
Evaluation Board (AL9910EV9)

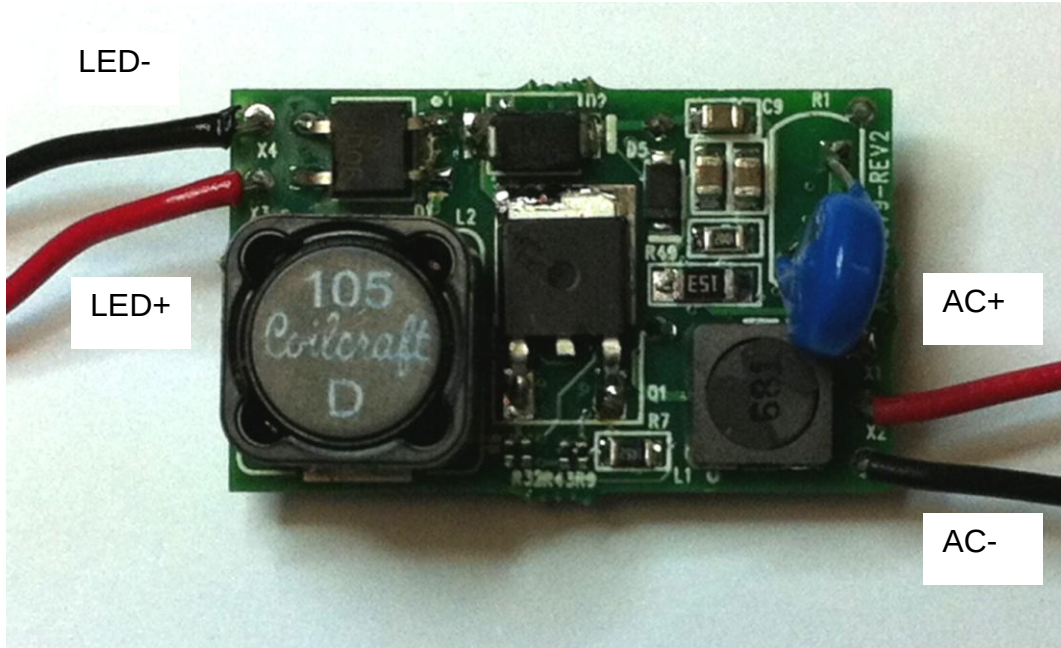
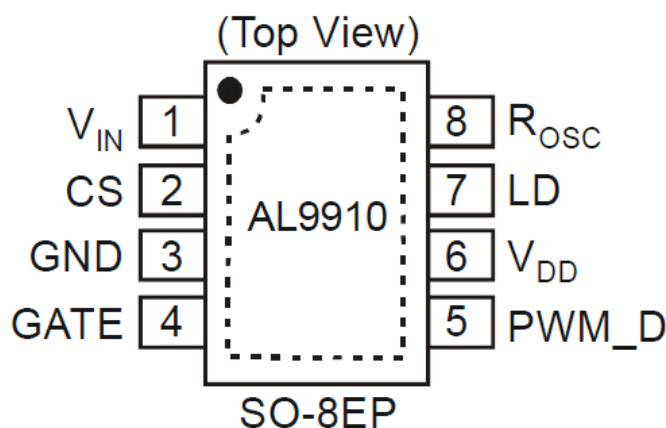


Figure 1: Top-View Evaluation Board

Features

- TRIAC Dimmable
- Work for both forward or reverse phase dimmers
- Wide dimming range from full brightness to around ~1%
- Selectable 8W-13W output power
- Active PFC with power factor >0.9
- No electrolytic capacitor
- Long operating life
- Typical Applications: Retrofit A19, E27, PAR38, PAR30 LED Light Bulbs

AL9910A Pin Assignment



AL9910A Pin Description

Pin Name	Pin Number	Descriptions
V _{IN}	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 _{DD}	6	Internally regulated supply voltage. 10V nominal for AL9910A. 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 _{OSC}	8	Oscillator control. A resistor connected between this pin and ground sets the PWM frequency.
ED PAD	EP	Exposed Pad (bottom). Connect to GND directly underneath the package.

Specifications

Parameter	Units	Value
AC Input Voltage	V, AC	200 - 240
Output Power	W	8 – 13
Power Factor	NA	>0.9
Efficiency	%	Up to 81%
ROHS Compliance	NA	Yes

I/O Terminals

Test conditions:Input Voltage: 230V_{AC}, 60HzLED Output Voltage: 36V_{DC}LED Output Current: 300mA**Connection Instructions:**

AC+ (X1) Input: Red – Hot

AC- (X2) Input: Black - Neutral

DC LED+ (X3) Output: LED+ (Red)

DC LED- (X4) Output: LED- (Black)

Board Dimension (components included):

WxLxH (in mm) = 20mm x 33mm x 19mm

Quick Start Guide

- 1) Connect +230V_{AC} AC power supply between AC+ (X1) and AC- (X2) headers.
- 2) Connect external LEDs to the output between LED+ (X3) and LED- (X4) headers.
- 3) Turn on the AC power supply.

Evaluation PCB Board Layouts

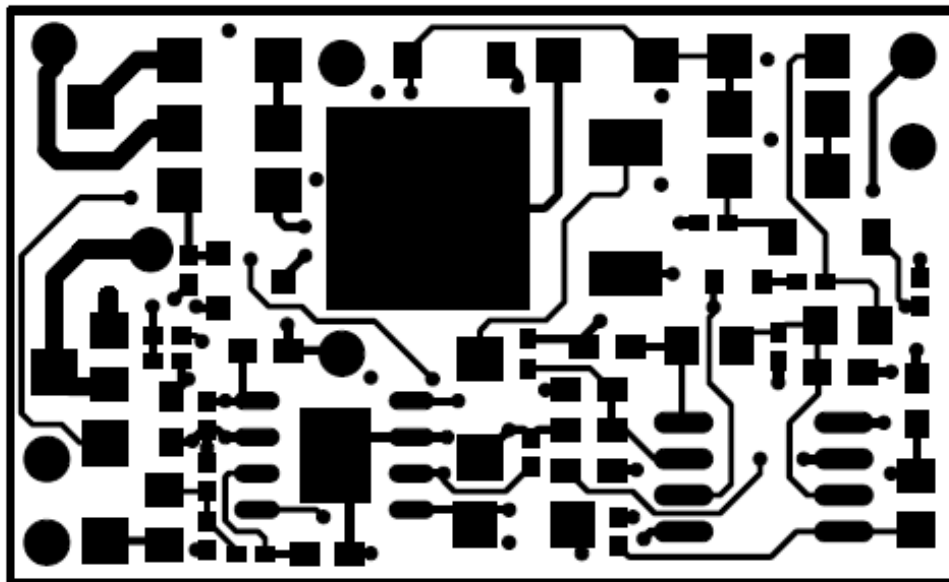


Figure 2: Top-View PCB Layout

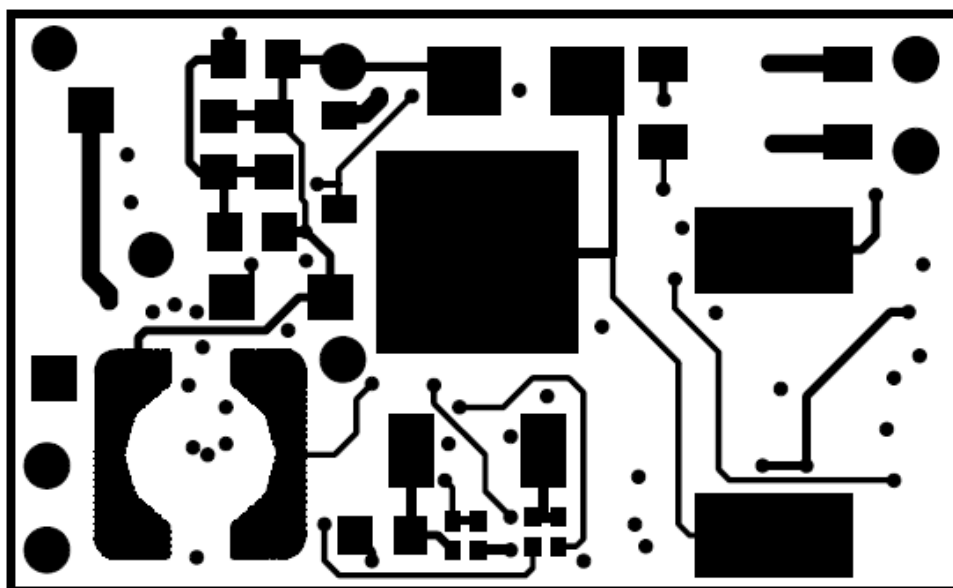


Figure 3: Bottom-View PCB Layout

List of Dimmers

Here is the current list of dimmers, which are successfully tested by our LED drivers.

- A) Philips Q82-M11
- B) Wuyun W13-C152

Schematic

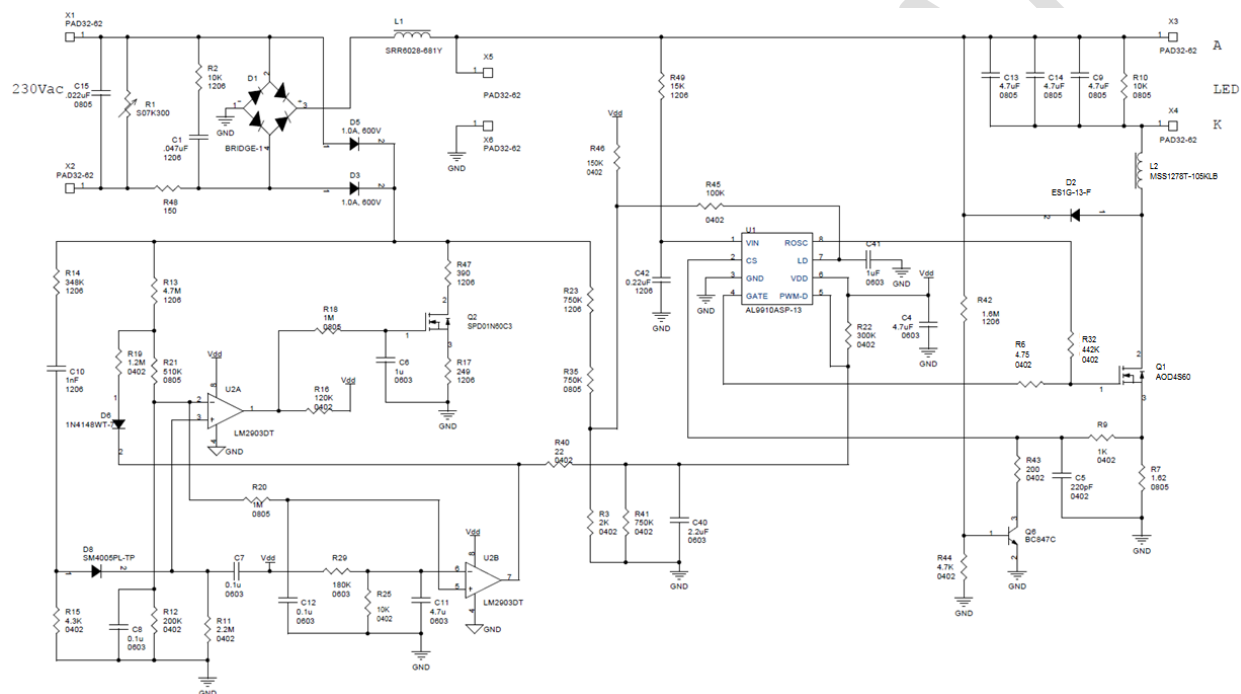


Figure 4: Evaluation Board Schematic

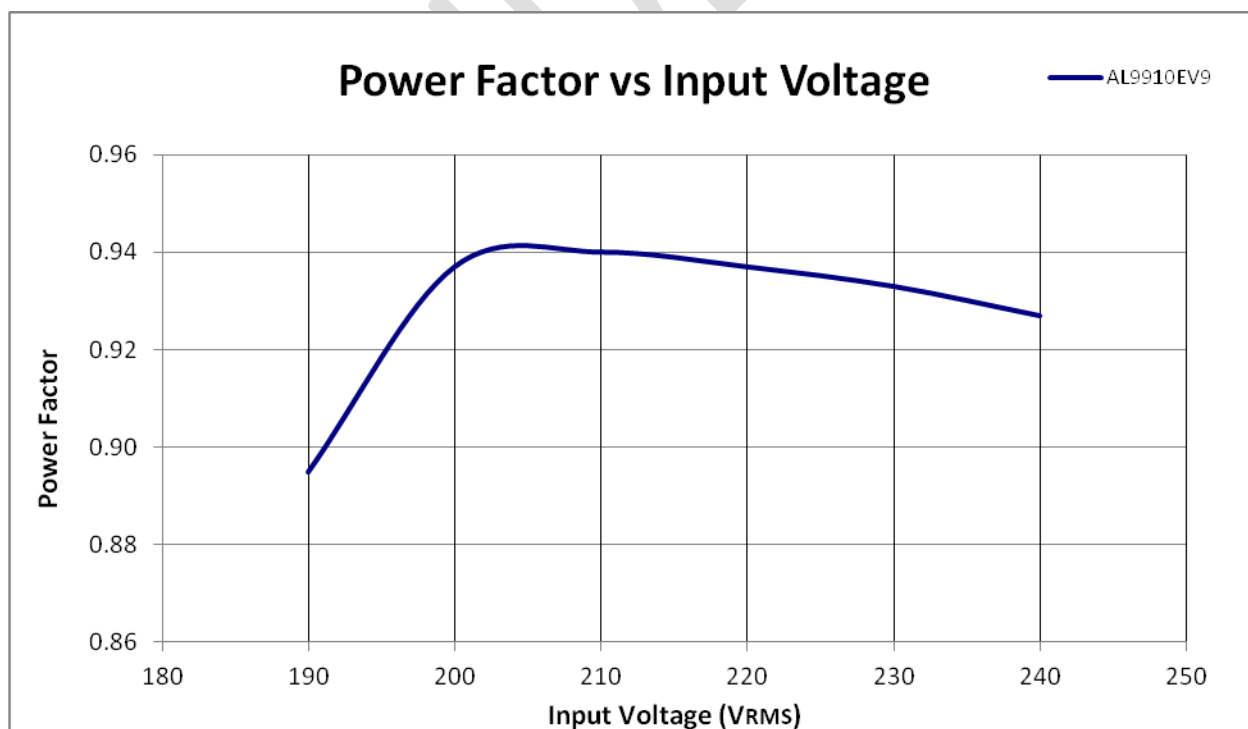
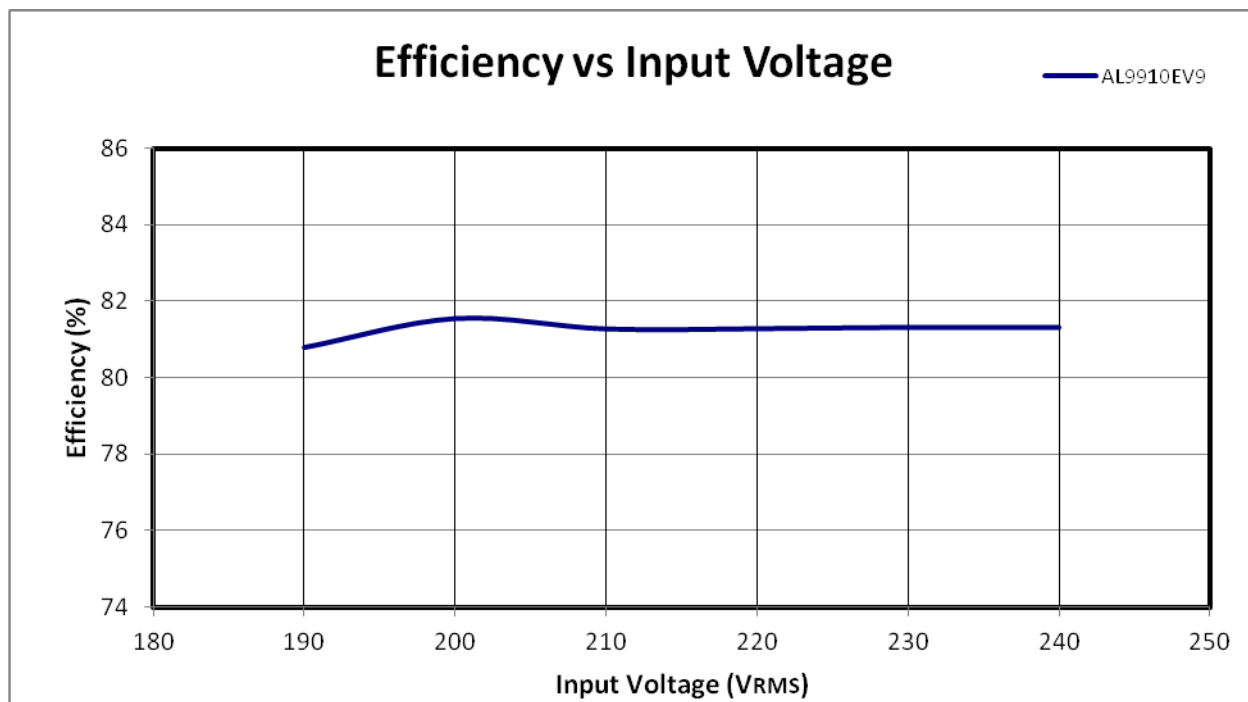
Bill of Material

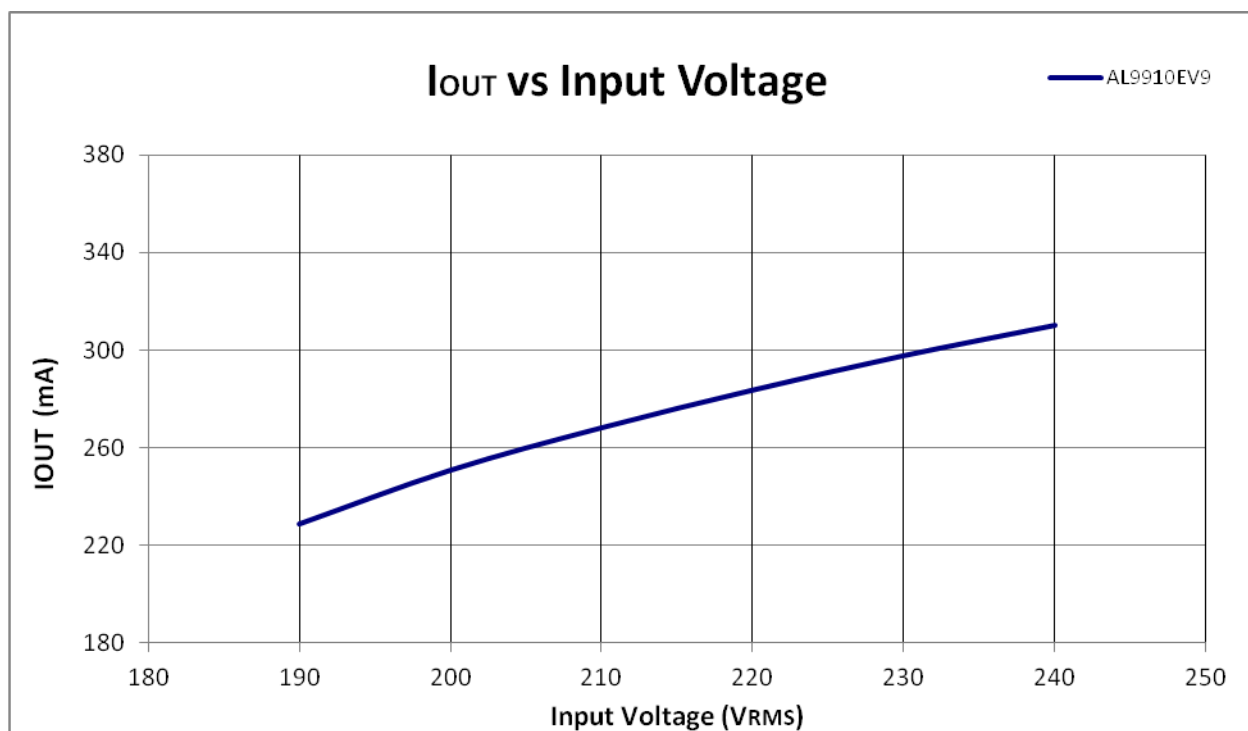
Item	Comment	Description	Size	Qty	Manufacturer	Part Number
C1	C1206 - 0.047u 630V	Multilayer Ceramic Capacitors (1206) 0.047μF 630V 10%	C1206	1	Murata	C3216X7T2J473M/SOFT
C4,	C0603 - 4.7u 16V	Multilayer Ceramic Capacitors (0603) 4.7μF 16V 10%	C0603	1	TDK	C1608X5R1C475M
C6, C41	C0603 - 1u 16V	Multilayer Ceramic Capacitors (0603) 1.0μF 16V 10%	C0603	2	TDK	C1608X7R1C105K
C5	C0402 - 220p 50V	Multilayer Ceramic Capacitors (0402) 220pF 50V 5%	C0402	1	Murata	GRM155R71H221JA01J
C7, C8, C12	C0603 - 0.1u 16V	Multilayer Ceramic Capacitors (0603) 0.1μF 16V 10%	C0603	3	Murata	GCM188R71C104KA37D
C9, C13, C14	C0805 - 4.7u 50V	Multilayer Ceramic Capacitors (0805) 4.7μF 50V 10%	C0805	3	TDK	C2012X5R1H475K
C10	C1206 - 1n 500V	Multilayer Ceramic Capacitors (1206) 1nF 500V 10%	C1206	1	Vishay/Vitramon	VJ1206Y102KXEAT5Z
C11	C0603 - 4.7u 10V	Multilayer Ceramic Capacitors (0603) 4.7μF 10V 10%	C0603	1	AVX	0603ZD475KAT2A
C15	C0805 - 0.022u 450V	Multilayer Ceramic Capacitors (0805) 0.022μF 450V 10%	C0805	1	TDK	C2012X7T2W223K
C40	C0603 - 2.2u 16V	Multilayer Ceramic Capacitors (0603) 2.2μF 16V 10%	C0603	1	TDK	C1608X5R1C225KT
C42	C1206 - 0.22u 250V	Multilayer Ceramic Capacitors (1206) 0.22μF 250V 10%	C1206	1	TDK	C3216X7T2E224K
X5- X6	C0.22μF, 250V	Polyester Film Capacitor	WxLxH (mm) 5.5 x 10.3 x 15.5	1	Panasonic	ECQ-E2224JB
D1	HD06	Bridge Rectifiers 0.8A, 600V	MiniDip	1	Diodes Inc	HD06-T
D2	ES1G-13-F	Diode Super-Fast 1.0A, 400V	SMA	1	Diodes Inc	ES1G-13-F
D3, D5, D8	SM4005PL- TP	Diode SIL 1.0A, 600V	Power lite 123	3	Micro Commercial Co	SM4005PL-TP
D6	1N4148WT	Fast Switching Diode 100V	SOD- 523	1	Diodes Inc	1N4148WT-7

L1	SRR6028-681Y	Power Inductors 680μH 220mA	L6028	1	Bourns	SRR6028-681Y
L2	MSS1278T-105KLB	Power Inductors 0.9A, 1mH	L12 x W12 x H7.8	1	CoilCraft	MSS1278T-105KLB
Q1	AOD4S60	MOSFET Power N-CH 600V, 4 Amp	D-PAK	1	Alpha Omega	AOD4S60
Q2	SPD01N60C3	MOSFET Power COOL MOS N-CH 650V, 0.8A	D-PAK	1	Infineon	SPD01N60C3
Q6	BC847C	NPN Surface Small Signal Transistor 100mA, 45V	SOT-23	1	Diodes Inc	BC847C-7-F
R1	S07K300	Varistors 300Vrms 7MM Radial	Disc 7mm	1	EPCOS	S07K300
R2	R1206 – 10k	Chip Resistor (1206) 10kΩ 1/10W 1%	R1206	1	Panasonic - ECG	ERJ-P8J103V
R3	R0402 - 2k	Chip Resistor (0402) 2kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF2001X
R6	R0402 – 4.75	Chip Resistor (0402) 4.75Ω 1/16W 1%	R0402	1	Vishay	CRCW04024R75FKED
R7	R0805 - 1.62	Chip Resistor (0805) 1.62Ω 1/8W 1%	R0805	1	Vishay	CRCW08051R62FKEA
R9	R0402 - 1k	Chip Resistor (0402) 1kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF1001X
R10	R0805 - 10k	Chip Resistor (0805) 10kΩ 1/8W 1%	R0805	1	Panasonic - ECG	ERJ-6ENF1002V
R11	R0402 - 2.2M	Chip Resistor (0402) 2.2MΩ 1/10W 5%	R0402	1	Panasonic - ECG	ERJ-2GEJ225X
R12	R0402 - 200k	Chip Resistor (0402) 200kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF2003X
R13	R1206 – 4.7M	Chip Resistor (1206) 4.7MΩ 1/4W 5%	R1206	1	Rohm Semiconductor	MCR18EZHZJ475
R14	R1206 - 348k	Chip Resistor (1206) 348kΩ 1/4W 1%	R0805	1	Vishay/Dale	CRCW1206348KFKEA
R15	R0402 - 4.3k	Chip Resistor (0402) 4.3kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF4301X
R16	R0402 - 120k	Chip Resistor (0402) 120kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF1203X
R17	R1206 – 249	Chip Resistor (1206) 249Ω 1/4W 1%	R1206	1	Rohm Semiconductor	MCR18EZHF2490
R47	R1206 – 200	Chip Resistor (1206) 200Ω 1/4W 1%	R1206	1	Panasonic - ECG	ERJ-8ENF2000V
R18, R20	R0805 - 1M	Chip Resistor (0805) 1MΩ 1/8W 1%	R0805	2	Panasonic - ECG	ERJ-6ENF1004V
R19	R0402 - 1.2M	Chip Resistor (0402) 1.2MΩ 1/10W 5%	R0402	1	Panasonic - ECG	ERJ-2GEJ125X
R21	R0805 - 510k	Chip Resistor (0805) 510kΩ 1/8W 1%	R0805	1	Panasonic - ECG	ERJ-6ENF5103V
R22	R0402 - 300k	Chip Resistor (0402) 300kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF3003X
R23	R1206 - 750k	Chip Resistor (1206) 750kΩ 1/3W 5%	R1206	1	Panasonic - ECG	ERJ-P08J754V

R35	R0805 - 750k	Chip Resistor (0805) 750kΩ 1/4W 5%	R0805	1	Panasonic - ECG	ERJ-P06J754V
R25	R0402 - 10k	Chip Resistor (0402) 10kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF1002X
R29	R0603 - 180k	Chip Resistor (0603) 180kΩ 1/10W 1%	R0603	1	Panasonic - ECG	ERJ-3EKF1803V
R32	R0402 - 442k	Chip Resistor (0402) 442kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF4423X
R40	R0402 - 22	Chip Resistor (0402) 22Ω 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF22R0X
R41	R0402 - 750k	Chip Resistor (0402) 750kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF7503X
R42	R1206 - 1.6M	Chip Resistor (1206) 1.6MΩ 1/4W 5%	R1206	1	Rohm Semiconductor	MCR18EZHJ165
R43	R0402 - 200	Chip Resistor (0402) 200Ω 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF2000X
R44	R0402 - 4.7k	Chip Resistor (0402) 4.7kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF4701X
R45	R0402 - 100k	Chip Resistor (0402) 100kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF1003X
R46	R0402 - 150k	Chip Resistor (0402) 150kΩ 1/10W 1%	R0402	1	Panasonic - ECG	ERJ-2RKF1503X
R47	R1206 - 390	Chip Resistor (1206) 390Ω 1/3W 5%	R1206	1	Rohm Semiconductor	ESR18EZPJ391
R48	Thru-hole - 150	Through-hole - 150Ω 1/2W 5%	Axial	1	Panasonic - ECG	ERD-S1TJ151V
R49	R1206 - 15k	Chip Resistor (1206) 15kΩ 1/3W 5%	R1206	1	Rohm Semiconductor	ESR18EZPJ153
U1	AL9910ASP -13	LED Drivers - 10V LED Driver PWM 85 to 277VAC	SO- 8EP	1	Diodes Inc	AL9910ASP-13
U2	LM2903	Comparator IC - Low Power Dual Voltage	SO-8	1	ST Microelectronics	LM2903DT

Functional Performance





Dimming Description

From the schematic circuit, U2A, R25, R29, R13, R21, R8, R12, R14, R15, C7, U2B, R25, R29, R20, C12, C11, R40, R3, R40 and R41 belong to a dimmer detector. The dimming circuit is functioning by comparing integral and differential portion of the voltage after the D3 & D5 diodes. R13, R21, R12 and C8 components are an integrator circuit with ~20ms integration time. R14, R15 and C10 components are a differentiator circuit with ~34us time constant. Voltage after differentiation through voltage divider (R14, R15) and D8 charging capacitor C7 charge. U2A compares integral and differential portions of AC input voltage. All voltage dividers above maintain a voltage such that if there is no triac dimmer present, then the voltage at pin #2 on U2A is greater than the voltage at pin #3. If a dimmer is present, then differential portion will be much higher. At any dimmer position, the differential will be greater than integral portion. Therefore, on the U2A output voltage is LOW if there is no dimmer and HIGH if there is a dimmer present. If there is a dimmer present, then a high voltage from the U2A output makes Q2 conductive and switching ON current sink (Q2). This current sink has a double functionality:

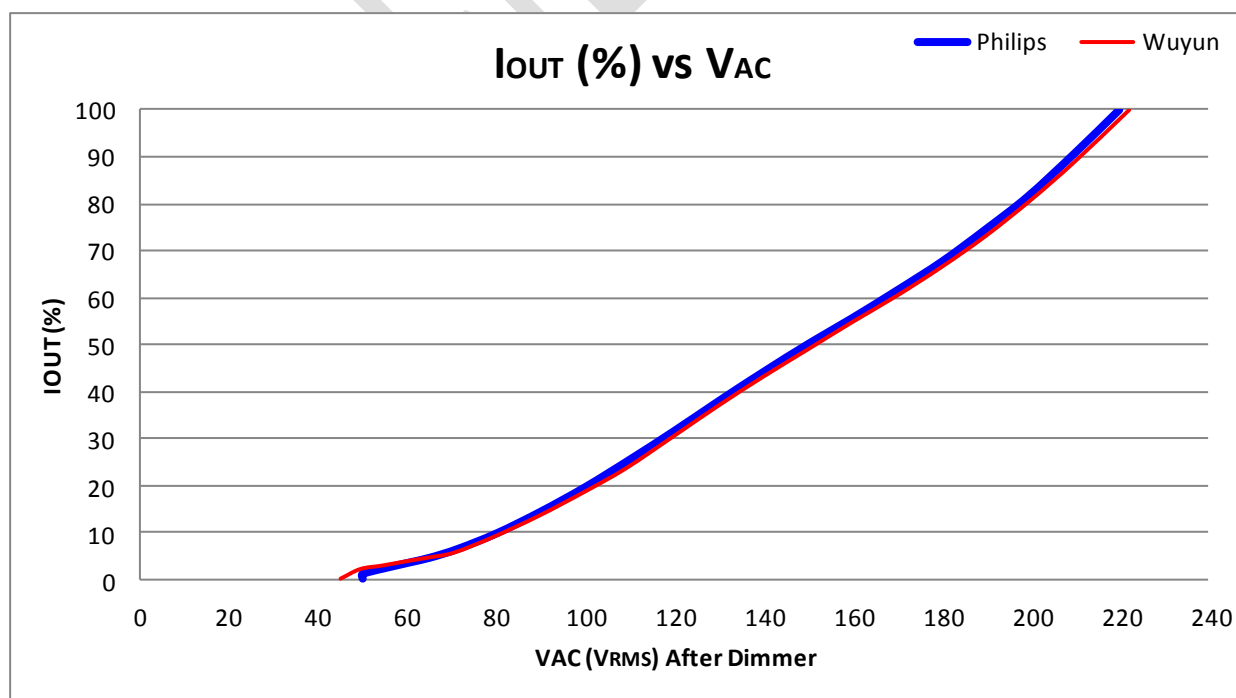
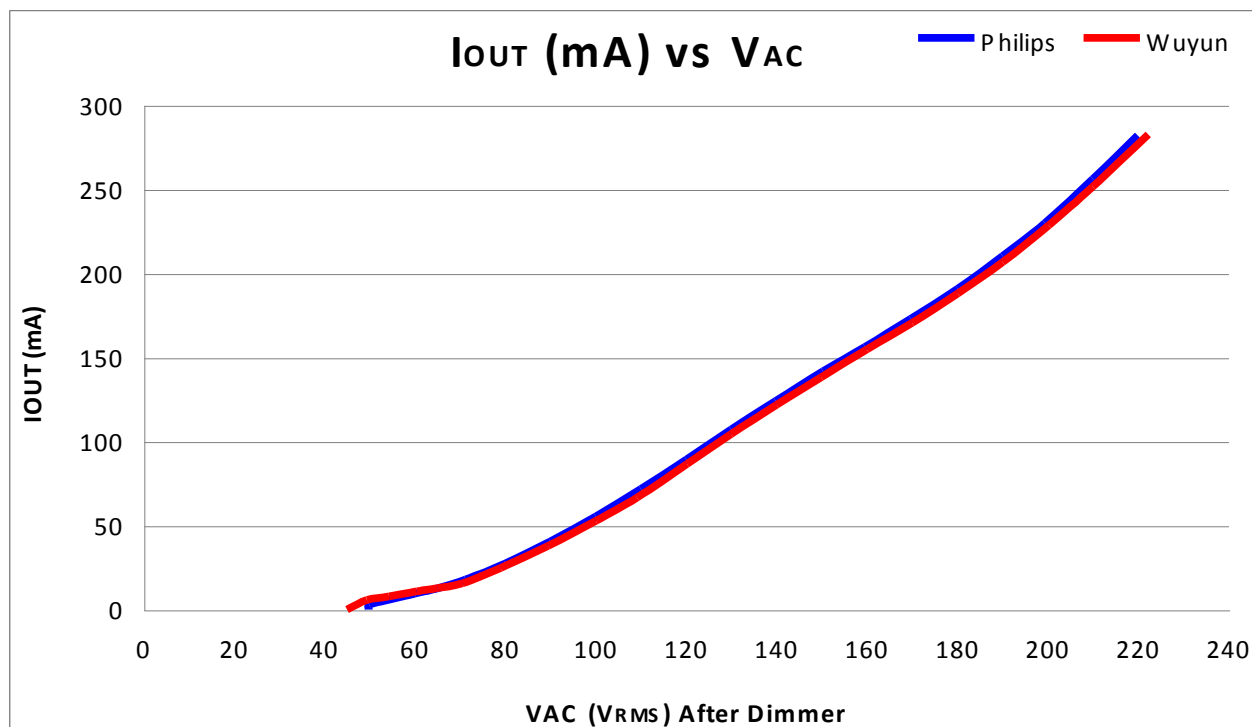
- 1) When dimmer's triac is conducting, it adds current necessary to keep triac conducting. Value of this current depends on R17 and Q2 V_{GS} voltage.
- 2) When dimmer's triac is OFF, Q2 is quickly discharging dimmer's capacitors. R28 makes it more stable and R47 is limiting U2A output current.

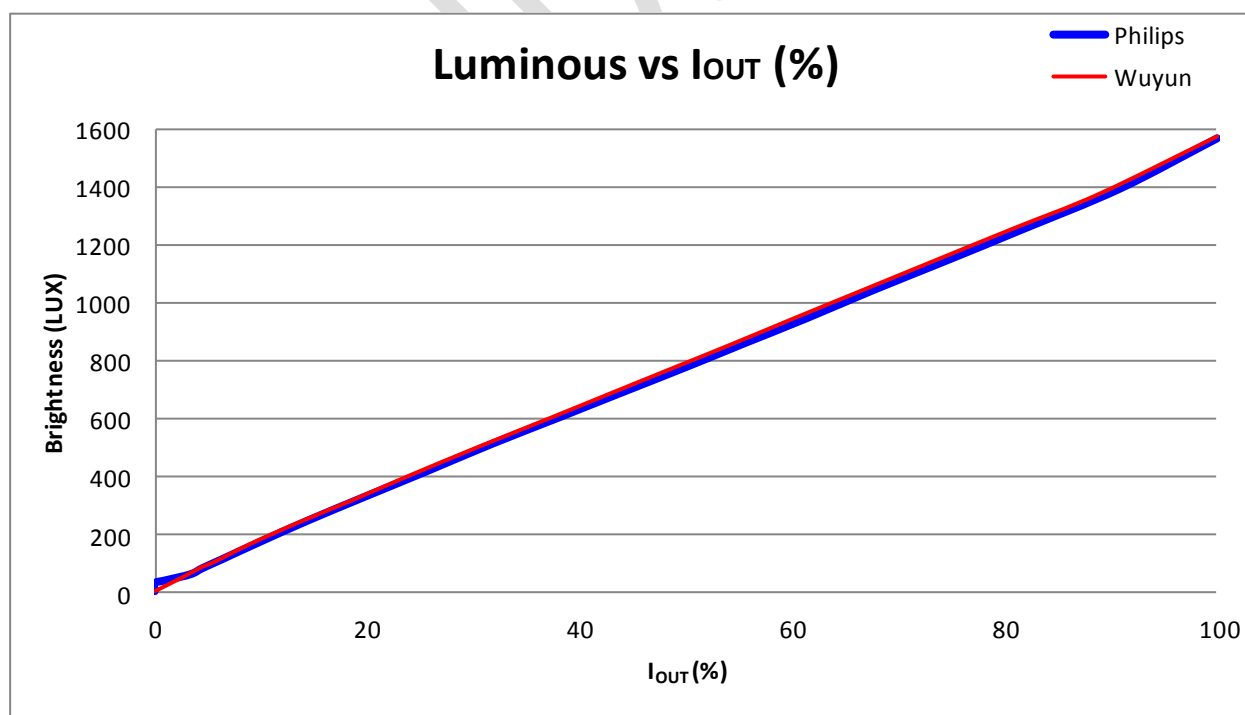
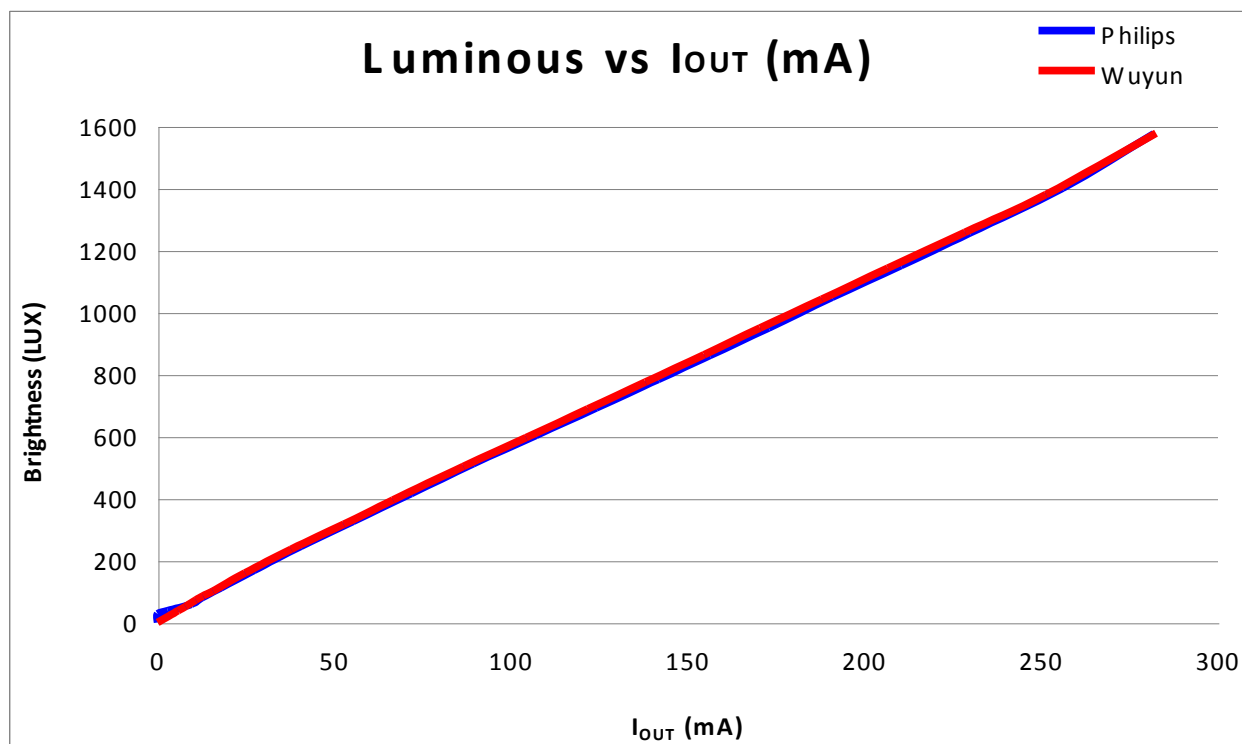
Schematic portion responsible for shutting down driver at a very low dimmer settings (low end) is assembled on U2B, R25, R29, R20, C12, C11, R40, R3, R40 and R41, which will prevent LED flickering.

Power factor correction circuit contains Q6, R43, R44 and R42. It is working as a controllable voltage divider (R9, Q6, R43, R44) in the current feedback loop. A voltage on C5 is a control voltage for Q6. It allows to bring input current shape close to the voltage shape and increase the power factor. R42 is used to limit current feedback in case of increased input AC voltage and reducing LED current from AC voltage changes.

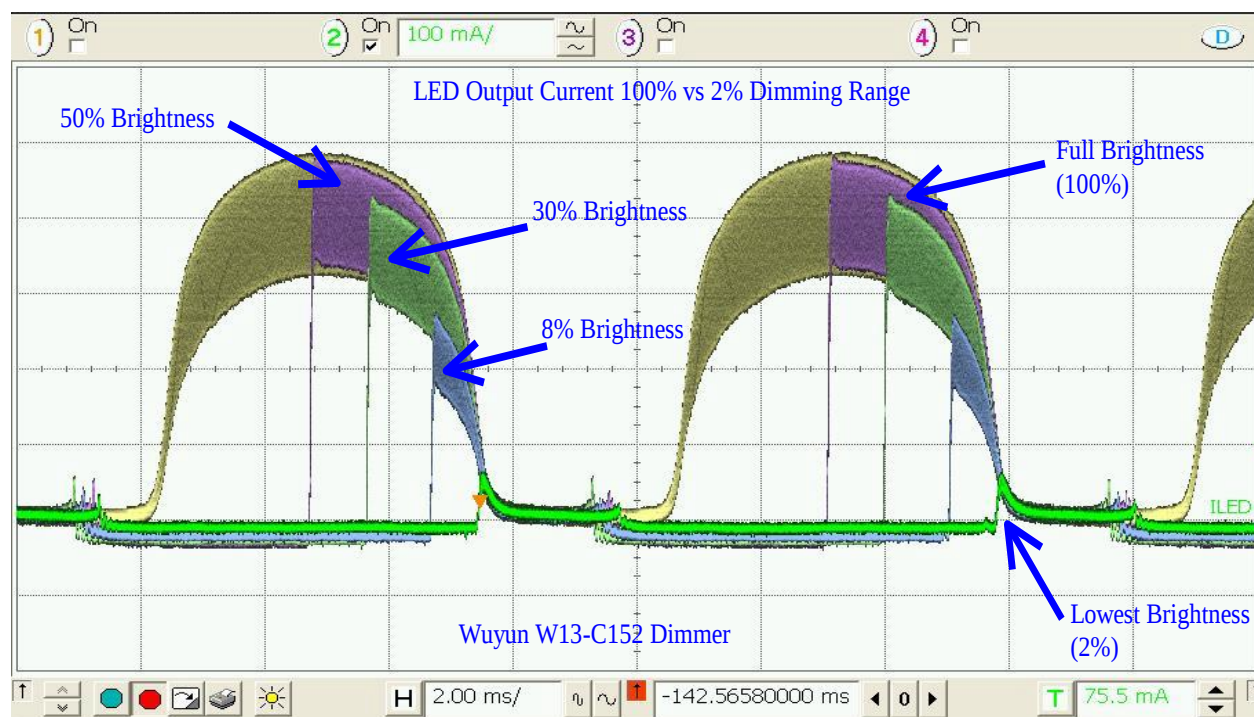
Dimming Performance

1) Philips Q82-M11 & Wuyun W13-C152 Dimmers

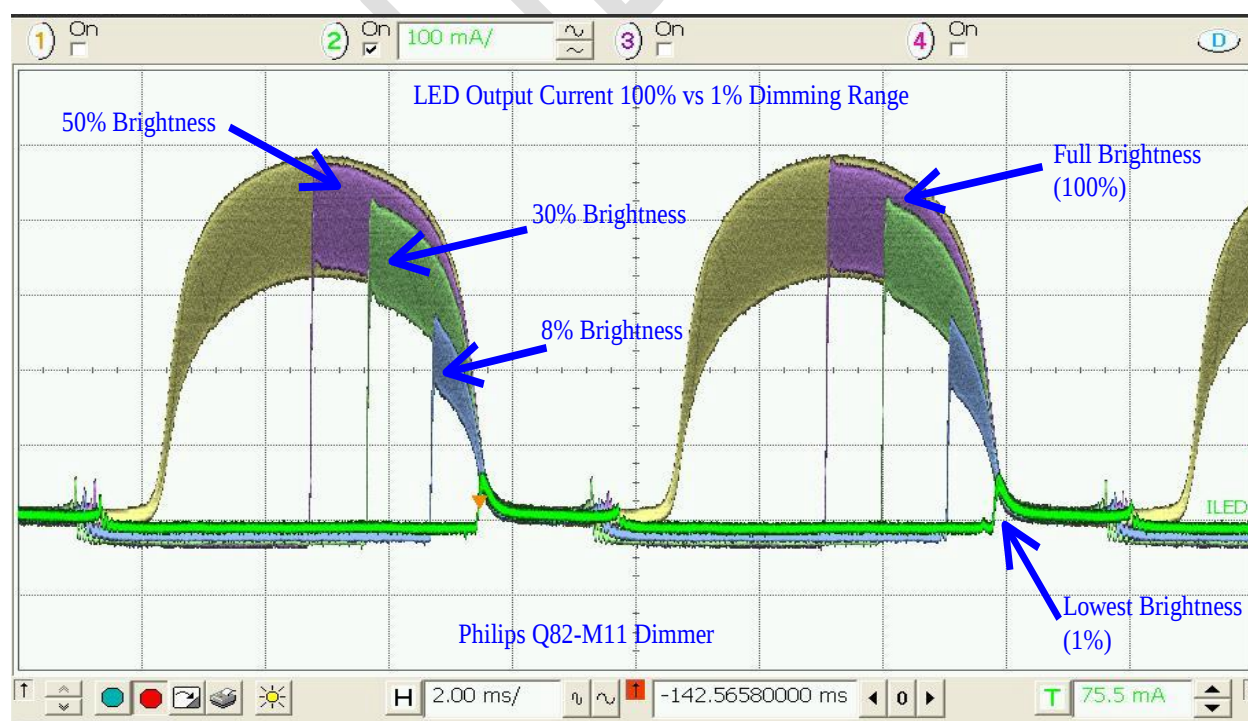




2) Wuyun W13-C152 LED Current Dimming Range Waveform



3) Philips Q82-M11 LED Current Dimming Range Waveform



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