LED Lighting Solutions
Quick Start Guide

With NXP Driver ICs

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Introduction

NXP's portfolio for LED lighting covers a wide range of applications, from low power, low cost, retrofit lamps to tube retrofit or higher power luminaires.

This booklet will provide designers with solutions that can easily be implemented using the design support material available on www.nxp.com (reference boards, schematics, Gerber files, user manuals…). It covers a full range of typical requirements, optimized for regional regulatory constraints.

NXP's LED drivers for lighting allow you to design for:

- High efficiency
- Small PCB area
- Very low component count
- Low cost system BOM
- Mains dimmable applications with high leading or trailing edge dimmer compatibility
- Accurate LED current
- High reliability, safety and lifetime

The solutions are based on the following product ranges:

- **SSL2108x / UBA3070:** a family of LED drivers for non-isolated applications that feature a very high efficiency and current accuracy, with a special focus on ease of integration, application size, and low system cost.
- **SSL2101 / SSL2102 / SSL2103:** a family of LED drivers compatible with mains dimmers, offering full flexibility on design parameters.
- **SSL4101:** for higher power applications when very high efficiency, high PF, and low THD are major targets.
- **Smart Lighting Networks:** hardware/software solution for connected light networks so you can create advanced lighting systems that are easily controlled by IP-enabled devices like Smartphones, Tablets, and PCs.

Designing a whole luminaire range is easy using NXP's full range of products that share the same core characteristics.

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1. SSL2108x / UBA3070 Non-Isolated LED Drivers

The SSL2108x and UBA3070 are a family of LED drivers for non-isolated applications that feature a very high efficiency and current accuracy, with a special focus on ease of integration, application size, and low system cost.

1.1 100V, 50-60 Hz, 7W, Non-Isolated, Non-Dimmable

The SSL21081 is a highly integrated switching mode LED driver which enables constant current driving from the AC mains input in a standard SO8 package. It is a solution for small LED retrofit lamp applications.

Key features include:

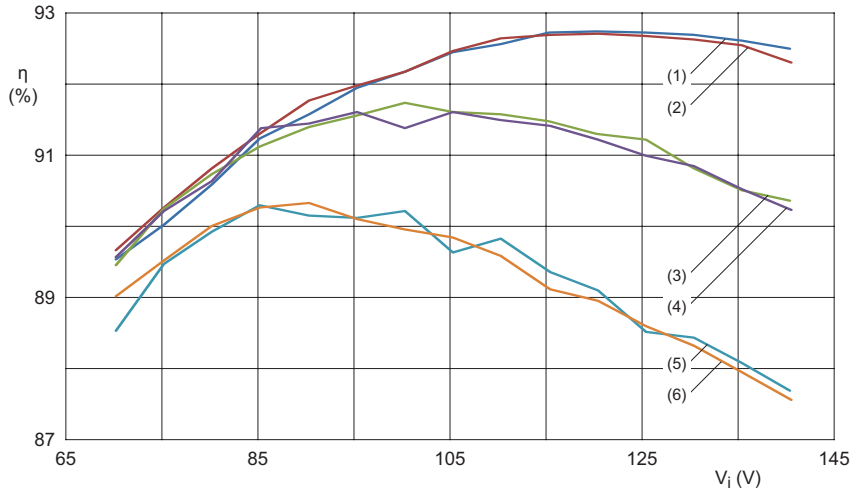
- Low BOM count: full application with 14 components is possible
- Small board size, fits E17, GU10
- High efficiency
- PWM dimming option
- External temperature control and protection option
- Compatible with wall switches with indication light

The SSL21081 supports buck converter topology and is suitable for non-isolated, non-dimmable LED retrofit lamps. It can drive a long LED string, up to a 70 V forward voltage and is most efficient with this type of LED module. The SSL2108x series is intended to operate at high output voltages. This board can be used in applications with small form factor lamp fittings, such as E17.

Table 1. Board Specifications

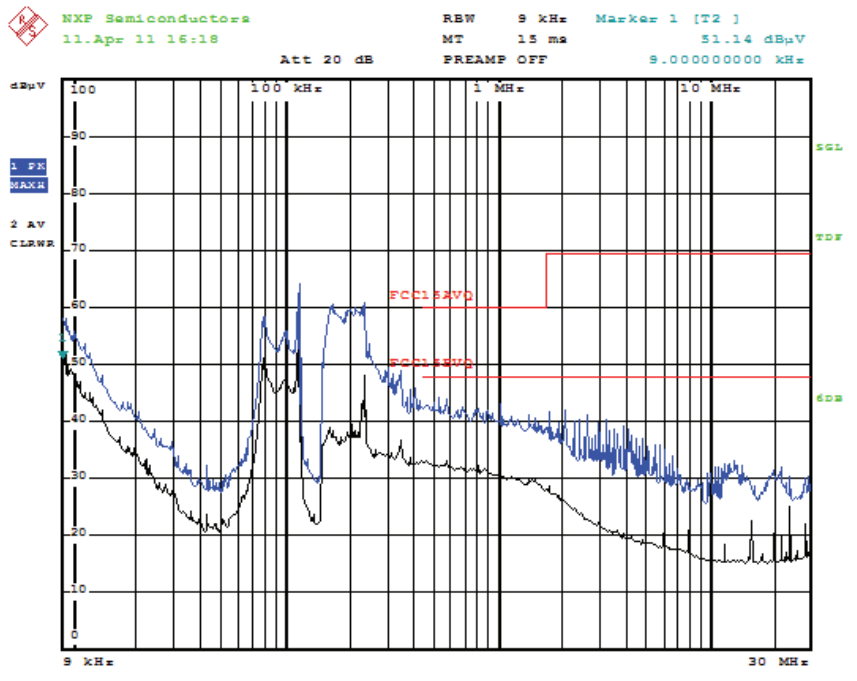
PARAMETER	VALUE	COMMENT
AC line input voltage	85 V to 138 VAC	The board is optimized for 100 V/60 Hz.
Output voltage	> 20 V (DC)	-
Output current	100 mA	at 100 VAC mains; 70 V LED
Output current dependency	better than ±5%	100 VAC ±10% at 70 V; 100 mA output
Efficiency	> 92%	100 VAC ±10% at 70 V; 100 mA output
Power factor	0.6	at 70 V; 100 mA output
Board dimension	22 x 18 x 12	Length x width x height in mm

SSL21081 Demo Board: Efficiency as a Function of Input Voltage for Different LED Configurations

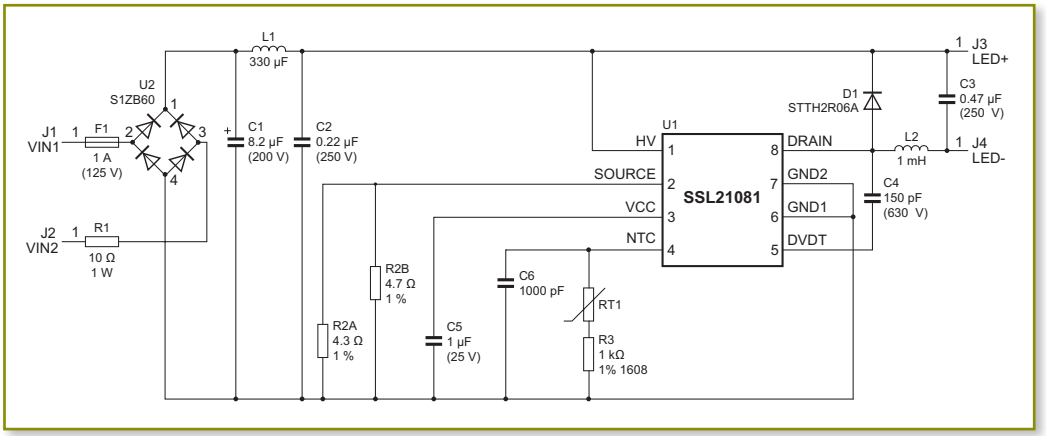


(1) 70 V; 50 Hz, (2) 70 V; 60 Hz, (3) 48 V; 50 Hz, (4) 48 V; 60 Hz, (5) 35 V; 50 Hz, (6) 35 V; 60 Hz

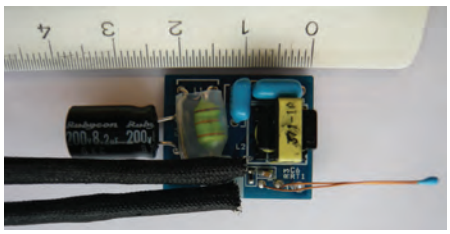
SSL21081 Demo Board: EMC Measurement L-Phase According to FCC15 Norm

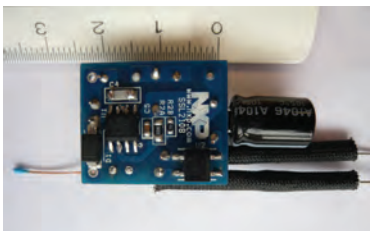


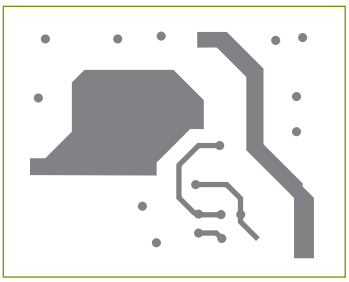
SSL21081 Board Schematic

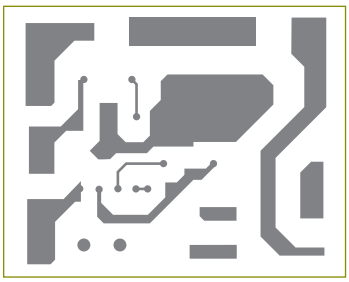


Actual SSL21081 PCB Photo and Layout









Further Reading: User Manual UM10482, Datasheet SSL2108x

Order Number (12nc): 9352 959 23598

Board ID: SSL21081DB01

1.2 100 V 50-60 Hz, 10 W-12 W, Non-Isolated, Non-Dimmable

The SSL21082 is a highly integrated switching mode LED driver which enables constant current driving from mains input. It is a solution for small LED retrofit lamp application's, especially for low-power factor design. This board can be used in applications with small form factor lamp fittings, such as E26.

Key features include:

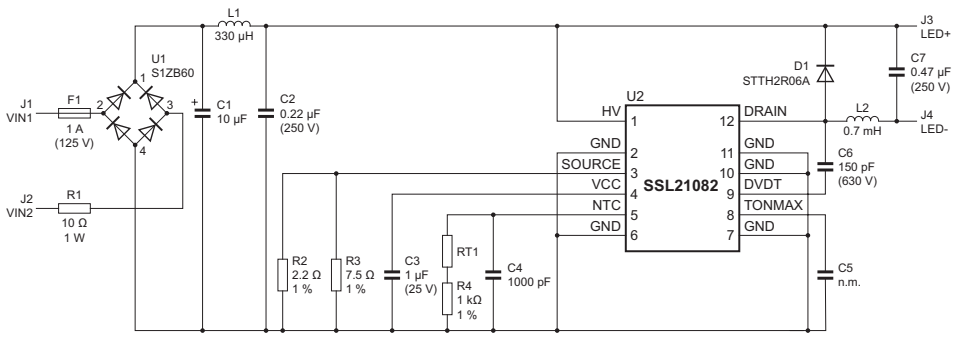
- Low BOM count, a full application is possible with 15 components
- High efficiency
- Small board size, fits E26
- PWM dimming option
- External temperature control and protection option
- Compatible with wall switches that have an indication light
- Brownout protection

The SSL21082 supports buck converter topology and is suitable for non-isolated, non-dimmable LED retrofit lamps. It can drive long LED strings with, for example, a 70 V forward voltage. The SSL2108 series is intended to operate with higher output voltages, as present in modern LED modules. It supports PWM dimming, is compatible with wall switches that have indication lights, and has an external temperature protection option to protect the board or the LEDs against over temperature.

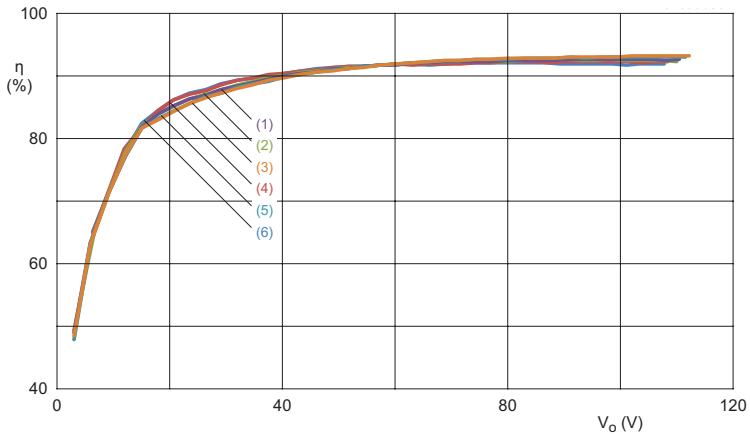
Table 2. Board Specifications

PARAMETER	VALUE	COMMENT
AC line input voltage	85 V to 138 VAC	The board is optimized for 100 VAC/60 Hz.
Output voltage	> 20 V (DC)	-
Output current	100 mA	at 100 VAC mains; 70 V LED
Output current dependency	better than ±5%	100 VAC ±10% at 70 V; 125 mA output
Efficiency	> 92%	100 VAC ±10% at 70 V; 125 mA output
Power factor	0.6	at 70 V; 125 mA output
Board dimension	30 x 19 x 12	Length x width x height in mm

SSL21082 Board Schematic

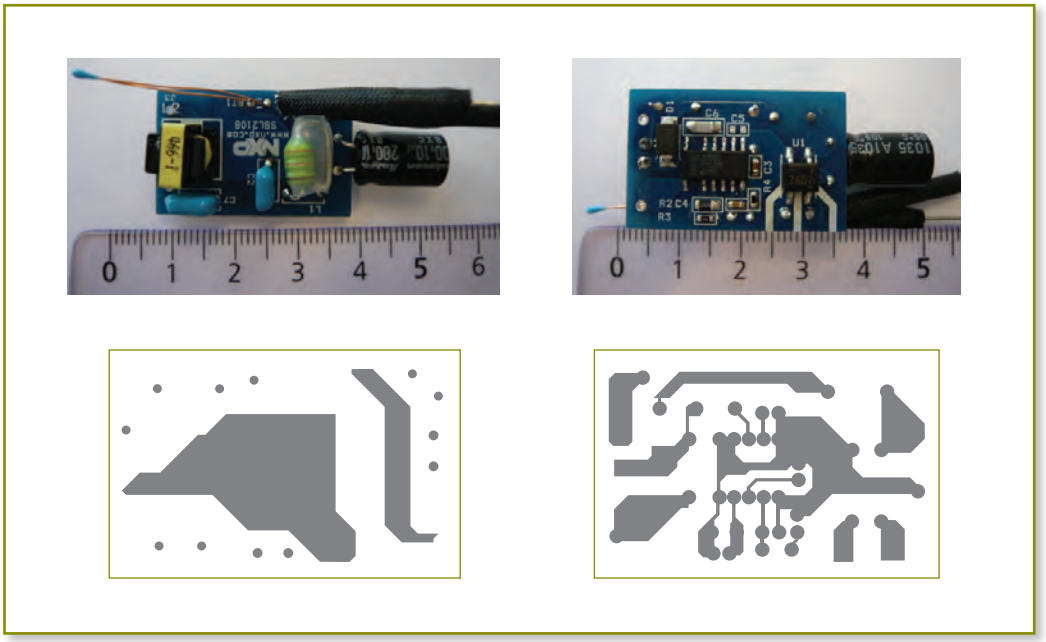


SSL21082 Demo Board: Efficiency as a Function of Output Voltage; for 100, 110, 120 VAC, 50-60 Hz



(1) 100 V; 50 Hz, (2) 100 V; 60 Hz, (3) 110 V; 50 Hz, (4) 110 V; 60 Hz, (5) 120 V; 50 Hz, (6) 120 V; 60 Hz

Actual SSL21082 PCB Photos and Layout



Further Reading: User manual UM10481, Datasheet SSL2108x

Order Number (12nc): 9352 959 25598

Board ID: SSL21082DB01

1.3 230 V, 50 Hz, 7.5 W-12 W, Non-Isolated, Non-Dimmable

The SSL21083 and SSL21084 are highly integrated switching mode LED drivers which enable constant current driving from the mains input. It is a solution for small LED retrofit lamp applications, especially for low-power factor design.

Key features include:

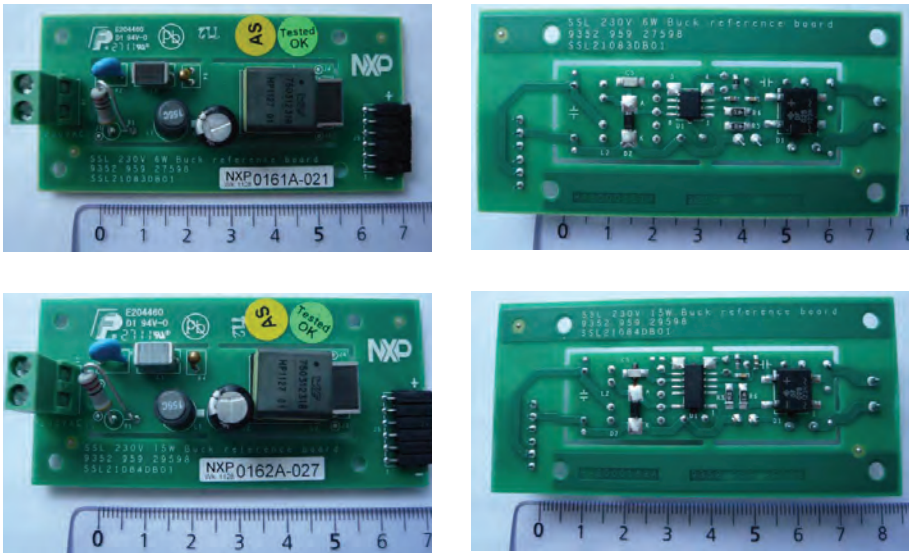
- High efficiency
- Small board size, fits GU10
- Low BOM count; full application with 14 components is possible
- Brownout protection (SSL21084)
- PWM dimming option
- External temperature control and protection option
- Compatible with wall switches with indication light

The SSL21083 and SSL21084 are buck converters that are controller suitable for non-isolated, non-dimmable LED retrofit lamps. They can drive long LED strings with, typically, 70 V forward voltages. The SSL2108x series is intended to operate with higher output voltages, as present in modern LED modules.

Table 3. Board Specifications

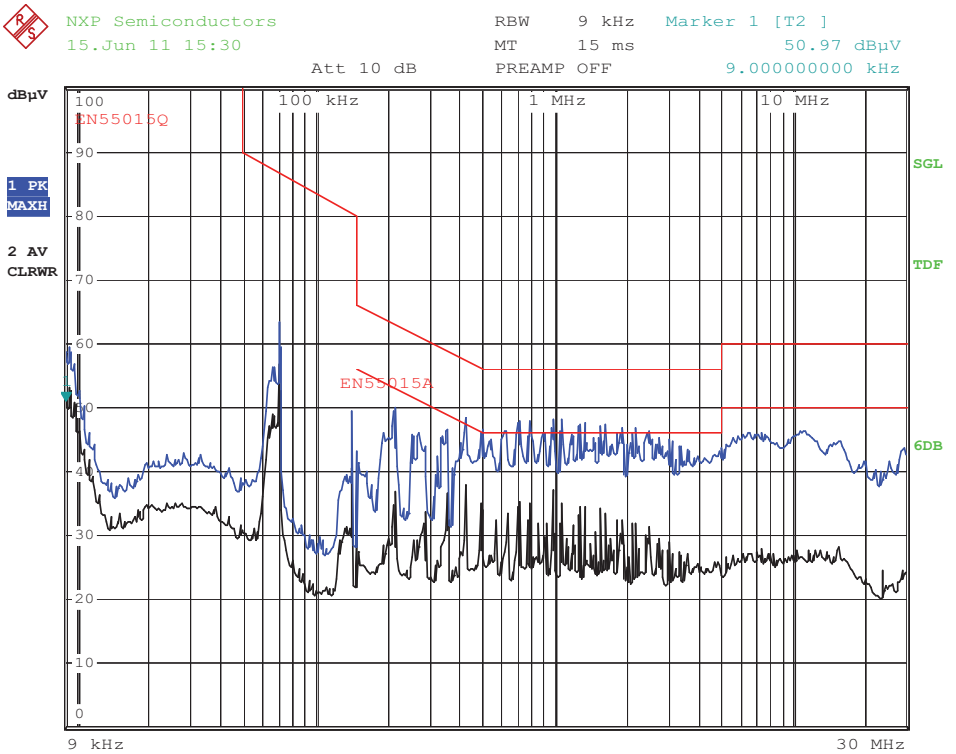
PARAMETER	VALUE	COMMENT
AC line input voltage	170 V (AC) to 260 V (AC)	optimized for 230 V (AC), 50 Hz
Output voltage	20 V (DC) to 130 V (DC)	-
Output current	96 mA at 92 V LED	±4% for 60 - 120 V LED
Maximum power into LED load	12.5W	-
Efficiency	> 94%	96 mA
Power factor	0.6 > 0.8	At 10 W; 70 V; 96 mA possible with lower efficiency
Board dimensions	17.5 x 53.5 x 17.5	Length x width x height in mm
NTC threshold	60 °C	Adjustable depending on NTC and R3
IEC61000-3-2 compliant	Yes	Po > 8.5W
IEC55015 compliant	Yes	-

PCB Photo (top: SSL21083; bottom: SSL21084)

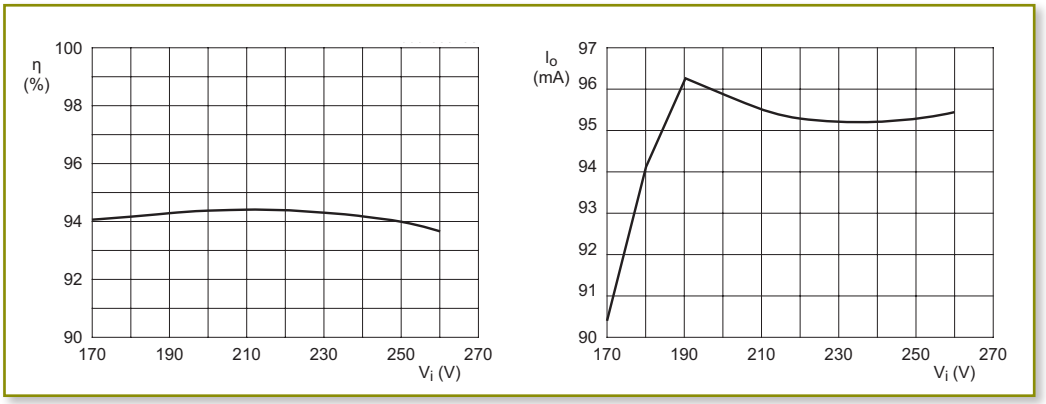


(1) Only inner part is needed for actual lamp.

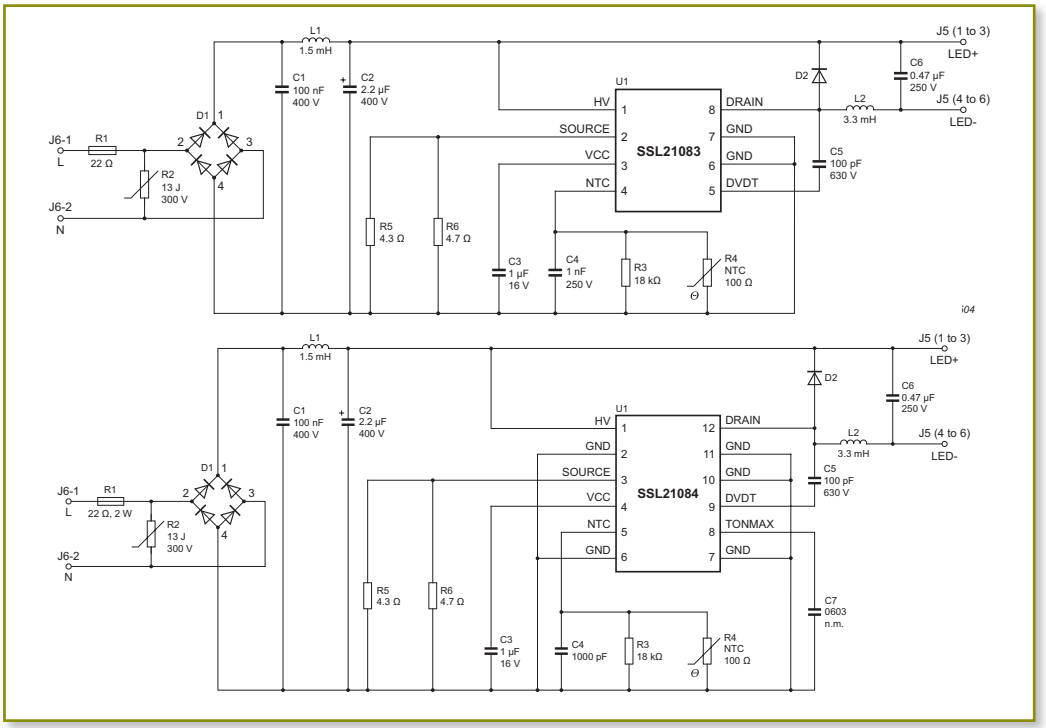
SSL21084 EMC Measurement L-Phase According to EN55015 Norm



SSL21083 Demo Board: Efficiency (left) and Output Line Regulation (right)



Board Schematics (top: SSL21083; bottom: SSL21084)



Further Reading: User Manual UM10501, Datasheet SSL2108x

Order Number (12nc): 9352 959 27598

Board ID: SSL21083DB01

Further Reading: User Manual UM10502, Datasheet SSL2108x

Order Number (12nc): 9352 959 29598

Board ID: SSL21084DB01

2. SSL2101 / SSL2102 / SSL2103 Mains Dimmable LED Drivers

The SSL210[123] is a family of LED drivers compatible with mains dimmers and offering full flexibility on design parameters.

2.1 120 V, 60 Hz, 7.5W, Isolated, Dimmable

This board is a 7.5W 120 V dimmable LED driver featuring the SSL2101. The board has a form factor that is compatible with the base of a GU10 LED lamp. The board uses a flyback converter to provide an isolated solution for mains-dimmable LED recessed-light applications.

Key features include:

- Wide dimming compatibility
- Deep dimming capability
- High power factor
- Small form factor, fits GU10
- Cost-effective

The board is available in two different versions, designed to support either a 5-LED or a 7-LED load with an output power of approximately 7.5W. The board operates at approximately 45 kHz and produces a regulated output current of 470 mA for the 5-LED load or 340 mA for the 7-LED load, with an efficiency of around 73%. Both versions are fully compliant with EMC regulations.

Table 4. Board Specifications

PARAMETER	VALUE	COMMENT
AC line input voltage	108 V (AC) to 132 V (AC)	Nominal input 120 V, 60 Hz
Output voltage	16 V 22 V	5-LED string load 7-LED string load
Output current	455 mA 330 mA	5-LED; ±3.5% 7-LED; ± 3.5%
Efficiency	73%	
Power factor	0.93 0.945	5-LED string load 7-LED string load
Output current ripple	30% 22%	5-LED string load 7-LED string load
Output current regulation	better than ±5%	±10% offset nominal line voltage

SSL2101 Board Dimensions and Photo

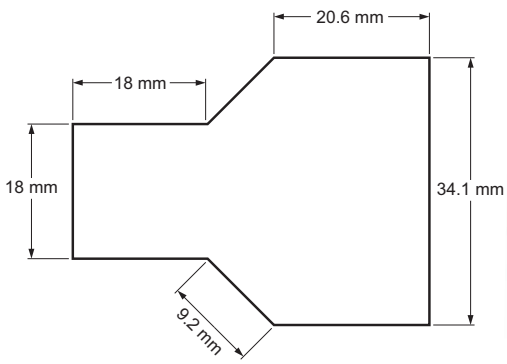
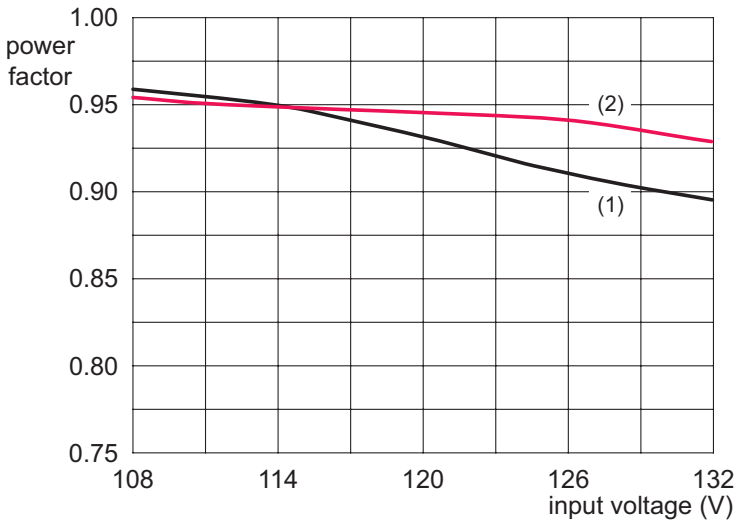


Table 5. Dimmer Compatibility

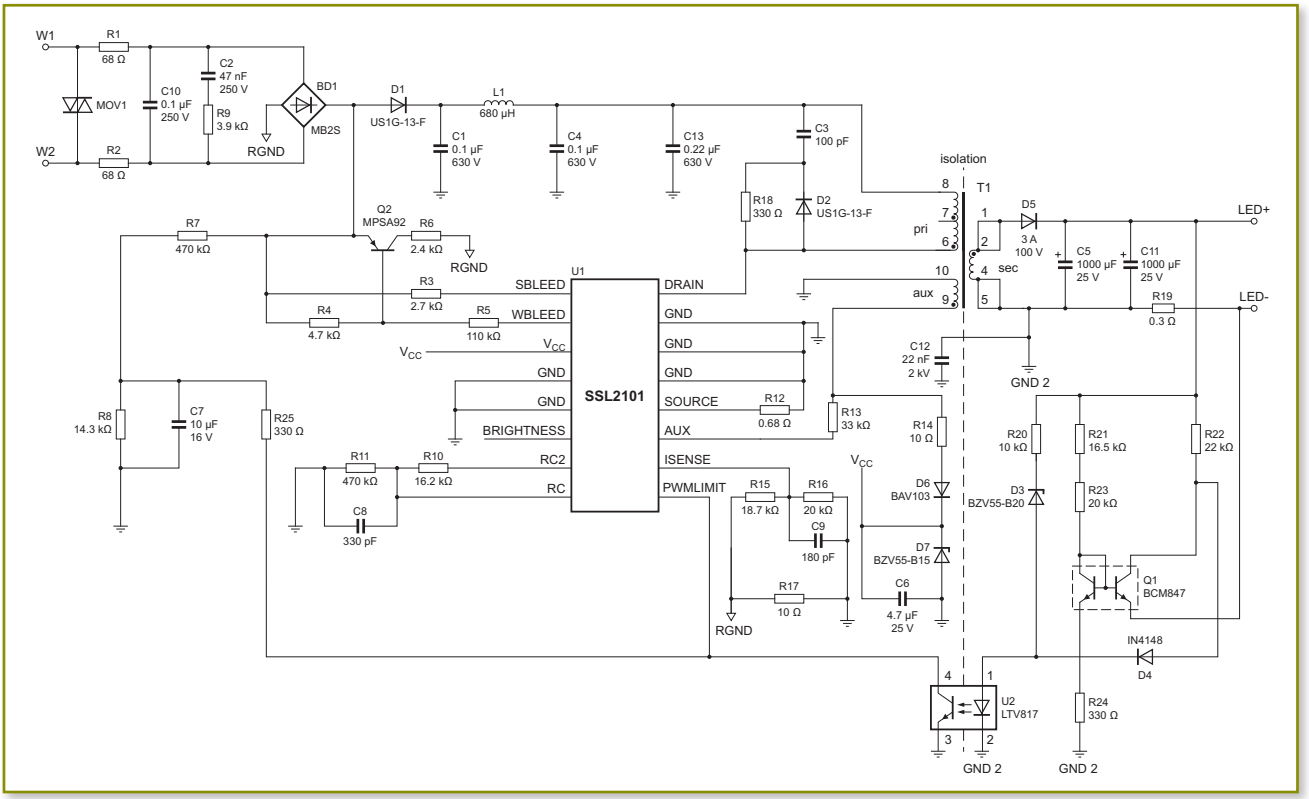
MANUFACTURER	TYPES
LUTRON	S-600, S-600P, S-600-H, TG-600PH, DVW-600PH, DVW-603GH, DVM-600PH, DV-603PG, DV-600P, DV Beta Build, CTCL-153PDH, GL-600PH, Credenza S31
LEVITON	6631, 6602, 6602-I, RPI06

SSL2101 Demo Board: Power Factor Over Input Voltage Range



(1) 5-LED (2) 7-LED

SSL2101 Board Schematic



Further Reading: User Manual UM10479, Datasheet SSL2101

Order Number (12nc): 9352 962 53598

Board ID: SSL2101DB05

2.2 120 V, 60 Hz, 7W, Non-Isolated, Dimmable

This board is a 7W 120 VAC triac dimmable LED driver featuring SSL2101. The board has a form factor that is compatible with the base of a GU10 LED lamp. The buck converter topology provides a simple and efficient solution for mains-dimmable LED recessed light applications not requiring galvanic isolation.

Key features include:

- Deep dimming capability
- Wide dimmer compatibility
- High power factor
- Small form factor, fits GU10
- Cost-effectiveness

The board is designed to drive a 5-LED load, delivering an output power of approximately 7W. The typical operating frequency is 54 kHz, and the reference board produces a steady output current of 440 mA at an efficiency > 73%. The board is fully compliant with EMC regulations.

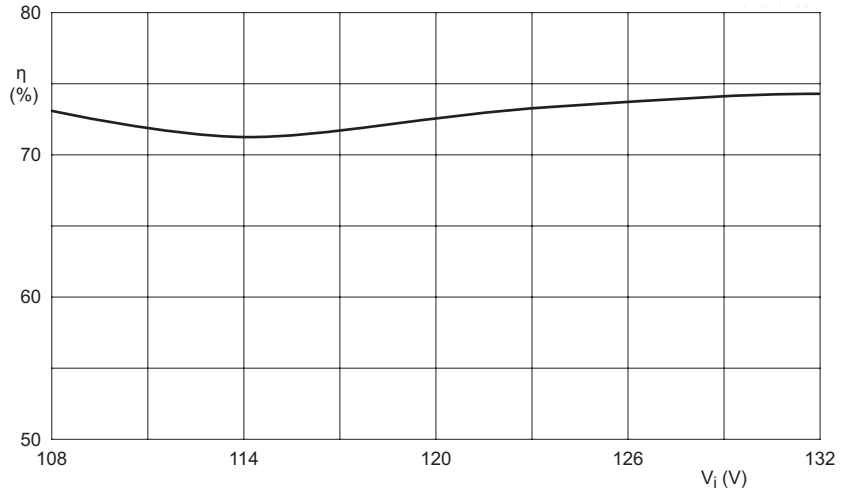
Table 6. Board Specifications

PARAMETER	VALUE	COMMENT
AC mains supply voltage	108 V (AC) to 132 V (AC)	nominal line input 120 V (AC), 60 Hz
Output	16 V; 440 mA	load: 5-LED string
Output current ripple	11.4%	-
Output current regulation	+11.8%; -10%	±10% offset nominal line voltage
Efficiency	>73%	-
Power Factor	0.924	-

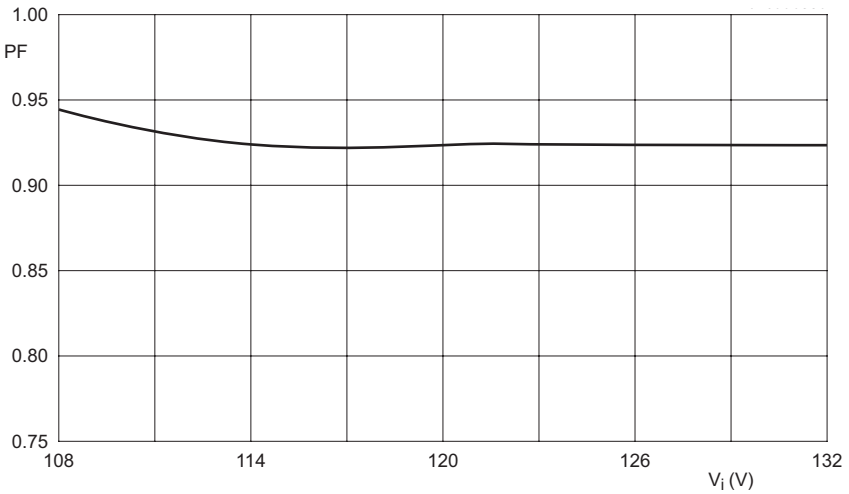
Table 7. Dimmer Compatibility

MANUFACTURER	TYPES
LUTRON	S-600, S-600P, S-600-H, TG-600PH, DVW-600PH, DVW-603GH, DVM-600PH, DV-603PG, DV-600P, DV Beta Build, CTCL-153PDH, GL-600PH, Credenza S31
LEVITON	6631, 6602, 6602-I, RPI06

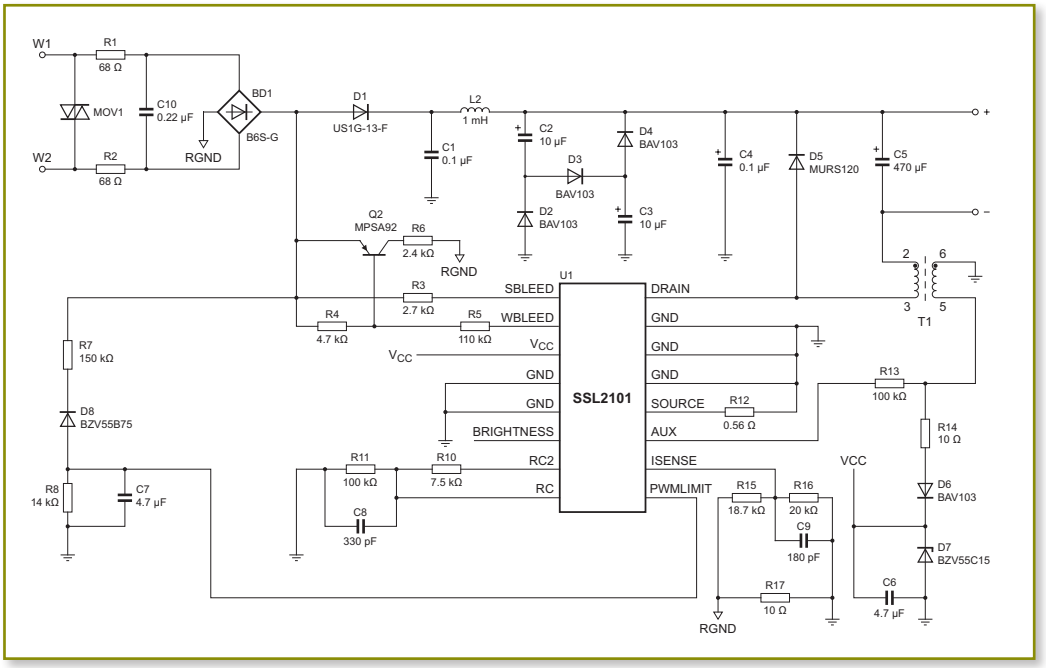
SSL2101 Demo Board: Efficiency as a Function of AC Mains Input Voltage



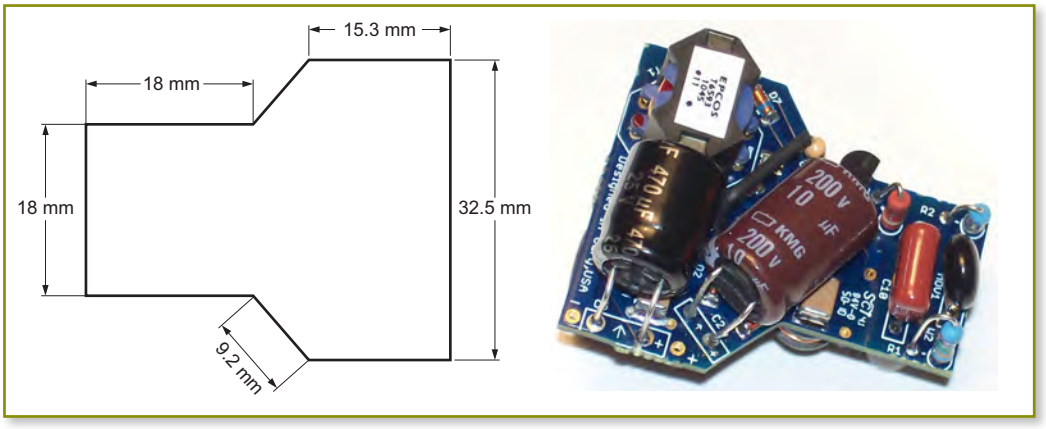
SSL2101 Demo Board: Power Factor as a Function of AC Mains Input Voltage



SSL2101 Board Schematic



SSL2101 Demo Board: PCB Dimensions and Photo



Further Reading: User Manual UM10485, Datasheet SSL2101

Order Number (12nc): 9352 962 54598

Board ID: SSL2101DB06

2.3 230 V, 50 Hz, 12 W, Non-Isolated, Dimmable

This circuit implements a Boundary Conduction Mode (BCM) buck converter using the SSL2103. It is mains-dimmable for both leading edge (triac) and trailing edge (transistor) dimmers. It is designed for demonstrating high performance and high efficiency. It produces a 400 mA regulated output current to drive 10 LEDs at a 230 V (AC) input. Efficiencies of up to 85% can be achieved.

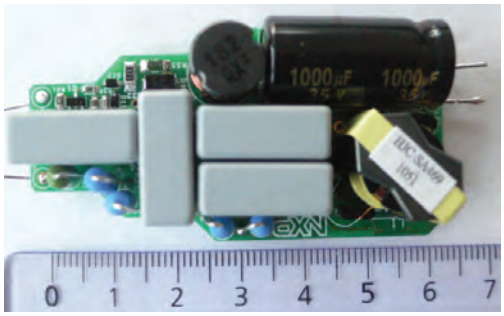
Key features include:

- Buck converter operating in Boundary Conduction Mode (BCM)
- Active damper and inrush current limiter
- Mains-dimmable with leading and trailing edge dimmers
- Intrinsically protected against short circuit
- Fits E27

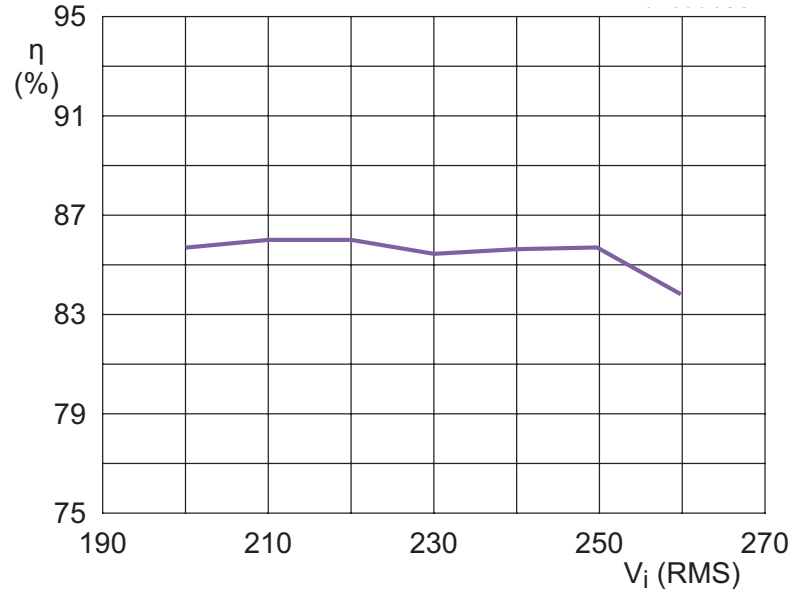
Table 8. Board Specifications

PARAMETER	VALUE	COMMENT
AC input voltage	200 V (AC) to 260 V (AC)	optimized for 230 V (AC) with 10% variation
Output voltage	31 V (DC)	10 LEDs connected
Output voltage protection	36 V (DC)	-
Output current	400 mA	At nominal input voltage
Output power	12.5 W	10 LEDs connected
Efficiency	> 85%	At nominal input voltage
Power factor	> 0.8	at nominal input voltage
Load current accuracy	better than 10%	at Tamb = 25 °C; Vi = 230 V (AC), ±10%
Dimming range	100% to10%	For triac dimmer
Board dimensions	63x 32 x 18	Length x width x height in mm

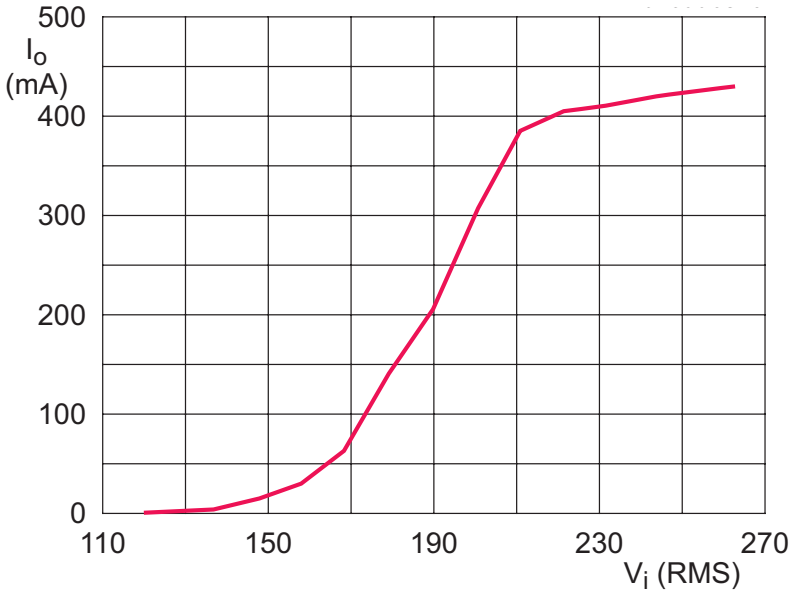
SSL2103 Demo Board Photo



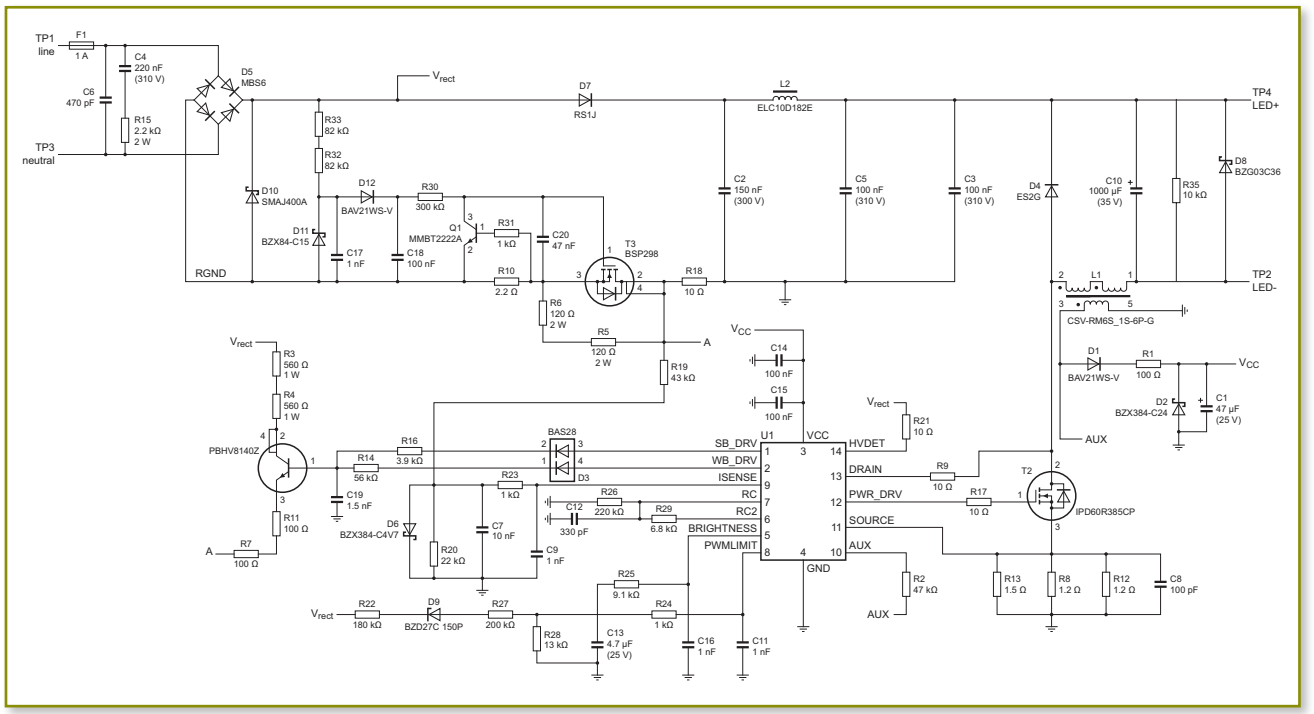
SSL2103 Demo Board: Efficiency as a Function of Input Voltage



SSL2103 Demo Board: Dimming Curve : Output current as a Function of Input Voltage



SSL2103 Board Schematic



SSL2103 Demo Board: Conducted Emissions for Line: AC Input = 230 V at 50 Hz (EN55015)

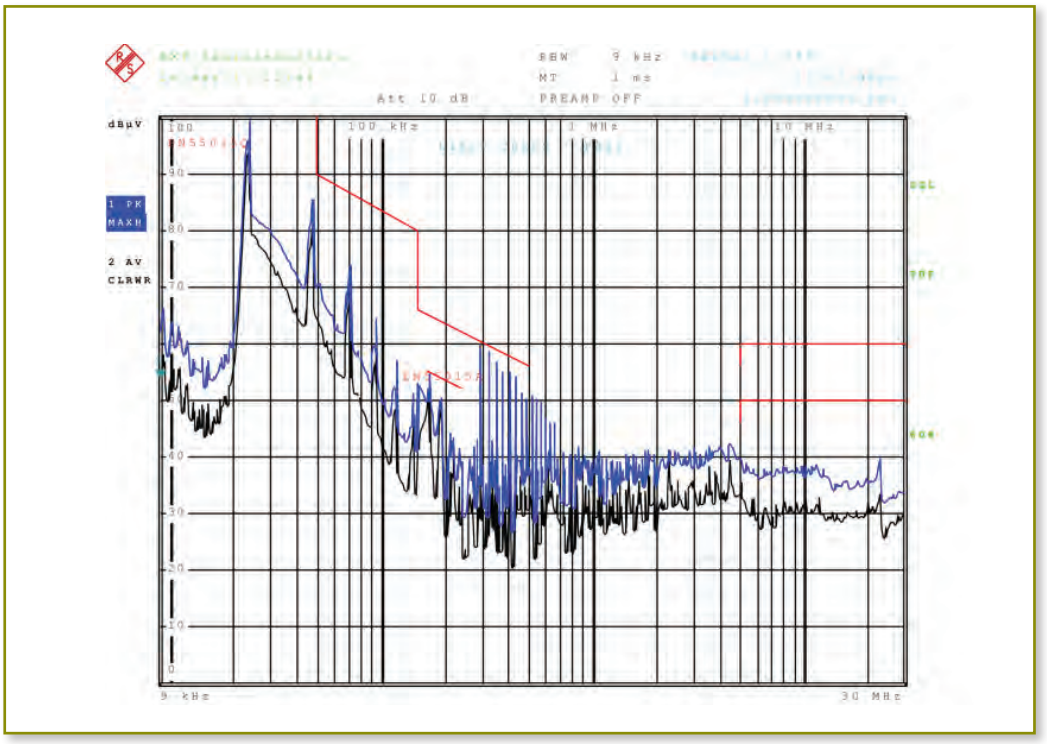


Table 9. Tested TRIAC Dimmers

MANUFACTURER	TYPE
Berker	2819
Berker	2873
Bush-Jaeger	2250U
Bush-Jaeger	2200U
Ehmann	T10
Gira	0300
Gira	1184
Opus	852.390x

Table 10. Tested Transistor Dimmers

MANUFACTURER	TYPE
Jung	243 EX
Jung	225 TDE
Berker	2874
Berker	286710
Bush-Jaeger	6513U
Gira	0307
PEHA	433 HAB
Legrand	784.06

Further Reading: User Manual UM10474, Datasheet SSL2103

Order Number (12nc): 9352 956 58598

Board ID: SSL2103DB04

3. SSL4101 High Power LED Driver

The SSL4101 is intended for higher power applications when very high efficiency, high PF, and low THD are major targets.

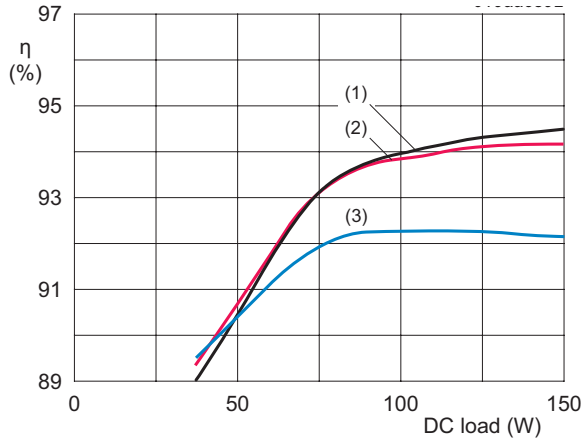
3.1 Universal Mains, 150W, High Efficiency, 4-Channel LED Driver

This board combines the SSL4101 AC-to-DC SSL driver, the TEA1761 synchronous rectifier, and UBA3070 DC-to-DC buck controller IC for maximum flexibility and performance. The overall efficiency for the unit from AC input to 4-channel DC output is 92%. The complete solution meets all safety and EMI regulations. Typical applications include street lighting, parking garage and area lighting, industrial high-bay and low-bay lighting and commercial interior lighting.

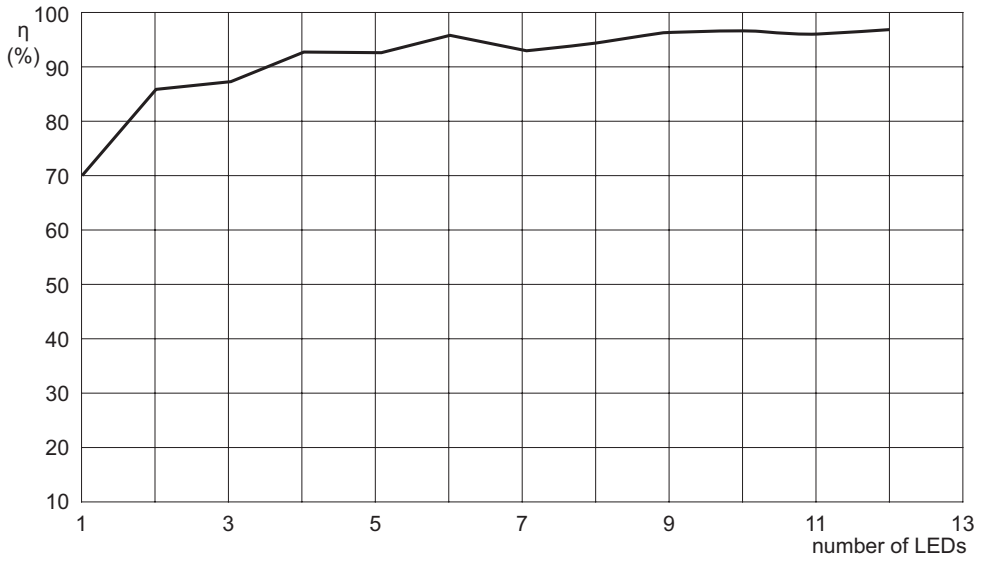
Key features include:

- 4-channel current output, 1A per channel @ 36 V (DC)
- Highly efficient > 90%
- High power factor > 0.90
- Universal mains: input 108-305 V (AC)
- Low input current total harmonic distortion (THD) < 10% (at full load)
- 4 x PWM dimming input control
- Small form factor
- Low BOM count.

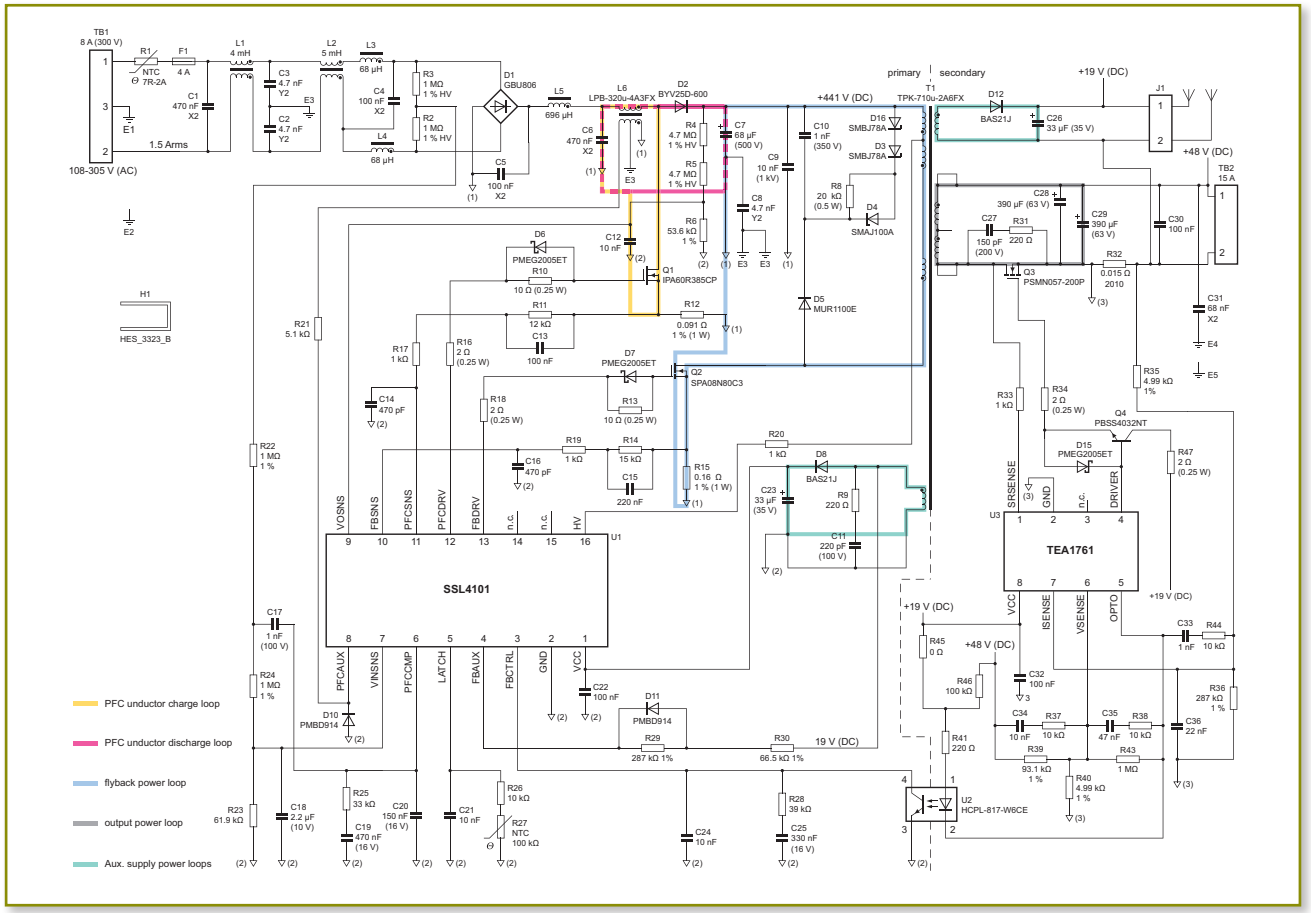
SSL4101DB01 Efficiency (η)
AC-DC converter as a function of DC output power (Po); (1) 277V; (2) 230V; (3) 120V



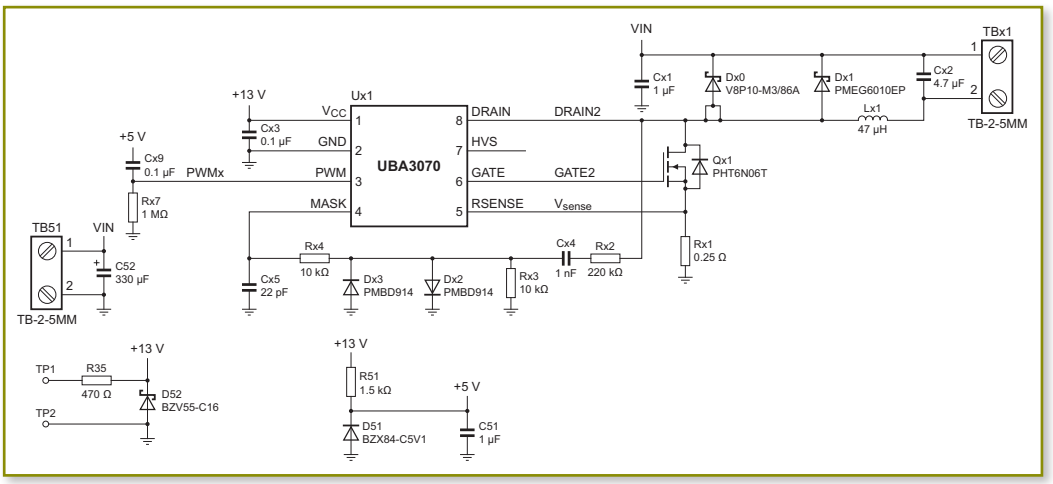
SSL4101DB01 Efficiency (η)
DC-DC convert as function of number of LEDs



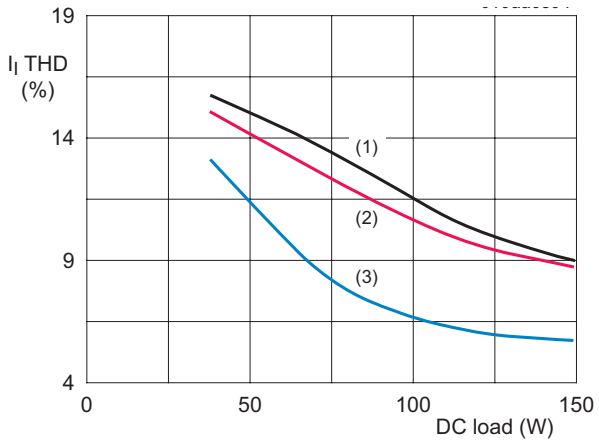
Schematic of the PFC+FB Controller SSL4101 together with the Synchronous Rectifier TEA1761



Schematic of one of the 4 DC-DC Buck Converters with the UBA3070



SSL4101DB01 Input Current (I_I) THD as a Function of DC Output Power (P_o)



(1) 277V (AC); (2) 230V (AC); (3) 120V (AC)

150W 4-Channel High Efficient LED Driver with SSL4101 and UBA3070

Further Reading: User Manual UM10469, UM10478, Datasheet SSL4101, UBA3070

Order Number (12nc): 9352 954 98598

Board ID: SSL4101DB02

4. Smart Lighting

Our complete hardware/software solutions enable IP connectivity, where every light bulb has its own IP address, so you can create advanced lighting systems that are easily controlled by devices such as smartphones, tablets and PCs.

4.1 120 V, 15W Smart Lighting Reference Design LED Lamp

15 W dimmable SSL2108 LED driver, using the SSL21081.

Key features of the LED driver include:

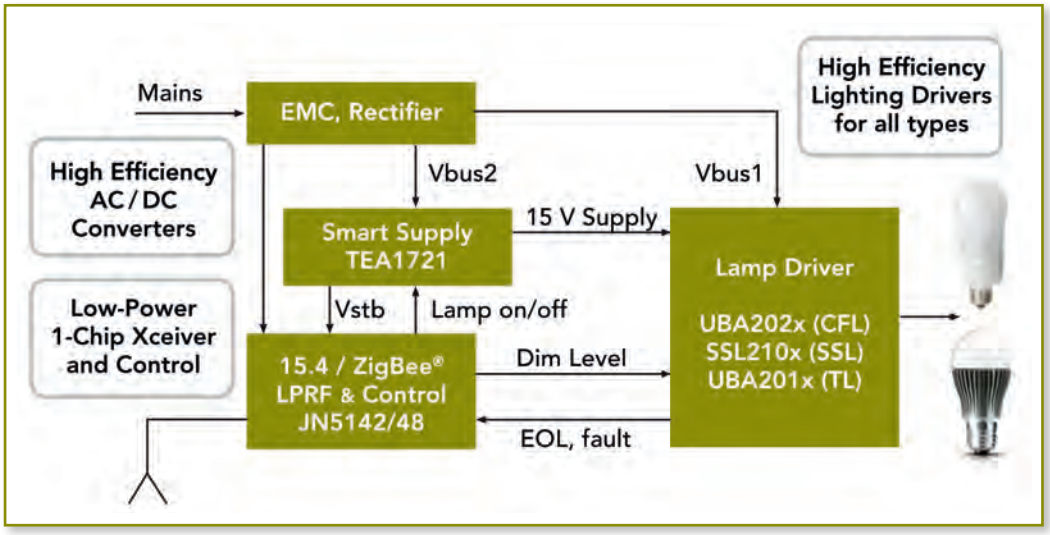
- True constant-current source
- PWM dimmable
- Buck mode, efficiency > 95%
- NTC temperature feedback
- No LED forward voltage required
- Low BOM cost and small size
- Extensive protections
- SO8 package

Key features of the RF board include:

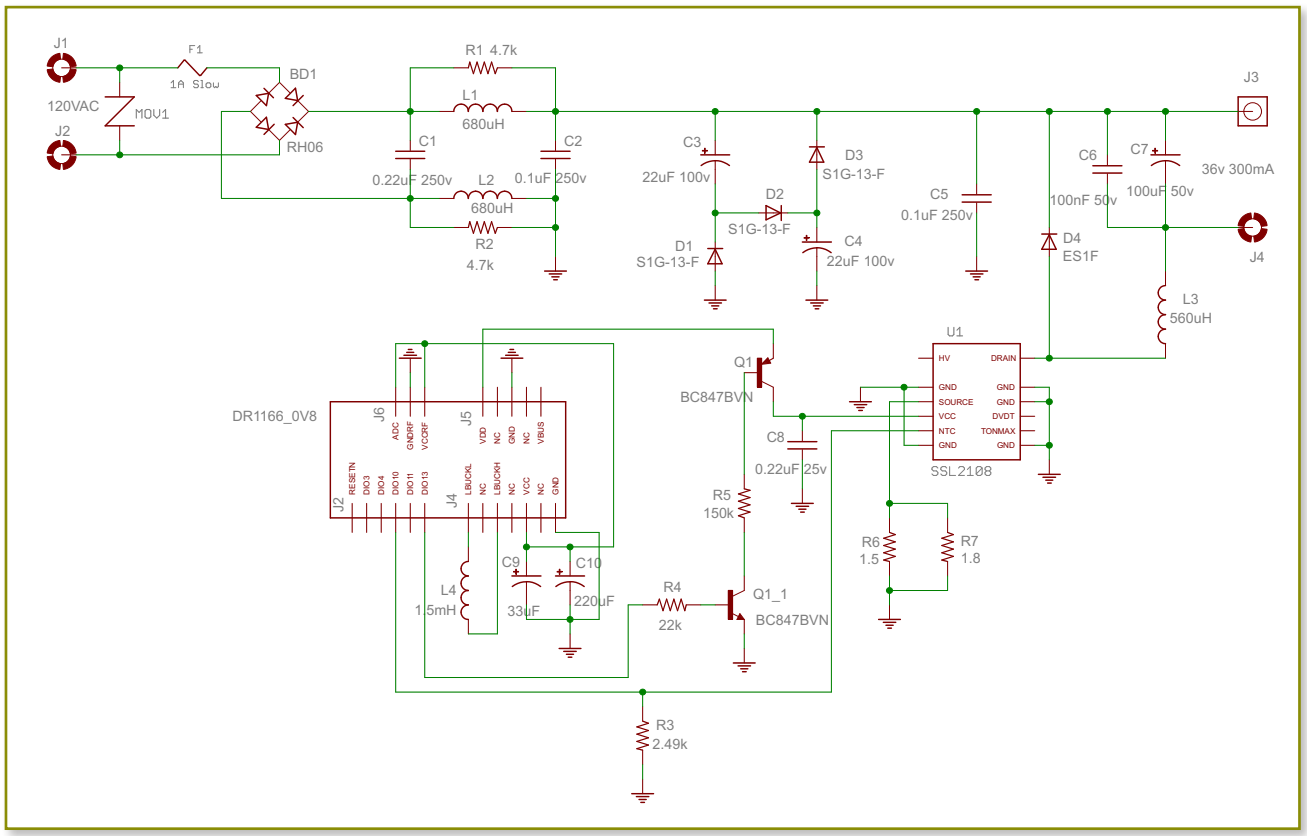
- 2.4 GHz IEEE 802.15.4 compliant
- Low operating power: 15/17.5 mA Tx/Rx
- Low sleep current: 0.1 µA deep sleep with IO-wake-up, 0.5 µA with timer running
- 98 dB link budget
- 128-bit AES encryption security processor
- Various MAC accelerator functions
- High-performance 32-bit, 32 MHz RISC CPU
- 128 kB ROM, 32/128 kB RAM
- Extensive set of peripherals, including I2C, SPI, UART, ADC, DAC, PWM, timers, GPIO
- On-chip temperature sensor
- QFN40/56 package

Additional information is available upon request.

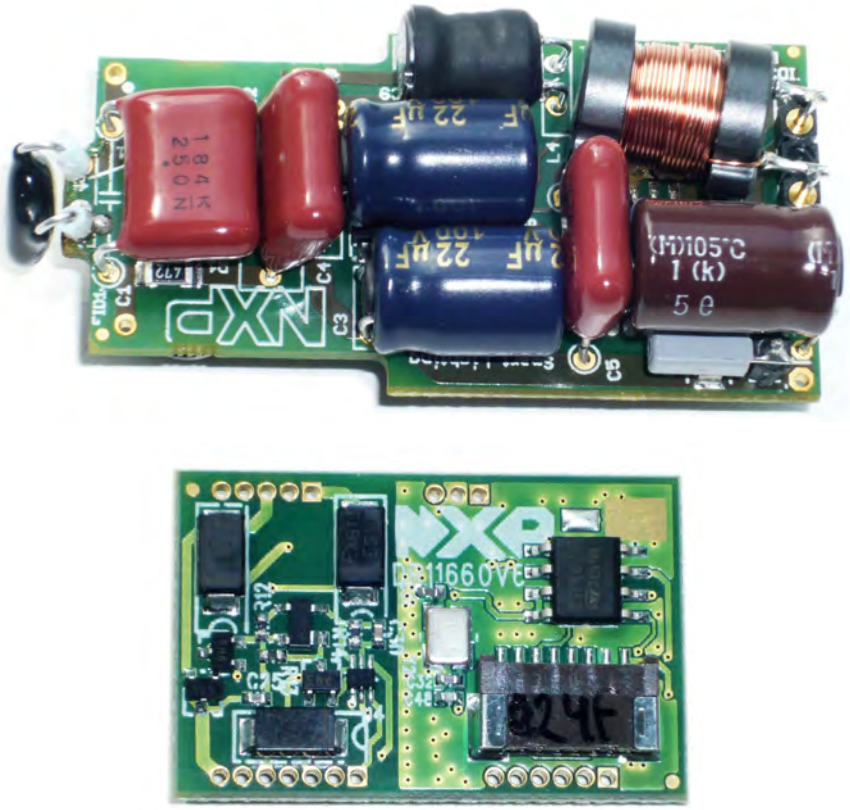
NXP Smart Lighting Solutions Platforms



15W Smart Lighting Reference Design Board Schematic



Top: LED Driver SSL21081; Bottom: Radio Module DR1166



5. Design Tools

5.1 LED Driver Design Tool

Our latest SSL design tool focuses on creating LED drivers from 2 W up to 25 W. The applications include:

- SSL retro-fit lamps (e.g. GU10, E27)
- LED modules, separate power supplies, e.g. LED spots, down-lights
- LED strings, e.g. retail display
- LED ballasts
- Contour lighting
- Channel letter lighting
- Other lighting applications

The tool generates schematic, bill of material and transformer parameters, calculates the design's efficiency, and presents an overview of losses. Also, for a better understanding of the application it can be simulated either online or even locally after downloading the schematics and simulator.

Get started today: **http://www.nxp.com/design-portal/ssl**

6. Relevant Links

6.1 Relevant Application Notes

AN10829 : SSL2101 dimmable high efficiency flyback design

AN10754 : SSL2101 and SSL2102 dimmable mains LED driver

AN10831 : SSL2102 30 W flyback triac dimmable LED driver

AN10952 : SSL2103 flexible, mains dimmable LED driver

AN11041 : SSL2108X driver for SSL applications

AN11054 : GreenChip III+ SSL4101 integrated PFC and flyback controller

AN10894 : Application aspects of the UBA3070 Switch-mode LED driver

AN10912 : SMPS EMC and layout guidelines

AN10937 : Dimmable LED based lamps

AN10876 : Buck converter for SSL applications

6.2 User Manuals

UM10474 : SSL2103 230 V 12 W E27 retrofit LED driver demo board

UM10485 : 120 V (AC) 7 W GU10 buck LED driver reference board using the SSL2101

UM10479 : SSL2101 120 V 7.5 W GU10 flyback reference board

UM10481 : SSL21082 reference board

UM10482 : SSL21081 LED driver reference board

UM10469 : 48 V/150 W demo board using the SSL4101

UM10478 : High-efficiency UBA3070 4-channel DC-to-DC LED driver demo board

UM10501 : SSL21083 reference board user manual

UM10502 : SSL21084 reference board

6.3 Literature

Smart lighting backgrounder

6.4 Online Tools

LED Design Tool http://www.nxp.com/design-portal/ssl

SSL2108x Buck Design Tool: on request

7. Legal information

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NXP Driver Quick Start Guide Index

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