UM10516

230 V 7 W GU10 buck converter SSL2101 reference board

Rev. 1 — 27 March 2012 **User manual**

Document information

Info	Content
Keywords	SSL2101, buck, LED driver, dimmable, GU10, high-Power Factor (PF)
Abstract	This document describes the application and operation of a 230 V 7 W dimmable LED driver featuring SSL2101. The reference board has a form factor that is compatible with the base of a GU10 LED lamp fittings used in Solid-State Lighting (SSL) applications.

Revision history

Rev	Date	Description
v.1	20120327	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 document describes the application and operation of a 230 V 7 W dimmable LED driver featuring SSL2101. The reference board has a GU10 LED lamp compatible form factor. The buck converter topology provides a simple and efficient solution for mains dimmable LED recessed light applications not requiring galvanic isolation.

Remark: Unless otherwise stated, all voltages are in V.

The total input power (VA) to the board is 230 V/41 mA = 9.4 W. The board is designed to drive a 5-LED load, delivering an output power of 6.5 W at 415 mA and 15.6 V (DC). The Power Factor (PF) is 0.9 which give an actual input power of 0.9 × 9.4 W = 8.5 W. The resulting efficiency is 76 %. The Total Harmonic Distortion (THD) is 30 %. The board complies with EMI and safety regulations.

Audible noise requirements of < 25 dBA are realized across the complete dimming range of currently available dimmers in the market.

The board dimensions are shown in Figure 1. The board is designed with the components allowing enough headroom when the board is inserted into a GU10 lamp base.

The assembled top and bottom board views are shown in Figure 2 and Figure 3.

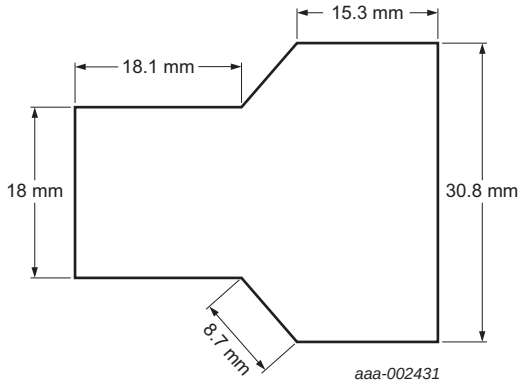


Fig 1. Dimensions of the reference board

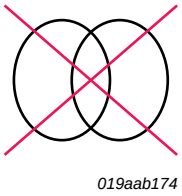
Fig 2. Reference board (top view)

Fig 3. Reference board (bottom 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 obligatory 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 4. Variable transformer (Variac) isolation symbols

3. Specifications

Table 1. Specifications for the reference board

Symbol	Parameter	Value
V_{mains}	AC mains supply voltage	230 V
V_{LED}	DC output voltage	15.6 V
I_{LED}	output current	415 mA
$\Delta I_o/\Delta V_o$	output voltage rejection	2 mA/V
η	efficiency	76 %
PF	Power Factor	0.9
f_{sw}	switching frequency	85 kHz

4. Functional description

4.1 General

The 230 V, 7 W buck reference board uses the SSL2101 control IC to drive a load of up to 5-LEDs. The SSL2101 is a Switched Mode Power Supply (SMPS) controller with an integrated MOSFET. Detailed information about the SSL2101 operation is contained in the *SSL2101 SMPS IC for dimmable LED lighting data sheet*.

The converter operates in Discontinuous Conduction Mode (DCM) or Boundary Conduction Mode (BCM). In BCM, valley switching detection is used to minimize magnetic component and switching losses while enhancing efficiency. A valley-fill circuit is added to obtain high-power factor.

The reference board is triac dimmable and can be used in combination with most leading and trailing edge dimmers. During dimming, the rectified mains voltage is averaged and attenuated and supplied to both BRIGHTNESS and PWMLIMIT pins of the SSL2101. As a consequence, the converter duty cycle or frequency is reduced and as a result the LED output current.

Dimming compatibility is defined as smooth dimming without any flashing artifacts across the complete dimming range. This reference board provides a dimming compatibility of > 85 % when tested with a current selection of 30 trailing and leading-edge dimmers.

5. Reference board connections

The GU10 LED driver board takes a 230 V, 50 Hz mains supply and supports a 5-LED load.

Remark: Make all connections with the input power is switched off.

- Connect the 5-LED load as output load together with power meter at both inputs and outputs.
- Connect V_{IN} (230 V/50 Hz) using an isolating transformer to the input connection points of the buck converter. Alternatively use an AC power supply with limited output current capability (for example; 200 mA).
- Increase V_{IN} to 230 V and measure the different parameters as shown in Table 2.
- When testing dimmer compatibility, connect a leading or trailing edge dimmer between V_{IN} and the buck converter input connection points.

Remark: Use protective a shield over application and never touch the board when measuring or testing.

Table 2. Input and output parameters

V_{IN} (V)	I_I (mA)	PF	P (W)	V_O	I_O	P_O	η (%)
230	41	0.9	8.5	15.6	415	6.5	0.76

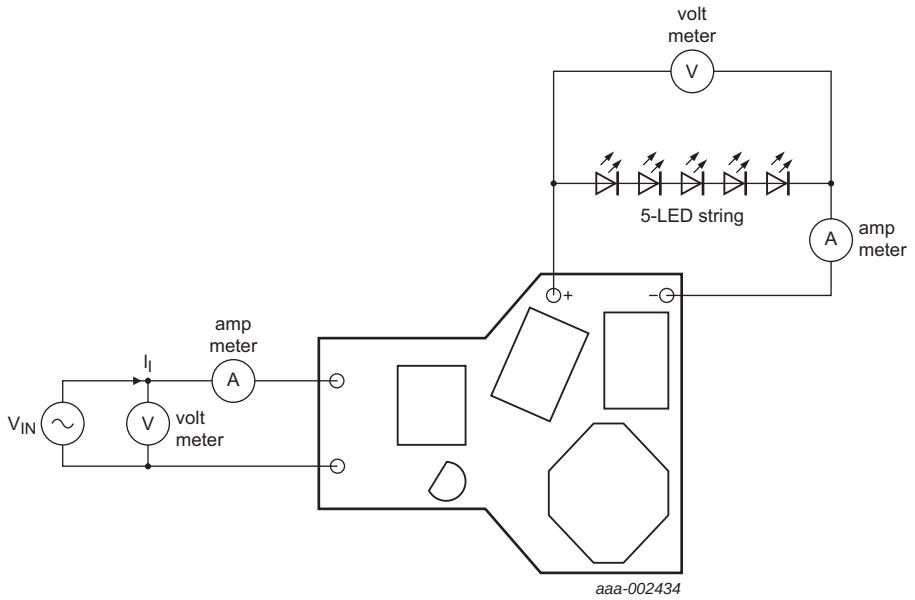


Fig 5. Connection to the reference board

Remark: Make all connections with the input power is switched off.

Remark: The board in Figure 5 shows the GU10 subboard. The connections can also be made to the outer (main) board.

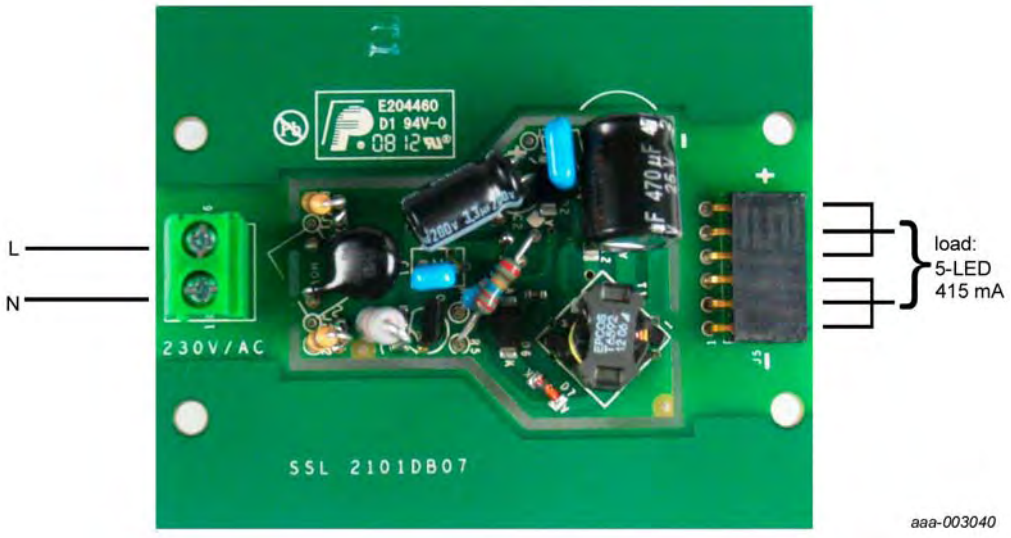


Fig 6. Connection to the reference board

6. Performance data

The performance was measured with 5 LEDs connected as output load. The performance data is shown in Figure 7 to Figure 10.

6.1 Efficiency

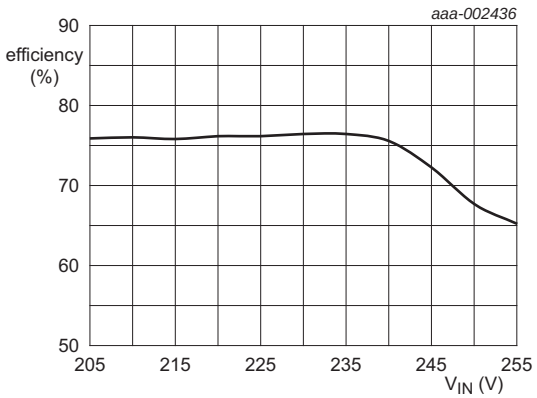


Fig 7. Efficiency as a function of AC mains input voltage

6.2 Output current

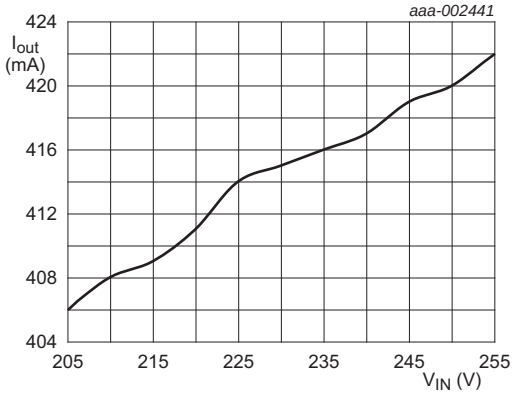


Fig 8. Output current as a function of AC mains input voltage

6.3 Power factor

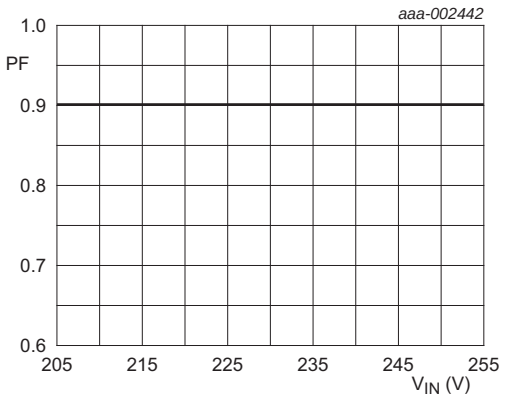


Fig 9. Power factor as a function of AC mains input voltage

6.4 Output voltage rejection

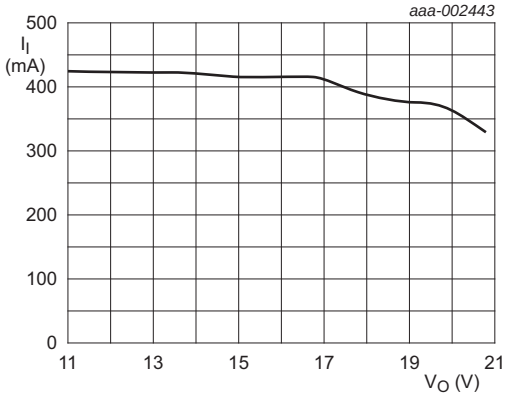


Fig 10. Output current as a function of Output voltage

6.5 ElectroMagnetic Interference (EMI)

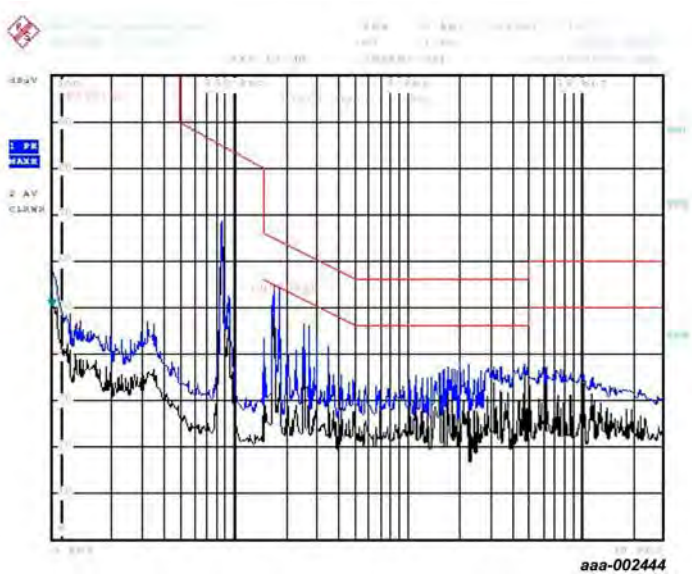


Fig 11. EMI: L and N phases

6.6 Weighted audible noise

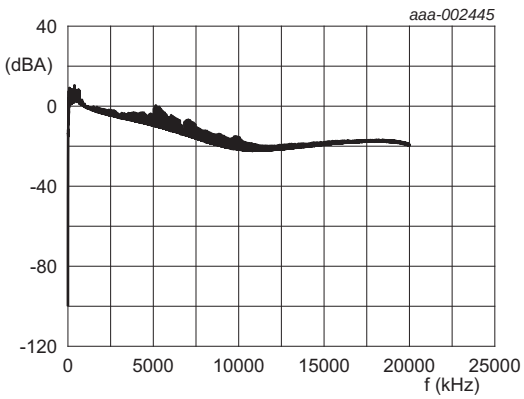


Fig 12. Weighted audible noise as a function of frequency

7. Schematic

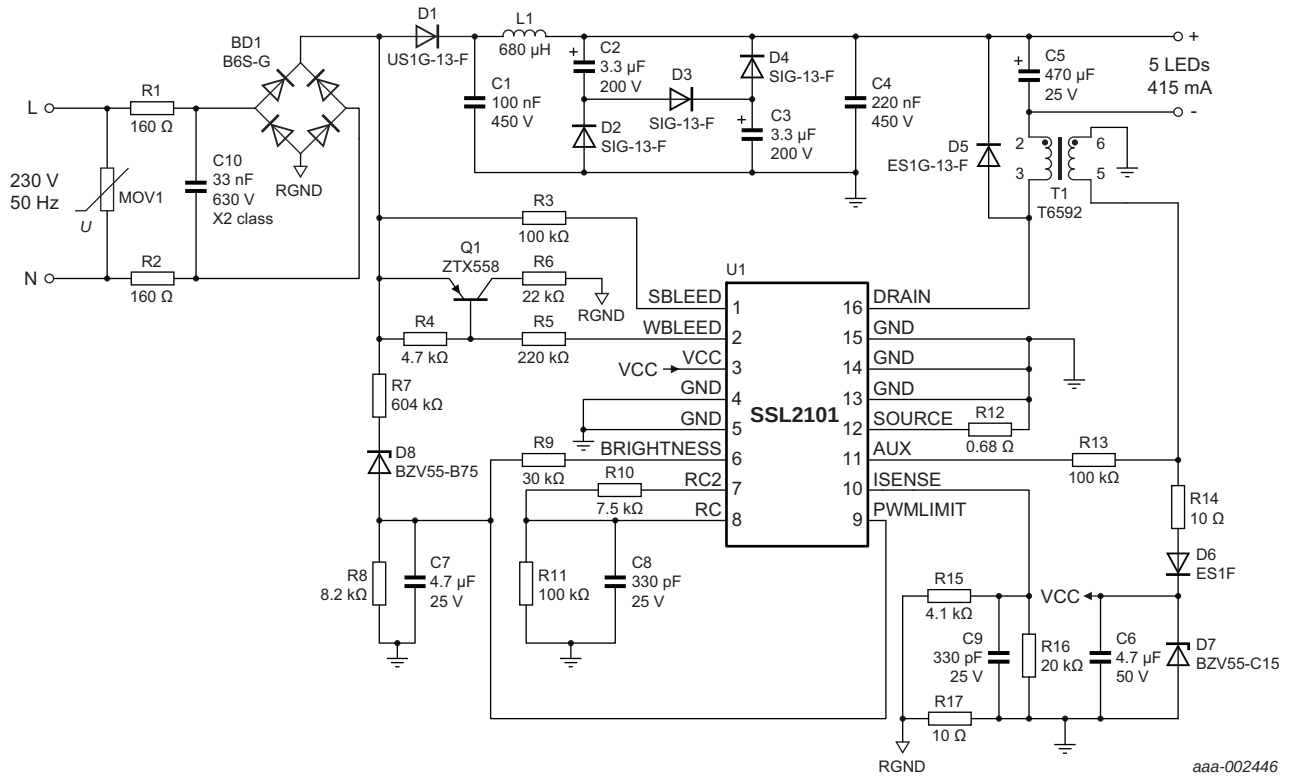


Fig 13. Schematic diagram: 230 V 7 W buck converter using the SSL2101

8. Bill of materials

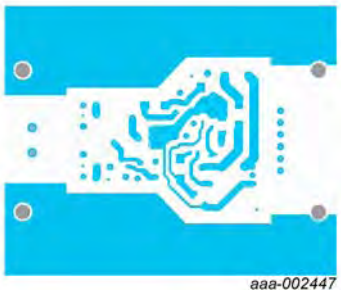
Table 3. Bill of materials

Part reference	Description/value	Manufacturer/part number
BD1	bridge rectifier; 600 V, 0.8 A	Comchip Technology; B6S-G
C1	0.1 μF; 450 V (DC); 10 %; epoxy coated ceramic; radial	Murata; RDED72W104K3K1
C2, C3	3.3 μF; 200 V; electrolytic; radial	Nichicon; UVZ2D3R3MED
C4	0.22 μF; 450 V (DC); 10 %; epoxy coated ceramic; radial	Murata; RDED72W224K5E1
C5	470 μF; 25 V; 20 %; electrolytic; radial	Panasonic - ECG; ECA-1EM471B
C6	4.7 μF; 50 V; 10 %; X5R ceramic; 1206	Taiyo Yuden; UMK316BJ475KL-T
C7	4.7 μF; 25 V; 20 %; X7R ceramic; 1206	TDK; C3216X7R1E475M
C8, C9	330 pF; 25 V; 5 %; COG (NPO); 0603	AVX; 06033A331JAT2A
C10	0.033 μF; 305 V (AC); 630 V (DC); 20 %; X2 class; radial	EPCOS; B32921C3333M; long lead
D1	fast diode; 400 V; 1 A; DO214AC	Diodes Inc.; US1G-13-F
D2, D3, D4	fast diodes; 400 V; 1 A; DO214AC	Diodes Inc.; S1G-13-F
D5	fast diode; 400 V; 1 A; DO214AC	Diodes Inc.; ES1G-13-F
D6	fast diode; 300 V; 1 A; DO214AC	Fairchild; ES1F
D7	Zener diode; 15 V; 500 mW; SOD80	NXP; BZV55-C15,135
D8	Zener diode; 75 V; 500 mW; SOD80	NXP; BZV55-B75,115
J1	wire-connection; 0.6 mm	-
J2	wire-connection; 0.6 mm	-
J3	wire-connection; 0.6 mm	-
J4	wire-connection; 0.6 mm	-
J5	receptacle 2.54 mm; single 6-way	SAMTEC; SSW-106-02-G-S-RA
J6	MKDSN 2.5/ 2-5.08	PHOENIX CONTACT; 1888687
L1	680 μH; 160 mA; (L × W × H = 7 × 7 × 3.2 mm)	Bourns Inc.; SRR7032-681M
MOV1	transient/surge absorber; 470 V	Panasonic - ECG; ERZ-V07D471
Q1	MOSFET PNP 400 V; 200 mA TO92-3	Diodes/Zetex; ZTX558
R1, R2	160 Ω; 0.25 W; 5 %; axial	Panasonic - ECG; ERD-S2TJ161V
R3	100 kΩ; 0.25 W; 5 %; axial	Panasonic - ECG; ERD-S2TJ104V
R4	4.7 kΩ; 0.1 W; 5 %; 0603	Panasonic - ECG; ERJ-3GEYJ472V
R5	220 kΩ; 0.25 W; 5 %; axial	Panasonic - ECG; ERD-S2TJ224V
R6	22 kΩ; 2 W; 5 %; axial	Vishay; PR02000202002JR500
R7	604 kΩ; 0.25 W; 1 %; 1206	Vishay; PR02000202202JR500
R8	8.2 kΩ, 0.1 W; 5 %; 0603	Vishay; CRCW1206604KFKEA
R9	30 kΩ; 0.1 W; 5 %; 0603	Multicomp; MC 0.063W 0603 8K2
R10	7.5 kΩ; 0.1 W; 5 %; 0603	Vishay; CRCW060330K0FKEA
R11, R13	100 kΩ; 0.1 W; 5 %; 0603	YAGEO; RC0603JR-077K5L
R12	680 mΩ; 0.25 W; 1 %; 1206	Bourns; CR0603-JW-104GLF
R14	10 Ω; 0.1 W; 5 %; 0603	Multicomp; MC1206W4F680LT5E

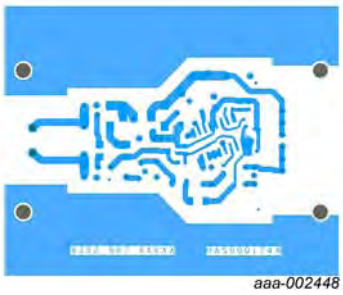
Table 3. Bill of materials *...continued*

Part reference	Description/value	Manufacturer/part number
R15	4.1 kΩ; 0.1 W; 1 %; 0603	Multicomp; MC0603SAF4121T5E
R16	20 kΩ; 0.1 W; 1 %; 0603	Bourns; CR0603-JW-203GLF
R17	10 Ω; 0.25 W; 1 %; 0805	Bourns; CR0603-JW-100GLF
T1	L_{pri} = 180 μH; N_{pri} : N_{sec} = 1.35 : 1	EPCOS; T6592
U1	SMPS controller IC for driving LED applications; SO16	NXP Semiconductor; SSL2101T

9. PCB layout



a. Top layer



b. Bottom layer -

Fig 14. Board layout

10. Inductor specification

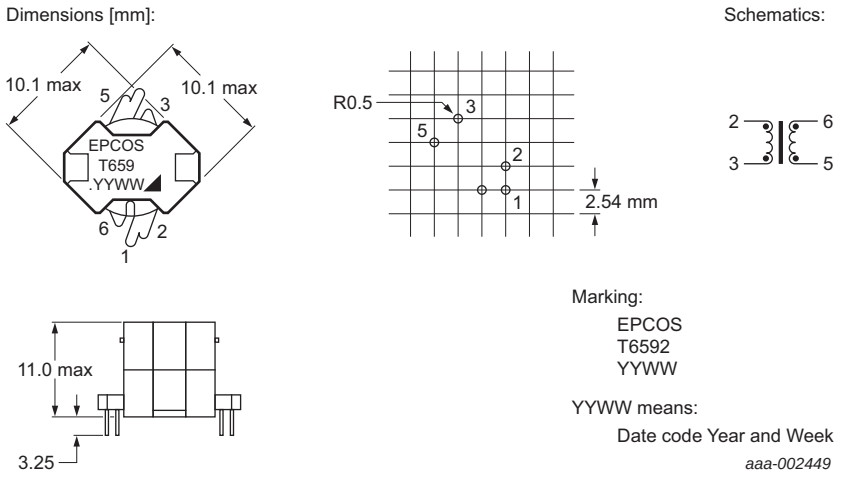


Fig 15. Inductor specification

Table 4. Electrical specification

All values are specified at 25 °C unless otherwise specified. All values without tolerances are typical values.

Parameter	Value	Comment
Inductance 2 to 3	180 μH, ±7 %	100 mV, 10 kHz
Inductance 2 to 3	143 μH minimum	100 mV, 10 kHz; 1 A (DC)
DCR 2 to 3	380 mΩ maximum	At 25 °C
DCR 6 to 5	830 mΩ maximum	At 25 °C
Turns Ratio 2 to 3 : 6 to 5	1.35 : 1	
HV 2 to 5	500 V	50/60Hz, 2 mA maximum, 2 s minimum
Leakage Inductance 2 to 3	12 μH maximum	with 5 to 6 shorted; 100 mV, 100 kHz

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