



## *Reference Design*

# ***AL9910EV8 Non-Dimmable 120V<sub>AC</sub> Evaluation Board***

**Case #1:**  
***(Input=120V<sub>AC</sub>; Output=48V/90mA)***

**Case #2:**  
***(Input=120V<sub>AC</sub>; Output=96V/45mA)***

***Applications: B10 Light Bulbs***

***-Customer: Cree-***

Date: October 27, 2011

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## 1. PURPOSE

### Introduction

We are using our AL9910 Non-Dimmable board to evaluate two test condition requirements using high-power LEDs from Cree for functional performance.

- 1) Test condition requirement #1: VIN=120VAC; OUT=48V/90mA.
- 2) Test condition requirement #2: VIN=120VAC; OUT=96V/45mA.

Customer: **Cree**

### Features

- Non-Dimmable
- Selectable 5W-8W output power
- Active PFC with power factor >0.9
- No electrolytic capacitor
- High temperature operation
- Long operating life
- Typical Applications: Retrofit B10/E27 LED Light Bulbs

### Specifications

Parameter	Units	Value
AC Input Voltage	V, AC	90 - 140
DC Output Voltage	V, DC	40 – 98
Output Current	mA	45 - 90
Output Power	W	3 – 6
Power Factor	NA	>0.9
Efficiency	%	87%-90%
Operating Ambient temperature	C	-40 to +85
Operating Junction Temperature	C	-40 to +125
ROHS Compliance	NA	Yes

### Test conditions:

Input Voltage: 120VAC, 60Hz  
 Output Voltage: 40VDC - 98VDC  
 Operating Ambient Temperature: -40°C to 85°C

### Connection Instructions:

AC+ Input: Red – Hot  
 AC- Input: Black - Neutral  
 DC LED+ Output: LED+ (Red)  
 DC LED- Output: LED- (Black)

### Board Dimension (components included):

WxLxH (in mm) = 18mm x 25mm x 13mm

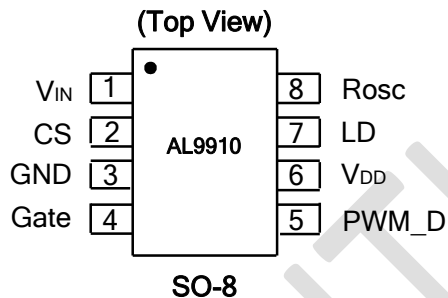
## 2. EVALUATION BOARD INFORMATION

### 2.1 AL9910 Pin Assignment and Description

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#### AL9910 Pin Assignment

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#### AL9910 Pin Description

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Pin Name	Pin Number	Description
V <sub>IN</sub>	1	Input voltage
CS	2	Senses LED string current
GND	3	Device ground
Gate	4	Drives the gate of the external MOSFET
PWM_D	5	Low Frequency PWM Dimming pin, also Enable input. Internal 100kΩ pull-down to GND
V <sub>DD</sub>	6	Internally regulated supply voltage. 7.5V nominal for AL9910. Can supply up to 1 mA for external circuitry. A sufficient storage capacitor is used to provide storage when the rectified AC input is near the zero crossings
LD	7	Linear Dimming by changing the current limit threshold at current sense comparator
R <sub>OSC</sub>	8	Oscillator control. A resistor connected between this pin and ground sets the PWM frequency.

## 2.2 Evaluation Board Schematic

2.1.1 Case #1 => Test conditions:  $V_{IN}=120V_{AC}$ ;  $OUT=48V/90mA$

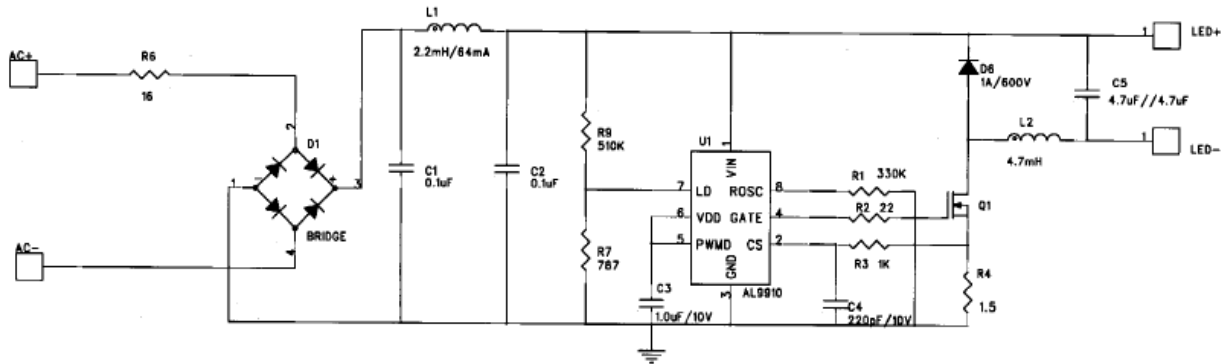


Figure 1: Evaluation Board Schematic (Case#1)

2.1.2 Case #2 => Test conditions:  $V_{IN}=120V_{AC}$ ;  $OUT=96V/45mA$

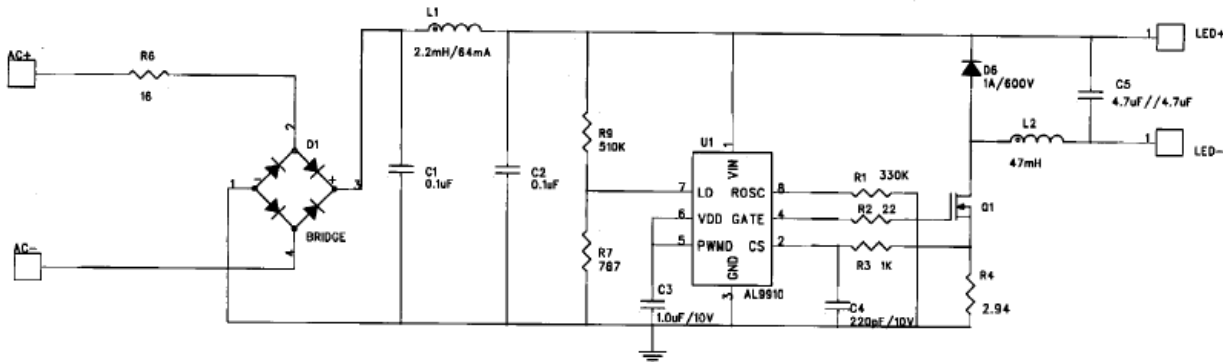


Figure 2: Evaluation Board Schematic (Case#2)

### 2.3 Evaluation Board BOM List

Case #1 => Test conditions: V <sub>IN</sub> =120V <sub>AC</sub> ; OUT=48V/90mA					
#	Name	Quantity	Part number	Manufacturer	Description
1	U1	1	AL9910S-13	Diodes	Universal High Voltage LED Driver
2	D1,2,3,4	1	HD02-T	Diodes	RECT BRIDGE GP 200V 0.8A MINIDIP
3	D6	1	MUR160-T	Diodes	DIODE ULTRA FAST 1A 600V DO-41
4	Q1	1	STD7NK40ZT4	ST	MOSFET N-CH 400V 5.4A DPAK
5	C4	1	C0402X7R1A221K	Vishay	CAP CER 220PF 10V X7R 01005
6	C3	1	C1608X7R1A105K	TDK	CAP CER 1.0UF 10V X7R 0603
7	R1	1	CRCW0402330KFKTD	Vishay	RES 330K OHM 1/16W 1% 0402 SMD
8	R3	1	CRCW04021K00FKED	Vishay	RES 1.0K OHM 1/16W 1% 0402 SMD
9	R2	1	CRCW040222R0FKED	Vishay	RES 22.0 OHM 1/16W 1% 0402 SMD
10	R4	1	CRCW08051R50FKEA	Vishay	RES 1.5 OHM 1/8W 1% 0805 SMD
11	R6	1	CRCW120616R0FKEA	Vishay	RES 16.0 OHM 1/4W 1% 1206 SMD
12	R9	1	CRCW1206510KJNEA	Vishay	RES 510K OHM 1/4W 5% 1206 SMD
13	R7	1	CRCW0402787RFKED	Vishay	RES 787 OHM 1/16W 1% 0402 SMD
14	C1, C2	2	VJ1812Y104KXETW1BC	Vishay	CAP Multilayer Cer (MLCC) – SMD / SMT 1812 0.1uF 500volts X7R 10%
16	C5	2	UMK325C7106MM-T	Taiyo	CAP CER 4.7uF//4.7uF 100V X7R 1210
16	L1	1	LPS5015-225ML	Coilcraft	Inductor 2.2mH 64mA
17	L2	1	13R475C	Murata	Inductor Radial 4.7mH 0.16A

Case #2 => Test conditions: V<sub>IN</sub>=120V<sub>AC</sub>; OUT=96V/45mA

#	Name	Quantity	Part number	Manufacturer	Description
1	U1	1	AL9910S-13	Diodes	Universal High Voltage LED Driver
2	D1,2,3, 4	1	HD02-T	Diodes	RECT BRIDGE GP 200V 0.8A MINIDIP
3	D6	1	MUR160-T	Diodes	DIODE ULTRA FAST 1A 600V DO-41
4	Q1	1	STD7NK40ZT4	ST	MOSFET N-CH 400V 5.4A DPAK
5	C4	1	C0402X7R1A221K	Vishay	CAP CER 220PF 10V X7R 01005
6	C3	1	C1608X7R1A105K	TDK	CAP CER 1.0UF 10V X7R 0603
7	R1	1	CRCW0402330KFKTD	Vishay	RES 330K OHM 1/16W 1% 0402 SMD
8	R3	1	CRCW04021K00FKED	Vishay	RES 1.0K OHM 1/16W 1% 0402 SMD
9	R2	1	CRCW040222R0FKED	Vishay	RES 22.0 OHM 1/16W 1% 0402 SMD
10	R4	1	CRCW08052R94FKEA	Vishay	RES 2.94 OHM 1/8W 1% 0805 SMD
11	R6	1	CRCW120616R0FKEA	Vishay	RES 16.0 OHM 1/4W 1% 1206 SMD
12	R9	1	CRCW1206510KJNEA	Vishay	RES 510K OHM 1/4W 5% 1206 SMD
13	R7	1	CRCW0402787RFKED	Vishay	RES 787 OHM 1/16W 1% 0402 SMD
14	C1, C2	2	VJ1812Y104KXETW1BC	Vishay	CAP Multilayer Cer (MLCC) – SMD / SMT 1812 0.1uF 500volts X7R 10%
16	C5	2	C3225X7S2A475K	TDK	CAP CER 4.7uF//4.7uF 100V 1210
16	L1	1	LPS5015-225ML	Coilcraft	Inductor 2.2mH 64mA
17	L2	1	13R476C	Murata	Inductor Radial 47mH 0.045A

2.4 Evaluation Board Layouts

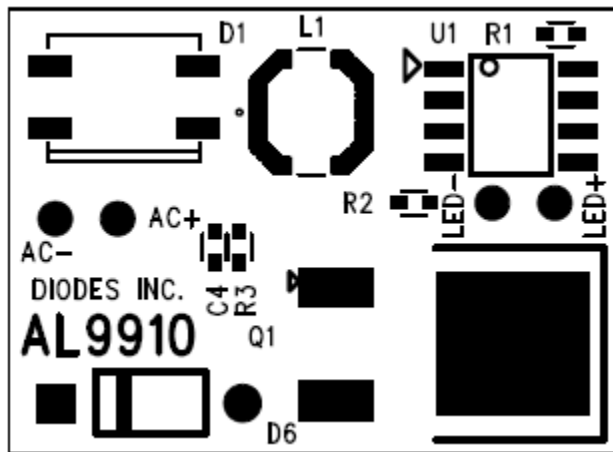


Figure 3: Top-View PCB Layout

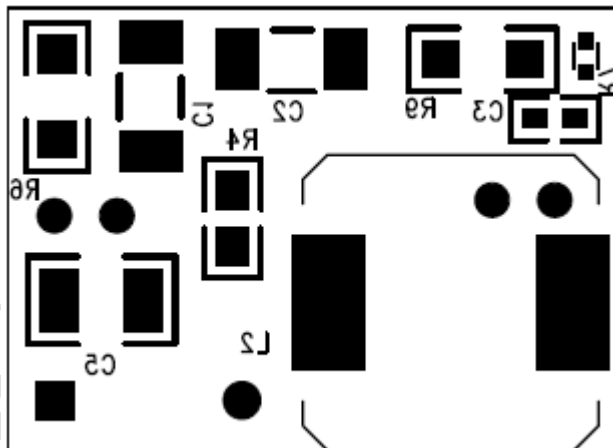


Figure 4: Bottom-View PCB Layout



## 2.5 Evaluation Board Snapshots



Figure 5: Top-View PCB Board

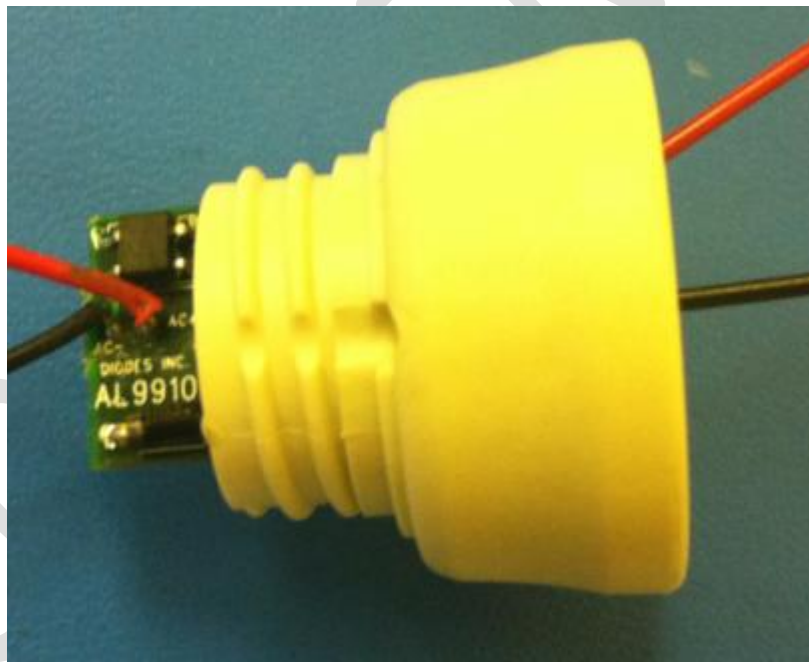
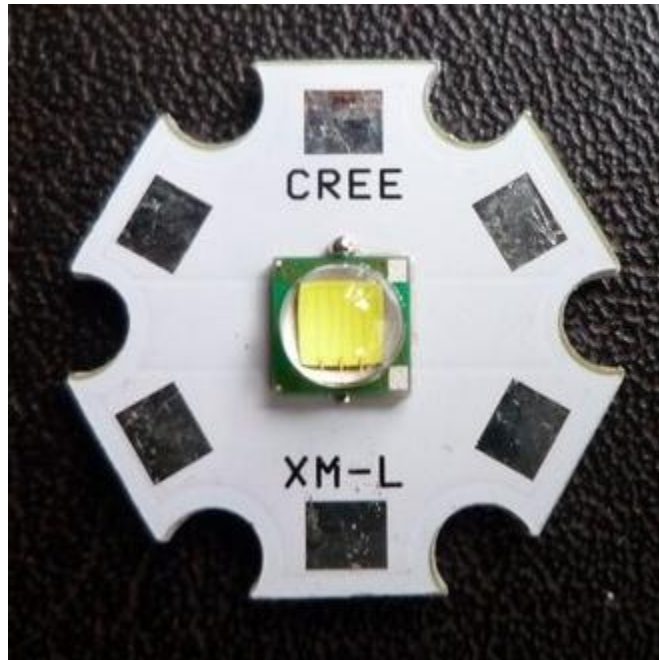


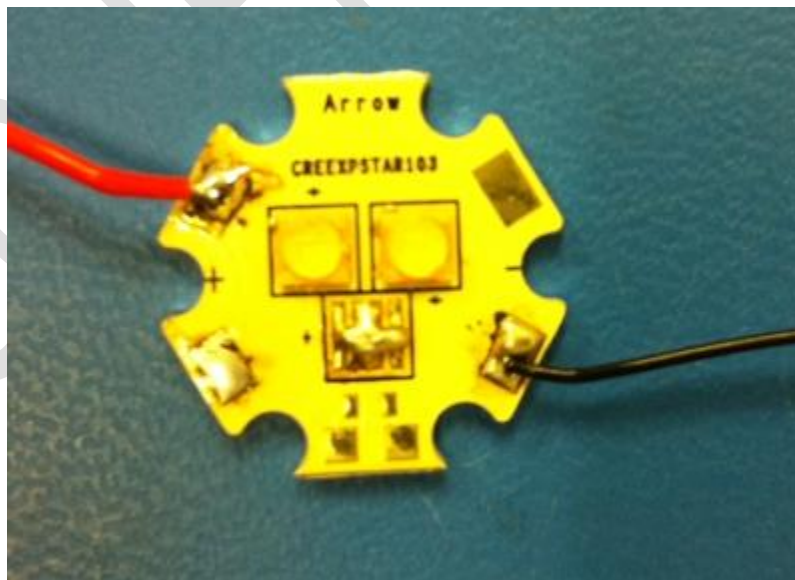
Figure 6: Top-View PCB Board in Bulb Module

### 3. LED OUTPUT

- 3.1 LED P/N: Cree XM-L T6  
LED Output: ~+48V (ideal)



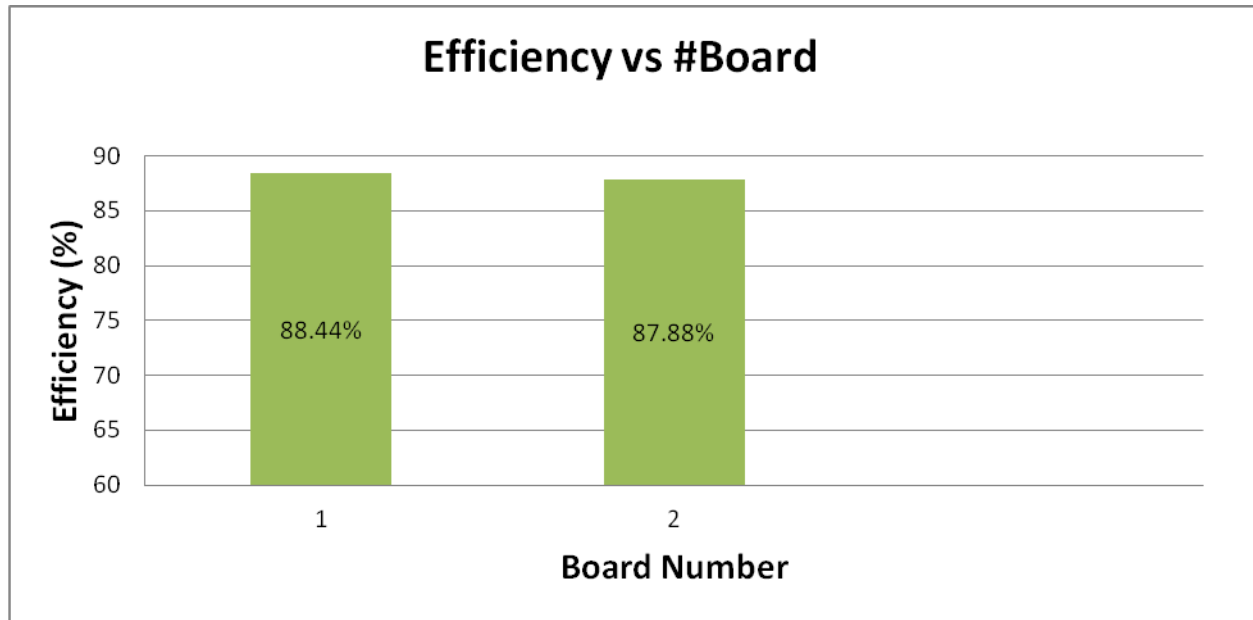
- 3.2 LED P/N: Cree XPSTAR103  
LED Output: ~+96V (ideal)



#### 4. EVALUATION BOARD TESTING SUMMARY

##### 4.1 Testing Results (case #1):

(Case #1 => Test conditions:  $V_{IN}=120V_{AC}$ ;  $OUT=48V/90mA$ ):

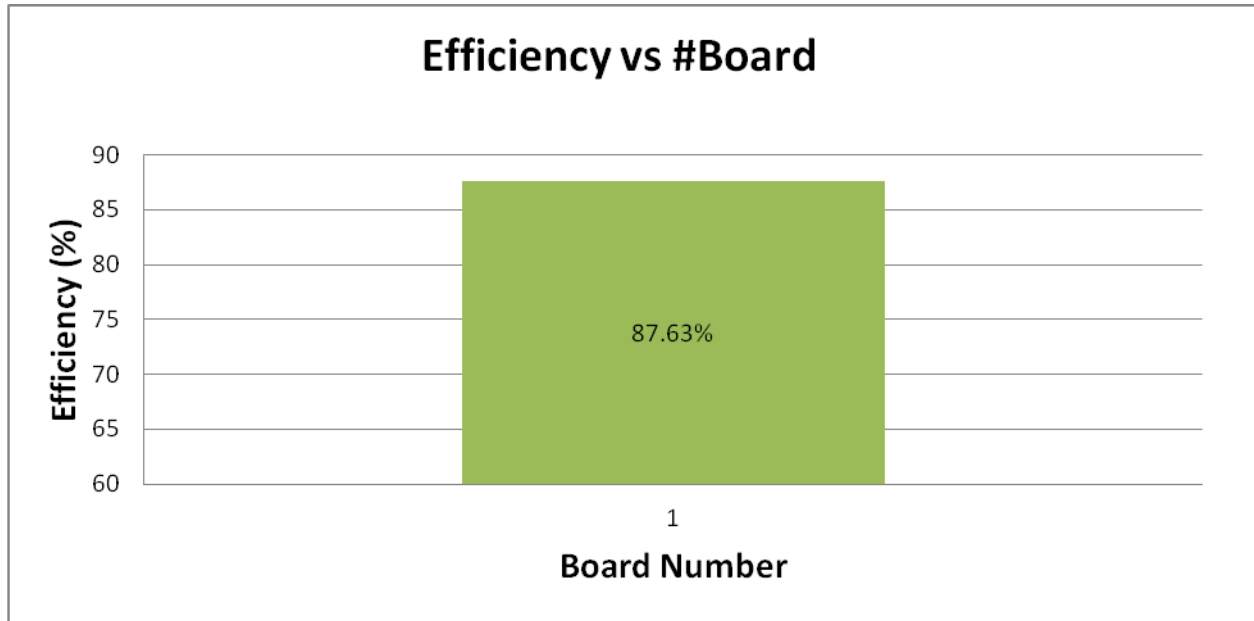


(Case #1 => Test conditions:  $V_{IN}=120V_{AC}$ ;  $OUT=48V/90mA$ ):

Board #	Cree LED	$V_{RMS}$ (V)	$I_{RMS}$ (mA)	$P_{IN}$ (W)	PFC	$V_{LED}$ (V)	$I_{LED}$ (mA)	$P_{OUT}$ (W)	Efficiency (%)
1	48V	120.52	34.45	4.032	0.969	41.35	91.14	3.566	88.44
2	48V	120.62	35.32	4.125	0.966	41.4	91.95	3.625	87.88

**4.2 Testing Results (case #2):**

(Case #2 => Test conditions:  $V_{IN}=120V_{AC}$ ;  $OUT=96V/45mA$ ):



(Case #2 => Test conditions:  $V_{IN}=120V_{AC}$ ;  $OUT=96V/45mA$ ):

Board #	Cree LED	$V_{RMS}$ (V)	$I_{RMS}$ (mA)	$P_{IN}$ (W)	PFC	$V_{LED}$ (V)	$I_{LED}$ (mA)	$P_{OUT}$ (W)	Efficiency (%)
1	96	120.02	37.03	4.227	0.962	94.43	46.17	3.704	87.63

## 5. CONCLUSION

It is concluded that the new circuit implementation of replacing the inductor (L2) and changing the R<sub>SENSE</sub> (R4) fully function as expected. As configured in a high-power 48V LED module, the efficiency is about ~88% and PFC is ~0.969. As configured in a high-power 96V LED module, the efficiency is about ~87.6% and PFC is ~0.962.

Main benefits are achieved in the high-power LED evaluation:

- 1) High Efficiency
- 2) High PFC (>0.9)
- 3) No electrolytic capacitor
- 4) Correct average LED output current
- 5) Suitable for E27 LED Light Bulbs

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