Design Example Report

Title	***5 W Universal Input, CV/CC Isolated Flyback LED Driver Using LYTSwitch™-2 LYT2002D***
Specification	90 VAC – 265 VAC Input; 6 V to 15 V, 335 mA Output
Application	LED Ballast
Author	Applications Engineering Department
Document Number	DER-434
Date	September 23, 2015
Revision	1.0

Summary and Features

- Accurate (primary-side control) constant current (CC)
  - Accurate CC, less than ±5% variation over load and line
- Provides ±5% constant voltage (CV)
- Wide LED load operating range (6 V to 15 V)
- Efficiency >80% at 230 VAC/Nominal Load
- Low-cost, low component count (23), small size PCB
- Fast start-up time (<10 ms) – no perceptible delay
- No-load consumption <30 mW at all line condition
- Integrated protection and reliability features
  - Output short-circuit protected with auto-recovery
  - Auto-recovering thermal shutdown with large hysteresis
  - No damage during brown-out conditions
  - Easily meets EN55015 and CISPR-22 Class B EMI standards

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Table of Contents

1 Introduction 4
2 Power Supply Specification 5
3 Schematic 6
4 Circuit Description 7
4.1 Input Filter 7
4.2 LYTSwitch-2 Primary 7
4.3 Output Rectification 7
4.4 Regulation 8
5 PCB Layout 9
6 Bill of Materials 10
7 Transformer Specification 11
7.1 Electrical Diagram 11
7.2 Electrical Specifications 11
7.3 Materials 11
7.4 Transformer Build Diagram 12
7.5 Winding Construction 12
7.6 Winding Illustration 13
8 Transformer Design Spreadsheet 17
9 Performance Data 20
9.1 Efficiency 20
9.2 Average Efficiency 21
9.3 Line and Load Regulation 22
9.4 CV/CC Characteristics 23
9.5 No-Load Input Power 24
9.6 Test Data 25
9.6.1 14 V LED Load 25
9.6.2 11 V LED Load 25
9.6.3 8 V LED Load 26
9.6.4 5 V LED Load 26
10 Thermal Performance 27
11 Waveforms 28
11.1 Input Voltage and Input Current Waveforms 28
11.2 Output Current and Output Voltage at Normal Operation 28
11.3 Output Voltage/ Current Rise and Fall 29
11.4 Voltage and Current Ripple 30
11.4.1 Constant Voltage (CV) Operation 30
11.4.2 Constant Current (CC) Operation 31
11.5 Drain Voltage and Current at Normal Operation 33
11.6 Start-up Drain Voltage and Current 33
11.7 Drain Current and Drain Voltage during Output Short Condition 34
11.8 Drain Current and Drain Voltage during Open-Loop Condition (R7 is Open) 35
11.9 Output Diode Current and Voltage Waveforms Normal Operation 36

11.10 Output Diode Current and Voltage Short-Circuit Waveforms........................37
11.11 Brown-out / Brown-in..37
11.12 Line Transient..38
11.13 500 ms ON, 500 ms OFF AC Cycling..39
12 Conducted EMI..40
12.1 Test Set-up..40
12.2 Conducted EMI..41
13 Line Surge Test..43
14 ESD..46
15 Revision History..47

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 the design for a universal input, 6 V to 15 V, 335 mA LED driver. This power supply utilizes the LYT2002D device from Power Integrations' LYTSwitch-2 family.

This document contains the power supply and transformer specifications, schematics, bill of materials, and typical performance characteristics pertaining to this power supply.

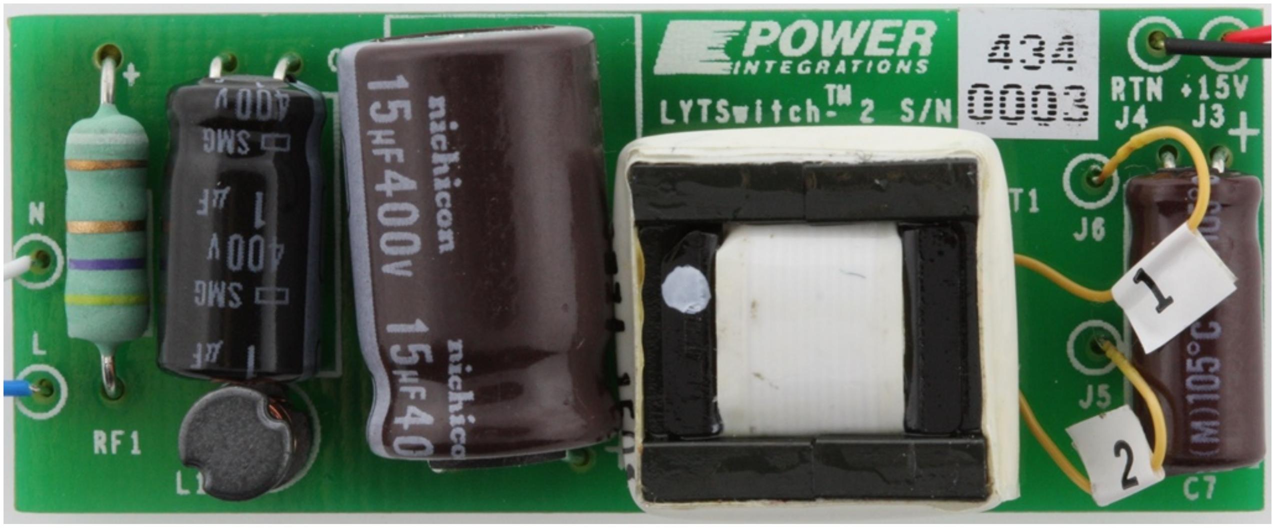

Figure 1 – Populated Circuit Board, Top View.

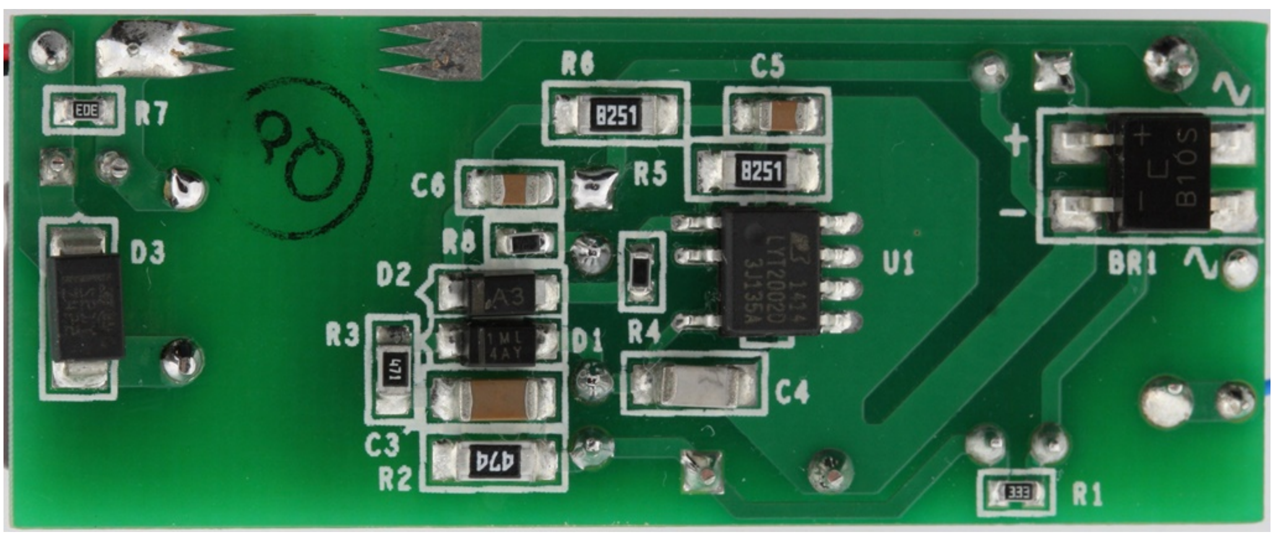

Figure 2 – Populated Circuit Board, Bottom View.

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		265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}		50/60		Hz	
No-load Input Power	P_{NL}		25		mW	Measure at V_{IN} = 230 VAC
Output						
Output Voltage	V_{OUT}	6		15	V	
Output Current	I_{OUT}		335		mA	25 ºC
Total Output Power						
Continuous Output Power	P_{OUT}			5	W	
Efficiency						
Full Load	η		80		%	Measured at P_{OUT} 25 ºC
Environmental						
Conducted EMI		CISPR 15B / EN55015B				>6 dB Margin
Safety		Designed to meet IEC950, UL1950 Class II				
Ring Wave (100 kHz)						
Differential Mode (L1-L2)			2.5		kV	1.2//50 µs Surge, IEC 1000-4-5, Series Impedance: 2 Ω
Differential Surge			500		V	
ESD						
Contact Discharge		-8		+8	kV	IEC 61000-4-2
Air Discharge		-15		+15	kV	
Ambient Temperature	T_{AMB}		40		ºC	

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3 Schematic

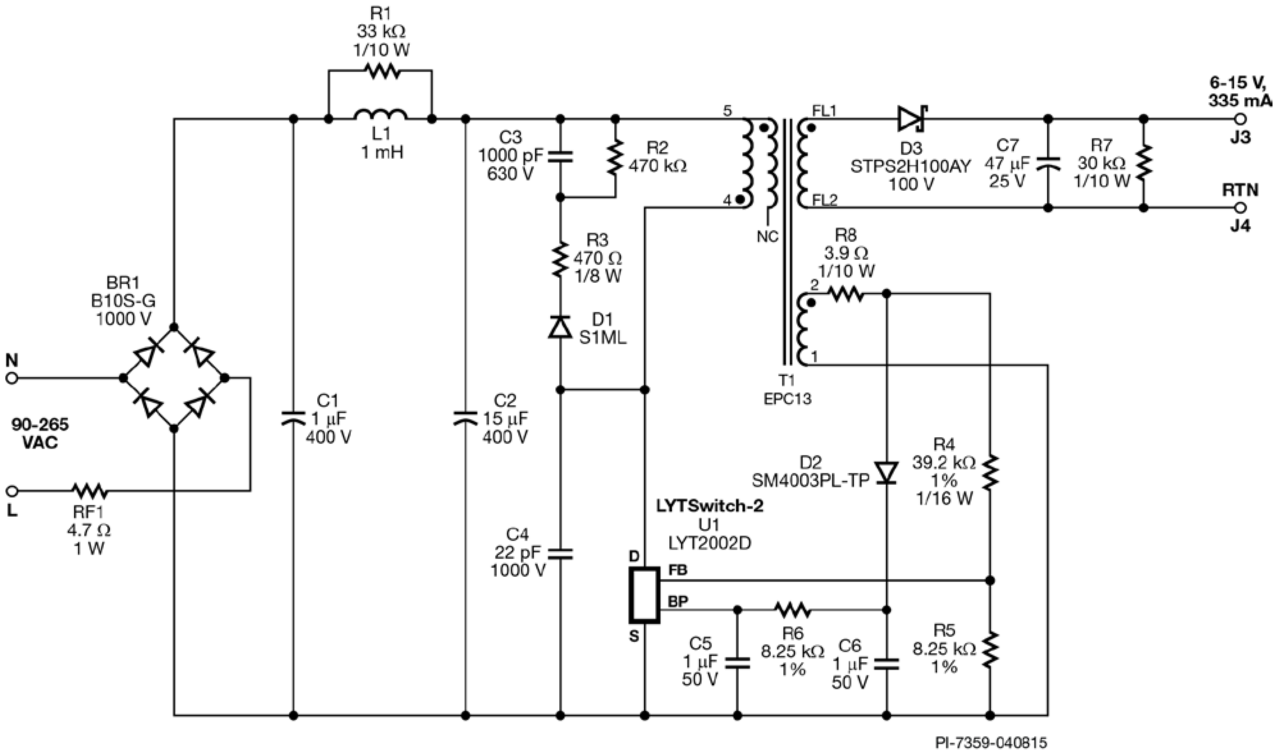

Figure 3 – Schematic.

4 Circuit Description

The LYTswitch-2 family of devices is a single-stage, cost effective and accurate controller with a monolithically integrated 725 V power MOSFET which is intended for constant voltage or constant current LED driver applications. The LYT2002D is configured as an isolated flyback topology CV/CC LED driver. It provides a regulated CV/CC output with high efficiency and low no-load input power.

4.1 Input Filter

The frequency jitter built into the LYT2002D IC allows the use of a simple and low cost π filter consisting of C1, C2 and L1. Resistor R1 which is connected across L1 serves to damp any LC resonance which may cause EMI. Bridge rectifier BR1 rectifies the input AC voltage to a pulsating DC. A low cost fusible resistor is used to provide protection against any component failure.

4.2 LYTSwitch-2 Primary

A flyback topology is used to provide isolation whilst providing high efficiency and low no-load input power. The LYTSwitch-2 device (U1) incorporates the power switching device, oscillator, CV/CC control engine, start-up and protection functions all in one IC. Its integrated 725 V power MOSFET allows sufficient voltage margin in universal input AC applications, including extended line swells.

The high-voltage DC from the input capacitors is fed to one end of the primary winding. The other end is connected to the DRAIN (D) pin of the LYT2002D. During turn on, the current flowing through the primary ramps to the LYT2002D fixed current limit. This current causes energy to be stored across the primary inductance. Upon turn off, energy stored in the primary inductance will then be coupled to the secondary through the secondary winding.

A low cost RCD clamp is formed by C3, R2, R3 and D1 limiting the drain voltage spike caused by the leakage inductance. A standard recovery diode (D1) is used to minimize ringing across the primary winding to optimize regulation and reduce EMI.

To reduce no-load input power, an external bias supply is used. The external bias supply is made up of D2, C6, and R6. Capacitor C5 provides local decoupling for the BYPASS (BP) pin of U1 which is the supply pin for the internal controller.

4.3 Output Rectification

The transformer's secondary output is rectified by D3, and filtered by C7. A 100 V Schottky diode is used to provide sufficient margin and high efficiency from the maximum reverse voltage of the diode. Output capacitor C7 is selected to provide <30% output current ripple based on the LED. However, the ripple current may be different depending on the type of LED used due to different dynamic resistance values. The value

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of C7 must be adjusted accordingly. Resistor R7 serves as a pre-load to prevent any voltage overshoot during no-load.

4.4 Regulation

The LYTSwitch-2 device regulates the output using a simple ON/OFF control for CV regulation, and frequency control for CC regulation. A feedback winding is used to sense the output voltage. The feedback resistors (R4 and R5) were selected using standard 1% resistor values to center both the no-load output voltage and constant current regulation thresholds. Resistor R8 serves to filter any feedback winding ringing which may cause output voltage instability.

5 PCB Layout

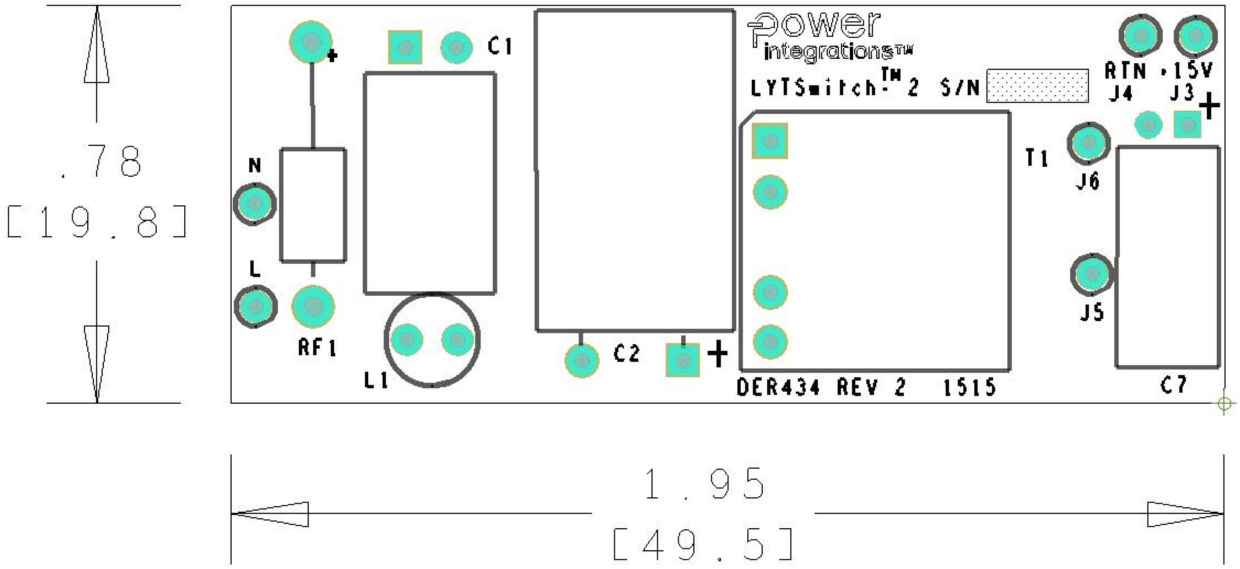

Figure 4 – Printed Circuit Board Layout, Top Side.

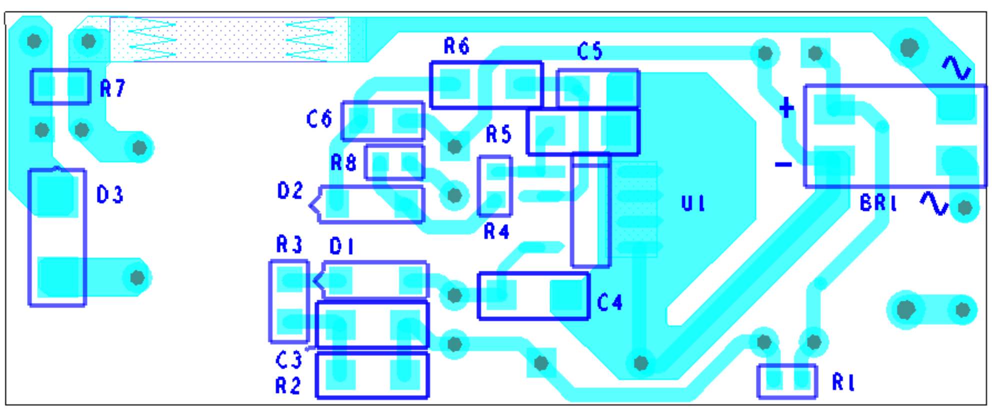

Figure 5 – Printed Circuit Board Layout, Bottom Side.

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6 Bill of Materials

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	1000 V, 0.8 A, Bridge Rectifier, SMD, MBS-1, 4-SOIC	B10S-G	Comchip
2	1	C1	1 μF, 400 V, Electrolytic, (6.3 x 11)	EKMG401ELL1R0MF11D	United Chemi-Con
3	1	C2	15 μF, 400 V, Electrolytic, (10 x 16)	UVC2G150MPD	Nichicon
4	1	C3	1000 pF, 630 V, Ceramic, X7R, 1206	C1206C102KBRACTU	Kemet
5	1	C4	22 pF, 1000 V, Ceramic, C0G, 1206	C1206C220KDGACTU	Kemet
6	2	C5 C6	1 μF, 50 V, Ceramic, X7R, 0805	C2012X7R1H105M	TDK
7	1	C7	47 μF, 25 V, Electrolytic, Very Low ESR, 300 mΩ, (5 x 11)	EKZE250ELL470ME11D	Nippon Chemi-Con
8	1	D1	1 kV, 1 A, Standard Recovery, SMA	S1ML	Taiwan Semi
9	1	D2	200 V, 1 A, Standard Recovery, SOD-123FL	SM4003PL-TP	Micro Commercial
10	1	D3	100 V, 2 A, Schottky, SMA	STPS2H100AY	ST Micro
11	1	L1	1 mH, 0.15 A, Ferrite Core	SBCP-47HY102B	Tokin
12	1	R1	33 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ333V	Panasonic
13	1	R2	470 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ474V	Panasonic
14	1	R3	470 Ω, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ471V	Panasonic
15	1	R4	39.2 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF3922V	Panasonic
16	2	R5 R6	8.25 kΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF8251V	Panasonic
17	1	R7	30 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ303V	Panasonic
18	1	R8	3.9 Ω, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ3R9V	Panasonic
19	1	RF1	4.7 Ω, 1 W, Fusible/Flame Proof Wire Wound	FKN1WSJR-52-4R7	Yago
20	1	T1	Bobbin, EPC13, Horizontal, 10 pins Transformer	BEPC-13-1110CPH SNX-R1774	TDK Santronics
21	1	Terminal, L	WIRE, #30 AWG 300 V, 3 inch, Blue		
22	1	Terminal, N	WIRE, #30 AWG 300 V, 3 inch, White		
23	1	Terminal, J3	WIRE, #30 AWG 3 inch, Red		
24	1	Terminal, J4	WIRE, #30 AWG 3 inch, Black		
25	1	U1	LYTSwitch-2, CV/CC, SO-8D	LYT2002D	Power Integrations

7 Transformer Specification

7.1 Electrical Diagram

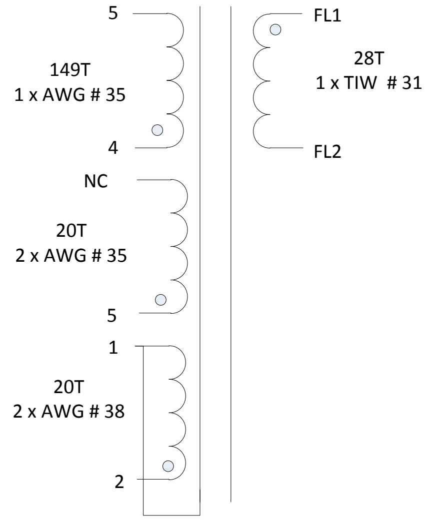

Figure 6 – Transformer Electrical Diagram.

7.2 Electrical Specifications

Electrical Strength	1 second, 60 Hz, from pins 1, 2, 4 to FL1, FL2.	3000 VAC
Primary Inductance	Pins 4-5, all other windings open, measured at 100 kHz, 0.4 V_{RMS}.	1.45 mH ±7%
Primary Leakage Inductance	Pins 4-5, all other windings shorted, measured at 100 kHz, 0.4 V_{RMS}.	45 µH Max

7.3 Material List

Item	Description
[1]	Core: EPC13.
[2]	Bobbin: EPC13, Horizontal, 10 pins. P/N: BEPC-13-1110CPH. (PI P/N: 25-00802-00).
[3]	Magnet wire: #35 AWG - Double coated.
[4]	Magnet wire: #38 AWG - Double coated.
[5]	Triple Insulated: #31 AWG (0.23 mm).
[6]	Tape: 3M 1298 Polyester Film, 7.0 mm wide, 2.0 mils thick, or equivalent.
[7]	Tape: 3M 1298 Polyester Film, 4.5 mm wide, 2.0 mils thick, or equivalent.
[8]	Non-insulated wire: #31 AWG.
[9]	Varnish: Dolph BC-359 or equivalent.

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7.4 Transformer Build Diagram

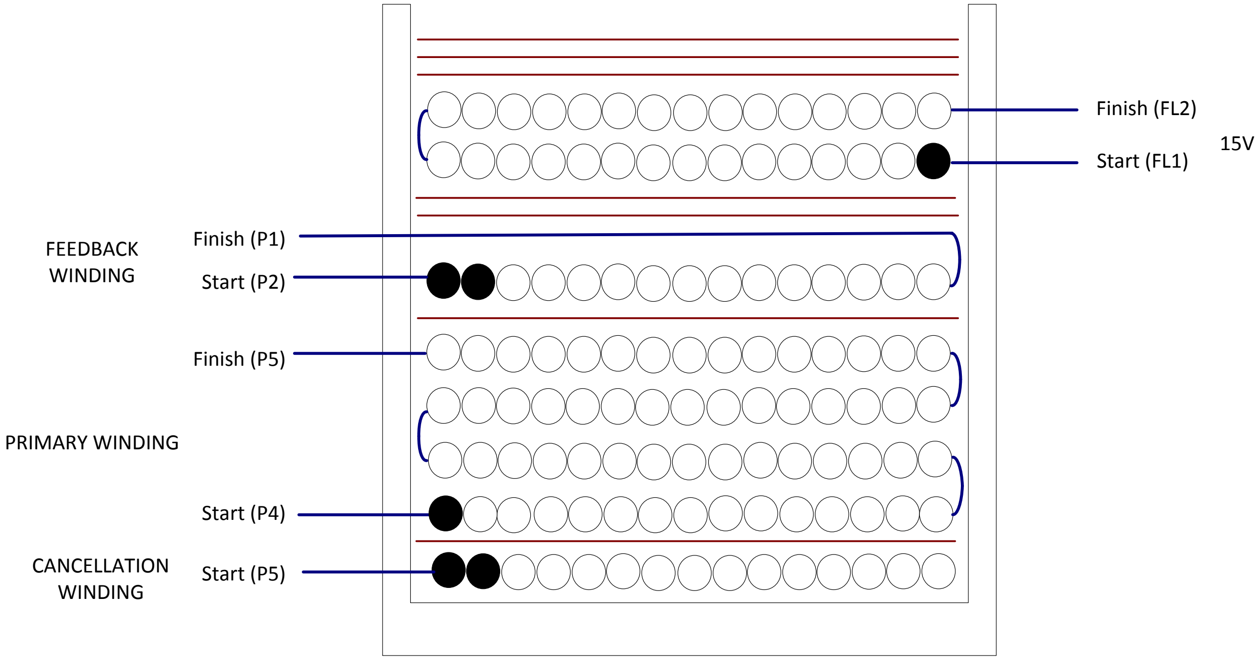
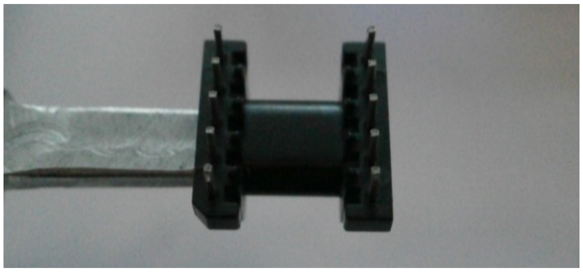
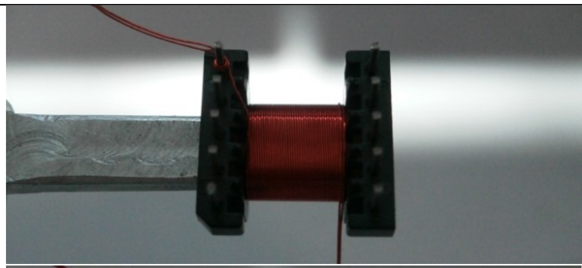
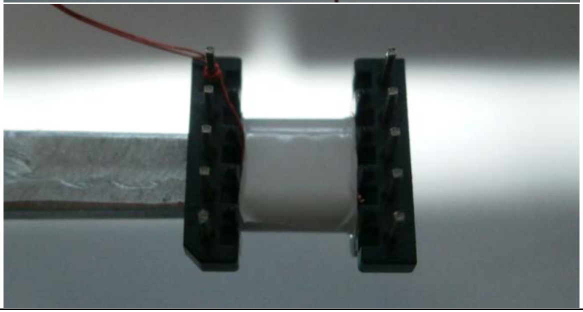


Figure 7 – Transformer Build Diagram.

7.5 Winding Construction

Winding Preparation	Place the bobbin item [2] on the mandrel with pins 1-5 on the left side. Winding direction is clockwise.
WD1 Cancellation	Starting at pin 5, wind 20 bifilar turns of wire item [3] in 1 layer. Leave end of winding unconnected.
Insulation1	Fix with 1 layer of tape item [6].
WD2 Primary	Starting at pin 4, wind 149 turns of wire item [3] in 4 layers. On the last layer, spread evenly across the entire bobbin width. Terminate at pin 5.
Insulation2	Fix with 1 layer of tape item [6].
WD3 Feedback	Starting at pin 2 wind 20 bifilar turns of wire item [4]. Terminate at pin 1.
Insulation	Fix with 1 layer of tape item [6].
WD3 Secondary	Starting with fly lead FL1 (J5) wind 28 turns of wire item [56] in counterclockwise direction. Finish with fly lead FL2 (J6).
Insulation	Fix with 3 layers of tape item [6] for insulation.
Core	Grind core to achieve 1.45 mH inductance. Assemble core halves and wrap 1 turn of wire item [8]. Terminate both ends to pin 1. Fix with core halves with tape item [7].
Remove Pins	Cut or remove pins 3, 6, 7, 8, 9 and 10.
Varnish	Dip varnish using item [9].

7.6 Winding Illustration

Winding Preparation		Place the bobbin item [2] on the mandrel with pins 1-5 on the left side. Winding direction is clockwise.
WD1 Cancellation Winding	 	Starting at pin 5, wind 20 bifilar turns of wire item [3] in 1 layer. Leave end of winding unconnected. Fix with 1 layer of tape item [6].

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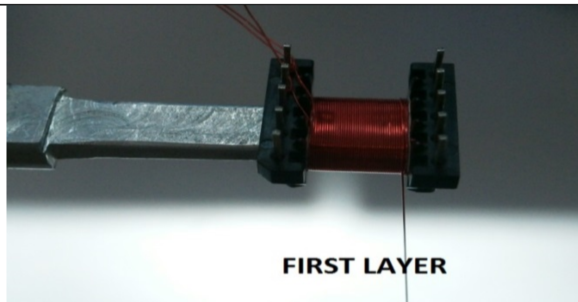
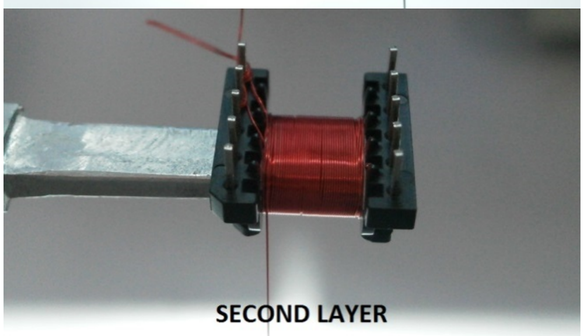
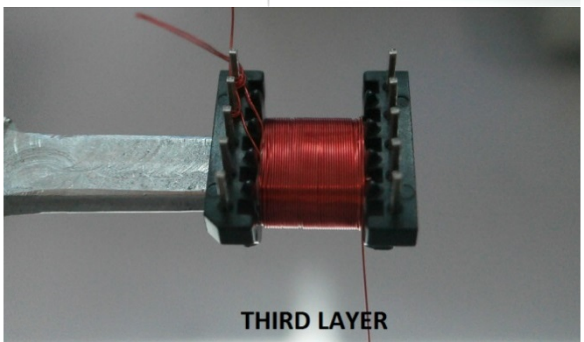
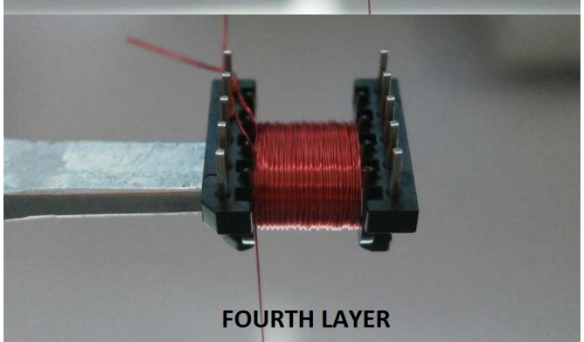
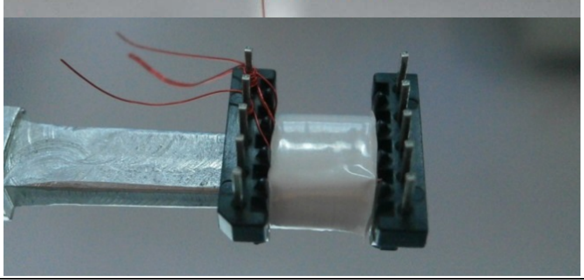
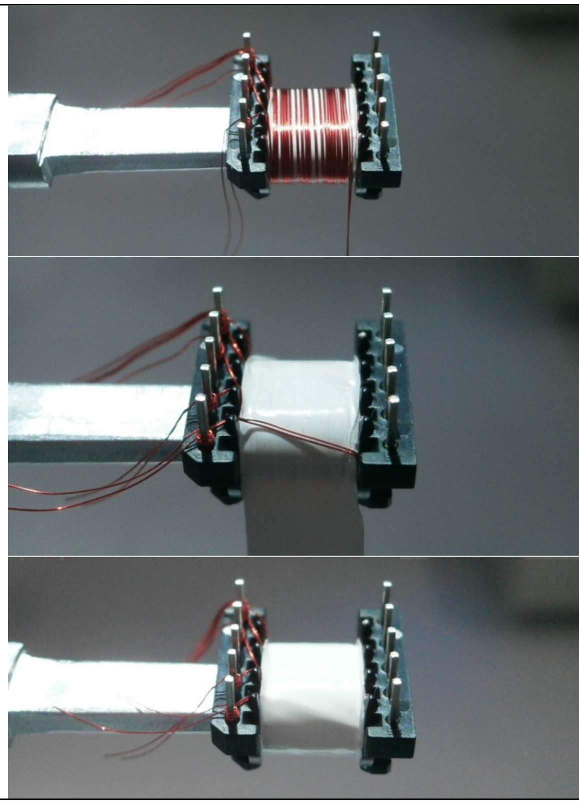
WD2 Primary Winding	    	Starting at pin 4, wind 149 turns of wire item [3] in 4 layers. On the last layer, spread evenly across the entire bobbin width. Terminate at pin 5. Fix winding with 1 layer of tape item [6]. See pictures for sequential winding procedure.

WD3 Feedback		Starting at pin 2 wind 20 bifilar turns of wire item [4]. Spread the winding evenly across the entire bobbin width. Fix half turn of winding with tape item [6]. Terminate winding at pin 1 by crossing over wire from secondary end of bobbin to the primary side. Complete 1 turn of the tape to completely fix the winding.

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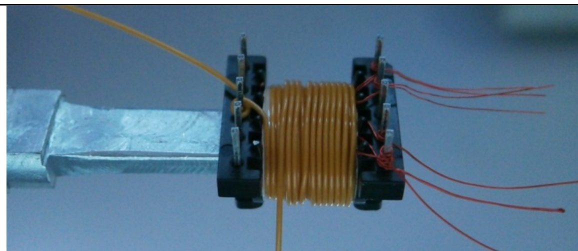
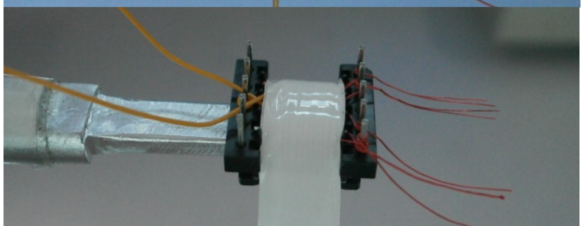
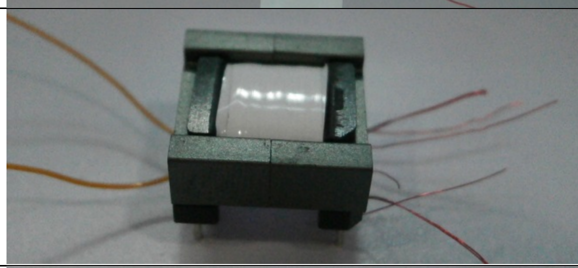
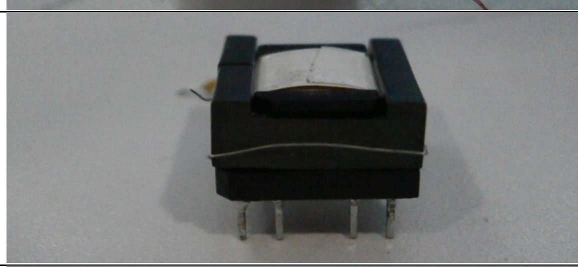
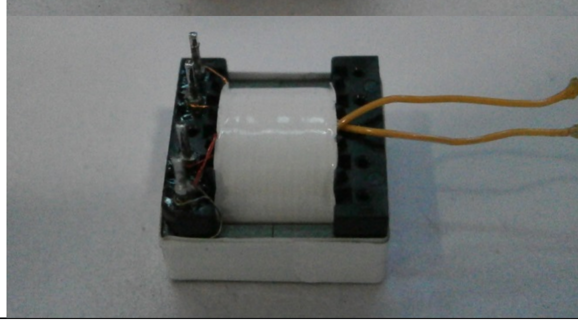
WD4 Secondary	 	Pull out the bobbin from the mandrel and insert back with pins 6-10 on the left side. Starting with fly lead FL1 (J5) wind 28 turns of wire item [56] in 2 layers. Finish with fly lead FL2 (J6). By turning the bobbin, effective winding direction will be counter clockwise. Fix winding with 3 layers of tape item [6] for insulation.
Assemble Core Halves		Grind core to achieve 1.45 mH primary inductance. Assemble core halves.
Ground Core		Wrap 1 turn of wire item [8]. Terminate both ends to pin 1.
Finish	 	Fix core halves with tape item [7]. Solder wires securely into pins, cut pins 3, 6, 7, 8, 9 and 10 and dip varnish with item [9].

8 Transformer Design Spreadsheet

ACDC_LYTSwitch-2_051614; Rev.2.0; Copyright Power Integrations 2014	INPUT	INFO	OUTPUT	UNIT	ACDC_LYTSwitch-2_051614_Rev2-0; Discontinuous Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					
VACMIN			90	V	Minimum AC Input Voltage
VACMAX			265	V	Maximum AC Input Voltage
fL			50	Hz	AC Mains Frequency
Application Type	Ballast-CC		Ballast-CC		Choose application type
VO	15.00		15.00	V	Output Voltage. This value is recommended to be 10% higher than the maximum LED Voltage
IO	0.33		0.33	A	Power Supply Output Current (corresponding to peak power)
Power			4.95	W	Continuous Output Power
n	0.81		0.81		Efficiency Estimate at output terminals
Z			0.50		Z Factor. Ratio of secondary side losses to the total losses in the power supply. Use 0.5 if no better data available
tC			3.00	ms	Bridge Rectifier Conduction Time Estimate
CIN	15.00		15.00	uF	Input Capacitance
ENTER LYTSwitch-2 VARIABLES					
Chosen Device	LYT2002D		LYT2002D		Chosen LYTSwitch-2 device
ILIMITMIN			0.30	A	Minimum Current Limit
ILIMITTYP			0.33	A	Typical Current Limit
ILIMITMAX			0.36	A	Maximum Current Limit
FS	72.00		72.00	kHz	Typical Device Switching Frequency at maximum power
VOR			82.48	V	Reflected Output Voltage (VOR < 135 V Recommended)
VDS			10.00	V	LYTSwitch-2 on-state Drain to Source Voltage
VD			0.50	V	Output Winding Diode Forward Voltage Drop
KP			1.45		KP assuming minimum LP, VMIN, and average switching frequency. Ensure that this value is above 1.30 for optimal operation
FEEDBACK WINDING PARAMETERS					
NFB	20.00		20.00		Feedback winding turns
VFLY			11.07	V	Flyback Voltage - Voltage on Feedback Winding during switch off time
VFOR			13.75	V	Forward voltage - Voltage on Feedback Winding during switch on time
BIAS WINDING PARAMETERS					
BIAS	Ext. bias		Ext. bias		Select between self bias or external bias to supply the IC.
VB	0.00		0.00	V	Bias Winding Voltage. Ensure that VB > VFLY. Bias winding is assumed to be AC-STACKED on top of Feedback winding
NB	.	Info	N/A		Bias winding is disabled. Verify on the bench that current value of VFLY is enough to supply the IC under all operating conditions
REXT			#NUM!	k-ohm	Suggested value of BYPASS pin resistor (use standard 5% resistor)
DESIGN PARAMETERS					
DCON	5.00		5.00	us	Desired output diode conduction time
DCON_FINAL			4.97	us	Final output conduction diode, assuming integer values for NP and NS

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TON			4.00	us	LYTSwitch-2 On-time (calculated at minimum inductance)
RUPPER		Info	37.13	k-ohm	Upper resistor in Feedback resistor divider. Once the initial prototype is running, it may be necessary to use the fine tuning section of this spreadsheet to adjust to the correct output current
RLOWER			7.89	k-ohm	Lower resistor in resistor divider
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type					
Core	EPC13		EPC13		Enter Transformer Core.
Custom_Core					Enter Core name if selection on drop down menu is "Custom"
Bobbin			EPC13_BOBBIN		Generic EPC13_BOBBIN
AE			12.40	mm^2	Core Effective Cross Sectional Area
LE			28.90	mm	Core Effective Path Length
AL			870.00	nH/turn^2	Ungapped Core Effective Inductance
BW			6.88	mm	Bobbin Physical Winding Width
M			0.00	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L	4.00		4.00		Number of Primary Layers
NS			28.00		Number of Secondary Turns. To adjust Secondary number of turns change DCON
DC INPUT VOLTAGE PARAMETERS					
VMIN			102.45	V	Minimum DC bus voltage
VMAX			374.77	V	Maximum DC bus voltage
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.36		Maximum duty cycle measured at VMIN
IAVG			0.07	A	Input Average current
IP			0.30	A	Peak primary current
IR			0.30	A	Primary ripple current
IRMS			0.12	A	Primary RMS current
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LPMIN			1352.63	uH	Minimum Primary Inductance
LPTYP			1454.44	uH	Typical Primary inductance
LP_TOLERANCE	7.00		7.00	%	Tolerance in primary inductance
NP			149.00		Primary number of turns. To adjust Primary number of turns change BM_TARGET
ALG			65.51	nH/turn^2	Gapped Core Effective Inductance
BM_TARGET	2600.00		2600.00	Gauss	Target Flux Density
BM			2597.78	Gauss	Maximum Operating Flux Density (calculated at nominal inductance), BM < 2600 is recommended
BP			2998.63	Gauss	Peak Operating Flux Density (calculated at maximum inducatnce and max current limit), BP < 3100 is recommended
BAC			1298.89	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			161.36		Relative Permeability of Ungapped Core
LG			0.24	mm	Gap Length (LG > 0.1 mm)
BWE			27.52	mm	Effective Bobbin Width
OD			0.18	mm	Maximum Primary Wire Diameter including insulation
INS			0.04	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.14	mm	Bare conductor diameter
AWG			35	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			32.00	Cmils	Bare conductor effective area in circular mils
CMA			260.82	Cmils/A	Primary Winding Current Capacity (200 < CMA <

					500)
TRANSFORMER SECONDARY DESIGN PARAMETERS					
ISP			1.61	A	Peak Secondary Current
ISRMS			0.73	A	Secondary RMS Current
IRIPPLE			0.65	A	Output Capacitor RMS Ripple Current
CMS			145.53	Cmils	Secondary Bare Conductor minimum circular mils
AWGS			28.00		Secondary Wire Gauge (Rounded up to next larger standard AWG value)
VOLTAGE STRESS PARAMETERS					
VDRAIN			567.98	V	Maximum Drain Voltage Estimate (Assumes 20% clamping voltage tolerance and an additional 10% temperature tolerance)
PIVS			85.43	V	Output Rectifier Maximum Peak Inverse Voltage
FINE TUNING					
RUPPER_ACTUAL	37.40		37.40	k-ohm	Actual Value of upper resistor (RUPPER) used on PCB
RLOWER_ACTUAL	7.87		7.87	k-ohm	Actual Value of lower resistor (RLOWER) used on PCB
Actual (Measued) Output Voltage (VDC)	15.00		15.00	V	Measured Output voltage from first prototype
Actual (Measured) Output Current (ADC)	0.32		0.32	Amps	Measured Output current from first prototype
RUPPER_FINE			38.57	k-ohm	New value of Upper resistor (RUPPER) in Feedback resistor divider. Nearest standard value is 38.3 k-ohms
RLOWER_FINE			8.12	k-ohm	New value of Lower resistor (RLOWER) in Feedback resistor divider. Nearest standard value is 8.06 k-ohms

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9 Performance Data

All measurements were taken with the board at open frame, 25 ºC ambient.

9.1 Efficiency

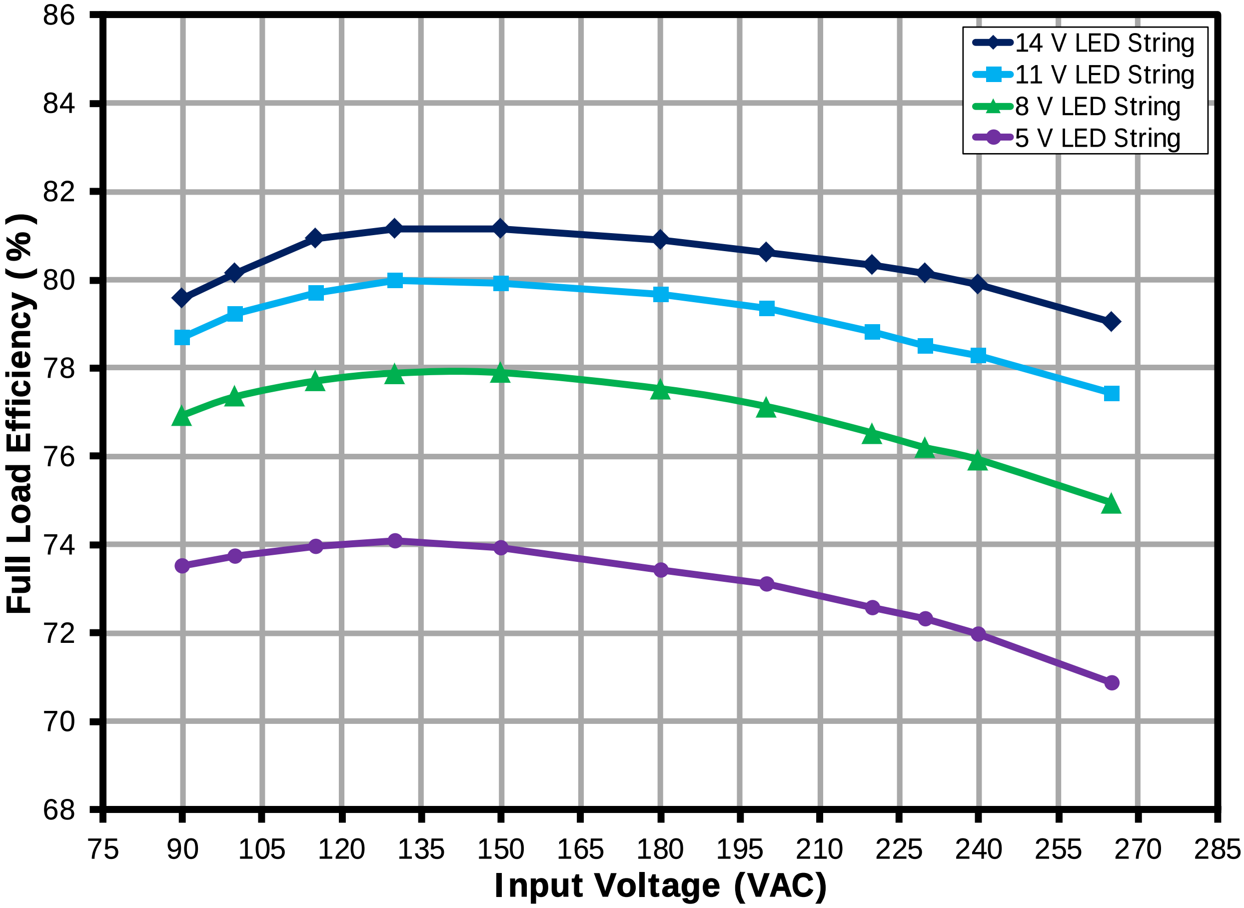

Figure 8 – Full Load Efficiency vs. Line and Load.

9.2 Average Efficiency

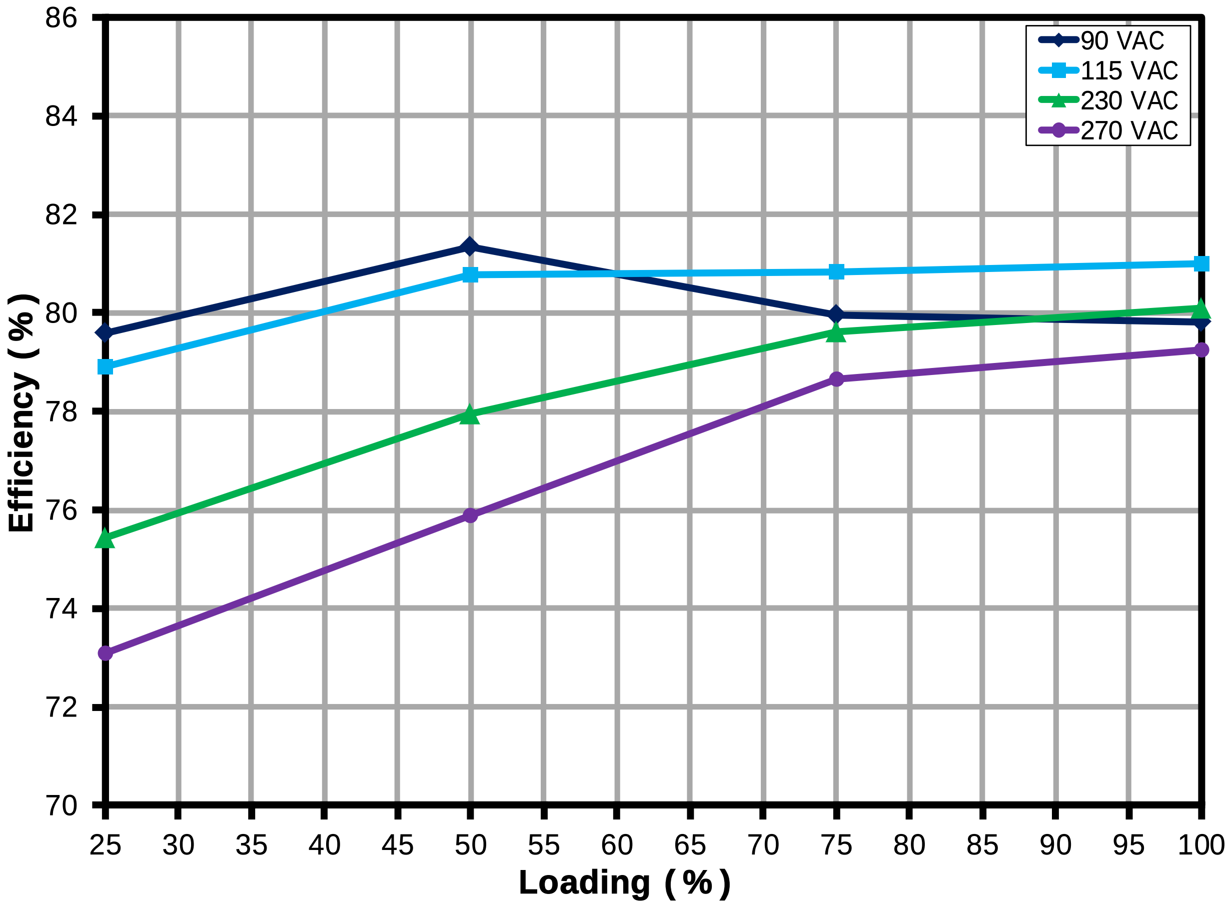

Figure 9 – Efficiency vs. Percent Load.

	Input Measurement					LED Load Measurement			Efficiency (%)
LOAD (%)	V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	% ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	
100	114.98	105.85	6.28	0.52	84.30	15.16	335.56	5.09	81.01
75	114.99	85.82	4.82	0.49	86.38	15.31	254.26	3.89	80.83
50	115.00	61.47	3.18	0.45	88.81	15.22	168.54	2.57	80.77
25	115.01	35.44	1.61	0.39	91.70	15.15	83.75	1.27	78.92
						AVERAGE EFFICIENCY			80.38

	Input Measurement					LED Load Measurement			Efficiency (%)
LOAD (%)	V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	% ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	
100	229.99	71.87	6.39	0.39	92.16	15.21	336.48	5.12	80.09
75	230.00	57.12	4.87	0.37	92.80	15.29	253.84	3.88	79.61
50	230.00	39.97	3.25	0.35	93.53	15.11	167.36	2.53	77.95
25	230.01	22.17	1.67	0.33	94.47	15.08	83.35	1.26	75.45
						AVERAGE EFFICIENCY			78.27

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9.3 Line and Load Regulation

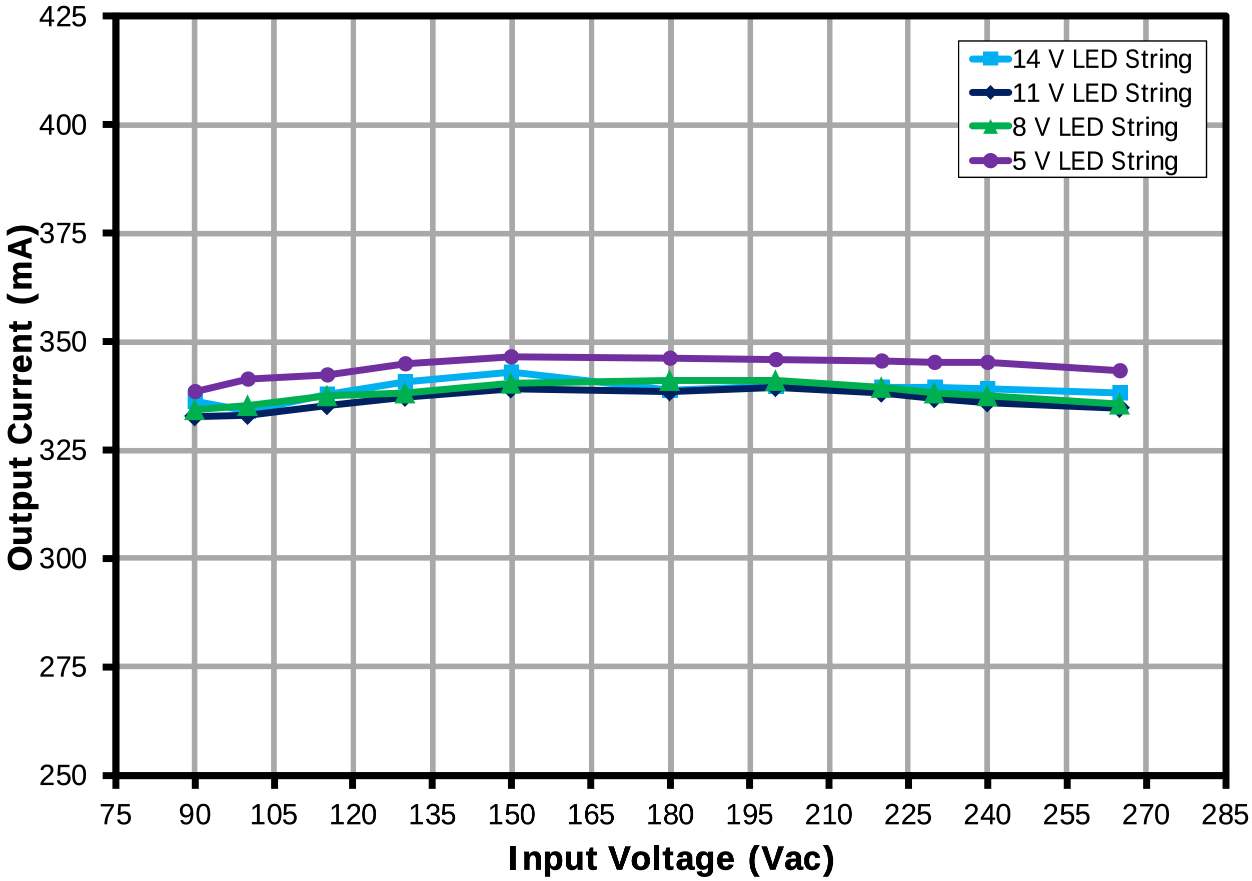

Figure 10 – Regulation vs. Line and Load.

9.4 CV/CC Characteristics

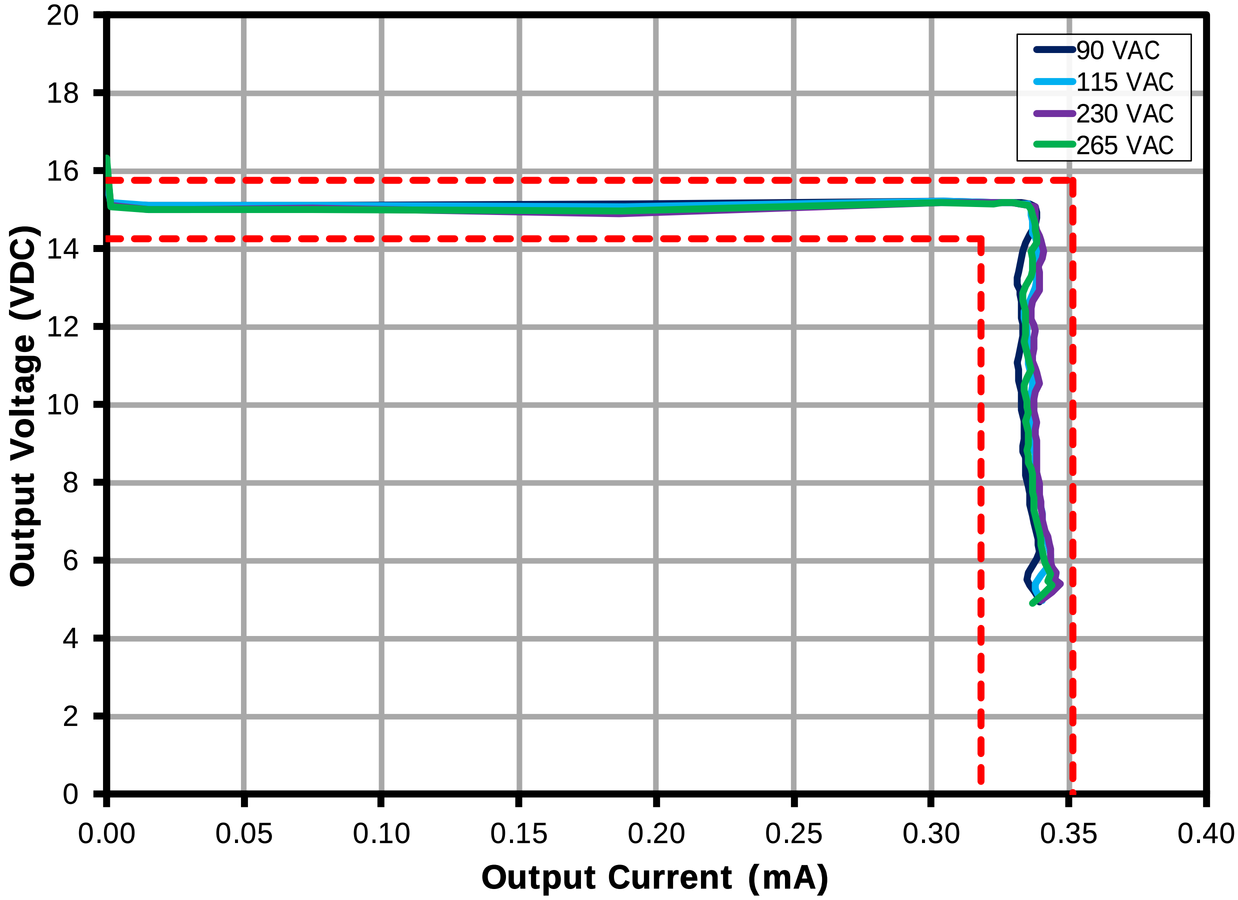

Figure 11 – CV/CC Characteristics.

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9.5 No-Load Input Power

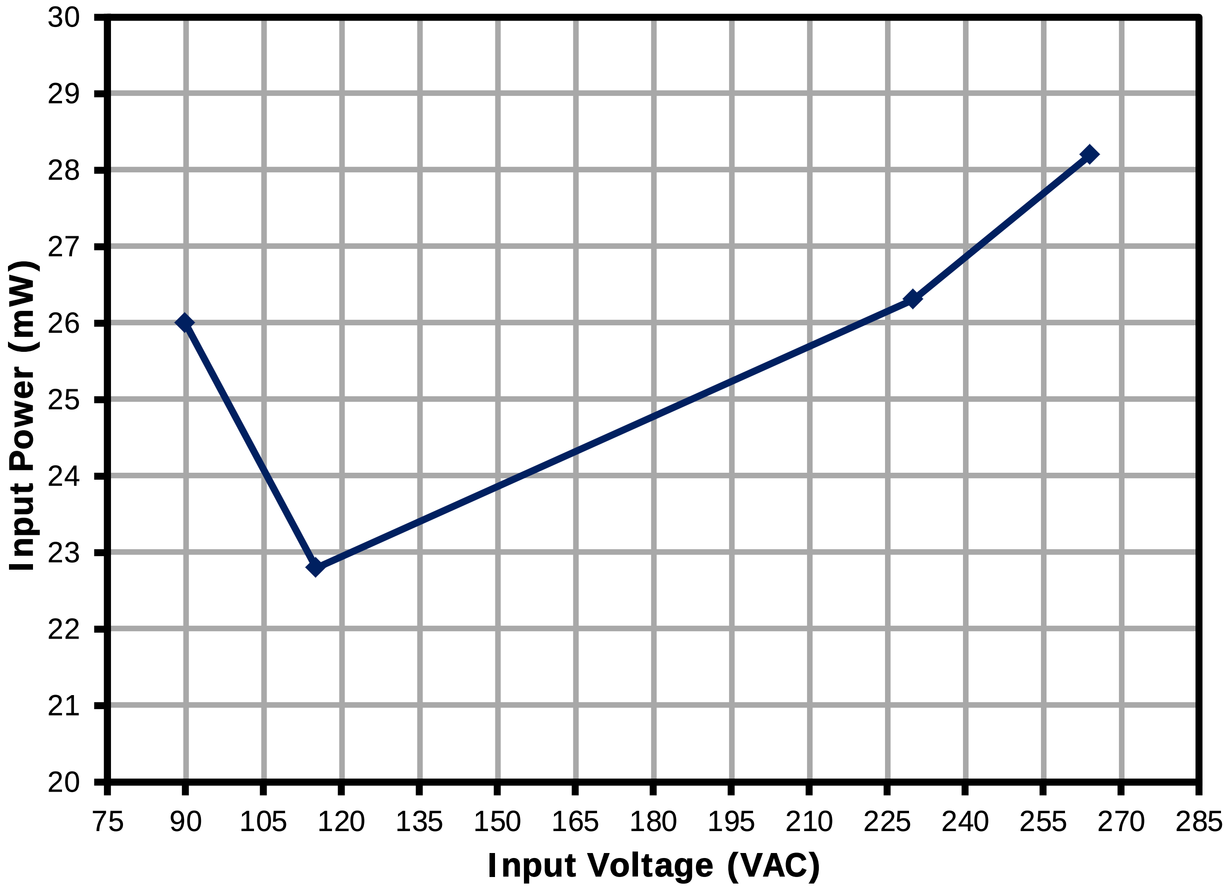

Figure 12 – No-Load Input Power.

Input		Input Measurement			Input Measurement (Integration)	
VAC (V_{RMS})	**Freq (Hz)**	**V_{IN} (V_{RMS})**	**I_{IN} (mA_{RMS})**	**P_{IN} (mW)**	**P_{OUT} (mW)**	**I_{OUT} (mA_{RMS})**
90	60	89.94	1.56	26.00	25.97	0.00
115	60	115.03	1.22	22.80	22.68	0.00
230	50	229.99	0.79	26.30	26.45	0.00
264	50	264.00	0.72	28.20	28.20	0.00

9.6 Test Data

9.6.1 14 V LED 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	89.89	124.02	6.11	0.55	81.56	14.46	336.23	4.86	79.58
100	60	99.92	114.72	6.03	0.53	83.56	14.45	334.14	4.83	80.14
115	60	114.99	105.48	6.04	0.50	85.79	14.45	337.98	4.89	80.94
130	60	129.98	98.63	6.07	0.47	87.42	14.46	340.80	4.93	81.15
150	60	149.93	91.03	6.11	0.45	89.05	14.46	343.11	4.96	81.16
180	50	179.96	78.87	6.05	0.43	90.15	14.44	338.71	4.89	80.89
200	50	200.00	74.57	6.09	0.41	91.08	14.44	339.68	4.91	80.62
220	50	219.94	70.59	6.10	0.39	91.79	14.44	339.32	4.90	80.32
230	50	229.96	68.82	6.11	0.39	92.11	14.44	339.38	4.90	80.14
240	50	239.98	67.10	6.13	0.38	92.38	14.43	339.13	4.90	79.90
265	50	265.00	63.24	6.17	0.37	92.88	14.43	338.11	4.88	79.05

9.6.2 11 V LED 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	89.90	103.01	4.86	0.52	83.73	11.47	332.86	3.82	78.68
100	60	99.92	96.01	4.82	0.50	85.47	11.47	332.90	3.82	79.22
115	60	115.00	88.39	4.83	0.47	87.35	11.47	335.16	3.85	79.69
130	60	129.99	82.31	4.84	0.45	88.76	11.48	337.16	3.87	80.00
150	60	149.93	75.91	4.87	0.43	90.10	11.48	339.12	3.89	79.91
180	50	179.97	66.52	4.88	0.41	91.10	11.47	338.54	3.89	79.68
200	50	200.00	62.81	4.91	0.39	91.89	11.48	339.50	3.90	79.37
220	50	219.95	59.20	4.92	0.38	92.46	11.47	338.20	3.88	78.83
230	50	229.97	57.53	4.92	0.37	92.73	11.47	336.98	3.87	78.51
240	50	239.99	55.89	4.92	0.37	92.92	11.47	335.96	3.85	78.27
265	50	265.01	52.55	4.96	0.36	93.40	11.46	334.56	3.84	77.42

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9.6.3 8 V LED 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	89.91	83.42	3.74	0.50	85.75	8.60	334.33	2.88	76.94
100	60	99.93	78.14	3.73	0.48	87.20	8.60	335.34	2.89	77.35
115	60	115.01	72.01	3.74	0.45	88.81	8.60	337.67	2.91	77.71
130	60	129.99	66.79	3.74	0.43	89.98	8.60	338.18	2.91	77.89
150	60	149.94	61.36	3.76	0.41	91.10	8.61	340.29	2.93	77.90
180	50	179.97	54.18	3.79	0.39	91.98	8.61	341.03	2.94	77.53
200	50	200.01	50.84	3.81	0.37	92.61	8.61	341.15	2.94	77.13
220	50	219.95	47.81	3.82	0.36	93.11	8.60	339.48	2.92	76.53
230	50	229.97	46.41	3.82	0.36	93.32	8.60	338.25	2.91	76.20
240	50	239.99	45.10	3.83	0.35	93.49	8.60	337.53	2.90	75.93
265	50	265.01	42.23	3.85	0.34	93.87	8.60	335.50	2.89	74.95

9.6.4 5 V LED 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	89.92	63.16	2.65	0.47	87.94	5.75	338.39	1.95	73.51
100	60	99.94	59.52	2.67	0.45	88.99	5.75	341.38	1.97	73.75
115	60	115.01	54.60	2.67	0.42	90.26	5.75	342.50	1.97	73.97
130	60	130.00	50.72	2.68	0.41	91.18	5.75	344.76	1.99	74.10
150	60	149.94	46.30	2.70	0.39	92.01	5.76	346.49	2.00	73.94
180	50	179.98	40.97	2.72	0.37	92.86	5.76	346.09	2.00	73.44
200	50	200.01	38.27	2.73	0.36	93.37	5.75	345.86	1.99	73.12
220	50	219.95	35.99	2.75	0.35	93.72	5.75	345.66	1.99	72.57
230	50	229.98	34.94	2.75	0.34	93.89	5.75	345.36	1.99	72.32
240	50	240.00	33.97	2.76	0.34	94.03	5.75	345.17	1.99	71.99
265	50	265.01	31.85	2.79	0.33	94.33	5.75	343.40	1.98	70.88

10 Thermal Performance

Images captured after running for >30 minutes at enclosed compartment (25°C ambient).

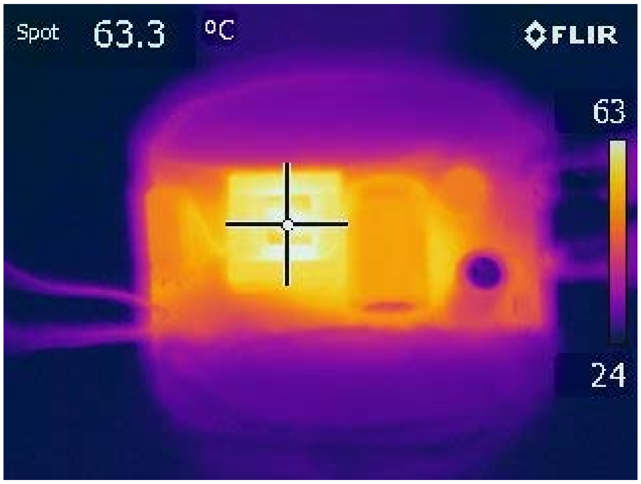

Figure 13 – 90 VAC, Thermal, Top Side.
SPOT1 (T1): 63.3 °C.

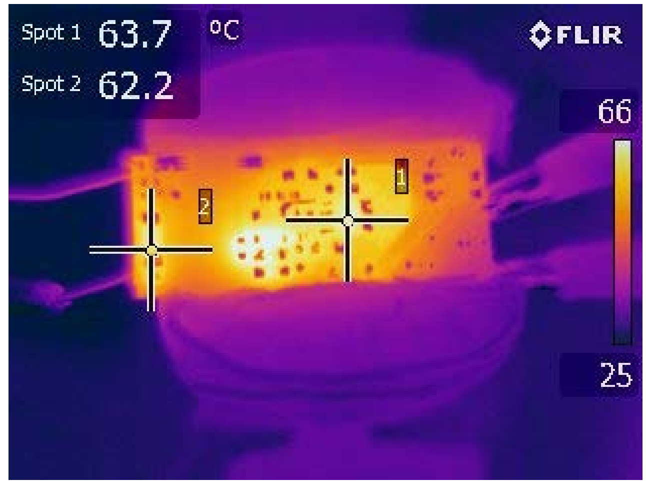

Figure 14 – 90 VAC, Thermal, Bottom Side.
SPOT1 (U1): 63.7 °C.
SPOT2 (D4): 62.2 °C.

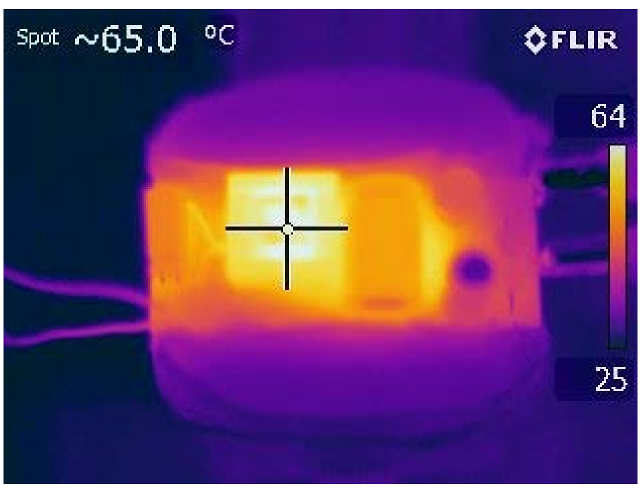

Figure 15 – 265 VAC, Thermal, Top Side.
SPOT1 (T1): 65.0 °C.

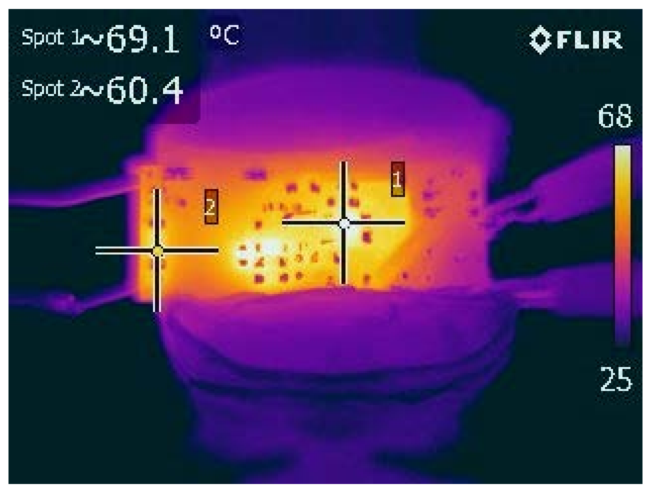

Figure 16 – 265 VAC, Thermal, Bottom Side.
SPOT1 (U1): 69.1 °C.
SPOT2 (D4): 60.4 °C.

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11 Waveforms

11.1 Input Voltage and Input Current Waveforms

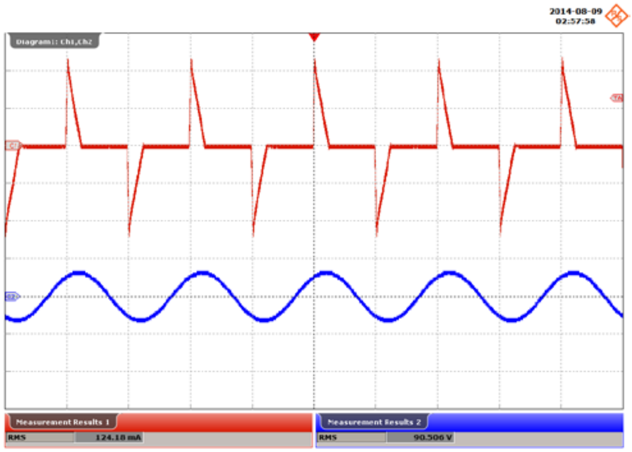

Figure 17 – 90 VAC, 50 Hz Full Load.
Upper: I_{IN}, 200 mA / div.
Lower: V_{IN}, 200 V, 10 ms / div.

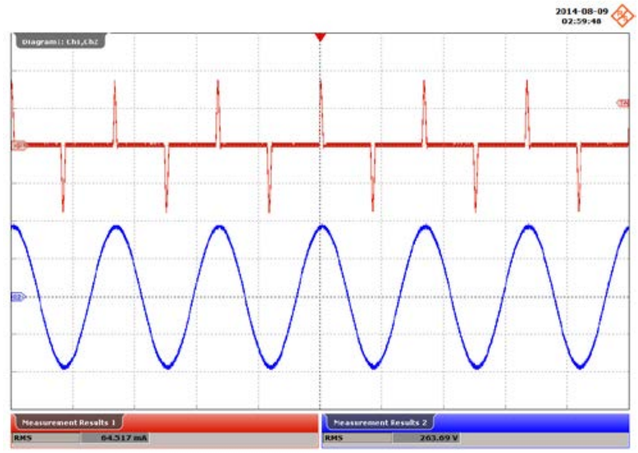

Figure 18 – 265 VAC, 50 Hz Full Load.
Upper: I_{IN}, 200 mA / div.
Lower: V_{IN}, 200 V, 10 ms / div.

11.2 Output Current and Output Voltage at Normal Operation

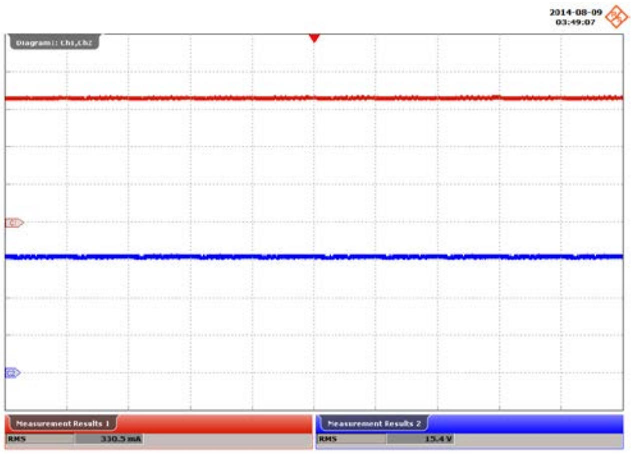

Figure 19 – 90 VAC, 50 Hz Full Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 5 V, 10 ms / div.

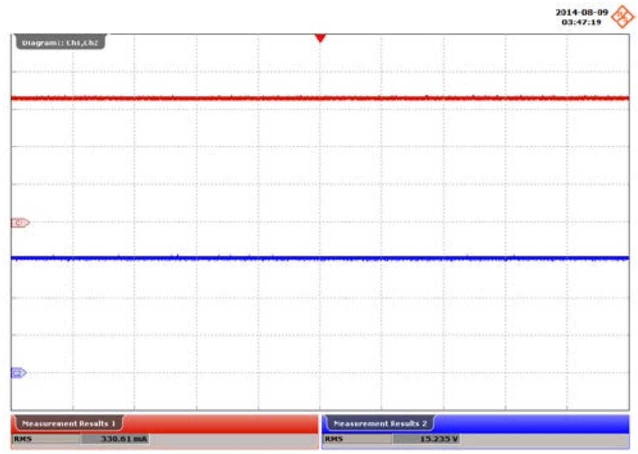

Figure 20 – 265 VAC, 50 Hz Full Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 5 V, 10 ms / div.

11.3 Output Voltage/ Current Rise and Fall

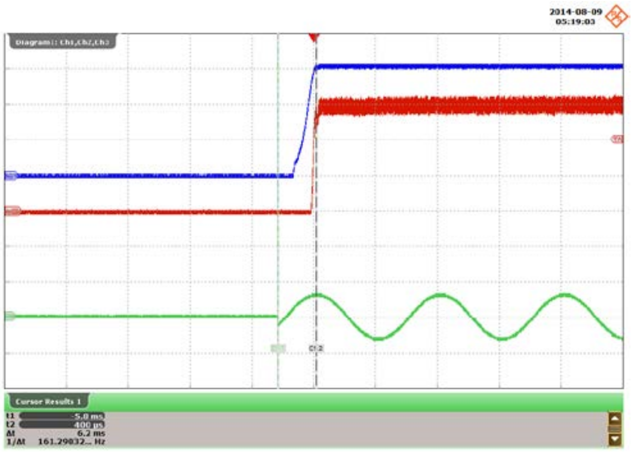

Figure 21 – 90 VAC, 50 Hz, Output Rise.
CH1: V_{OUT}, 5 V / div.
CH2: I_{OUT}, 100 mA / div.
CH3: V_{IN}, 200 V / div., 10 ms / div.
Start-up Time: 6.2 ms.

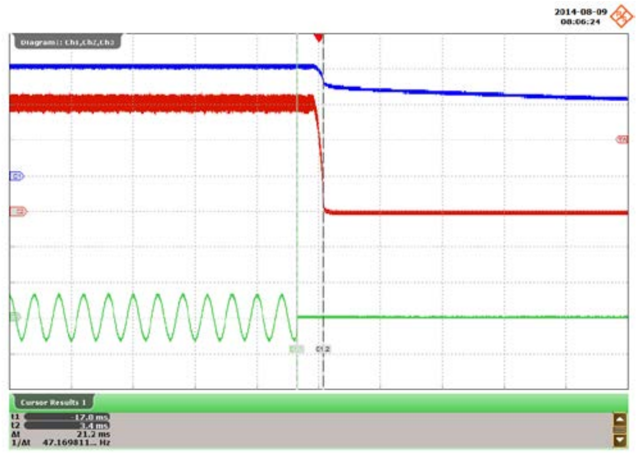

Figure 22 – 90 VAC, 50 Hz, Output Fall.
CH1: V_{OUT}, 5 V / div.
CH2: I_{OUT}, 100 mA / div.
CH3: V_{IN}, 200 V / div., 50 ms / div.
Hold-up Time: 21.2 ms.

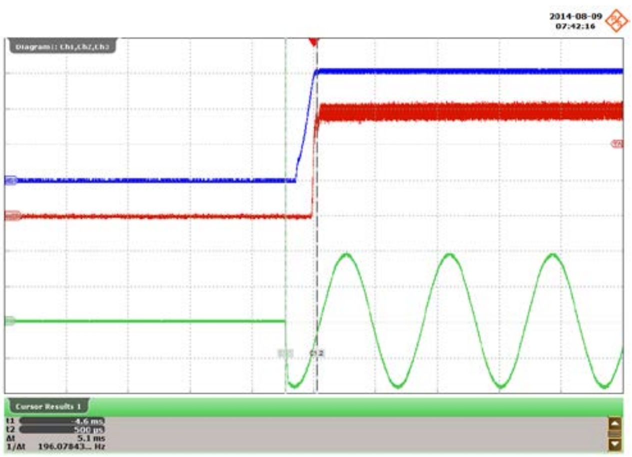

Figure 23 – 265 VAC, 60 Hz, Output Rise.
Upper: V_{OUT}, 5 V / div.
Middle: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 200 V / div., 20 ms / div.
Start-up Time: 5.1 ms.

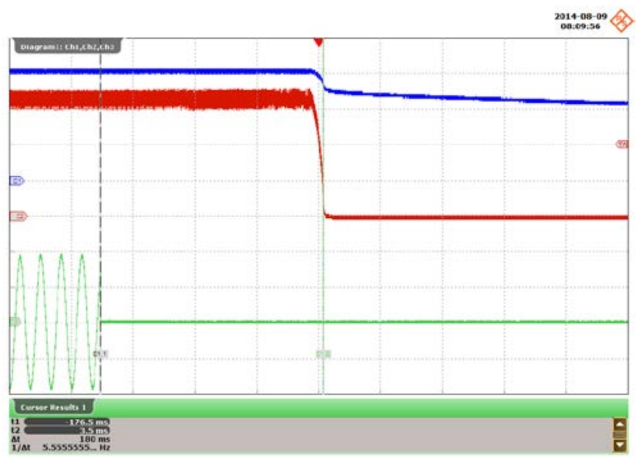

Figure 24 – 265 VAC, 60 Hz, Output Fall.
Upper: V_{OUT}, 5 V / div.
Middle: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 200 V / div., 100 ms / div.
Hold-up Time: 180 ms.

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11.4 Voltage and Current Ripple

11.4.1 Constant Voltage (CV) Operation

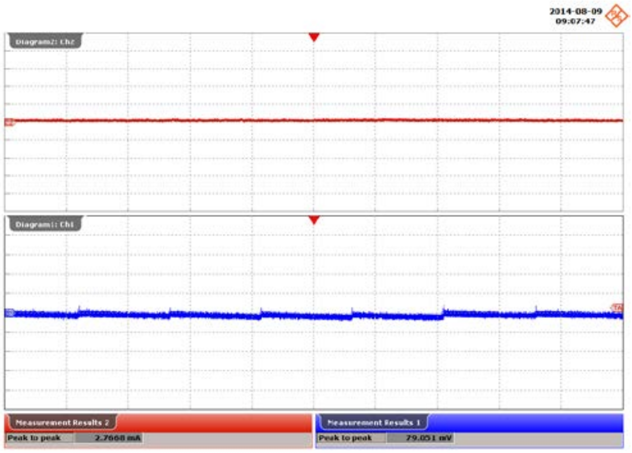

Figure 25 – 115 VAC, 50 Hz. No-Load.
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 1 ms / div.

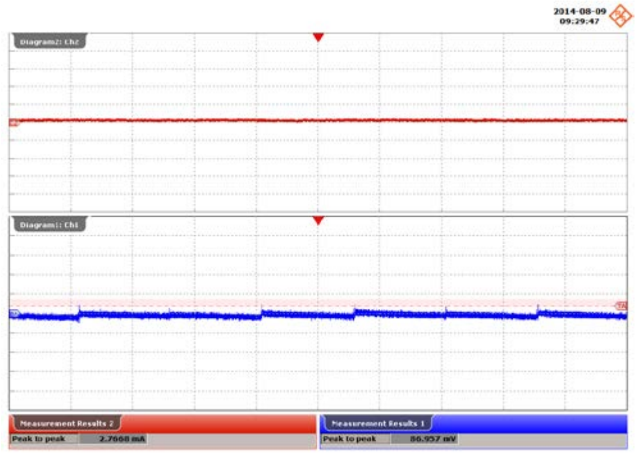

Figure 26 – 230 VAC, 60 Hz. No-Load.
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV,1 ms / div.

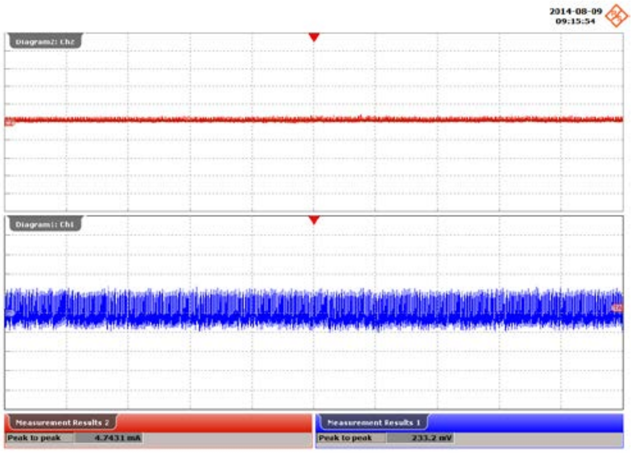

Figure 27 – 115 VAC, 50 Hz. 167 mA Load (50%).
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 1 ms / div.

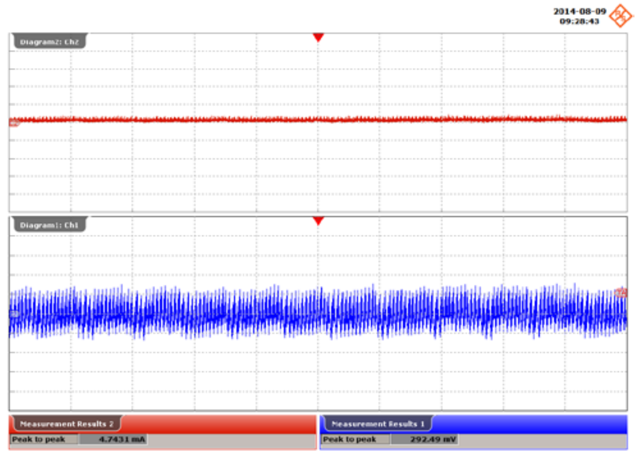

Figure 28 – 230 VAC, 60 Hz. 167 mA Load (50%).
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 1 ms / div.

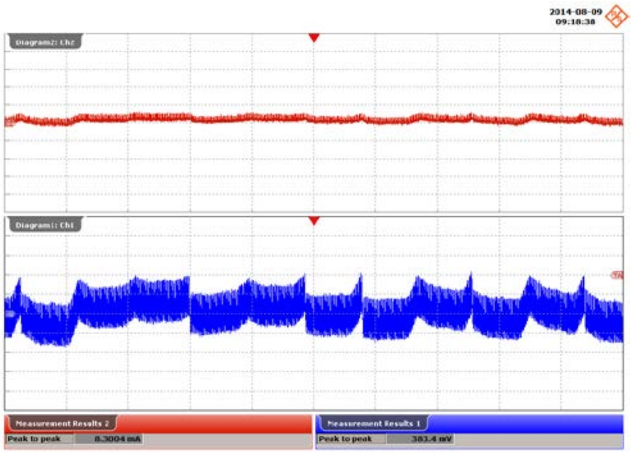

Figure 29 – 115 VAC, 50 Hz. 335 mA Load (100%).
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 1 ms / div.

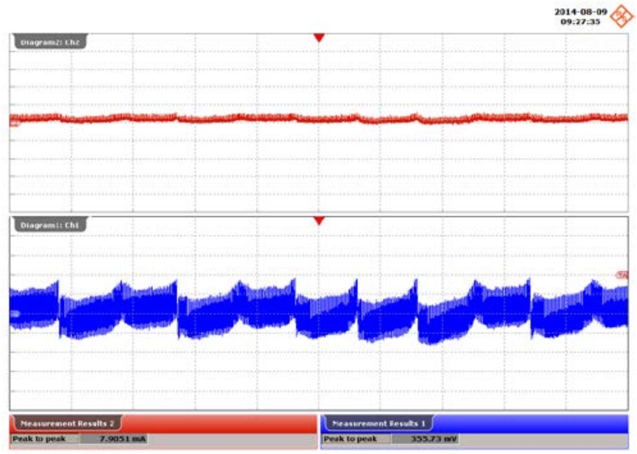

Figure 30 – 230 VAC, 60 Hz. 130 mA Load (100%).
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 1 ms / div.

11.4.2 Constant Current (CC) Operation

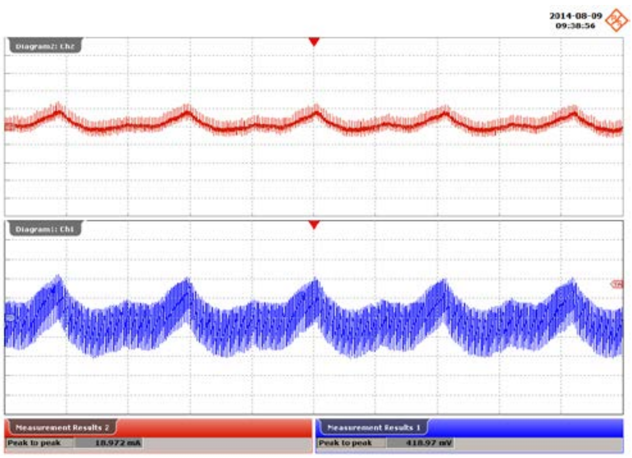

Figure 31 – 115 VAC, 50 Hz. 6 V Output.
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 1 ms / div.

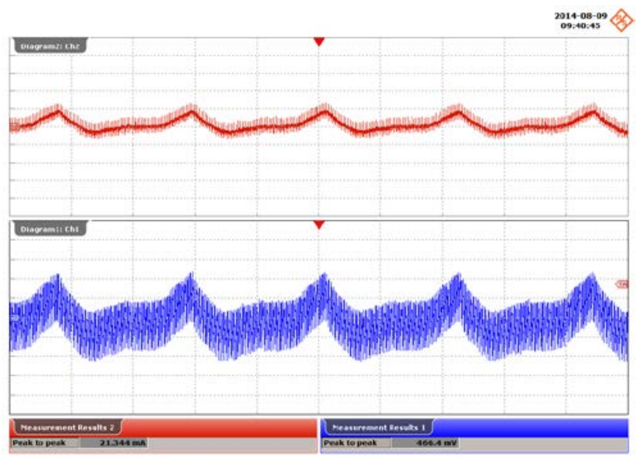

Figure 32 – 230 VAC, 60 Hz. 6 V Output.
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 1 ms / div.

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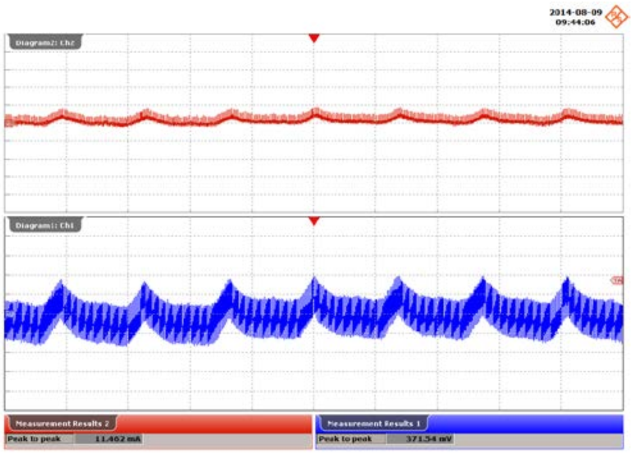

Figure 33 – 115 VAC, 50 Hz. 10 V Output.
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 1 ms / div.

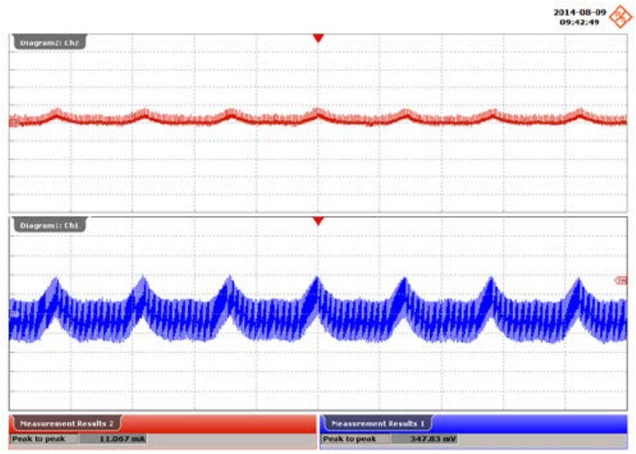

Figure 34 – 230 VAC, 60 Hz. 10 V Output.
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 1 ms / div.

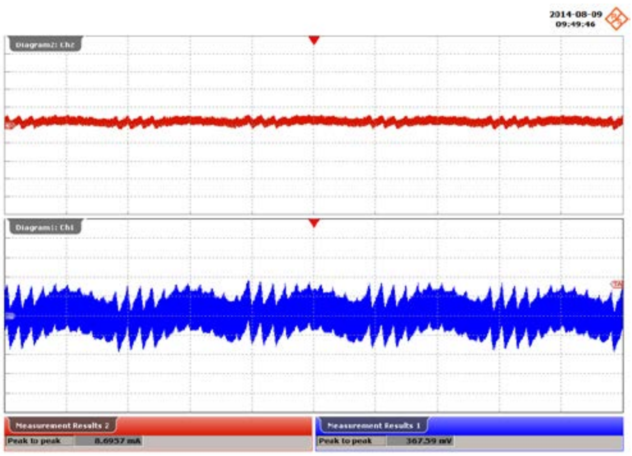

Figure 35 – 115 VAC, 50 Hz. 14 V Output.
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 5 ms / div.

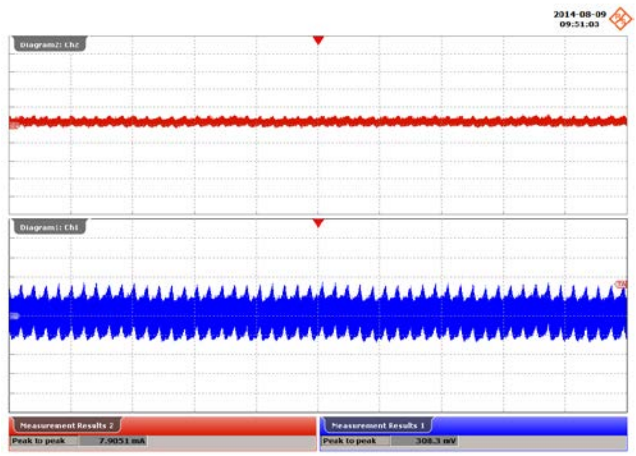

Figure 36 – 230 VAC, 60 Hz. 14 V Output.
Upper: $I_{OUT(RIPPLE)}$, 10 mA / div.
Lower: $V_{OUT(RIPPLE)}$, 100 mV, 5 ms / div.

11.5 Drain Voltage and Current at Normal Operation

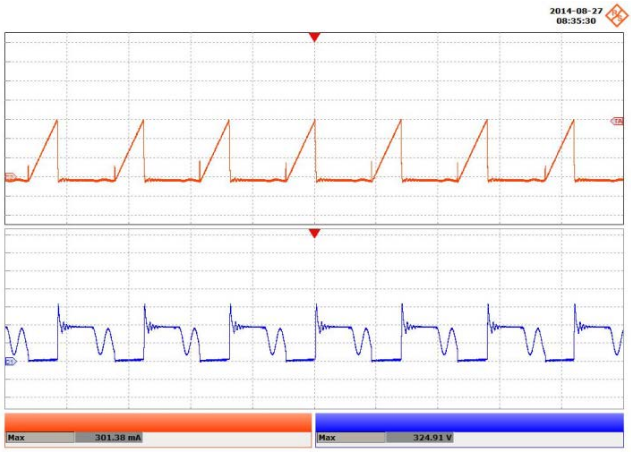

Figure 37 – 90 VAC, 60 Hz.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 10 µs / div.
Max V_{DRAIN}: 324.91 V.
Max I_{DRAIN}: 301.38 mA.

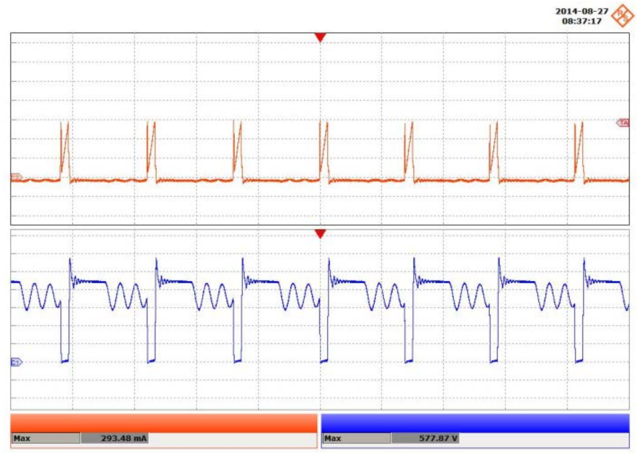

Figure 38 – 270 VAC, 50 Hz.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 10 µs / div.
Max V_{DRAIN}: 577.87 V.
Max I_{DRAIN}: 293.48 mA.

11.6 Start-up Drain Voltage and Current

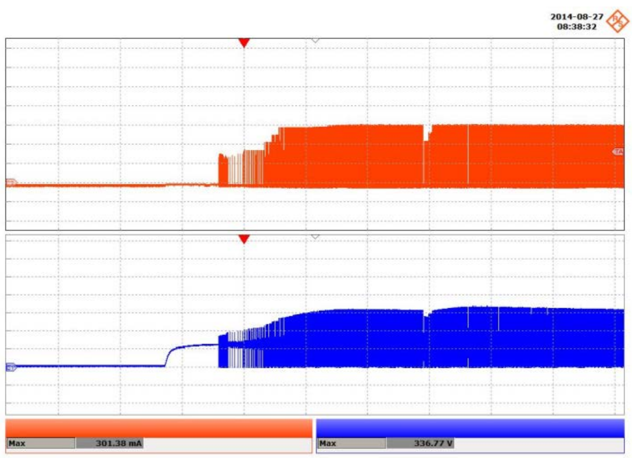

Figure 39 – 90 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 2 ms / div.
Max V_{DRAIN}: 336.77 V.
Max I_{DRAIN}: 301.387 mA.

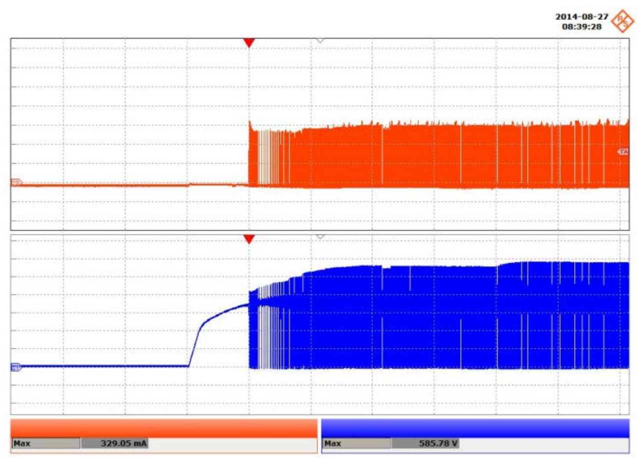

Figure 40 – 270 VAC, 50 Hz Start-up.
Upper: I_{DRAIN}, 200 mA / div.
Lower: V_{DRAIN}, 200 V, 2 ms / div.
Max V_{DRAIN}: 585.78 V.
Max I_{DRAIN}: 329.05 mA.

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11.7 Drain Current and Drain Voltage during Output Short Condition

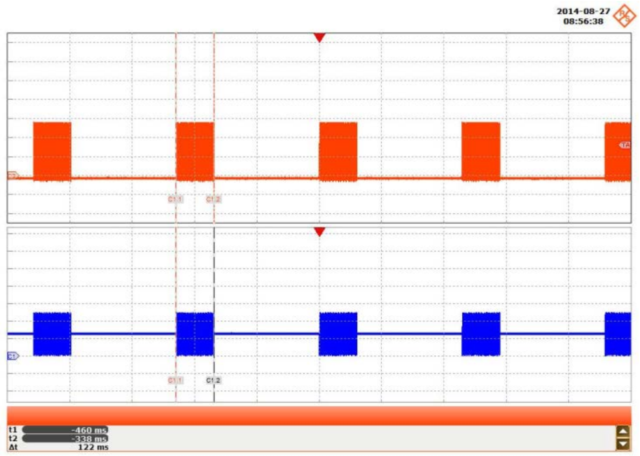

Figure 41 – 90 VAC, 60 Hz Output Short Condition.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 200 ms / div.

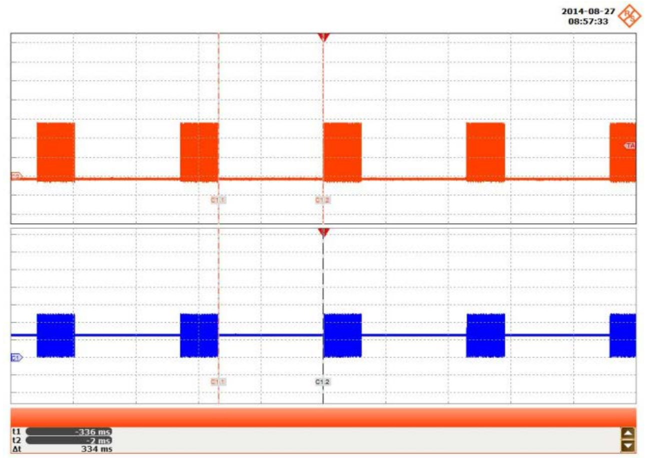

Figure 42 – 90 VAC, 60 Hz Output Short Condition.
Upper: I_{DRAIN}, 200 mA / div.
Lower: V_{DRAIN}, 200 V, 200 ms / div.

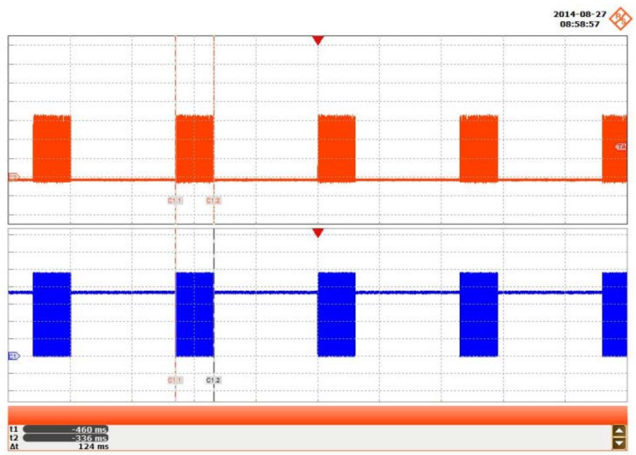

Figure 43 – 270 VAC, 50 Hz Output Short.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 200 ms / div.

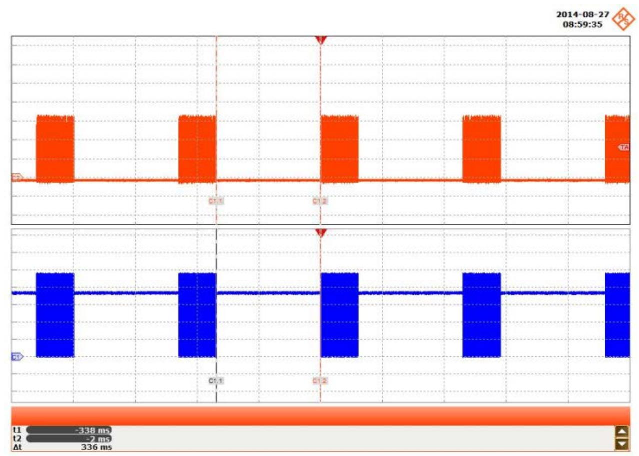

Figure 44 – 270 VAC, 50 Hz Output Short.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 200 ms / div.

11.8 Drain Current and Drain Voltage during Open-Loop Condition (R7 is Open)

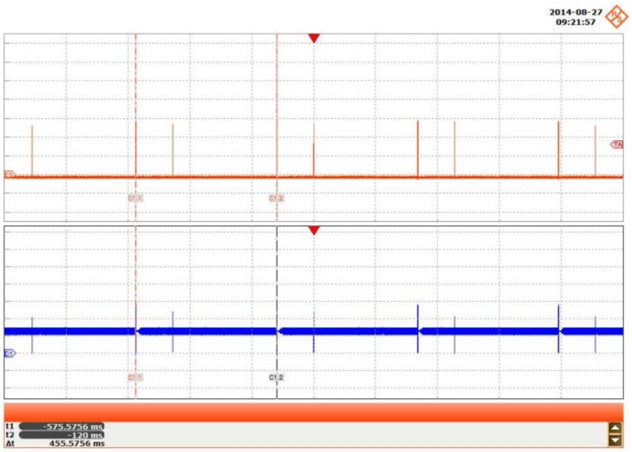

Figure 45 – 90 VAC, 50 Hz Open-loop.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 200 ms / div.

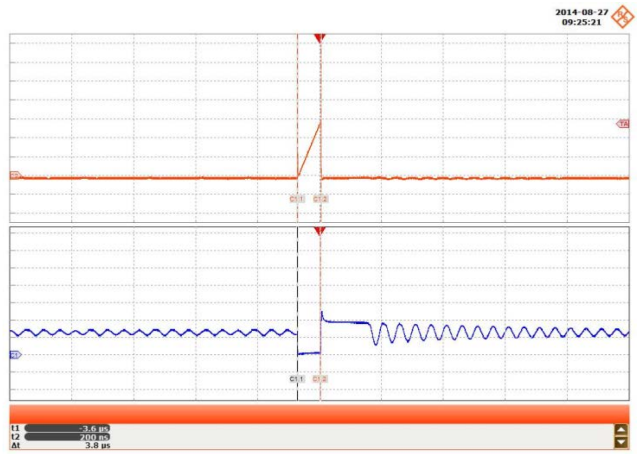

Figure 46 – 90 VAC, 50 Hz Open-loop.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 10 μs / div.

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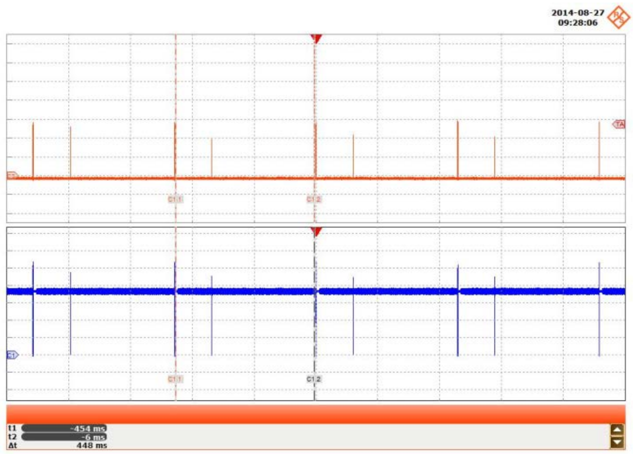

Figure 47 – 265 VAC, 50 Hz Open-loop.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 200 ms / div.

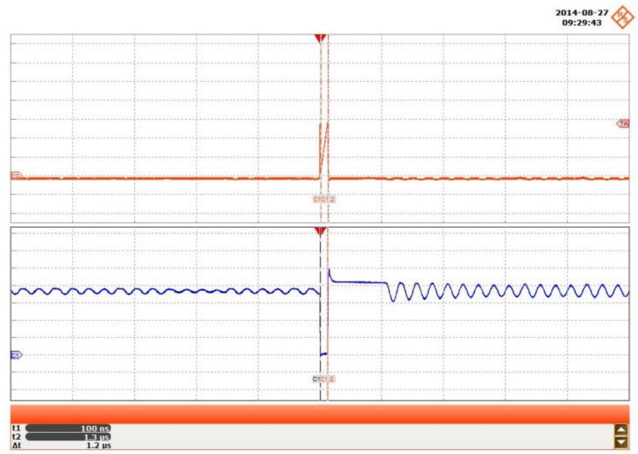

Figure 48 – 265 VAC, 50 Hz Open-loop.
Upper: I_{DRAIN}, 100 mA / div.
Lower: V_{DRAIN}, 100 V, 10 µs / div.

11.9 Output Diode Current and Voltage Waveforms Normal Operation

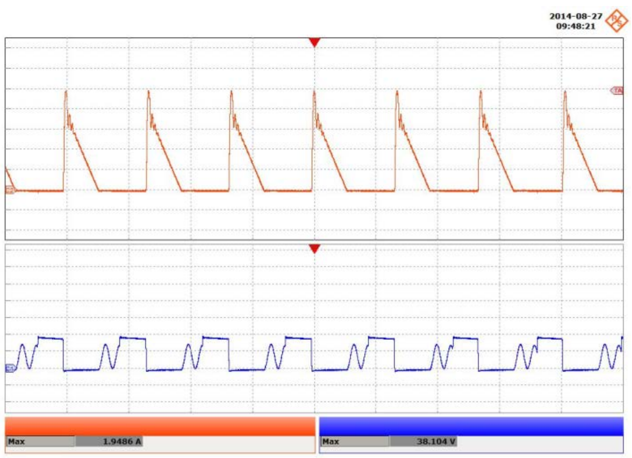

Figure 49 – 90 VAC, 60 Hz.
Upper: I_{D3}, 400 mA / div.
Lower: V_{D3}, 20 V, 10 µs / div.
Max V_{D3}: 38.104 V.
Max I_{D3}: 1.9486 A.

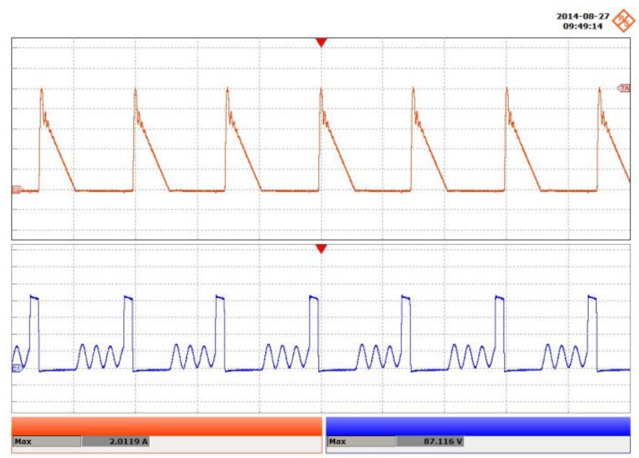

Figure 50 – 265 VAC, 50 Hz.
Upper: I_{D3}, 400 mA / div.
Lower: V_{D3}, 20 V, 10 µs / div.
Max V_{D3}: 87.116 V.
Max I_{D3}: 2.0119 A.

11.10 Output Diode Current and Voltage Short-Circuit Waveforms

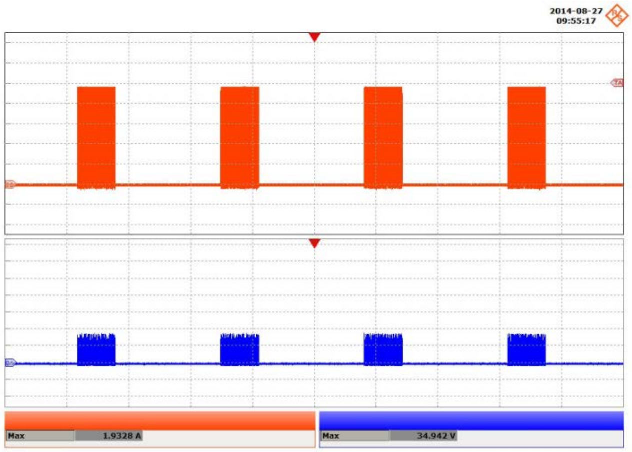

Figure 51 – 90 VAC, 60 Hz.
Upper: I_{D3}, 400 mA / div.
Lower: V_{D3}, 20 V, 200 ms / div.
Max V_{D3}: 34.942.
Max I_{D3}: 1.9328 A.

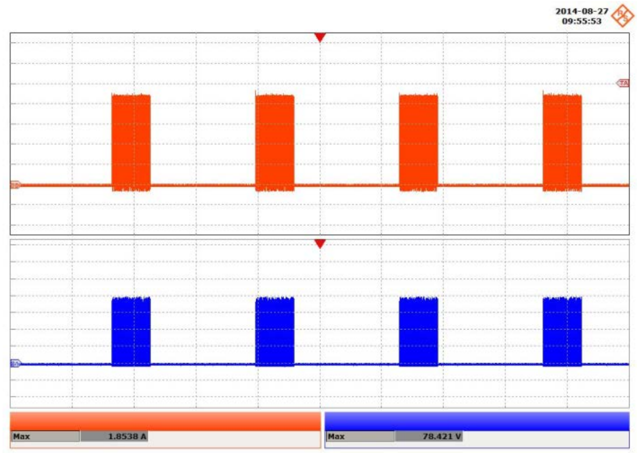

Figure 52 – 265 VAC, 50 Hz.
Upper: I_{D3}, 400 mA / div.
Lower: V_{D3}, 20 V, 200 ms / div.
Max V_{D3}: 78.421 V.
Max I_{D3}: 1.8538 A.

11.11 Brown-out / Brown-in

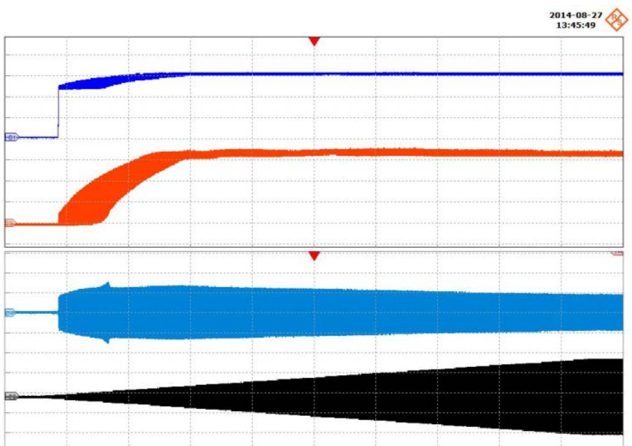

Figure 53 – Brown-out Condition.
CH1: V_{OUT}, 5 V / div.
CH3: I_{OUT}, 100 mA / div.
CH2: I_{IN}, 200 mA / div.
CH4: V_{IN}, 200 V / div, 30 s / div.

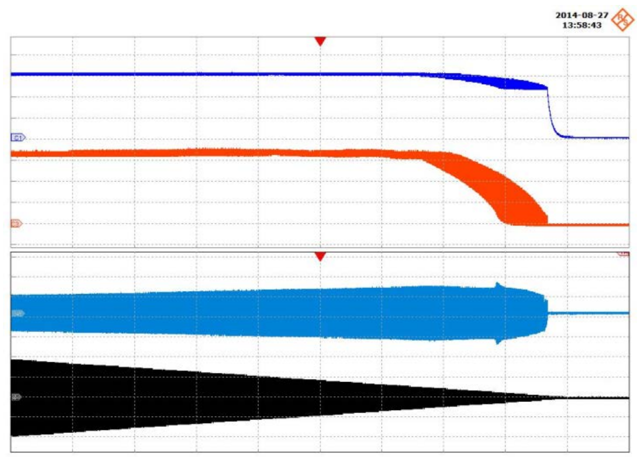

Figure 54 –Brown-in Condition.
CH1: V_{OUT}, 5 V / div.
CH3: I_{OUT}, 100 mA / div.
CH2: I_{IN}, 200 mA / div.
CH4: V_{IN}, 200 V / div, 30 s / div.

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11.12 Line Transient

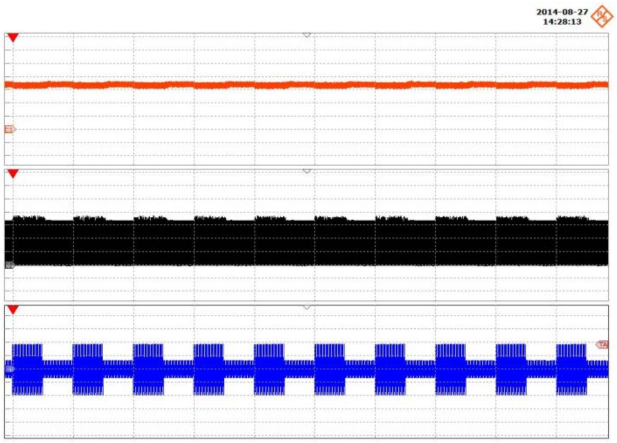

Figure 55 – 90 VAC to 265 VAC Line Transient.
Upper: I_{OUT}, 100 mA / div.
Middle: I_{DRAIN},100 mA / div.
Lower: V_{IN}, 200 V / div., 1 s / div.

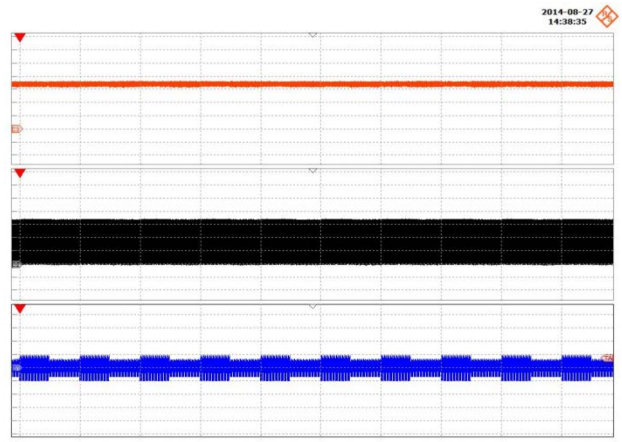

Figure 56 – 90 VAC to 132 VAC Line Transient.
Upper: I_{OUT}, 100 mA / div.
Middle: I_{DRAIN}, 100 mA / div.
Lower: V_{IN}, 200 V / div., 1 s / div.

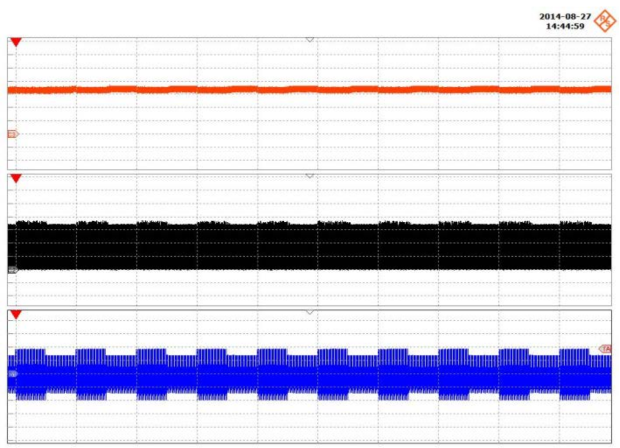

Figure 57 – 195 VAC to 265 VAC Line Transient.
Upper: I_{OUT}, 100 mA / div.
Middle: I_{DRAIN}, 100 mA / div.
Lower: V_{IN}, 200 V / div., 1 s / div.

11.13 500 ms ON, 500 ms OFF AC Cycling

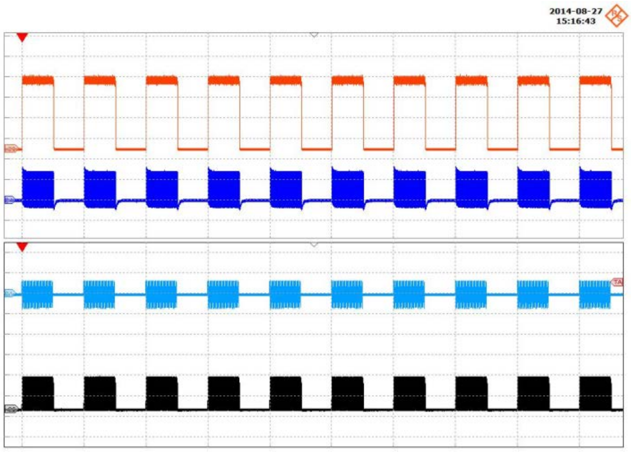

Figure 58 – 90 VAC, 500 ms ON-OFF Cycling.
CH4: I_{OUT}, 100 mA / div.
CH3: I_{DRAIN}, 100 mA / div.
CH2: V_{IN}, 200 V / div.
CH1: V_{DRAIN}, 200 V / div., 1 s / div.

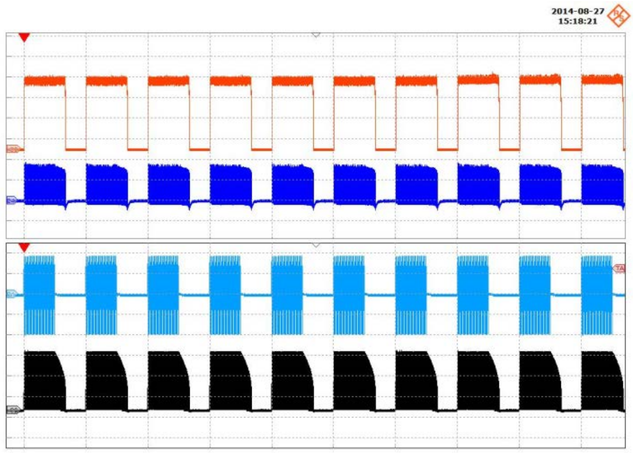

Figure 59 – 265 VAC, 500 ms ON-OFF Cycling.
CH4: I_{OUT}, 100 mA / div.
CH3: I_{DRAIN}, 100 mA / div.
CH2: V_{IN}, 200 V / div.
CH1: V_{DRAIN}, 200 V / div., 1 s / div.

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12 Conducted EMI

12.1 Test Set-up

The unit was tested using LED load (54 V, 130 mA) for CC and resistor-LED load (60 V, 118 mA) for CV.

EMI Receiver: Rohde & Schwarz ESRP
Line Impedance Stabilization Network: ENV216
Pulse Limiter: ESH3-Z2

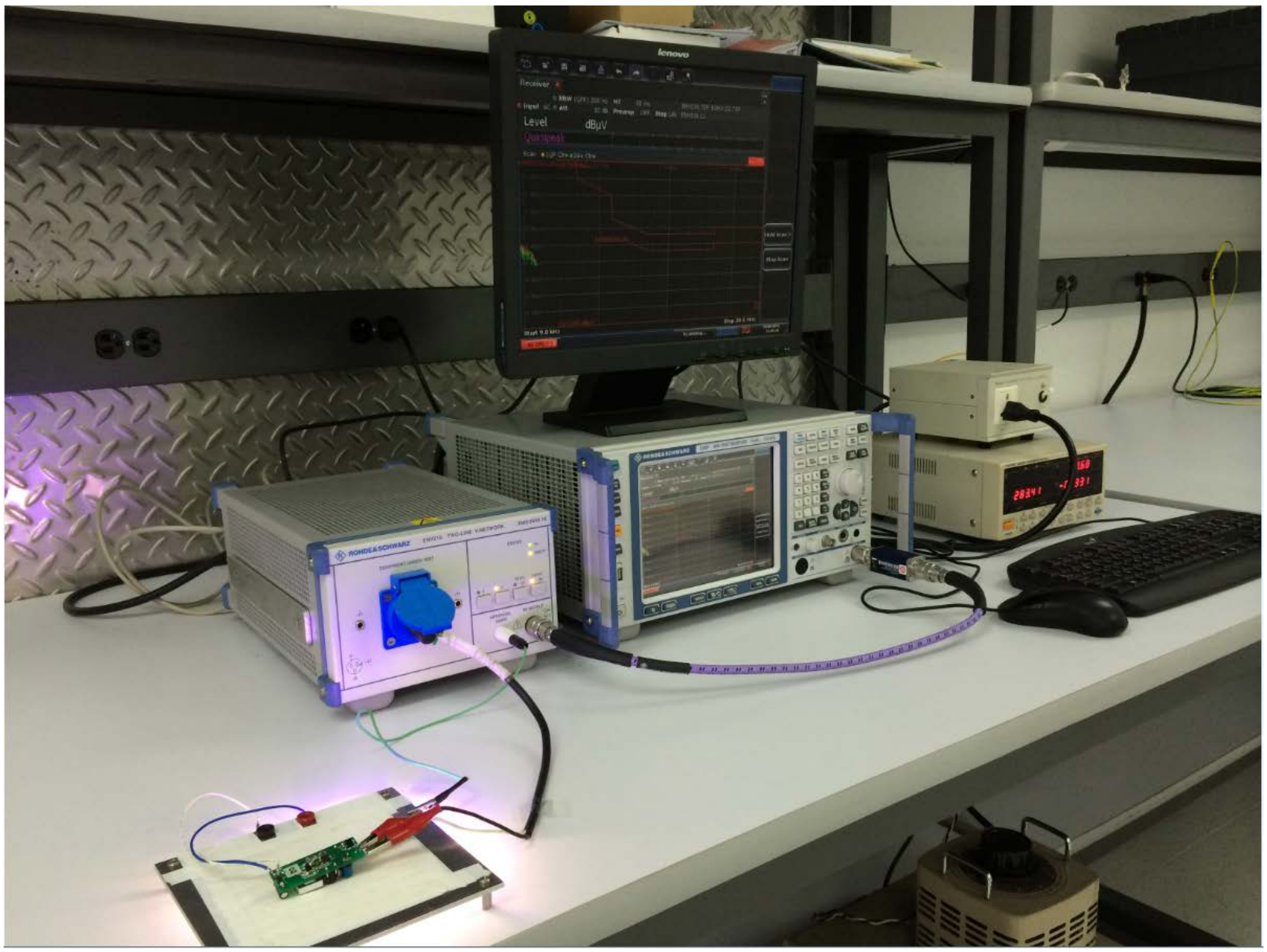
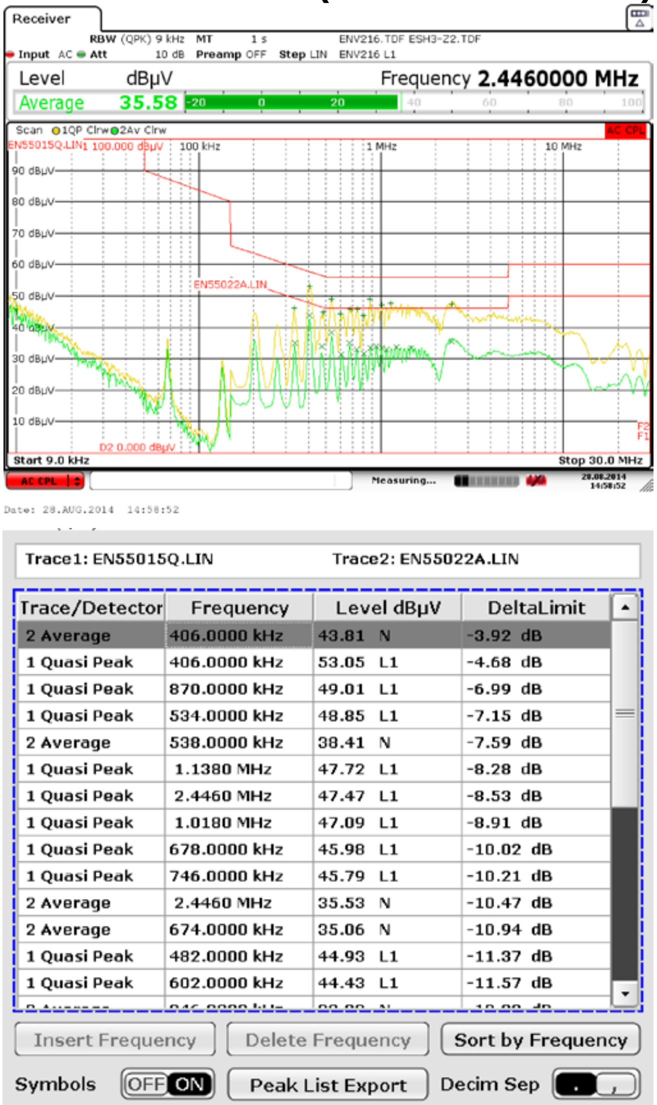


Figure 60 – Conducted EMI Set-up (With and Without EARTH Connection).

12.2 Conducted EMI

With Ground Plane (Connected to Earth) **With Ground Plane (Floating)**



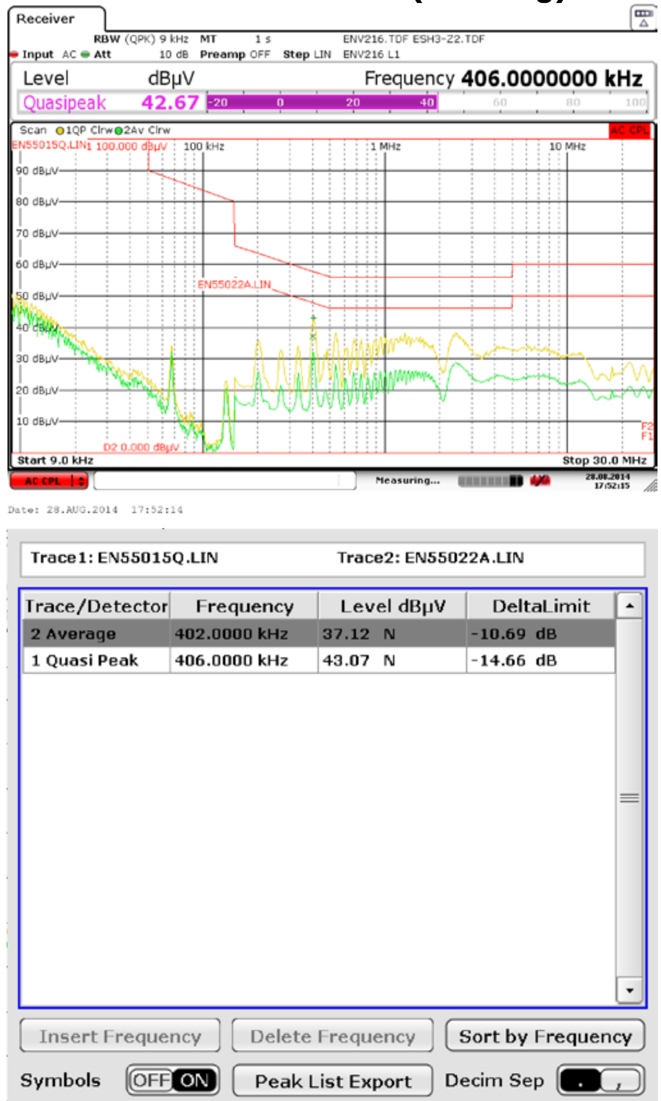


Figure 61 – 115 VAC, 60 Hz, 15 V 333 mA LED Load, EN55015 B Limits (Quasi-Peak Scan).

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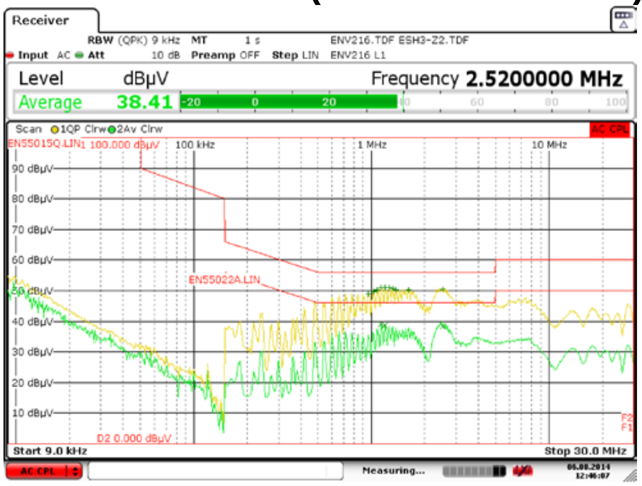
With Ground Plane (Connected to Earth)



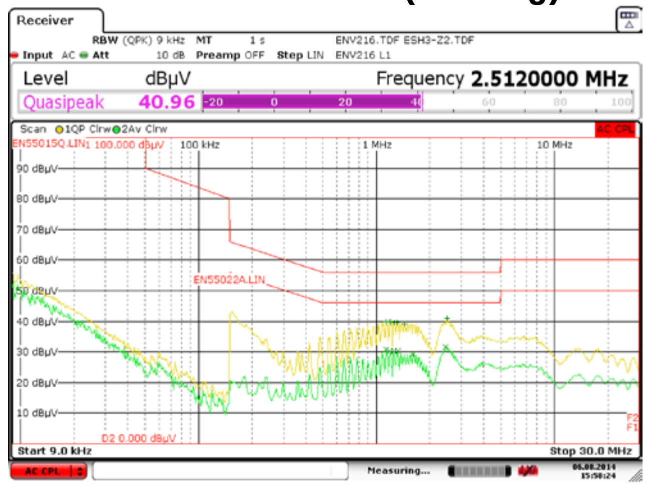
Trace1: EN55015Q.LIN Trace2: EN55022A.LIN

Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	958.0000 kHz	49.01 L1	-6.99 dB
1 Quasi Peak	1.0340 MHz	49.66 L1	-6.34 dB
1 Quasi Peak	1.0780 MHz	50.20 L1	-5.80 dB
1 Quasi Peak	1.1380 MHz	50.91 L1	-5.09 dB
2 Average	1.1380 MHz	39.01 L1	-6.99 dB
1 Quasi Peak	1.1980 MHz	51.13 L1	-4.87 dB
2 Average	1.1980 MHz	38.64 L1	-7.36 dB
1 Quasi Peak	1.2580 MHz	50.91 L1	-5.09 dB
1 Quasi Peak	1.3180 MHz	50.84 L1	-5.16 dB
1 Quasi Peak	1.3740 MHz	50.14 L1	-5.86 dB
1 Quasi Peak	1.6180 MHz	50.17 L1	-5.83 dB
1 Quasi Peak	2.5160 MHz	50.45 L1	-5.55 dB
2 Average	2.5200 MHz	38.39 L1	-7.61 dB

Insert Frequency | Delete Frequency | Sort by Delta Limit

Symbols OFF ON | Peak List Export | Decim Sep . ,

With Ground Plane (Floating)



Trace1: EN55015Q.LIN Trace2: EN55022A.LIN

Trace/Detector	Frequency	Level dBµV	DeltaLimit
1 Quasi Peak	1.1340 MHz	39.95 L1	-16.05 dB
2 Average	1.1380 MHz	30.87 L1	-15.13 dB
1 Quasi Peak	1.1940 MHz	39.93 L1	-16.07 dB
2 Average	1.1980 MHz	30.44 L1	-15.56 dB
1 Quasi Peak	1.2540 MHz	39.62 L1	-16.38 dB
2 Average	1.2580 MHz	30.33 L1	-15.67 dB
1 Quasi Peak	1.3140 MHz	39.70 L1	-16.30 dB
2 Average	1.3180 MHz	30.21 L1	-15.79 dB
1 Quasi Peak	1.4340 MHz	39.20 L1	-16.80 dB
2 Average	1.6140 MHz	29.29 L1	-16.71 dB
2 Average	2.4560 MHz	31.58 L1	-14.42 dB
1 Quasi Peak	2.5120 MHz	40.92 L1	-15.08 dB

Insert Frequency | Delete Frequency | Sort by Delta Limit

Symbols OFF ON | Peak List Export | Decim Sep . ,

Figure 62 – 230 VAC, 60 Hz, 15 V 333 mA LED Load, EN55015 B Limits (Quasi-Peak Scan).

13 Line Surge Test

The unit was subjected to ±2500 V, 100 kHz ring wave and ±1kV differential surge using 10 strikes at each condition. A test failure was defined as a non-recoverable interruption of output requiring supply repair or recycling of input voltage.

Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Type	Test Result (Pass/Fail)
+2500	115	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
-2500	115	L1, L2	90	100 kHz Ring Wave (500 A)	Pass
+2500	115	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
-2500	115	L1, L2	90	100 kHz Ring Wave (500 A)	Pass

Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Type	Test Result (Pass/Fail)
+2500	230	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
-2500	230	L1, L2	90	100 kHz Ring Wave (500 A)	Pass
+2500	230	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
-2500	230	L1, L2	90	100 kHz Ring Wave (500 A)	Pass

Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Type	Test Result (Pass/Fail)
+1 kV	115	L1, L2	0	Surge (2Ω)	Pass
-1 kV	115	L1, L2	90	Surge (2Ω)	Pass
+1 kV	115	L1, L2	0	Surge (2Ω)	Pass
-1 kV	115	L1, L2	90	Surge (2Ω)	Pass

Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Type	Test Result (Pass/Fail)
+1 kV	230	L1, L2	0	Surge (2Ω)	Pass
-1 kV	230	L1, L2	90	Surge (2Ω)	Pass
+1 kV	230	L1, L2	0	Surge (2Ω)	Pass
-1 kV	230	L1, L2	90	Surge (2Ω)	Pass

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Figure 63 – 115 VAC, +1 kV Differential Surge, 90°. V_{DRAIN}, 200 V / div., 2 ms / div.

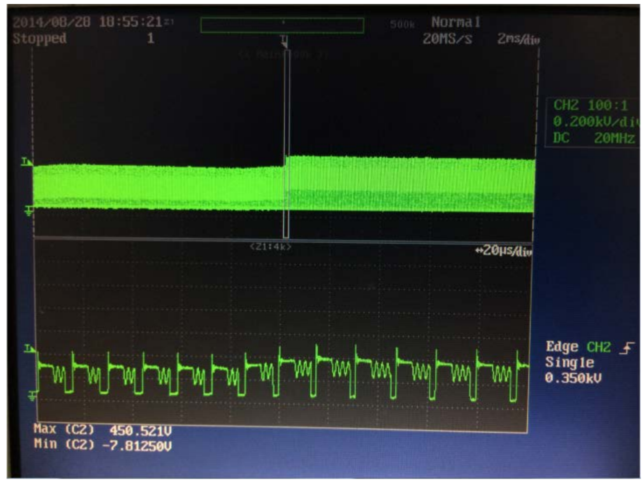

Figure 64 – 115 VAC, -1 kV Differential Surge, 90°. V_{DRAIN}, 200 V / div., 2 ms / div.

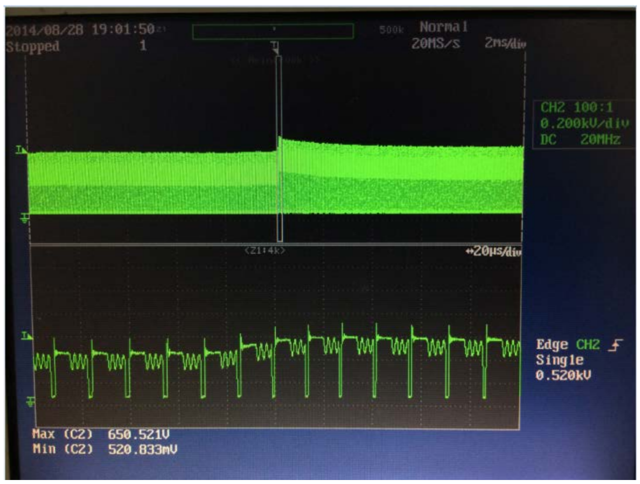

Figure 65 – 230 VAC, +1 kV Differential Surge, 90°. V_{DRAIN}, 200 V / div., 2 ms / div.

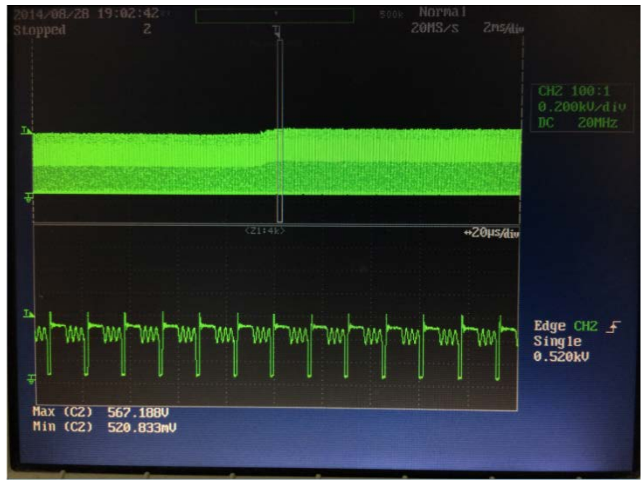

Figure 66 – 230 VAC, -1 kV Differential Surge, 90°. V_{DRAIN}, 200 V / div., 2 ms / div.

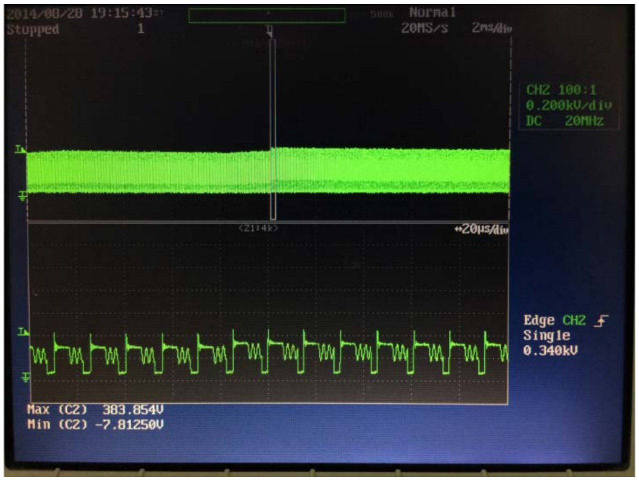

Figure 67 – 115 VAC, +2.5 kV Ring Wave Surge, 90º. V_{DRAIN}, 200 V / div., 2 ms / div.

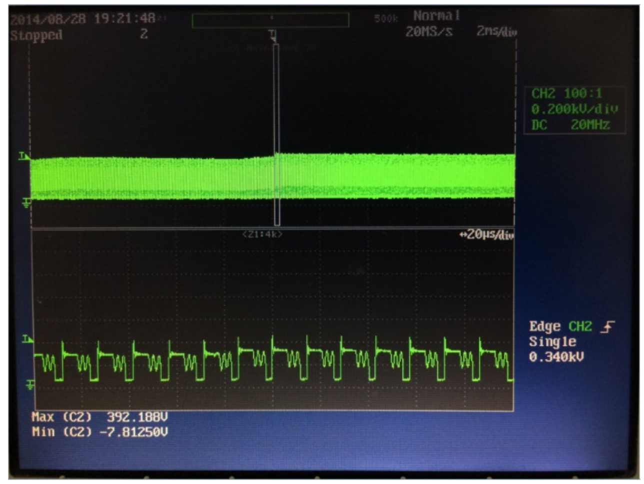

Figure 68 – 115 VAC -2.5 kV Ring Wave Surge, 90º. V_{DRAIN}, 200 V / div., 2 ms / div.

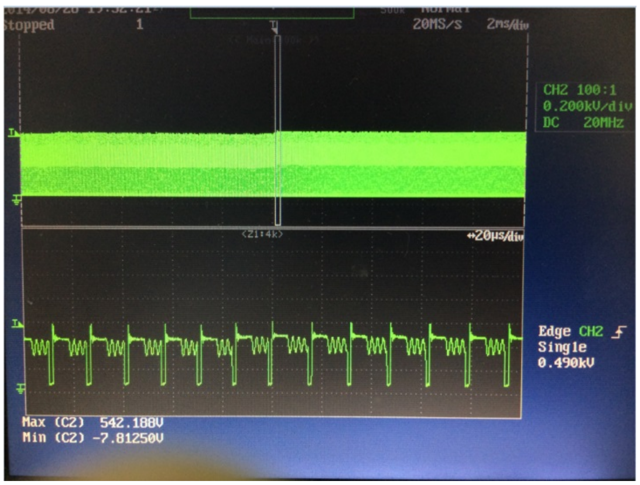

Figure 69 – 230 VAC, +2.5 kV Ring Wave Surge, 90º. V_{DRAIN}, 200 V / div., 2 ms / div.

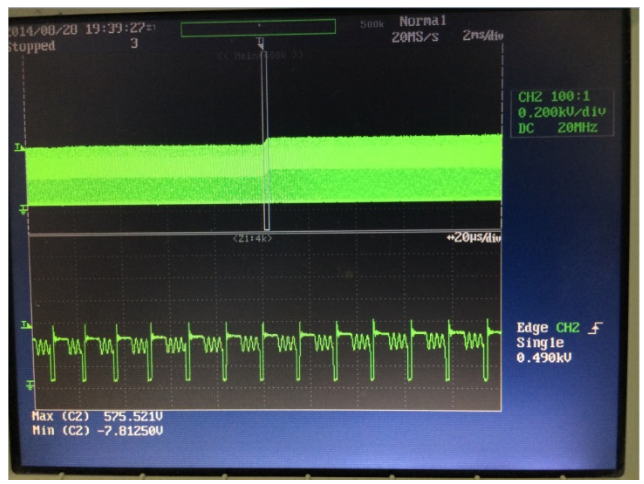

Figure 70 – 230 VAC, -2.5 kV Ring Wave Surge, 90º. V_{DRAIN}, 200 V / div., 2 ms / div.

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14 ESD

Both air and contact output ESD discharge tests were performed to IEC61000-4-2. input voltage was 230 VAC, with a 60 Hz frequency. The LED driver was operated driving full load LED string.

ESD Level (kV)	Input Voltage (VAC)	Injection Location	Type	Events	Test Result (Pass/Fail)
+15	230	Output/RTN	Air	10 strikes	Pass
-15	230	Output/RTN	Air	10 strikes	Pass
+8	230	Output/RTN	Contact	10 strikes	Pass
-8	230	Output/RTN	Contact	10 strikes	Pass

15 Revision History

Date	Author	Revision	Description and Changes	Reviewed
23-Sep-15	AP	1.0	Initial Release	Apps & Mktg

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