UM10582

SSL21151 5 W universal non-dimmable flyback GU10 demo board

Rev. 1 — 11 December 2012 **User manual**

Document information

Info	Content
Keywords	SSL21151, SSL21151DB1090, LED Driver, LED retrofit lamp, universal input, isolated, primary sensing
Abstract	This user manual describes the operation of an SSL21151 5 W universal non-dimmable flyback GU10 demo board

Revision history

Rev	Date	Description
v.1	20121211	first issue

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1. Introduction

This user manual describes the performance, technical data and connection of the SSL21151 5 W universal non-dim flyback GU10 demo board. The SSL2115x series is an NXP Semiconductors driver IC intended to provide a low cost, small form factor LED driver. This board is designed for universal mains input operation.

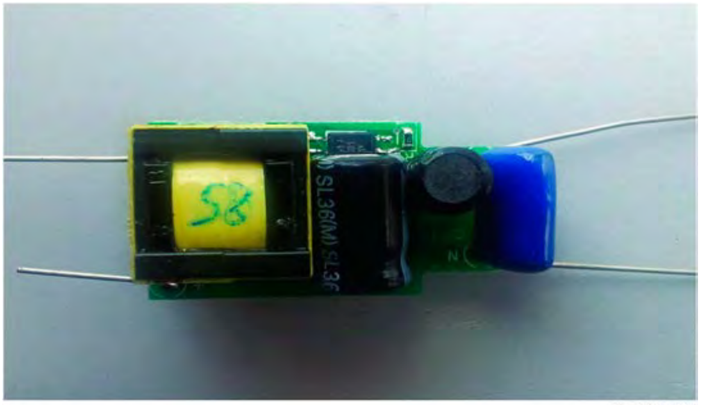

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Fig 1. SSL21151 5 W demo board (front view)

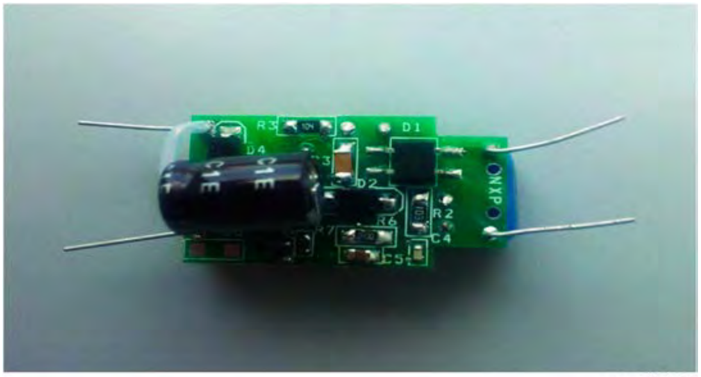

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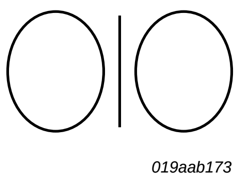
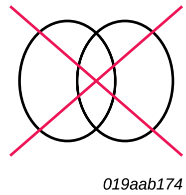
Fig 2. SSL21151 5 W demo board (back view)

2. Safety Warning

This board is connected to the mains voltage. Avoid touching the board while it is connected to the mains voltage. An isolated housing is mandatory when used in uncontrolled, non-laboratory environments. Galvanic isolation of the mains phase using a variable transformer is always recommended.



a. isolated



b. non-isolated

Fig 3. Variable transformer isolation symbols

3. Specifications

Table 1. Specifications for the SSL21151 5 W demo board

Symbol	Parameter	Value
V_{mains}	mains input voltage	85 V (AC) to 265 V (AC); 50 Hz or 60 Hz
f_{mains}	mains input frequency	50 Hz or 60 Hz
$V_{O(LED)}$	LED output voltage	6 V (DC) to 12 V (DC)
$I_{O(LED)}$	LED output current	310 mA (typical)
$V_{O(ovp)}$	overvoltage protection output voltage	14 V (DC) at R9 = 10 kΩ
$\Delta I_{O(LED)}/\Delta V_{mains}$	line regulation	±4 % at input voltage between 85 V (AC) and 265 V (AC)
$\Delta I_{O(LED)}/\Delta V_{O(LED)}$	load regulation	±2 % at output voltage between 6 V (DC) and 12 V (DC)
I_{ripple}	current ripple	±15 %
$P_{o(max)}$	maximum output power	4 W
η	efficiency	80 % at V_{mains} = 230 V (AC) and 12 V (DC) output voltage at T_{amb} = 30 °C
PF	Power Factor	>0.5 at 230 V (AC) input voltage
f_{SW}	switching frequency	25 kHz to 48 kHz at output voltage between 6 V (DC) and 12 V (DC)
T_{oper}	operating temperature	–20 °C to +105 °C ambient
PCB size (L × W × H)	30 mm × 18 mm × 20 mm	

Remark: EMC Compliance - FCC15 CE/RE and EN55015 CE/RE

4. SSL21151 5 W demo board connections

The SSL21151 5 W board is optimized for a mains supply between 85 V (AC) to 265 V (AC) at 50 Hz to 60 Hz. In addition, the board has been designed to work with multiple high-power LEDs with a total operating voltage between 6 V and 12 V. The output current is set to 310 mA at 230 V (AC) input voltage. The output voltage is limited to 14 V.

It is recommended that you mount the board in an isolated box for demonstration purposes.

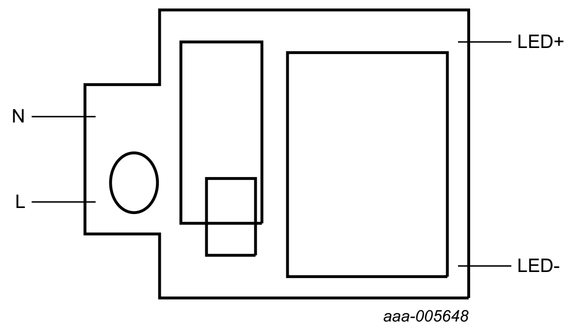


Fig 4. Connection to the SSL21151 5 W demo board front (view)

If a galvanic isolated transformer is used, place it between the AC source and the evaluation board. The board output is connected to a series of LEDs (a string of 2 to 4 pieces).

5. Functional description

The board is equipped with the SSL21151. Figure 11, shows the schematic of the board.

The IC has several internal functions that control and drive the flyback converter. A high-voltage switch is integrated in the IC. This switch is situated between the DRAIN and SOURCE pins, and controls the flyback input power.

When this switch is set to the conductive state, a current starts to run that stores energy in the transformer T1. If the duty factor exceeds a maximum of 75 %, or the voltage on the SOURCE pin exceeds 0.555 V, this current is interrupted. In the next part of cycle, the energy stored in the transformer is discharged over D4 in the output capacitor C6 and the load absorbs it.

Equip the input circuit of the converter with a partially capacitive filter. This filter, which is a combination of C2, L2 and C7 blocks most of the disturbance which the converter input current generates. The drawback with this filter is that it reduces the power factor because of the capacitive load. A lower converter power in relation to the capacitive value of this filter causes a lower power factor.

Feedback input senses the voltage on the auxiliary winding using a resistive divider during the secondary stroke. The sense voltage represents the voltage on the output winding. At no-load output voltage (CV mode), the sensed voltage is regulated at 2.5 V. When the sensed voltage (at high-load) drops below 2.5 V, the regulation changes to Constant Current (CC) mode. The overvoltage protection (OVP latch) level on the SENSE pin is 3.2 V.

5.1 V_{CC} supply

The charging current flows from the high-voltage DRAIN pin via an internal start-up current source to the VCC pin. The IC starts switching when the voltage on the VCC pin (V_{CC}) exceeds the start-up level of 19 V (maximum).

After start-up, an auxiliary winding connection provides an external supply. Design the voltage of the auxiliary winding to ensure that V_{CC} has a minimum value of 9.5 V (maximum UVLO). When V_{CC} drops below the $V_{CC(UVLO)}$ level of 8.5 V (typical), the IC stops switching and is reset. When V_{CC} is above 35 V, a leakage current occurs. Never apply a V_{CC} above 35 V.

If an open-circuit occurs on the LEDs, the output voltage increases at each cycle of the AC/DC converter. Energy is no longer transferred to the LEDs. The energy accumulated at the primary side is transferred to the supply of the IC using the auxiliary winding. On this demo board, a small pre-load R9 provides a proper working application. The output voltage is regulated at 14 V while the LEDs are being disconnected.

Use IC internal overtemperature protection in this board. The OTP threshold temperature is 150 °C (typical) and the OTP trip hysteresis temperature is 50 °C. An external temperature-dependent resistor can be applied for LED OTP. To provide this OTP, place an NTC between the SENSE and GND pins (not implemented on this board).

6. System Optimization

The following modifications can be made to meet application specifications.

6.1 Change the output ripple current

The LED voltage, the LED dynamic resistance and the output capacitor determine the output current ripple. The current value of C6 is chosen to optimize capacitor size with light output. A ripple of ±15 % results in an expected deterioration of light output <1 % (M. Weiland 28-07-2006).

The size for the buffer capacitor can be estimated from the following equation:

$$C6 = \frac{I_{O(LED)}}{\Delta I} \times \frac{1}{6 \times f_{mains} \times R_{dyn}} \quad (1)$$

When using a series of LEDs, the dynamic resistance of each LED can be added to the total dynamic resistance. f_{mains} is the AC mains frequency using 50 Hz or 60 Hz.

6.2 Change the output current

The power component and transformer train are dimensioned for output currents up to 350 mA, but losses increase as the current increases. Resistor R6 limits the primary peak current and thus maximum output power. The output current can be set by varying the value of R6. R6 can be estimated using the following equations:

$$I_{L(pri)} = V_{ref(high)pk}/(R6) \quad (2)$$

Where $V_{ref(high)pk}$ = 0.555 V.

$$L = \frac{(I_{LED} \times U_{max})}{0.85 \times \eta \times f_{sw(high)} \times 0.5 \times I_{pk}{}^2} \quad (3)$$

Where:

- η is the efficiency of converter
- $f_{sw(high)}$ is the high switching frequency
- U_{max} is the maximum combined voltage of the connected LEDs and the voltage drop of the output rectifier
- L is the the primary inductance of the flyback transformer
- I_{pk} is the peak current of the primary side in the flyback transformer
- I_{LED} is the output LED current

6.3 High accuracy design recommendations

- Good coupling of auxiliary winding and secondary winding Np1 : Ns : Nf : Np2
- Use 1 % (or better) devices for resistors connected to the SOURCE and SENSE pins.
- Use 5 % (or better) inductance tolerance for the primary winding of the flyback transformer.

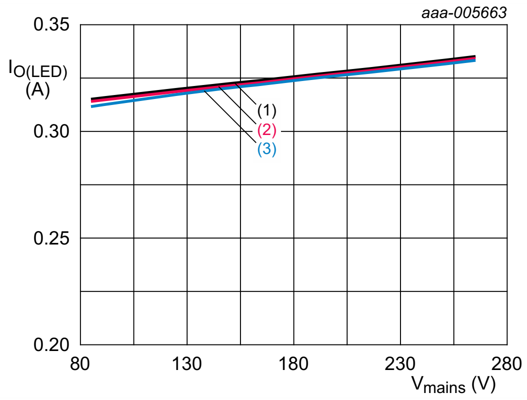
6.4 LED voltage select recommendations

The converter must be able to handle the lowest specified LED voltage. The auxiliary winding of the transformer generates the supply voltage of the IC. The minimum and maximum requirements for the supply voltage of the IC have a given ratio. Therefore, the ratio of the lowest and highest LED voltage is also determined.

Choose the auxiliary voltage carefully if a large LED voltage ratio is required. An LED voltage ratio up to three can be realized with this IC.

7. Performance data

7.1 Line Regulation



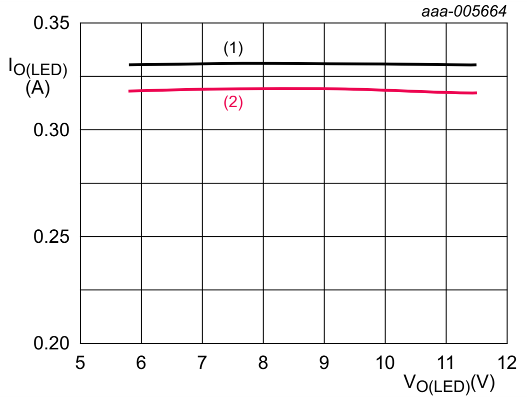
(1) $V_{O(LED)}$ = 9 V (DC)

(2) $V_{O(LED)}$ = 6 V (DC)

(3) $V_{O(LED)}$ = 12 V (DC)

Fig 5. Line Regulation

7.2 Load regulation



(1) V_{in} = 230 V (AC)

(2) V_{in} = 120 V (AC)

Fig 6. Load regulation

7.3 Electromagnetic Conductance (EMC)

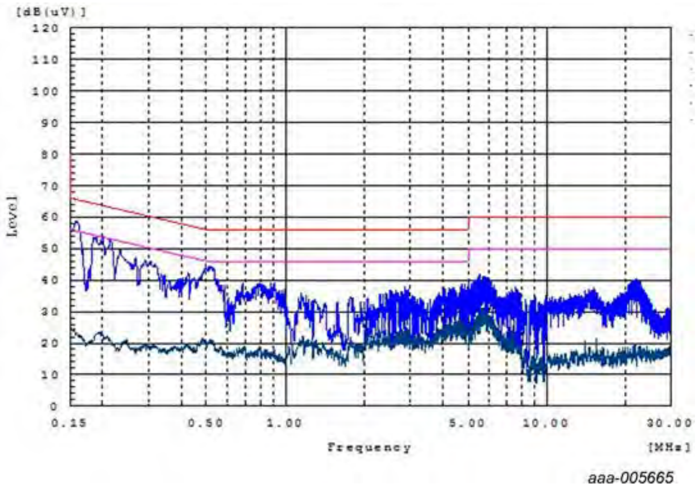


Fig 7. Conducted Emission: Line

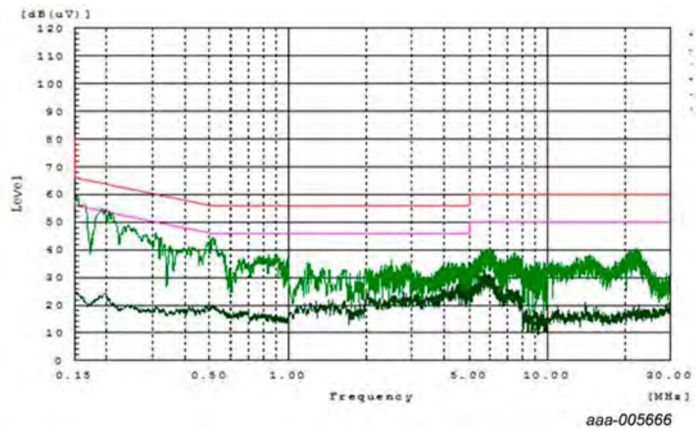


Fig 8. Conducted Emission: Neutral

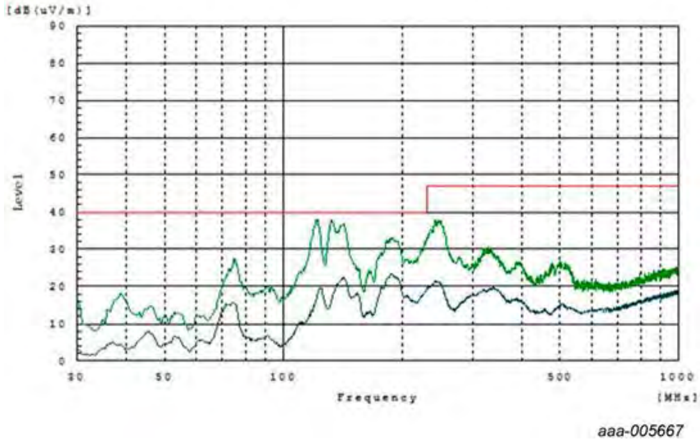


Fig 9. Radiated Emission: Horizontal

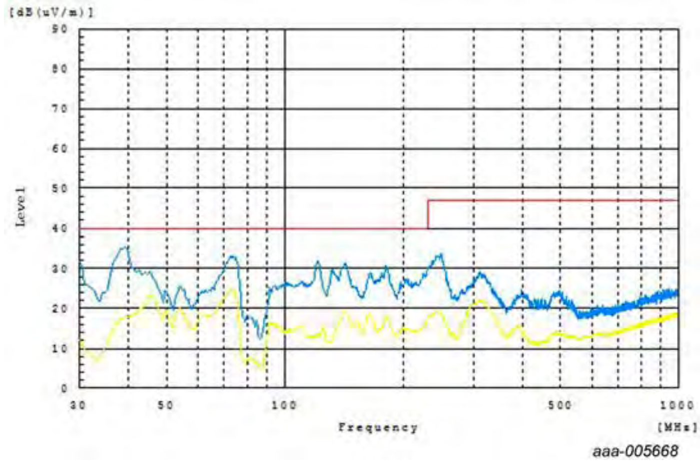


Fig 10. Radiated Emission: Vertical

8. SSL21151 5 W demo board schematic

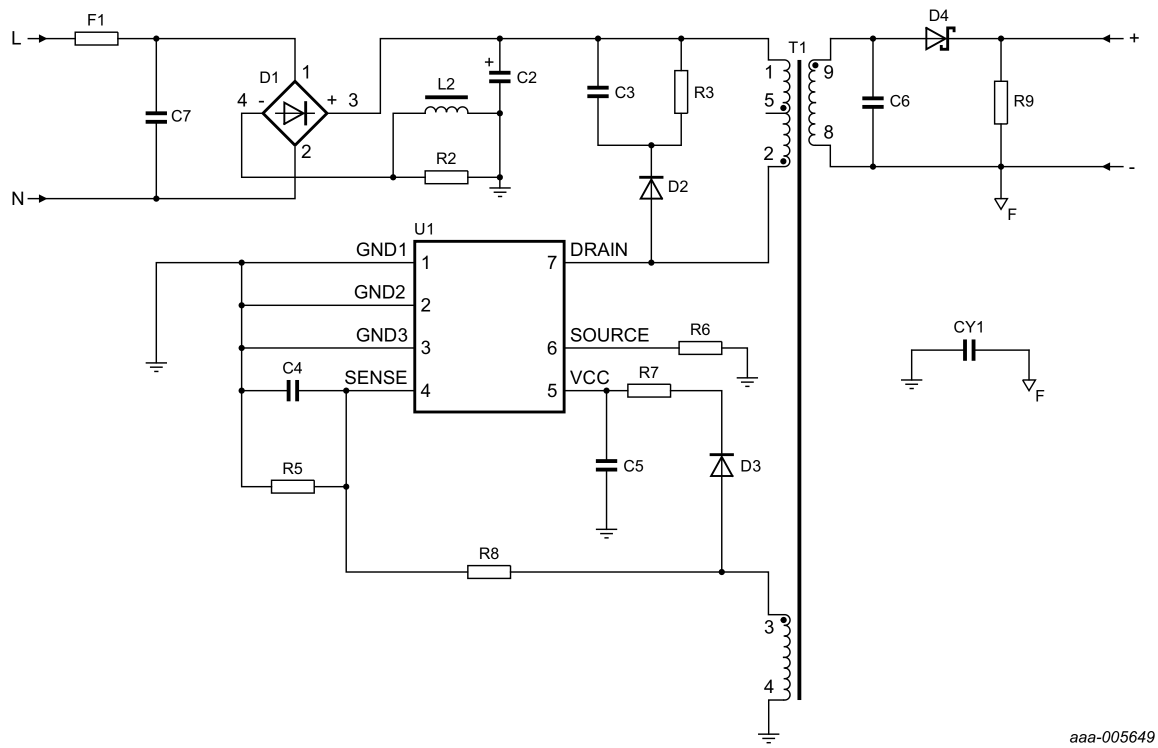


Fig 11. SSL21151 5 W demo board schematic

9. Bill of Materials (BOM)

Table 2. Bill of Materials

Reference	Description and Value	Part number	Manufacturer
C2	capacitor; electrolytic; 4.7 μF; 400 V; 8 × 12 mm	-	Yonming
C3	capacitor; 470 pF; 630 V; X7R; 1206	-	Murata
C4	capacitor; 10 pF; 35 V; X7R; 0603	-	Murata
C5	capacitor; 4.7 μF; 35 V; X7R; 0805	-	Murata
C6	capacitor; electrolytic; 470 μF; 16 V; 8 × 12 mm	-	Yonming
C7	capacitor; 47 nF; 400 V; pitch 5 mm	-	Fara
CY1	Y capacitor; 1 nF; 250 V; 1812	GA352QR7GF102KW01L	Murata
D1	rectifier bridge; fast; 0.5 A; 600 V; MBS	MB6S	Vishay
D2	diode; 1 A; 700 V; M7	-	SIYU
D3	diode; 1 A; 700 V; M7	-	SIYU
D4	diode; Schottky; 2 A; 100 V	SSL210A	SIYU
F1	fuse; slow; lead type; 250 V; 1 A	-	Conquer
L2	inductor; axial; 1 mH; 5 × 7 mm; 0508	-	ABC TW
R2	resistor; 10 kΩ; ±5 %; 1206	-	Yageo
R3	resistor; 100 kΩ; ±5 %; 1206	-	Yageo
R5	resistor; 5.1 kΩ; ±5 %; 0603	-	Yageo
R6	resistor; 2 Ω; ±1 %;1206	-	Yageo
R7	resistor; 150 Ω; ±5 %; 0603	-	Yageo
R8	resistor; 56 kΩ; ±1 %; 0603	-	Yageo
R9	resistor; 10 kΩ; ±5 %;1206	-	Yageo
T1	transformer; 5 pin + 5 pin	EPC13	WE
U1	IC controller; SO-7	SSL21151	NXP Semiconductors

10. Transformer specification

10.1 Transformer pin allocation

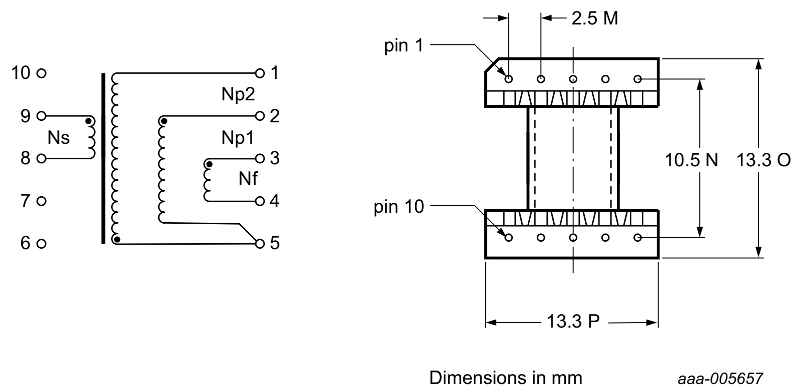


Fig 12. Transformer pin allocation

10.2 Winding specifications

Table 3. Winding Specifications

Number	Section	Wire	Layers	Turns	Start pin	End pin
1	Np 1	Ø 0.1 mm	2	100	2	5
2	Nf	Ø 0.1 mm	2	70	3	4
3	Ns	Ø 0.25 mm	1	30	9	8
4	Np2	Ø 0.1 mm	2	100	5	1

10.3 Electrical characteristics

Table 4. Electrical characteristics

Section	Inductance
Np1 + Np2	2 mH ±5 % at 50 kHz at 1 V
Ns	48 µH ±5 % at 50 kHz at 1 V

10.4 Core and Bobbin

- Core: FEE-13 NC-2H Nicera or equivalent material
- Bobbin: EPC-13 TAIWAN SHULIN

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