Reference Design Report

Title	36 W Isolated Flyback Power Supply Using TinySwitch-5 TNY5094K
Specification	90 VAC – 420 VAC Input 12 V / 3 A Output
Application	Appliances
Product family	TinySwitch-5
Document No.	RDR-1099
Date	August 27, 2026
Revision	B

Summary and Features

- Delivers 36 W output from 90 VAC to 420 VAC
- Up to 150 kHz switching frequency for small transformer
- >88% full load efficiency at 115 VAC
- >89% full load efficiency at 230 VAC
- >87% full load efficiency at 420 VAC
- >70% efficient at 230 VAC and 300 mW input power
- <100 mW no-load input power at 420 VAC
- Extensive protection features including:
    - Over Temperature Protection (OTP)
    - Short Circuit Protection
    - Over Power Protection
- Class B Conducted EMI
- 90% average efficiency

Power Integrations
5245 Hellyer Avenue, San Jose, CA 95138 USA.
+1 408 414 9200 | **Power.com**

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1 Introduction

This engineering report describes a flyback converter that provides an isolated output voltage of 12 V at 3 A from a wide input voltage range of 90 VAC to 420 VAC. This power supply utilizes TNY5094K from the TinySwitch-5™ family of ICs.

The report contains the power supply specification, bill of materials (BOM), transformer construction information, schematic and printed circuit board (PCB) layout, along with performance data and electrical waveforms.

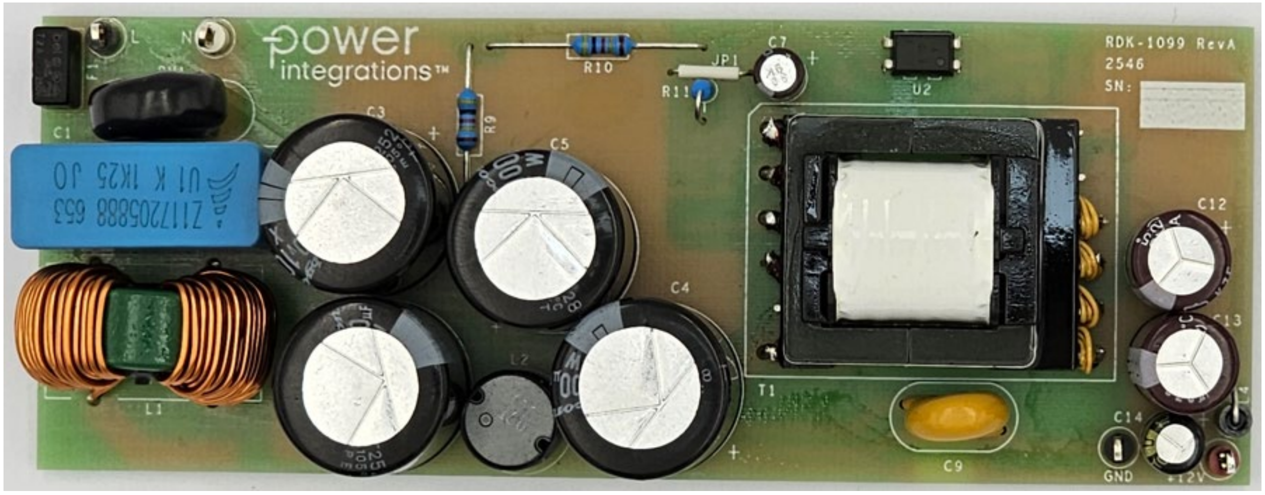

Figure 1 – Top View

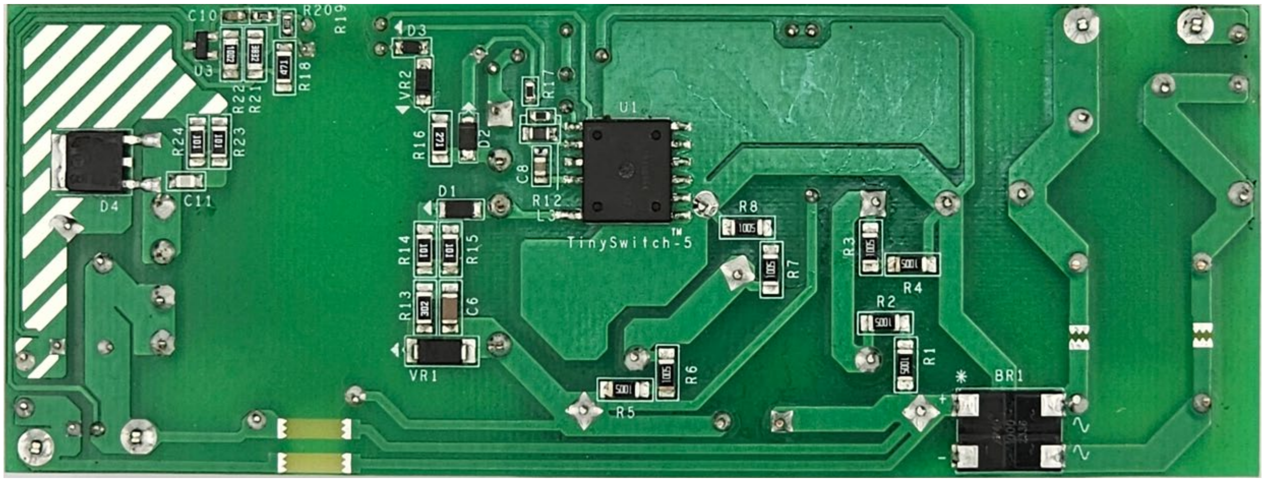

Figure 2 – Side View

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.	Typical	Max.	Units	Comment
Input						
Voltage	V_{IN}	90	115/230	420	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power (230 VAC)				60	mW	
Output 1						
Output Voltage	V_{OUT1}	11.4	12	12.6	V	±5%
Output Ripple Voltage	$V_{RIPPLE1}$			180	mV	20 MHz Bandwidth
Output Current	I_{OUT1}	0		3	A	
Total Output Power						
Continuous Output Power	P_{OUT}		36		W	
Efficiency						
Full Load 115 VAC	$\eta_{115\ VAC}$	87			%	Measured at P_{OUT} 25 °C
Full Load 230 VAC	$\eta_{230\ VAC}$	88			%	
Average efficiency at 25, 50, 75 and 100% of P_{OUT}	η_{DOE}	87.4			%	Measured at Nominal Input 115 VAC and 230 VAC
Environmental						
Conducted EMI		Meets CISPR22B/EN55022B				
Surge (Differential)				±1	kV	1.2/50 ms 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

Table 1 – Power Supply Specification

3 Schematic

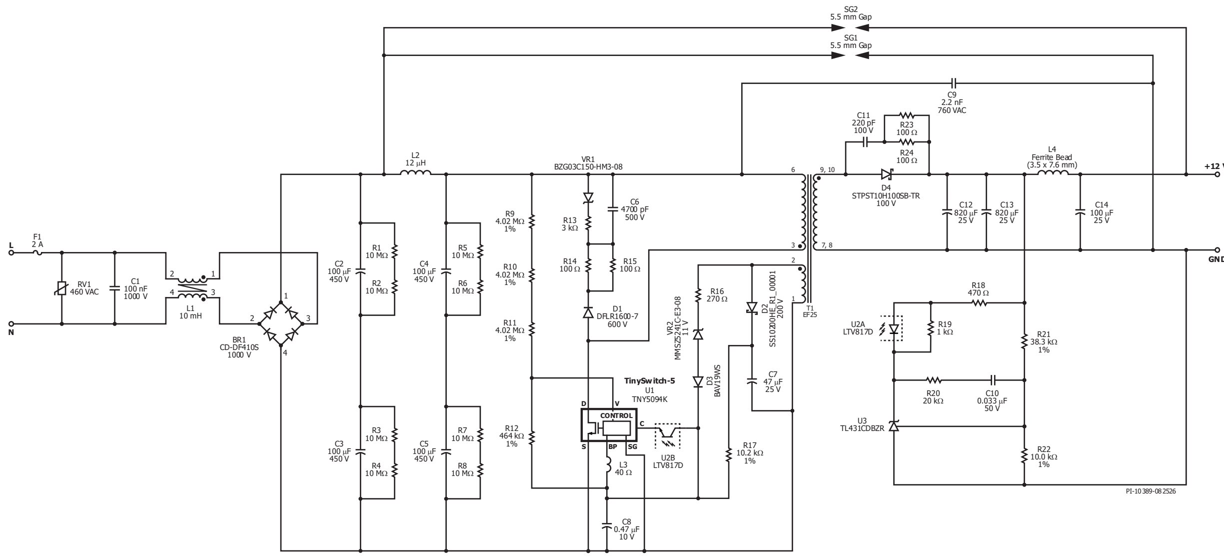

Figure 3 – Schematic

4 Circuit Description

This power supply employs a TNY5094K off-line switcher, (U1), in a flyback configuration. IC U1 has an integrated 900 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. X Capacitor C1 together with common mode choke L1 forms an EMI filter that attenuates both common mode and differential mode conducted EMI. Bulk Capacitors C2, C3, C4 and C5 together with differential mode choke L2 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 C2, C3, C4 and C5.

4.2 TinySwitch-5 Primary

The TNY5094K 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 C2 and C4, 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 RCDZ clamp network that consists of D1, R13, R14, R15, C6 and VR1. The RZCD arrangement prevents the voltage across the capacitor C6 discharging below a minimum value (defined by the voltage rating of VR1 and resistor R13) and therefore minimizes clamp dissipation under light and no-load conditions. Parallel resistors R14 and R15 are used together with capacitor C6 to damp high frequency ringing and improve EMI. This arrangement was selected to reduce clamp losses under light and no-load conditions. Y capacitor C9, connected between the primary and secondary side helps improve EMI.

The TNY5094K regulates the output by adjusting the power MOSFET off time duration based on the current into its CONTROL pin. The power supply output voltage is sensed on the secondary side by shunt regulator U3 and provides a feedback signal to the primary side through optocoupler U2.

The line undervoltage and overvoltage are determined by the current supplied from resistors R9, R10 and R11 to the V pin. R12 is connected in between BP pin and V pin to widen the input line range.

R16, D3 and VR2 are used for output overvoltage protection. An increase in output voltage causes an increase in the bias winding voltage, sensed by VR2. Once VR2 is activated, it will inject current to the BP pin causing the IC U1 to shut down and undergo auto-restart.

Bypass capacitor C8 serves as a decoupling capacitor and is placed as physically 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. Capacitor C8 stores enough energy to ensure the power supply output reaches regulation. After start-up, the bias winding via diode D2 and capacitor C7 powers the controller via the current through resistor R17. Resistor R17 was used to set the typical bias current of the IC U1. Ferrite bead L3 minimizes the noise coming to 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 C12, C13, L4 and C14. Resistors R23 and R24 and capacitor C11 snubs the voltage spike caused by the commutation of D4. Low ESR capacitors C12 and C13 help in minimizing output voltage ripple, while post filter L4 and C14 further attenuates high frequency noise and ripple.

4.4 Output Feedback

The reference IC, U3 or TL431CDBZR, is used to set the output voltage programmed via the feedback resistor divider R21 and R22. The TL431CDBZR varies its cathode voltage to keep its input voltage constant (equal to 2.50 V, ±2.2%). As the cathode voltage changes, the current through the optocoupler LED and transistor within U2 changes. R18, R20 and C10 provide stable operation throughout the range of operation, while resistor R19 ensures minimum bias to U3.

5 PCB Layout

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

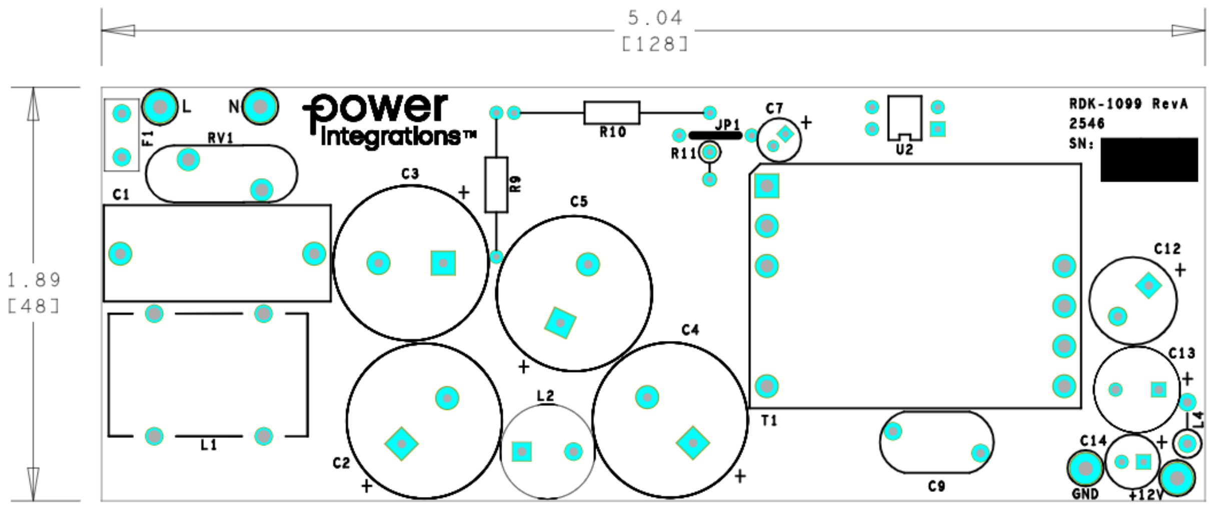

Figure 4 – Printed Circuit Layout, Top

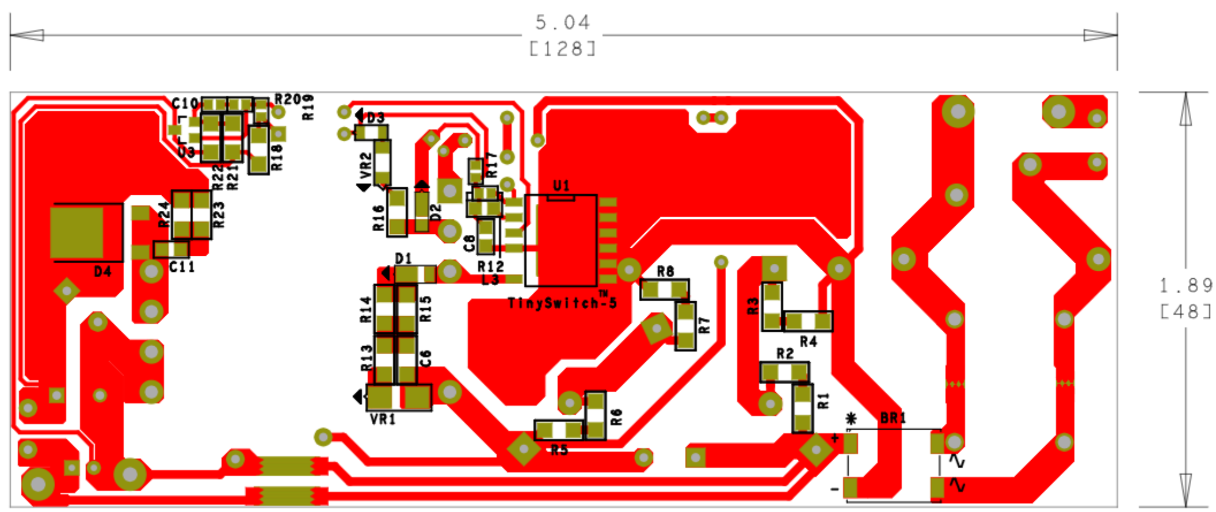

Figure 5 – Printed Circuit Layout, Bottom

6 Performance Data

6.1 Full Load Efficiency vs. Line

Test condition: Soak for 15 minutes at each line voltage prior to taking measurements.

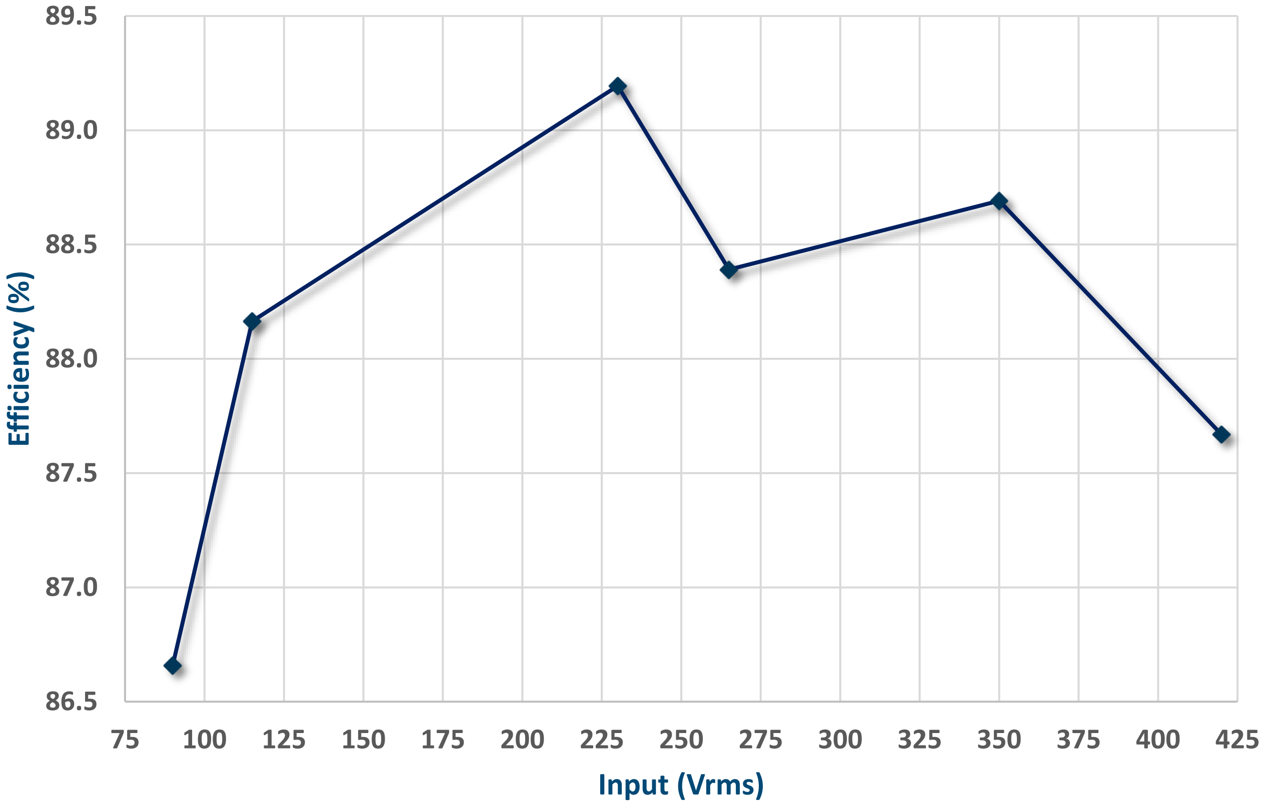

Figure 6 – Efficiency vs Input Voltage

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)	(%)	(%)
90	60	90.1	857	41.7	12.0	3.00	36	-0.01	86.7
115	60	115	743	40.8	12.0	3.00	36	0.00	88.2
230	50	230	495	40.3	12.0	3.00	36	0.01	89.2
265	50	265	466	40.7	12.0	3.00	36	-0.01	88.4
350	50	348	200	40.6	12.0	3.00	36	0.01	88.7
420	50	419	176	41.1	12.0	3.00	36	0.00	87.7

6.2 Efficiency vs. Load

Test Condition: Soak for 15 minutes at full load each line voltage prior to taking measurements, and 10 seconds for each load point.

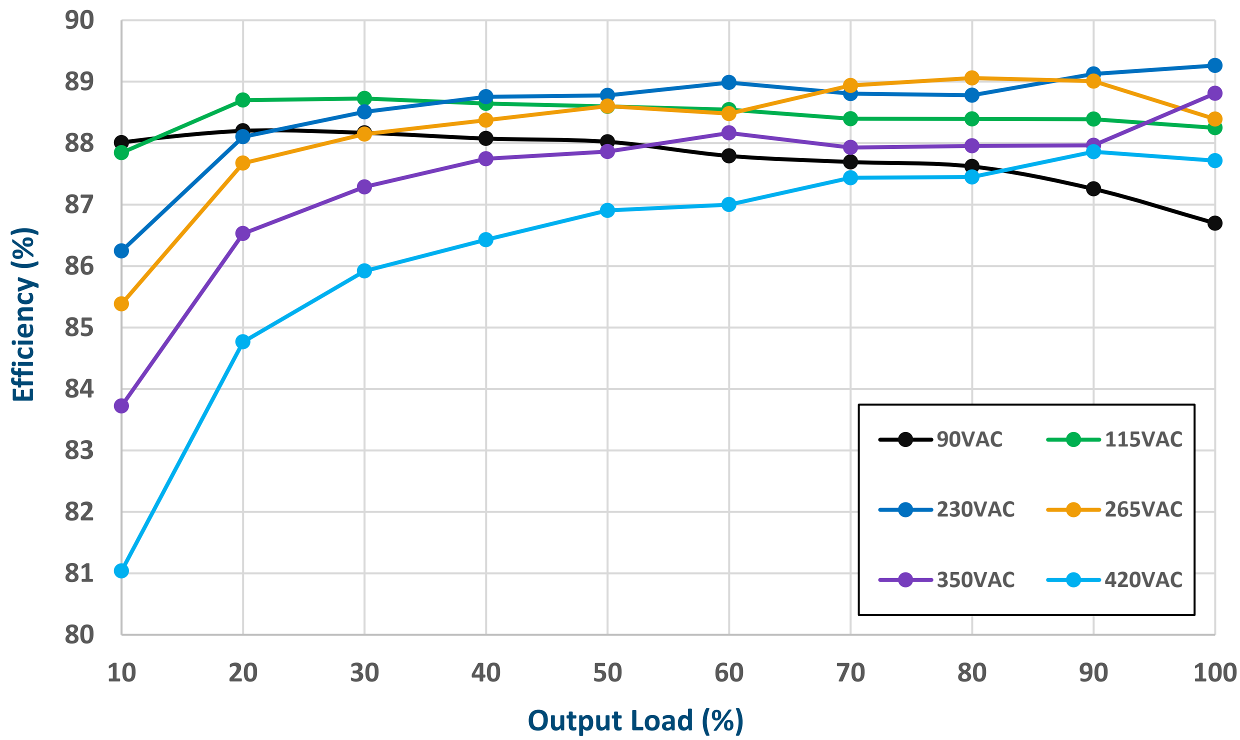

Figure 7 – Efficiency vs Percentage Load

VAC (RMS)	Freq (Hz)	V_{IN} (RMS)	I_{IN} (mA)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	V_{REG} (%)	Efficiency (%)
90	60	89.9	856	41.6	12.0	3.00	36.1	0.32	86.7
90	60	90.1	780	37.3	12.0	2.70	32.5	0.33	87.3
90	60	90.0	707	33.0	12.0	2.40	28.9	0.35	87.6
90	60	90.0	635	28.8	12.0	2.10	25.3	0.36	87.7
90	60	90.0	561	24.7	12.0	1.80	21.7	0.37	87.8
90	60	90.0	484	20.5	12.0	1.50	18.1	0.39	88.0
90	60	90.0	406	16.4	12.0	1.20	14.5	0.39	88.1

90	60	90.1	324	12.3	12.0	0.90	10.8	0.40	88.2
90	60	90.0	236	8.19	12.0	0.60	7.23	0.41	88.2
90	60	89.9	132	4.10	12.0	0.30	3.61	0.42	88.0
90	60	90.0	19.1	0.04	12.0	0.00	0.00	0.42	---

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	744	40.8	12.0	3.00	36.0	-0.01	88.3
115	60	115	684	36.6	12.0	2.70	32.4	0.00	88.4
115	60	115	624	32.6	12.0	2.40	28.8	0.01	88.4
115	60	115	562	28.5	12.0	2.10	25.2	0.02	88.4
115	60	115	499	24.4	12.0	1.80	21.6	0.03	88.5
115	60	115	434	20.3	12.0	1.50	18.0	0.03	88.6
115	60	115	368	16.2	12.0	1.20	14.4	0.05	88.7
115	60	115	295	12.2	12.0	0.90	10.8	0.06	88.7
115	60	115	210	8.12	12.0	0.60	7.20	0.08	88.7
115	60	115	114	4.10	12.0	0.30	3.60	0.15	87.8
115	60	115	14.1	0.04	12.0	0.00	0.00	0.16	---

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	495	40.3	12.0	3.00	36.0	0.00	89.3
230	50	230	458	36.3	12.0	2.70	32.4	0.01	89.1
230	50	230	421	32.4	12.0	2.40	28.8	0.01	88.8
230	50	230	379	28.4	12.0	2.10	25.2	0.02	88.8
230	50	230	333	24.3	12.0	1.80	21.6	0.03	89.0

230	50	230	285	20.3	12.0	1.50	18.0	0.04	88.8
230	50	230	234	16.2	12.0	1.20	14.4	0.05	88.8
230	50	230	182	12.2	12.0	0.90	10.8	0.07	88.5
230	50	230	127	8.17	12.0	0.60	7.20	0.08	88.1
230	50	230	67.8	4.18	12.0	0.30	3.60	0.15	86.2
230	50	230	15.5	0.08	12.0	0.13	0.00	0.16	---

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	465	40.7	12.0	3.00	36.0	0.00	88.4
265	50	265	423	36.4	12.0	2.70	32.3	0.01	89.0
265	50	265	382	32.3	12.0	2.40	28.8	0.02	89.1
265	50	265	340	28.3	12.0	2.10	25.2	0.03	88.9
265	50	265	298	24.4	12.0	1.80	21.6	0.03	88.5
265	50	265	254	20.3	12.0	1.50	18.0	0.04	88.6
265	50	265	209	16.3	12.0	1.20	14.4	0.06	88.4
265	50	265	162	12.3	12.0	0.90	10.8	0.07	88.2
265	50	265	114	8.21	12.0	0.60	7.20	0.08	87.7
265	50	265	61.7	4.22	12.0	0.30	3.60	0.15	85.4
265	50	265	16.5	0.10	12.0	0.13	0.00	0.16	---

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)	(%)	(%)
350	50	348	200	40.5	12.0	3.00	36.0	0.00	88.8
350	50	348	184	36.8	12.0	2.70	32.4	0.01	88.0
350	50	349	165	32.7	12.0	2.40	28.8	0.02	88.0

350	50	349	147	28.7	12.0	2.10	25.2	0.03	87.9
350	50	349	128	24.5	12.0	1.80	21.6	0.03	88.1
350	50	349	109	20.5	12.0	1.50	18.0	0.05	87.9
350	50	349	90.2	16.4	12.0	1.20	14.4	0.06	87.8
350	50	349	70.6	12.4	12.0	0.90	10.8	0.08	87.3
350	50	350	50.4	8.32	12.0	0.60	7.20	0.08	86.5
350	50	350	29.6	4.30	12.0	0.30	3.60	0.15	83.7
350	50	350	11.2	0.13	12.0	0.13	0.00	0.17	---

VAC (RMS)	Freq (Hz)	V_{IN} (RMS)	I_{IN} (mA)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	V_{REG} (%)	Efficiency (%)
420	50	419	176	41.0	12.0	3.00	36.0	0.01	87.7
420	50	419	160	36.9	12.0	2.70	32.4	0.02	87.9
420	50	419	145	32.9	12.0	2.40	28.8	0.03	87.5
420	50	419	129	28.8	12.0	2.10	25.2	0.03	87.4
420	50	419	113	24.8	12.0	1.80	21.6	0.04	87.0
420	50	419	96.5	20.7	12.0	1.50	18.0	0.06	86.9
420	50	419	80.0	16.7	12.0	1.20	14.4	0.07	86.4
420	50	420	62.9	12.6	12.0	0.90	10.8	0.08	85.9
420	50	420	45.5	8.49	12.0	0.60	7.20	0.09	84.8
420	50	420	28.0	4.45	12.0	0.30	3.60	0.17	81.0
420	50	420	14.1	0.64	12.0	0.14	0.36	0.17	---

6.3 Average and 10% Efficiency

6.3.1 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%	40.8	12.0	3.00	36.0	88.2	**88.5**	**87.4**
75%	30.5	12.0	2.25	27.0	88.7		
50%	20.4	12.0	1.50	18.0	88.5		
25%	10.2	12.0	0.75	9.00	88.6		
10%	4.08	12.0	0.30	3.60	88.3	---	---

6.3.2 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%	40.4	12.0	3.60	36.0	89.2	**88.8**	**87.4**
75%	30.4	12.0	2.25	27.0	89.0		
50%	20.3	12.0	1.50	18.0	88.7		
25%	10.2	12.0	0.75	9.01	88.4		
10%	4.2	12.0	0.30	3.60	86.8	---	---

6.4 No Load Input Power

Test Condition: Soak for 15 minutes at each line voltage point before taking measurements with 1-minute integration time.

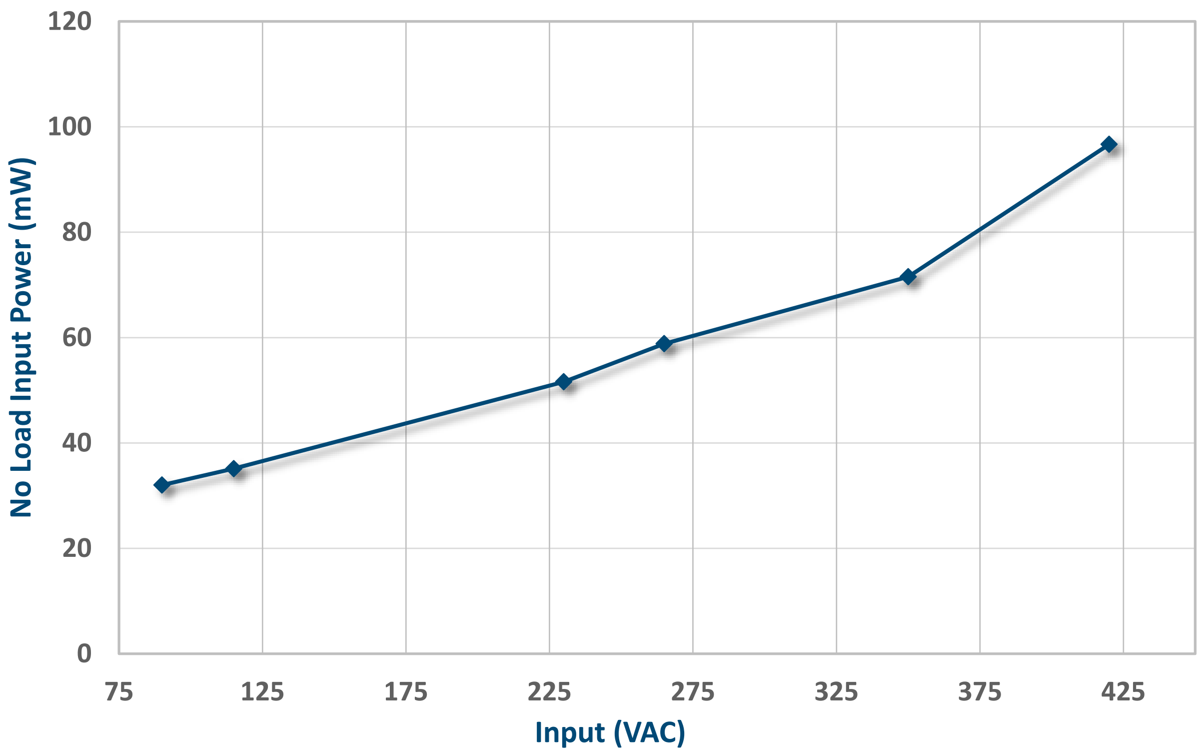

Figure 8 – No-Load Input Power vs. Line at Room Temperature

VAC (RMS)	No Load P_{IN} (mW)
90	32.0
115	35.1
230	51.6
265	58.8
350	71.5
420	96.7

6.5 Line Regulation

Test Condition: Soak for 15 minutes at each line voltage prior to taking measurements.

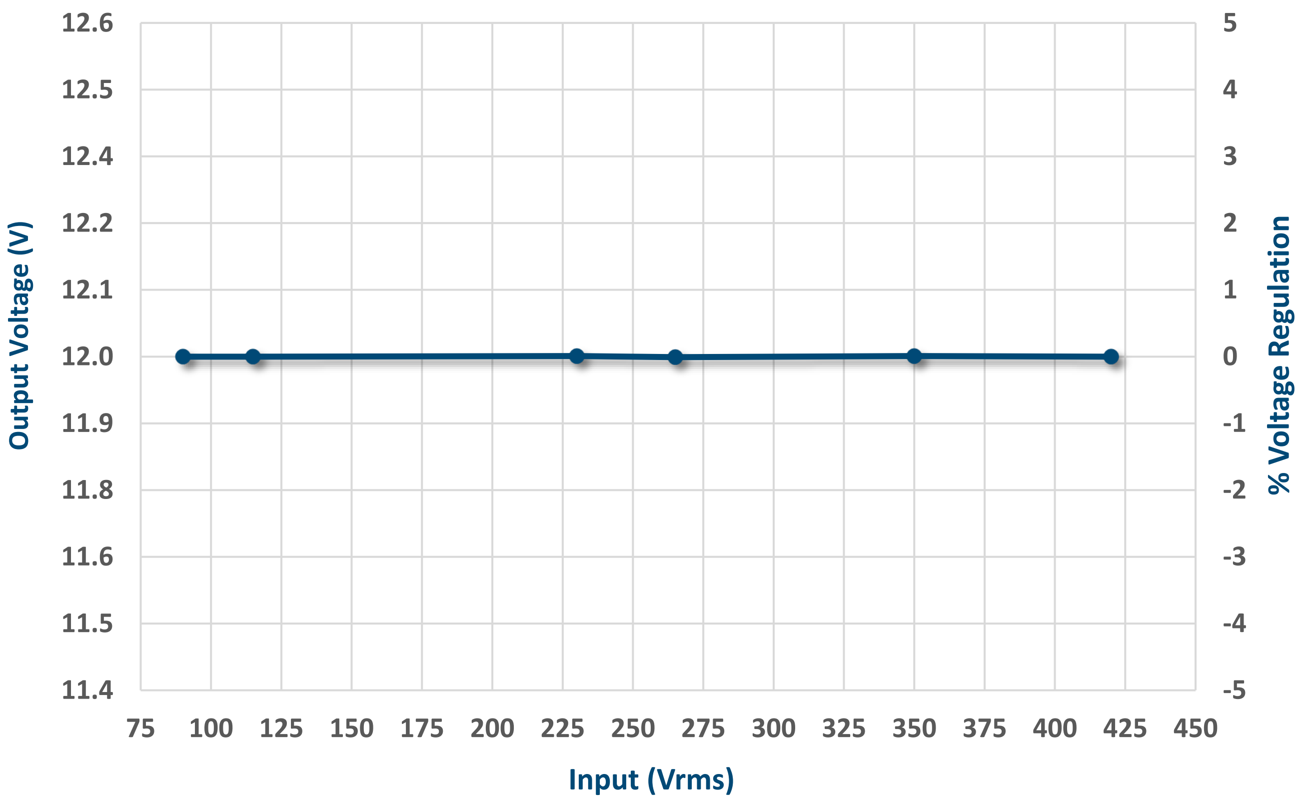

Figure 9 – Output Voltage vs. Percent Load

6.6 Load Regulation

Test Condition: Soak for 15 minutes at full load for each line voltage prior to taking measurements, and 10 seconds for each load point.

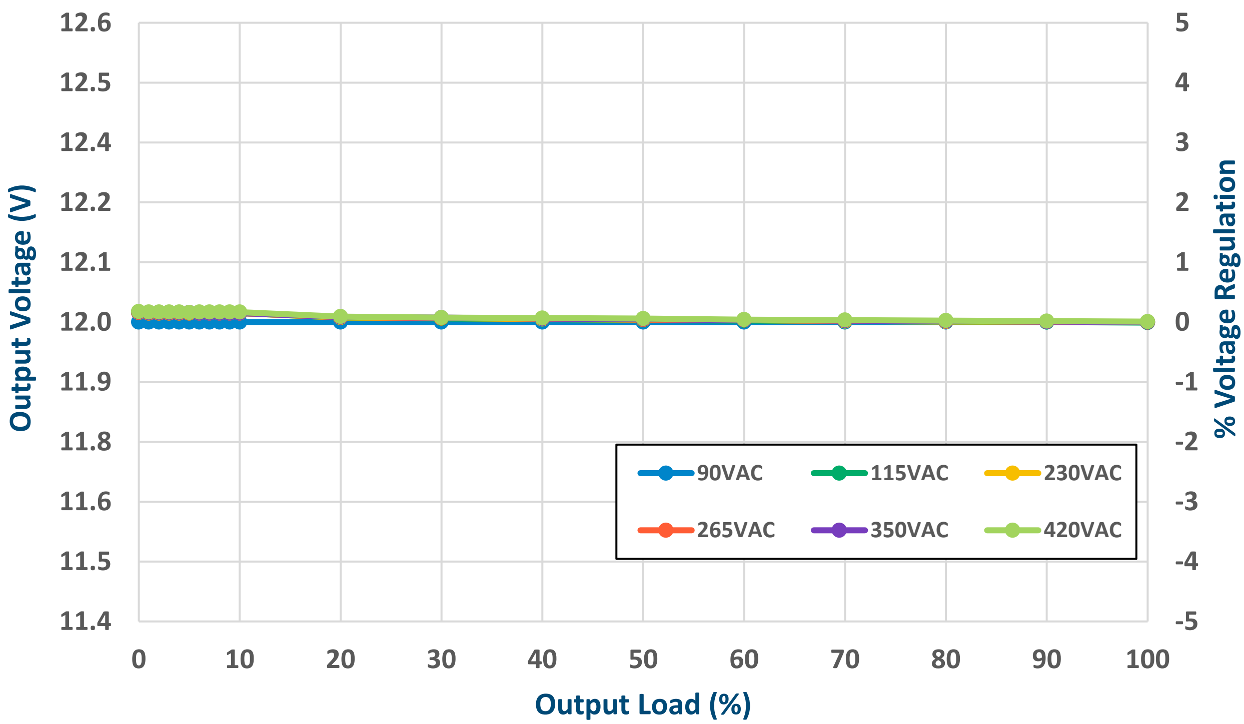

Figure 10 – Output Voltage vs. Percent Load

6.7 Standby Efficiency

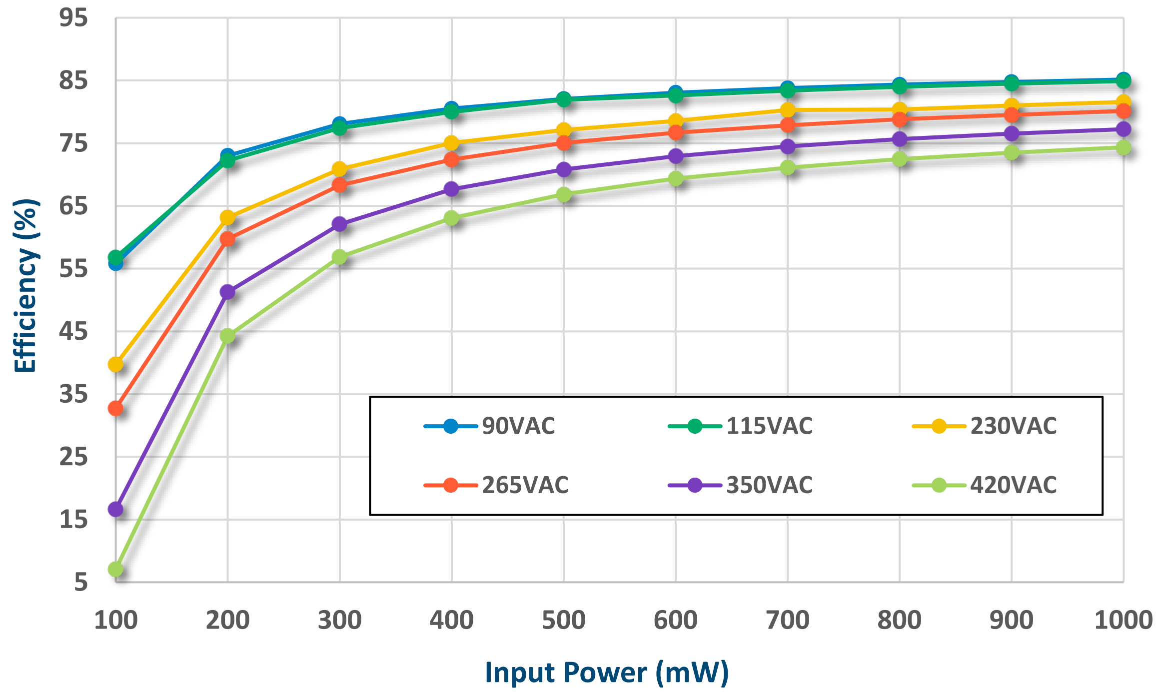

Figure 11 – Efficiency vs. Input Power

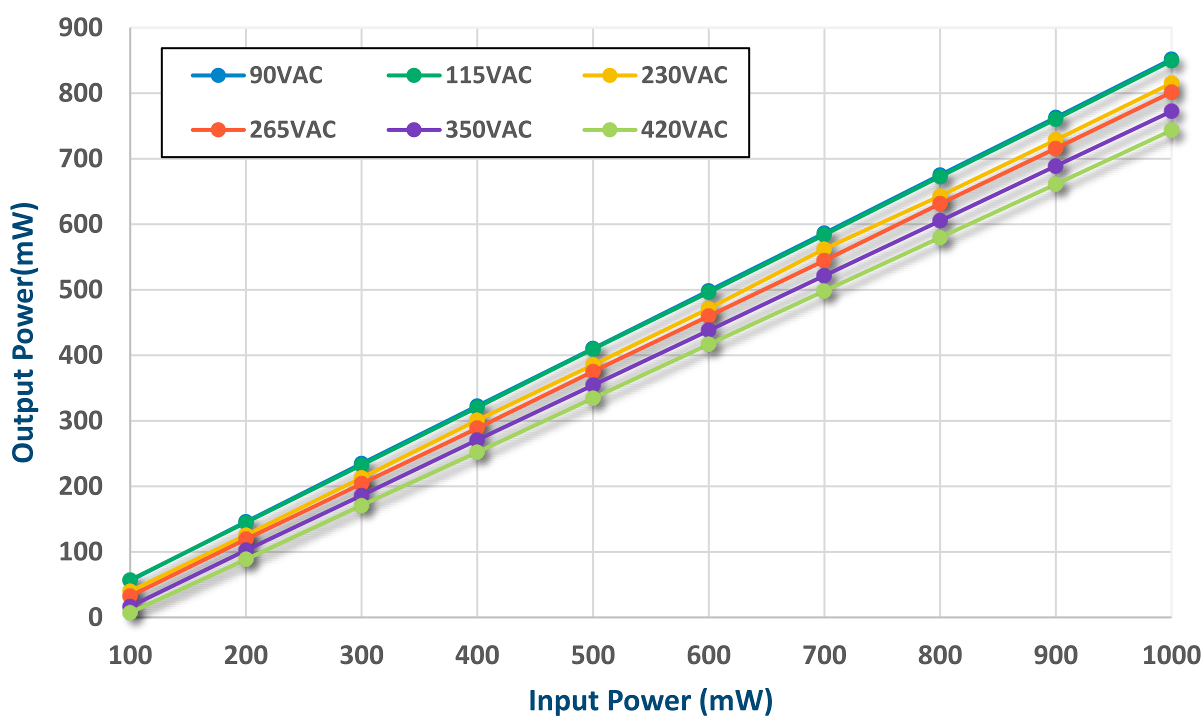

Figure 12 – Output Power vs. Input Power

7 Waveforms

7.1 Output Start-up

7.1.1 Full Load CC Mode

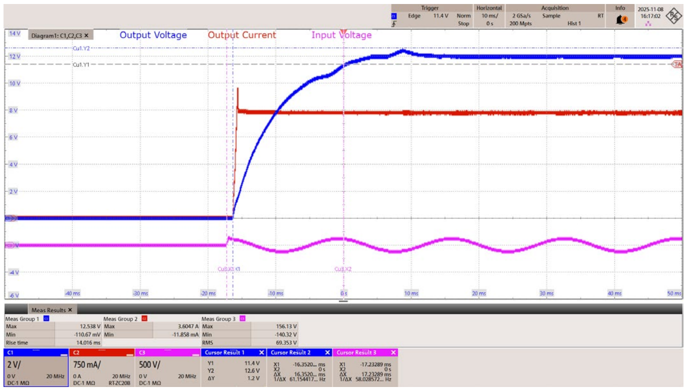

Figure 13 – 90 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 14.0 ms
$T_{0VAC\ to\ Regulation}$ = 17.2 ms
$T_{VOUT=0V\ to\ Regulation}$ = 16.4 ms
V_{MAX} = 12.5 V

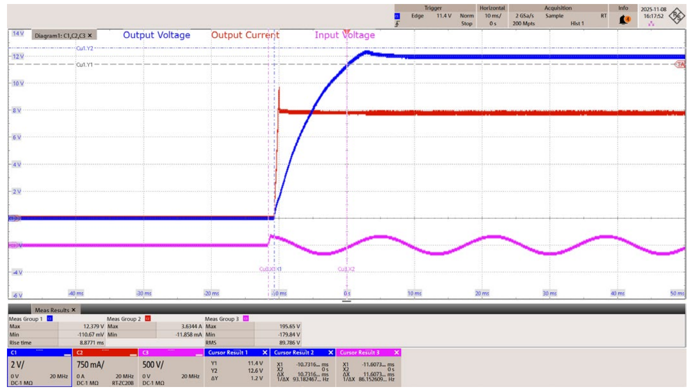

Figure 14 – 115 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 8.88 ms
$T_{0VAC\ to\ Regulation}$ = 11.6 ms
$T_{VOUT=0V\ to\ Regulation}$ = 10.7 ms
V_{MAX} = 12.4 V

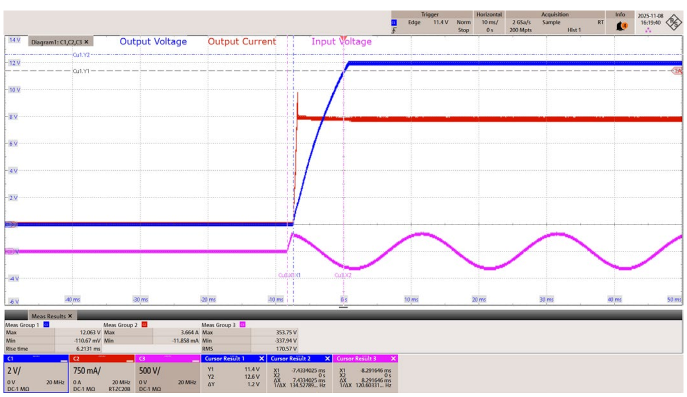

Figure 15 – 230 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 6.21 ms
$T_{0VAC\ to\ Regulation}$ = 8.29 ms
$T_{VOUT=0V\ to\ Regulation}$ = 7.43 ms
V_{MAX} = 12.1 V

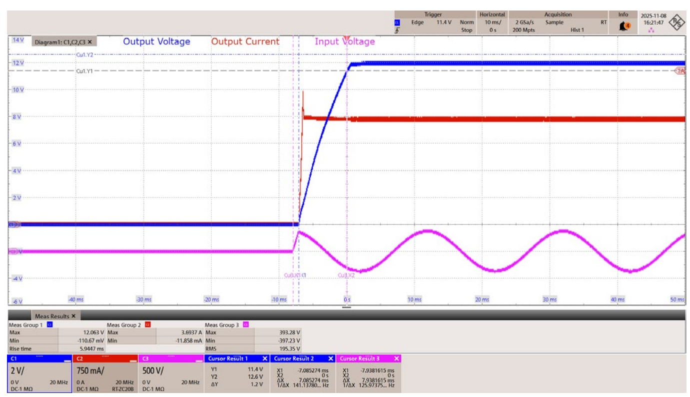

Figure 16 – 265 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 5.94 ms
$T_{0VAC\ to\ Regulation}$ = 7.94 ms
$T_{VOUT=0V\ to\ Regulation}$ = 7.09 ms
V_{MAX} = 12.1 V

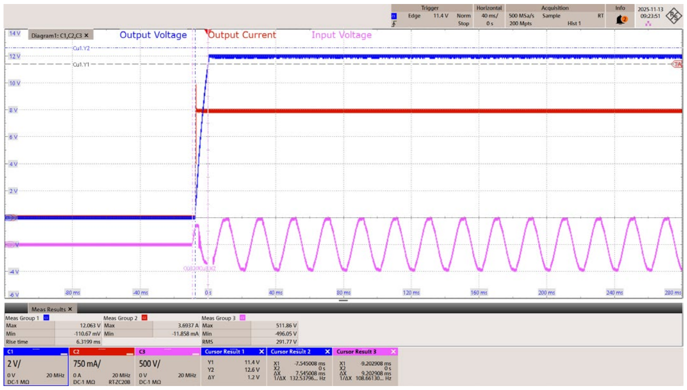

Figure 17 – 350 VAC 50 Hz.

CH1: V_{OUT}, 2 V / div., 40 ms / div.
CH2: I_{OUT}, 750 mA / div., 40 ms / div.
CH3: Input Voltage, 500 V / div., 40 ms / div.
V_o Rise Time = 6.32 ms
$T_{0VAC\ to\ Regulation}$ = 9.20 ms
$T_{VOUT=0V\ to\ Regulation}$ = 7.55 ms
V_{MAX} = 12.1 V

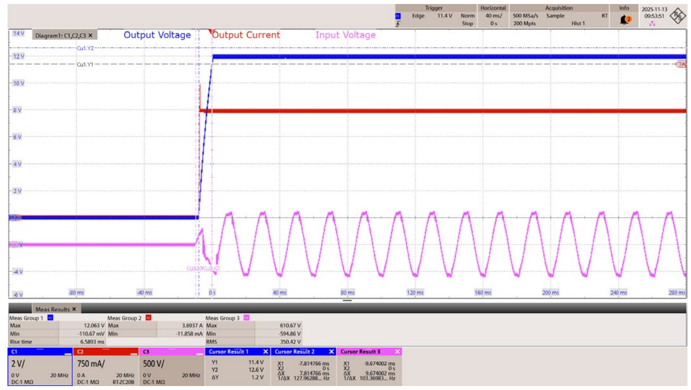

Figure 18 – 420 VAC 50 Hz.

CH1: V_{OUT}, 2 V / div., 40 ms / div.
CH2: I_{OUT}, 750 mA / div., 40 ms / div.
CH3: Input Voltage, 500 V / div., 40 ms / div.
V_o Rise Time = 6.59 ms
$T_{0VAC\ to\ Regulation}$ = 9.67 ms
$T_{VOUT=0V\ to\ Regulation}$ = 7.81 ms
V_{MAX} = 12.1 V

7.1.2 Full Load CR Mode

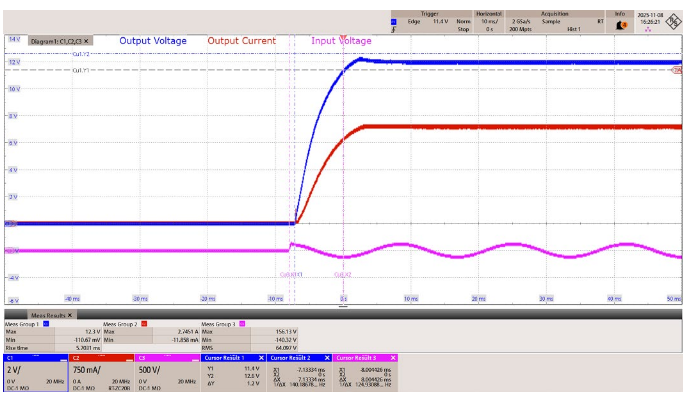

Figure 19 – 90 VAC 60 Hz.

CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 5.70 ms
$T_{0VAC\ to\ Regulation}$ = 8.00 ms
$T_{VOUT=0V\ to\ Regulation}$ = 7.13 ms
V_{MAX} = 12.3 V

Figure 20 – 115 VAC 60 Hz.

CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 4.91 ms
$T_{0VAC\ to\ Regulation}$ = 6.91 ms
$T_{VOUT=0V\ to\ Regulation}$ = 6.05 ms
V_{MAX} = 12.1 V

Figure 21 – 230 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 4.08 ms
$T_{0VAC\ to\ Regulation}$ = 5.79 ms
$T_{VOUT=0V\ to\ Regulation}$ = 4.93 ms
V_{MAX} = 12.1 V

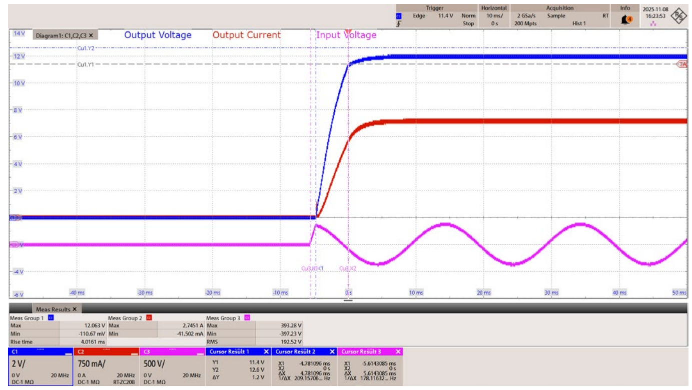

Figure 22 – 265 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 4.02 ms
$T_{0VAC\ to\ Regulation}$ = 5.61 ms
$T_{VOUT=0V\ to\ Regulation}$ = 4.78 ms
V_{MAX} = 12.1 V

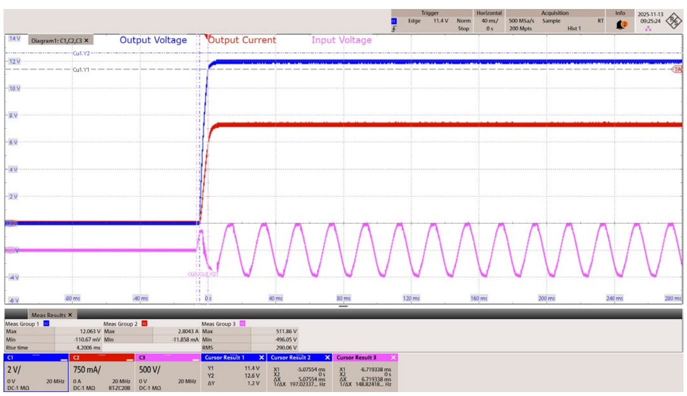

Figure 23 – 350 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 40 ms / div.
CH2: I_{OUT}, 750 mA / div., 40 ms / div.
CH3: Input Voltage, 500 V / div., 40 ms / div.
V_o Rise Time = 4.20 ms
$T_{0VAC\ to\ Regulation}$ = 6.72 ms
$T_{VOUT=0V\ to\ Regulation}$ = 5.08 ms
V_{MAX} = 12.1 V

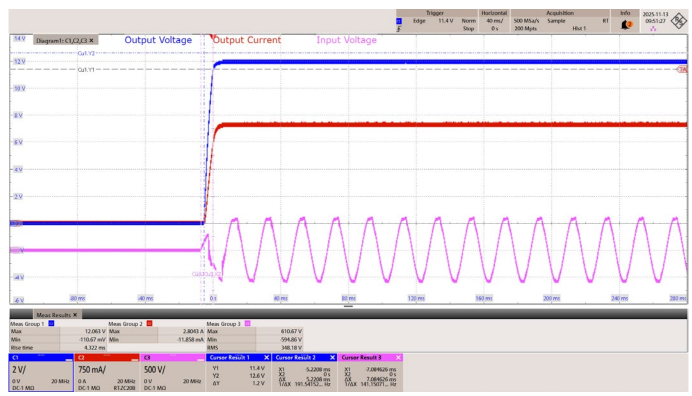

Figure 24 – 420 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 40 ms / div.
CH2: I_{OUT}, 750 mA / div., 40 ms / div.
CH3: Input Voltage, 500 V / div., 40 ms / div.
V_o Rise Time = 4.32 ms
$T_{0VAC\ to\ Regulation}$ = 7.08 ms
$T_{VOUT=0V\ to\ Regulation}$ = 5.22 ms
V_{MAX} = 12.1 V

7.1.3 No Load

Figure 25 – 90 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 4.01 ms
$T_{0VAC\ to\ Regulation}$ = 6.04 ms
$T_{VOUT=0V\ to\ Regulation}$ = 5.13 ms
V_{MAX} = 12.1 V

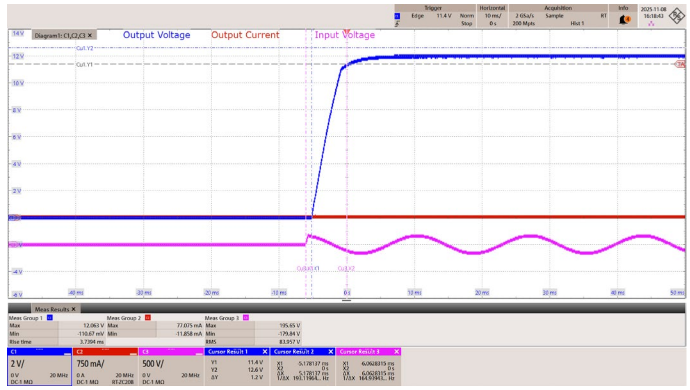

Figure 26 – 115 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 3.74 ms
$T_{0VAC\ to\ Regulation}$ = 6.06 ms
$T_{VOUT=0V\ to\ Regulation}$ = 5.18 ms
V_{MAX} = 12.1 V

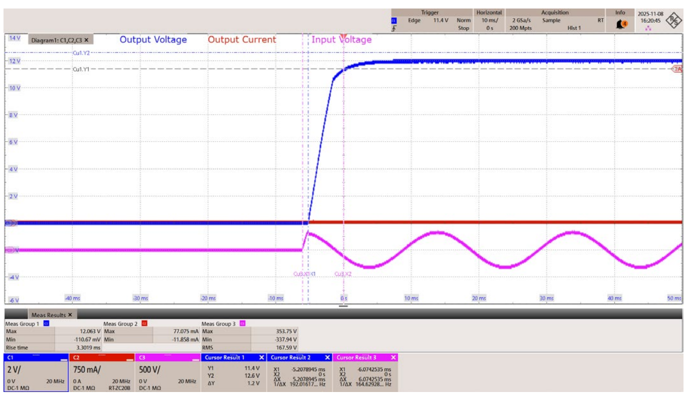

Figure 27 – 230 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 3.30 ms
$T_{0VAC\ to\ Regulation}$ = 6.07 ms
$T_{VOUT=0V\ to\ Regulation}$ = 5.21 ms
V_{MAX} = 12.1 V

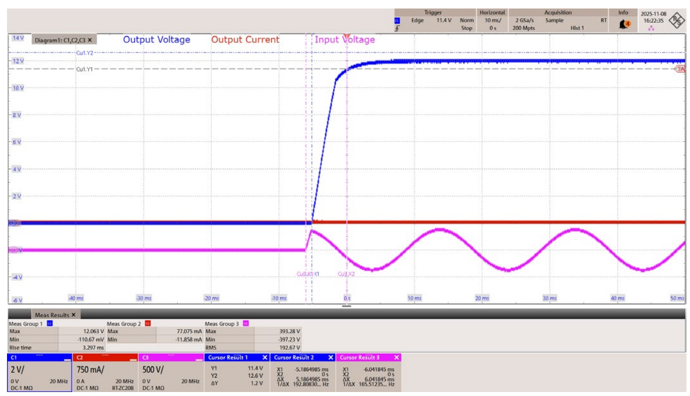

Figure 28 – 265 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 10 ms / div.
CH2: I_{OUT}, 750 mA / div., 10 ms / div.
CH3: Input Voltage, 500 V / div., 10 ms / div.
V_o Rise Time = 3.30 ms
$T_{0VAC\ to\ Regulation}$ = 6.04 ms
$T_{VOUT=0V\ to\ Regulation}$ = 5.19 ms
V_{MAX} = 12.1 V

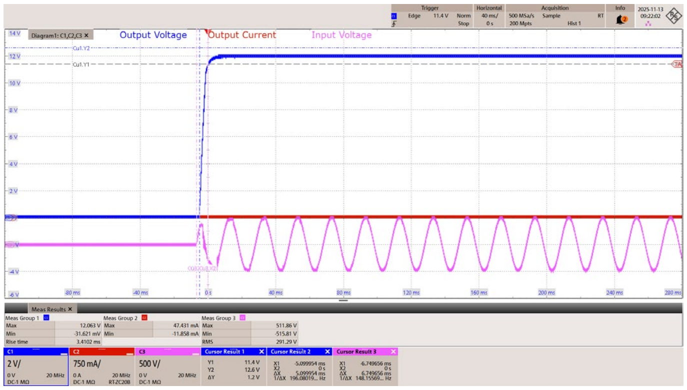

Figure 29 – 350 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 40 ms / div.
CH2: I_{OUT}, 750 mA / div., 40 ms / div.
CH3: Input Voltage, 500 V / div., 40 ms / div.
V_o Rise Time = 3.41 ms
$T_{0VAC\ to\ Regulation}$ = 6.75 ms
$T_{VOUT=0V\ to\ Regulation}$ = 5.10 ms
V_{MAX} = 12.1 V

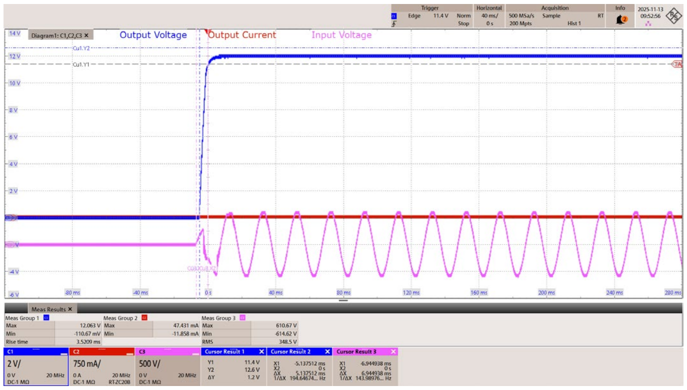

Figure 30 – 420 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 40 ms / div.
CH2: I_{OUT}, 750 mA / div., 40 ms / div.
CH3: Input Voltage, 500 V / div., 40 ms / div
V_o Rise Time = 3.52 ms
$T_{0VAC\ to\ Regulation}$ = 6.94 ms
$T_{VOUT=0V\ to\ Regulation}$ = 5.14 ms
V_{MAX} = 12.1 V

7.2 Switching Waveforms

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

7.2.1.1 Full Load

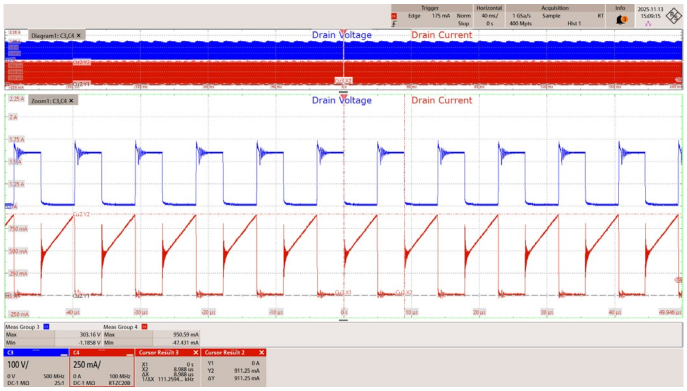

Figure 31 – 90 VAC 60 Hz.
CH3: V_{DS}, 100 V / div., 40 ms / div.
CH4: I_{DS}, 250 mA / div., 40 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 303 V
$I_{DS(MAX)}$ = 951 mA

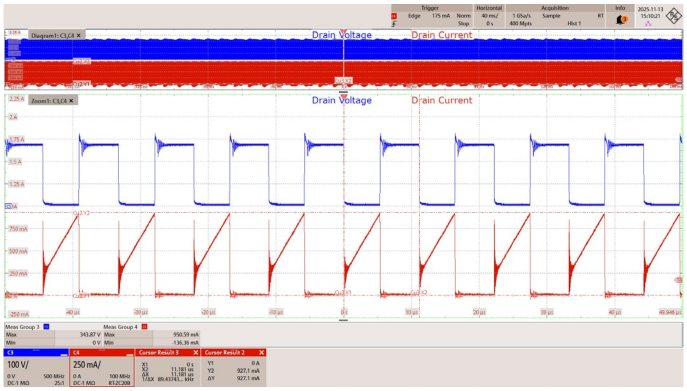

Figure 32 – 115 VAC 60 Hz.
CH3: V_{DS}, 100 V / div., 40 ms / div.
CH4: I_{DS}, 250 mA / div., 40 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 344 V
$I_{DS(MAX)}$ = 951 mA

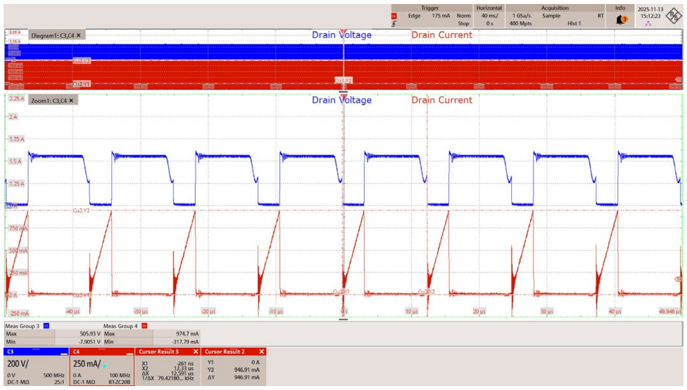

Figure 33 – 230 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 40 ms / div.
CH4: I_{DS}, 250 mA / div., 40 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ =506 V
$I_{DS(MAX)}$ = 975 mA

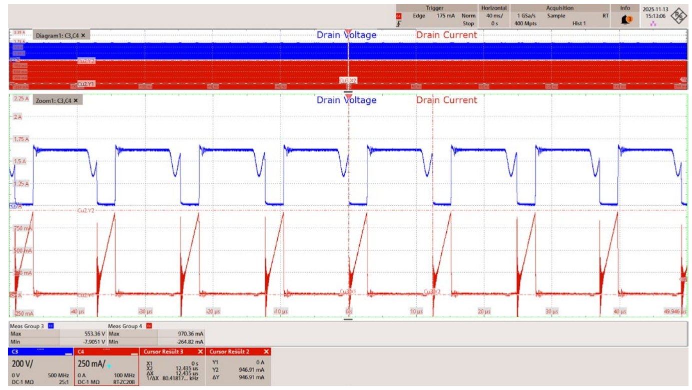

Figure 34 – 265 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 40 ms / div.
CH4: I_{DS}, 250 mA / div., 40 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 553 V
$I_{DS(MAX)}$ = 970 mA

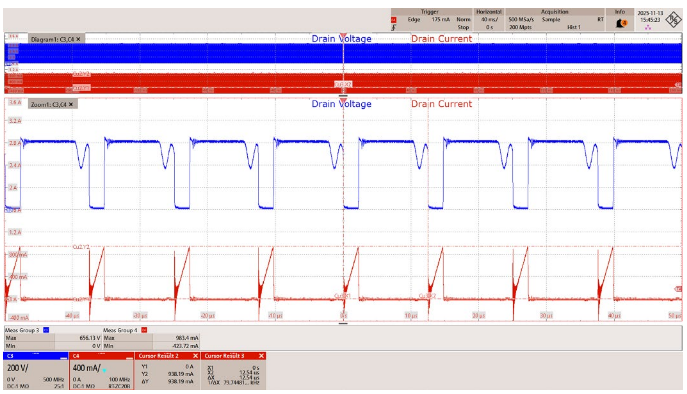

Figure 35 – 350 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 40 ms / div.
CH4: I_{DS}, 400 mA / div., 40 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 656 V
$I_{DS(MAX)}$ = 983 mA

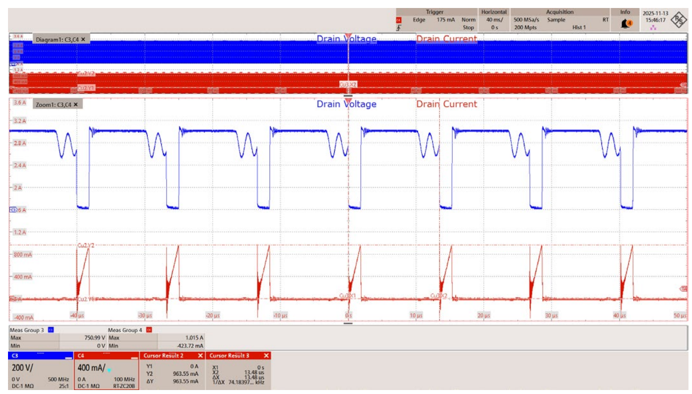

Figure 36 – 420 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 40 ms / div.
CH4: I_{DS}, 400 mA / div., 40 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 751 V
$I_{DS(MAX)}$ = 1.02 A

7.2.1.2 No Load

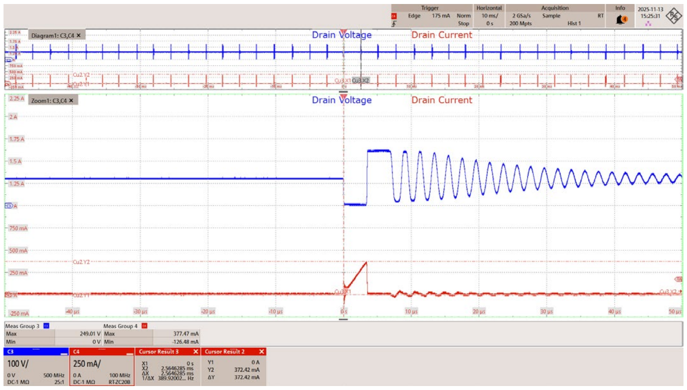

Figure 37 – 90 VAC 60 Hz.
CH3: V_{DS}, 100 V / div., 10 ms / div.
CH4: I_{DS}, 250 mA / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 249 V
$I_{DS(MAX)}$ = 377 mA

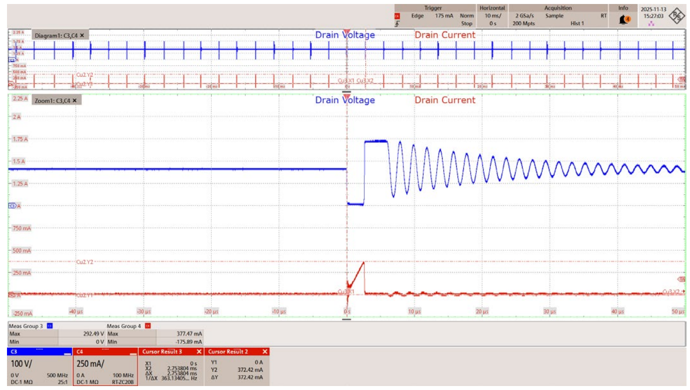

Figure 38 – 115 VAC 60 Hz.
CH3: V_{DS}, 100 V / div., 10 ms / div.
CH4: I_{DS}, 250 mA / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 292 V
$I_{DS(MAX)}$ = 377 mA

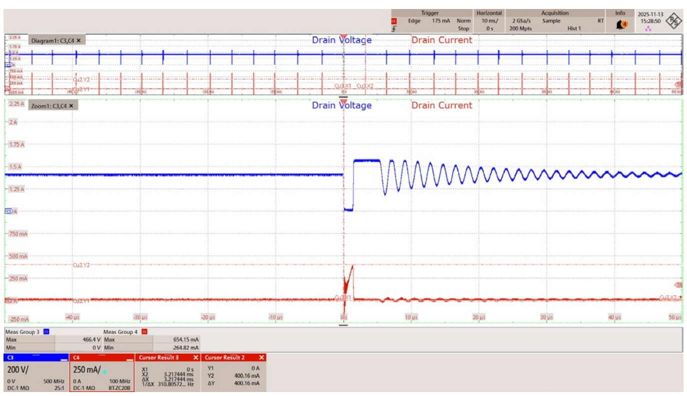

Figure 39 – 230 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 10 ms / div.
CH4: I_{DS}, 250 mA / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 466 V
$I_{DS(MAX)}$ = 654 mA

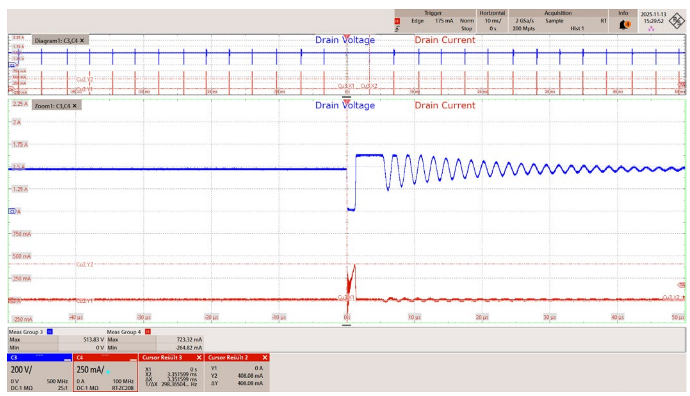

Figure 40 – 265 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 10 ms / div.
CH4: I_{DS}, 250 mA / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 514 V
$I_{DS(MAX)}$ = 723 mA

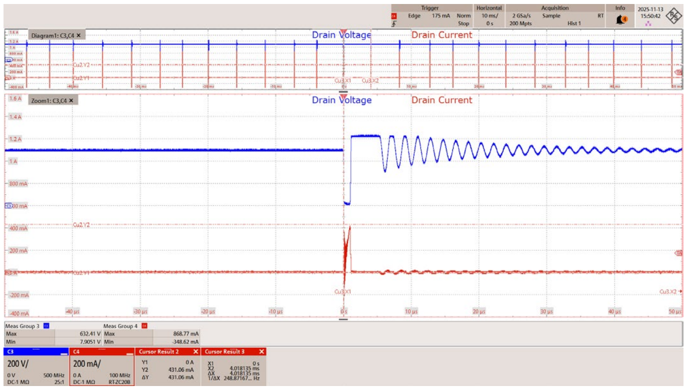

Figure 41 – 350 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 10 ms / div.
CH4: I_{DS}, 200 mA / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 632 V
$I_{DS(MAX)}$ = 869 mA

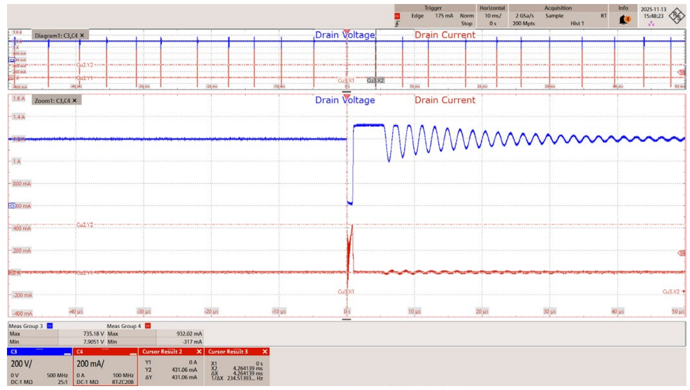

Figure 42 – 420 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 10 ms / div.
CH4: I_{DS}, 200 mA / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 735 V
$I_{DS(MAX)}$ = 932 mA

7.2.2 Primary MOSFET Drain-Source Voltage and Current Start-up Operation

7.2.2.1 Full Load

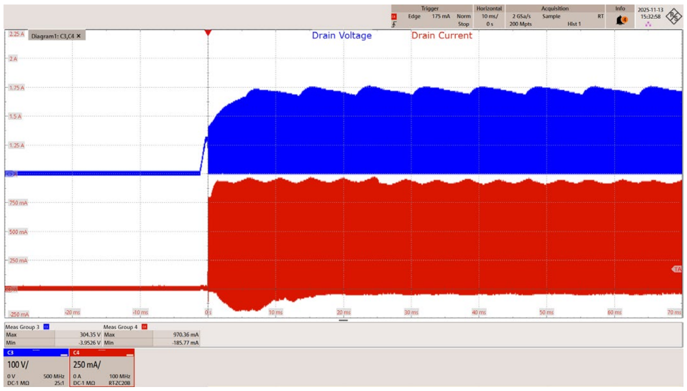

Figure 43 – 90 VAC 60 Hz.
CH3: V_{DS}, 100 V / div., 10 ms / div.
CH4: I_{DS}, 250 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 304 V
$I_{DS(MAX)}$ = 970 mA

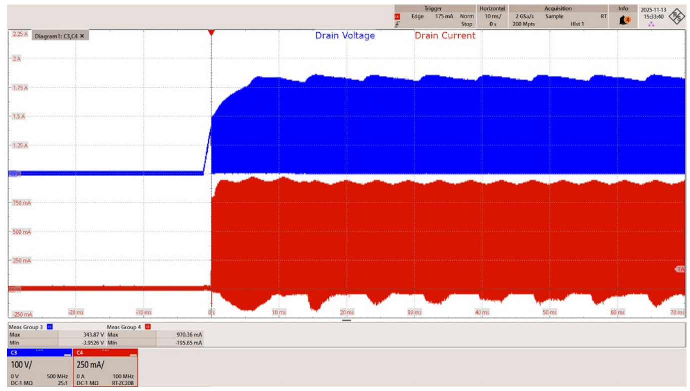

Figure 44 – 115 VAC 60 Hz.
CH3: V_{DS}, 100 V / div., 10 ms / div.
CH4: I_{DS}, 250 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 344 V
$I_{DS(MAX)}$ = 970 mA

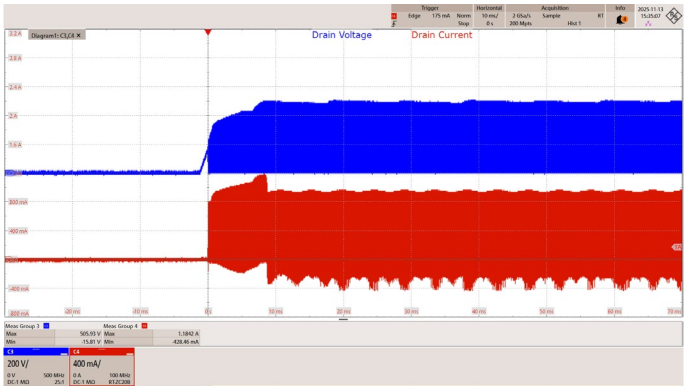

Figure 45 – 230 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 10 ms / div.
CH4: I_{DS}, 400 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 506 V
$I_{DS(MAX)}$ = 1.18 A

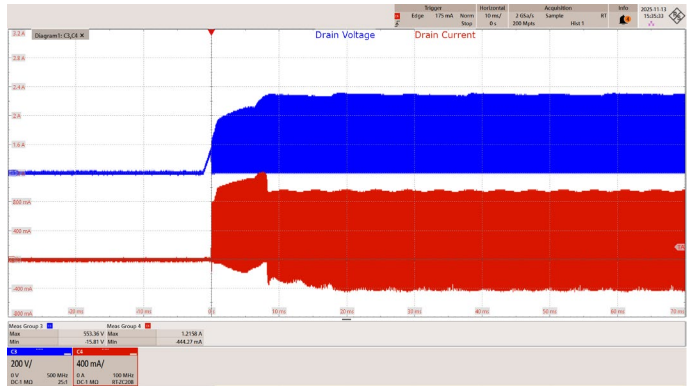

Figure 46 – 265 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 10 ms / div.
CH4: I_{DS}, 400 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 553 V
$I_{DS(MAX)}$ = 1.22 A

Figure 47 – 350 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 10 ms / div.
CH4: I_{DS}, 400 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 664 V
$I_{DS(MAX)}$ = 1.23 A

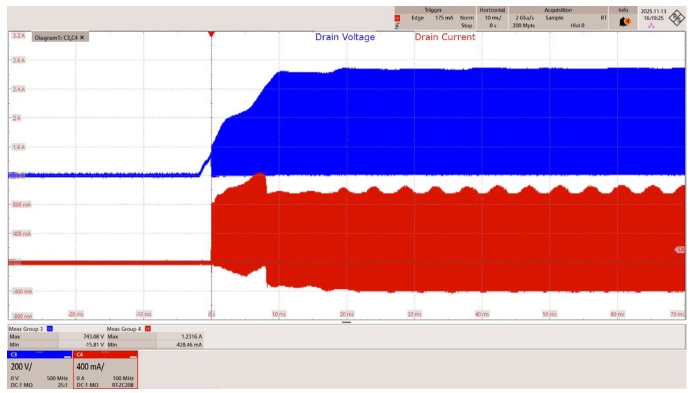

Figure 48 – 420 VAC 50 Hz.
CH3: V_{DS}, 200 V / div., 10 ms / div.
CH4: I_{DS}, 400 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 743 V
$I_{DS(MAX)}$ = 1.23 A

7.2.2.2 No Load

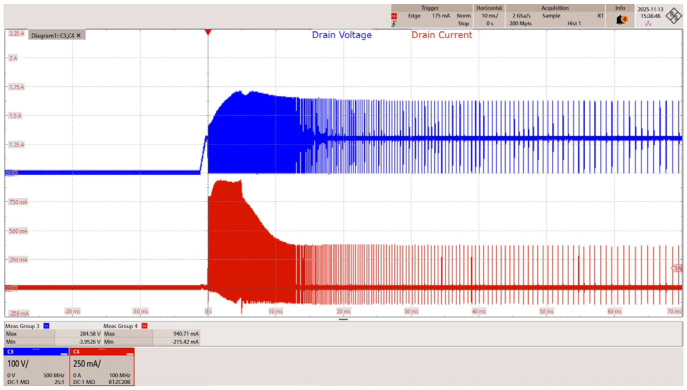

Figure 49 – 90 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 10 ms / div.
CH2: I_{DS}, 250 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 285 V
$I_{DS(MAX)}$ = 941 mA

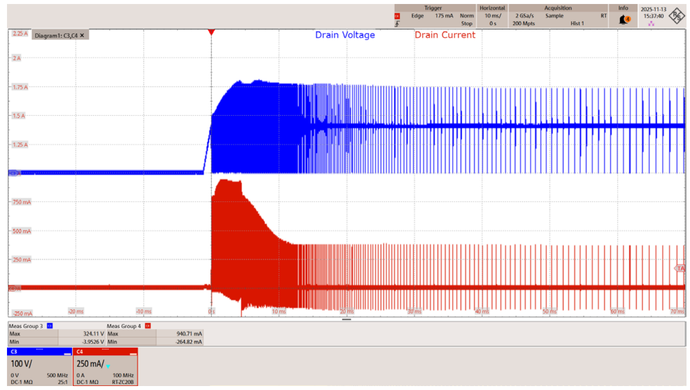

Figure 50 – 115 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 10 ms / div.
CH2: I_{DS}, 250 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 324 V
$I_{DS(MAX)}$ = 941 mA

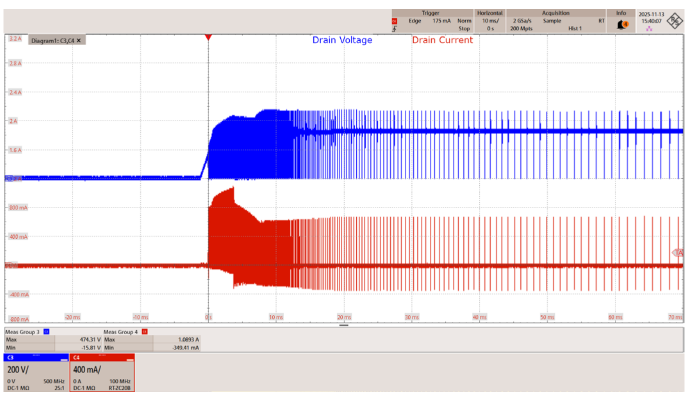

Figure 51 – 230 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 400 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 473 V
$I_{DS(MAX)}$ = 1.09 A

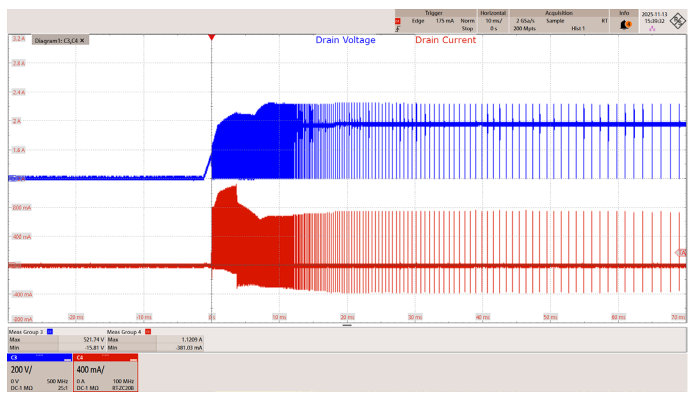

Figure 52 – 265 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 400 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 522 V
$I_{DS(MAX)}$ = 1.12 A

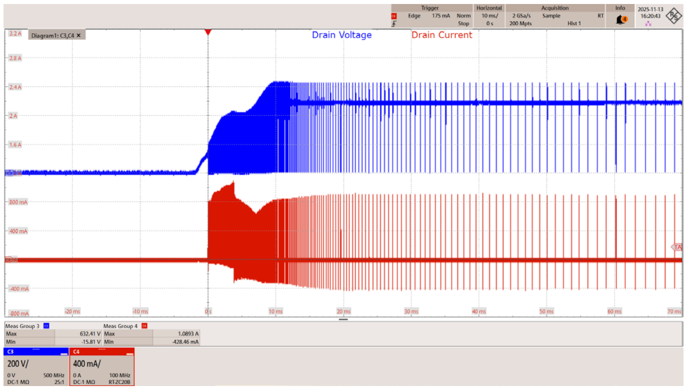

Figure 53 – 350 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 400 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 632 V
$I_{DS(MAX)}$ = 1.09 A

Figure 54 – 420 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 400 mA / div., 10 ms / div.
$V_{DS(MAX)}$ = 719 V
$I_{DS(MAX)}$ = 1.11 A

7.2.3 Freewheeling Diode Voltage at Start-up

7.2.3.1 Full Load

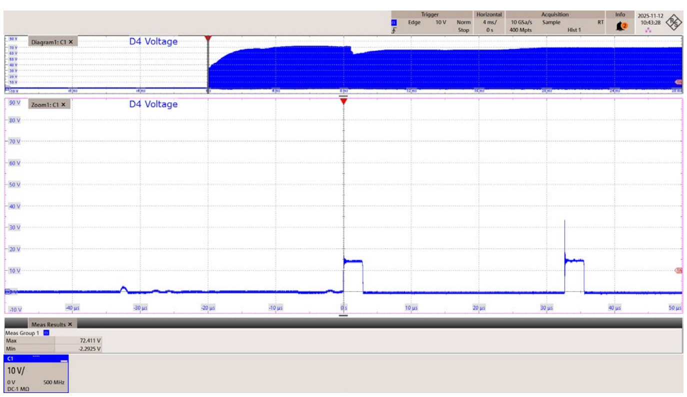

Figure 55 – 90 VAC 60 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 72.4 V

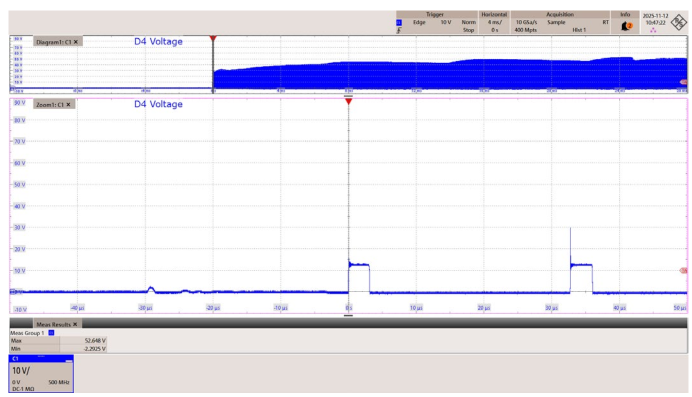

Figure 56 – 115 VAC 60 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 52.6 V

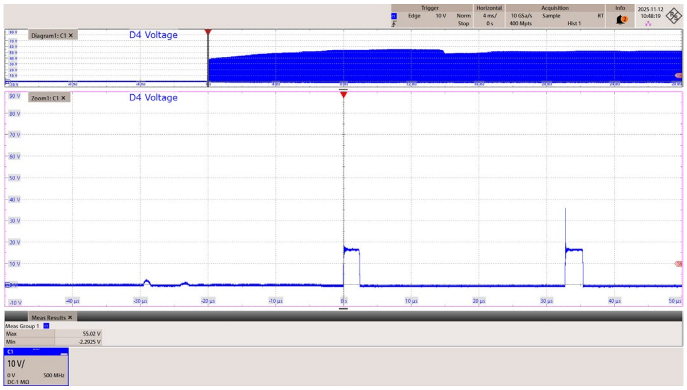

Figure 57 – 230 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 55.0 V

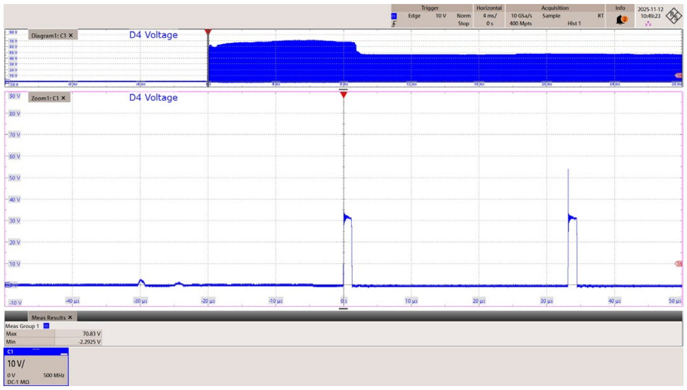

Figure 58 – 265 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 70.8 V

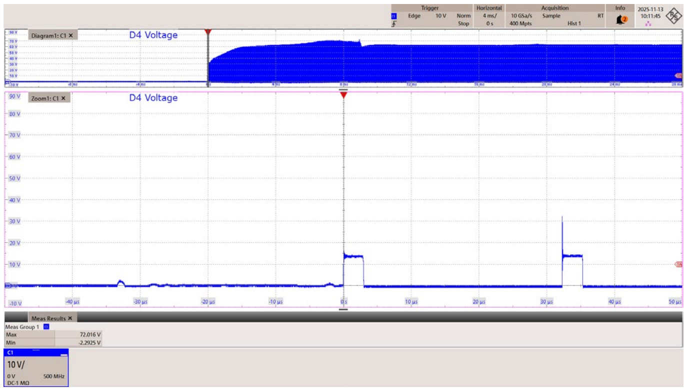

Figure 59 – 350 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 72.0 V

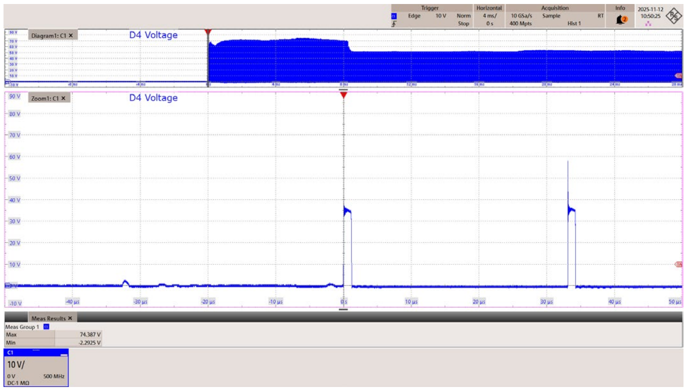

Figure 60 – 420 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 74.4 V

7.2.3.2 No Load

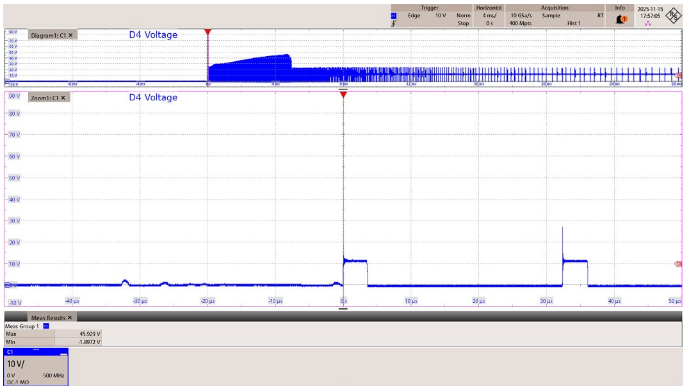

Figure 61 – 90 VAC 60 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 45.9 V

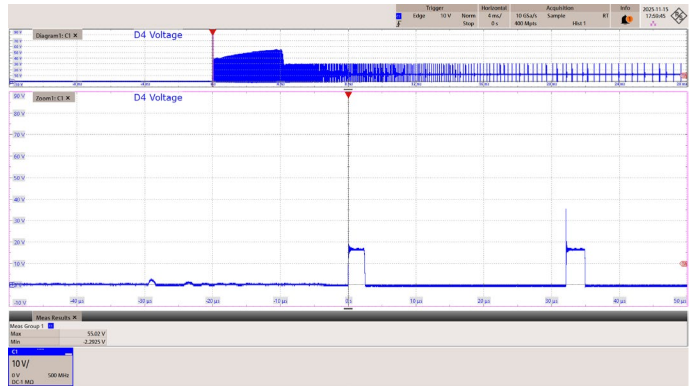

Figure 62 – 115 VAC 60 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 55.0 V

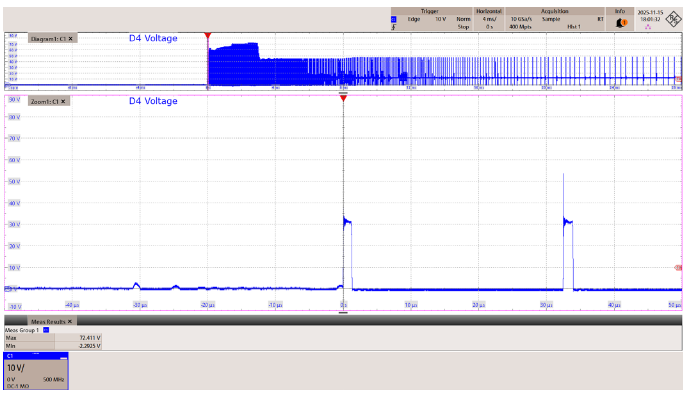

Figure 63 – 230 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 72.4 V

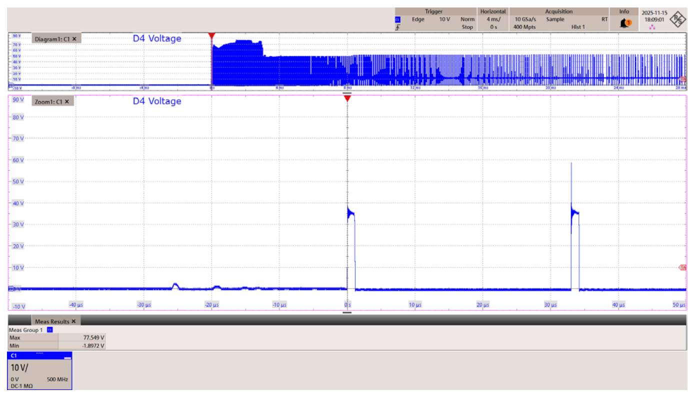

Figure 64 – 265 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 77.5 V

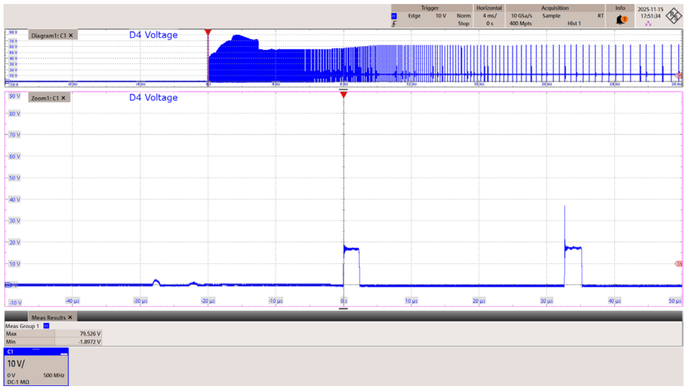

Figure 65 – 350 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 79.5 V

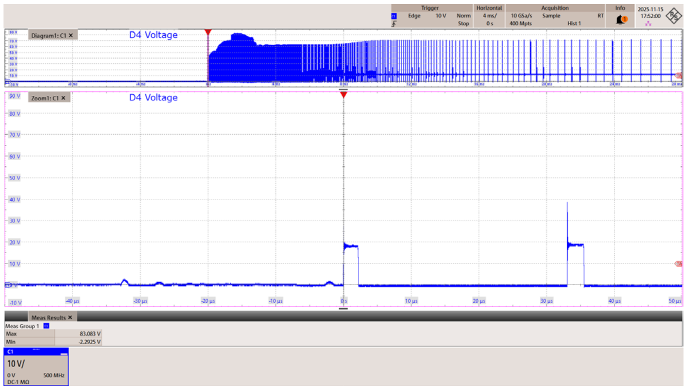

Figure 66 – 420 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 83.1 V

7.2.4 Freewheeling Diode Voltage and Current during Normal Operation

7.2.4.1 Full Load

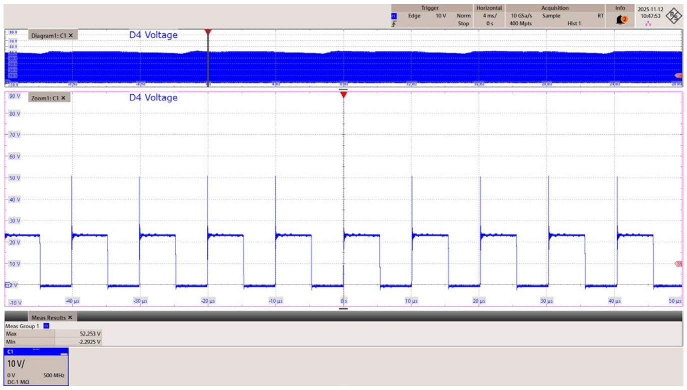

Figure 67 – 90 VAC 60 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 52.3 V

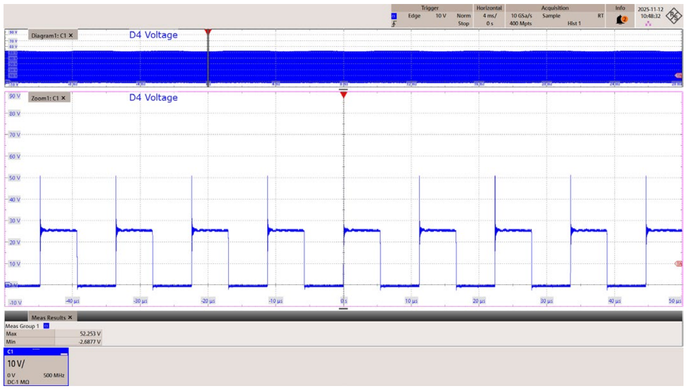

Figure 68 – 115 VAC 60 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 52.3 V

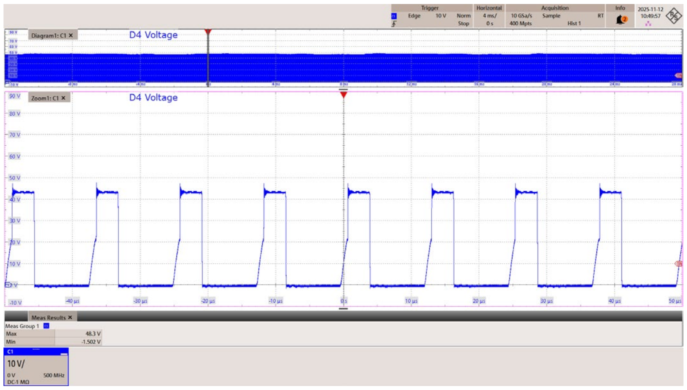

Figure 69 – 230 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 48.3 V

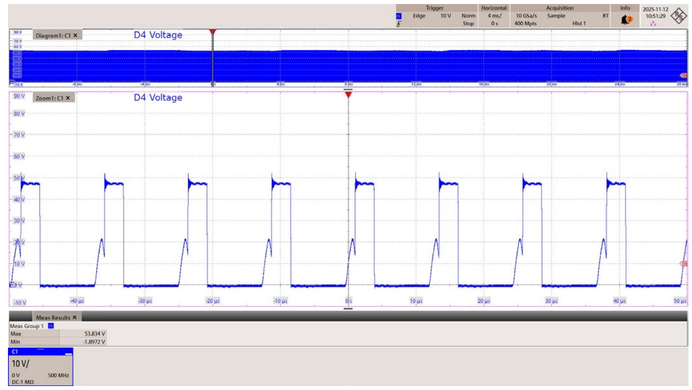

Figure 70 – 265 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 53.8 V

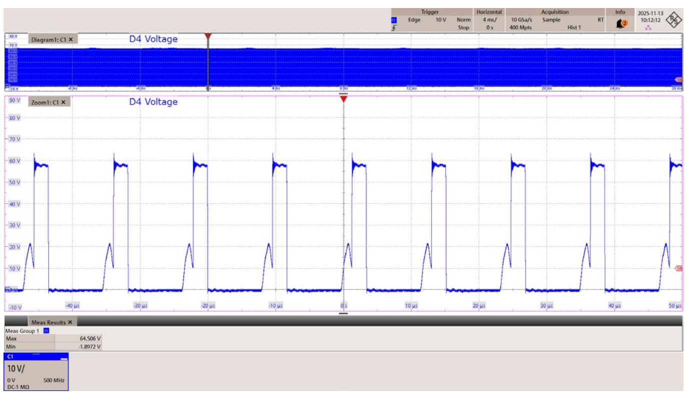

Figure 71 – 350 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 64.5 V

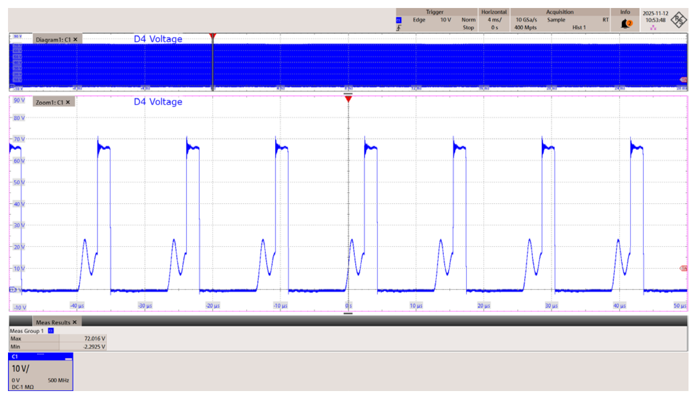

Figure 72 – 420 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 72.0 V

7.2.4.2 No Load

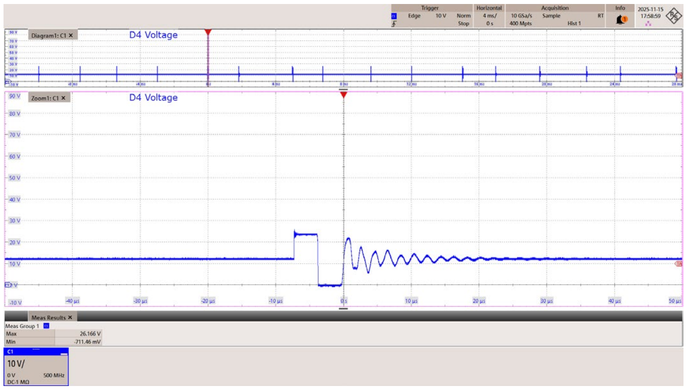

Figure 73 – 90 VAC 60 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 26.2 V

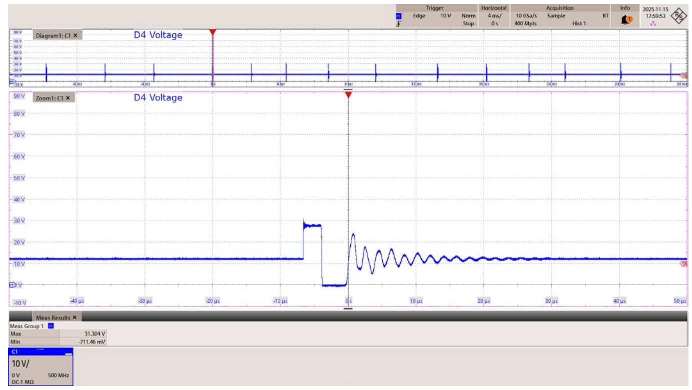

Figure 74 – 115 VAC 60 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 31.3 V

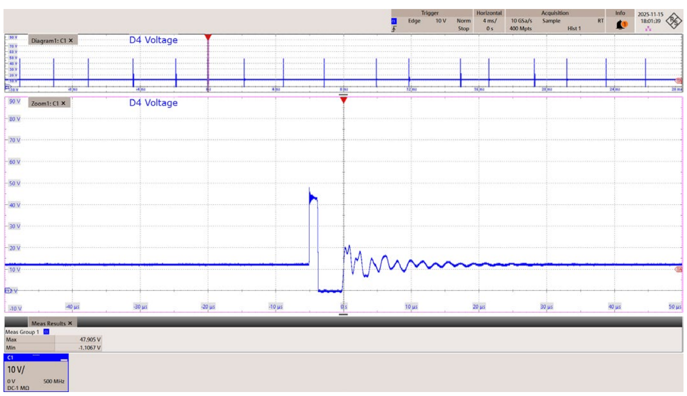

Figure 75 – 230 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 47.9 V

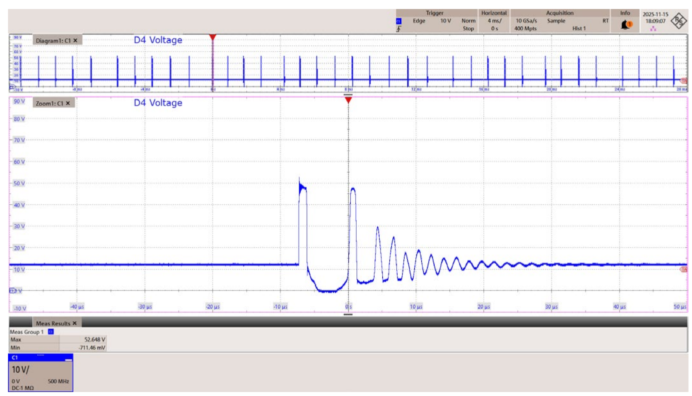

Figure 76 – 265 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 52.6 V

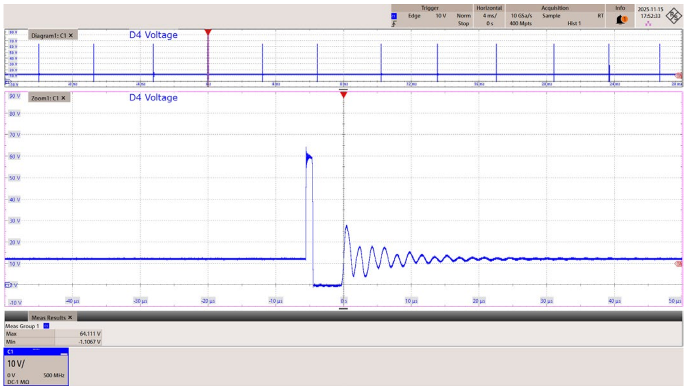

Figure 77 – 350 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 64.1 V

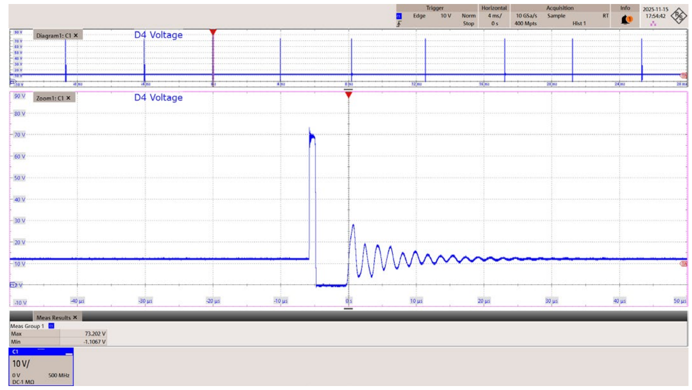

Figure 78 – 420 VAC 50 Hz.
CH1: V_Sec Diode, 10 V / div., 4 ms / div.
Zoom: 10 μs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 73.2 V

7.3 Load Transient Response

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

7.3.1 Transient 0% - 100% Load Change

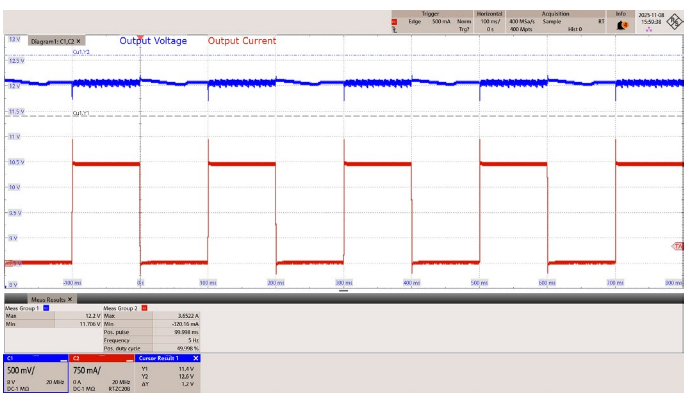

Figure 79 – 90 VAC 60 Hz.
CH1: V_{OUT}, 500 mV / div., 100 ms / div.
CH2: I_{OUT}, 750 mA / div., 100 ms / div.
V_{OUT}: V_{MAX}: 12.2 V
V_{MIN}: 11.7 V

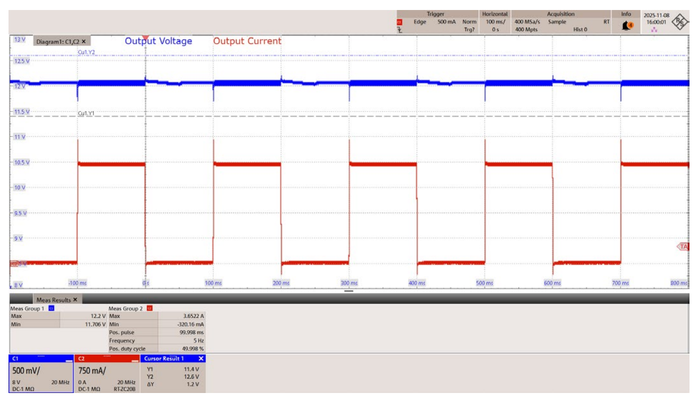

Figure 80 – 115 VAC 60 Hz.
CH1: V_{OUT}, 500 mV / div., 100 ms / div.
CH2: I_{OUT}, 750 mA / div., 100 ms / div.
V_{OUT}: V_{MAX}: 12.2 V
V_{MIN}: 11.7 V

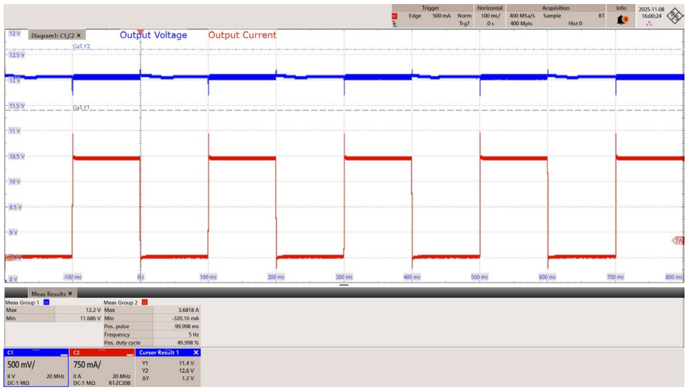

Figure 81 – 230 VAC 50 Hz.
CH1: V_{OUT}, 500 mV / div., 100 ms / div.
CH2: I_{OUT}, 750 mA / div., 100 ms / div.
V_{OUT}: V_{MAX}: 12.2 V
V_{MIN}: 11.7 V

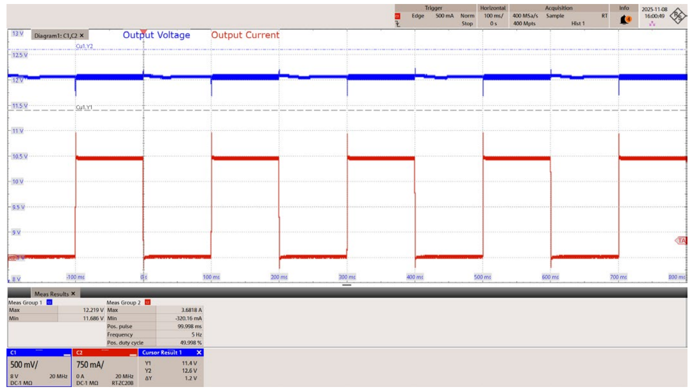

Figure 82 – 265 VAC 50 Hz.
CH1: V_{OUT}, 500 mV / div., 100 ms / div.
CH2: I_{OUT}, 750 mA / div., 100 ms / div.
V_{OUT}: V_{MAX}: 12.2 V
V_{MIN}: 11.7 V

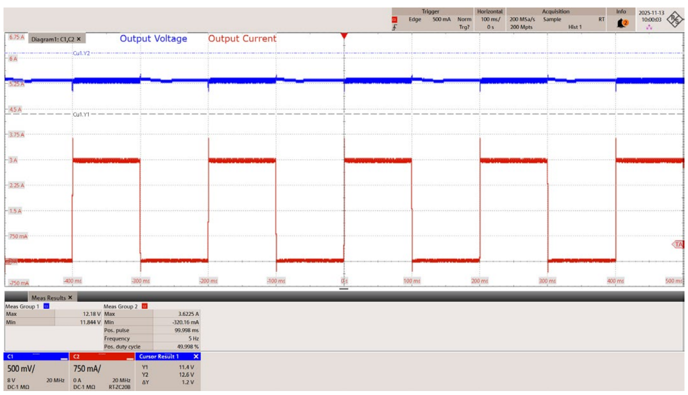

Figure 83 – 350 VAC 50 Hz.
CH1: V_{OUT}, 500 mV / div., 100 ms / div.
CH2: I_{OUT}, 750 mA / div., 100 ms / div.
V_{OUT}: V_{MAX}: 12.2 V
V_{MIN}: 11.8 V

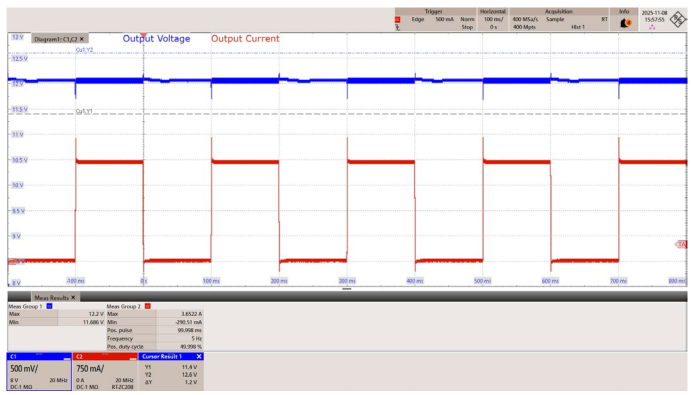

Figure 84 – 420 VAC 50 Hz.
CH1: V_{OUT}, 500 mV / div., 100 ms / div.
CH2: I_{OUT}, 750 mA / div., 100 ms / div.
V_{OUT}: V_{MAX}: 12.2 V
V_{MIN}: 11.7 V

7.4 Output Voltage Ripple

7.4.1 Ripple Measurement Techniques

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 the figures 87 and 88.

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).

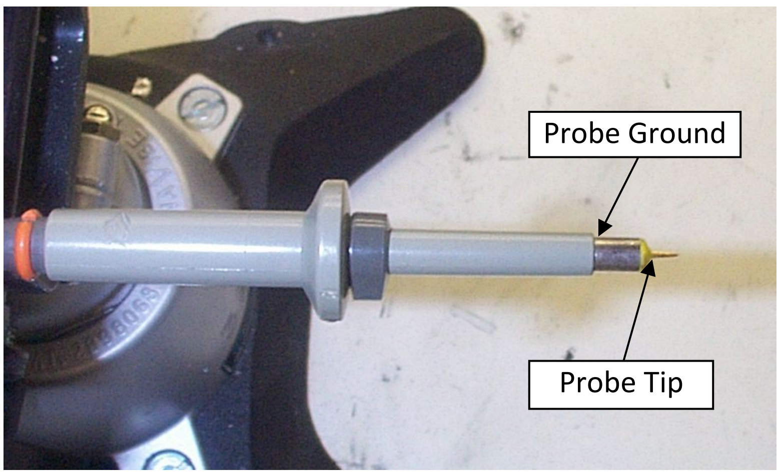

Figure 85 – Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed.)

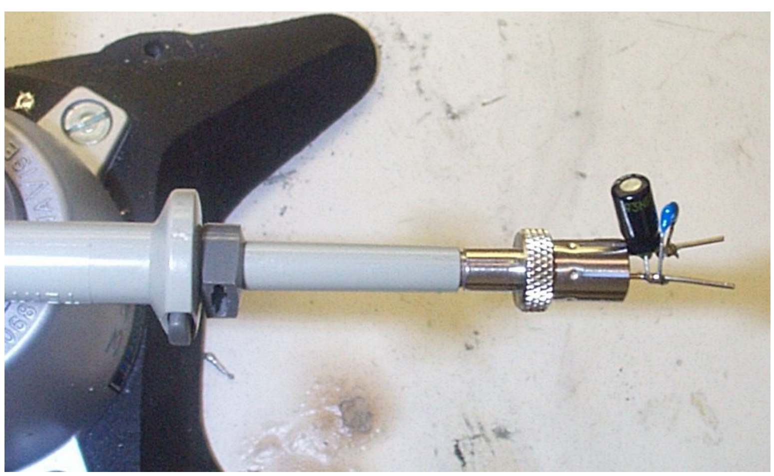

Figure 86 – Oscilloscope Probe with Probe Master (www.probemaster.com) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added.)

7.4.2 Measurement Results

Note: All ripple measurements were taken at PCB end.

7.4.2.1 100 % Load Condition

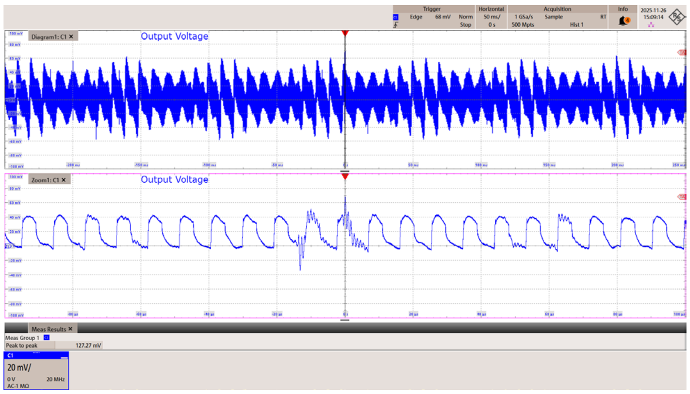

Figure 87 – 90 VAC 60 Hz.
CH1: Output Ripple, 20 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 127 mV

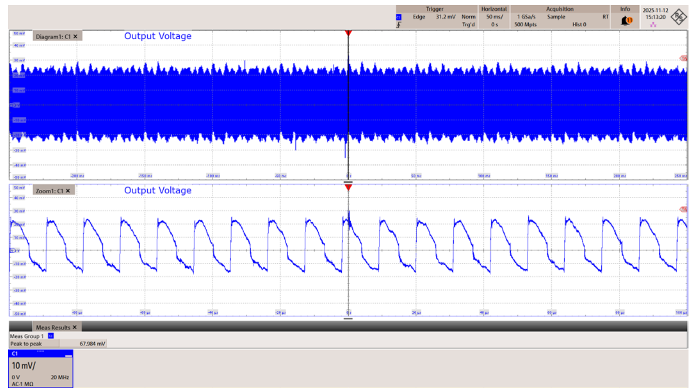

Figure 88 – 115 VAC 60 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 68.0 mV

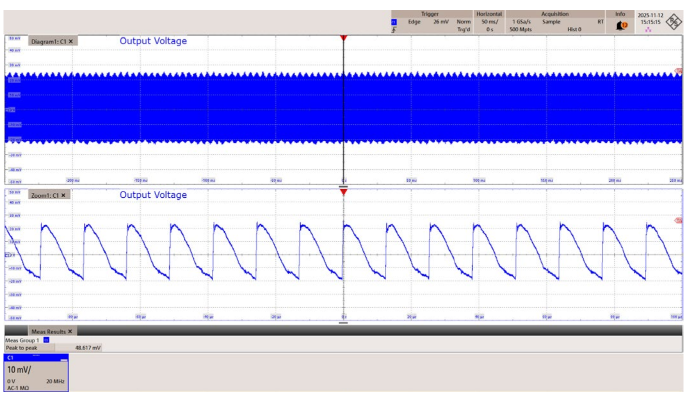

Figure 89 – 230 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 48.6 mV

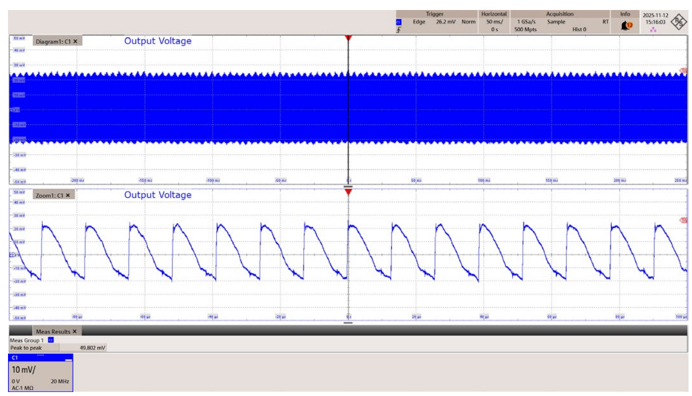

Figure 90 – 265 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 49.8 mV

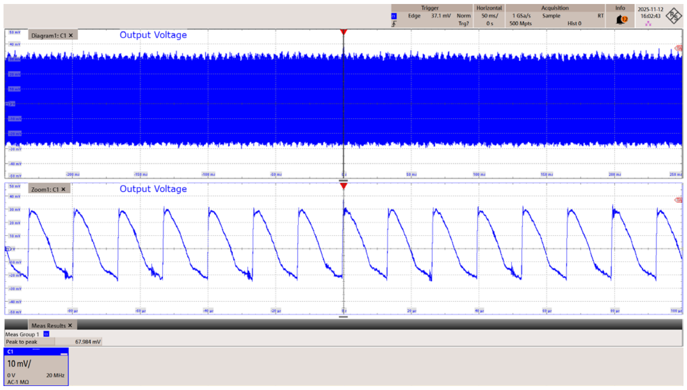

Figure 91 – 350 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 68.0 mV

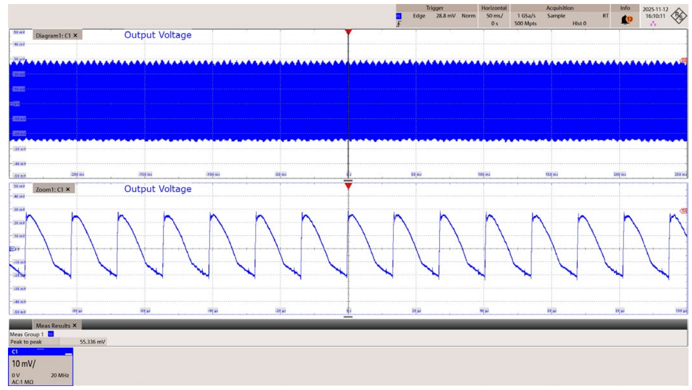

Figure 92 – 420 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 55.3 mV

7.4.2.2 75% Load Condition

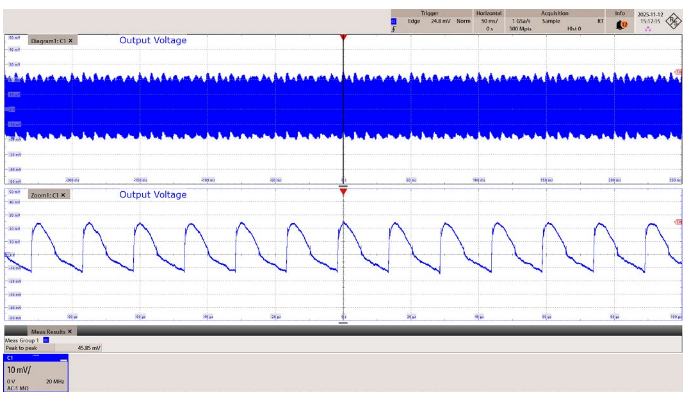

Figure 93 – 90 VAC 60 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 45.9 mV

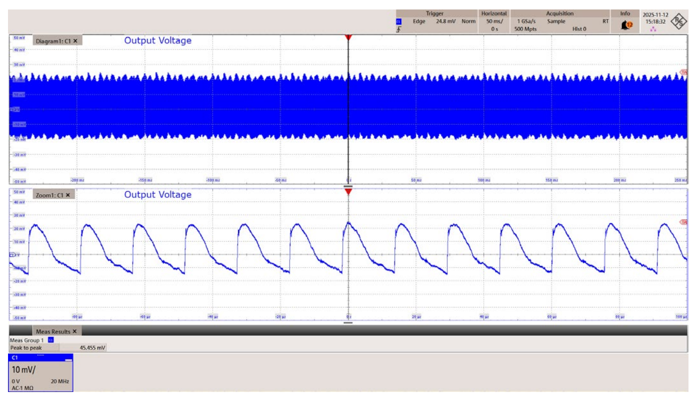

Figure 94 – 115 VAC 60 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 45.5 mV

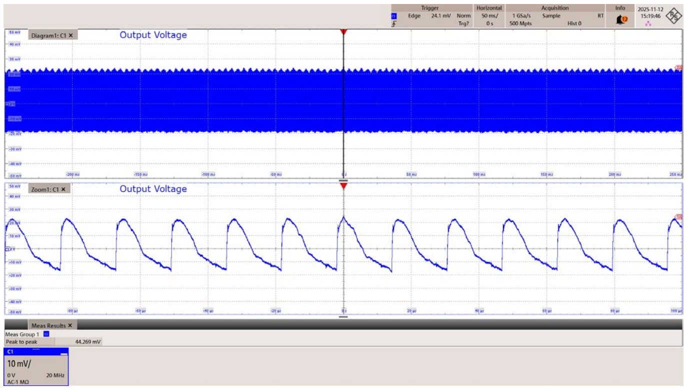

Figure 95 – 230 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 44.2 mV

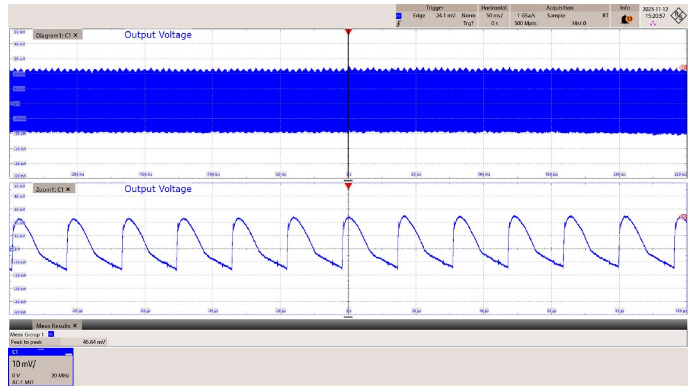

Figure 96 – 265 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 46.6 mV

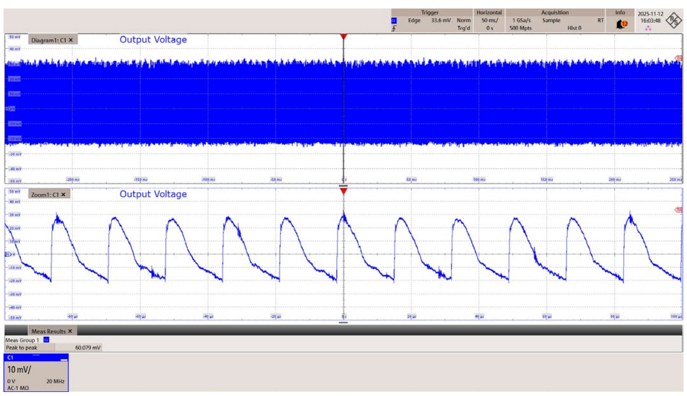

Figure 97 – 350 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 60.1 mV

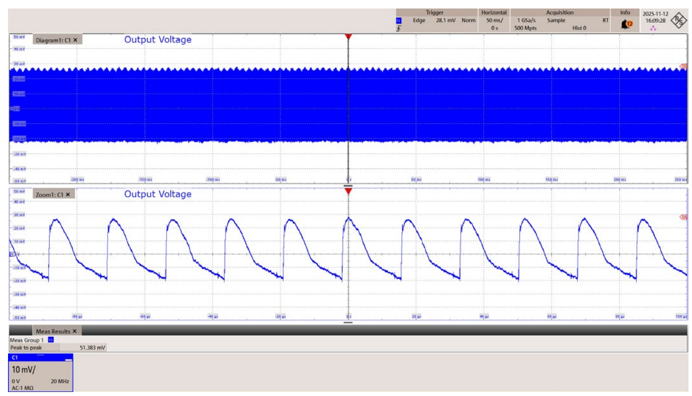

Figure 98 – 420 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 51.4 mV

7.4.2.3 50% Load Condition

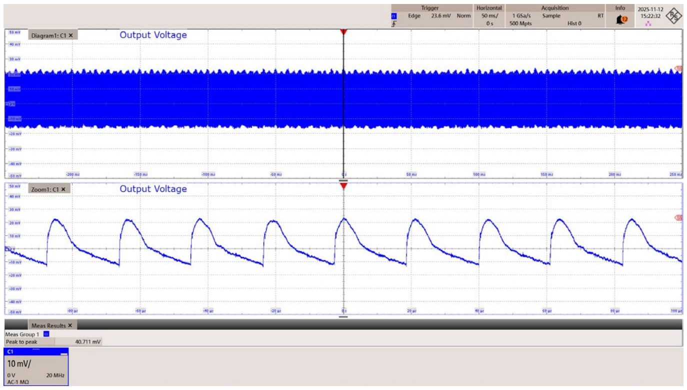

Figure 99 – 90 VAC 60 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 40.7 mV

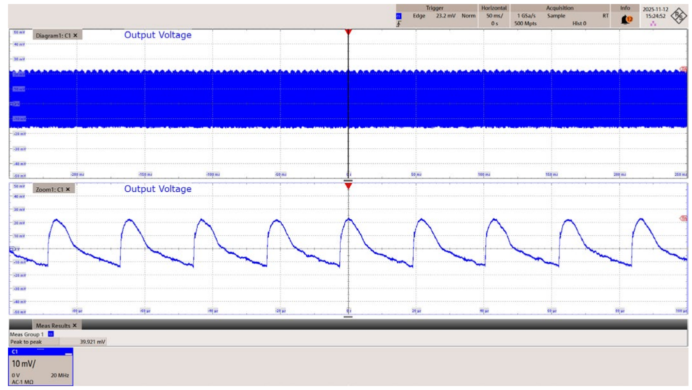

Figure 100 – 115 VAC 60 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 39.9 mV

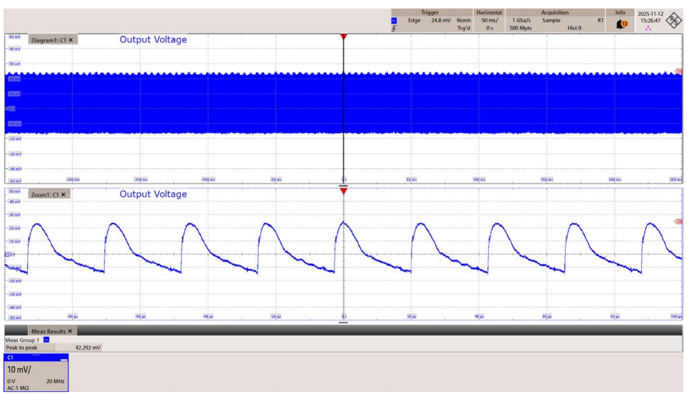

Figure 101 – 230 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 42.3 mV

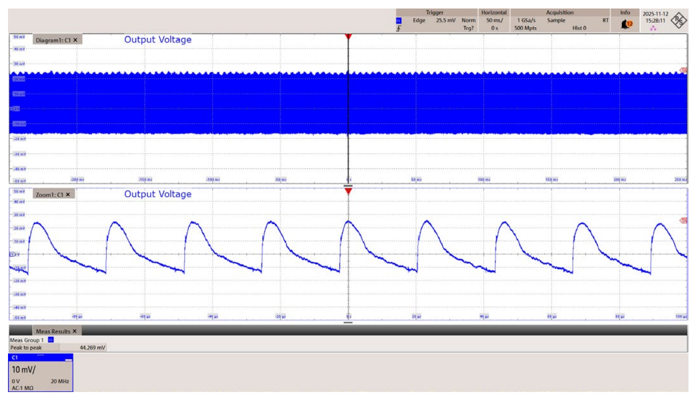

Figure 102 – 265 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 44.3 mV

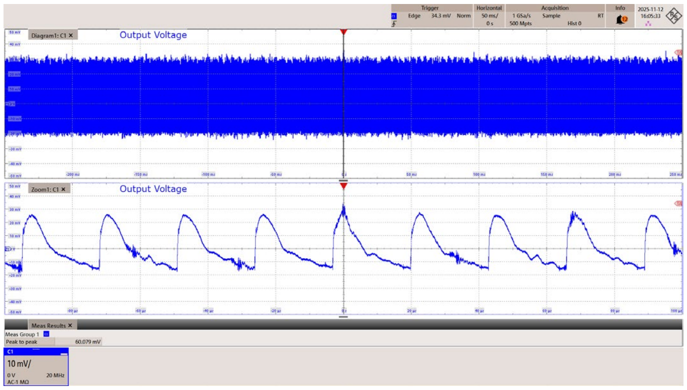

Figure 103 – 350 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 60.1 mV

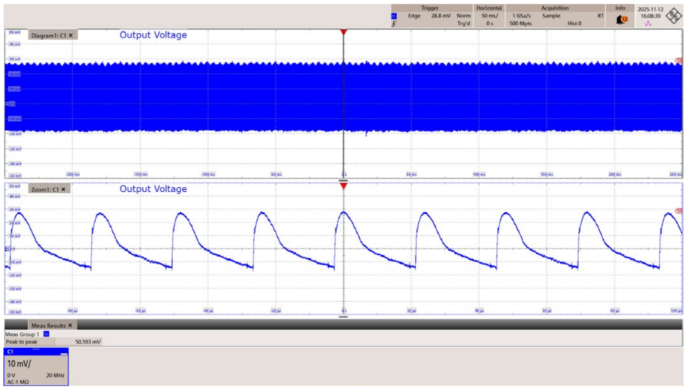

Figure 104 – 420 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 50.6 mV

7.4.2.4 25% Load Condition

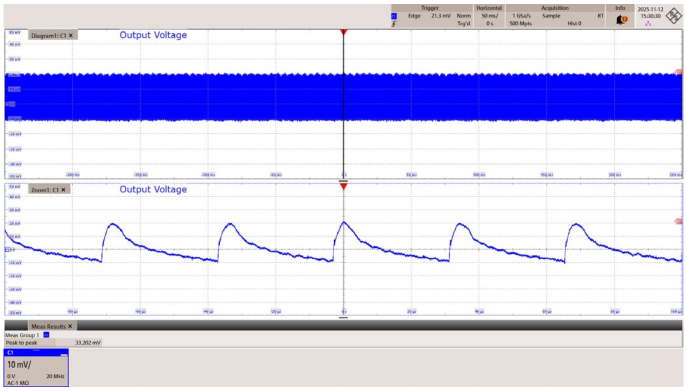

Figure 105 – 90 VAC 60 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 33.2 mV

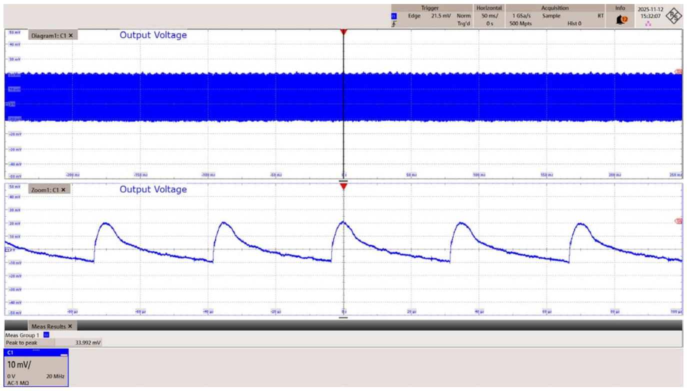

Figure 106 – 115 VAC 60 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 34.0 mV

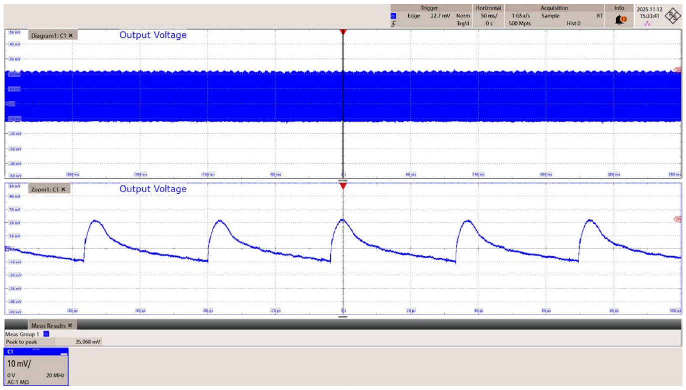

Figure 107 – 230 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 36.0 mV

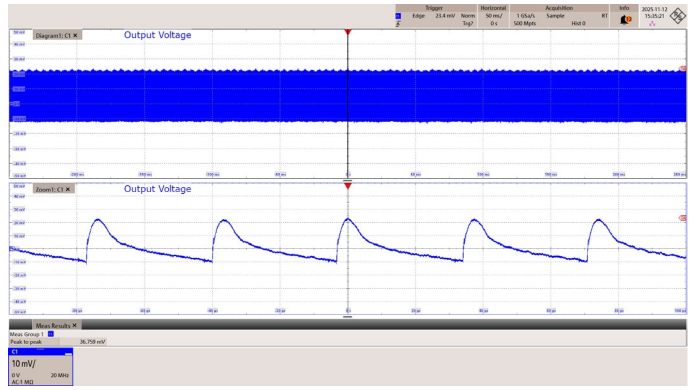

Figure 108 – 265 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 36.8 mV

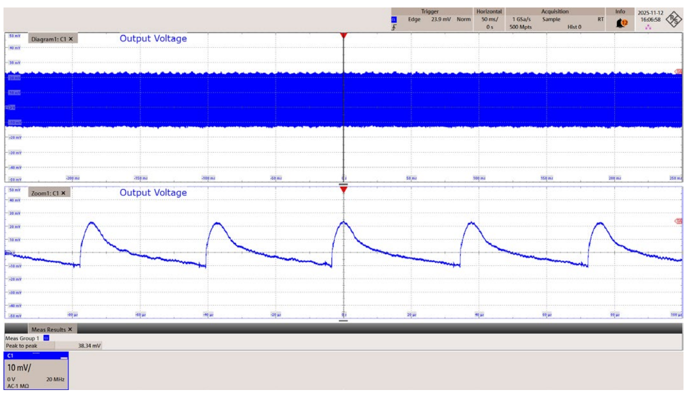

Figure 109 – 350 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 38.3 mV

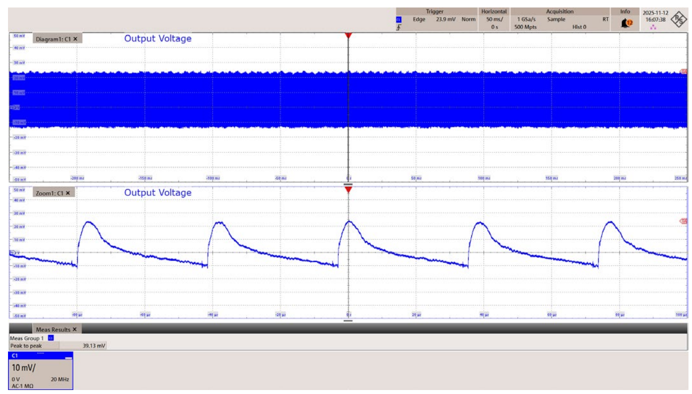

Figure 110 – 420 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 µs / div.
Output Ripple = 39.1 mV

7.4.2.5 0% Load Condition

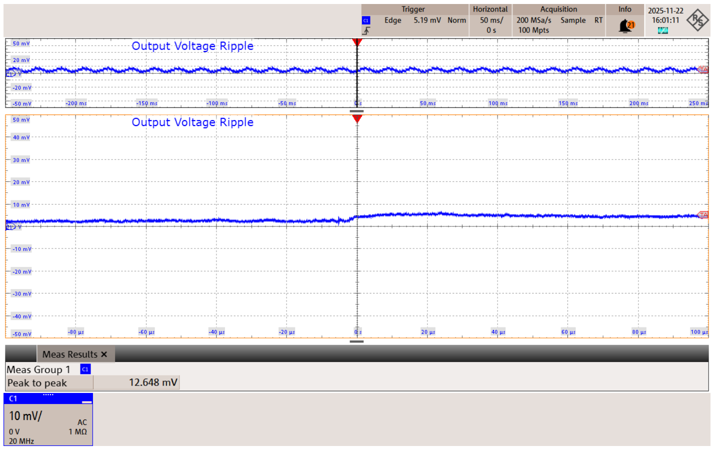

Figure 111 – 90 VAC 60 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 μs / div.
Output Ripple = 12.6 mV

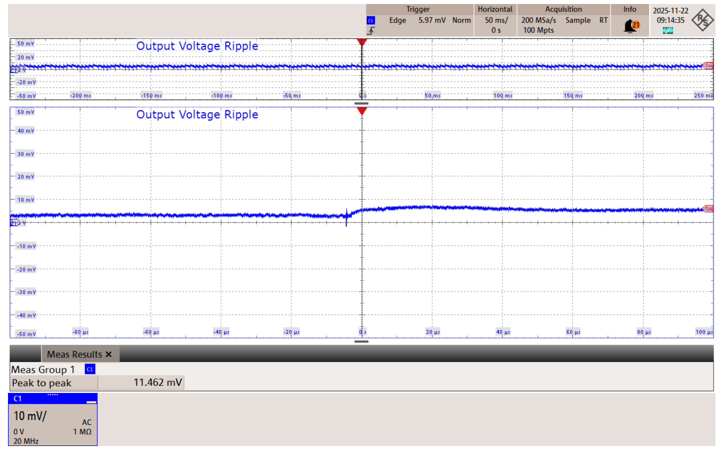

Figure 112 – 115 VAC 60 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 μs / div.
Output Ripple = 11.5 mV

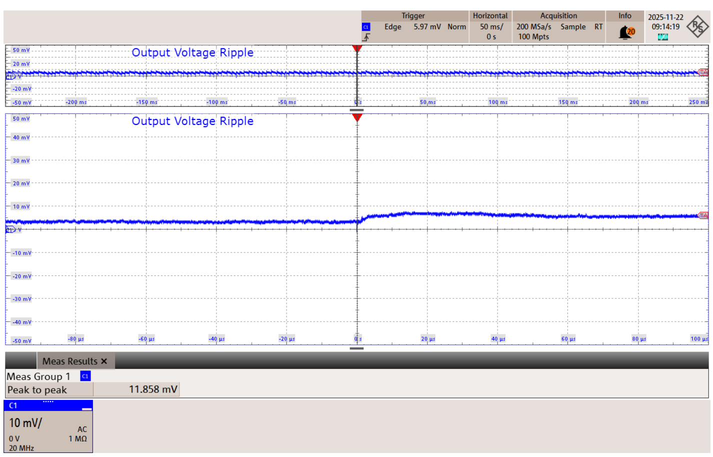

Figure 113 – 230 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 μs / div.
Output Ripple = 11.9 mV

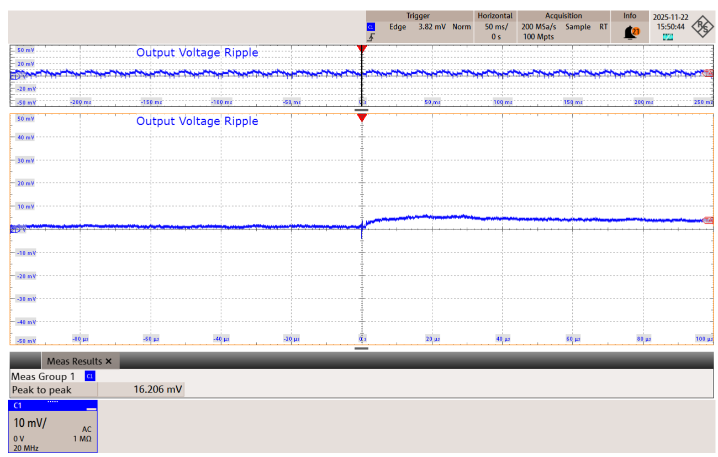

Figure 114 – 265 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 μs / div.
Output Ripple = 16.2 mV

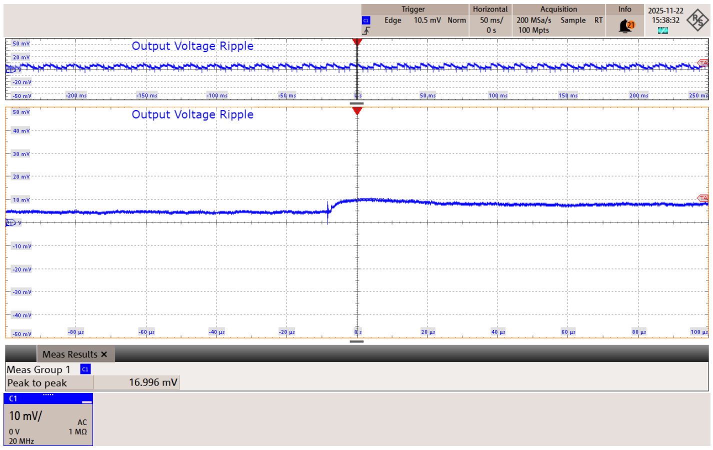

Figure 115 – 350 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 μs / div.
Output Ripple = 17.0 mV

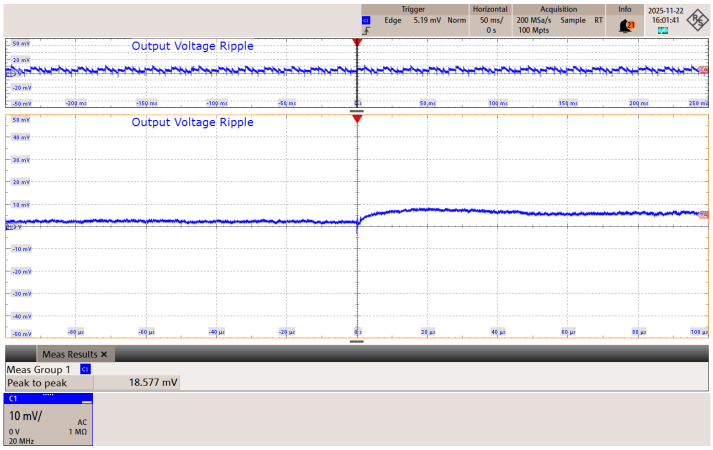

Figure 116 – 420 VAC 50 Hz.
CH1: Output Ripple, 10 mV / div., 50 ms / div.
Zoom: 20 μs / div.
Output Ripple = 18.6 mV

7.4.3 Output Ripple Voltage Graph

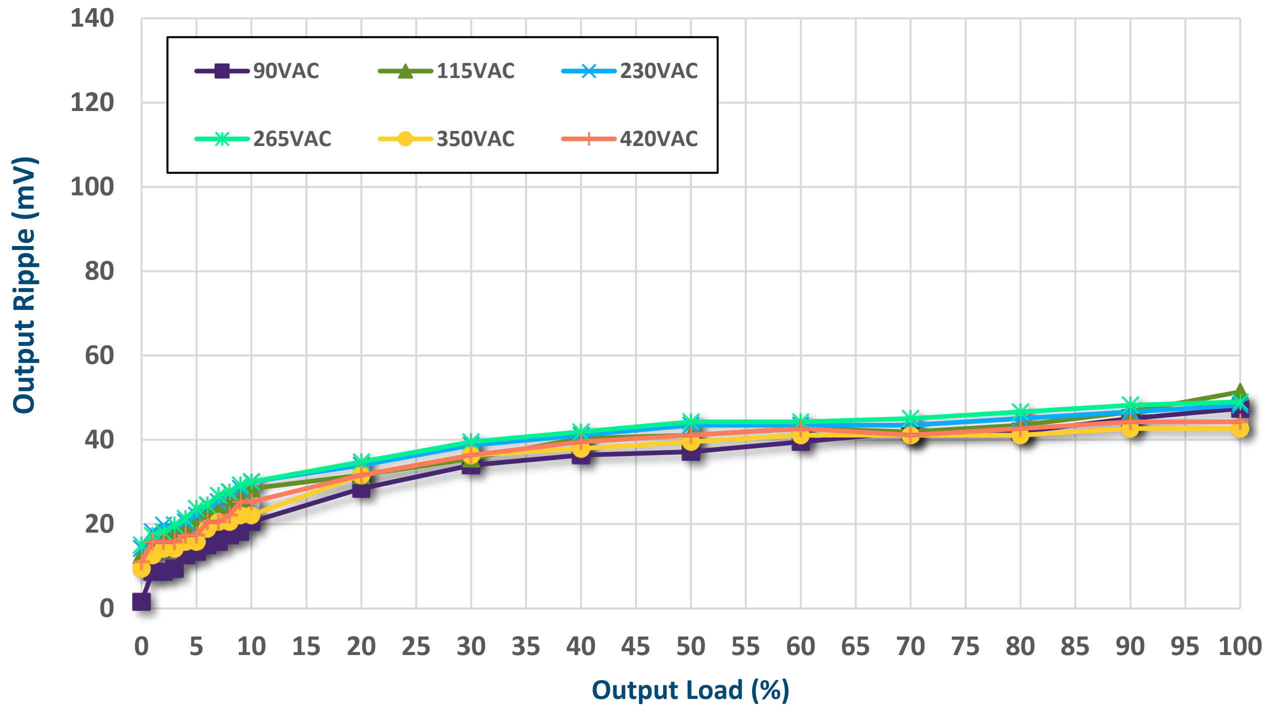

Figure 117 – Voltage Ripple (Measured at edge of PCB at Room Temperature).

8 Thermal Performance

8.1 25 °C Ambient Thermals

8.1.1 90 VAC Full Load at 25 °C Ambient

Test result after 60 mins running continuously inside an enclosure at 90 VAC full load using FLIR thermal camera to measure component temperature.

Figure 118 – 90 VAC 60 Hz. Top Side Discrete Component Thermals.

Component	Temperature (°C)
Ambient	26.6
Transformer (T1)	70.5

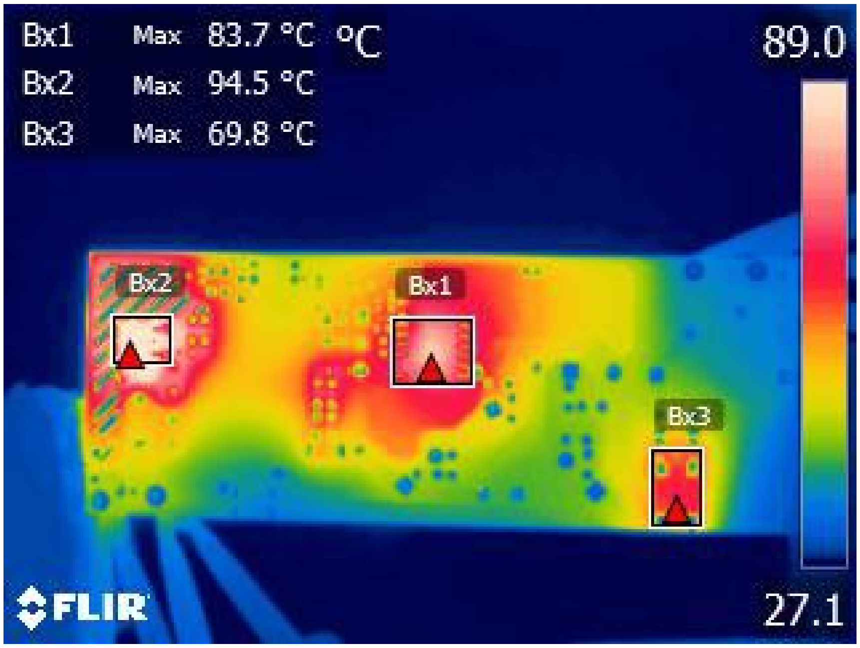

Figure 119 – 90 VAC 60 Hz. Bottom Side Thermals.

Component	Temperature (°C)
Ambient	27.1
TNY5094K (U1)	83.7
Secondary Diode (D4)	94.5
Bridge Rectifier (BR1)	69.8

8.1.2 420 VAC Full Load at 25 °C Ambient

Test result after 60 mins running continuously inside an enclosure at 420 VAC full load using FLIR thermal camera to measure component temperature.

Figure 120 – 420 VAC 50 Hz. Top Side Discrete Component Thermals.

Component	Temperature (°C)
Ambient	26.8
Transformer (T1)	76.1

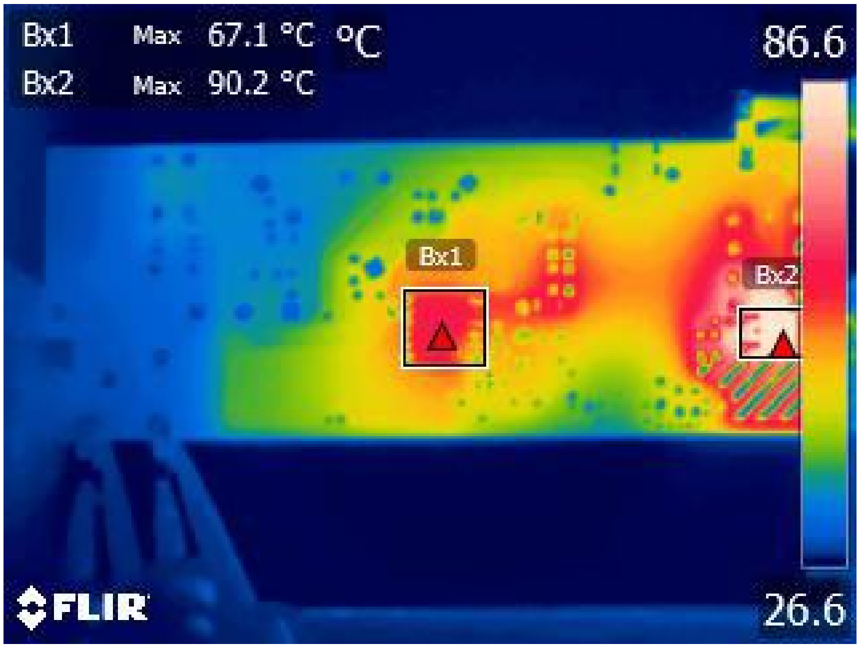

Figure 121 – 420 VAC 50 Hz. Bottom Side Thermals.

Component	Temperature (°C)
Ambient	26.6
TNY5094K (U1)	67.1
Secondary Diode (D4)	90.2

8.2 40 °C Ambient Thermals

8.2.1 90 VAC Full Load at 40 °C Ambient

Test result after 60 minutes running continuously at 90 VAC and full load.

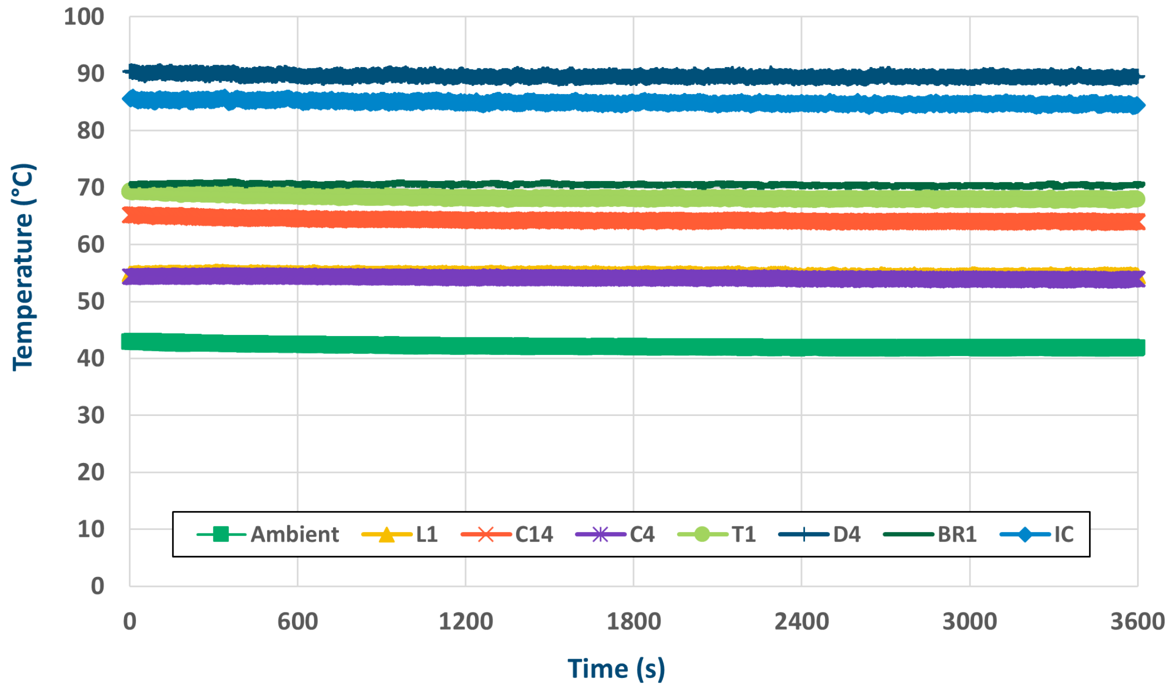

Figure 122 – 90 VAC 60 Hz. 40 °C Ambient Component Thermals.

Component	Temperature (°C)
Ambient	41.7
TNY5094K (U1)	84.5
Bridge Rectifier (BR1)	70.3
Secondary Diode (D4)	89.2
Transformer (T1)	67.8
Bulk Capacitor (C4)	53.8
Output Capacitor (C14)	64
CMC (L1)	54.5

8.2.2 420 VAC Full Load at 40 °C Ambient

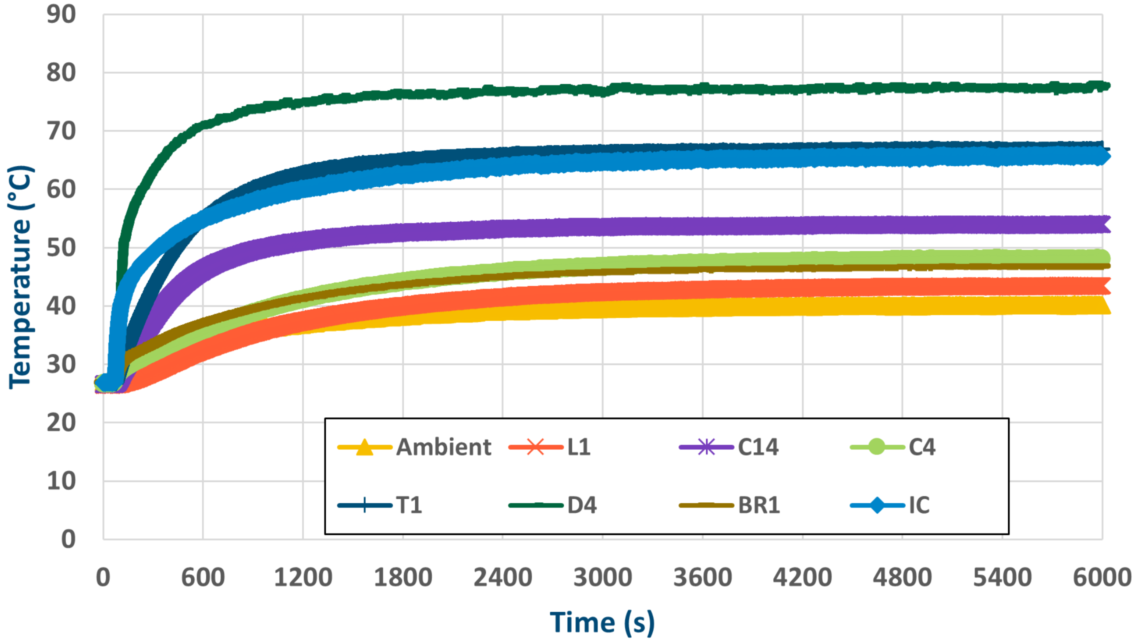

Figure 123 – 420 VAC 50 Hz. 40 °C Ambient Component Thermals.

Component	Temperature (°C)
Ambient	40.1
TNY5094K (U1)	65.7
Bridge Rectifier (BR1)	46.7
Secondary Diode (D4)	77.9
Transformer (T1)	66.8
Bulk Capacitor (C4)	48.2
Output Capacitor (C14)	54.0
CMC (L1)	43.5

9 Fault Condition

9.1 Output Short-Circuit Protection (OSCP)

9.1.1 Start-Up Short-Circuit

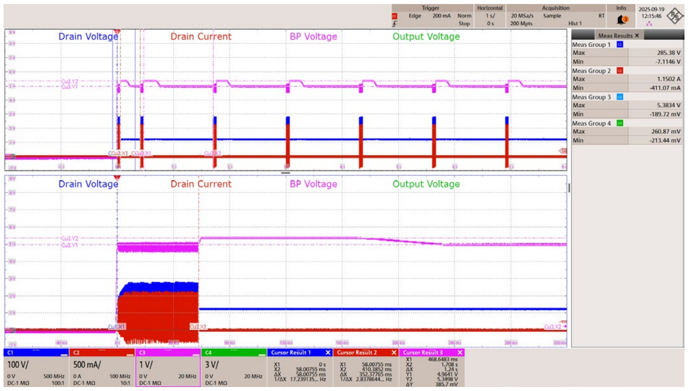

Figure 124 – 90 VAC 60 Hz. Output Short.
CH1: $V_{DS,}$ 100 V / div., 1 s / div.
CH2: $I_{DS,}$ 500 mA / div., 1 s / div.
CH3: $V_{BP,}$ 1 V / div., 1 s / div.
CH2: $V_{OUT,}$ 3 V / div., 1 s / div.
Zoom: 40 ms / div.
$V_{DS(MAX)}$ = 285 V
$I_{DS(MAX)}$ = 1.15 A
$t_{AR\_(OFF)1}$ = 352 ms
$t_{AR\_(OFF)2}$ = 1.24 s
$t_{AR(ON)}$ = 58.0 ms

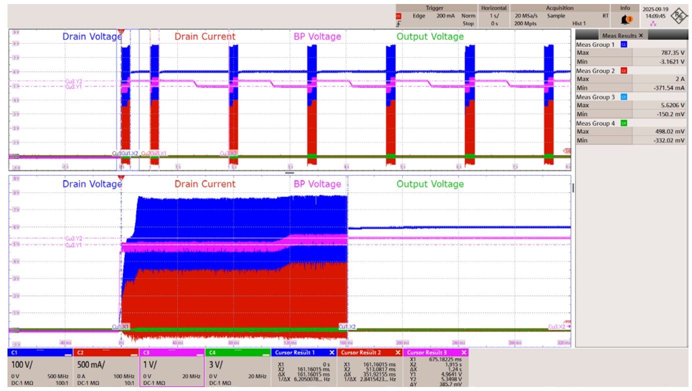

Figure 125 – 420 VAC 50 Hz Output Short.
CH1: $V_{DS,}$ 100 V / div., 1 s / div.
CH2: $I_{DS,}$ 500 mA / div., 1 s / div.
CH3: $V_{BP,}$ 1 V / div., 1 s / div.
CH2: $V_{OUT,}$ 3 V / div., 1 s / div.
Zoom: 40 ms / div.
$V_{DS(MAX)}$ = 787 V
$I_{DS(MAX)}$ = 2.00 A
$t_{AR\_(OFF)1}$ = 352 ms
$t_{AR\_(OFF)2}$ = 1.24 s
$t_{AR(ON)}$ = 161 ms

9.1.2 Running Short-Circuit

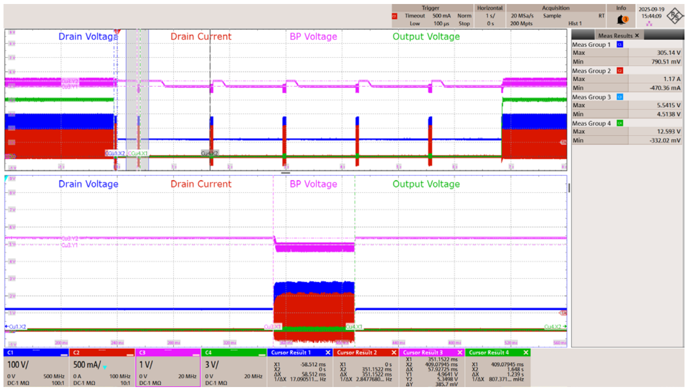

Figure 126 – 90 VAC 60 Hz. Output Short.
CH1: $V_{DS,}$ 100 V / div., 1 s / div.
CH2: $I_{DS,}$ 500 mA / div., 1 s / div.
CH3: $V_{BP,}$ 1 V / div., 1 s / div.
CH2: $V_{OUT,}$ 3 V / div., 1 s / div.
Zoom: 40 ms / div.
$V_{DS(MAX)}$ = 305 V
$I_{DS(MAX)}$ = 1.17 A
$t_{AR\_(OFF)1}$ = 351 ms
$t_{AR\_(OFF)2}$ = 1.24 s
$t_{AR(ON)}$ = 57.9 ms

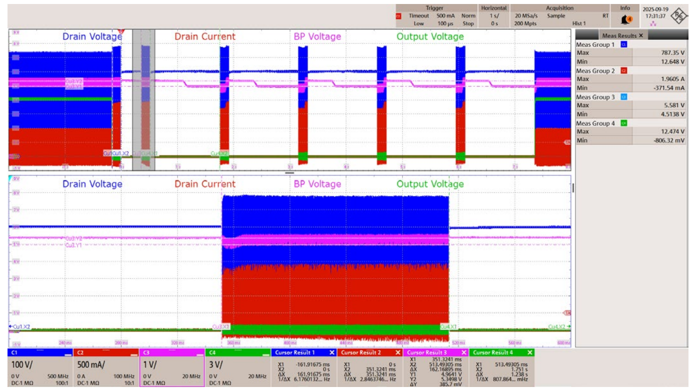

Figure 127 – 265 VAC 50 Hz Output Short.
CH1: $V_{DS,}$ 100 V / div., 1 s / div.
CH2: $I_{DS,}$ 500 mA / div., 1 s / div.
CH3: $V_{BP,}$ 1 V / div., 1 s / div.
CH2: $V_{OUT,}$ 3 V / div., 1 s / div.
Zoom: 40 ms / div.
$V_{DS(MAX)}$ = 787.4 V
$I_{DS(MAX)}$ = 1.96 A
$t_{AR\_(OFF)1}$ = 351 ms
$t_{AR\_(OFF)2}$ = 1.24 s
$t_{AR(ON)}$ = 162 ms

9.1.2.1 Output Short-Circuit Input Power

Input Voltage	Output Short-Circuit Input Power
90 VAC	27.2 mW
115 VAC	35.5 mW
230 VAC	72.7 mW
265 VAC	85.0 mW
350 VAC	169 mW
420 VAC	208 mW

9.1.3 Output Short-Circuit IC Thermal

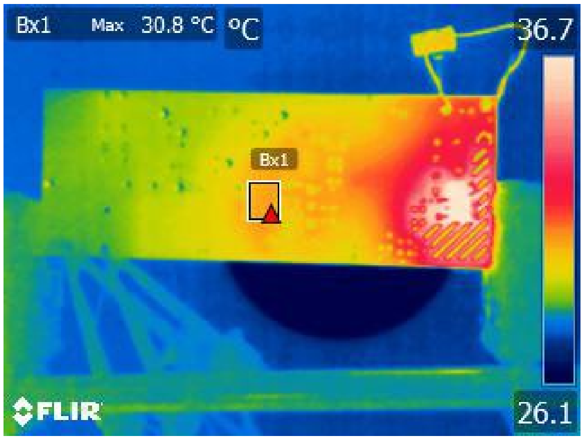

Figure 128 – 90 VAC 60 Hz. Output Short.
IC temperature: 30.8 °C
Ambient Temperature: 26.1 °C

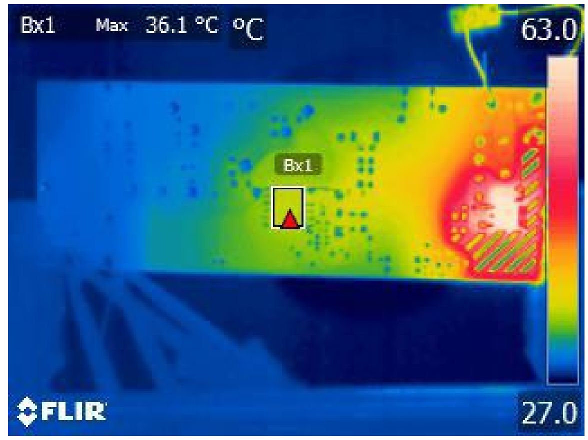

Figure 129 – 420 VAC 50 Hz Output Short.
IC temperature: 36.1 °C
Ambient Temperature: 27.0 °C

9.2 Overpower Protection

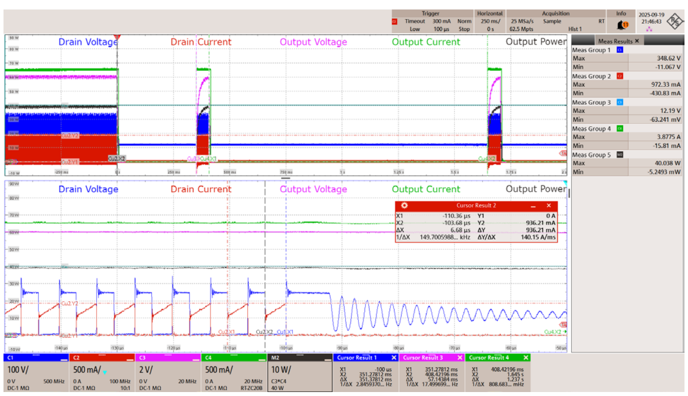

Figure 130 – 90 VAC 60 Hz.
CH1: V_{DS}, 100 V / div., 250 ms / div.
CH2: I_{DS}, 500 mA / div., 250 ms / div.
CH3: V_{OUT}, 2 V / div., 250 ms / div.
CH2: I_{OUT}, 500 mA / div., 250 ms / div.
M2: P_{OUT}, 10 W / div., 250 ms / div.
Zoom: 10 µs / div.
$P_{OUT(MAX)}$ = 40.0 W
$t_{AR\_(OFF)1}$ = 351 ms
$t_{AR\_(OFF)2}$ = 1.24 s
$t_{AR(ON)}$ = 57.1 ms

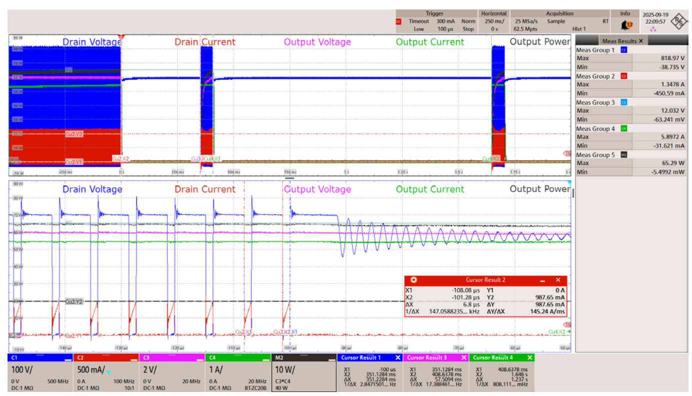

Figure 131 – 420 VAC 50 Hz.
CH1: V_{DS}, 100 V / div., 250 ms / div.
CH2: I_{DS}, 500 mA / div., 250 ms / div.
CH3: V_{OUT}, 2 V / div., 250 ms / div.
CH2: I_{OUT}, 1 A / div., 250 ms / div.
M1: P_{OUT}, 10 W / div., 250 ms / div.
Zoom: 10 µs / div.
$P_{OUT(MAX)}$ = 65.3 W
$t_{AR\_(OFF)1}$ = 351 ms
$t_{AR\_(OFF)2}$ = 1.24 s
$t_{AR(ON)}$ = 57.5 ms

9.3 Output Overvoltage Protection

9.3.1 Start-up OVP

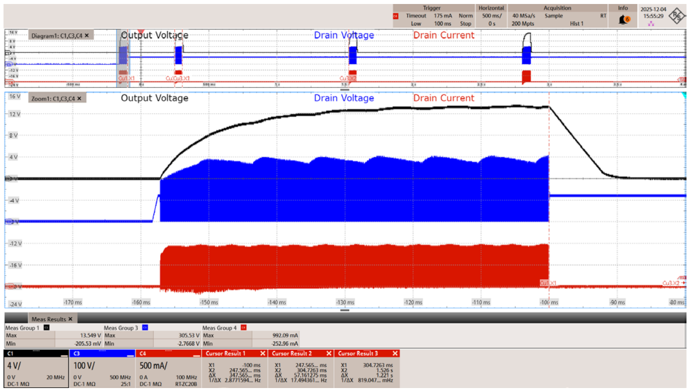

Figure 132 – 90 VAC 60 Hz. Full Load.
CH1: V_{OUT}, 4 V / div., 500 ms / div.
CH3: V_{DS}, 100 V / div., 500 ms / div.
CH4: I_{DS}, 500 mA / div., 500 ms / div.
Zoom: 10 ms / div.
$V_{DS(MAX)}$ = 306 V
$I_{DS(MAX)}$ = 992 mA
$V_{O(MAX)}$ = 13.6 V
$t_{AR\_(OFF)1}$ = 348 ms
$t_{AR\_(OFF)2}$ = 1.22 s$t_{AR(ON)}$ = 57.2 ms

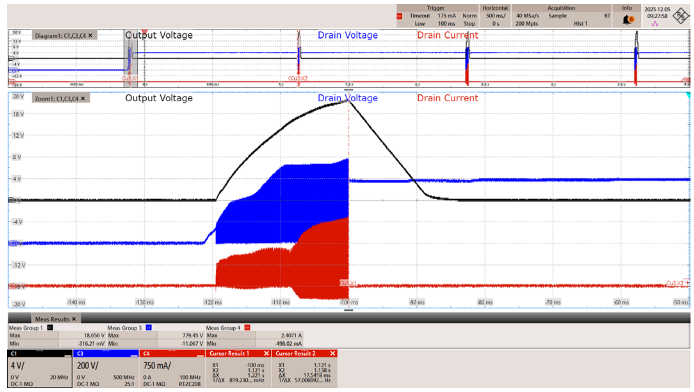

Figure 133 – 420 VAC 50 Hz Output Short. Full Load.
CH1: V_{OUT}, 4 V / div., 500 ms / div.
CH3: V_{DS}, 200 V / div., 500 ms / div.
CH4: I_{DS}, 750 mA / div., 500 ms / div.
Zoom: 10 ms / div.
$V_{DS(MAX)}$ = 779 V
$I_{DS(MAX)}$ = 2.41 mA
$V_{O(MAX)}$ = 18.7 V
$t_{AR\_(OFF)}$ = 1.22 s
$t_{AR(ON)}$ = 17.5 ms

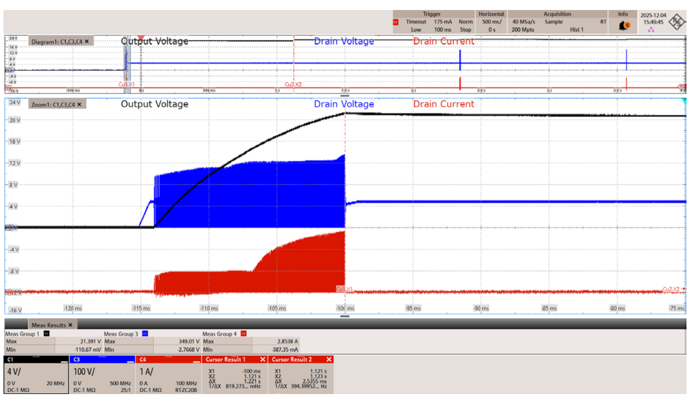

Figure 134 – 90 VAC 60 Hz. No Load.
CH1: V_{OUT}, 4 V / div., 500 ms / div.
CH3: V_{DS}, 100 V / div., 500 ms / div.
CH4: I_{DS}, 1 A / div., 500 ms / div.
Zoom: 5 ms / div.
$V_{DS(MAX)}$ = 349 V
$I_{DS(MAX)}$ = 2.85 A
$V_{O(MAX)}$ = 21.4 V
$t_{AR\_(OFF)}$ = 1.22 s
$t_{AR(ON)}$ = 2.54 ms

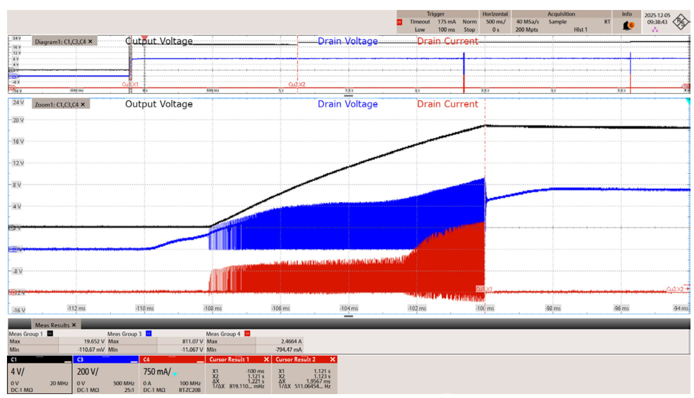

Figure 135 – 420 VAC 50 Hz. No Load
CH1: V_{OUT}, 4 V / div., 500 ms / div.
CH3: V_{DS}, 200 V / div., 500 ms / div.
CH4: I_{DS}, 750 mA / div., 500 ms / div.
Zoom: 2 ms / div.
$V_{DS(MAX)}$ = 811 V
$I_{DS(MAX)}$ = 2.47 A
$V_{O(MAX)}$ = 19.7 V
$t_{AR\_(OFF)}$ = 1.22 s
$t_{AR(ON)}$ = 1.96 ms

9.3.2 Running OVP

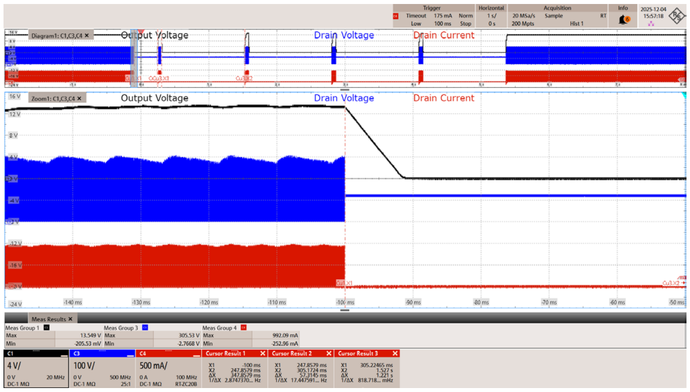

Figure 136 – 90 VAC 60 Hz. Full Load.
CH1: V_{OUT}, 4 V / div., 1 s / div.
CH3: V_{DS}, 100 V / div., 1 s / div.
CH4: I_{DS}, 500 mA / div., 1 s / div.
Zoom: 10 ms / div.
$V_{DS(MAX)}$ = 306 V
$I_{DS(MAX)}$ = 992 mA
$V_{O(MAX)}$ = 13.5 V
$t_{AR\_(OFF)1}$ = 348 ms
$t_{AR\_(OFF)2}$ = 1.22 s
$t_{AR(ON)}$ = 57.3 ms

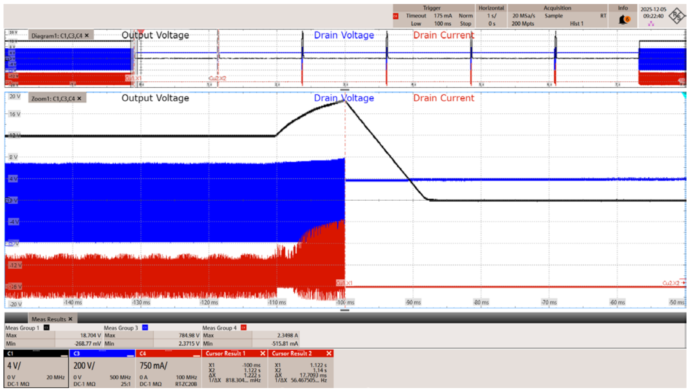

Figure 137 – 420 VAC 50 Hz. Full Load.
CH1: V_{OUT}, 4 V / div., 1 s / div.
CH3: V_{DS}, 200 V / div., 1 s / div.
CH4: I_{DS}, 750 mA / div., 1 s / div.
Zoom: 10 ms / div.
$V_{DS(MAX)}$ = 785 V
$I_{DS(MAX)}$ = 2.35 A
$V_{O(MAX)}$ = 18.7 V
$t_{AR\_(OFF)}$ = 1.22 s
$t_{AR(ON)}$ = 17.7 ms

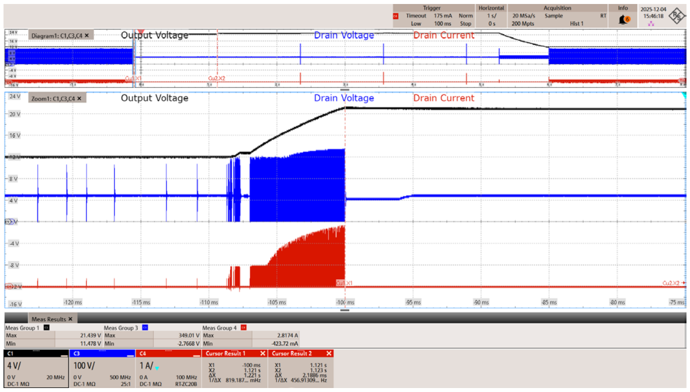

Figure 138 – 90 VAC 60 Hz. No Load.
CH1: V_{OUT}, 4 V / div., 1 s / div.
CH3: V_{DS}, 100 V / div., 1 s / div.
CH4: I_{DS}, 1 A / div., 1 s / div.
Zoom: 5 ms / div.
$V_{DS(MAX)}$ = 349 V
$I_{DS(MAX)}$ = 2.81 A
$V_{O(MAX)}$ = 21.4 V
$t_{AR\_(OFF)}$ = 1.22 s
$t_{AR(ON)}$ = 2.19 ms

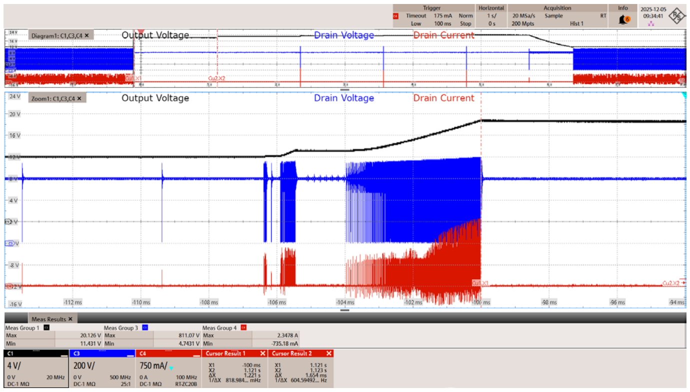

Figure 139 – 420 VAC 50 Hz. No Load.
CH1: V_{OUT}, 4 V / div., 1 s / div.
CH3: V_{DS}, 200 V / div., 1 s / div.
CH4: I_{DS}, 750 mA / div., 1 s / div.
Zoom: 2 ms / div.
$V_{DS(MAX)}$ = 811 V
$I_{DS(MAX)}$ = 2.35 A
$V_{O(MAX)}$ = 20.1 V
$t_{AR\_(OFF)}$ = 1.22 s
$t_{AR(ON)}$ = 1.65 ms

9.4 Over Temperature Protection (OTP) and Hysteresis

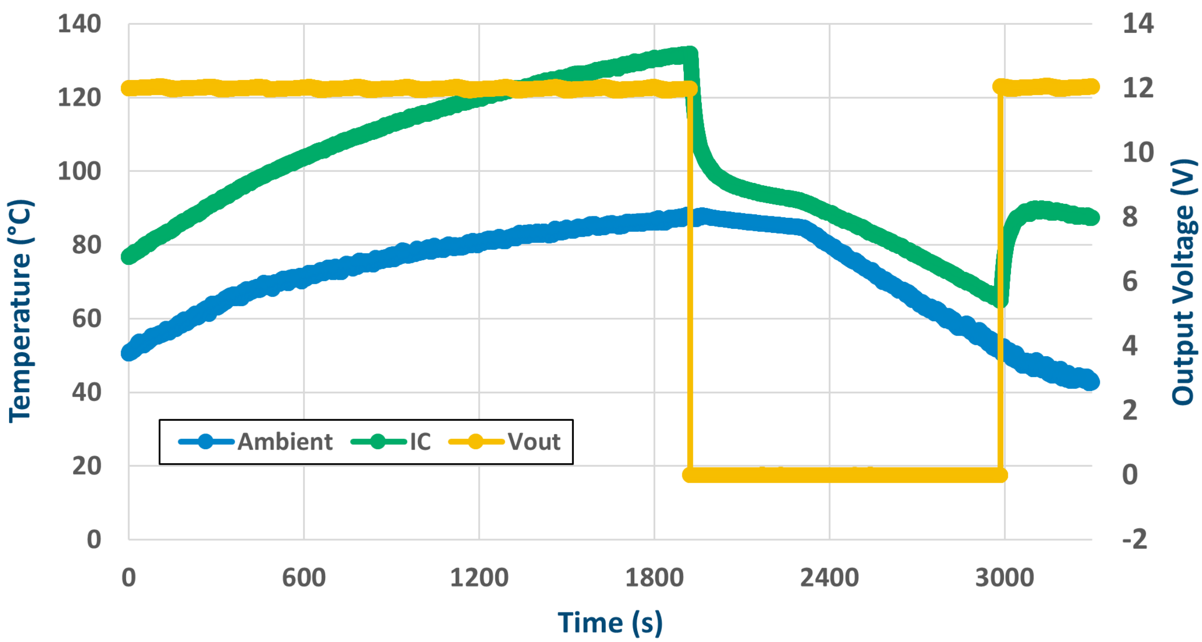

Figure 140 – 85 VAC 60 Hz. Full Load OTP

OTP Temperature	132 °C
Recovery Temperature	64.9 °C
Hysteresis	67.1 °C

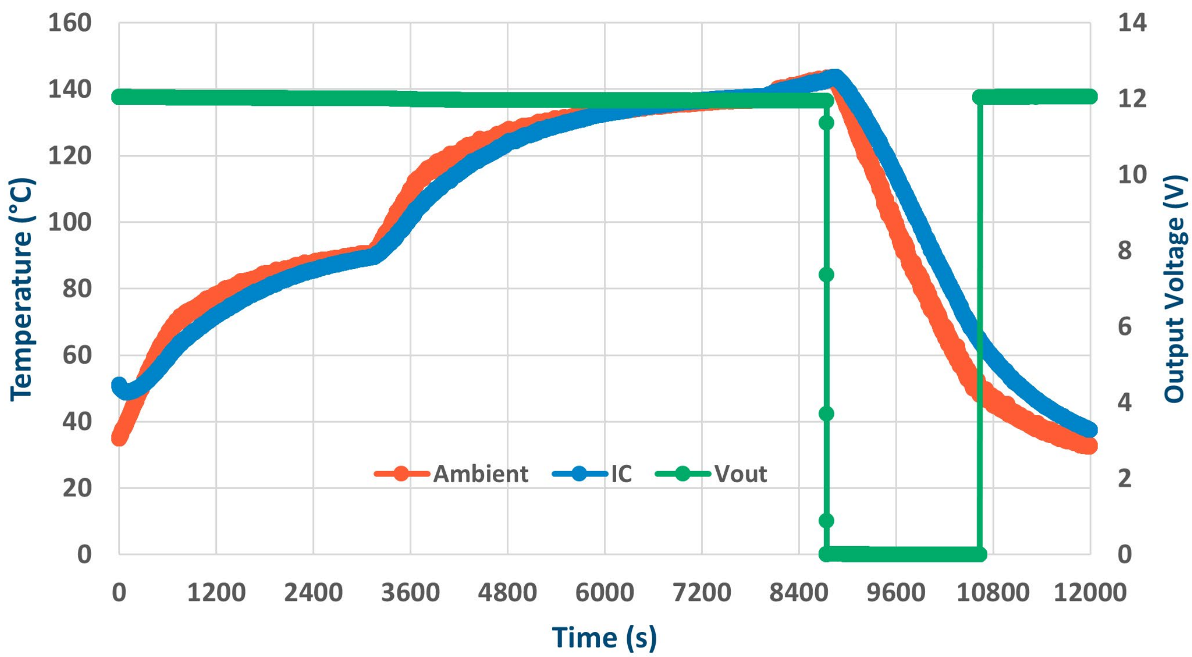

Figure 141 – 90 VAC 1% Load OTP.

OTP Temperature	143 °C
Recovery Temperature	64.5 °C
Hysteresis	78.5 °C

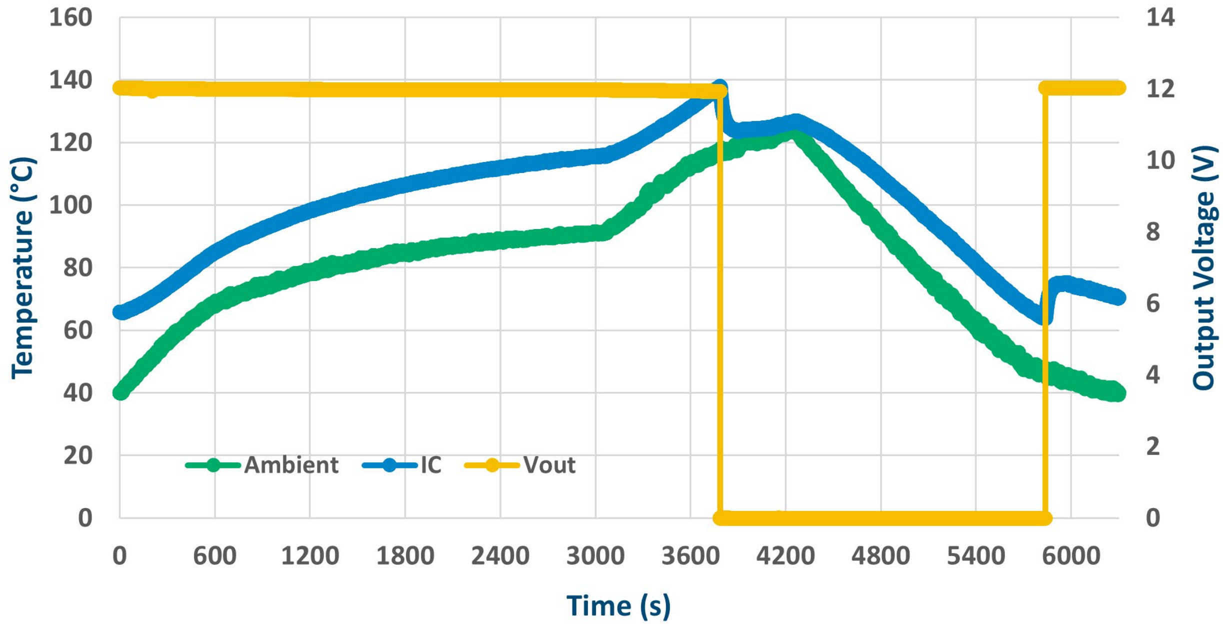

Figure 142 – 420 VAC Full Load OTP.

OTP Temperature	138 °C
Recovery Temperature	63.9 °C
Hysteresis	74.1 °C

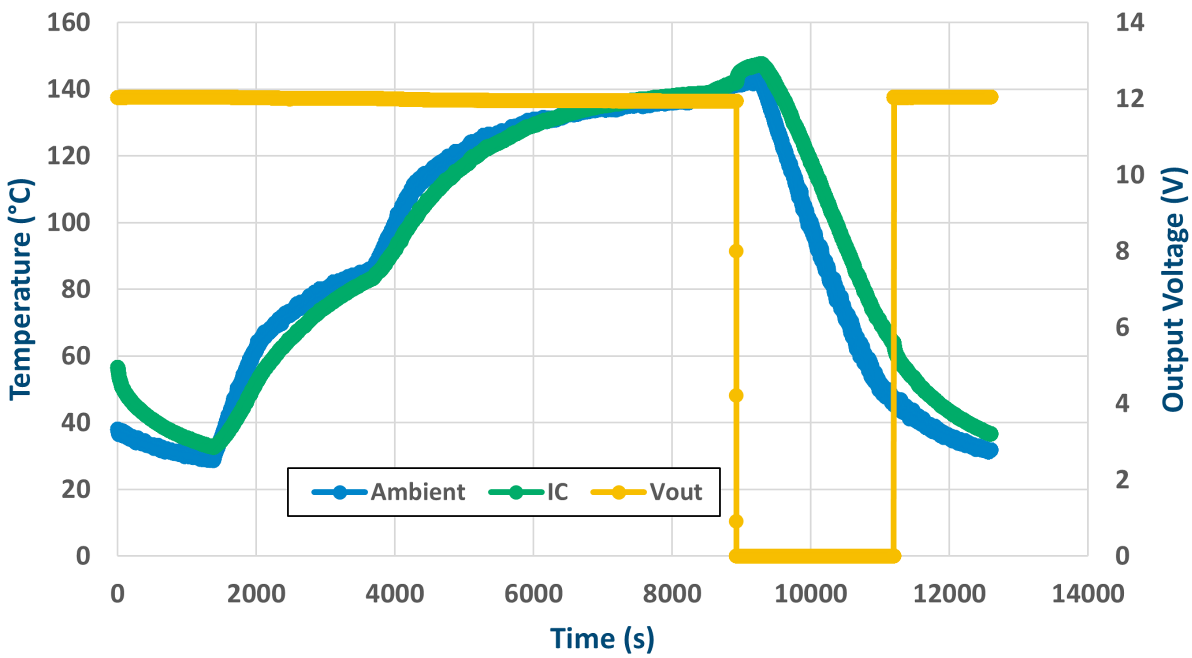

Figure 143 – 420 VAC 1% Load OTP.

OTP Temperature	142 °C
Recovery Temperature	63.9 °C
Hysteresis	78.1 °C

10 Conducted EMI

Conducted emissions tests were performed at 115 VAC and 230 VAC at full load (12 V and 3 A). Measurements were taken with floating ground.

10.1 Test Set-up Equipment

10.1.1 Equipment and Load Used

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 RLOAD resistance is 12 Ω.

Figure 144 – EMI Test Set-up

10.2 Output Float

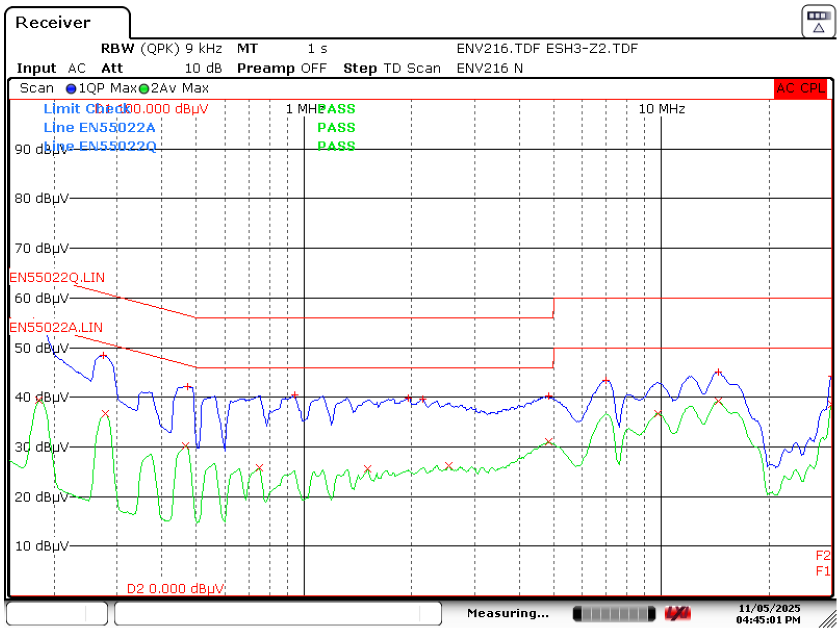

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Figure 145 – 115 VAC 60 Hz. Line / Neutral – Floating.

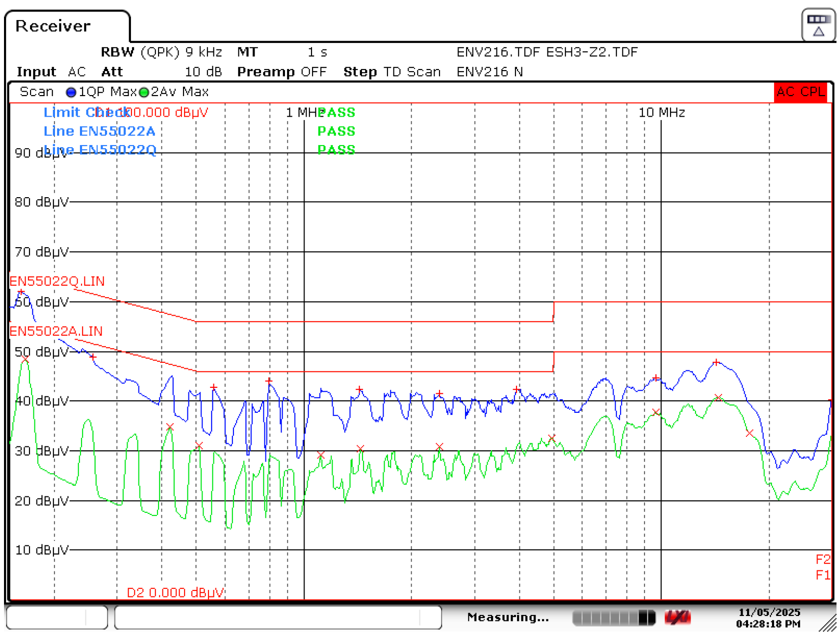

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Figure 146 – 230 VAC 50 Hz. Line / Neutral – Floating.

11 Electrostatic Discharge (ESD)

All ESD strikes were applied at the end of the cable with 230 VAC input voltage and full load.

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.

12 Combination Wave (Differential Mode)

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

12.1 115 VAC

Passed 2 kV Surge voltage

Surge Voltage	Phase Angle	IEC Coupling	Generator Impedance	Number of Strikes	Results
+2000 V	0°	L, N	2 Ω	10	PASS – No AR
–2000 V	0°	L, N	2 Ω	10	PASS – No AR
+2000 V	90°	L, N	2 Ω	10	PASS – No AR
–2000 V	90°	L, N	2 Ω	10	PASS – No AR
+2000 V	180°	L, N	2 Ω	10	PASS – No AR
–2000 V	180°	L, N	2 Ω	10	PASS – No AR
+2000 V	270°	L, N	2 Ω	10	PASS – No AR
–2000 V	270°	L, N	2 Ω	10	PASS – No AR

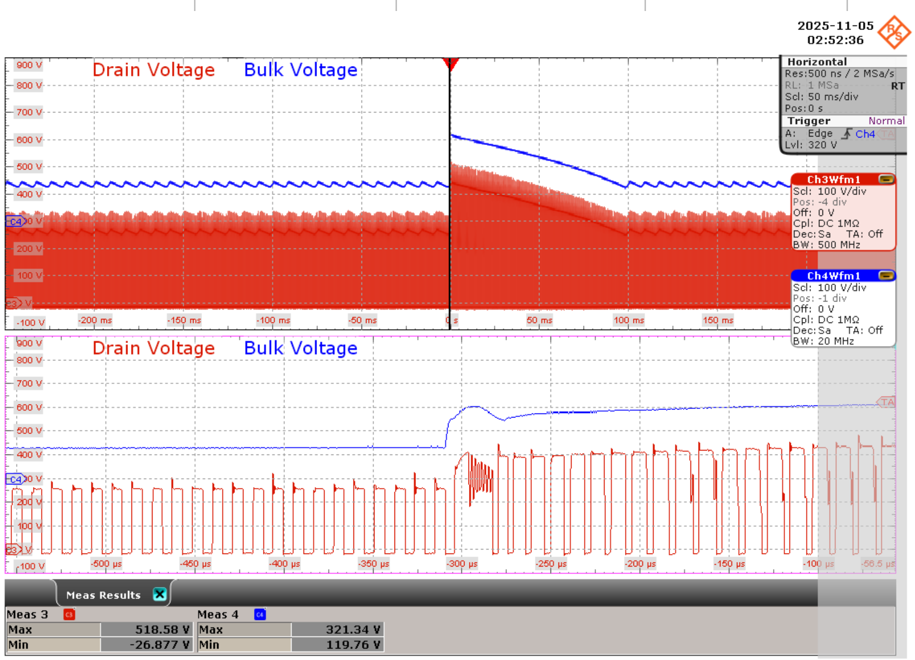


Figure 147 – 115 VAC 60 Hz., 2 kV 270° surge event
CH3: Drain Voltage, 100 V / div., 50 ms / div.
CH4: Bulk Voltage, 100 V / div., 50 ms / div.
Drain Voltage$_{(MAX)}$ = 519 V
Bulk Voltage$_{(MAX)}$ = 321 V

12.2 230 VAC

Passed 2 kV Surge voltage

Surge Voltage	Phase Angle	IEC Coupling	Generator Impedance	Number of Strikes	Results
+2000 V	0°	L, N	2 Ω	10	PASS – No AR
–2000 V	0°	L, N	2 Ω	10	PASS – No AR
+2000 V	90°	L, N	2 Ω	10	PASS – No AR
–2000 V	90°	L, N	2 Ω	10	PASS – No AR
+2000 V	180°	L, N	2 Ω	10	PASS – No AR
–2000 V	180°	L, N	2 Ω	10	PASS – No AR
+2000 V	270°	L, N	2 Ω	10	PASS – No AR
–2000 V	270°	L, N	2 Ω	10	PASS – No AR

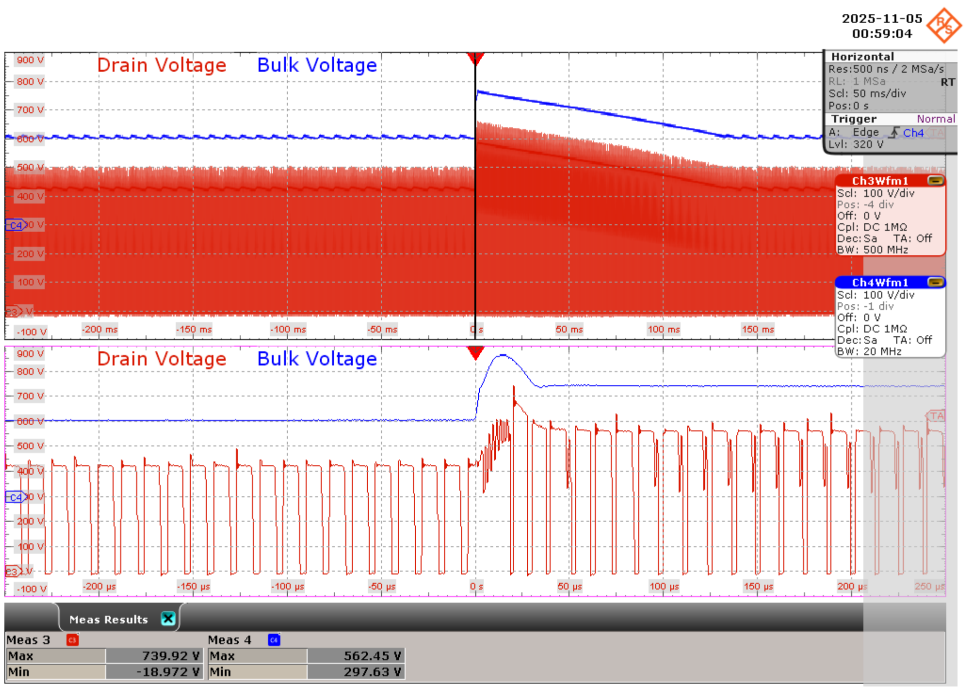


Figure 148 – 230 VAC 50 Hz., -2 kV 270° surge event
CH3: Drain Voltage, 100 V / div., 50 ms / div.
CH4: Bulk Voltage, 100 V / div., 50 ms / div.
Drain Voltage$_{(MAX)}$ = 740 V
Bulk Voltage$_{(MAX)}$ = 562 V

13 Ring Wave (Common Mode)

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

13.1 115 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 Ω	10	PASS – No AR
–4000 V	0°	L/N - PE	12 Ω	10	PASS – No AR
+4000 V	90°	L/N - PE	12 Ω	10	PASS – No AR
–4000 V	90°	L/N - PE	12 Ω	10	PASS – No AR
+4000 V	180°	L/N - PE	12 Ω	10	PASS – No AR
–4000 V	180°	L/N - PE	12 Ω	10	PASS – No AR
+4000 V	270°	L/N - PE	12 Ω	10	PASS – No AR
–4000 V	270°	L/N - PE	12 Ω	10	PASS – No AR

13.2 230 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 Ω	10	PASS – No AR
–4000 V	0°	L/N - PE	12 Ω	10	PASS – No AR
+4000 V	90°	L/N - PE	12 Ω	10	PASS – No AR
–4000 V	90°	L/N - PE	12 Ω	10	PASS – No AR
+4000 V	180°	L/N - PE	12 Ω	10	PASS – No AR
–4000 V	180°	L/N - PE	12 Ω	10	PASS – No AR
+4000 V	270°	L/N - PE	12 Ω	10	PASS – No AR
–4000 V	270°	L/N - PE	12 Ω	10	PASS – No AR

14 EFT

Tested at 230 VAC input voltage and full Load

14.1 115 VAC

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

–4000 V	90°	15 ms	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	90°	750 µs	750 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	90°	750 µs	750 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	180°	15 ms	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	180°	15 ms	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	180°	750 µs	750 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	180°	750 µs	750 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	270°	15 ms	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	270°	15 ms	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	270°	750 µs	750 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	270°	750 µs	750 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR

14.2 230 VAC

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
+4000 V	0°	5 kHz	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	0°	5 kHz	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	0°	100 kHz	750 µs	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	0°	100 kHz	750 µs	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	90°	5 kHz	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	90°	5 kHz	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	90°	100 kHz	750 µs	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	90°	100 kHz	750 µs	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	180°	5 kHz	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	180°	5 kHz	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	180°	100 kHz	750 µs	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	180°	100 kHz	750 µs	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	270°	5 kHz	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	270°	5 kHz	15 ms	300 ms	120 s	L1/L2 - PE	PASS – No AR
+4000 V	270°	100 kHz	750 µs	300 ms	120 s	L1/L2 - PE	PASS – No AR
–4000 V	270°	100 kHz	750 µs	300 ms	120 s	L1/L2 - PE	PASS – No AR

15 Bode Plot

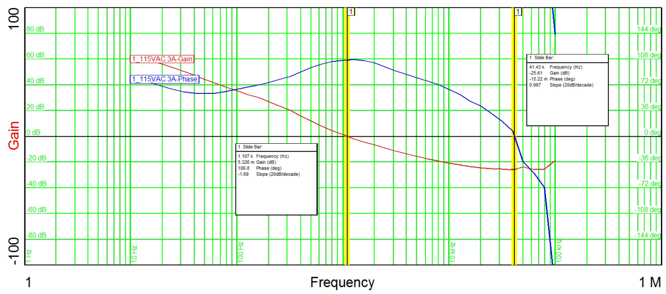


Figure 149 – 115 VAC, 60Hz, Io = 3 A
GM = 25.6 dB
PM = 107°
$f_{crossover}$ = 1.11 kHz

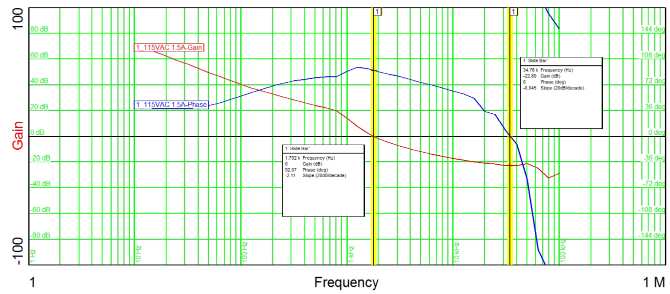


Figure 150 – 115 VAC, 60Hz, Io = 1.5 A
GM = 22.9 dB
PM = 92.1°
$f_{crossover}$ = 1.79 kHz

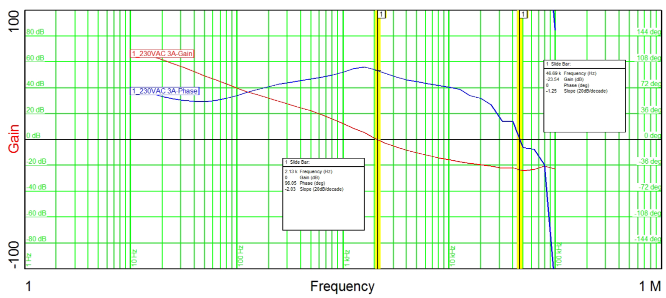


Figure 151 – 230 VAC, 50Hz, Io = 3 A
GM = 23.5 dB
PM = 96.1°
$f_{crossover}$ = 2.13 kHz

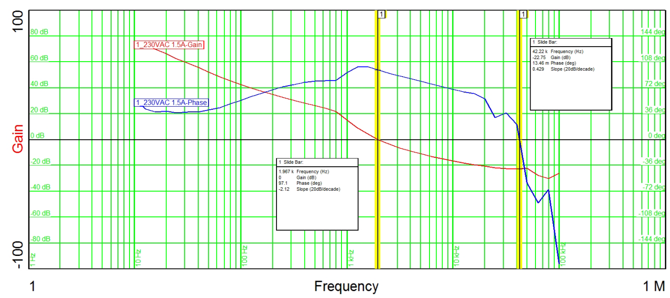


Figure 152 – 230 VAC, 50Hz, Io = 1.5 A
GM = 22.8 dB
PM = 97.1°
$f_{crossover}$ = 1.97 kHz

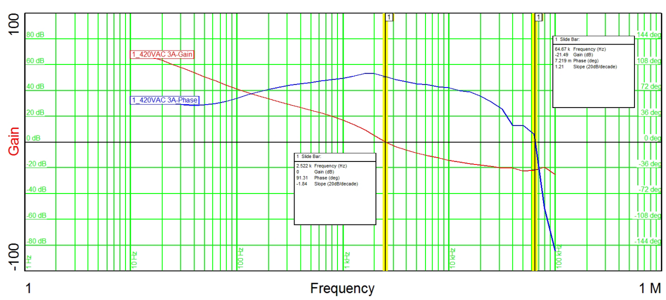


Figure 153 – 420 VAC, 50Hz, Io = 3 A
GM = 21.5 dB
PM = 91.3°
$f_{crossover}$ = 2.52 kHz

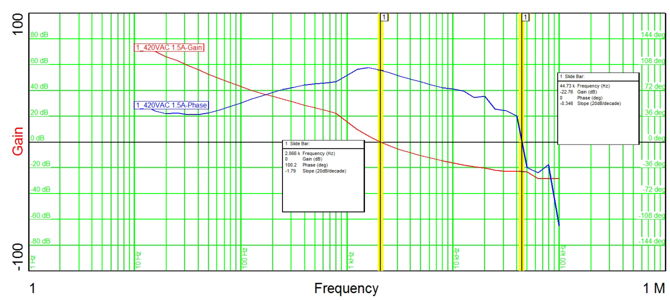


Figure 154 – 420 VAC, 50Hz, Io = 1.5 A
GM = 22.8 dB
PM = 100°
$f_{crossover}$ = 2.07 kHz

16 Bill of Materials

16.1 Electrical BOM

Item	Quantity	Designator	Description	Manufacturer Part Number	Manufacturer
1	BR1	1	1000 V, 4 A, Bridge Rectifier, SMD, DFS	Diodes Incorporated	CD-DF410S
2	C1	1	100 nF, 1000 V, Film	Epcos	B81141C1104M
3	C2 C3 C4 C5	4	100 µF, 450 V, Electrolytic, (18 x 25)	Rubycon	450HXW100MEFR18X25
4	C6	1	4700 pF ±5% 500 V Ceramic Capacitor C0G, NP0 1206 (3216 Metric)	Kemet	C1206C472JCGACAUTO
5	C7	1	47 µF, 25 V, Electrolytic, Very Low ESR, 300 mOhm, (5 x 11)	Nippon Chemi-Con	EKZE250ELL470ME11D
6	C8	1	0.47 µF, ±5%, 10 V, Ceramic Capacitor X7R, 0805 (2012 Metric)	Vishay Vitramon	VJ0805Y474JXQTW1BC
7	C9	1	CAP, 2200 pF, ±20%, 760 VAC, Ceramic Capacitor Y5U (E) Radial, Disc	Vishay/ BC Components	AY1222M47Y5UC63L0
8	C10	1	0.033 µF, ±5%, 50 V, Ceramic, X7R, 0603 (1608 Metric)	AVX Corp	06035C333JAT2A
9	C11	1	220 pF, 100 V, Ceramic, X7R, 0805	AVX	08051C221KAT2A
10	C12 C13	2	820 µF, 25 V, Electrolytic, Very Low ESR, 22 mOhm, (10 x 25)	Nippon Chemi-Con	EKZE250ELL821MJ25S
11	C14	1	100 µF, 25 V, Electrolytic, Very Low ESR, 130 mOhm, (6.3 x 11)	Nippon Chemi-Con	EKZE250ELL101MF11D
12	D1	1	600 V, 1 A, Rectifier, Glass Passivated, POWERDI123	Diodes Inc	DFLR1600-7
13	D2	1	Diode, Schottky, 200 V, 1 A, Surface Mount SOD-123HE	Panjit International Inc.	SS10200HE_R1_00001
14	D3	1	100 V, 0.2 A, Fast Switching, 50 ns, SOD-323	Diode Inc.	BAV19WS-7-F
15	D4	1	DIODE, SCHOTTKY, 10 A, 100 V, TO-252-3, DPak (2 Leads + Tab), SC-63	STMicroelectronics	STPST10H100SB-TR
16	F1	1	2 A, 250 V, Slow, Long Time Lag, RST	Bel Fuse Inc	0HAAL2000-01
17	L1	1	Common Mode Choke, 10 mH, 60 mOhms DCR, Toroidal	XFMRS	XF0093PI-VOCMC

18	L2	1	Fixed Inductor, 12 µH @100 KHz, ±10%, 5.1 A, 0.035 ohm, AEC-Q200, Unshielded, Ferrite, Radial, -40 °C ~ 85 °C, 11 x 11.5 mm	Coilcraft	RFB1010-120L
19	L3	1	FERRITE Bead, 40 Ohms @ 100 MHz, 1 Ferrite Bead 0805 (2012 Metric), 600 mA, 1000 mOhm, AEC-Q200	MFBA3V2012K-400-R	Eaton – Electronics Division
20	L4	1	3.5 mm x 7.6 mm, 75 Ohms at 25 MHz, 22 AWG hole, Ferrite Bead	Fair-Rite	2743004112
21	R1 R2 R3 R4 R5 R6 R7 R8	8	RES, 10 M, 5%, 1/4 W, Thick Film, 1206	YAGEO	RC1206FR-0710ML
22	R9 R10 R11	3	RES, 4.02 M, 1%, 1/4 W, Metal Film, 100ppm/C, -55-155C, 250 V	Yageo	MFR-25FRF52-4M02
23	R12	1	RES, 464 k, 1%, 1/10 W, Thick Film, 0603	Panasonic	ERJ-3EKF4643V
24	R13	1	RES, 3.0 k, 5%, 2/3 W, Thick Film, 1206	Panasonic	ERJ-P08J302V
25	R14 R15 R23 R24	4	RES, 100 R, 5%, 2/3 W, Thick Film, 1206	Panasonic	ERJ-P08J101V
26	R16	1	RES, 270 R, 5%, 2/3 W, Thick Film, 1206	Panasonic	ERJ-P08J271V
27	R17	1	RES, 10.2 k, 1%, 1/10 W, Thick Film, 0603	Panasonic	ERJ-3EKF1022V
28	R18	1	RES, 470 R, 5%, 2/3 W, Thick Film, 1206	Panasonic	ERJ-P08J471V
29	R19	1	RES, 1 k, 5%, 1/10 W, Thick Film, 0603	Panasonic	ERJ-3GEYJ102V
30	R20	1	RES, 20 k, 5%, 1/10 W, Thick Film, 0603	Panasonic	ERJ-3GEYJ203V
31	R21	1	RES, 38.3 k, 1%, 1/4 W, Thick Film, 1206	Panasonic	ERJ-8ENF3832V
32	R22	1	RES, 10.0 k, 1%, 1/4 W, Thick Film, 1206	Panasonic	ERJ-8ENF1002V
33	RV1	1	460 VAC, 150J, 14 mm, RADIAL	Panasonic	ERZ-V14D751
34	T1	1	Bobbin, EF25, Horizontal, 12 pins	Ying Chin	YC2504
35	U1	1	TinySwitch-5, TNY5094K, eSOP-12P	Power Integrations	TNY5094K
36	U2	1	Optocoupler, 35 V, CTR 300-600%, 4-DIP	Liteon	LTV-817D
37	U3	1	IC, Shunt Regulator Adj., 2.495 V, 2.2%, 100 mA, 0 °C ~ 70 °C (TA), SOT23-3, TO-236-3, SC-59, SOT-23-3	Texas Instruments	TL431CDBZR

38	VR1	1	Zener Diode, 150 V, 1.25 W, ±6%, Surface Mount, DO-214AC (SMA)	Vishay Semiconductors	BZG03C150-HM3-08
39	VR2	1	Zener Diode, 11 V, ±2%, 500 mW, Surface Mount, SOD-123	Vishay General Semiconductor - Diodes Division	MMSZ5241C-E3-08

16.2 Mechanical BOM

Item	Quantity	Designator	Description	Manufacturer Part Number	Manufacturer
1	+12 V	1	Test Point, RED, THRU-HOLE MOUNT	Keystone	5010
2	GND L	2	Test Point, BLK, THRU-HOLE MOUNT	Keystone	5011
3	N	1	Test Point, WHT, THRU-HOLE MOUNT	Keystone	5012
4	JP1	1	Wire Jumper, Non insulated, 22 AWG, 0.4 in	Alpha	298

17 Transformer Specification

17.1 Electrical Diagram

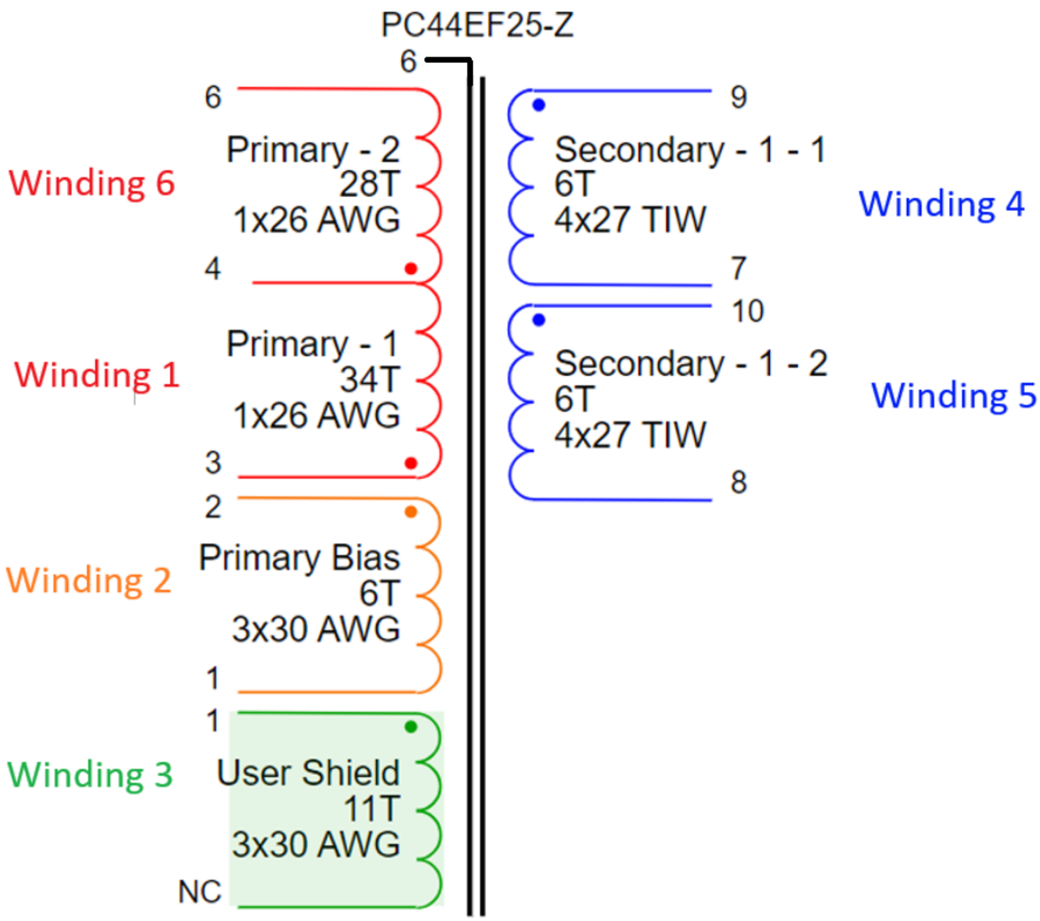


Figure 155 – Transformer Schematic

17.2 Electrical Specifications

Parameter	Condition	Specification
Nominal Primary Inductance	Measured at 1 V_{PK-PK}, 100 kHz switching frequency, between pin 3 and pin 6 with all other windings open	320 μH
Tolerance	Tolerance of Primary Inductance	±5%
Leakage Inductance	Measured between Pin 3 and Pin 6 with all other windings shorted	< 10.24 μH

17.3 Material List

Item	Description
[1]	Core: PC44EF25-Z, PC44, gapped for ALG of 267 nH / T^2
[2]	Bobbin, EF25, Horizontal, 12 pins
[3]	Varnish: Dolph BC 359 or Equivalent
[4]	Single core wire: 26 AWG (0.404 mm), insulation Heavy Build (OD: 0.452 mm) IEC 60317-56, IEC 60950 Annex U
[5]	Separation Tape: Polyester film [1 mil (25.4 micrometers) base thickness], 15.9 mm wide
[6]	Single core wire: 30 AWG (0.254 mm), insulation Heavy Build (OD: 0.297 mm) IEC 60317-56, IEC 60950 Annex U
[7]	Triple Insulated Wire: 27 AWG (0.361 mm), insulation TEX-E (OD: 0.561 mm) UL 2353 UL 1950/IEC 60950-1, Annex U (UL 1411, UL 60950-1) 1000V VRMS, class B, reinforced insolation
[8]	Polyester Tape: 7 mm

17.4 Transformer Build Diagram

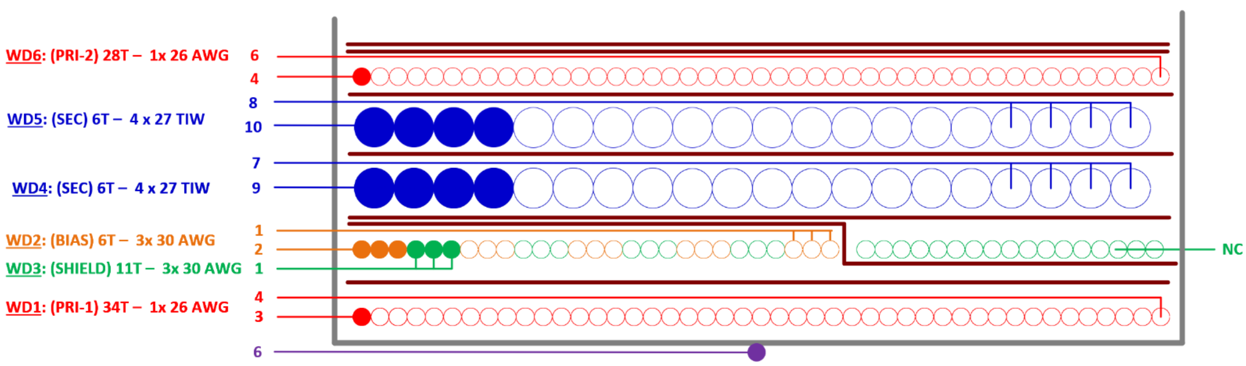


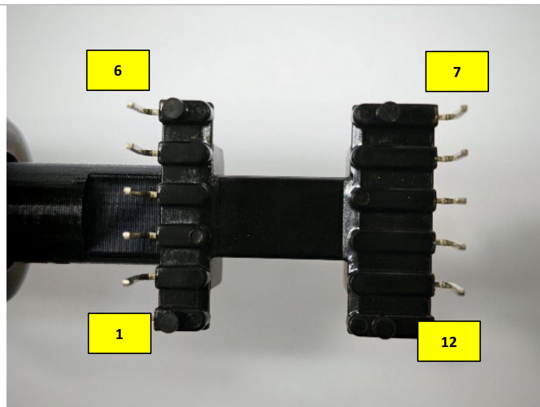
Figure 156 – Transformer Build Diagram

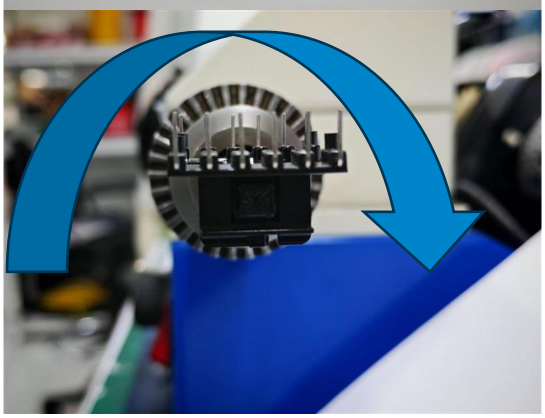
17.5 Transformer Instructions

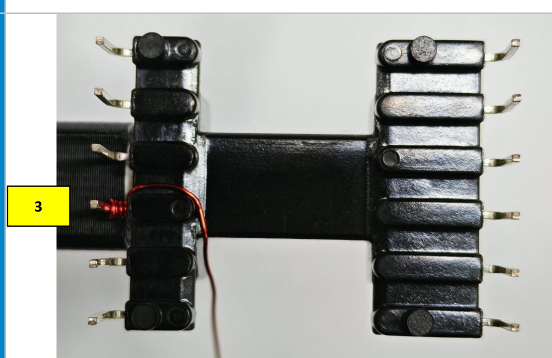
Preparation	Place the bobbin Item [2] such that pins 1-6 are on left side while 7-12 are on right side. The shorter side signifies the side of Pin 1. Winding direction is clockwise as shown.
WD1 **1st Primary**	Start with 1 strand of Item [4] from Pin 3. Wind 34 turns in Clockwise direction for the first layer from left to right. To hold the winding, apply 1 layer of tape, Item [5]. Finish this winding on Pin 4.
WD2 and WD3 **Bias and Shield Primary**	Start with 3 strands of Item [6] from Pin 1 for WD3 and another 3 strands of Item [6] from Pin 2 for WD2. Wind 6 turns of WD2 and WD3 in Clockwise direction for the first layer from left to right. To hold the winding, apply 1 layer of tape, Item [5]. Bend the end of WD2 by 90 degrees and terminate WD2 to Pin 1. Wind 5 turns of WD3 to fill the remaining width of the

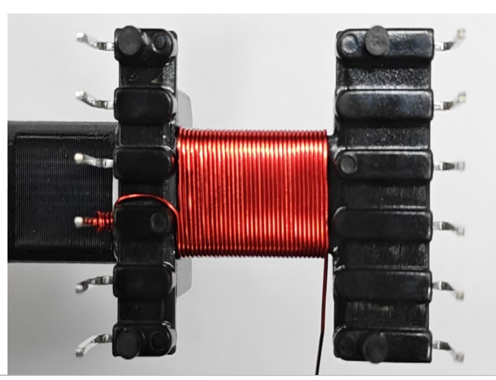
	2nd layer. To hold the winding WD3, apply 1 layer of tape, Item [5]. Bend the end of WD3 by 90 degrees and terminate winding WD3 on NC.
WD4 Secondary	Start with 4 strands of Item [7] at Pin 9. Wind 6 turns of WD4 in Clockwise direction for the 3rd layer from right to left. To hold the winding, apply 1 layer of tape, Item [5]. Bend the end of WD4 by 90 degrees and terminate WD4 to Pin 7.
WD5 Secondary	Start with 4 strands of Item [7] at Pin 10. Wind 6 turns of WD5 in Clockwise direction for the 4th layer from right to left. To hold the winding, apply 1 layer of tape, Item [5]. Bend the end of WD5 by 90 degrees and terminate WD5 to Pin 8.
WD6 2nd Primary	Start with 1 strand of Item [4] from Pin 4. Wind 28 turns in Clockwise direction for the 5th layer from left to right. To hold the winding, apply 1 layer of tape, Item [5]. Finish this winding on Pin 6. Apply 1 layer of tape Item [5] for insulation of WD6.
Assembly	Cut the excess wires and solder them to transformer pins. Cut Pin 4 lead and remove pins 5, 11 and 12. Grind the center leg of the upper half of Item [1] to get 1024 μH measured between Pin 3 and Pin 6 with all other pins open. Wrap the body of transformer with 2 layers of tape Item [8]. Measure Primary Inductance between Pin 3 and Pin 6 with all other pins open, then Leakage Inductance between Pin 3 and Pin 6 with all other pins shorted together.
Finish	Varnish using Item [3]. Check Primary Inductance and Leakage Inductance to confirm that the varnished transformer is within specification.

17.6 Transformer Winding Illustrations

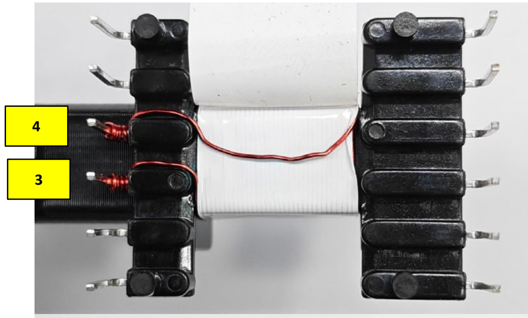
<table>
<tr>
<td>Winding Preparation</td>
<td>

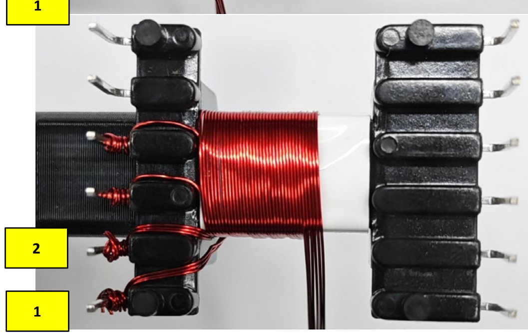
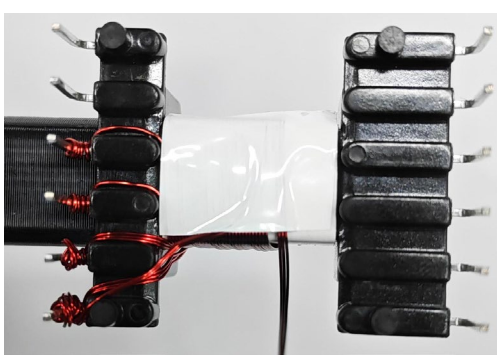
</td>
<td>Place the bobbin Item [2] such that pins 1-6 are on left side while 7-12 are on right side. The shorter side signifies the side of Pin 1.

Winding direction is clockwise as shown.</td>
</tr>
<tr>
<td>WD1
1st Primary</td>
<td>

</td>
<td>Start with 1 strand of Item [4] from Pin 3.

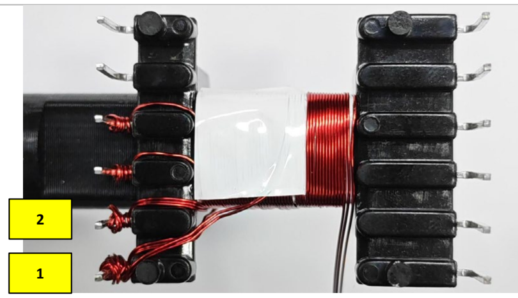
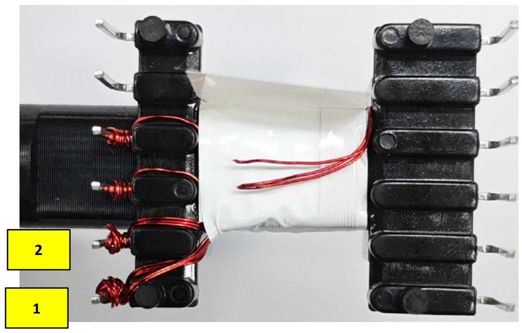
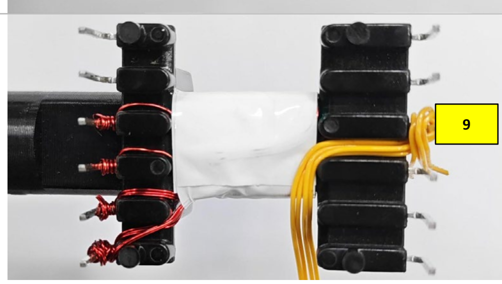
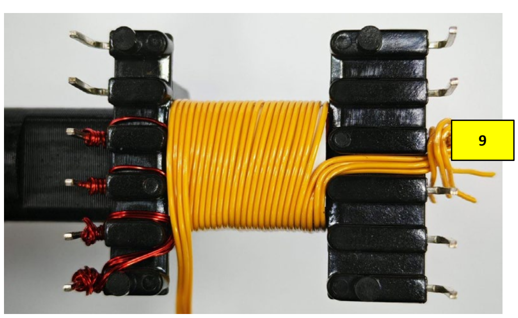
Wind 34 turns in Clockwise direction for the first layer from left to right.</td>
</tr>
</table>

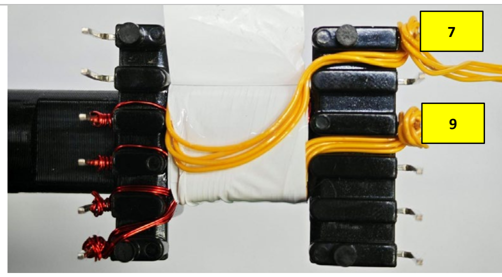
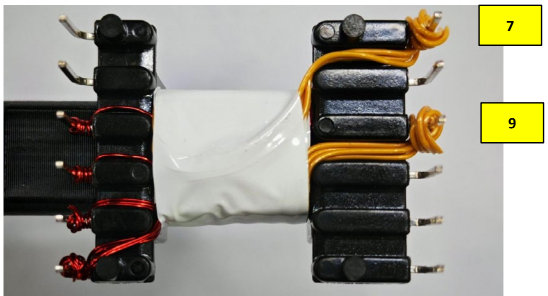
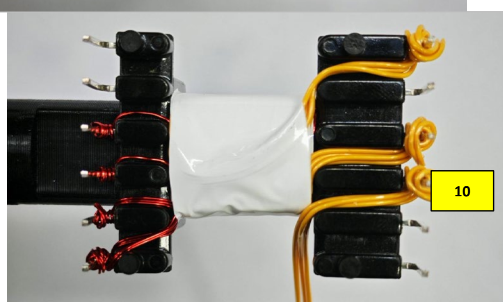
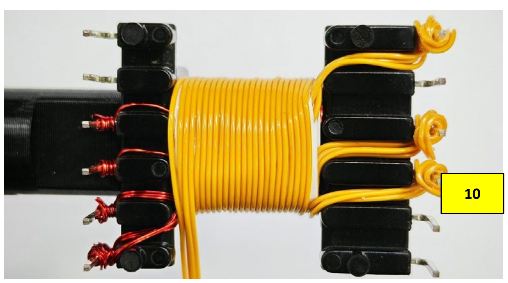
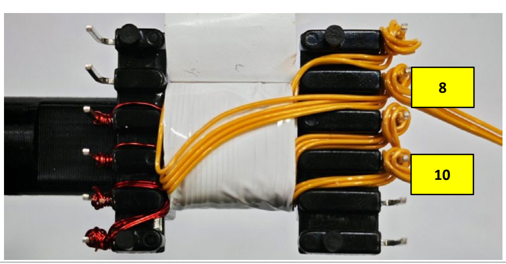
<table>
<tr>
<td></td>
<td></td>
<td>To hold the winding, apply 1 layer of tape, Item [5].

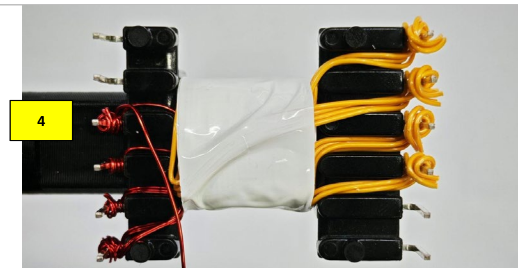
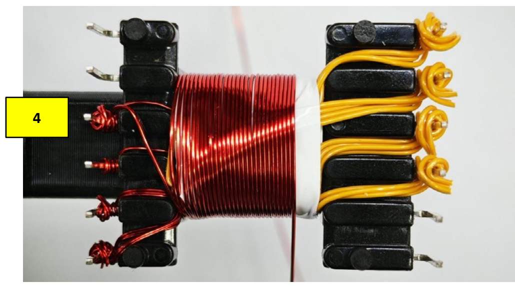
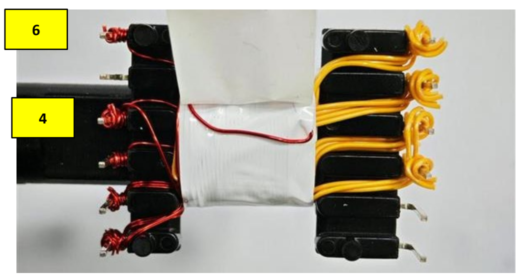
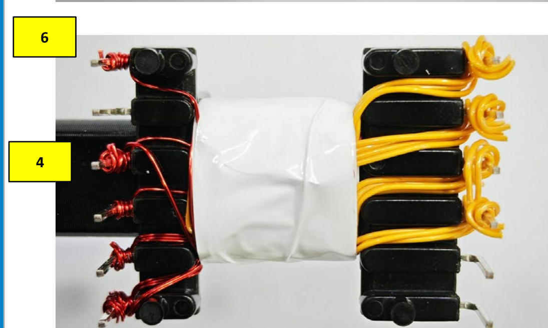
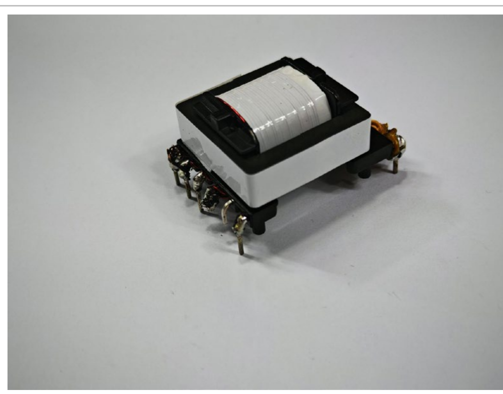
Finish this winding on Pin 4.</td>
</tr>
<tr>
<td>WD2 and WD3 Bias and Shield Primary</td>
<td></td>
<td>Start with 3 strands of Item [6] from Pin 1 for WD3 and another 3 strands of Item [6] from Pin 2 for WD2.

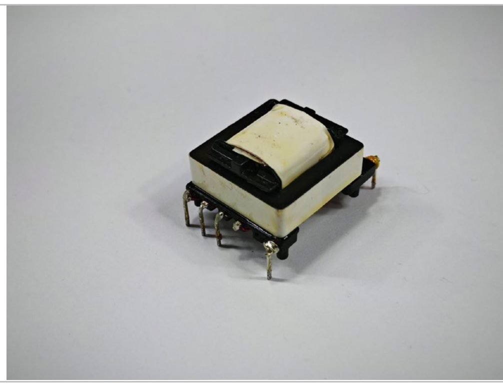
Wind 6 turns of WD2 and WD3 in Clockwise direction for the first layer from left to right.

To hold the winding, apply 1 layer of tape, Item [5]. Bend the end of WD2 by 90 degrees and terminate WD2 to Pin 1.</td>
</tr>
</table>

		Wind 5 turns of WD3 to fill the remaining width of the 2nd layer.
		To hold the winding WD3, apply 1 layer of tape, Item [5]. Bend the end of WD3 by 90 degrees and terminate winding WD3 on NC.
		
WD4 Secondary		Start with 4 strands of Item [7] at Pin 9.
		Wind 6 turns of WD4 in Clockwise direction for the 3rd layer from right to left.

	 	To hold the winding, apply 1 layer of tape, Item [5]. Bend the end of WD4 by 90 degrees and terminate WD4 to Pin 7.
WD5 Secondary	  	Start with 4 strands of Item [7] at Pin 10. Wind 6 turns of WD5 in Clockwise direction for the 4th layer from right to left. To hold the winding, apply 1 layer of tape, Item [5]. Bend the end of WD5 by 90 degrees and terminate WD5 to Pin 8.

WD6 **2nd Primary**	   	Start with 1 strand of Item [4] from Pin 4. Wind 28 turns in Clockwise direction for the 5th layer from left to right. To hold the winding, apply 1 layer of tape, Item [5]. Finish this winding on Pin 6. Apply 1 layer of tape Item [5] for insulation of WD6.
Assembly		Cut the excess wires and solder them to transformer pins. Cut Pin 4 lead and remove pins 5, 11 and 12. Grind the center leg of the upper half of Item [1] to get 1024 µH measured between Pin 3 and Pin 6 with all other pins open. Wrap the body of transformer with 2 layers of tape Item [8].

		Measure Primary Inductance between Pin 3 and Pin 6 with all other pins open, then Leakage Inductance between Pin 3 and Pin 6 with all other pins shorted together.
Finish		Varnish using Item [3]. Check Primary Inductance and Leakage Inductance to confirm that the varnished transformer is within specification.

18 Design Spreadsheet

1	**ACDC_TinySwitch5_Flyback_081526; Rev.3.0; Copyright Power Integrations 2026**	**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	90		90	V	Minimum AC input voltage
5	VIN_MAX	420		420	V	Maximum AC input voltage
6	VIN_RANGE			WIDE RANGE UNIVERSAL		Range of AC input voltage
7	LINEFREQ			60	Hz	AC Input voltage frequency
8	CAP_INPUT	100.0		100.0	μF	Input capacitor
9	VOUT			12.00	V	Output voltage at the board
10	IOUT	3.000		3.000	A	Output current
11	POUT			36.00	W	Output power
12	EFFICIENCY	0.88		0.88		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
17						
18	PRIMARY CONTROLLER SELECTION					
19	DEVICE_SERIES	TNY5094		TNY5094		Generic device code
20	ILIMIT_MODE	STANDARD		STANDARD		Device current limit mode
21	PACKAGE_DEVICE	eSOP		eSOP		Device Package
22	VDRAIN_BREAKDOWN	900		900	V	Device breakdown voltage
23	DEVICE_CODE			TNY5094K		Actual device code
24	POUT_MAX			55	W	Power capability of the device based on thermal performance
25	RDSON_100DEG			5.02	Ω	Primary switch on time drain resistance at 100 °C
26	ILIMIT_MIN			0.893	A	Minimum current limit of the primary switch
27	ILIMIT_TYP			0.960	A	Typical current limit of the primary switch
28	ILIMIT_MAX			1.027	A	Maximum current limit of the primary switch
29	VDRAIN_ON_PRSW			1.90	V	Primary switch on time drain voltage
30	VDRAIN_OFF_PRSW			800.6	V	Peak drain voltage on the primary switch during turn-off. A leakage spike voltage of 78 V is assumed
33						
34	WORST CASE ELECTRICAL PARAMETERS					
35	FSWITCHING_MAX	124250		124250	Hz	Maximum switching frequency at full load and valley of the rectified minimum AC input voltage.
36	VOR	130.0		130.0	V	Secondary voltage reflected to the primary when the primary switch turns off
37	VMIN			103.69	V	Valley of the minimum input AC voltage at full load
38	KP			0.51		Measure of continuous/discontinuous mode of operation
39	MODE_OPERATION			CCM		Mode of operation
40	DUTYCYCLE			0.561		Primary switch duty cycle

41	TIME_ON			9.47	µs	Primary switch on-time
42	TIME_ON_AT_FSWITCHING_MAX			4.51	µs	Primary switch on-time at FSWITCHING_MAX
43	TIME_OFF			3.53	µs	Primary switch off-time at 90 VAC, 36 W, and 124250 Hz.
44	LPRIMARY_MIN			972.6	µH	Minimum primary inductance
45	LPRIMARY_TYP			1023.8	µH	Typical primary inductance
46	LPRIMARY_TOL	5.0		5.0	%	Primary inductance tolerance
47	LPRIMARY_MAX			1075.0	µH	Maximum primary inductance
48						
49	PRIMARY CURRENT					
50	IPEAK_PRIMARY			1.012	A	Primary switch peak current
51	IPEDESTAL_PRIMARY			0.443	A	Primary switch current pedestal
52	IAVG_PRIMARY			0.378	A	Primary switch average current
53	IRIPPLE_PRIMARY			0.678	A	Primary switch ripple current
54	IRMS_PRIMARY			0.525	A	Primary switch RMS current
55						
56	SECONDARY CURRENT					
57	IPEAK_SECONDARY			10.461	A	Secondary winding peak current
58	IPEDESTAL_SECONDARY			4.576	A	Secondary winding current pedestal
59	IRMS_SECONDARY			4.803	A	Secondary winding RMS current
60						
61						
62						
63	TRANSFORMER CONSTRUCTION PARAMETERS					
64	CORE SELECTION					
65	CORE	Custom		Custom		Core selection. Refer to the 'Transformer Construction' tab to see the detailed report
66	CORE CODE	PC44EF25-Z		PC44EF25-Z		Core code
67	AE	52.50		52.50	mm^2	Core cross sectional area
68	LE	53.10		53.10	mm	Core magnetic path length
69	AL	2370		2370	$nH/turns^2$	Ungapped core effective inductance
70	VE	2790.0		2790.0	mm^3	Core volume
71	BOBBIN	EF25 Vertical		EF25 Vertical		Bobbin
72	AW	61.00		61.00	mm^2	Window area of the bobbin
73	BW	15.90		15.90	mm	Bobbin width
74	MARGIN			0.0	mm	Safety margin width (Half the primary to secondary creepage distance)
75						
76	PRIMARY WINDING					
77	NPRIMARY			62	turns	Primary turns
78	BPEAK			3502	Gauss	Peak flux density
79	BMAX			3315	Gauss	Maximum flux density
80	BAC			1090	Gauss	AC flux density (0.5 x Peak to Peak)
81	ALG			266	$nH/turns^2$	Typical gapped core effective inductance
82	LG			0.220	mm	Core gap length
83						
84	PRIMARY BIAS WINDING					
85	NBIAS_PRIMARY			6	turns	Primary bias winding number of turns
86						

87	SECONDARY WINDING					
88	NSECONDARY			6	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	WIDE_RANGE_UVOV	YES		YES		Enable Wide-Range UV/OV
97						
98	LINE UNDERVOLTAGE					
99	BROWN-IN REQURED	85.00		85.00	V	Required AC RMS/DC line voltage brown-in threshold
100	RINJ			464	kΩ	Resistor connected between BP pin and V pin. For Wide-range UV/OV only.
101	RLS			13.06	MΩ	Connect 4.42 MOhm, 4.32 MOhm, 4.32 MOhm resistors in series to the V-pin for the required UV/OV threshold
102	BROWN-IN ACTUAL			33.6V - 84.4V	V	Actual AC RMS/DC brown-in range
103	BROWN-OUT ACTUAL			41.3	V	Actual AC RMS/DC brown-out range
104						
105	LINE OVERVOLTAGE					
106	OVERVOLTAGE_LINE			420.4V - 507V	V	Actual AC RMS/DC line over-voltage range
107						
108	PRIMARY BIAS DIODE					
109	VBIAS_PRIMARY			12.0	V	Rectified primary bias voltage
110	VF_BIAS_PRIMARY			0.70	V	Bias winding diode forward drop
111	VREVERSE_BIASDIODE_PRIMARY			69.35	V	Bias diode reverse voltage (not accounting parasitic voltage ring)
112	CBIAS_PRIMARY			47	μF	Bias winding rectification capacitor
113	CBP			0.47	μF	BP pin capacitor
114						
117	SECONDARY COMPONENTS					
118	VREF_REG	2.50		2.50	V	Reference voltage of the feedback
119	RFB_UPPER			38.30	kΩ	Upper feedback resistor (connected to the first output voltage)
120	RFB_LOWER			10.00	kΩ	Lower feedback resistor
121						
122	SECONDARY BIAS DIODE					
123	USE_SECONDARY_BIAS	NO		NO		Use secondary bias winding for the design
124	VBIAS_SECONDARY			NA	V	Rectified secondary bias voltage
125	VF_BIAS_SECONDARY			NA	V	Bias winding diode forward drop
126	VREVERSE_BIASDIODE_SECONDARY			NA	V	Bias diode reverse voltage (not accounting parasitic voltage ring)

127	CBIAS_SECONDARY			NA	µF	Bias winding rectification capacitor
128						
130	MULTIPLE OUTPUT PARAMETERS					
131	OUTPUT 1					
132	VOUT1			12.00	V	Output 1 voltage
133	IOUT1			3.00	A	Output 1 current
134	POUT1			36.00	W	Output 1 power
135	VD1			0.70	V	Forward voltage drop of diode for output 1
136	NS1			6	turns	Number of turns for output 1
137	ISPEAK1			10.46	A	Instantaneous peak value of the secondary current for output 1
138	ISRMS1			4.803	A	Root-mean-squared value of the secondary current for output 1
139	ISRIPPLE1			3.751	A	Current ripple on the secondary waveform for output 1
140	PIV1_CALCULATED			82.99	V	Computed peak inverse voltage stress on the diode for output 1
141	OUTPUT_RECTIFIER1	MBR10100		MBR10100		Selected diode for output 1
142	PIV1_RATING			100.00	V	Peak inverse voltage rating on the diode for output 1
143	TRR1			0.00	ns	Reverse recovery time of the diode for output 1
144	IFM1			10.00	A	Maximum forward continuous current of the diode for output 1
145	PLOSS_DIODE1			2.47	W	Maximum diode power loss for output 1

19 Revision History

Revision	Notes	Author	Date
A	Initial Release	AJF	5/12/2026
B	Update 85 VAC to 90 VAC Update Ferrite Bead to 40 Ω	RPA	8/27/2026

Power Integrations
5245 Hellyer Avenue, San Jose, CA 95138 USA.
+1 408 414 9200 | **Power.com**