Design Example Report

Title	***5.1 W Non-Dimmable, High Power Factor, Non-Isolated Buck LED Driver Using LYTSwitch™-0 LYT0006D***
Specification	90 VAC – 132 VAC Input; 38 V, 135 mA Output
Application	GU10 LED Driver Lamp Replacement
Author	Applications Engineering Department
Document Number	DER-387
Date	September 25, 2013
Revision	1.0

Summary and Features

- Single-stage high power factor (>0.7 at 115 V) and accurate constant current (CC) output
- Low cost, low component count and small PCB footprint solution
- Highly energy efficient, 85 % at 120 VAC input
- Fast start-up time (<20 ms) – no perceptible delay
- Integrated protection and reliability features
  - Auto-recovering thermal shutdown with large hysteresis protects both components and PCB
  - No damage during brown-out conditions
- Meets IEC ring wave, differential line surge and EN55015 conducted EMI

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Important Note:
Although this board is designed to satisfy safety isolation requirements, the engineering prototype has not been agency approved. Therefore, all testing should be performed using an isolation transformer to provide the AC input to the prototype board.

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1 Introduction

This document describes a cost effective power supply utilizing the LYTSwitch^{TM}-0 family (LYT0006D) in a highly compact buck topology.

This power supply operates over an input voltage range of 90 VAC to 132 VAC. The DC bus voltage is high enough to support a 38 V output when using a buck topology. In a buck converter the output voltage must always be lower than the input voltage. The output voltage is also limited by the maximum duty cycle of the LYTSwitch-0, which also requires the input voltage to be larger than the output voltage.

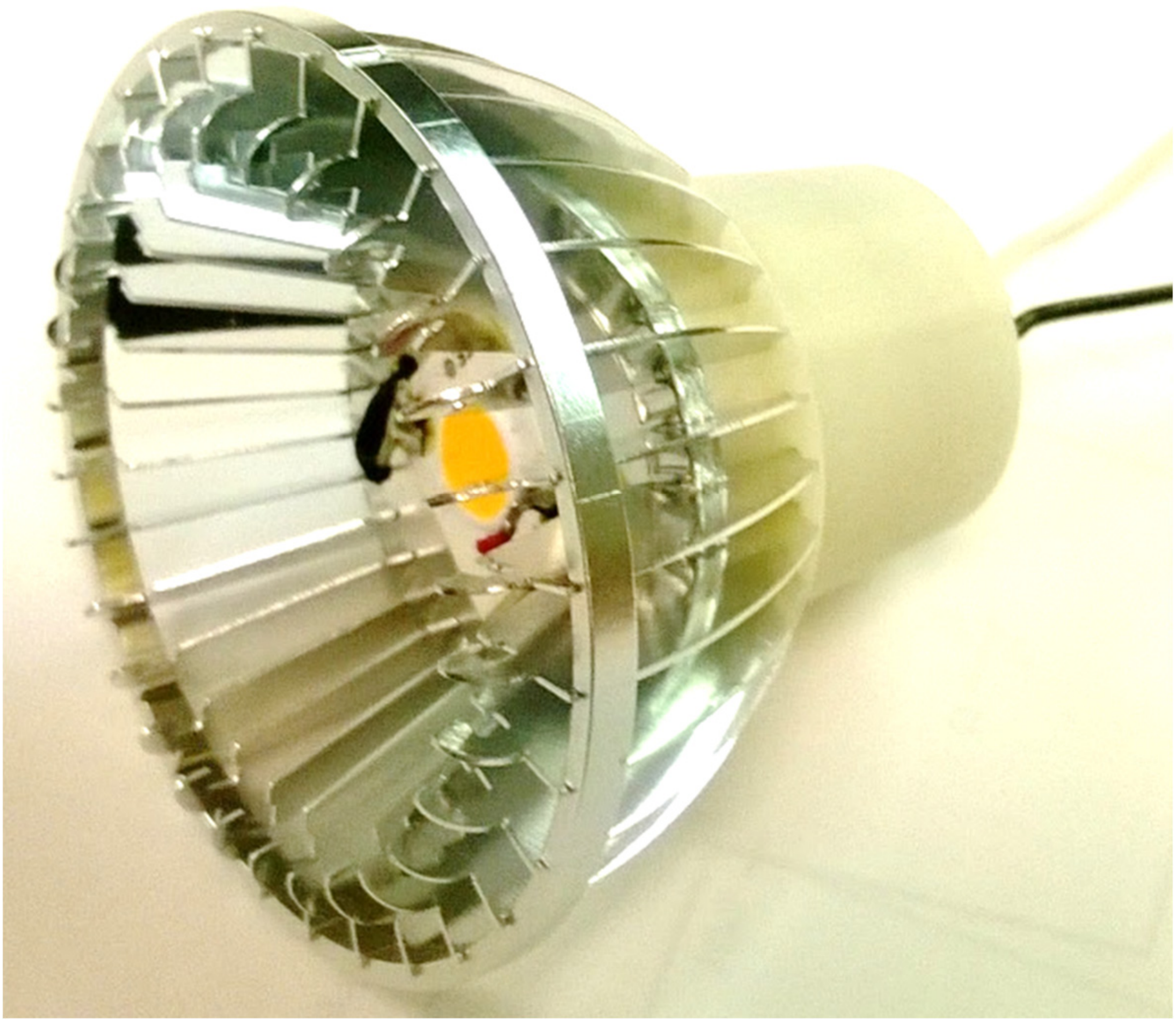

Figure 1 – GU10 Bulb from CREE.

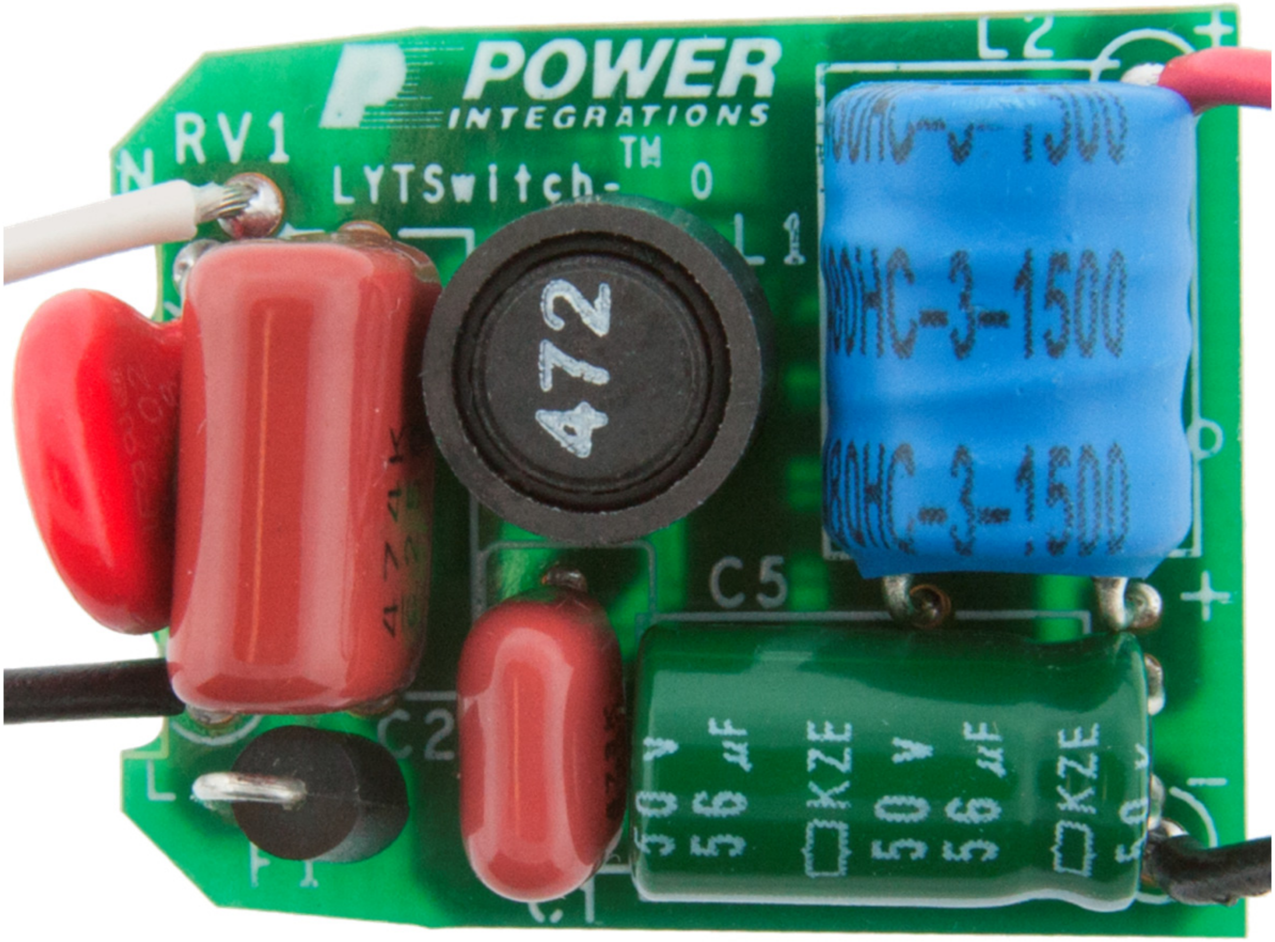

Figure 2 – Populated Circuit Board Photograph, Top.

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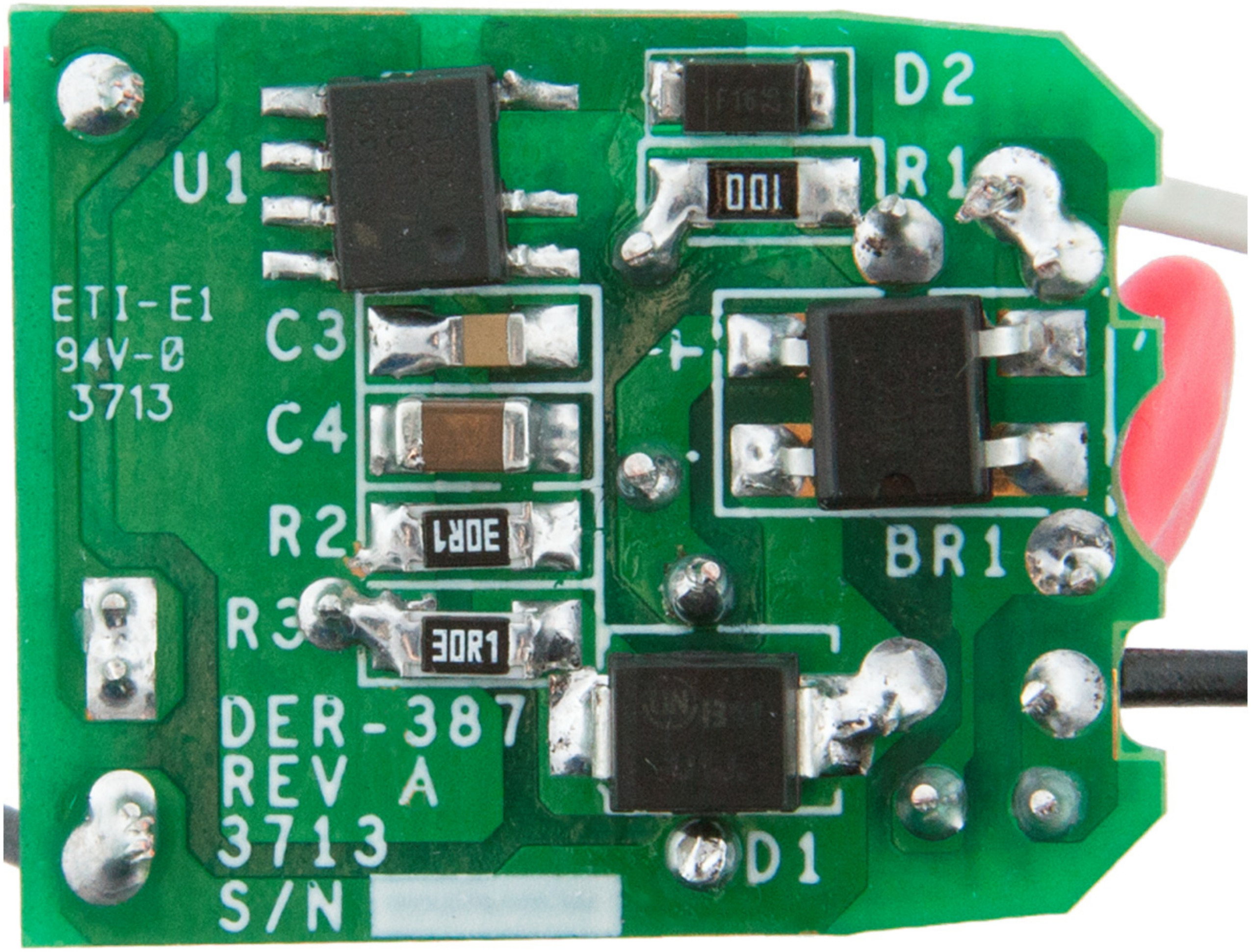

Figure 3 – Populated Circuit Board Photograph, Bottom.

2 Power Supply Specification

The table below represents the minimum acceptable performance of the design. Actual performance is listed in the results section.

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage Operation	V_{IN}	90		132	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	60		Hz	Operating frequency is not limited. Adjust sense resistor if application is for 400 Hz line.
Output						
Output Voltage	V_{OUT}		38		V	
Output Current	I_{OUT}		135		mA	±5% at 90 VAC - 132 VAC
Total Output Power						
Continuous Output Power	P_{OUT}		5.1		W	
Efficiency						
120 VAC; 38 V LED	η		85		%	Measured at P_{OUT} 25 °C
Power Factor						
120 VAC; 38 V LED	PF		0.7			Measured at P_{OUT} 25 °C
Environmental						
Conducted EMI		Meets CISPR22B / EN55015B				
Line Surge Differential Mode (L1-L2)			0.5		kV	1.2/50 µs surge, IEC 1000-4-5, Series Impedance: Differential Mode: 2 Ω
Ring Wave (100 kHz) Differential Mode (L1-L2)			2.5		kV	500 A short circuit Series Impedance: Differential Mode: 2 Ω
Ambient Temperature	T_{AMB}			50	°C	See thermal results section

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3 Schematic

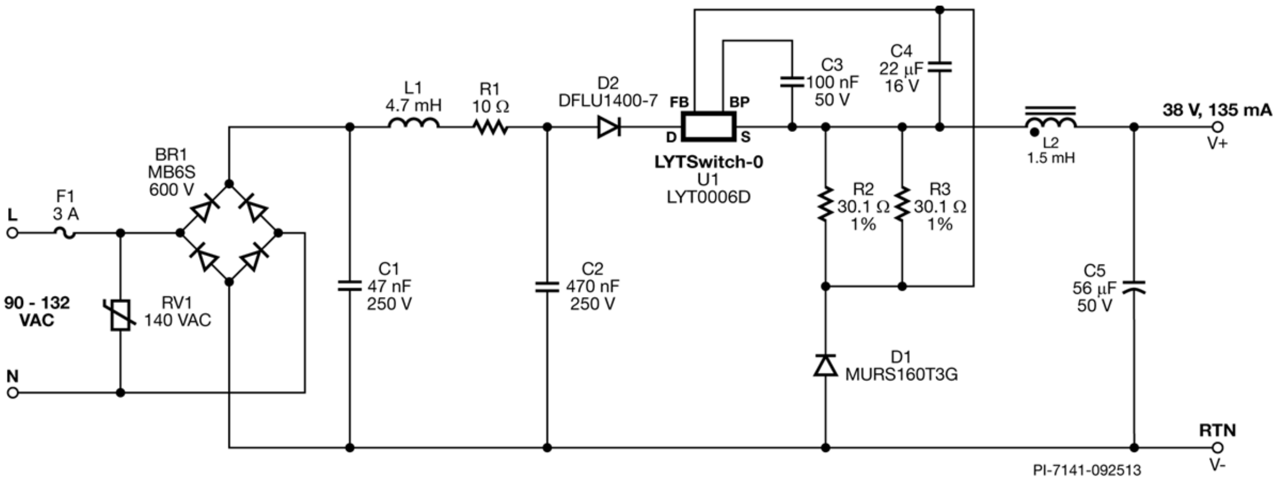

Figure 4 – Schematic.

4 Circuit Description

The power supply shown in Figure 4 uses the LYT0006D (U1) in a high-side buck configuration to deliver a constant 135 mA current at an output voltage of 38 VDC. The power supply is designed for driving LEDs, which should always be driven with a constant current (CC).

4.1 Input EMI Filtering

Fuse F1 provides circuit protection for abnormal conditions. Bridge BR1 provides full wave rectification. Capacitor C1, C2 and differential choke L1 form a π filter in order meet conducted EMI standards. Resistor R1 is used for damping the input stage filter for better pf performance. Capacitor C1 and C2 are also used for energy storage reducing line noise and protecting against line surge.

4.2 LYTSwitch-0

LYTSwitch-0 is optimized to achieve a simple and cost effective LED driver with good line and temperature regulation from 0 to 100 °C (LYTSwitch-0 case temperature). The PIXls spreadsheet was used to achieve the best line regulation by balancing the power inductor and the sense resistor. The total input capacitance will also have some effect but this can be corrected by adjusting the sense resistor (R2, R3) to optimize performance.

The LYTSwitch-0 family has built-in thermal limit to protect the power supply in case the bulb is subjected to excessive temperature.

The buck converter stage is consists of the integrated power MOSFET switch within LYT0006D (U1), a freewheeling diode (D1), sense resistor (R2, R3), power inductor L2 and output capacitor (C5). The converter is operating mostly in DCM in order to limit the cycles of reverse current. A fast freewheeling diode was selected to minimize the switching losses.

4.3 Output Rectification

A fast output diode (D1) was used to achieve good efficiency and reduce temperature. Typically in LED applications, the ambient temperature in the enclosure is above 70°C. An output rectifier with low t_{RR} (<35 ns) is recommended as low t_{RR} would minimize the switching losses especially in the power MOSFET during the diode's transition to reverse blocking mode.

4.4 Output Feedback

Regulation is maintained by skipping switching cycles. As the output current rises, the voltage into the FB pin will rise. If this exceeds V_{FB} then subsequent cycles will be skipped until the voltage reduces below V_{FB}. Current is sensed via R2-R3 and filtered by C4, then fed to the FB pin for accurate regulation. The key to achieving good line regulation lies in balancing the power inductor and sense resistor values, with the calculated minimum inductance.

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The bypass capacitor (C4) is connected between the FEEDBACK pin and the SOURCE pin which helps reduce power loss during output current sensing. The capacitor acts as sample-and-hold element for the feedback current information which is fed into the FB pin. No limiting resistor is required between the FB pin and C4 because the peak voltage will not exceed the maximum input voltage rating of the device pin.

4.5 No Open-Load Protection

The unit has no open-load protection.

5 PCB Layout

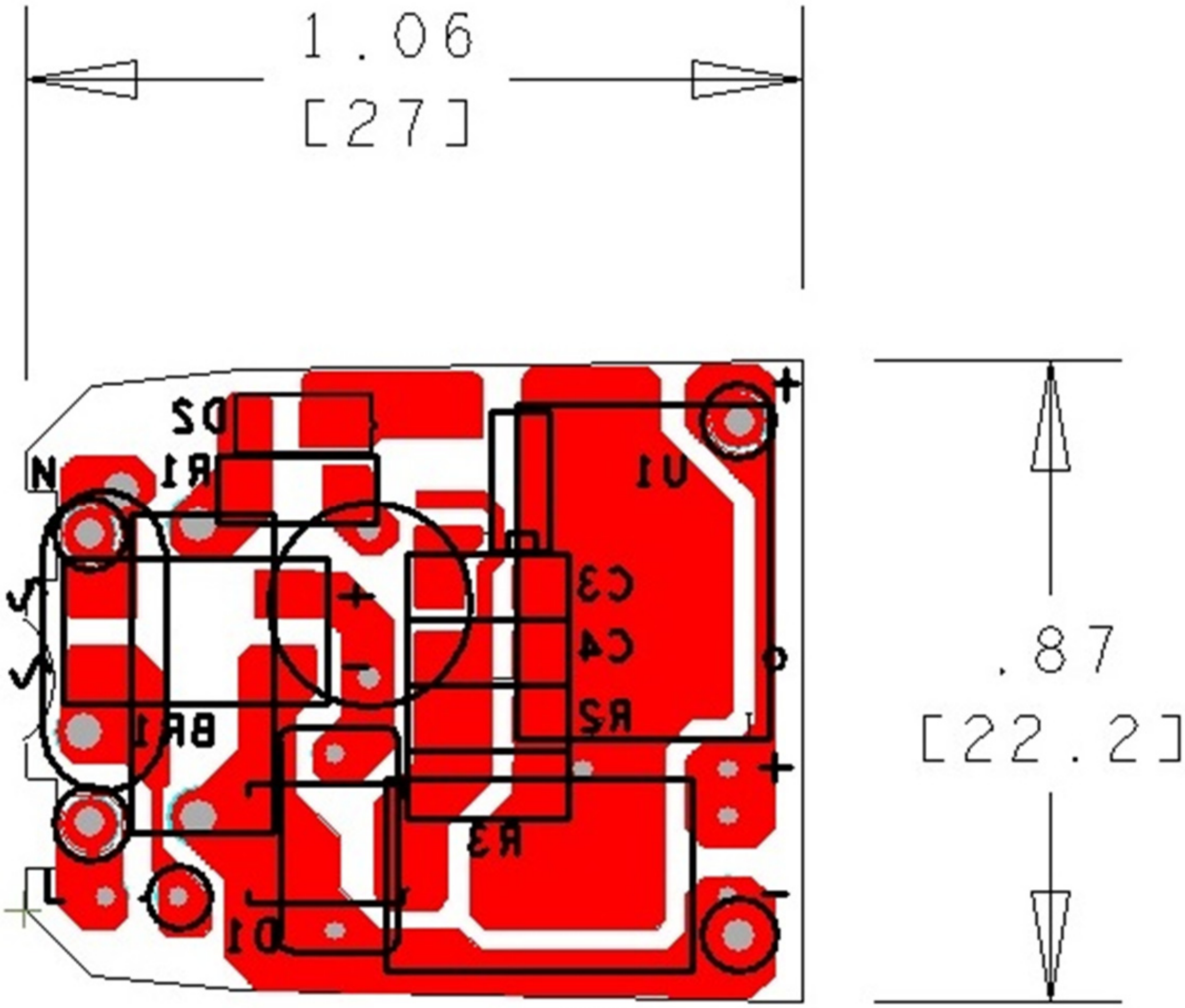

Figure 5 – Printed Circuit Layout, Bottom View.

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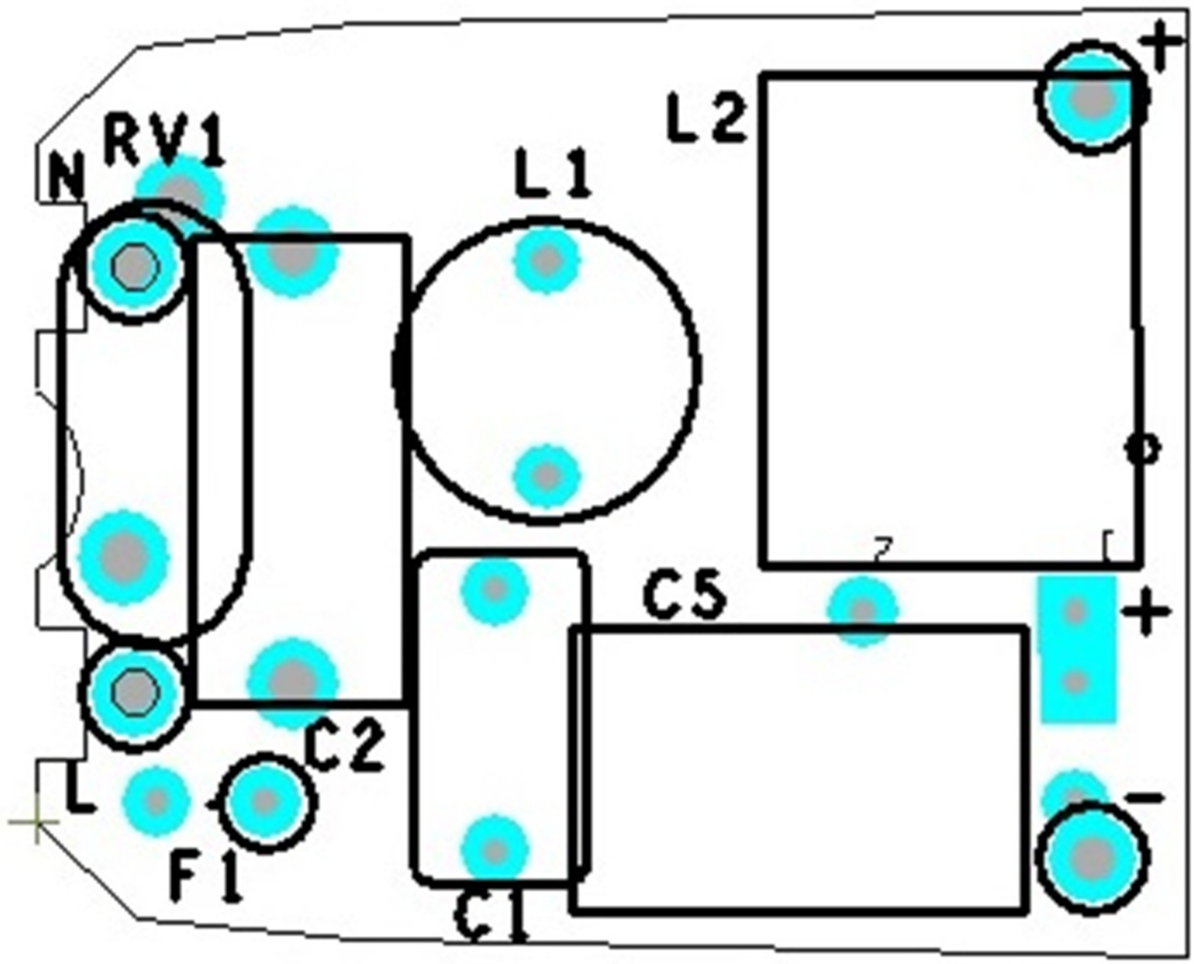

Figure 6 – Printed Circuit Layout, Top View.

6 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	600 V, 0.5 A, Bridge Rectifier, SMD, MBS-1, 4-SOIC	MB6S-TP	Micro Commercial
2	1	C1	47 nF, 250 V, Film	ECQ-E2473KB	Panasonic
3	1	C2	470 nF, 250 V, Film	ECQ-E2474KB	Panasonic
4	1	C3	100 nF, 50 V, Ceramic, X7R, 1206	GRM319R71H104KA01D	Murata
5	1	C4	22 μF, 16 V, Ceramic, X5R, 1206	EMK316BJ226ML-T	Taiyo Yuden
6	1	C5	56 μF, 50 V, Electrolytic, Very Low ESR, 140 mΩ, (6.3 x 11)	EKZE500ELL560MF11D	Nippon Chemi-Con
7	1	D1	600 V, 1 A, Ultrafast Recovery, 35 ns, SMB Case	MURS160T3G	On Semi
8	1	D2	400 V, 1A, DIODE SUP FAST 1A PWRDI 123	DFLU1400-7	Diodes, Inc.
9	1	F1	3 A, 125 V, Fast, Microfuse, Axial	MQ3	Bel Fuse
10	1	L1	4.7 mH, 0.11 A, Shielded Radial Choke Coil	RL-8054-1-472KR11-S	Renco Electronics
11	1	L2	1.5 mH, 0.46 A, 10%	RL-5480HC-3-1500	Renco Electronics
12	1	R1	10 Ω, 5%, 1/4 W, Pulse Proof, Thick Film, 1206	SR1206JR-0710RL	Yago
13	1	R2	30.1 Ω, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF30R1V	Panasonic
14	1	R3	30.1 Ω, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF30R1V	Panasonic
15	1	RV1	140 V, 12 J, 7 mm, RADIAL	V140LA2P	Littlefuse
16	1	U1	LinkSwitch-TN, SMD-8C	LYT0006D	Power Integrations

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7 Design Spreadsheet

ACDC_LYTSwitch-0_062013; Rev.1.0; Copyright Power Integrations 2013	INPUT	OUTPUT	UNIT	LYTSwitch-0_Rev_1-0.xls: LYTSwitchZero Design Spreadsheet
INPUT VARIABLES				
VACMIN	90	90.00	Volts	Minimum AC Input Voltage
VACNOM	120	120.00	Volts	Nominal AC Input Voltage
VACMAX	132	132.00	Volts	Maximum AC Input Voltage
FL	60	60.00	Hertz	Select Line Frequency
VO	38	38.00	Volts	Output Voltage
IO	137.500	138	mA	Output Current
Pout		5.23	W	Output Power
EFFICIENCY		0.90		Overall Efficiency Estimate (Adjust to match Calculated, or enter Measured Efficiency)
CIN	0.51	0.51	uF	Input Filter Capacitor
DC INPUT VARIABLES				
VMIN		38.1	Volts	Minimum DC Bus Voltage
VMAX		186.7	Volts	Maximum DC bus Voltage
LYTSwitchZero				
LYTSwitchZero	**LYT0006**	LYT0006		Selected LYTSwitchZero. Ordering info - Suffix P/G indicates DIP 8 package; suffix D indicates SO8 package; second suffix N indicates lead free RoHS compliance
ILIMIT		0.375	Amps	Typical Current Limit
ILIMIT_MIN		0.333	Amps	Minimum Current Limit
ILIMIT_MAX		0.401	Amps	Maximum Current Limit
FSMIN		62000	Hertz	Minimum Switching Frequency
IRMS		104.55	mA	Expected RMS current through LYTSwitch
VDS		4.8	Volts	Maximum On-State Drain To Source Voltage drop
DIODE				
VD		0.70	Volts	Freewheeling Diode Forward Voltage Drop
VRR		400	Volts	Recommended PIV rating of Freewheeling Diode
IF		1	Amps	Recommended Diode Continuous Current Rating
Diode Recommendation		BYV26C		Suggested Freewheeling Diode
OUTPUT INDUCTOR				
Core type	**Off-the-Shelf**	Off-the-Shelf		Select core type between Ferrite and Off-the-Shelf
Core size				Select core size
Custom Core	**RL-5480HC-3-1500**			Enter custom core description (if used)
AE		N/A	mm^2	Core Effective Cross Sectional Area
LE		N/A	mm	Core Effective Path Length
AL		N/A	nH/T^2	Ungapped Core Effective Inductance
BW		N/A	mm	Bobbin Physical Winding Width
NL		N/A		Number of turns on inductor
BP		N/A	Gauss	Peak flux density
LG		N/A	mm	Gap length
OD		N/A	mm	Maximum Primary Wire Diameter including insulation
INS		N/A	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA		N/A	mm	Bare conductor diameter
AWG		N/A	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM		N/A	Cmils	Bare conductor effective area in circular mils

CMA		N/A	Cmils/Amp	CAN DECREASE CMA < 500 (decrease L(primary layers),increase NS,use smaller Core)
L		N/A		Number of layers
LP_MIN	1500.00	1500	uH	Minimum value of Output Inductor, Recommended Standard Value
IO_Average		135.5	mA	Average output current (Nominal input voltage)
ILRMS		172.69	mA	Estimated RMS inductor current (at VMAX)
FEEDBACK COMPONENTS				
RFB	15.05	15.05	Ohms	Feedback Resistor. Use closest standard 1% value. Use Goal seek to adjust (or manually adadjust) value of RFB such that IO_VACNOM equals the specified value of IO
CFB		22	uF	Feedback Capacitor
OUTPUT REGULATION				
IO_VACMIN		135.5	mA	Output Current at VACMIN
IO_VACNOM		135.6	mA	Output Current at VACNOM
IO_VACMAX		135.0	mA	Output Current at VACMAX

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8 Performance Data

All measurements performed at room temperature (≈25 ºC) unless otherwise specified.

8.1 Test Data for 38 V LED Load

Input Measurement					Load Measurement			Calculation		
V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	%ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	P_{CAL} (W)	Efficiency (%)	Loss (W)
90.03	83.58	6.279	0.834	63.61	38.6900	136.910	5.356	5.30	85.30	0.92
100.00	79.13	6.286	0.794	72.99	38.7150	137.290	5.363	5.32	85.31	0.92
115.04	73.38	6.259	0.742	84.27	38.7350	136.910	5.338	5.30	85.28	0.92
120.03	72.09	6.249	0.722	88.02	38.7340	136.710	5.327	5.30	85.24	0.92
132.06	69.09	6.233	0.683	96.1	38.7390	136.340	5.307	5.28	85.14	0.93

Table 1 – Test Data for 38 V LED Load.

8.2 Efficiency

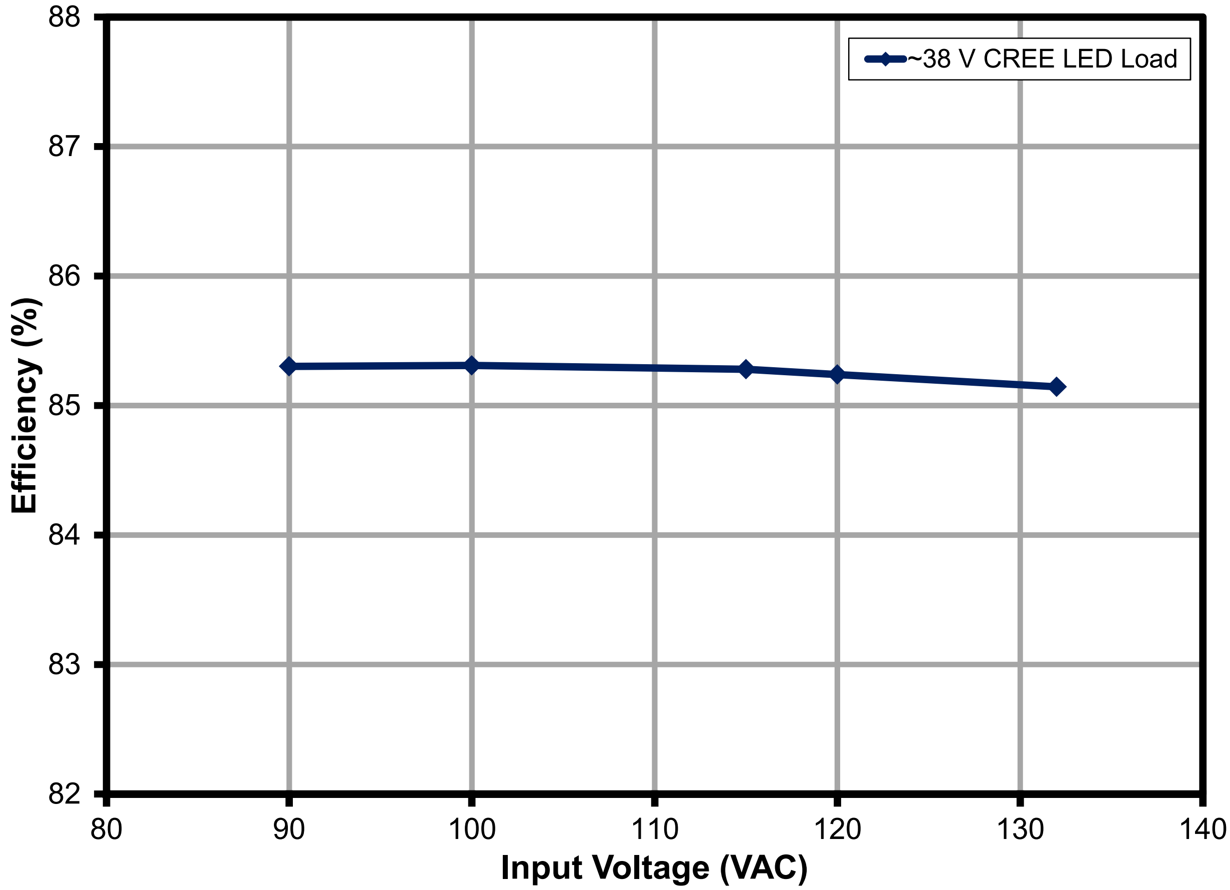

Figure 7 – Efficiency with Respect to AC Input Voltage. 90-132 VAC (60 Hz) Input.

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8.3 Output Current Regulation

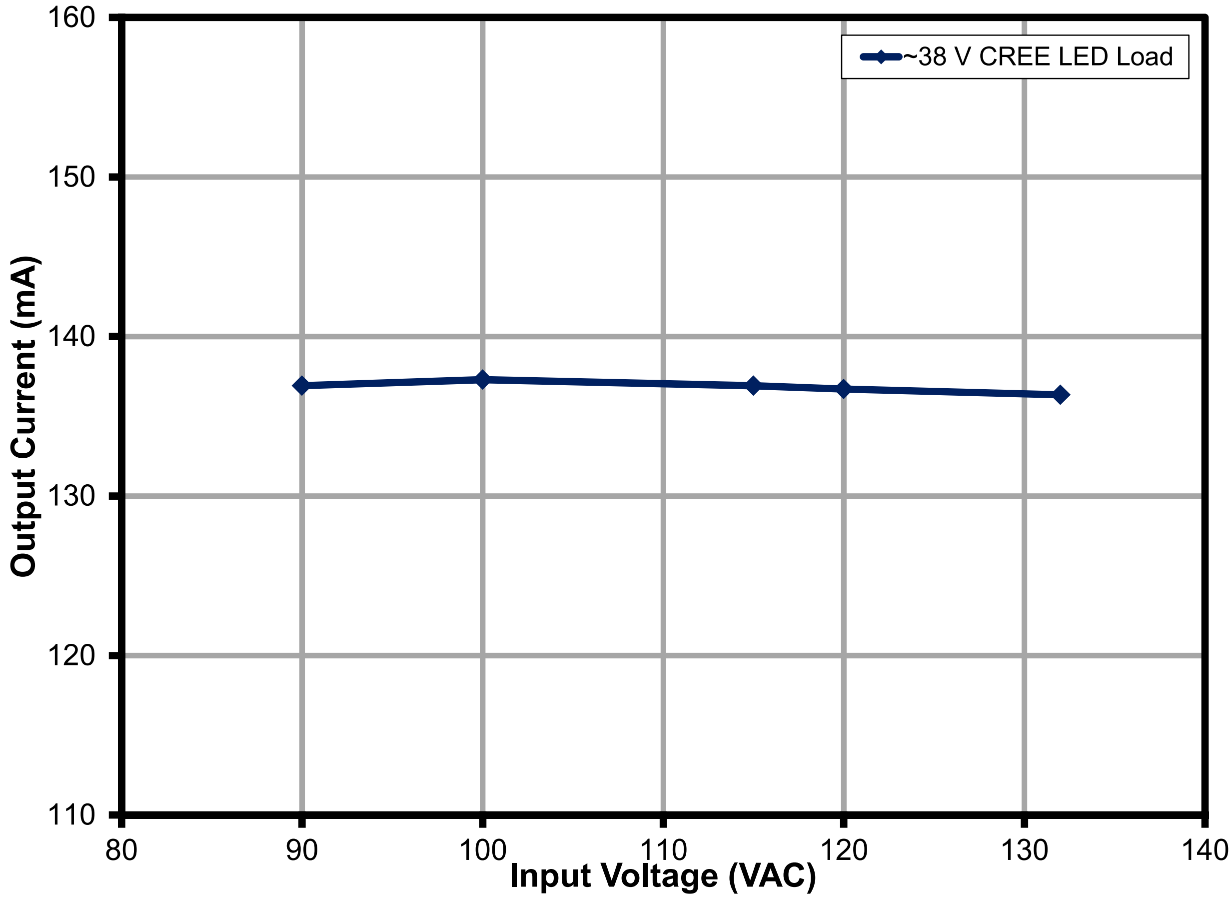

Figure 8 – Line Regulation.

8.4 Power Factor

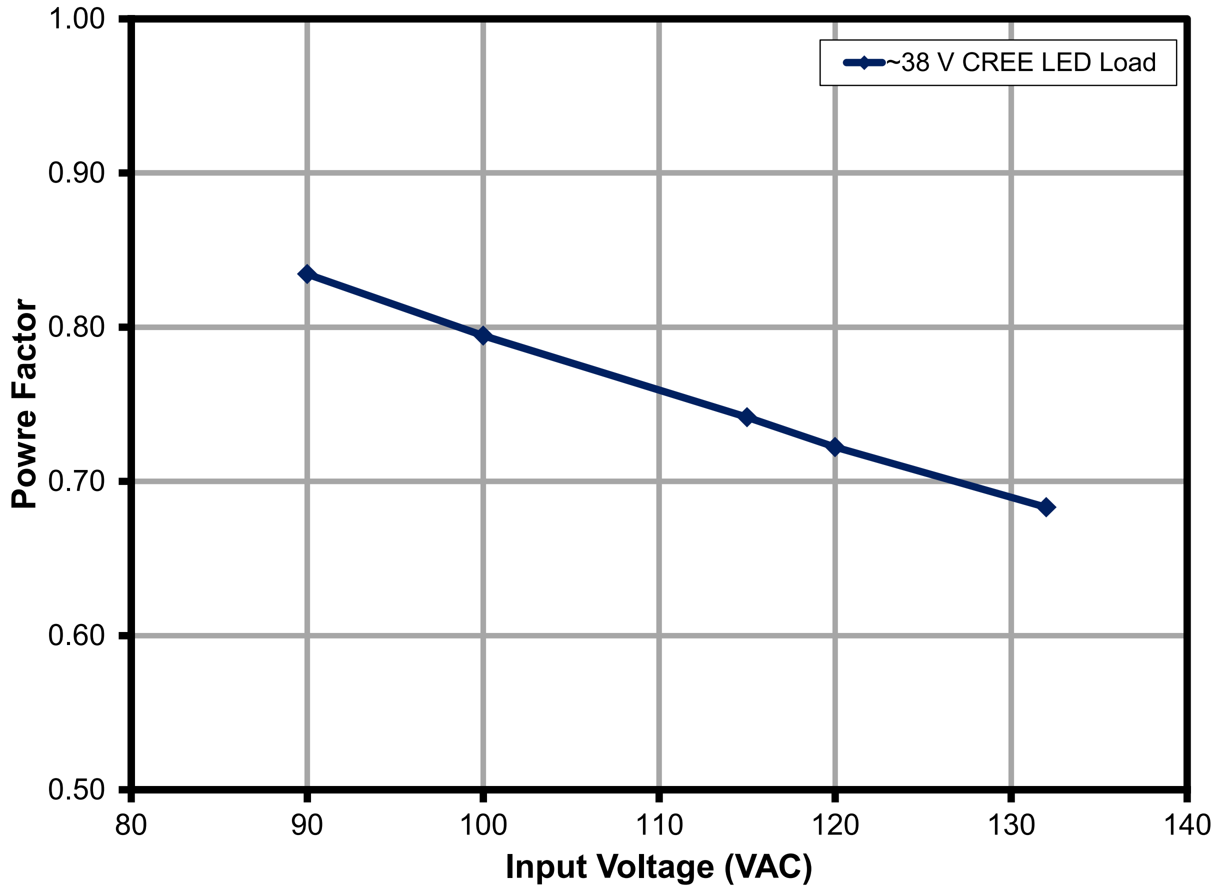

Figure 9 – Line Regulation.

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9 Thermal Performance

9.1 Thermal Set-up

The LED Driver was placed inside a GU10 assembly provided by CREE and the thermal test was conducted with the unit placed inside the chamber.

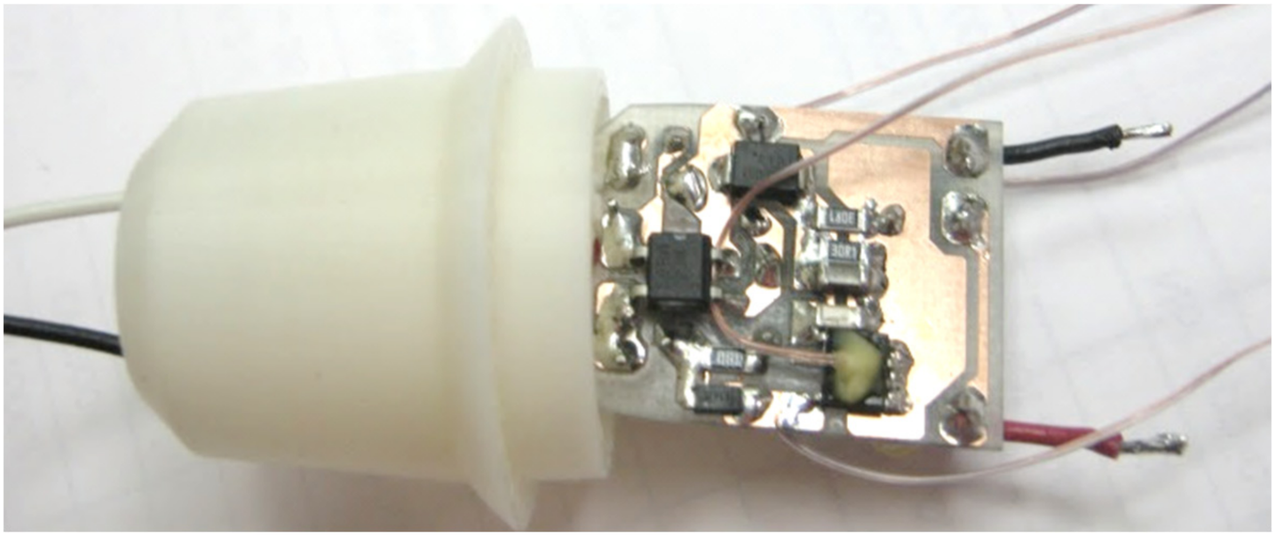

Figure 10 – Bottom Side Thermocouple Location.

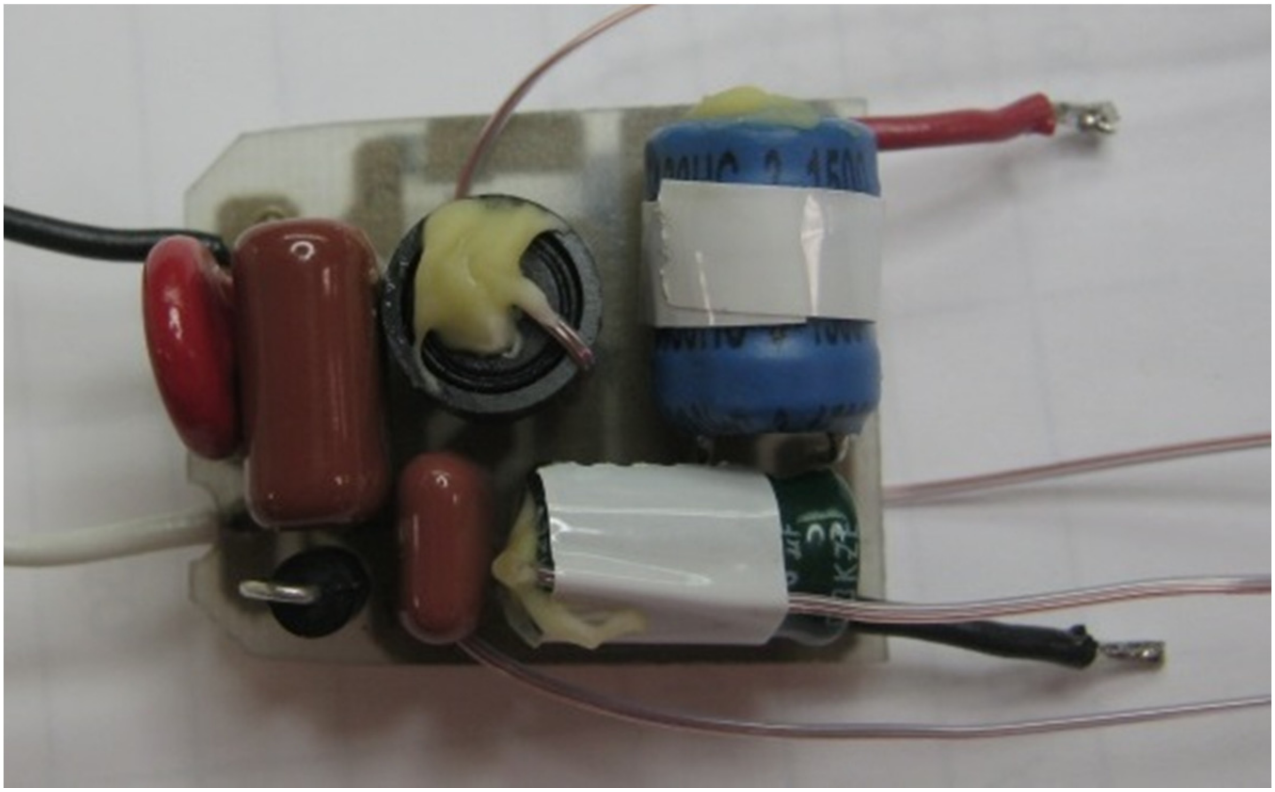

Figure 11 – Top Side Thermocouple Location.

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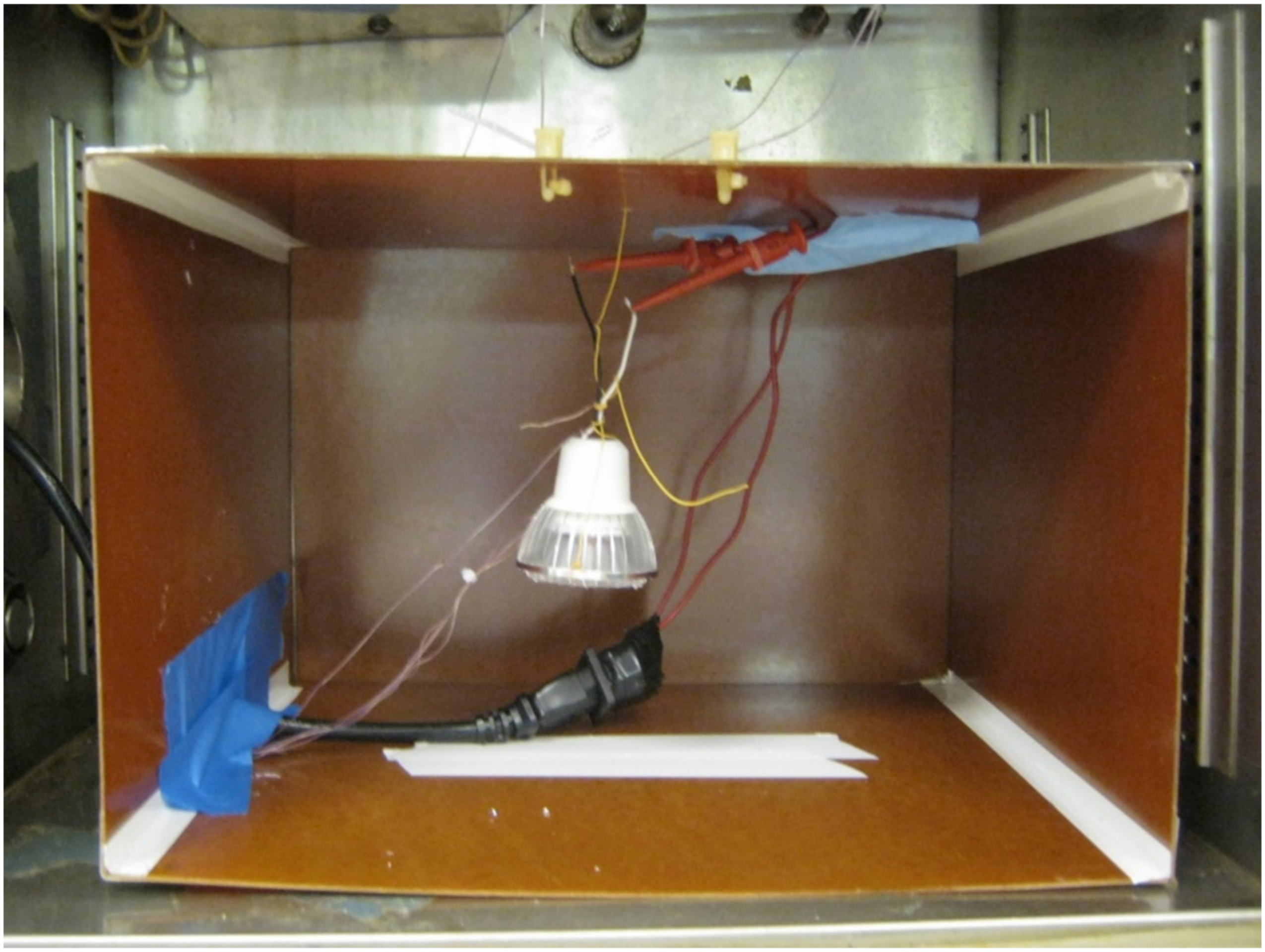

Figure 12 – GU10 Bulb Placed Inside an Enclosed Box to Prevent Air Flow from the Fan of the Thermal Chamber.

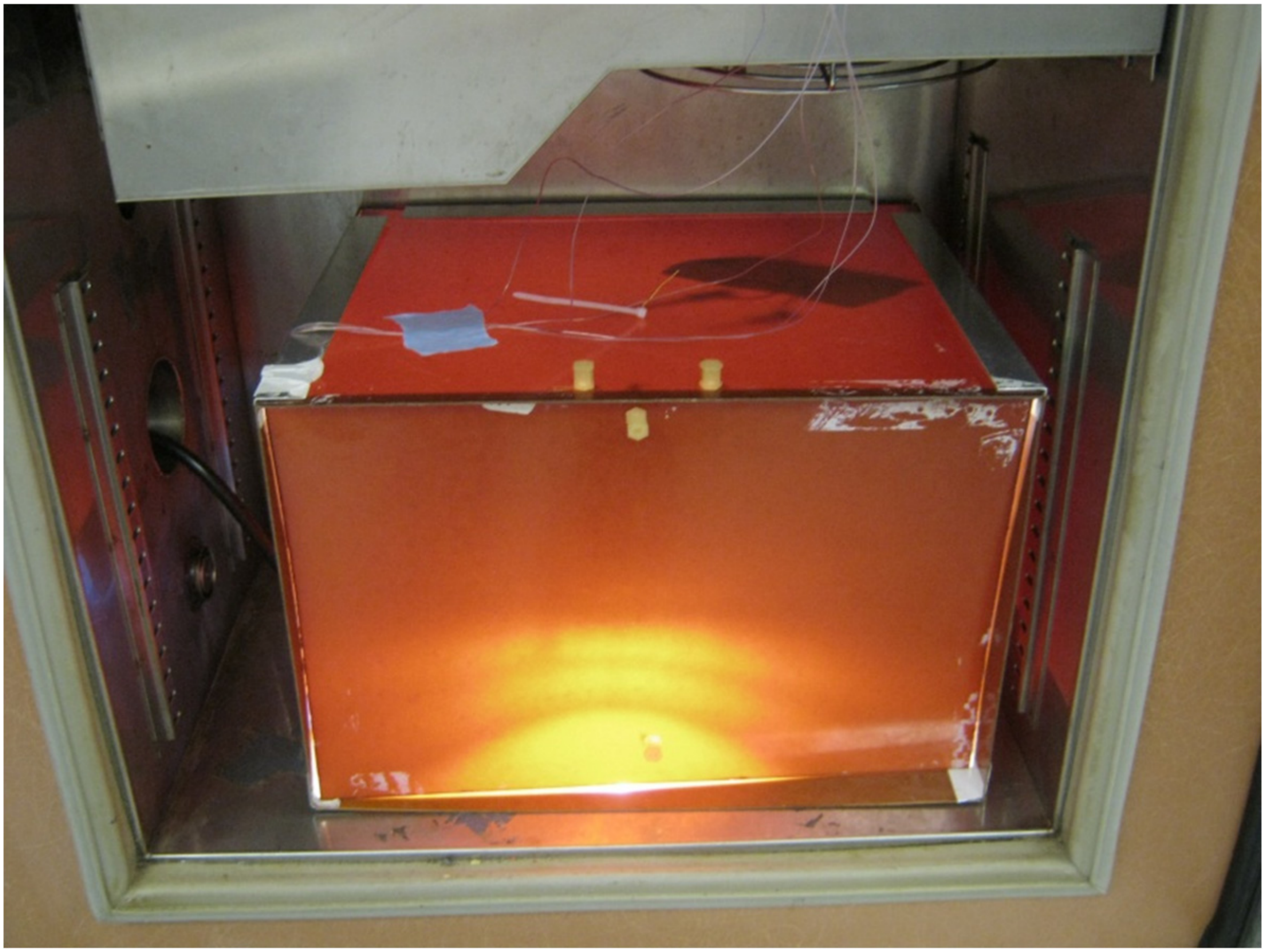

Figure 13 – UUT Placed Inside an Enclosed Box as Shown.

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9.2 *Thermal Results*

9.2.1 Input: 90 VAC / 60 Hz
Load: 38 V LED Load

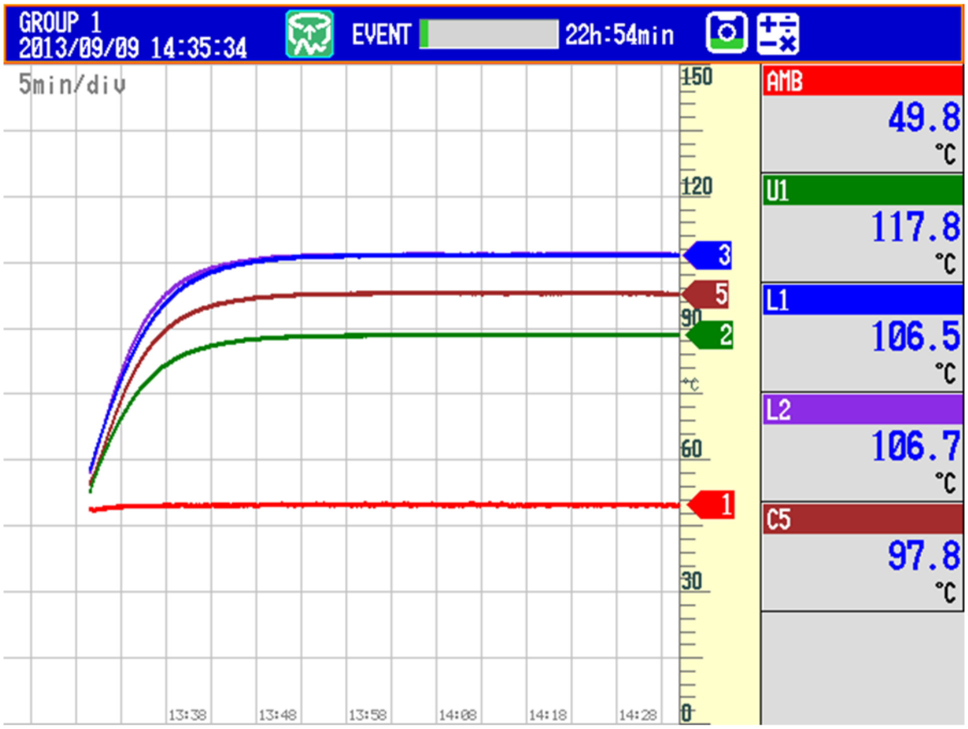

Figure 14 – Thermal Measurement at 90 VAC Input, ~50 ºC External Ambient.

Location	Description	Temperature (ºC)
AMB	External Ambient	49.8
U1	LYT0006D	117.8
L1	Differential Choke	106.5
L2	Power Inductor	106.7
C5	Output Capacitor	97.8

Table 2 – 90 VAC Input Critical Components Thermal Measurement.

9.2.2 Input: 120 VAC / 60 Hz
Load: 38 V LED Load

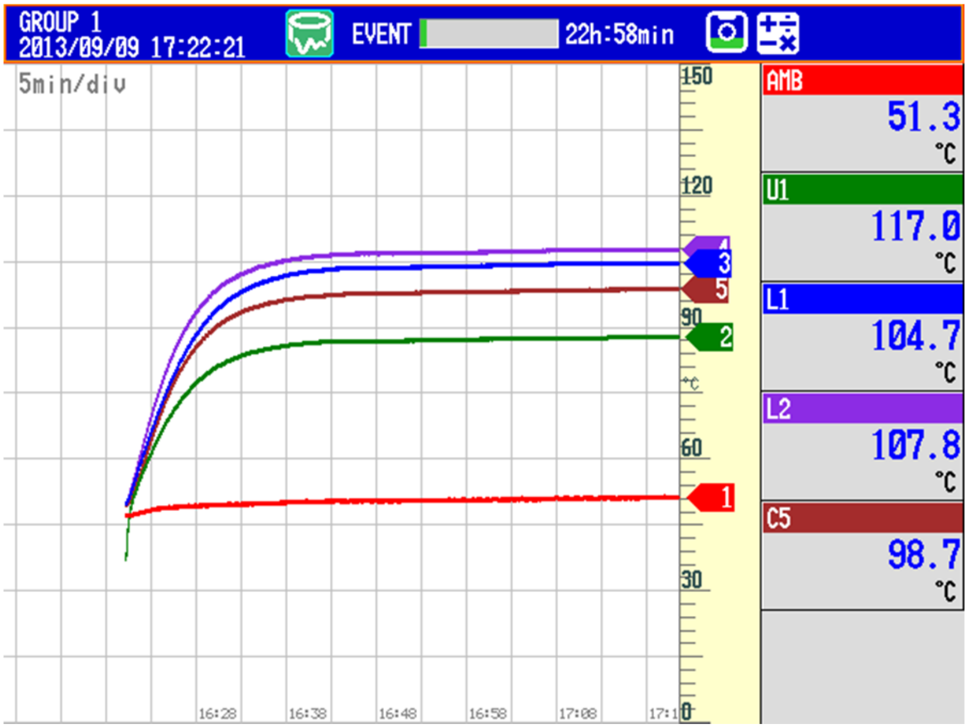

Figure 15 – Thermal Measurement at 120 VAC Input, ~50 ºC Ambient.

Location	Description	Temperature (ºC)
AMB	External Ambient	51.3
U1	LYT0006D	117
L1	Differential Choke	104.7
L2	Power Inductor	107.8
C5	Output Capacitor	98.7

Table 3 – 120 VAC Input Critical Components Thermal Measurement.

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9.2.3 Input: 132 VAC / 60 Hz
Load: 38 V LED Load

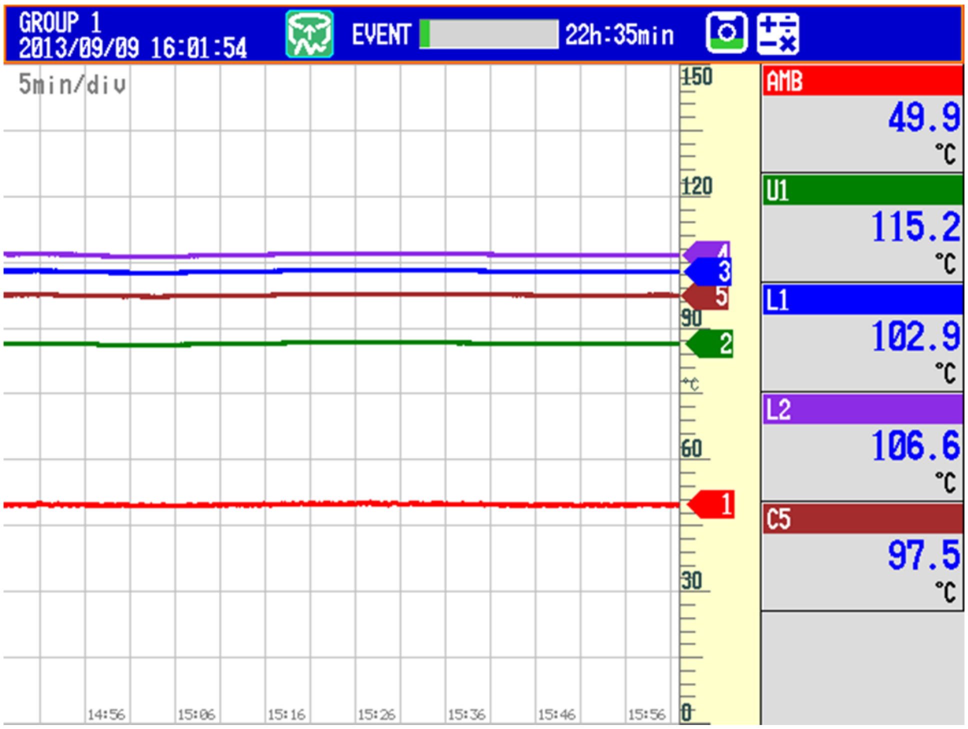

Figure 16 – Thermal Measurement at 132 VAC Input, ~50 ºC Ambient.

Location	Description	Temperature
AMB	External Ambient	49.9
U1	LYT0006D	115.2
L1	Differential Choke	102.9
L2	Power Inductor	106.6
C5	Output Capacitor	97.5

Table 4 – 132 VAC Input Critical Components Thermal Measurement.

10 Waveforms

10.1 Drain Voltage Normal Operation

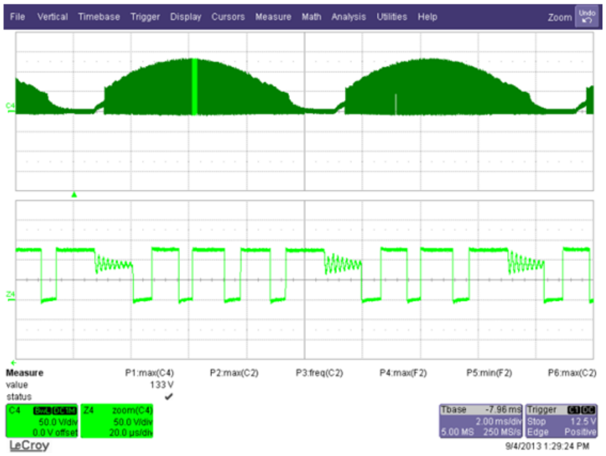

Figure 17 – 90 VAC, 60Hz, Full Load.
Ch4: V_{D-S}, 50 V / div., 2 ms / div.
Z4: V_{D-S}, 50 V, 20 μs / div.

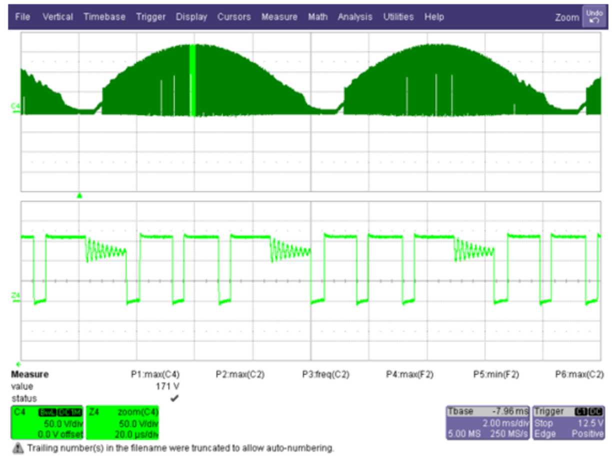

Figure 18 – 115 VAC, Full Load.
Ch4: V_{D-S}, 50 V / div., 2 ms / div.
Z4: V_{D-S}, 50 V, 20 μs / div.

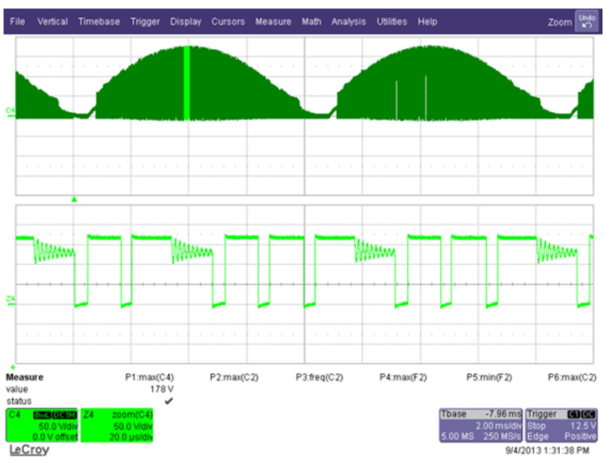

Figure 19 – 120 VAC, 60Hz, Full Load.
Ch4: V_{D-S}, 50 V / div., 2 ms / div.
Z4: V_{D-S}, 50 V, 20 μs / div.

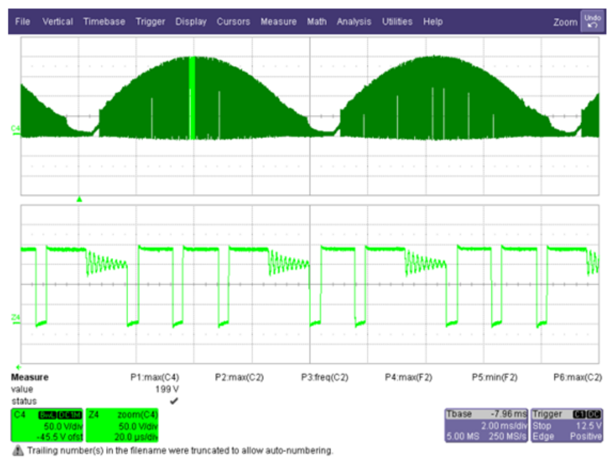

Figure 20 – 132 VAC, Full Load.
Ch4: V_{D-S}, 50 V / div., 2 ms / div.
Z4: V_{D-S}, 50 V, 20 μs / div.

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10.2 Drain Current at Normal Operation

Missing pulses are normal and are used to regulate the output current. These missing pulses are present every time the sense resistor (R2, R3) voltage-drop reaches 1.65 V. The unit will enter into auto-restart if there is not at least one missing pulse within 50 ms. For some designs wherein the power inductance is high and operating mostly in CCM, a reverse current may be present. One way to avoid this is by increasing the device size or increase input capacitance or adding a blocking diode in the drain. See AN-60 for more details.

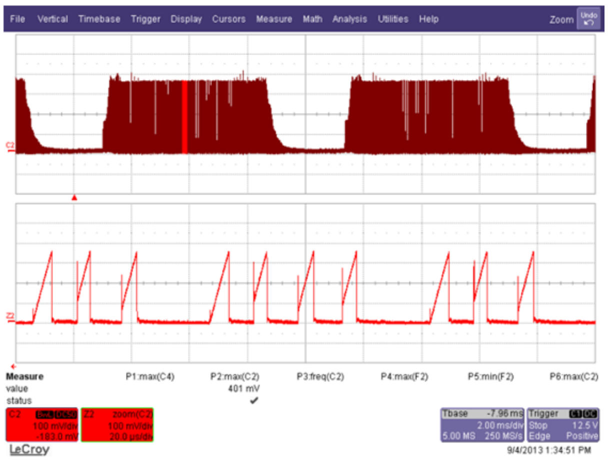

Figure 21 – 90 VAC, 60 Hz, 38 V_{LED}.
Ch2: I_{D-S}, 100 mA / div., 2 ms / div.
Z2: I_{D-S}, 100 mA, 20 μs / div.

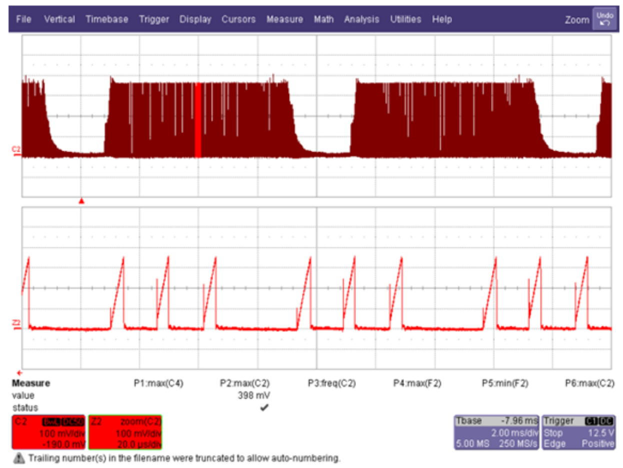

Figure 22 – 115 VAC, 60 Hz, 38 V_{LED}.
Ch2: I_{D-S}, 100 mA / div., 2 ms / div.
Z2: I_{D-S}, 100 mA, 20 μs / div.

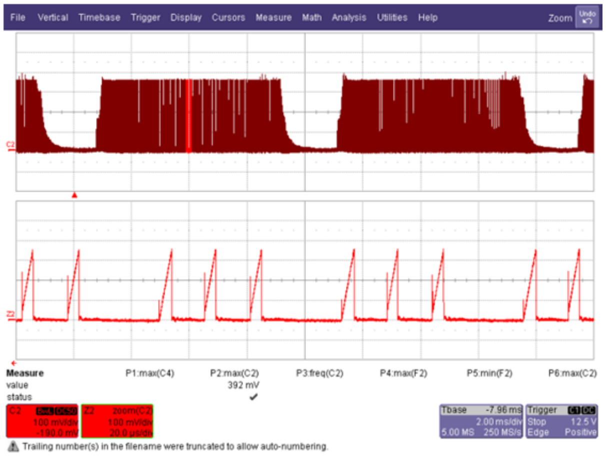

Figure 23 – 120 VAC, 60 Hz, 38 V_{LED}.
Ch2: I_{D-S}, 100 mA / div., 2 ms / div.
Z2: I_{D-S}, 100 mA, 20 μs / div.

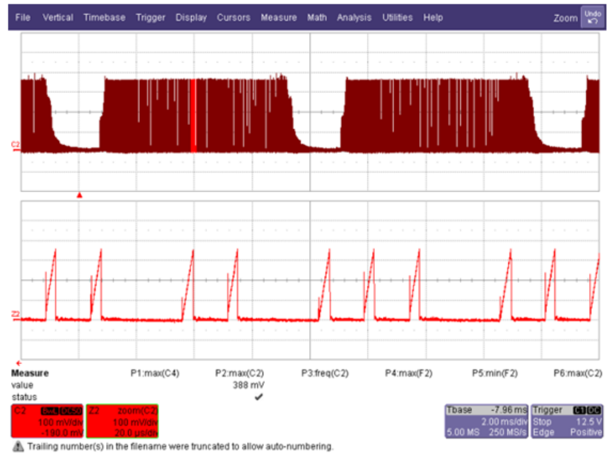

Figure 24 – 132 VAC, 60 Hz, 38 V_{LED}.
Ch2: I_{D-S}, 100 mA / div., 2 ms / div.
Z2: I_{D-S}, 100 mA, 20 μs / div.

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10.3 Drain Voltage and Current When Output Short

Device is operating within the range and no inductor saturation was observed.

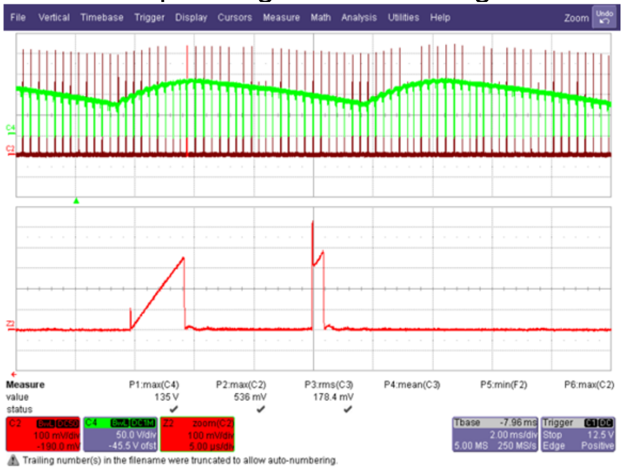

Figure 25 – 90VAC Input, Output Short.
Ch4: V_{D-S}; 50 V / div., 2 ms / div
Ch2: I_{D-S}; 100 mA / div., 2 ms /div
Z2: I_{D-S}; 100 mA / div., 5 μs / div

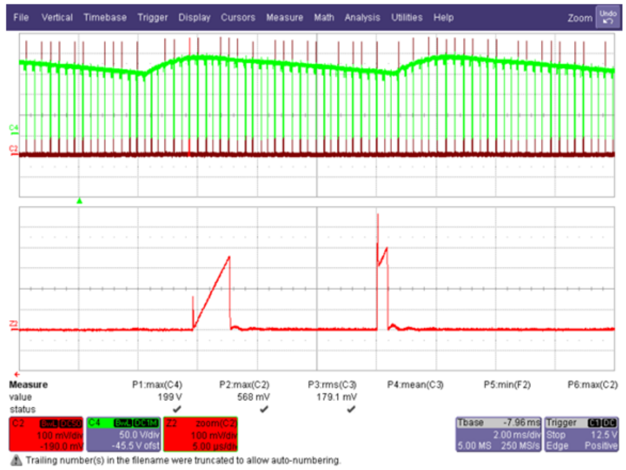

Figure 26 – 132VAC Input, Output Short.
Ch4: V_{D-S}; 50 V / div., 2 ms / div.
Ch2: I_{D-S}; 100 mA / div., 2 ms /div.
Z2: I_{D-S}; 100 mA / div., 5 μs / div.

10.4 Drain Voltage and Current Start-up Profile

Device is operating within the range and no inductor saturation was observed.

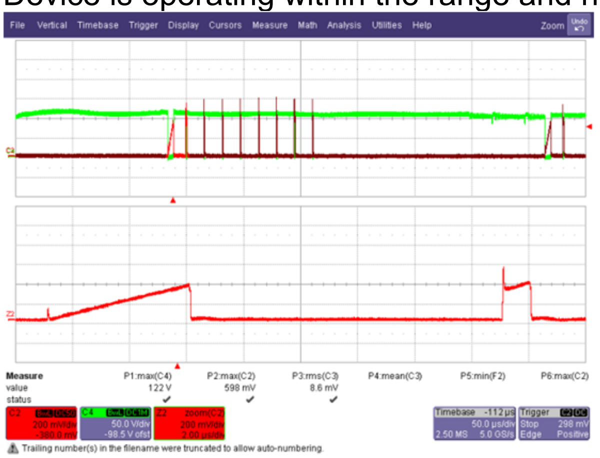

Figure 27 – 90 VAC / 60 Hz Start-up.
Ch4: V_{D-S}; 50 V / div., 50 μs / div.
Ch2: I_{D-S}; 200 mA / div., 50 μs / div.
Z2: I_{D-S}; 200 mA / div., 2 μs / div.

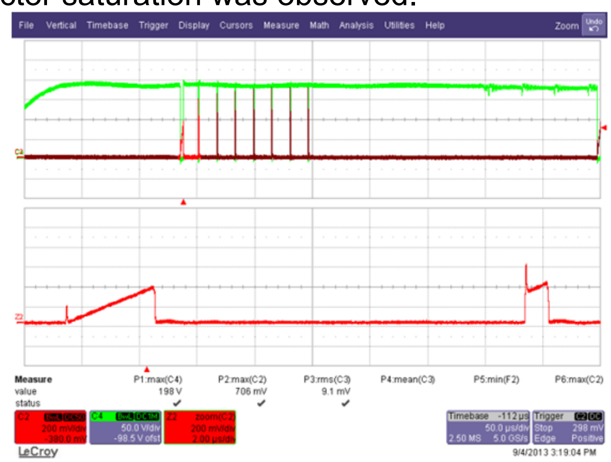

Figure 28 – 132 VAC / 60 Hz Start-up.
Ch4: V_{D-S}; 50 V / div., 50 μs /div.
Ch2: I_{D-S}; 200 mA / div., 50 μs /div.
Z2: I_{D-S}; 200 mA / div., 2 μs /div.

10.5 Output Current Start-up and Power-Down Profile

Output current/light is present in just one AC cycle, <20 ms.

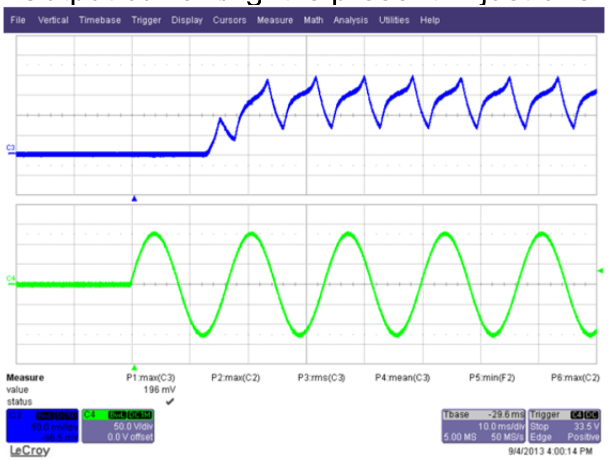

Figure 29 – 90 VAC, 60Hz, Full Load Start-up.
Ch3: I_{OUT}, 50 mA / div., 10 ms / div.
Ch4: V_{IN}, 50 V / div., 10 ms /div.

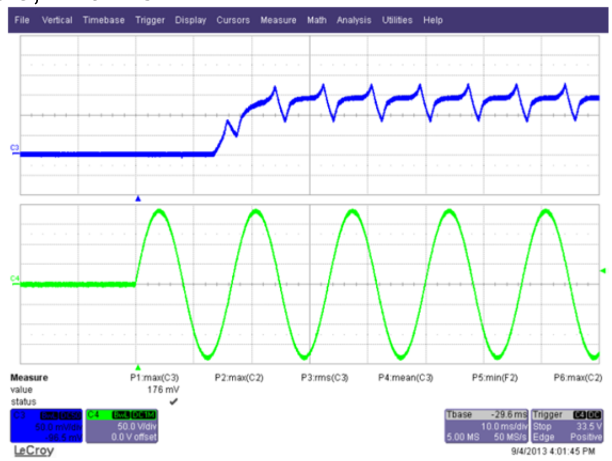

Figure 30 – 132 VAC, 60Hz, Full Load Start-up.
Ch3: I_{OUT}, 50 mA / div., 10 ms / div.
Ch4: V_{IN}, 50 V / div., 10 ms / div.

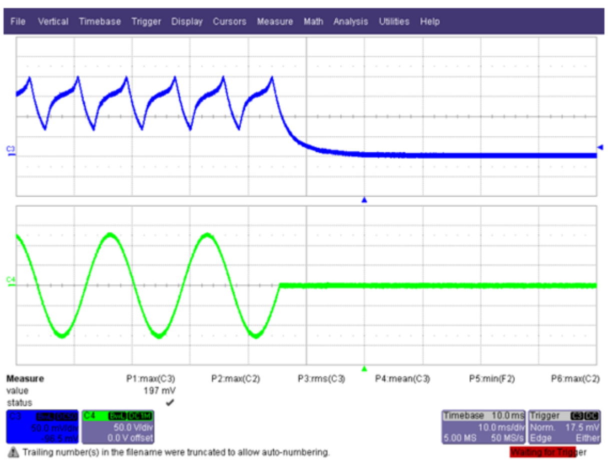

Figure 31 – 90 VAC, 60Hz, Full Load, Power Down.
Ch3: I_{OUT}, 50 mA / div., 10 ms / div.
Ch4: V_{IN}, 50 V / div., 10 ms / div.

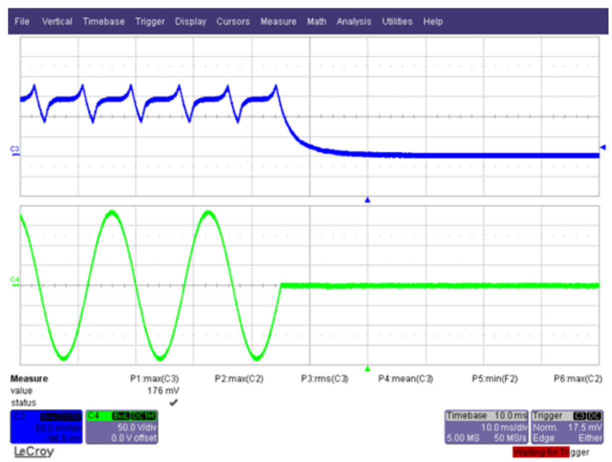

Figure 32 – 132 VAC, 60Hz, Full Load, Power Down.
Ch3: I_{OUT}, 50 mA / div., 10 ms / div.
Ch4: V_{IN}, 50 V / div., 10 ms / div.

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10.6 Input-Output Profile

There is no limitation to the amount of output capacitance that can be added. If the application requires less output current ripple then increasing the output capacitance is straight forward. Note that the output current waveform below will vary depending on LED load impedance and will vary according to LED type.

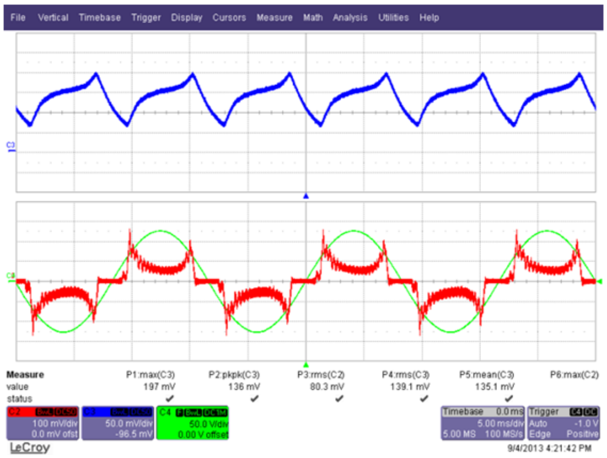

Figure 33 – 90 VAC, 60 Hz, Full Load.
Ch3: I_{OUT}, 50 mA / div., 5 ms / div.
Ch2: I_{IN}, 100 mA / div., 5 ms / div.
Ch4: V_{IN}, 50 V / div., 5 ms / div.

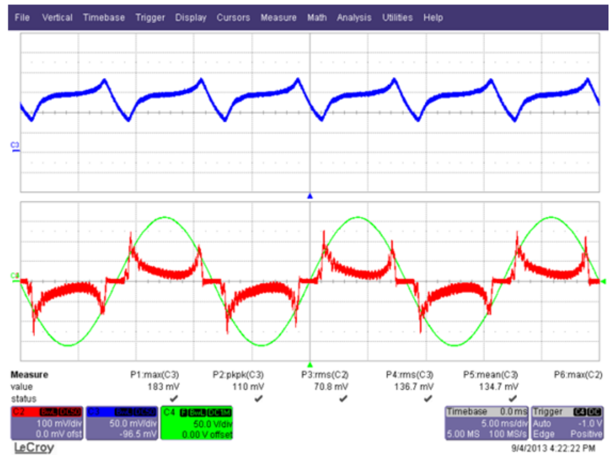

Figure 34 – 115 VAC, Full Load.
Ch3: I_{OUT}, 50 mA / div., 5 ms / div.
Ch2: I_{IN}, 100 mA / div., 5 ms / div.
Ch4: V_{IN}, 50 V / div., 5 ms / div.

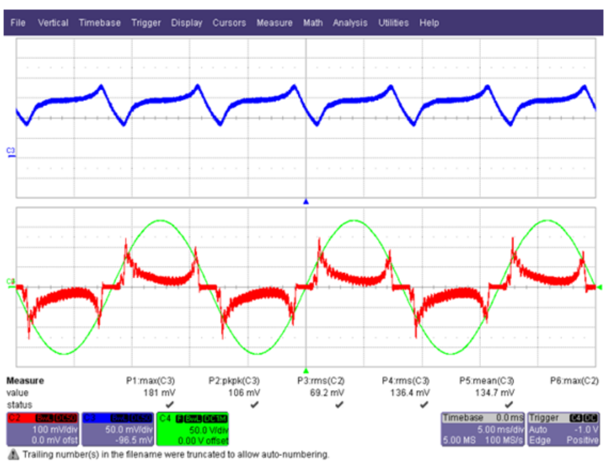

Figure 35 – 120 VAC, 60 Hz, Full Load.
Ch3: I_{OUT}, 50 mA / div., 5 ms / div.
Ch2: I_{IN}, 100 mA / div., 5 ms / div.
Ch4: V_{IN}, 50 V / div., 5 ms / div.

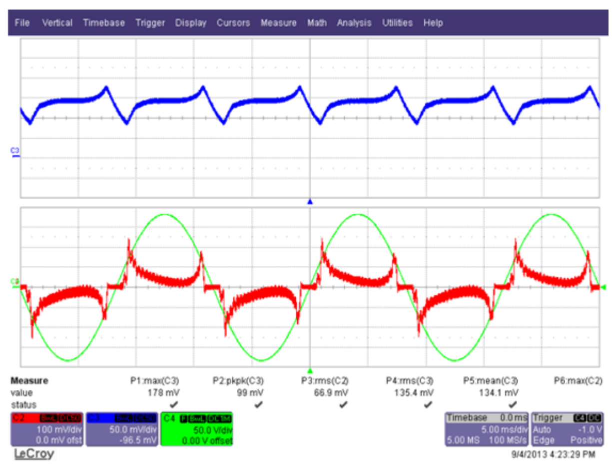

Figure 36 – 132 VAC, Full Load.
Ch3: I_{OUT}, 50 mA / div., 5 ms / div.
Ch2: I_{IN}, 100 mA / div., 5 ms / div.
Ch4: V_{IN}, 50 V / div., 5 ms / div.

10.7 Brown-out/ Brown-in

No failure of any component during brown-out test of 0.5 V / sec AC cut-in and cut-off.

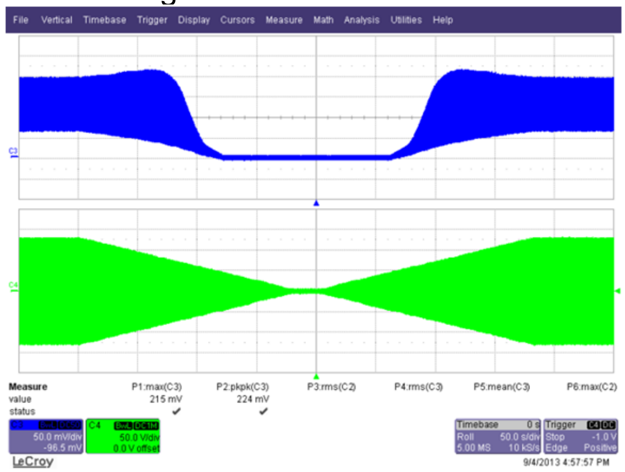

Figure 37 – Brown-out Test at 0.5 V / s. The Unit is Able to Operate Normally Without Any Failure and Without Flicker.
Ch4: V_{IN}, 50 V / div.
Ch3: I_{OUT}, 50 mA / div.
Time Scale: 50 s / div.

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11 Line Surge

Differential input line 500 V surge testing was completed on a single test unit to IEC61000-4-5. Input voltage was set at 120 VAC / 60 Hz.

Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+500	120	L to N	90	Pass
-500	120	L to N	90	Pass
+500	120	L to N	0	Pass
-500	120	L to N	0	Pass

Unit passed under all test conditions.

Differential ring input line surge testing was completed on a single test unit to IEC61000-4-5. Input voltage was set at 120 VAC / 60 Hz. Output was loaded at full load and operation was verified following each surge event.

Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+2500	120	L to N	90	Pass
-2500	120	L to N	90	Pass
+2500	120	L to N	0	Pass
-2500	120	L to N	0	Pass

Unit passed under all test conditions.

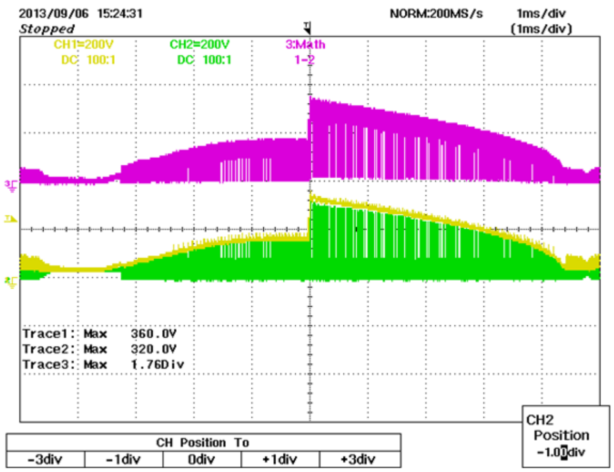

Figure 38 – Differential Line Surge at 500 V / 90°.
Peak Drain Voltage Recorded is 360 V.
Ch1: V_{DRAIN}, 200 V / div.
Ch2: V_{SOURCE}, 200 V / div.
Ch3: $V_{D\text{-}S}$, 200 V / div.
Time Scale: 1 ms / div.

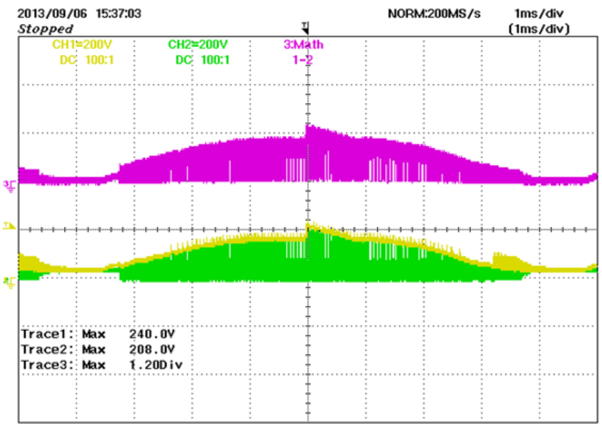

Figure 39 – Differential Ring Surge at 2500 V / 90°.
Peak Drain Voltage Recorded is 240 V.
Ch1: V_{DRAIN}, 200 V / div.
Ch2: V_{SOURCE}, 200 V / div.
Ch3: $V_{D\text{-}S}$, 200 V / div.
Time Scale: 1 ms / div.

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12 Conducted EMI

12.1 Test Set-up

The LED driver was placed inside a GU10 assembly with 38 V LED load and then mounted inside a metallic cone as shown in Figure 40.

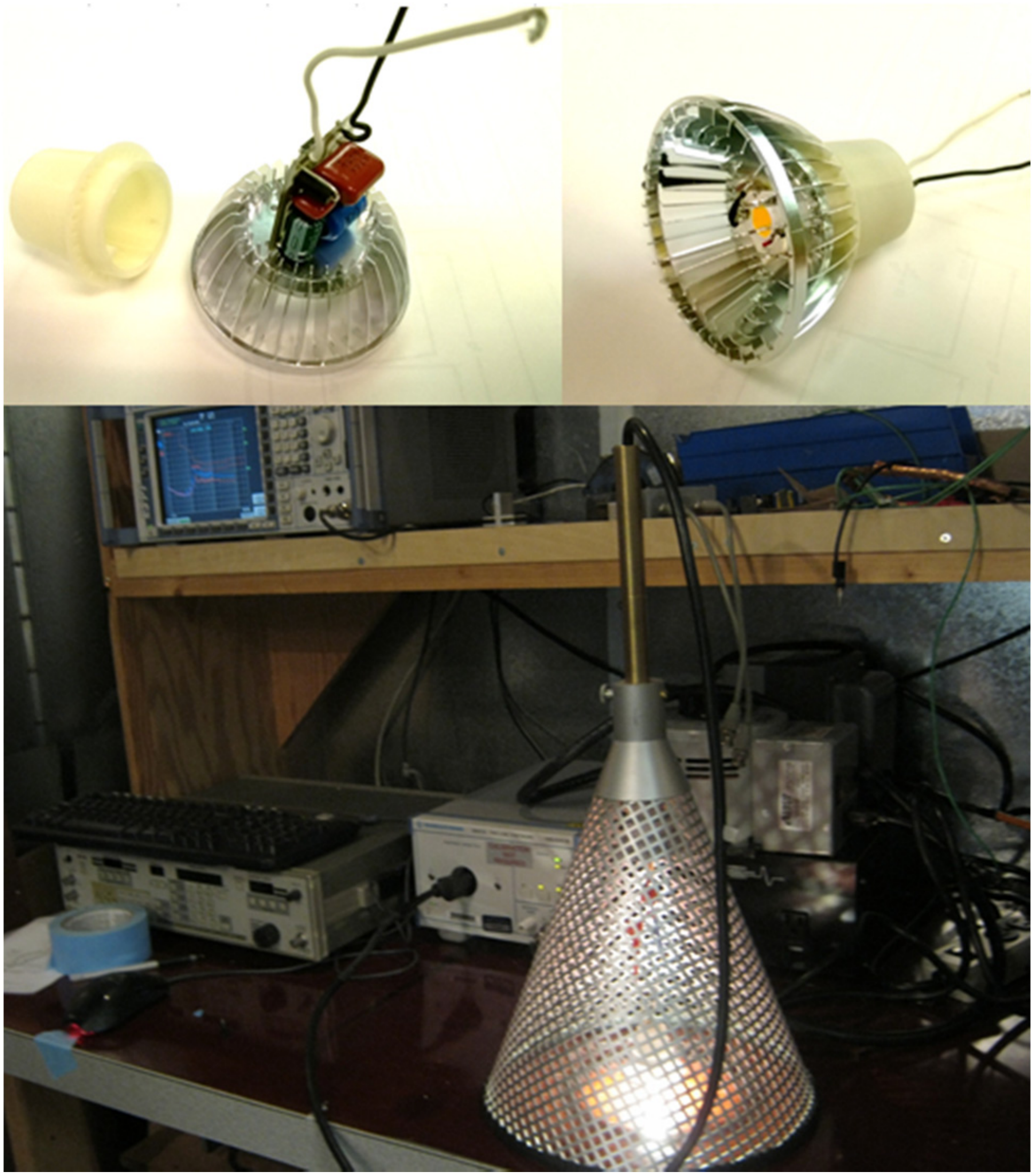

Figure 40 – Conducted EMI Test Set-up. UUT mounted inside the metallic cone.

12.2 Test Result

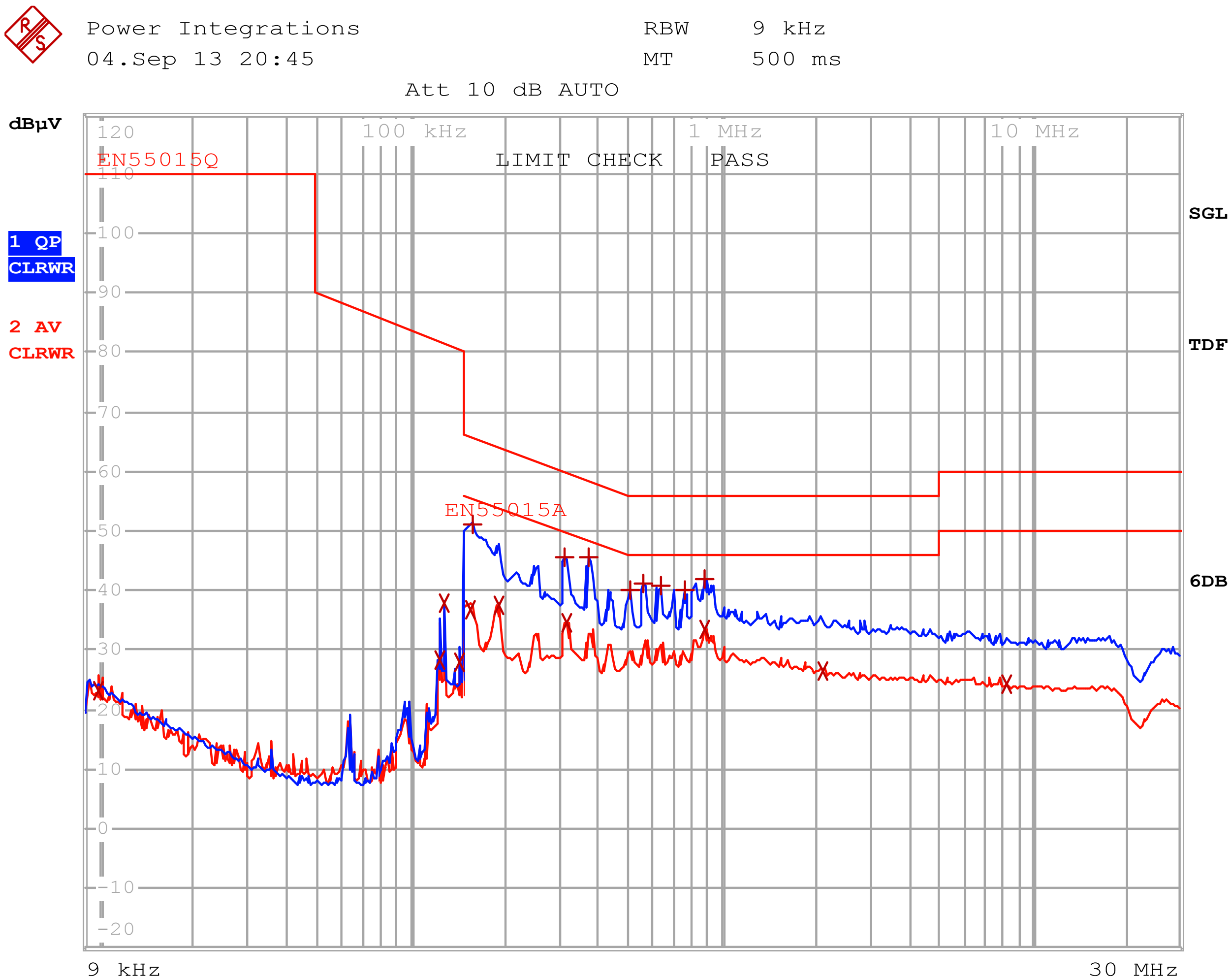

Figure 41 – Conducted EMI, Maximum Steady State Load, 115 VAC, 60 Hz, and EN55015 B Limits.

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EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55015Q

Trace2: EN55015A

Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV		DELTA LIMIT dB
2	Average	9.74571035065 kHz	23.12	N gnd	
2	Average	123.243440661 kHz	28.25	N gnd	
2	Average	126.977840157 kHz	37.69	L1 gnd	
2	Average	143.081808561 kHz	28.08	L1 gnd	
2	Average	154.54515 kHz	36.76	L1 gnd	-18.99
1	Quasi Peak	157.651507515 kHz	51.02	L1 gnd	-14.56
2	Average	190.46019728 kHz	37.61	L1 gnd	-16.39
1	Quasi Peak	310.135545783 kHz	45.43	L1 gnd	-14.52
2	Average	316.369270253 kHz	34.57	L1 gnd	-15.23
1	Quasi Peak	370.967850209 kHz	45.66	L1 gnd	-12.81
1	Quasi Peak	505.008700673 kHz	40.00	L1 gnd	-15.99
1	Quasi Peak	557.843784289 kHz	41.32	L1 gnd	-14.67
1	Quasi Peak	634.878262431 kHz	40.64	L1 gnd	-15.35
1	Quasi Peak	759.408030975 kHz	39.95	L1 gnd	-16.04
1	Quasi Peak	881.64914842 kHz	41.95	L1 gnd	-14.04
2	Average	881.64914842 kHz	33.28	L1 gnd	-12.71
2	Average	2.09534389698 MHz	26.61	L1 gnd	-19.38
2	Average	8.18999279463 MHz	24.27	N gnd	-25.72

Table 5 – Conducted EMI Final Measurements, Maximum Steady State Load, 115 VAC, 60 Hz, and EN55015 B Limits.

13 Revision History

Date	Author	Revision	Description & changes	Reviewed
25-Sep-13	CA	1.0	Initial Release	Apps & Mktg

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