

LED Driver ICs

EVAL-LED-ICL8001G-Bulb02

Quasi-Resonant Flyback Converter for Phase Cut Dimming with High Power Factor

ICL8001G

Application Note

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ICL8001G

Revision History: 2010-02-12, Revision 1.0

Previous Version: --/--

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1 Content

The EVAL-LED-ICL8001G-Bulb02 demonstrates the single-stage flyback and PFC controller ICL8001G in an LED Bulb application. Its quasiresonant operation mode, primary side control, integrated PFC and phase-cut dimming control makes it the best in class system solution for dimmable LED bulbs.

2 Evaluation Board

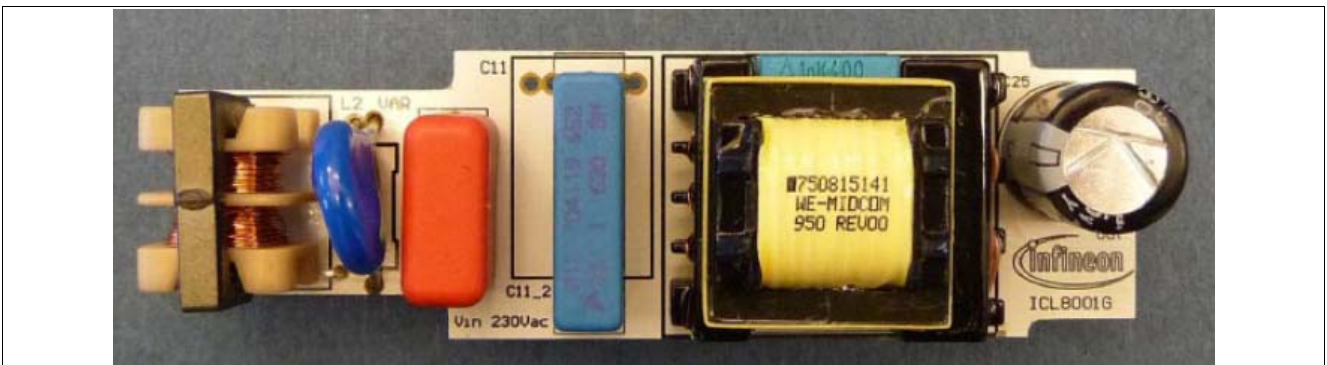


Figure 1 EVAL-LED-ICL8001G-Bulb02 Top Side

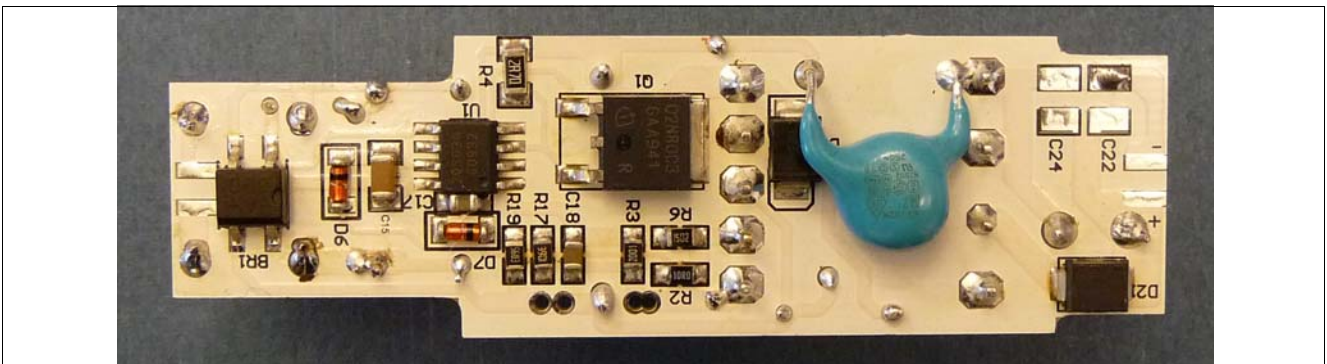


Figure 2 EVAL-LED-ICL8001G-Bulb02 Bottom Side

3 List of Features

- High, stable efficiency over wide operating range through quasiresonant operation mode
- Primary side flyback control with integrated PFC and phase-cut dimming
- Energy efficient phase cut dimming
- Power cell for VCC pre-charging with constant current
- Built-in digital soft-start
- Foldback correction and cycle-by-cycle peak current limitation
- VCC over- and under-voltage lockout
- Auto restart mode for short circuit protection
- Adjustable latch-off mode for output overvoltage protection
- Best in class system BOM for dimmable bulbs

4 Technical Specification

Table 1 provides a summary of the EVAL-LED-ICL8001G-Bulb02 performance specification. The Input Voltage indications refer to the RMS voltage without modification by means of phase cut dimmer.

Table 1 Performance Specification

Specification	Min	Typ	Max	Unit
Input Voltage	207	230	253	AC V
Output Voltage	23	26	29	V
Output Current	380	350	320	mA
Output Power	9.0	9.1	9.2	W

5 Setup and Results

5.1 Input / Output sliding contact description

5.1.1 Vin

Input sliding contact for AC supply. Please see **Table 1** for the maximum input voltage.

5.1.2 Vout

Output sliding contact for output DC voltage with polarity indication. This output is isolated from the AC input supply. If you connect an additional load via this connector please make sure not to exceed the maximum output voltage- and power ratings as stated in **Table 1**.

5.2 Setup

For non-dimming operation of the board it is sufficient to connect the sliding contact for Vin directly to the input AC voltage (see **Table 1** for input voltage range). For dimming operation the phase cut dimmer shall be connected to the Vin contacts according the dimmer switch instructions of the dimmer manufacturer.

Attention:

Please be aware that high voltages of approximately 800 V will be accessible on the board.

5.3 Power Up

The ICL8001G integrates a start-up cell. This allows for short start-up times of the system without sacrificing the efficiency. **Figure 3** demonstrates a startup time from mains voltage switch on to light out of about 120ms for a VCC capacitance of C15 = 10uF.

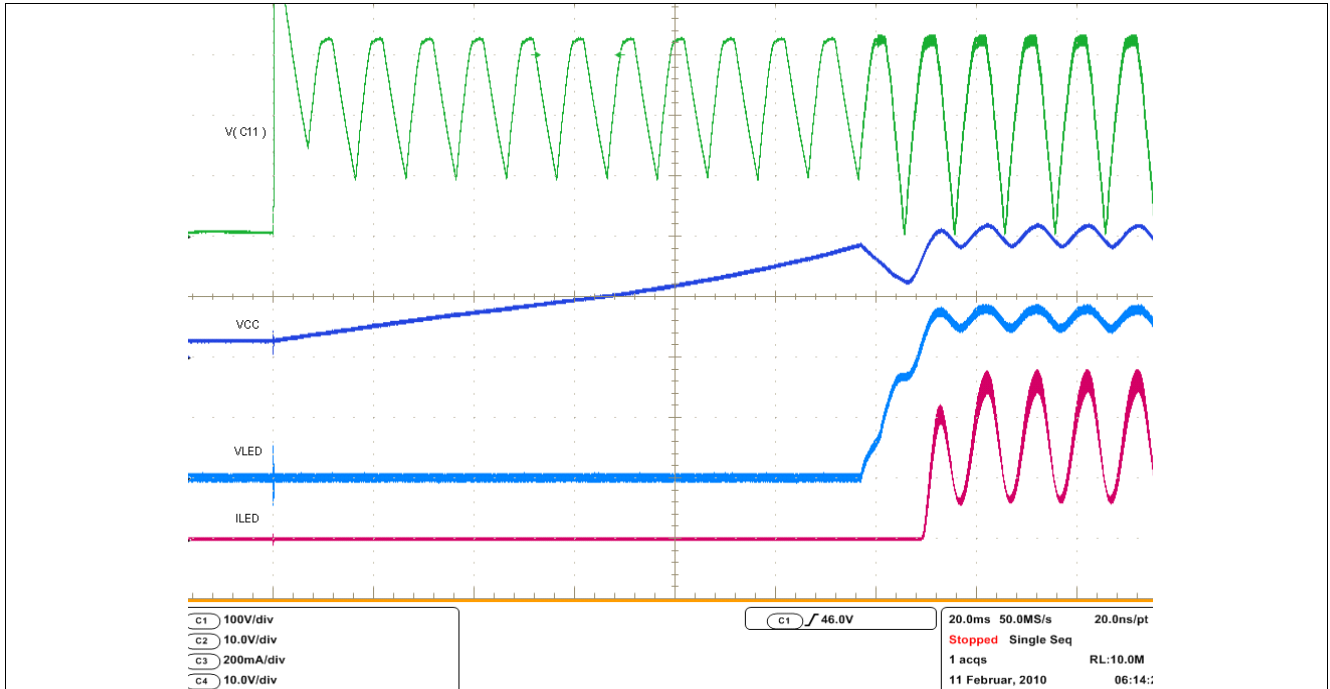


Figure 3 Startup: Rectified mains input voltage (green), Controller VCC (dark blue), output voltage (blue), and output current (red)

5.4 Operation

The ICL8001G is a quasiresonant flyback controller. **Figure 4** shows typical switching waveforms at the MOSFET Q1 on the primary side.

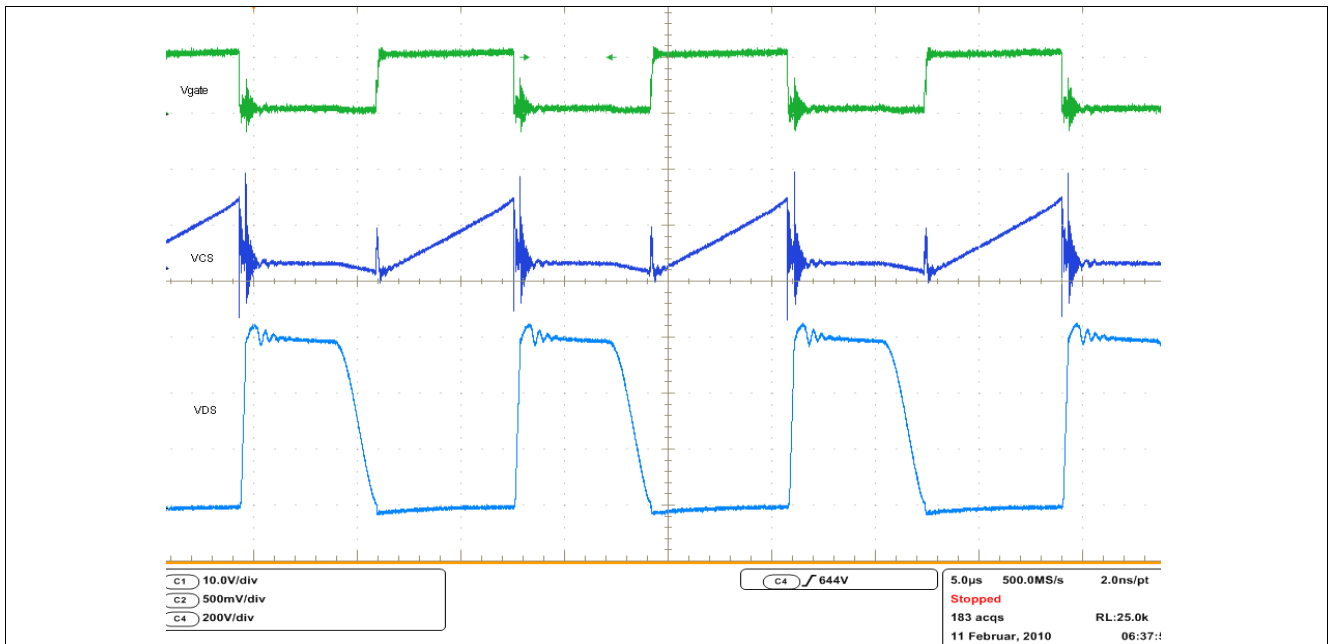


Figure 4 Typical switching waveforms at 230 Vac mains voltage: Gate Drive voltage Vgs, shunt signal VCS and Drain Source Voltage VDS showing quasi resonant on-switching at the first valley approaching zero-voltage

5.5 Constant Output Power Control

The ICL8001G allows for regulation of the approximate constant output power at fixed phase cut dimming position or fixed input AC voltage. See **Figure 5** for the measured output regulation characteristic at output voltage variation. At LED forward voltage decrease the driver power is lowered.

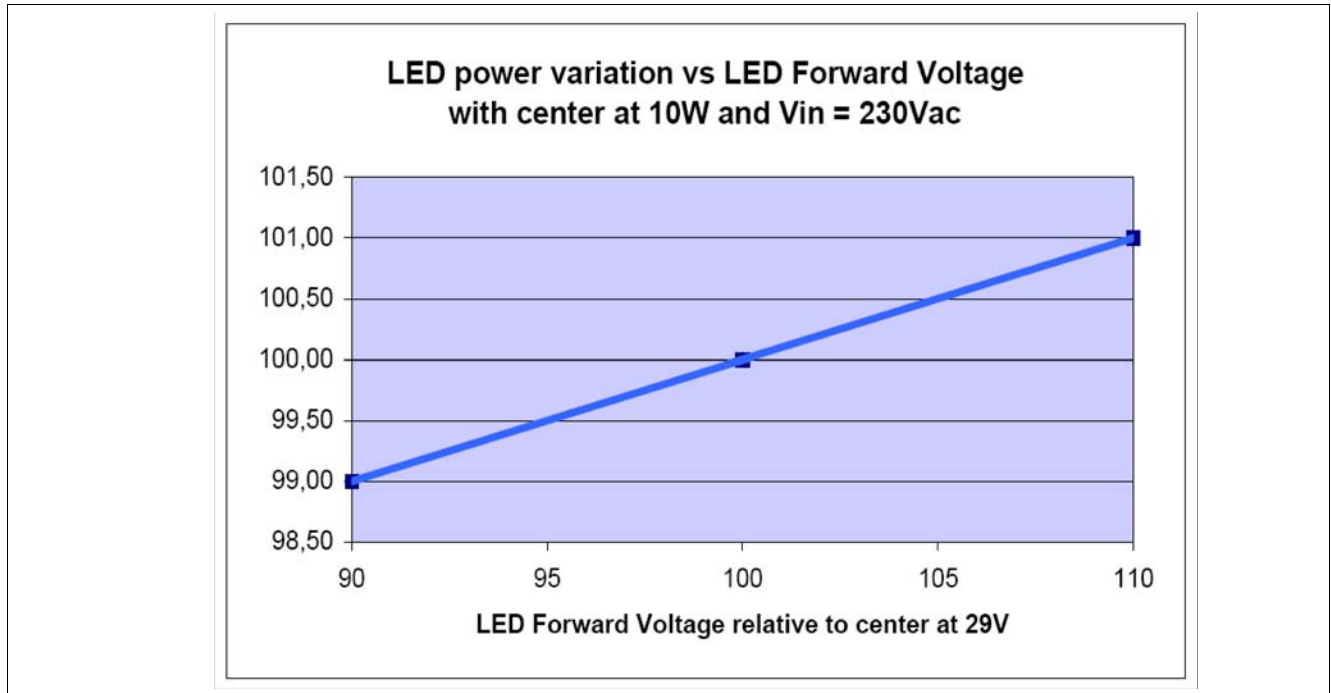


Figure 5 Approximate constant output power characteristics

5.6 Output Current Ripple

The output capacitor (C25 = 220uF) is sized for an output current ripple which exhibits no visible light modulation. If a smaller LED current ripple is required, a larger capacitance (C25) up to 470uF can be placed on the board.

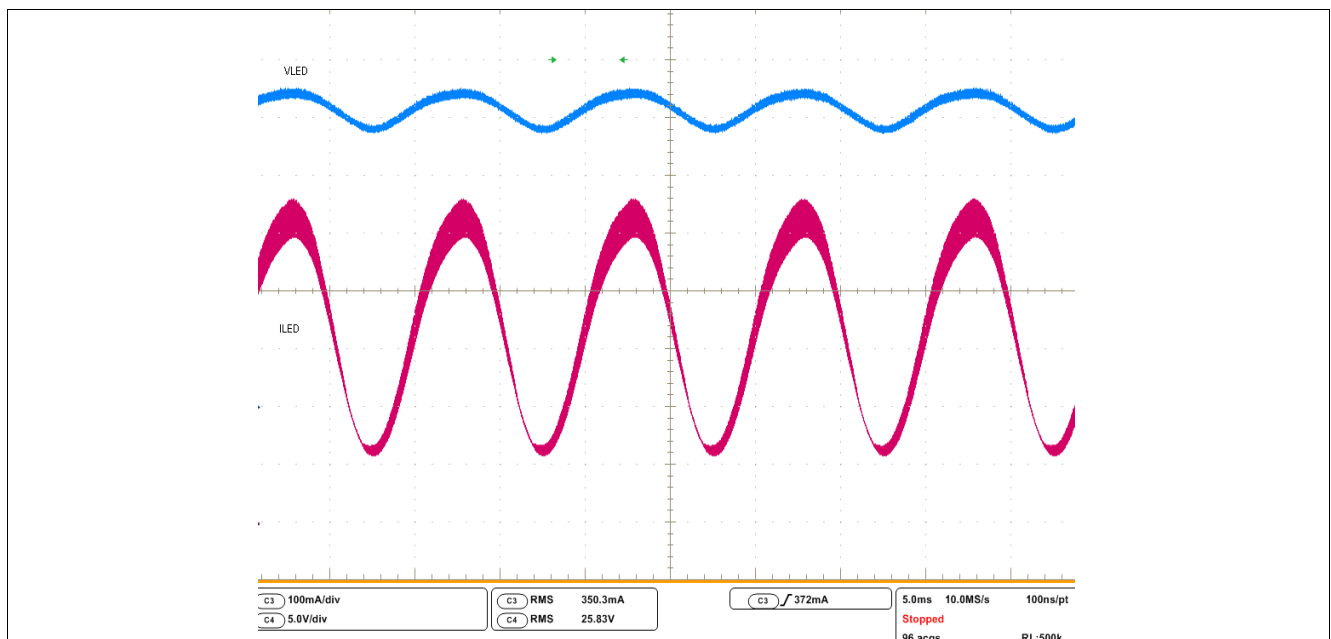


Figure 6 Typical Waveforms: Output voltage (blue) and output current (red)

5.7 Input Current Harmonics

The input current harmonics amplitudes fulfill the requirements of EN 61000-3-2 standard for input power range $P_{in} < 25W$ as well as $P_{in} > 25W$. The power factor can be adjusted to $PF > 99\%$. but the optimization for phase cut dimming especially leading edge dimmer switches may lead to lower values.

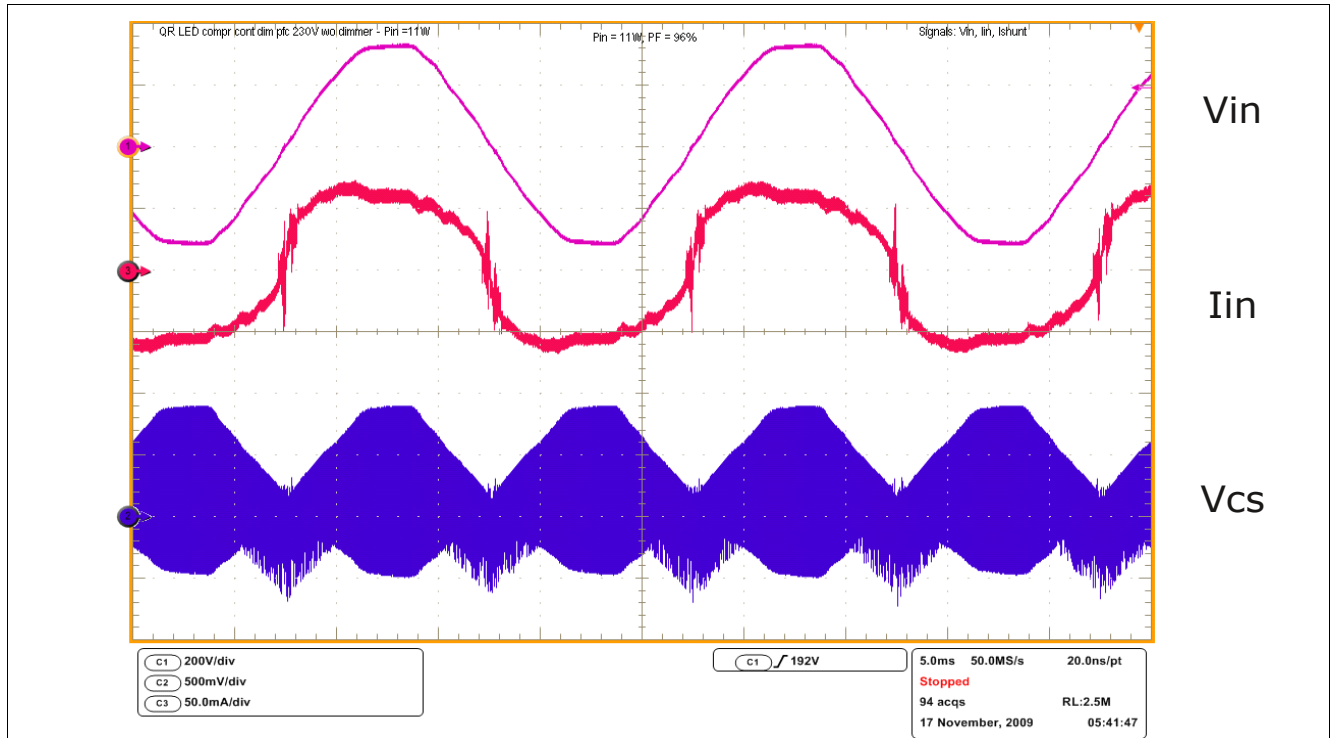


Figure 7 Input voltage V_{in} , Input current I_{in} and shunt voltage V_{cs}

5.8 Driver Efficiency

The driver efficiency curve exhibits high efficiency also for low dimming levels.

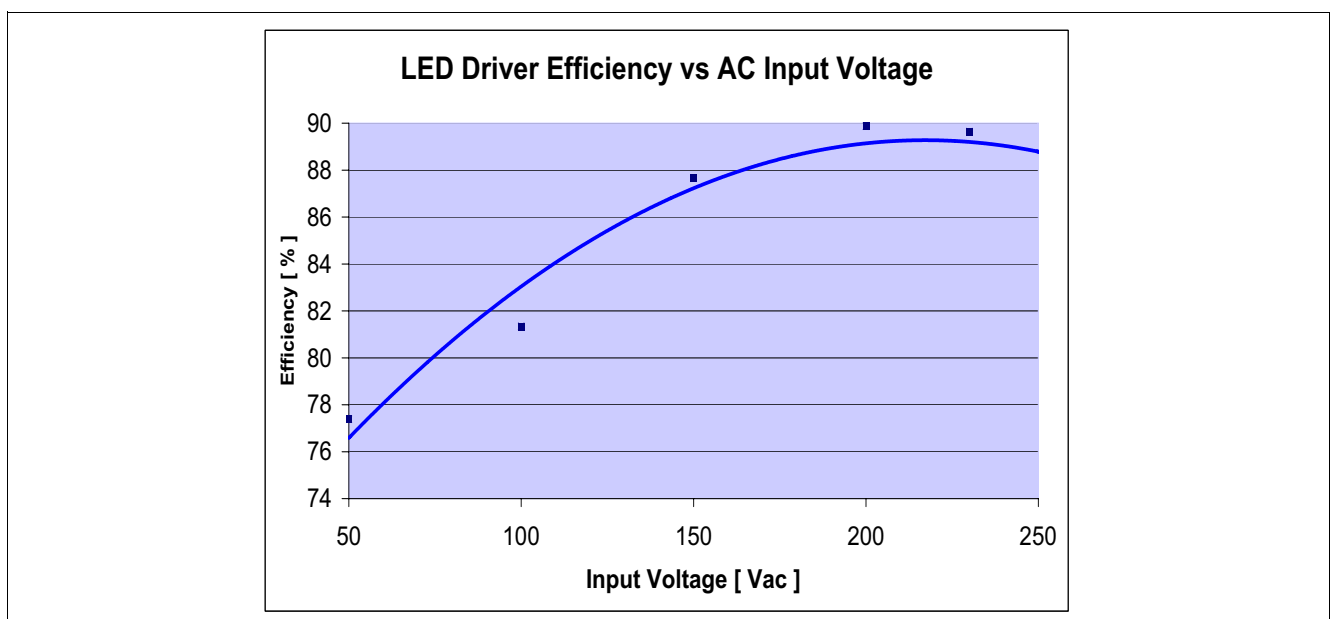


Figure 8 LED Driver efficiency at variable input voltage

5.9 Protection

The ICL8001G provides a full set of protection features as detailed in [Table 2](#).

Table 2 Protection Features

VCC Overvoltage	Auto Restart
VCC Undervoltage	Auto Restart
Over Temperature	Auto Restart
Output Overvoltage	Latch Off
Output Short Circuit	Latch Off

7.2 Bill of Material

 EVAL-LED-ICL8001G-Bulb02 BOM for 230V / 10W Primary Control / Dimming / High PF		
Component	Value	Package
U1	ICL8001G	P-DSO-8 / Infineon
BR	Rectifier 600V / 0.5A RMB6S	SMD
D5	MURS 160 / 600V 1.0A	MELF-B
D6	LL4148	Mini-MELF
D7	LL4148	Mini-MELF
D21	60V, 2A, Schottky Diode	403A / ON Semi MBR5260T3G
Q1	SPD02N80C3	D-PAK / Infineon
C1	68nF/250VAC MKP-X2	RM10 / WIMA
C5	1.0nF/250VAC-Y1	RM10 / Murata DE1E3KX102MA5B
C11	33nF / 630V	RM15 EPCOS B32529/520/521/522
C12	1.0nF / 400V	EPCOS B32520C6102K
C15	10uF / 25V	1206
C17	2.2nF / 25V	0805
C18	470pF / 25V	0805
C22, C24	not assembled	1206
C25	220uF / 35V / Elko	RM 5, diameter 10, height 12
L1	2 x 15mH / 0.4A	EPCOS B82731
L2	BC inductor 1mH / 130mA	axial / EPCOS B78108S1105J
T1	Transformer EF16/9 - L35 = 6.3mH	Würth 750815141
	L68 = 39,2uH / L12 = 20,0uH	N35 = 190 / N68 = 14 / N12 = 10
R1	100k	axial
R2	10R0	0805
R3	2k0	0805
R4	2R7	1206
R5	Varistor / 275Vac	RM10 EPCOS S10K275
R6	15k	0805
R17	3k9	0805
R19	560k	0805
J1	Jumper	below L1
J2	Jumper	below T1

Figure 12 EVAL-LED-ICL8001G-Bulb02 Bill Of Material

7.3 Transformer

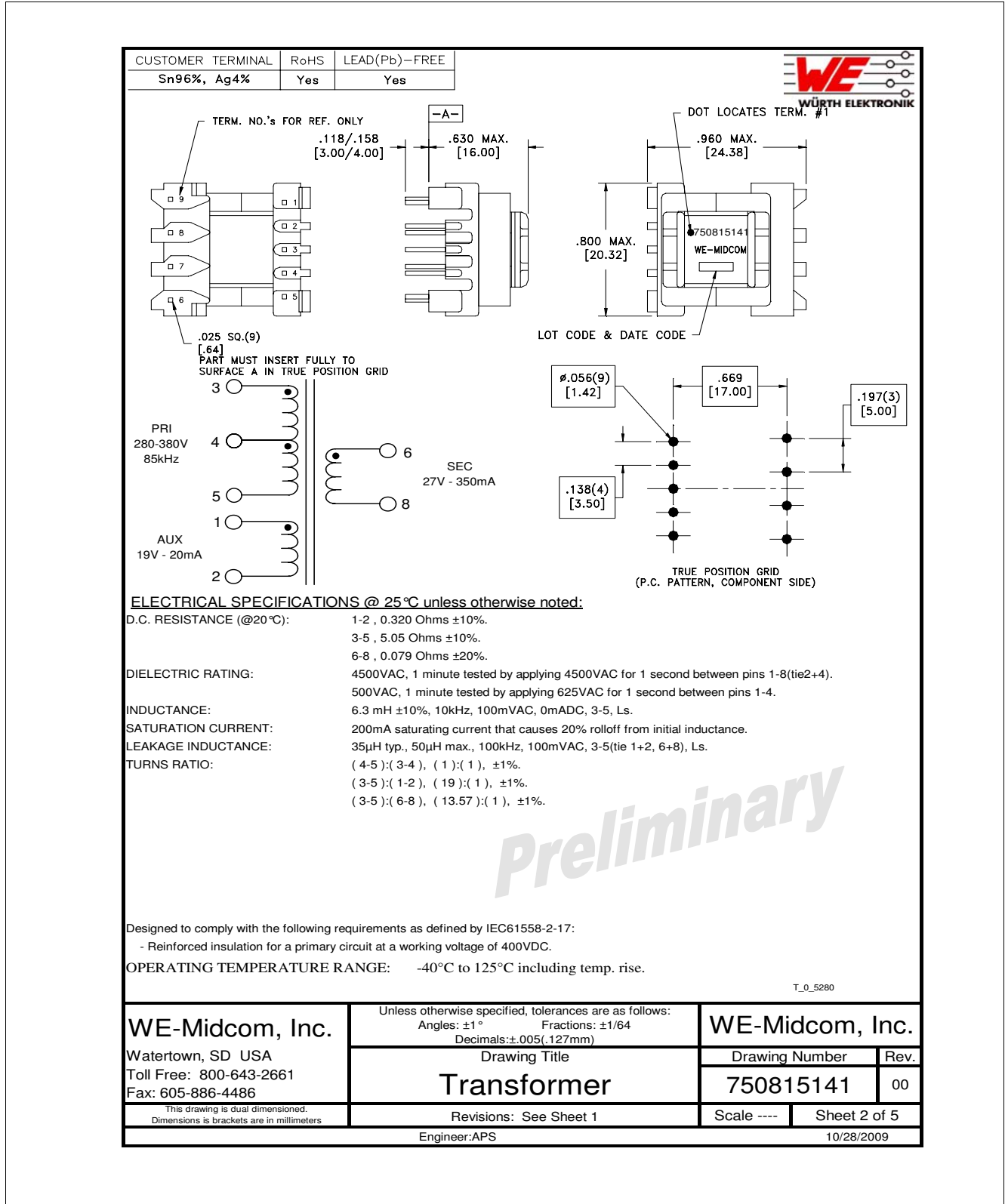


Figure 13 EVAL-LED-ICL8001G-Bulb02 Trafo Design

7.4 Related Documentation From Infineon

[ICL8001G Preliminary Datasheet](http://www.infineon.com) at www.infineon.com

[Quasi-Resonant Controller Appnote](http://www.infineon.com) at www.infineon.com

[Quasi-Resonant Controller Design Tips](http://www.infineon.com) at www.infineon.com

www.infineon.com