UM10474

SSL2103 230 V 12 W E27 retrofit LED driver demo board

Rev. 1 — 19 July 2011 **User manual**

Document information

Info	Content
Keywords	SSL2103, LED driver, main dimmable, non-isolated, AC/DC
Abstract	User manual for the SSL2103 12 W Buck demo board

Revision history

Rev	Date	Description
v.1	20110719	first issue

Contact information

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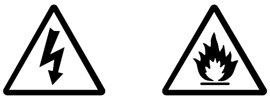
1. Introduction

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.

This SSL2103 user manual is intended for 230 V applications of 12 W demo boards of E27-type (and similar type) retrofit light sources.

The circuit implements a Boundary Conduction Mode (BCM) buck converter. It is mains dimmable for both forward phase (triac) dimmers, and reverse phase (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. With the help of an external MOSFET, an efficiency of up to 85 % can be achieved.

This demo board is connected to a high AC voltage (up to 265 V). Avoid touching the demo board during operation. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Galvanic isolation of the mains phase using a fixed or variable transformer (Variac) is always recommended. These devices are recognized by the symbols shown in Figure 1.

a. Isolated

b. Not isolated

Fig 1. Variac isolation symbols

2. Features

Key reference board features include:

- Buck converter operating in Boundary Conduction Mode (BCM)
- Designed to operate with an input voltage of 230 V at 50 Hz, ±10 %
- Optimized for an output power of 12 W (10 LEDs) at 400 mA output current
- Active damper and inrush current limiter
- Main dimmable with leading and trailing dimmers
- Intrinsically protected against short circuit

3. Connecting the board

The board is designed for a 230 V (AC), 50 Hz mains supply. This application is optimized for a 12 W LED load (10 LEDs), the output voltage must not exceed 35 V.

Do not supply the board without the LED load because this damages the protection Zener diode (D8, see Figure 5).

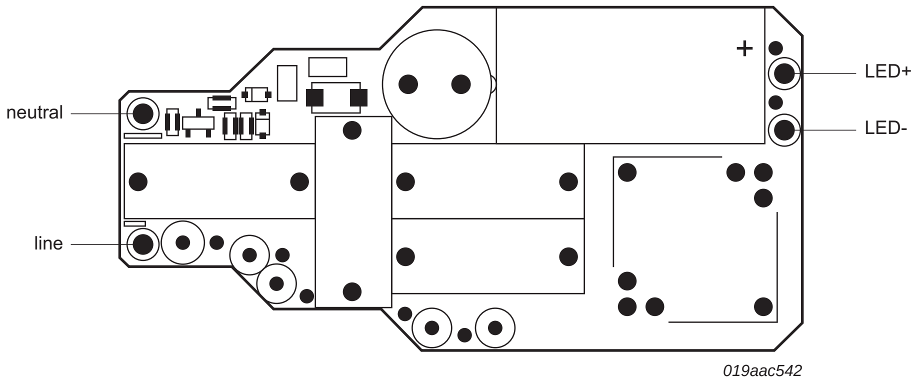


Fig 2. Board connections

Place the galvanic isolated transformer between the AC source and the dimmer/demo board. Connect the string of 10 LEDs as shown in Figure 2.

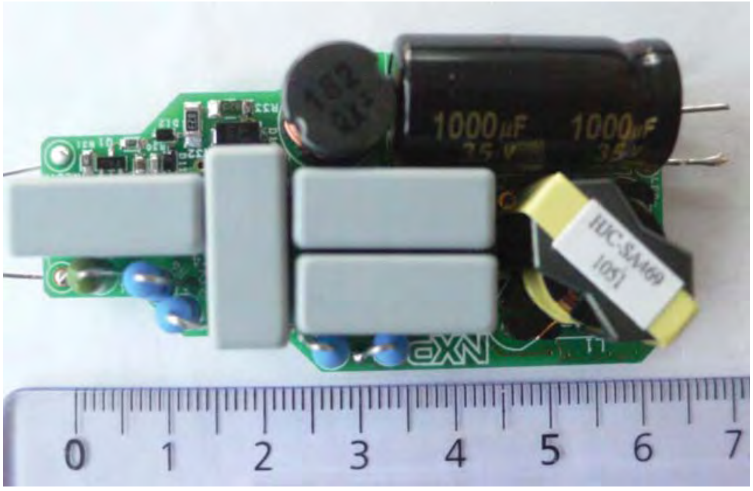
4. Specifications

Table 1 gives the specifications for the SSL2103 12 W LED driver.

Table 1. Specifications

Description	Value	Comment
AC line input voltage	200 V (AC) to 260 V (AC)	optimized for 230 V (AC) with 10 % variation
output voltage (LED voltage)	31 V (DC)	load = 10 LEDs
output voltage protection	36 V (DC)	by Zener diode
output power (LED power)	12.5 W	load = 10 LEDs
efficiency	> 85 %	at T_{amb} = 25 °C, nominal input voltage (see Figure 9).
power factor	> 0.8	at nominal input voltage (See Figure 8).
output current (LED current)	400 mA	at T_{amb} = 25 °C, nominal input voltage.
load current accuracy/ input voltage dependency	< 10 %	at T_{amb} = 25 °C; V_i = 230 V (AC), ±10 % (see Figure 7)
output current ripple	120 mA	see Figure 12
switching frequency	30 kHz	nominal frequency
dimming range	100 % to 10 %	for triac dimmer
board dimensions (l × w × h)	63 mm × 32 mm × 18 mm	
operating temperature	0 °C to 70 °C	
EMC compliance	EN55015	conducted emissions

5. Board photos



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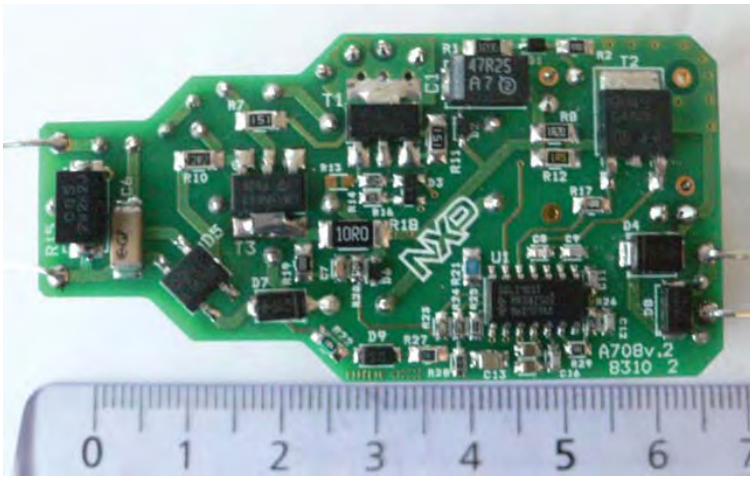
a. Top



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b. Bottom

Fig 3. Board photos

6. Dimmers

NXP Semiconductors has tested numerous dimmers for compatibility. The dimming performance of the board may vary as different dimmers have different specifications. Table 2 and Table 3 show the range of dimmers that have been tested and found to be compatible with the board.

Table 2. TRIAC dimmers

Manufacturer	Type	Voltage (V (AC))	Power range (W)	Load
Berker	2819	230	60 to 400	incandescent
Berker	2873	230	20 to 500	halogen/incandescent
Bush-Jaeger	2250U	230	60 to 600	halogen/incandescent
Bush-Jaeger	2200U	230	60 to 400	incandescent
Ehmann	T10	230	60 to 300	incandescent
Gira	0300	230	60 to 400	incandescent
Gira	1184	230	60 to 400	incandescent
Opus	852.390	230	60 to 400	incandescent

Table 3. Transistor dimmers

Manufacturer	Type	Voltage (V (AC))	Power range (W)	Load
Jung	243 EX	230	20 to 360	halogen/incandescent
Jung	225 TDE	230	20 to 525	halogen/incandescent
Berker	2874	230	20 to 525	halogen/incandescent
Berker	286710	230	20 to 360	halogen/incandescent
Bush-Jaeger	6513U	230	40 to 420	halogen/incandescent
Gira	0307	230	20 to 525	halogen/incandescent
PEHA	433 HAB	230	20 to 315	halogen/incandescent
Legrand	784.06	230	40 to 300	halogen/incandescent

7. Functional description

The IC SSL2103 is an extension to the SSL2101/SSL2102 platform and gives designers the flexibility to use any power level by controlling external switches. In this application, it controls the buck converter part and ensures proper dimmer operation.
One of these switches controls the buck operation and is opened when the voltage on the SOURCE pin exceeds 0.5 V.

When dimmers are used, the circuit detects the rectified voltage change and reduces the duty cycle and oscillator frequency to reduce the output current.

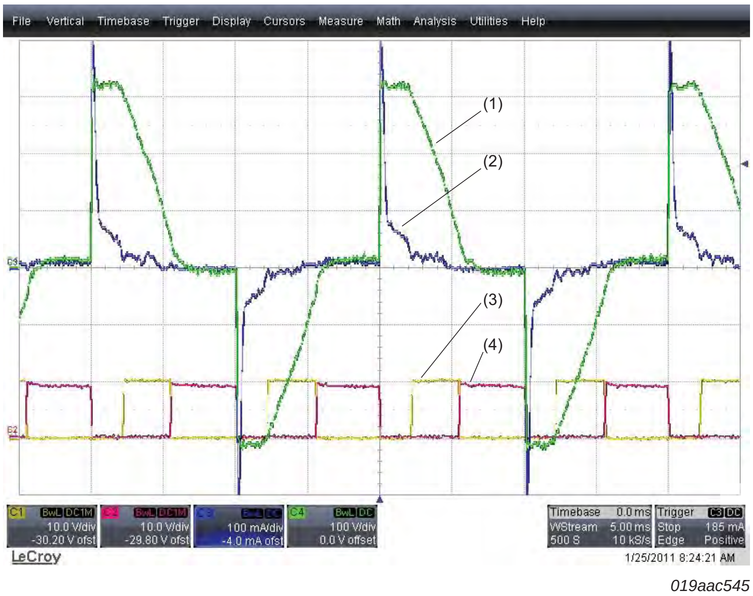
The circuit has a bleeding circuit that can drive two external current sinks: the weak bleeder (pin WB_DRV) and the strong bleeder (pin SB_DRV).

When the voltage on the HVDET pin drops below a certain value (52 V typical), the strong bleeder command is on. This state provides a current path that loads the dimmer during zero voltage crossing. The dimmer timer is reset.

When the voltage on the HVDET pin exceeds 52 V and the voltage on pin ISENSE exceeds −100 mV, the weak bleeder command switches on. This provides a current path that loads the dimmer while the converter draws insufficient current to stabilize the dimmer latching.

In this application, both bleeder commands activate the same bipolar transistor (T1) using two different base currents to drive it. 50 mA for the strong bleeder and 20 mA for the weak bleeder.

The strong bleeder always switches while the weak bleeder does not switch on until the output power drops in a dimmed operation. It allows the system to operate with the majority of field installed dimmers. Figure 4 shows the bleeder drive outputs in a dimmed operation.



(1) Input voltage

(2) Input current

(3) WB_DRV command

(4) SB_DRV command

Fig 4. Dimmed bleeder operation

7.1 Dimming detection

The dimming reference voltage is derived from a non-buffered rectified mains voltage. The dimming range is detected by sensing the average rectified voltage by a resistive divider. Use the the voltage on pins BRIGHTNESS and PWMLIMIT to set the converter duty factor and frequency (see Figure 5). The peak current through the inductor is reduced by balancing the voltage levels at these two inputs before the frequency of the converter drops, thus eliminating audible noise from the winding.

7.2 Active damping and inrush current

A damper is required to limit inrush current. Inrush current occurs when the input capacitors encounter fast voltage changes as in the following situations:

- When the board is hot-plugged into an AC input source.
- When the board is fed from a leading-edge phase cut dimmer.

There are many ways to perform damping. A single resistor is the cheapest solution but it can lead to thermal issues and low efficiency. The damper resistor has a major impact on the power losses of the system. At low power ratings (< 10 W), a serial resistor is suitable because the losses are acceptable. At higher power ratings, an active circuit becomes the preferred solution to achieve high efficiency.

The solution applied here is an active damper using a MOSFET transistor (T3). T3 is used to bypass damping resistors R5 and R6 following inrush current. The MOSFET is ON when the current in the circuit is low enough to keep the bipolar transistor Q1 from pulling down the gate of the MOSFET (T3) (see Figure 5).

8. Board schematic

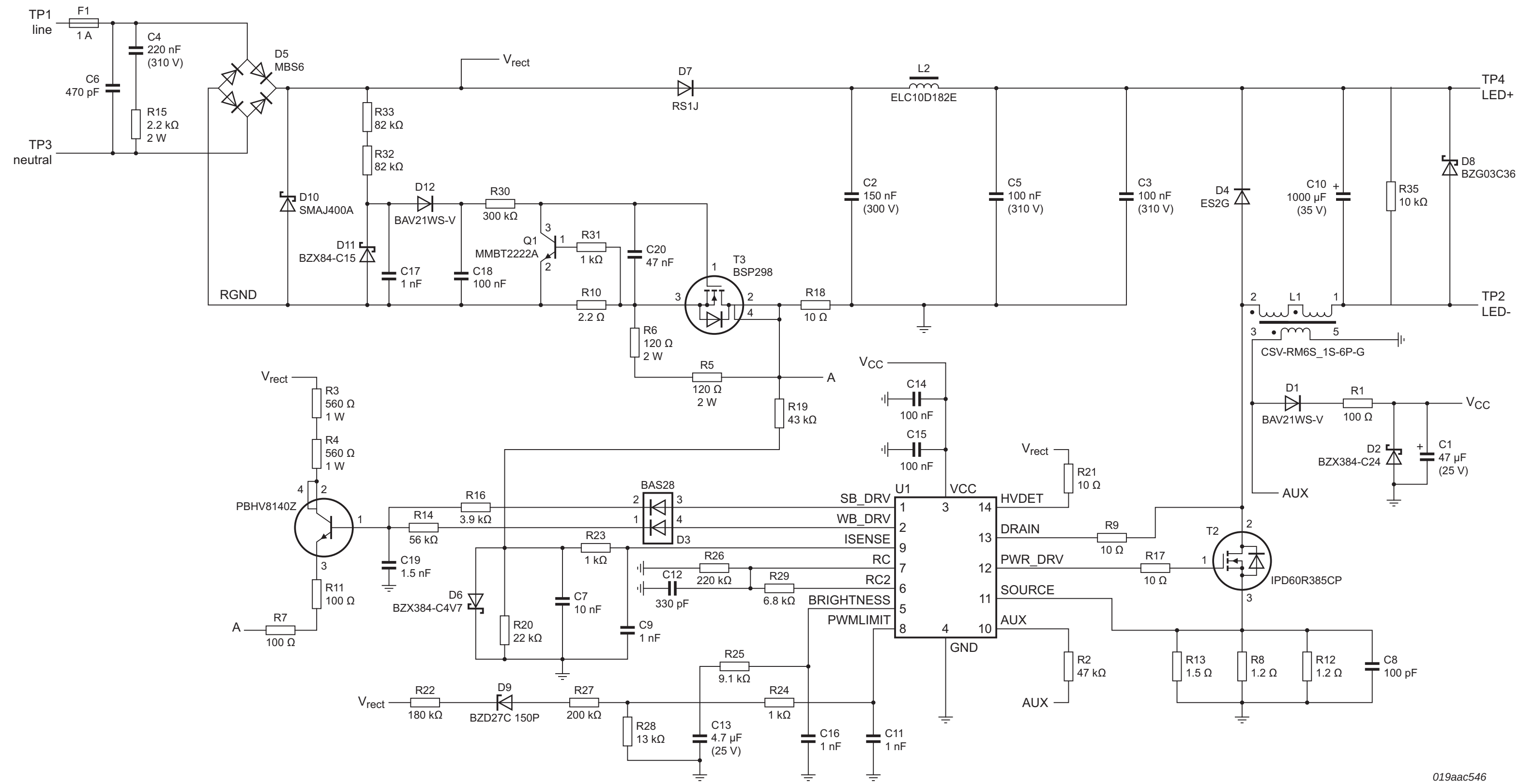


Fig 5. Board schematic

9. Bill Of Materials (BOM)

Table 4. Bill of materials

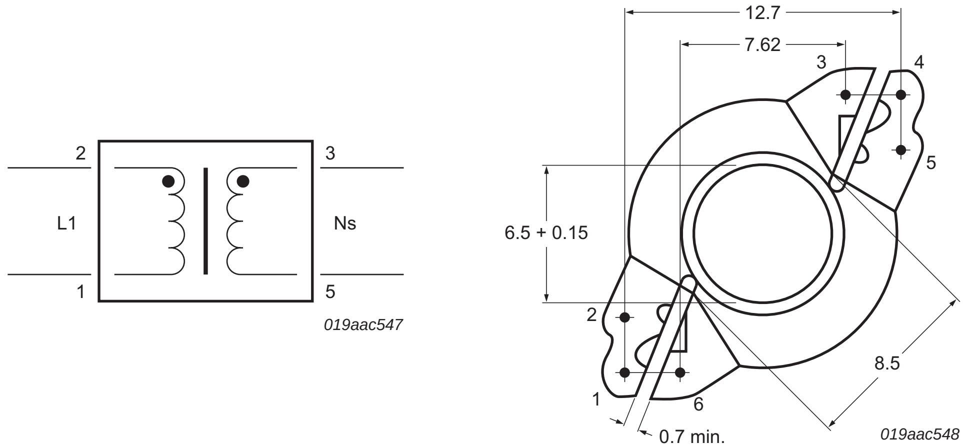
Part no.	Ref.	Value	Power (W)	Tolerance (%)	Voltage (V)	Package	SMD	Type	Manufacturer
1	F1	1 A	-	-	-	-	N	0263001.HAT1L	Littelfuse
2	R1	100 Ω	0.5	5	200	1206	Y	-	-
3	R2	47 kΩ	0.25	5	150	0805	Y	-	-
4	R3	560 Ω	2	5	350	-	N	MFP2	Welwyn
5	R4	560 Ω	2	5	350	-	N	MFP2	Welwyn
6	R5	120 Ω	2	5	350	-	N	MFP2	Welwyn
7	R6	120 Ω	2	5	350	-	N	MFP2	Welwyn
8	R7	100 Ω	0.5	5	200	1206	Y	-	-
9	R8	1.2 Ω	0.5	5	200	1206	Y	-	-
10	R9	10 Ω	0.25	5	150	0805	Y	-	-
11	R10	2.2 Ω	0.5	5	200	1206	Y	-	-
12	R11	100 Ω	0.5	5	200	1206	Y	-	-
13	R12	1.2 Ω	0.5	5	200	1206	Y	-	-
14	R13	1.5 Ω	0.5	5	200	1206	Y	-	-
15	R14	56 kΩ	0.1	1	50	0603	Y	-	-
16	R15	2.2 kΩ	2	5	300	-	Y	-	-
17	R16	3.9 kΩ	0.1	1	50	0603	Y	-	-
18	R17	10 Ω	0.25	5	150	0805	Y	-	-
19	R18	10 Ω	0.5	1	400	2010	Y	-	-
20	R19	43 kΩ	0.1	1	50	0603	Y	-	-
21	R20	22 kΩ	0.1	1	50	0603	Y	-	-
22	R21	10 Ω	0.25	5	150	0805	Y	-	-
23	R22	180 kΩ	0.25	5	150	0805	Y	-	-
24	R23	1 kΩ	0.1	1	50	0603	Y	-	-
25	R24	1 kΩ	0.1	1	50	0603	Y	-	-
26	R25	9.1 kΩ	0.1	1	50	0603	Y	-	-
27	R26	220 kΩ	0.1	1	50	0603	Y	-	-
28	R27	200 kΩ	0.25	5	150	0805	Y	-	-
29	R28	13 kΩ	0.1	1	50	0603	Y	-	-
30	R29	6.8 kΩ	0.1	1	50	0603	Y	-	-
31	R30	300 kΩ	0.1	1	50	0603	Y	-	-
32	R31	1 kΩ	0.1	1	50	0603	Y	-	-
33	R32	82 kΩ	0.5	5	200	1206	Y	-	-
34	R33	82 kΩ	0.5	5	200	1206	Y	-	-
35	R35	10 kΩ	0.25	5	150	0805	Y	-	-
36	C1	47 μF	-	10	25	2917	N	TR3D476K025C0150	Vishay
37	C2	150 nF	-	20	300	Poly	N	BFC233841154	Vishay
38	C3	100 nF	-	20	300	Poly	N	BFC233841104	Vishay

Table 4. Bill of materials *...continued*

Part no.	Ref.	Value	Power (W)	Tolerance (%)	Voltage (V)	Package	SMD	Type	Manufacturer
39	C4	220 nF	-	20	310	Poly	N	BFC233922224	Vishay
40	C5	100 nF	-	20	300	Poly	N	BFC233841104	Vishay
41	C6	470 pF	-	10	250	2211	Y	GA352QR7GF471KW01L	Murata
42	C7	10 nF	-	10	50	0603	Y	-	-
43	C8	100 pF	-	10	50	0603	Y	-	-
44	C9	1 nF	-	10	50	0603	Y	-	-
45	C10	1000 μF	-	20	35	Radial	N	EEUFM1V102	Panasonic
46	C11	1 nF	-	10	50	0603	Y	-	-
47	C12	330 pF	-	10	50	0603	Y	-	-
48	C13	4.7 μF	-	10	25	0805	Y	-	-
49	C14	100 nF	-	10	50	0603	Y	-	-
50	C15	100 nF	-	10	50	0603	Y	-	-
51	C16	1 nF	-	10	50	0603	Y	-	-
52	C17	1 nF	-	10	50	0603	Y	-	-
53	C18	100 nF	-	10	50	0603	Y	-	-
54	C19	1.5 nF	-	10	50	0603	Y	-	-
55	C20	47 nF	-	10	50	0603	Y	-	-
56	L1	1 mH	-	-	-	RM6	N	3C90	-
57	L2	1.8 mH	-	-	-	Radial	N	ELC10D182E	Panasonic
58	D1	0.2 A	0.2	-	250	SOD323	Y	BAV21WS	Vishay
59	D2	24 V	0.3	5	-	SOD323	Y	BZX384-C24	NXP Semiconductors
60	D3	signal	0.25	-	85	SOT143	Y	BAS28	NXP Semiconductors
61	D4	2 A	-	-	400	SMB	Y	ES2G	Vishay
62	D5	0.5 A	-	-	600	TO269AA	Y	MB6S	Vishay
63	D6	4.7 V	0.3	5	-	SOD323	Y	BZX384-C4V7	NXP
64	D7	1 A	-	-	600	SMA	Y	RS1J	Vishay
65	D8	36 V	3	-	-	SMA	Y	BZG03C36	Vishay
66	D9	150 V	0.8	-	-	DO-219AB	Y	BZD27C150P	Vishay
67	D10	400 V	400	5	400	DO-214AC	Y	SMAJ400A	Littelfuse
68	D11	15 V	0.3	5	-	SOD-323	Y	BZX384-C15	NXP
69	D12	0.2 A	0.2	-	250	SOD-323	Y	BAV21WS	Vishay
70	Q1	NPN	0.25	-	40	SOT23	Y	MMBT2222A	NXP Semiconductors
71	T1	NPN	-	-	400	SOT223	Y	PBHV8140Z	NXP Semiconductors
72	T2	MOSFET	-	-	600	DPAK	Y	IPD60R385CP	Infineon
73	T3	MOSFET	-	-	400	SOT223	Y	BPS298	Infineon
74	U1	-	-	-	-	SO-14	Y	SSL2103	NXP Semiconductors

10. Inductor specification

Figure 6 shows the Inductor schematic:



a. Schematic

b. Bottom view

Fig 6. Inductor schematic

10.1 Winding specification

Table 5. Winding specification

Number	Section	Wire	Layers	Turns	Pin	
					Begin	End
1	L1	0.355	-	80	2	1
2	tape ISO	0.1	-	-	-	-
3	Ns	0.2	-	40	3	5
4	tape ISO	0.1	-	-	-	-

10.2 Electric characteristics

Table 6. Inductance

Section	Inductance (±5 % at 100 mA)
L1	1024 μH
Ns	256 μH

10.3 Core and bobbin

- Core: RM6S-3C90-AL160
- Bobbin: CSV-RM6S-1S-6P-G

11. Appendix

11.1 Output current

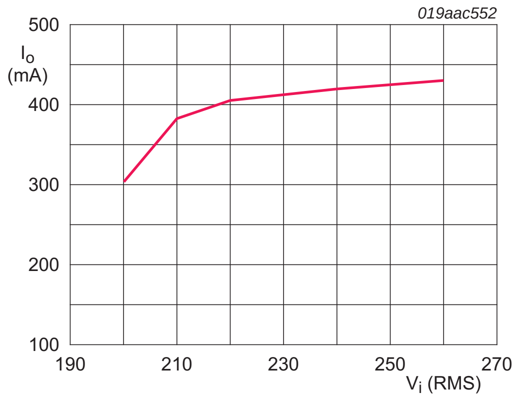


Fig 7. Output current as a function of input voltage

11.2 Power factor

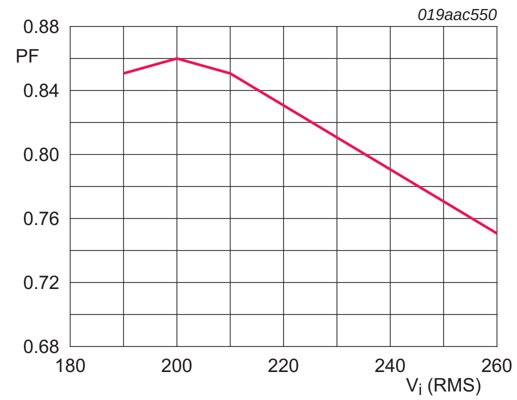


Fig 8. Power factor as a function of input voltage

11.3 Efficiency

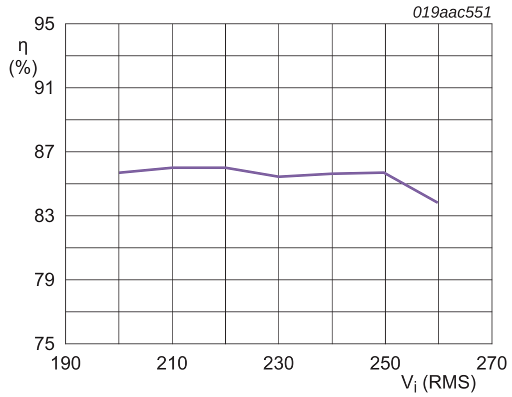


Fig 9. Efficiency as a function of input voltage

11.4 Dimming curve

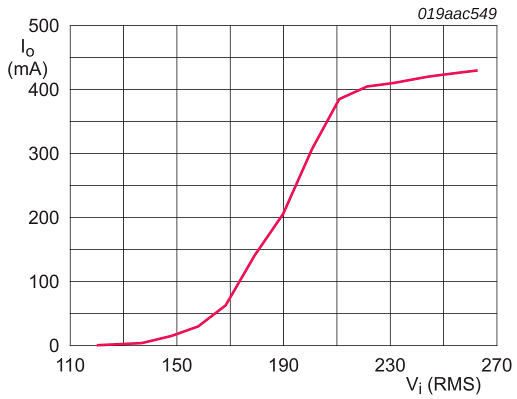
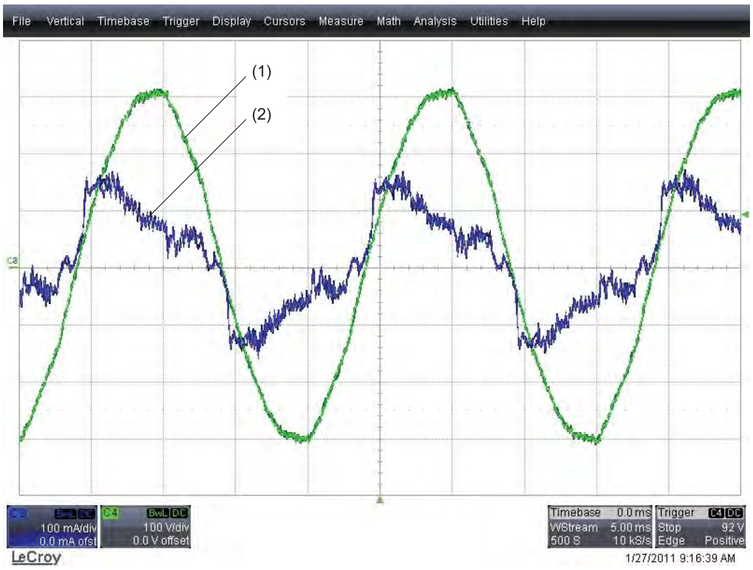


Fig 10. Output current as a function of input voltage

11.5 Input current



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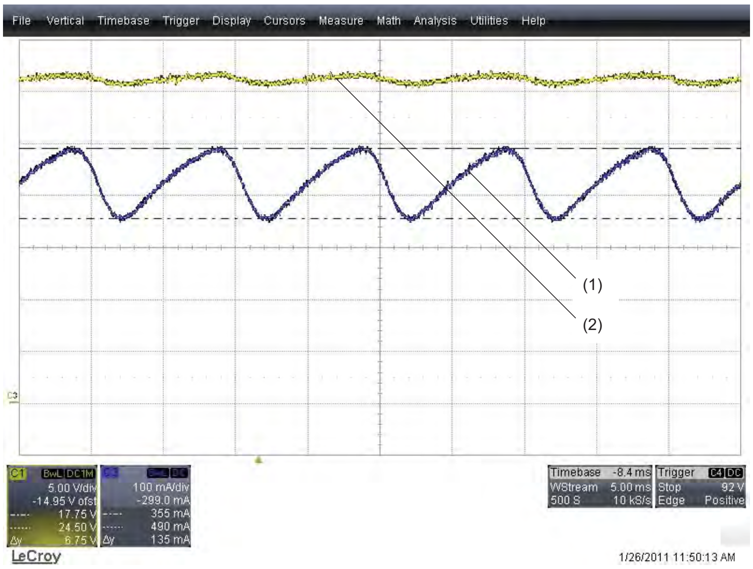
(1) Input voltage

(2) Input current

Fig 11. Input current and input voltage

11.6 Output ripple current



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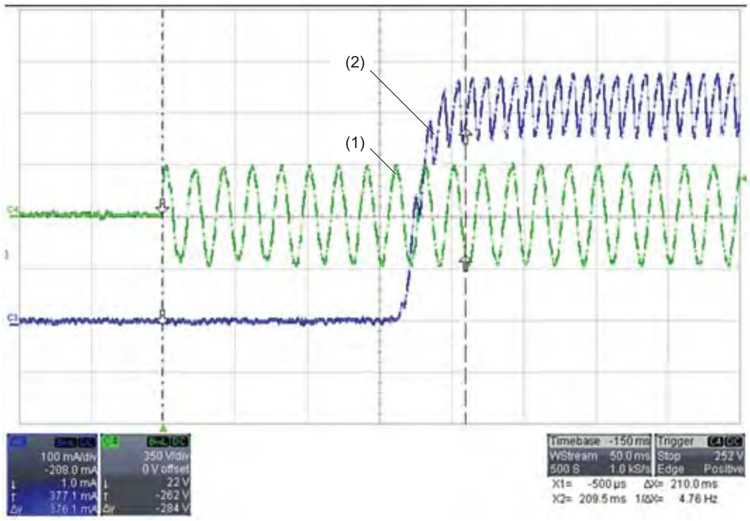
(1) LED current

(2) Output voltage

Fig 12. Output current and output voltage

11.7 Start-up time



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(1) Input voltage

(2) LED current

Fig 13. Start-up time to nominal output current: 210 ms

11.8 Conducted EMI Test results per standard EN55015

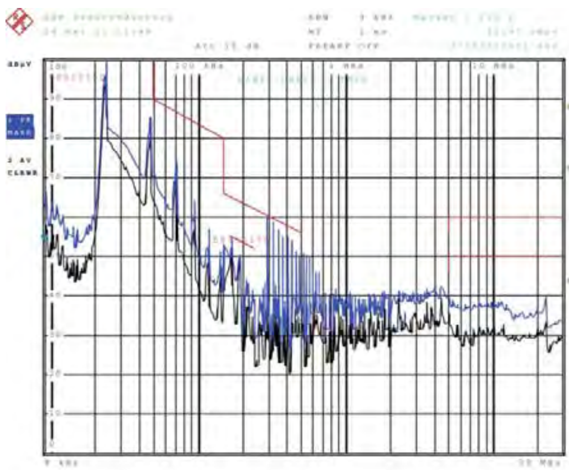

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Fig 14. Conducted emissions for line: AC input = 230 V at 50 Hz

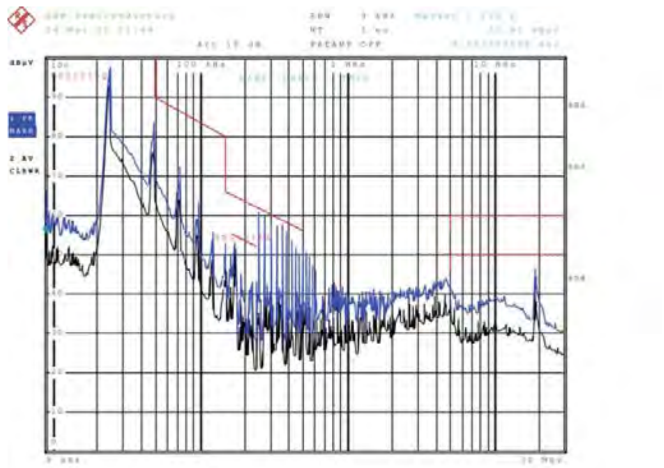

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Fig 15. Conducted emissions for neutral: AC input = 230 V at 50 Hz

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