Design Example Report

Title	**120 W Isolated Flyback Power Supply Using TOPSwitch™-JX TOP271EG**
Specification	85 VAC – 265 VAC Input 24.0 V / 5 A Output
Application	Appliances
Author	Applications Engineering Department
Document Number	DER-1026
Date	July 9, 2025
Revision	A

Summary and Features

- Integrated protection
    - Auto-recovery output over current (OCP) and short-circuit
    - Primary sensed output overvoltage shutdown (OVP)
    - Over temperature
    - Line undervoltage (UVLO) and line overvoltage
- 88.5% full Load efficiency @ 115 VAC and 90% full Load efficiency @ 230 VAC
- 90% average efficiency

Power Integrations
5245 Hellyer Avenue, San Jose, CA 95138 USA.
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com

Table of Contents

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

1 Introduction

This engineering report describes a flyback converter that provides an isolated output voltage of 24 V at 5 A from a wide input voltage range of 85 VAC to 265 VAC. This power supply utilizes the TOP271EG from the TOPSwitch™-JX family of ICs.

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

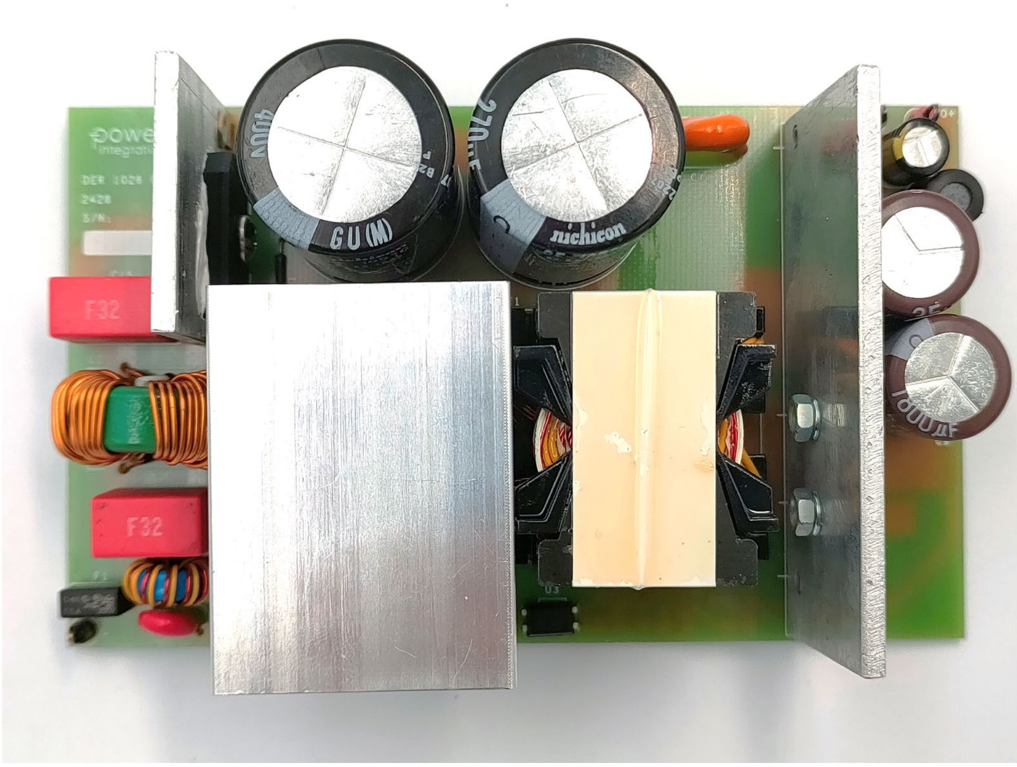


Figure 1 – Top View.

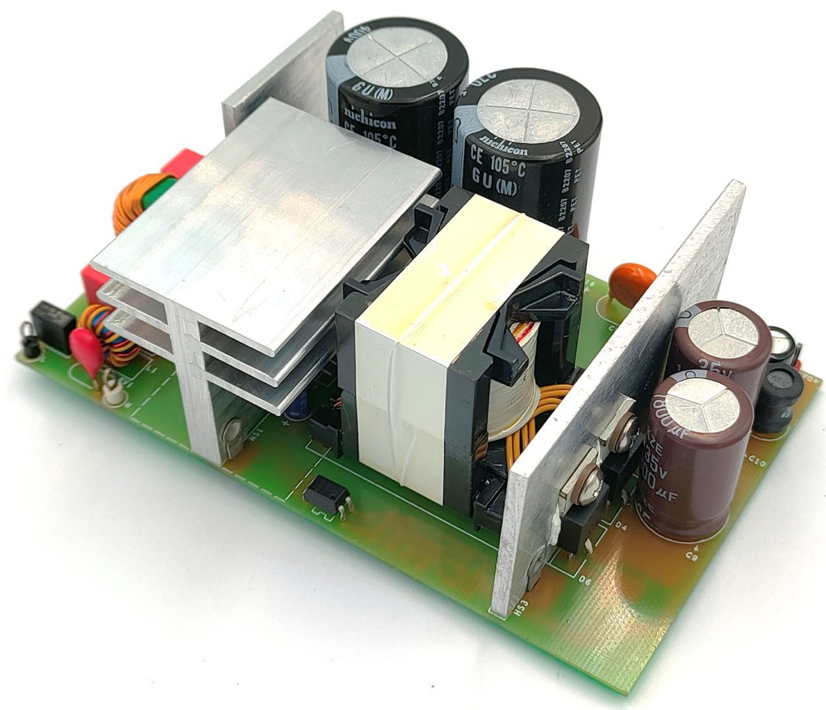


Figure 2 – Side View.

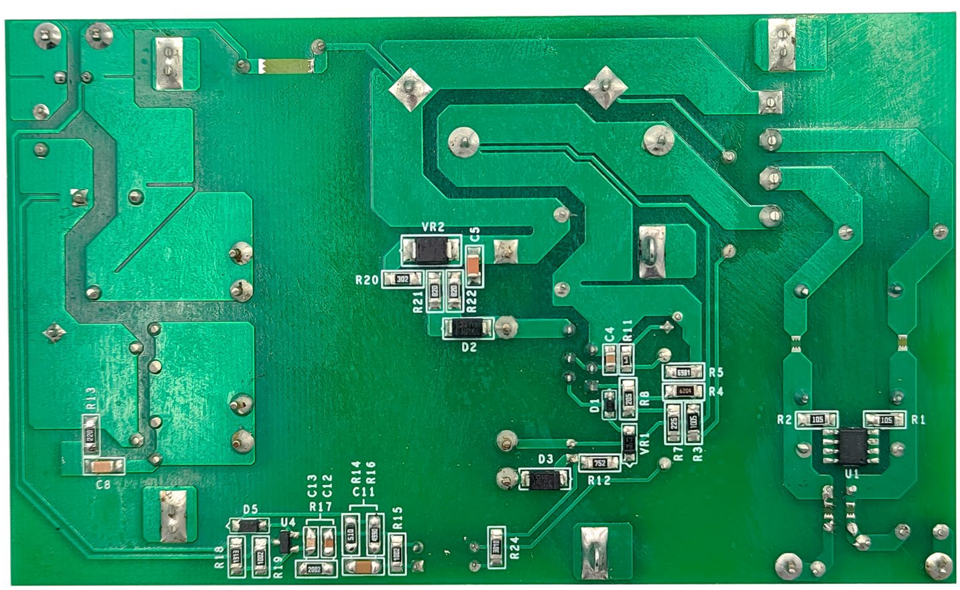


Figure 3 – Bottom View.

2 Power Supply Specification

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

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	85	115/230	265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50 / 60	64	Hz	
No-load Input Power (230 VAC)				210	mW	
Output1						
Output Voltage	V_{OUT1}	22.8	24	25.2	V	± 5%
Output Ripple Voltage	$V_{RIPPLE1}$			150	mV	20 MHz Bandwidth.
Output Current	I_{OUT1}	0		5	A	
Total Output Power						
Continuous Output Power	P_{OUT}	0		120	W	
Efficiency						
Full Load 115 VAC	$\eta_{115\ VAC}$	88.5			%	Measured at P_{OUT} 25 °C.
Full Load 230 VAC	$\eta_{230\ VAC}$	90			%	
Average efficiency at 25, 50, 75 and 100 % of P_{OUT}	η_{DOE6}	88			%	Measured at Nominal Input 115 VAC and 230 VAC.
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Surge (Differential)				±1	kV	1.2/50 µs Surge, IEC 61000-4-5
Ring Wave (Common Mode)				±4	kV	
Electrical Fast Transient				±4	kV	
ESD – Air Discharge				±16.5	kV	
ESD – Contact Discharge				±8.8	kV	
Ambient Temperature	T_{AMB}	0		40	°C	Free Convection, Sea Level.

Table 1 – Power Supply Specification

3 Schematic

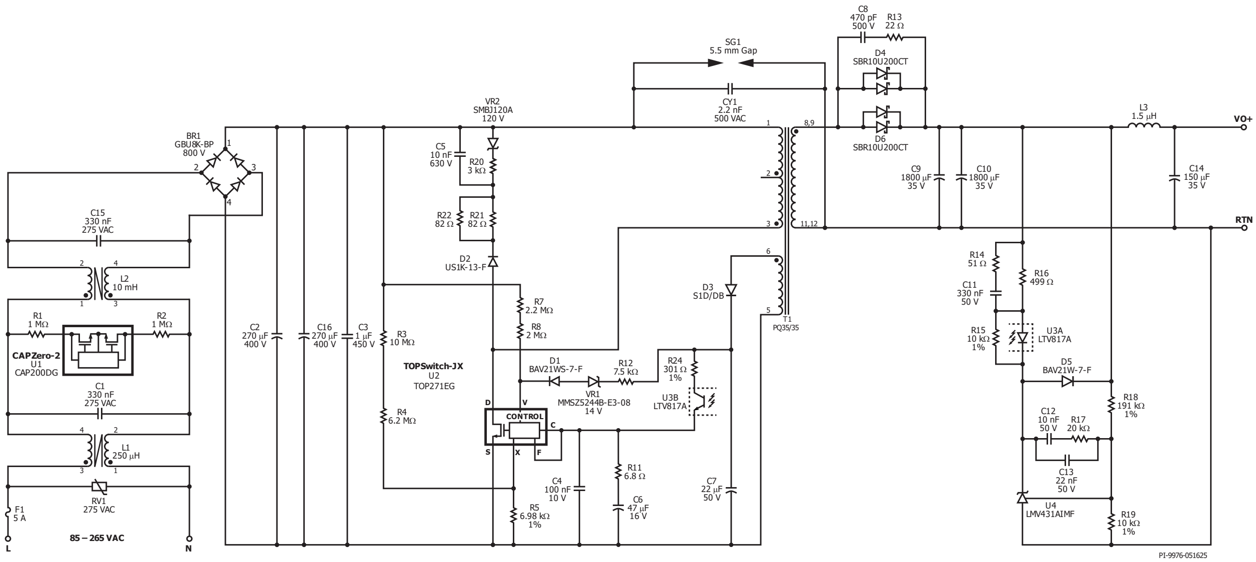


Figure 4 – Schematic.

4 Circuit Description

This power supply employs a TOP271EG off-line switcher IC, (U2), in a flyback configuration. IC U2 has an integrated 725 V power MOSFET and a multi-mode controller. Current fed to the control pin provides information to the controller which applies a multi-mode load-dependent control approach to provide output regulation.

4.1 Input EMI Filtering and Rectification

Fuse F1 isolates the circuit and provides protection from component failure. Varistor RV1 suppresses line transient voltages. X capacitors C1 and C15 together with common mode choke L1 and L2 form an EMI filter that attenuates both common mode and differential mode conducted EMI. Resistors R1 and R2 together with the CAP200DG IC (U1) discharge C1 and C15 when AC power is removed. BR1 converts the AC line voltage into the DC voltage seen across bulk capacitors C2 and C16.

4.2 TOPSwitch-JX Primary

The TOP271EG device (U2) 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 C16, and the other side is connected to the DRAIN pin of U2. C3 provides additional filtering close to the switching node. 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 a RZCD clamp network that consists of D2, R20, R21, R22, VR2, and C5. The RZCD arrangement prevents the voltage across the capacitor C5 discharging below a minimum value (defined by the voltage rating of VR2), minimizing clamp dissipation under light and no-load conditions. Resistor R20 limits current to VR2, while resistor R21 and R22 are used together with capacitor C5 to damp-out high frequency ringing and improve EMI. Y capacitor CY1, connected between the primary and secondary side helps improve EMI.

The TOP271EG IC regulates output based on the current into its CONTROL pin. The power supply output voltage is sensed on the secondary side by shunt regulator U4 and provides a feedback signal to the primary side through optocoupler U3. Biasing is provided by diode D3 and capacitor C7, while resistor R24 properly bias the transistor side of optocoupler U3.

The line undervoltage is determined by the current supplied from resistors R7 and R8 to the V pin. R12, VR1, and D1 are used for output overvoltage protection. An increase in output voltage causes an increase in the voltage across the bias winding on the primary side, which is sensed by VR1. Once VR1 is activated, it will inject current to the V pin causing the IC to enter auto-restart.

Capacitor C6 provides the auto-restart timing for U2, start-up and loop compensation. At start-up, this capacitor is charged through the DRAIN (D) pin. Once it is charged, U2 begins to switch. Capacitor C6 stores enough energy to ensure the power supply output reaches regulation. After start-up, the bias winding powers the controller via the current through the optocoupler U3 into the CONTROL pin. Bypass capacitor C4 is placed close as possible to U2. Resistor R11 provides additional loop compensation.

X pin resistor R5 is used to select the current limit of the IC, while resistors R3 and R4 bias the current limit as a function of the input line voltage. This allows U2 to limit output power at high line while supporting the rated power at low line.

At no-load condition, U2 enters Multi-Cycle-Modulation (MCM) mode where it switches at a typical frequency of 30 kHz. This results in extremely low losses under no-load conditions.

4.3 Output Rectification

Ultrafast diodes D4 and D6 rectify the 24 V secondary winding output of T1. The output voltage is filtered by C9, C10, L3, and C14. Resistor R13 and capacitor C8 snubs the voltage spike caused by the commutation of D4 and D6. Low ESR capacitors C9 and C10 minimize output voltage ripple, while post filter L3 and C14 further attenuate noise and ripple.

4.4 Output Feedback

The reference IC, U4 (LMV431), is used to set the output voltage and is programmed by the resistor-divider formed by R18 and R19. The LMV431 was chosen to reduce no-load consumption by reducing the bias current needed. U4 varies its cathode voltage to keep its input voltage constant (1.24 V, ±1%). As the cathode voltage changes, the current through the LED and transistor within U3 changes. The RC network R17, C12, and C13 provide compensation for the feedback loop. The RC network comprising R14 and C11 provide a phase boost to improve phase margin. Resistor R16 limits gain to ensure stability across the operating range. D5 provides a soft finish rise of the output, while R15 ensures minimum bias to U4 during startup.

5 PCB Layout

Layers: 1 Layer
Board Thickness: 1.6 mm.
Copper Thickness: 2 oz.
Material: FR4

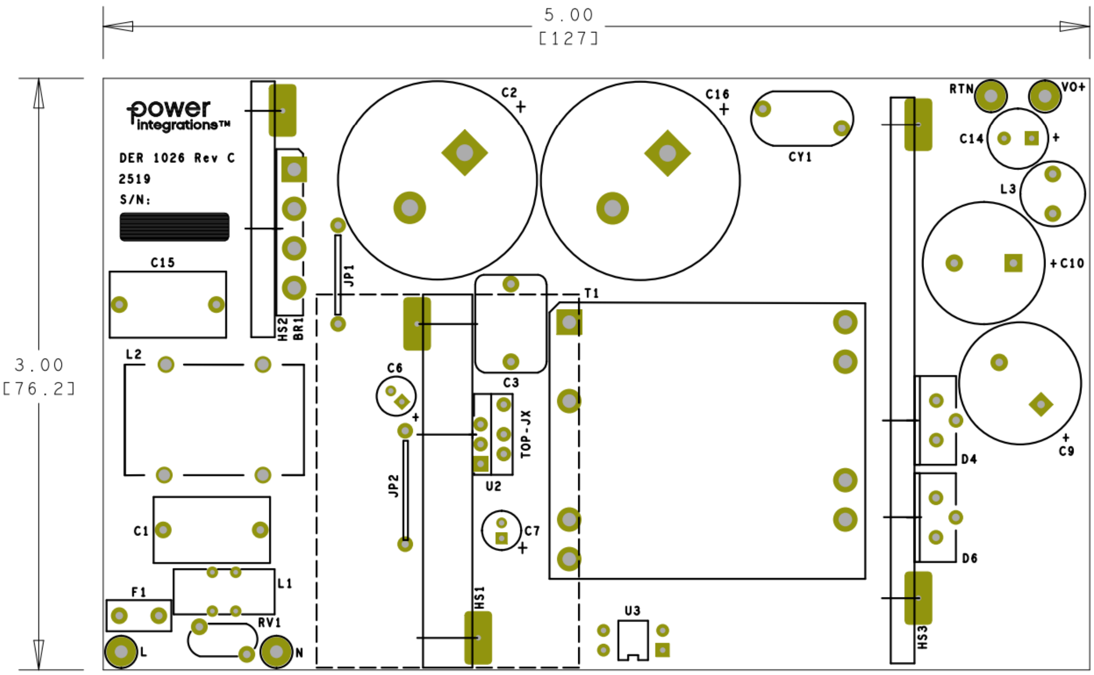


Figure 5 – Printed Circuit Board, Top View.

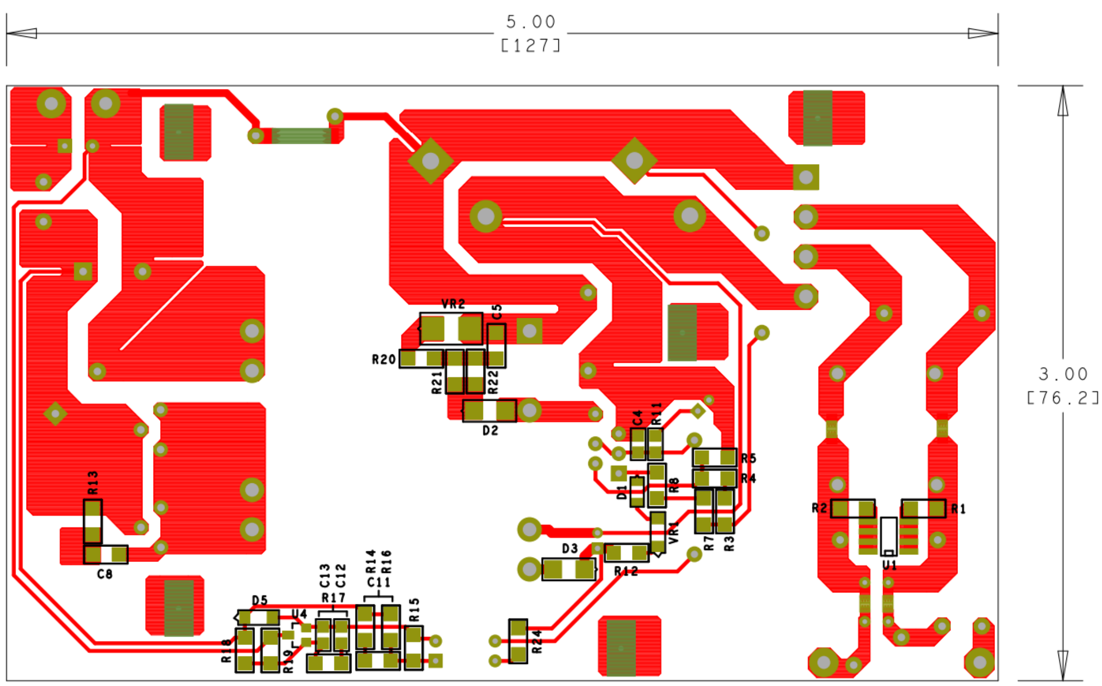


Figure 6 – Printed Circuit Board, Bottom View.

6 Bill of Materials

6.1 Electrical BOM

Item	Qty.	Ref Des	Description	Mfr. Part Number	Manufacturer
1	1	BR1	800 V, 8 A, Bridge Rectifier, GBU Case	GBU8K-BP	Micro Commercial Co.
2	2	C1 C15	330 nF, ±10%, 275 VAC, Polypropylene Film, X2, 15.00 mm x 8.50 mm	890324024003CS	Wurth Electronics Inc.
3	2	C2 C16	270 μF, 400 V, Aluminum Electrolytic Capacitors, Radial, Can - Snap-In, 3000 Hrs @ 105 °C, (25 x 45)	LGU2G271MELA	Nichicon
4	1	C3	CAP, FILM, 1.0 μF, 10%, 450 VDC, RADIAL	ECW-FD2W105Q1	Panasonic
5	1	C4	100 nF, 0.1 μF,10 V, Ceramic, X7R, 0805	0805ZC104MAT2A	AVX Corporation
6	1	C5	10 nF, 630 V, Ceramic, X7R, 1206	C1206C103KBRACTU	Kemet
7	1	C6	47 μF, 16 V, Electrolytic, Gen Purpose, (5 x 11.5)	ECA-1CHG470	Panasonic
8	1	C7	22 μF, 50 V, Aluminum Electrolytic Capacitors, Radial, Can 2000 Hrs @ 85°C, (5 x 11), LS 2 mm	EEU-FM1H220H	Panasonic Electronic Components
9	1	C8	470 pF, ±10%, 500 V, X7R, Ceramic Capacitor, Surface Mount, MLCC 1206 (3216 Metric)	CC1206KKX7RBBB471	Yageo
10	2	C9 C10	1800 μF, 35 V, Electrolytic, Very Low ESR, 16 mOhm, (16 x 25)	EKZE350ELL182ML25S	Nippon Chemi-Con
11	1	C11	330 nF, 50 V, Ceramic, X7R, 1206	12065C334KAT2A	AVX Corp
12	1	C12	10 nF, 50 V, Ceramic, X7R, 0805	C0805X103K5RAC7210	Kemet
13	1	C13	22 nF, 50 V, Ceramic, X7R, 0805	CC0805KRX7R9BB223	Yageo
14	1	C14	150 μF, 35 V, Electrolytic, Gen. Purpose, (8 x 11.5)	EEU-FM1V151	Panasonic
15	1	CY1	2200 PF, ±20%, 500 VAC (Y1), 760 VAC (X1), Ceramic, Y5U (E), RADIAL	440LD22-R	Vishay
16	1	D1	250 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV21WS-7-F	Diode Inc.
17	1	D2	800 V, 1 A, Fast Recovery, 500 ns, SMA	US1K-13-F	Diodes, Inc
18	1	D3	200 V, 1 A, Fast Recovery, 250 ns, SMA	S1D-13-F	Diodes, Inc
19	2	D4 D6	200 V, 10 A, Dual Schottky, TO-220AB	SBR10U200CT	Diodes Incorporated
20	1	D5	250 V, 0.2 A, Fast Switching, 50 ns, SOD-123	BAV21W-7-F	Diode Inc.
21	1	F1	5 A, 250 V, Slow, Long Time Lag, RST	RST 5	Belfuse
22	1	L1	250 μH, Toroidal Common Mode Choke, custom, DER-1026, wound on 32-00376-00 core	30-00624-00	Power Integrations
23	1	L2	Common Mode Choke, 10 mH, 60 mOhms DCR, Toroidal	XF0093PI-VOCMC	XFMRS
24	1	L3	1.5 μH, 8.5 A, Hi Current, Radial	6000-1R5M-RC	JW Miller
25	2	R1 R2	RES, 1.0 M, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J105V	Panasonic
26	1	R3	RES, 10 M, 5%, 1/4 W, Thick Film, 1206	RC1206FR-0710ML	YAGEO
27	1	R4	RES, 6.2 M, 1%, 1/4 W, Thick Film, 1206	KTR18EZPF6204	Rohm Semi
28	1	R5	RES, 6.98 k, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF6981V	Panasonic
29	1	R7	RES, 2.2 M, 5%, 1/4 W, Thick Film, 1206	RC1206JR-072M2L	YAGEO
30	1	R8	RES, 2.0 M, 5%, 1/4 W, Thick Film, 1206	RC1206JR-072ML	YAGEO
31	1	R11	RES, 6.8 R, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ6R8V	Panasonic
32	1	R12	RES, 7.5 k, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J752V	Panasonic
33	1	R13	RES, 22 R, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J220V	Panasonic
34	1	R14	RES, 51 R, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J510V	Panasonic

35	1	R15	RES, 10.0 k, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1002V	Panasonic
36	1	R16	RES, 499 R, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF4990V	Panasonic
37	1	R17	RES, 20.0 k, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF2002V	Panasonic
38	1	R18	RES, 191 k, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1913V	Panasonic
39	1	R19	RES, 10 kOhms, ±1%, ±200 ppm/°C, 0.5 W, 1/2 W Chip Resistor 1206 (3216 Metric), Moisture Resistant, Thick Film	RC1206FR-7W10KL	Yageo
40	1	R20	RES, 3.0 k, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J302V	Panasonic
41	2	R21 R22	RES, 82 R, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J820V	Panasonic
42	1	R24	RES, 301 R, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF3010V	Panasonic
43	1	RV1	275 VAC, 23 J, 7 mm, RADIAL	V275LA4P	Littlefuse
44 45	1	T1	Bobbin, PQ35/35, Vertical, 12 pins	BQ35/35-1112CPFR	TDK
				CPV-PQ35/35-1S-12P-Z	Ferroxcube
46	1	U1	CAPZero-2, CAP200DG, SO-8C	CAP200DG	Power Integrations
46	1	U2	TOPSwitch-JX, TOP271EG, eSIP-7F	TOP271EG	Power Integrations
47	1	U3	Optocoupler, 35 V, CTR 80-160%, 4-DIP	LTV-817A	Liteon
48	1	U4	1.24 V Shunt Regulator IC, 1%, -40 to 85 C, SOT23-3	LMV431AIMF/NOPB	Texas Instruments
49	1	VR1	DIODE ZENER 14 V 500 MW SOD123	MMSZ5244B-E3-08	Vishay Semiconductor Diodes Division
50	1	VR2	193 V Clamp, 3.1 A Ipp, Unidirectional TVS Diode, Surface Mount DO-214AA (SMBJ)	SMBJ120A	Littelfuse

Table 2 – Electrical Bill of Materials.

6.2 Mechanical BOM

Item	Qty	Ref Des	Description	Mfr. Part Number	Manufacturer
1	1	ESIP CLIP1	Heatsink Hardware, Edge Clip, 12.40 mm x 6.50 mm	TRK-24	Kang Tang Hardware Enterprise Co. Ltd.
2	1	HS1	SHTM, Heat Sink, TOP-JX IC, DER-1026	61-00357-00	Custom
3	1	HS2	SHTM, Heat Sink, Diode Bridge, DER-1026	61-00355-00	Custom
4	1	HS3	SHTM, Heat Sink, Diode SECDIODE, DER-1026	61-00356-00	Custom
5	1	JP1	Wire Jumper, Insulated, 24 AWG, 0.5 in	C2003A-12-02	Gen Cable
6	1	JP2	Wire Jumper, Insulated, 24 AWG, 0.6 in	C2003A-12-02	Gen Cable
7	3	NUT1 NUT3 NUT4	Nut, Hex, Metric, M3 SS	68024082	Import
8	1	NUT2	Nut, Hex 6-32, SS	HNSS 632	Building Fasteners
9	1	SCREW1	SCR, Phillips, M3 X12 mm, Panhead Mach, Metric SS with rubber O-ring.	SM3X12MM-2701	APM HEXSEAL
10	1	SCREW2	SCREW MACHINE PHIL 6-32 X 3/8 SS	PMSSS 632 0038 PH	Building Fasteners
11	2	SCREW3 SCREW4	SCR, Phillips, M3 X8 mm, Panhead Mach, Metric SS with rubber O-ring.	RM3X8MM 2701	APM HEXSEAL
12	5	TE1-TE5	Terminal, Eyelet, Tin Plated Brass, Zierick PN 190	190	Zierick
13	2	TP1 TP4	Test Point, BLK, THRU-HOLE MOUNT	5011	Keystone
14	1	TP2	Test Point, WHT, THRU-HOLE MOUNT	5012	Keystone
15	1	TP3	Test Point, RED, THRU-HOLE MOUNT	5010	Keystone
16	3	WASHER1 WASHER3 WASHER4	Washer, Lk, M 3 Zinc, Metric	MLWZ 003	Building Fasteners
17	1	WASHER2	Washer Flat #6, SS	FWSS 006	Building Fasteners
18	2	WASHER5 WASHER6	Washer, Shoulder, #4, 0.125 Shoulder x 0.140 Dia, Polyphenylene Sulfide PPS	7721-3PPSG	Aavid Thermalloy
19	4	GREASE1 GREASE2 GREASE3 GREASE4	Thermal Silicone Compound, 2 oz Jar	120-2	Wakefield-Vette

Table 3 – Mechanical Bill of Materials.

7 Transformer Specification

7.1 Electrical Diagram

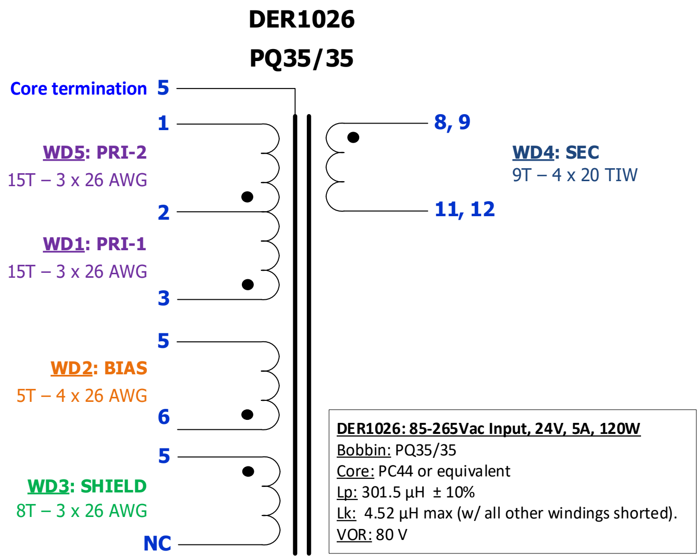


Figure 7 – Transformer Electrical Diagram.

7.2 Electrical Specifications

Parameter	Condition	Spec.
Nominal Primary Inductance	**Measured at 1 V_{PK-PK}, 100 kHz switching frequency, between pin 1 and pin 3 with all other windings open.**	**302 µH**
Tolerance	**Tolerance of Primary Inductance.**	**±10%**
Leakage Inductance	**Measured across primary winding with all other windings shorted.**	**< 4.52 µH**

Table 4 – Transformer Electrical Specifications.

7.3 Material List

Item	Description
[1]	Core: PQ35/35, PC44
[2]	Bobbin: Phenolic BQ35/35-1112CPFR (TDK) or CPV-PQ35/35-1S-12P-Z (Ferroxcube) or equivalent.
[3]	Magnet Wire: #26 AWG.
[4]	TIW Wire: #20 AWG.
[5]	Polyester Tape: 21 mm.
[6]	Polyester Tape: 16 mm.
[7]	Polyester Tape: 14.5 mm.
[8]	Varnish: Dolph BC 359; or Equivalent.
[9]	Bus Wire: #28 AWG, Alpha Wire, Tinned Copper; or Equivalent.

Table 5 – Transformer Material List.

7.4 Transformer Build Diagram

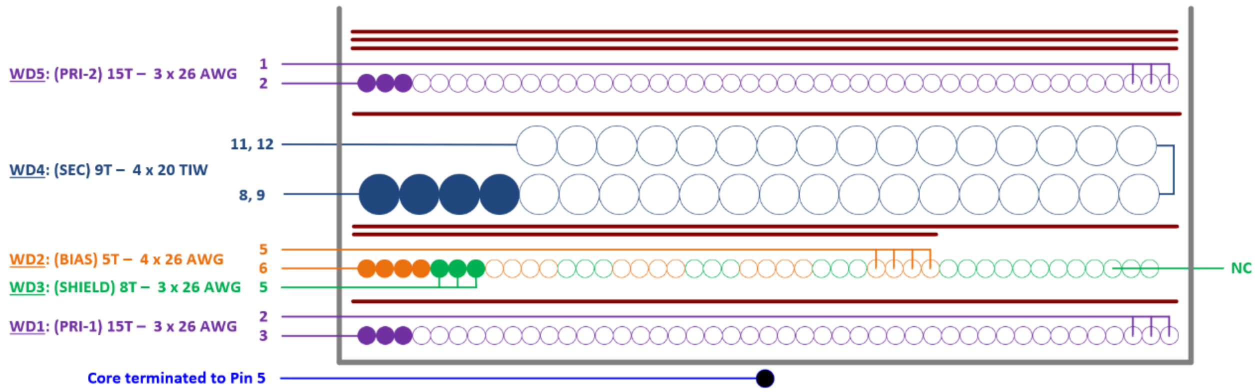


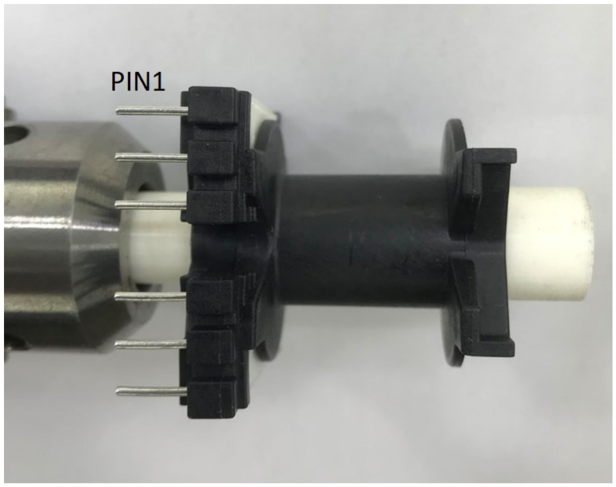
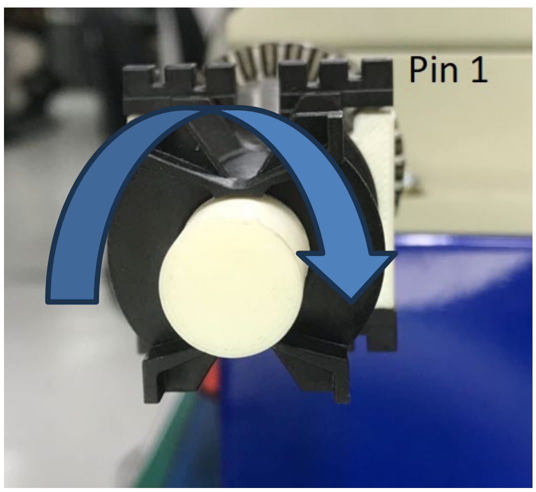
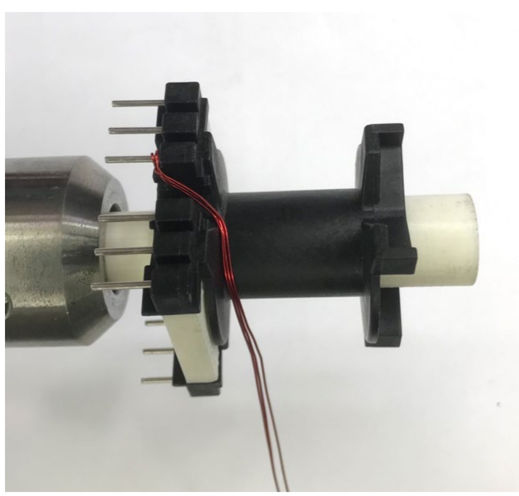
Figure 8 – Transformer Build Diagram.

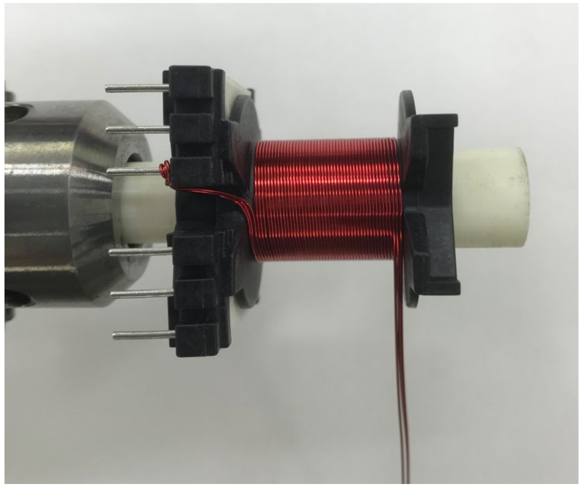
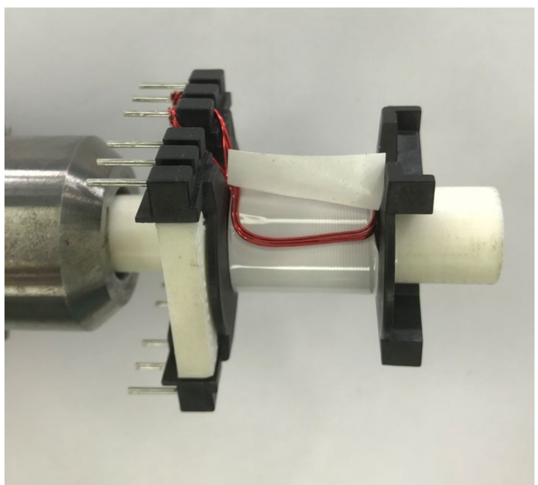
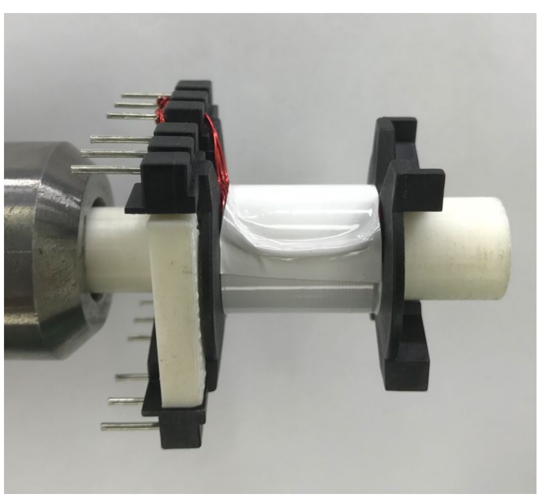
7.5 Transformer Instructions

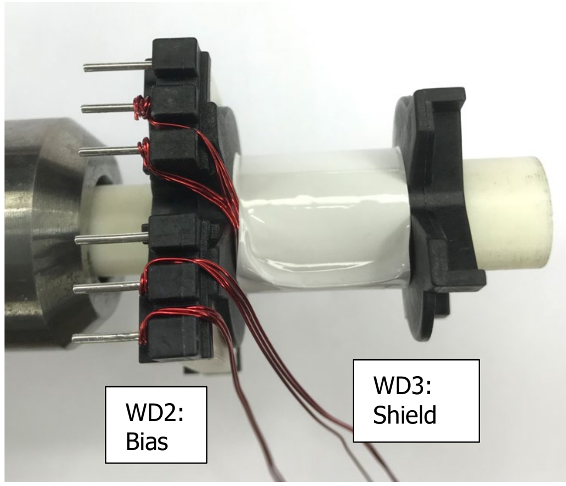
Winding Preparation	Position the bobbin Item [2] on the mandrel, pins facing the direction of the winding machine, pin 1 on the upper side and pin 6 on the lower side. Winding direction is clockwise.
WD1 1st Primary	Prepare 3 strands of wire Item [3]. Start at pin 3, wind 15 turns of wire Item [3] in 1 layer from left to right.
Insulation	Apply 1 layer of tape Item [5] for insulation and leave enough to cover the wire going back to the pin side. Finish WD1 at pin 2. Wrap the tape to cover WD1.
WD2 & WD3 Bias and Shield	Prepare 7 strands of wire Item [3]. Start WD2 at pin 6 with 4 strands. Mark the end of WD2 to avoid confusion. Start WD3 at pin 5 with 3 strands. Wind all the wires together for 5 turns from left to right. Apply 1 layer of tape Item [6] to hold wires in place and leave enough to cover the wire going back to the pin side. Exit WD2 to the left, and finish WD2 at pin 5. Wrap the tape to cover WD2. Wind the remaining 3 turns for WD3.
Insulation	Apply 1 layer of tape Item [5] for insulation and leave enough to cover the wire going back to the pin side. Bend the end of WD3 90 degrees, cut as shown and leave it floating. Wrap the tape to cover WD3 and WD2.
WD4 Secondary	Prepare 4 strands of wire Item [4]. Start 4 strands of wire Item [4] at pin 8 and 9, wind 4 wires 9 turns in parallel in 2 layers.
Insulation	Finish WD4 at pin 11 and 12. Use 1 layer of tape Item [5] for insulation.
WD5 2nd Primary	Prepare 3 strands of wire Item [3]. Start at pin 2, wind 15 turns of wire Item [3] in 1 layer from left to right.
Insulation	Apply 1 layer of tape Item [5] for insulation. Finish WD5 at pin 1. Wrap the tape to cover WD5 and apply 2 additional layers of tape Item [5].
Assembly	Grind the center leg of the upper half of Item [1] to get 301.5 µH measured between Pin 1 and Pin 3 with all other pins open. Use Item [9] and wrap it around Item [1], then solder to Pin 5. Wrap the body of transformer with 3 layers of tape Item [7].
Finish	Varnish using Item [8]. Check again Primary and Leakage Inductance if within specifications.

Table 6 – Transformer Assembly Instructions.

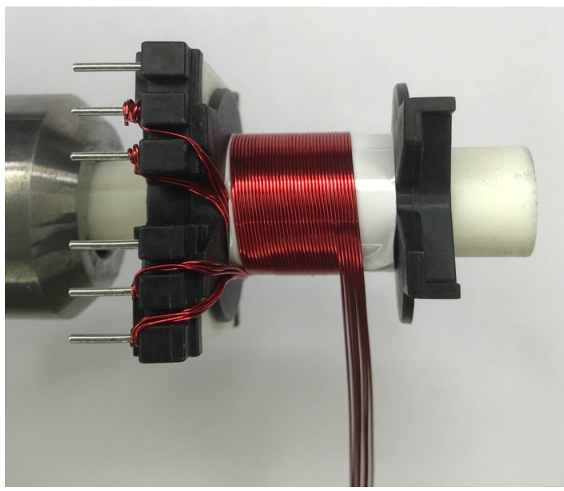
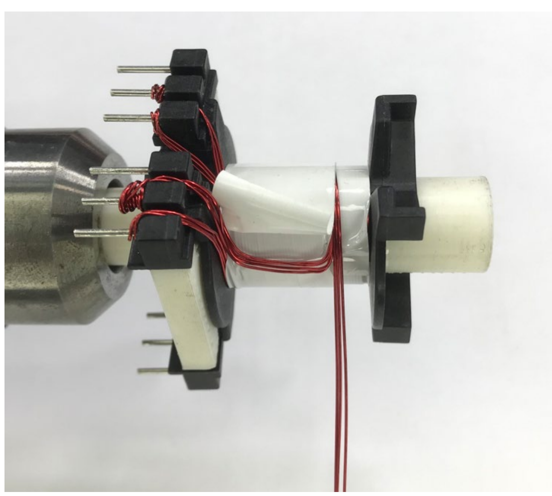
7.6 Transformer Winding Illustrations

Winding Preparation	 	Position the bobbin Item [2] on the mandrel, pins facing the direction of the winding machine, pin 1 on the upper side and pin 6 on the lower side. Winding direction is clockwise.
WD1 1st Primary		Prepare 3 strands of wire Item [3].

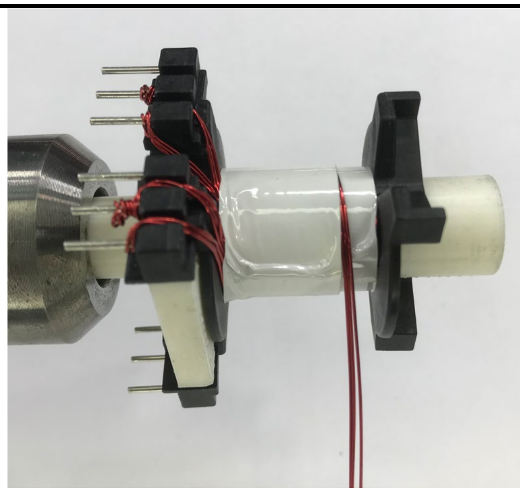
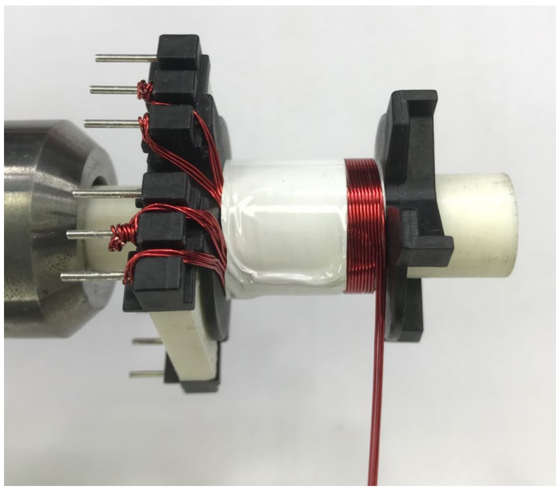
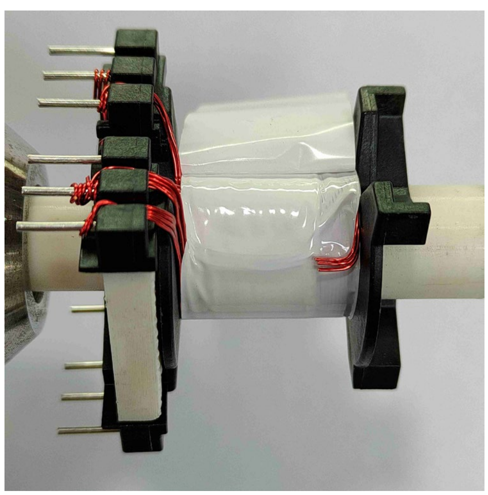
		Start at pin 3, wind 15 turns of wire Item [3] in 1 layer from left to right.
Insulation	 	Apply 1 layer of tape Item [5] for insulation and leave enough to cover the wire going back to the pin side. Finish WD1 at pin 2. Wrap the tape to cover WD1.

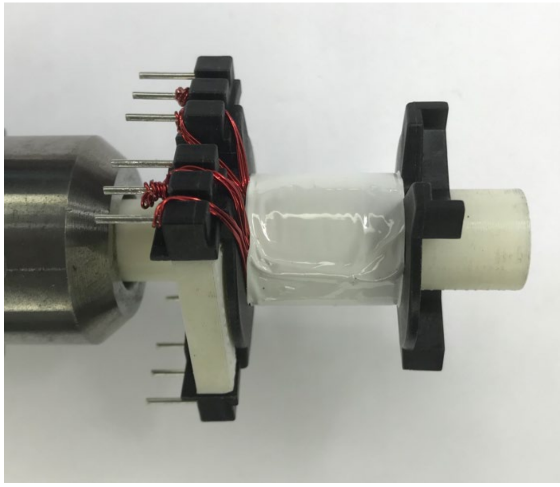
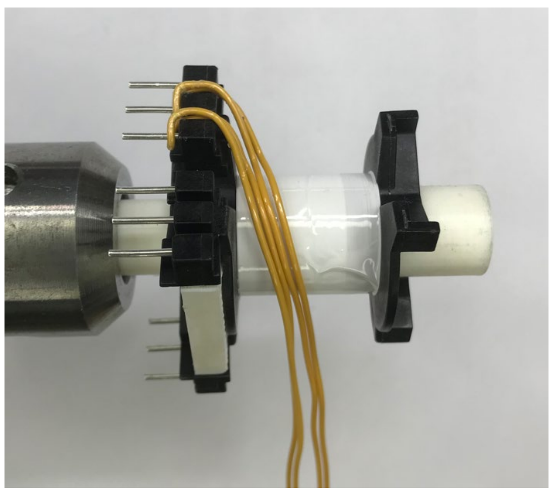
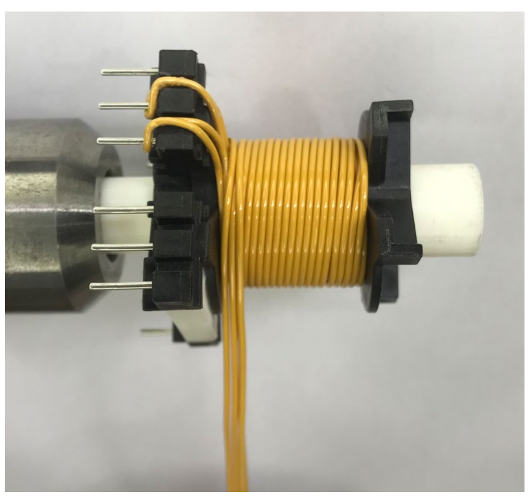
<table>
<tr><td rowspan="3">WD2 & WD3 Bias and Shield</td><td>
</td><td>Prepare 7 strands of wire Item [3].

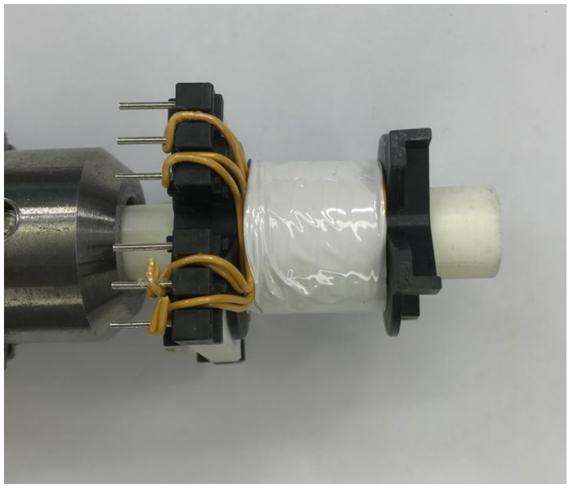
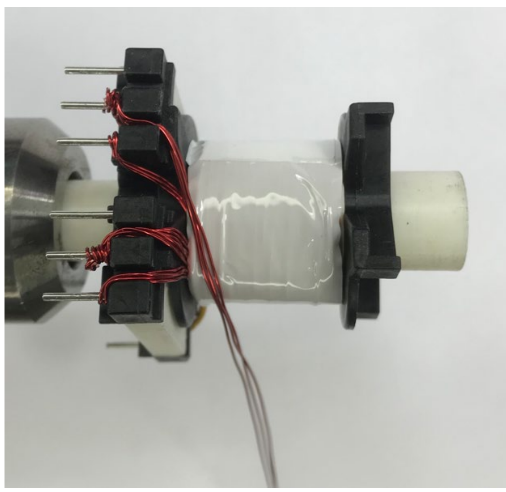
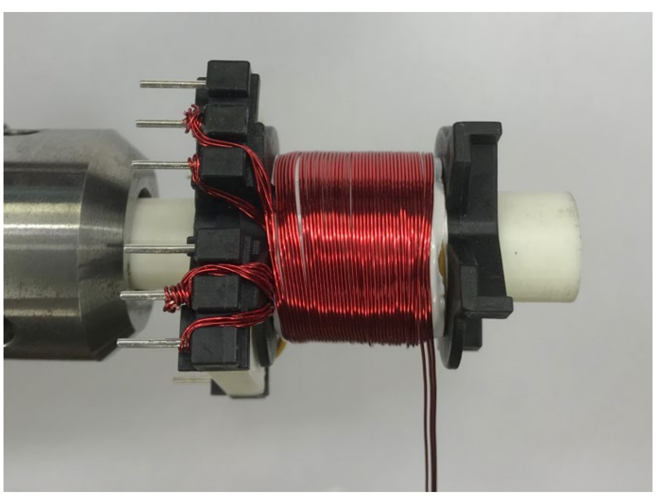
Start WD2 at pin 6 with 4 strands. Mark the end of WD2 to avoid confusion.

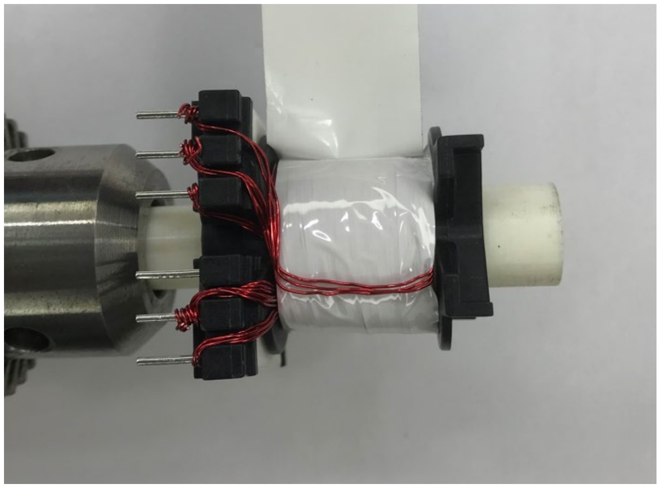
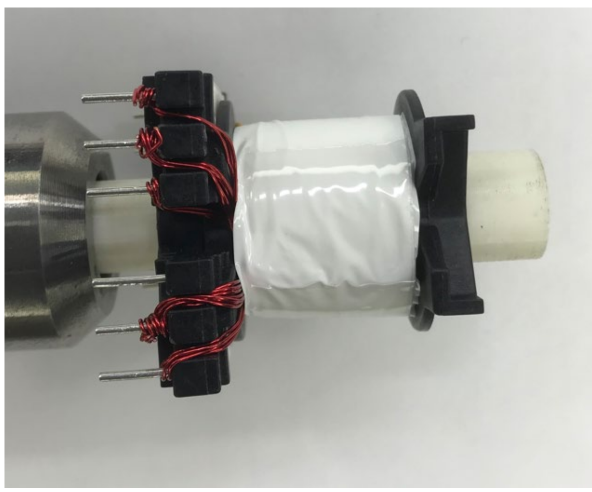
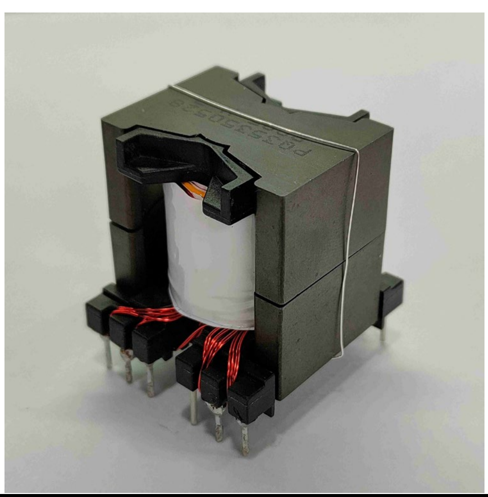
Start WD3 at pin 5 with 3 strands.</td></tr>
<tr><td></td><td>Wind all the wires together for 5 turns from left to right.</td></tr>
<tr><td></td><td>Apply 1 layer of tape Item [6] to hold wires in place and leave enough to cover the wire going back to the pin side.

Exit WD2 to the left, and finish WD2 at pin 5.</td></tr>
</table>

		Wrap the tape to cover WD2.
		Wind the remaining 3 turns for WD3.
Insulation		Apply 1 layer of tape Item [5] for insulation and leave enough to cover the wire going back to the pin side. Bend the end of WD3 90 degrees, cut as shown and leave it floating.

		Wrap the tape to cover WD3 and WD2.
WD4 Secondary	 	Prepare 4 strands of wire Item [4]. Start 4 strands of wire Item [4] at pin 8 and 9, wind 4 wires 9 turns in parallel in 2 layers.

Insulation		Finish WD4 at pin 11 and 12. Use 1 layer of tape Item [5] for insulation.
WD5 **2nd Primary**	 	Prepare 3 strands of wire Item [3]. Start at pin 2, wind 15 turns of wire Item [3] in 1 layer from left to right.

Insulation	 	Apply 1 layer of tape Item [5] for insulation. Finish WD5 at pin 1. Wrap the tape to cover WD5 and apply 2 additional layers of tape Item [5].
Assembly		Grind the center leg of the upper half of Item [1] to get 302 µH measured between Pin 1 and Pin 3 with all other pins open. Use Item [9] and wrap it around Item [1], then solder to Pin 5.

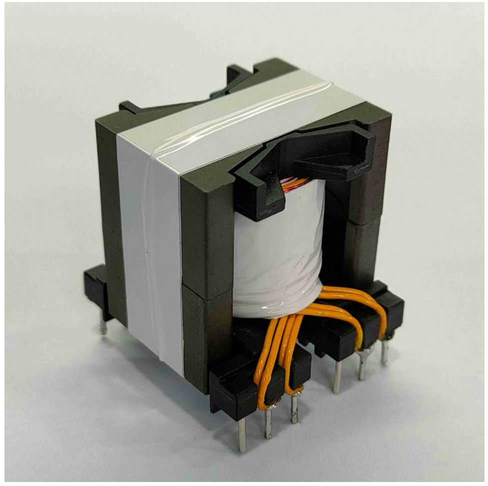
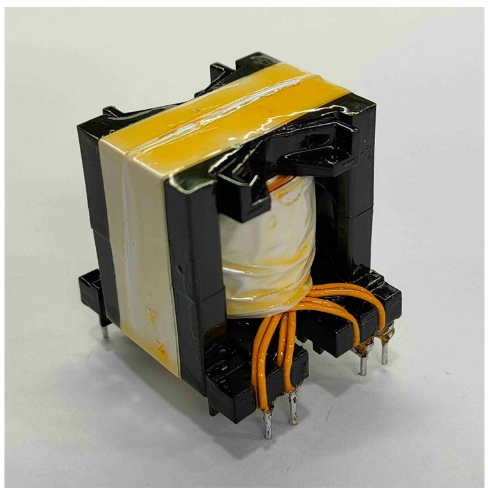
		Wrap the body of transformer with 3 layers of tape Item [7].
Finish		Varnish using Item [8]. Check Primary and leakage inductance.

Table 7 – Transformer Winding Illustrations.

8 Common Mode Choke L1 Specification

8.1 Electrical Diagram

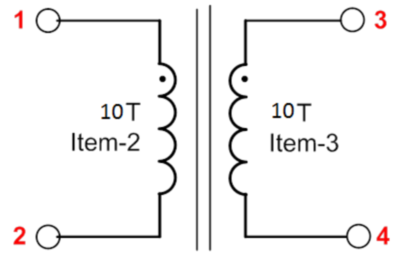


Figure 9 – Choke Electrical Diagram.

8.2 Electrical Specifications

Parameter	Condition	Spec.
Winding Inductance	Pin 1 – Pin 2 (or Pin 3 – Pin 4), all other windings open, measured at 100 kHz, $1V_{RMS}$.	**250 μH ± 20%**

Table 8 – Common Mode Choke (L1) Electrical Specifications.

8.3 Material List

Item	Description
[1]	Toroid Core: 32-00376-00 (Blue), Mfg Part Number: B64290L0038X046
[2]	Triple Insulated Wire: #24 AWG, Triple Coated.
[3]	Magnet Wire: #24 AWG, Double Coated.

Table 9 – Common Mode Choke (L1) Material List.

8.4 Common Mode Choke Construction

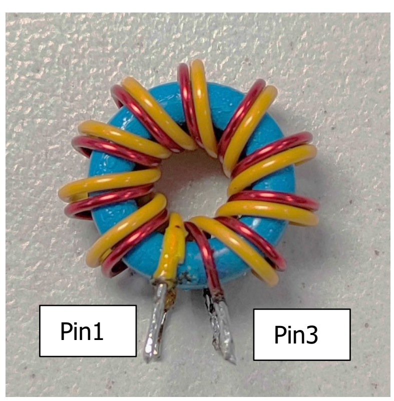


Figure 10 – Finished Choke.

Winding & Termination	Using 1 Strand each of Items [2] and [3], wind 10 bifilar turns on core [1]. Trim leads to within 5 mm of core, tin last 4 mm of leads.

Table 10 – Common Mode Choke (L1) Construction.

9 Design Spreadsheet

1	ACDC_TOPSwitchJX_062521; Rev.2.1; Copyright Power Integrations 2021	INPUT	INFO	OUTPUT	UNITS	TOPSwitch-JX Flyback Design Spreadsheet
2	**Application Variables**					
3	VAC_RANGE			Universal		Input voltage range
4	VAC_MIN	85		85	V	Minimum input RMS voltage
5	VAC_MAX	265		265	V	Maximum input RMS voltage
6	FL			50	Hz	Line frequency
7	VOUT	24.00		24.00	V	Output voltage
8	IOUT			5.00	A	Output current
9	POUT	120.0		120.0	W	Output power
10	POUT_PEAK			120.0	W	Peak output power
11	EFFICIENCY_ACDC			0.86		AC-DC efficiency
12	FACTOR_Z			0.50		Z-factor
15	**Input Side Components**					
16	**Input Capacitor**					
17	CIN	540.0		540.0	μF	Input capacitance
18	VF_BRIDGEDIODE	1.00		1.00	V	Input bridge diode forward voltage
19	VAC_MIN_VLY			100.4	V	Valley of the rectified minimum input AC voltage when delivering POUT. During peak power delivery, the valley of the rectified minimum input AC voltage is 100.4 V
21	**V-Pin**					
22	UVOV TYPE	UVOV		UVOV		Standard under-voltage and over-voltage. Refer to page.13 of the TopSwitch-JX spreadsheet
23	UNDERVOLTAGE			62.5 - 78.6	V	Actual RMS under-voltage range
24	OVERVOLTAGE			301.7 - 337	V	Actual RMS over-voltage range
25	RLS1			4.02	MΩ	1% resistor connected from the rectified line voltage to the V-pin
26	RLS2			NA	kΩ	Not required
28	**X-Pin**					
29	KI	1.1		0.9 - 1.1		Typical current limit reduction factor target
30	ILIMIT_KI_RANGE			4.327 - 6.085	A	Minimum current limit based on KI
31	RIL			6.98	kΩ	Current limit programming resistor (1%) connected to the X-pin. Refer to page.31 of the TOPSwitch-JX datasheet
32	RPL			17.800	MΩ	Power limiting resistor (1%) connected from the rectified input voltage to the X-pin. Refer to page.14 of the TOPSwitch-JX datasheet
34	**Bias Winding**					
35	VBIAS			12.00	V	Target rectified bias winding voltage at low-load
36	VF_BIAS			0.70	V	Bias winding rectifier diode on-time voltage drop
37	VBIAS_OVP			18.00	V	Target rectified bias winding voltage to trigger output over-voltage
38	VZ_OVP			16.00	V	Zener voltage (1%) required for bias winding sensed output over-voltage. Refer to fig.15 in the TOPSwitch-JX datasheet
39	R_OVP			3.74	kΩ	Resistor (1%) required for bias winding sensed output over-voltage. Refer to fig.15 in the TOPSwitch-JX datasheet
42	**TOPSwitch-JX**					
43	PACKAGE	eSIP-7C		eSIP-7C		TOPSwitch Package

44	HEATSINK	Metal		Metal		TOPSwitch Heatsink
45	ENCLOSURE	Open Frame		Open Frame		Power supply enclosure
46	MODE_FREQUENCY	H		H		Frequency operation mode (F=132 kHz, H=66 kHz)
47	DEVICE	TOP271		TOP271EG		TOPSwitch device
48	PMAX			177	W	TOPSwitch device maximum power capability
49	ILIMIT_MIN			4.808	A	Minimum TOPSwitch current limit
50	ILIMIT_MAX			5.532	A	Maximum TOPSwitch current limit
51	VDSON			2.384	V	TOPSwitch on-time drain to source voltage
52	VDSOFF			502.8	V	TOPSwitch off-time drain to source voltage
55	**Electrical Parameters (Worst Case)**					
56	KP	0.550		0.474		Measure of continuous/discontinuous mode of operation. The actual KP calculated based on tolerance may be lower than the value entered
57	DUTY			0.449		Primary switch duty cycle
58	IAVG_PRI			1.324	A	Primary switch average current
59	IPK_PRI			4.313	A	Primary switch peak current
60	IRMS_PRI			2.045	A	Primary Switch RMS current
61	IRIPPLE_PRI			4.013	A	Primary Switch ripple current
62	IPK_SEC			14.375	A	Secondary rectifier peak current
63	IRMS_SEC			7.544	A	Secondary winding RMS current
66	**Transformer**					
67	LP_TYP			301.5	μH	Typical primary magnetizing inductance
68	LP_RANGE			271.4 - 331.7	μH	Range of primary magnetizing inductance to ensure power delivery
69	LP_TOL	10.0		10.0	%	Magnetizing inductance tolerance
70	VOR	80.0		80.0	V	Secondary winding voltage reflected to the primary winding
72	**Core/Bobbin Selection**					
73	CORE	PQ35/35		PQ35/35		Transformer core selection - refer to the Transformer Parameters tab to verify fit
74	CORE CODE			PQ35/35-3C95		Core code
75	AE			190.0	mm^2	Core cross sectional area
76	LE			86.1	mm	Core magnetic path length
77	AL			6000	nH/turns^2	Ungapped core effective inductance
78	VE			16300	mm^3	Core volume
79	BOBBIN			CPV-PQ35/35-1S-12P-Z		Bobbin
80	AW			152.00	mm^2	Window area of the bobbin
81	BW			20.80	mm	Bobbin width
82	MARGIN			0.00	mm	Safety margin width (Half the primary to secondary creepage distance)
84	**Winding Parameters**					
85	NP			30		Primary winding number of turns
86	NB			5		Bias winding number of turns
87	NS			9		Secondary winding number of turns
88	BPEAK			0.3541	T	Transformer core's peak flux density
89	BMAX			0.2365	T	Transformer core's operating flux density
90	BAC			0.0650	T	Transformer core AC flux density (0.5 x Peak-Peak)
91	ALG			335.0	nH/turns^2	Gapped core effective inductance (Typical)
92	LG			0.67	mm	Core gap length
95	**Output Stage**					
96	**Output 1**					

97	VOUT1			24.00		Output voltage
98	IOUT1			5.00		Output current
99	POUT1			120.00		Output power
100	IRMS_SEC1			7.544		Secondary winding RMS current
101	IRIPPLE_COUT1			5.649		Output capacitor ripple current
102	NS1			9		Secondary winding number of turns
103	VDSOFF_DIODE1			135.8		Output rectifier off-time voltage stress (not incl. the parasitic ring)
104	PN_DIODE1			SBR10U200		Suggested output rectifier Schottky diode
105	VRRM_DIODE1			200		Output rectifier rated reverse repetitive voltage
106	VF_DIODE1			0.88		Output rectifier rated on-time voltage drop
107	IF_DIODE1			10.0		Output rectifier rated average forward current
109	**Output 2**					
110	VOUT2					Output voltage
111	IOUT2					Output current
112	POUT2					Output power
113	IRMS_SEC2					Secondary winding RMS current
114	IRIPPLE_COUT2					Output capacitor ripple current
115	NS2					Secondary winding number of turns
116	VDSOFF_DIODE2					Output rectifier off-time voltage stress (not incl. the parasitic ring)
117	PN_DIODE2					Suggested output rectifier Schottky diode
118	VRRM_DIODE2					Output rectifier rated reverse repetitive voltage
119	VF_DIODE2					Output rectifier rated on-time voltage drop
120	IF_DIODE2					Output rectifier rated average forward current
121						
122	**Output 3**					
123	VOUT3					Output voltage
124	IOUT3					Output current
125	POUT3					Output power
126	IRMS_SEC3					Secondary winding RMS current
127	IRIPPLE_COUT3					Output capacitor ripple current
128	NS3					Secondary winding number of turns
129	VDSOFF_DIODE3					Output rectifier off-time voltage stress (not incl. the parasitic ring)
130	PN_DIODE3					Suggested output rectifier Schottky diode
131	VRRM_DIODE3					Output rectifier rated reverse repetitive voltage
132	VF_DIODE3					Output rectifier rated on-time voltage drop
133	IF_DIODE3					Output rectifier rated average forward current
134						
135	POUT_TOTAL			120		Total output power
136	NEGATIVE OUTPUT	N/A		N/A		Select the negative output voltage index (E.g. Select 3 if you want the 3rd output to be negative)
137	VDSOFF_DIODE3					Output rectifier off-time voltage stress (not incl. the parasitic ring)

Table 11 – DER-1026 PIXls Spreadsheet.

Note: Actual RPL used is 16.2 MΩ, close to computed RPL, due to limited resistor value availability.

10 Heat Sinks

10.1 TOPSwitch-JX Heat Sink

10.1.1 TOPSwitch-JX Heat Sink

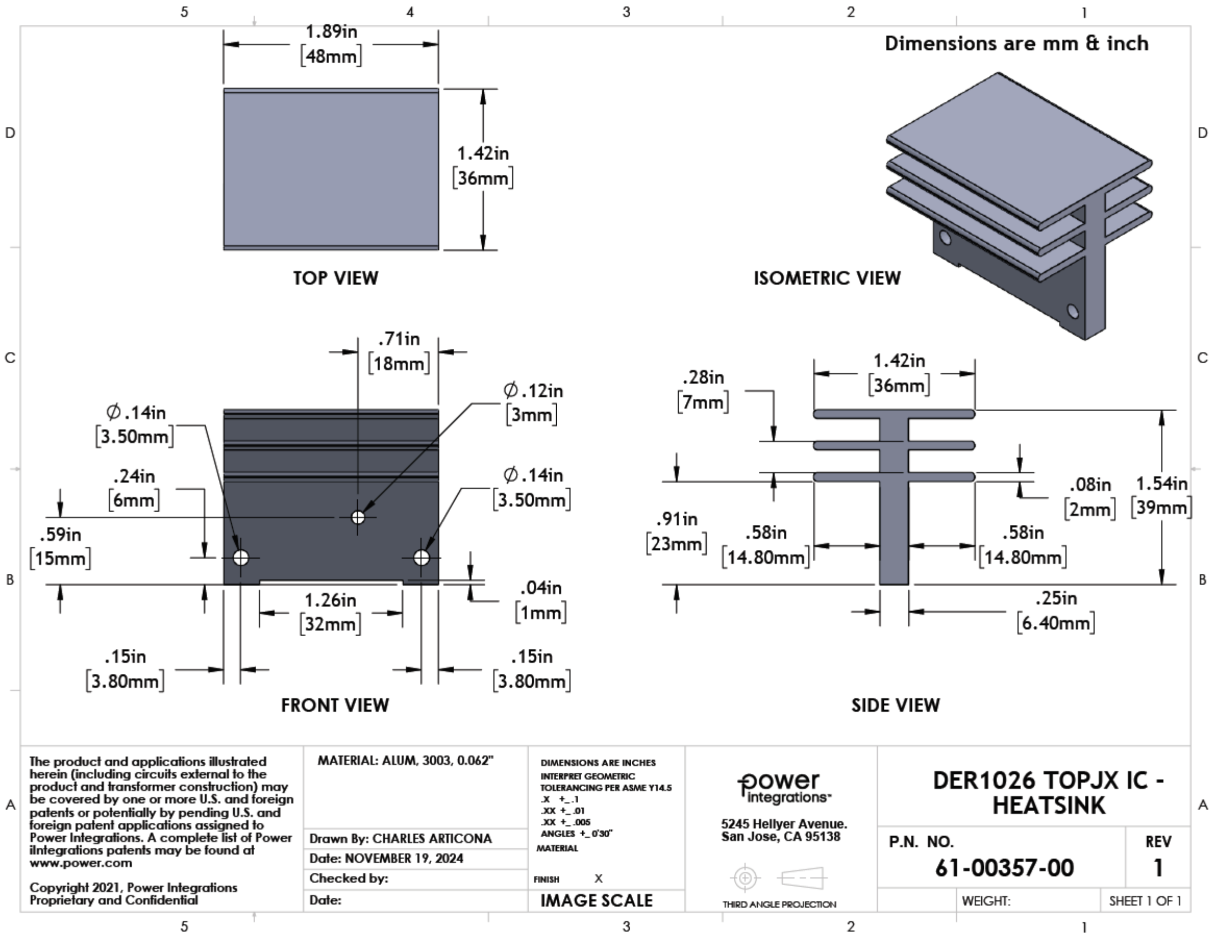
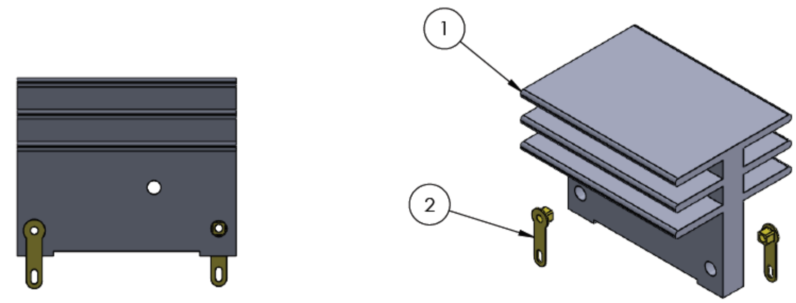


Figure 11 – DER-1026 TOPSwitch-JX Heat Sink.

10.1.2 Finished TOPSwitch-JX Heat Sink with Hardware

Dimensions are mm & inch



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00357-00	SHTM, Heat Sink, TOP-JX IC, DER-1026	1
2	60-00016-00	Terminal Eyelet, Tin Plated Brass, Zierick, PN 190	2

The product and applications illustrated herein (including circuits external to the product and transformer construction) may be covered by one or more U.S. and foreign patents or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power iIntegrations patents may be found at www.power.com

Copyright 2024, Power Integrations Proprietary and Confidential

Material:

Drawn By: Charles Articona
Date: November 20, 2024
Checked by:
Date:

DIMENSIONS ARE INCHES
INTERPRET GEOMETRIC TOLERANCING PER ASME Y14.5
.X +_.1
.XX +_.01
.XX +_.005
ANGLES +_0'30"
MATERIAL
FINISH X
IMAGE SCALE

power integrations
5245 Hellyer Avenue.
San Jose, CA 95138

THIRD ANGLE PROJECTION

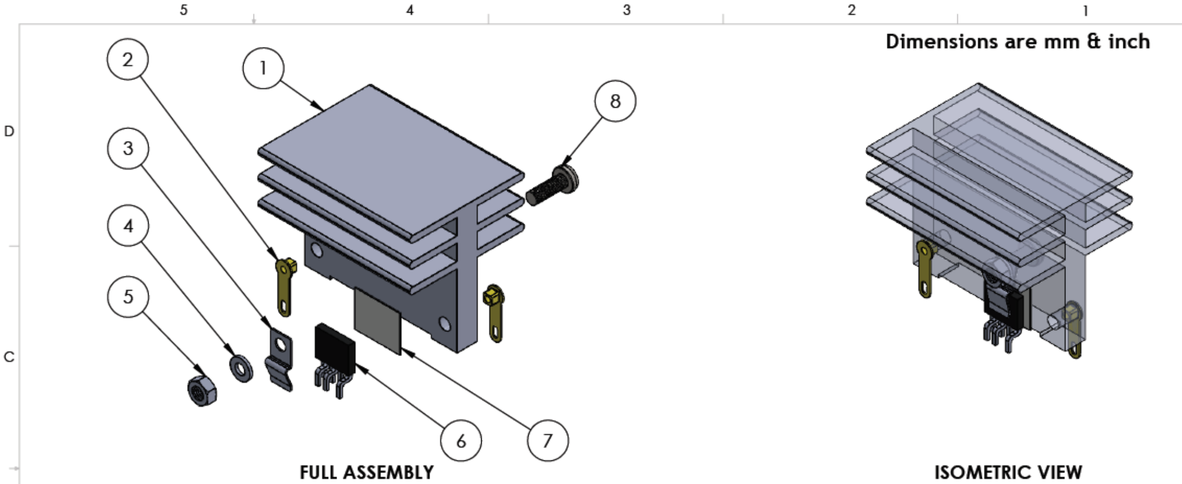
DER 1026 IC HEATSINK FAB

P.N. NO. 61-00357-01 REV 1

WEIGHT: SHEET 1 OF 1

Figure 12 – DER-1026 Finished TOPSwitch-JX Heat Sink with Hardware.

10.1.3 TOPSwitch-JX Heat Sink Assembly



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00357-00	SHTM, Heat Sink, TOP-JX IC, DER-1026	1
2	60-00016-00	Terminal Eyelet, Tin Plated Brass, Zierick, PN 190	2
3	60-00037-00	Heatsink Hardware, Edge Clip, 12.40 mm x 6.50 mm	1
4	75-00059-00	Washer, Lk, M 3 Zinc, Metric	1
5	75-00055-00	Nut Hex, Metric M3 SS	1
6	10-00378-00	TOPSwitch-JX, TOP271EG, eSIP-7F	1
7	60-00099-00	Thermal Silicone Compound, 2 OZ Jar	1
8	75-00214-00	SCR, Phillips, M3 X 12 mm, Panhead Mach	1

The product and applications illustrated herein (including circuits external to the product and transformer construction) may be covered by one or more U.S. and foreign patents or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power iIntegrations patents may be found at www.power.com

Material:
Drawn By: Charles Articona
Date: November 19, 2024
Checked by:
Date:

DIMENSIONS ARE INCHES
INTERPRET GEOMETRIC TOLERANCING PER ASME Y14.5
.X +_.1
.XX +_.01
.XX +_.005
ANGLES +_0°30'
MATERIAL
FINISH X
IMAGE SCALE

power integrations
5245 Hellyer Avenue.
San Jose, CA 95138
THIRD ANGLE PROJECTION

DER 1026 IC HEATSINK ASSEMBLY
P.N. NO. 61-00357-02
REV 1
WEIGHT:
SHEET 1 OF 1

Figure 13 – DER-1026 TOPSwitch-JX Heat Sink Assembly.

10.2 Bridge Rectifier Heat Sink

10.2.1 Bridge Rectifier Heat Sink

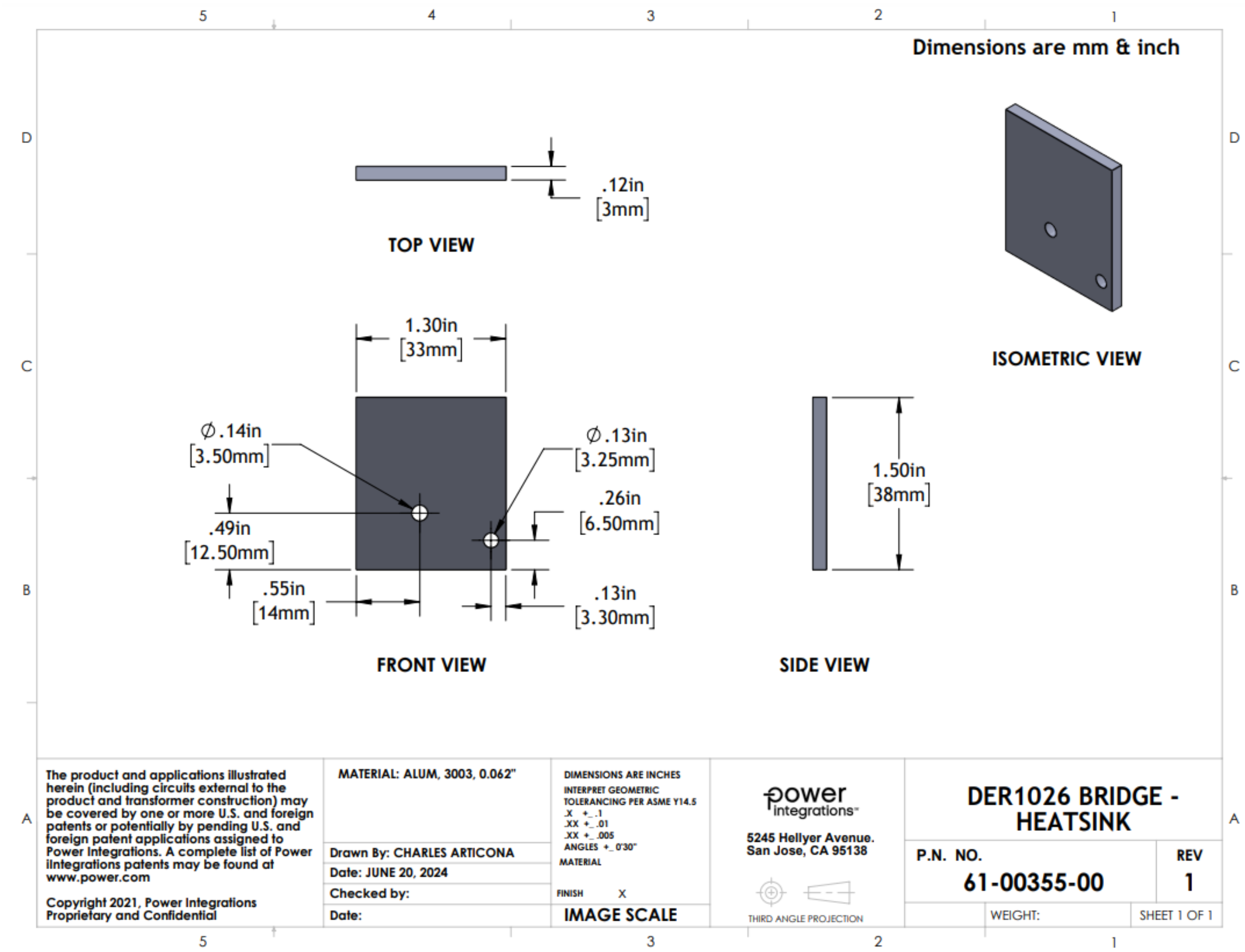
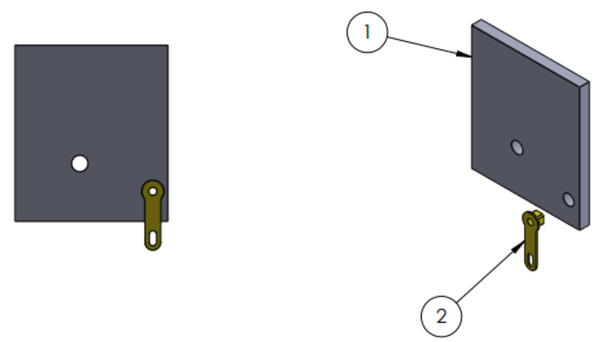


Figure 14 – DER-1026 Bridge Rectifier Heat Sink.

10.2.2 Finished Bridge Rectifier Heat Sink with Hardware

Dimensions are mm & inch



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00355-00	SHTM, Heat Sink, Diode Bridge, DER-1026	1
2	60-00016-00	Terminal Eyelet, Tin Plated Brass, Zierick, PN 190	1

The product and applications illustrated herein (including circuits external to the product and transformer construction) may be covered by one or more U.S. and foreign patents or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power iIntegrations patents may be found at www.power.com

Material:

Drawn By: Charles Articona
Date: July 26, 2024
Checked by:
Date:

DIMENSIONS ARE INCHES
INTERPRET GEOMETRIC TOLERANCING PER ASME Y14.5
.X +_ .1
.XX +_ .01
.XX +_ .005
ANGLES +_ 0'30"
MATERIAL
FINISH X
IMAGE SCALE

power integrations
5245 Hellyer Avenue.
San Jose, CA 95138
THIRD ANGLE PROJECTION

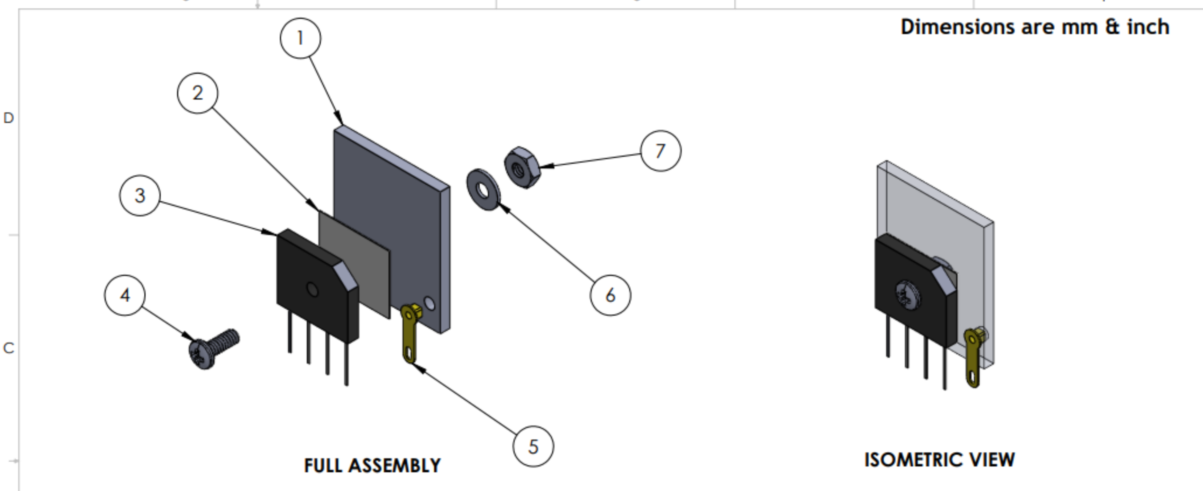
DER1026 BRIDGE HEATSINK FAB

P.N. NO. 61-00355-01 REV 1

WEIGHT: SHEET 1 OF 1

Figure 15 – DER-1026 Bridge Rectifier Heat Sink with Hardware.

10.2.3 Bridge Rectifier Heat Sink Assembly



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00355-00	SHTM, Heat Sink, Diode Bridge, DER-1026	1
2	60-00099-00	Thermal Silicone Compound, 2 OZ Jar	1
3	15-00347-00	800V, 8A, Bridge Rectifier, GBU Case	1
4	75-00009-00	SCREW MACHINE PHIL 6-32 X 3/8 SS	1
5	60-00016-00	Terminal Eyelet, Tin Plated Brass, Zierick, PN 190	1
6	75-00033-00	Washer Flat #6, SS	1
7	75-00025-00	Nut, Hex 6-32, SS	1

The product and applications illustrated herein (including circuits external to the product and transformer construction) may be covered by one or more U.S. and foreign patents or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations patents may be found at www.power.com

Material:
Drawn By: Charles Articona
Date: July 26, 2024
Checked by:
Date:

DIMENSIONS ARE INCHES
INTERPRET GEOMETRIC TOLERANCING PER ASME Y14.5
.X +_ .1
.XX +_ .01
.XX +_ .005
ANGLES +_ 0'30"
MATERIAL
FINISH X
IMAGE SCALE

power integrations
5245 Hellyer Avenue.
San Jose, CA 95138
THIRD ANGLE PROJECTION

DER1026 BRIDGE HEATSINK ASSEMBLY
P.N. NO. 61-00355-02
REV 1
WEIGHT:
SHEET 1 OF 1

Figure 16 – DER-1026 Bridge Rectifier Heat Sink Assembly.

10.3 Secondary Diode Heat Sink

10.3.1 Secondary Diode Heat Sink

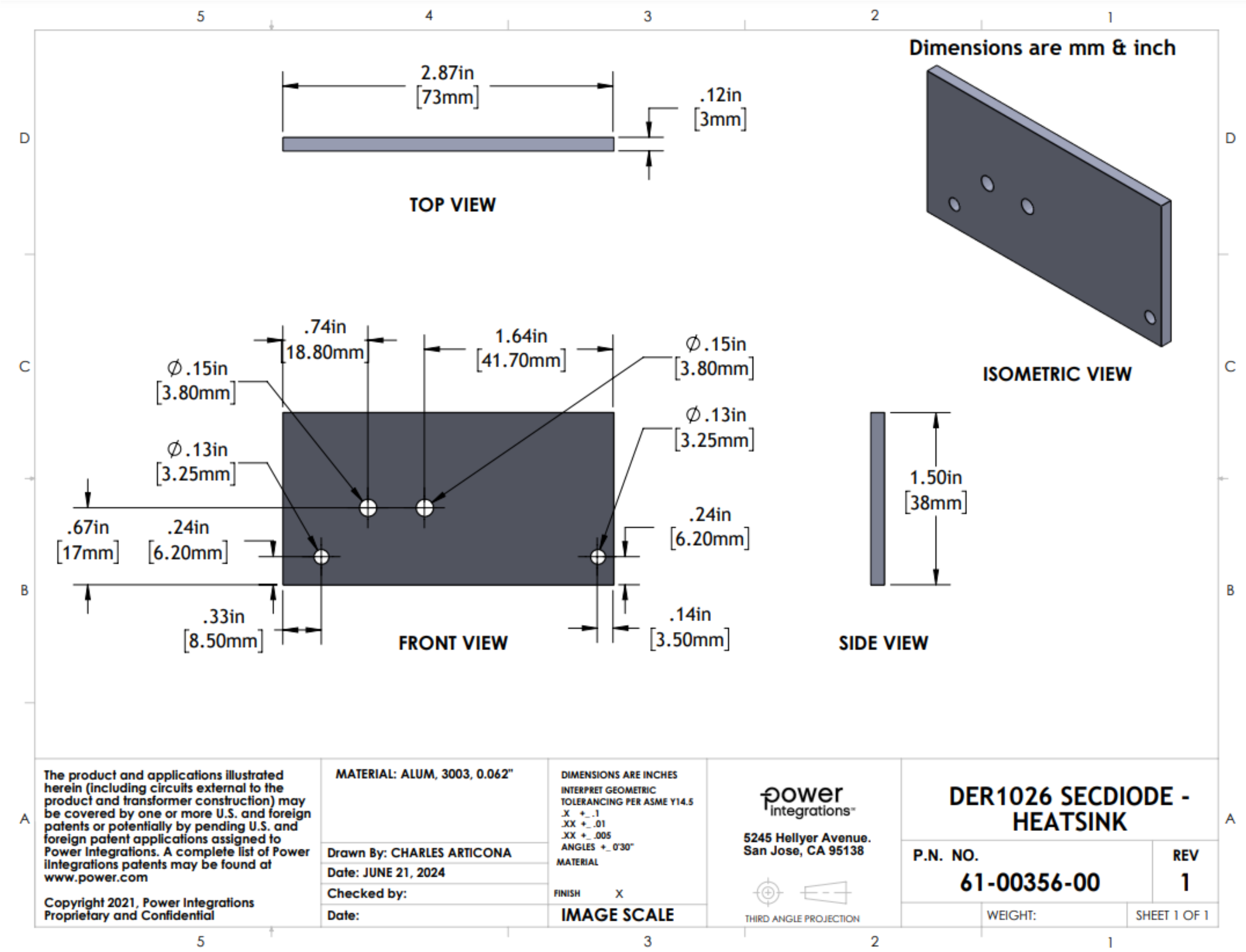


Figure 17 – DER-1026 Secondary Diode Heat Sink.

10.3.2 Finished Secondary Diode Heat Sink with Hardware

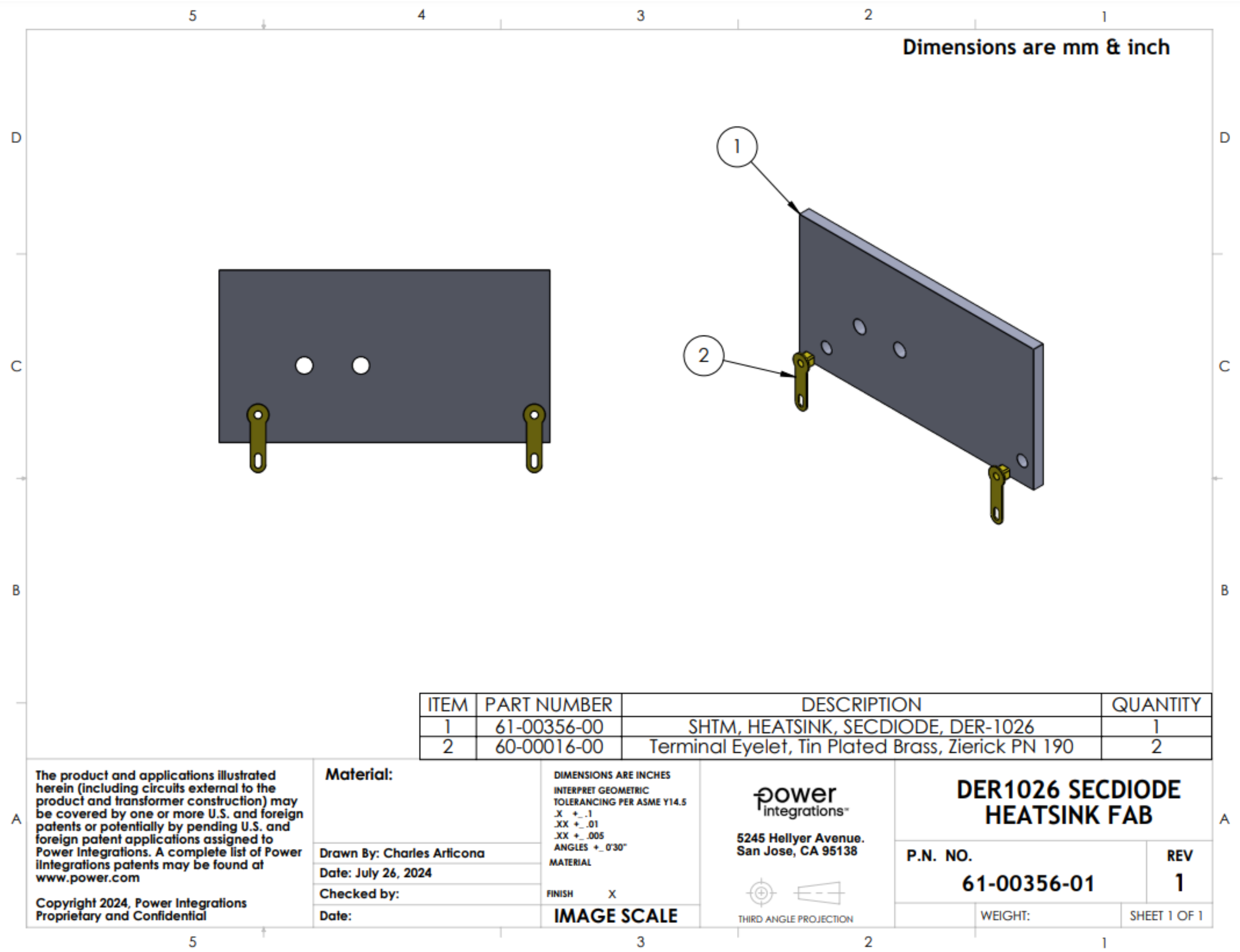
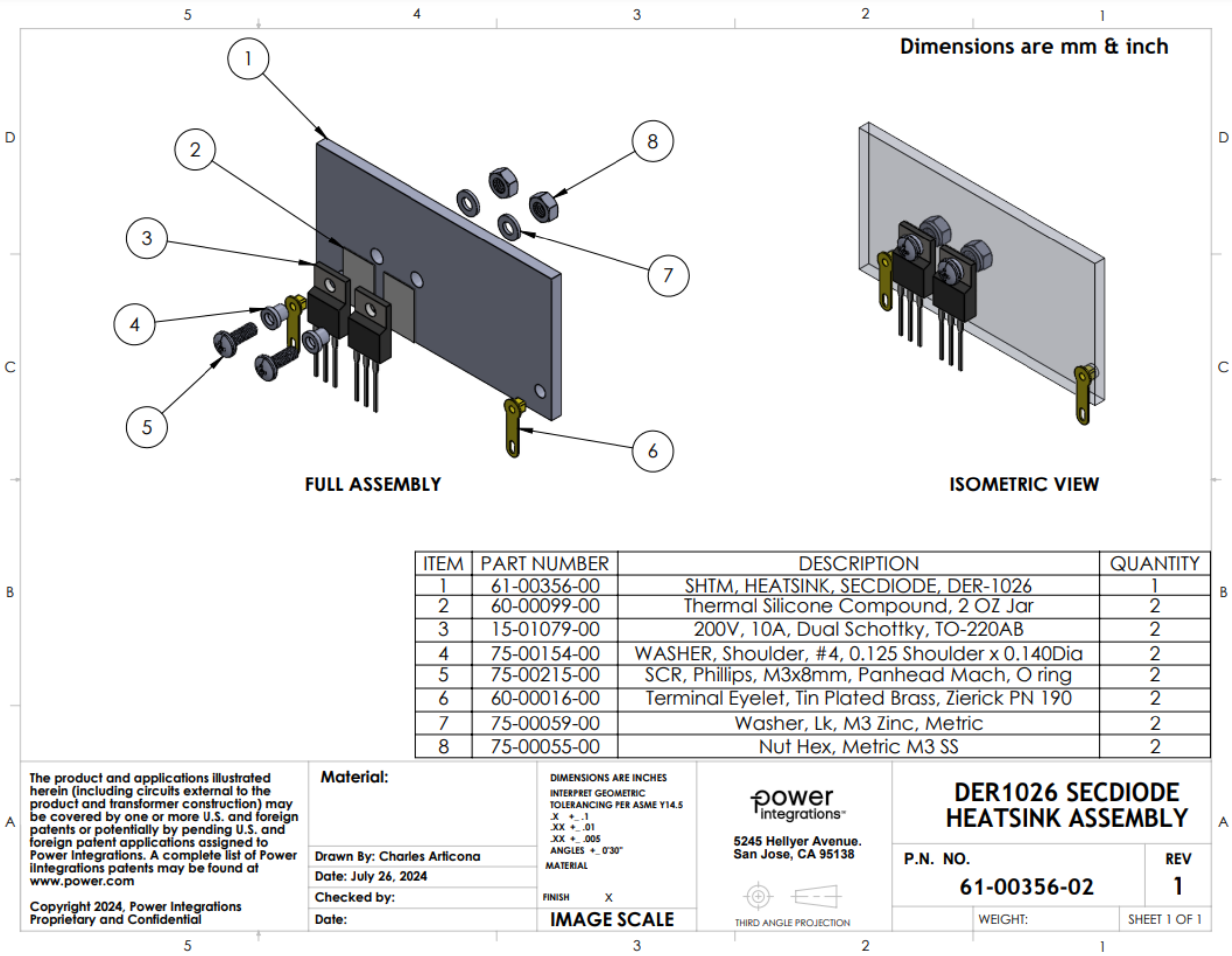


Figure 18 – DER-1026 Secondary Diode Heat Sink with Hardware.

10.3.3 Secondary Diode Heat Sink Assembly



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00356-00	SHTM, HEATSINK, SECDIODE, DER-1026	1
2	60-00099-00	Thermal Silicone Compound, 2 OZ Jar	2
3	15-01079-00	200V, 10A, Dual Schottky, TO-220AB	2
4	75-00154-00	WASHER, Shoulder, #4, 0.125 Shoulder x 0.140Dia	2
5	75-00215-00	SCR, Phillips, M3x8mm, Panhead Mach, O ring	2
6	60-00016-00	Terminal Eyelet, Tin Plated Brass, Zierick PN 190	2
7	75-00059-00	Washer, Lk, M3 Zinc, Metric	2
8	75-00055-00	Nut Hex, Metric M3 SS	2

Figure 19 – DER-1026 Secondary Diode Heat Sink Assembly.

11 Performance Data

11.1 Full Load Efficiency vs. Line

Test Condition: Soak for 15 minutes for each line.

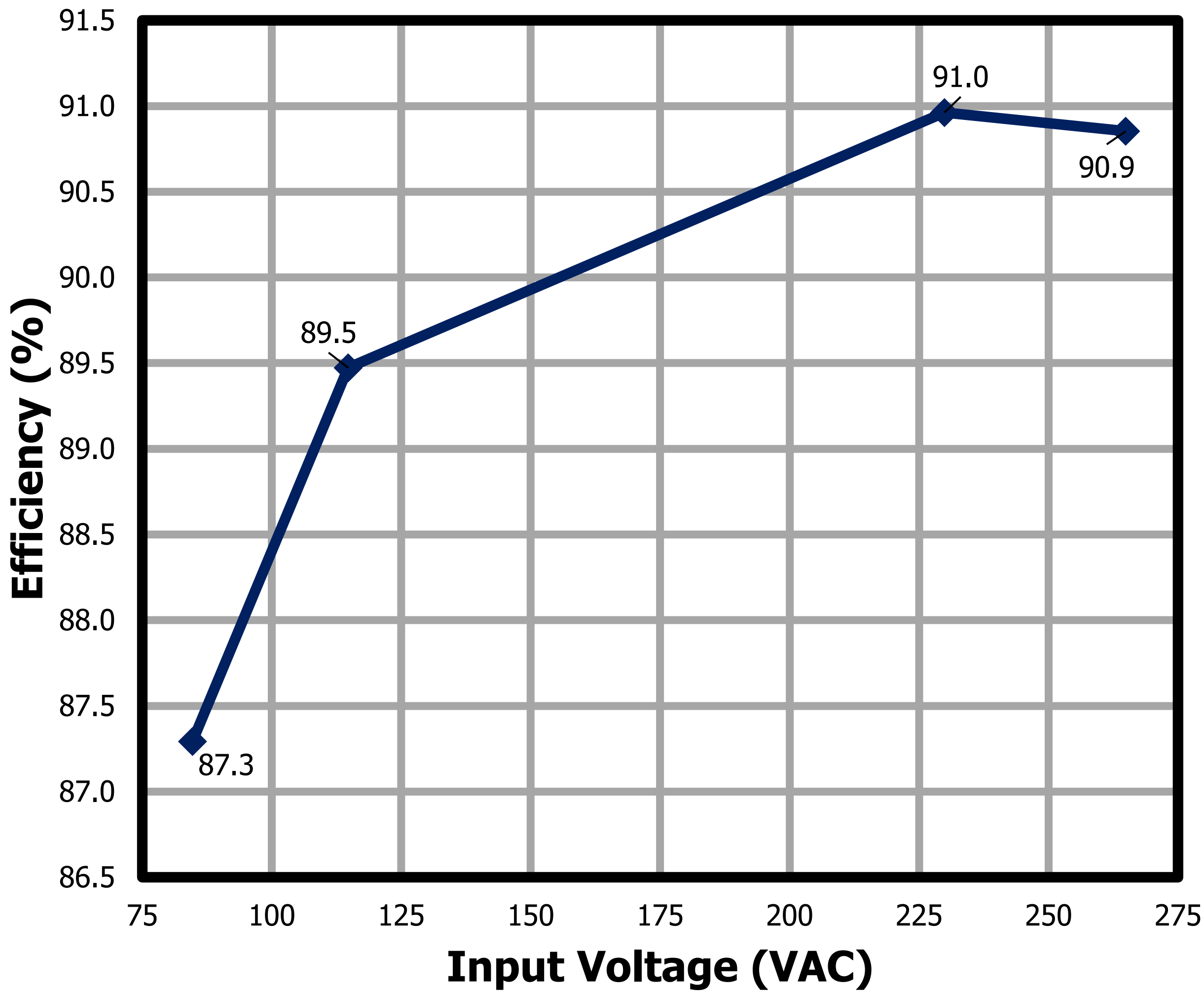


Figure 20 – Efficiency vs. Input Voltage.

11.2 Efficiency vs. Load

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

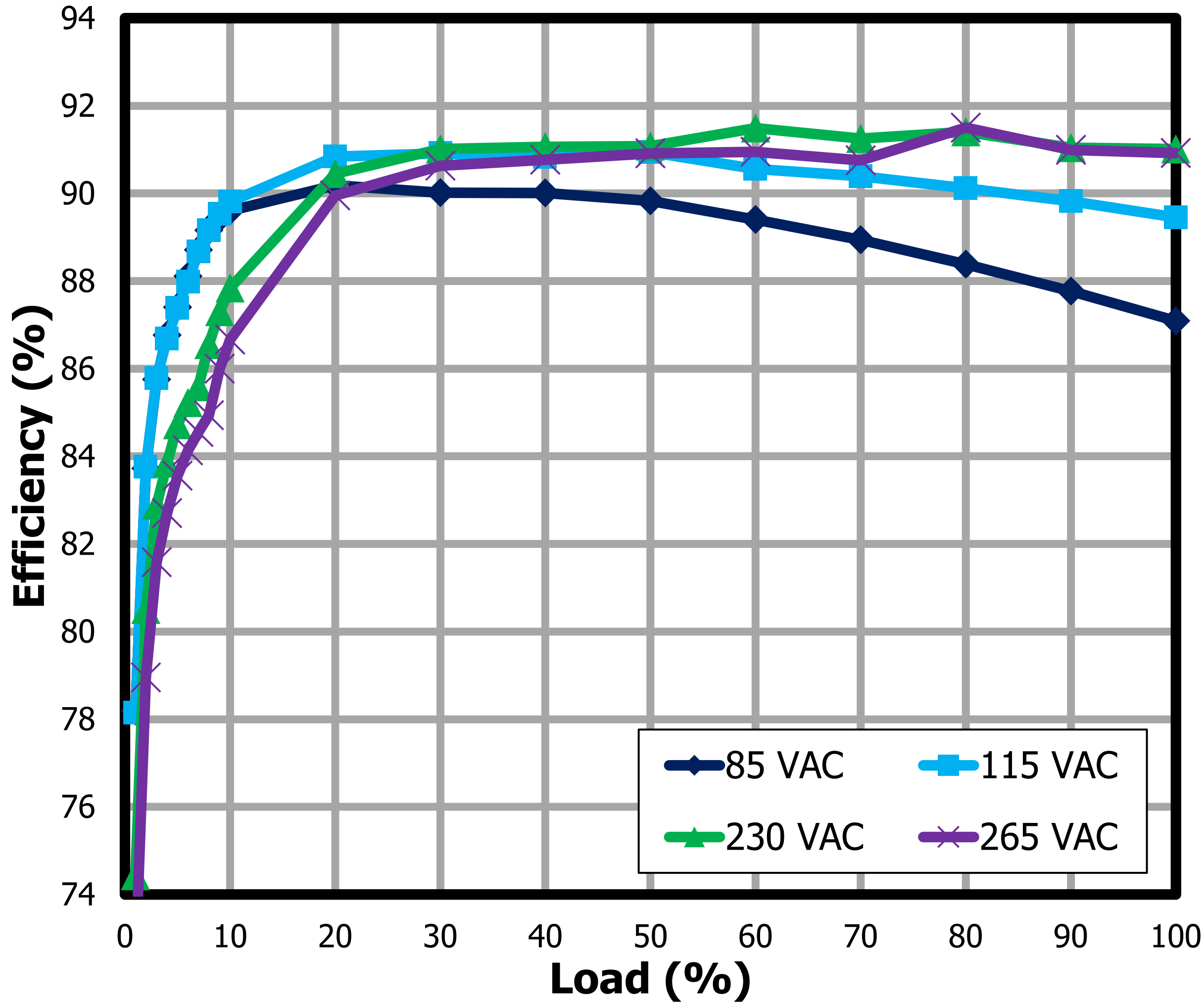


Figure 21 – Efficiency vs. Percentage Load.

11.3 Average and 10% Efficiency

11.3.1 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)	(VDC)	(mA_{DC})	(W)	(%)	(%)	(%)
100%	131	23.5	4997	117	89.6	**90.4**	88
75%	99.2	23.9	3748	89.6	90.3		
50%	66.6	24.2	2499	60.5	91.0		
25%	33.5	24.4	1248	30.4	90.9		
10%	13.6	24.4	499	12.2	89.8	---	---

Table 12 – Average and 10% Efficiency at 115 VAC.

11.3.2 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)	(VDC)	(mA_{DC})	(W)	(%)	(%)	(%)
100%	132	24.0	4997	120	91.0	**91.2**	88
75%	99.0	24.2	3748	90.7	91.6		
50%	66.6	24.3	2498	60.7	91.1		
25%	33.5	24.4	1248	30.4	90.9		
10%	13.9	24.4	499	12.2	87.9	---	---

Table 13 – Average and 10% Efficiency at 230 VAC.

11.4 No-Load Input Power

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

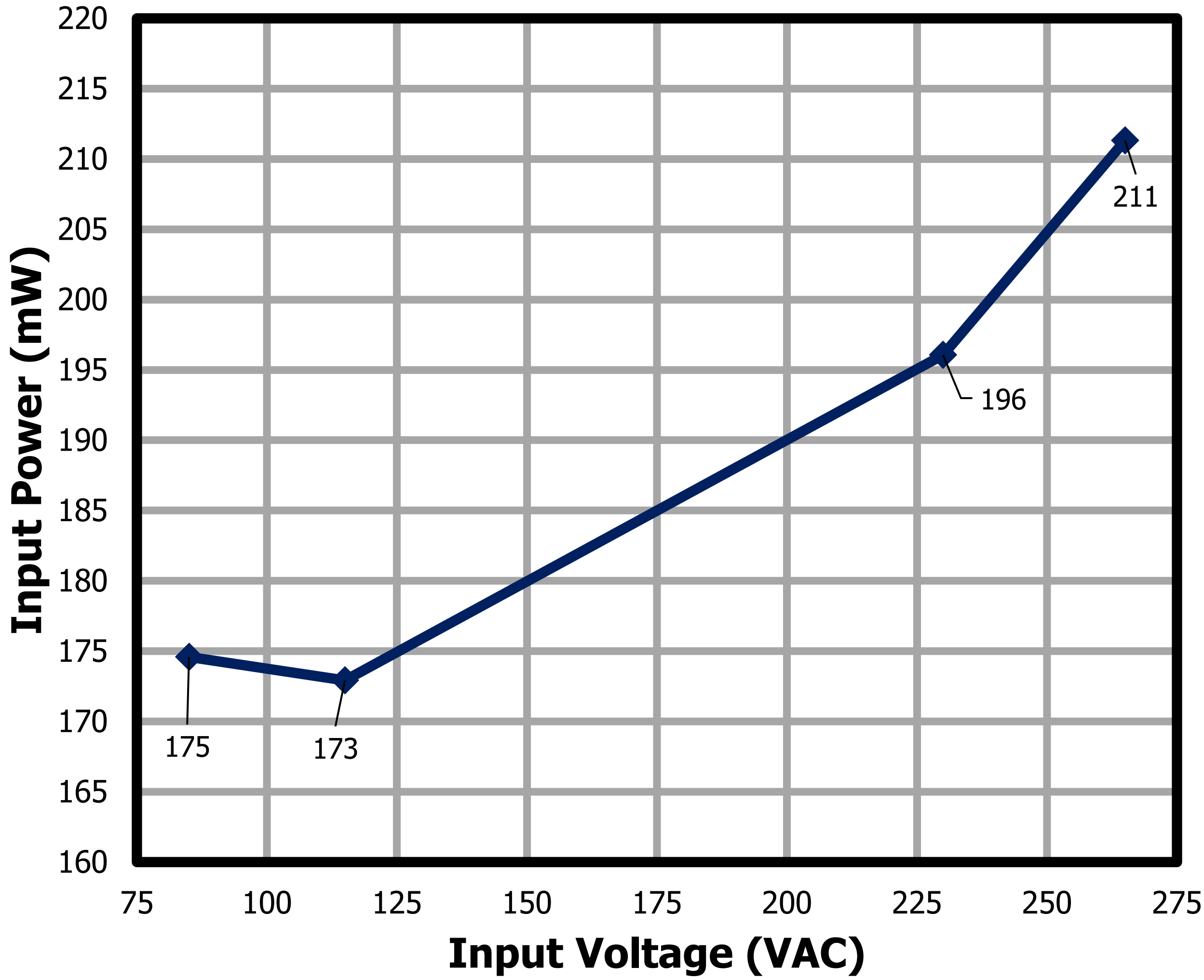


Figure 22 – No-Load Input Power vs. Line at Room Temperature.

11.5 Line Regulation

Test Condition: Soak for 15 minutes for each line.

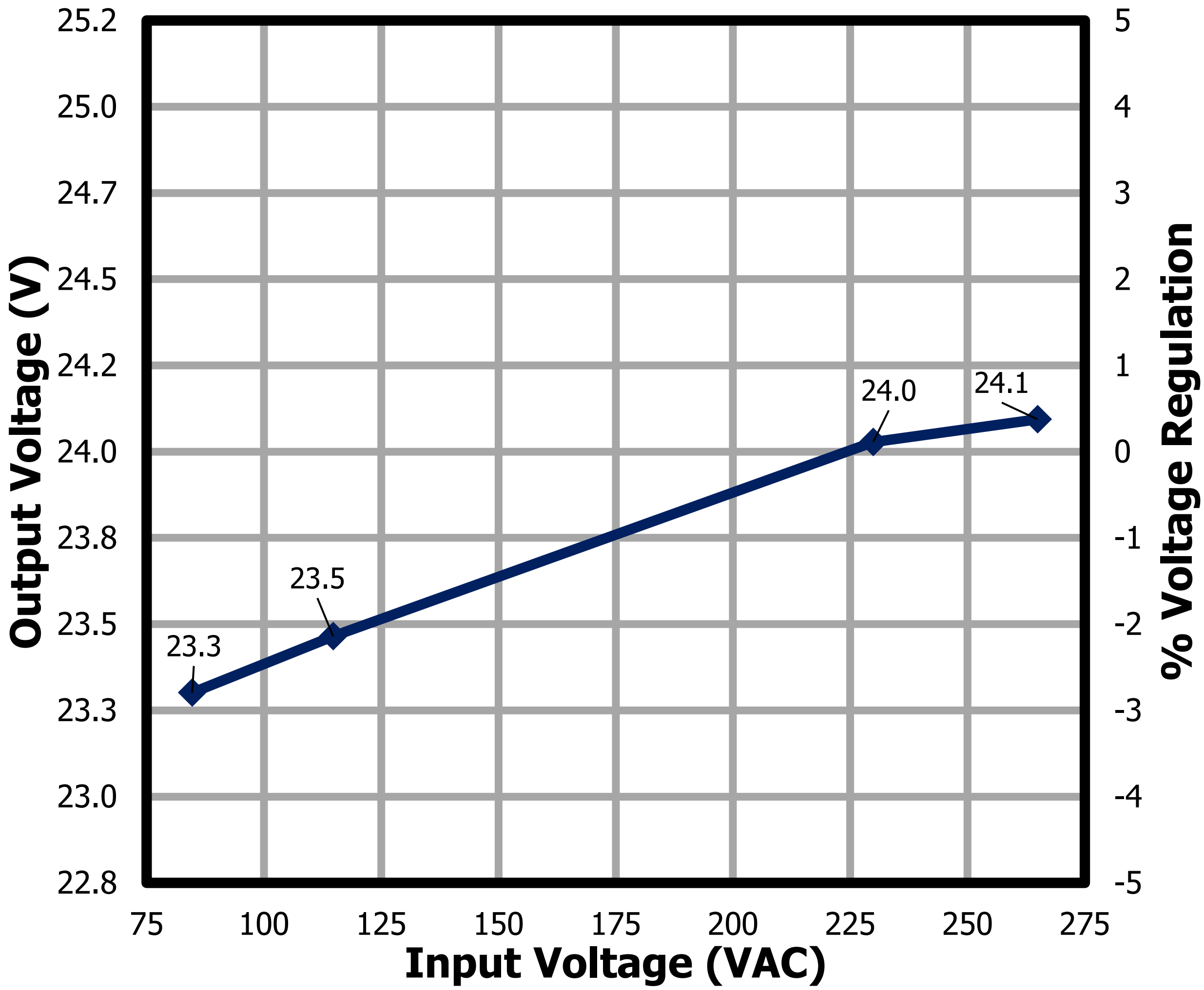


Figure 23 – Output Voltage vs. Line Voltage.

11.6 Load Regulation

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

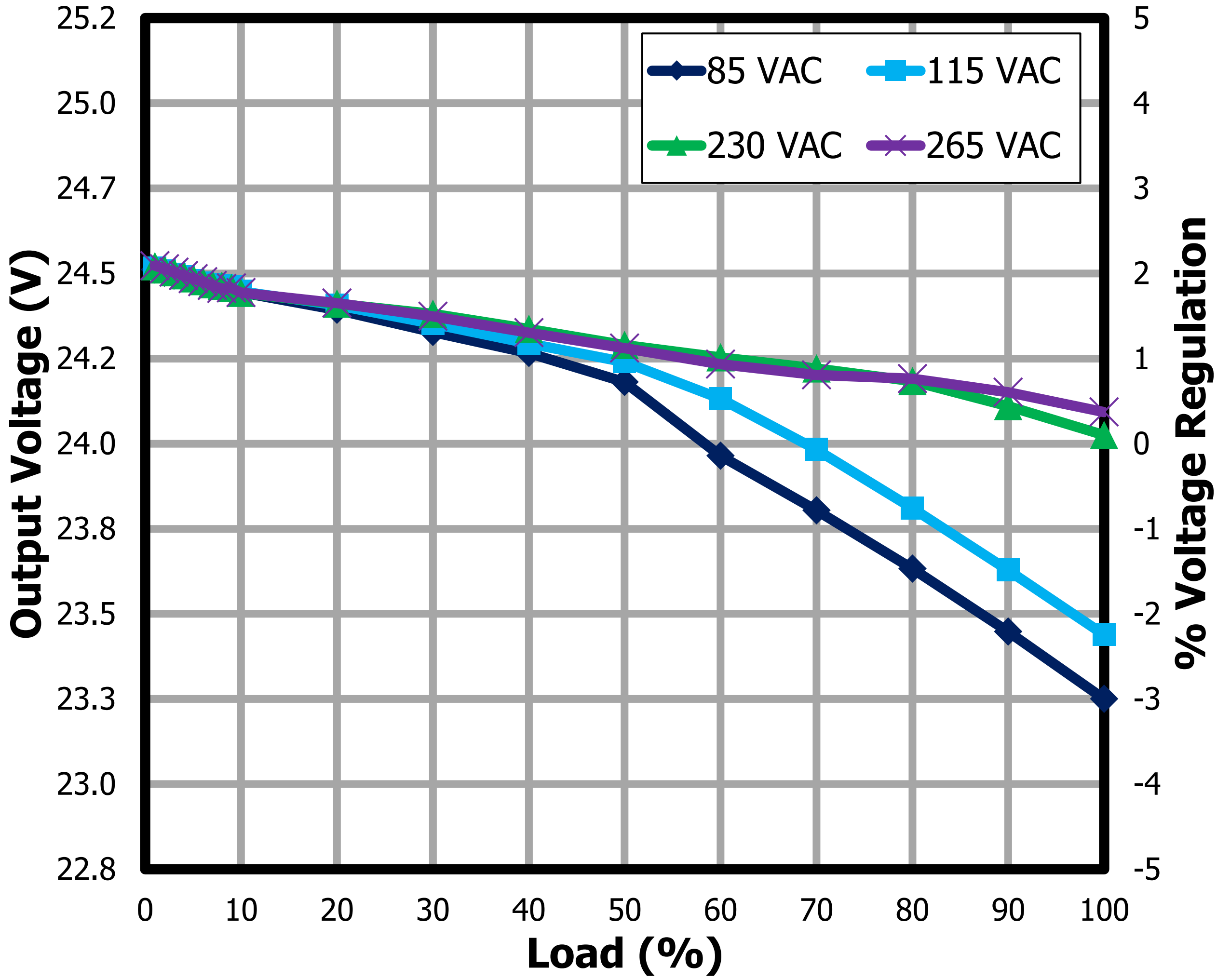


Figure 24 – Output Voltage vs. Percent Load.

12 Waveforms

12.1 Load Transient Response

Test Condition: Dynamic load frequency = 10 Hz, Duty cycle = 50 %
Slew Rate = 0.8 A / µs

12.1.1 Transient 0% - 100% Load Change

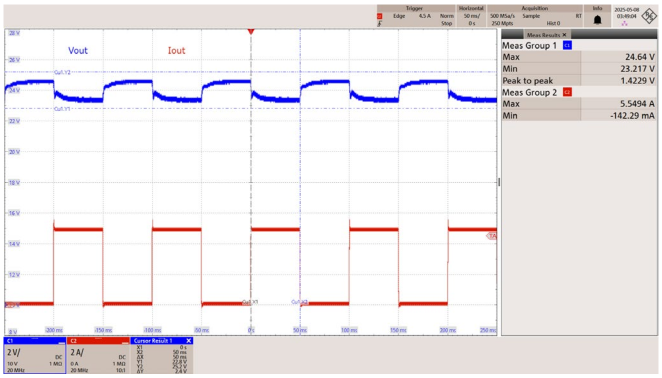


Figure 25 – 85 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 50 ms / div.
CH2: I_{OUT}, 2 A / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.6 V
V_{MIN}: 23.2 V

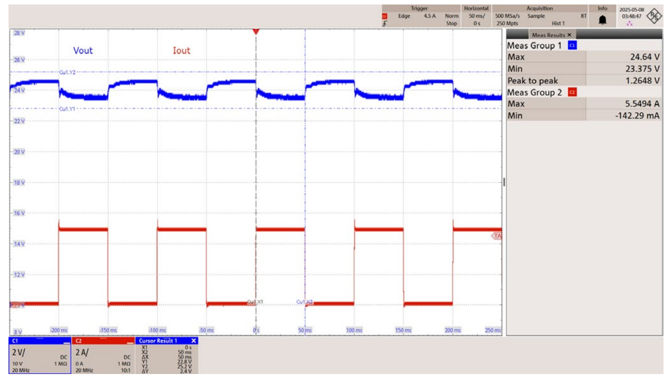


Figure 26 – 115 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 50 ms / div.
CH2: I_{OUT}, 2 A / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.6 V
V_{MIN}: 23.4 V

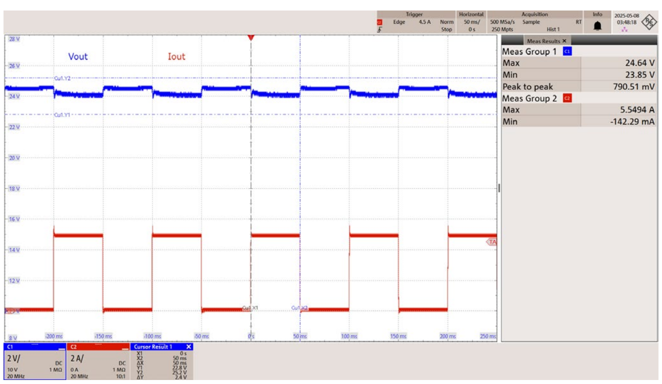


Figure 27 – 230 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 50 ms / div.
CH2: I_{OUT}, 2 A / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.6 V
V_{MIN}: 23.9 V

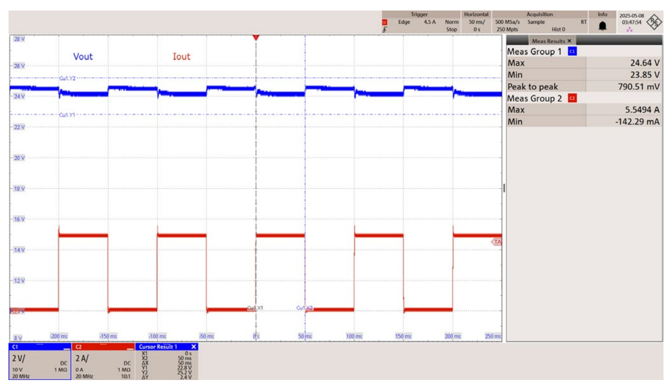


Figure 28 – 265 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 50 ms / div.
CH2: I_{OUT}, 2 A / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.6 V
V_{MIN}: 23.9 V

12.1.2 Transient 10% - 100% Load Change

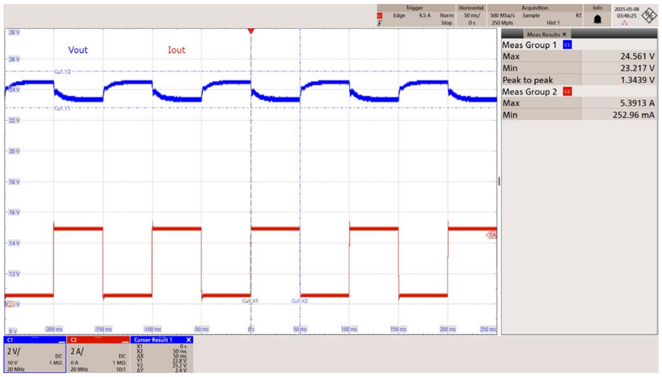


Figure 29 – 85 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 50 ms / div.
CH2: I_{OUT}, 2 A / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.6 V
V_{MIN}: 23.2 V

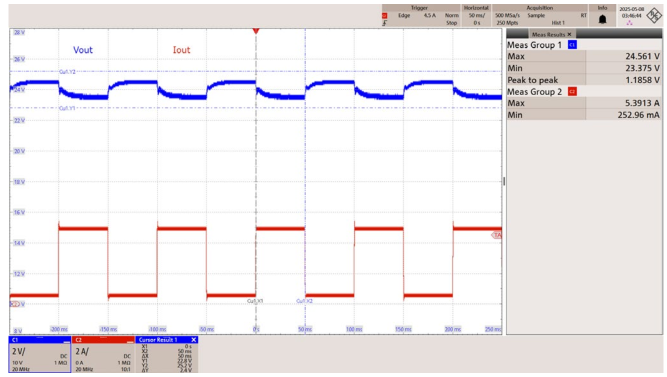


Figure 30 – 115 VAC 60 Hz.
CH1: V_{OUT}, 2 V / div., 50 ms / div.
CH2: I_{OUT}, 2 A / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.6 V
V_{MIN}: 23.4 V

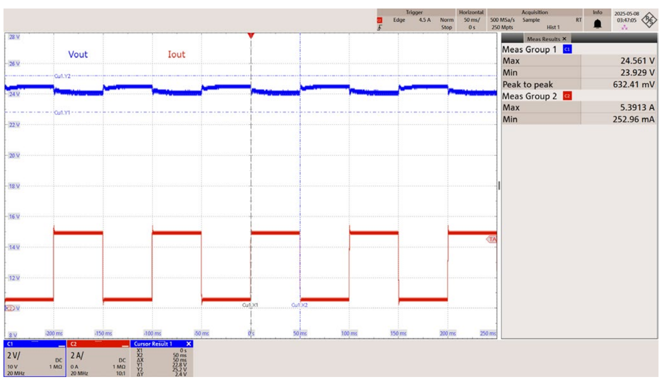


Figure 31 – 230 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 50 ms / div.
CH2: I_{OUT}, 2 A / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.6 V
V_{MIN}: 23.9 V

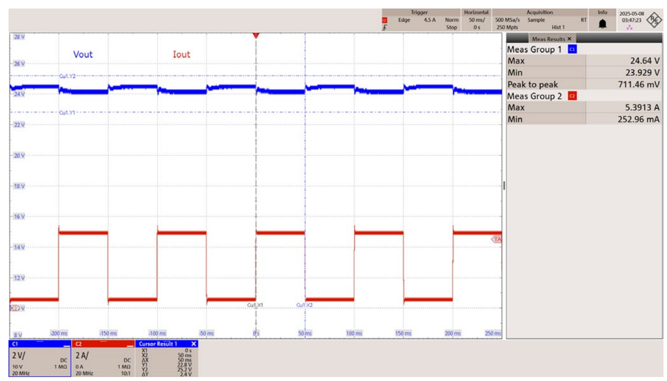


Figure 32 – 265 VAC 50 Hz.
CH1: V_{OUT}, 2 V / div., 50 ms / div.
CH2: I_{OUT}, 2 A / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.6 V
V_{MIN}: 23.9 V

12.2 Output Start-up

12.2.1 Full Load CC Mode

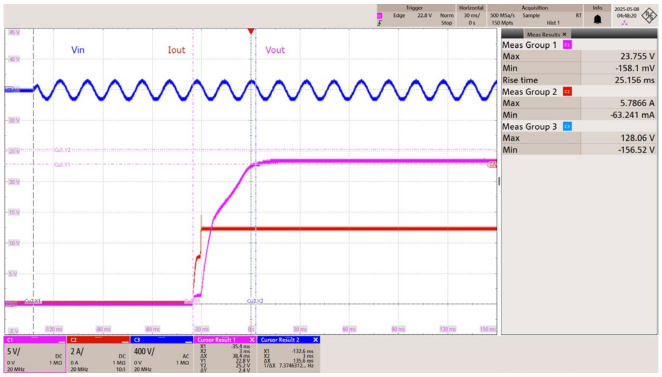


Figure 33 – 85 VAC 60 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 38.4 ms.
V_{MAX} = 23.8 V

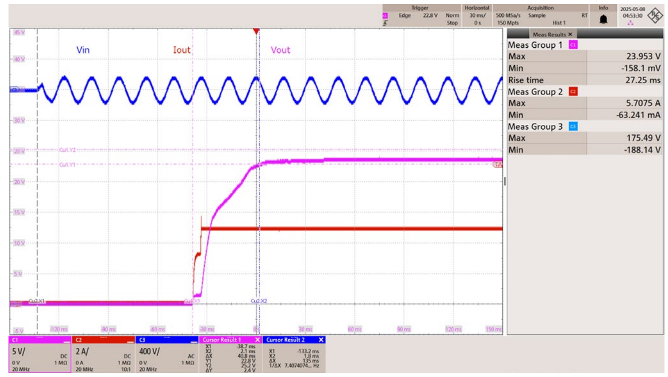


Figure 34 – 115 VAC 60 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 40.8 ms.
V_{MAX} = 24.0 V

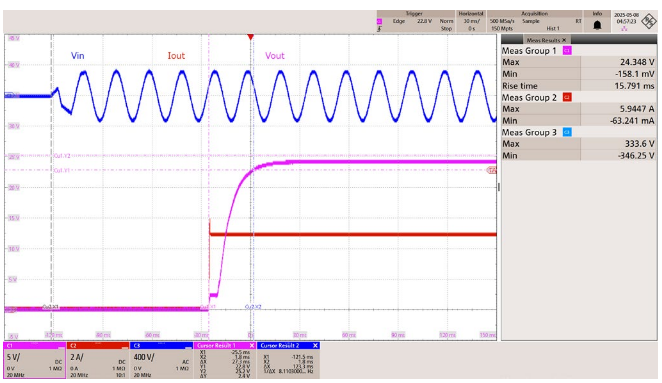


Figure 35 – 230 VAC 50 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 27.3 ms.
V_{MAX} = 24.3 V

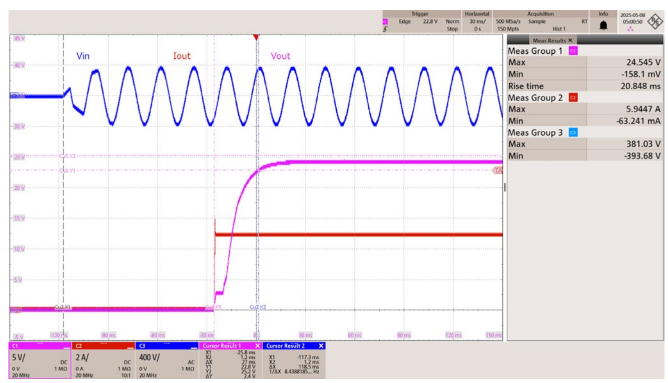


Figure 36 – 265 VAC 50 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 27 ms.
V_{MAX} = 24.5 V

12.2.2 Full Load CR Mode

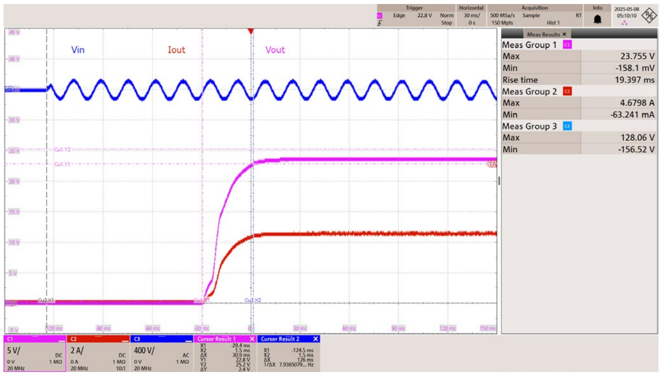


Figure 37 – 85 VAC 60 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 30.9 ms.
V_{MAX} = 23.8 V

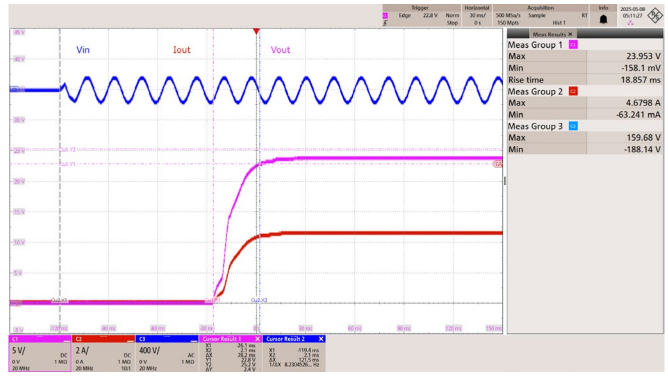


Figure 38 – 115 VAC 60 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 28.2 ms.
V_{MAX} = 24.0 V

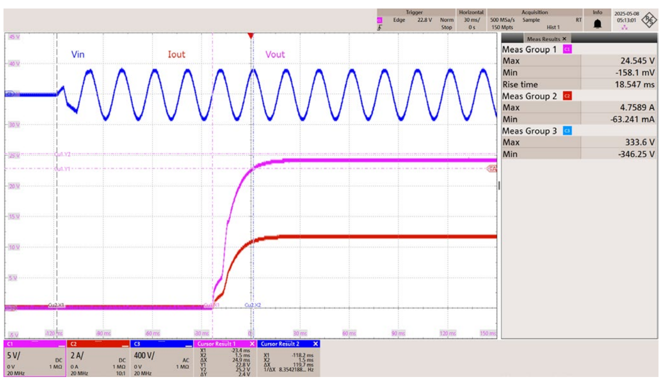


Figure 39 – 230 VAC 50 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 24.9 ms.
V_{MAX} = 24.5 V

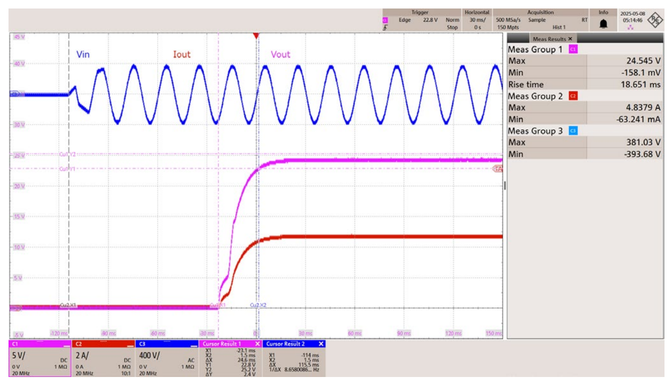


Figure 40 – 265 VAC 50 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 24.6 ms.
V_{MAX} = 24.5 V

12.2.3 No Load

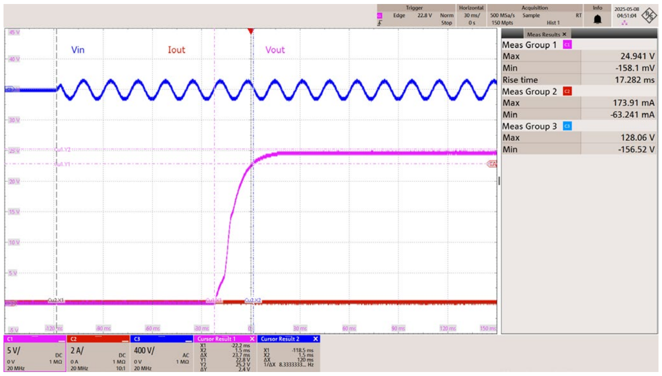


Figure 41 – 85 VAC 60 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 23.7 ms.
V_{MAX} = 24.9 V

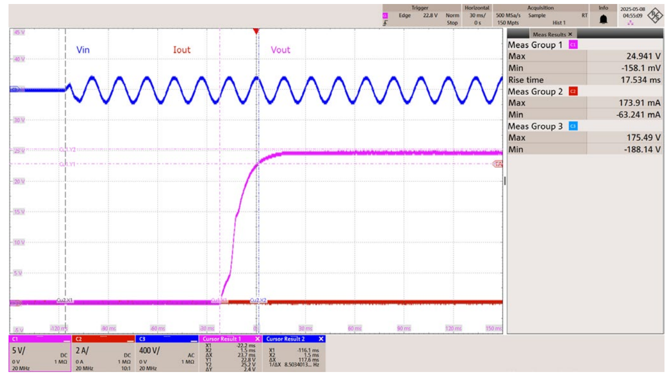


Figure 42 – 115 VAC 60 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 23.7 ms.
V_{MAX} = 24.9 V

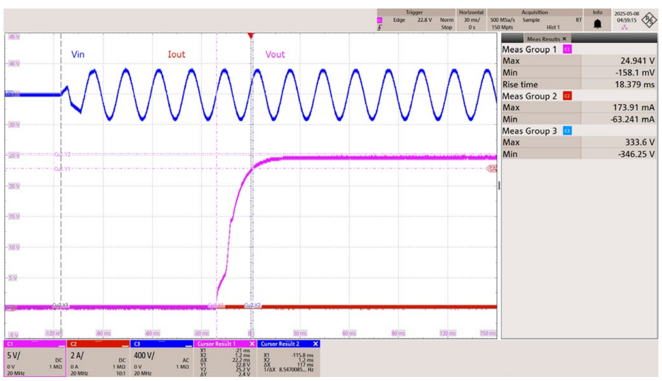


Figure 43 – 230 VAC 50 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 22.2 ms.
V_{MAX} = 24.9 V

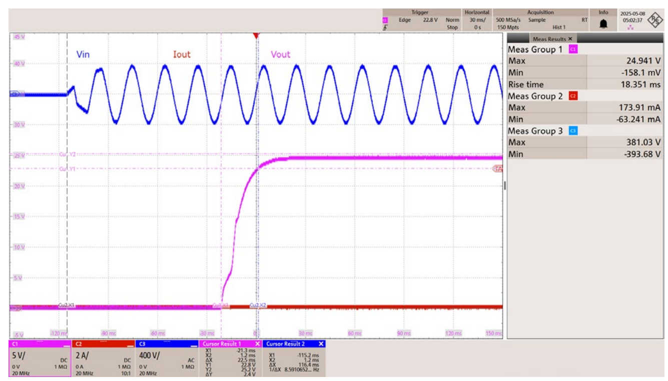


Figure 44 – 265 VAC 50 Hz.
CH1: V_{OUT}, 5 V / div., 30 ms / div.
CH2: I_{OUT}, 2 A / div., 30 ms / div.
CH3: V_{IN}, 400 V / div., 30 ms / div.
Rise Time = 22.5 ms.
V_{MAX} = 24.9 V

12.3 Switching Waveforms

12.3.1 Primary MOSFET Drain-Source Voltage and Current during Normal Operation

12.3.1.1 Full Load

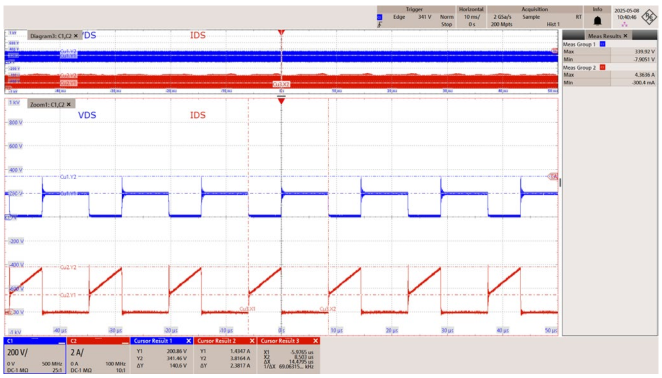


Figure 45 – 85 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 340 V
$I_{DS(MAX)}$ = 4.36 A

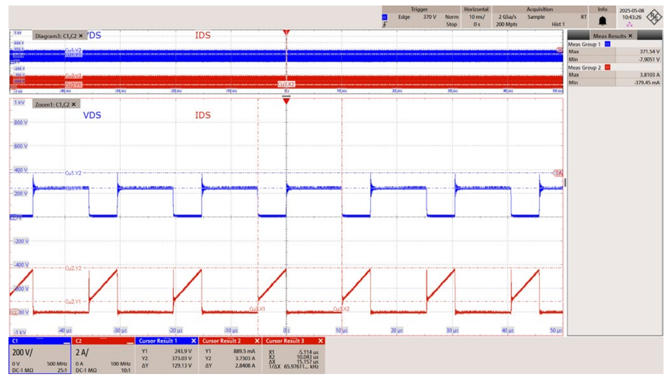


Figure 46 – 115 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 372 V
$I_{DS(MAX)}$ = 3.81 A

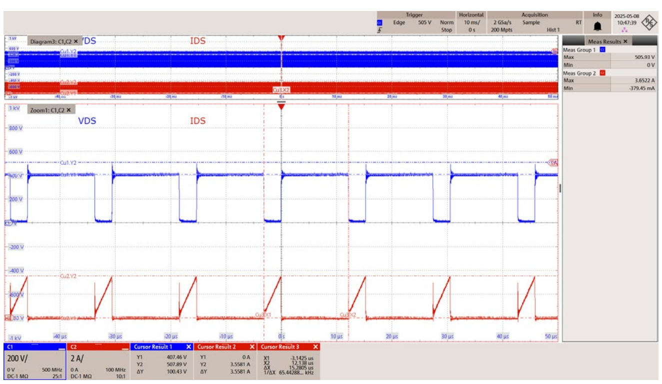


Figure 47 – 230 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 506 V
$I_{DS(MAX)}$ = 3.65 A

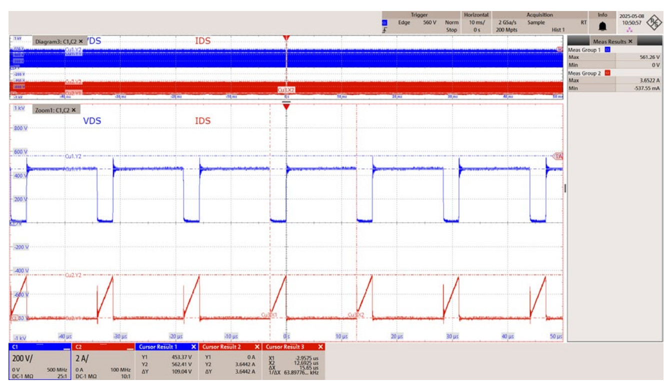


Figure 48 – 265 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 561 V
$I_{DS(MAX)}$ = 3.65 A

12.3.1.2 No Load

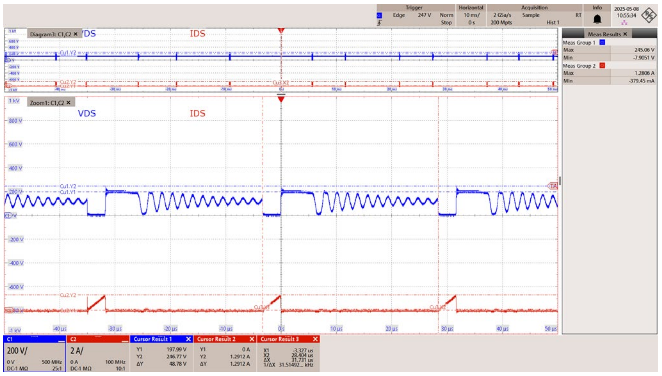


Figure 49 – 85 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 245 V
$I_{DS(MAX)}$ = 1.28 A

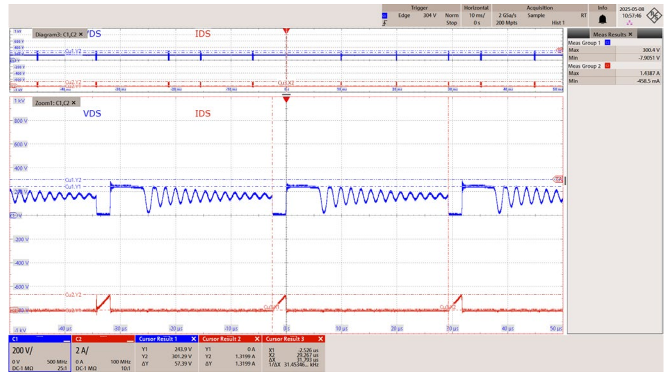


Figure 50 – 115 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 300 V
$I_{DS(MAX)}$ = 1.44 A

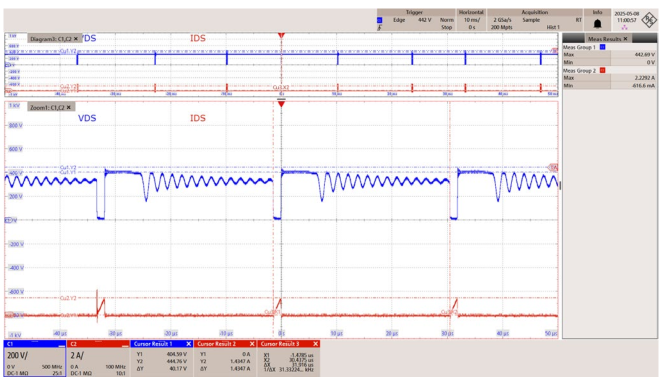


Figure 51 – 230 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 413 V
$I_{DS(MAX)}$ = 2.23 A

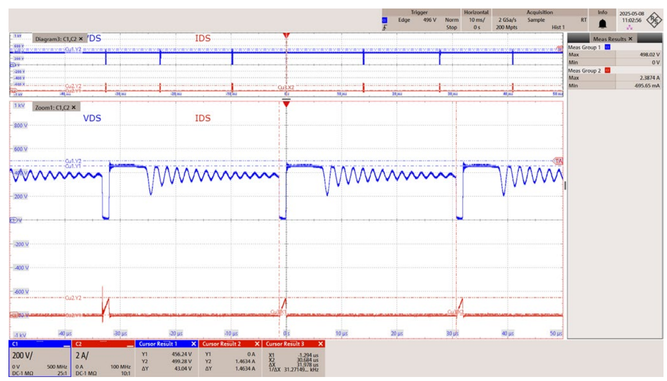


Figure 52 – 265 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 498 V
$I_{DS(MAX)}$ = 2.39 A

12.3.2 Primary MOSFET Drain-Source Voltage and Current at Start-up

12.3.2.1 Full Load

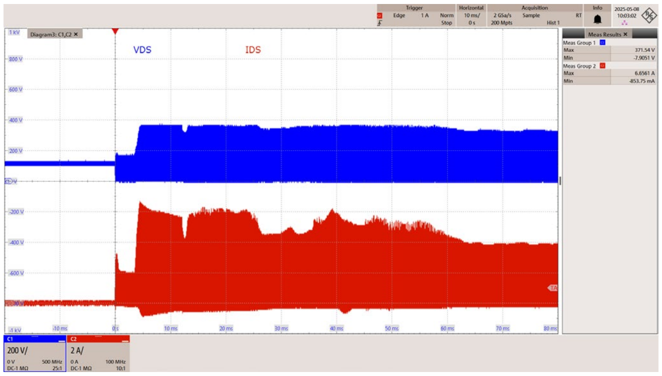


Figure 53 – 85 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
$V_{DS(MAX)}$ = 372 V
$I_{DS(MAX)}$ = 6.66 A

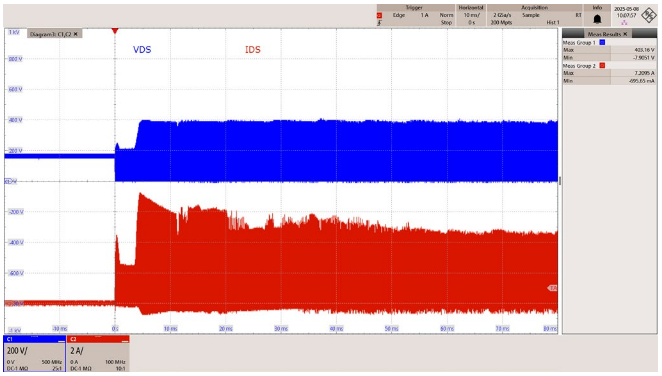


Figure 54 – 115 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
$V_{DS(MAX)}$ = 403 V
$I_{DS(MAX)}$ = 7.21 A

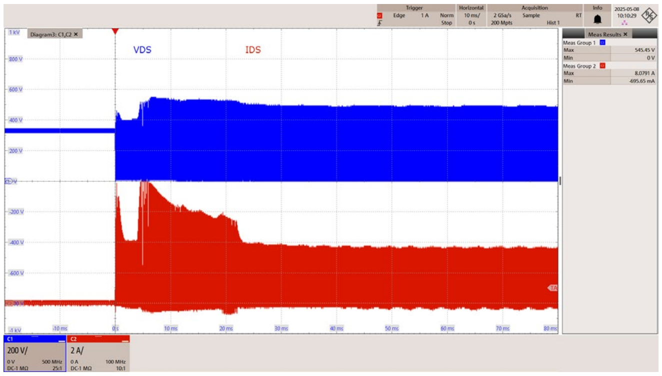


Figure 55 – 230 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
$V_{DS(MAX)}$ = 545 V
$I_{DS(MAX)}$ =8.08 A

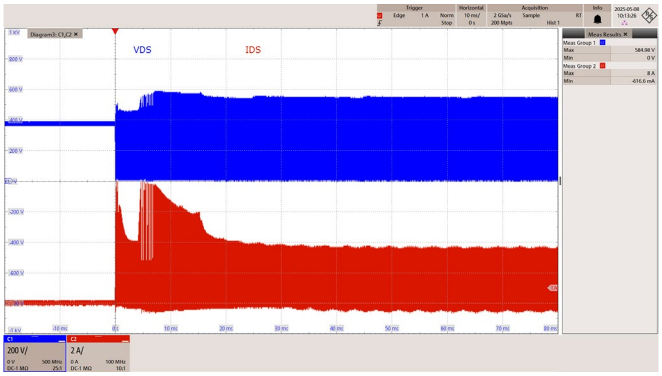


Figure 56 – 265 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
$V_{DS(MAX)}$ = 585 V
$I_{DS(MAX)}$ = 8 A

12.3.2.2 No Load

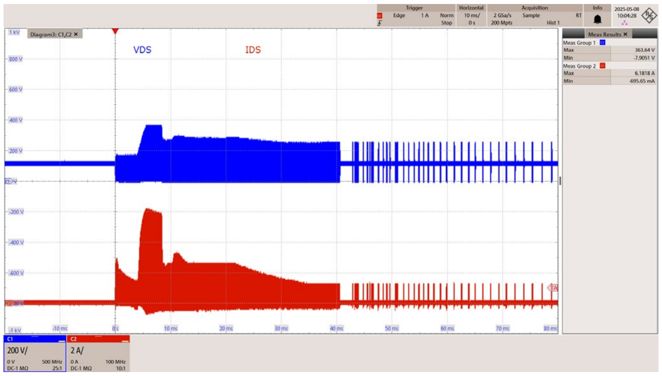


Figure 57 – 85 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
$V_{DS(MAX)}$ = 364 V
$I_{DS(MAX)}$ = 6.18 A

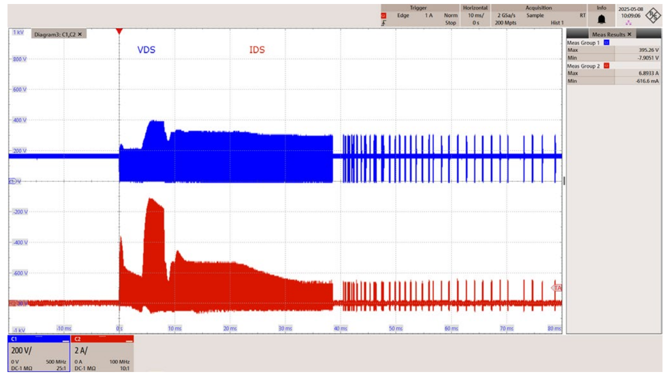


Figure 58 – 115 VAC 60 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
$V_{DS(MAX)}$ = 395 V
$I_{DS(MAX)}$ = 6.89 A

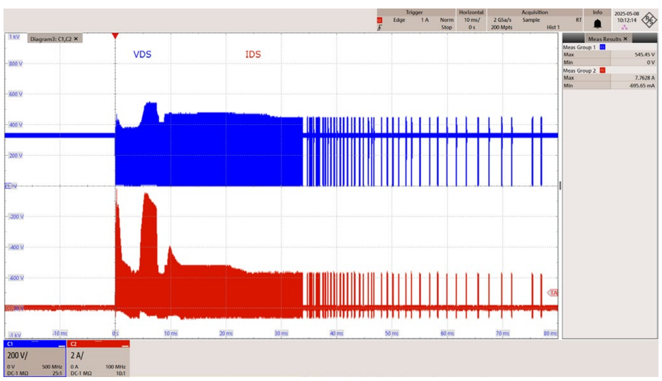


Figure 59 – 230 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
$V_{DS(MAX)}$ = 545 V
$I_{DS(MAX)}$ = 7.76 A

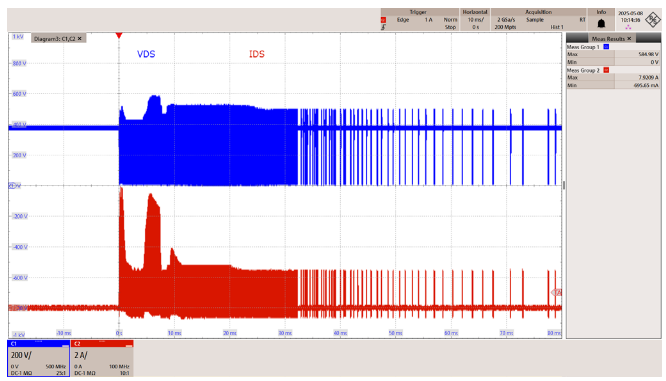


Figure 60 – 265 VAC 50 Hz.
CH1: V_{DS}, 200 V / div., 10 ms / div.
CH2: I_{DS}, 2 A / div., 10 ms / div.
$V_{DS(MAX)}$ = 585 V
$I_{DS(MAX)}$ = 7.92 A

12.3.3 Freewheeling Diode Voltage and Current during Normal Operation

12.3.3.1 Full Load

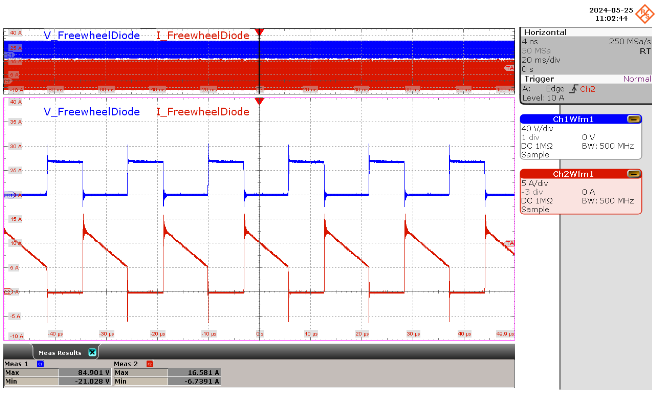


Figure 61 – 85 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 84.9 V
$I_{FreewheelDiode(MAX)}$ = 16.6 A

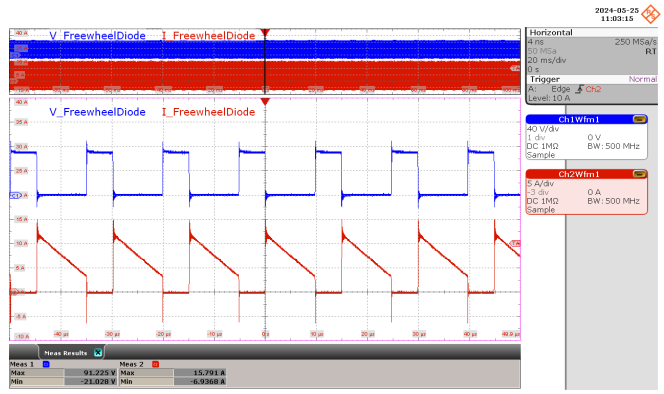


Figure 62 – 115 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 91.2 V
$I_{FreewheelDiode(MAX)}$ = 15.8 A

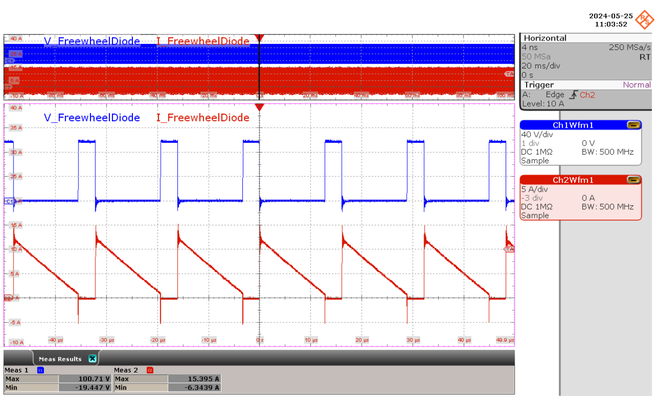


Figure 63 – 230 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 101 V
$I_{FreewheelDiode(MAX)}$ = 15.4 A

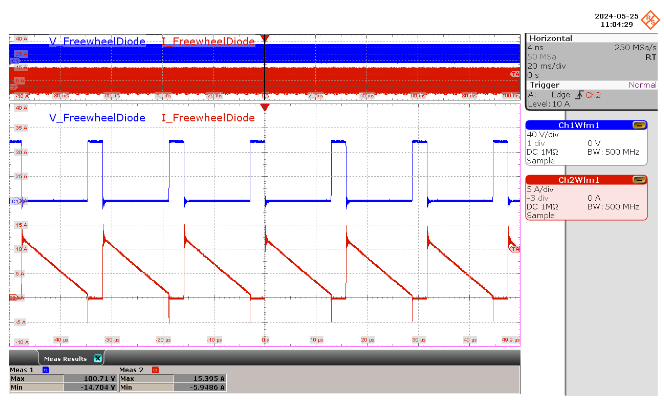


Figure 64 – 265 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 101 V
$I_{FreewheelDiode(MAX)}$ = 15.4 A

12.3.3.2 No Load

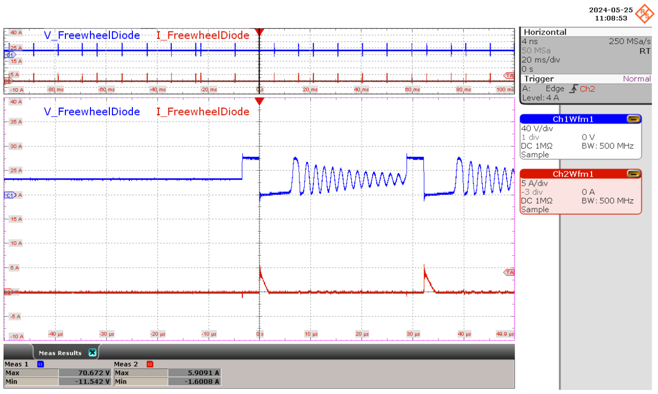


Figure 65 – 85 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 70.7 V
$I_{FreewheelDiode(MAX)}$ = 5.90 A

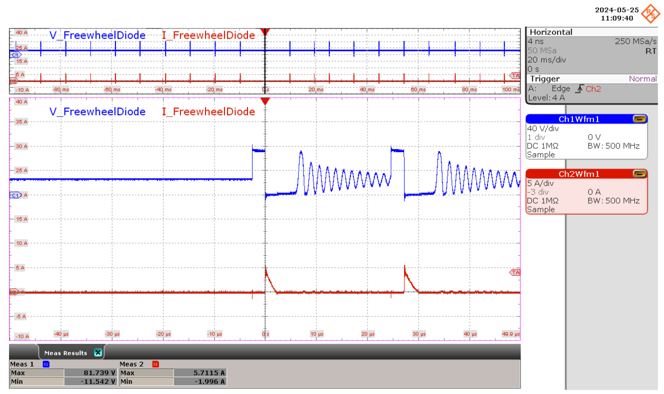


Figure 66 – 115 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 81.7 V
$I_{FreewheelDiode(MAX)}$ = 5.71 A

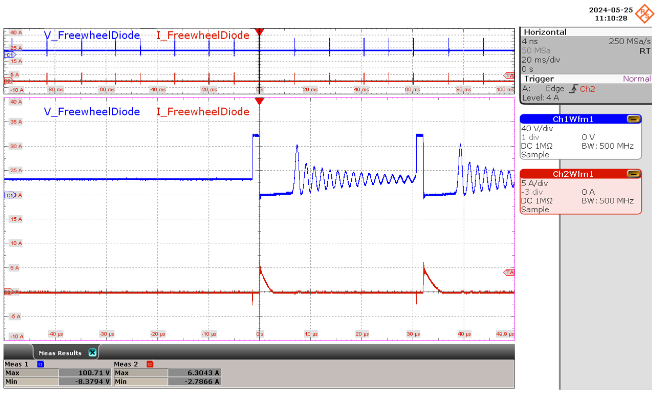


Figure 67 – 230 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 101 V
$I_{FreewheelDiode(MAX)}$ = 6.30 A

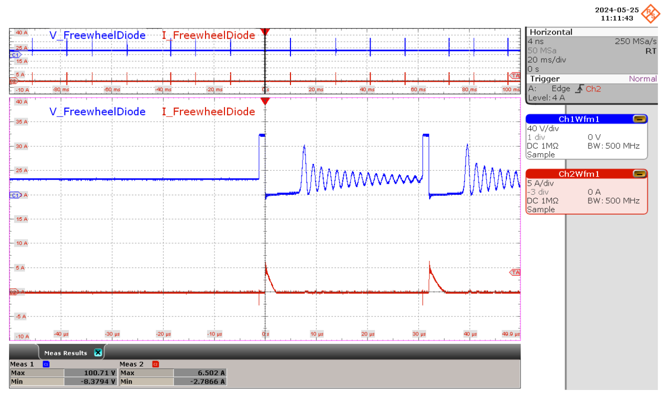


Figure 68 – 265 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 101 V
$I_{FreewheelDiode(MAX)}$ = 6.50 A

12.3.4 Freewheeling Diode Voltage and Current at Start-Up

12.3.4.1 Full Load

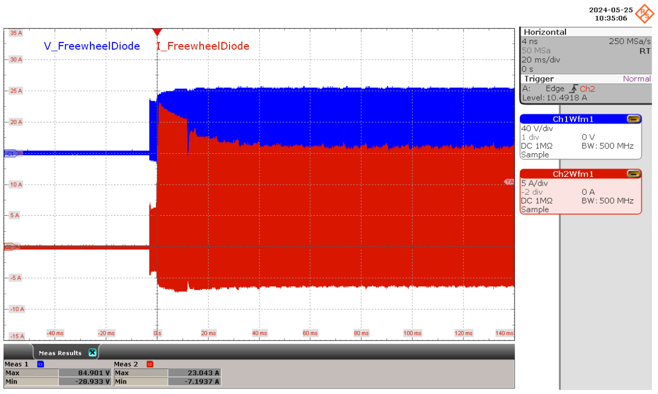


Figure 69 – 85 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
$V_{FreewheelDiode(MAX)}$ = 84.9 V
$I_{FreewheelDiode(MAX)}$ = 23.0 A

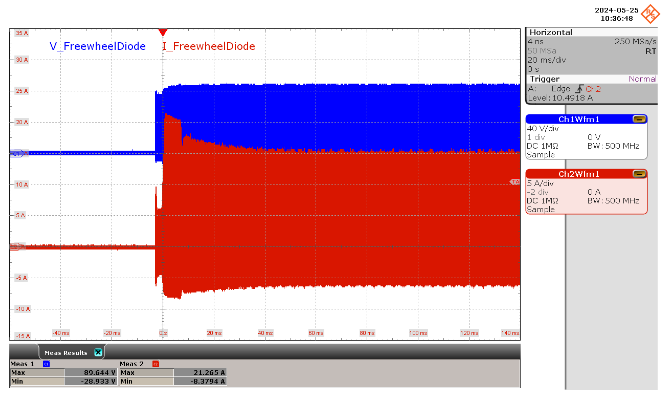


Figure 70 – 115 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
$V_{FreewheelDiode(MAX)}$ = 89.6 V
$I_{FreewheelDiode(MAX)}$ = 21.3 A

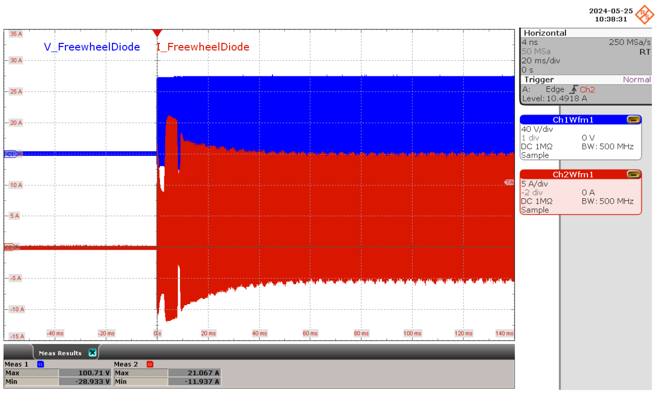


Figure 71 – 230 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
$V_{FreewheelDiode(MAX)}$ = 101 V
$I_{FreewheelDiode(MAX)}$ = 21.1 A

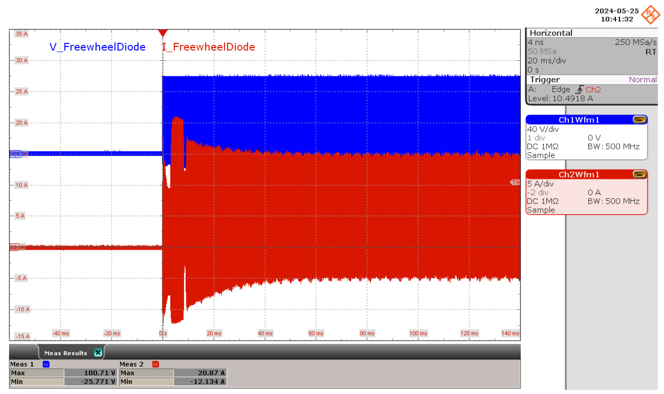


Figure 72 – 265 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
$V_{FreewheelDiode(MAX)}$ = 101 V
$I_{FreewheelDiode(MAX)}$ = 20.9 A

12.3.4.2 No Load

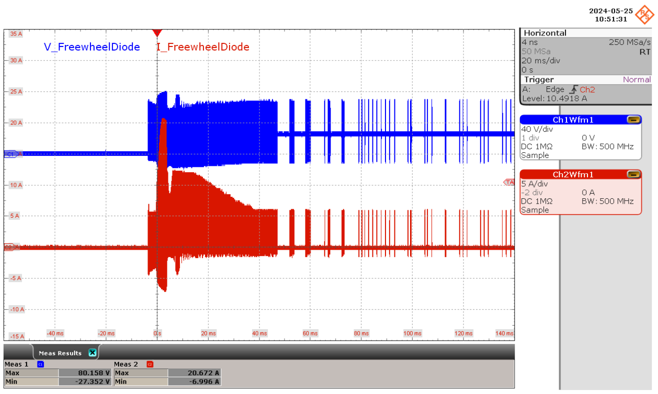


Figure 73 – 85 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
$V_{FreewheelDiode(MAX)}$ = 80.2 V
$I_{FreewheelDiode(MAX)}$ = 20.7 A

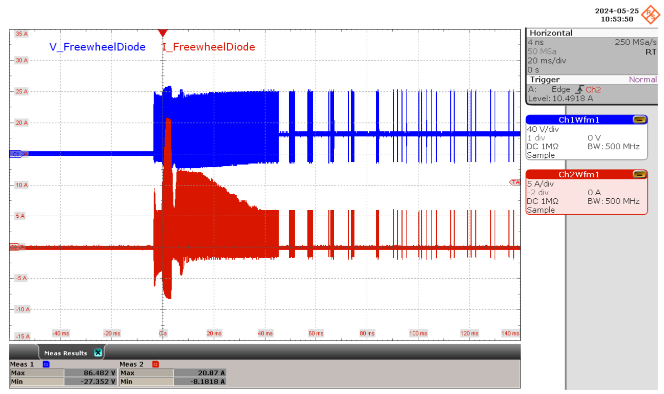


Figure 74 – 115 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
$V_{FreewheelDiode(MAX)}$ = 86.5 V
$I_{FreewheelDiode(MAX)}$ = 20.8 A

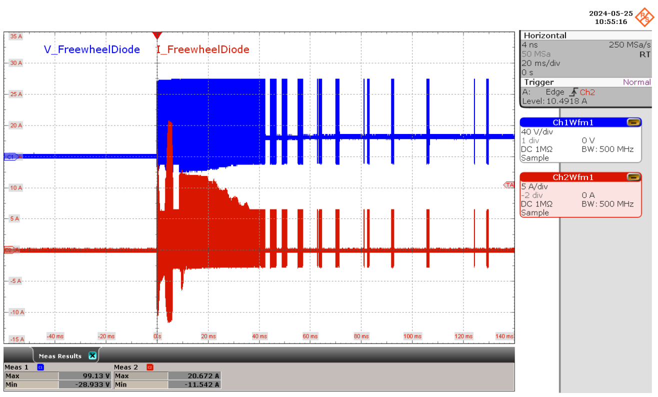


Figure 75 – 230 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
$V_{FreewheelDiode(MAX)}$ = 99.1 V
$I_{FreewheelDiode(MAX)}$ = 20.7 A

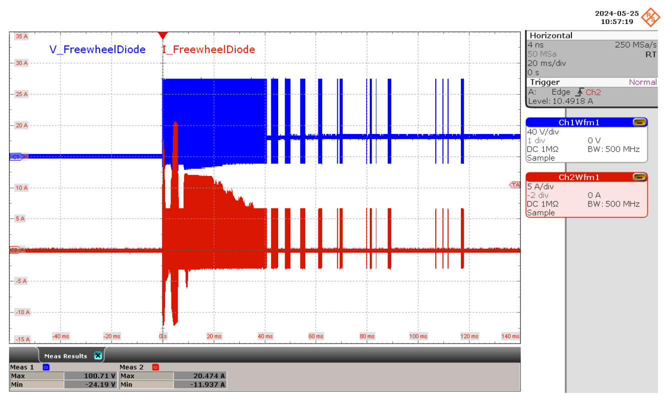


Figure 76 – 265 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 40 V / div., 20 ms / div.
CH2: $I_{FreewheelDiode}$, 5 A / div., 20 ms / div.
$V_{FreewheelDiode(MAX)}$ = 101 V
$I_{FreewheelDiode(MAX)}$ = 20.5 A

12.4 Brown-In and Brown-Out

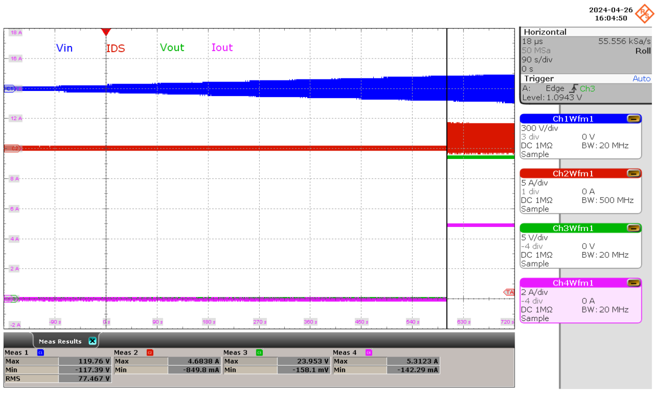


Figure 77 – Brown-In Full Load.
CH1: V_{IN}, 300 V / div., 90 s / div.
CH2: I_{DS}, 5 A / div., 90 s / div.
CH3: V_{OUT}, 5 V / div., 90 s / div.
CH4: I_{OUT}, 2 A / div., 90 s / div.
$V_{BROWN-IN}$ = 77.5 V_{RMS}.

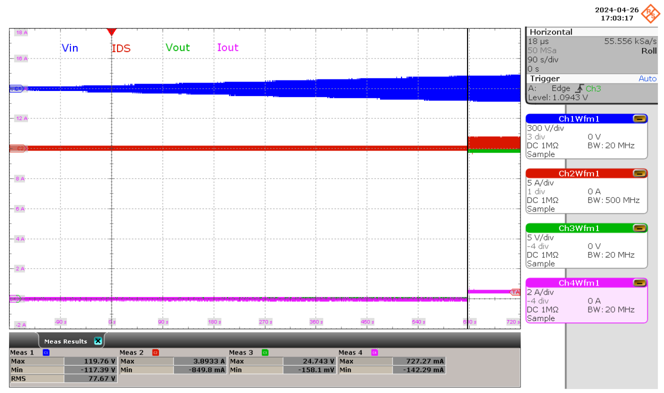


Figure 78 – Brown-In 10% Load.
CH1: V_{IN}, 300 V / div., 90 s / div.
CH2: I_{DS}, 5 A / div., 90 s / div.
CH3: V_{OUT}, 5 V / div., 90 s / div.
CH4: I_{OUT}, 2 A / div., 90 s / div.
$V_{BROWN-IN}$ = 77.7 V_{RMS}.

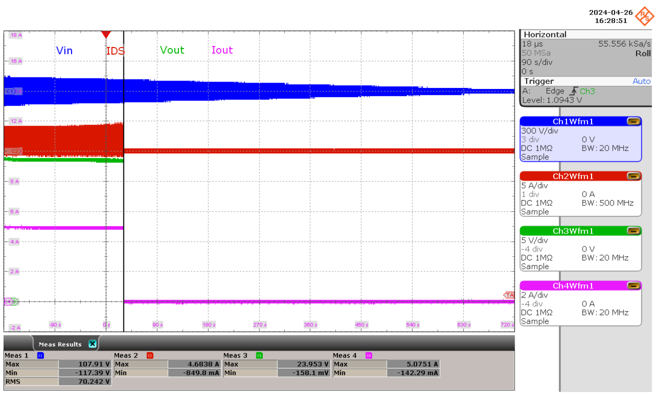


Figure 79 – Brown-Out Full Load.
CH1: V_{IN}, 300 V / div., 90 s / div.
CH2: I_{DS}, 5 A / div., 90 s / div.
CH3: V_{OUT}, 5 V / div., 90 s / div.
CH4: I_{OUT}, 2 A / div., 90 s / div.
$V_{BROWN-OUT}$ = 70.2 V_{RMS}.

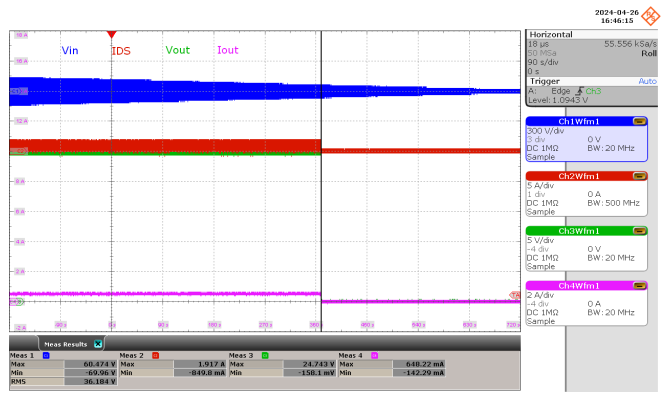


Figure 80 – Brown-Out 10% Load.
CH1: V_{IN}, 300 V / div., 90 s / div.
CH2: I_{DS}, 5 A / div., 90 s / div.
CH3: V_{OUT}, 5 V / div., 90 s / div.
CH4: I_{OUT}, 2 A / div., 90 s / div.
$V_{BROWN-OUT}$ = 36.2 V_{RMS}.

12.5 Output Voltage Ripple

12.5.1 Ripple Measurement Technique

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

The 4987BA probe adapter was affixed with two capacitors tied in parallel across the probe tip. The capacitors include one (1) 0.1 μF / 50 V ceramic type and one (1) 47 μF / 50 V aluminum electrolytic. The aluminum electrolytic type capacitor is polarized, so proper polarity across DC outputs must be maintained (see below).

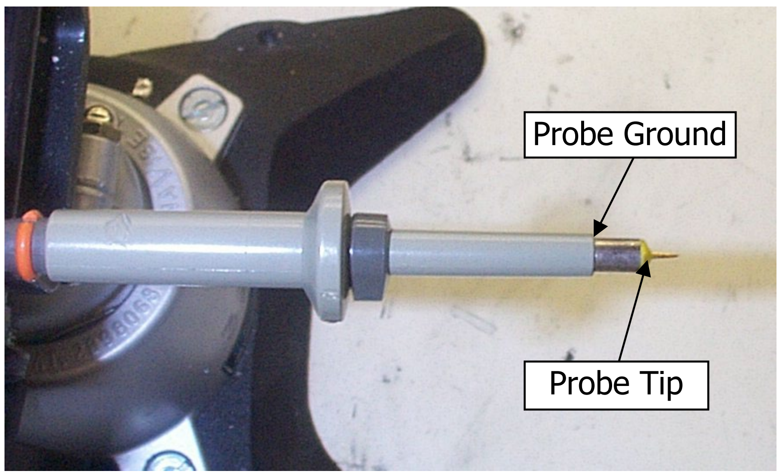


Figure 81 – Oscilloscope Probe Prepared for Ripple Measurement. (Probe cover and Ground Lead Removed.)

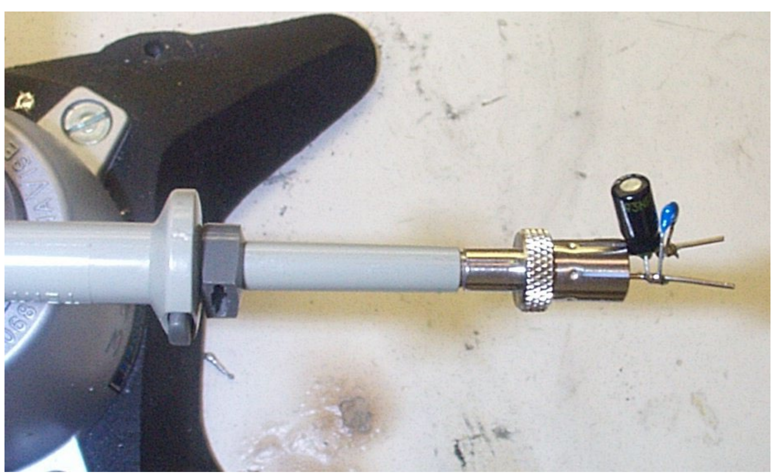


Figure 82 – Oscilloscope Probe with Probe Master (**www.probemaster.com**) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added.)

12.5.2 Measurement Results

Note: All ripple measurements were taken at the edge of the PCB.

12.5.2.1 100% Load

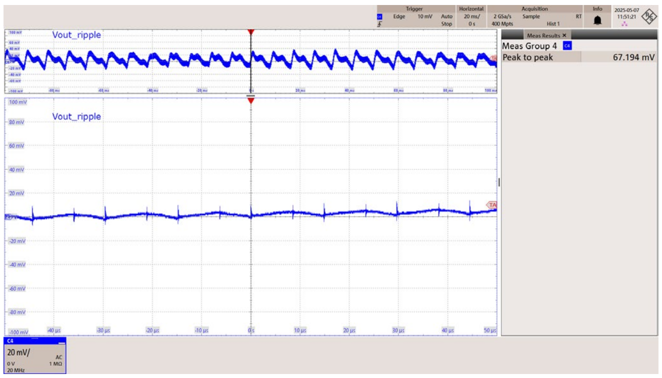


Figure 83 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 67.2 mV

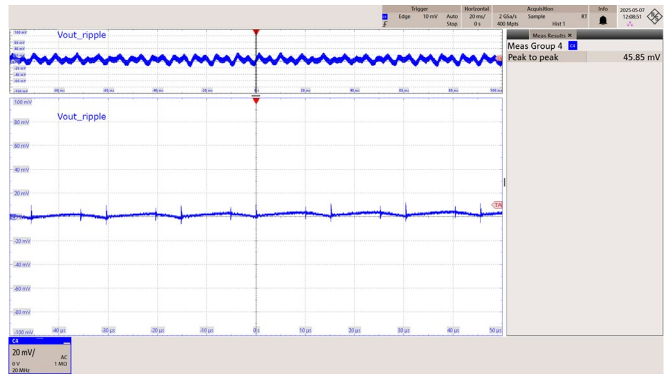


Figure 84 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 45.9 mV

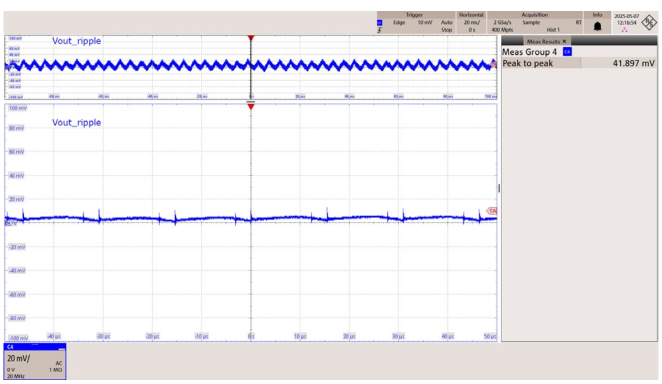


Figure 85 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 41.9 mV

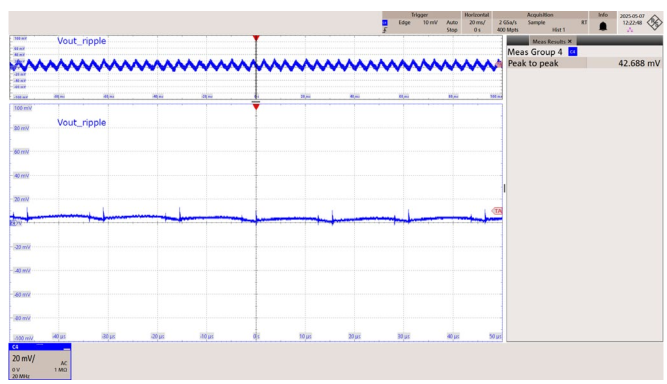


Figure 86 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 42.7 mV

12.5.2.2 75% Load

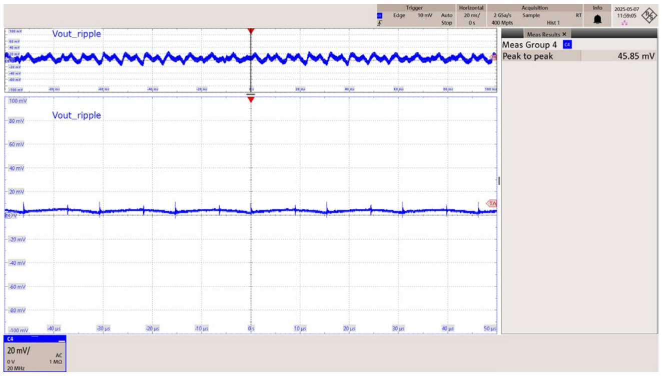


Figure 87 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 45.9 mV

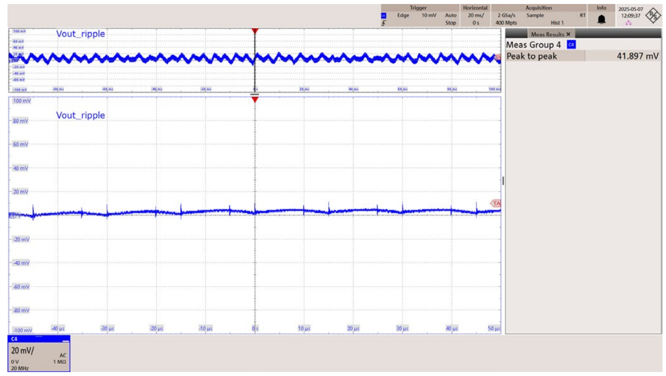


Figure 88 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 41.9 mV

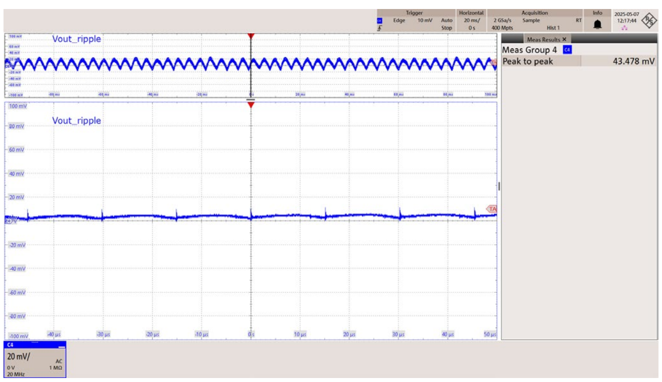


Figure 89 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 43.5 mV

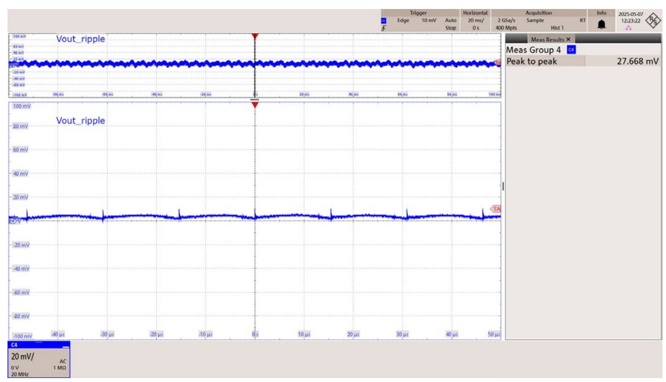


Figure 90 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 27.7 m

12.5.2.3 50% Load

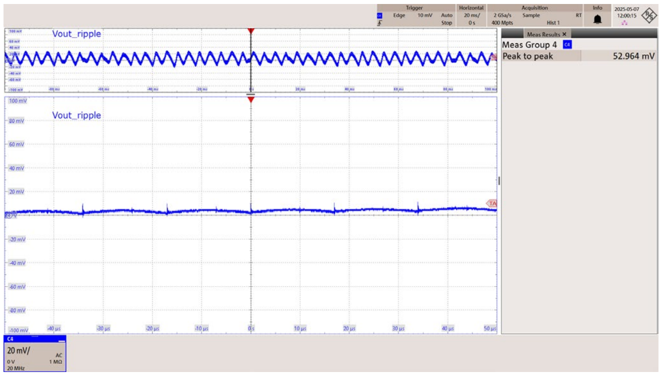


Figure 91 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 53 mV

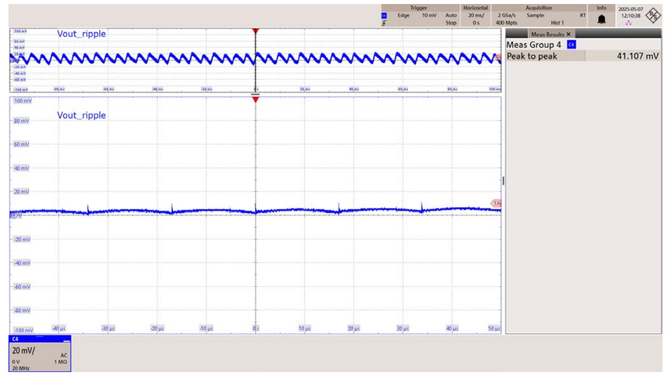


Figure 92 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 41.1 mV

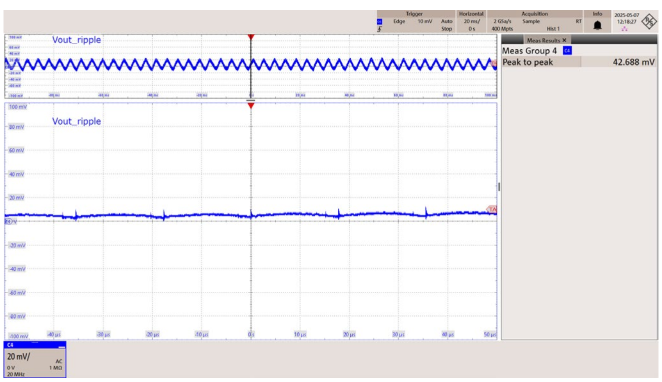


Figure 93 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 42.7 mV

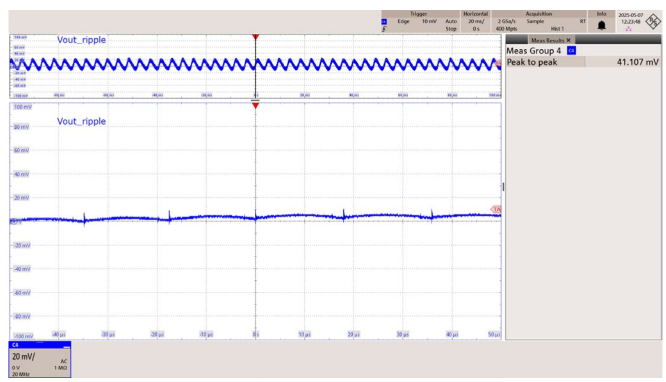


Figure 94 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 41.1 mV

12.5.2.4 25% Load

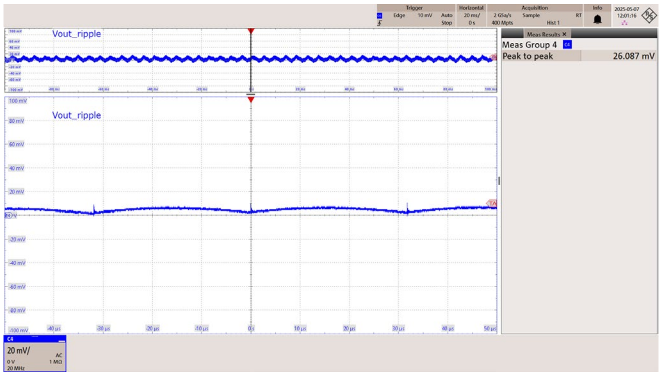


Figure 95 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 26.1 mV

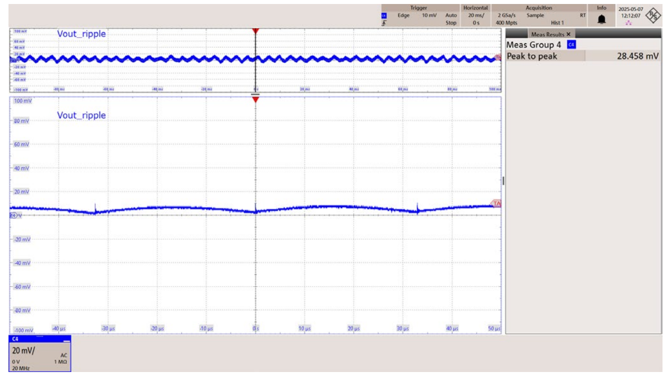


Figure 96 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 28.5 mV

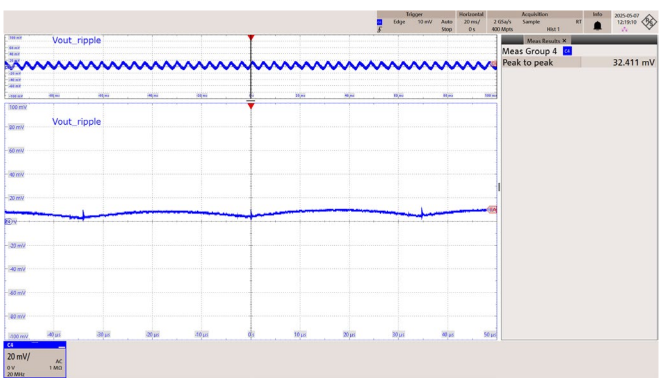


Figure 97 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 32.4 mV

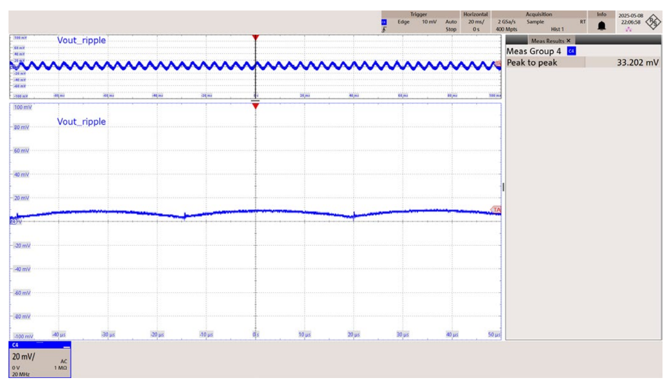


Figure 98 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 33.2 mV

12.5.2.5 10% Load

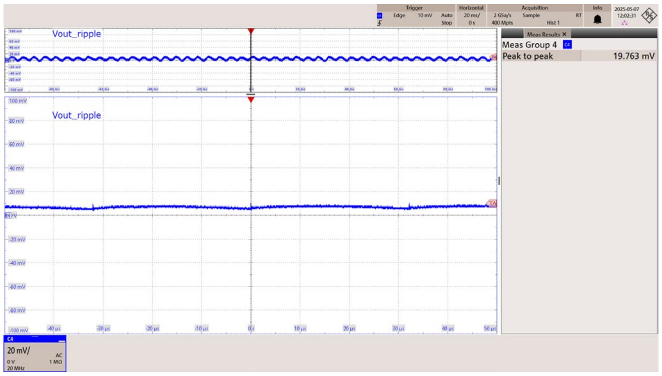


Figure 99 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 19.8 mV

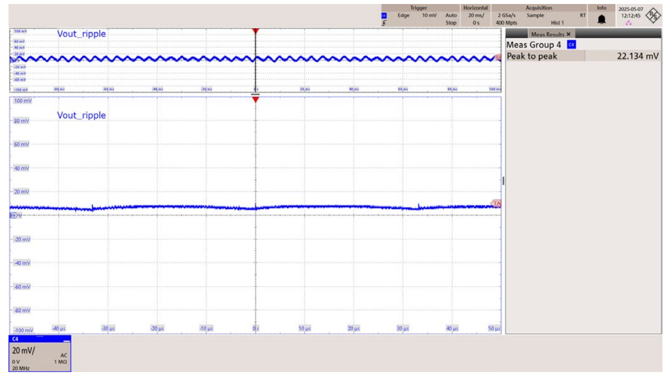


Figure 100 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 22.1 mV

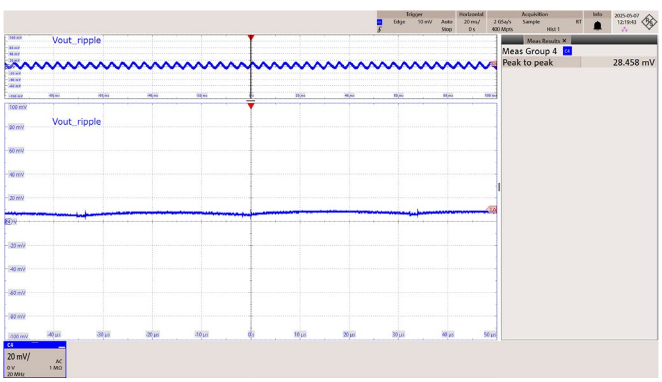


Figure 101 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 28.5 mV

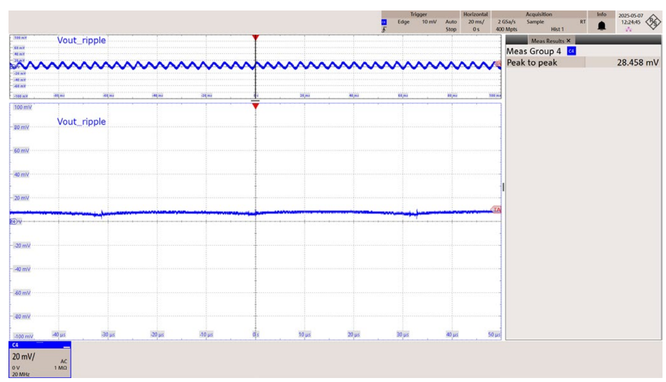


Figure 102 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 20 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 28.5 mV

12.5.3 Output Ripple Voltage Graph

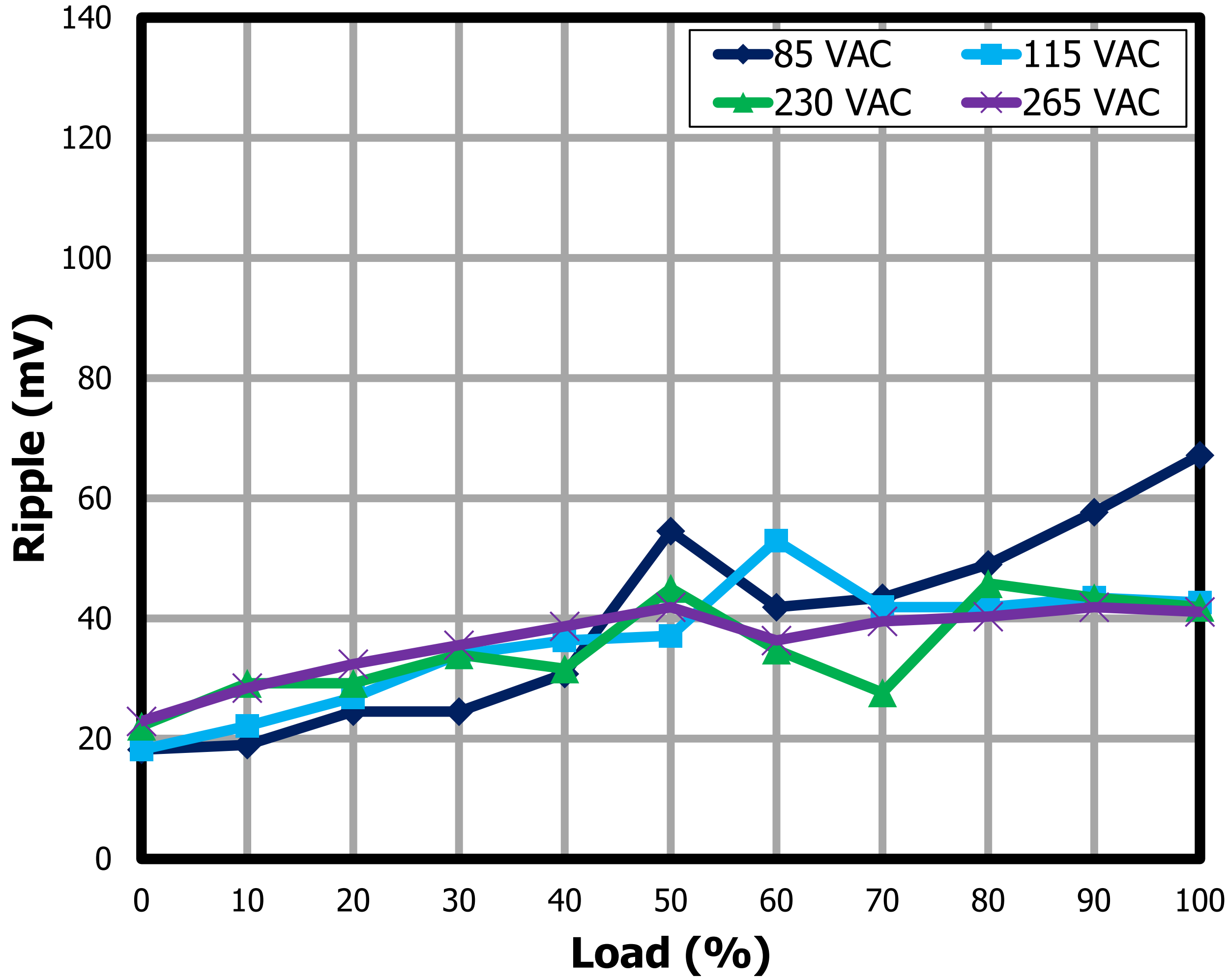


Figure 103 – Voltage Ripple (Measured at PCB End at Room Temperature).

13 Thermal Performance

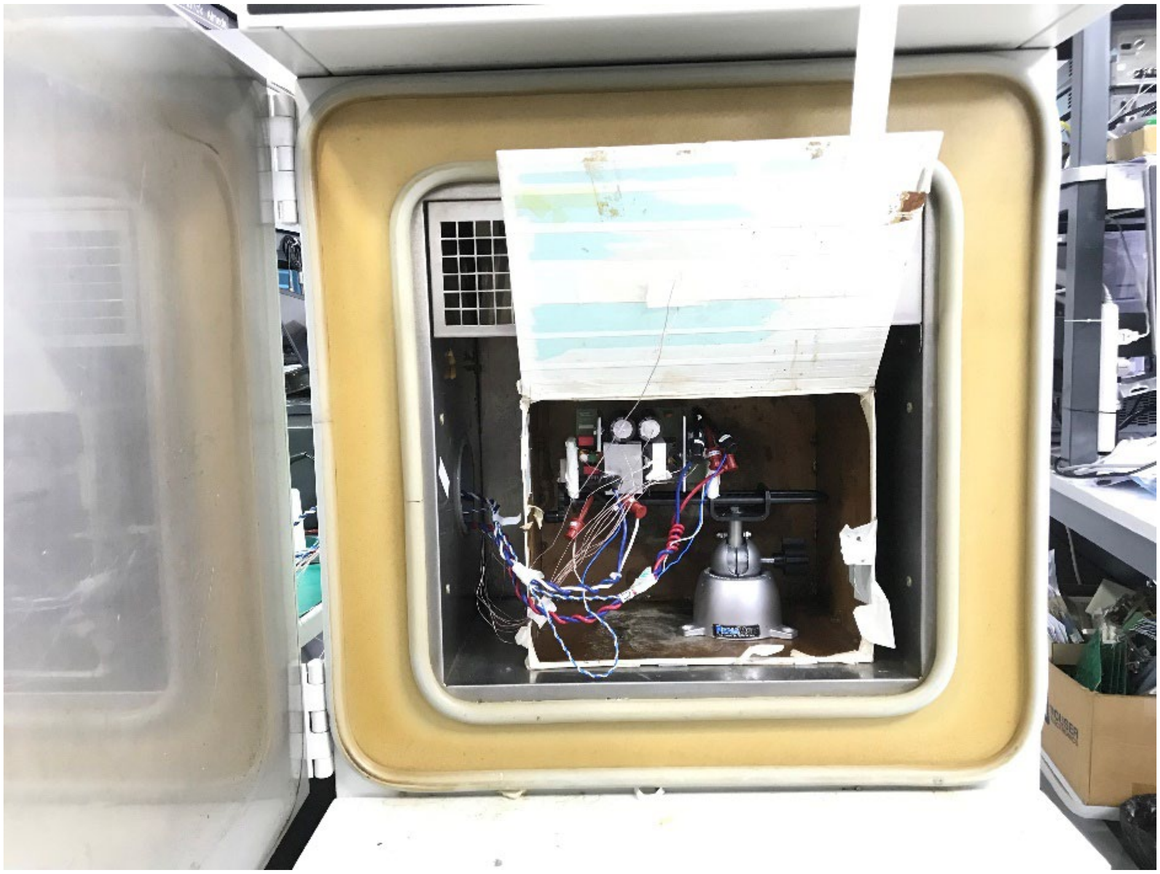


Figure 104 – Thermal Performance Set-up Using Thermal Chamber.

13.1 25 °C Ambient Thermals

To measure the temperature of components U2, T1, BR1, D4, D6, C9, C16, and L2, a T-type thermocouple was attached to each component. The thermal data were then fed to the data logger. A thermal chamber was utilized to maintain a constant ambient temperature at 25 °C.

13.1.1 85 VAC Full Load at 25 °C Ambient

Test result after 90 minutes at 85 VAC and full load.

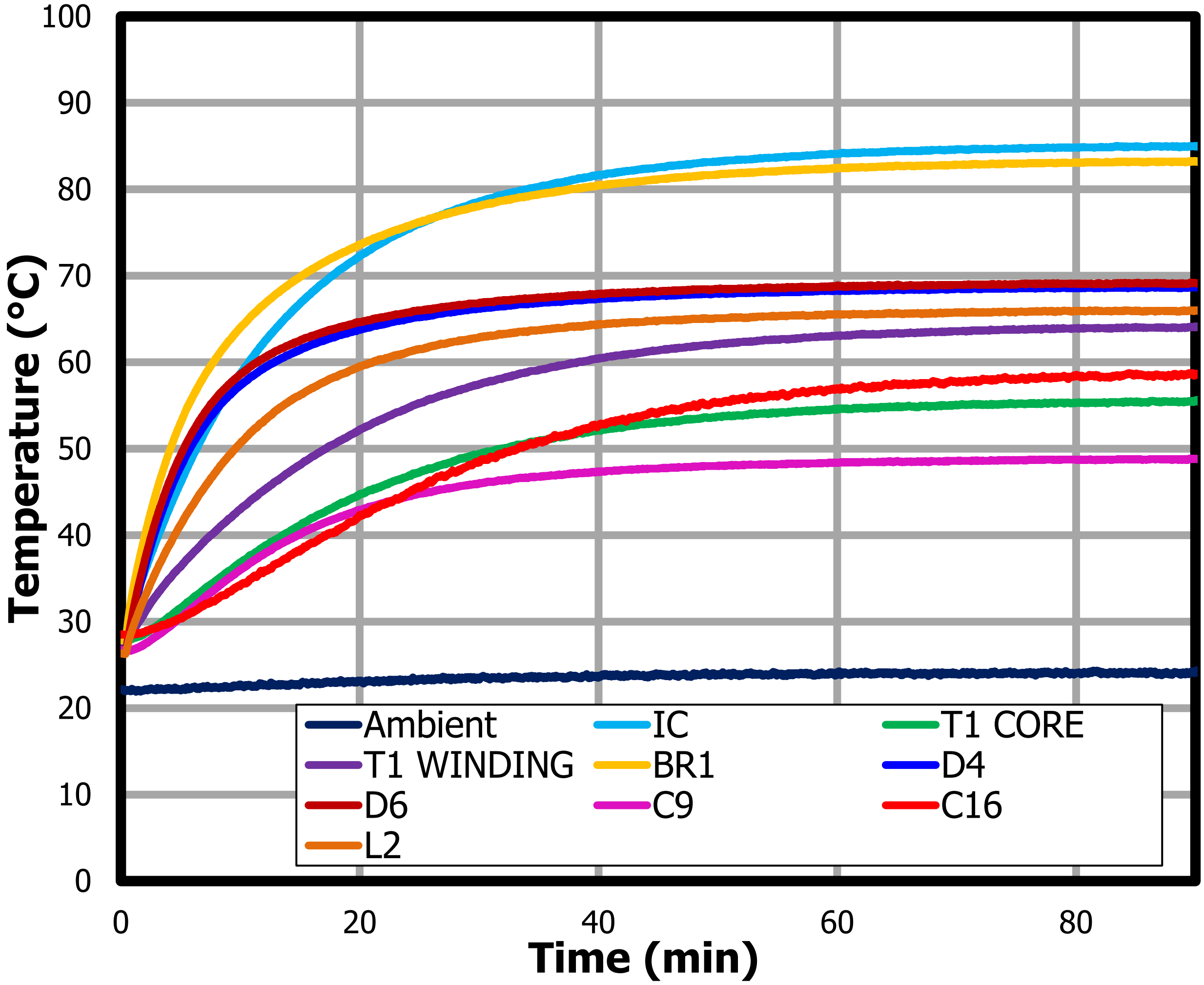


Figure 105 – 85 VAC 60 Hz. Top Side Discrete Component Thermals.

Component	Temperature (°C)
Ambient	24.1
TOP271EG (U2)	85.0
Transformer Core (T1)	55.6
Transformer Winding (T1)	64.2
Bridge (BR1)	83.2
FreeWheeling Diode (D4)	68.7
FreeWheeling Diode (D6)	69.1
Output Capacitor (C9)	48.8
Bulk Capacitor (C16)	58.7
CMC (L2)	66.0

Table 14 – 85 VAC 60Hz. Top Side Discrete Component Thermal Measurements.

13.1.2 265 VAC Full Load at 25 °C Ambient

Test result after 90 minutes at 265 VAC and full load.

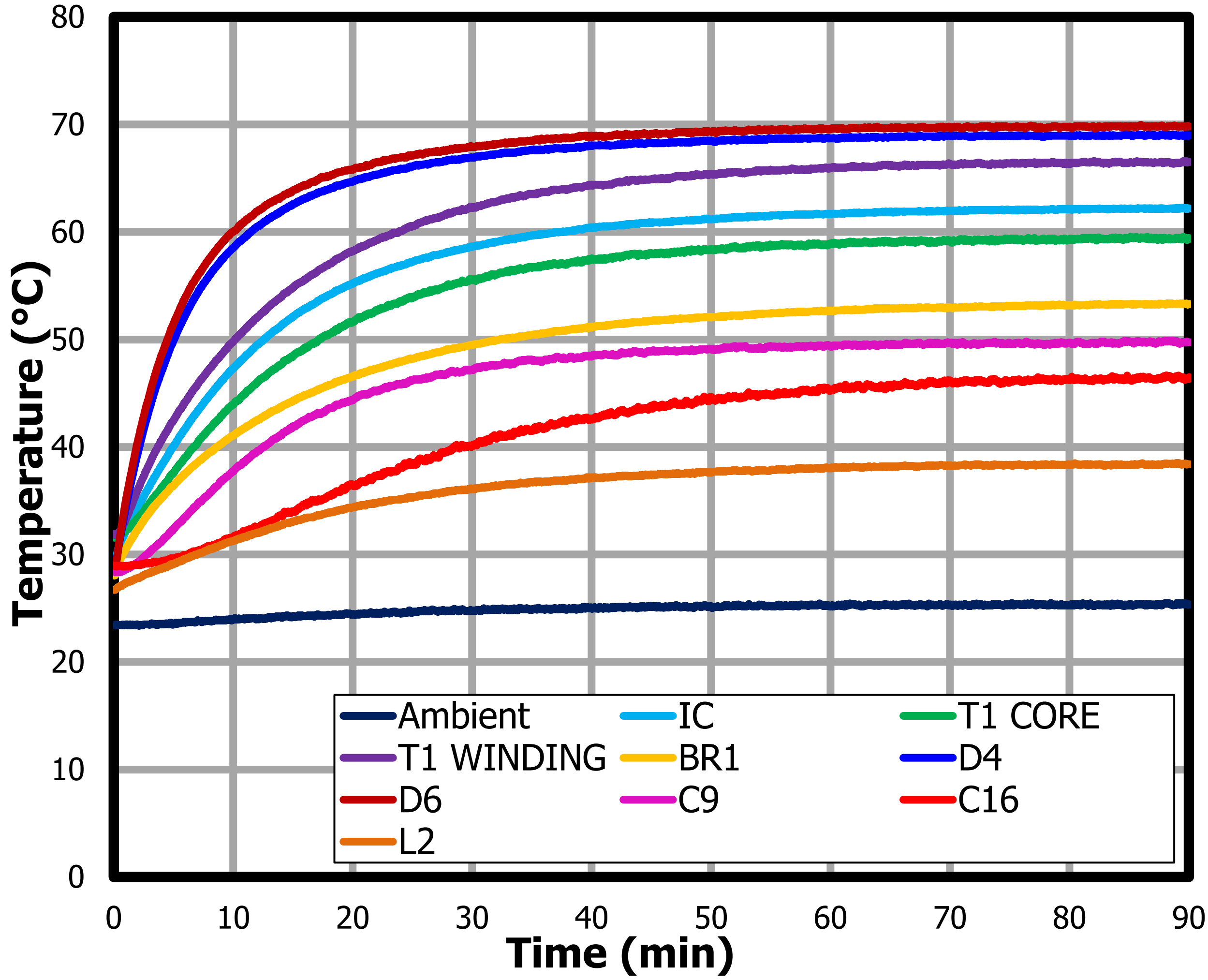


Figure 106 – 265 VAC 50 Hz. Top Side Discrete Component Thermals.

Component	Temperature (°C)
Ambient	25.4
TOP271EG (U2)	62.2
Transformer Core (T1)	59.4
Transformer Winding (T1)	66.5
Bridge (BR1)	53.3
FreeWheeling Diode (D4)	69.0
FreeWheeling Diode (D6)	69.8
Output Capacitor (C9)	49.8
Bulk Capacitor (C16)	46.4
CMC (L2)	38.4

Table 15 – 265 VAC 50Hz. Top Side Discrete Component Thermal Measurements.

13.2 40 °C Ambient Thermals

A thermal chamber is utilized to maintain a constant ambient temperature at 40 °C. To measure the temperature of the top side discrete components U2, T1, BR1, D4, D6, C9, C16, and L2, a T-type thermocouple was attached to each component. The thermal data were then fed to the data logger.

13.2.1 85 VAC Full Load at 40 ºC Ambient (Thermal Chamber)

Test result after 90 minutes at 85 VAC and full load.

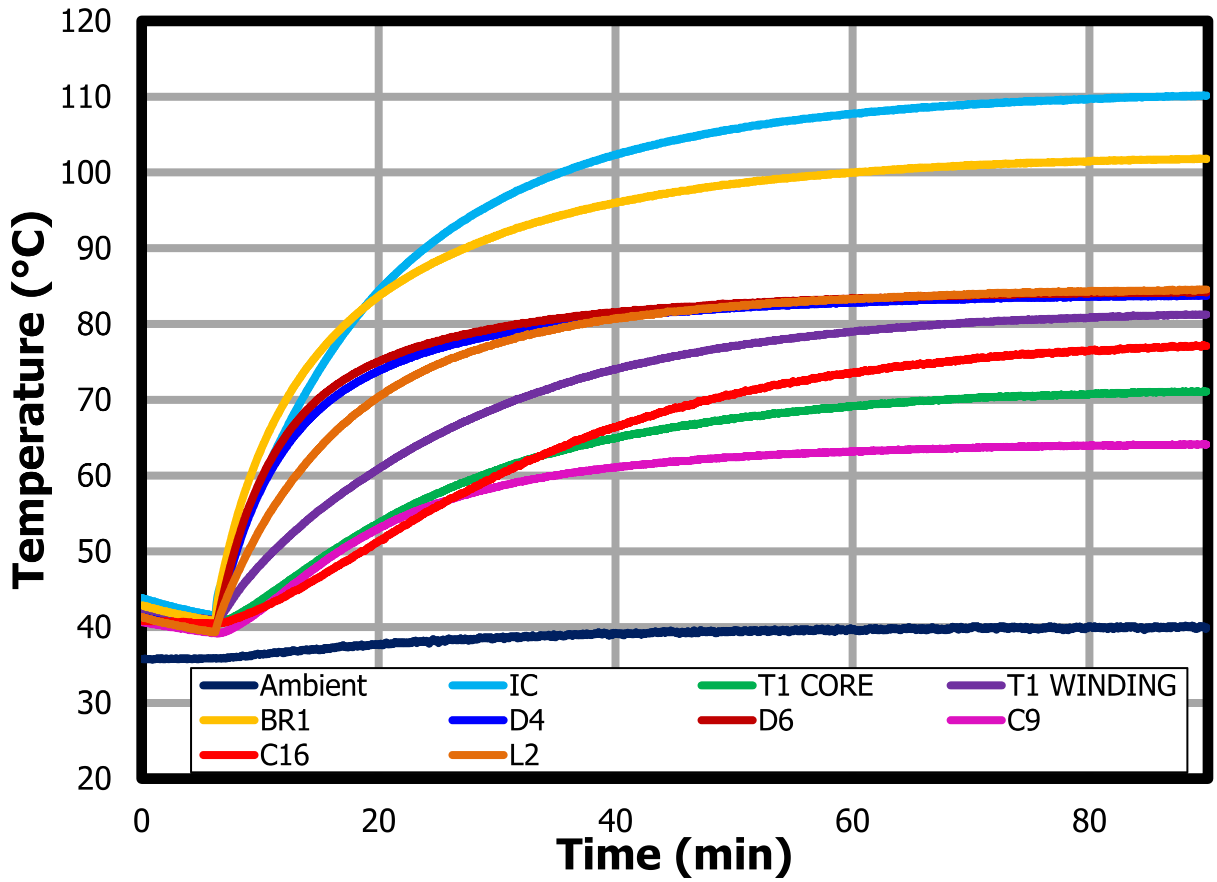


Figure 107 – 85 VAC 60 Hz. Thermals at 40 °C Ambient.

Component	Temperature (°C)
Ambient	40.0
TOP271EG (U2)	110
Transformer Core (T1)	71.1
Transformer Winding (T1)	81.3
Bridge (BR1)	102
FreeWheeling Diode (D4)	83.7
FreeWheeling Diode (D6)	84.2
Output Capacitor (C9)	64.1
Bulk Capacitor (C3)	77.1
CMC (L2)	84.6

Table 16 – 85 VAC 60Hz. Thermal Measurements at 40 °C Ambient.

13.2.2 265 VAC Full Load at 40 ºC Ambient (Thermal Chamber)

Test result after 90 minutes at 265 VAC and full load.

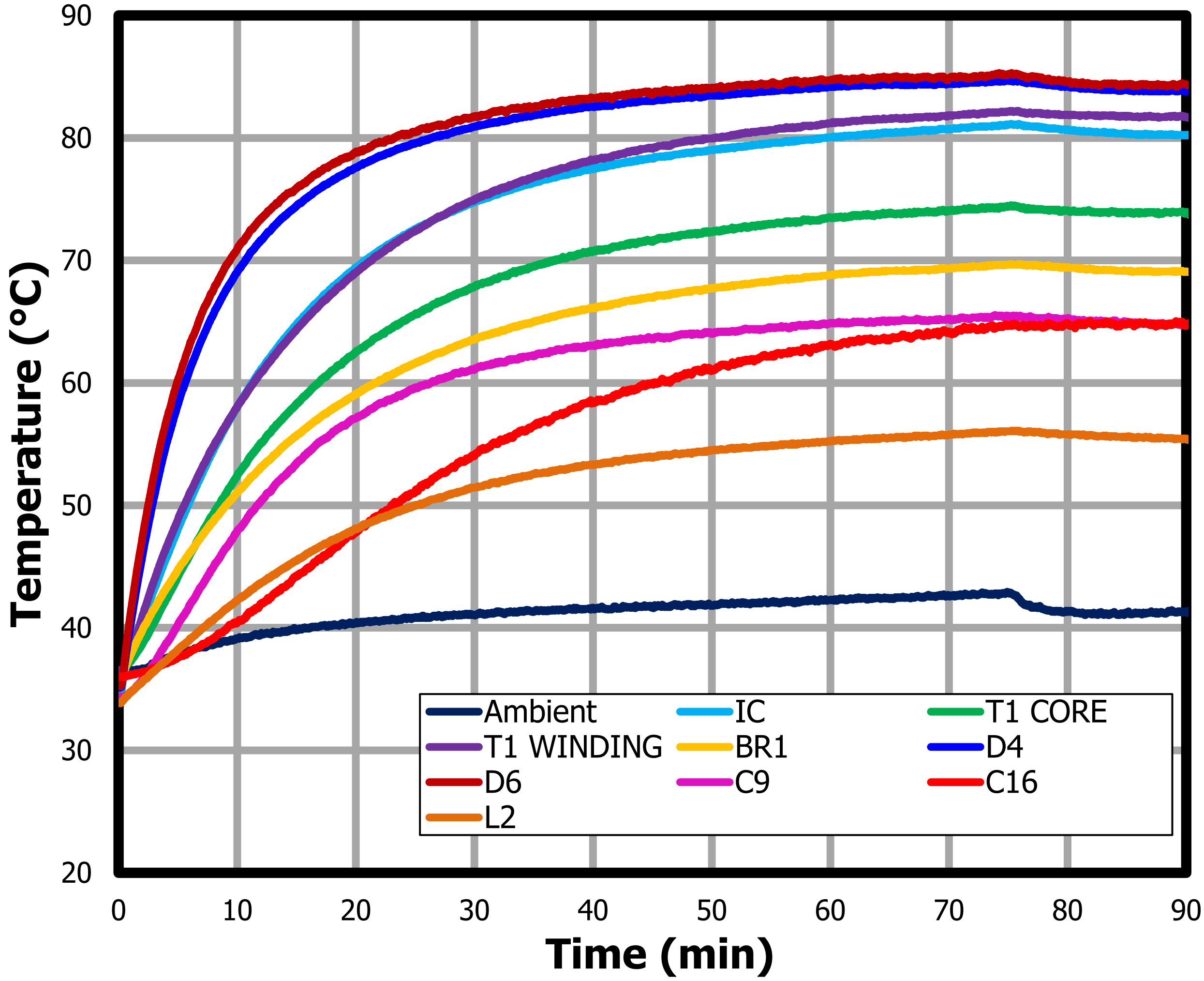


Figure 108 – 265 VAC 50 Hz. Thermals at 40 °C Ambient.

Component	Temperature (°C)
Ambient	41.4
TOP271EG (U2)	80.3
Transformer Core (T1)	73.9
Transformer Winding (T1)	81.7
Bridge (BR1)	69.1
FreeWheeling Diode (D4)	83.9
FreeWheeling Diode (D6)	84.4
Output Capacitor (C9)	64.9
Bulk Capacitor (C16)	65.0
CMC (L2)	55.5

Table 17 – 265 VAC 50Hz. Thermal Measurements at 40 °C Ambient.

14 Fault Condition

14.1 Output Short-Circuit Protection

14.1.1 Start-Up Short-Circuit

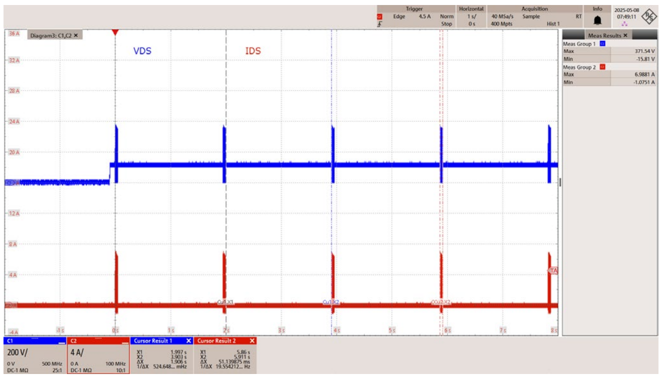


Figure 109 – 85 VAC 60 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 372 V
$I_{DS(MAX)}$ = 6.99 A
t_{AR_ON} = 51.1 ms
t_{AR_OFF} = 1.91 s

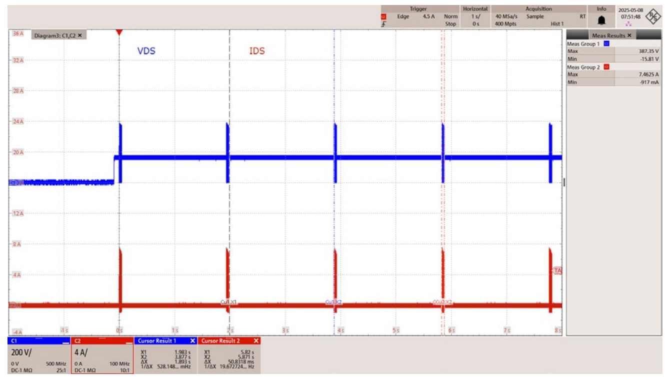


Figure 110 – 115 VAC 60 Hz Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 387 V
$I_{DS(MAX)}$ = 7.46 A
t_{AR_ON} = 50.8 ms
t_{AR_OFF} = 1.89 s

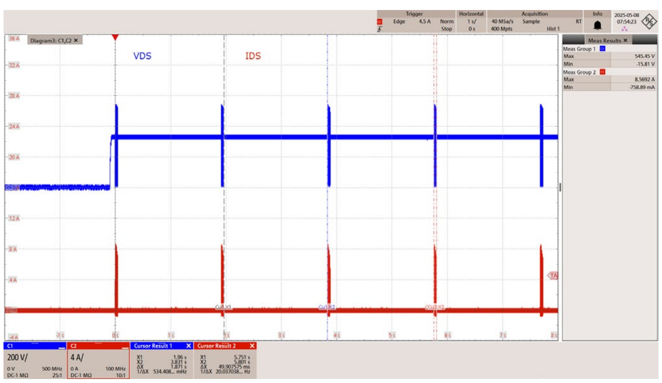


Figure 111 –230 VAC 50 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 545 V
$I_{DS(MAX)}$ = 8.57 A
t_{AR_ON} = 49.9 ms
t_{AR_OFF} = 1.87 s

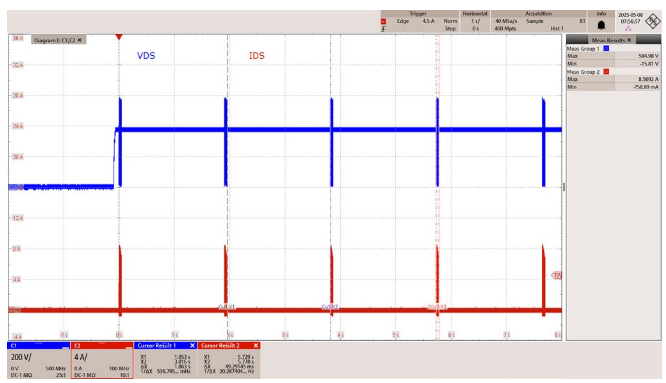


Figure 112 –265 VAC 50 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 585 V
$I_{DS(MAX)}$ = 8.57 A
t_{AR_ON} = 49.3 ms
t_{AR_OFF} = 1.86 s

14.1.2 Running Short-Circuit

14.1.2.1 Full Load To Short-Circuit

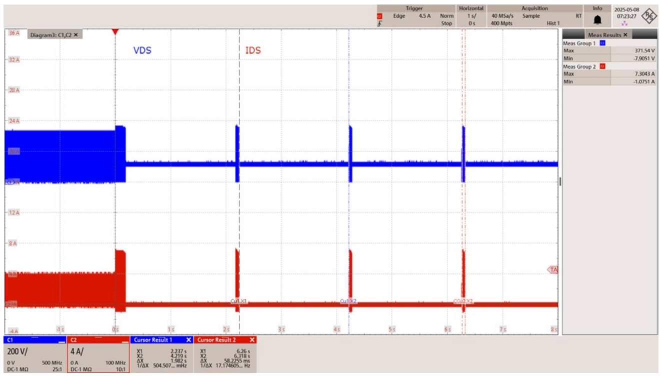


Figure 113 – 85 VAC 60 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 372 V
$I_{DS(MAX)}$ = 7.3 A
t_{AR_ON} = 58.2 ms
t_{AR_OFF} = 1.98 s

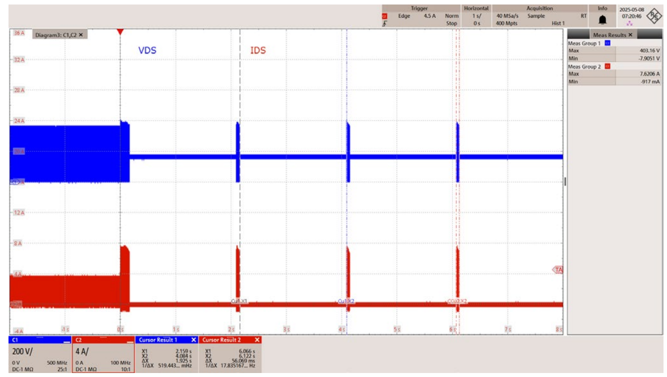


Figure 114 – 115 VAC 60 Hz Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 403 V
$I_{DS(MAX)}$ = 7.62 A
t_{AR_ON} = 56.1 ms
t_{AR_OFF} = 1.93 s

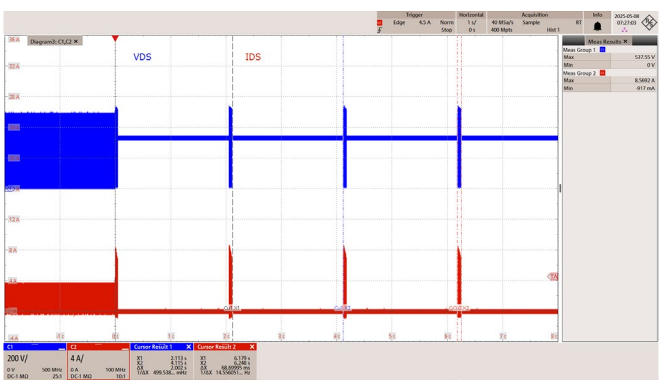


Figure 115 –230 VAC 50 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 538 V
$I_{DS(MAX)}$ = 8.57 A
t_{AR_ON} = 68.7 ms
t_{AR_OFF} = 2 s

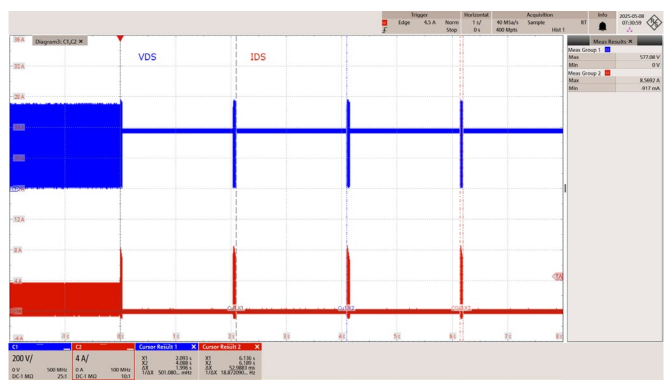


Figure 116 –265 VAC 50 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 577 V
$I_{DS(MAX)}$ = 8.57 A
t_{AR_ON} = 53 ms
t_{AR_OFF} = 2 s

14.1.2.2 No Load To Short-Circuit

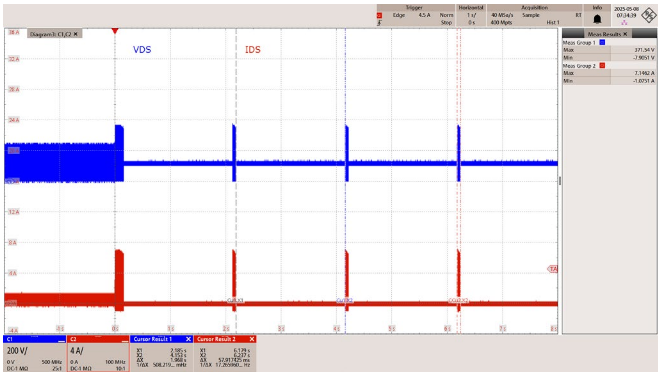


Figure 117 – 85 VAC 60 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 372 V
$I_{DS(MAX)}$ = 7.15 A
t_{AR_ON} = 57.9 ms
t_{AR_OFF} = 1.97 s

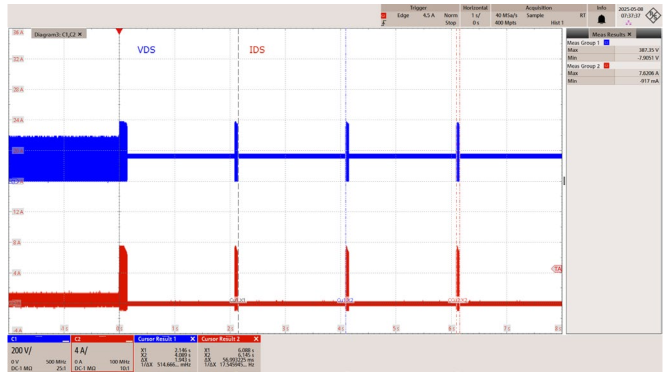


Figure 118 – 115 VAC 60 Hz Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 387 V
$I_{DS(MAX)}$ = 7.62 A
t_{AR_ON} = 57 ms
t_{AR_OFF} = 1.94 s

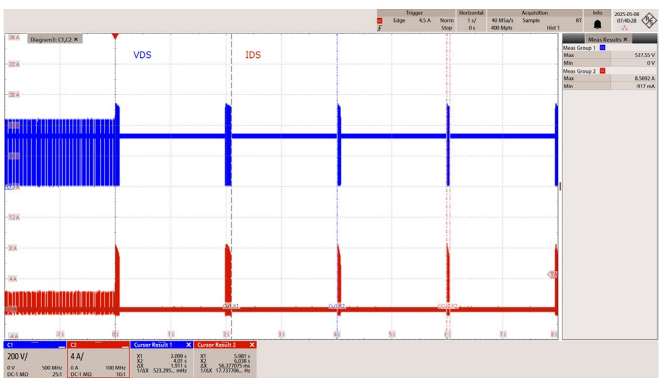


Figure 119 – 230 VAC 50 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 538 V
$I_{DS(MAX)}$ = 8.57 A
t_{AR_ON} = 56.4 ms
t_{AR_OFF} = 1.91 s

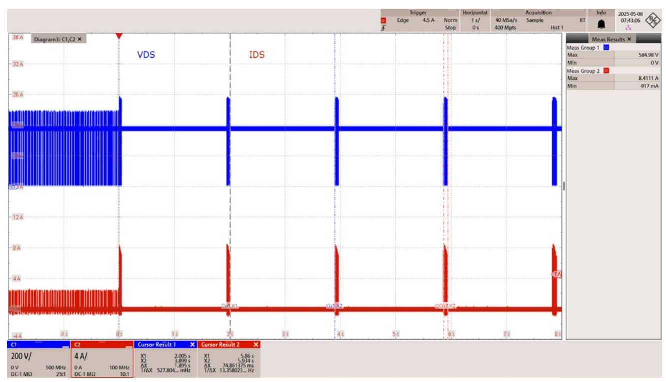


Figure 120 –265 VAC 50 Hz. Output Short.
CH1: V_{DS}, 200 V / div., 1 s / div.
CH2: I_{DS}, 4 A / div., 1 s / div.
$V_{DS(MAX)}$ = 585 V
$I_{DS(MAX)}$ = 8.41 A
t_{AR_ON} = 74.9 ms
t_{AR_OFF} = 1.9 s

Component	Temperature (°C)
Ambient	25.3
TOP271EG (U2)	26.2
Transformer Core (T1)	26.2
Transformer Winding (T1)	26.4
Bridge (BR1)	25.5
FreeWheeling Diode (D4)	28.4
FreeWheeling Diode (D6)	28.5
Output Capacitor (C9)	26.5
Bulk Capacitor (C16)	25.4
CMC (L2)	25.4

Table 18 – 85 VAC 60 Hz. Discrete Component Temperatures Output Short
(1 hr. soak inside thermal chamber)

Component	Temperature (°C)
Ambient	25.5
TOP271EG (U2)	28.0
Transformer Core (T1)	26.8
Transformer Winding (T1)	27.1
Bridge (BR1)	25.9
FreeWheeling Diode (D4)	28.8
FreeWheeling Diode (D6)	28.9
Output Capacitor (C9)	26.9
Bulk Capacitor (C16)	26.2
CMC (L2)	25.8

Table 19 – 265 VAC 50 Hz. Discrete Component Temperatures Output Short
(1 hr. soak inside thermal chamber)

14.2 Output Overvoltage Protection

Output overvoltage condition was simulated by opening feedback resistor R18. Overvoltage protection was implemented by primary-side output overvoltage circuit VR1, D1, and R12.

14.2.1 Start-Up OVP

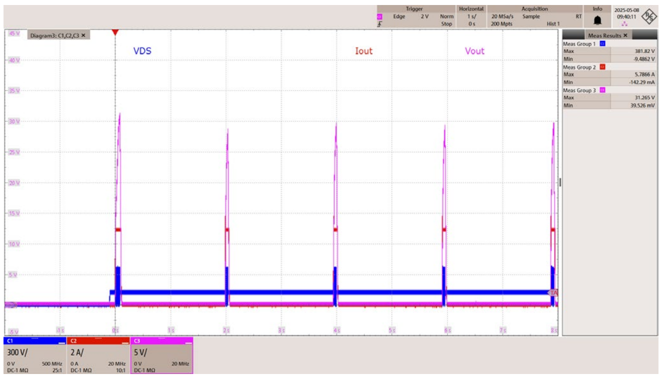


Figure 121 – 85 VAC 60 Hz. Full Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 31.3 V

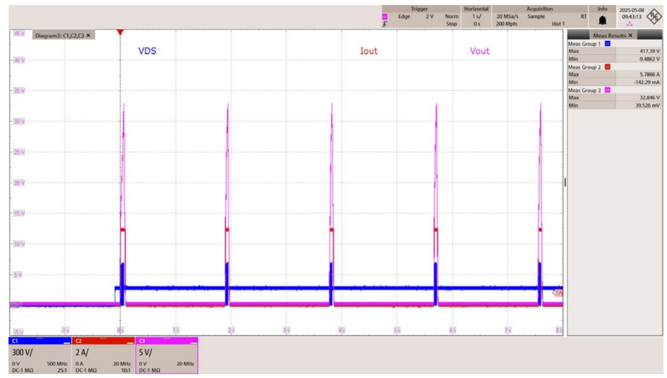


Figure 122 – 115 VAC 60 Hz. Full Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 32.8 V

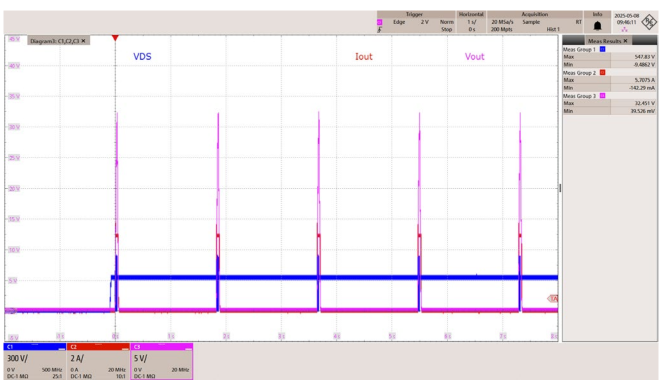


Figure 123 – 230 VAC 50 Hz. Full Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 32.5 V

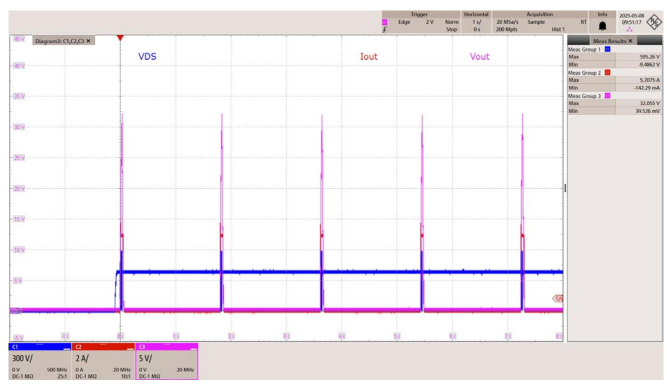


Figure 124 – 265 VAC 50 Hz. Full Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 32.1 V

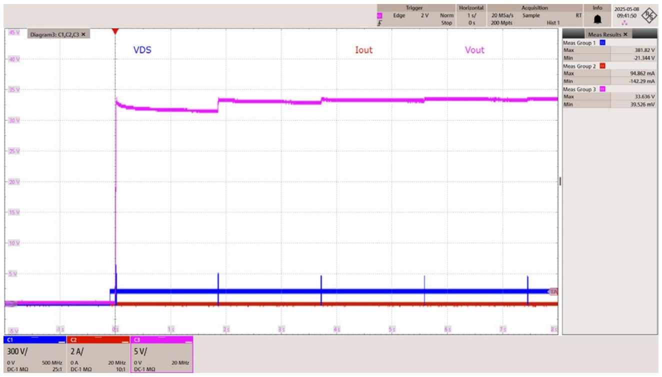


Figure 125 – 85 VAC 60 Hz. No Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 33.6 V

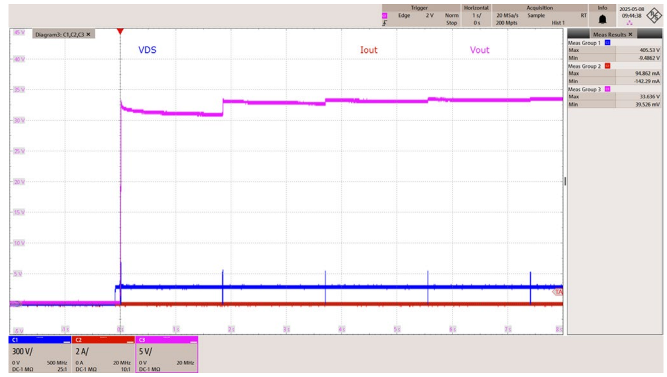


Figure 126 – 115 VAC 60 Hz. No Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 33.6 V

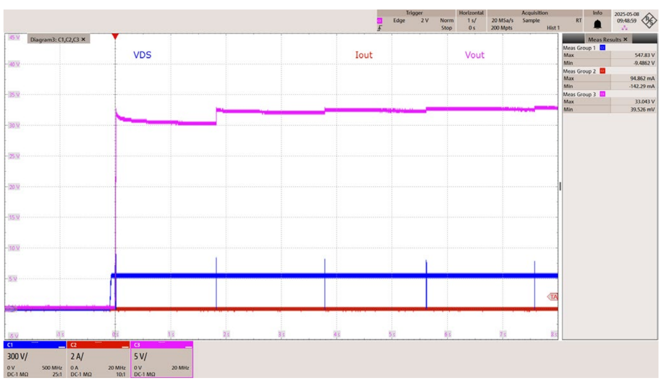


Figure 127 – 230 VAC 50 Hz. No Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 33 V

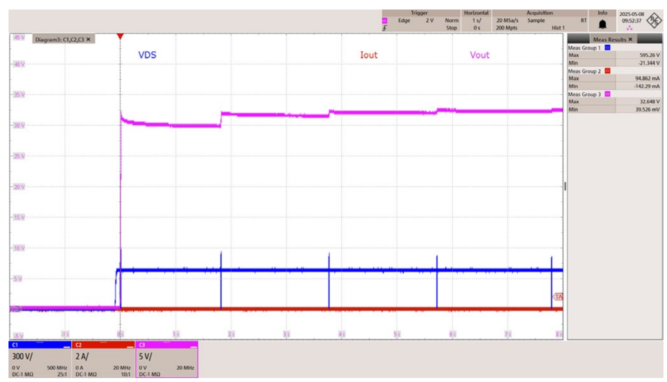
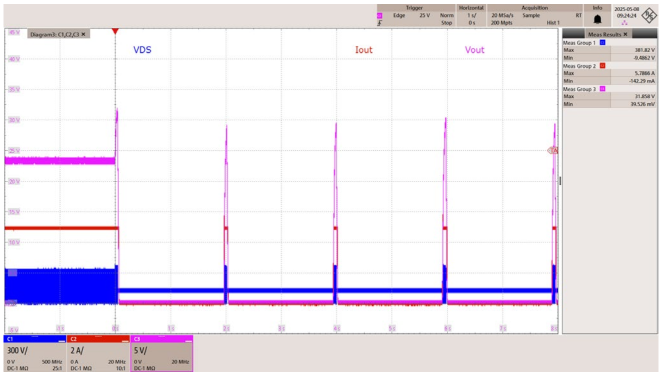


Figure 128 – 265 VAC 50 Hz. No Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 32.6 V

14.2.2 OVP Triggered During Normal Operation



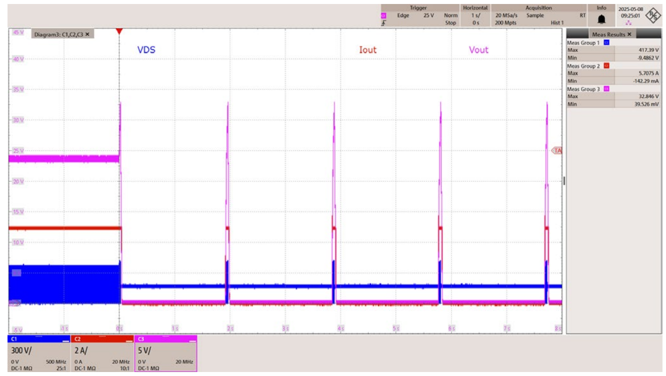
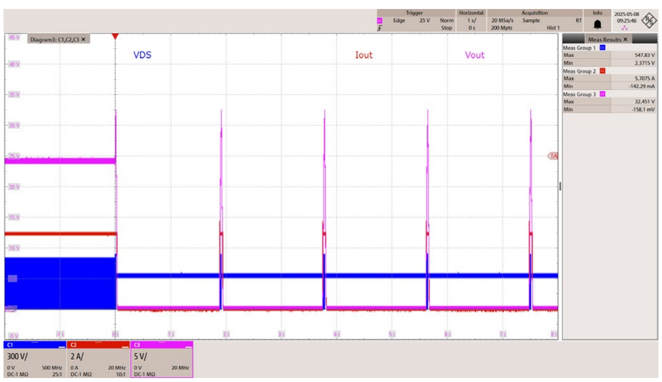


Figure 129 – 85 VAC 60 Hz. Full Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 31.9 V

Figure 130 – 115 VAC 60 Hz. Full Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 32.8 V



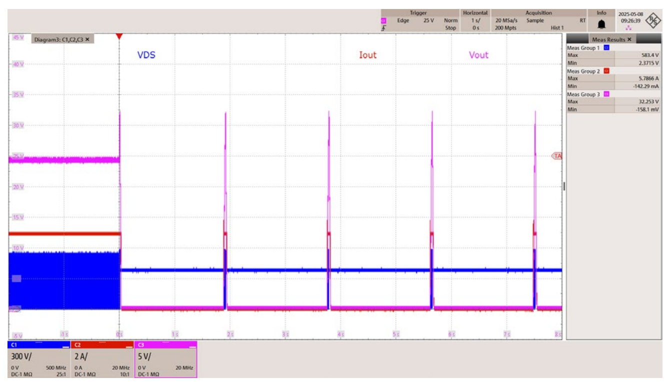


Figure 131 – 230 VAC 50 Hz. Full Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 32.5 V

Figure 132 – 265 VAC 50 Hz. Full Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 32.3 V

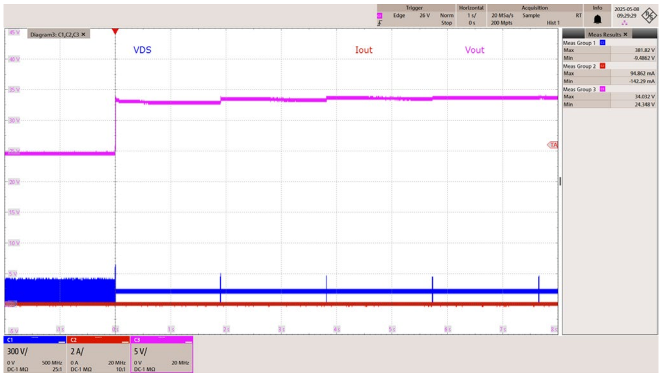


Figure 133 – 85 VAC 60 Hz. No Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 34 V

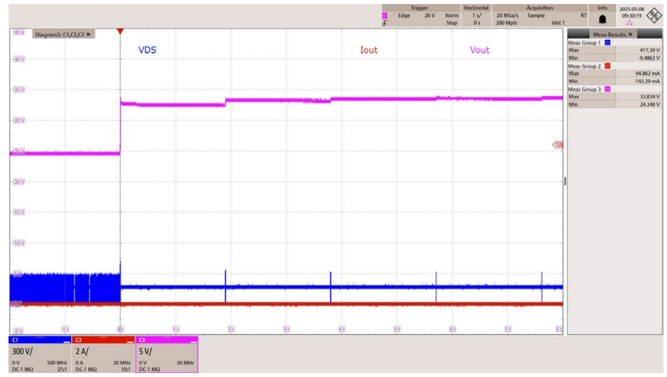


Figure 134 – 115 VAC 60 Hz. No Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 33.8 V

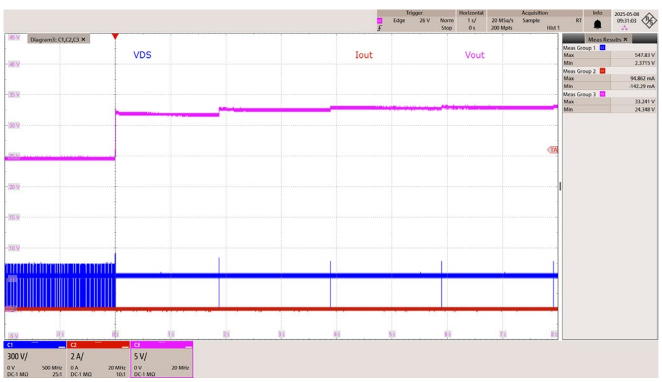


Figure 135 – 230 VAC 50 Hz. No Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 33.2 V

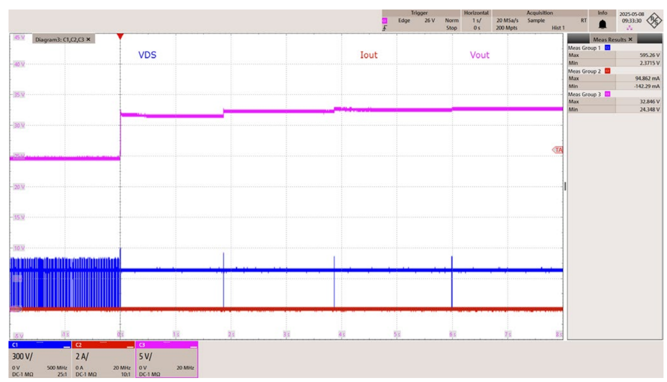


Figure 136 – 265 VAC 50 Hz. No Load.
CH1: V_{DS}, 300 V / div., 1 s / div.
CH2: I_{OUT} 2 A / div., 1 s / div.
CH3: V_{OUT}, 5 V / div., 1 s / div.
$VOUT_{MAX}$: 32.8 V

14.3 Over Temperature Protection (OTP) and Hysteresis

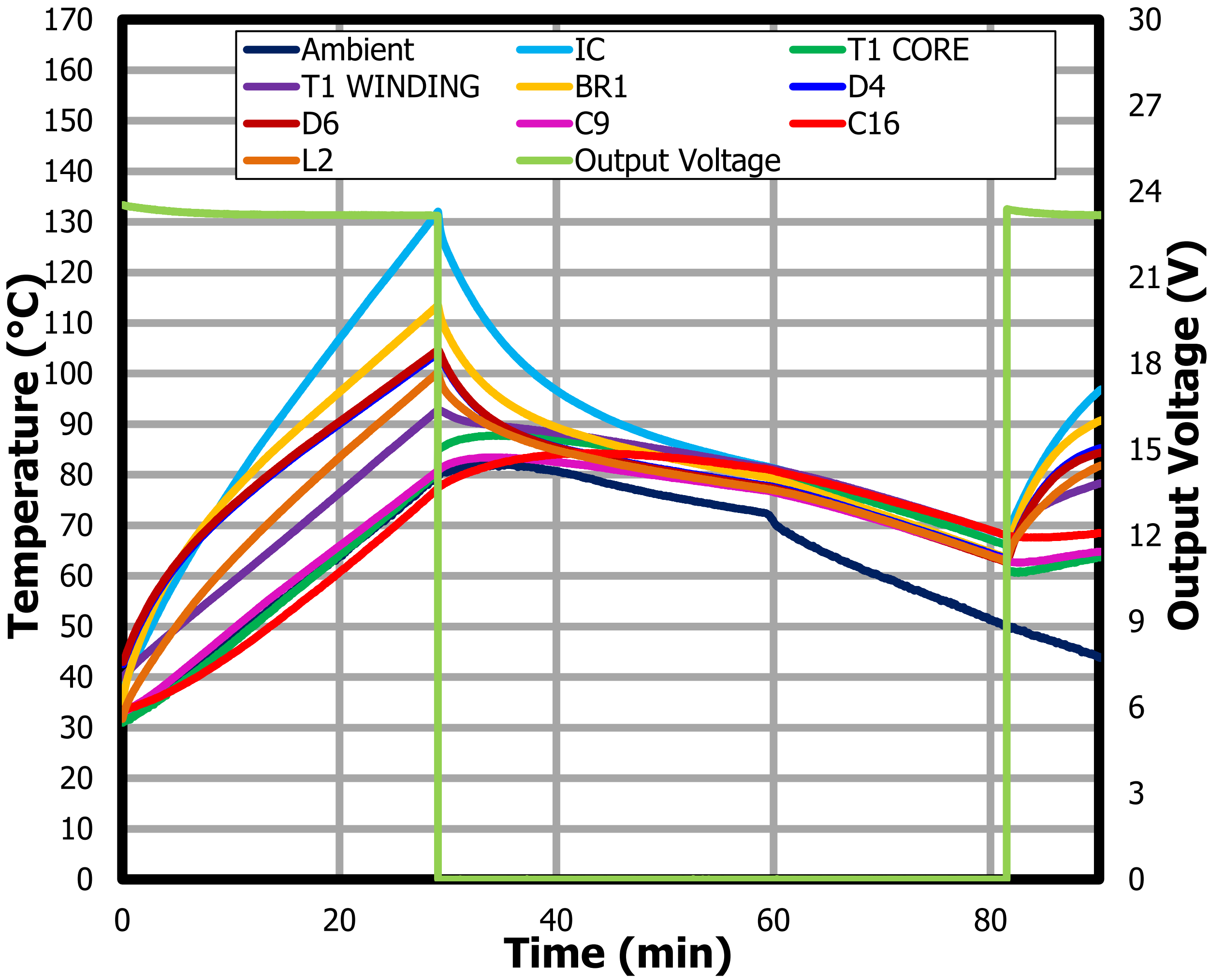


Figure 137 – 85 VAC 60 Hz. Full Load OTP.

Component	At OTP Trigger Temperature (°C)	At Recovery Temperature (°C)
Ambient	79.8	50.1
TOP271EG (U2)	132	66.0
Transformer Core (T1)	84.9	60.8
Transformer Winding (T1)	92.9	67.9
Bridge (BR1)	114	63.6
FreeWheeling Diode (D4)	104	63.6
FreeWheeling Diode (D6)	105	62.7
Output Capacitor (C9)	80.8	63.0
Bulk Capacitor (C16)	77.4	68.0
CMC (L2)	100	62.9

Table 20 – 85 VAC 60 Hz. Full Load IC Temperature during OTP and recovery.

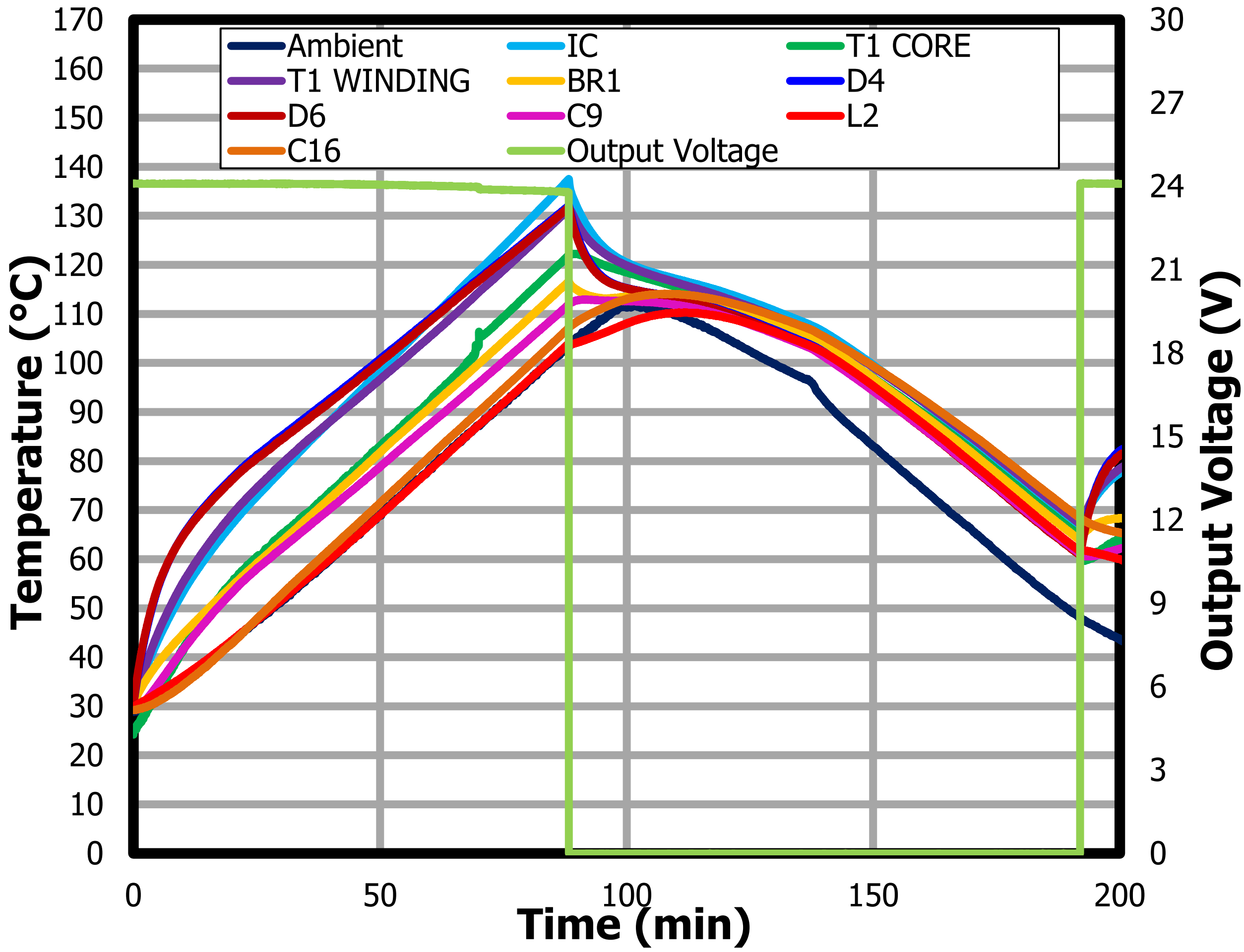


Figure 138 – 265 VAC 50 Hz. Full Load OTP.

Component	At OTP Trigger Temperature (°C)	At Recovery Temperature (°C)
Ambient	104	48.0
TOP271EG (U2)	138	66.1
Transformer Core (T1)	122	64.8
Transformer Winding (T1)	131	67.2
Bridge (BR1)	117	63.8
FreeWheeling Diode (D4)	132	61.5
FreeWheeling Diode (D6)	132	60.8
Output Capacitor (C9)	112	61.1
Bulk Capacitor (C16)	107	68.3
CMC (L2)	104	61.6

Table 21 – 265 VAC 50 Hz. Full Load IC Temperature during OTP and recovery.

Input (VAC)	IC Temperature (°C)	
	OTP Shutdown	Recover
85	132	66.0
265	138	66.1

Table 22 – Summary of IC OTP Shutdown and Recovery temperatures.

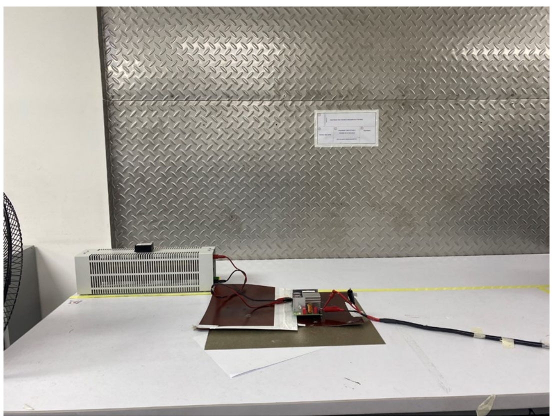
15 Conducted EMI

Conducted emissions tests were performed at 115 VAC and 230 VAC at full load (24 V and 5 A). Measurements were taken with floating ground.

15.1 Test Set-up Equipment

15.1.1 Equipment and Load Used

1. Rohde and Schwarz ENV216 two-line V-network.
2. Rohde and Schwarz ESRP EMI test receiver.
3. Yokogawa WT310E digital power meter.
4. Chroma measurement test fixture A662003.
5. Input voltage set at 115 VAC and 230 VAC.
6. 24 V RLOAD resistance is 4.8 ohms.



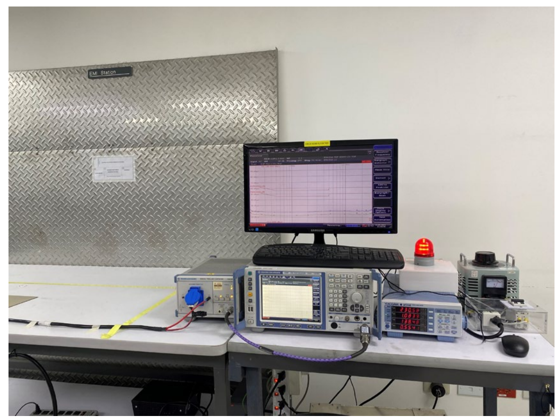


Figure 139 – EMI Test Set-up.

15.2 Output Float

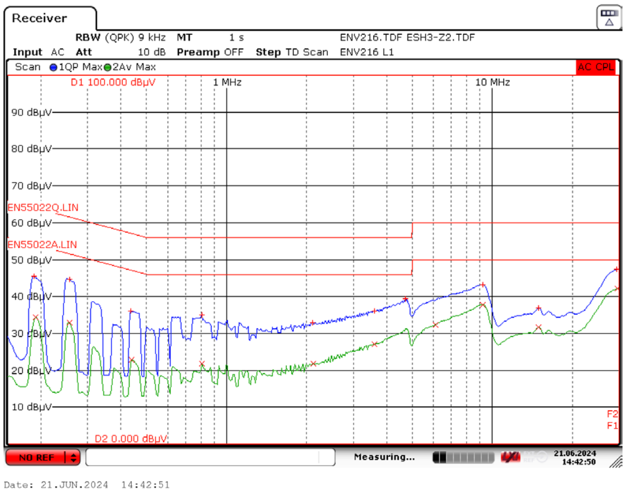


Figure 140 – 115 VAC 60 Hz.
Line with Floating

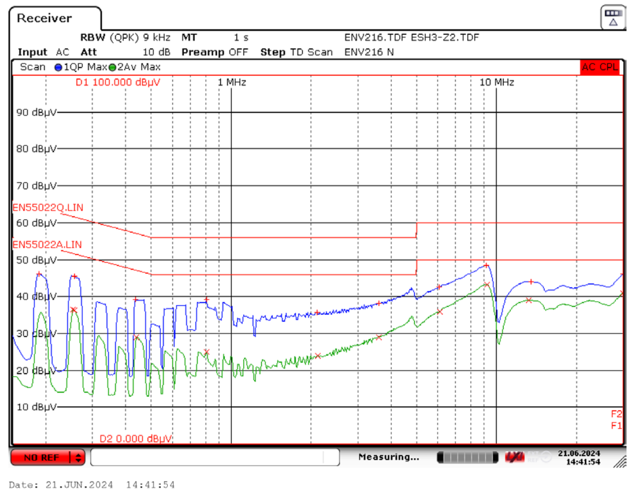


Figure 141 – 115 VAC 60 Hz.
Neutral with Floating

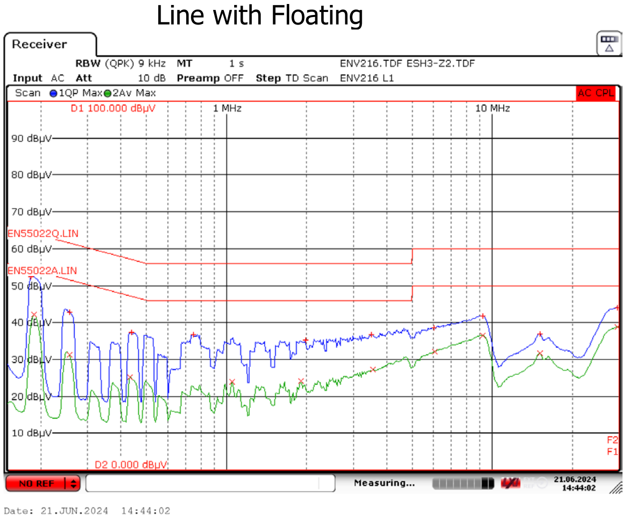


Figure 142 – 230 VAC 60 Hz.
Line with Floating

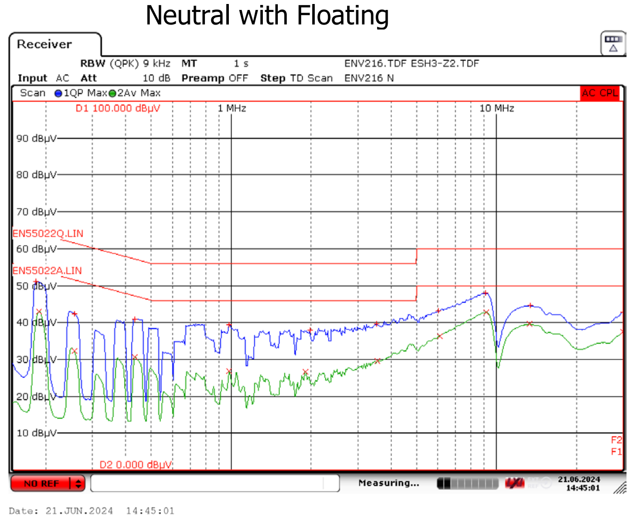


Figure 143 – 230 VAC 60 Hz.
Neutral with Floating

16 Line Surge

IEC61000-4-5 differential mode and common mode input line surge testing was completed on a single test unit. Input voltage was set at 230 VAC / 60 Hz. Output was loaded to full load and operation was verified following each surge event.

16.1 Differential Mode Surge

DM Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
+1000	230	L to N	0	PASS – No AR
-1000	230	L to N	0	PASS – No AR
+1000	230	L to N	90	PASS – No AR
-1000	230	L to N	90	PASS – No AR
+1000	230	L to N	180	PASS – No AR
-1000	230	L to N	180	PASS – No AR
+1000	230	L to N	270	PASS – No AR
-1000	230	L to N	270	PASS – No AR

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

Table 23 – Differential Mode Surge Test Summary.

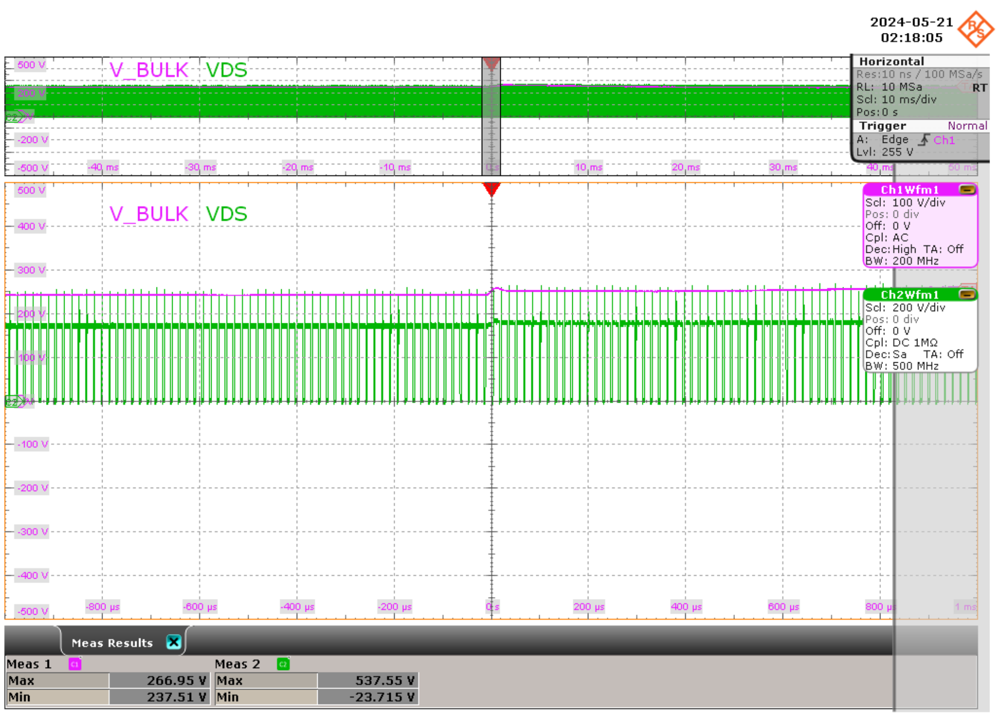


Figure 144 – Differential Mode Surge Input AC and V_{DS} Waveform.
Ch1: Bulk Voltage 100 V / div., 10 ms / div.
Ch2: V_{DS} 200 V / div., 10 ms /div.
Zoom: 200 μs / div.
$V_{DS(MAX)}$: 538 V.

16.2 Common Mode Ring Wave Surge

Surge Voltage	Phase Angle	IEC Coupling	Generator Impedance	Number Strikes	Result
+4000V	0º	L,N → PE	12 Ω	10	PASS – No AR
–4000V	0º	L,N → PE	12 Ω	10	PASS – No AR
+4000V	90º	L,N → PE	12 Ω	10	PASS – No AR
–4000V	90º	L,N → PE	12 Ω	10	PASS – No AR
+4000V	270º	L,N → PE	12 Ω	10	PASS – No AR
–4000V	270º	L,N → PE	12 Ω	10	PASS – No AR

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

Table 24 – Common Mode Ring Wave Surge Test Summary.

17 EFT

Input voltage was set at 230 VAC / 60 Hz. Output was loaded at full load and operation was verified following each surge event.

Surge Voltage	Phase Angle	IEC Coupling	Frequency	Burst Time	Reception Time	Step Duration	Result
+4000V	0º	L to N	5 kHz	15 ms	300 ms	120 s	PASS – No AR
–4000V	0º	L to N	5 kHz	15 ms	300 ms	120 s	PASS – No AR
+4000V	0º	L to N	100 kHz	750 μs	300 ms	120 s	PASS – No AR
–4000V	0º	L to N	100 kHz	750 μs	300 ms	120 s	PASS – No AR
+4000V	90º	L to N	5 kHz	15 ms	300 ms	120 s	PASS – No AR
–4000V	90º	L to N	5 kHz	15 ms	300 ms	120 s	PASS – No AR
+4000V	90º	L to N	100 kHz	750 μs	300 ms	120 s	PASS – No AR
–4000V	90º	L to N	100 kHz	750 μs	300 ms	120 s	PASS – No AR
+4000V	180º	L to N	5 kHz	15 ms	300 ms	120 s	PASS – No AR
–4000V	180º	L to N	5 kHz	15 ms	300 ms	120 s	PASS – No AR
+4000V	180º	L to N	100 kHz	750 μs	300 ms	120 s	PASS – No AR
–4000V	180º	L to N	100 kHz	750 μs	300 ms	120 s	PASS – No AR
+4000V	270º	L to N	5 kHz	15 ms	300 ms	120 s	PASS – No AR
–4000V	270º	L to N	5 kHz	15 ms	300 ms	120 s	PASS – No AR
+4000V	270º	L to N	100 kHz	750 μs	300 ms	120 s	PASS – No AR
–4000V	270º	L to N	100 kHz	750 μs	300 ms	120 s	PASS – No AR

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

Table 25 – EFT Test Summary.

18 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	24 V	10	PASS – No AR
-8.8	24 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.

Table 26 – ESD Contact Discharge Test Summary.

Passed ±16.5 kV air discharge

Air Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+16.5	24 V	10	PASS – No AR
-16.5	24 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.

Table 27 – ESD Air Discharge Test Summary.

19 Revision History

Date	Author	Revision	Description and Changes	Reviewed
9-July-25	RPL/RMD/KCP/RPA	A	Initial Release.	Apps & Mktg

For the latest updates, visit our website: www.power.com

For patent information, Life support policy, trademark information and to access a list of Power Integrations worldwide Sales and engineering support locations and services, please use the links below.

https://www.power.com/company/sales/sales-offices

Power Integrations, Inc.
Tel: +1 408 414 9200 Fax: +1 408 414 9201
www.power.com