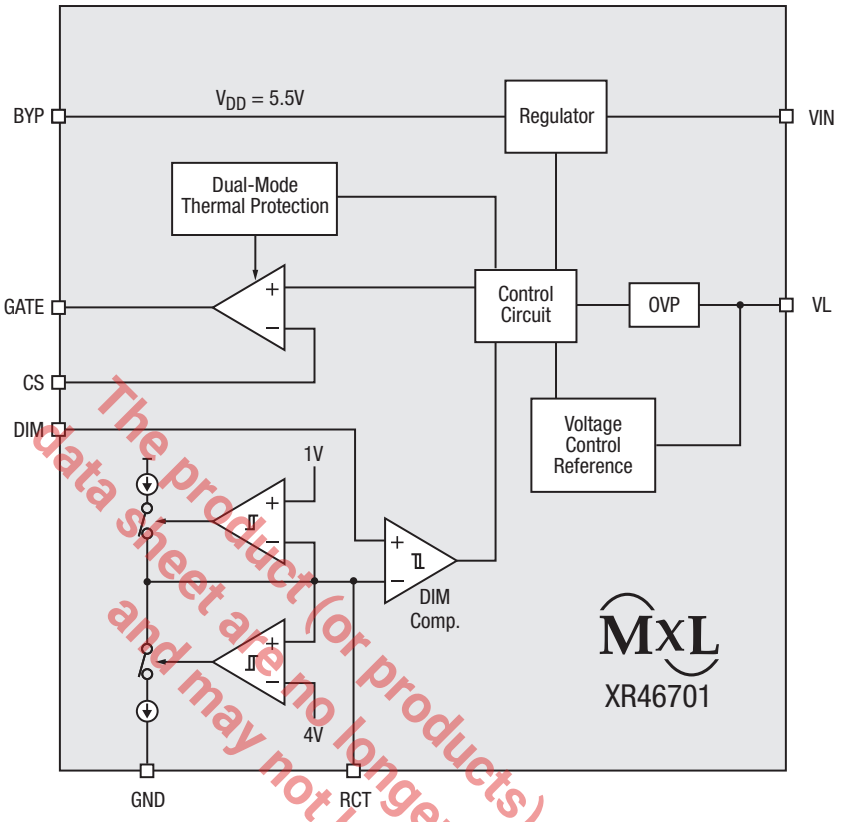


Figure 2: Functional Block Diagram

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%/°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.

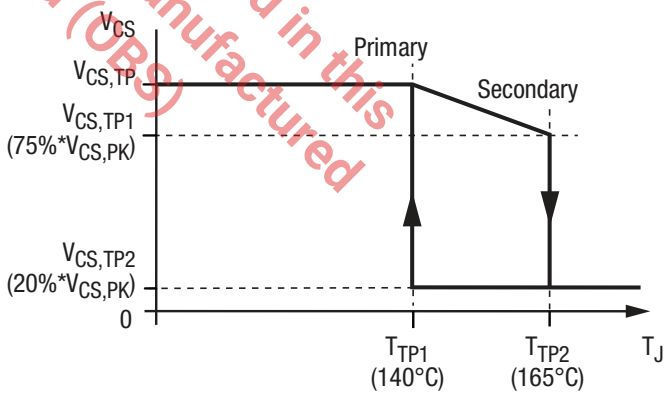


Figure 3: Dual-Mode Thermal Protection

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 ±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.

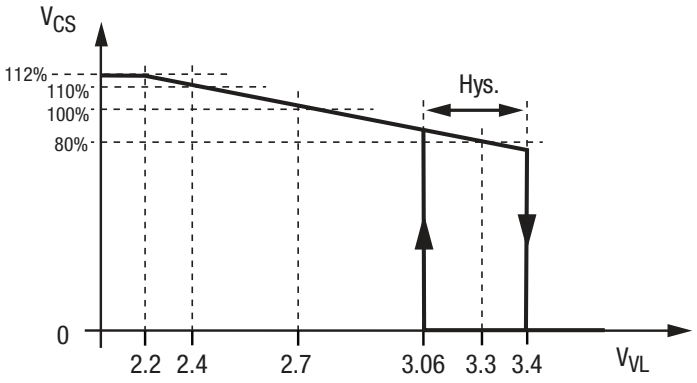


Figure 4: Line Regulation and OVP

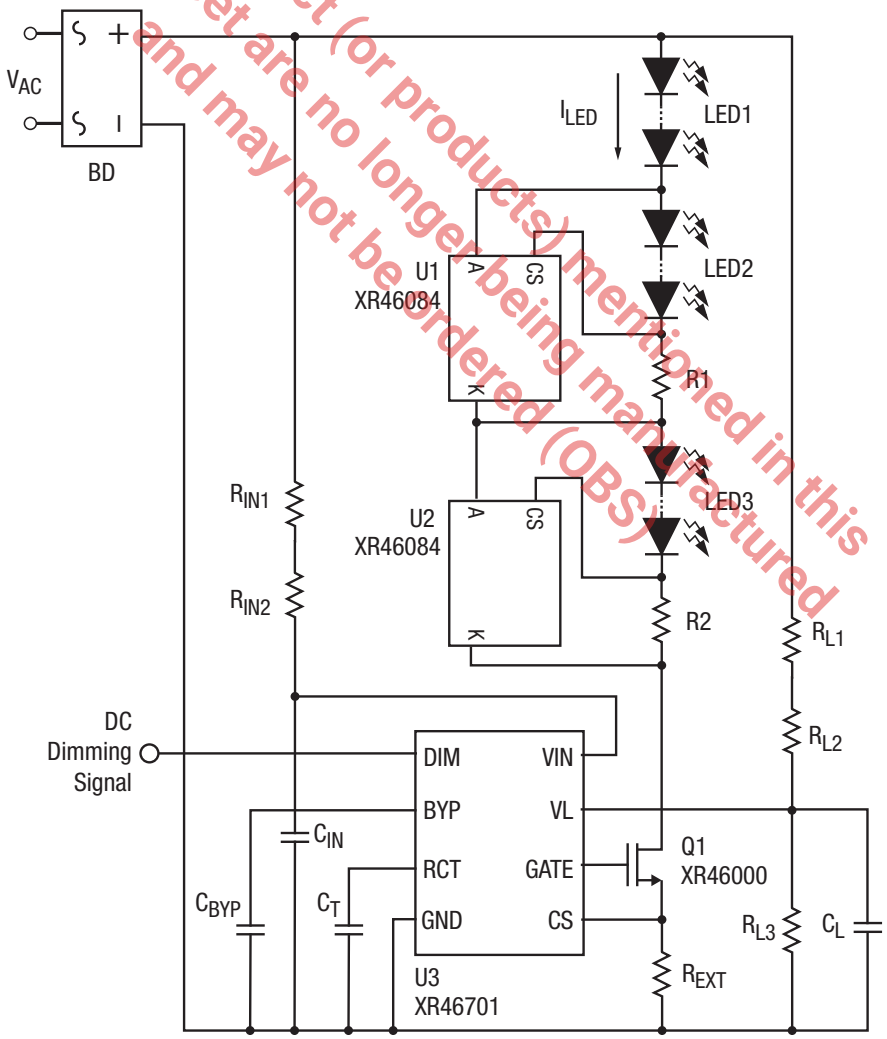


Figure 5: DC to PWM Dimming

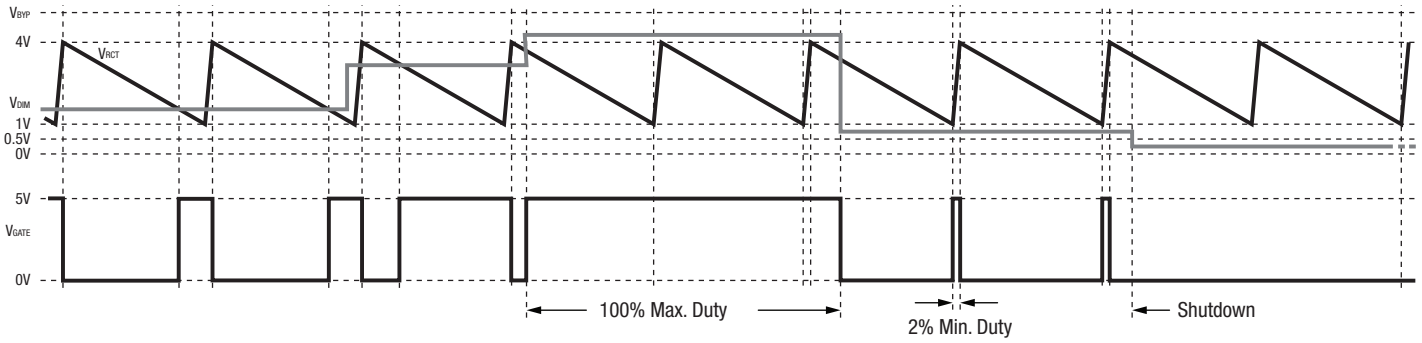


Figure 6: PWM Dimming Timing

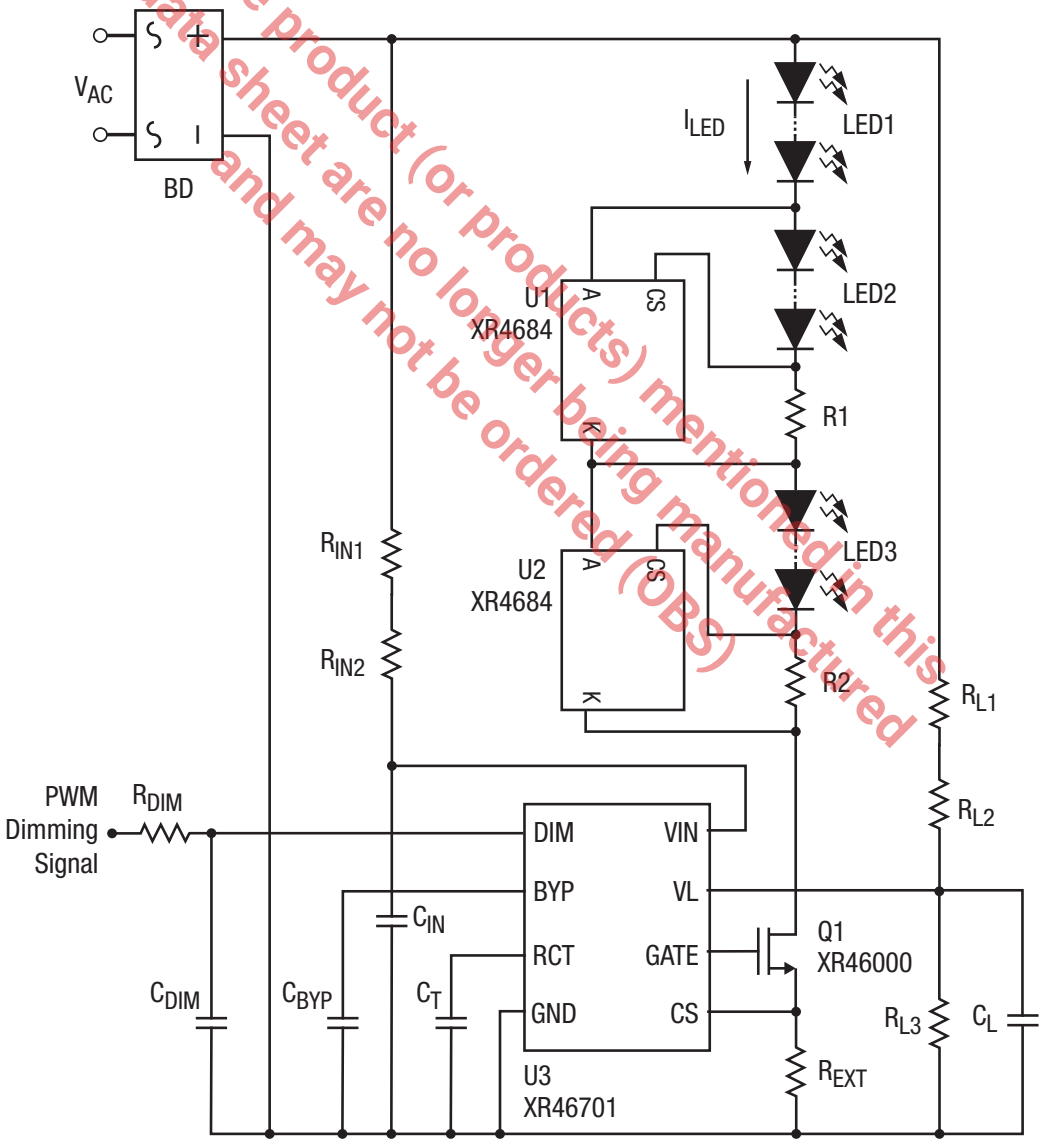
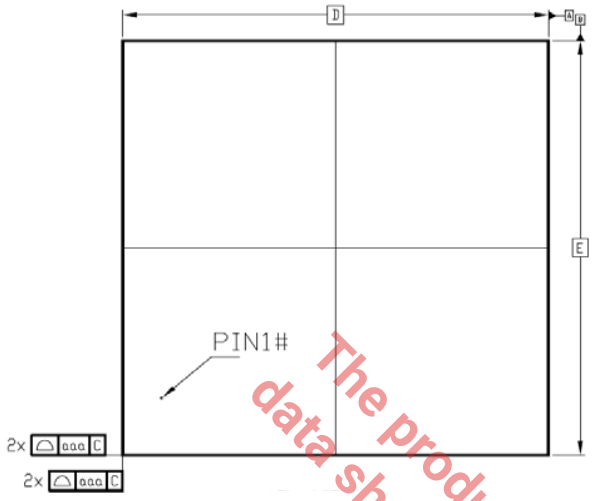


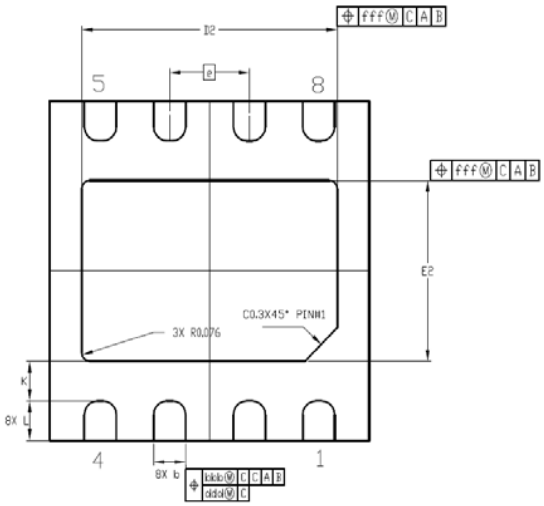
Figure 7: PWM Dimming

Mechanical Dimensions

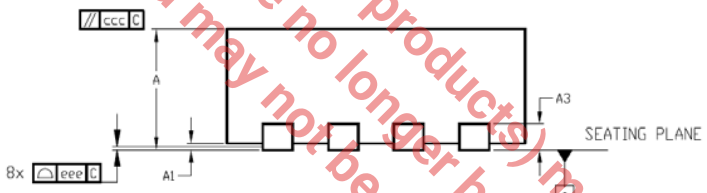
TDFN-8



TOP VIEW



BOTTOM VIEW



SIDE VIEW

SYMBOL \ DIM	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	

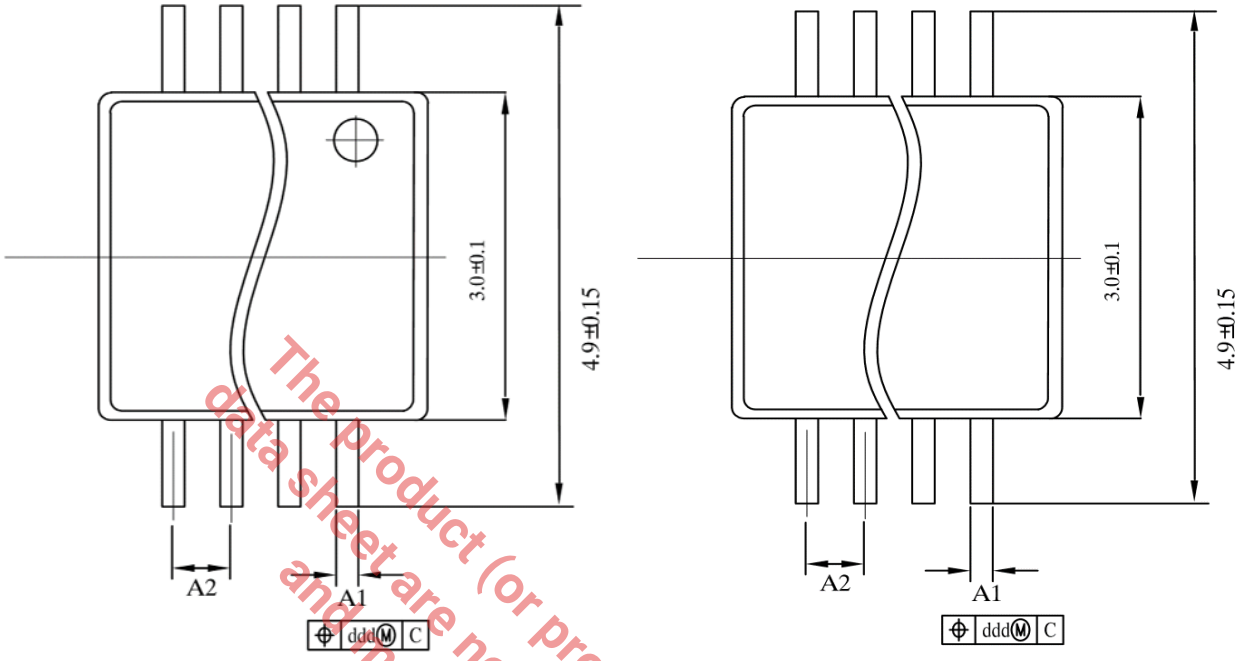
TERMINAL DETAILS

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

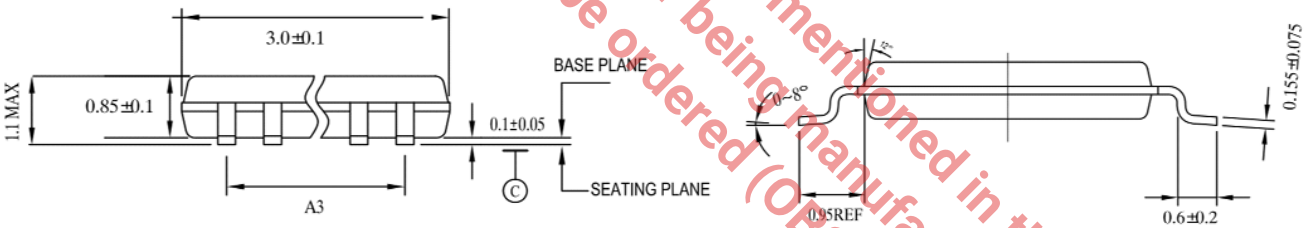
Drawing No. : POD - 00000088

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 Jedec MO-187F

Drawing No. : POD - 00000127

Ordering Information[1]

Part Number	Operating Temperature Range	Lead-Free	Package	Packaging Method
XR46701IHBTR	-40°C ≤ T_J ≤ 125°C	Yes[2]	DFN-8	Tape and reel
XR46701IRBTR	-40°C ≤ T_J ≤ 125°C		MSOP-8	Tape and reel

NOTE:
1. Refer to www.exar.com/XR46701 for most up-to-date Ordering Information.
2. Visit www.exar.com for additional information on Environmental Rating.

Revision History

Revision	Date	Description
1A	September 2017	Initial release.

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