UM10570

SSL4101DB02 4-channel high-efficiency universal mains constant current LED driver demo board

Rev. 1 — 5 June 2012 **User manual**

Document information

Info	Content
Keywords	SSL4101, GreenChip III+, SSL, low cost, LED driver, mains supply, UBA3070, user manual
Abstract	This user manual describes the SSL4101DB02 4-channel demo board. which demonstrates the LED driving capabilities of the SSL4101 and UBA3070.

Revision history

Rev	Date	Description
v.1	20120605	first issue

Contact information

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1. Introduction

WARNING

Lethal voltage and fire ignition hazard

The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

The SSL4101DB02 4-channel demo board demonstrates the LED driving capabilities of the SSL4101 and UBA3070 devices.

Each channel is individually dimmable using Pulse Width Modulation (PWM) or an analog signal. The circuit implements a universal mains low THD PFC, a highly efficient flyback controller and four Boundary Conduction Mode (BCM) buck converters. The BCM buck converter is a true switch-mode current source. 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.

Key features include:

- Up to 92 % efficiency
- Low THDI and high PF
- User configured output current requiring no custom-made magnetic components
- Intrinsically protected against short-circuit, open-load and overtemperature conditions
- BCM buck converters operate as true switch-mode current sources
- Low-cost LED driver solution
- Small form factor
- PWM or analog dimming
- Independent or combined control of channels
- No LED binning required

Applications:

Typical target applications for the 4-channel demo board include:

- Street lighting
- High and low bay lighting
- Refrigeration lighting

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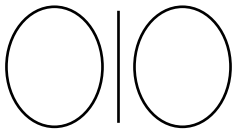
Fig 1. SSL4101DB02 demo board

2. Safety Warning

The demo board application is AC mains voltage powered. Avoid touching the board when power is applied. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Always provide galvanic isolation of the mains phase using a variable transformer. The following symbols identify isolated and non-isolated devices.



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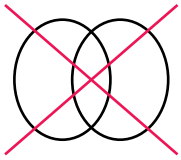
a. Isolated.



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b. Non-isolated

Fig 2. Isolated and non-isolated symbols

3. SSL4101DB02 specification

Table 1. Specification

Parameter	Value	Comment
Output current	4 × 1 A	each channel can be individually controlled and changed.
Output voltage	up to 43 V	depends on LED forward voltage and string length
Output Power	Up to 43 W per channel	sum of all 4-channels cannot exceed 145 W.
Supply voltage	108 V (AC) to 305 V (AC)	-
Input frequency	49 Hz to 61 Hz	-
Power factor	> 0.95	-
THDI	< 20 %	-
Efficiency	up to 92 %	depends on total power, LED forward voltage and string length

4. Functional description

The SSL4101DB02 demo board consists of the SSL4101DB01 (Ref. 1), 48 V, 150 W demo board together with the 4-channel UBA3070DB01 (Ref. 2) demo board. See the UM10469 (Ref. 3) and UM10478 (Ref. 4) user manuals for details about these boards.

The output connector TB2 of board SSL4101DB01 is connected to the input connector TB51of board UBA3070DB01 board. To supply the UBA3070 ICs, the auxiliary power output connector J1 on the SSL4101DB01 board is connected to TP1, TP2 on the UBA3070DB01 board.

When operating, the rectified mains are efficiently boosted by the PFC to 440 V (DC). The efficient flyback converter transforms boosted supply in to 48 V at 3.125 A. The supply is then rectified with a synchronous rectifier using the TEA1761 SR controller IC. Each of the four BCM buck converters can drive four LED strings at up to 43 V at 1 A.

5. Performance data

5.1 Efficiency considerations

The efficiency of the SSL4101DB02 board depends on multiple factors:

- AC mains voltage
- Output current of the flyback
- Output voltage of the buck converter

The total efficiency is the product of the separate efficiency numbers.

5.2 PFC efficiency

The PFC is a boost converter with fixed output voltage. The PFC has the highest efficiency during high mains conditions. Conversely, the PFC has the lowest efficiency in low mains conditions. The efficiency also depends on the power level and the resulting current in the PFC.

Table 2. PFC efficiency for different input voltages and power levels

Supply voltage (V (AC))	Input power (W)	Efficiency (%)
120	41	96.4
	80	96.7
	160	96.4
230	41	96.1
	79	97.9
	156	98.5
277	41	95.9
	79	96.4
	156	98.8

5.3 Flyback converter efficiency

The flyback converter has a 440 V fixed input from the PFC and provides a 48 V output voltage. Only the current levels determine the difference in efficiency.

Table 3. Flyback converter efficiency for different output currents

Output current (A)	Efficiency (%)
0.78	95
1.56	96.4
2.34	96.8
3.12	96.7

5.4 Buck converter

Buck converter efficiency is dependent on the output voltage, the LEDs forward voltage and the number of LEDs in the string. This efficiency dependency is because the buck converter output is a constant current. The efficiency varies between 97 % for the highest output voltage to 70 % for a single 3.6 V LED at 1 A.

Table 4. Buck converter efficiency
Input voltage is 48V, output current 1A.

Output voltage (V (AC))	Input current (A)	Efficiency (%)
3.6	0.11	70.1
6.9	0.18	85.6
10.1	0.25	87.6
13.4	0.31	92.8
16.6	0.38	92.7
19.9	0.45	95.8
23.1	0.52	93.2
26.4	0.58	94.5
29.8	0.68	96.6
33.5	0.77	96.5
36.8	0.85	96.3
40.2	0.94	97.1

5.5 Maximum power

The PFC plus flyback controller deliver up to 150 W to the buck converters. The maximum output power can be calculated based on the efficiency of the buck converter.

The maximum output power is 145 W at an efficiency of 96.5 % independent of the number of channels used. When all 4-channels are used, the maximum power per channel is 36 W. If fewer channels used, the maximum power increases.

4-channels each at 40 V, 1 A with an efficiency of 97 % require an input power of 165 W. This 165 W output power is more than the 150 W maximum that the SSL4101DB01 can deliver. The maximum output voltage of the buck converters when all 4-channels are used is approximately 35 V.

5.6 Dimming and IEC-61000-3-2

Remark: Take care when using PWM dimming.

The requirements for IEC-61000-3-2 state that *“in any dimming position, the harmonic current shall not exceed the value of current allowed in the maximum load condition”*.

When PWM dimming is used, the harmonic currents can exceed the limits depending on the frequency and duty-cycle. Exceeding the limits is not an issue when no dimming or analog dimming are used.

6. Abbreviations

Table 5. Abbreviations

Acronym	Description
BCM	Boundary Condition Mode
DCM	Discontinuous Conduction Mode
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
THDI	Total Harmonic Distortion of the Current
LED	Light Emitting Diode
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
PF	Power Factor
PFC	Power Factor Correction
PWM	Pulse-Width Modulation

7. References

[1] **SSL4101DB01 —** 150 W SSL reference design.

[2] **UBA3070DB01 —** 4-channel DC-to-DC LED driver demo board.

[3] **UM10469 —** User Manual 48 V/150 W demo board using the SSL4101.

[4] **UM10478 —** User Manual UBA3070 4-channel DC-to-DC LED driver demo board.

[5] **SSL4101 —** Data sheet: GreenChip III+ SMPS Control IC.

[6] **UBA3070 —** Data sheet: LED backlight driver IC.

[7] **AN11054 —** Application note: GreenChip III+ SSL4101 integrated PFC and flyback controller.

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