Design Example Report

Title	***18 W TRIAC Dimmable, High Efficiency Power Factor Corrected, Non-Isolated Buck-Boost LED Driver Using LYTSwitch™ -3 LYT3318D***
Specification	90 VAC – 132 VAC Input; 72 V_{TYP}, 260 mA_{TYP} Output
Application	A19 LED Driver
Author	Applications Engineering Department
Document Number	DER-512
Date	March 1, 2016
Revision	1.0

Summary and Features

- Single-stage power factor corrected, PF >0.9
- Accurate constant LED current (CC) regulation, ±5%
- High efficiency
- Low cost and low component count for compact PCB solution
- TRIAC dimmable
  - Works with a wide selection of TRIAC dimmers
  - Fast start-up time (<500 ms) – no perceptible delay
- Integrated protection features
  - No Load and output short-circuit protection
  - Thermal fold back and over temperature protection
  - No damage during line brown-out or brown-in conditions
- Meets IEC 2.5 kV ring wave, 1 kV differential 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 engineering report describes a TRIAC dimmable, non-isolated buck-boost LED driver designed to drive a nominal LED voltage string of 72 V at 260 mA from an input voltage range of 90 VAC to 132 VAC. The LED driver utilizes the LYT3318D from the LYTSwitch-3 family of devices.

LYTSwitch-3 is a family of devices which are designed especially for TRIAC dimmable LED drivers with a single stage PFC function and accurate LED current control.

DER-512 is a single stage 18.72 W TRIAC dimmable LED driver with constant current output. Key design goals were high efficiency, compact PCB and excellent dimming compatibility. The design is intended for bulb LED applications.

This document contains the power supply specification, schematic, bill of materials, transformer documentation, printed circuit layout, design spreadsheet and performance data.

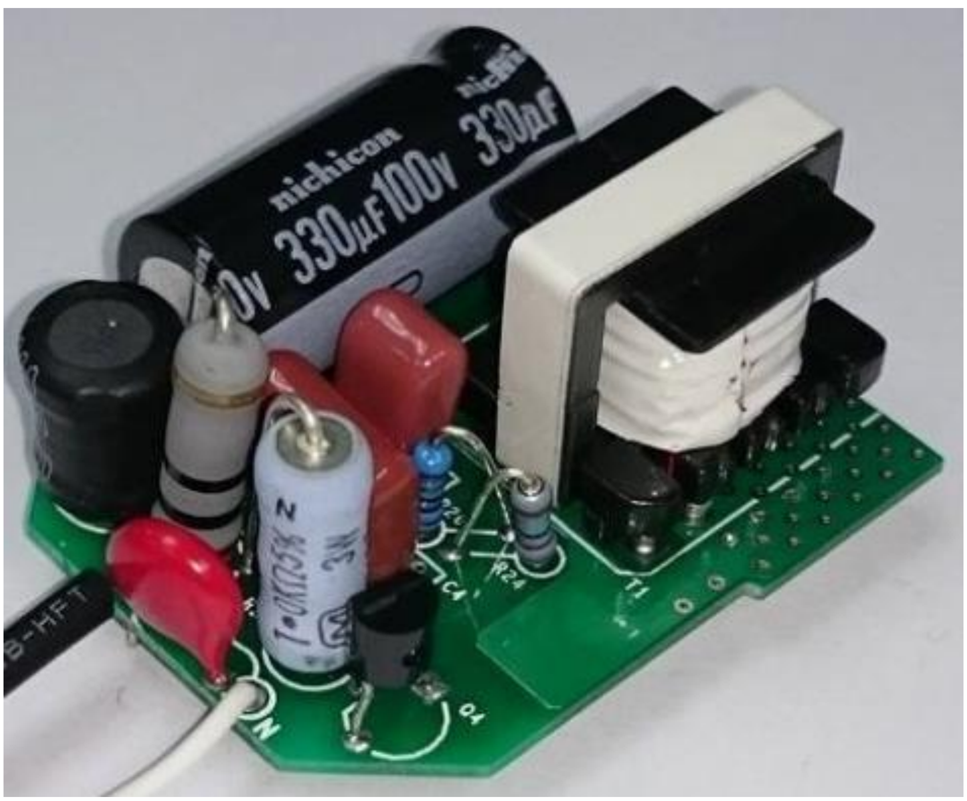

Figure 1 – Populated Circuit Board.

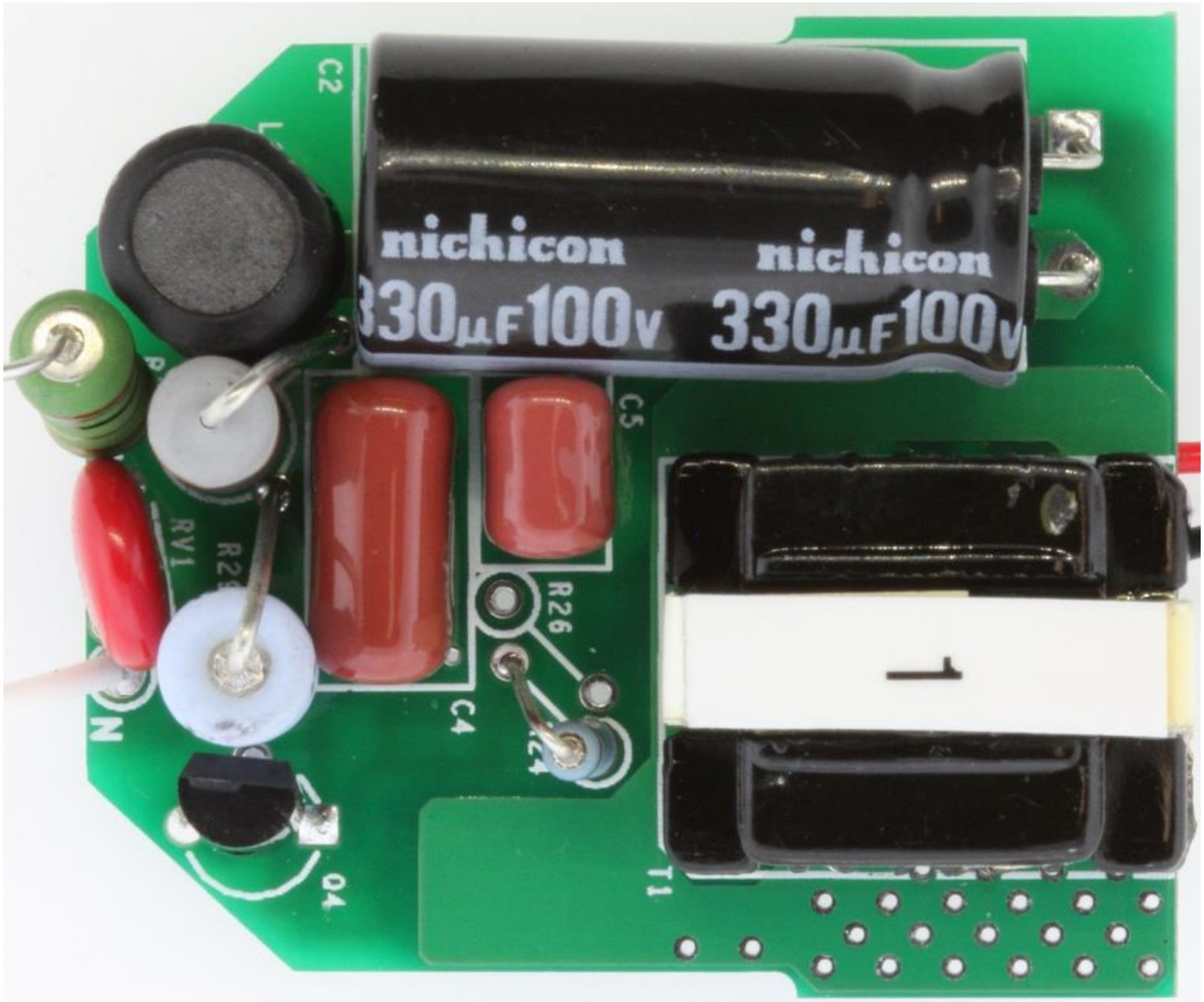

Figure 2 – Populated Circuit Board, Top View.

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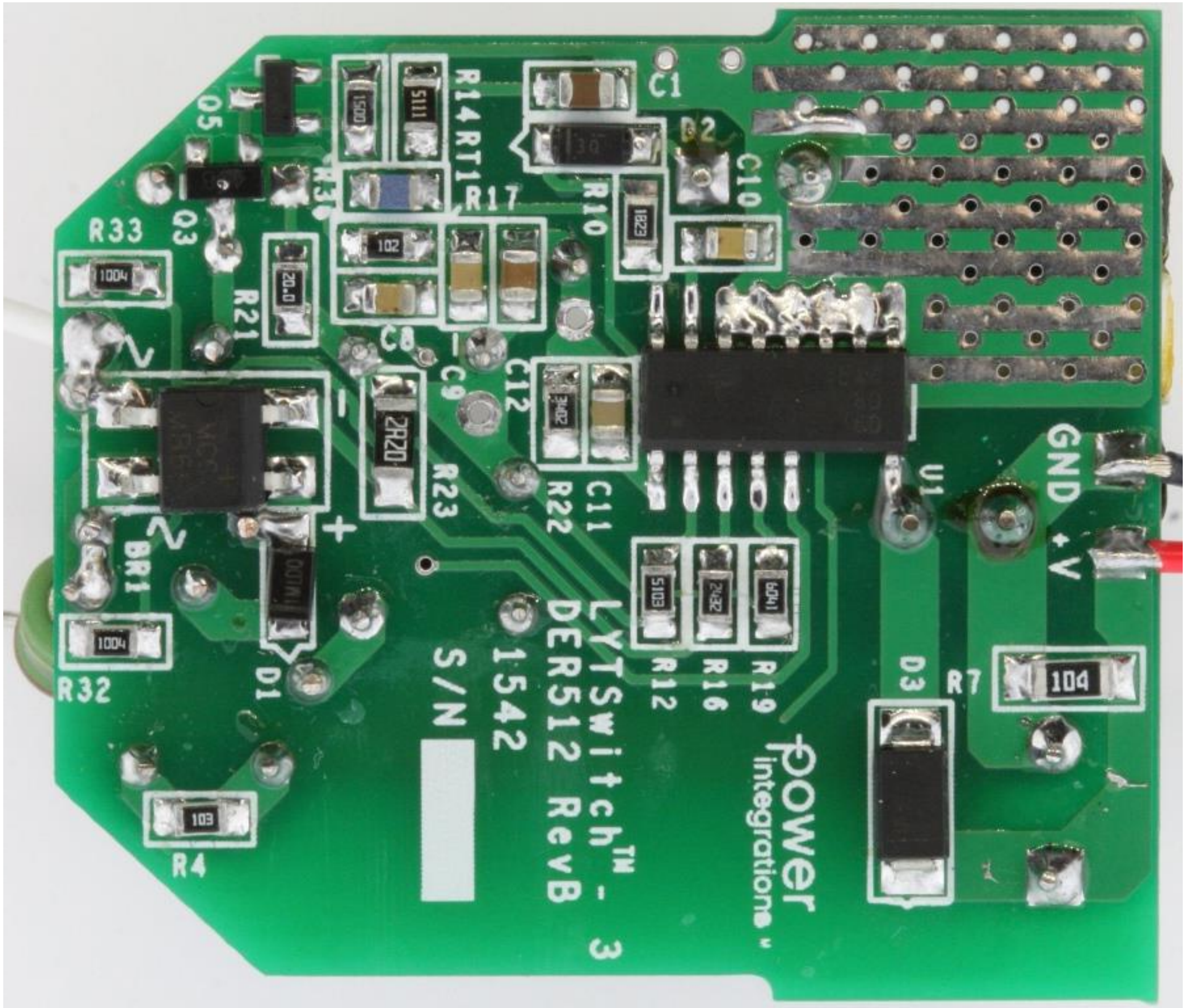

Figure 3 – Populated Circuit Board, Bottom View.

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	V_{IN}	90	115	132	VAC	2 Wire – no P.E.
Frequency	f_{LINE}		60		Hz	
Output						
Output Voltage	V_{OUT}	65	72	79	V	
Output Current	I_{OUT}	247	260	273	mA	
Total Output Power						
Continuous Output Power	P_{OUT}		19		W	
Efficiency						
Full Load	η		85		%	Measured at 115 VAC, 25 °C.
Environmental						
Conducted EMI		CISPR 15B / EN55015B				
Safety		Isolated				
Ring Wave (100 kHz)			2.5		kV	
Differential Mode (L1-L2)			1.0		kV	
Power Factor			0.9			Measured at 230 VAC, 50 Hz.
Ambient Temperature	T_{AMB}			40	°C	Free convection, sea level, in bulb casing with potting.

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3 Schematic

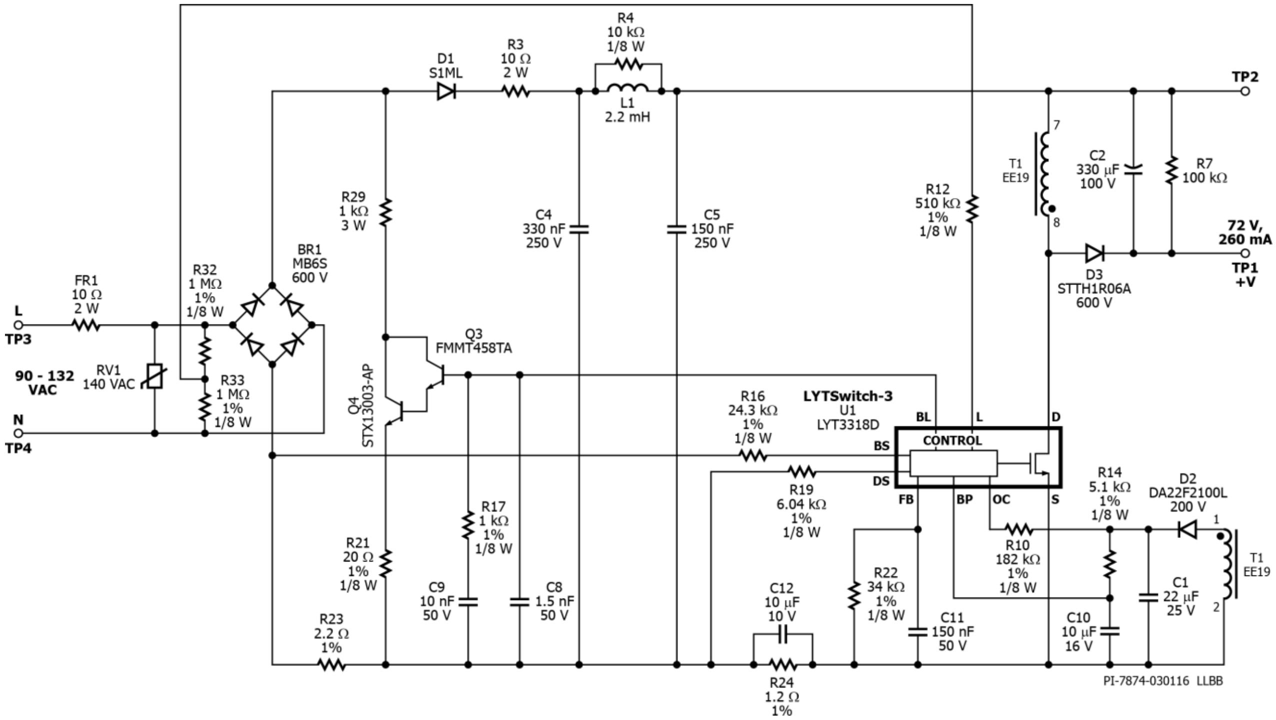

Figure 4 – Schematic.

4 Circuit Description

LYTSwitch-3 combines a high-voltage power MOSFET switch with a power supply controller in a single package. The LYTSwitch-3 controller provides a single-stage power factor correction, LED current control and dimming control.

4.1 Input Stage

Fusible resistor FR1 provides protection against component failures. A fusible resistor is used to aid in providing damping action to the input current ringing when connected to a phase cut dimmer. Varistor RV1 provides clamping during differential line surge events to limit the maximum voltage spike across the switch.

Bridge rectifier BR1 rectifies the input AC to provide the pulsating DC input to the pi filter consisting of C4, C5 and L1. Values of C4, C5 and L1 were chosen to provide the best balance between high power factor, EMI performance, dimming compatibility and cost.

4.2 LYTSwitch-3 Primary Control Circuit

DER-512 is a non-isolated buck-boost converter. This topology is chosen to provide the best dimming compatibility, high PF and low THD. During turn-on of the internal MOSFET, current flows from the un-dotted end of the inductor to the dotted end through the internal MOSFET and back to the input. During this period, energy is stored in the magnetizing inductance of the inductor. This energy is then transferred to the output through the output diode D3 during switch turn-off. Output capacitor C2 provides filtering to minimize LED ripple current. R7 serves as pre-load.

An auxiliary winding on the transformer provides external bias to the LYT3318D through the bias circuit consisting of C1, D2 and R14. Resistor R14 limits the current flowing into the BYPASS (BP) pin of LYT3318D with C10 providing both decoupling and energy storage for the device. The value of R14 is chosen such that device dissipation is minimized without compromising device supply cutoff which could occur during dimming conditions where input conduction angle is at a minimum.

The LYTswitch-3 IC provides excellent dimming performance by directly monitoring the input voltage and actual conduction angle. This information is made available to the device through R12, R32 and R33 which connects to the LINE SENSE pin. Overvoltage protection is achieved through this pin together with LED current control with respect to input voltage.

Output current is controlled through the FEEDBACK (FB) pin. A voltage proportional to the output current is induced across R24. This voltage is constantly monitored by the FB pin and is used to provide constant current control. This voltage is compared to the voltage across R22 internally to a reference voltage which varies linearly with the conduction angle when in dimming mode. The reference is 300 mV during full conduction (no dimmer detected). Capacitor C11 filters the voltage across the sense resistors.

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The OUTPUT COMPENSATION (OC) pin of LYT3318D senses the output voltage through the voltage across the bias. This information is used by LYTSwitch-3 to maintain a constant LED current with respect to variation in LED string voltage. Resistor R15 is calculated based on the output overvoltage protection point.

4.3 TRIAC Phase Dimming Control with LYTSwitch-3 Smart Bleeder Drive

The LYTSwitch-3 IC integrates an active bleeder control to provide the highest dimmer compatibility possible for LED drivers without sacrificing driver efficiency, power factor and %THD.

Resistor R3 dampens the driver input current ringing when the TRIAC in a dimmer turns on. The fusible resistor FR1 also provides significant damping to the ringing.

Diode D1 serves as a blocking diode to prevent the active bleeder from drawing current from the input capacitors once it turns on. This is needed to increase dimmer compatibility of the driver.

The active bleeder and control circuit consists of R16, R17, R21, R23, R29, C8, C9, Q3 and Q4. This network is directly driven by the LYT3328D through the BLEEDER CONTROL (BL) pin. Given that the input current is the sum between the bleeder current when dimming and the converter current, this current flows through R23 and induces a voltage which is then compared through R16 to a 120 mV reference on the BLEEDER SENSE (BS) pin. Based on the input current level the BL pin drives the bleeder circuit to maintain the input current as programmed by R23.

Resistor R29 is the bleeder resistor with Q3 and Q4 forming a Darlington pair transistor to act as switch for the bleeder resistor. R17, R21, C8 and C9 form a stabilization network.

5 PCB Layout

Note : Locations Q5, RT1 and R36 are optional components.

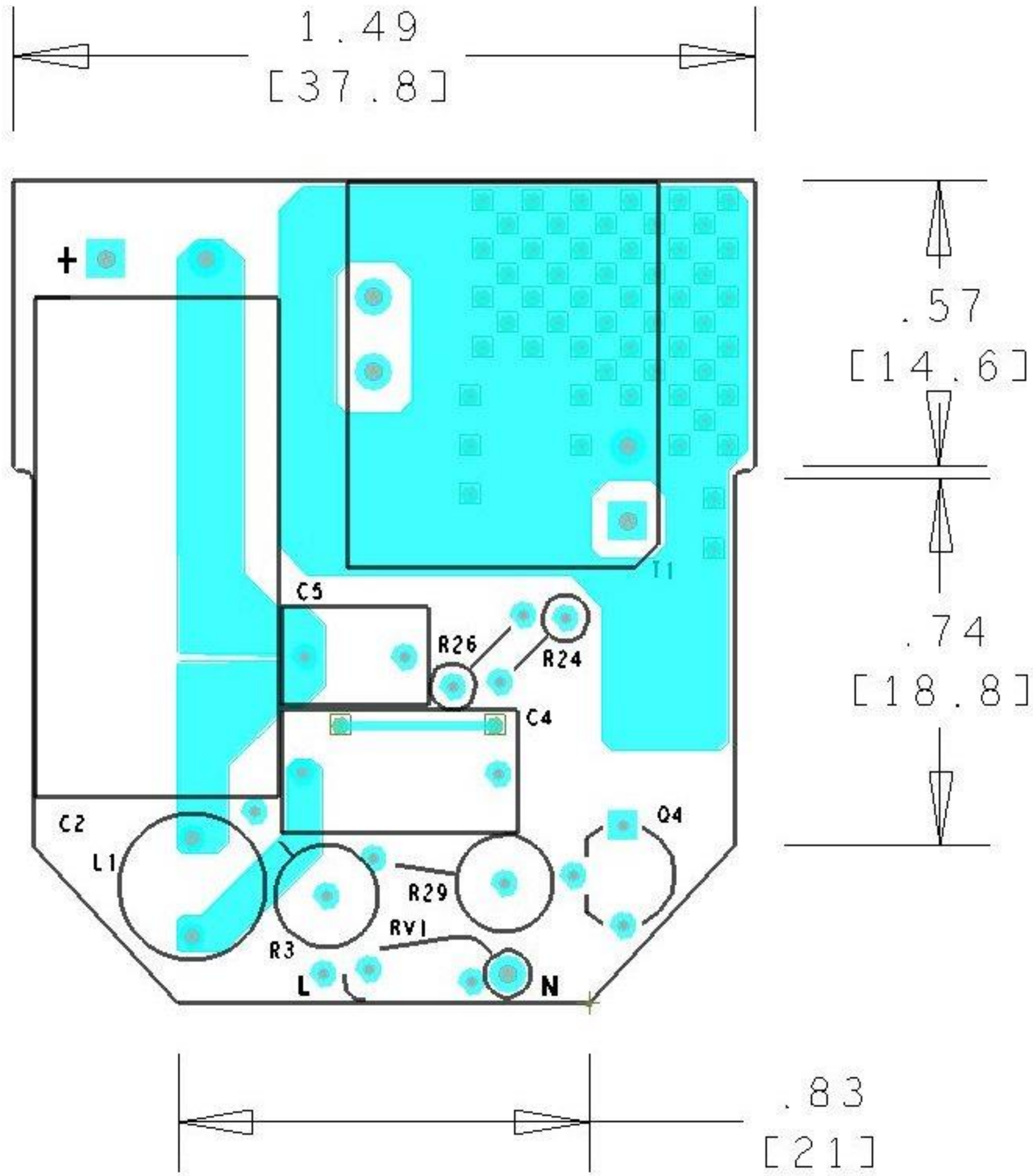

Figure 5 – Top Side.

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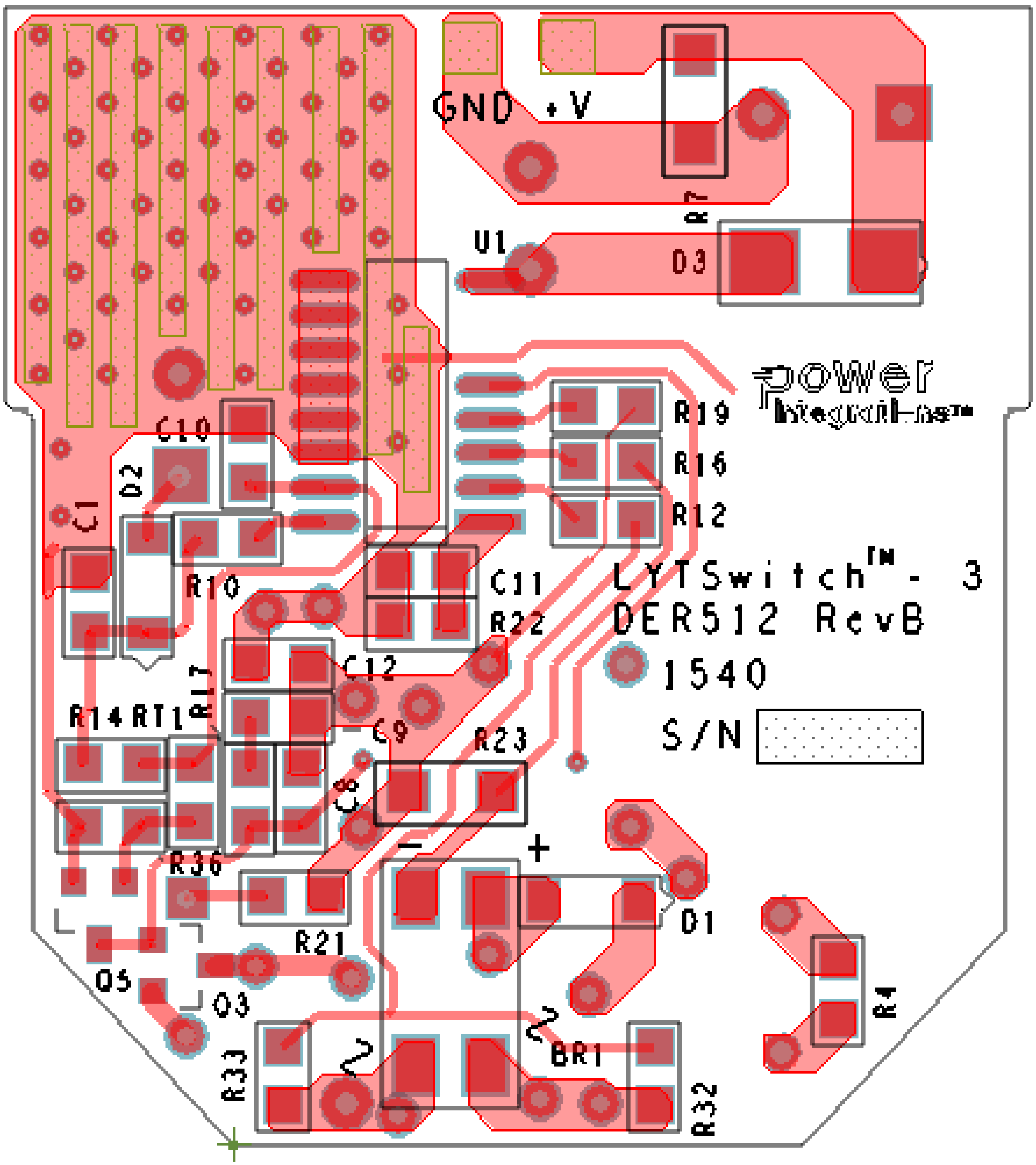

Figure 6 – Bottom Side.

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	22 μF, 25 V, Ceramic, X5R, 0805	C2012X5R1E226M125AC	TDK
3	1	C2	330 μF, 100 V, Electrolytic, (12.5 x 25)	UVZ2A331MHD	Nichicon
4	1	C4	330 nF, 250 V, 5%, Polypropylene Metalized	ECW-F2334JAQ	Panasonic
5	1	C5	150 nF, 250 V, Radial, Film	B32529C3154J	Epcos
6	1	C8	1.5 nF, 50 V, Ceramic, X7R, 0805	CC0805KRX7R9BB152	Yageo
7	1	C9	10 nF, 50 V, Ceramic, X7R, 0805	C0805C103K5RACTU	Kemet
8	1	C10	10 μF, 16 V, Ceramic, X5R, 0805	GRM21BR61C106KE15L	Murata
9	1	C11	150 nF, 50 V, Ceramic, X7R, 0805	CL21B154KBFNNNE	Samsung
10	1	C12	10 μF, 10 V, Ceramic, X7R, 0805	C2012X7R1A106M	TDK
11	1	D1	1K V, 1 A, Standard Recovery, SMA	S1ML	TAIWAN SEMI
12	1	D2	200 V, 1 A, MINI2	DA22F2100L	Panasonic
13	1	D3	600 V, 1 A, Ultrafast Recovery, 45 ns, DO-214AC, SMA	STTH1R06A	ST Micro
14	1	FR1	10 R, 5%, 2 W, Wirewound, Fusible	FW20A10R0JA	Bourns
15	1	L1	2.2 mH, 0.19 A, Ferrite Core	CTCH895F-222K	CT Parts
16	1	Q3	NPN, HP, 400V, 225Ma, SOT23-3	FMMT458TA	Diodes, Inc.
17	1	Q4	NPN, Power BJT, 400 V, 1 A, TO-92	STX13003-AP	ST Micro
18	1	R3	10 Ω, 5%, 2 W, Metal Oxide	RSF200JB-10R	Yageo
19	1	R4	10 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ103V	Panasonic
20	1	R7	100 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ104V	Panasonic
21	1	R10	182 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1823V	Panasonic
22	1	R12	510 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF5103V	Panasonic
23	1	R14	5.1 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ512V	Panasonic
24	1	R16	24.3 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF2432V	Panasonic
25	1	R17	1.00 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1001V	Panasonic
26	1	R19	6.04 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF6041V	Panasonic
27	1	R21	20 Ω, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF20R0V	Panasonic
28	1	R22	34 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF3402V	Panasonic
29	1	R23	2.2 Ω, 1%, 1/4 W, Thick Film, 1206	RC1206FR-072R2L	Yageo
30	1	R24	1.2 Ω, 1%, 1/4 W, Metal Film	MF1/4DCT52R1R20F	KOA
31	1	R29	1 kΩ, 5%, 3 W, Metal Oxide	ERG-3SJ102	Panasonic
32	2	R32 R33	1 MΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1004V	Panasonic
33	1	RV1	140 V, 12 J, 7 mm, RADIAL	V140LA2P	Littlefuse
34	1	T1	Bobbin, EE19, Vertical, 10 pins	YC-1902	Ying Chin
35	1	U1	LYTSwitch-3, SO-16C	LYT3328D	Power Integrations

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7 Inductor Spreadsheet

ACDC_LYTSwitch-3-Buck-Boost_040915; Rev.0.5; Copyright Power Integrations 2015	**INPUT**	**INFO**	**OUTPUT**	**UNIT**	**ACDC_LYTSwitch-3-Buck-Boost_032515; LYTSwitch-3 Buck-Boost Transformer Design Spreadsheet**
ENTER APPLICATION VARIABLES					
VACMIN	90.00		90.00	V	Minimum AC Input Voltage
VACNOM	115.00		115.00	V	Typical AC Input Voltage
VACMAX	132.00		132.00	V	Maximum AC Input Voltage
FL			50.00	Hz	Minimum line frequency
VO_MIN			64.8	V	Guaranteed minimum VO that maintains output regulation
VO	72.0		72.0	V	Worst case normal operating output voltage
VO_OVP_MIN			88.3	V	Minimum Voltage at which output voltage protection may be activated
IO	260.0		260.0	mA	Average output current specification
n	0.87		0.87	%/100	Total power supply efficiency
Z			0.50		Loss allocation factor
PO			18.72	W	Total output power
VD			0.70	V	Output diode forward voltage drop
LYTSwitch-3 DESIGN VARIABLES					
Select Breakdown Voltage	650		650	V	Choose between 650V and 725V
Device	LYT33X8		LYT33X8		Chosen LYTSwitch-3 Device
Final device code			LYT3318		
Select Dimming Curve Option	1		1		Dimming curve 1
RBS2			24	k-ohm	RBS2 resistor to select dimming curve
ILIMITMIN			2.860	A	Minimum device current limit
ILIMITTYP			3.075	A	Typical Current Limit
ILIMITMAX			3.290	A	Maximum Current Limit
TON			3.50	us	Expected on-time of MOSFET at low line and PO
FSW			120.0	kHz	Expected switching frequency at low line and PO
Duty Cycle			42.0	%	Expected operating duty cycle at low line and PO
IRMS			0.488	A	Nominal RMS current through the switch at low line
IPK			1.938	A	Worst Case Peak current
KDP			1.10		Ratio between off-time of switch and reset time of core at VACNOM
ENTER INDUCTOR CORE/CONSTRUCTION VARIABLES					
Core Type	EE19		EE19		Core Type
Core Part Number			PC40EE19-Z		If custom core is used - Enter part number here
Bobbin part number			BE-19-116-CP		Bobbin Part number (if available)
AE			23.00	mm^2	Core Effective Cross Sectional Area
LE			39.40	mm	Core Effective Path Length
AL			1250	nH/T^2	Ungapped Core Effective Inductance
BW			9.10	mm	Bobbin Physical Winding Width
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LPMIN			219	uH	Minimum Inductance
LP	230		230	uH	Typical value of Primary Inductance
LP Tolerance	5.00		5	%	Tolerance of Primary Inductance
N	80.00		80	Turns	Number of Turns
ALG			36	nH/T^2	Gapped Core Effective Inductance
BM			2423	Gauss	Operating Flux Density. Maintain value below 3300 G
BP			4318	Gauss	!!! Reduce peak flux density (BP < 4200

					G) by increasing NP, selecting a bigger core or decreasing KDP
BAC			1212	Gauss	Worst case AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
LG			0.804	mm	Gap Length (Lg > 0.1 mm)
Layers	4.0		4.0		The actual number of layers that fits the input value after standardizing the wire size is 4.03
IL_RMS			0.801	A	Worst case RMS Current through the inductor
AWG			26	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			256	Cmils	Bare conductor effective area in circular mils
CMA			320	Cmils/A	Primary Winding Current Capacity (200 < CMA < 500)
Current Density (J)			6.22	A/mm^2	Inductor Winding Current density (3.8 < J < 9.75 A/mm^2)
Bias Section					
TURNS_BIAS			25.00	Turns	
VBIAS	22.00		22.00	V	
PIVBS			80.34	V	
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			42.02	%	Duty cycle measured at minimum input voltage
IAVG			0.25	A	Input average current measured on the Mosfet at the minimum input voltage
IP			1.85	A	Peak Drain current at minimum input voltage
ISW_RMS			0.49	A	MOSFET RMS current measured at the minimum input voltage
ID_RMS			0.19	A	RMS current of freewheeling diode at minimum input voltage
IL_RMS			0.53	A	RMS current of the of the inductor at the minimum input voltage
FEEDBACK AND BYPASS PIN PARAMETERS					
n_MEASURED			0.87		Measured efficiency (this value is used for resistor calculations only)
VBIAS_MEASURED			22.00	V	Bias voltage (across the bias capacitor) measured on a prototype unit
VOUT_MEASURED			72.00	V	Load voltage measured on a prototype unit
RDS_T			0.9272	ohm	Theoretical calculation for RDS sense resistor
RDS			0.93	ohm	Rds resistor calculation assuming E96 / 1%
CDS			10.00	uF	Cds Capacitor Calculation
ROVP			200.00	k-ohm	OC pin resistor (E96 / 1%)
RL			1.96	M-ohm	L pin resistor (E96 / 1%)
RFB_T			38904.30	ohm	Calculated value of RFB, using RDS_T
RFB			39.20	k-ohm	Feedback pin resistor (E96 / 1%)
CFB_T			154.22	nF	Feedback pin capacitor (for 6ms time constant)
CFB			150	nF	Feedback pin capacitor E12 standard value
RSUP			15.80	k-ohm	Bias supply resistor assuming 1mA current necessary to supply BP
Output Parameters					
VDRAIN			306	V	Estimated worst case drain voltage at VACMAX and VO_MAX
PIVD			303.3	V	Peak Inverse Voltage at VO_MAX on output diode

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BLEEDER COMPONENTS					
I_HOLD			40.00	mA	Required bleeder holding current
RBS1			3.00	Ohm	Exact value of RBS1 resistor

Note: Driver was designed with high efficiency and temperature performance considered which resulted to the warning on line 51. This is because the inductance was chosen such that RMS currents are minimized. Core saturation was not observed when the driver was tested at worst case conditions.

8 Inductor Specification

8.1 Electrical Diagram

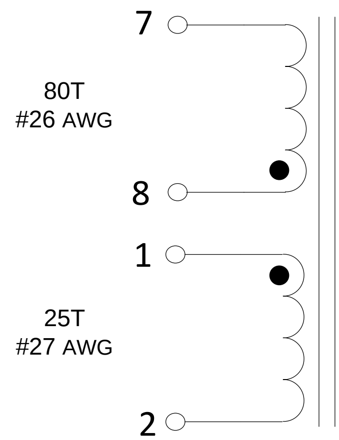

Figure 7 – Inductor Electrical Diagram.

8.2 Electrical Specifications

Parameter	Condition	Spec.
Nominal Primary Inductance	Measured at 1 V pk-pk, 100 kHz switching frequency, between pin 7 and pin 8, with all other windings open.	230 μH
Tolerance	Tolerance of primary inductance.	±5%
Primary Leakage Inductance	Pins 7-8, with pins 1-2 shorted, measured at 100 kHz, 0.4 V_{RMS}.	5 μH (Max.)

8.3 Material List

Item	Description
[1]	Core: EE19 PC44 or Equivalent.
[2]	Bobbin, EE19, Horizontal, 10 Pins, Part No. 25-00894-00.
[3]	Magnet Wire: #26 AWG.
[4]	Magnet Wire: #27 AWG.
[5]	Transformer Tape: 9 mm.
[6]	Transformer Tape: 4.9 mm.

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8.4 Transformer Build Diagram

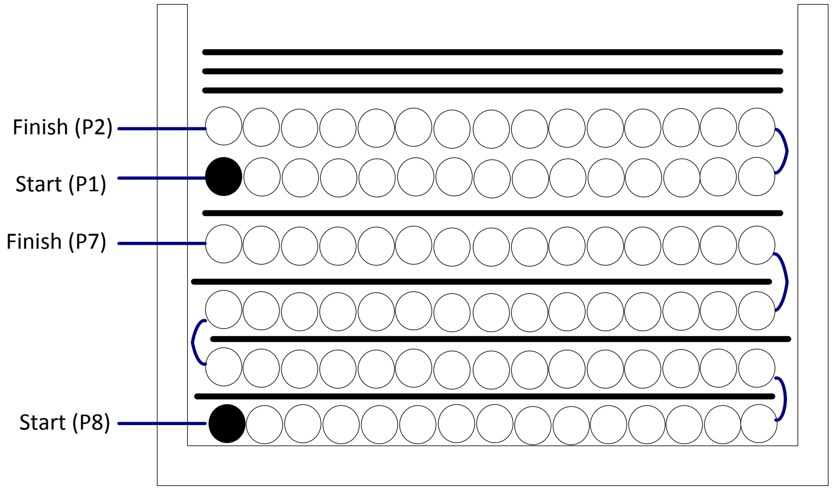
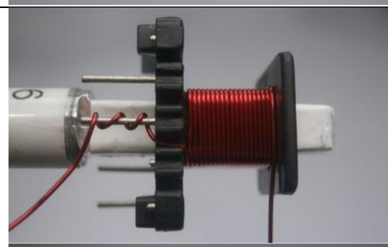
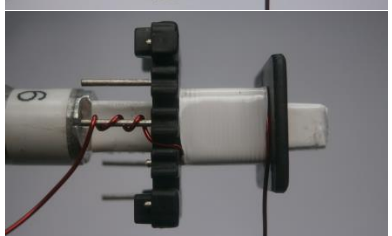
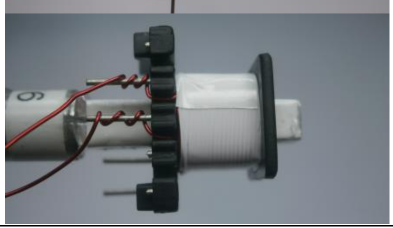


Figure 8 – Transformer Build Diagram.

8.5 Inductor Construction

Bobbin	Place item [2] bobbin on winding machine with pins on the left side of the mandrel.
Winding 1	Starting at pin 8 wind 80 turns of wire item [3] in clockwise direction. Add 1 layer of item [5] tape after every layer of winding. Terminate other end of the wire to pin 7.
Insulation	Add 1 layer of tape, item [5], for insulation.
Winding 2	Starting at pin 6 wind 18 turns of wire item [3] in clockwise direction. Spread the winding evenly across the whole bobbin width. Terminate other end of the wire to pin 8.
Insulation	Add 1 layer of tape, item [5], for insulation.
Winding 3	Starting at pin 1 wind 25 turns of wire item [4] in clockwise direction. Terminate other end of the wire to pin 2.
Insulation	Add 3 layers of tape, item [5], for insulation.
Core Grinding	Grind the center leg of one core until it meets the nominal inductance of 230 μH.
Assemble Core	Assemble the core item [1] halves to the bobbin.
Fix Core	Fix core with 3 layers of tape item [6]
Pins	Remove pins 3, 4, 5, 6, 9 and 10.
Finish	Dip the transformer assembly in varnish.

8.6 Inductor Construction Photos

Winding Preparation		Place item [2] bobbin on winding machine with pins facing left.
WD1	   	Start at pin 8, wind 80 turns of wire item [3] in counter clockwise direction. After every layer, fix winding with 1 layer item [5] tape. On the last layer spread winding evenly across the bobbin width and terminate at pin 7. Fix with 1 layer item [5] tape.

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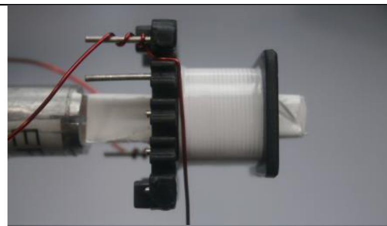
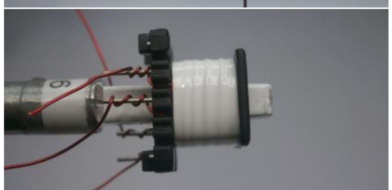
WD2	   	Start at pin 1, wind 25 turns of wire item [4], spread evenly across the bobbin width on the last layer and terminate at pin 2. Fix with 3 layers of item [5] tape.
Gap Core		Grind one core half [item1] center leg to achieve 230 μH inductance.
Final Assembly	  	Assemble core halves. Gapped core should be placed at the bottom side of the bobbin. Fix cores with 3 layers of item [6] tape. Remove pins 3, 4, 5, 6, 9 and 10. Dip varnish with item [7]

9 Performance Data

All measurements were performed at room temperature. 1 minute soak time was applied before measurement.

9.1 Efficiency

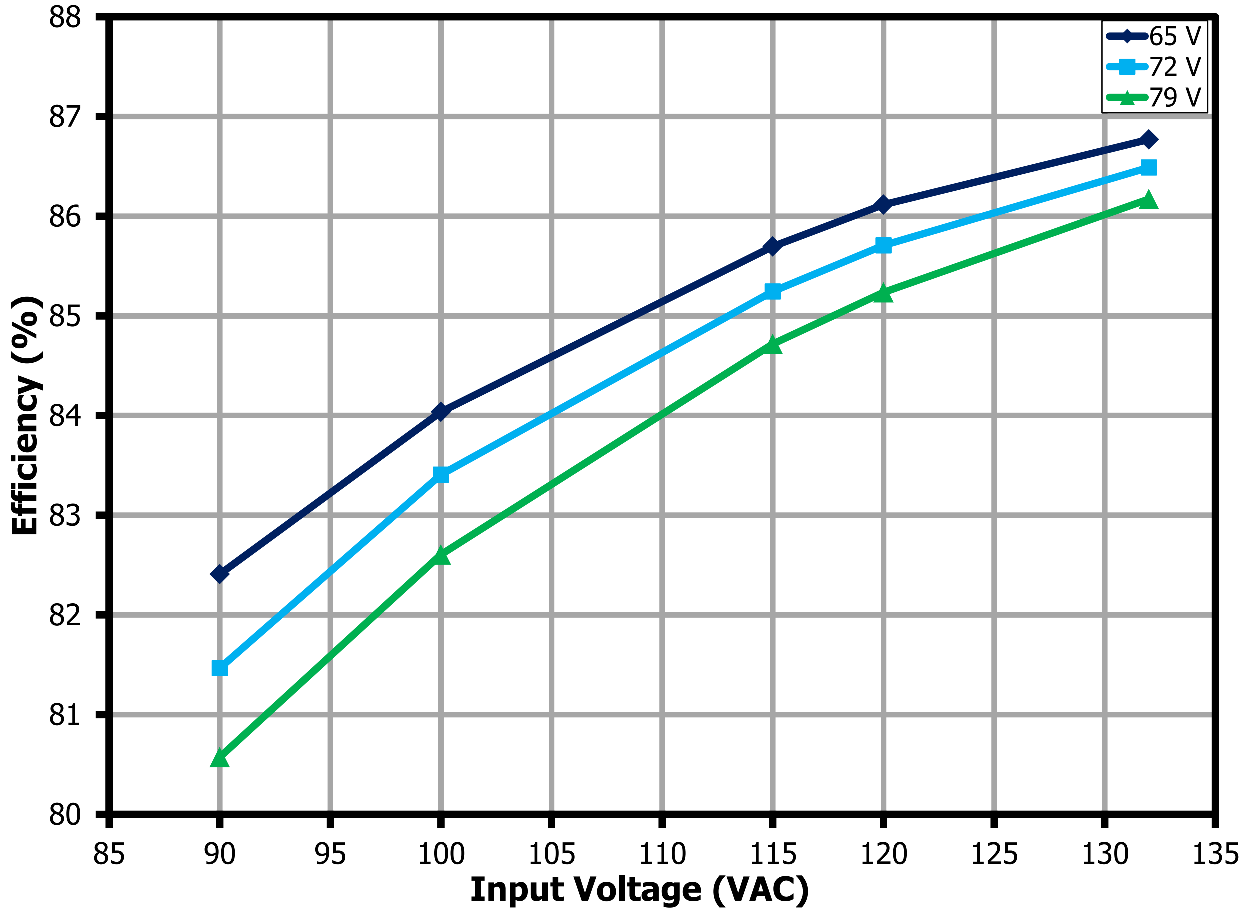


Figure 9 – Efficiency vs. Line and Load.

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9.2 Line Regulation

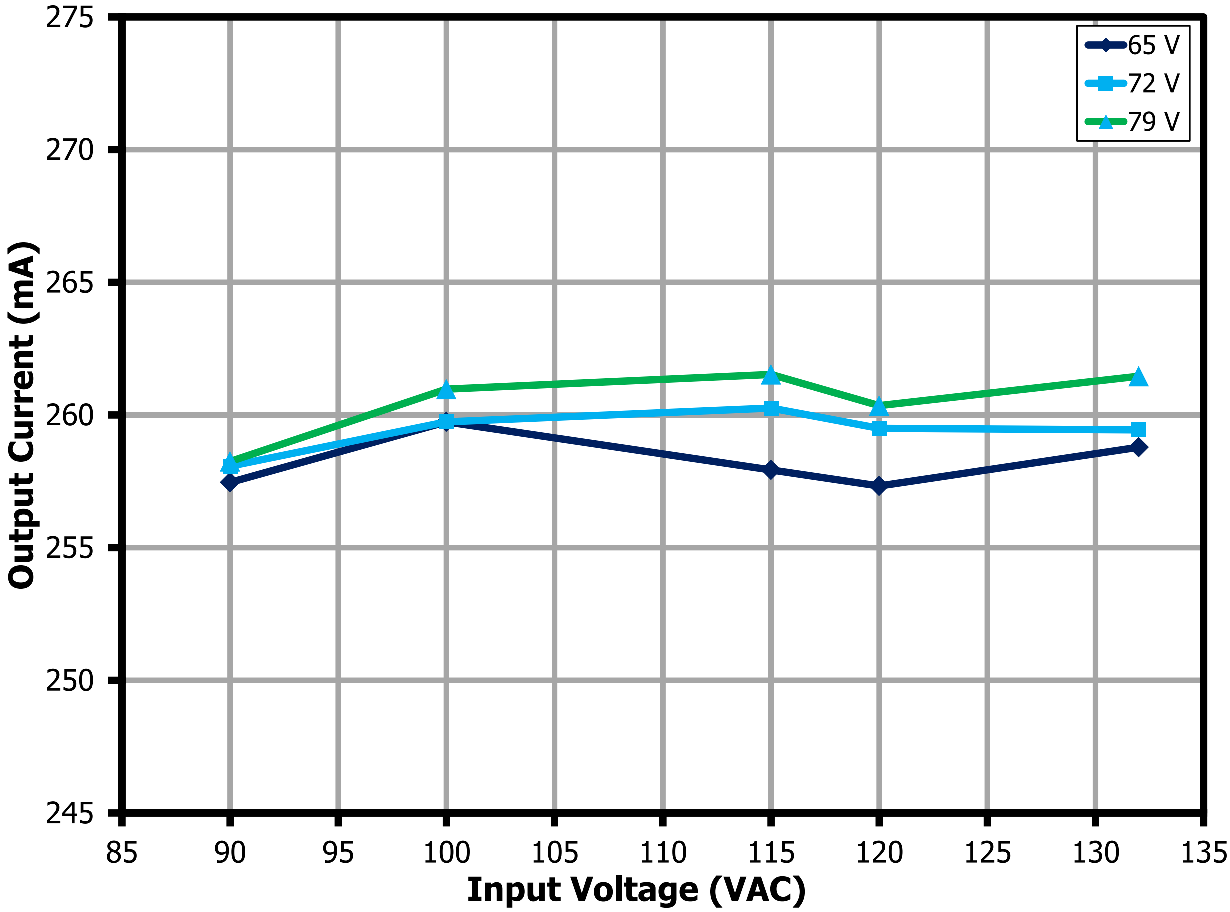

Figure 10 – Regulation vs. Line and Load.

9.3 Power Factor

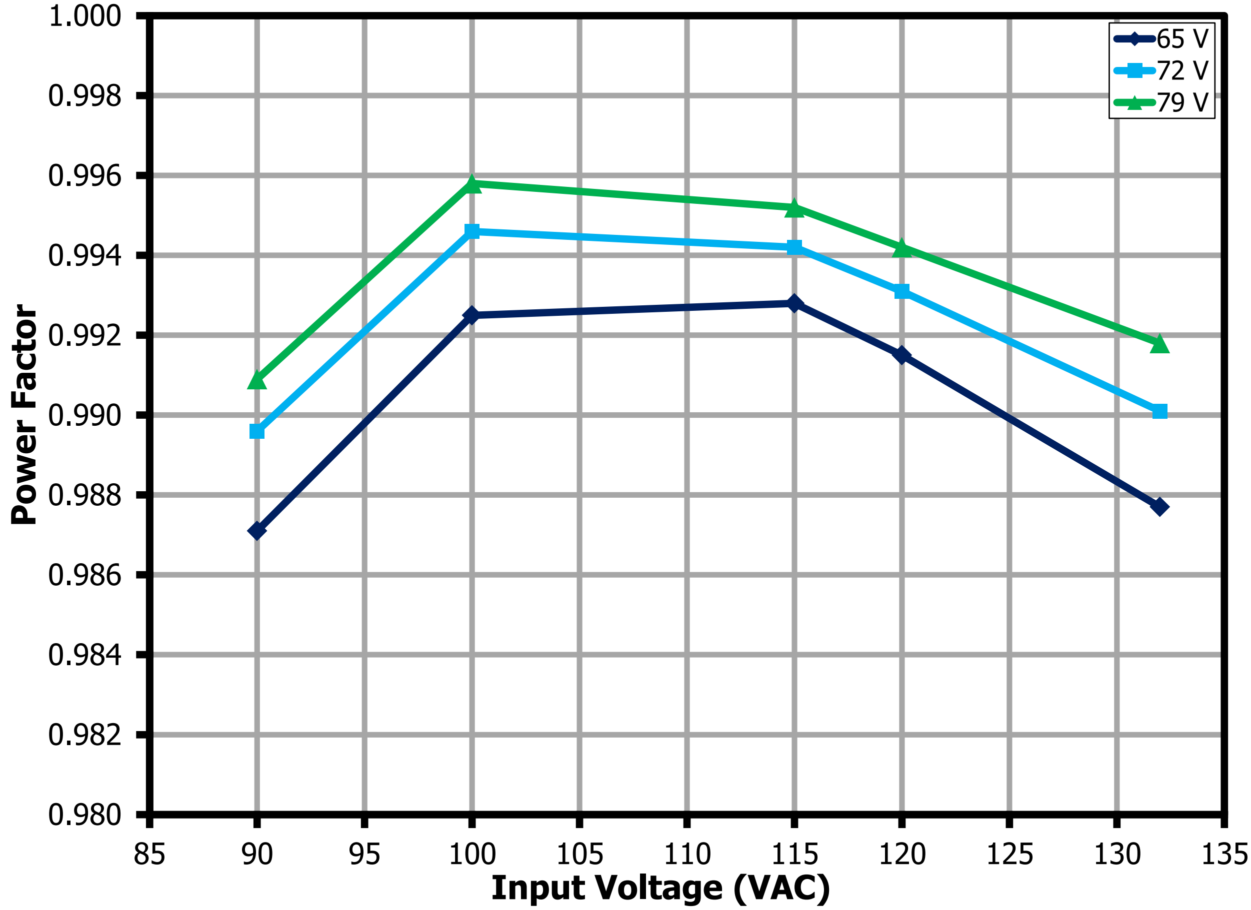

Figure 11 – Power Factor vs. Line and Load.

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9.4 %ATHD

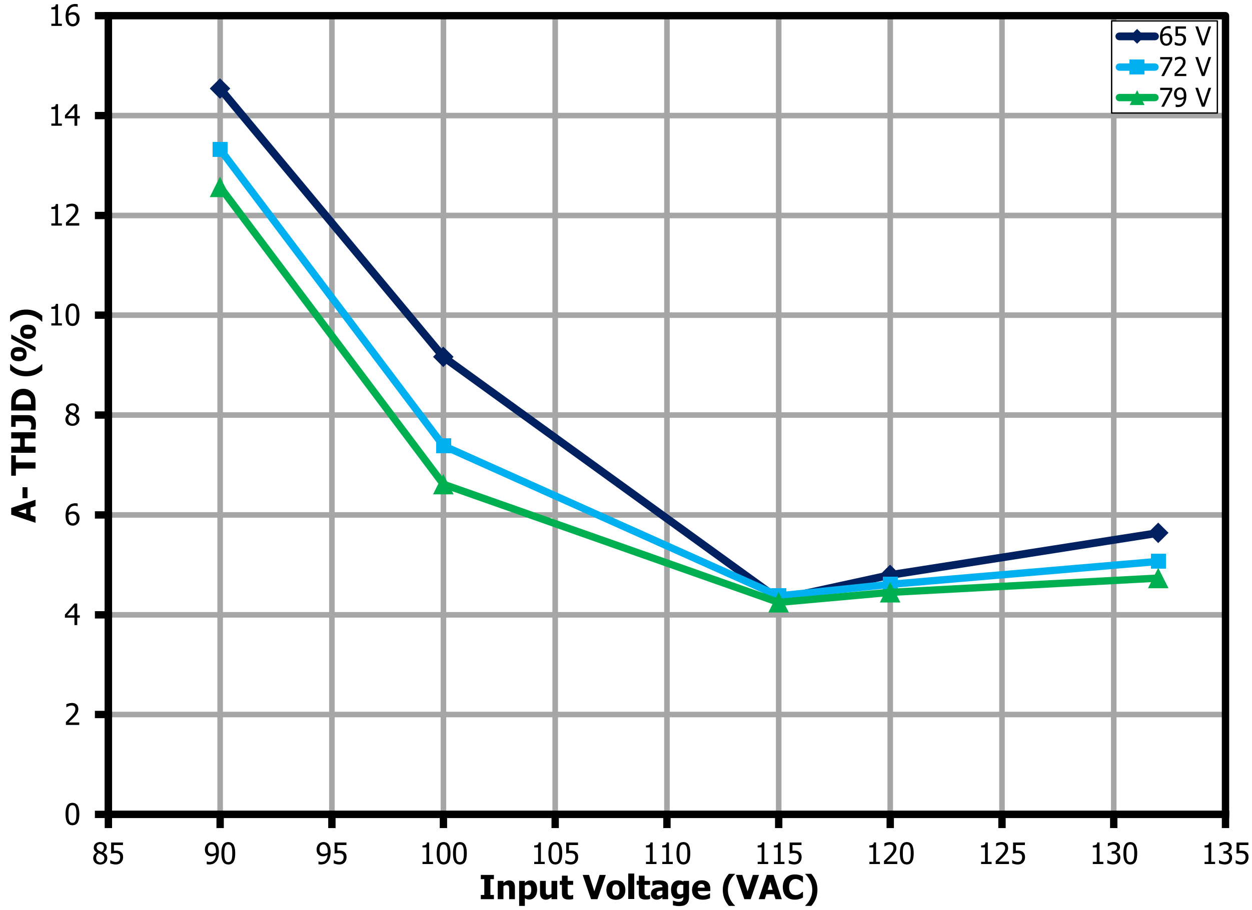

Figure 12 – %ATHD vs. Line and LED Load at 115 VAC, 60 Hz.

9.5 Harmonics

9.5.1 65 V Output

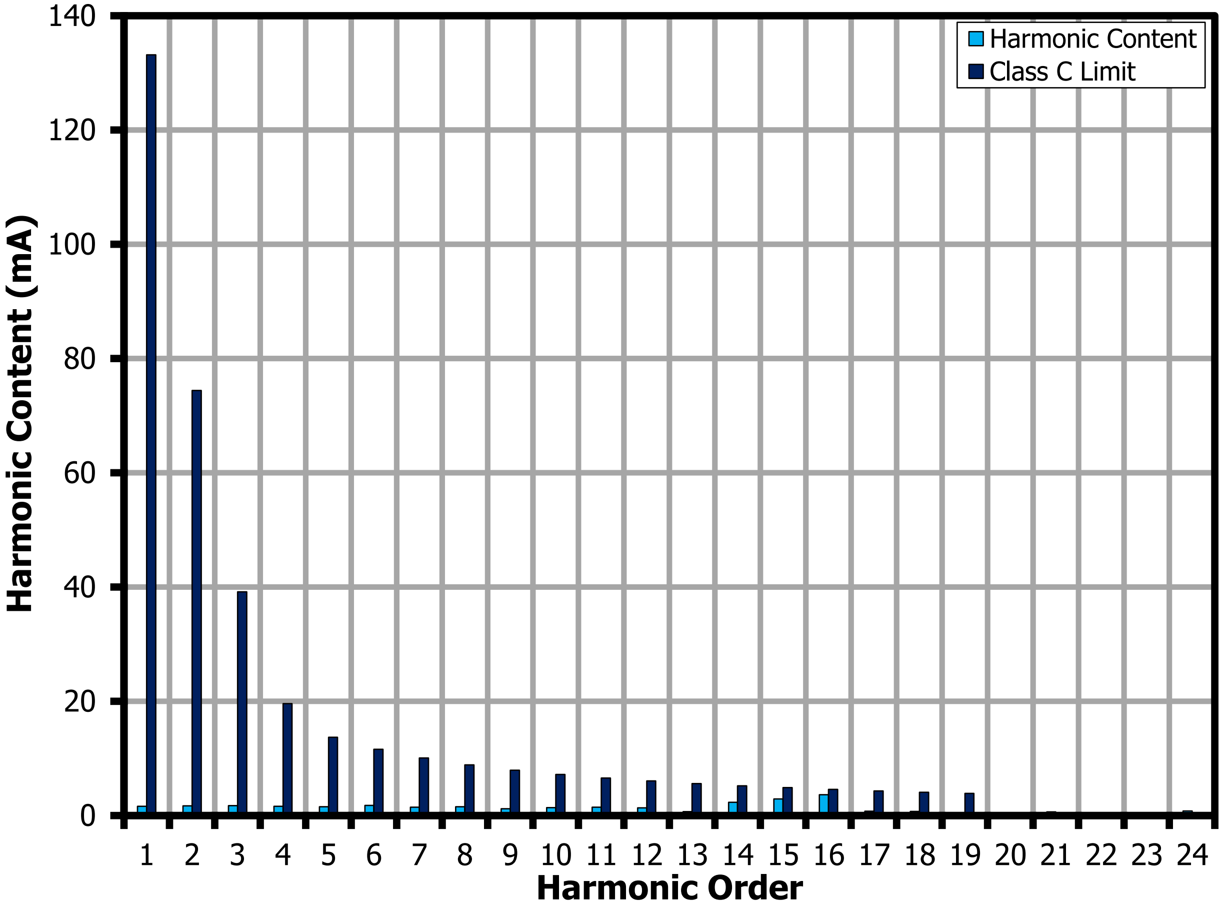

Figure 13 – 24 V Input Current Harmonics at 115 VAC, 60 Hz.

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9.5.2 72 V Output

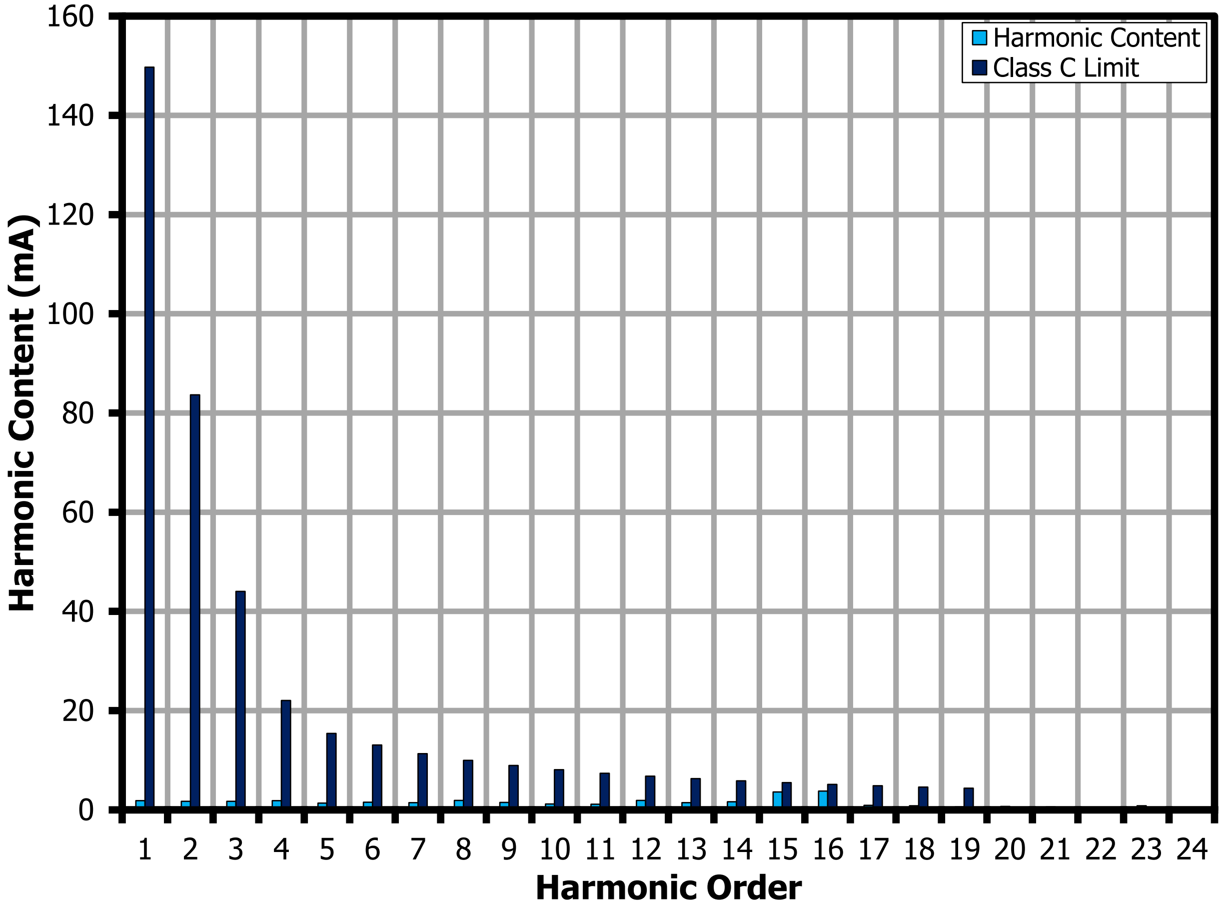

Figure 14 – 27 V Input Current Harmonics at 115 VAC, 60 Hz.

9.5.3 79 V Output

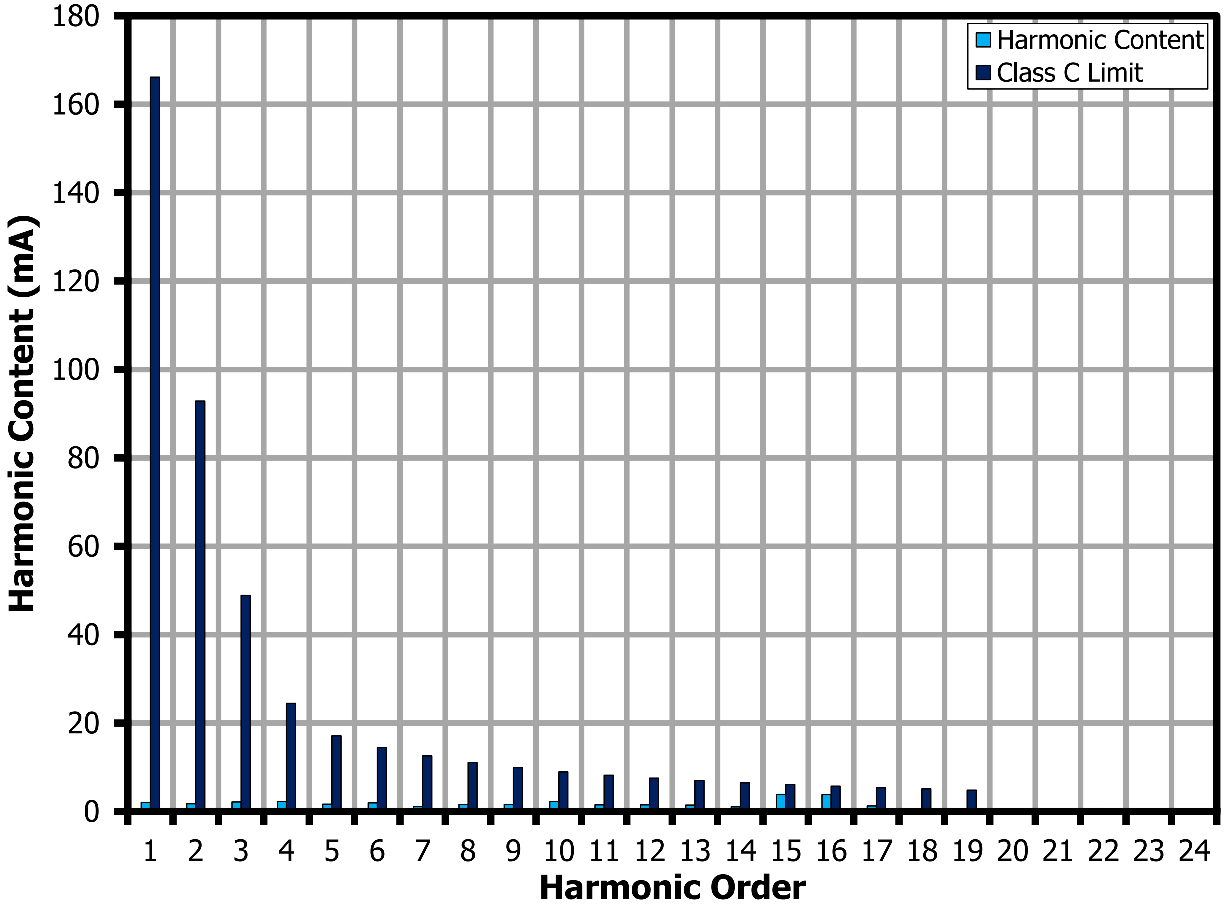

Figure 15 – 30 V Input Current Harmonics at 115 VAC, 60 Hz.

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10 Test Data

10.1 Test Data, 65 V Load

Input		Input Measurement					LED Load Measurement			Efficiency (%)
VAC (V_{RMS})	Freq (Hz)	V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	%ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	
90	60	89.97	228.90	20.33	0.987	14.54	64.96	257.46	16.75	82.41
100	60	99.99	202.82	20.13	0.993	9.164	65.02	259.74	16.91	84.04
115	60	114.97	171.56	19.58	0.993	4.311	64.97	257.93	16.78	85.70
120	60	119.94	163.46	19.44	0.992	4.798	64.96	257.32	16.74	86.11
132	60	132.00	148.90	19.41	0.988	5.638	65.00	258.78	16.84	86.77

10.2 Test Data, 72 V Load

Input		Input Measurement					LED Load Measurement			Efficiency (%)
VAC (V_{RMS})	Freq (Hz)	V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	%ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	
90	60	89.97	256.39	22.83	0.990	13.32	71.97	258.07	18.60	81.47
100	60	99.99	225.78	22.46	0.995	7.387	72.02	259.74	18.73	83.41
115	60	114.97	192.63	22.02	0.994	4.378	72.03	260.26	18.77	85.24
120	60	119.94	183.27	21.83	0.993	4.61	72.01	259.50	18.71	85.71
132	60	132.00	165.47	21.63	0.990	5.067	72.01	259.44	18.70	86.49

10.3 Test Data, 79 V Load

Input		Input Measurement					LED Load Measurement			Efficiency (%)
VAC (V_{RMS})	Freq (Hz)	V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	%ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	
90	60	89.97	284.25	25.34	0.991	12.57	78.98	258.25	20.42	80.57
100	60	99.99	251.11	25.00	0.996	6.615	79.06	260.97	20.65	82.60
115	60	114.97	213.56	24.44	0.995	4.25	79.08	261.53	20.70	84.72
120	60	119.94	202.69	24.17	0.994	4.449	79.04	260.35	20.60	85.24
132	60	132.00	183.44	24.02	0.992	4.734	79.07	261.46	20.69	86.17

10.4 Harmonic Content at 115 VAC

10.4.1 65 V Load

V	Freq	I (mA$_{RMS}$)	P	PF	%THD
115	60.00	171.56	19.5830	0.9928	4.311
nth Order	**mA Content**	**% Content**	**Limit <25 W**	**Limit >25 W**	**Remarks**
1	162.97				
2	0.16	0.10%		2.00%	
3	1.62	0.99%	133.1644	29.78%	Pass
5	1.69	1.04%	74.4154	10.00%	Pass
7	1.73	1.06%	39.1660	7.00%	Pass
9	1.60	0.98%	19.5830	5.00%	Pass
11	1.54	0.94%	13.7081	3.00%	Pass
13	1.75	1.07%	11.5992	3.00%	Pass
15	1.43	0.88%	10.0526	3.00%	Pass
17	1.53	0.94%	8.8699	3.00%	Pass
19	1.19	0.73%	7.9363	3.00%	Pass
21	1.37	0.84%	7.1804	3.00%	Pass
23	1.46	0.90%	6.5560	3.00%	Pass
25	1.32	0.81%	6.0316	3.00%	Pass
27	0.68	0.42%	5.5848	3.00%	Pass
29	2.29	1.41%	5.1996	3.00%	Pass
31	2.88	1.77%	4.8642	3.00%	Pass
33	3.62	2.22%	4.5694	3.00%	Pass
35	0.73	0.45%	4.3083	3.00%	Pass
37	0.71	0.44%	4.0754	3.00%	Pass
39	0.42	0.26%	3.8664	3.00%	Pass
41	0.43	0.26%			
43	0.63	0.39%			
45	0.45	0.28%			
47	0.24	0.15%			
49	0.77	0.47%			

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10.4.2 72 V Load

V	**Freq**	**I (mA$_{RMS}$)**	**P**	**PF**	**%THD**
115	60.00	192.63	22.0180	0.9942	4.378
nth Order	**mA Content**	**% Content**	**Limit <25 W**	**Limit >25 W**	**Remarks**
1	182.99				
2	0.24	0.13%		2.00%	
3	1.83	1.00%	149.7224	29.83%	Pass
5	1.71	0.93%	83.6684	10.00%	Pass
7	1.73	0.95%	44.0360	7.00%	Pass
9	1.86	1.02%	22.0180	5.00%	Pass
11	1.34	0.73%	15.4126	3.00%	Pass
13	1.53	0.84%	13.0414	3.00%	Pass
15	1.43	0.78%	11.3026	3.00%	Pass
17	1.87	1.02%	9.9729	3.00%	Pass
19	1.50	0.82%	8.9231	3.00%	Pass
21	1.17	0.64%	8.0733	3.00%	Pass
23	1.14	0.62%	7.3712	3.00%	Pass
25	1.87	1.02%	6.7815	3.00%	Pass
27	1.43	0.78%	6.2792	3.00%	Pass
29	1.61	0.88%	5.8462	3.00%	Pass
31	3.60	1.97%	5.4690	3.00%	Pass
33	3.78	2.07%	5.1375	3.00%	Pass
35	0.89	0.49%	4.8440	3.00%	Pass
37	0.82	0.45%	4.5821	3.00%	Pass
39	0.59	0.32%	4.3471	3.00%	Pass
41	0.67	0.37%			
43	0.57	0.31%			
45	0.37	0.20%			
47	0.81	0.44%			
49	0.24	0.13%			

10.4.3 79 V Load

V	Freq	I (mArms)	P	PF	%THD
115	60.00	213.56	24.4350	0.9952	4.25
nth Order	**mA Content**	**% Content**	**Limit <25 W**	**Limit >25 W**	**Remarks**
1	202.54				
2	0.11	0.05%		2.00%	
3	2.04	1.01%	166.1580	29.86%	Pass
5	1.72	0.85%	92.8530	10.00%	Pass
7	2.16	1.07%	48.8700	7.00%	Pass
9	2.22	1.10%	24.4350	5.00%	Pass
11	1.63	0.80%	17.1045	3.00%	Pass
13	1.95	0.96%	14.4730	3.00%	Pass
15	1.09	0.54%	12.5433	3.00%	Pass
17	1.60	0.79%	11.0676	3.00%	Pass
19	1.57	0.78%	9.9026	3.00%	Pass
21	2.23	1.10%	8.9595	3.00%	Pass
23	1.47	0.73%	8.1804	3.00%	Pass
25	1.47	0.73%	7.5260	3.00%	Pass
27	1.43	0.71%	6.9685	3.00%	Pass
29	1.05	0.52%	6.4879	3.00%	Pass
31	3.84	1.90%	6.0693	3.00%	Pass
33	3.78	1.87%	5.7015	3.00%	Pass
35	1.21	0.60%	5.3757	3.00%	Pass
37	0.40	0.20%	5.0851	3.00%	Pass
39	0.65	0.32%	4.8243	3.00%	Pass
41	0.51	0.25%			
43	0.40	0.20%			
45	0.69	0.34%			
47	0.36	0.18%			
49	0.51	0.25%			

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11 Dimming Performance Data

TRIAC dimming results were taken at an input voltage of 115 VAC, 60 Hz line frequency, room temperature, and a nominal 72 V LED load.

11.1 Dimming Curve

Agilent 6812B AC source programmed as perfect leading edge dimmer

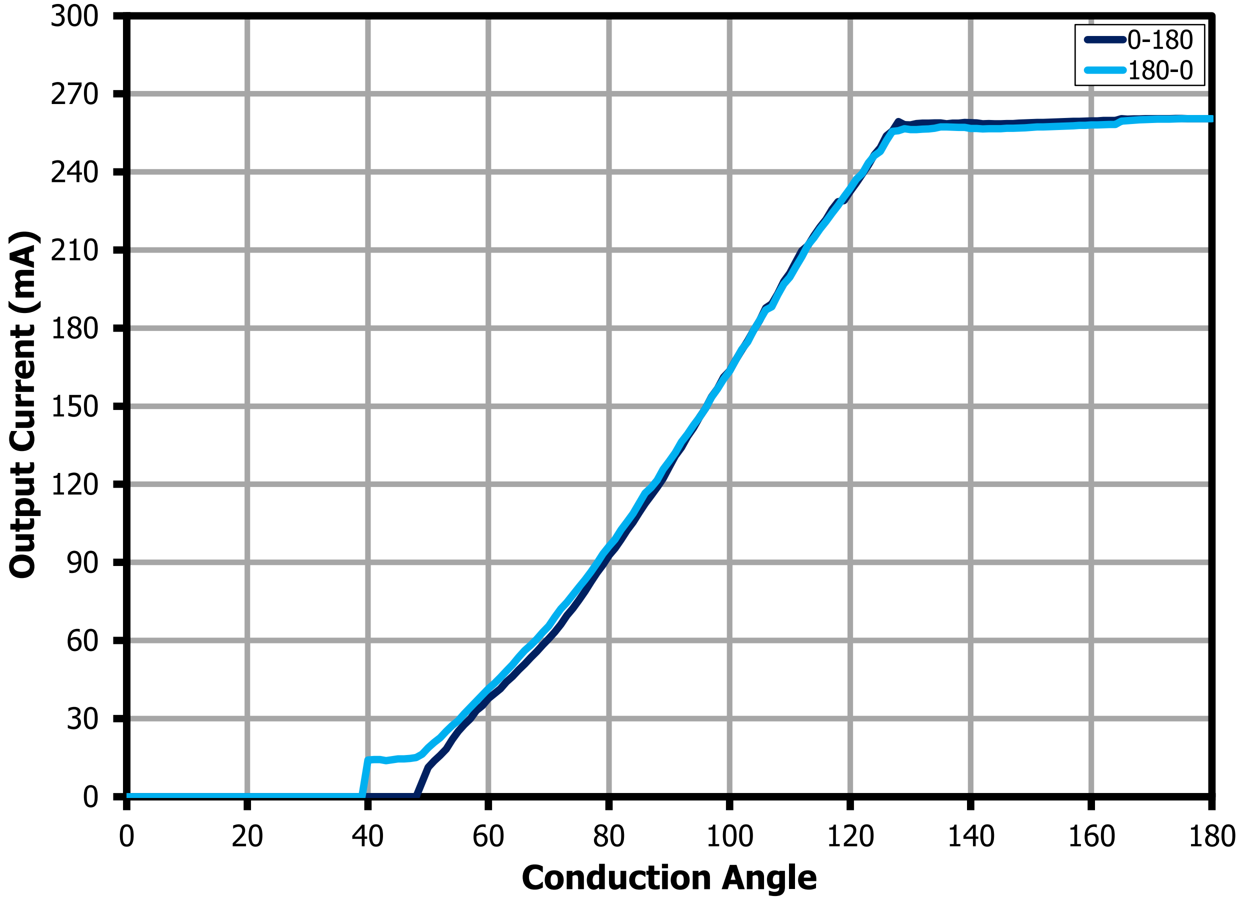

Figure 16 – Dimming Curve at 115 VAC, 60 Hz Input.

11.2 Dimming Efficiency

Measurements were made using a programmable AC source to provide the leading edge chopped AC input. For this test, the bleeder is already active.

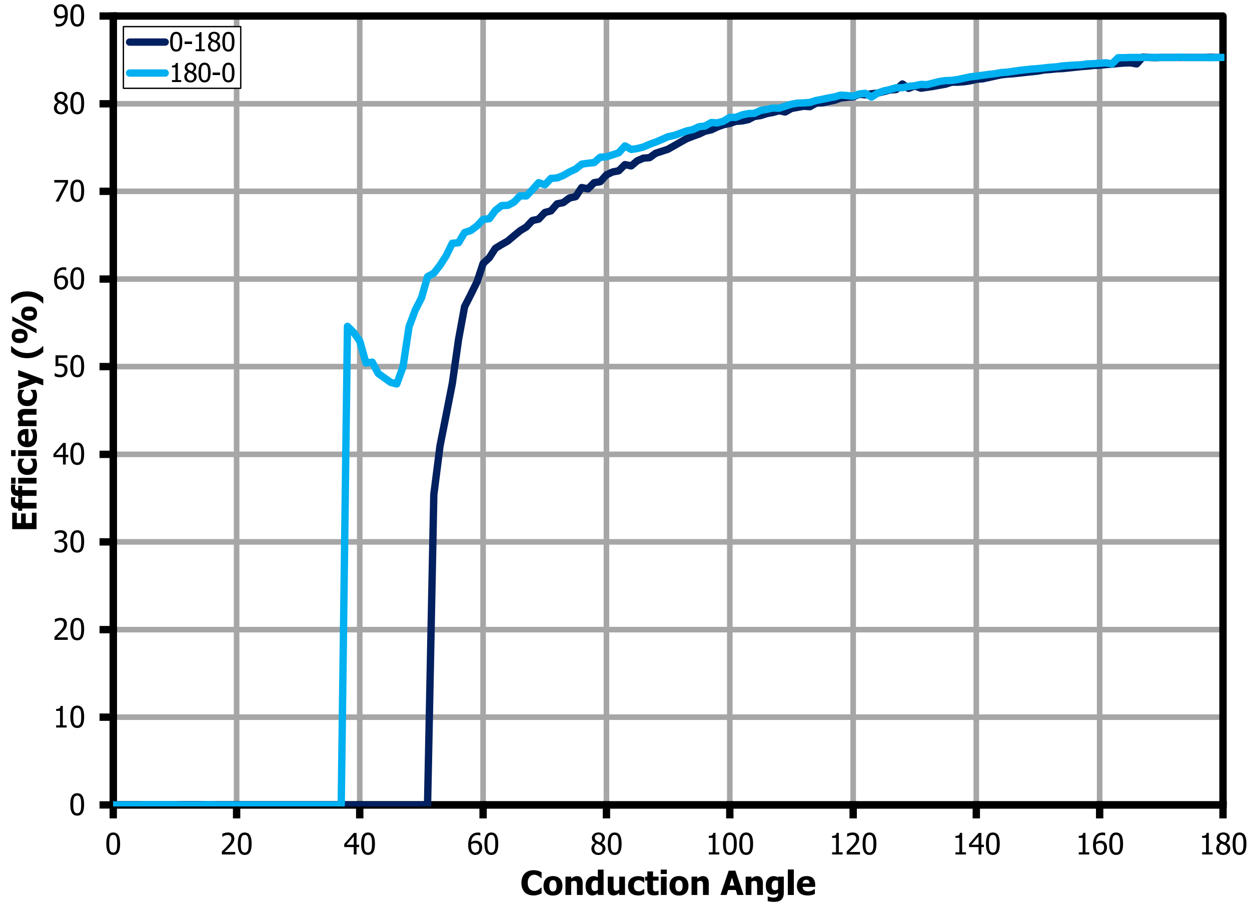

Figure 17 – Dimming Efficiency at 115 VAC, 60 Hz Input.

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11.3 Driver Power Loss During Dimming

Measurements were made using a programmable AC source to provide the leading edge chopped AC input. For this test, the bleeder is already active.

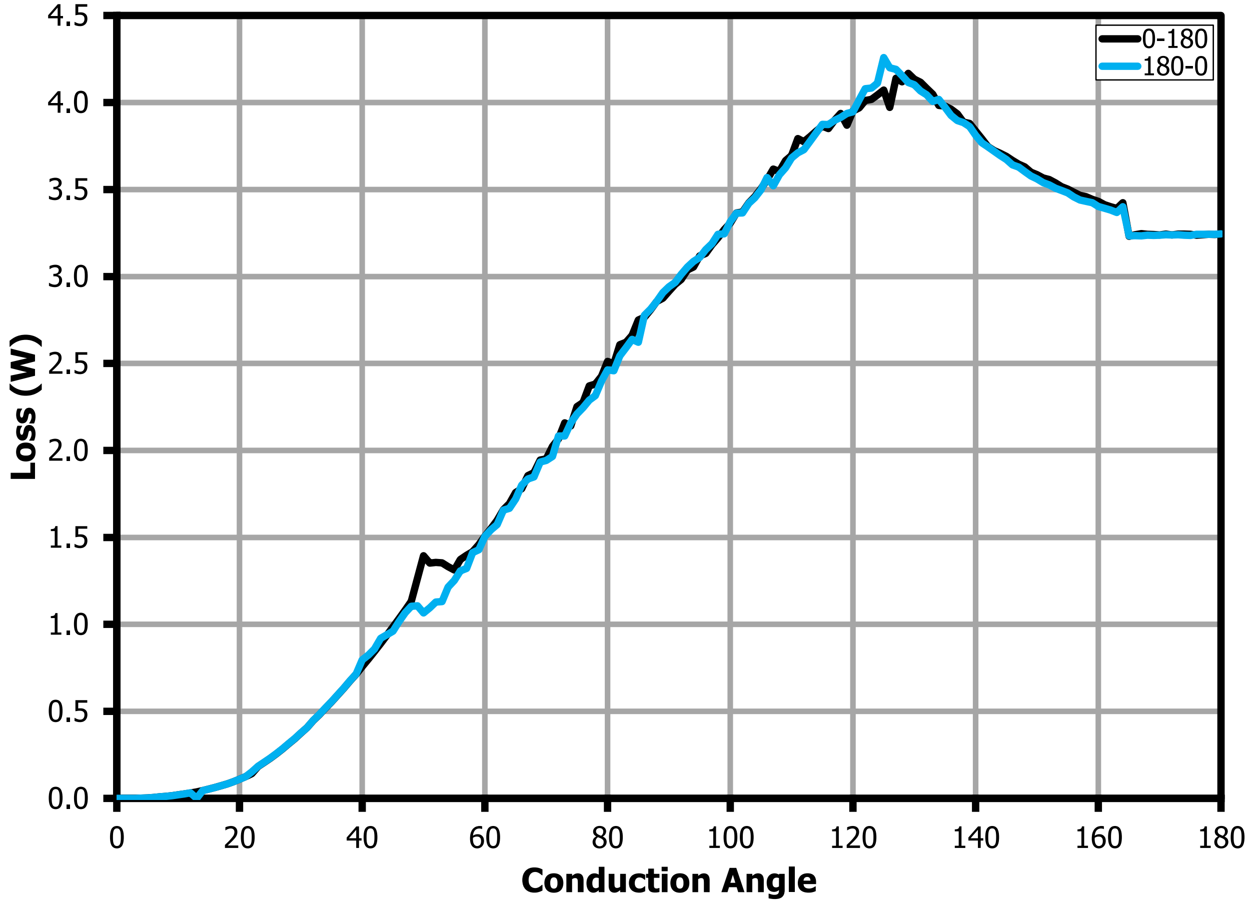

Figure 18 – Dimming Power Loss at 115 VAC, 60 Hz Input

11.4 Dimming Compatibility with Available Dimmers

The following dimmers were tested at 25 ºC ambient temperature with utility line input (~120 VAC, 60 Hz) and 72 V LED load.

No	Brand	Model	Type	Max. (mA)	Min. (mA)
1	LUTRON	AY-10PNL-WH	L	264.62	20.6
2	LUTRON	AY-603PG-WH	L	208.38	21.6
3	LUTRON	AY-603P-WH	L	266.8	21.48
4	LUTRON	AYLV-600P-WH	L	268.23	22.34
5	LUTRON	AYLV-603P-WH	L	265.2	20.88
6	LUTRON	GLV-600-IV	L	267.05	20.6
7	LUTRON	LG-600PH-WH	L	265.25	21.08
8	LUTRON	DV-600P-WH	L	264.2	20.6
9	LUTRON	DV-603P-WH	L	265.87	20.3
10	LUTRON	DVLV-103P-WH	L	268.88	25.89
11	LUTRON	DVLV-10P-WH	L	262.21	19
12	LUTRON	DVPDC-203P-WH	L	265.93	58.8
13	LUTRON	DVW-603PGH-WH	L	222.6	24.05
14	LUTRON	DVWCL-153PH-WH	L	260.19	20.08
15	LUTRON	GL-600-WH	L	263.3	20.45
16	LUTRON	LG-603PGH-WH	L	218.56	21.03
17	LUTRON	CTCL-153P-WH	L	263.4	20.2
18	LUTRON	MACL-153M-WH	L	260.1	20
19	LEVITON	R02-06613-PLW	L	265.17	19.8
20	LEVITON	R62-RP106-1LW	L	265.4	23.1
21	LUTRON	S-1000-WH	L	264.4	20.35
22	LUTRON	S-103PNL-WH	L	263.7	20.18
23	LUTRON	S-103P-WH	L	261.8	20.8
24	LUTRON	S-10P-WH	L	263.09	20.2
25	LUTRON	S-600PH-WH	L	262.75	19.9
26	LUTRON	S-600PNLH-WH	L	261.22	20.19
27	LUTRON	S-600P-WH	L	263.47	21.37
28	LUTRON	S-600-WH	L	262.18	24.4
29	LUTRON	S-603PGH-WH	L	210.8	20.1
30	LUTRON	S-603PNLH-WH	L	265	20.3
31	LUTRON	SPSELV-600-WH	T	276.77	31.5
32	LUTRON	LGCL-153PLH-WH	L	265.1	20.76
33	LUTRON	MALV-600-WH	L	267.31	27.5
34	LEGRAND	HCL453PTCCCV6	L	267.9	41.52
35	LEGRAND	1PE04-1LZ	T	275.3	23.9
36	LUTRON	AYCL-153P-WH	L	264.97	20.3
37	LUTRON	SCL-153P-WH	L	265.16	26.04
38	LUTRON	RRD-10ND-WH	L	265.29	19.9
39	LUTRON	RRD-6NA-WH	T	267.8	25.4
40	LEVITON	VPM10-1LZ	L	265.73	19.7
41	LUTRON	N-600-WH	L	266.3	21.4
42	LUTRON	NTELV-600-WH	T	264.88	24.68
43	LUTRON	NT-603P-WH	L	266.58	21.58
44	LUTRON	DVF-103P-WH	L	263.82	46.07
45	LEVITON	1PSD6-1LZ	L	263.25	21.18
46	LEVITON	1PVD6-1LZ	L	265.13	22.8
47	LEVITON	1PL06-10Z	L	268.2	20.2
48	LEVITON	6672	L	264.14	20.45
49	COOPER	SI06P	L	267.38	20.9
50	COOPER	SLC03P-W-K-L	L	264.77	58.05

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51	LUTRON	SLV600P-WH	L	263.65	20.7
52	LUTRON	SLV-603P-WH	L	265.15	20.58
53	LUTRON	SPSLV-1000-WH	L	268.5	19.19
54	LUTRON	TG-10PR-WH	L	266.73	20.09
55	LUTRON	TGCL-153PH-WH	L	266.17	20.4
56	LEVITON	1P106	L	268.44	19.74
57	COOPER	R106-W-K	L	263.9	27.5
58	COOPER	9530WS-K	L	265.16	20.95
59	LEVITON	601-6631-1	L	263.7	20.6
60	LEVITON	AT106-1LA	L	265.4	19.9
61	LEVITON	6683	L	263.9	20.5
62	LEVITON	1P106-1LZ	L	265.95	20.4
63	LEVITON	6681	L	264.83	20.38
64	LEVITON	6633-PLW	L	265.41	20.6
65	GE	18019	L	262.97	21.26
66	GE	18023	L	263.8	27.3
67	GE	18022	L	263.4	19.77
68	LUTRON	MRF2-6ND-120-BI	L	263.43	20.45
69	LUTRON	RRD-6NA-WH	T	265.58	25.7
70	LUTRON	D-600P-WH	L	276.57	22.4
71	LUTRON	DVCL-153P-WH	L	262.19	21.68
72	LUTRON	AY-600PNL-WH	L	264.7	19.6
73	LUTRON	LXELV-600PL-WH	T	271.21	25.16
74	LUTRON	NTELV-300-WH	T	264.44	25
75	LUTRON	NT-600-WH	L	263.73	20.5
76	LUTRON	DVELV-300P-WH	T	264.55	24.9
77	LUTRON	SELV-300P-WH	T	264.59	25.68
78	LEVITON	6674	L	264.01	19.7
79	LEVITON	6641	L	262.34	20.25
80	LEVITON	6602	L	264.9	20.38
81	LEVITON	TBL03	L	265.89	19.6
82	LEVITON	6615		272	25.58

12 Thermal Performance

Thermal measurements were performed with the power supply operating at 25 ^{0} C ambient temperature with nominal output of 72 V LED load. The power supply was soaked until component temperatures stabilized. The LED driver was potted inside the enclosure.

12.1 Non-Dimming

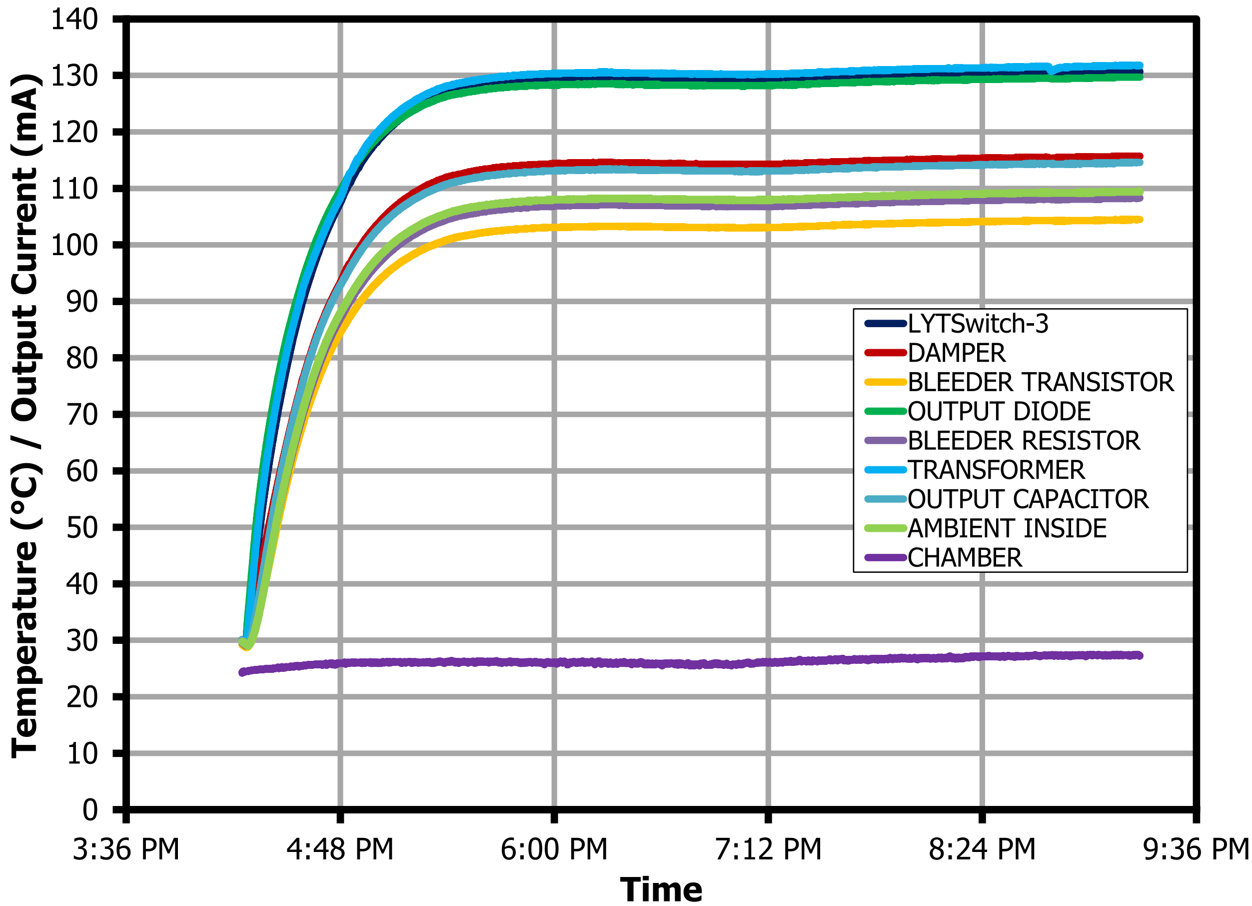

Figure 19 –

Component	115 VAC
Ambient	27.3 °C
LYTSwitch-3 IC	130.7 °C
Damper Resistor	115.7 °C
Bleeder Transistor	104.5 °C
Output Diode	129.7 °C
Bleeder Resistor	108.3 °C
Transformer	131.8 °C
Unit Internal Ambient	109.4 °C
Output Capacitor	114.6 °C

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12.2 Dimming

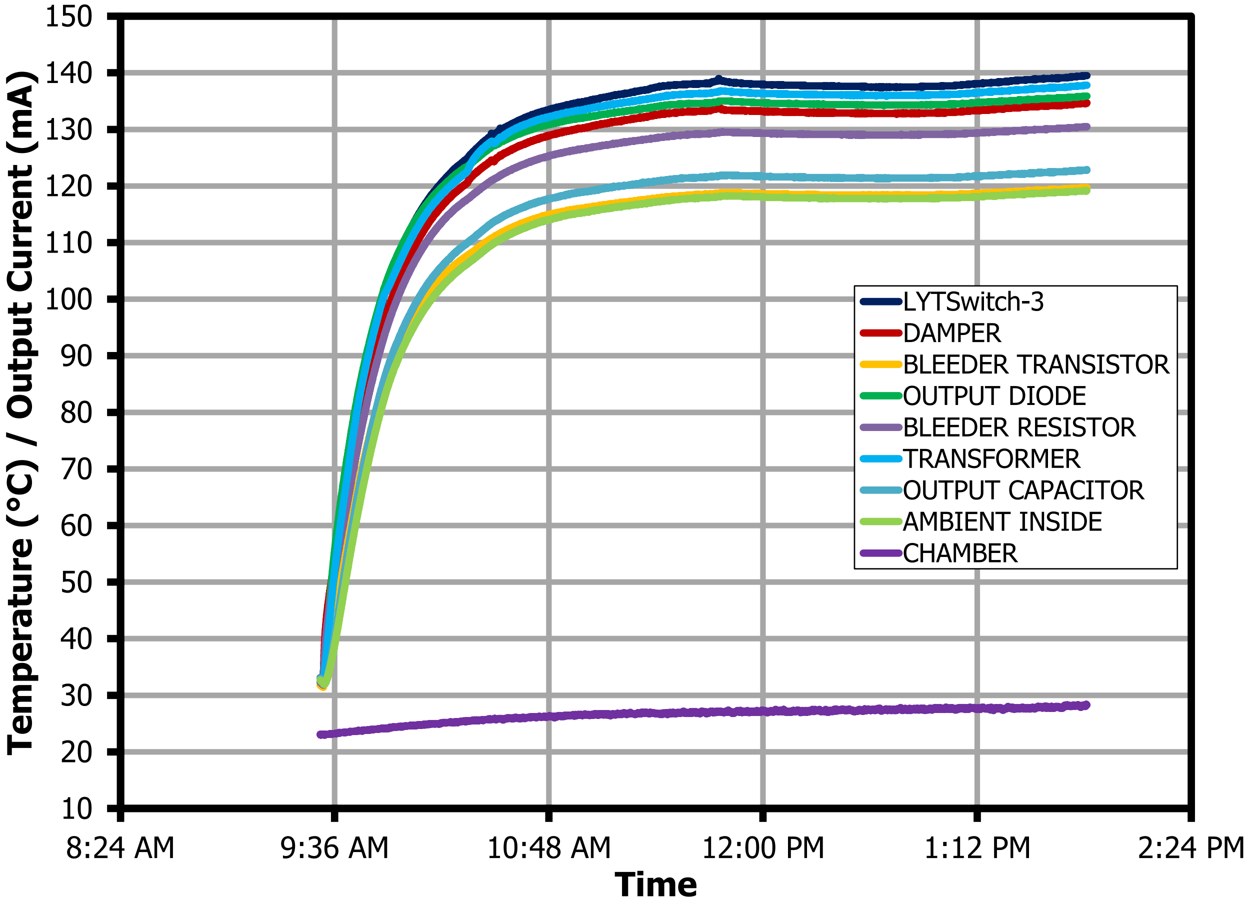

Figure 20 –

Component	115 VAC
Ambient	28.3 °C
LYTSwitch-3	139.5 °C
Damper Resistor	134.7 °C
Bleeder Transistor	119.7 °C
Output Diode	135.9 °C
Bleeder Resistor	130.5 °C
Transformer	137.8 °C
Unit Internal Ambient	119.2 °C
Output Capacitor	122.8 °C

13 Waveforms

13.1 Input Voltage and Input Current Waveforms

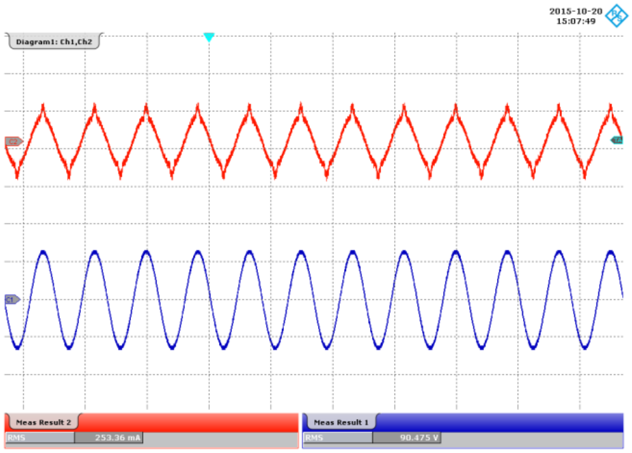

Figure 21 – 90 VAC, 72 V LED Load.
Upper: I_{IN}, 500 mA / div.
Lower: V_{IN}, 100 V / div., 20 ms / div.

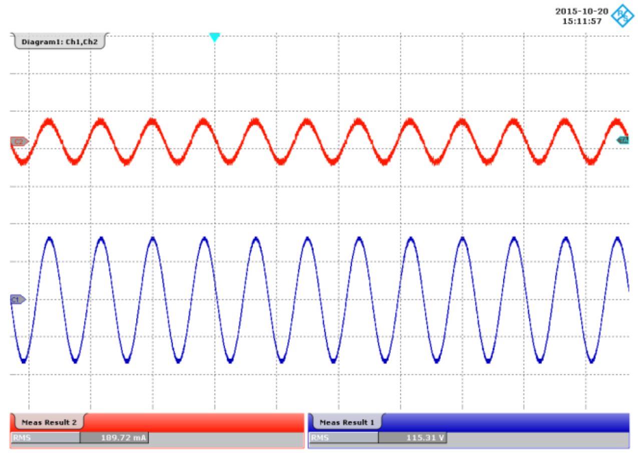

Figure 22 – 115 VAC, 72 V LED Load.
Upper: I_{IN}, 500 mA / div.
Lower: V_{IN}, 100 V / div., 20 ms / div.

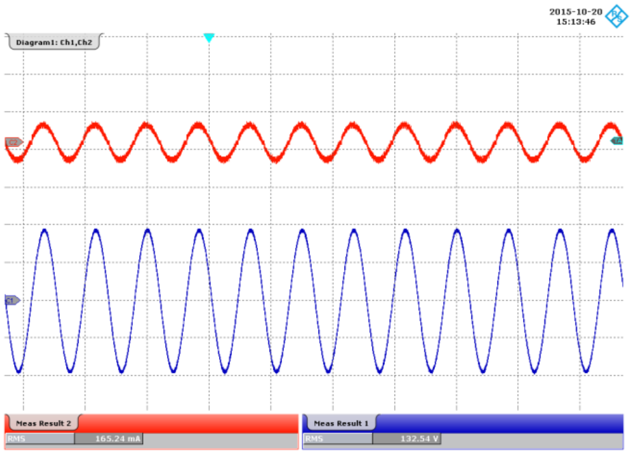

Figure 23 – 132 VAC, 72 V LED Load.
Upper: I_{IN}, 500 mA / div.
Lower: V_{IN}, 100 V / div., 20 ms / div.

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13.2 Output Current Rise and Fall

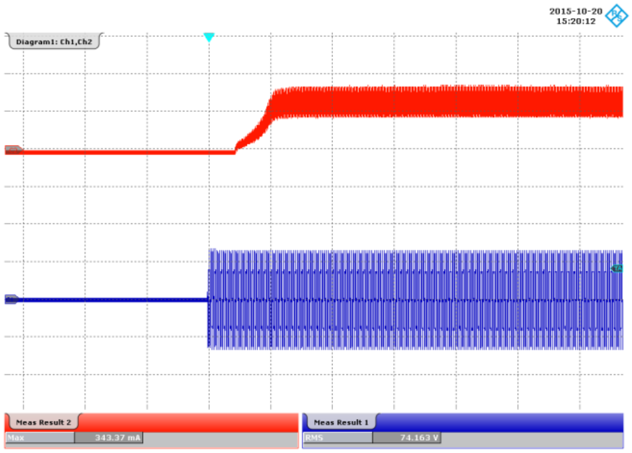

Figure 24 – 90 VAC, 72 V LED Load, Output Rise.
Upper: I_{OUT}, 200 mA / div.
Lower: V_{IN}, 100 V / div., 500 ms / div.

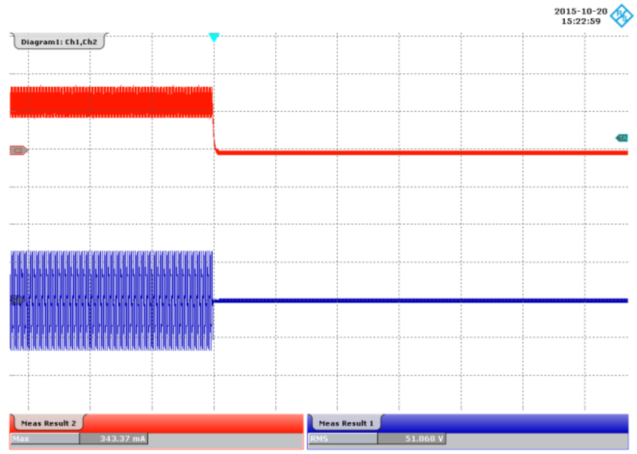

Figure 25 – 90 VAC, 72 V LED Load, Output Fall.
Upper: I_{OUT}, 200 mA / div.
Lower: V_{IN}, 100 V / div., 500 ms / div.

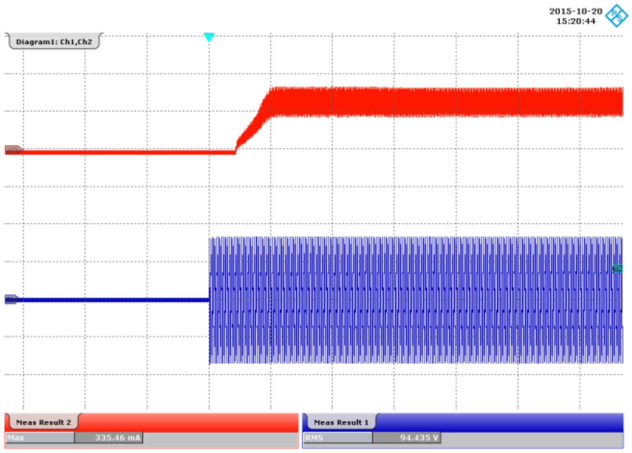

Figure 26 – 115 VAC, 72 V LED Load, Output Rise.
Upper: I_{OUT}, 200 mA / div.
Lower: V_{IN}, 100 V / div., 500 ms / div.

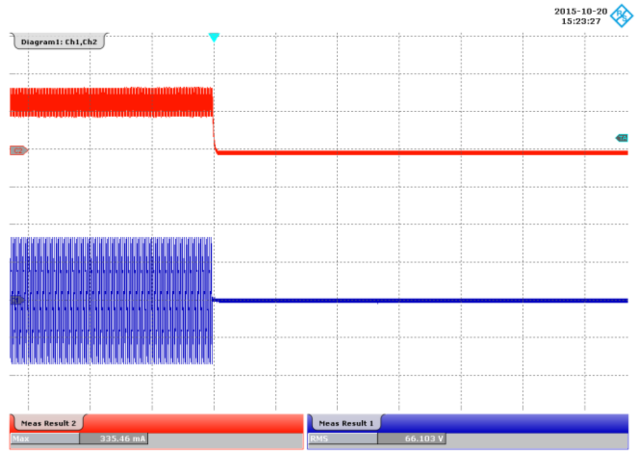

Figure 27 – 115 VAC, 72 V LED Load, Output Fall.
Upper: I_{OUT}, 200 mA / div.
Lower: V_{IN}, 100 V / div., 500 ms / div.

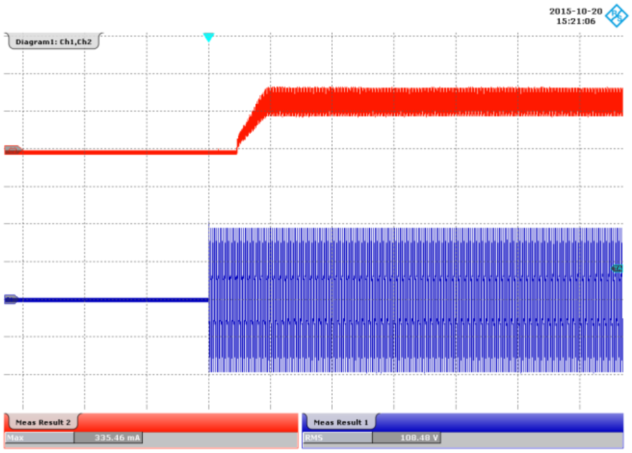

Figure 28 – 132 VAC, 72 V LED Load, Output Rise.
Upper: I_{OUT}, 200 mA / div.
Lower: V_{IN}, 100 V / div., 500 ms / div.

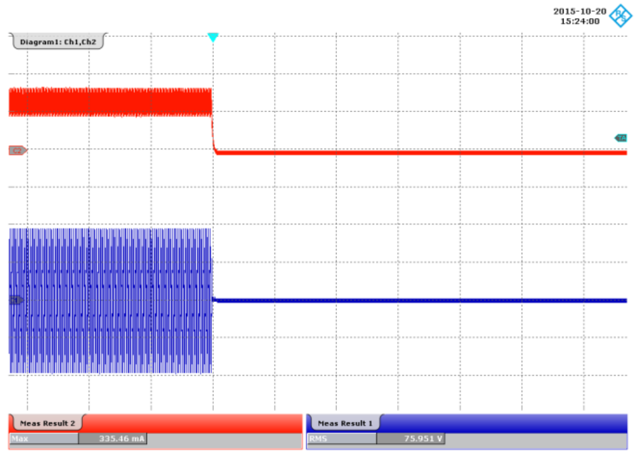

Figure 29 – 132 VAC, 72 V LED Load, Output Fall.
Upper: I_{OUT}, 200 mA / div.
Lower: V_{IN}, 100 V / div., 500 ms / div.

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13.3 Drain Voltage and Current in Normal Operation

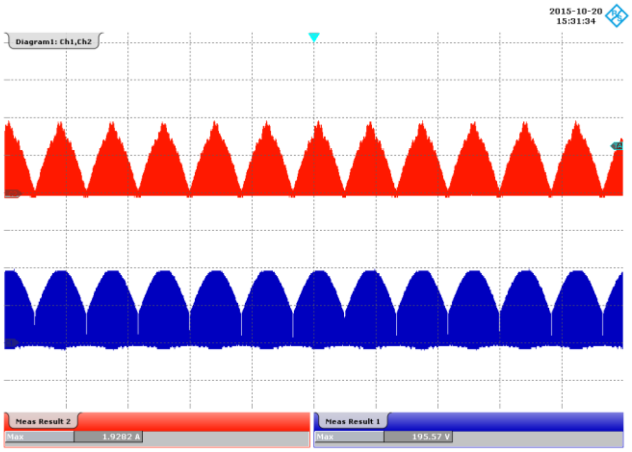

Figure 30 – 90 VAC, 72 V LED Load.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V / div., 10 ms / div.

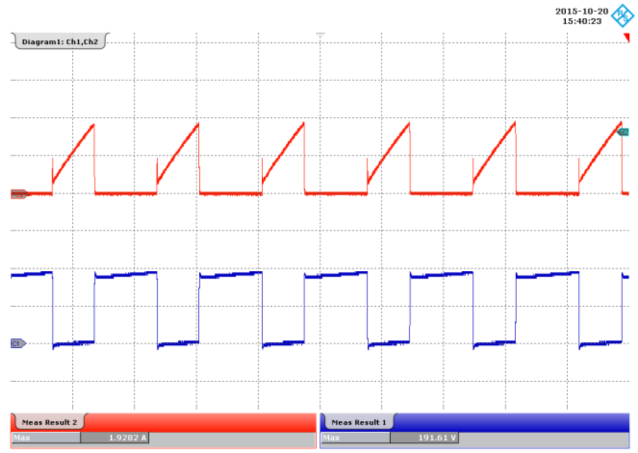

Figure 31 – 90 VAC, 72 V LED Load.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V / div., 5 μs / div.

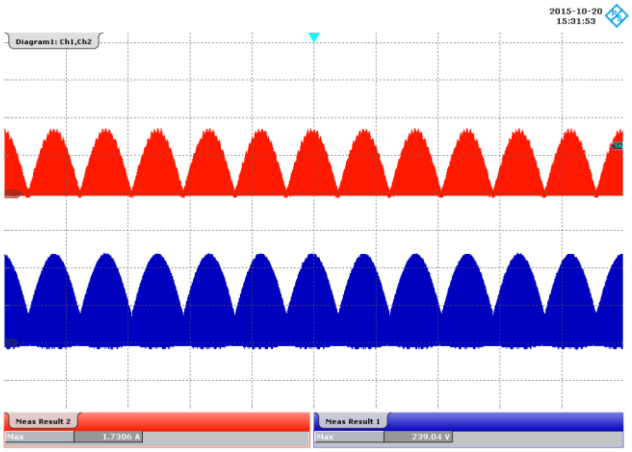

Figure 32 – 115 VAC, 72 V LED Load.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V / div., 10 ms / div.

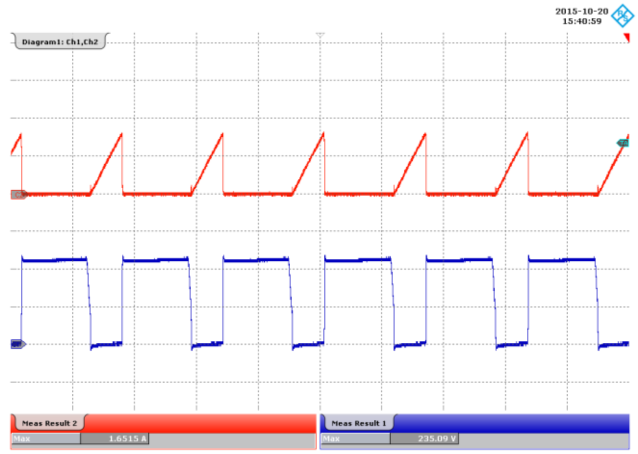

Figure 33 – 115 VAC, 72 V LED Load.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V / div., 5 μs / div.

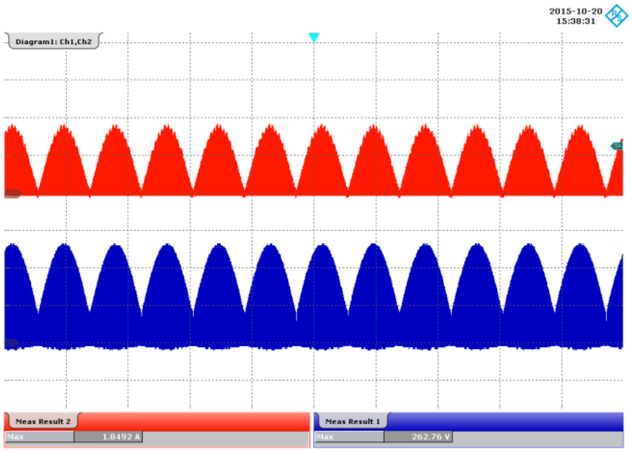

Figure 34 – 132 VAC, 72 V LED Load.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V / div., 10 ms / div.

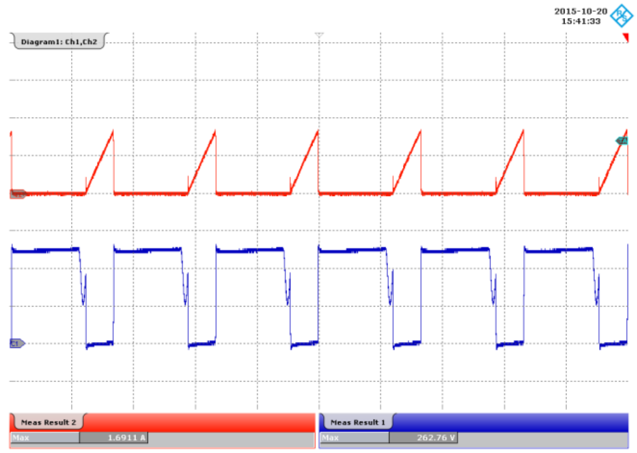

Figure 35 – 132 VAC, 72 V LED Load.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V / div., 5 μs / div.

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13.4 Drain Voltage and Current Start-up Profile

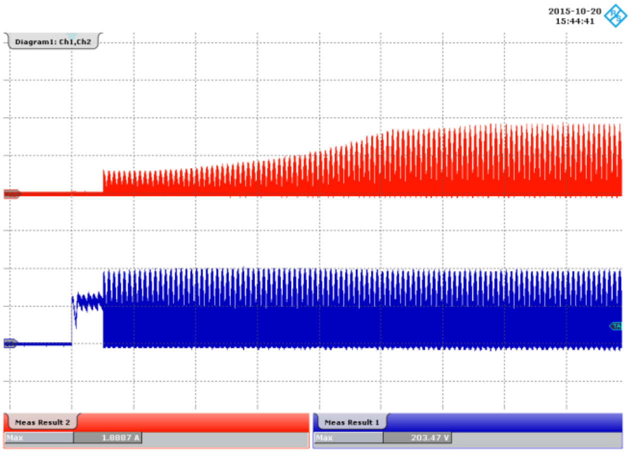

Figure 36 – 90 VAC, 72 V LED Load.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V / div., 20 ms /div.

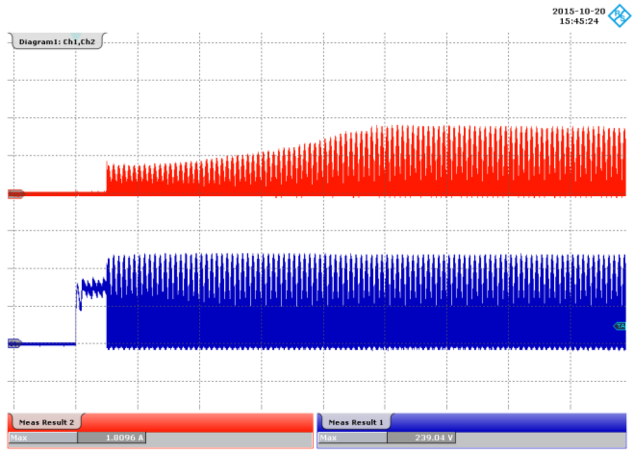

Figure 37 – 115 VAC, 72 V LED Load.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V / div., 20 ms /div.

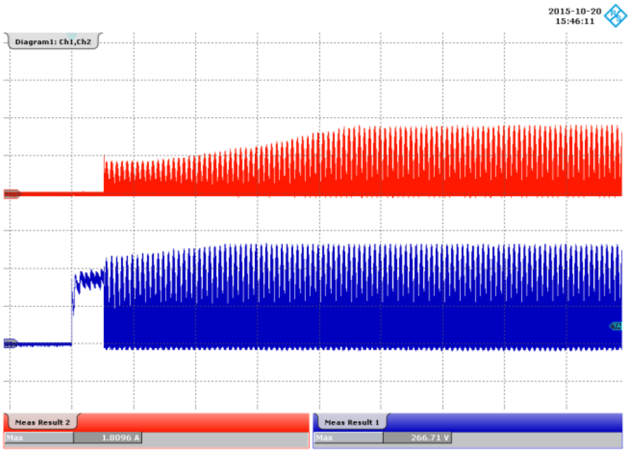

Figure 38 – 132 VAC, 72 V LED Load.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V / div., 20 ms /div.

13.5 Drain Voltage and Current during Output Short-Circuit Condition

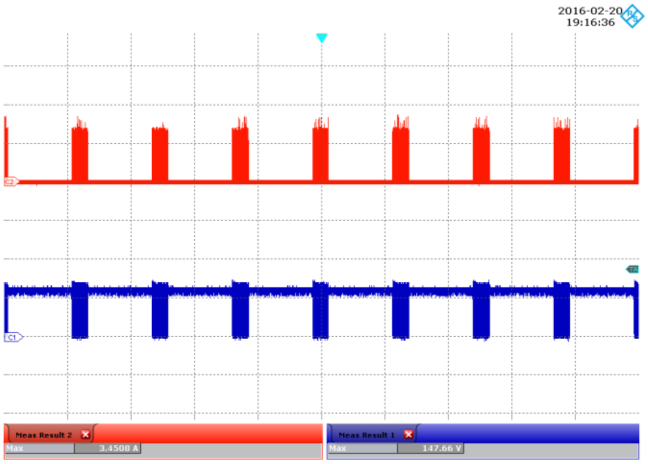

Figure 39 – 90 VAC, Output Short.
Upper: I_{DRAIN}, 2 A / div.
Lower: V_{DRAIN}, 100 V / div., 2 s / div.

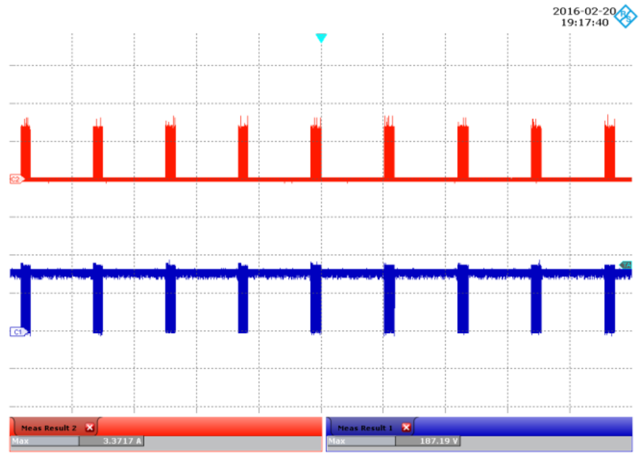

Figure 40 – 115 VAC, Output Short.
Upper: I_{DRAIN}, 2 A / div.
Lower: V_{DRAIN}, 100 V / div., 2 s / div.

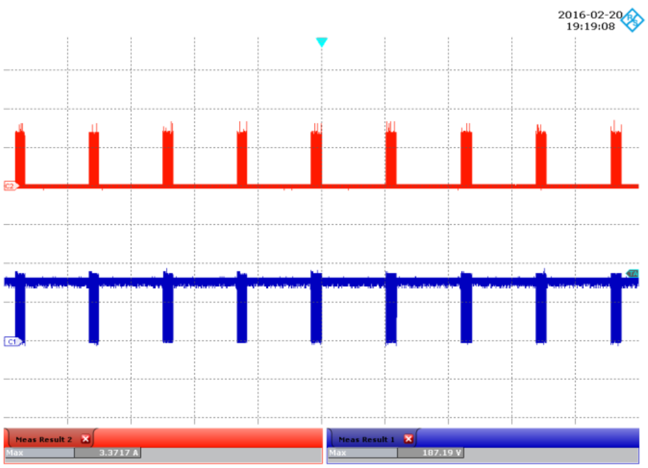

Figure 41 – 132 VAC, Output Short.
Upper: I_{DRAIN}, 2 A / div.
Lower: V_{DRAIN}, 100 V / div., 2 s / div.

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13.6 Output Diode Voltage and Current in Normal Operation

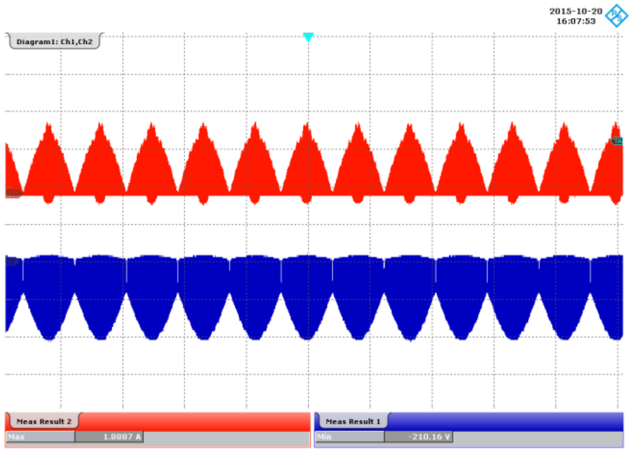

Figure 42 – 90 VAC, 72 V LED Load.
Upper: I_{DIODE}, 1 A / div.
Lower: V_{DIODE}, 100 V / div., 10 ms / div.

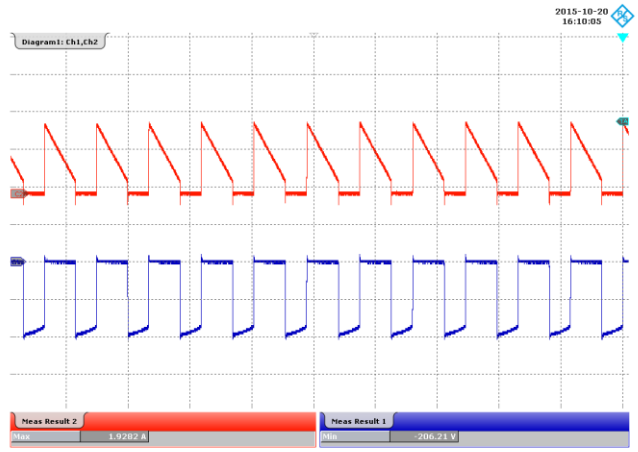

Figure 43 – 90 VAC, 72 V LED Load.
Upper: I_{DIODE}, 1 A / div.
Lower: V_{DIODE}, 100 V / div., 10 µs / div.

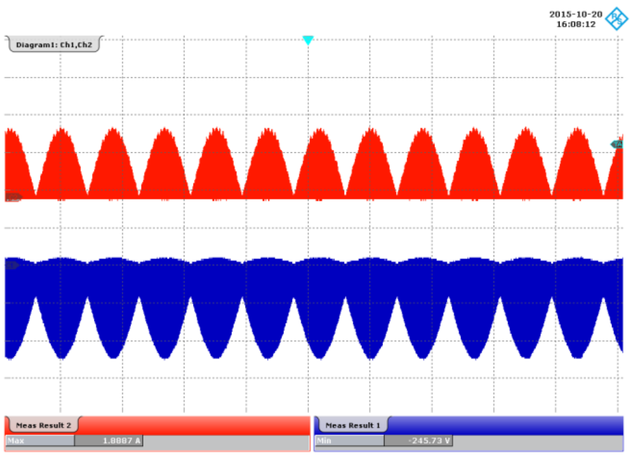

Figure 44 – 115 VAC, 72 V LED Load.
Upper: I_{DIODE}, 1 A / div.
Lower: V_{DIODE}, 100 V / div., 10 ms / div.

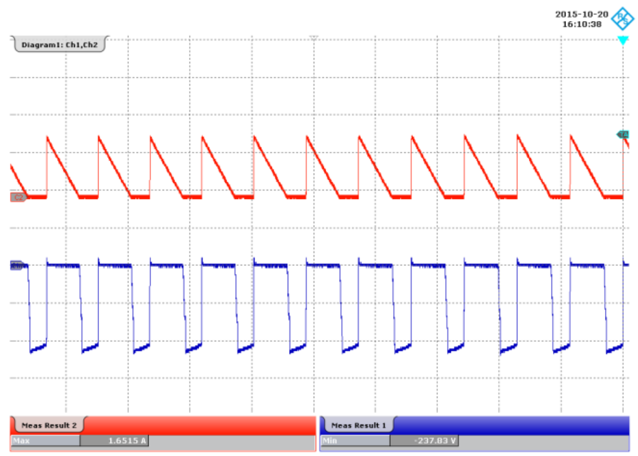

Figure 45 – 115 VAC, 72 V LED Load.
Upper: I_{DIODE}, 1 A / div.
Lower: V_{DIODE}, 100 V / div., 10 µs / div.

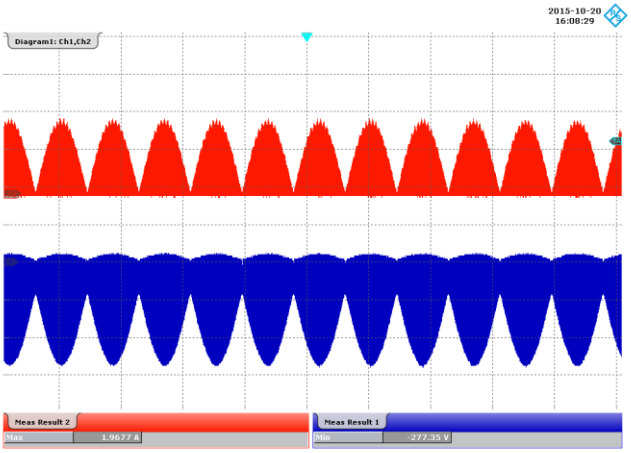

Figure 46 – 132 VAC, 72 V LED Load.
Upper: I_{DIODE}, 1 A / div.
Lower: V_{DIODE}, 100 V / div., 10 ms / div.

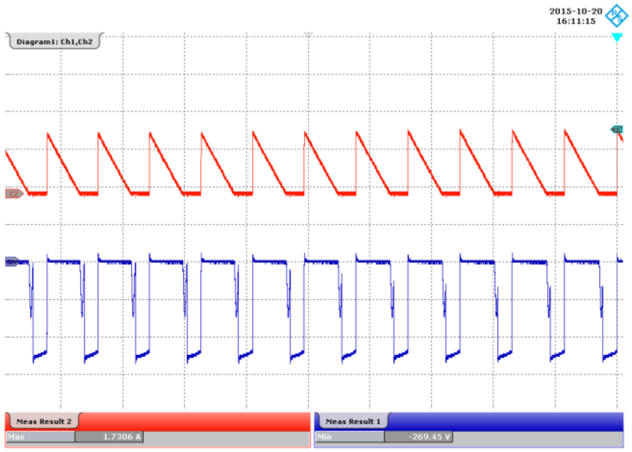

Figure 47 – 132 VAC, 72 V LED Load.
Upper: I_{DIODE}, 1 A / div.
Lower: V_{DIODE}, 100 V / div., 10 μs / div.

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13.7 Output Voltage and Current – Open LED Load

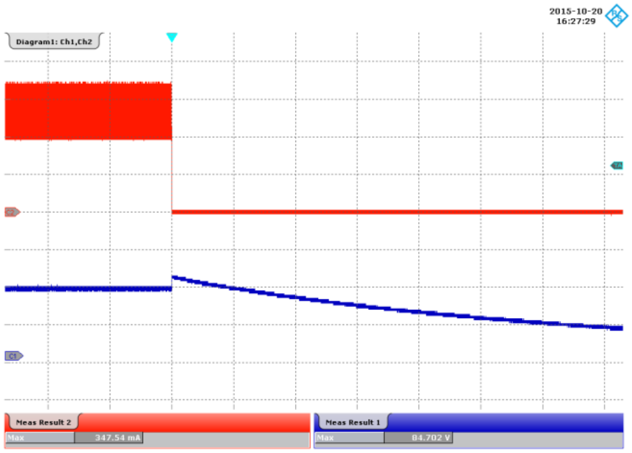

Figure 48 – 90 VAC, 72 V LED Load,
Running Open Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 40 V / div., 10 s / div.

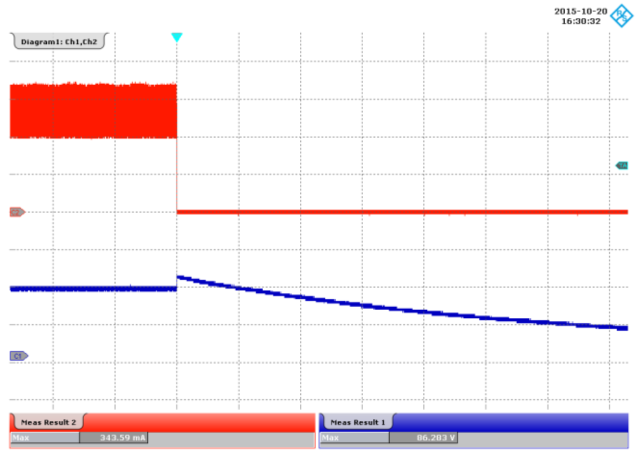

Figure 49 – 115 VAC, 72 V LED Load,
Running Open Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 40 V / div., 10 s / div.

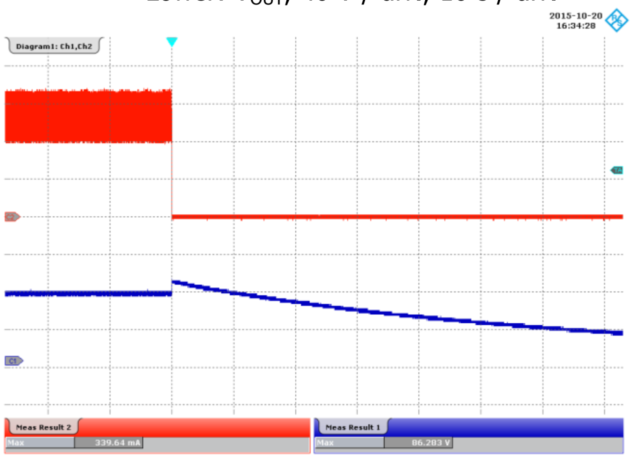

Figure 50 – 132 VAC, 72 V LED Load,
Running Open Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 40 V / div., 10 s / div.

13.8 Output Ripple Current

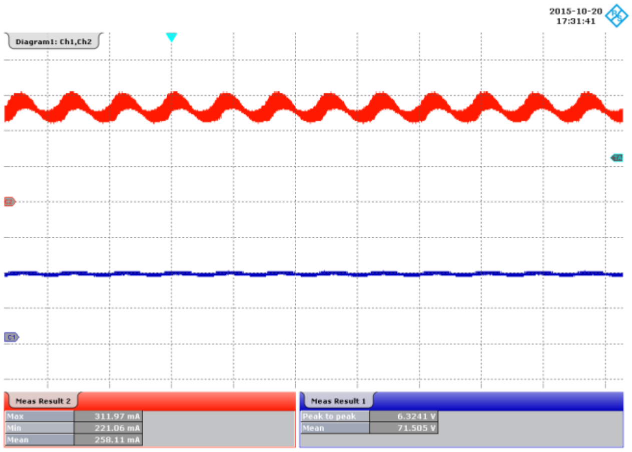

Figure 51 – 90 VAC, 60 Hz, 72 V LED Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 40 V / div., 10 ms / div.

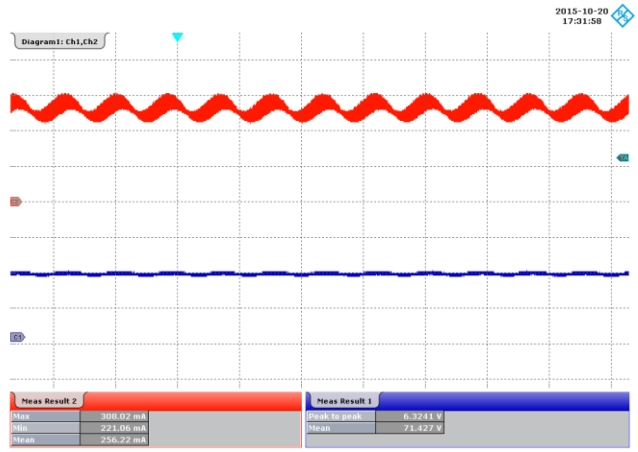

Figure 52 – 115 VAC, 60 Hz, 72 V LED Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 40 V / div., 10 ms / div.

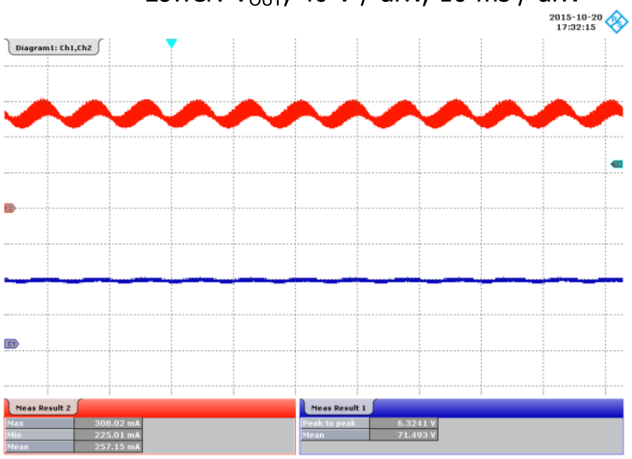

Figure 53 – 132 VAC, 60 Hz, 72 V LED Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 40 V / div., 10 ms / div.

V_{IN}	$I_{O(MAX)}$ (mA)	$I_{O(MIN)}$ (mA)	I_{MEAN}	Ripple Ratio (I_{RP-P}/I_{MEAN})	% Flicker 100 x (I_{RP-P} / $I_{O(MAX)}$ + $I_{O(MIN)}$)
90 VAC	311.97	221.06	258.11	0.35	17%
115VAC	308.02	221.06	256.22	0.34	16%
132 VAC	308.02	225.01	257.15	0.32	16%

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14 Dimming Waveforms

14.1 Input Voltage and Output Current Waveforms – Leading Edge Dimmer

Input: 120 VAC, 60 Hz
Output: 72V LED load
Dimmer: Lutron S-600P-WH

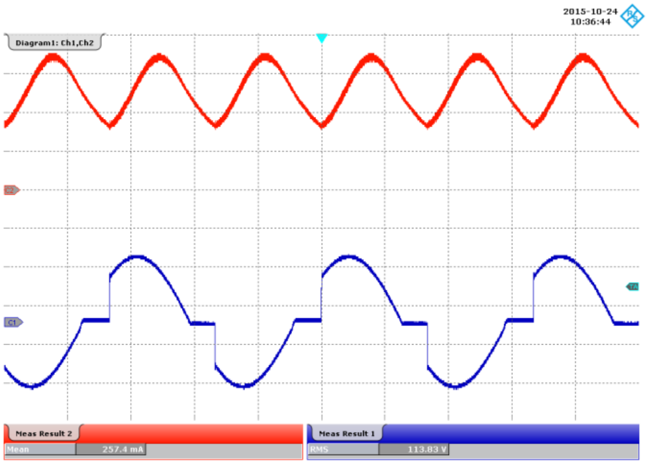

Figure 54 – 130º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 100 V / div., 5 ms / div.

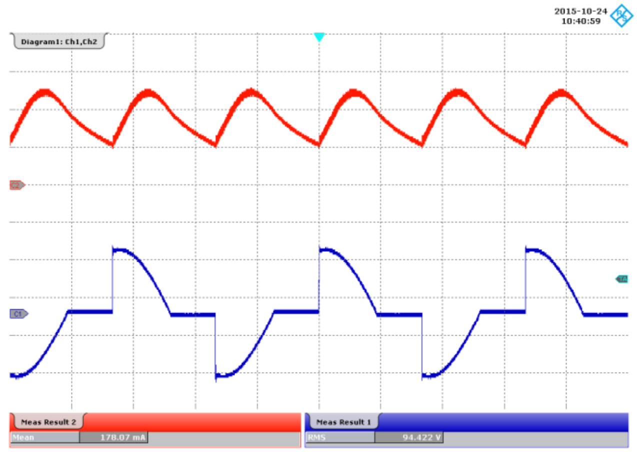

Figure 55 – 105º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 100 V / div., 5 ms / div.

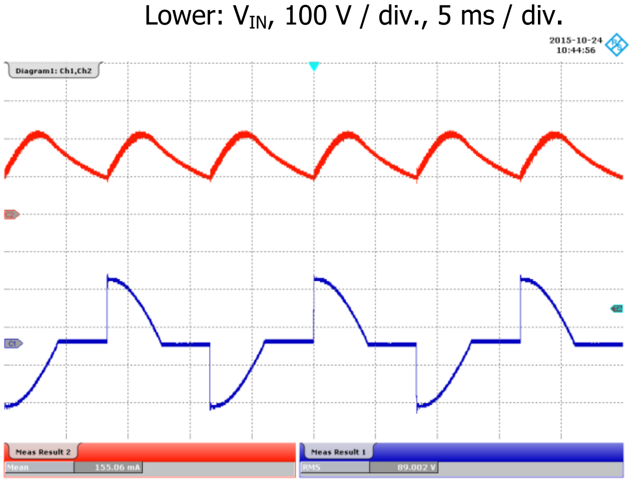

Figure 56 – 90º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 100 V / div., 5 ms / div.

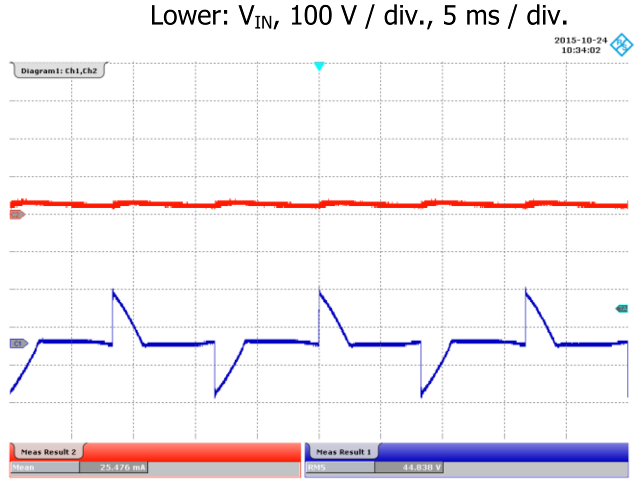

Figure 57 – 45º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 100 V / div., 5 ms / div.

14.2 Input Voltage, Input Current and Bleeder Current Waveforms – Leading Edge Dimmer

Input: 120 VAC, 60 Hz
Output: 72V LED load
Dimmer: Lutron S-600P-WH

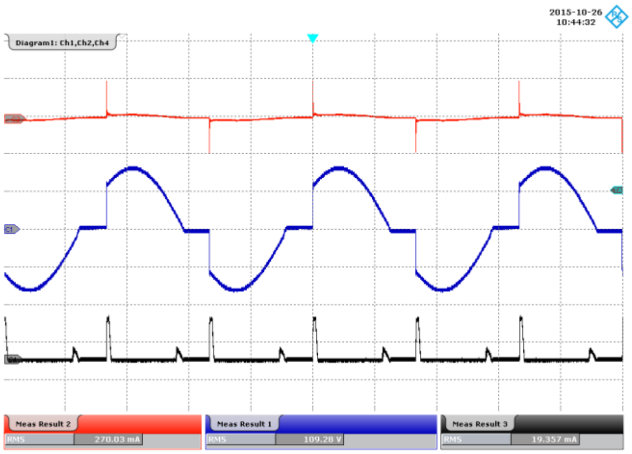

Figure 58 – 130º Conduction Angle.
Upper: I_{IN}, 100 mA / div.
Middle: V_{IN}, 100 V / div., 5 ms / div.
Lower: I_{BLEED}, 4 A / div., 5 ms / div.

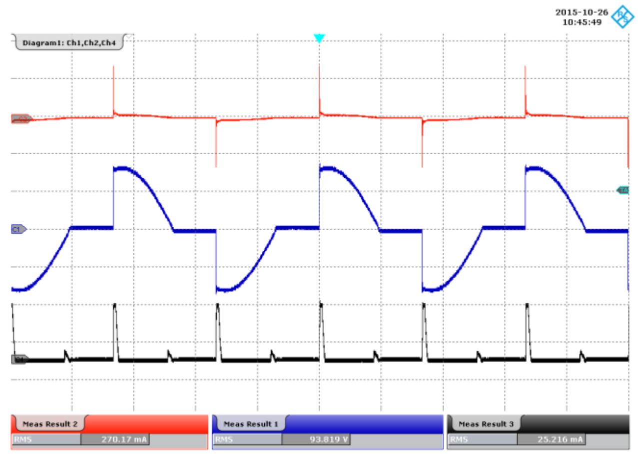

Figure 59 – 105º Conduction Angle.
Upper: I_{IN}, 100 mA / div.
Middle: V_{IN}, 100 V / div., 5 ms / div.
Lower: I_{BLEED}, 4 A / div., 5 ms / div.

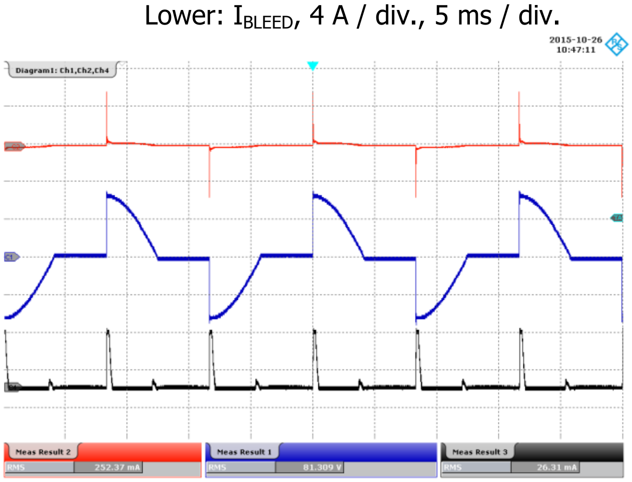

Figure 60 – 190º Conduction Angle.
Upper: I_{IN}, 100 mA / div.
Middle: V_{IN}, 100 V / div., 5 ms / div.
Lower: I_{BLEED}, 4 A / div., 5 ms / div.

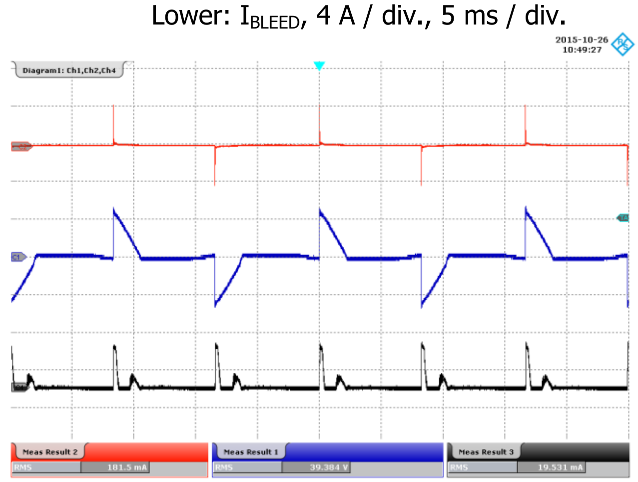

Figure 61 – 45º Conduction Angle.
Upper: I_{IN}, 100 mA / div.
Middle: V_{IN}, 100 V / div., 5 ms / div.
Lower: I_{BLEED}, 4 A / div., 5 ms / div.

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16 AC Cycling Test

No output current overshoot was observed during on - off cycling.

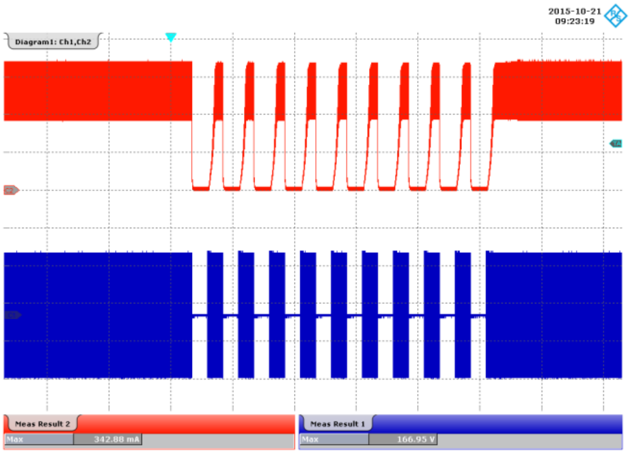

Figure 62 – 115 VAC, 72 V LED Load.
1 s On – 1 Sec Off.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 100 V / div., 4 s / div.

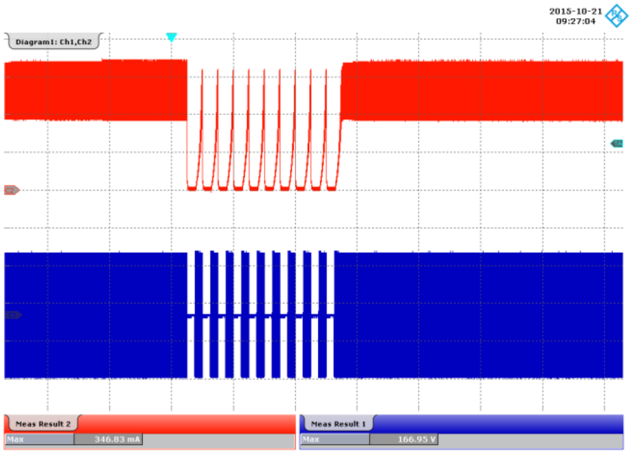

Figure 63 – 115 VAC, 72 V LED Load.
500 ms On – 500 ms Off.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 100 V / div., 4 s / div.

17 Conducted EMI

17.1 Test Set-up

17.1.1 Equipment and Load Used

1. Rohde and Schwarz ENV216 two line V-network.
2. Rohde and Schwarz ESRP EMI test receiver.
3. Hioki 3322 power hitester.
4. Chroma measurement test fixture.
5. 27 V LED load with input voltage set at 115 VAC.

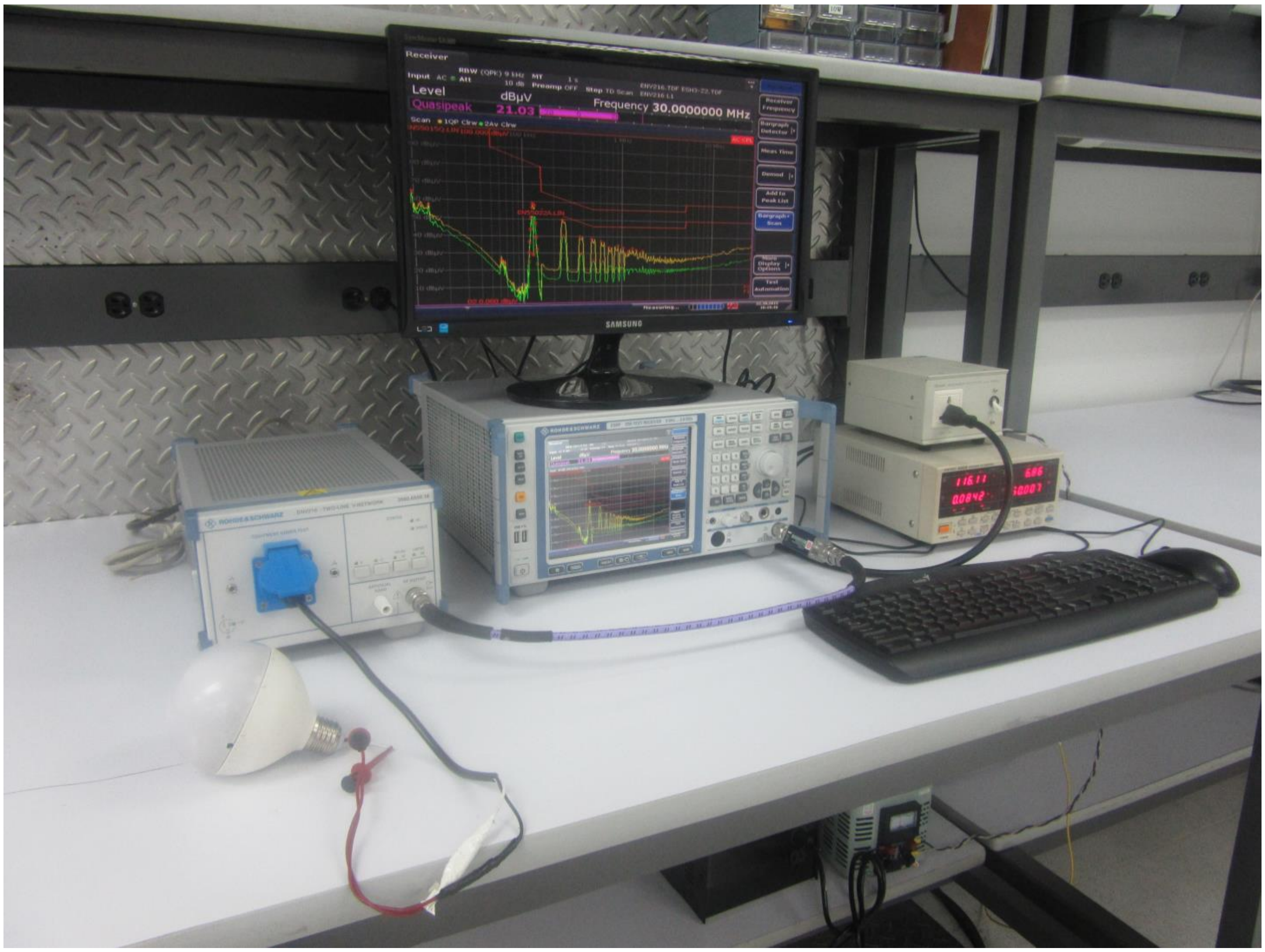

Figure 64 – Conducted EMI Test Set-up.

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17.2 EMI Test Result

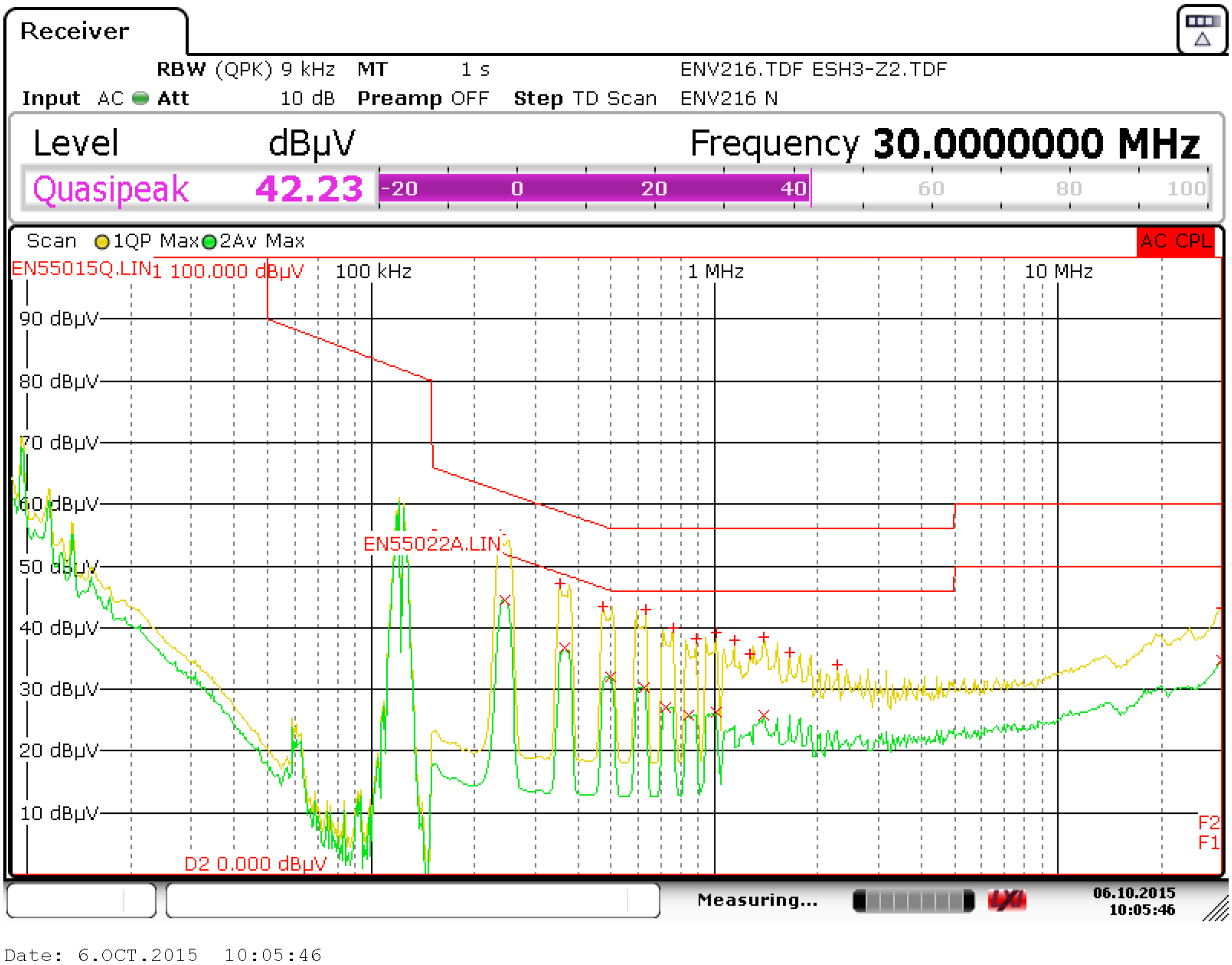

Figure 65 – Conducted EMI, 27 V LED Load with Metal Heat Sink Grounded, 230 VAC, 50 Hz, and EN55015 B Limits.

Trace1: EN55015Q.LIN Trace2: EN55022A.LIN

Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	237.7500 kHz	55.09 L1	-7.08 dB
2 Average	246.7500 kHz	44.50 L1	-7.37 dB
1 Quasi Peak	354.7500 kHz	47.06 L1	-11.79 dB
2 Average	366.0000 kHz	36.61 L1	-11.98 dB
1 Quasi Peak	474.0000 kHz	43.49 L1	-12.95 dB
1 Quasi Peak	633.7500 kHz	42.83 L1	-13.17 dB
2 Average	496.5000 kHz	32.08 L1	-13.98 dB
2 Average	29.9513 MHz	34.79 L1	-15.21 dB
2 Average	622.5000 kHz	30.31 L1	-15.69 dB
1 Quasi Peak	759.7500 kHz	40.06 L1	-15.94 dB
1 Quasi Peak	30.0000 MHz	43.24 L1	-16.76 dB
1 Quasi Peak	1.0140 MHz	39.22 L1	-16.78 dB
1 Quasi Peak	1.3965 MHz	38.55 L1	-17.45 dB
1 Quasi Peak	888.0000 kHz	38.23 L1	-17.77 dB

Figure 66 – Conducted EMI, 27 V LED Load with Metal Heat Sink Grounded, Final Measurement Results.

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18 Line Surge

The unit was subjected to ±2500 V, 100 kHz ring wave and ±1000 V differential surge using 10 strikes at each condition. A test failure was defined as a non-recoverable interruption of output requiring repair or recycling of input voltage.

Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+1000	230	L to N	0	Pass
-1000	230	L to N	0	Pass
+1000	230	L to N	90	Pass
-1000	230	L to N	90	Pass

Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+2500	230	L to N	0	Pass
-2500	230	L to N	0	Pass
+2500	230	L to N	90	Pass
-2500	230	L to N	90	Pass

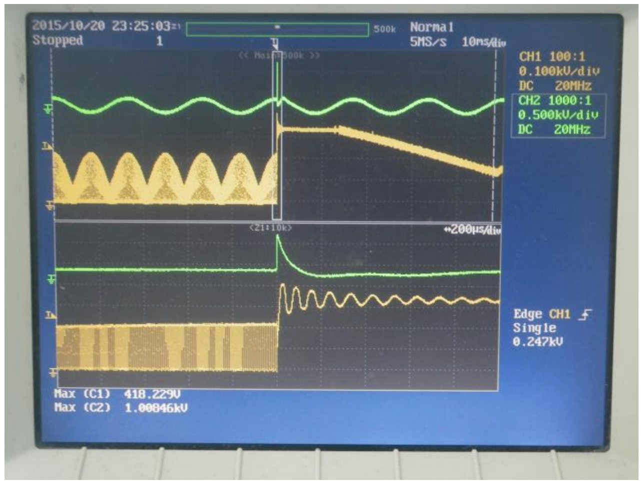

Figure 67 – +1000 kV Differential Surge, 90 ºC Phase.

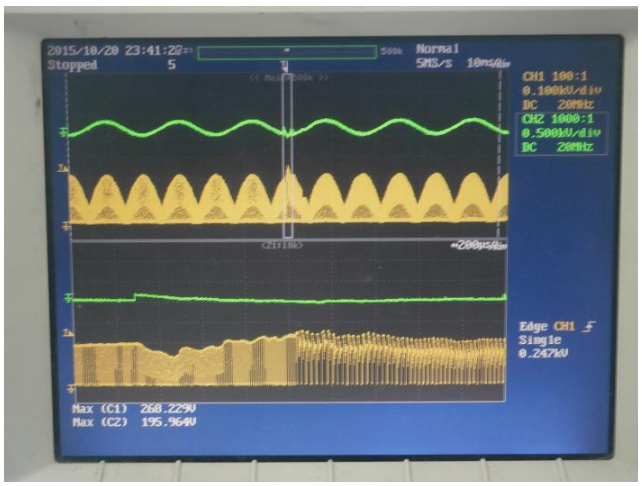

Figure 68 – +2500 kV Ring Wave, 90 ºC Phase.

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19 Brown-in/Brown-out Test

No failure of any component was seen during brownout test of 0.5 V / sec AC cut-in and cut-off.

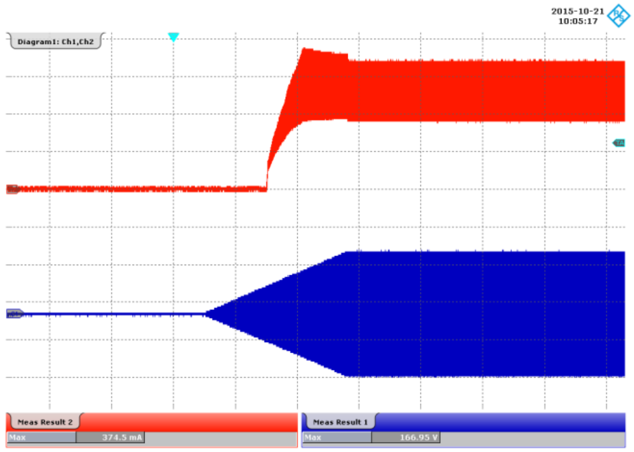

Figure 69 – Brown-in Test at 0.5 V / s. The Unit is Able to Operate Normally Without Any Failure and Without Flicker.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 100 V / div.
Time Scale: 50 s / div.

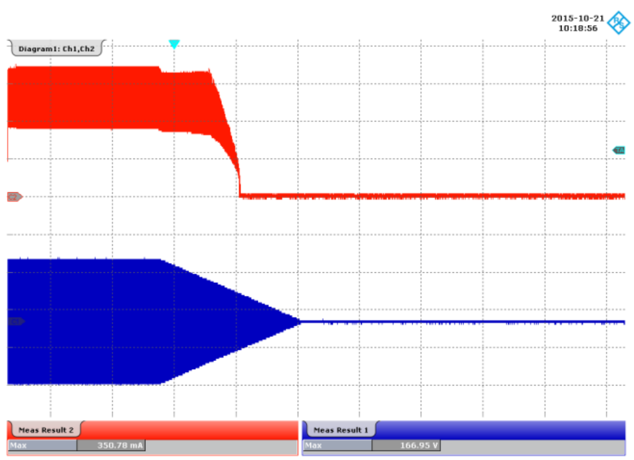

Figure 70 – Brown-out Test at 0.5 V / s. The Unit is Able to Operate Normally Without Any Failure and Without Flicker.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 100 V / div.
Time Scale: 50 s / div.

20 Revision History

Date	Author	Revision	Description and Changes	Reviewed
01-Mar-16	AM	1.0	Initial release	Apps & Mktg

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