Reference Design Report

Title	**12 W Isolated Flyback Power Supply Using TinySwitch-5 (TNY5071K)**
Specification	85-265 VAC Input; 12 V / 1 A Output
Application	Appliance
Author	Applications Engineering Department
Document Number	RDR-1090
Date	December 19, 2025
Revision	A

Summary and Features

- Up to 150 kHz switching frequency for small transformer.
- >86% full load efficiency at 115 VAC and 230 VAC
- >87% average efficiency at 115 VAC and 230 VAC
- >70% efficient at 230 VAC and 300 mW input power
- <55 mW no-load input power at 230 VAC
- Delivers 12 W output from 85 VAC to 265 VAC
- Extensive protection features including:
    - Line Under Voltage Protection
    - Line Over Voltage Protection
    - Over Temperature Protection (OTP)
    - Short Circuit Protection
    - Over Power Protection
    - Over Voltage Protection

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Table of Contents

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.

1 Introduction

This engineering report describes a flyback converter that provides an isolated nominal output voltage of 12 V at 1 A from a wide input voltage range of 85 VAC to 265 VAC. This power supply utilizes the TNY5071K from the TinySwitch™-5 family of ICs.

This document contains the complete power supply specification, bill of materials, transformer construction, circuit schematic and printed circuit board layout, along with performance data and electrical waveforms.

Figure 1 – Isometric View.

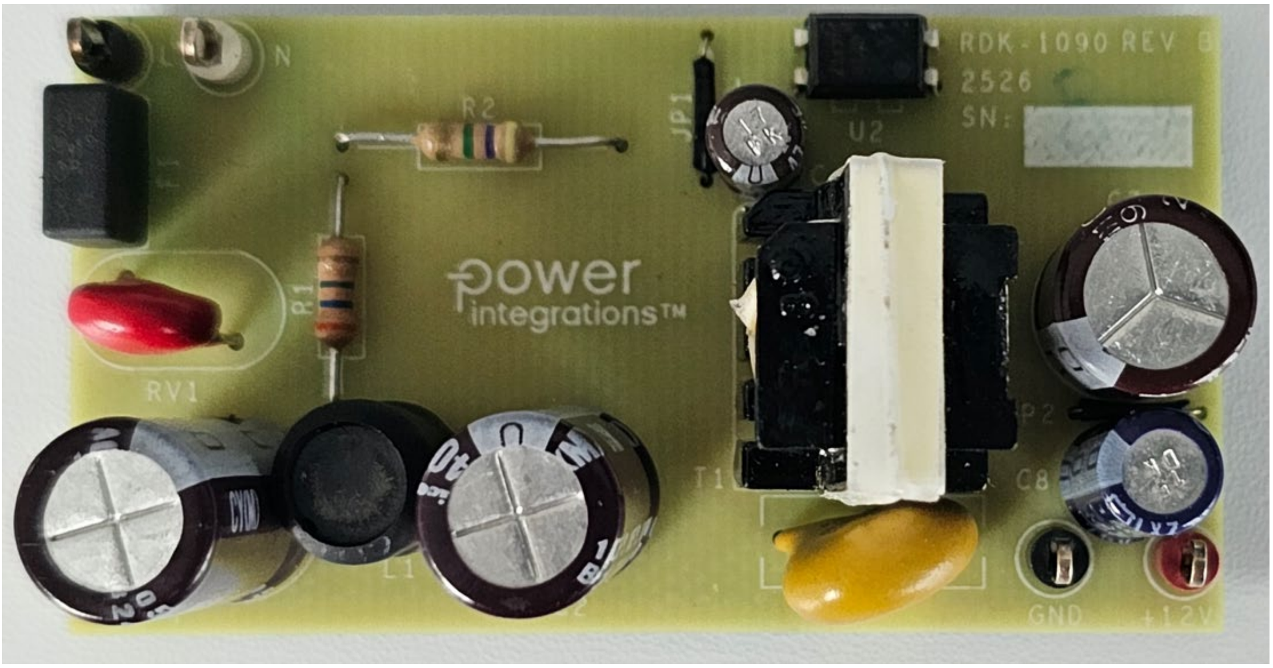


Figure 2 – Top View.

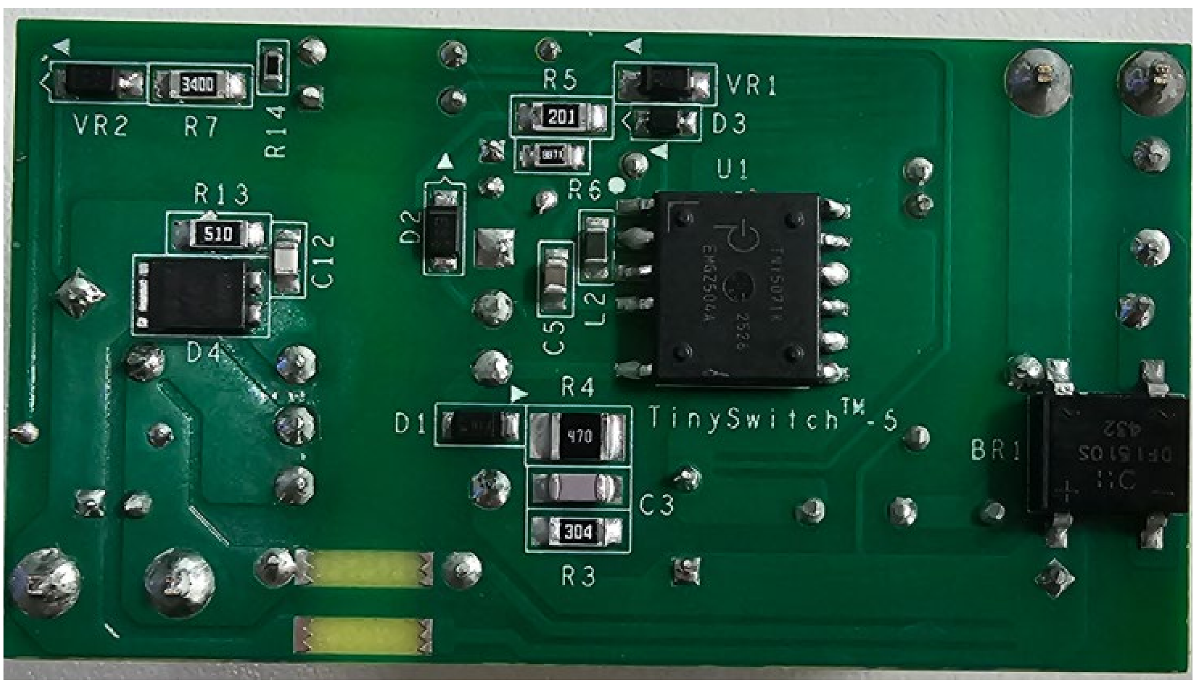


Figure 3 – Bottom View.

2 Power Supply Specification

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

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	85	115/230	265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power (230 VAC)				55	mW	
Output1						
Output Voltage	V_{OUT1}	11.4	12	12.6	V	± 5%
Output Ripple Voltage	$V_{RIPPLE1}$			240	mV	20 MHz Bandwidth.
Output Current	I_{OUT1}	0		1	A	
Total Output Power						
Continuous Output Power	P_{OUT}		12		W	
Efficiency						
Full Load 115 VAC	$\eta_{115\ VAC}$	86			%	Measured at P_{OUT} 25°C.
Full Load 230 VAC	$\eta_{230\ VAC}$	86			%	
Average efficiency at 25, 50, 75 and 100% of P_{OUT}	η_{DOE}	83			%	Measured at Nominal Input 115 VAC and 230 VAC.
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Surge (Differential)				±1	kV	1.2/50 μs Surge, IEC 61000-4-5.
Ring Wave (Common Mode)				±4	kV	
Electrical Fast Transient				±4	kV	
ESD – Air Discharge				±16.5	kV	
ESD – Contact Discharge				±8.8	kV	
Ambient Temperature	T_{AMB}	0		40	°C	Free Convection, Sea Level.

3 Schematic

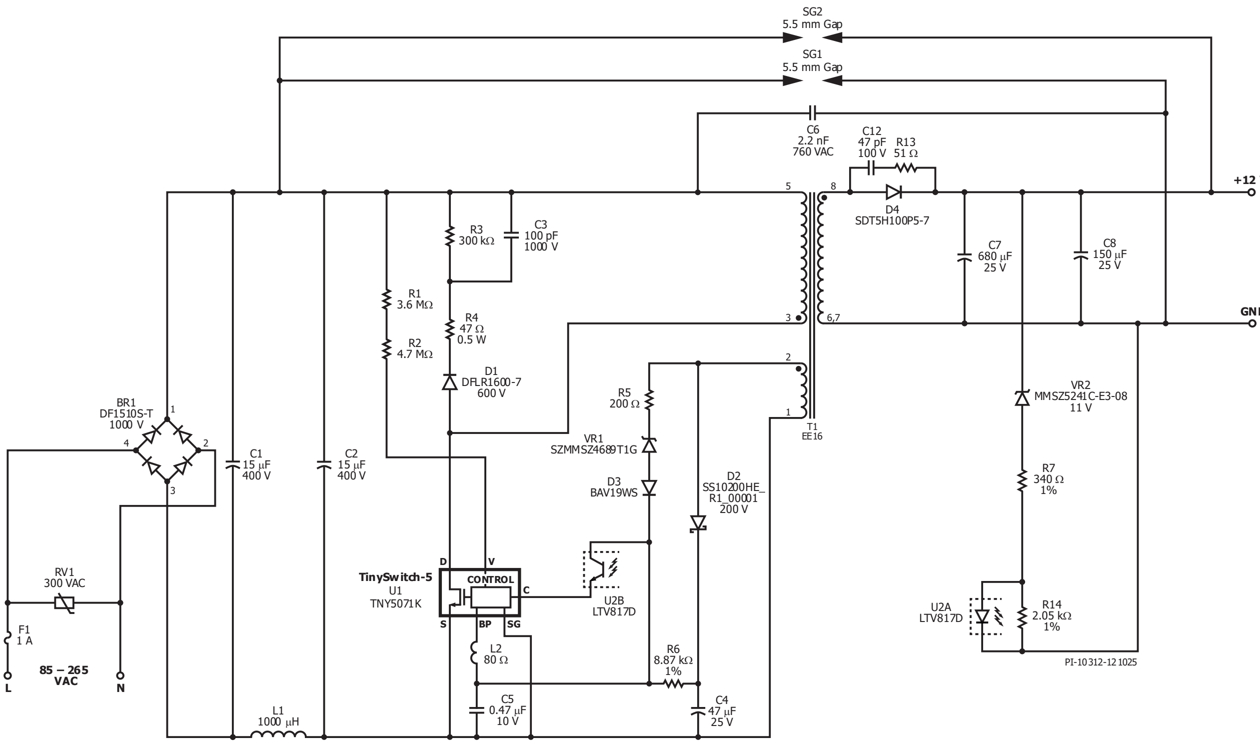


Figure 4 – Schematic.

4 Circuit Description

This power supply employs a TNY5071K off-line switcher IC, (U1), in a flyback configuration. IC U1 has an integrated 725 V power MOSFET. It regulates the output by adjusting the power MOSFET off time duration, which is proportional to the current fed into its CONTROL pin.

4.1 Input EMI Filtering and Rectification

Fuse F1 isolates the circuit and provides protection from component failure. Varistor RV1 suppresses line transient voltage surge seen by the power supply. Bulk capacitors C1 and C2 together with differential mode choke L1 forms an EMI filter that attenuates both common mode and differential mode conducted EMI. BR1 converts the AC line voltage into the DC voltage seen across bulk capacitors C1 and C2.

4.2 TinySwitch-5 Primary

The TNY5071K device (U1) integrates an oscillator, a switch controller, start-up and protection circuitry, and a power MOSFET, all on one monolithic IC. One side of the power transformer (T1) primary winding is connected to the positive side of the bulk capacitors C1 and C2, and the other side is connected to the DRAIN pin of U1. When the MOSFET turns off, the leakage inductance of the transformer induces a voltage spike on the drain node. The spike amplitude is limited by an RCD clamp network that consists of D1, R3, R4, and C3. Resistor R4 is used together with capacitor C3 to damp-out high frequency ringing and improve EMI. Y capacitor C6, connected between the primary and secondary sides helps improve EMI.

The TNY5071K IC regulates the output by adjusting the power MOSFET off-time duration based on the current fed into its CONTROL pin. The power supply output voltage is sensed on the secondary side by Zener diode VR2 and feedback is provided to the primary side through optocoupler U2.

Line undervoltage and overvoltage are determined by the current supplied to the V Pin via resistors R1 and R2. R5, D3, and VR1 are used for output overvoltage protection. An increase in output voltage causes an increase in the bias winding voltage, sensed by VR1. Once the VR1 reverse voltage threshold is exceeded it will begin to inject current into the BP pin causing IC U1 to shut down and undergo auto-restart.

Bypass capacitor C5 should be placed as close as possible to U1. At start-up, this capacitor is charged through the DRAIN (D) pin. Once it is charged, U1 begins to switch. After start-up, the bias winding powers the controller via diode D2 and capacitor C4 delivering current through resistor R6. Resistor R6 was used to set the typical bias current to the BYPASS pin of IC U1. Ferrite bead L2 minimizes noise on the BP Pin and should be place close as possible to the IC.

4.3 Output Rectification

Schottky diode D4 rectifies the secondary winding output of T1. The output voltage is filtered by C7 and C8. Resistor R13 and capacitor C12 snub the voltage spike caused by the commutation of D4. Low ESR capacitors C7 and C8 help in minimizing output voltage ripple.

4.4 Output Feedback

The output voltage regulation set point controlled by the voltage that develops across Zener diode VR2, R7 and the LED in optocoupler U2. The values of R7 and R14 can be adjusted to fine-tune the set point. When the output voltage rises above the Zener voltage, the LED current in U2 increases. The increase in optocoupler LED current will lead to a higher current fed to the C pin. This will result in an increase in primary switch off-time.

5 PCB Layout

5.1 PCB Specification

- Layer: 1
- Board Thickness: 1.6 mm.
- Copper Thickness: 2 oz.
- Finishing: LF HASL
- Material: FR4
- Solder mask: Green
- Silkscreen: White

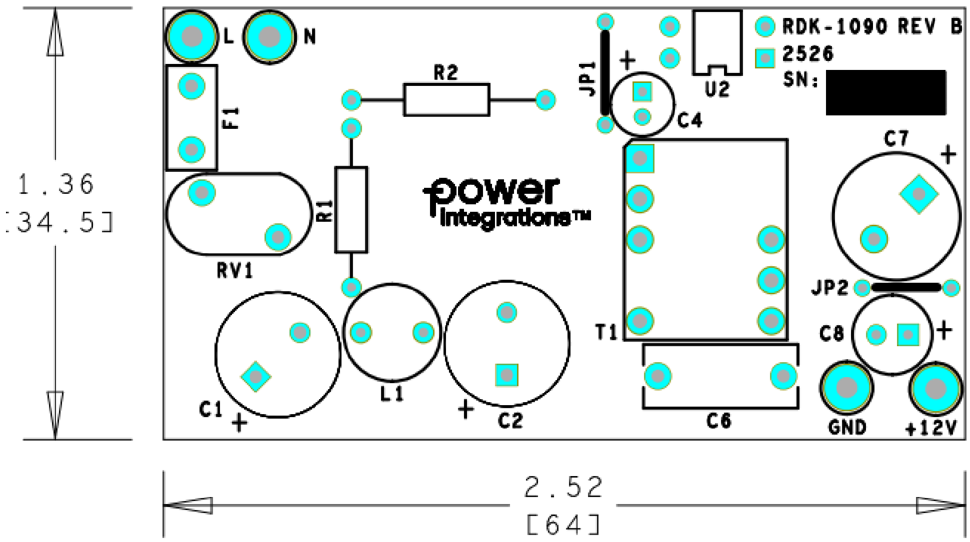


Figure 5 – Printed Circuit Board, Top View.

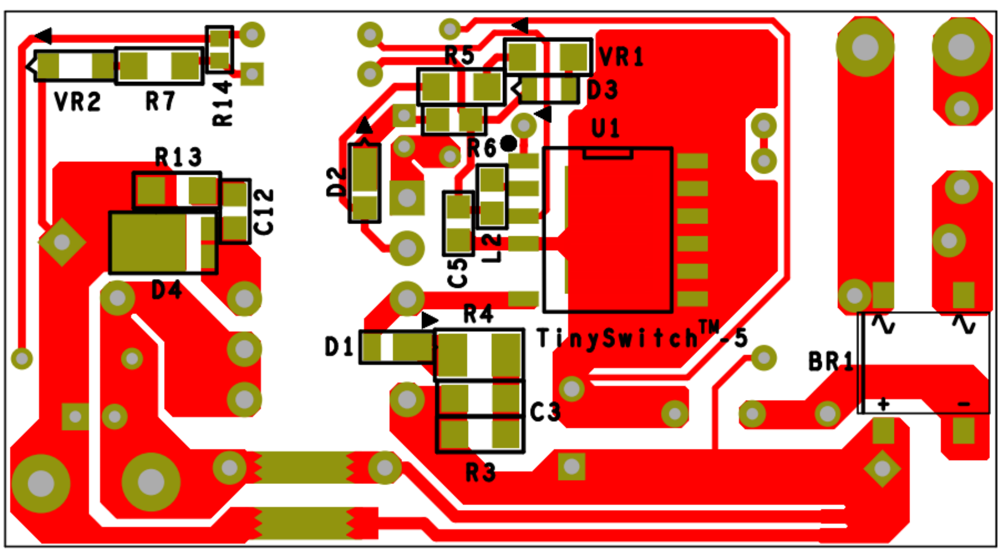


Figure 6 – Printed Circuit Board, Bottom View.

6 Bill of Materials

6.1 Electrical BOM

Item	Ref Des	Qty.	Description	Mfr. Part Number	Manufacturer
1	BR1	1	Bridge Rectifier, Single Phase, Standard, 1 kV, Surface Mount DF-S, DF-S,4-SMD	DF1510S-T	Diodes Incorporated
2	C1 C2	2	15 μF, 400 V, Electrolytic, (10 x 20)	UCY2G150MPD	Nichicon
3	C3	1	100 pF, 1000 V, Ceramic, NP0, 1206	102R18N101JV4E	Johanson Dielectrics Inc.
4	C4	1	47 μF, 25 V, Electrolytic, Very Low ESR, 300 mOhm, (5 x 11)	EKZE250ELL470ME11D	Nippon Chemi-Con
5	C5	1	0.47 μF, ±5%, 10 V, Ceramic Capacitor X7R, 0805 (2012 Metric)	VJ0805Y474JXQTW1BC	Vishay Vitramon
6	C6	1	CAP, 2200 pF, ±20%, 760 VAC, Ceramic Capacitor Y5U (E) Radial, Disc	AY1222M47Y5UC63L0	Vishay/ BC Components
7	C7	1	680 μF, 25 V, Electrolytic, Very Low ESR, 32 mOhm, (10 x 16)	EKZH250EC3681MJ16S	Nippon Chemi-Con
8	C8	1	150 μF, 25 V, Electrolytic, Low ESR, 180 mOhm, (6.3 x 15)	ELXZ250ELL151MF15D	Nippon Chemi-Con
9	C12	1	47 pF, 100 V, Ceramic, COG, 0805	08051A470JAT2A	Kemet
10	D1	1	600 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1600-7	Diodes Inc
11	D2	1	Diode, Schottky, 200 V, 1 A, Surface Mount SOD-123HE	SS10200HE_R1_00001	Panjit International Inc.
12	D3	1	100 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV19WS-7-F	Diode Inc.
13	D4	1	100 V, 5 A, Schottky, SMD, POWERD15, PowerDI™ 5	SDT5H100P5-7	Diode Inc.
14	F1	1	1 A, 250 V, Slow, Long Time Lag, RST 1	RST 1	Belfuse
15	L1	1	1000 μH, 0.3 A	RLB0914-102KL	Bourns
16	L2	1	FERRITE Bead, 80 Ohms @ 100 MHz, 1 Signal Line, Ferrite Bead 0805 (2012 Metric), 300 mA, 300 mOhm	EBMS201209K800	Max Echo
17	R1	1	RES, 3.6 M, 5%, 1/4 W, Carbon Film	CFR-25JB-3M6	Yageo
18	R2	1	RES, 4.7 M, 5%, 1/4 W, Carbon Film	CFR-25JB-4M7	Yageo
19	R3	1	RES, 300 k, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J304V	Panasonic
20	R4	1	RES, 47 Ohm, ±5%, 0.75 W, 1210 (3225 Metric), Pulse Withstanding, Thick Film	CRCW121047R0JNEAHP	Vishay Dale
21	R5	1	RES, 200 R, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J201V	Panasonic
22	R6	1	RES, 8.87 k, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF8871V	Panasonic
23	R7	1	RES, 340 R, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF3400V	Panasonic
24	R13	1	RES, 51 R, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J510V	Panasonic
25	R14	1	RES, 2.05 k, 1%, 1/10 W, Thick Film, 0603	ERJ-3EKF2051V	Panasonic
26	RV1	1	300 VAC, 25 J, 7 mm, RADIAL	V300LA4P	Littelfuse
27	T1	1	Bobbin, EE16 Vertical, 10 pins, DER-839	YW-527-00B	Yih-Hwa Enterprises

28	U1	1	TinySwitch-5, TNY5071K, eSOP-12P	TNY5071K	Power Integrations
29	U2	1	Opto coupler, 35 V, CTR 300-600%, 4-DIP	LTV-817D	Liteon
30	VR1	1	Zener Diode 5.1 V 500 mW ±5% Surface Mount SOD-123	SZMMSZ4689T1G	ON Semiconductor
31	VR2	1	Zener Diode, 11 V, ±2%, 500 mW, Surface Mount, SOD-123	MMSZ5241C-E3-08	Vishay General Semiconductor - Diodes Division

6.2 Mechanical BOM

Item	Ref Des	Qty.	Description	Mfr. Part Number	Manufacturer
1	+12 V	1	Test Point, RED, THRU-HOLE MOUNT	5010	Keystone
2	GND L	2	Test Point, RED, THRU-HOLE MOUNT	5011	Keystone
3	JP1 JP2	2	Wire Jumper, Insulated, 24 AWG, 0.2 in	C2003A-12-02	Gen Cable
4	N	1	Test Point, WHT, THRU-HOLE MOUNT	5012	Keystone

7 Transformer Specification

7.1 Electrical Diagram

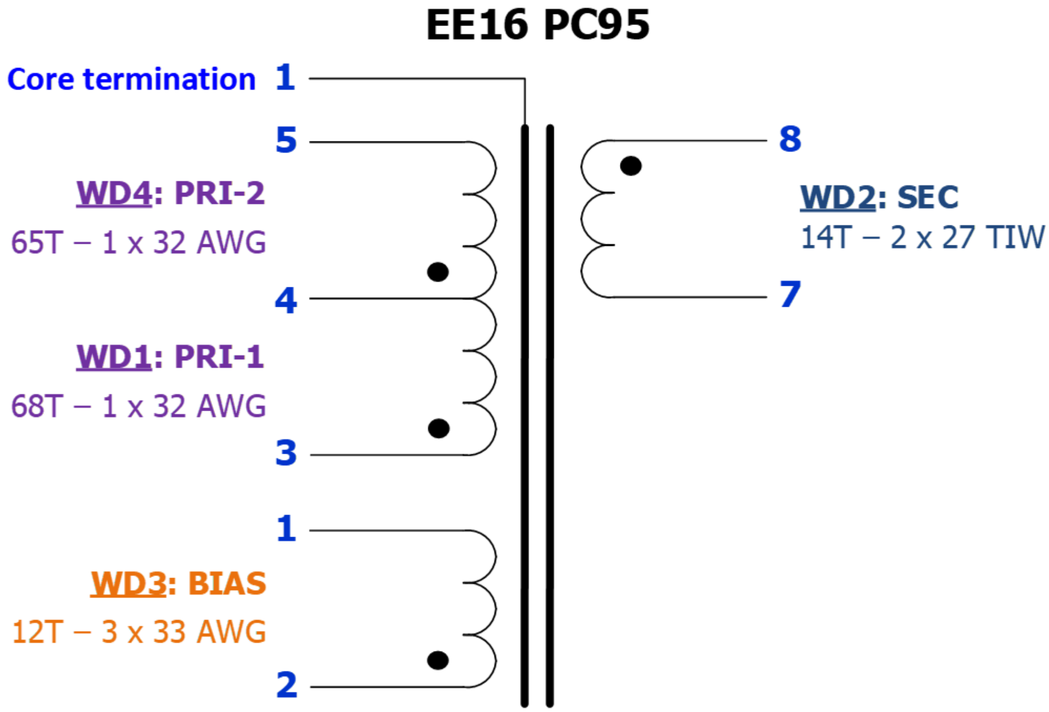


Figure 7 – Transformer Electrical Diagram.

7.2 Electrical Specifications

Parameter	Condition	Spec.
Nominal Primary Inductance	Measured at 1 V_{PK-PK}, typical switching frequency, between pin 3 to pin 5, with all other Windings open.	2093 µH
Tolerance	Tolerance of Primary Inductance.	±10%
Leakage Inductance	Measured between Pin 3 to Pin 5, with all other Windings shorted.	< 20.93 µH

7.3 Material List

Item	Description
[1]	Core: EE16 PC95
[2]	Bobbin: EE16, Vertical, 10 pins (Mfg PN: YW-527-00B, Mfg: Yih-Hwa Enterprises)
[3]	Bus wire: #28 AWG, Alpha Wire, Tinned Copper, 80 mm Length
[4]	Varnish: Dolph BC 359 or Equivalent
[5]	Magnet Wire: #32 AWG
[6]	Polyester Tape: 8.5 mm
[7]	Triple Insulated Wire: #27 AWG
[8]	Magnet Wire: #33 AWG
[9]	Polyester Tape: 4 mm

7.4 Transformer Build Diagram

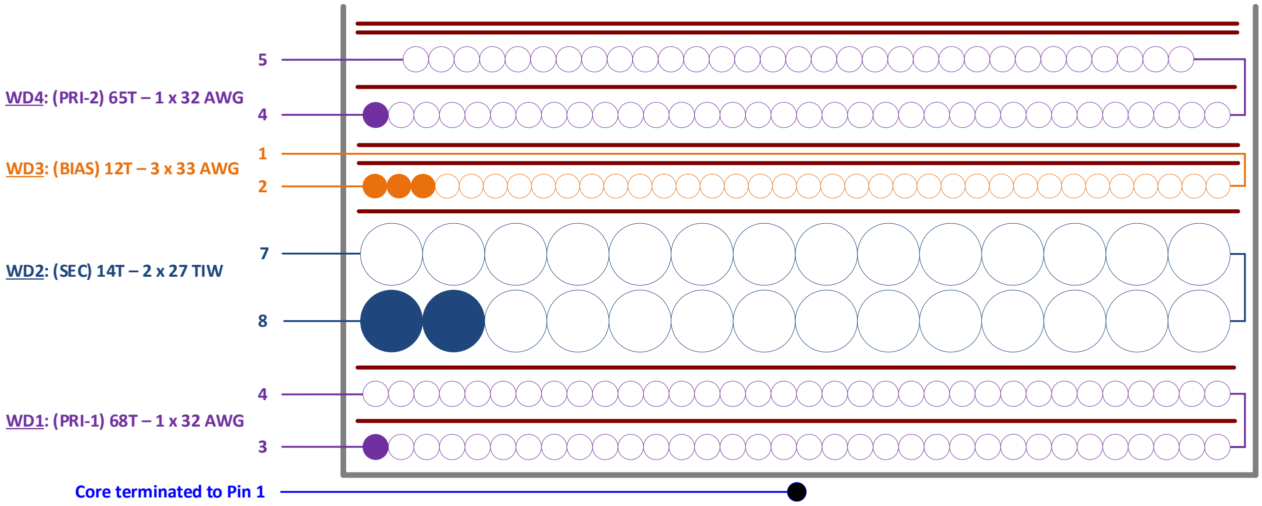
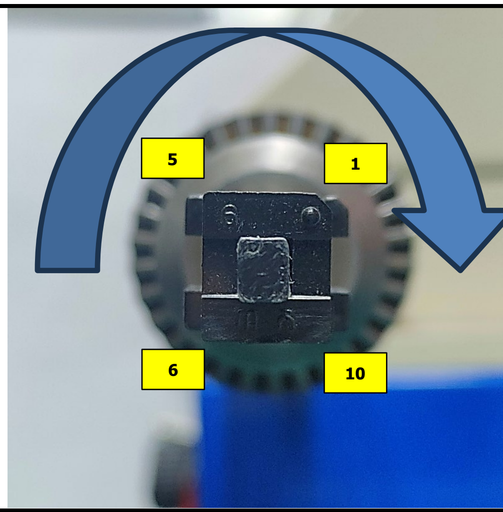
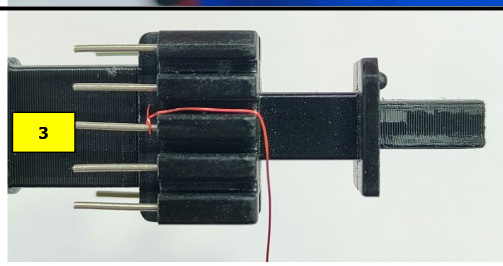


Figure 8 – Transformer Build Diagram.

7.5 Transformer Instructions

Preparation	Place the bobbin Item [2] such that pins 1-5 are on upper side while 6-10 are on lower side. The notch on the bobbin signifies Pin 1. Winding direction is clockwise as shown.
WD1 1st Primary	Start with 1 lead of Item [5] from Pin 3, and wind 68 turns in Clockwise direction in total of 2 layers. Wind one layer from left to right. Before each new layer, apply 1 layer of tape, Item [6]. At the end of 1st layer, continue to wind the next layer towards the beginning of the previous layer. Finish this winding on Pin 4.
Insulation	Apply 1 layer of tape Item [6] for insulation.
WD2 Secondary	Start with 2 leads of Item [7] at pin 8, and wind 14 turns in Clockwise direction in total of 2 layers. Wind one layer from left to right. At the end of 1st layer, continue to wind the next layer towards the beginning of the previous layer. Finish this winding on Pin 7.
Insulation	Apply 1 layer of tape Item [6] for insulation.
WD3 Bias	Start with 3 leads of Item [8] at Pin 2, and wind 12 turns in Clockwise direction in total of 1 layer. Wind one layer from left to right.
Insulation	Apply 1 layer of tape Item [6] for insulation and to hold wires in place. Bend the end of WD3 90 degrees and finish WD3 on pin 1. Finish wrapping the tape to cover WD3.
WD4 2nd Primary	Start with 1 lead of Item [5] from Pin 4, and wind 65 turns in Clockwise direction in total of 2 layers. Wind one layer from left to right. Before each new layer, apply 1 layer of tape, Item [6]. At the end of 1st layer, continue to wind the next layer towards the beginning of the previous layer. Finish this winding on Pin 5.
Insulation	Apply 2 layers of tape Item [6] for insulation.
Assembly	Grind the center leg of the upper half of Item [1] to get 2093 μH measured between Pin 3 and Pin 5 with all other pins open. Use Item [3] and wrap it around Item [1], then solder to Pin 1. Wrap the body of transformer with 2 layers of tape Item [9]. Measure Primary Inductance between Pin 3 and Pin 5 with all other pins open, then Leakage Inductance between Pin 3 and Pin 5 with all other pins shorted together.
Finish	Varnish using Item [4]. Check Primary Inductance and Leakage Inductance to confirm that the varnished transformer is within specification.

7.6 Transformer Winding Illustrations

<table>
<tr><td>Preparation</td><td>
</td><td>Place the bobbin Item [2] such that pins 1-5 are on upper side while 6-10 are on lower side. The notch on the bobbin signifies Pin 1. Winding direction is clockwise as shown.</td></tr>
<tr><td rowspan="4">WD1
1st Primary</td><td>
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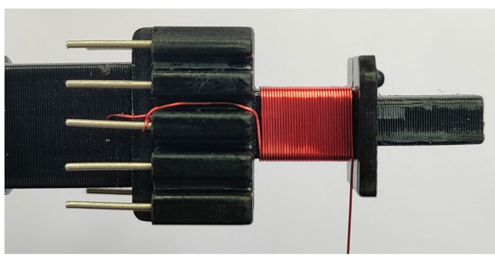
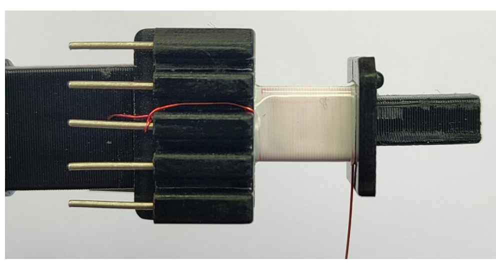
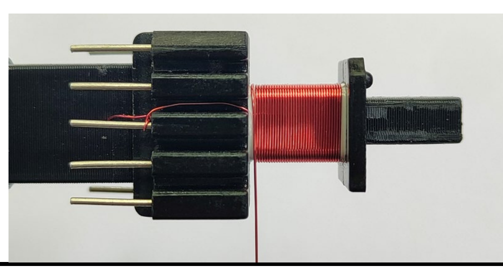
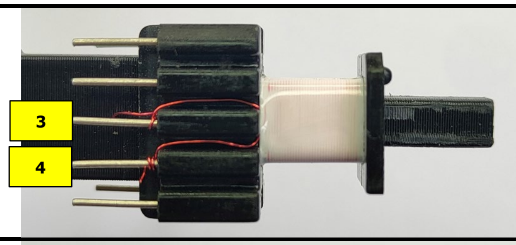
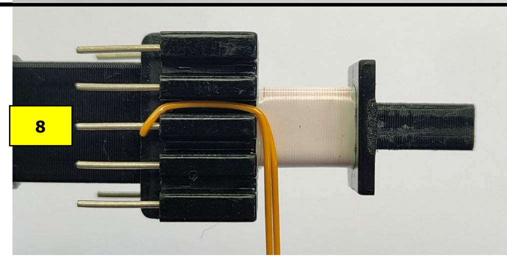
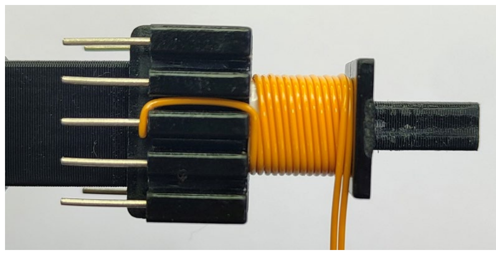
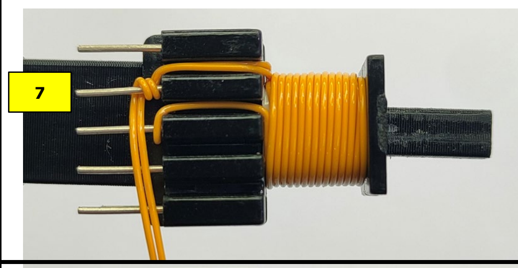
<tr><td></td><td>Wind one layer from left to right.</td></tr>
<tr><td></td><td>Before each new layer, apply 1 layer of tape, Item [6].</td></tr>
<tr><td></td><td>At the end of 1st layer, continue to wind the next layer towards the beginning of the previous layer. Finish this winding on Pin 4.</td></tr>
</table>

Insulation		Apply 1 layer of tape Item [6] for insulation.
WD2 Secondary		Start with 2 leads of Item [7] at pin 8, and wind 14 turns in Clockwise direction in total of 2 layers.
		Wind one layer from left to right.
		At the end of 1st layer, continue to wind the next layer towards the beginning of the previous layer. Finish this winding on Pin 7.
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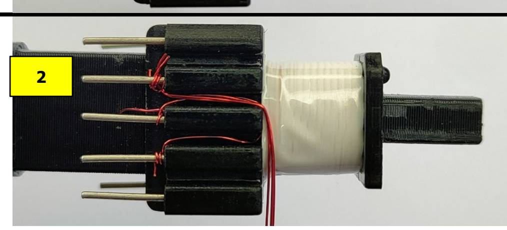
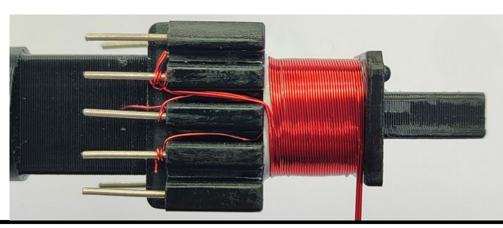
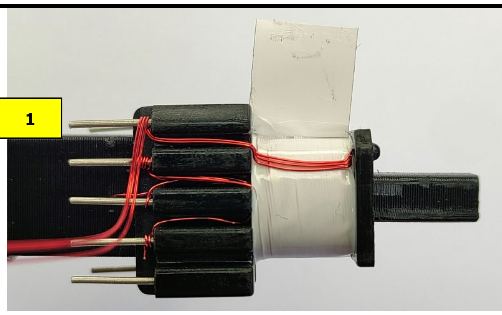
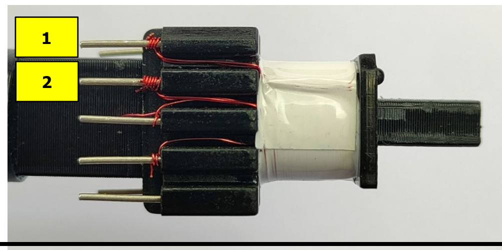
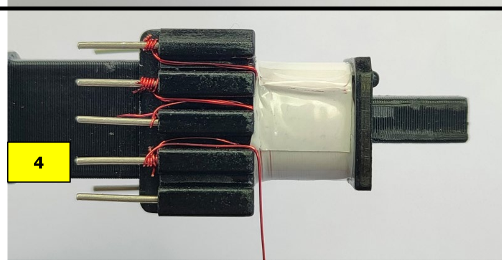
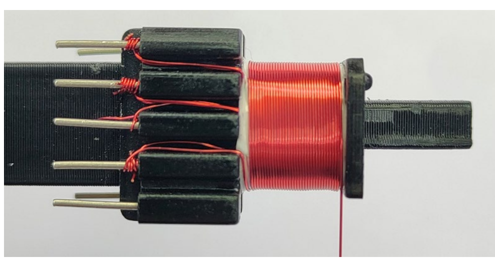
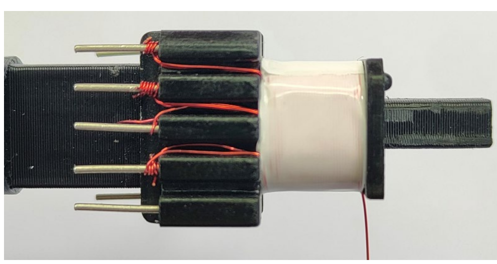
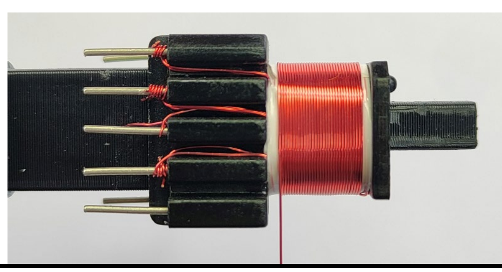
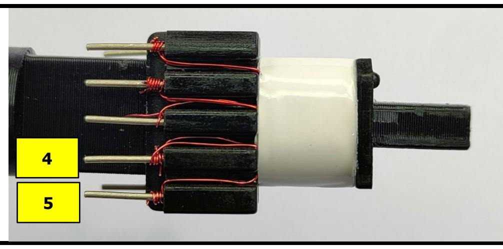
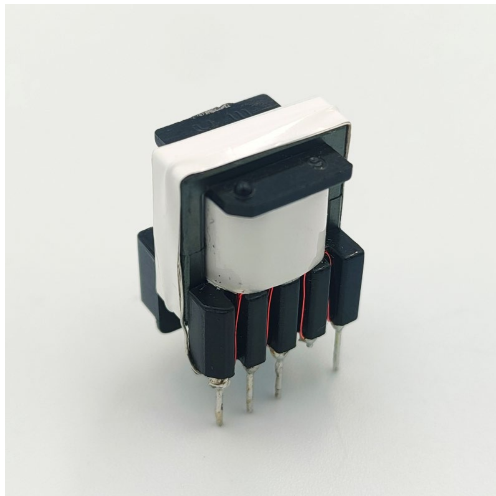
WD3 Bias		Start with 3 leads of Item [8] at Pin 2, and wind 12 turns in Clockwise direction in total of 1 layer.
		Wind one layer from left to right.

Insulation		Apply 1 layer of tape Item [6] for insulation and to hold wires in place. Bend the end of WD3 90 degrees and finish WD3 on pin 1.
		Finish wrapping the tape to cover WD3.
WD4 **2nd Primary**		Start with 1 lead of Item [5] from Pin 4, and wind 65 turns in Clockwise direction in total of 2 layers.
		Wind one layer from left to right.
		Before each new layer, apply 1 layer of tape, Item [6].
		At the end of 1st layer, continue to wind the next layer towards the beginning of the previous layer. Finish this winding on Pin 5.

Insulation		Apply 2 layers of tape Item [6] for insulation.
Assembly		Grind the center leg of the upper half of Item [1] to get 2093 μH measured between Pin 3 and Pin 5 with all other pins open. Use Item [3] and wrap it around Item [1], then solder to Pin 1. Wrap the body of transformer with 2 layers of tape Item [9]. Measure Primary Inductance between Pin 3 and Pin 5 with all other pins open, then Leakage Inductance between Pin 3 and Pin 5 with all other pins shorted together.
Finish		Varnish using Item [4]. Check Primary Inductance and Leakage Inductance to confirm that the varnished transformer is within specification.

8 Design Spreadsheet

1	**ACDC_TinySwitch5-NPC_Flyback_032925; Rev.0.2; Copyright Power Integrations 2025**	**INPUT**	**INFO**	**OUTPUT**	**UNITS**	**TinySwitch5 Single/Multi Output Flyback Design Spreadsheet**
2	APPLICATION VARIABLES					Design Title
3	INPUT_TYPE	AC		AC		Input Type
4	VIN_MIN	85		85	V	Minimum AC input voltage
5	VIN_MAX	265		265	V	Maximum AC input voltage
6	VIN_RANGE			85-265	VAC	Range of AC input voltage
7	LINEFREQ			60	Hz	AC Input voltage frequency
8	CAP_INPUT	30.0		30.0	μF	Input capacitor
9	VOUT	12.00		12.00	V	Output voltage at the board
10	IOUT	1.000		1.000	A	Output current
11	POUT			12.00	W	Output power
12	EFFICIENCY			0.87		AC-DC efficiency estimate at full load given that the converter is switching at the valley of the rectified minimum input AC voltage
13	FACTOR_Z			0.50		Z-factor estimate
14	ENCLOSURE	OPEN FRAME		OPEN FRAME		Power supply enclosure
15						
16						
17						
18	PRIMARY CONTROLLER SELECTION					
19	DEVICE_SERIES	TNY5071		TNY5071		Generic device code
20	ILIMIT_MODE	STANDARD		STANDARD		Device current limit mode
21	PACKAGE_DEVICE	eSOP		eSOP		Device Package
22	DEVICE_CODE			TNY5071K		Actual device code
23	POUT_MAX			15	W	Power capability of the device based on thermal performance
24	RDSON_100DEG			15.58	Ω	Primary switch on time drain resistance at 100 °C
25	ILIMIT_MIN			0.348	A	Minimum current limit of the primary switch
26	ILIMIT_TYP			0.375	A	Typical current limit of the primary switch
27	ILIMIT_MAX			0.402	A	Maximum current limit of the primary switch
28	VDRAIN_BREAKDOWN			725	V	Device breakdown voltage
29	VDRAIN_ON_PRSW			2.23	V	Primary switch on time drain voltage
30	VDRAIN_OFF_PRSW			523.4	V	Peak drain voltage on the primary switch during turn-off. A 30 V leakage spike voltage is assumed
31						
32						
33						
34	WORST CASE ELECTRICAL PARAMETERS					
35	FSWITCHING_MAX			130000	Hz	Maximum switching frequency at full load and valley of the rectified minimum AC input voltage.
36	VOR	120.0		120.0	V	Secondary voltage reflected to the primary when the primary switch turns off

37	VMIN			92.22	V	Valley of the minimum input AC voltage at full load
38	KP			0.57		Measure of continuous/discontinuous mode of operation
39	MODE_OPERATION			CCM		Mode of operation
40	DUTYCYCLE			0.571		Primary switch duty cycle
41	TIME_ON			13.50	µs	Primary switch on-time
42	TIME_ON_AT_FSWITCHING_MAX			4.40	µs	Primary switch on-time at FSWITCHING_MAX
43	TIME_OFF			3.30	µs	Primary switch off-time at 85 VAC, 12 W, and 130000 Hz.
44	LPRIMARY_MIN			1883.4	µH	Minimum primary inductance
45	LPRIMARY_TYP			2092.7	µH	Typical primary inductance
46	LPRIMARY_TOL			10.0	%	Primary inductance tolerance
47	LPRIMARY_MAX			2302.0	µH	Maximum primary inductance
48						
49	PRIMARY CURRENT					
50	IPEAK_PRIMARY			0.399	A	Primary switch peak current
51	IPEDESTAL_PRIMARY			0.150	A	Primary switch current pedestal
52	IAVG_PRIMARY			0.143	A	Primary switch average current
53	IRIPPLE_PRIMARY			0.296	A	Primary switch ripple current
54	IRMS_PRIMARY			0.200	A	Primary switch RMS current
55						
56	SECONDARY CURRENT					
57	IPEAK_SECONDARY			3.789	A	Secondary winding peak current
58	IPEDESTAL_SECONDARY			1.426	A	Secondary winding current pedestal
59	IRMS_SECONDARY			1.648	A	Secondary winding RMS current
60						
61						
62						
63	TRANSFORMER CONSTRUCTION PARAMETERS					
64	CORE SELECTION					
65	CORE	EE16 - Custom		EE16 - Custom		Core selection. Refer to the 'Transformer Construction' tab to see the detailed report
66	CORE CODE			PC95EE16		Core code
67	AE			19.00	mm^2	Core cross sectional area
68	LE			34.50	mm	Core magnetic path length
69	AL			1140	nH/turns^2	Ungapped core effective inductance
70	VE			656.0	mm^3	Core volume
71	BOBBIN			BE16-116CPFR		Bobbin
72	AW			26.90	mm^2	Window area of the bobbin
73	BW			8.50	mm	Bobbin width
74	MARGIN			0.0	mm	Safety margin width (Half the primary to secondary creepage distance)
75						

76	PRIMARY WINDING					
77	NPRIMARY			133		Primary turns
78	BPEAK			3780	Gauss	Peak flux density
79	BMAX			3571	Gauss	Maximum flux density
80	BAC			1286	Gauss	AC flux density (0.5 x Peak to Peak)
81	ALG			118	nH/turns^2	Typical gapped core effective inductance
82	LG			0.181	mm	Core gap length
83						
84	PRIMARY BIAS WINDING					
85	NBIAS_PRIMARY			12	turns	Primary bias winding number of turns
86						
87	SECONDARY WINDING					
88	NSECONDARY	14		14	turns	Secondary winding number of turns
89						
90	SECONDARY BIAS WINDING					
91	NBIAS_SECONDARY			NA	turns	Secondary bias winding number of turns
92						
93						
94						
95	PRIMARY COMPONENTS SELECTION					
96	LINE UNDERVOLTAGE					
97	BROWN-IN REQURED			76.08	V	Required AC RMS/DC line voltage brown-in threshold
98	RLS			8.04	MΩ	Connect two 4.02 MOhm resistors to the V-pin for the required UV/OV threshold
99	BROWN-IN ACTUAL			63.5V - 78.6V	V	Actual AC RMS/DC brown-in range
100	BROWN-OUT ACTUAL			55V - 67.9V	V	Actual AC RMS/DC brown-out range
101						
102	LINE OVERVOLTAGE					
103	OVERVOLTAGE_LINE			285.4V - 355.2V	V	Actual AC RMS/DC line over-voltage range
104						
105	PRIMARY BIAS DIODE					
106	VBIAS_PRIMARY	10.0		10.0	V	Rectified primary bias voltage
107	VF_BIAS_PRIMARY			0.70	V	Bias winding diode forward drop
108	VREVERSE_BIASDIODE_PRIMARY			43.97	V	Bias diode reverse voltage (not accounting parasitic voltage ring)
109	CBIAS_PRIMARY			47	μF	Bias winding rectification capacitor
110	CBP			0.47	μF	BP pin capacitor
111						
112						
113						
114	SECONDARY COMPONENTS					
115	VREF_REG	2.50		2.50	V	Reference voltage of the feedback
116	RFB_UPPER			38.30	kΩ	Upper feedback resistor (connected to the first output voltage)
117	RFB_LOWER			10.00	kΩ	Lower feedback resistor
118						

119	SECONDARY BIAS DIODE					
120	USE_SECONDARY_BIAS	AUTO		NO		Use secondary bias winding for the design
121	VBIAS_SECONDARY			NA	V	Rectified secondary bias voltage
122	VF_BIAS_SECONDARY			NA	V	Bias winding diode forward drop
123	VREVERSE_BIASDIODE_SECONDARY			NA	V	Bias diode reverse voltage (not accounting parasitic voltage ring)
124	CBIAS_SECONDARY			NA	μF	Bias winding rectification capacitor
125						
126						
127	MULTIPLE OUTPUT PARAMETERS					
128	OUTPUT 1					
129	VOUT1			12.00	V	Output 1 voltage
130	IOUT1			1.00	A	Output 1 current
131	POUT1			12.00	W	Output 1 power
132	VD1			0.70	V	Forward voltage drop of diode for output 1
133	NS1			14.00	turns	Number of turns for output 1
134	ISPEAK1			3.79	A	Instantaneous peak value of the secondary current for output 1
135	ISRMS1			1.648	A	Root-mean-squared value of the secondary current for output 1
136	ISRIPPLE1			1.310	A	Current ripple on the secondary waveform for output 1
137	PIV1_CALCULATED			61.28	V	Computed peak inverse voltage stress on the diode for output 1
138	OUTPUT_RECTIFIER1	AUTO		SB380		Recommended diode for output 1.
139	PIV1_RATING			80.00	V	Peak inverse voltage rating on the diode for output 1
140	TRR1			0.00	ns	Reverse recovery time of the diode for output 1
141	IFM1			3.00	A	Maximum forward continuous current of the diode for output 1
142	PLOSS_DIODE1			1.23	W	Maximum diode power loss for output 1

9 Performance Data

9.1 Full Load Efficiency vs. Line

Test condition: Soak for 15 minutes for each line.

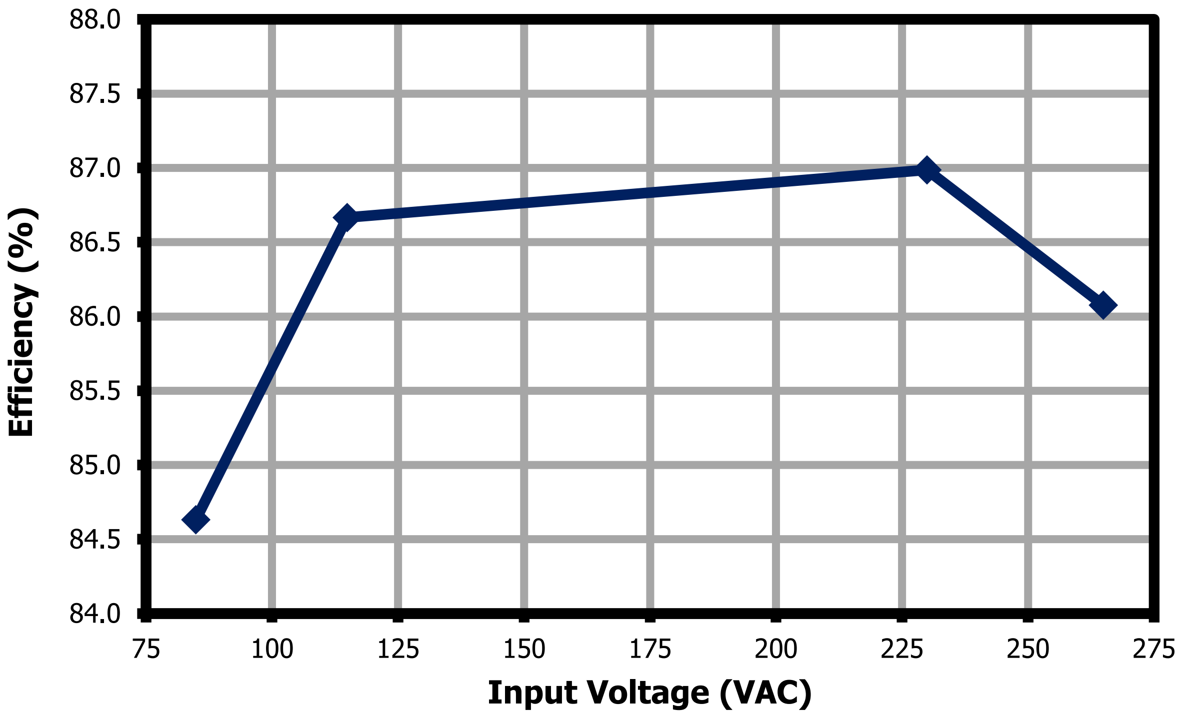


Figure 9 – Efficiency vs. Input Voltage.

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(%)
85	60	84.9	301	14.3	12.1	1.00	12.1	0.92	84.6
115	60	115	245	14.0	12.2	1.00	12.1	1.21	86.7
230	50	230	165	14.0	12.2	1.00	12.2	1.31	87.0
265	50	265	154	14.1	12.2	1.00	12.2	1.3	86.1

9.2 Efficiency vs. Load

Test Condition: Soak for 15 minutes each line at full load, and 10 seconds for each load.

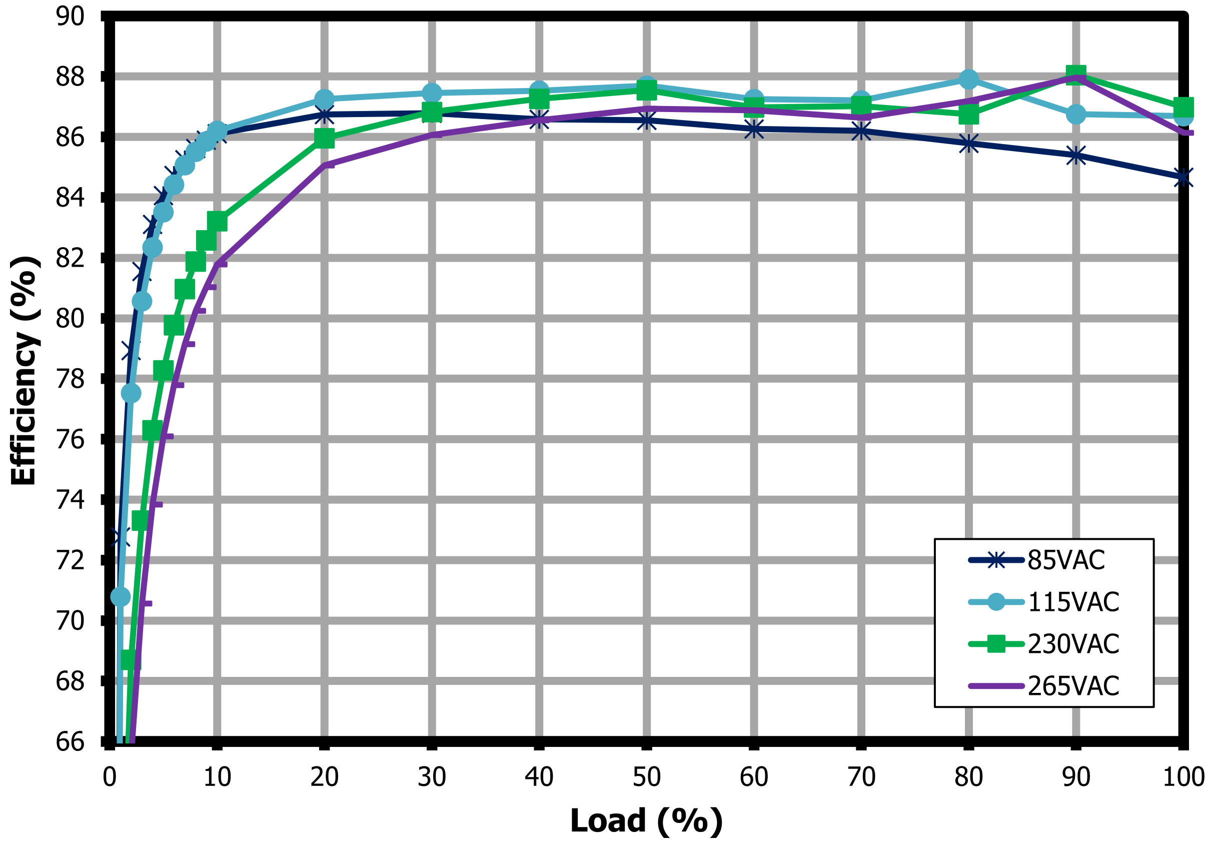


Figure 10 – Efficiency vs. Percentage Load.

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(%)
85	60	84.9	302	14.3	12.1	1.0	12.1	0.95	84.7
85	60	84.9	276	12.8	12.1	0.9	10.9	1.11	85.4
85	60	85.0	250	11.3	12.1	0.8	9.71	1.18	85.8
85	60	85.0	224	9.9	12.2	0.7	8.50	1.23	86.2
85	60	85.0	197	8.5	12.2	0.6	7.29	1.28	86.3
85	60	85.0	170	7.02	12.2	0.5	6.07	1.30	86.6
85	60	85.0	142	5.61	12.2	0.4	4.86	1.33	86.6
85	60	85.0	112	4.20	12.2	0.3	3.64	1.33	86.8
85	60	85.0	82.3	2.80	12.2	0.2	2.43	1.33	86.7
85	60	85.0	45.3	1.40	12.1	0.1	1.21	0.99	86.1
85	60	85.0	2.5	0.03	12.1	0.00	0.00	0.95	

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(%)
115	60	115	246	14.0	12.1	1.0	12.1	1.13	86.7
115	60	115	226	12.6	12.1	0.9	10.9	1.18	86.8
115	60	115	203	11.2	12.2	0.8	9.71	1.22	87.9
115	60	115	184	9.75	12.2	0.7	8.50	1.27	87.2
115	60	115	164	8.35	12.2	0.6	7.29	1.28	87.3
115	60	115	143	6.93	12.2	0.5	6.07	1.28	87.7
115	60	115	121	5.55	12.2	0.4	4.86	1.29	87.5
115	60	115	94.3	4.17	12.2	0.3	3.64	1.29	87.5
115	60	115	66.1	2.78	12.2	0.2	2.43	1.28	87.3
115	60	115	35.9	1.40	12.1	0.1	1.21	0.87	86.2
115	60	115	2.17	0.03	12.1	0.00	0.00	0.88	

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(%)
230	50	230	164	14.0	12.1	1.0	12.1	1.17	87.0
230	50	230	150	12.4	12.2	0.9	10.9	1.22	88.1
230	50	230	139	11.2	12.2	0.8	9.72	1.25	86.8
230	50	230	123	9.77	12.2	0.7	8.50	1.28	87.0
230	50	230	108	8.38	12.2	0.6	7.29	1.29	87
230	50	230	89.6	6.94	12.2	0.5	6.07	1.30	87.6
230	50	230	73.6	5.57	12.2	0.4	4.86	1.31	87.3
230	50	230	57.1	4.20	12.2	0.3	3.64	1.30	86.8
230	50	230	40.0	2.82	12.2	0.2	2.43	1.30	86
230	50	230	22.1	1.45	12.1	0.1	1.21	0.84	83.2
230	50	230	1.66	0.07	12.1	0.00	0.00	0.86	

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(%)
265	50	265	153	14.1	12.2	1.0	12.1	1.24	86.1
265	50	265	137	12.4	12.2	0.9	10.9	1.28	88.0
265	50	265	125	11.2	12.2	0.8	9.72	1.32	87.1
265	50	265	111	9.82	12.2	0.7	8.51	1.34	86.6
265	50	265	95.1	8.40	12.2	0.6	7.29	1.36	86.9
265	50	265	80.8	6.99	12.2	0.5	6.08	1.36	86.9
265	50	265	66.4	5.62	12.2	0.4	4.86	1.34	86.6
265	50	265	51.5	4.23	12.2	0.3	3.64	1.34	86.1
265	50	265	36.2	2.86	12.2	0.2	2.43	1.33	85.1
265	50	265	20.1	1.48	12.1	0.1	1.21	0.83	81.8
265	50	265	1.53	0.09	12.1	0.00	0.00	0.86	

9.3 Average and 10% Efficiency

9.3.1 Average and 10% Efficiency at 115 VAC

Load	P_{IN}	V_{OUT} at PCB	I_{OUT}	P_{OUT}	Efficiency at PCB	Average Efficiency	DOE6 Limit
(A)	(W)	(V_{DC})	(A_{DC})	(W)	(%)	(%)	(%)
100%	14.0	12.2	1.00	12.2	86.7	**87.3**	**83.0**
75%	10.4	12.2	0.75	9.12	87.4		
50%	6.93	12.2	0.50	6.08	87.7		
25%	3.48	12.2	0.25	3.04	87.4		
10%	1.41	12.2	0.10	1.21	86.3	---	---

9.3.2 Average and 10% Efficiency at 230 VAC

Load	P_{IN}	V_{OUT} at PCB	I_{OUT}	P_{OUT}	Efficiency at PCB	Average Efficiency	DOE6 Limit
(A)	(W)	(V_{DC})	(A_{DC})	(W)	(%)	(%)	(%)
100%	14.0	12.2	1.00	12.2	87.1	**87.2**	**83.0**
75%	10.4	12.2	0.75	9.12	88.0		
50%	6.95	12.2	0.50	6.08	87.5		
25%	3.52	12.2	0.25	3.04	86.5		
10%	1.46	12.2	0.10	1.21	83.2	---	---

9.4 No-Load Input Power

Test Condition: Soak for 15 minutes each line and 1 minute integration time.

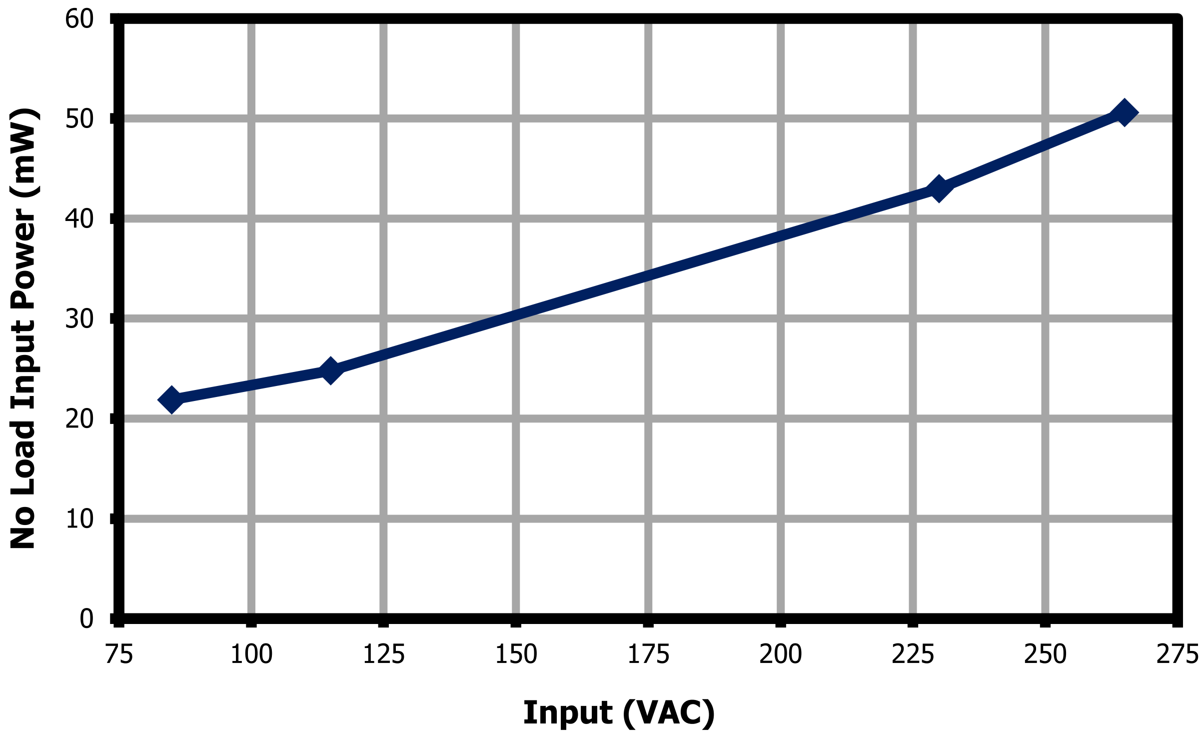


Figure 11 – No-Load Input Power vs. Line at Room Temperature.

VAC	No Load P_{IN}
(RMS)	(mW)
85	21.9
115	24.8
230	43.0
265	50.6

9.5 Line Regulation

Test Condition: Soak for 15 minutes for each line.

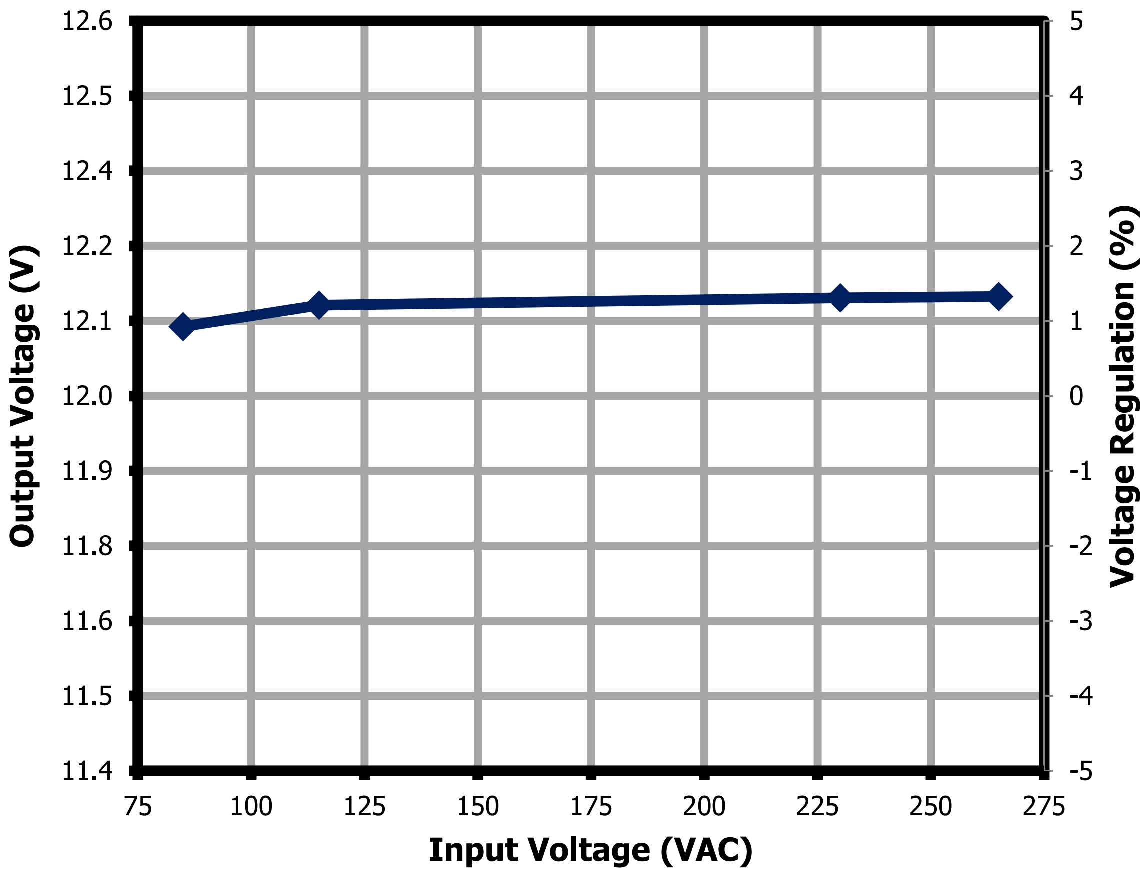


Figure 12 – Output Voltage vs. Line Voltage.

9.6 Load Regulation

Test Condition: Soak for 15 minutes each line at full load, and 10 seconds for each load.

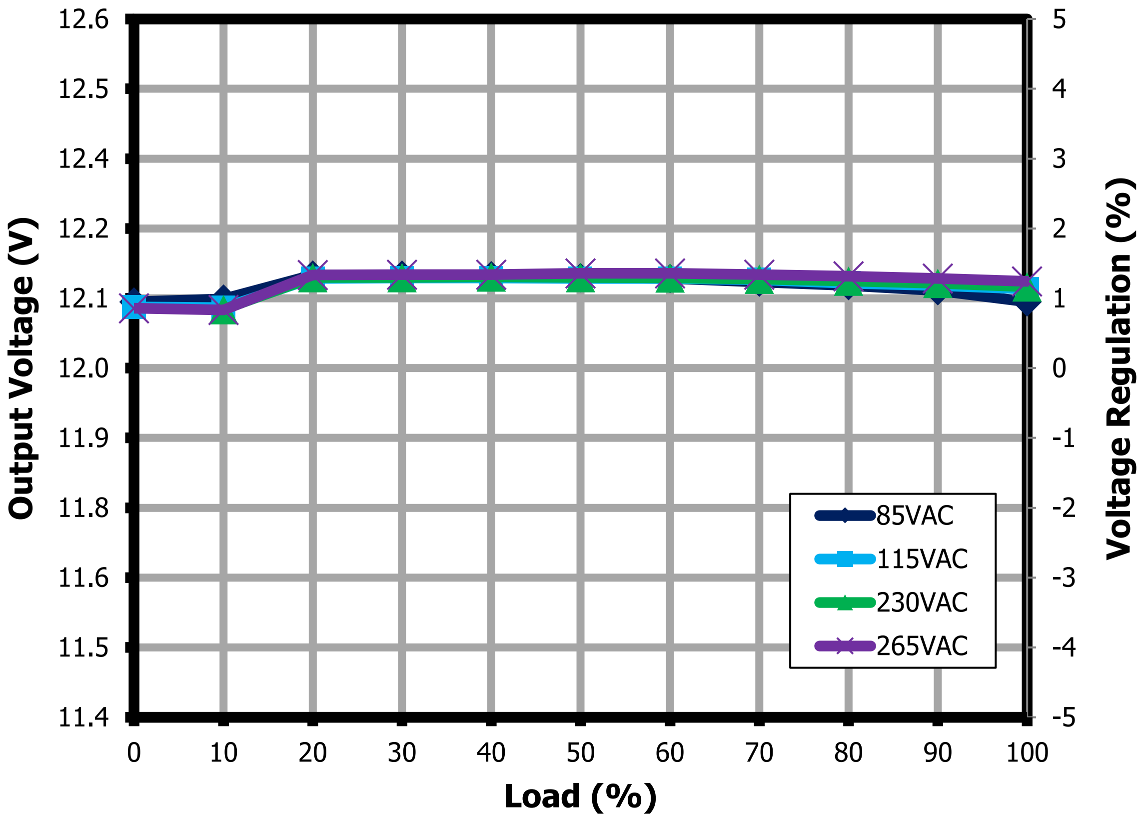


Figure 13 – Output Voltage vs. Percent Load.

9.7 Standby Efficiency

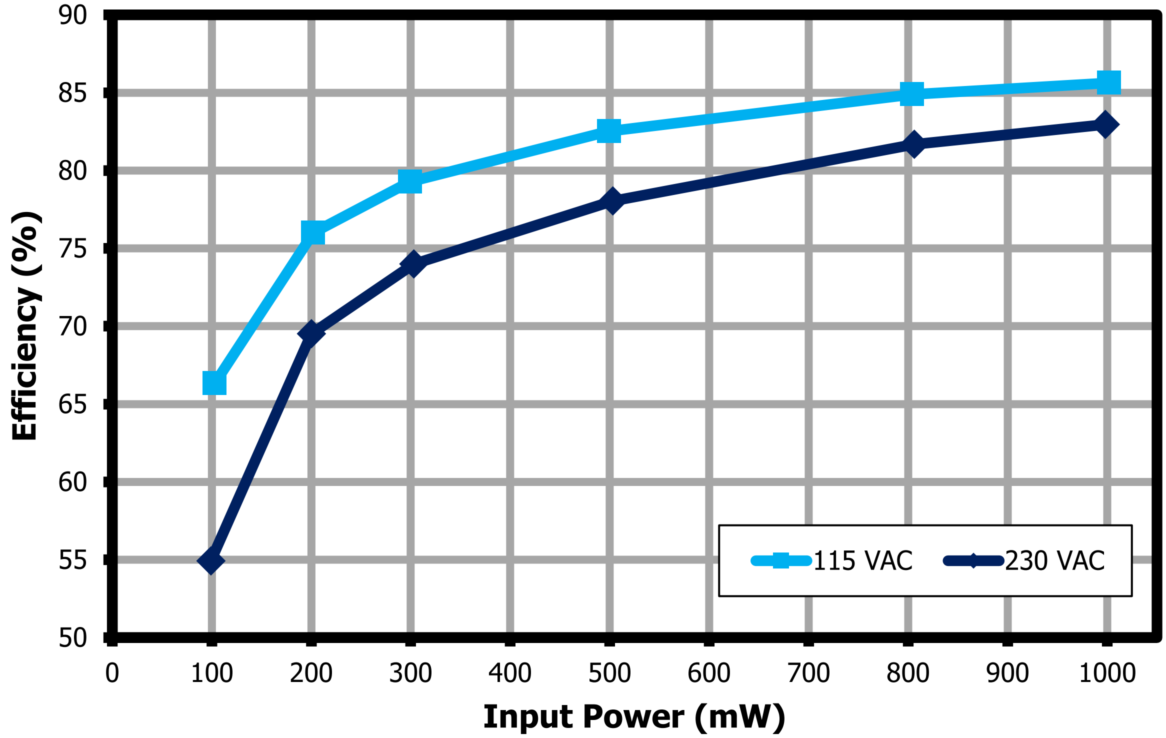


Figure 14 – Efficiency vs. Input Power.

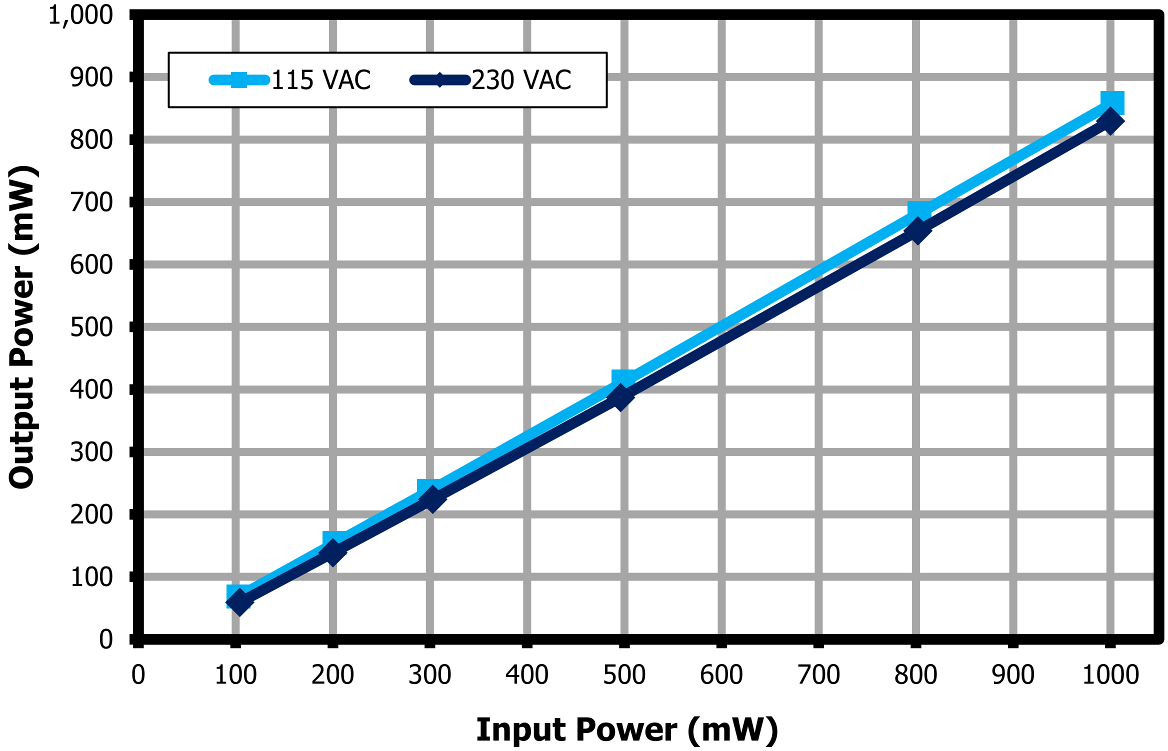


Figure 15 – Output Power vs. Input Power.

10 Waveforms

10.1 Switching Waveforms

10.1.1 Primary MOSFET Drain-Source Voltage and Current at Normal Operation

10.1.1.1 Full Load

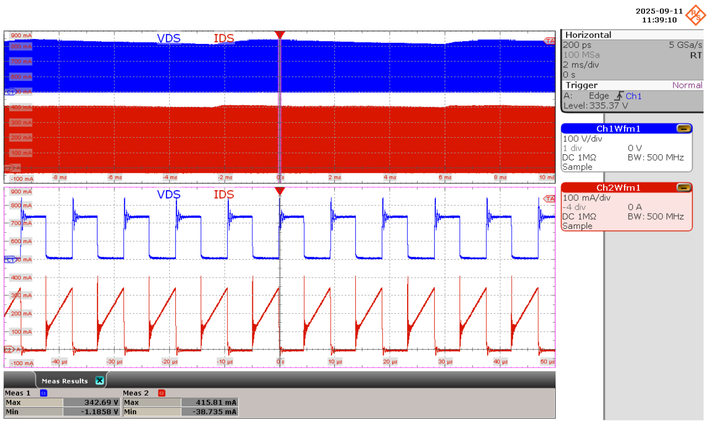


Figure 16 – 85 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 2 ms / div.
CH2: I_{DS}, 100 mA / div., 2 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 343 V
$I_{DS(MAX)}$ = 416 mA

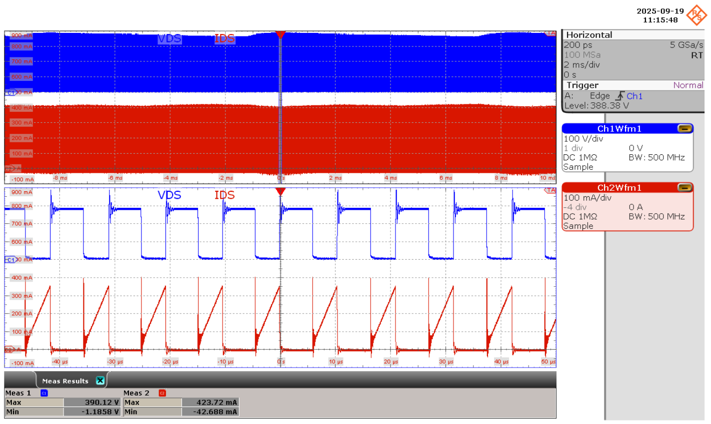


Figure 17 – 115 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 2 ms / div.
CH2: I_{DS}, 100 mA / div., 2 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 390 V
$I_{DS(MAX)}$ = 424 mA

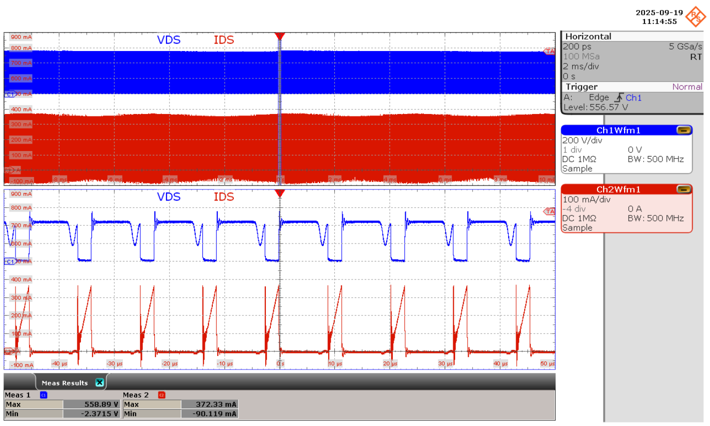


Figure 18 – 230 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 2 ms / div.
CH2: I_{DS}, 100 mA / div., 2 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 559 V
$I_{DS(MAX)}$ = 372 mA

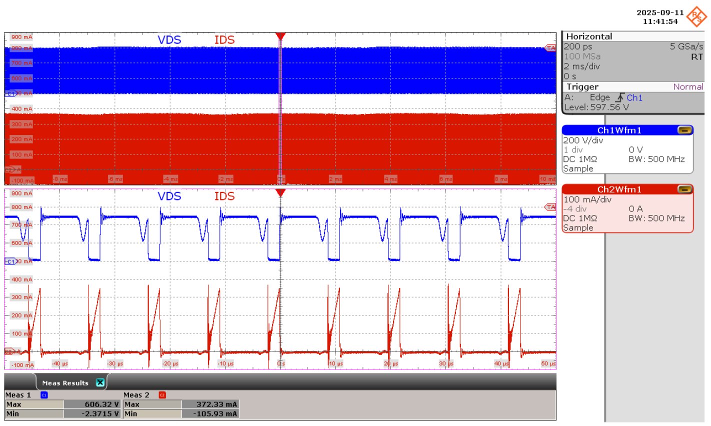


Figure 19 – 265 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 2 ms / div.
CH2: I_{DS}, 100 mA / div., 2 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 606 V
$I_{DS(MAX)}$ = 372 mA

10.1.1.2 No Load

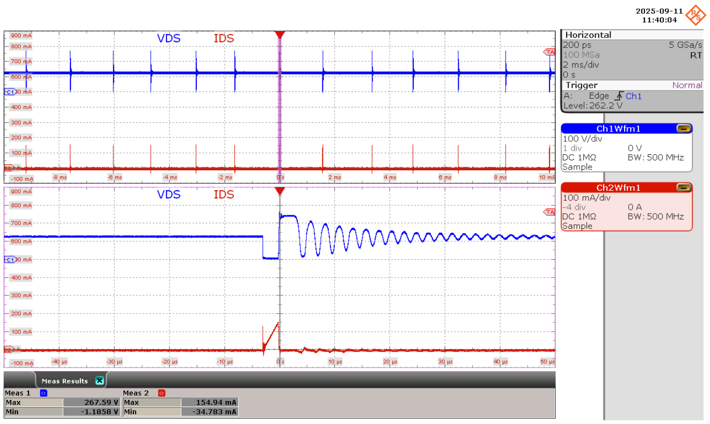


Figure 20 – 85 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 2 ms / div.
CH2: I_{DS}, 100 mA / div., 2 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 268 V
$I_{DS(MAX)}$ = 155 mA

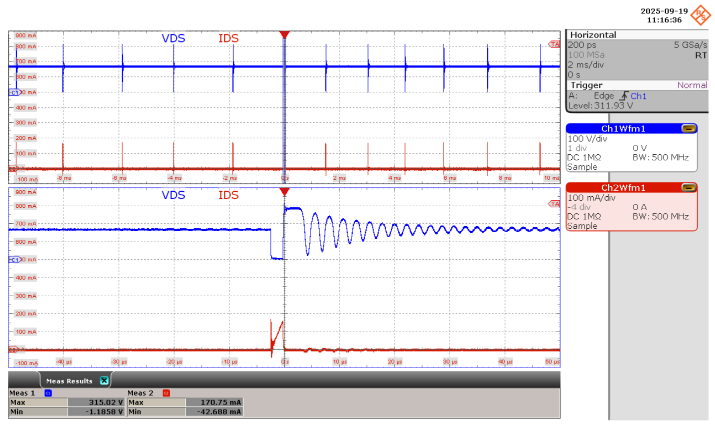


Figure 21 – 115 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 2 ms / div.
CH2: I_{DS}, 100 mA / div., 2 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 315 V
$I_{DS(MAX)}$ = 171 mA

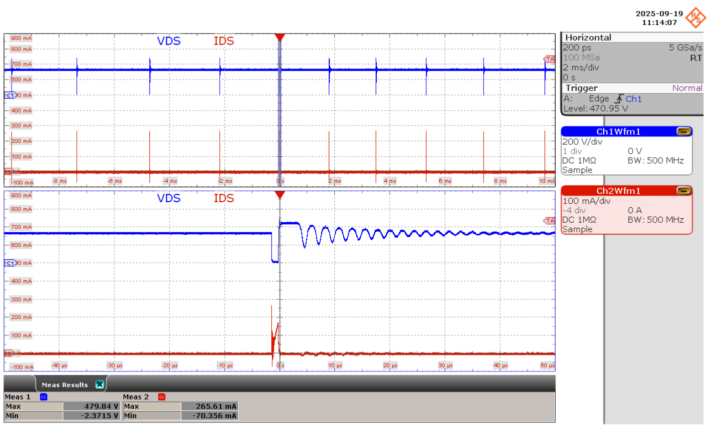


Figure 22 – 230 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 2 ms / div.
CH2: I_{DS}, 100 mA / div., 2 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 480 V
$I_{DS(MAX)}$ = 266 mA

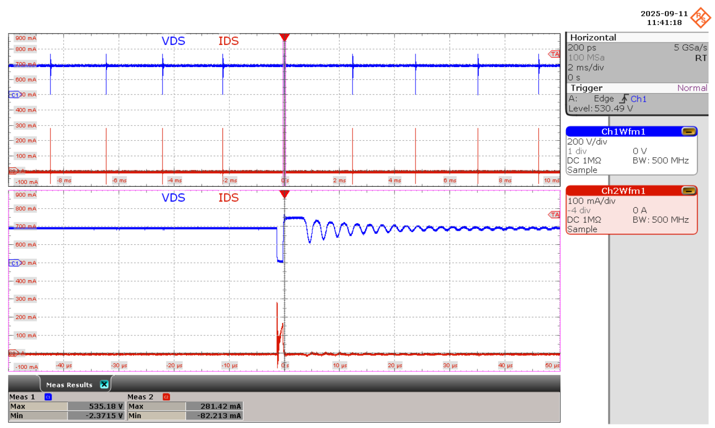


Figure 23 – 265 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 2 ms / div.
CH2: I_{DS}, 100 mA / div., 2 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 535 V
$I_{DS(MAX)}$ = 281 mA

10.1.2 Primary MOSFET Drain-Source Voltage and Current at Start-up Operation

10.1.2.1 Full Load

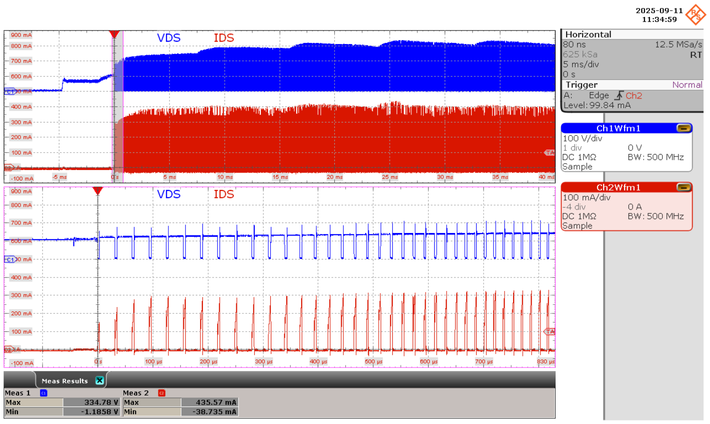


Figure 24 – 85 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 5 ms / div.
CH2: I_{DS}, 100 mA / div., 5 ms / div.
Zoom: 100 µs / div.
$V_{DS(MAX)}$ = 335 V
$I_{DS(MAX)}$ = 436 mA

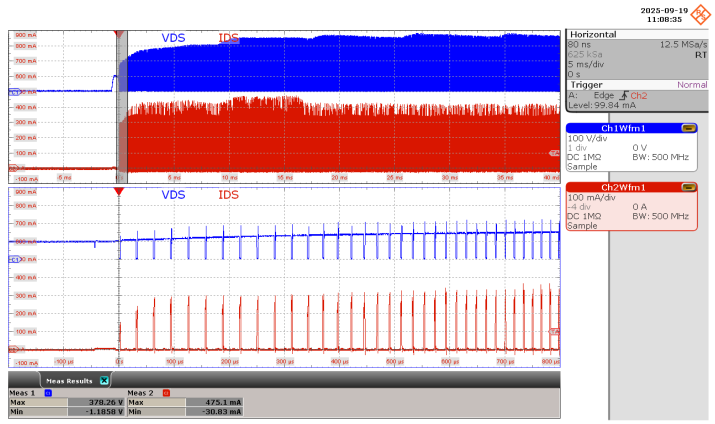


Figure 25 – 115 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 5 ms / div.
CH2: I_{DS}, 100 mA / div., 5 ms / div.
Zoom: 100 µs / div.
$V_{DS(MAX)}$ = 378 V
$I_{DS(MAX)}$ = 475 mA

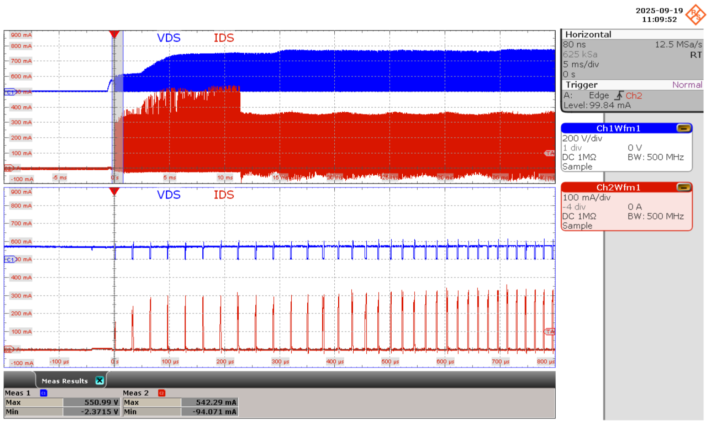


Figure 26 – 230 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 5 ms / div.
CH2: I_{DS}, 100 mA / div., 5 ms / div.
Zoom: 100 µs / div.
$V_{DS(MAX)}$ = 551 V
$I_{DS(MAX)}$ = 542 mA

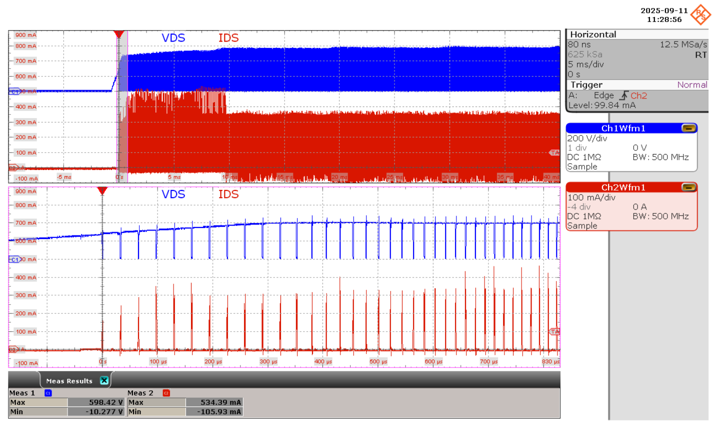


Figure 27 – 265 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 5 ms / div.
CH2: I_{DS}, 100 mA / div., 5 ms / div.
Zoom: 100 µs / div.
$V_{DS(MAX)}$ = 598 V
$I_{DS(MAX)}$ = 534 mA

10.1.2.2 No Load

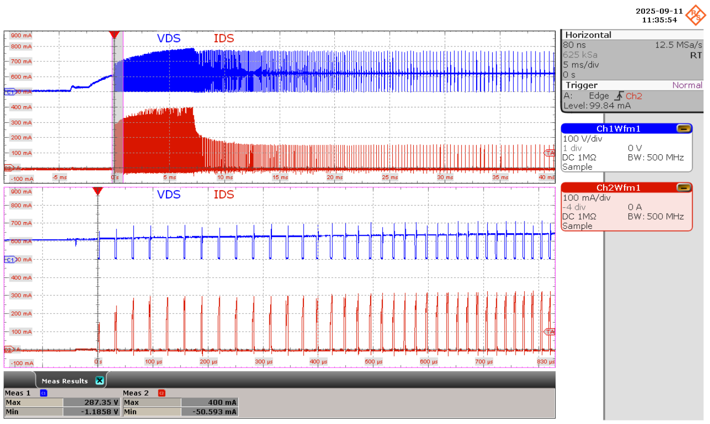


Figure 28 – 85 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 5 ms / div.
CH2: I_{DS}, 100 mA / div., 5 ms / div.
Zoom: 100 µs / div.
$V_{DS(MAX)}$ = 287 V
$I_{DS(MAX)}$ = 400 mA

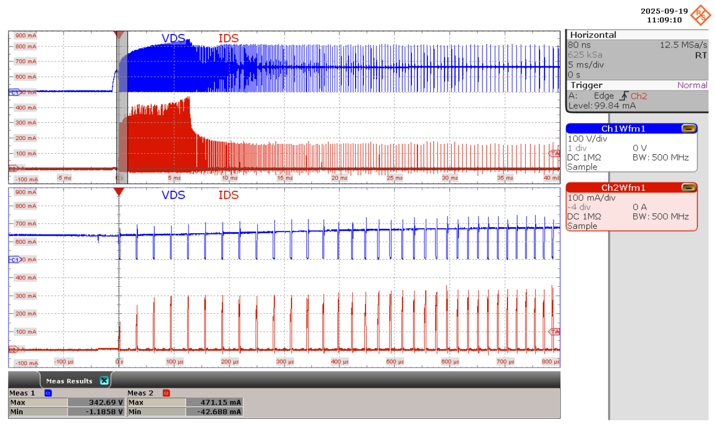


Figure 29 – 115 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 5 ms / div.
CH2: I_{DS}, 100 mA / div., 5 ms / div.
Zoom: 100 µs / div.
$V_{DS(MAX)}$ = 343 V
$I_{DS(MAX)}$ = 471 mA

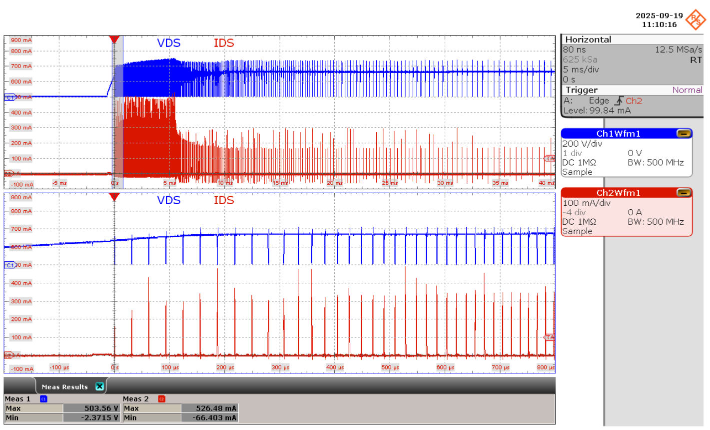


Figure 30 – 230 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 5 ms / div.
CH2: I_{DS}, 100 mA / div., 5 ms / div.
Zoom: 100 µs / div.
$V_{DS(MAX)}$ = 504 V
$I_{DS(MAX)}$ = 526 mA

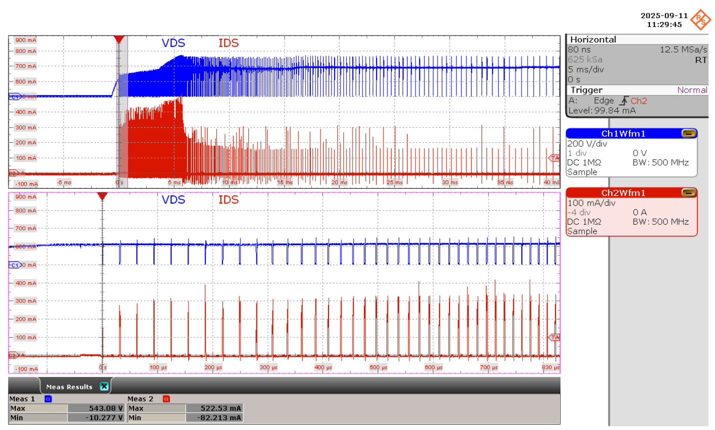


Figure 31 – 265 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 5 ms / div.
CH2: I_{DS}, 100 mA / div., 5 ms / div.
Zoom: 100 µs / div.
$V_{DS(MAX)}$ = 543 V
$I_{DS(MAX)}$ = 523 mA

10.1.3 Freewheeling Diode Voltage at Normal Operation

10.1.3.1 Full Load

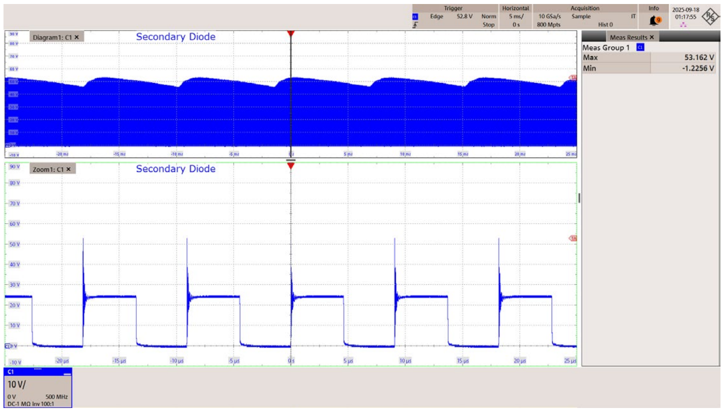


Figure 32 – 85 VAC 60 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 53.2 V

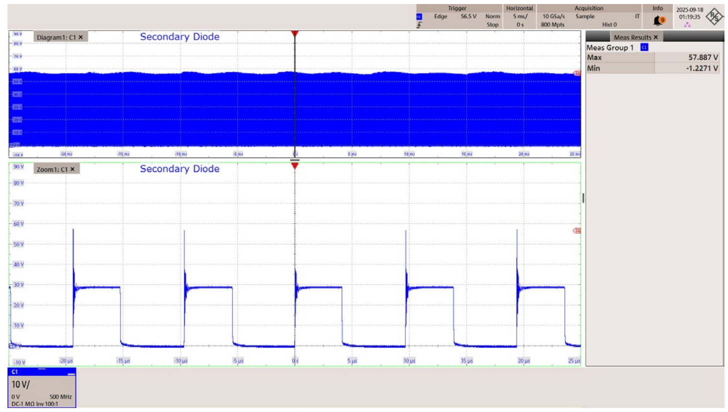


Figure 33 – 115 VAC 60 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 57.9 V

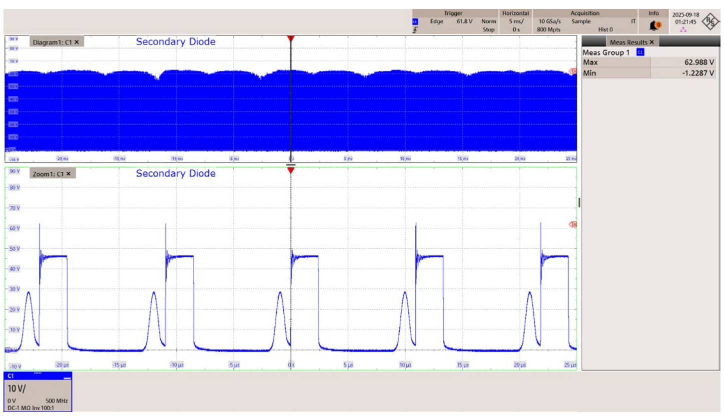


Figure 34 – 230 VAC 50 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 63.0 V

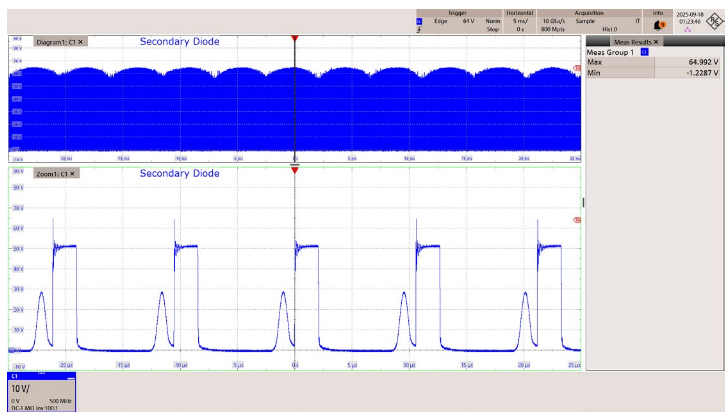


Figure 35 – 265 VAC 50 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 65.0 V

10.1.3.2 No Load

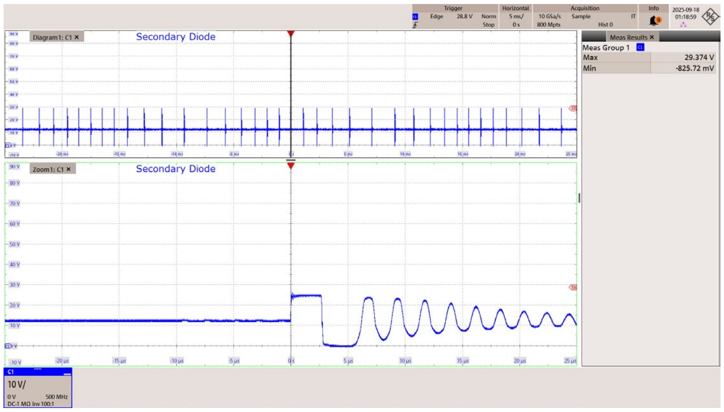


Figure 36 – 85 VAC 60 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 29.4 V

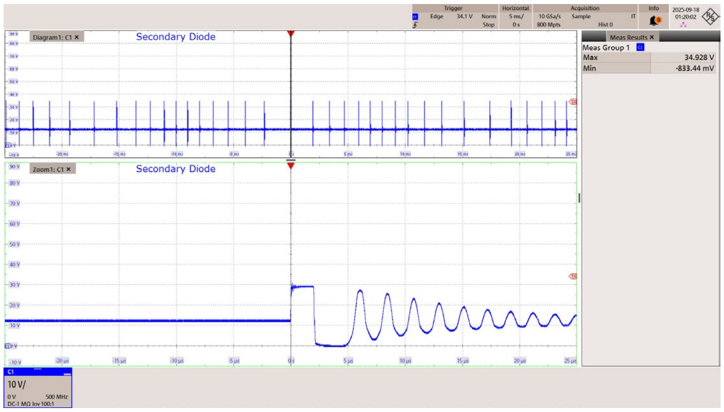


Figure 37 – 115 VAC 60 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 34.9 V

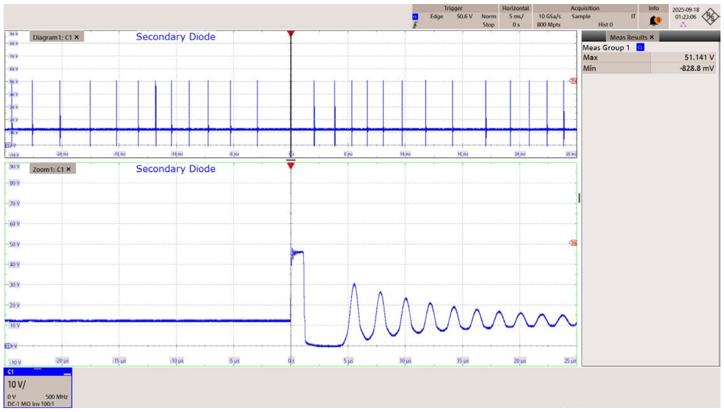


Figure 38 – 230 VAC 50 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 51.1 V

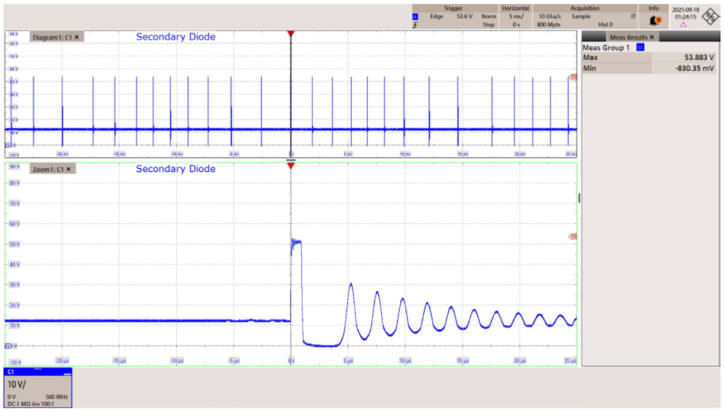


Figure 39 – 265 VAC 50 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 53.9 V

10.1.4 Freewheeling Diode Voltage at Start-Up

10.1.4.1 Full Load

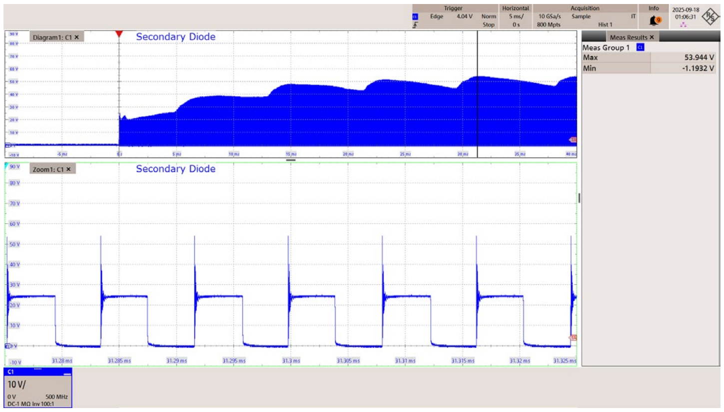


Figure 40 – 85 VAC 60 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 53.9 V

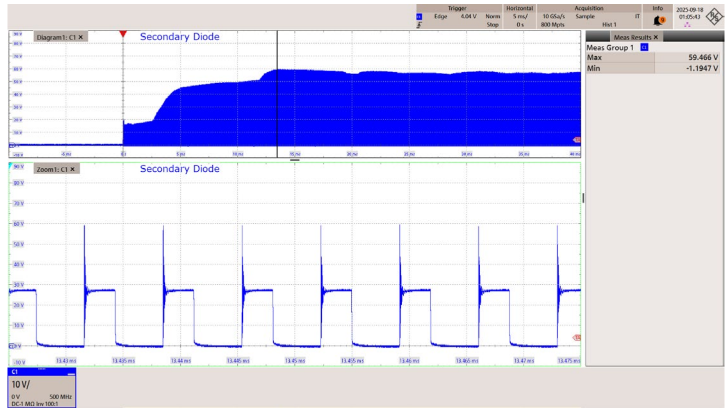


Figure 41 – 115 VAC 60 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 59.5 V

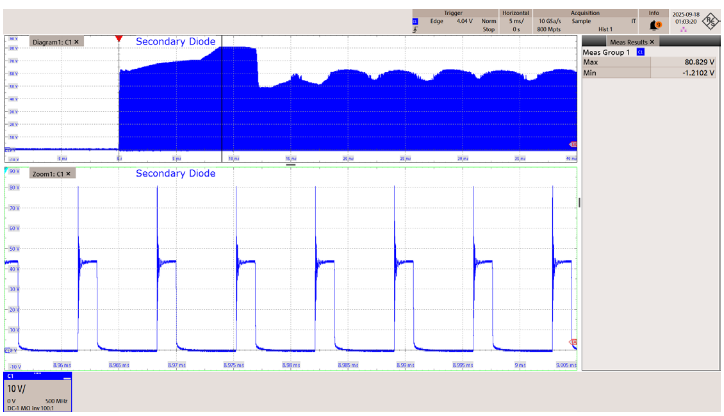


Figure 42 – 230 VAC 50 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 80.8 V

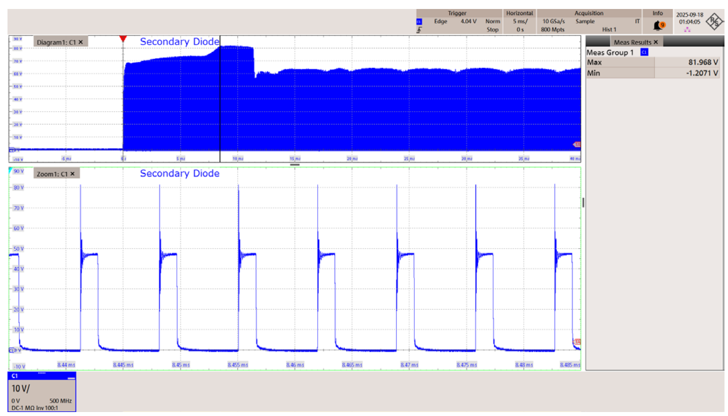


Figure 43 – 265 VAC 50 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 82.0 V

10.1.4.2 No Load

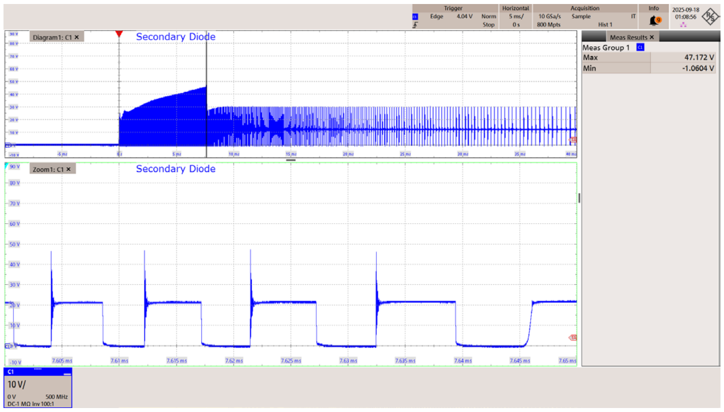


Figure 44 – 85 VAC 60 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 47.2 V

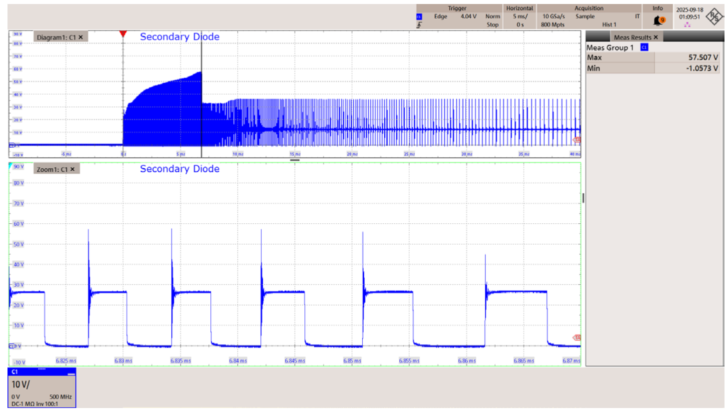


Figure 45 – 115 VAC 60 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 57.5 V

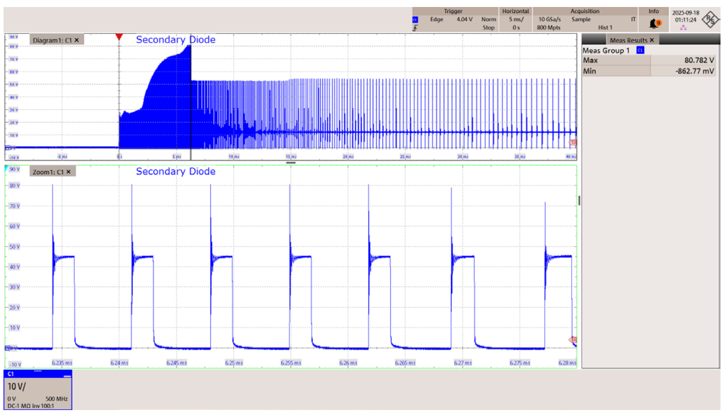


Figure 46 – 230 VAC 50 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 80.8 V

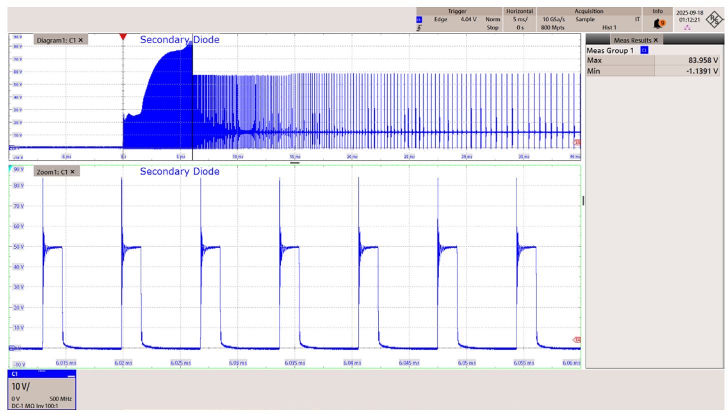


Figure 47 – 265 VAC 50 Hz.
CH1: Sec Diode, 10 V / div., 5 ms / div.
Zoom: 5 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 84.0 V

10.2 Output Start-up

10.2.1 Full Load CC Mode

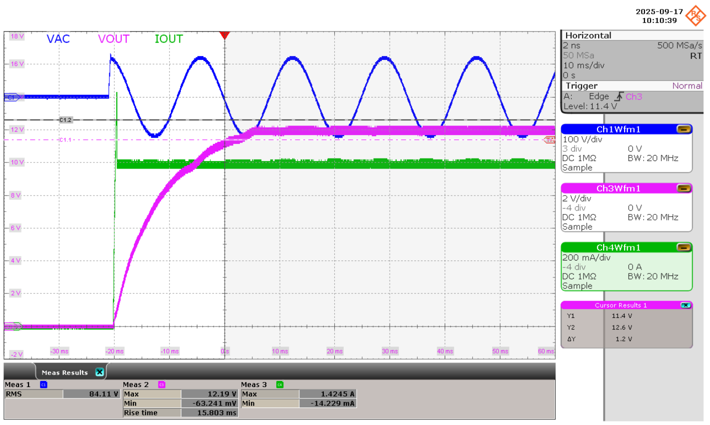


Figure 48 – 85 VAC 60 Hz.
CH1: Input Voltage, 100 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 15.8 ms
V_{MAX} = 12.2 V

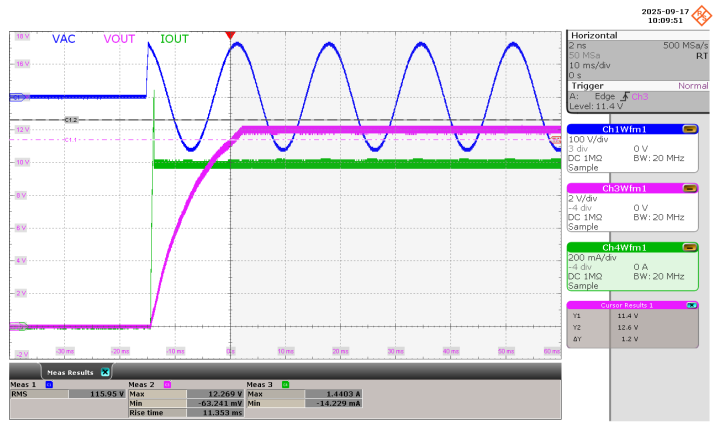


Figure 49 – 115 VAC 60 Hz.
CH1: Input Voltage, 100 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 11.4 ms
V_{MAX} = 12.3 V

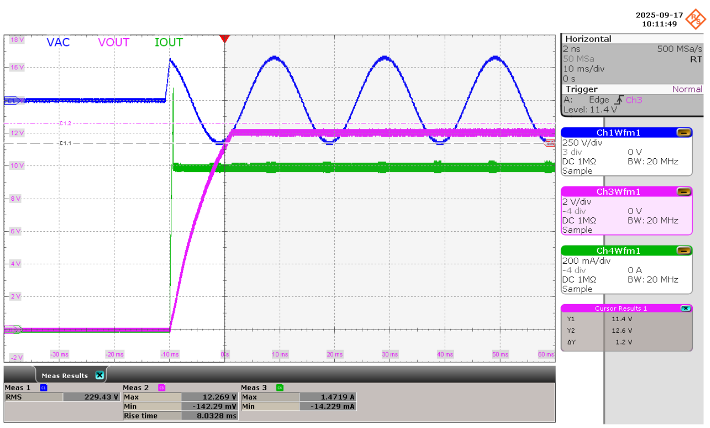


Figure 50 – 230 VAC 50 Hz.
CH1: Input Voltage, 250 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 8.03 ms
V_{MAX} = 12.3 V

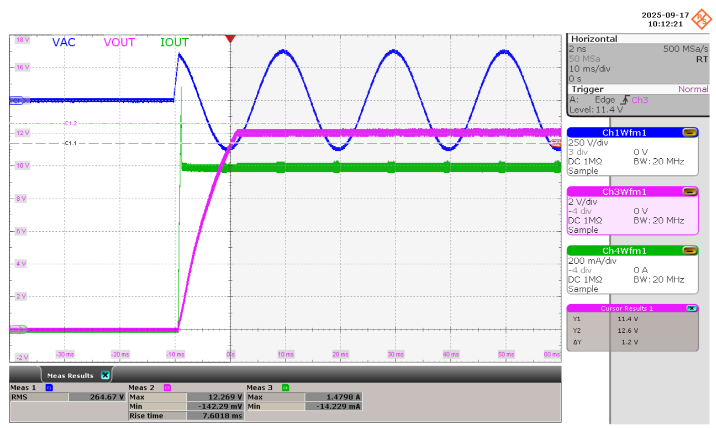


Figure 51 – 265 VAC 50 Hz.
CH1: Input Voltage, 250 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 7.60 ms
V_{MAX} = 12.3 V

10.2.2 Full Load CR Mode

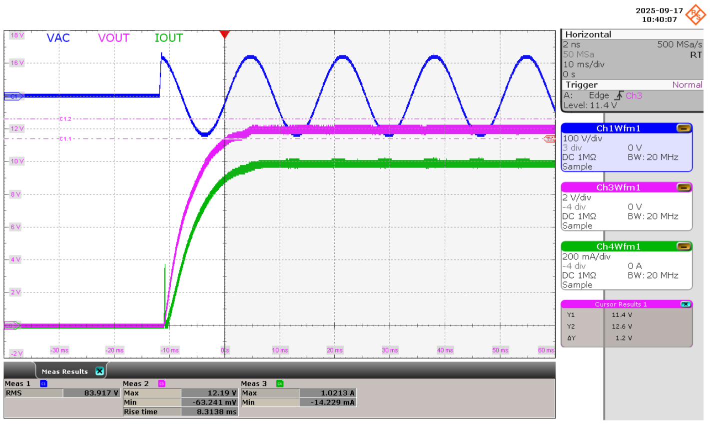


Figure 52 – 85 VAC 60 Hz.
CH1: Input Voltage, 100 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 8.31 ms
V_{MAX} = 12.2 V

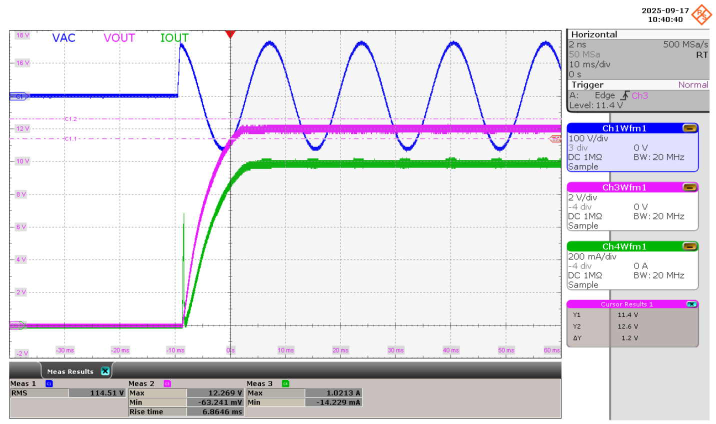


Figure 53 – 115 VAC 60 Hz.
CH1: Input Voltage, 100 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 6.86 ms
V_{MAX} = 12.3 V

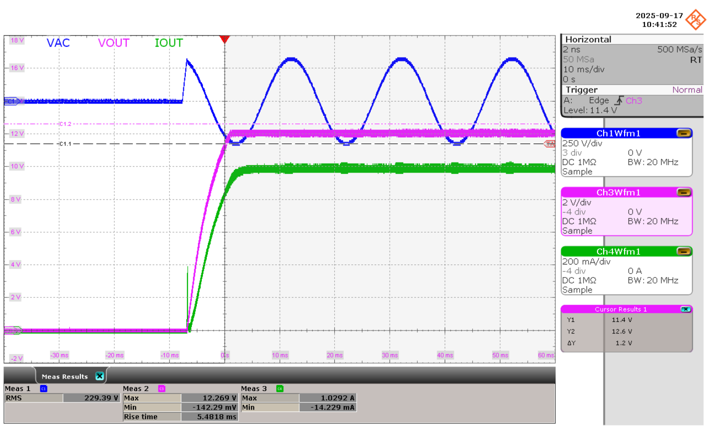


Figure 54 – 230 VAC 50 Hz.
CH1: Input Voltage, 250 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 5.48 ms
V_{MAX} = 12.3 V

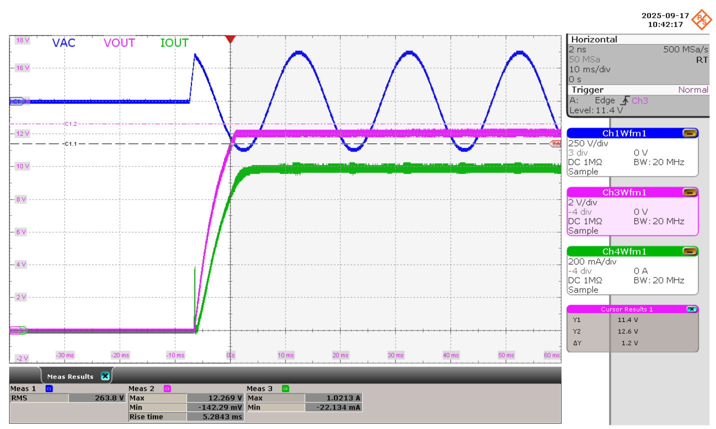


Figure 55 – 265 VAC 50 Hz.
CH1: Input Voltage, 250 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 5.28 ms
V_{MAX} = 12.3 V

10.2.3 No Load

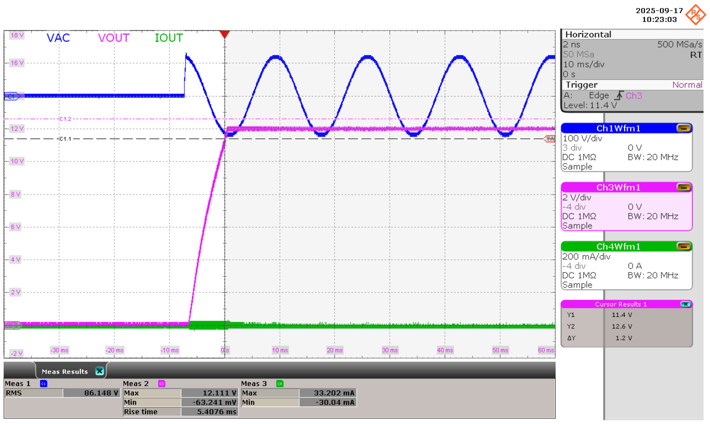


Figure 56 – 85 VAC 60 Hz.
CH1: Input Voltage, 100 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 5.41 ms
V_{MAX} = 12.1 V

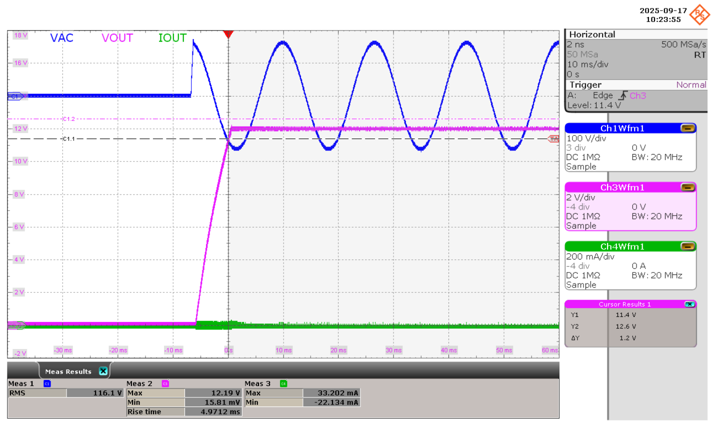


Figure 57 – 115 VAC 60 Hz.
CH1: Input Voltage, 100 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 4.97 ms
V_{MAX} = 12.2 V

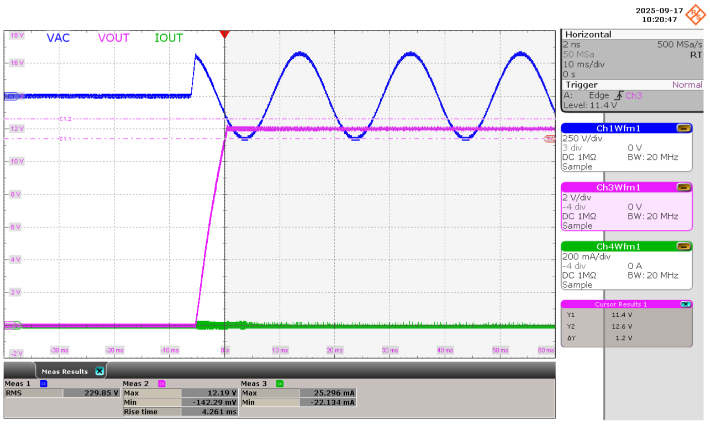


Figure 58 – 230 VAC 50 Hz.
CH1: Input Voltage, 250 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 4.26 ms
V_{MAX} = 12.2 V

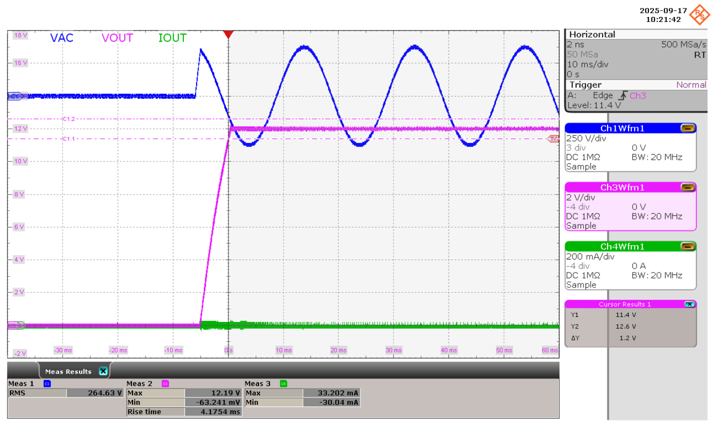


Figure 59 – 265 VAC 50 Hz.
CH1: Input Voltage, 250 V / div., 10 ms / div.
CH3: V_{OUT}, 2 V / div., 10 ms / div.
CH4: I_{OUT}, 200 mA / div., 10 ms / div.
V_O Rise Time = 4.18 ms
V_{MAX} = 12.2 V

10.3 Output Voltage Ripple

10.3.1 Ripple Measurement Technique

For DC output ripple measurements, a modified oscilloscope test probe must be utilized to reduce spurious signals due to pick-up. Details of the probe modification are provided in figure 60 and 61 below.

The 4987BA probe adapter is affixed with two capacitors tied in parallel across the probe tip. The capacitors include one 0.1 μF / 50 V ceramic type and one 47 μF / 50 V aluminum electrolytic. The aluminum electrolytic type capacitor is polarized, so proper polarity across DC outputs must be maintained (see below).

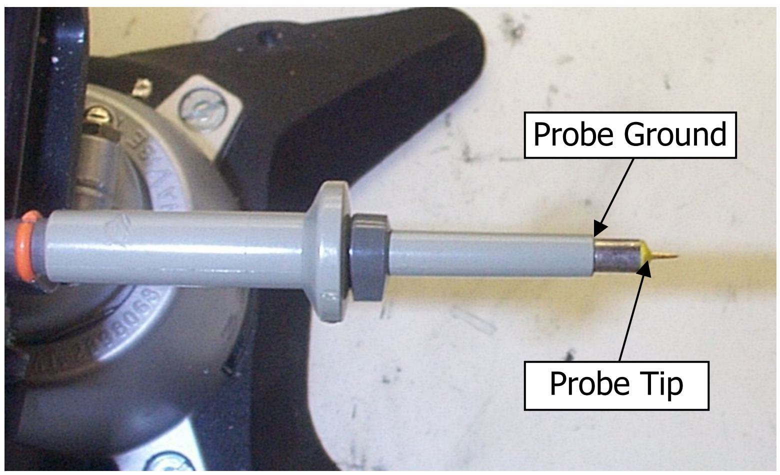


Figure 60 – Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed.)

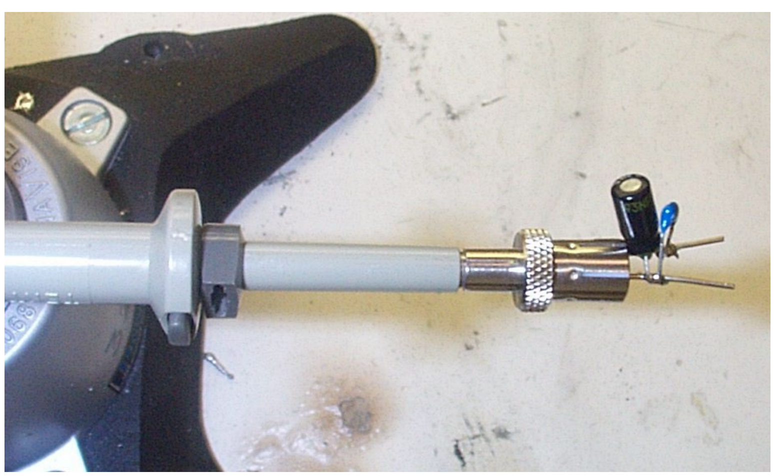


Figure 61 – Oscilloscope Probe with Probe Master (**www.probemaster.com**) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added.)

10.3.2 Measurement Results

Note: All ripple measurements were taken at PCB end.

10.3.2.1 100 % Load Condition

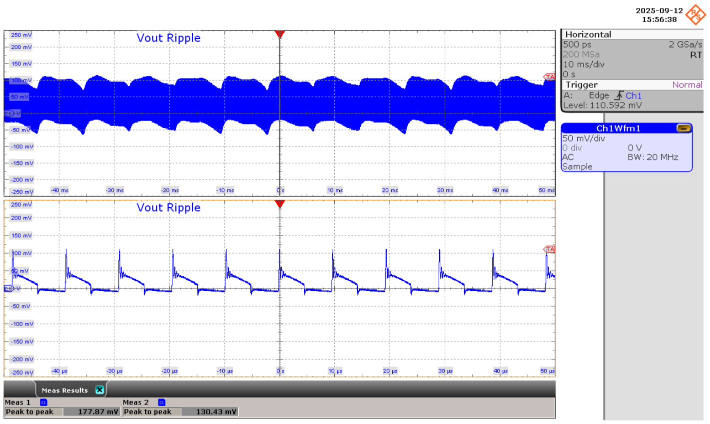


Figure 62 – 85 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 178 mV

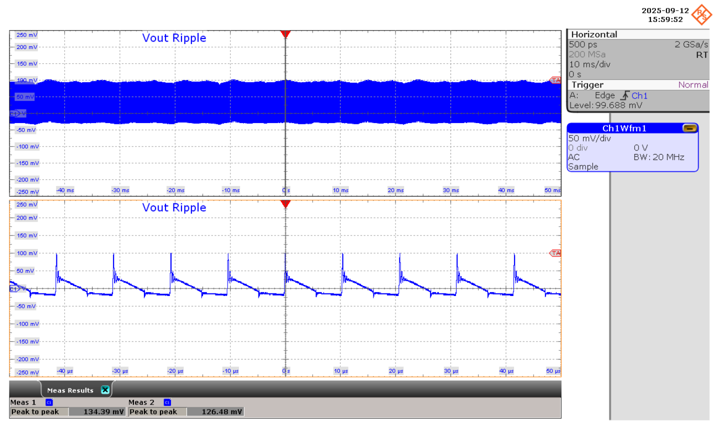


Figure 63 – 115 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 134 mV

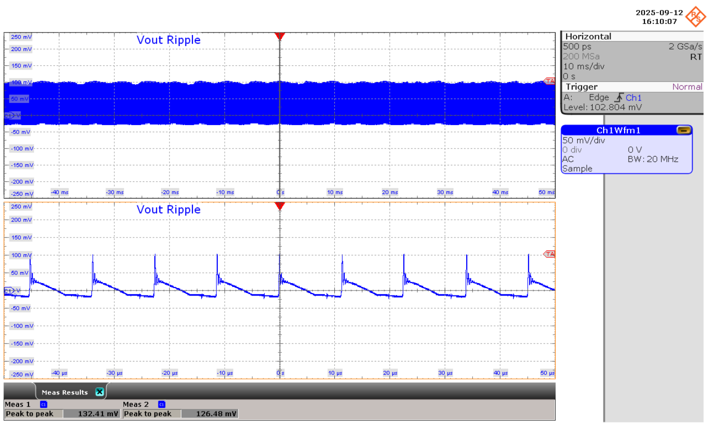


Figure 64 – 230 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 132 mV

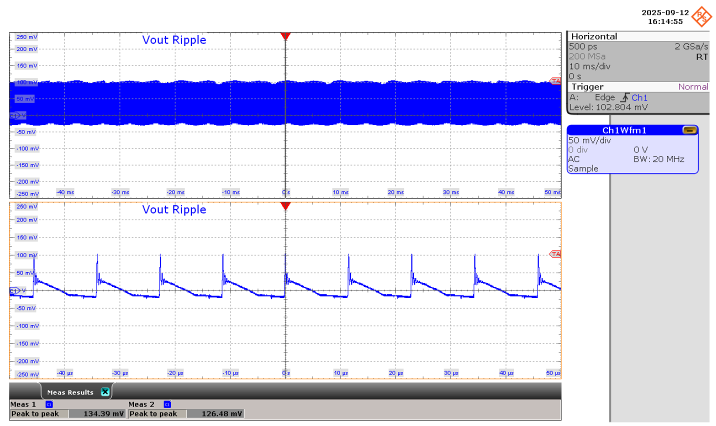


Figure 65 – 265 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 134 mV

10.3.2.2 75% Load Condition

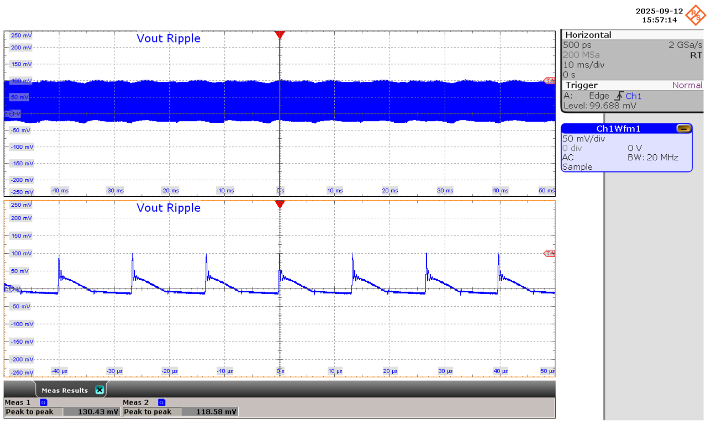


Figure 66 – 85 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 µs / div.
Output Ripple = 130 mV

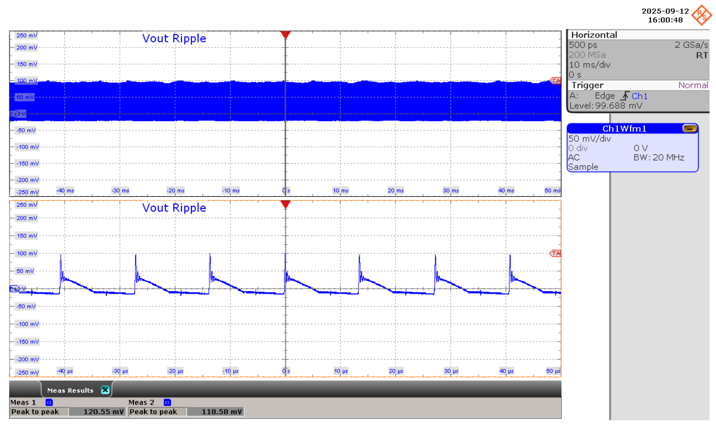


Figure 67 – 115 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 µs / div.
Output Ripple = 121 mV

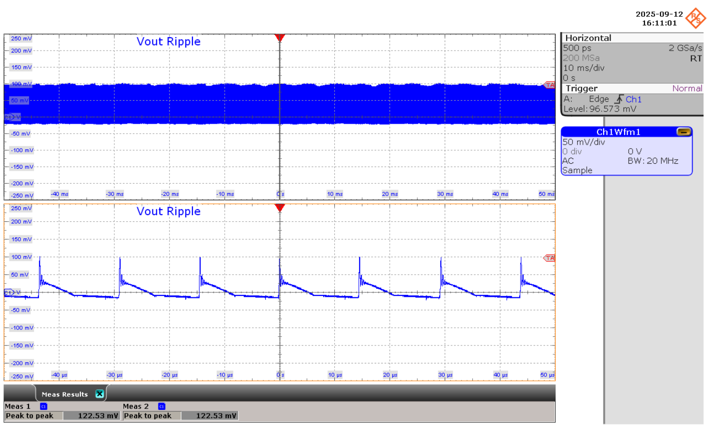


Figure 68 – 230 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 µs / div.
Output Ripple = 123 mV

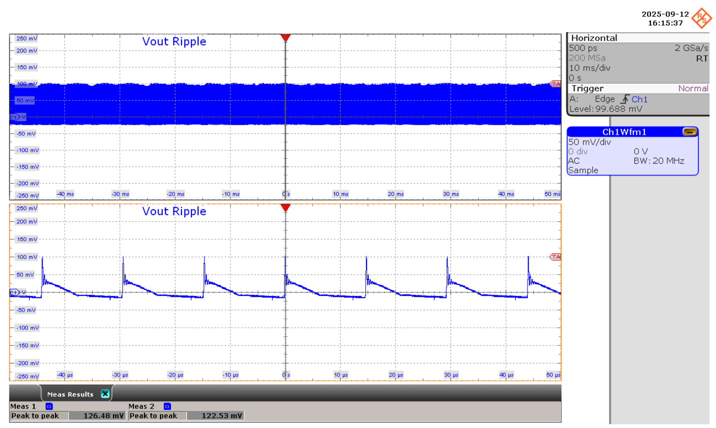


Figure 69 – 265 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 µs / div.
Output Ripple = 126 mV

10.3.2.3 50% Load Condition

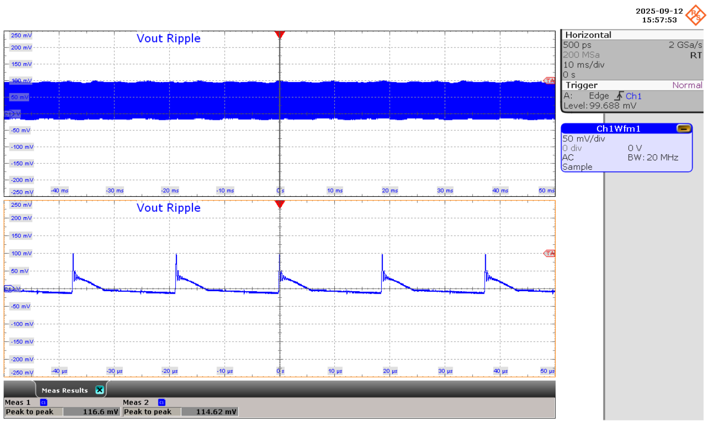


Figure 70 – 85 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 117 mV

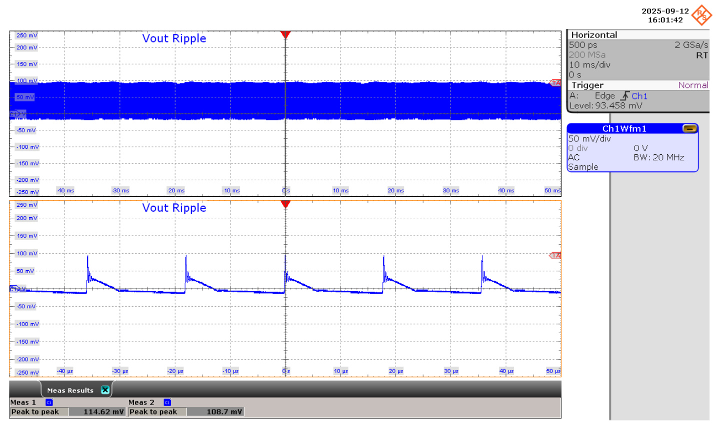


Figure 71 – 115 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 115 mV

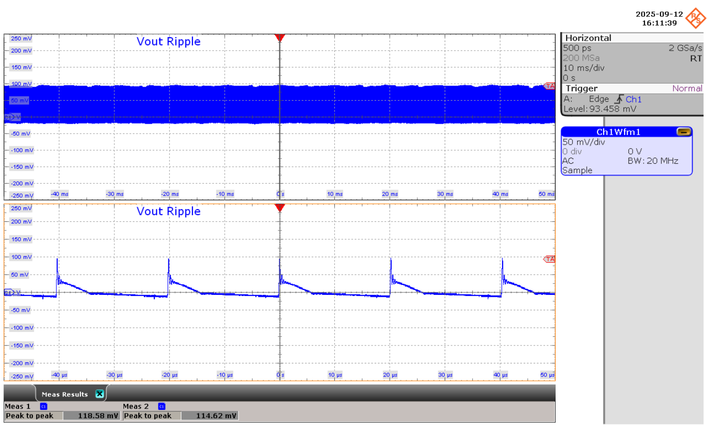


Figure 72 – 230 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 119 mV

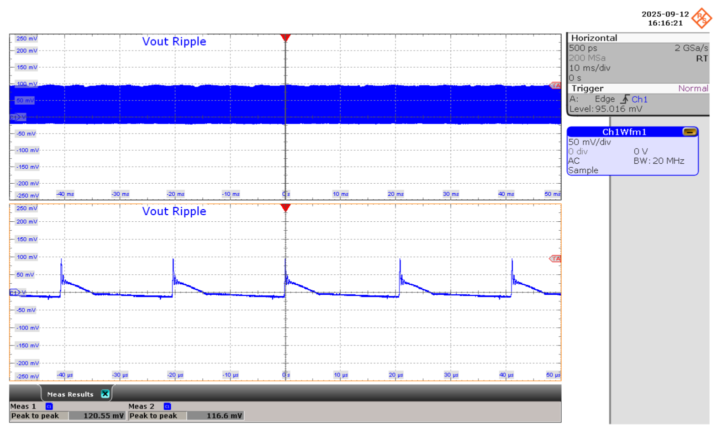


Figure 73 – 265 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 121 mV

10.3.2.4 25% Load Condition

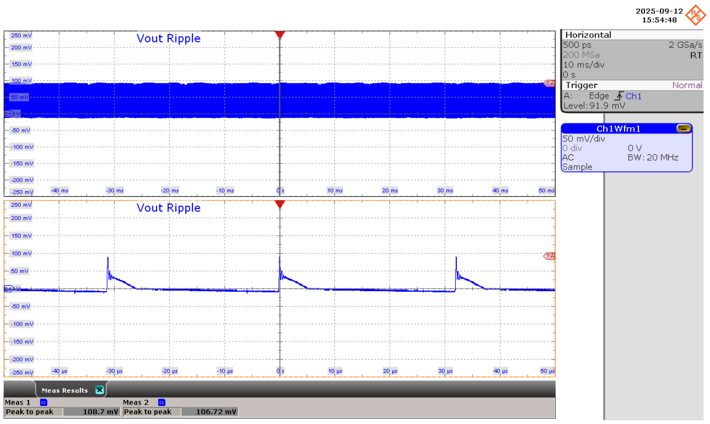


Figure 74 – 85 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 µs / div.
Output Ripple = 107 mV

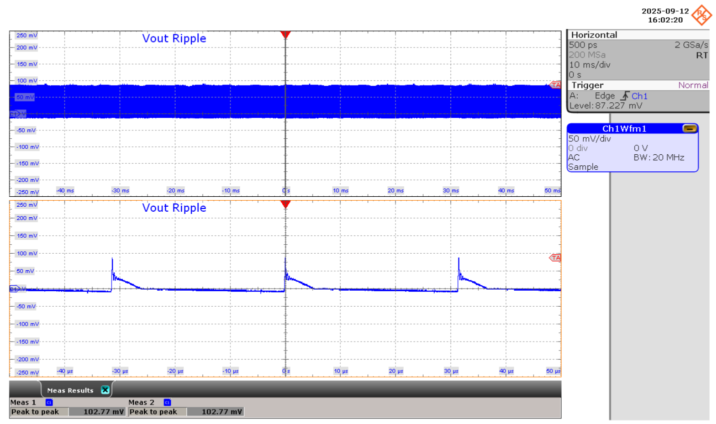


Figure 75 – 115 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 µs / div.
Output Ripple = 103 mV

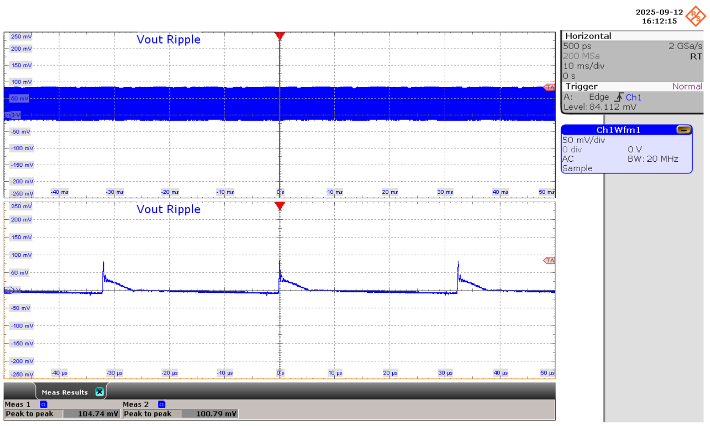


Figure 76 – 230 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 µs / div.
Output Ripple = 105 mV

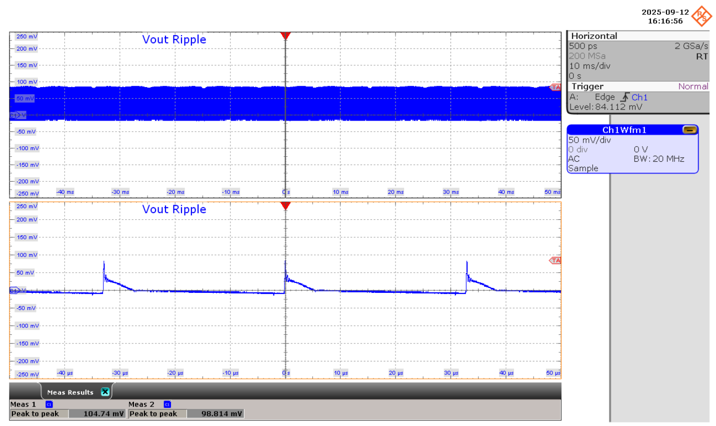


Figure 77 – 265 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 µs / div.
Output Ripple = 105 mV

10.3.2.5 10% Load Condition

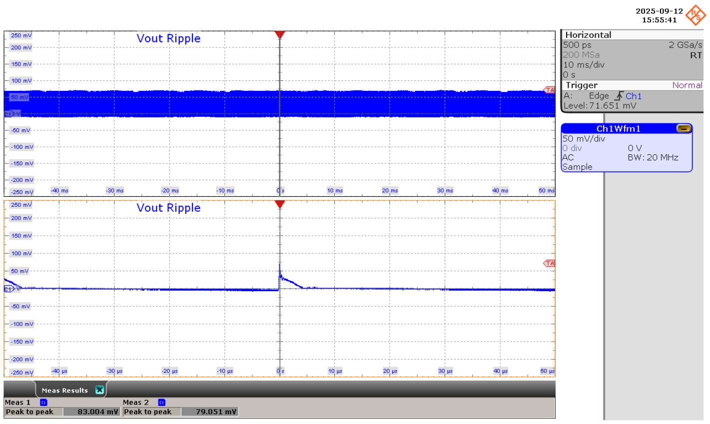


Figure 78 – 85 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 83 mV

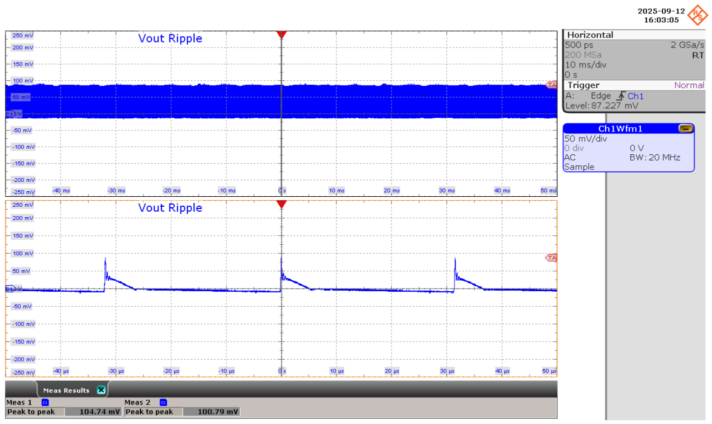


Figure 79 – 115 VAC 60 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 105 mV

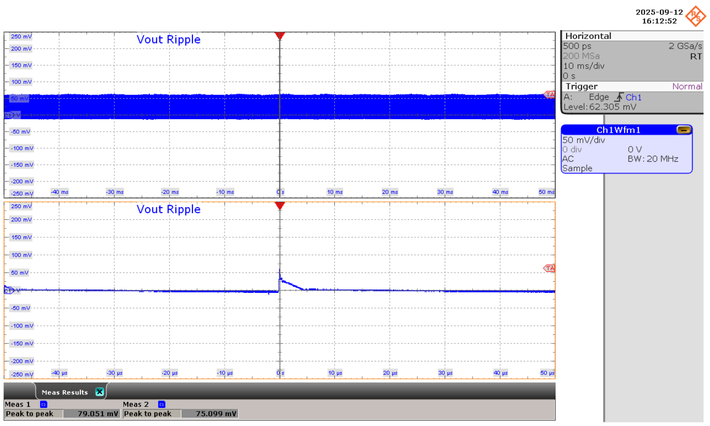


Figure 80 – 230 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 79.1 mV

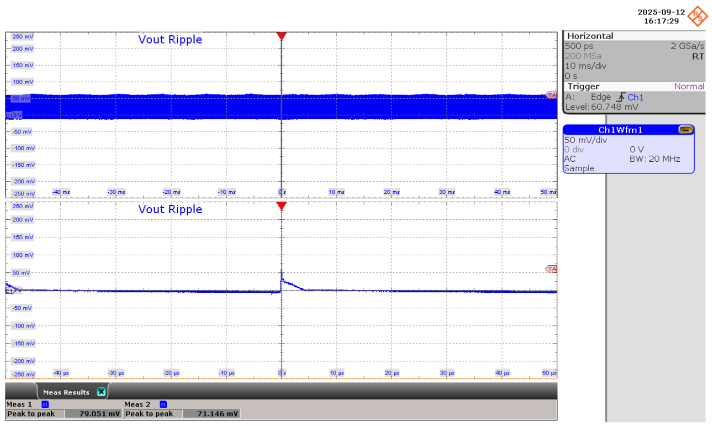


Figure 81 – 265 VAC 50 Hz.
CH1: Output Ripple, 50 mV / div., 10 ms / div.
Zoom = 10 μs / div.
Output Ripple = 79.1 mV

10.3.3 Output Ripple Voltage Graph

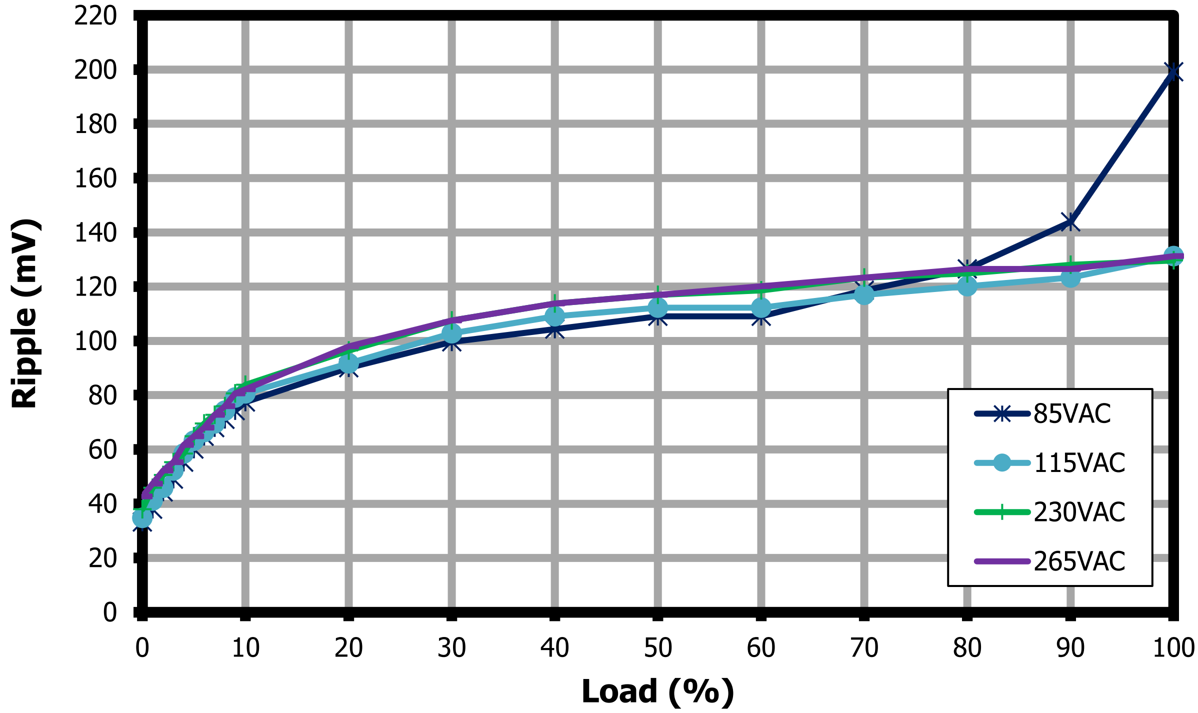


Figure 82 – Voltage Ripple (Measured at edge of PCB at Room Temperature).

10.4 Load Transient Response

Test Condition: Dynamic load frequency = 5 Hz, Duty cycle = 50%
Slew Rate = 0.8 A / µs

10.4.1 Transient 0% - 100% Load Change

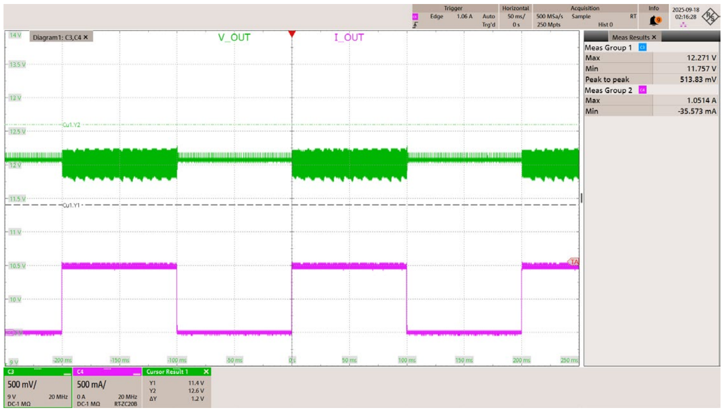


Figure 83 – 85 VAC 60 Hz.
CH3: V_{OUT}, 500 mV / div., 50 ms / div.
CH4: I_{OUT}, 500 mA / div., 50 ms / div.
V_{OUT}: V_{MAX}: 12.3 V
V_{MIN}: 11.8 V

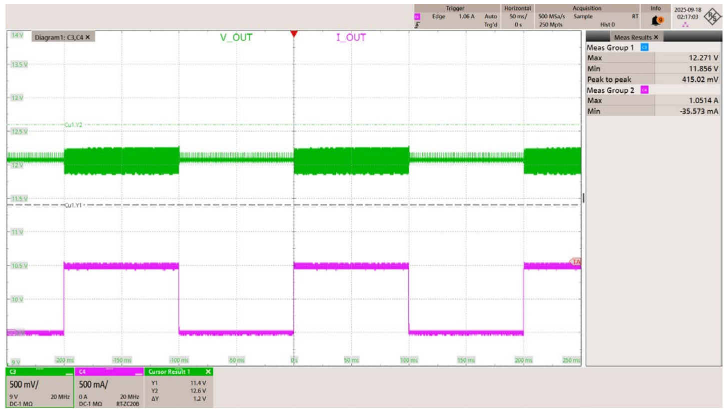


Figure 84 – 115 VAC 60 Hz.
CH3: V_{OUT}, 500 mV / div., 50 ms / div.
CH4: I_{OUT}, 500 mA / div., 50 ms / div.
V_{OUT}: V_{MAX}: 12.3 V
V_{MIN}: 11.9 V

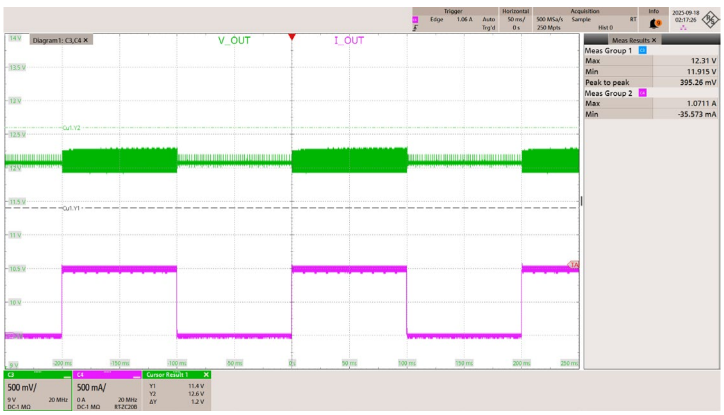


Figure 85 – 230 VAC 50 Hz.
CH3: V_{OUT}, 500 mV / div., 50 ms / div.
CH4: I_{OUT}, 500 mA / div., 50 ms / div.
V_{OUT}: V_{MAX}: 12.3 V
V_{MIN}: 11.9 V

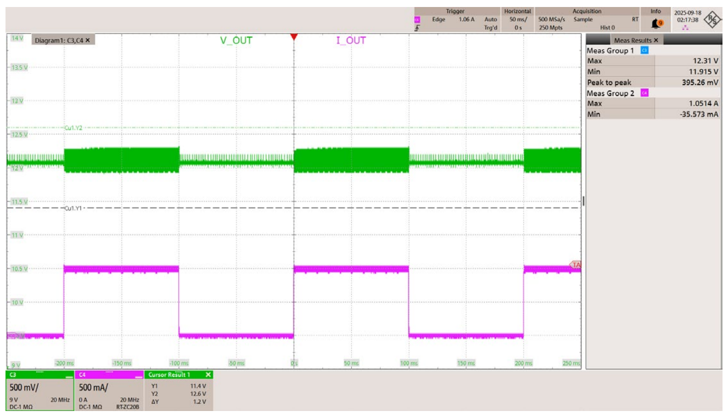


Figure 86 – 265 VAC 50 Hz.
CH3: V_{OUT}, 500 mV / div., 50 ms / div.
CH4: I_{OUT}, 500 mA / div., 50 ms / div.
V_{OUT}: V_{MAX}: 12.3 V
V_{MIN}: 11.9 V

11 Thermal Performance

11.1 25 °C Ambient Thermals

11.1.1 85 VAC Full Load at 25 °C Ambient

Test result after 60 minutes running continuously at 85 VAC full load.

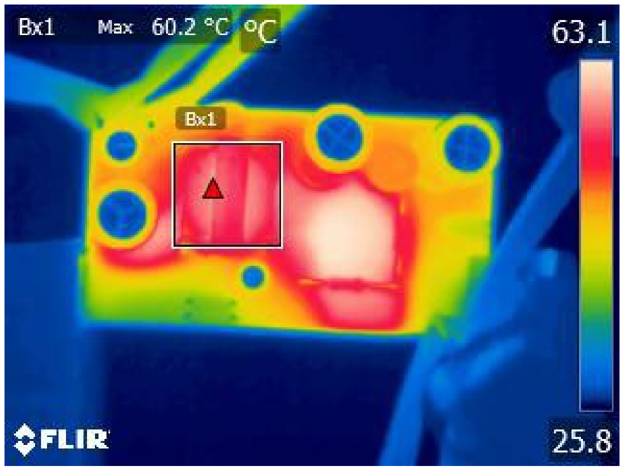


Figure 87 – 85 VAC 60 Hz. Top Side Discrete Component Thermals.

Component	Temperature (°C)
Ambient	25.8
Transformer (T1)	60.2

Figure 88 – 85 VAC 60 Hz. Bottom Side Thermals.

Component	Temperature (°C)
Ambient	26.7
TNY5071K (U1)	63.3
Secondary Diode (D4)	62.0

11.1.2 265 VAC Full Load at 25 °C Ambient

Test result after 60 minutes running continuously at 265 VAC full load.

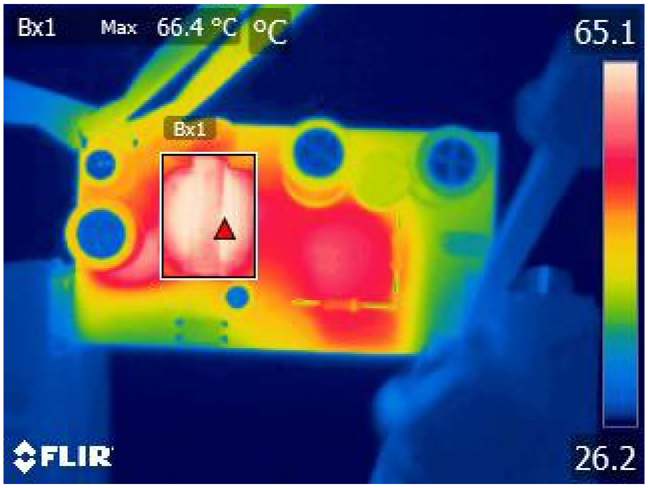


Figure 89 – 265 VAC 60 Hz. Top Side Discrete Component Thermals.

Component	Temperature (°C)
Ambient	26.2
Transformer (T1)	66.4

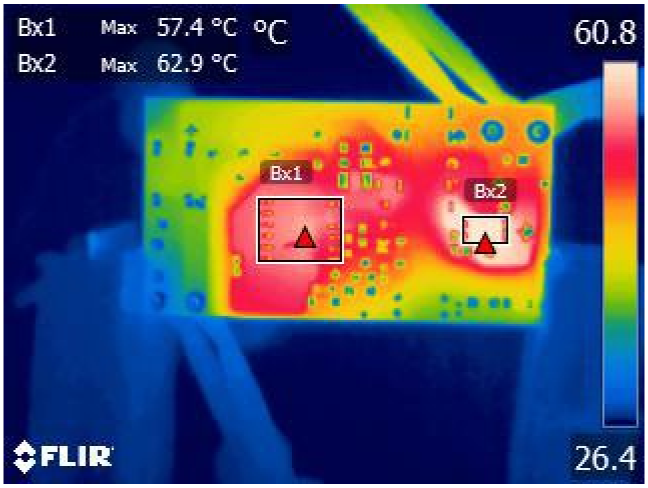


Figure 90 – 265 VAC 60 Hz. Bottom Side Thermals.

Component	Temperature (°C)
Ambient	26.4
TNY5071K (U1)	57.4
Secondary Diode (D4)	62.9

12 Fault Condition

12.1 Output Short-Circuit Protection

12.1.1 Start-Up Short

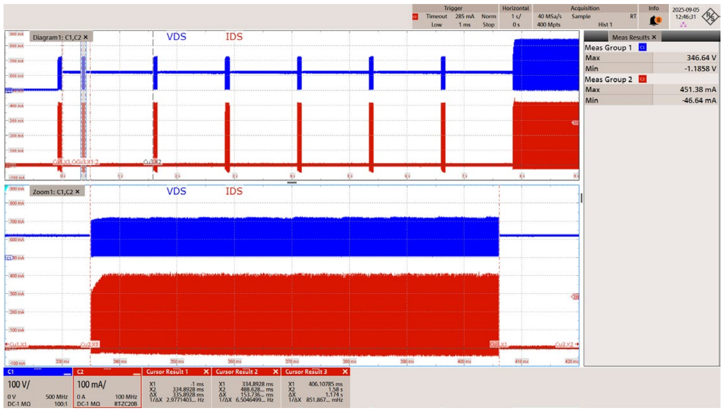


Figure 91 – 85 VAC 60 Hz. Output Short.
CH1: V_{DS}, 100 V / div., 1 s / div.
CH2: I_{DS}, 100 mA / div., 1 s / div.
$V_{DS(MAX)}$ = 347 V
$I_{DS(MAX)}$ = 451 mA
$t_{AR(OFF)1}$ = 336 ms
$t_{AR(OFF)2}$ = 1.17 s
$t_{AR(ON)}$ = 154 ms

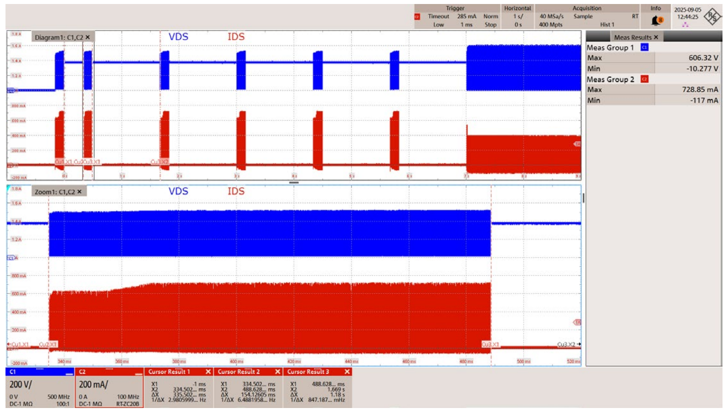


Figure 92 – 265 VAC 50 Hz. Output Short.
CH1: V_{DS}, 100 V / div., 1 s / div.
CH2: I_{DS}, 100 mA / div., 1 s / div.
$V_{DS(MAX)}$ = 606 V
$I_{DS(MAX)}$ = 729 mA
$t_{AR(OFF)1}$ = 336 ms
$t_{AR(OFF)2}$ = 1.18 s
$t_{AR(ON)}$ = 154 ms

12.1.2 Running Short

12.1.2.1 Full Load

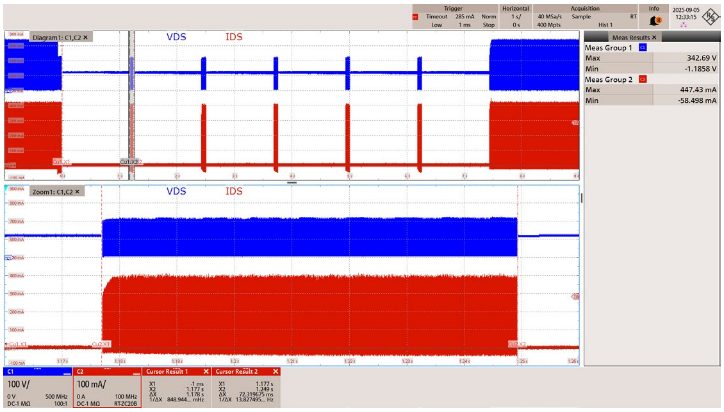


Figure 93 – 85 VAC 60 Hz. Output Short.
CH1: V_{DS}, 100 V / div., 1 s / div.
CH2: I_{DS}, 100 mA / div., 1 s / div.
$V_{DS(MAX)}$ = 343 V
$I_{DS(MAX)}$ = 447 mA
$t_{AR(OFF)1}$ = 1.18 s
$t_{AR(ON)}$ = 72.3 ms

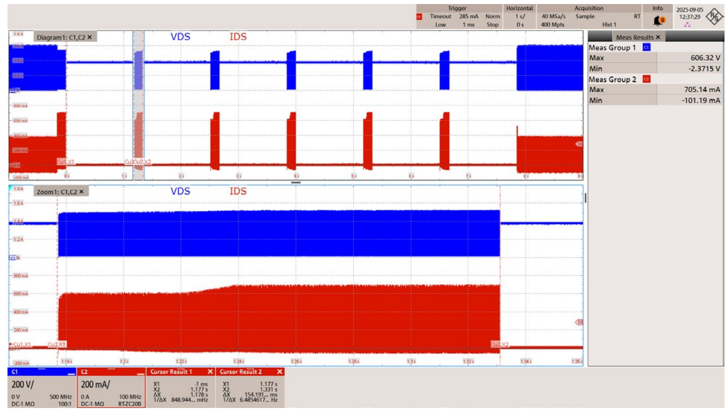


Figure 94 – 265 VAC 50 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 200 mA / div., 1 s / div.
$V_{DS(MAX)}$ = 606 V
$I_{DS(MAX)}$ = 705 mA
$t_{AR(OFF)1}$ = 1.18 s
$t_{AR(ON)}$ = 154 ms

12.1.3 Output Short IC Thermals

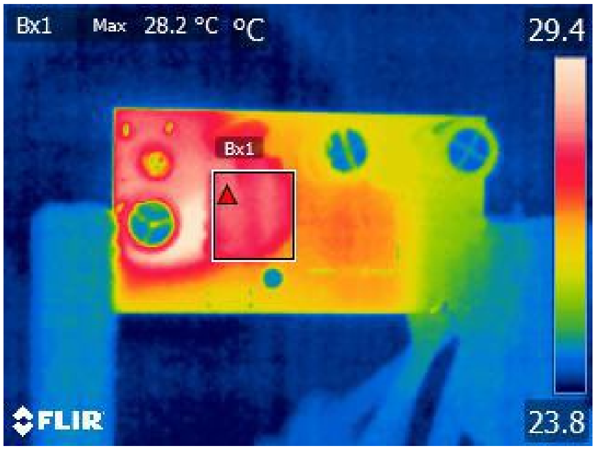


Figure 95 – 85 VAC 60 Hz. Output Short, Top.
1 Hour Soak
Ambient = 23.8 °C
Transformer = 28.2 °C

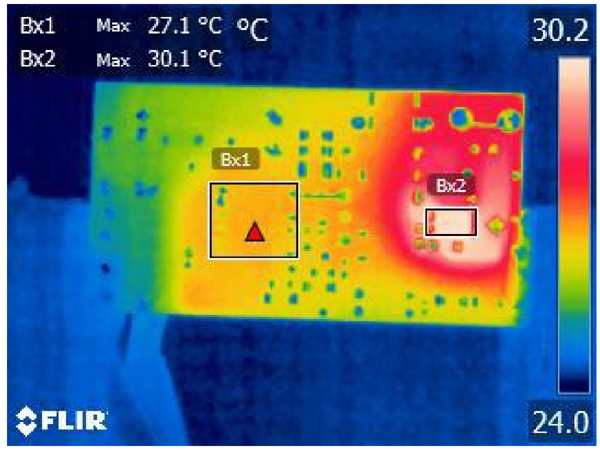


Figure 96 – 85 VAC 60 Hz. Output Short, Bottom.
1 Hour Soak
Ambient = 24 °C
TNY5071K = 27.1 °C
Secondary Diode = 30.1 °C

Figure 97 – 265 VAC 50 Hz. Output Short, Top.
1 Hour Soak
Ambient = 23.8 °C
Transformer = 31.8 °C

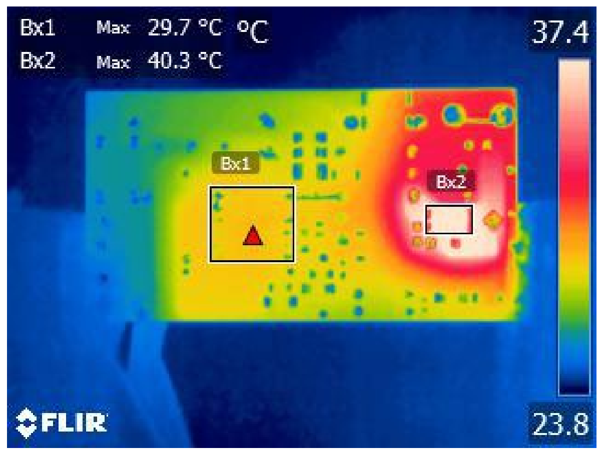


Figure 98 – 265 VAC 50 Hz. Output Short, Bottom.
1 Hour Soak
Ambient = 23.8 °C
TNY5071K = 29.7 °C
Secondary Diode = 40.3 °C

12.2 Overpower Protection

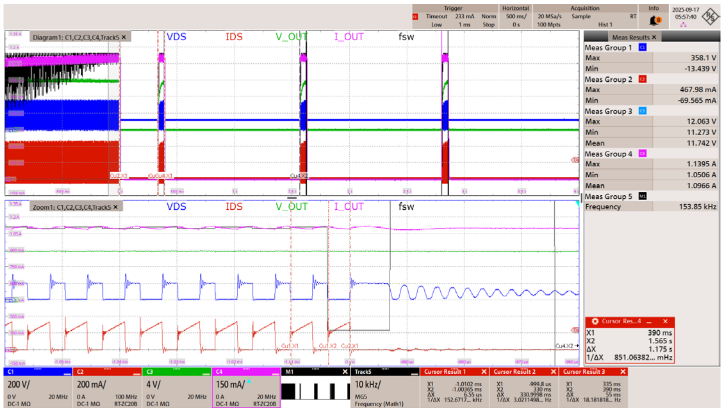


Figure 99 – 85 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 500 ms / div.
CH2: I_{DS}, 200 mA / div., 500 ms / div.
CH3: V_{OUT}, 4 V / div., 500 ms / div.
CH4: I_{OUT}, 150 mA / div., 500 ms / div.
Track5: F_{SW}, 10 KhZ / div., 500 ms / div.
Zoom: 10 μs / div.
$P_{OUT(MAX)}$ = 13.7 W
$t_{AR(OFF)1}$ = 331 ms
$t_{AR(OFF)2}$ = 1.18 s
$t_{AR(ON)}$ = 55.0 ms

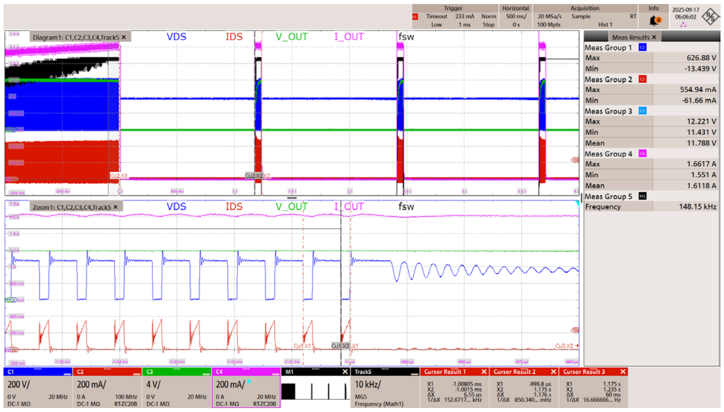


Figure 100 – 265 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 500 ms / div.
CH2: I_{DS}, 200 mA / div., 500 ms / div.
CH3: V_{OUT}, 4 V / div., 500 ms / div.
CH4: I_{OUT}, 150 mA / div., 500 ms / div.
Track5: F_{SW}, 10 KhZ / div., 500 ms / div.
Zoom: 10 μs / div.
$P_{OUT(MAX)}$ = 20.3 W
$t_{AR(OFF)}$ = 1.18 s
$t_{AR(ON)}$ = 60.0 ms

12.3 Output Overvoltage Protection

12.3.1 Full Load OVP

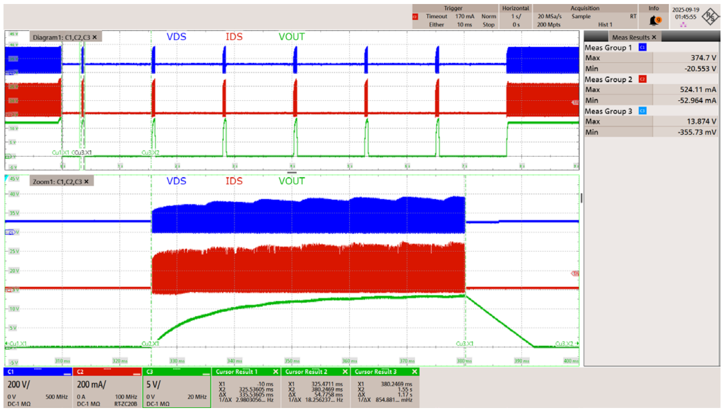


Figure 101 – 85 VAC 60 Hz. Running OVP.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 200 mA / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
Zoom: 10 μs
$V_{DS(MAX)}$ = 375 V
$I_{DS(MAX)}$ = 524 mA
$V_{O(MAX)}$ = 13.9 V

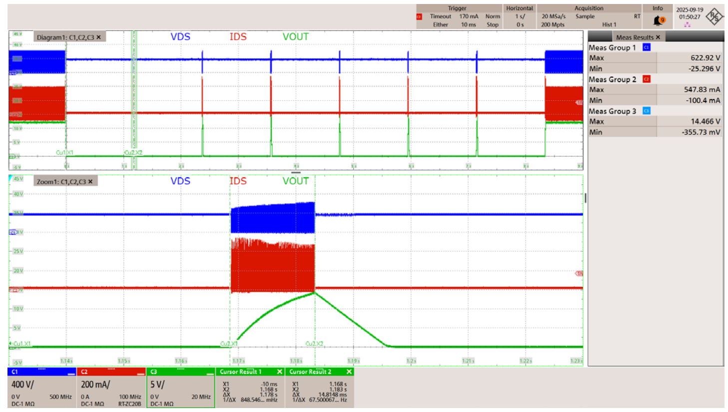


Figure 102 – 265 VAC 60 Hz. Running OVP.
CH1: V_{DS}, 400 V / div., 1 s / div.
CH2: I_{DS}, 200 mA / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
Zoom: 10 μs
$V_{DS(MAX)}$ = 623 V
$I_{DS(MAX)}$ = 548 mA
$V_{O(MAX)}$ = 14.5 V

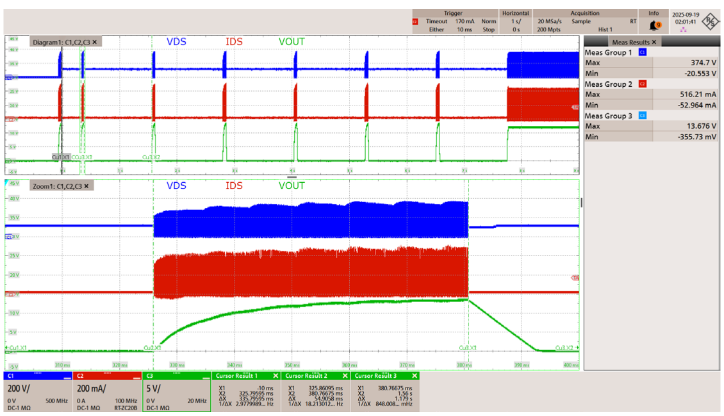


Figure 103 – 230 VAC 50 Hz. Start-up OVP.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 200 mA / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
Zoom: 10 μs
$V_{DS(MAX)}$ = 375 V
$I_{DS(MAX)}$ = 516 mA
$V_{O(MAX)}$ = 13.7 V

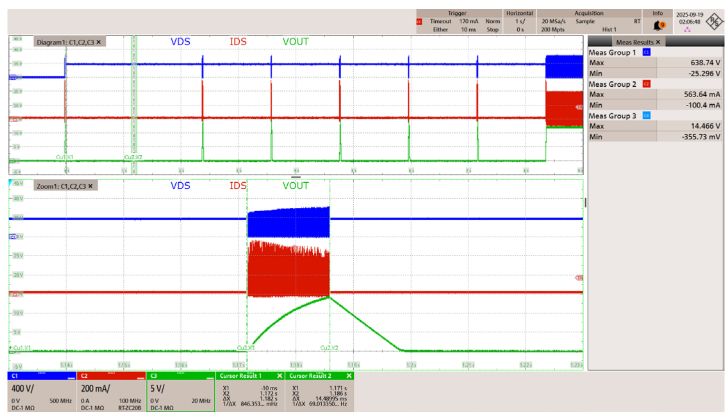


Figure 104 – 265 VAC 50 Hz. Start-up OVP.
CH1: V_{DS}, 400 V / div., 1 s / div.
CH2: I_{DS}, 200 mA / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
Zoom: 10 μs
$V_{DS(MAX)}$ = 639 V
$I_{DS(MAX)}$ = 564 mA
$V_{O(MAX)}$ = 14.5 V

12.3.2 No Load OVP

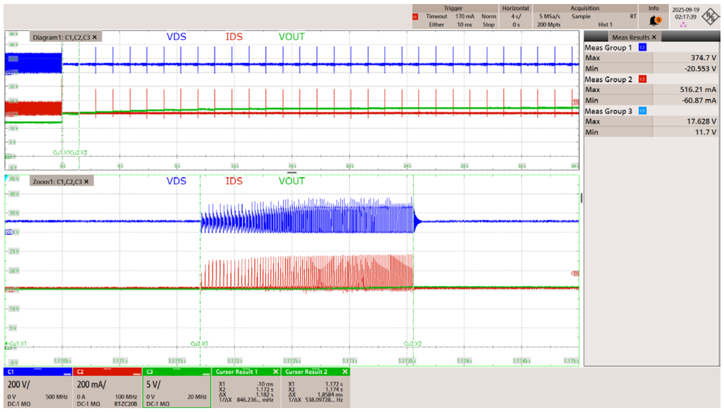


Figure 105 – 85 VAC 60 Hz. Running OVP.
CH1: V_{DS}, 200 V / div., 4 s / div.
CH2: I_{DS}, 200 mA / div., 4 s / div.
CH3: V_{OUT}, 5 V / div., 4 s / div.
Zoom: 500 µs
$V_{DS(MAX)}$ = 375 V
$I_{DS(MAX)}$ = 516 mA
$V_{O(MAX)}$ = 17.6 V

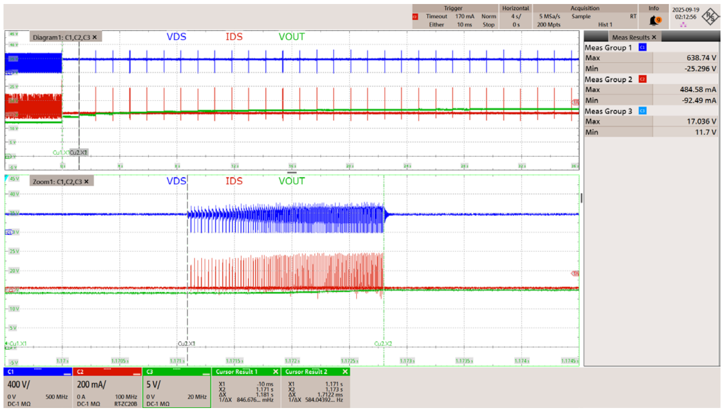


Figure 106 – 265 VAC 60 Hz. Running OVP.
CH1: V_{DS}, 400 V / div., 4 s / div.
CH2: I_{DS}, 200 mA / div., 4 s / div.
CH3: V_{OUT}, 5 V / div., 4 s / div.
Zoom: 500 µs
$V_{DS(MAX)}$ = 639 V
$I_{DS(MAX)}$ = 485 mA
$V_{O(MAX)}$ = 17.0 V

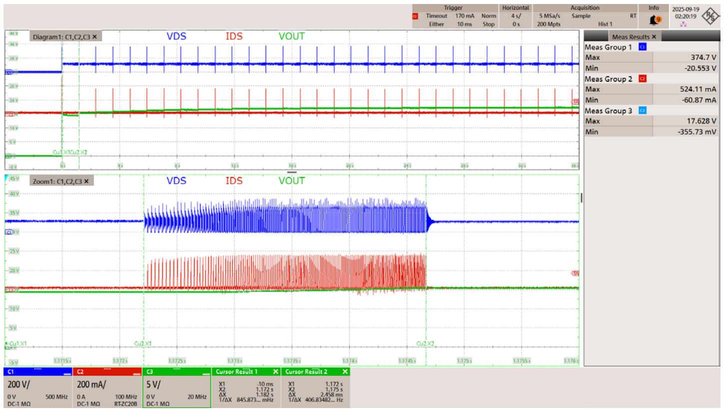


Figure 107 – 85 VAC 60 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 4 s / div.
CH2: I_{DS}, 200 mA / div., 4 s / div.
CH3: V_{OUT}, 5 V / div., 4 s / div.
Zoom: 500 µs
$V_{DS(MAX)}$ = 375 V
$I_{DS(MAX)}$ = 524 mA
$V_{O(MAX)}$ = 17.6 V

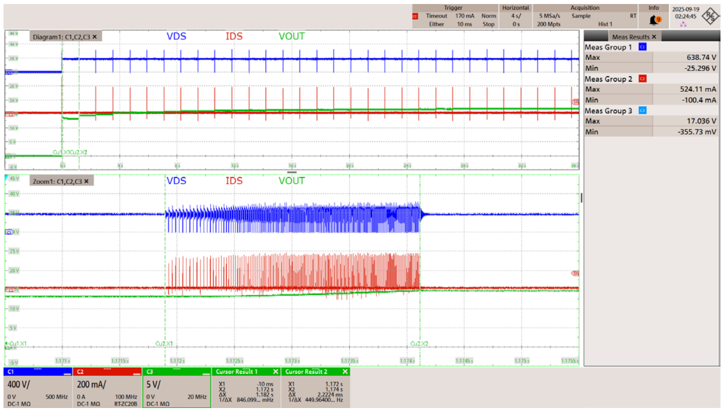


Figure 108 – 265 VAC 50 Hz. Output Short.
CH1: V_{DS}, 400 V / div., 4 s / div.
CH2: I_{DS}, 200 mA / div., 4 s / div.
CH3: V_{OUT}, 5 V / div., 4 s / div.
Zoom: 500 µs
$V_{DS(MAX)}$ = 639 V
$I_{DS(MAX)}$ = 524 mA
$V_{O(MAX)}$ = 17.0 V

12.4 Overtemperature Protection

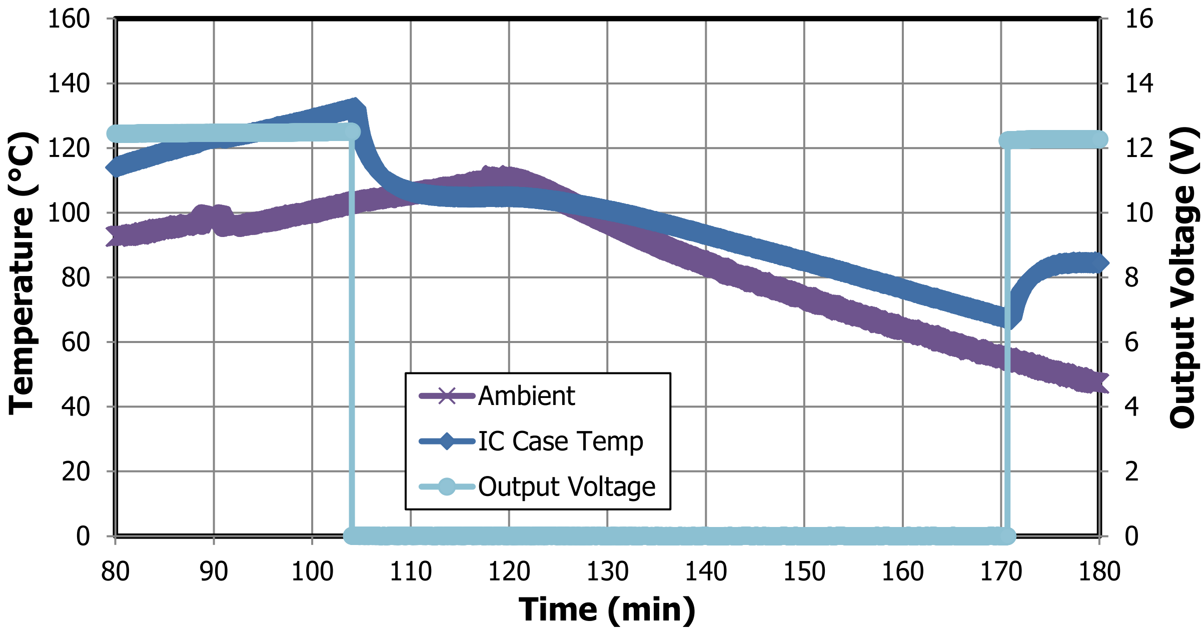


Figure 109 – 85 VAC Full Load OTP.

OTP Temperature	132 °C
Recovery Temperature	66.9 °C
Hysteresis	65.6 °C

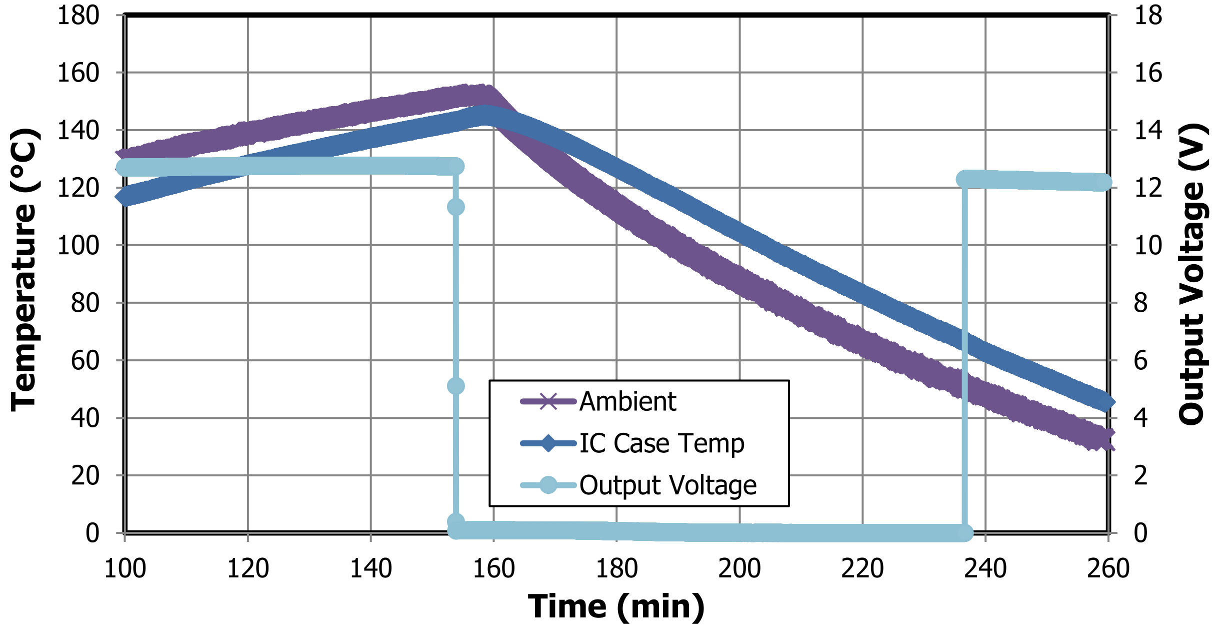


Figure 110 – 85 VAC 1% Load OTP.

OTP Temperature	143 °C
Recovery Temperature	66.2 °C
Hysteresis	76.8 °C

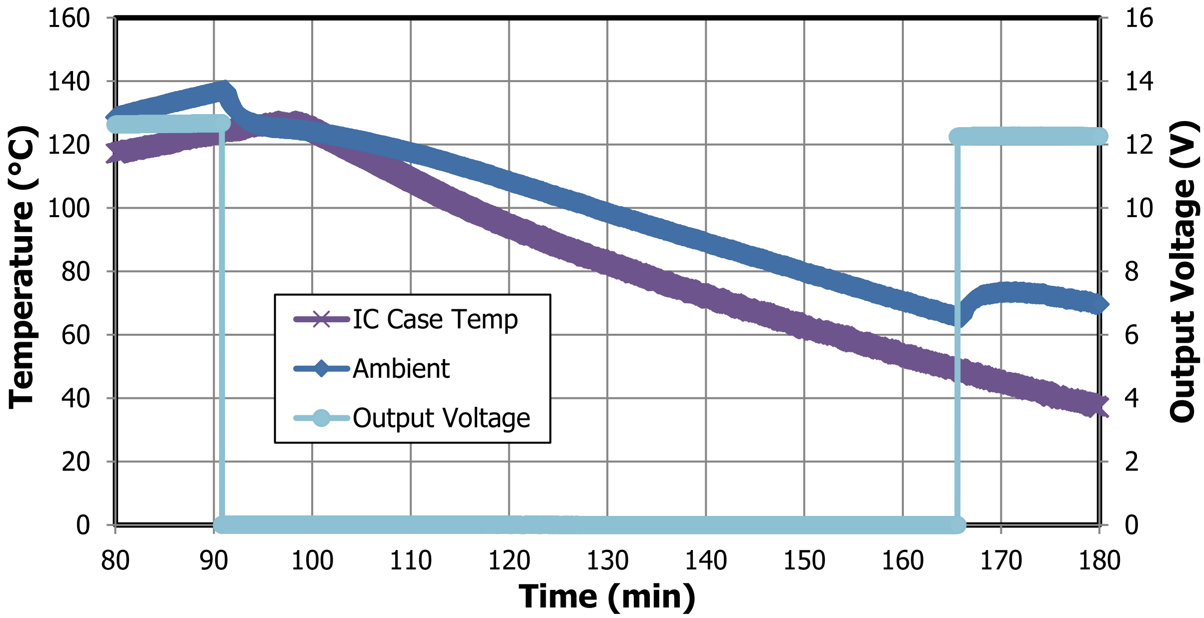


Figure 111 – 265 VAC Full Load OTP.

OTP Temperature	138 °C
Recovery Temperature	64.5 °C
Hysteresis	72.8 °C

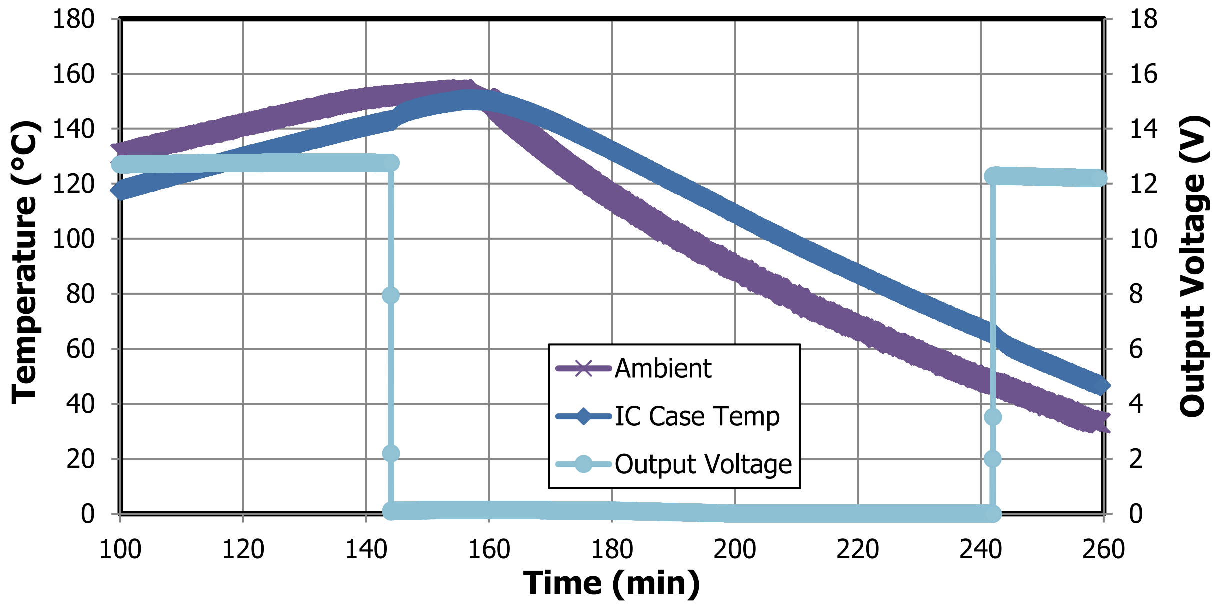


Figure 112 – 265 VAC 1% Load OTP.

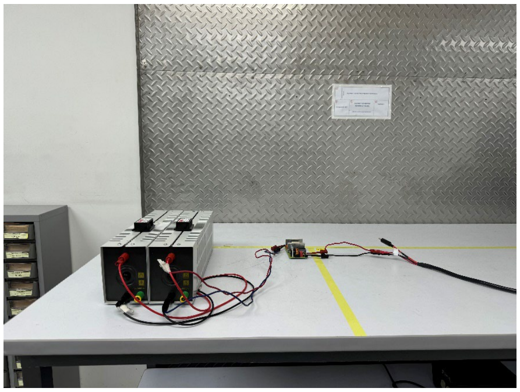
OTP Temperature	143 °C
Recovery Temperature	65.2 °C
Hysteresis	77.9 °C

13 Conducted EMI

Conducted emissions tests were performed at 115 VAC and 230 VAC at full load (12 V, A). Measurements were taken with floating ground.

13.1 Test Set-up Equipment

1. Rohde and Schwarz ENV216 two-line V-network.
2. Rohde and Schwarz ESRP EMI test receiver.
3. Input voltage set at 115 VAC and 230 VAC.
4. 12 V R_{LOAD} resistance is 12 Ohms.



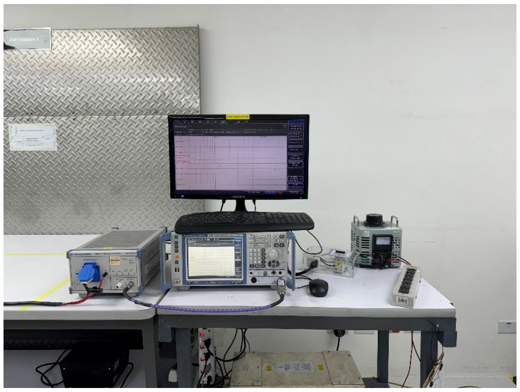
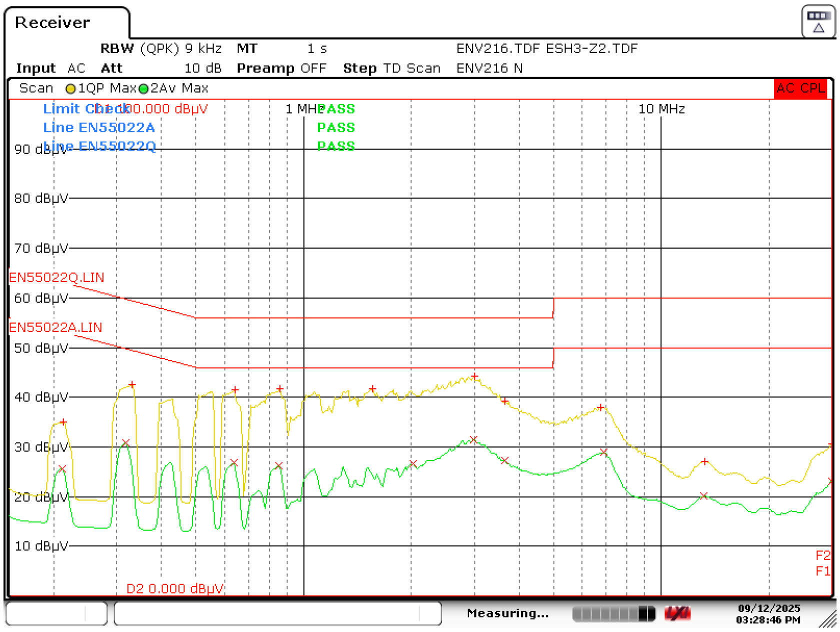


Figure 113 – EMI Test Set-up.

13.2 Output Float



Date: 12.SEP.2025 15:28:47

Figure 114 – 115 VAC 60 Hz. Line / Neutral – Floating.

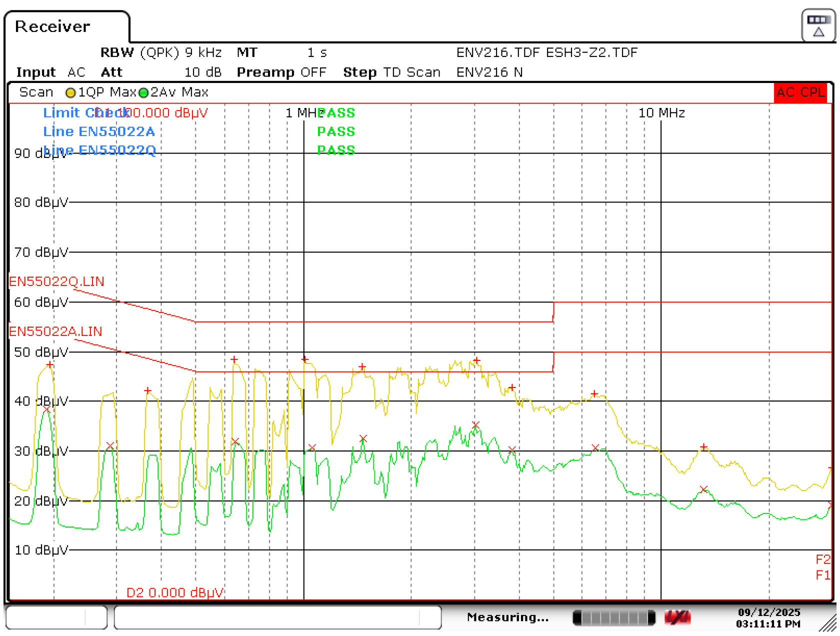


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Figure 115 – 230 VAC 50 Hz. Line / Neutral – Floating.

14 ESD

All ESD strikes were applied at PCB end and full load.

14.1 115 VAC ESD

Passed ±8.8 kV contact discharge

Contact Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+8.8	12 V	10	PASS – No AR
-8.8	12 V	10	PASS – No AR
+8.8	GND	10	PASS – No AR
-8.8	GND	10	PASS – No AR

Note: In all PASS results, power supply is still functional after the test.

Passed ±16.5 kV air discharge

Air Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+16.5	12 V	10	PASS – No AR
-16.5	12 V	10	PASS – No AR
+16.5	GND	10	PASS – No AR
-16.5	GND	10	PASS – No AR

Note: In all PASS results, power supply is still functional after the test.

14.2 230 VAC ESD

Passed ±8.8 kV contact discharge

Contact Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+8.8	12 V	10	PASS – No AR
-8.8	12 V	10	PASS – No AR
+8.8	GND	10	PASS – No AR
-8.8	GND	10	PASS – No AR

Note: In all PASS results, power supply is still functional after the test.

Passed ±16.5 kV air discharge

Air Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+16.5	12 V	10	PASS – No AR
-16.5	12 V	10	PASS – No AR
+16.5	GND	10	PASS – No AR
-16.5	GND	10	PASS – No AR

Note: In all PASS results, power supply is still functional after the test.

15 Combination Wave (Differential Mode)

Tested at 230 VAC input voltage and full load

15.1 230 VAC

Passed 1 kV Surge voltage

Surge Voltage	Phase Angle	IEC Coupling	Generator Impedance	Number of Strikes	Results
+1000 V	0°	L, N	2Ω	10	PASS – No AR
–1000 V	0°	L, N	2Ω	10	PASS – No AR
+1000 V	90°	L, N	2Ω	10	PASS – No AR
–1000 V	90°	L, N	2Ω	10	PASS – No AR
+1000 V	180°	L, N	2Ω	10	PASS – No AR
–1000 V	180°	L, N	2Ω	10	PASS – No AR
+1000 V	270°	L, N	2Ω	10	PASS – No AR
–1000 V	270°	L, N	2Ω	10	PASS – No AR

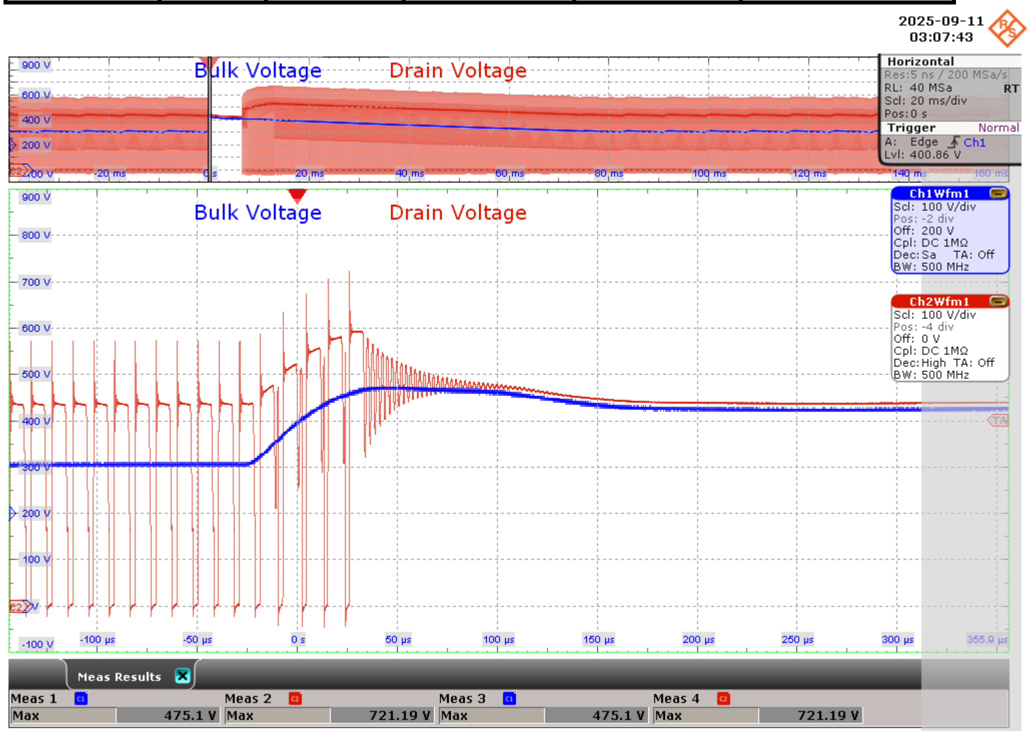

Figure 116 – 230 VAC, -1 kV 270° surge event.
CH 1: Bulk Voltage: 100 V / div., 20 ms / div.
CH 2: Drain Voltage: 100 V / div., 20 ms / div.
Zoom: 50 μs/div.
Bulk voltage, max = 475 V
Drain current, max = 721 V

16 Ring Wave (Common Mode)

Tested at 115 VAC and 230 VAC input voltage and full load

16.1 115 VAC

115 VAC: 4 kV Surge Event

Surge Voltage	Phase Angle	IEC Coupling	Generator Impedance	Number of Strikes	Results
+4000 V	0°	L/N - PE	12	10	PASS – No AR
–4000 V	0°	L/N - PE	12	10	PASS – No AR
+4000 V	90°	L/N - PE	12	10	PASS – No AR
–4000 V	90°	L/N - PE	12	10	PASS – No AR
+4000 V	180°	L/N - PE	12	10	PASS – No AR
–4000 V	180°	L/N - PE	12	10	PASS – No AR
+4000 V	270°	L/N - PE	12	10	PASS – No AR
–4000 V	270°	L/N - PE	12	10	PASS – No AR

16.2 230 VAC

230 VAC: 4 kV Surge Event

Surge Voltage	Phase Angle	IEC Coupling	Generator Impedance	Number of Strikes	Results
+4000 V	0°	L/N - PE	12	10	PASS – No AR
–4000 V	0°	L/N - PE	12	10	PASS – No AR
+4000 V	90°	L/N - PE	12	10	PASS – No AR
–4000 V	90°	L/N - PE	12	10	PASS – No AR
+4000 V	180°	L/N - PE	12	10	PASS – No AR
–4000 V	180°	L/N - PE	12	10	PASS – No AR
+4000 V	270°	L/N - PE	12	10	PASS – No AR
–4000 V	270°	L/N - PE	12	10	PASS – No AR

17 EFT

Tested at 230 VAC Input Voltage and Full Load

17.1 115 VAC EFT

Surge Voltage	Injection Phase	Frequency	T-Burst	T-Rep	Test Duration	Injection Location	Remarks
+4000 V	0°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	0°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	0°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	0°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	90°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	90°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	90°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	90°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	180°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	180°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	180°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	180°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	270°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	270°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	270°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	270°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR

17.2 230 VAC EFT

Surge Voltage	Injection Phase	Frequency	T-Burst	T-Rep	Test Duration	Injection Location	Remarks
+4000 V	0°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	0°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	0°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	0°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	90°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	90°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	90°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	90°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	180°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	180°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	180°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	180°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	270°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	270°	5 kHz	15 ms	300 ms	120 s	L1/L2	PASS – No AR
+4000 V	270°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR
–4000 V	270°	100 kHz	750 μs	300 ms	120 s	L1/L2	PASS – No AR

18 Bode Plot

Tested at 115 VAC and 230 VAC input voltage and full load

18.1 115 VAC

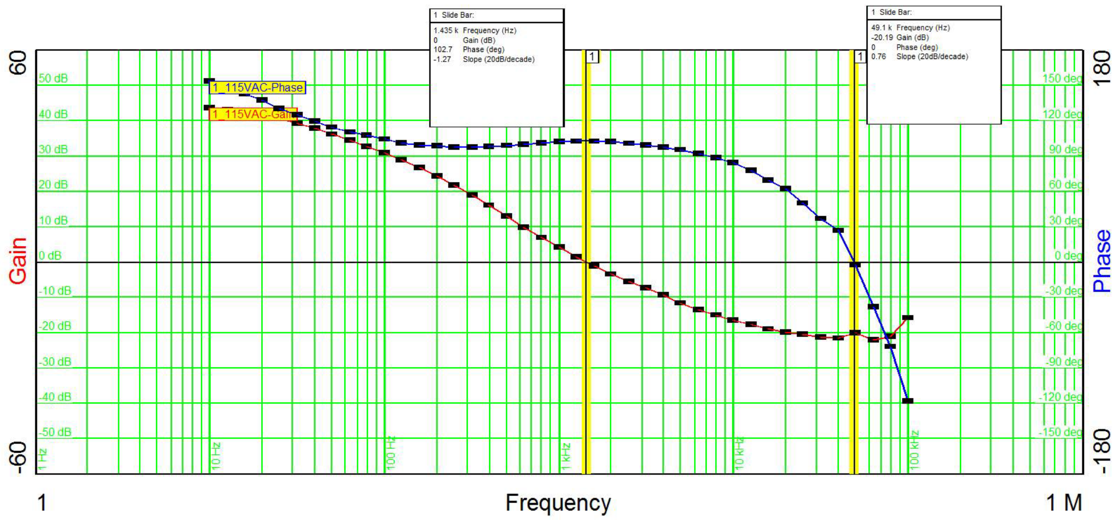

Figure 117 – 115 VAC, 60 Hz, Full Load.
$F_{crossover}$ = 1.44 kHz
Phase Margin = 103°
Gain Margin = 20.2 dB

18.2 230 VAC

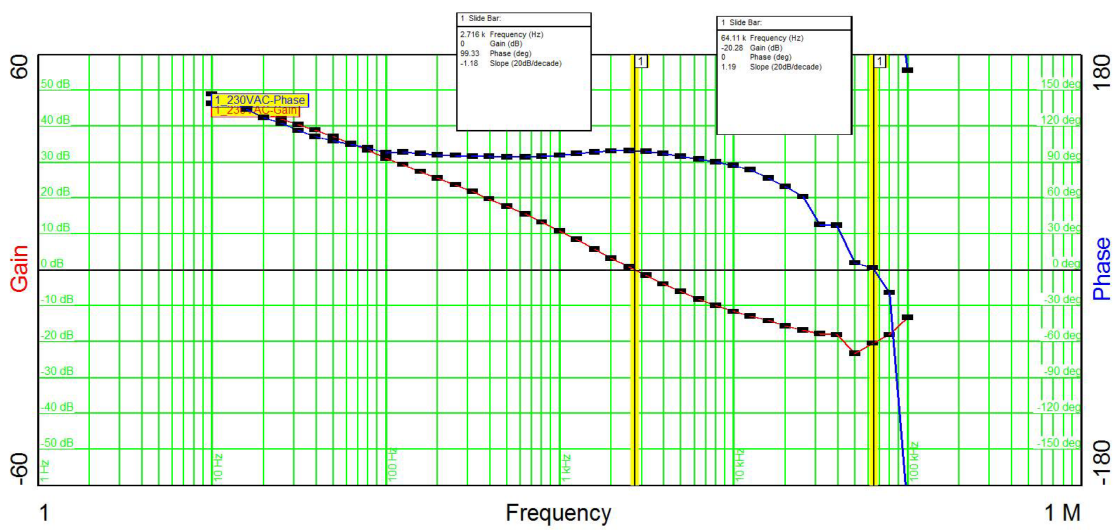

Figure 118 – 230 VAC, 50 Hz, Full Load.
$F_{crossover}$ = 2.72 kHz
Phase Margin = 99.3°
Gain Margin = 20.3 dB

19 Appendix

19.1 Line Regulation With Varying Ambient Temperature

PSU was placed inside a thermal chamber. PSU was soaked for 1 hour for each temperature. After 1 hour, line regulation was measured.

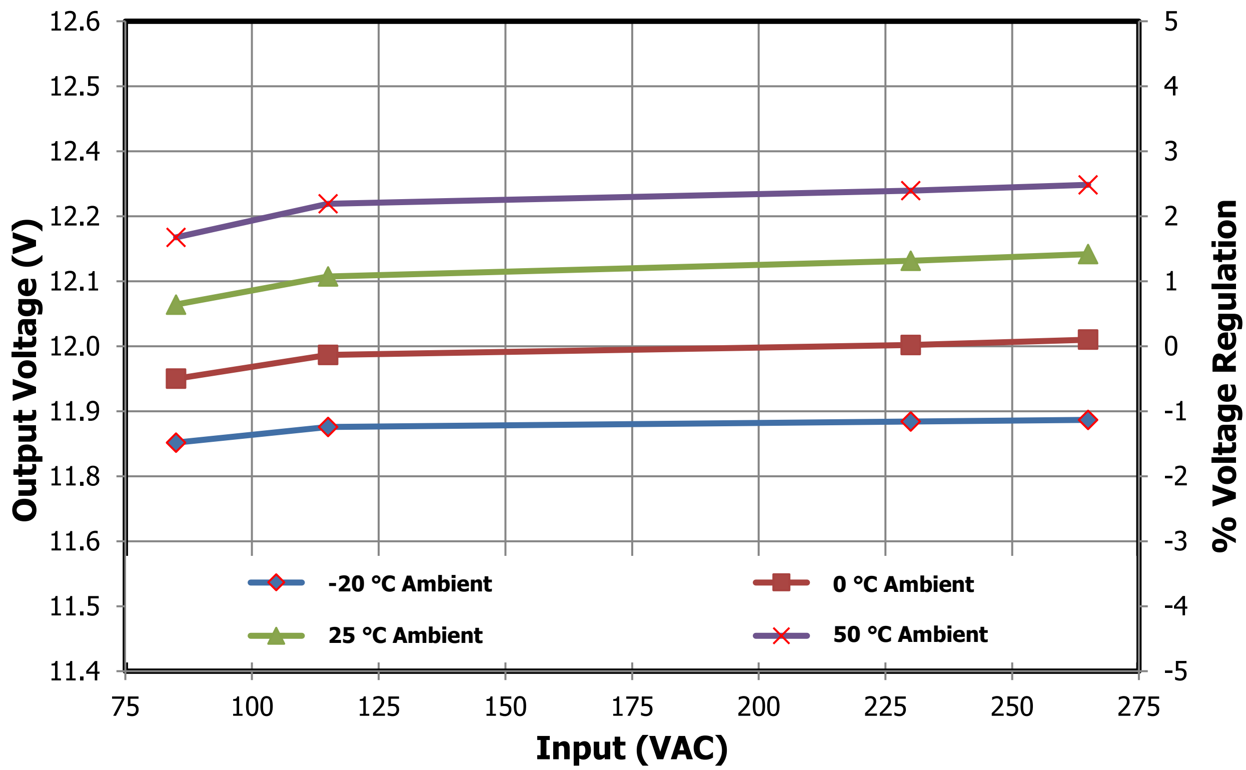

Figure 119 – Output Voltage vs. Line Voltage with Varying Ambient Temperature.

The voltage across the Zener diode will vary with temperature. This in turn will have an effect on output regulation as it forms part of the feedback loop.

20 Revision History

Date	Author	Revision	Description & Changes	Reviewed
19-Dec-25	JA, JPM, RPA	A	Initial Release	Apps & Mktg.

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