
Evaluation Board (AL9910EV9)

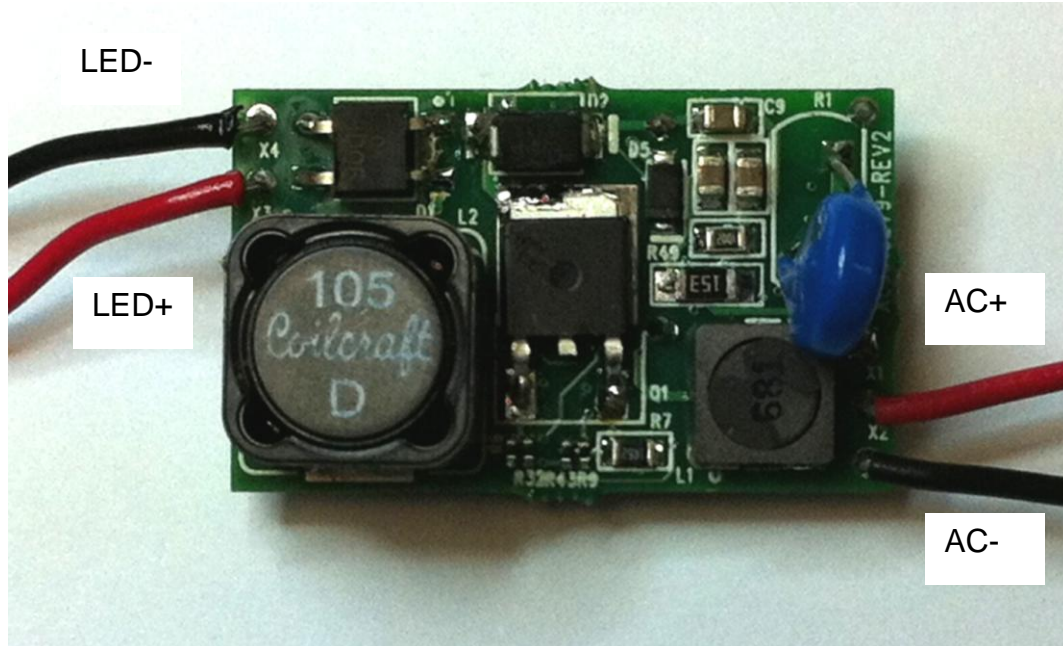
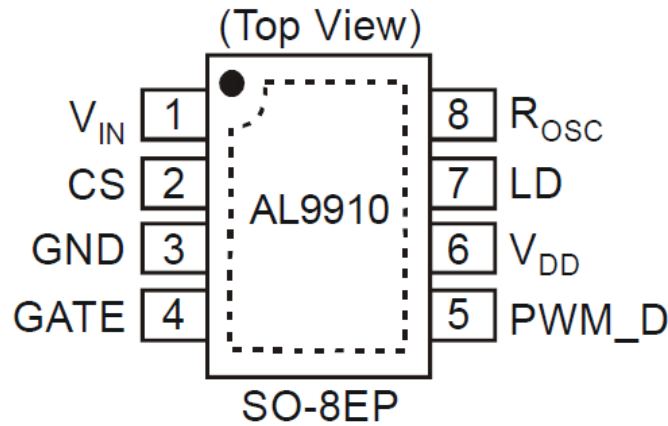


Figure 1: Top-View Evaluation Board

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}, 60Hz

LED 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

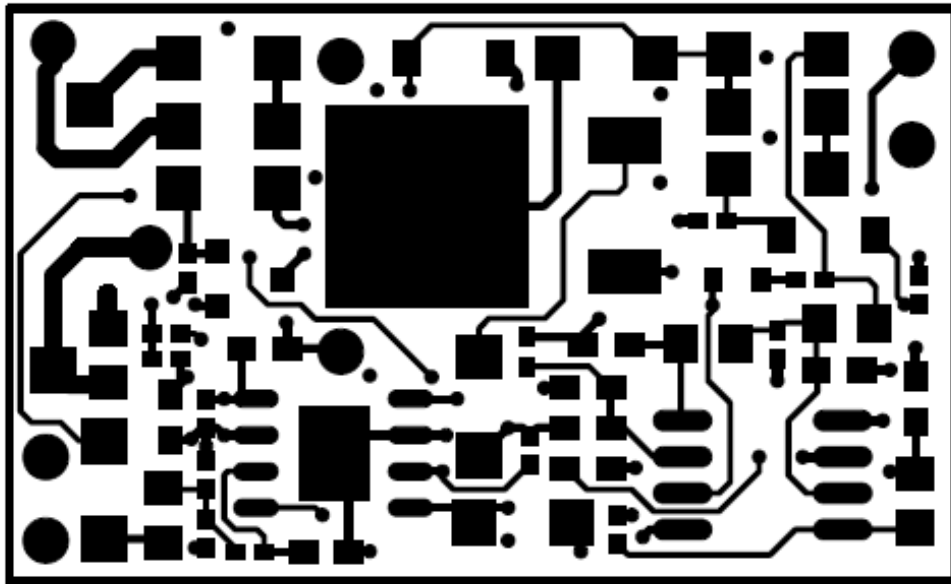


Figure 2: Top-View PCB Layout

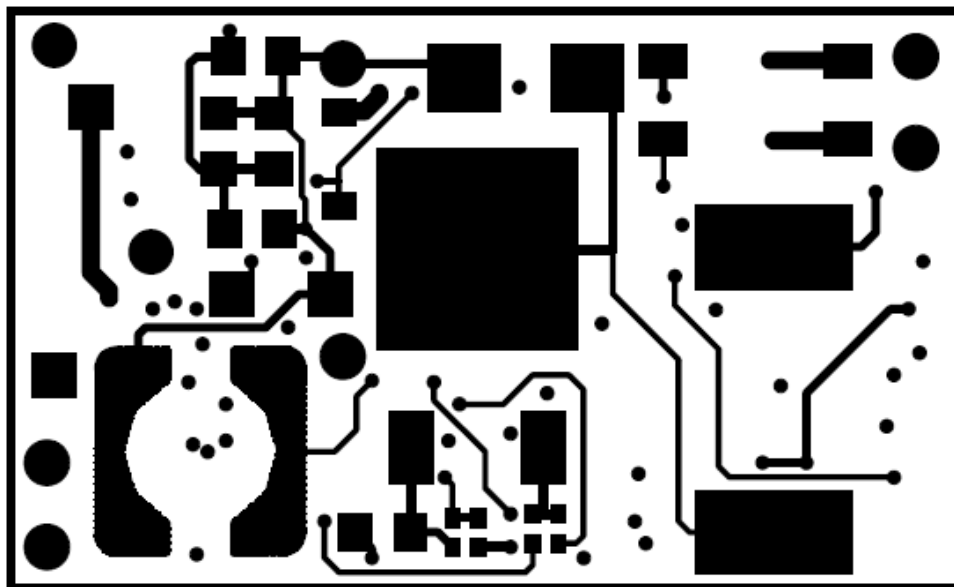


Figure 3: Bottom-View PCB Layout

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

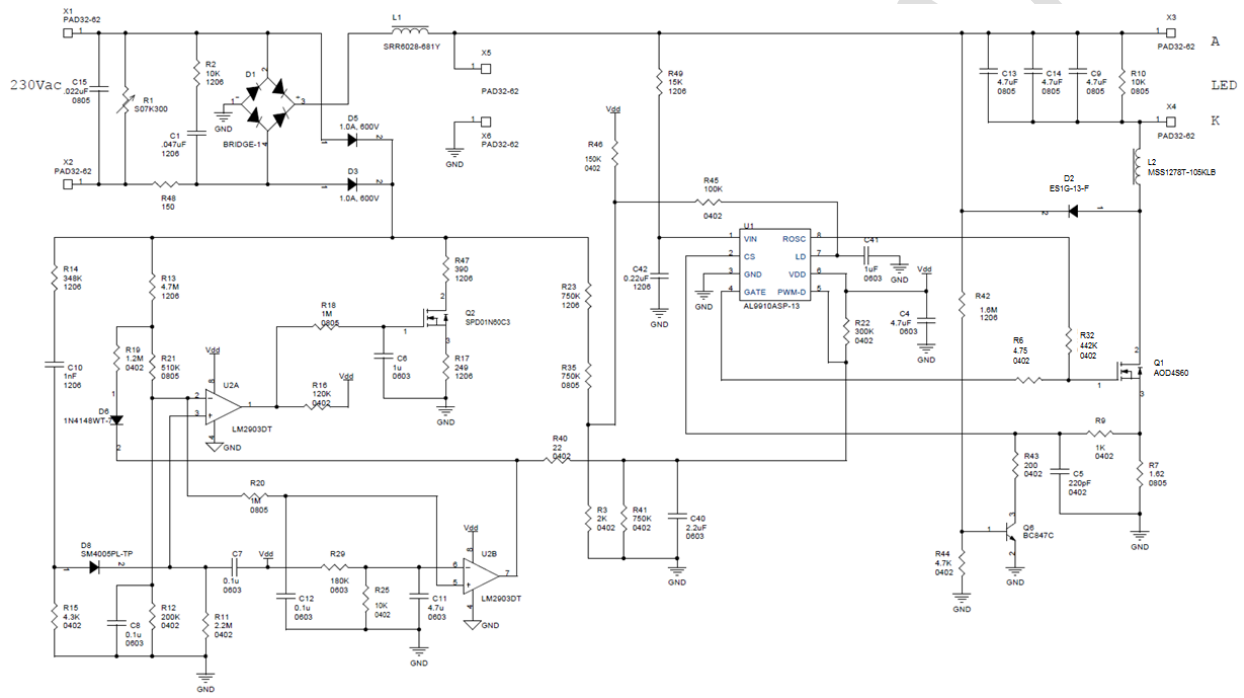


Figure 4: Evaluation Board Schematic

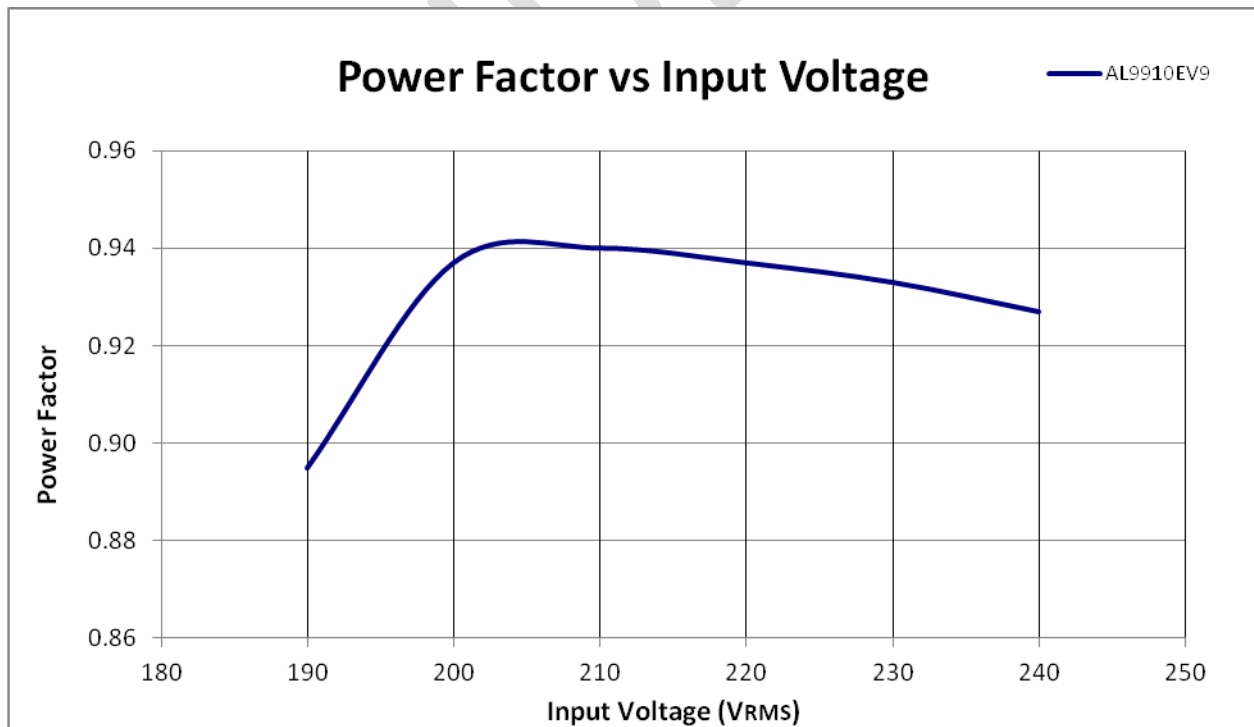
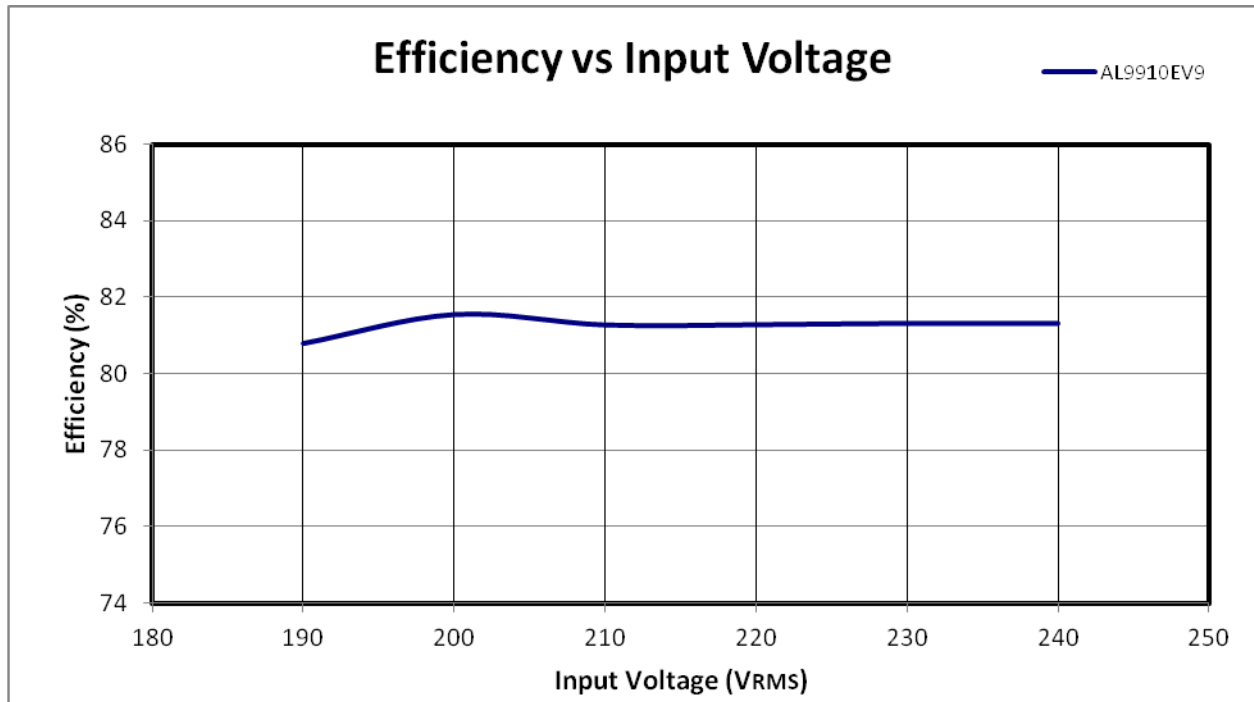
Bill of Material

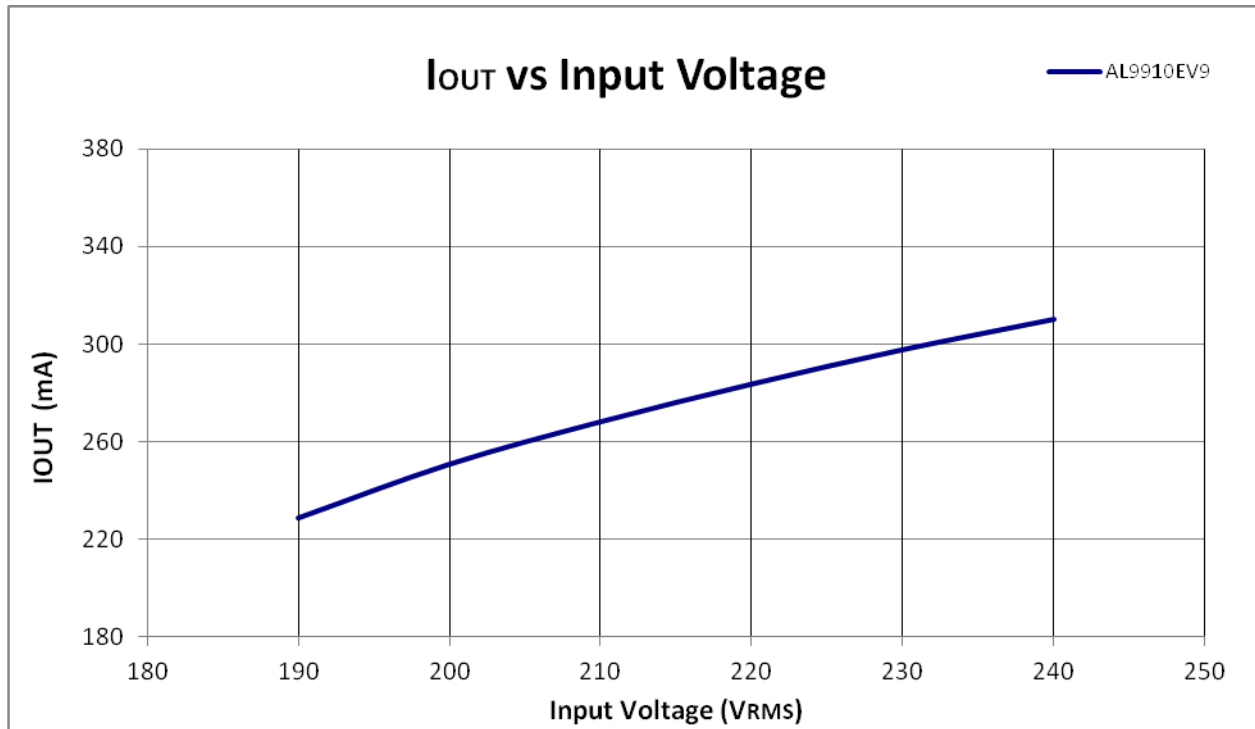
| Item | Comment | Description | Size | Qty | Manufacturer | Part Number |
|--------------------|------------------------|---|--|-----|------------------------|---------------------|
| C1 | C1206 - 0.047u 630V | Multilayer Ceramic Capacitors (1206) 0.047µF 630V 10% | C1206 | 1 | Murata | C3216X7T2J473M/SOFT |
| 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 | MCR18EZHJ475 |
| 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 | MCR18EZH2490 |
| 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





CONFIDENTIAL

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:

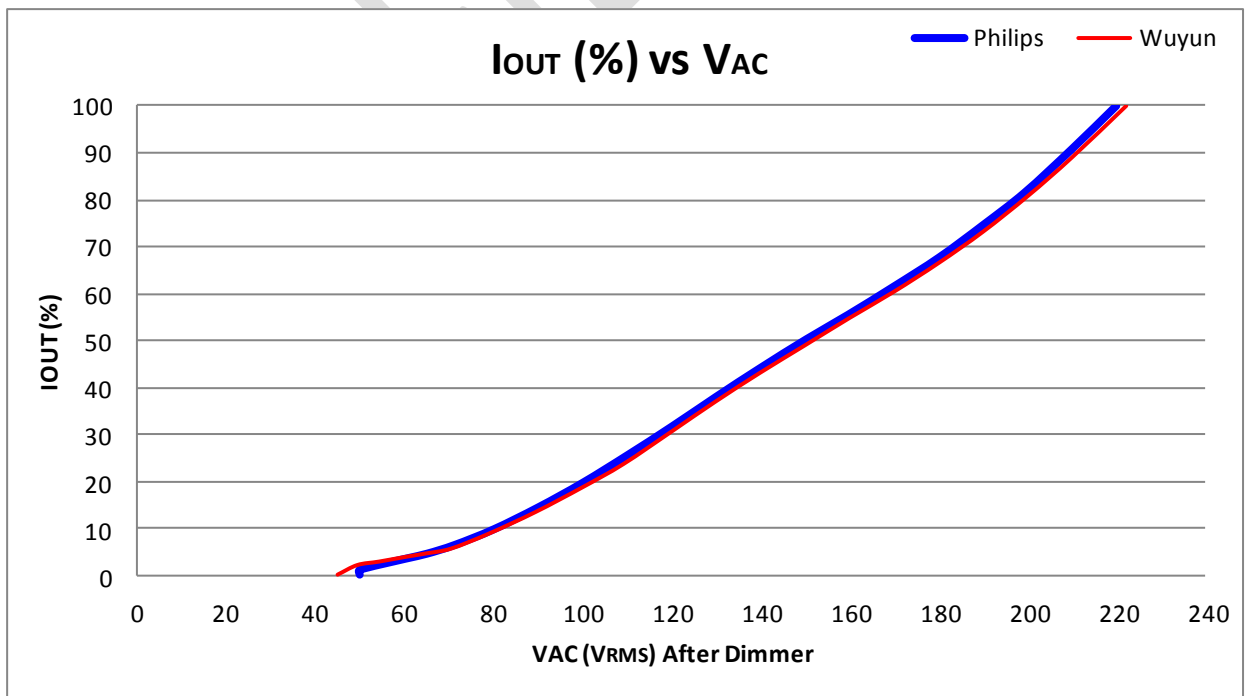
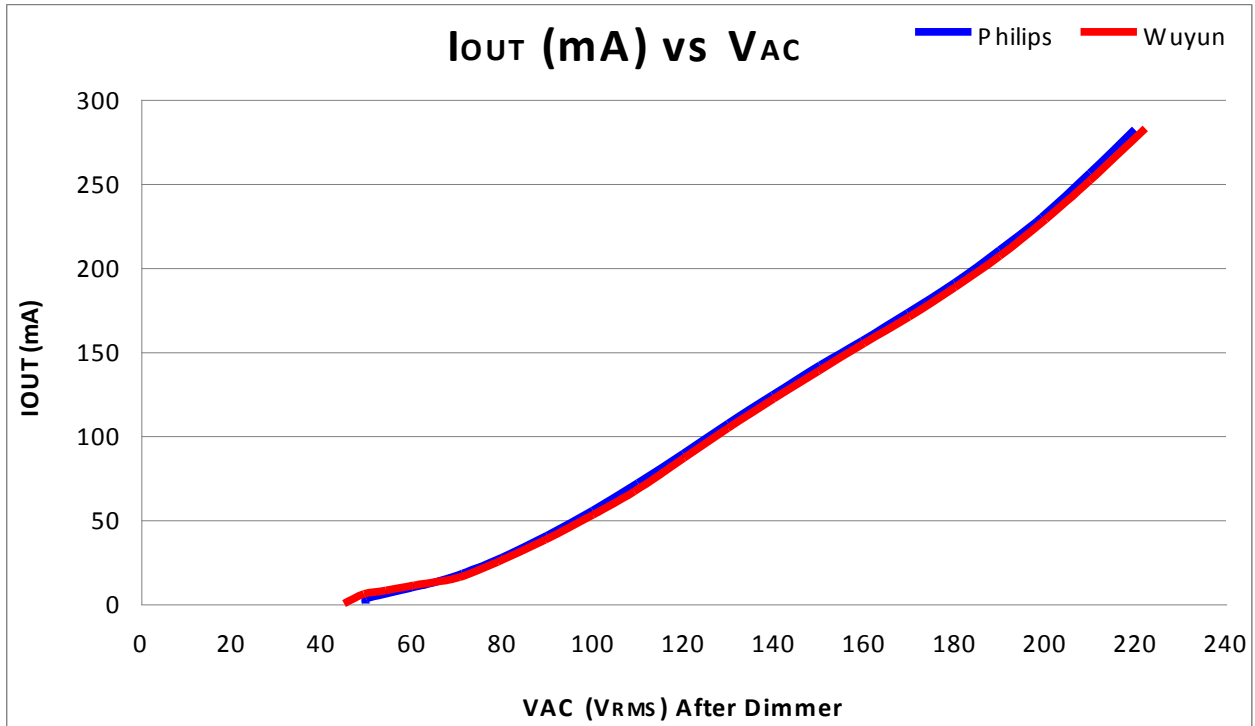
- 1) When dimmer's triac is conducting, it adds current necessary to keep triac conducting. Value of this current depends on R17 and Q2 V_{GS} voltage.
- 2) When dimmer's triac is OFF, Q2 is quickly discharging dimmer's capacitors. R28 makes it more stable and R47 is limiting U2A output current.

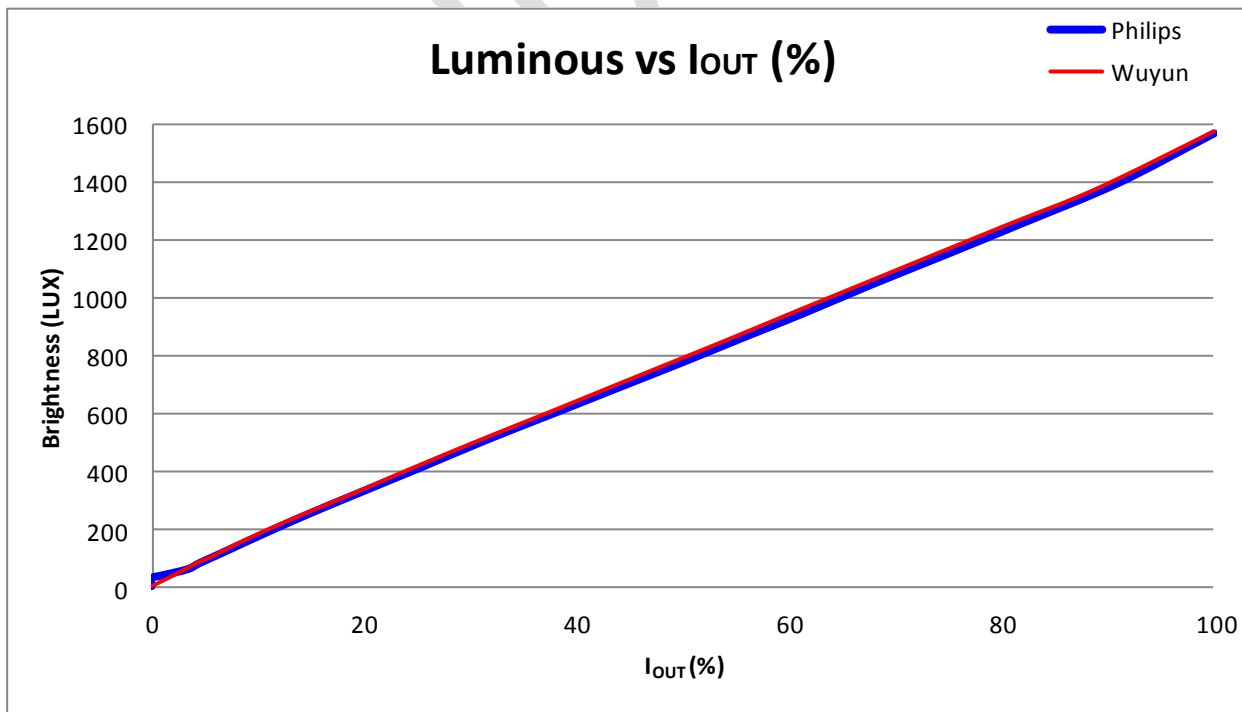
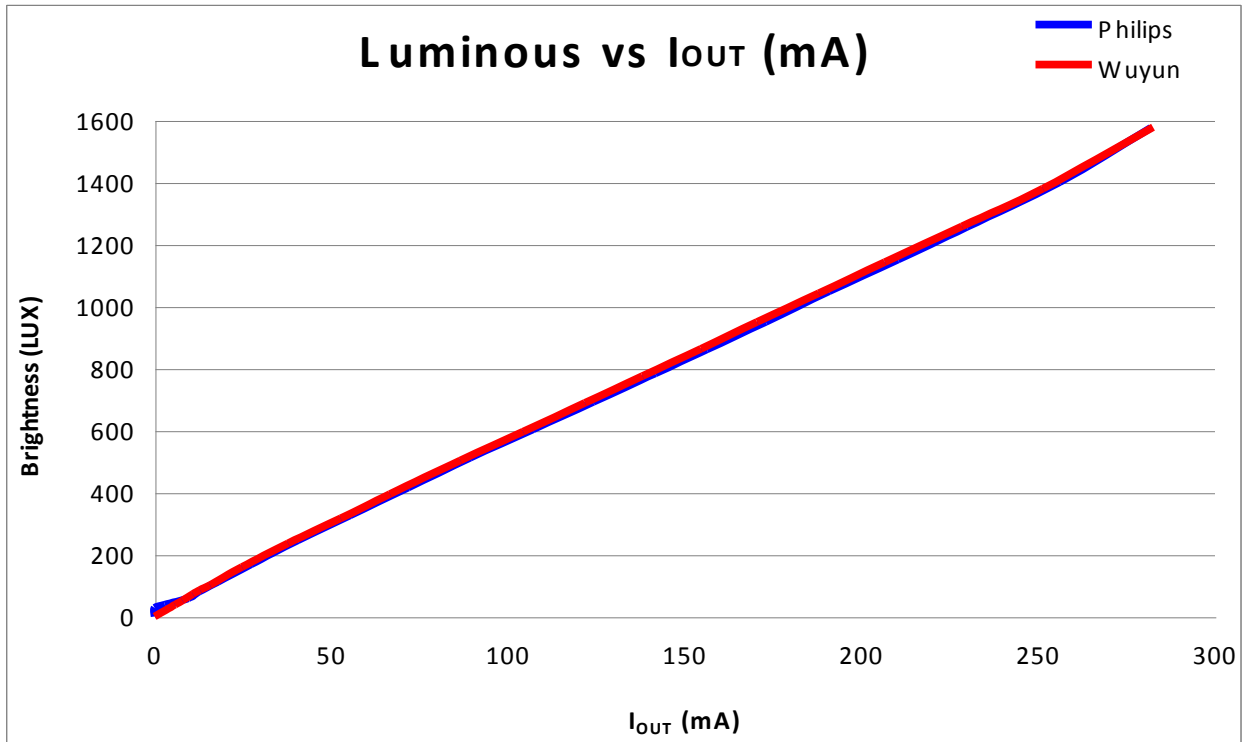
Schematic portion responsible for shutting down driver at a very low dimmer settings (low end) is assembled on U2B, R25, R29, R20, C12, C11, R40, R3, R40 and R41, which will prevent LED flickering.

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.

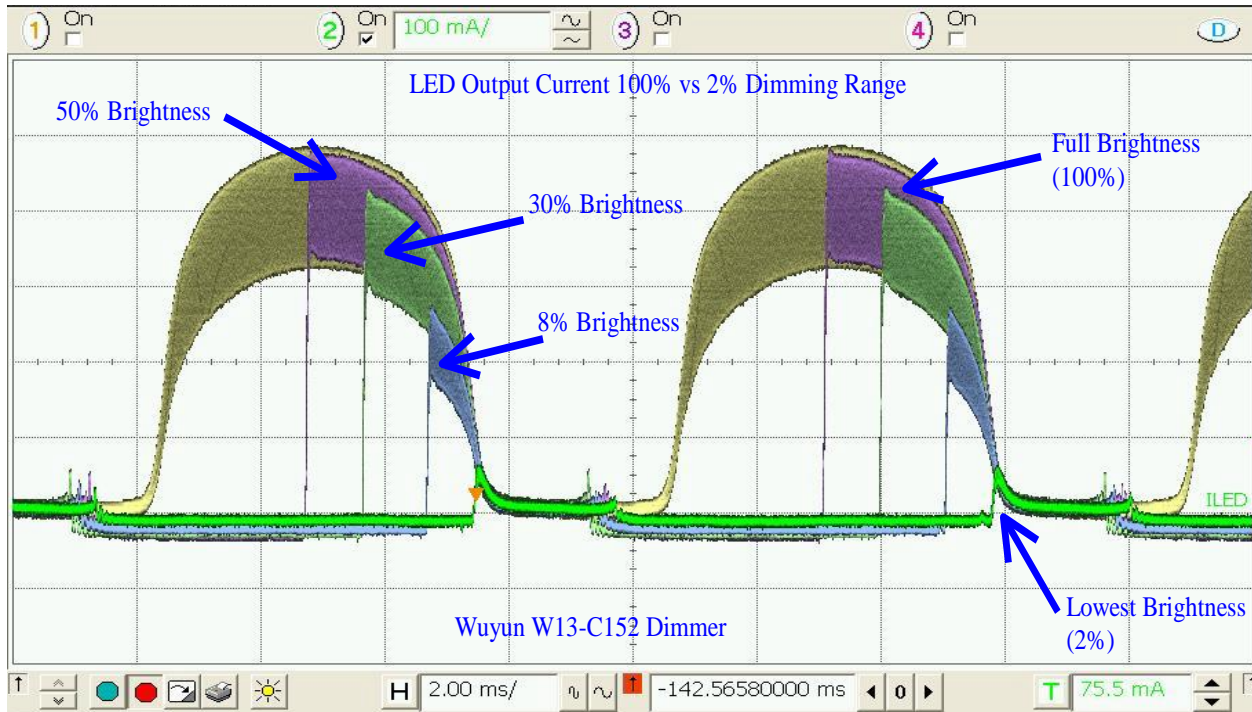
Dimming Performance

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

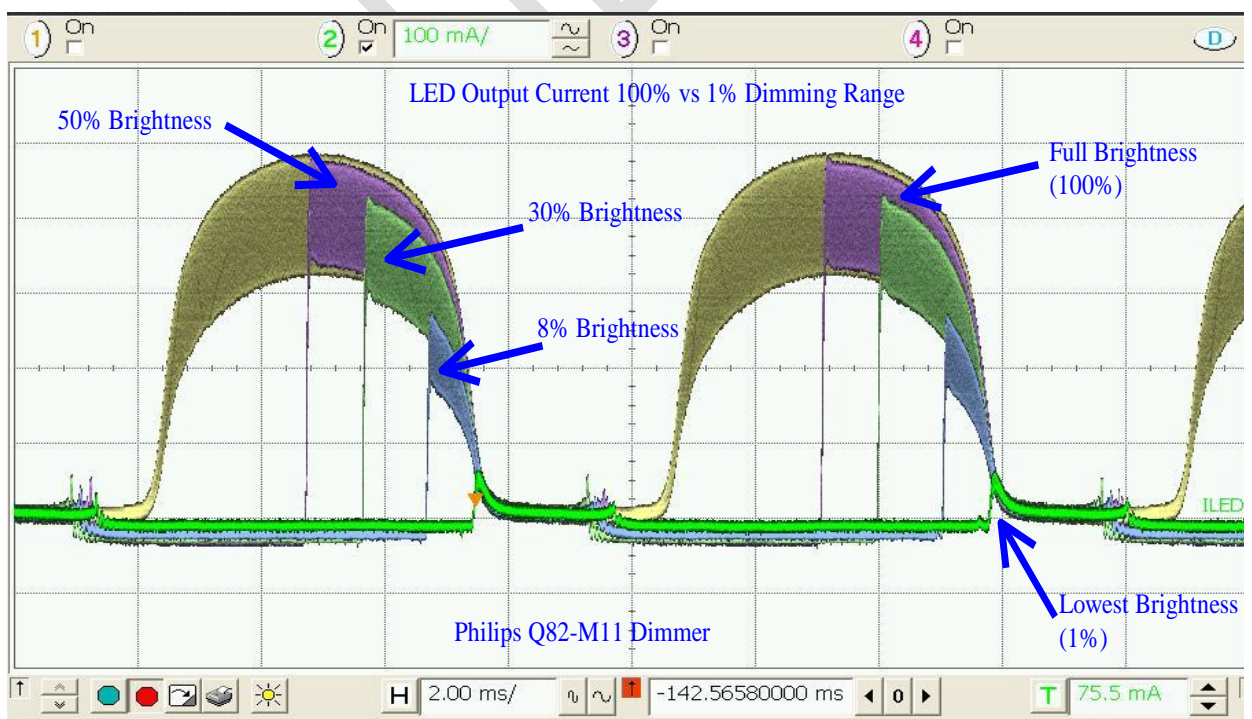




2) Wuyun W13-C152 LED Current Dimming Range Waveform



3) Philips Q82-M11 LED Current Dimming Range Waveform



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