XR46084

Three Terminal Current Controller

Description

The XR46084 is a Three Terminal Current Controller (TTCC) for regulating the current flowing through an LED string.

The application of the XR46084 is configured in parallel with an LED string. The XR46084 can work as voltage controlled current source, current regulator, or cut-off. It is suitable for the applications adopting periodical AC voltage source.

The layout is very flexible allowing for PCB designs in any conceivable shape. Whether high bay, downlights, or unique architectural shapes the XR46084 can provide an excellent LED lighting solution.

FEATURES

- System
  - All solid state components
  - No electrolytic capacitor required
  - Compact size to minimize mechanical cost
  - Driver-on-board and chip-on-board available which minimize process flow and assembly cost
  - High PF and low THD performance
  - High efficiency achieved
  - Flexible PCB layout style
  - Wide range of LED forward voltage selection
  - Distributed heat to several chips
  - TRIAC dimmable
- Chip
  - 88V input sustaining voltage
  - < 3V dropout voltage for up to 150mA regulating current

APPLICATIONS

- LED Lighting Applications
  - Downlight
  - High bay
  - Specialty
  - Architectural

Typical Application

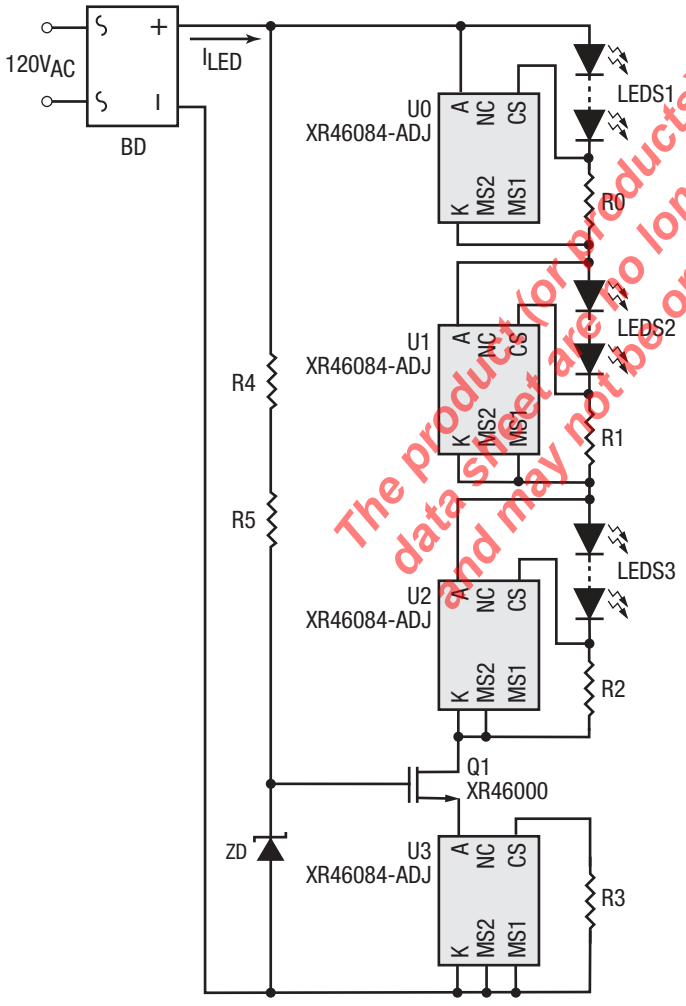


Figure 1. Typical Application

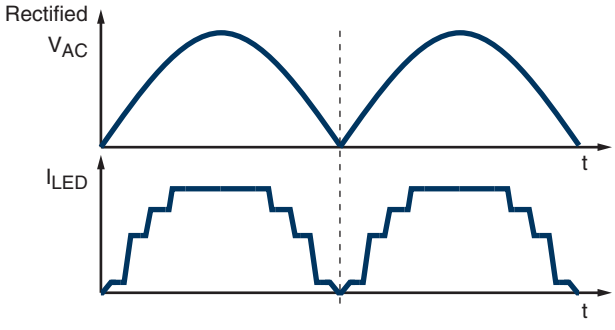


Figure 2. Typical Performance

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 A to K ..... -0.3V to 88V

Sustaining voltage CS, MS1, MS2 to K..... -0.3V to 1V

Regulating current 150mA

Maximum operating junction temperature, T_J..... 165°C

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

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

NOTE:

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

Regulating current (with adequate heat sinking)[1], I_{AK}..... 130mA

Input voltage[1], V_{AK} .....3V to 80V

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

Operating free-air temperature range, T_A.... -40°C to 100°C

NOTE:

1. Due to thermal dissipation consideration, the maximum LED Vf in parallel should decrease with the regulating current.

Electrical Characteristics

Unless otherwise noted, typical values are at T_A = 25°C.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
I_{PEAK0}	Peak regulating current[1][2]	V_{AK} = 5V, Mode 0 (MS1/MS2 connected to K)	Option C1	38.4	40	41.6	mA
			Option C2	63.4	66	68.6	
			Option C3	49.9	52	54.1	
			Option D1	76.8	80	83.2	
			Option D2	124.8	130	135.2	
			Option D3	99.8	104	108.2	
I_{PEAK0}/I_{PEAK0}	Current ratio of mode selection[1]	All Options (C1/C2/C3/D1/D2/D3) V_{AK} = 5V	Mode 0 (MS1/MS2 connected to K)		100		%
I_{PEAK1}/I_{PEAK0}			Mode 1 (MS1 open, MS2 connected to K)	75	80	85	
I_{PEAK2}/I_{PEAK0}			Mode 2 (MS2 open, MS1 connected to K)	50	55	60	
I_{PEAK3}/I_{PEAK0}			Mode 3 (MS1/ MS2 open)	32	35	38	
$\Delta I_{LR}/I_{PEAKx}$ (x = 0 to 3)	Regulating current line regulation[3]	Option C1/C2/C3/D1/D2/D3, Mode 1 to 3, V_{AK} = 5V and 40V			±1	±2	%
		Option C1/C2/C3/D1/D2/D3, Mode 0, V_{AK} = 5V and 40V		-4	-8	-15	
V_{CS}	CS pin voltage	Option ADJ, Mode 0, V_{AK} = 5V, with 1KΩ external resistor between CS and K		0.26	0.27	0.28	V
$\Delta V_{LR}/V_{CS}$	CS pin voltage line regulation[4]	Option ADJ, Mode 1 to 3, V_{AK} = 5V and 40V with 1KΩ external resistor between CS and K			±1	±2	%
		Option ADJ, Mode 0, V_{AK} = 5V and 40V with 1KΩ external resistor between CS and K		-4	-8	-15	
V_{DROP}	Dropout voltage[5]	Mode 0 (MS1/ MS2 connected to K)			2.8	3.8	V
T_{TP}	Thermal protection trip temperature	When T_J is higher than T_{TP}, the peak regulating current decreases to I_{TP} linearly.		120	130		°C
I_{TP}/I_{PEAKx} (x = 0 to 3)	Thermal protection mode regulating current	T_J = 175°C			50		%

NOTES:

1. For ADJ option, the regulating current is determined by an external resistor, R_{EXT}, connected between the CS pin and the K pin. The mode selection function will not change the current ratio of option ADJ. To activate the line regulation function, the chip (U3) connected in series with the LED string should be set in Mode 0 (MS1 and MS2 connected to pin K). The regulating current will be: $I_{PEAK} = 0.27/R_{EXT}$

   And the maximum regulating current of second step (ex: U2 in Mode 1) should not exceed 80% of the top level (ex: U3 in Mode 0), otherwise the circuit operation might become abnormal when OTP function is activated. It is strongly recommended to set at 75%.

Electrical Characteristics (Continued)

NOTES: (Continued)

2. The user can add an external resistor R_{EXT} between the CS pin and the K pin of U3 (Mode 0, serial connected to the LED string) to increase the regulating current of option C1, C2, C3, D1, D2 and D3, as shown in below. For U1 ~ U2 (Mode 1 ~ Mode 3, parallel connected to the LED string), adding an external resistor R_{EXT} between the CS pin and the K pin may cause abnormal operation and chip damage.

   For option C1/ C2/ C3, the regulating current variation $\Delta I_{PEAK}/I_{PEAK} = 6.25/R_{EXT}$.

   For option D1/ D2/ D3, the regulating current variation $\Delta I_{PEAK}/I_{PEAK} = 3.13/R_{EXT}$.

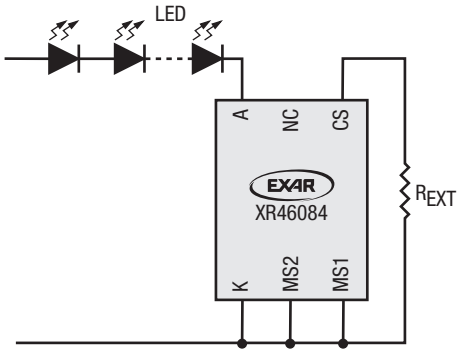


Figure 3. External Resistor to Increase Regulating Current

Table 1. U3 (Mode 0) Regulating Current

	Without External Resistor	With 100Ω External Resistor
Option C1	40	42.5
Option C2	66	70.1
Option C3	52	55.3
Option D1	80	82.5
Option D2	132	136.1
Option D3	104	107.3

3. The Regulating Current Line Regulation is defined as:

   For Mode 1~3: $$\Delta I_{LR}/I_{PEAKx} = \frac{I_{AK\ (V_{AK}\ =\ 40V)} - I_{AK\ (V_{AK}\ =\ 5V)}}{I_{AK\ (V_{AK}\ =\ 5V)}},\ x = 1\sim3$$

   For Mode 0: $$\Delta I_{LR}/I_{PEAK0} = \frac{I_{AK\ (V_{AK}\ =\ 40V)} - I_{AK\ (V_{AK}\ =\ 5V)}}{I_{AK\ (V_{AK}\ =\ 5V)}}$$

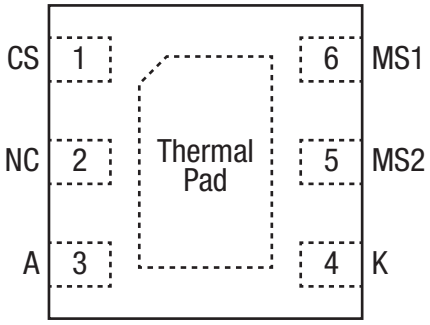
4. The CS Pin Voltage Line Regulation is defined as:

   For Mode 1~3: $$\Delta V_{LR}/V_{CS} = \frac{V_{CS\ (V_{AK}\ =\ 40V)} - V_{CS\ (V_{AK}\ =\ 5V)}}{V_{CS\ (V_{AK}\ =\ 5V)}}$$

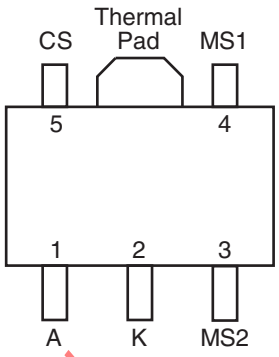
   For Mode 0: $$\Delta V_{LR}/V_{CS} = \frac{V_{CS\ (V_{AK}\ =\ 40V)} - V_{CS\ (V_{AK}\ =\ 5V)}}{V_{CS\ (V_{AK}\ =\ 5V)}}$$

5. Dropout voltage = V_{AK} @ 90% × (I_{PEAK0} @ V_{AK} = 5V)

Pin Configuration



2mm x 2mm TDFN-6



SOT-89-5

Pin Functions

Pin Number		Pin Name	Description
TDFN-6	SOT-89-5		
1	5	CS	Current sense pin. Connected to negative end of LED string.
3	1	A	Regulating current input pin. Connected to positive end of LED string.
4	2	K	Regulating current output pin. This is effectively a ground pin.
5	3	MS2	Mode selection pin 2. Floating or connecting to pin K only.
6	4	MS1	Mode selection pin 1. Floating or connecting to pin K only.
2	-	NC	No Connection
Exposed Thermal Pad			Exposed thermal pad of the chip. Use this pin to enhance the power dissipation ability. The thermal conductivity will be improved if a copper foil on PCB is soldered with the thermal pad. It is recommended to connect the thermal pad to pin K.

Functional Block Diagram

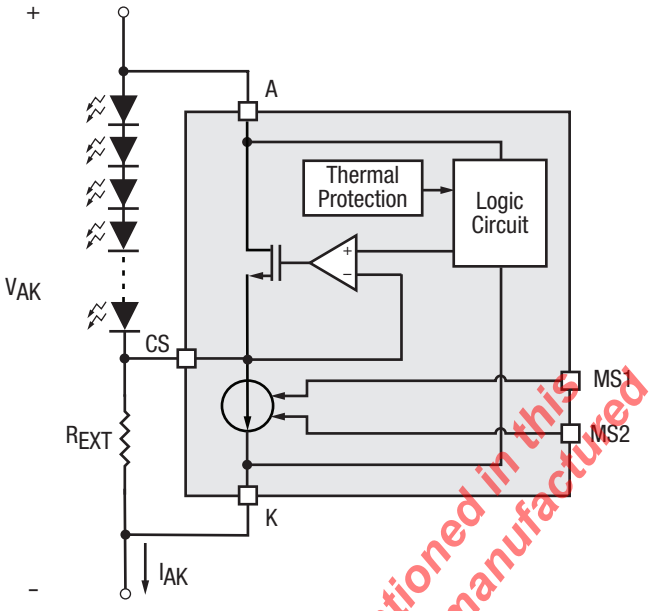


Figure 5. Functional Block Diagram

I-V Curve

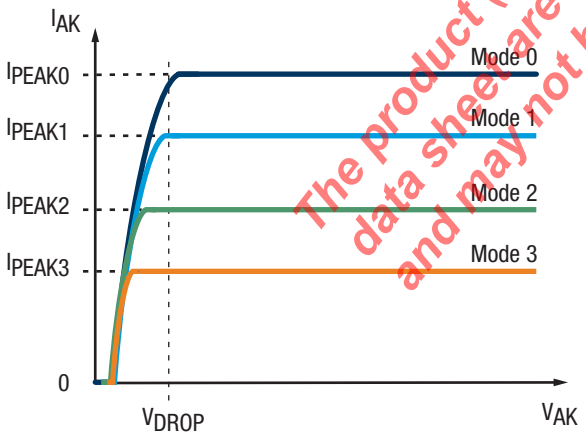


Figure 6. Cx/Dx Options

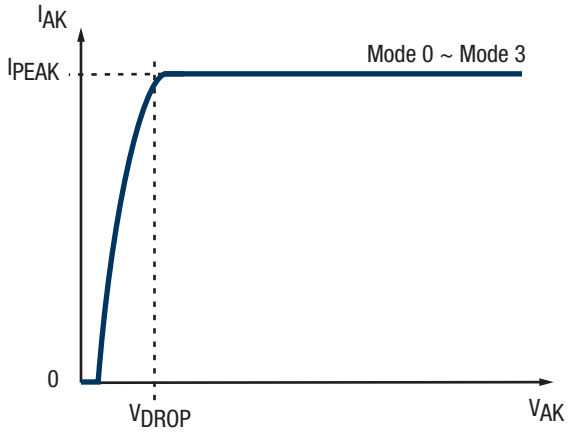


Figure 7. ADJ Option

Applications Information

220V_{AC}/10W LED Light Engine

- 3 steps, PF = 0.98, THD = 16%
- To pass 1KV surge test, Q1 can be changed to 800V NMOS

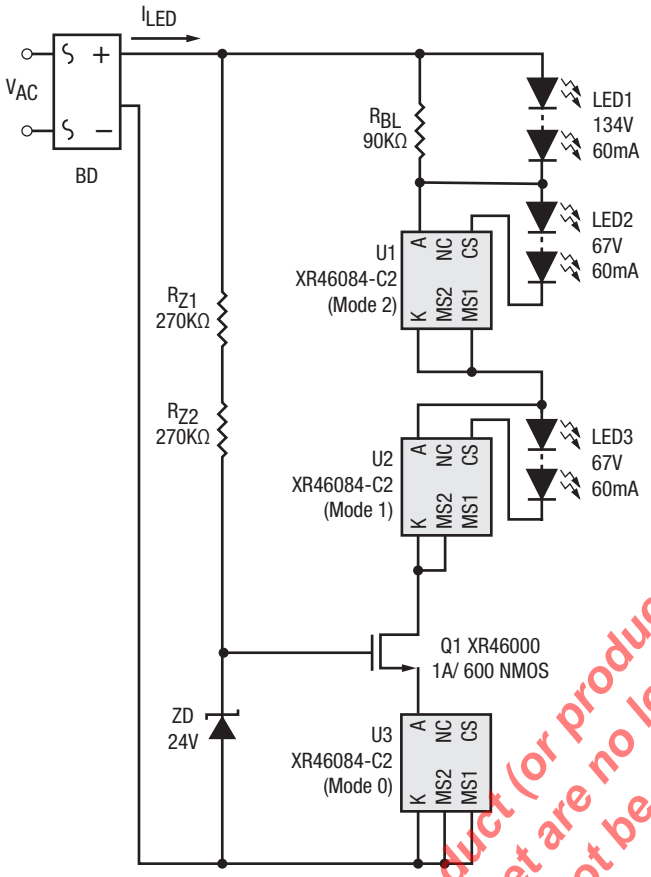


Figure 8. C2 Option

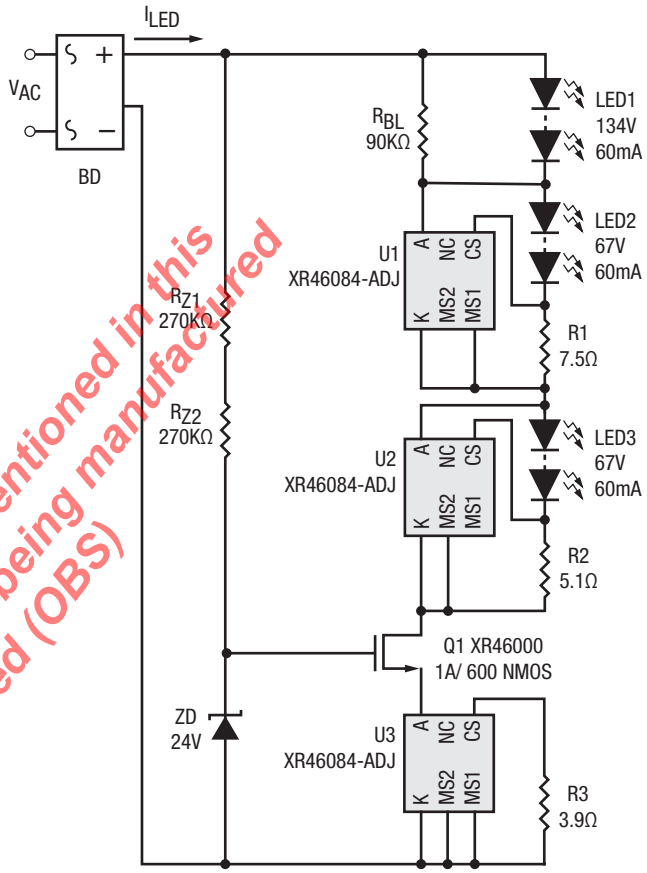


Figure 9. ADJ Option

Applications Information (Continued)

10W LED Light Engine

- 3 steps, PF = 0.98, THD = 16%
- To pass 1KV surge test, Q1 can be changed to 800V NMOS

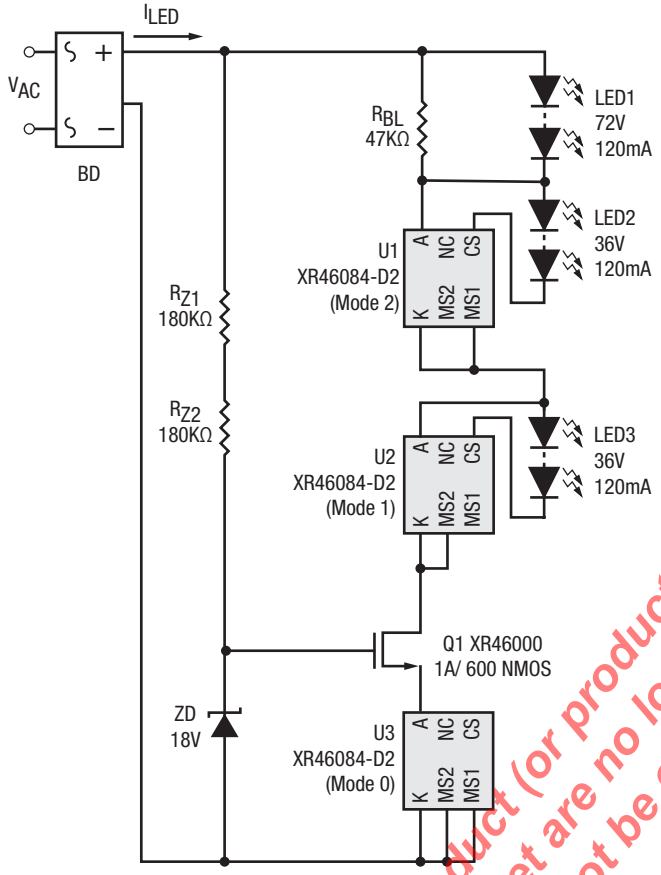


Figure 10. D2 Option

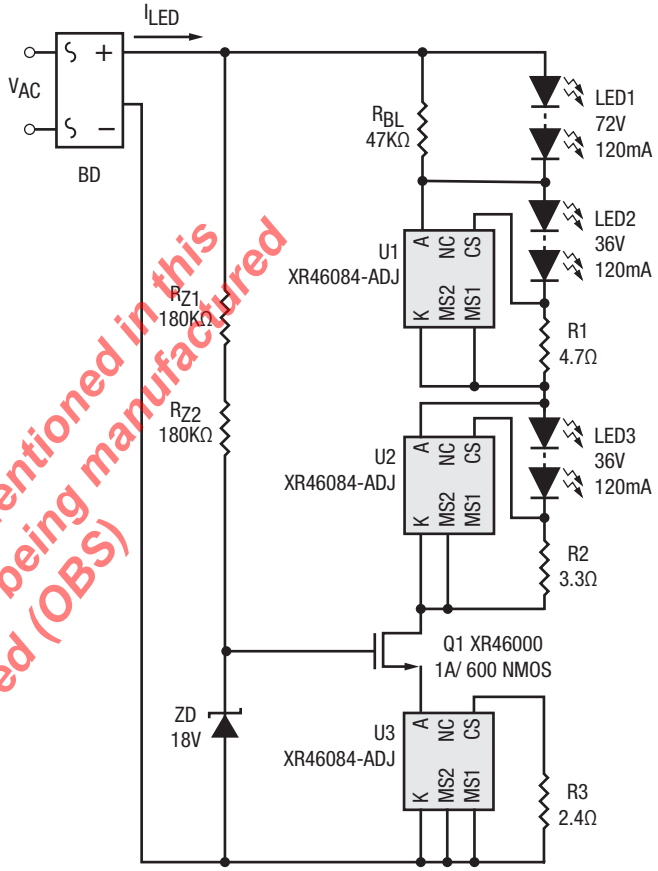


Figure 11. ADJ Option

Applications Information (Continued)

Active Load

In order to be compatible with more types of TRIAC dimmers (phase-cut dimmers), an additional active load is needed for better dimming performance, as shown in below:

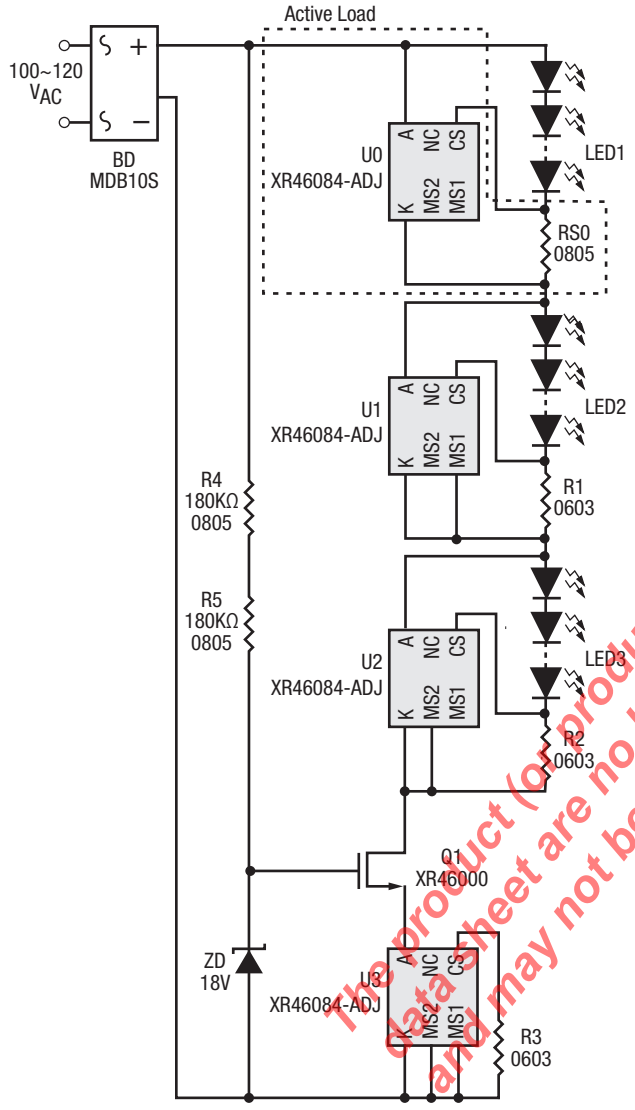


Figure 12. 120 V_{AC} TRIAC Dimmable 3-Step Solution

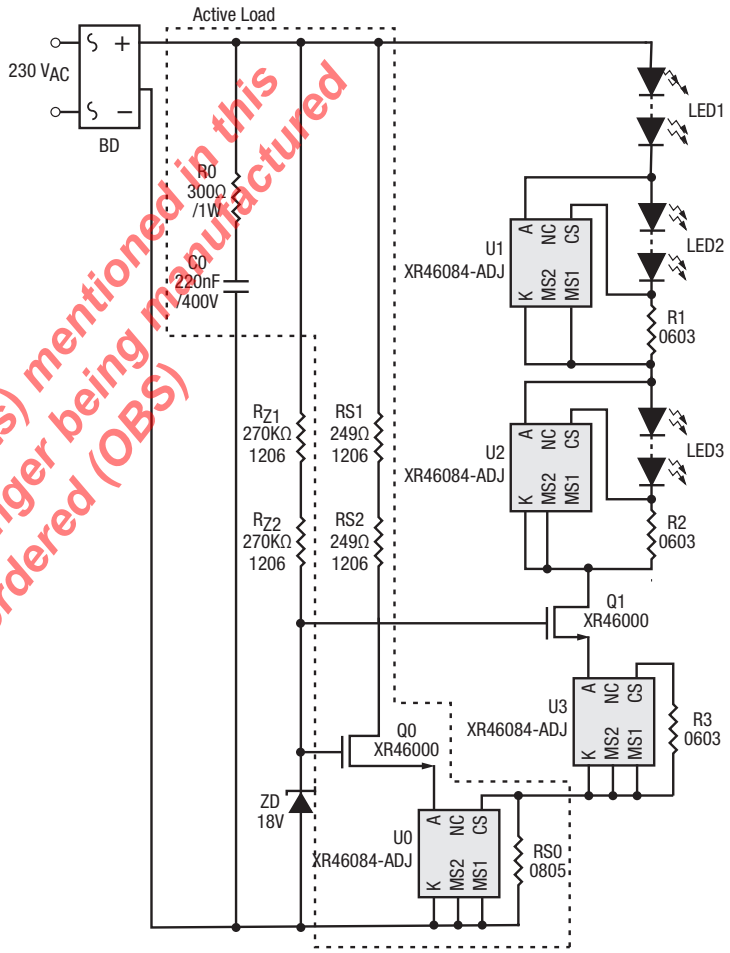


Figure 13. 230 V_{AC} TRIAC Dimmable 3-Step Solution

Applications Information (Continued)

Linear Type Thermal Protection

When the junction temperature T_J rises to the Thermal Protection Trip Temperature T_{TP} (typically 130°C), the current sense voltage V_{CS} starts to decrease linearly at a slope of -1.1%/°C. The LED driving current decreases proportionally with the V_{CS} voltage. The system will function normally during the thermal protection mode with the lower driving current, but the power dissipation of the system will decrease until thermal equilibrium is reached.

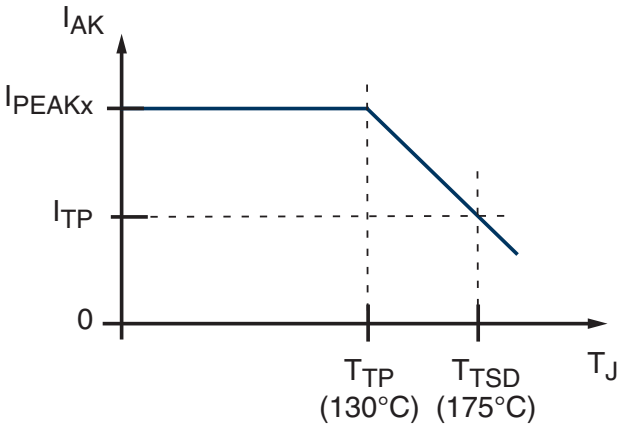
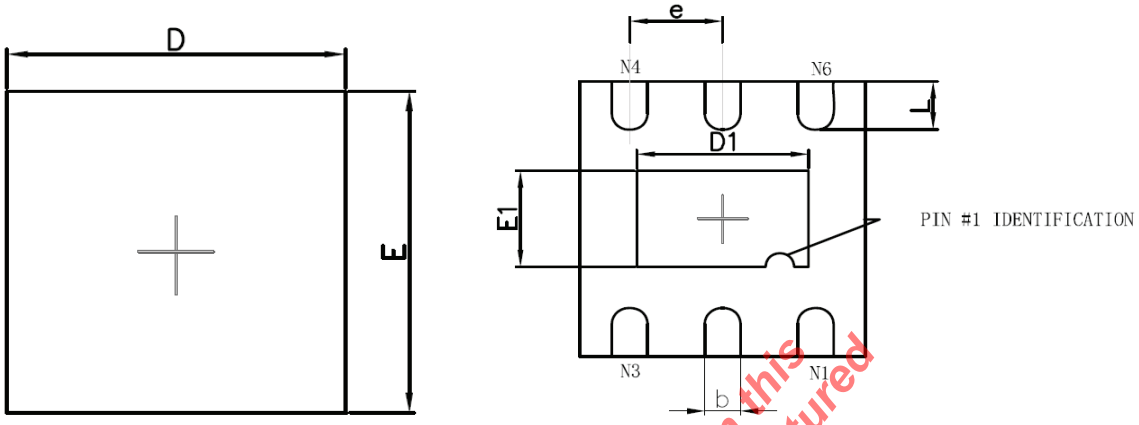


Figure 14. Peak Regulating Current vs. T_J

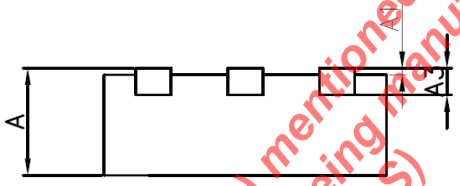
Package Description

TDFN6 2x2



TOP VIEW

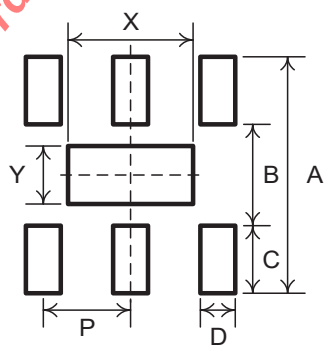
BOTTOM VIEW



SIDE VIEW

Symbol	Dimensions In Millimeters		
	Min.	Nom	Max.
A	0.700	0.750	0.800
A1	0.000	NA	0.050
A3		0.203REF.	
D	1.924	2.000	2.076
E	1.924	2.000	2.076
D1	1.100	1.200	1.300
E1	0.600	0.700	0.800
k		0.200MIN.	
b	0.200	0.250	0.300
e		0.650TYP.	
L	0.274	0.350	0.426

TERMINAL DETAILS



SYMBOLS	Footprint Dimension
A	2.80
B	1.20
C	0.80
D	0.35
P	0.65
X	1.40
Y	0.70

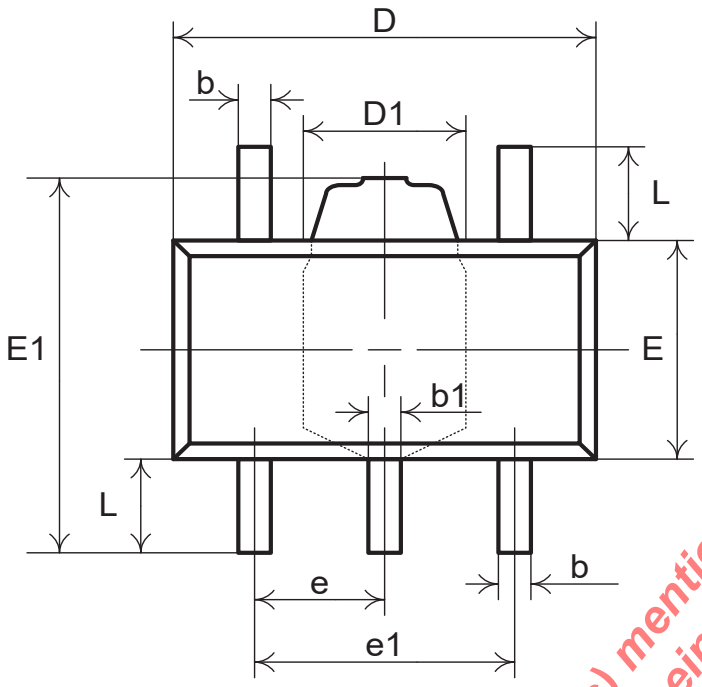
TYPICAL RECOMMENDED LAND PATTERN

Drawing No. : POD - 00000072
Revision: A

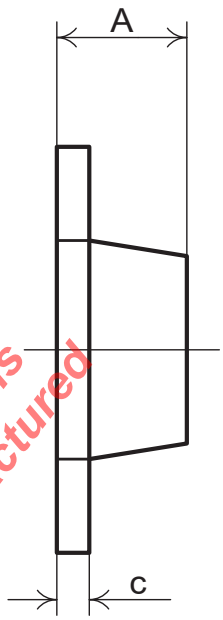
1. All dimensioins are in Millimeters
2. Dimensions and tolerance per Jedec MO-220

Package Description (Continued)

SOT-89-5



TOP VIEW

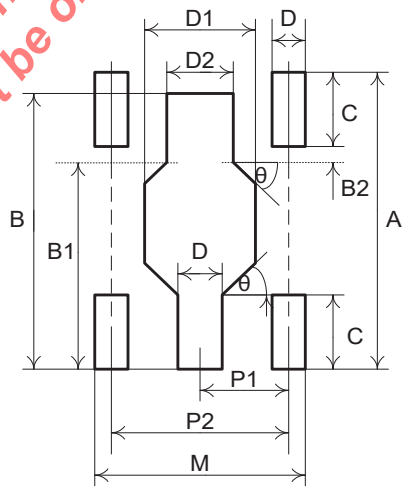


SIDE VIEW

SYMBOLS	MIN.	MAX.
A	1.40	1.60
b	0.32	0.52
b1	0.36	0.56
c	0.35	0.44
D	4.40	4.60
D1	1.40	1.80
E	2.30	2.60
E1	3.94	4.25
e	1.50 TYP	
e1	2.90	3.10
L	0.90	1.10

UNIT: MILLIMETERS

TERMINAL DETAILS



SYMBOLS	Footprint Dimension
A	5.20
B	4.80
B1	3.60
B2	0.25
C	1.35
D	0.70
D1	1.90
D2	1.30
M	3.70
P1	1.50
P2	3.00
θ	45°

UNIT: MILLIMETERS

TYPICAL RECOMMENDED LAND PATTERN

- All dimensioins are in Millimeters

Drawing No. : POD - 00000097
Revision: A

Ordering Information[1]

Part Number	Regulating Current (mA)	Operating Temperature Range	Lead-Free	Package	Packag Method
XR46084EHTR-C1[3]	40	-40°C ≤ T_J ≤ 150°C	Yes[2]	TDFN6 2x2	Reel
XR46084EHTR-C2[3]	66				
XR46084EHTR-C3[3]	52				
XR46084EHTR-D1[3]	80				
XR46084EHTR-D2[3]	130				
XR46084EHTR-D3[3]	104				
XR46084EHTR-ADJ	Determined by external resistor only				
XR46084ESFTR-C1[3]	40	-40°C ≤ T_J ≤ 150°C	Yes[2]	SOT-89-5	Reel
XR46084ESFTR-C2[3]	66				
XR46084ESFTR-C3[3]	52				
XR46084ESFTR-D1[3]	80				
XR46084ESFTR-D2[3]	130				
XR46084ESFTR-D3[3]	104				
XR46084ESFTR-ADJ	Determined by external resistor only				
XR46084ECF-C1[3]	40	-40°C ≤ T_J ≤ 150°C	Yes[2]	Dice	Wafer
XR46084ECF-C2[3]	66				
XR46084ECF-C3[3]	52				
XR46084ECF-D1[3]	80				
XR46084ECF-D2[3]	130				
XR46084ECF-D3[3]	104				
XR46084ECF-ADJ[3]	Determined by external resistor only				

NOTE:
1. Refer to www.exar.com/XR46084 for most up-to-date Ordering Information.
2. Visit www.exar.com for more information.
3. Contact factory for availability.

Revision History

Revision	Date	Description
1A	Aug 2016	Initial release
1B	Oct 2016	Updated Typical Application, Package Descriptions and Ordering Information table.
1C	Aug 2017	Added Linear Type Thermal Protection section in Application Information. Updated to MaxLinear logo. Updated format.

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