Design Example Report

Title	**120 W Isolated Flyback Power Supply Using TinySwitch™-5 TNY5077E**
Specification	85 VAC – 265 VAC Input; 24.0 V / 5 A Output
Application	Appliance
Author	Applications Engineering Department
Document Number	DER-1027
Date	March 11, 2025
Revision	A

Summary and Features

- Up to 150 kHz switching frequency for small transformer.
- >90% full load efficiency @ 115 VAC and >91% full load efficiency @ 230 VAC
- >90% average efficiency @ 115 VAC and 230 VAC
- <80 mW no-load input power at 230 VAC
- Continuous 120 W output power from 85 VAC to 265 VAC
- Extensive protection features including
  - Line UVP
  - Line OVP
  - OTP
  - Short Circuit Protection
  - Over Power Protection.
- Class B Conducted EMI with > 6db margin.

Power Integrations

5245 Hellyer Avenue, San Jose, CA 95138 USA.

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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 designed to provide an isolated nominal output voltage of 24 V at 5 A load from a wide input voltage range of 85 VAC to 265 VAC. This power supply utilizes the TNY5077E from the TinySwitch-5 family of ICs.

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

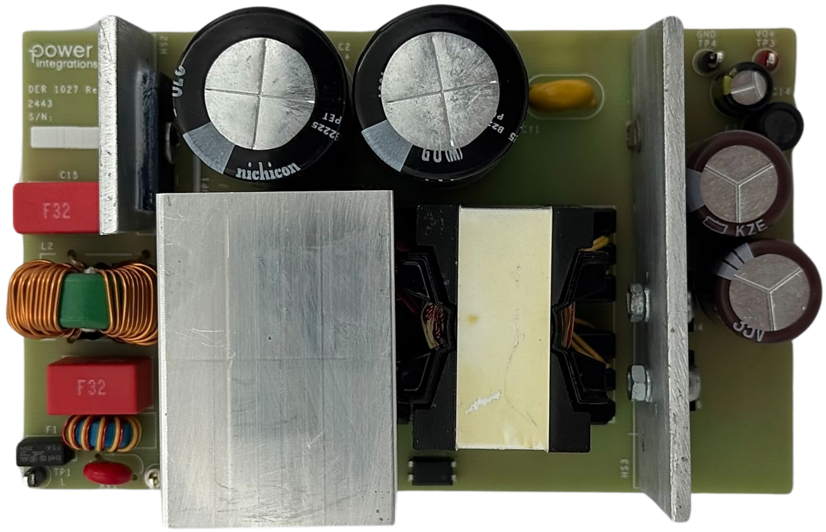


Figure 1 – Photograph, Top View.

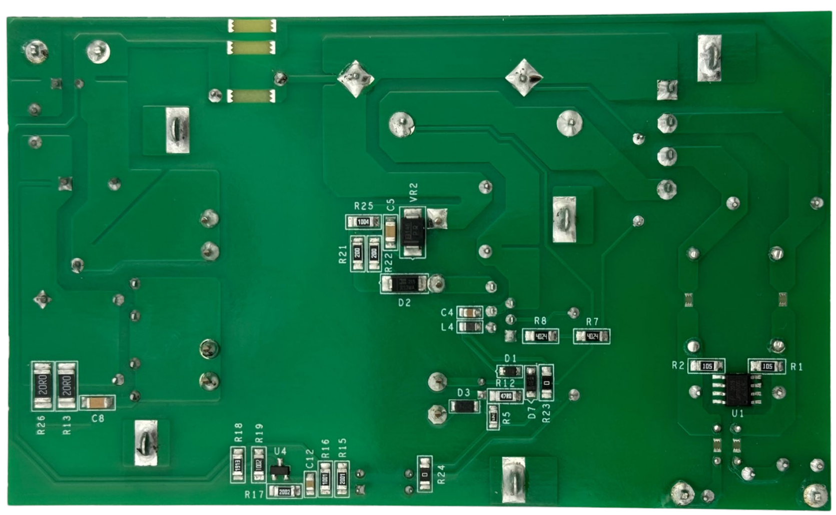


Figure 2 – Photograph, Bottom View.

Figure 3 – Photograph, Side View.

2 Power Supply Specification

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

Description	Symbol	Min	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)				80	mW	
Output1						
Output Voltage	V_{OUT1}	22.8	24	25.2	V	± 5%
Output Ripple Voltage	$V_{RIPPLE1}$			240	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	$\eta_{115\ VAC}$	89			%	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}	90			%	Measured at Nominal Input 115 VAC and 230 VAC.
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Surge (Differential)				±2	kV	1.2/50 µs Surge, IEC 61000-4-5
Ring Wave (Common Mode)				±6	kV	
Electrical Fast Transient				±4	kV	
ESD – Air Discharge				±16.5	kV	
ESD – Contact Discharge				±8.8	kV	
Ambient Temperature	T_{AMB}	0		40	°C	Free Convection, Sea Level.

3 Schematic

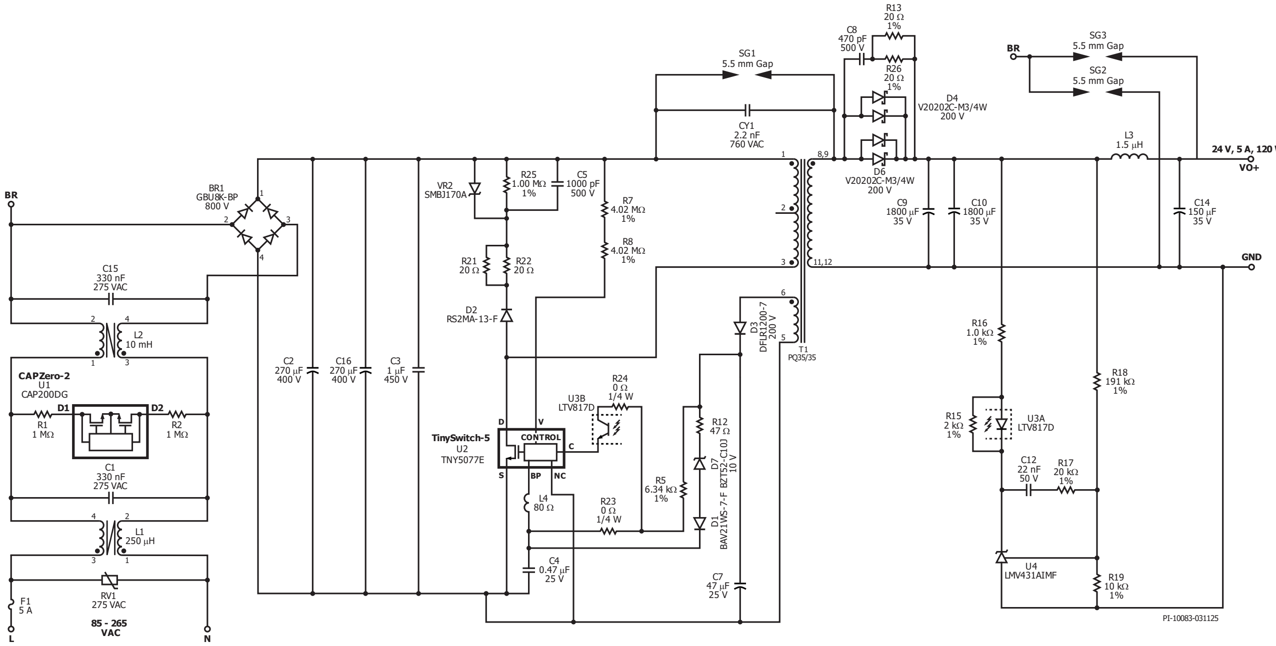


Figure 4 – DER-1027 Schematic

4 Circuit Description

This power supply employs a TNY5077E off-line switcher, (U2), in a flyback configuration. IC U2 has an integrated 725 V power MOSFET. It regulates the output by adjusting the power MOSFET off time duration, which is proportional to the current fed into its CONTROL pin.

4.1 Input EMI Filtering and Rectification

Fuse F1 isolates the circuit and provides protection from component failure. Varistor RV1 suppresses line transient voltage surge seen by the power supply. X capacitors C1 and C15 together with common mode choke L1 and L2 form an EMI filter that attenuates conducted EMI. Resistors R1 and R2 together with the CAP200DG (U1) IC 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 TinySwitch-5 Primary

The TNY5077E device (U2) integrates an oscillator, a switch controller, start-up and protection circuitry, and a power MOSFET, in 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 closer 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 RCDZ clamp network that consists of D2, R21, R22, R25, VR2, and C5. The RCDZ arrangement prevents the voltage across the capacitor C5 discharging below a minimum value (defined by the voltage rating of VR2) and therefore minimizes clamp dissipation under light and no-load conditions. Resistor R21 and R22 are used together with capacitor C5 to damp high frequency ringing and improve EMI. This arrangement was selected to reduce clamp losses under light and no-load conditions. Y capacitor CY1, connected between the primary and secondary side helps improve EMI.

The TNY5077E regulates the output by adjusting the MOSFET off time 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 the bias winding, diode D3 and capacitor C7.

Line undervoltage and overvoltage is determined by the current supplied from resistors R7 and R8 to the V pin. Resistor R12, blocking diode D1, and Zener D7 are used for output overvoltage protection. An increase in output voltage causes an increase in the bias winding on the primary side, sensed by Zener D7. Once Zener D7 is activated, it will inject current to the BP pin causing the IC U2 to enter auto-restart.

Bypass capacitor C4 serves as the current limit selector and is placed as physically close as possible to U2 to optimize noise suppression. The capacitance value of C4 is used to select primary switch current Limit (ILIM). In this case 47 μF was used to select standard

ILIM for the IC. At start-up, this capacitor is charged through the DRAIN (D) pin. Once it is charged, U2 begins to switch. Capacitor C4 stores enough energy to ensure the power supply output reaches regulation. After start-up, the bias winding powers the controller via the current through resistor R5. Resistor R5 was used to set the typical bias current of the IC U2. Ferrite bead L4 minimizes the noise on the BP Pin.

4.3 Output Rectification

Schottky 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, R26, and capacitor C8 snubs the voltage spike caused by the commutation of D4 and D6. Low ESR capacitor C9 and C10 help in minimizing output voltage ripple, while post filter L3 and C14 further attenuates noise and ripple.

4.4 Output Feedback

The reference IC, U4 (LMV431), is used to set the output voltage and is programmed via the feedback resistor divider R18 and R19. An LMV431 was chosen to reduce no-load consumption by reducing the bias current needed by the reference IC. The LMV431 varies its cathode voltage to keep its input voltage constant (equal to 1.24 V, ±1%). As the cathode voltage changes, the current through the optocoupler LED (and therefore the primary-side transistor) within U3 changes. R16, R17 and C12 increase loop stability, while resistor R15 ensures minimum bias to U4.

5 PCB Layout

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

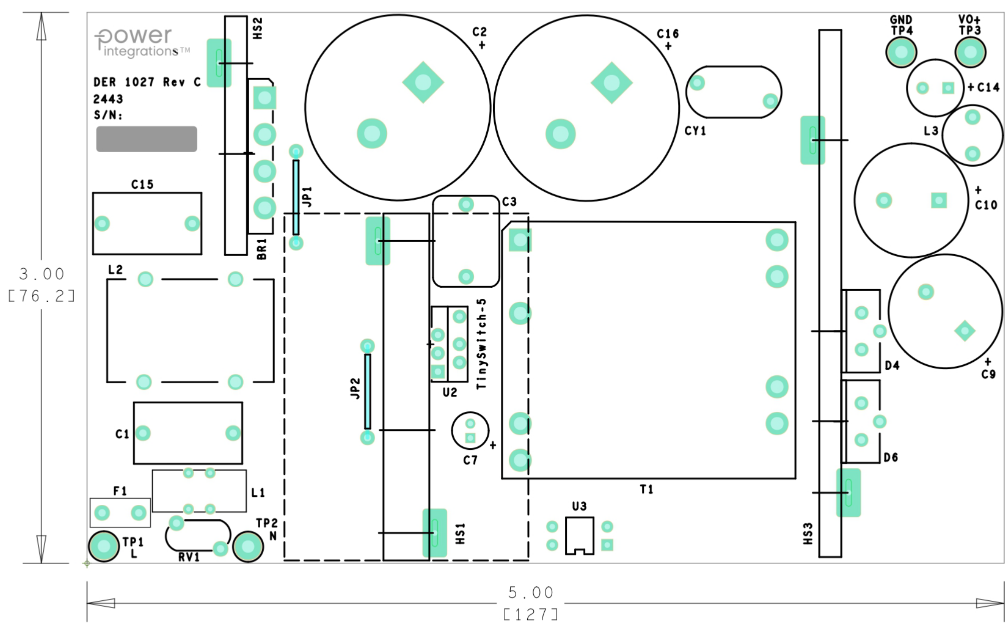


Figure 5 – Printed Circuit Board, Top View.

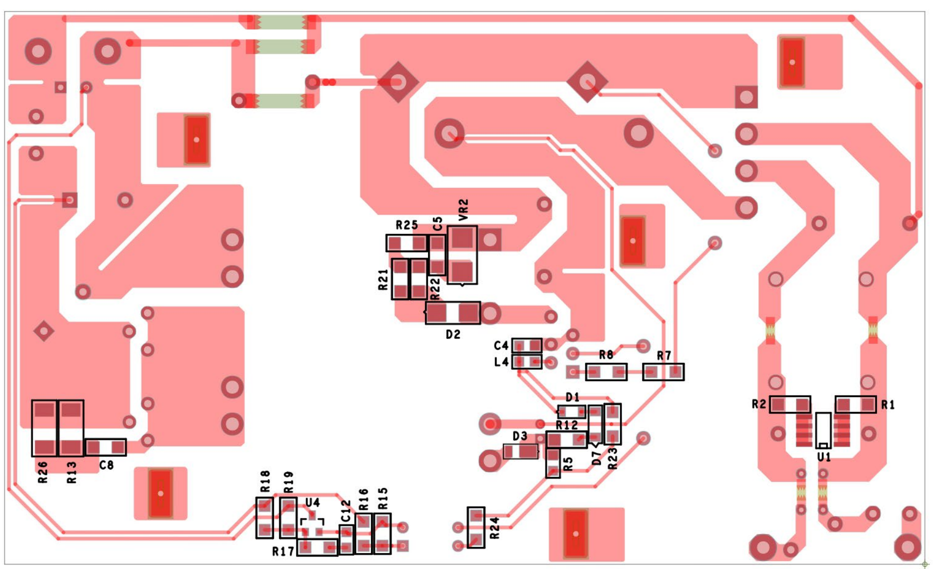


Figure 6 – Printed Circuit Board, Bottom View.

6 Bill of Materials

6.1 Electrical BOM

Item	Qty.	Ref Des	Description	Mfr. Part Number	Mfr.
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, 15.00mm x 8.50mm	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 uF, 10%, 450 VDC, RADIAL	ECW-FD2W105Q1	Panasonic
5	1	C4	0.47 uF, ±10%,25 V, Ceramic Capacitor, X7R, 0805 (2012 Metric)	CGA4J2X7R1E474K 125AA	TDK Corporation
6	1	C5	1000 pF, ±10%, 500V, Ceramic Capacitor X7R, 1206 (3216 Metric)	CL31B102KGFNNN E	Samsung Electro-Mechanics
7	1	C7	47 uF, 25 V, Electrolytic, Very Low ESR, 300 mOhm, (5 x 11)	EKZE250ELL470ME 11D	Nippon Chemi-Con
8	1	C8	470 pF, ±10%, 500V, X7R, Ceramic Capacitor, Surface Mount, MLCC 1206 (3216 Metric)	CC1206KKX7RBBB 471	Yageo
9	2	C9 C10	1800 uF, 35 V, Electrolytic, Very Low ESR, 16 mOhm, (16 x 25)	EKZE350ELL182ML 25S	Nippon Chemi-Con
10	1	C12	22 nF, 50 V, Ceramic, X7R, 0805	CC0805KRX7R9BB 223	Yageo
11	1	C14	150 uF, 35 V, Electrolytic, Gen. Purpose, (8 x 11.5)	EEU-FM1V151	Panasonic
12	1	CY1	CAP, 2200pF, ±20% ,760 VAC, Ceramic Capacitor Y5U (E) Radial, Disc	AY1222M47Y5UC6 3L0	Vishay/ BC Components
13	1	D1	250 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV21WS-7-F	Diode Inc.
14	1	D2	1000 V, 1.5 A, Glass Passivated, DO-214AC	RS2MA-13-F	Diodes Inc
15	1	D3	200 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1200-7	Diodes Inc
16	2	D4 D6	Diode Array,1 Pair, Common Cathode, 200 V, 10A, Through Hole TO-220-3	V20202C-M3/4W	Vishay Semiconductor Diodes Division
17	1	D7	Zener Diode 10 V 350 mW ±6% Surface Mount SOD-123	BZT52-C10J	Nexperia USA Inc.
18	1	F1	5 A, 250 V, Slow, Long Time Lag, RST	RST 5	Belfuse
19	1	L1	250 µH, Toroidal Common Mode Choke, custom, DER-1026, wound on 32-00376-00 core	30-00624-00	Power Integrations
20	1	L2	Common Mode Choke, 10mH, 60 mOhms DCR, Toroidal	XF0093PI-VOCMC	XFMRS
21	1	L3	1.5 uH, 8.5 A, Hi Current, Radial (See 30-00623-00 for alternate)	6000-1R5M-RC	JW Miller

22	1	L4	FERRITE Bead, 80 Ohms @ 100 MHz, 1 Signal Line, Ferrite Bead 0805 (2012 Metric), 300 mA, 300 mOhm	EBMS201209K800	Max Echo
23	2	R1 R2	RES, 1.0 M, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J105V	Panasonic
24	1	R5	RES, 6.34 k, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF6341V	Panasonic
25	2	R7 R8	RES, 4.02M Ohm, ±1%, 0.25 W, 1/4 W, 1206 (3216 Metric), Moisture Resistant, Thick Film	RC1206FR-074M02L	Yageo
26	1	R12	RES, 47.0 R, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF47R0V	Panasonic
27	2	R13 R26	RES, 20 Ohm, ±1%, 1W, 2010 (5025 Metric,) Pulse Withstanding, Thick Film	CRCW201020R0FKEFHP	Vishay/Dale
28	1	R15	RES, 2 k, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF2001V	Panasonic
29	1	R16	RES, 1.0 k, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1001V	Panasonic
30	1	R17	RES, 20.0 k, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF2002V	Panasonic
31	1	R18	RES, 191 k, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1913V	Panasonic
32	1	R19	RES,10 kOhms, ±1%, ±200ppm/°C, 0.5W, 1/2W Chip Resistor 1206 (3216 Metric), Moisture Resistant, Thick Film	RC1206FR-7W10KL	Yageo
33	2	R21 R22	RES, 20 R, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J200V	Panasonic
34	2	R23 R24	RES, 0 Ohms, Jumper, 0.25W, 1/4W, Chip Resistor 1206 (3216 Metric), Moisture Resistant Thick Film	RC1206JR-070RL	Yageo
35	1	R25	RES, 1.00 M, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1004V	Panasonic
36	1	RV1	275 VAC, 23 J, 7 mm, RADIAL	V275LA4P	Littlefuse
37	1	T1	Bobbin, PQ35/35, Vertical, 12 pins	BQ35/35-1112CPFR	TDK
38	1	U1	CAPZero-2, CAP200DG, SO-8C	CAP200DG	Power Integrations
39	1	U2	TinySwitch-5, TNY5077E, eSIP-7C	TNY5077E	Power Integrations
40	1	U3	Opto coupler, 35 V, CTR 300-600%, 4-DIP	LTV-817D	Liteon
41	1	U4	1.24V Shunt Regulator IC, 1%, -40 to 85 C, SOT23-3	LMV431AIMF/NOPB	Texas Instruments
42	1	VR2	DIODE, TVS, 170 V, 600 W, UNI, 5%, SMD	SMBJ170A	Bourns

6.2 Mechanical BOM

Item	Qty.	Ref Des	Description	Mfr. Part Number	Mfr.
1	1	ESIP CLIP1	Heatsink Hardware, Edge Clip, 12.40 mm x 6.50 mm	TRK-24	Kang Tang Hardware Enterpise Co. Ltd.
2	1	HS1	SHTM, Heat Sink, DER-1027_TNY5077E IC - HEATSINK, Composition: Aluminum Extrusion	61-00377-00	Custom
3	1	HS2	SHTM, Heat Sink, Diode Diode Bridge, DER-1027	61-00360-00	Custom
4	1	HS3	SHTM, Heat Sink, Diode SECDIODE, DER-1027	61-00361-00	Custom
5	2	JP1 JP2	Wire Jumper, Insulated, TFE,22 AWG, 0.5 in	C2004-12-02	Alpha
6	3	NUT1 NUT3 NUT4	Nut, Hex, Metric, M3 SS	68024082	Import
7	1	NUT2	Nut, Hex 6-32, SS	HNSS 632	Building Fasteners
8	1	SCREW1	SCR, Phillips, M3 X12 mm, Panhead Mach, Metric SS with rubber O-ring.	SM3X12MM-2701	APM HEXSEAL
9	1	SCREW2	SCREW MACHINE PHIL 6-32 X 3/8 SS	PMSSS 632 0038 PH	Building Fasteners
10	2	SCREW3 SCREW4	SCR, Phillips, M3 X8 mm, Panhead Mach, Metric SS with rubber O-ring.	RM3X8MM 2701	APM HEXSEAL
11	5	TE1-TE5	Terminal, Eyelet, Tin Plated Brass, Zierick PN 190	190	Zierick
12	2	TP1 TP4	Test Point, BLK, THRU-HOLE MOUNT	5011	Keystone
13	1	TP2	Test Point, WHT, THRU-HOLE MOUNT	5012	Keystone
14	1	TP3	Test Point, RED, THRU-HOLE MOUNT	5010	Keystone
15	3	WASHER1 WASHER3 WASHER4	Washer, Lk, M 3 Zinc, Metric	MLWZ 003	Building Fasteners
16	1	WASHER2	Washer Flat #6, SS	FWSS 006	Building Fasteners
17	2	WASHER5 WASHER6	Washer, Shoulder, #4, 0.125 Shoulder x 0.140 Dia, Polyphenylene Sulfide PPS	7721-3PPSG	Aavid Thermalloy
18	4	GREASE1 GREASE2 GREASE3 GREASE4	Thermal Silicone Compound ,2 oz Jar	120-2	Wakefield-Vette

7 Transformer Specification

7.1 Electrical Diagram

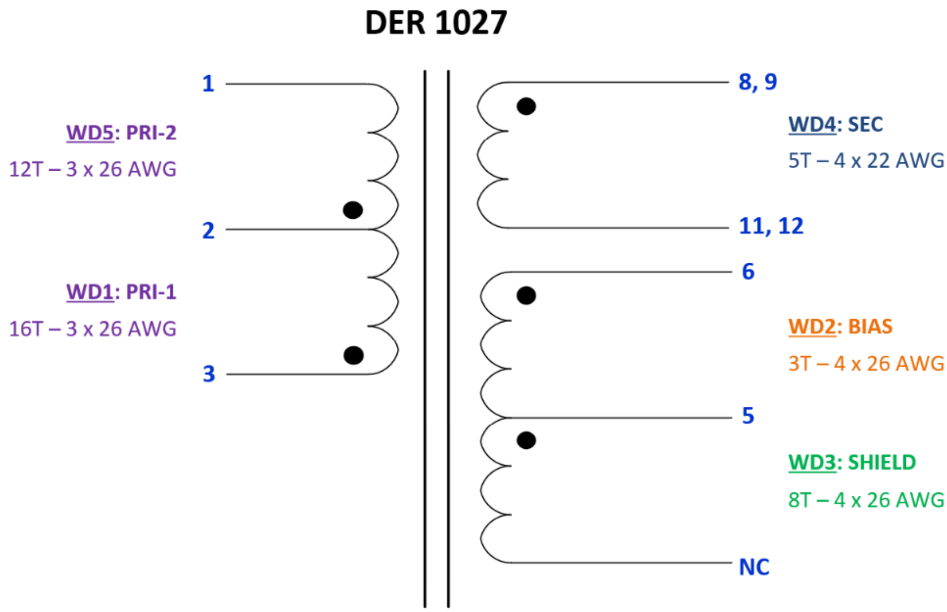


Figure 7 – Transformer Electrical Diagram.

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.**	**451 μH**
Tolerance	**Tolerance of Primary Inductance.**	**±5%**
Leakage Inductance	**Measured across primary winding with all other windings shorted.**	**< 4.51 μH**

7.3 Material List

Item	Description
[1]	Core: PQ35/35, 3C95
[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: #22 AWG.
[5]	Polyester Tape: 21 mm.
[6]	Polyester Tape: 11 mm.
[7]	Polyester Tape: 14.5 mm.
[8]	Varnish: Dolph BC 359; or Equivalent.

7.4 Transformer Build Diagram

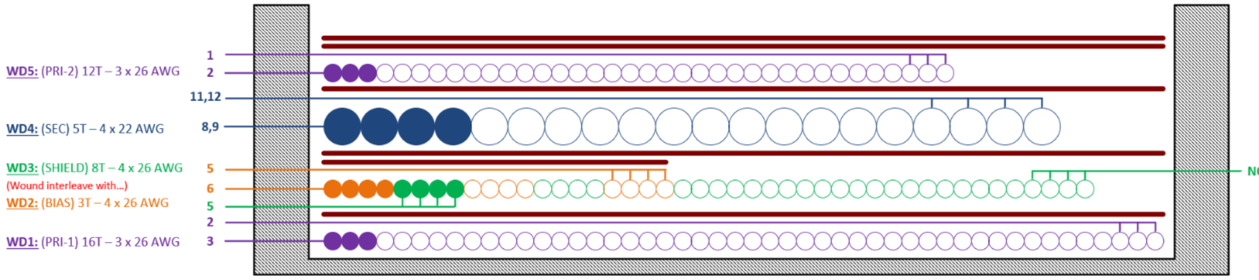
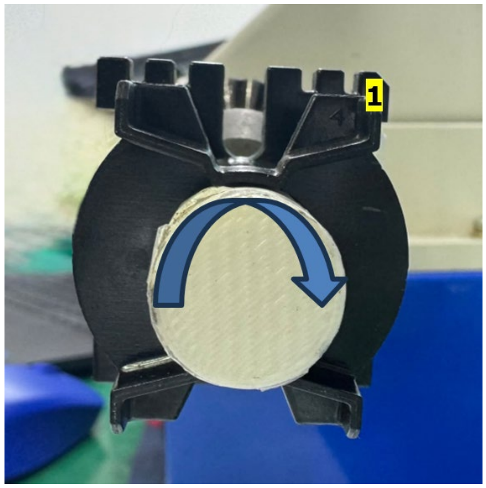
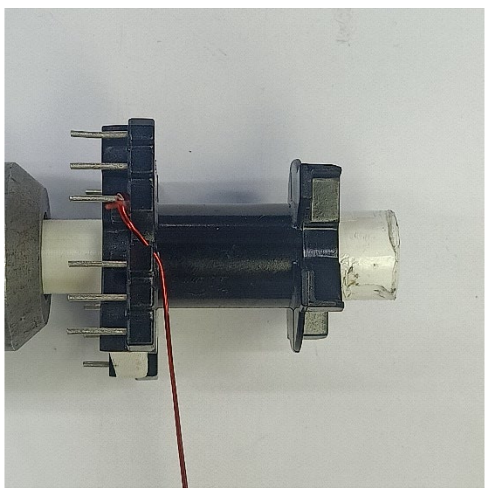
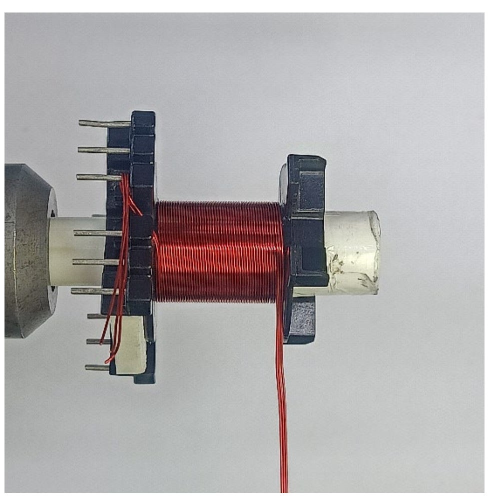


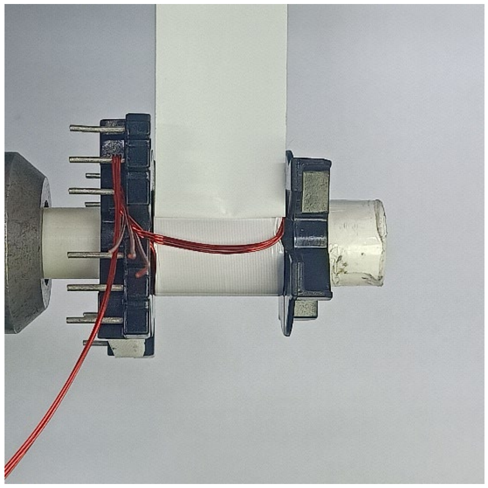
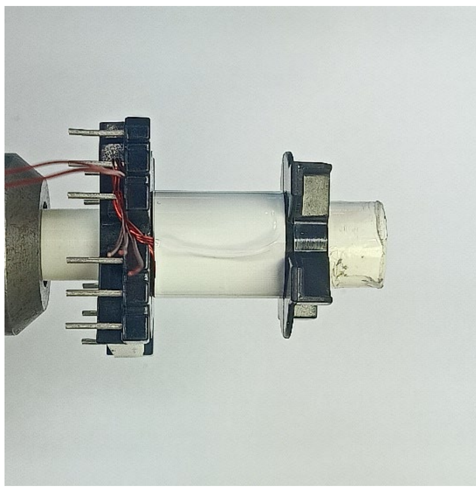
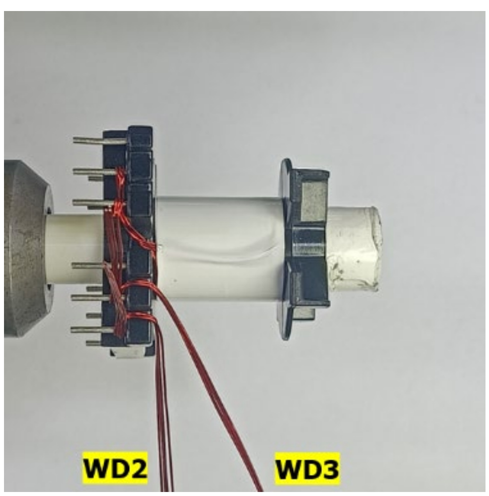
Figure 8 – Transformer Build Diagram.

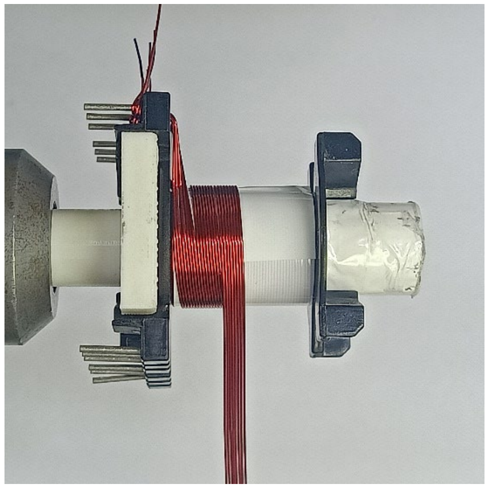
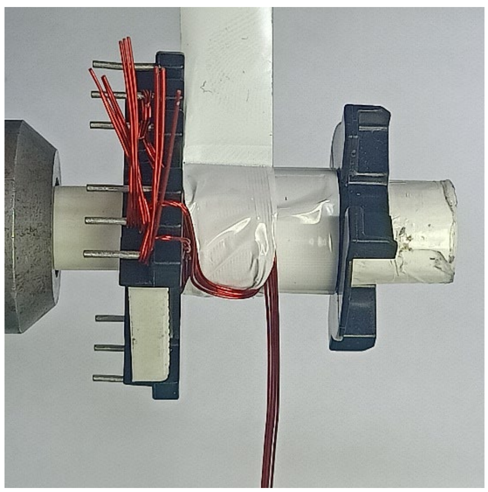
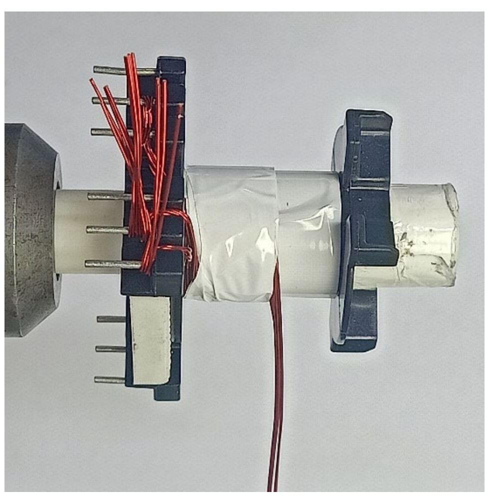
7.5 Transformer Instructions

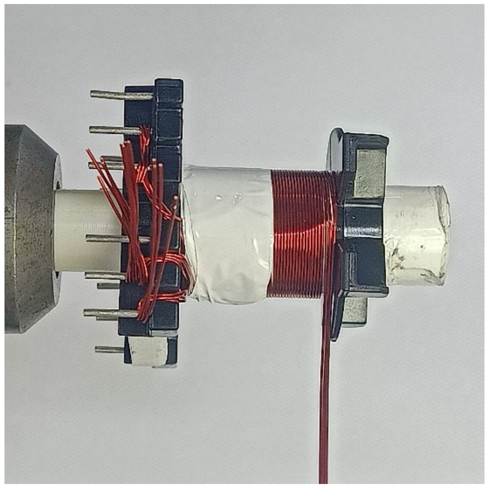
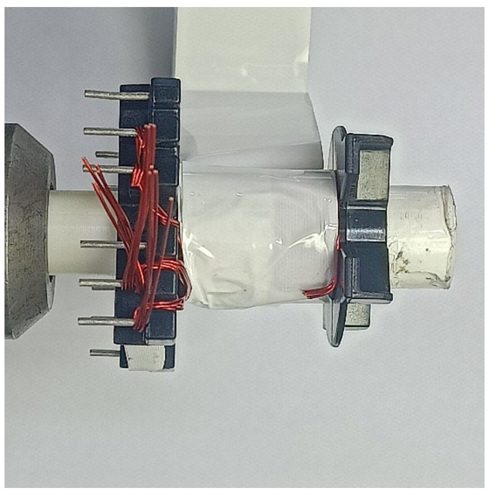
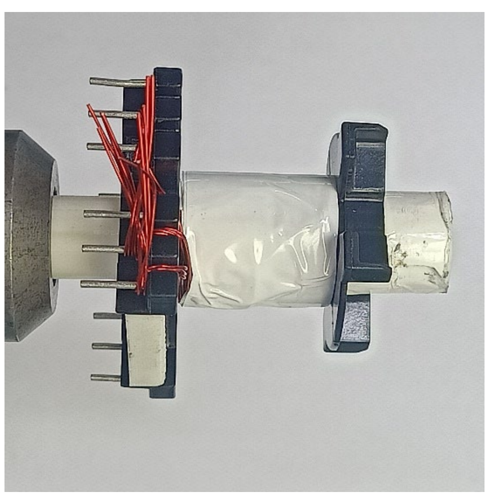
Winding Preparation	Place the bobbin Item [2] such that pins 1-6 are on upper side while 7-12 are on lower side. The notch on the bobbin signifies Pin 1. Winding direction is clockwise as shown.
WD1 1st Primary	Prepare 3 strands of wire Item [3] at Pin 3. Wind 16 turns of wire Item [3] in 1 layer from left to right.
Insulation	Apply 1 layer of tape Item [5] for insulation and to hold the wires in place. Bend the end of WD1 90 degrees and finish WD1 on Pin 2. Wrap the tape to cover WD1.
WD2 & WD3 Bias and Shield	Prepare 4 strands of wire Item [3] at Pin 6 WD2 and 4 strands of wire Item [3] at Pin 5 WD3. Wind all the wires together for 3 turns. Apply 1 layer of tape Item [6] for insulation and to hold the wires in place. Bend the end of WD2 90 degrees and finish WD2 on Pin 5. Wrap the tape to cover WD2. Wind the remaining 5 turns for WD3.
Insulation	Apply 1 layer of tape Item [5] for insulation and to hold the wires in place. Bend the end of WD3 90 degrees, cut as shown, and leave it floating. Wrap the tape to cover WD2 and WD3.
WD4 Secondary	Prepare 4 strands of wire Item [4], 2 strands at Pin 8 and 2 strands at Pin 9. Wind 5 turns of wire Item [4] in 1 layer from left to right.
Insulation	Apply 1 layer of tape Item [5] for insulation and to hold the wires in place. Bend the end of WD4 90 degrees. Finish WD4 with 2 strands ending at Pin 11 and 2 strands ending at Pin 12. Wrap the tape to cover WD4.
WD5 2nd Primary	Prepare 3 strands of wire Item [3] at Pin 2. Wind 12 turns of wire Item [3] in 1 layer from left to right.
Insulation	Apply 1 layer of tape Item [5] for insulation and to hold the wires in place. Bend the end of WD5 90 degrees and finish WD5 on 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 451 μH measured between Pin 1 and Pin 3 with all other pins open. Wrap the body of transformer with 2 layers of tape Item [7]. Measure Primary Inductance between Pin 1 and Pin 3 with all other pins open, then Leakage Inductance between Pin 1 and Pin 3 with all other pins shorted together.
Finish	Varnish using Item [8]. Check again Primary and Leakage Inductance if within specifications.

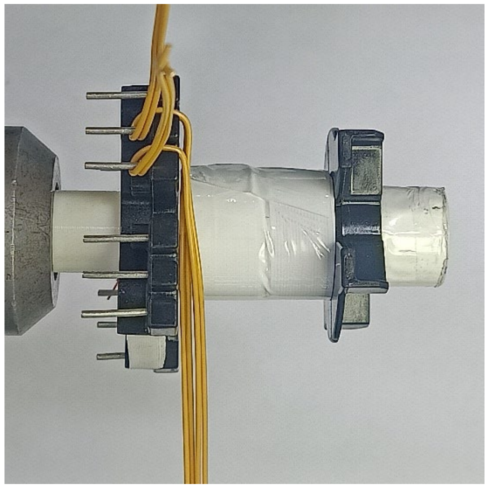
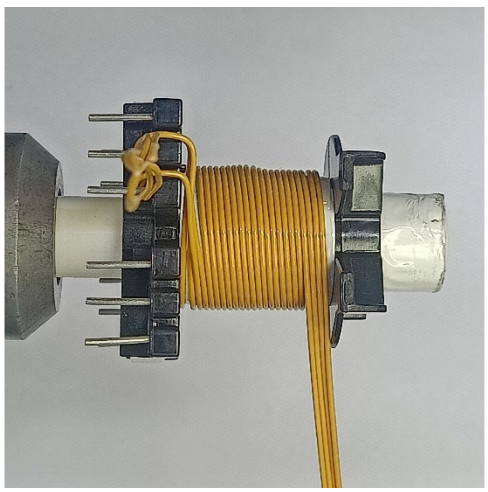
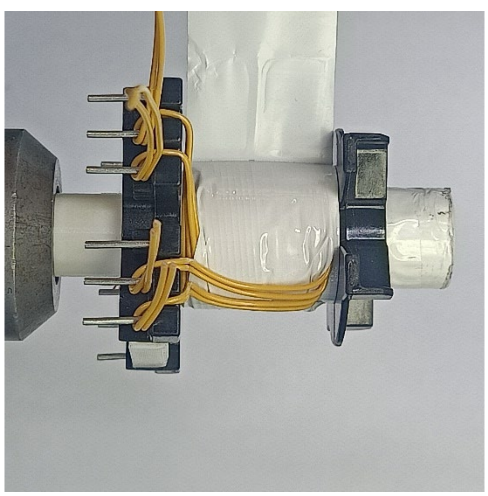
7.6 Transformer Winding Illustrations

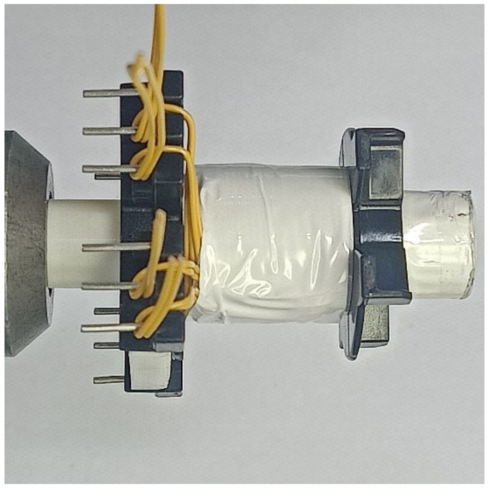
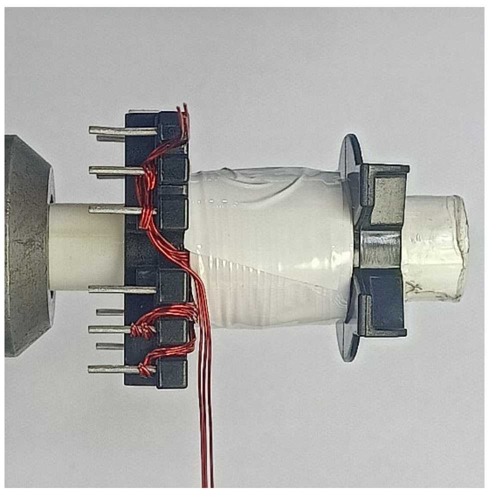
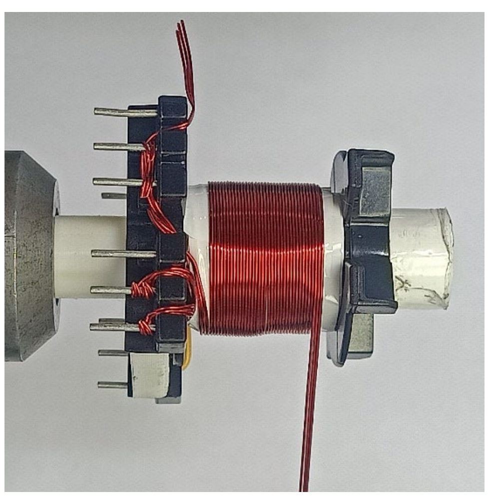
Winding Preparation		Place the bobbin Item [2] such that pins 1-6 are on upper side while 7-12 are on lower side. The notch on the bobbin signifies Pin 1. Winding direction is clockwise as shown.
WD1 1st Primary		Prepare 3 strands of wire Item [3] at Pin 3.
		Wind 16 turns of wire Item [3] in 1 layer from left to right.

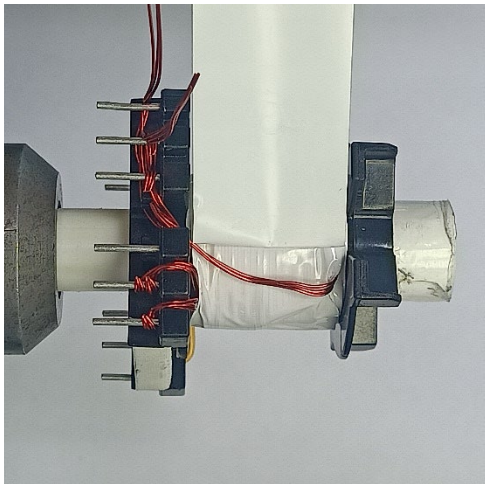
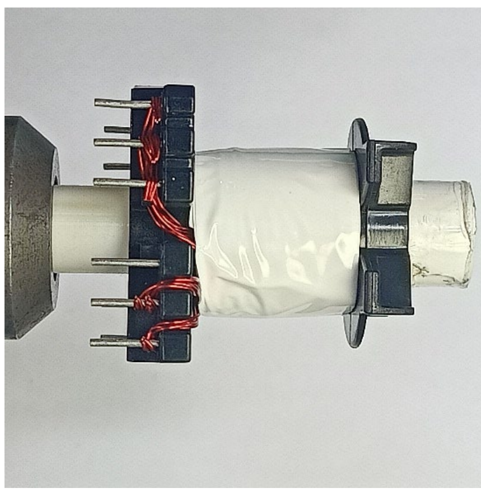
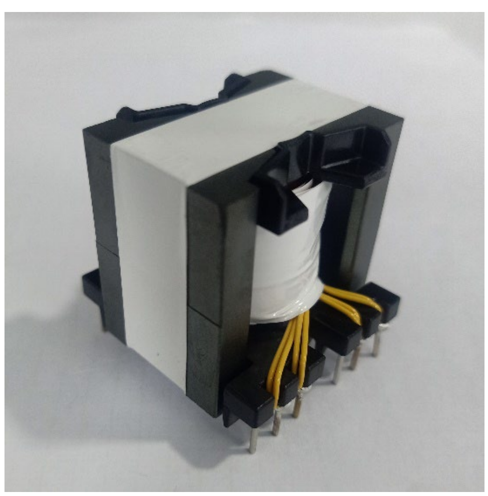
Insulation	 	Apply 1 layer of tape Item [5] for insulation and to hold the wires in place. Bend the end of WD1 90 degrees and finish WD1 on Pin 2. Wrap the tape to cover WD1.
WD2 & WD3 Bias and Shield		Prepare 4 strands of wire Item [3] at Pin 6 WD2 and 4 strands of wire Item [3] at Pin 5 WD3.

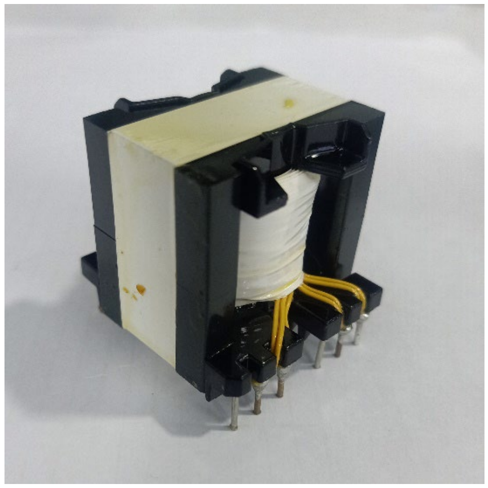
		Wind all the wires together for 3 turns.
		Apply 1 layer of tape Item [6] for insulation and to hold the wires in place. Bend the end of WD2 90 degrees and finish WD2 on Pin 5.
		Wrap the tape to cover WD2.

		Wind the remaining 5 turns for WD3.
Insulation		Apply 1 layer of tape Item [5] for insulation and to hold the wires in place. Bend the end of WD3 90 degrees, cut as shown, and leave it floating.
		Wrap the tape to cover WD2 and WD3.

WD4 Secondary		Prepare 4 strands of wire Item [4], 2 strands at Pin 8 and 2 strands at Pin 9.
		Wind 5 turns of wire Item [4] in 1 layer from left to right.
Insulation		Apply 1 layer of tape Item [5] for insulation and to hold the wires in place. Bend the end of WD4 90 degrees. Finish WD4 with 2 strands ending at Pin 11 and 2 strands ending at Pin 12.

<table>
<tr><td></td><td></td><td>Wrap the tape to cover WD4.</td></tr>
<tr><td rowspan="2">WD5
2nd Primary</td><td></td><td>Prepare 3 strands of wire Item [3] at Pin 2.</td></tr>
<tr><td></td><td>Wind 12 turns of wire Item [3] in 1 layer from left to right.</td></tr>
</table>

Insulation		Apply 1 layer of tape Item [5] for insulation and to hold the wires in place. Bend the end of WD5 90 degrees and finish WD5 on 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 451 µH measured between Pin 1 and Pin 3 with all other pins open. Wrap the body of transformer with 2 layers of tape Item [6]. Measure Primary Inductance between Pin 1 and Pin 3 with all other pins open, then Leakage Inductance between Pin 1 and Pin 3 with all other pins shorted together.

Finish		Varnish using Item [8]. Check again Primary and Leakage Inductance if within specifications.

8 Common Mode Choke L1 Specification (30-00624-00)

8.1 Electrical Diagram

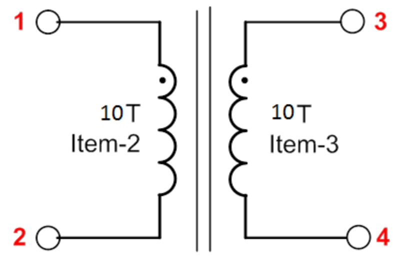


Figure 9 – Choke Electrical Diagram.

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%**

8.3 Material List

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

8.4 Common Mode Choke Construction

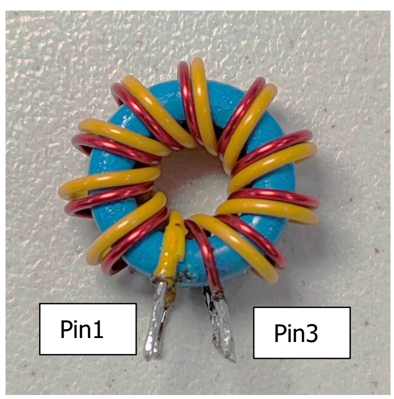


Figure 10 – Finished Choke.

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. Finished choke should resemble above figure.

9 Design Spreadsheet

1	ACDC_TinySwitch5_Flyback_021825; Rev.0.2; Copyright Power Integrations 2025	INPUT	INFO	OUTPUT	UNITS	TinySwitch5 Single/Multi Output Flyback Design Spreadsheet
2	**APPLICATION VARIABLES**					
3	INPUT_TYPE	AC		AC		Input Type
4	VIN_MIN	85		85	V	Minimum AC input voltage
5	VIN_MAX	265		265	V	Maximum AC input voltage
6	VIN_RANGE			85-265	VAC	Range of AC input voltage
7	LINEFREQ	60		60	Hz	AC Input voltage frequency
8	CAP_INPUT	540.0		540.0	uF	Input capacitor
9	VOUT	24.00		24.00	V	Output voltage at the board
10	IOUT	5.000		5.000	A	Output current
11	POUT			120.00	W	Output power
12	EFFICIENCY	0.88		0.88		AC-DC efficiency estimate at full load given that the converter is switching at the valley of the rectified minimum input AC voltage
13	FACTOR_Z	0.60		0.60		Z-factor estimate
14	ENCLOSURE	OPEN FRAME		OPEN FRAME		Power supply enclosure
18	**PRIMARY CONTROLLER SELECTION**					
19	DEVICE_SERIES	TNY5077		TNY5077		Generic device code
20	ILIMIT_MODE	STANDARD		STANDARD		Device current limit mode
21	PACKAGE_DEVICE	eSIP		eSIP		Device Package
22	DEVICE_CODE			TNY5077E		Actual device code
23	POUT_MAX			120	W	Power capability of the device based on thermal performance
24	RDSON_100DEG			1.83	Ω	Primary switch on time drain resistance at 100 °C
25	ILIMIT_MIN			2.926	A	Minimum current limit of the primary switch
26	ILIMIT_TYP			3.180	A	Typical current limit of the primary switch
27	ILIMIT_MAX			3.434	A	Maximum current limit of the primary switch
28	VDRAIN_BREAKDOWN			725	V	Device breakdown voltage
29	VDRAIN_ON_PRSW			2.33	V	Primary switch on time drain voltage
30	VDRAIN_OFF_PRSW			537.4	V	Peak drain voltage on the primary switch during turn-off. A 30V leakage spike voltage is assumed
34	**WORST CASE ELECTRICAL PARAMETERS**					
35	FSWITCHING_MAX	99000		99000	Hz	Maximum switching frequency at full load and valley of the rectified minimum AC input voltage.
36	VOR	134.0		134.0	V	Secondary voltage reflected to the primary when the primary switch turns off
37	VMIN			104.40	V	Valley of the minimum input AC voltage at full load
38	KP		Info	0.46		Design is too continuous and may result in leading edge SOA triggering: increase the VOR
39	MODE_OPERATION			CCM		Mode of operation

40	DUTYCYCLE			0.568		Primary switch duty cycle
41	TIME_ON			13.50	us	Primary switch on-time
42	TIME_ON_AT_FSWITCHING_MAX			5.73	us	Primary switch on-time at FSWITCHING_MAX
43	TIME_OFF			4.37	us	Primary switch off-time at 85 VAC, 120W, and 100000Hz.
44	LPRIMARY_MIN			428.1	uH	Minimum primary inductance
45	LPRIMARY_TYP			450.6	uH	Typical primary inductance
46	LPRIMARY_TOL	5.0		5.0	%	Primary inductance tolerance
47	LPRIMARY_MAX			473.2	uH	Maximum primary inductance
48						
49	**PRIMARY CURRENT**					
50	IPEAK_PRIMARY			3.266	A	Primary switch peak current
51	IPEDESTAL_PRIMARY			1.578	A	Primary switch current pedestal
52	IAVG_PRIMARY			1.272	A	Primary switch average current
53	IRIPPLE_PRIMARY			2.051	A	Primary switch ripple current
54	IRMS_PRIMARY			1.746	A	Primary switch RMS current
56	**SECONDARY CURRENT**					
57	IPEAK_SECONDARY			18.289	A	Secondary winding peak current
58	IPEDESTAL_SECONDARY			8.834	A	Secondary winding current pedestal
59	IRMS_SECONDARY			8.534	A	Secondary winding RMS current
63	**TRANSFORMER CONSTRUCTION PARAMETERS**					
64	**CORE SELECTION**					
65	CORE	PQ35		PQ35		Core selection. Refer to the 'Transformer Construction' tab to see the detailed report
66	CORE CODE			PQ35/35-3C95		Core code
67	AE			190.00	mm^2	Core cross sectional area
68	LE			86.10	mm	Core magnetic path length
69	AL			6600	nH/turns^2	Ungapped core effective inductance
70	VE			16300.0	mm^3	Core volume
71	BOBBIN			CPV-PQ35/35-1S-12P-Z		Bobbin
72	AW			146.64	mm^2	Window area of the bobbin
73	BW			20.80	mm	Bobbin width
74	MARGIN			0.0	mm	Safety margin width (Half the primary to secondary creepage distance)
75						
76	**PRIMARY WINDING**					
77	NPRIMARY			28		Primary turns
78	BPEAK			3153	Gauss	Peak flux density
79	BMAX			2874	Gauss	Maximum flux density
80	BAC			882	Gauss	AC flux density (0.5 x Peak to Peak)
81	ALG			575	nH/turns^2	Typical gapped core effective inductance
82	LG			0.379	mm	Core gap length
83						
84	**PRIMARY BIAS WINDING**					
85	NBIAS_PRIMARY			3	turns	Primary bias winding number of turns
86						
87	**SECONDARY WINDING**					

88	NSECONDARY	5		5	turns	Secondary winding number of turns
89						
90	**SECONDARY BIAS WINDING**					
91	NBIAS_SECONDARY			NA	turns	Secondary bias winding number of turns
95	**PRIMARY COMPONENTS SELECTION**					
96	**LINE UNDERVOLTAGE**					
97	BROWN-IN REQURED			76.08	V	Required AC RMS/DC line voltage brown-in threshold
98	RLS			8.04	MΩ	Connect two 4.02 MOhm resistors to the V-pin for the required UV/OV threshold
99	BROWN-IN ACTUAL			63.5V – 78.6V	V	Actual AC RMS/DC brown-in range
100	BROWN-OUT ACTUAL			55V – 67.9V	V	Actual AC RMS/DC brown-out range
101						
102	**LINE OVERVOLTAGE**					
103	OVERVOLTAGE_LINE			285.4V – 355.2V	V	Actual AC RMS/DC line over-voltage range
104						
105	**PRIMARY BIAS DIODE**					
106	VBIAS_PRIMARY			12.0	V	Rectified primary bias voltage
107	VF_BIAS_PRIMARY			0.70	V	Bias winding diode forward drop
108	VREVERSE_BIASDIODE_PRIMARY			54.40	V	Bias diode reverse voltage (not accounting parasitic voltage ring)
109	CBIAS_PRIMARY			47	uF	Bias winding rectification capacitor
110	CBP			0.47	uF	BP pin capacitor
114	**SECONDARY COMPONENTS**					
115	VREF_REG	1.24		1.24	V	Reference voltage of the feedback
116	RFB_UPPER			182.00	kΩ	Upper feedback resistor (connected to the first output voltage)
117	RFB_LOWER			10.00	kΩ	Lower feedback resistor
118						
119	**SECONDARY BIAS DIODE**					
120	USE_SECONDARY_BIAS	NO		NO		Use secondary bias winding for the design
121	VBIAS_SECONDARY			NA	V	Rectified secondary bias voltage
122	VF_BIAS_SECONDARY			NA	V	Bias winding diode forward drop
123	VREVERSE_BIASDIODE_SECONDARY			NA	V	Bias diode reverse voltage (not accounting parasitic voltage ring)
124	CBIAS_SECONDARY			NA	uF	Bias winding rectification capacitor
127	**MULTIPLE OUTPUT PARAMETERS**					
128	**OUTPUT 1**					
129	VOUT1			24.00	V	Output 1 voltage
130	IOUT1			5.00	A	Output 1 current
131	POUT1			120.00	W	Output 1 power
132	VD1			0.70	V	Forward voltage drop of diode for output 1
133	NS1			5.00	turns	Number of turns for output 1

134	ISPEAK1			18.29	A	Instantaneous peak value of the secondary current for output 1
135	ISRMS1			8.534	A	Root-mean-squared value of the secondary current for output 1
136	ISRIPPLE1			6.915	A	Current ripple on the secondary waveform for output 1
137	PIV1_CALCULATED			108.31	V	Computed peak inverse voltage stress on the diode for output 1
138	OUTPUT_RECTIFIER1	AUTO		BYV32-200		Recommended diode for output 1.
139	PIV1_RATING			200.00	V	Peak inverse voltage rating on the diode for output 1
140	TRR1			25.00	ns	Reverse recovery time of the diode for output 1
141	IFM1			18.00	A	Maximum forward continuous current of the diode for output 1
142	PLOSS_DIODE1			6.73	W	Maximum diode power loss for output 1
143						

10 Heat Sinks

10.1 TinySwitch-5 Heat Sink

10.1.1 TinySwitch-5 Heat Sink Metal Drawing

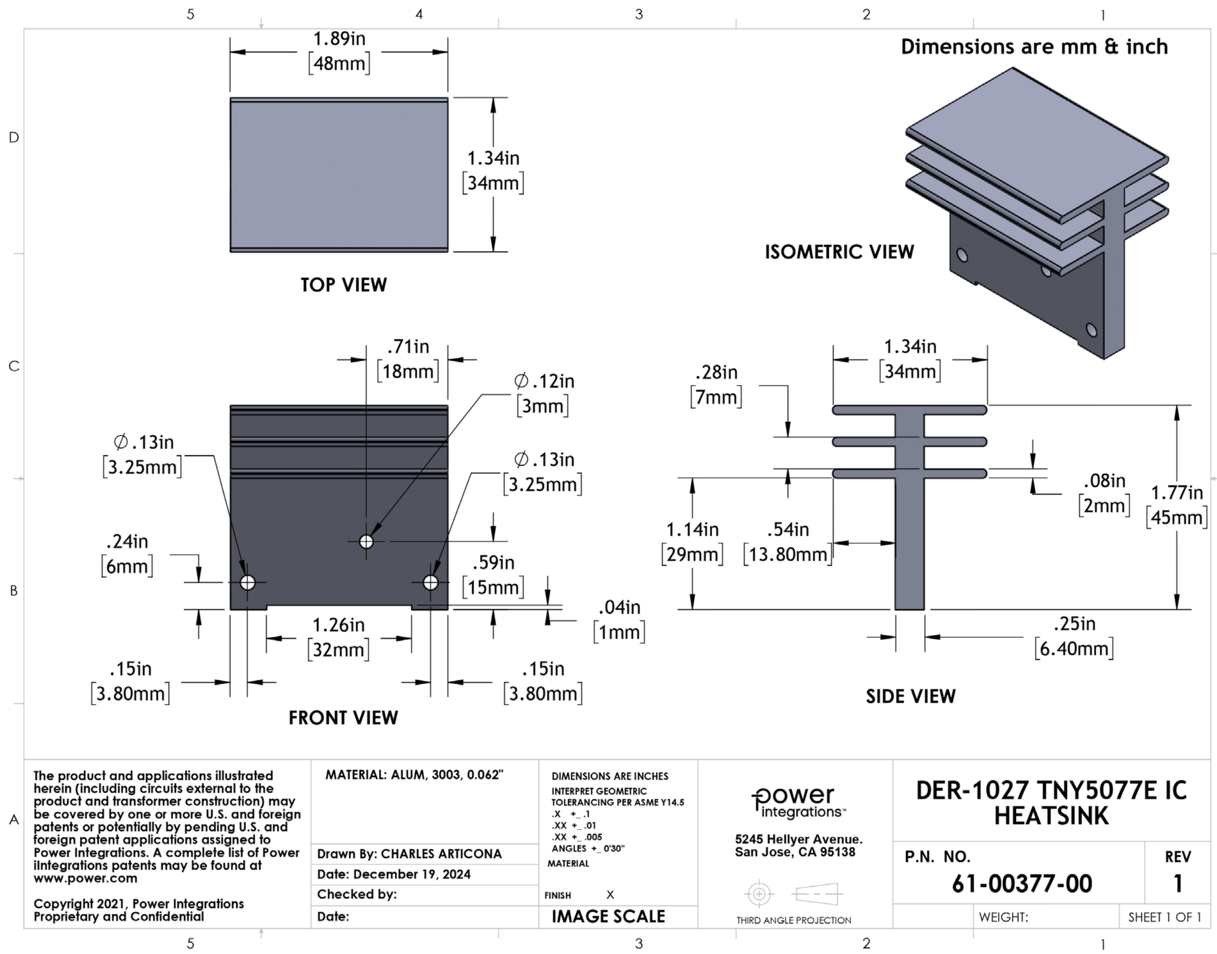
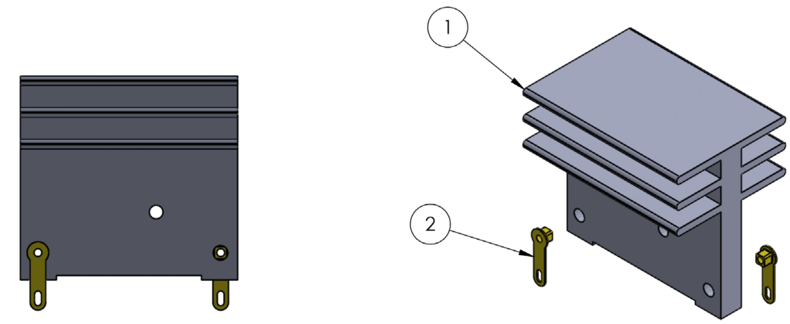


Figure 11 – DER-1027 TinySwitch-5 Heat Sink Metal Drawing.

10.1.2 Finished TinySwitch-5 Heat Sink with Hardware

Dimensions are mm & inch



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00377-00	SHTM, Heat Sink, DER-1027_TNY5077E IC	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

Material:

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

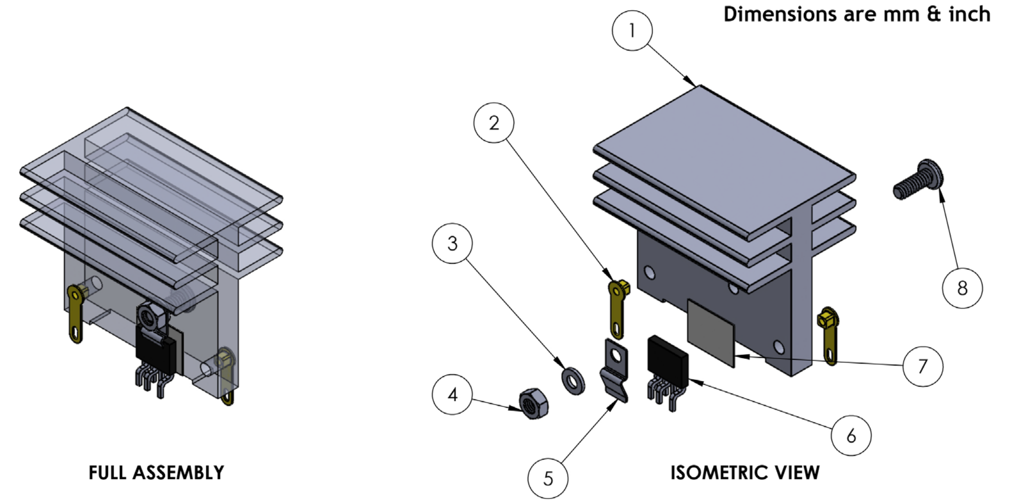
DIMENSIONS ARE INCHES
INTERPRET GEOMETRIC TOLERANCING PER ASME Y14.5
.X +_ .1
.XX +_ .01
.XX +_ .005
ANGLES +_ 0'30"
MATERIAL
FINISH X
IMAGE SCALE

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

DER-1027 TYN5077E IC HEATSINK FAB
P.N. NO. 61-00377-01
REV 1
WEIGHT:
SHEET 1 OF 1

Figure 12 – DER-1027 TinySwitch-5 Heat Sink with Hardware.

10.1.3 TinySwitch-5 Heat Sink Assembly



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00377-00	SHTM, Heat Sink, DER-1027_TNY5077E IC	1
2	60-00016-00	Terminal Eyelet, Tin Plated Brass, Zierick, PN 190	2
3	75-00059-00	Washer, Lk, M 3 Zinc, Metric	1
4	75-00055-00	Nut Hex, Metric M3 SS	1
5	60-00037-00	Heatsink Hardware, Edge Clip, 12.40mm x 6.50mm	1
6	10-01629-00	TinySwitch-5, TNY5077E, eSIP-7C	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: July 17, 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-1027 TYN5077E IC HEATSINK ASSEMBLY
P.N. NO. 61-00377-02
REV 1
WEIGHT:
SHEET 1 OF 1

Figure 13 – DER1027 TinySwitch-5 Heat Sink Assembly.

10.2 Bridge Rectifier Heat Sink

10.2.1 Bridge Rectifier Heat Sink Metal Drawing

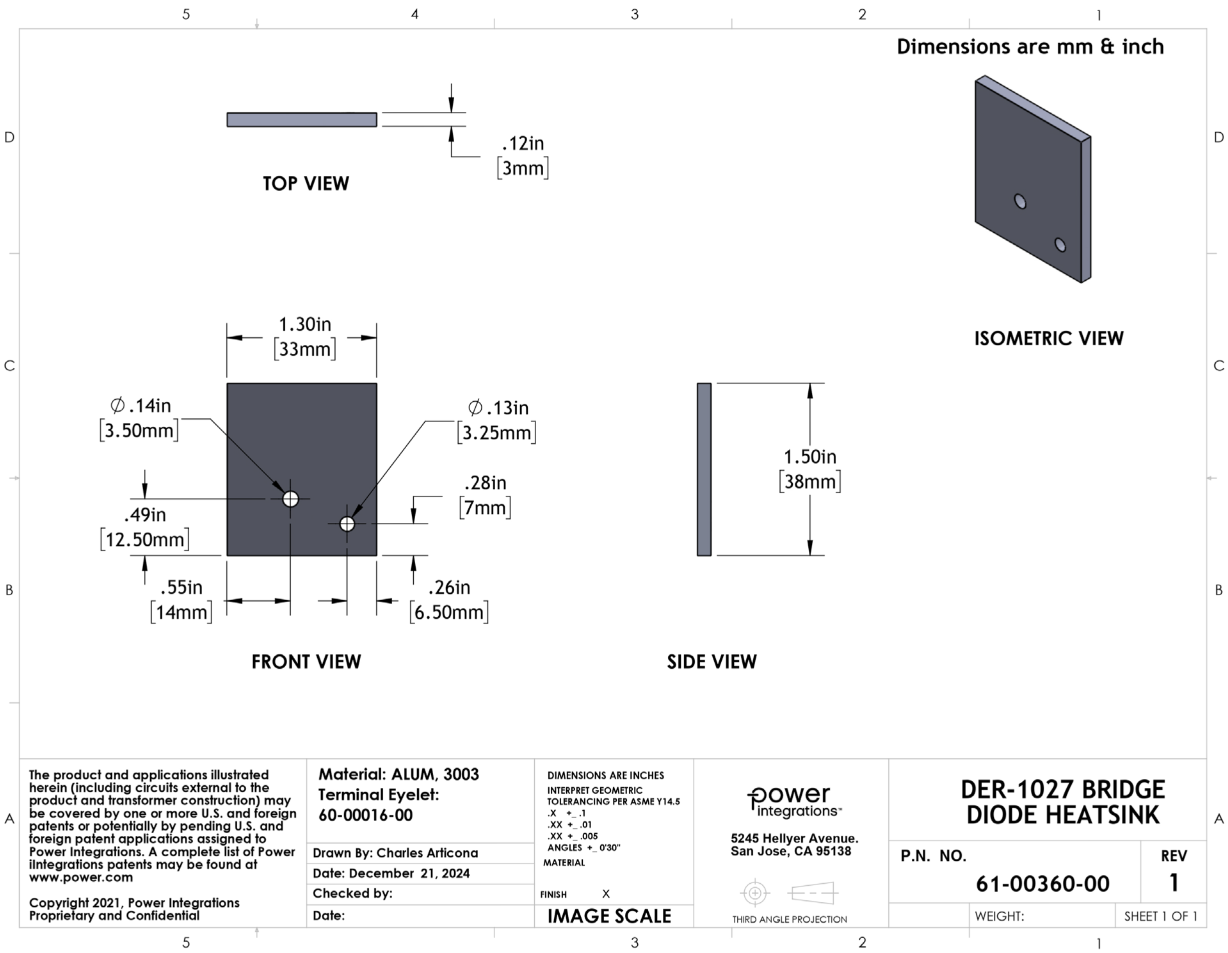
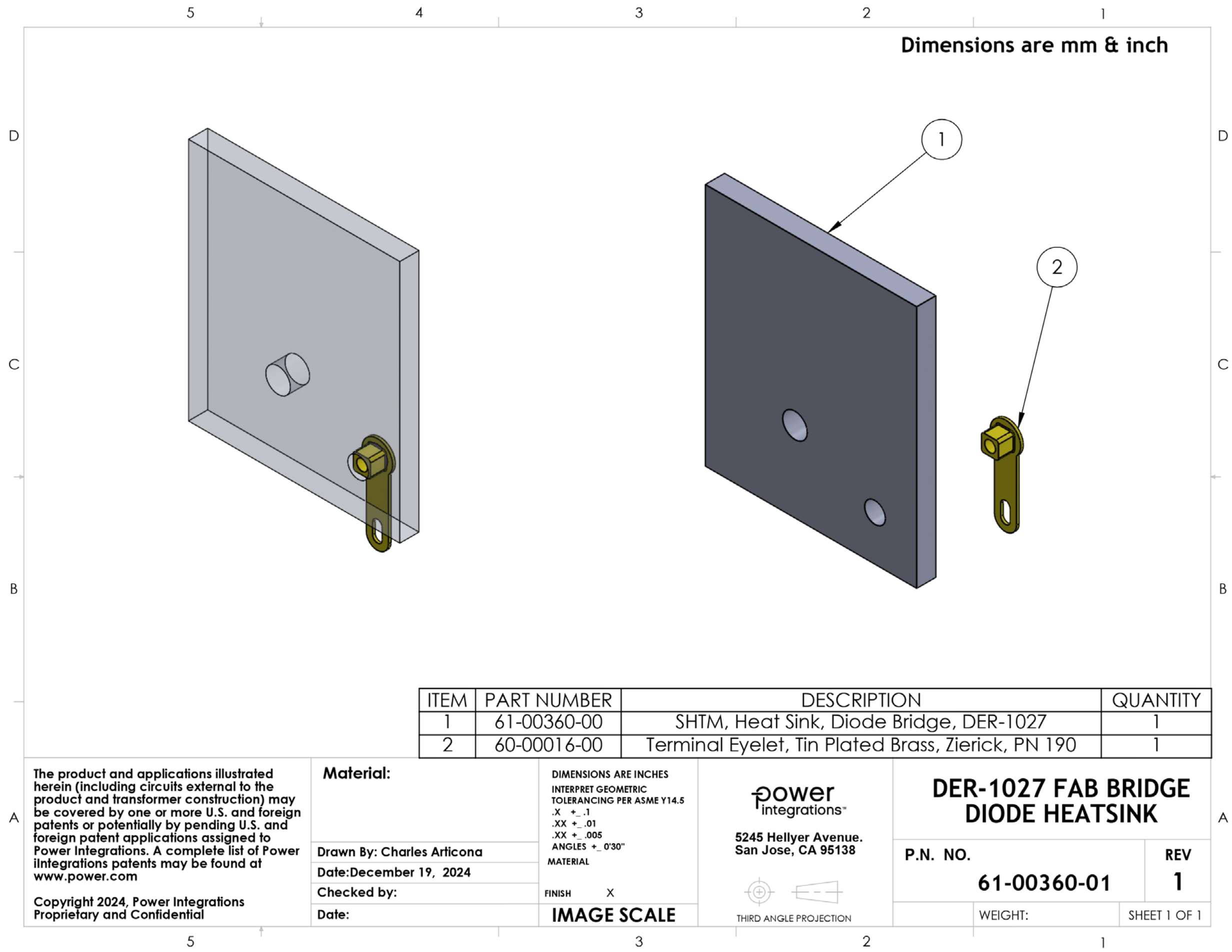


Figure 14 – DER-1027 Bridge Rectifier Heat Sink Metal Drawing.

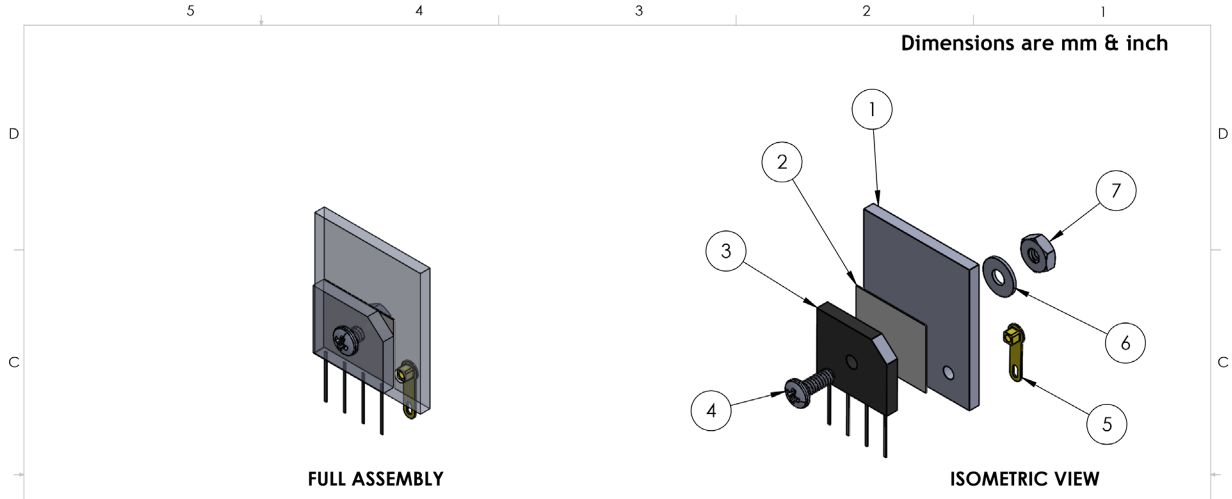
10.2.2 Finished Bridge Rectifier Heat Sink with Hardware



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00360-00	SHTM, Heat Sink, Diode Bridge, DER-1027	1
2	60-00016-00	Terminal Eyelet, Tin Plated Brass, Zierick, PN 190	1

Figure 15 – DER-1027 Bridge Rectifier Heat Sink with Hardware.

10.2.3 Bridge Rectifier Heat Sink Assembly



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00360-00	SHTM, Heat Sink, Diode Bridge, DER-1027	1
2	60-00099-00	Thermal Silicone Compound, 2 OZ Jar	1
3	15-00347-00	800 V, 8 A, 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 iintegrations patents may be found at www.power.com

Material:
Drawn By: Charles Articona
Date: December 21, 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-1027 BRIDGE HEATSINK ASSEMBLY
P.N. NO. 61-00360-02
REV 1
WEIGHT:
SHEET 1 OF 1

Figure 16 – DER-1027 Bridge Rectifier Heat Sink Assembly.

10.3 Secondary Diode Heat Sink

10.3.1 Secondary Diode Heat Sink Metal Drawing

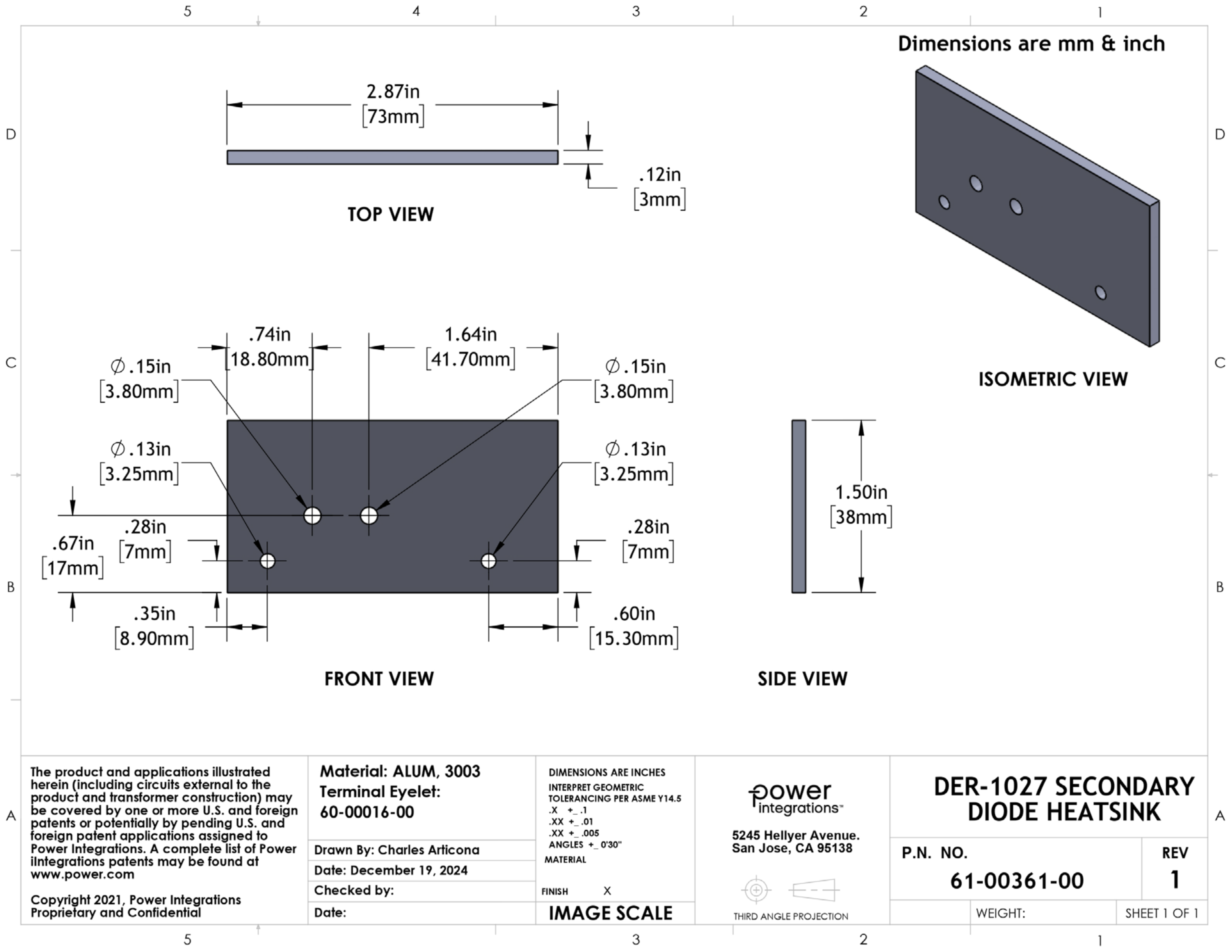
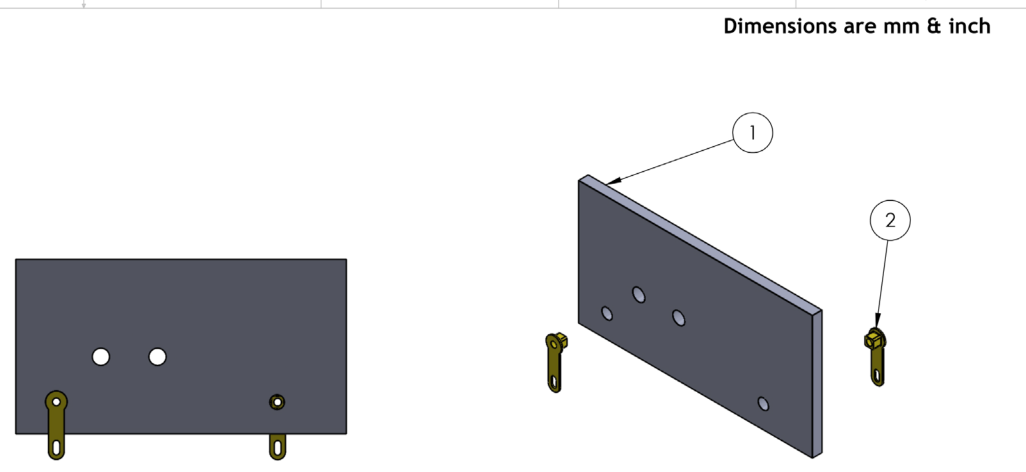


Figure 17 – DER-1027 Secondary Diode Heat Sink Metal Drawing.

10.3.2 Finished Secondary Diode Heat Sink with Hardware



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00361-00	SHTM, Heat Sink, Diode SECDIODE, DER-1027	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

Material:

Drawn By: Charles Articona
Date:December 19, 2024
Checked by:
Date:

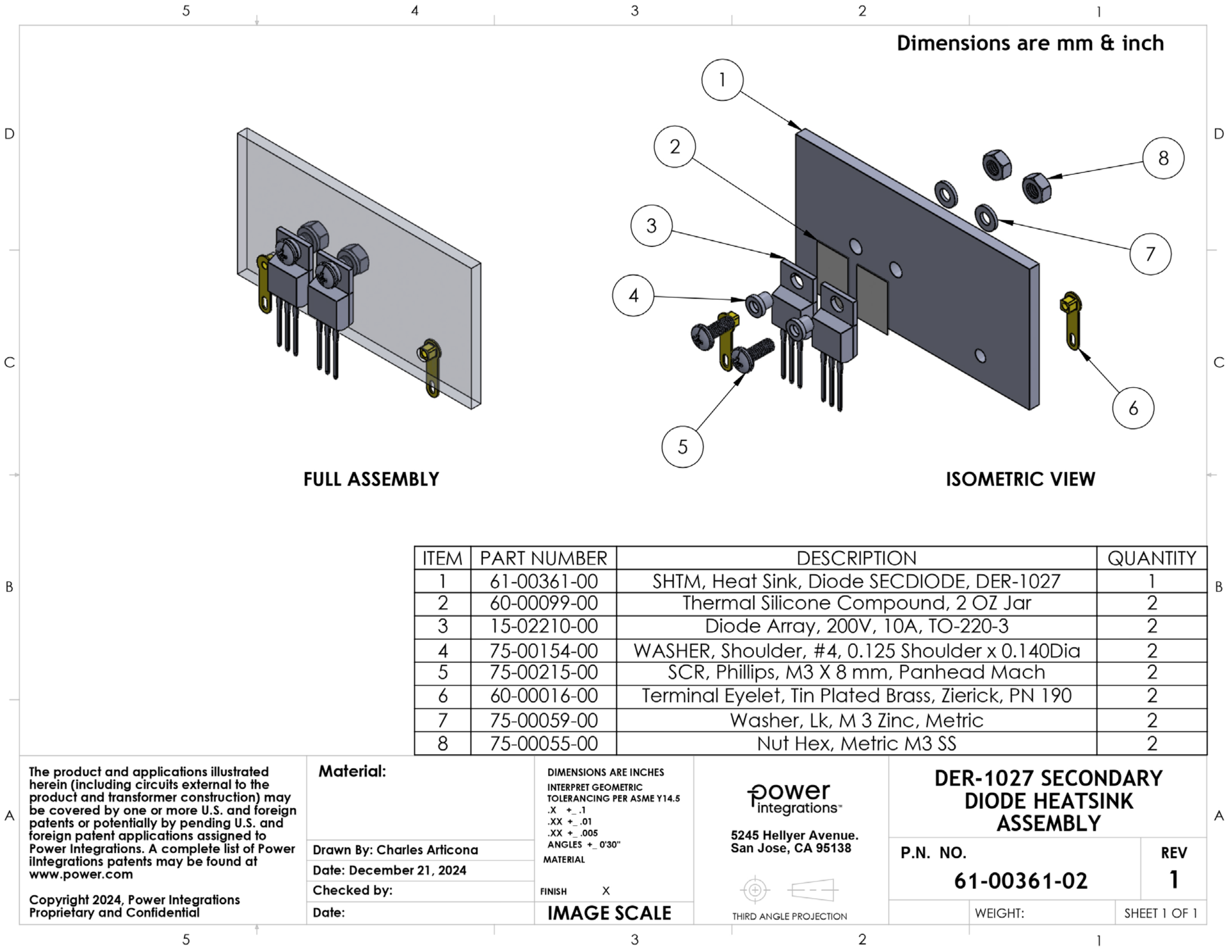
DIMENSIONS ARE INCHES
INTERPRET GEOMETRIC TOLERANCING PER ASME Y14.5
.X +_ .1
.XX +_ .01
.XX +_ .005
ANGLES +_ 0'30"
MATERIAL
FINISH X
IMAGE SCALE

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

DER-1027 SECONDARY DIODE FAB
P.N. NO. 61-00361-01
REV 1
WEIGHT:
SHEET 1 OF 1

Figure 18 – DER-1027 Secondary Diode Heat Sink with Hardware.

10.3.3 Secondary Diode Heat Sink Assembly



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	61-00361-00	SHTM, Heat Sink, Diode SECDIODE, DER-1027	1
2	60-00099-00	Thermal Silicone Compound, 2 OZ Jar	2
3	15-02210-00	Diode Array, 200V, 10A, TO-220-3	2
4	75-00154-00	WASHER, Shoulder, #4, 0.125 Shoulder x 0.140Dia	2
5	75-00215-00	SCR, Phillips, M3 X 8 mm, Panhead Mach	2
6	60-00016-00	Terminal Eyelet, Tin Plated Brass, Zierick, PN 190	2
7	75-00059-00	Washer, Lk, M 3 Zinc, Metric	2
8	75-00055-00	Nut Hex, Metric M3 SS	2

Figure 19 – DER-1027 Secondary Diode Heat Sink Assembly.

11 Performance Data

11.1.1 Full Load Efficiency vs. Line

Test Condition: Soak for 15 minutes for each line.

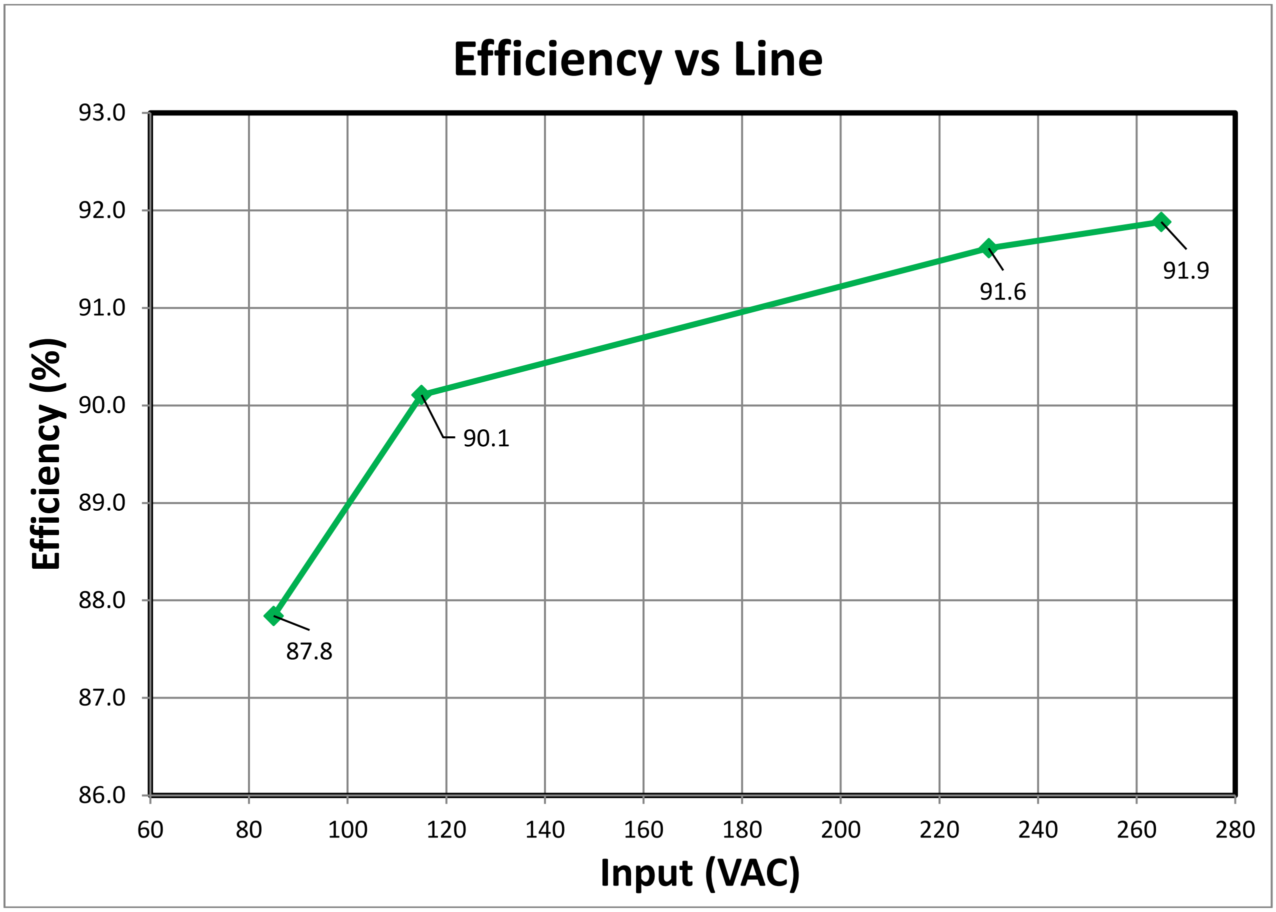


Figure 20 – Efficiency vs. Input Voltage.

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	**(Hz)**	**(RMS)**	**(mA)**	**(W)**	**(V)**	**(A)**	**(W)**	**(%)**	**(%)**
85	60.0	85	3164	139	24.4	5	122	1.53	87.8
115	60.0	115	2454	135	24.4	5	122	1.58	90.1
230	50.0	230	1430	133	24.3	5	122	1.41	91.6
265	50.0	265	1285	132	24.3	5	122	1.33	91.9

11.2 Line Regulation

Test Condition: Soak for 15 minutes for each line.

Figure 21 – Output Voltage vs. Line Voltage.

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(%)
85	60.0	85	3164	139	24.4	5	122	1.53	87.8
115	60.0	115	2454	135	24.4	5	122	1.58	90.1
230	50.0	230	1430	133	24.3	5	122	1.41	91.6
265	50.0	265	1285	132	24.3	5	122	1.33	91.9

11.3 Efficiency vs. Load

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

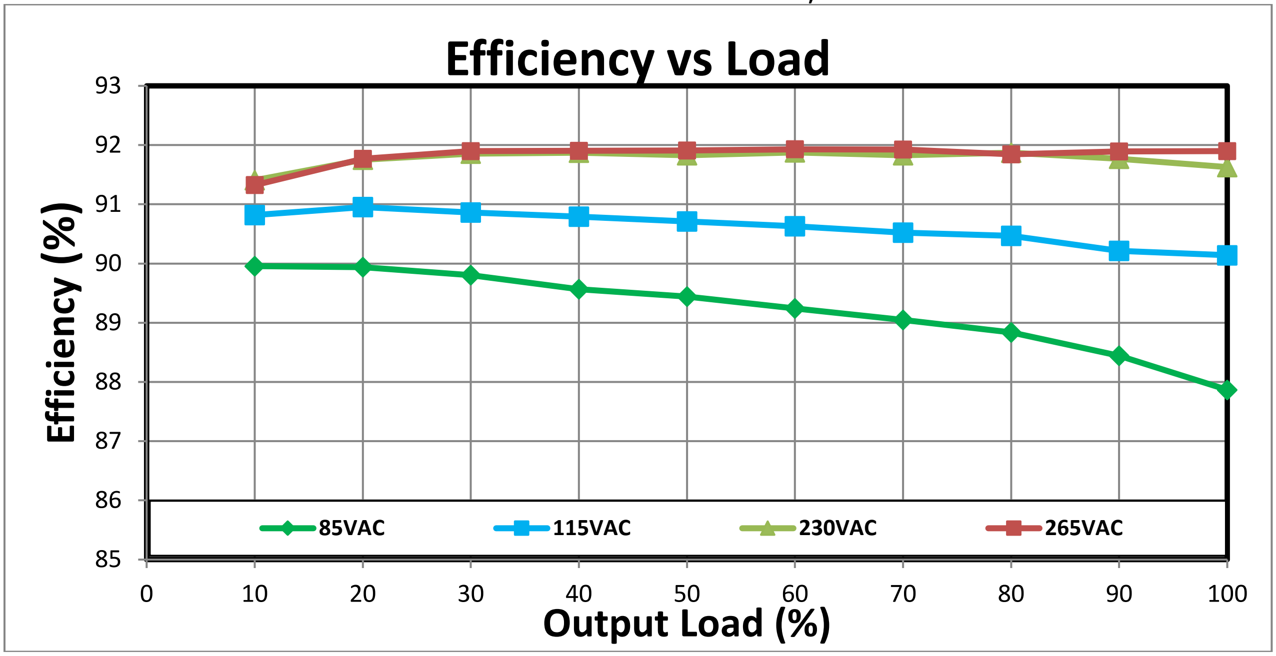


Figure 22 – Efficiency vs. Percentage Load.

11.4 Load Regulation

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

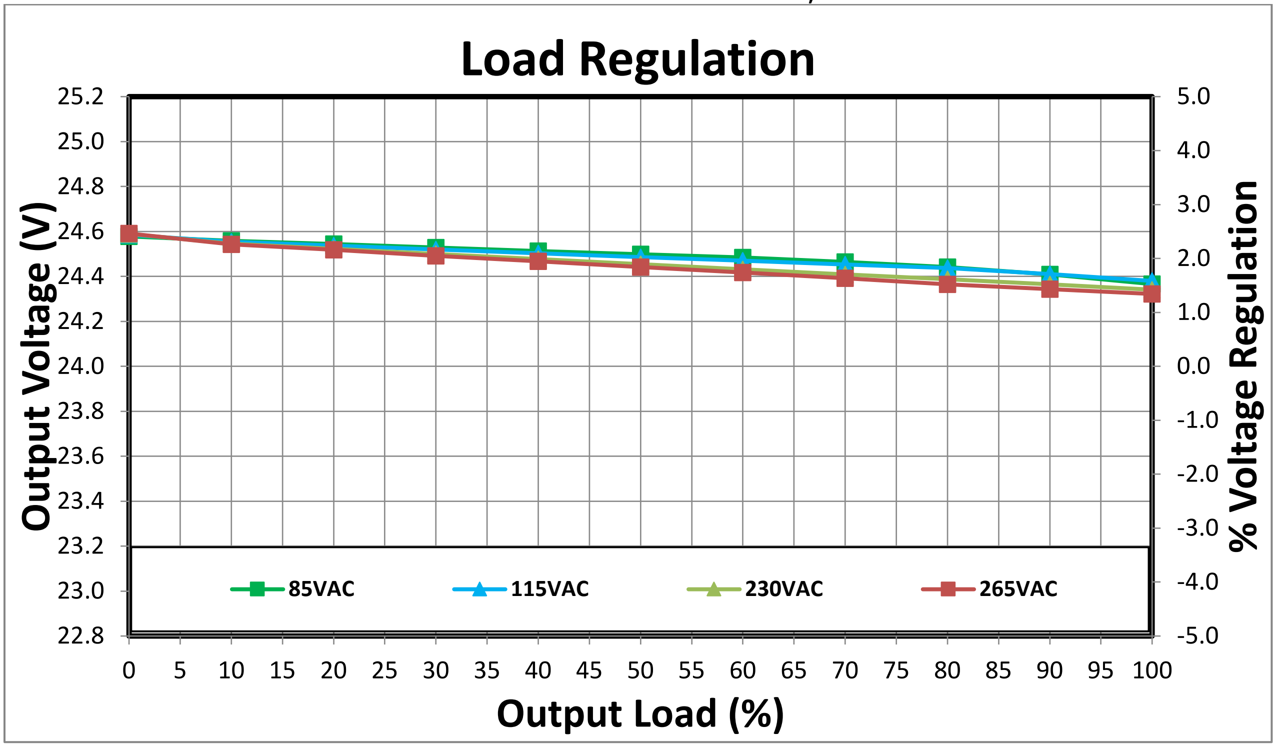


Figure 23 – Output Voltage vs. Percent Load.

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(mA)	(W)	(%)	(%)
85	60	85	3160	139	24.4	4999	122	1.53	87.9
85	60	85	2867	124	24.4	4499	110	1.70	88.4
85	60	85	2577	110	24.4	3999	97.7	1.84	88.8
85	60	85	2288	96.1	24.5	3500	85.6	1.93	89.0
85	60	85	1993	82.3	24.5	2999	73.4	2.02	89.2
85	60	85	1694	68.5	24.5	2500	61.2	2.08	89.4
85	60	85	1388	54.7	24.5	2000	49.0	2.14	89.6
85	60	85	1074	41.0	24.5	1500	36.8	2.20	89.8
85	60	85	749	27.3	24.5	1000	24.5	2.27	89.9
85	60	85	407	13.7	24.6	500	12.3	2.33	90.0
85	60	85	38.4	0.05	24.6		0.00	2.41	

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(mA)	(W)	(%)	(%)
115	60	115	2447	135.2	24.4	4999	122	1.58	90.1
115	60	115	2232	121.7	24.4	4499	110	1.71	90.2
115	60	115	2002	108.0	24.4	3999	97.7	1.82	90.5
115	60	115	1776	94.5	24.5	3499	85.6	1.89	90.5
115	60	115	1553	81.0	24.5	2999	73.4	1.96	90.6
115	60	115	1322	67.5	24.5	2500	61.2	2.03	90.7
115	60	115	1086	54.0	24.5	2000	49.0	2.10	90.8
115	60	115	842	40.5	24.5	1500	36.8	2.17	90.9
115	60	115	589	27.0	24.5	1000	24.5	2.24	91.0
115	60	115	322	13.5	24.6	500	12.3	2.31	90.8
115	60	115	42.1	0.06	24.59		0.00	2.44	

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(mA)	(W)	(%)	(%)
230	50	230	1430	133	24.3	4999	122	1.42	91.6
230	50	230	1302	119	24.4	4499	110	1.52	91.8
230	50	230	1176	106	24.4	3999	97.5	1.62	91.9
230	50	230	1049	93.0	24.4	3500	85.4	1.70	91.8
230	50	230	919	79.8	24.4	2999	73.3	1.80	91.9
230	50	230	785	66.6	24.5	2500	61.1	1.90	91.8
230	50	230	647	53.3	24.5	2000	49.0	1.99	91.9
230	50	230	504	40.0	24.5	1500	36.8	2.08	91.9
230	50	230	355	26.7	24.5	1000	24.5	2.18	91.8
230	50	230	199	13.4	24.5	501	12.3	2.28	91.4
230	50	230	55.2	0.09	24.6		0.00	2.45	

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(mA)	(W)	(%)	(%)
265	50	265	1284	132	24.3	4999	122	1.34	91.9
265	50	265	1168	119	24.3	4499	110	1.43	91.9
265	50	265	1051	106	24.4	3999	97.4	1.52	91.8
265	50	265	932	92.9	24.4	3499	85.4	1.63	91.9
265	50	265	813	79.7	24.4	2999	73.2	1.74	91.9
265	50	265	693	66.5	24.4	2500	61.1	1.84	91.9
265	50	265	572	53.2	24.5	2000	48.9	1.95	91.9
265	50	265	447	40.0	24.5	1500	36.7	2.05	91.9
265	50	265	317	26.7	24.5	1000	24.5	2.16	91.8
265	50	265	181	13.5	24.5	501	12.3	2.26	91.3
265	50	265	61.2	0.11	24.59		0.00	2.46	

11.5 Average and 10% Efficiency

11.5.1 Average and 10% Efficiency at 115 VAC

Load	P_{IN}	V_{OUT} at PCB	I_{OUT}	P_{OUT}	Efficiency at PCB	Average Efficiency	DOE6 Limit
(A)	(W)	(V_{DC})	(mA_{DC})	(W)	(%)	(%)	(%)
100%	135	24.4	4999	122	90.2	**90.5**	88.0
75%	101	24.4	3749	91.6	90.4		
50%	67.5	24.5	2500	61.2	90.7		
25%	33.7	24.5	1250	30.7	90.9		
10%	13.5	24.6	500	12.3	90.8	---	---

11.5.2 Average and 10% Efficiency at 230 VAC

Load	P_{IN}	V_{OUT} at PCB	I_{OUT}	P_{OUT}	Efficiency at PCB	Average Efficiency	DOE6 Limit
(A)	(W)	(V_{DC})	(mA_{DC})	(W)	(%)	(%)	(%)
100%	133	24.3	4999	122	91.5	**91.7**	88.0
75%	99.7	24.4	3749	91.5	91.8		
50%	66.6	24.5	2500	61.1	91.8		
25%	33.4	24.5	1250	30.6	91.7		
10%	13.5	24.6	500	12.3	91.3	---	---

11.5.3 No-Load Input Power

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

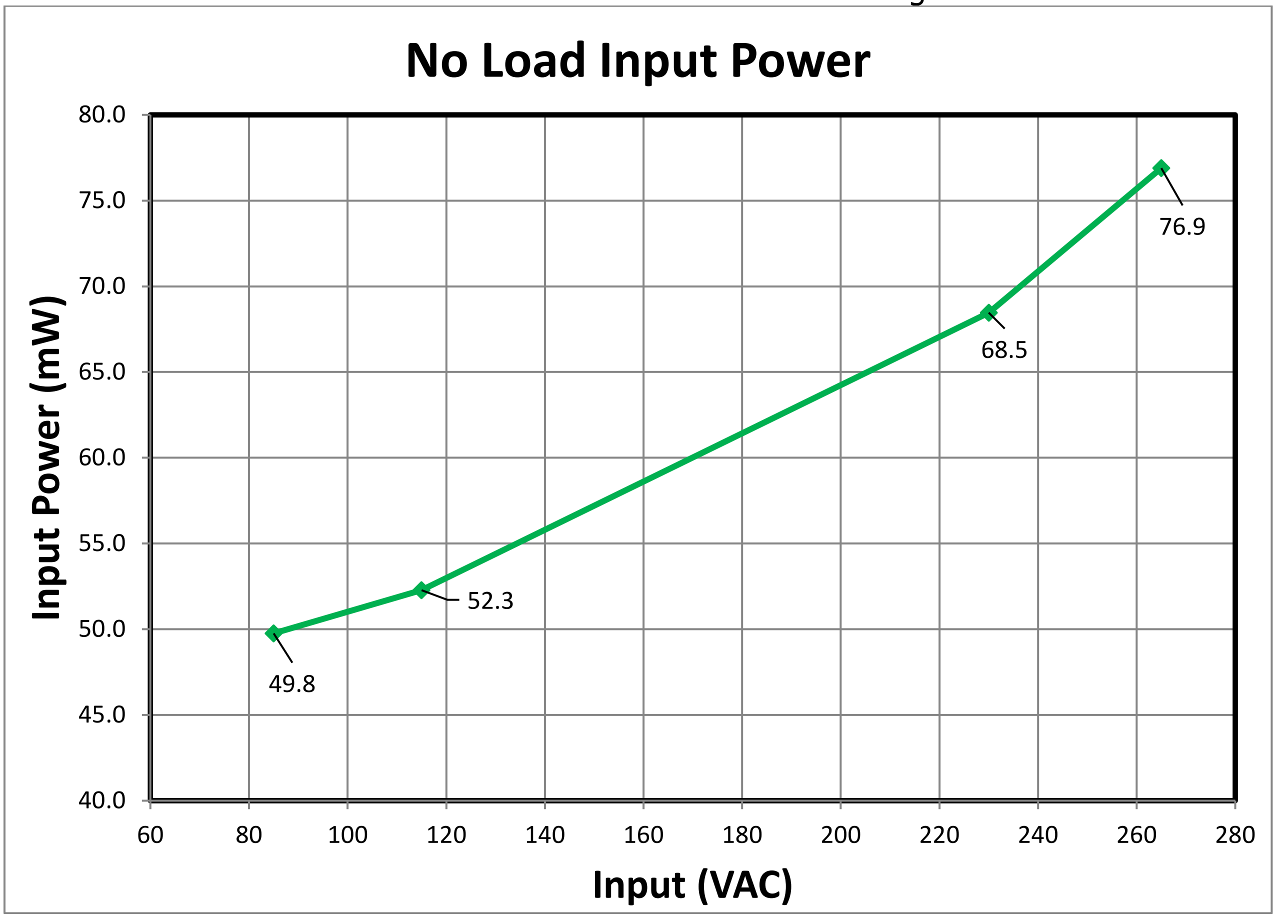


Figure 24 – No-Load Input Power vs. Line at Room Temperature.

VAC	Freq	V_{IN}	I_{IN}	P_{IN}
(RMS)	**(Hz)**	**(RMS)**	**(mA)**	**(mW)**
85.0	60.0	85.0	38.4	49.8
115	60.0	115	42.2	52.3
230	50.0	230	55.3	68.5
265	50.0	265	61.2	76.9

11.6 Standby Input Power

11.6.1 Standby Efficiency

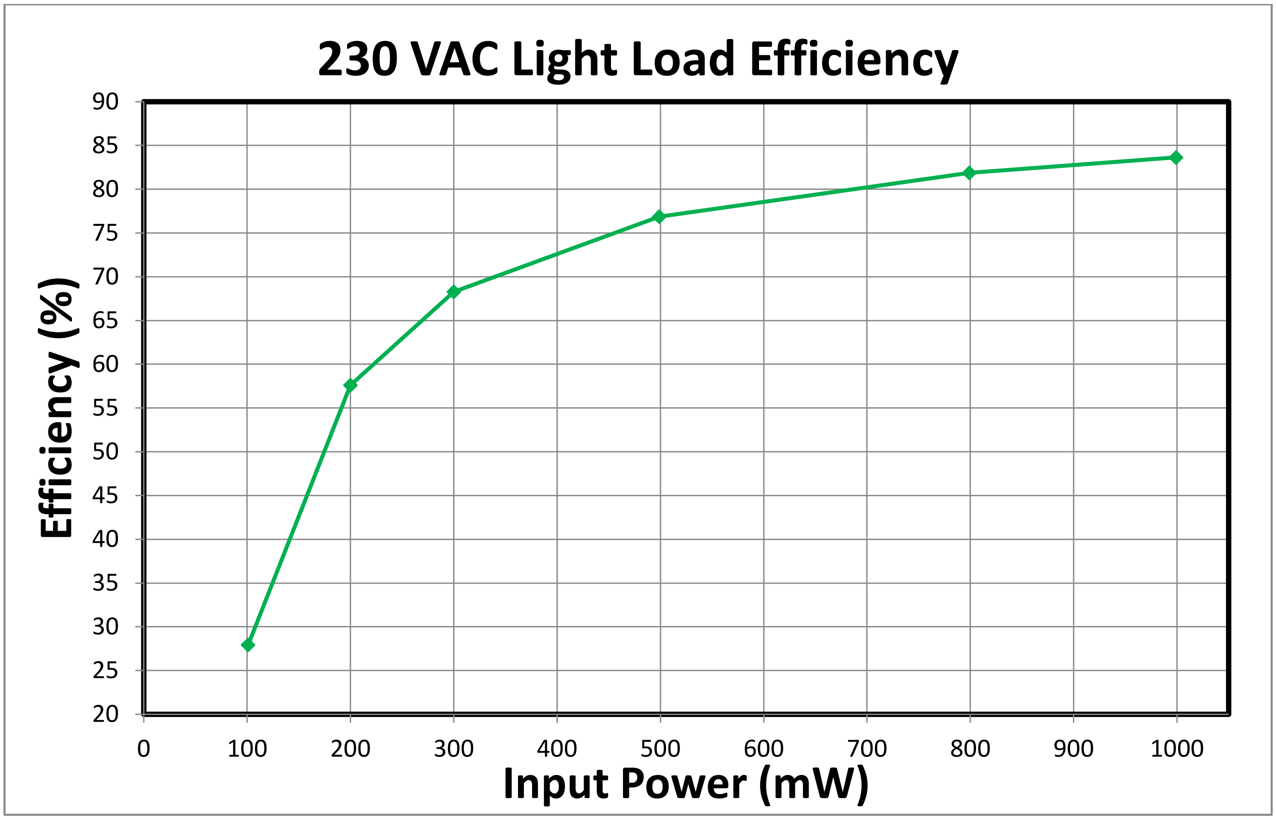


Figure 25 – Efficiency vs. Input Power

11.6.2 Standby Input Power

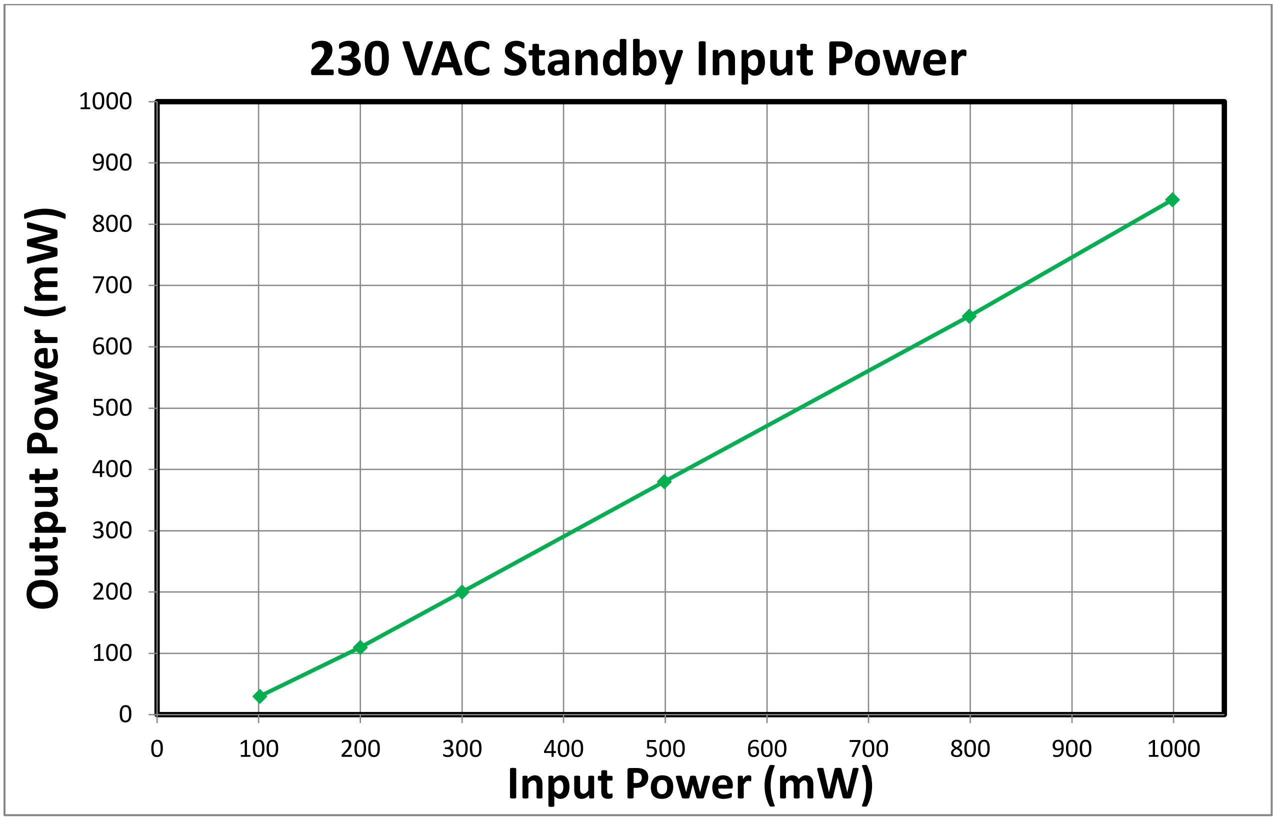


Figure 26 – Output Power vs. Input Power

12 Waveforms

12.1 Output Start-up

12.1.1 Full Load (E-Load Constant Current Mode)

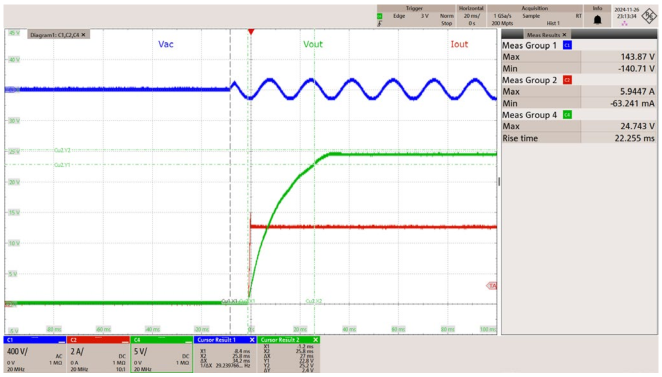


Figure 27 – 85 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 27 ms.
V_{MAX} = 24.7 V

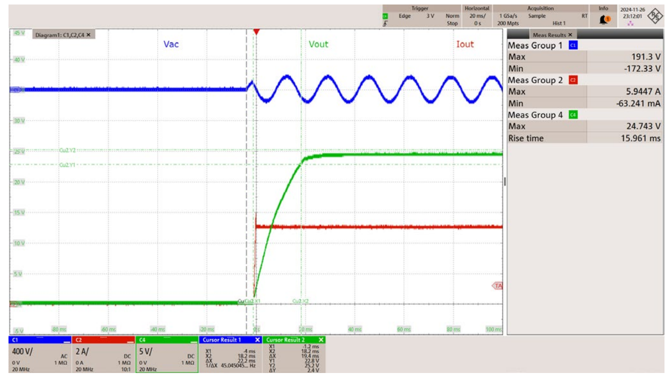


Figure 28 – 115 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 19.4 ms.
V_{MAX} = 24.7 V

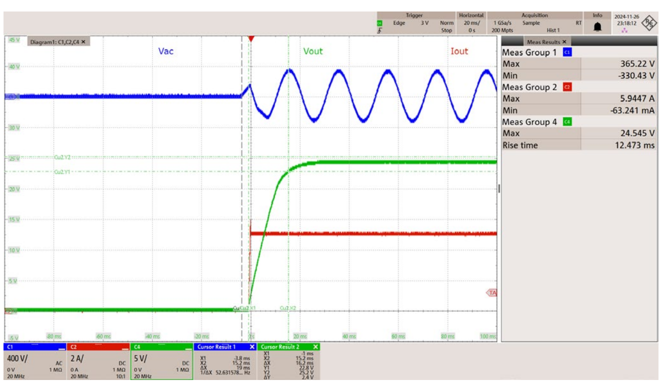


Figure 29 – 230 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 16.2 ms.
V_{MAX} = 24.5 V

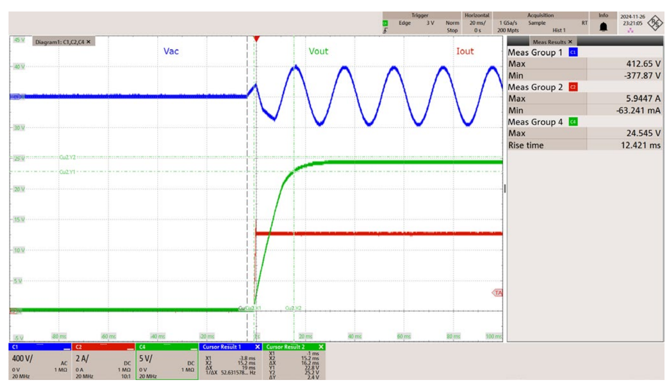


Figure 30 – 265 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 16.2 ms.
V_{MAX} = 24.5 V

12.1.2 Full Load (E-Load Constant Resistance Mode)

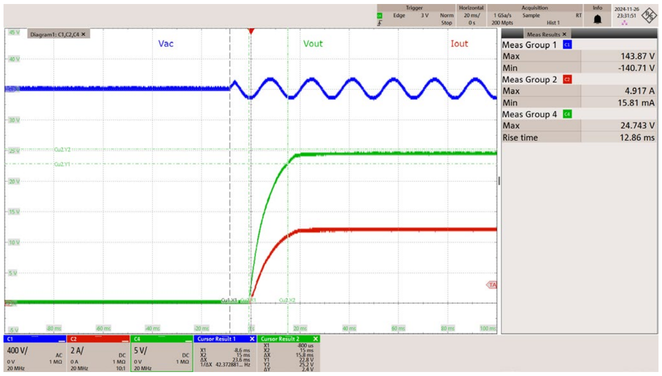


Figure 31 – 85 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 15.8 ms.
V_{MAX} = 24.7 V

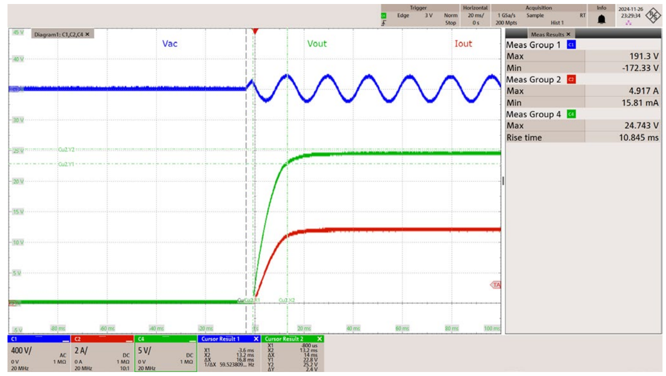


Figure 32 – 115 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 14 ms.
V_{MAX} = 24.7 V

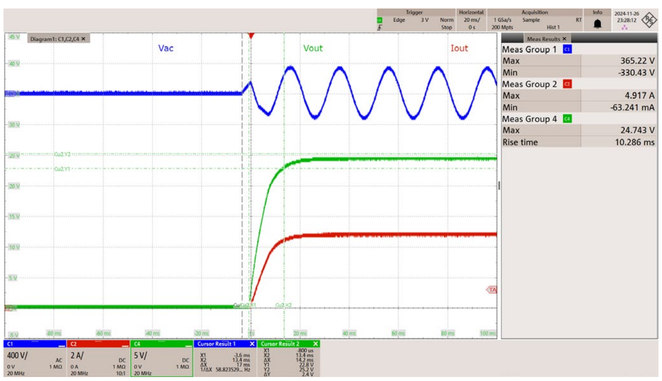


Figure 33 – 230 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 14.2 ms.
V_{MAX} = 24.7 V

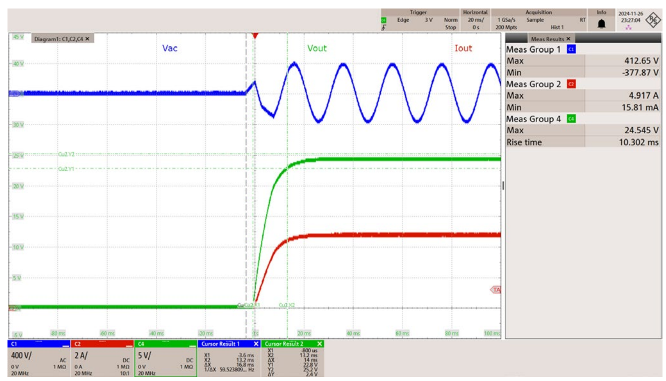


Figure 34 – 265 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 14 ms.
V_{MAX} = 24.5 V

12.1.3 No Load

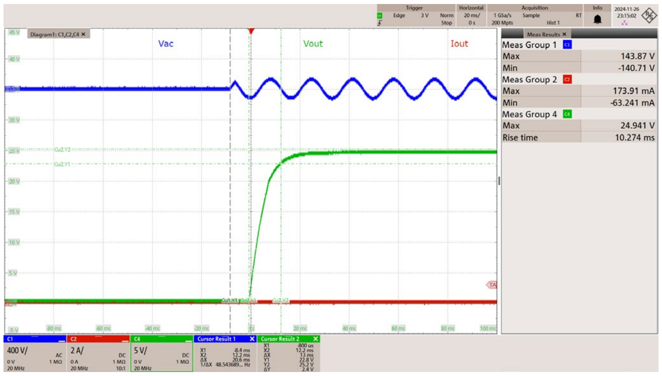


Figure 35 – 85 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 13 ms.
V_{MAX} = 24.9 V

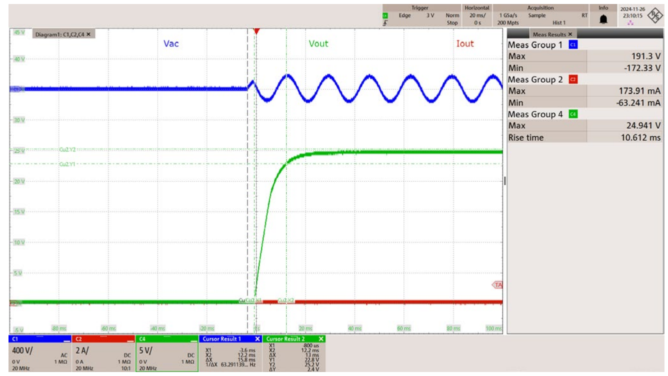


Figure 36 – 115 VAC 60 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 13 ms.
V_{MAX} = 24.9 V

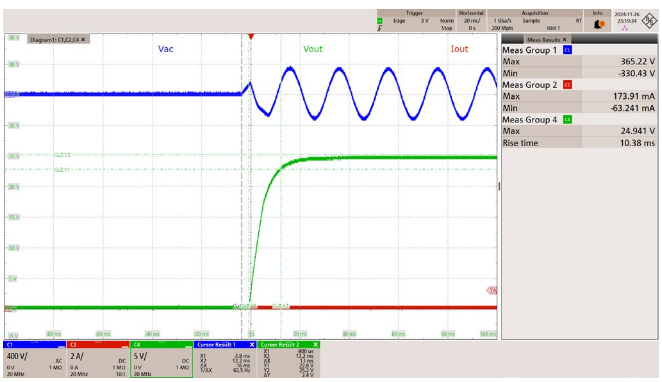


Figure 37 – 230 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 13 ms.
V_{MAX} = 24.9 V

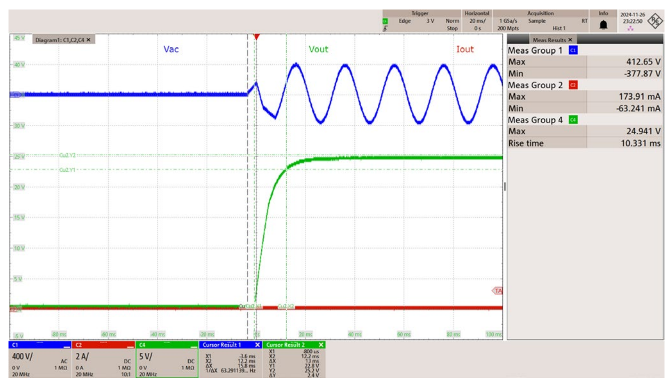


Figure 38 – 265 VAC 50 Hz.
CH1: V_{IN}, 400 V / div., 20 ms / div.
CH2: I_{OUT}, 2 A / div., 20 ms / div.
CH4: V_{OUT}, 5 V / div., 20 ms / div.
Rise Time = 13 ms.
V_{MAX} = 24.9 V

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

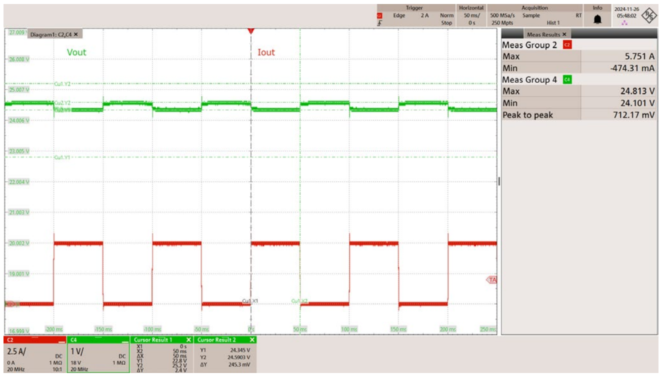


Figure 39 – 85 VAC 60 Hz.
CH2: I_{OUT}, 2.5 A / div., 50 ms / div.
CH4: V_{OUT}, 1 V / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.8 V
V_{MIN}: 24.1 V

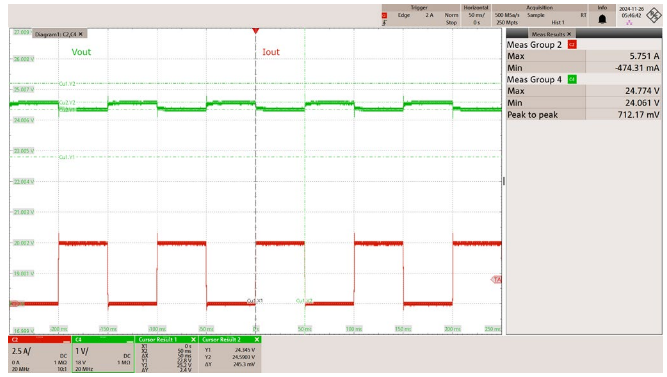


Figure 40 – 115 VAC 60 Hz.
CH2: I_{OUT}, 2.5 A / div., 50 ms / div.
CH4: V_{OUT}, 1 V / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.8 V
V_{MIN}: 24.1 V

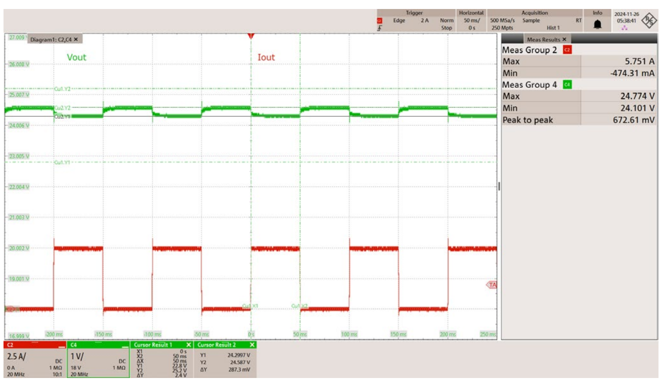


Figure 41 – 230 VAC 50 Hz.
CH2: I_{OUT}, 2.5 A / div., 50 ms / div.
CH4: V_{OUT}, 1 V / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.8 V
V_{MIN}: 24.1 V

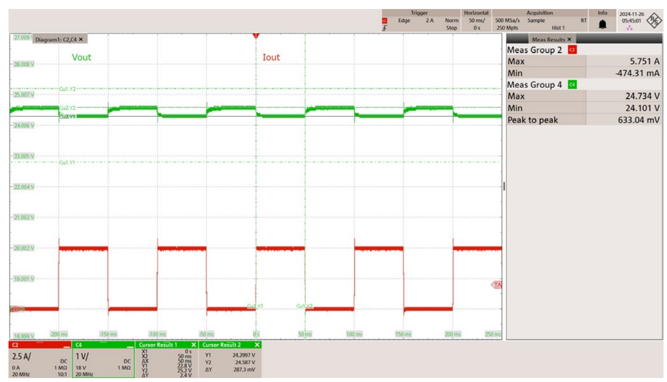


Figure 42 – 265 VAC 50 Hz.
CH2: I_{OUT}, 2.5 A / div., 50 ms / div.
CH4: V_{OUT}, 1 V / div., 50 ms / div.
V_{OUT}: V_{MAX}: 24.7 V
V_{MIN}: 24.1 V

12.2 Switching Waveforms

12.2.1 Primary MOSFET VDS and IDS at Normal Operation

12.2.1.1 Full Load

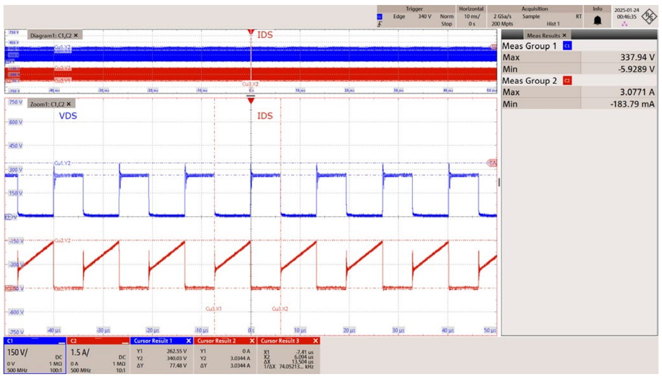


Figure 43 – 85 VAC 60 Hz.
CH1: V_{DS}, 150 V / div., 10 ms / div.
CH2: I_{DS}, 1.5 A / div., 10 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 338 V
$I_{DS(MAX)}$ = 3.08 A

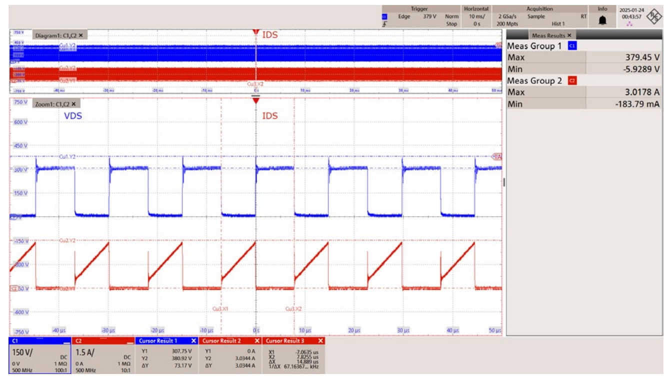


Figure 44 – 115 VAC 60 Hz.
CH1: V_{DS}, 150 V / div., 10 ms / div.
CH2: I_{DS}, 1.5 A / div., 10 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 379 V
$I_{DS(MAX)}$ = 3.02 A

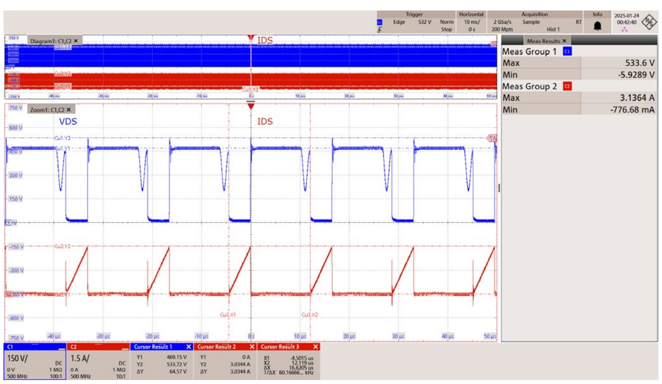


Figure 45 – 230 VAC 50 Hz.
CH1: V_{DS}, 150 V / div., 10 ms / div.
CH2: I_{DS}, 1.5 A / div., 10 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 534 V
$I_{DS(MAX)}$ = 3.14 A

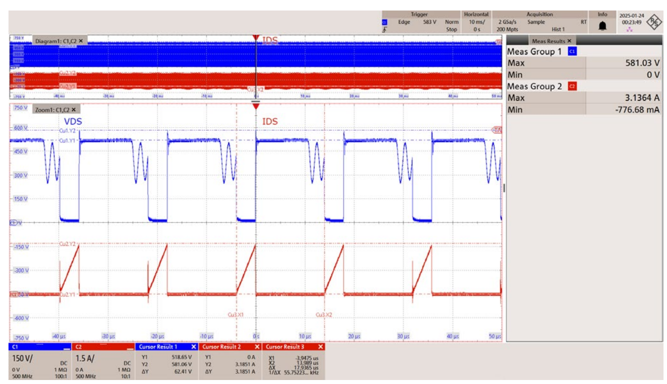


Figure 46 – 265 VAC 50 Hz.
CH1: V_{DS}, 150 V / div., 10 ms / div.
CH2: I_{DS}, 1.5 A / div., 10 ms / div.
Zoom: 10 μs / div.
$V_{DS(MAX)}$ = 581 V
$I_{DS(MAX)}$ = 3.14 A

12.2.1.2 No Load

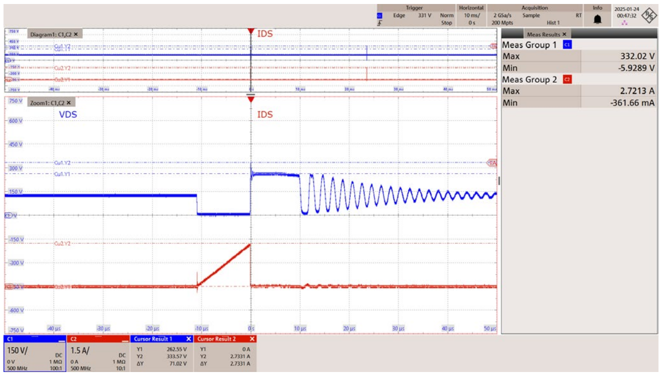


Figure 47 – 85 VAC 60 Hz.
CH1: V_{DS}, 150 V / div., 10 ms / div.
CH2: I_{DS}, 1.5 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 332 V
$I_{DS(MAX)}$ = 2.72 A

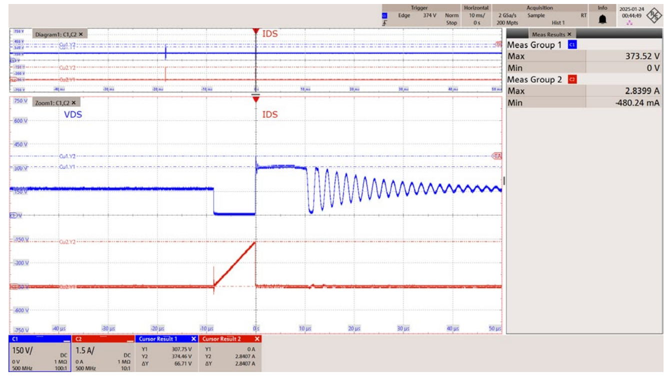


Figure 48 – 115 VAC 60 Hz.
CH1: V_{DS}, 150 V / div., 10 ms / div.
CH2: I_{DS}, 1.5 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 374 V
$I_{DS(MAX)}$ = 2.84 A

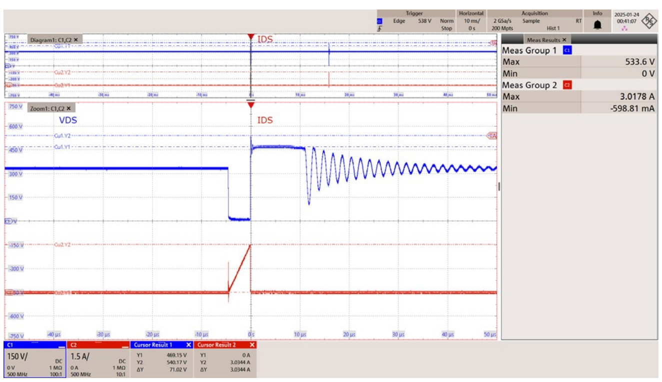


Figure 49 – 230 VAC 50 Hz.
CH1: V_{DS}, 150 V / div., 10 ms / div.
CH2: I_{DS}, 1.5 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 534 V
$I_{DS(MAX)}$ = 3.02 A

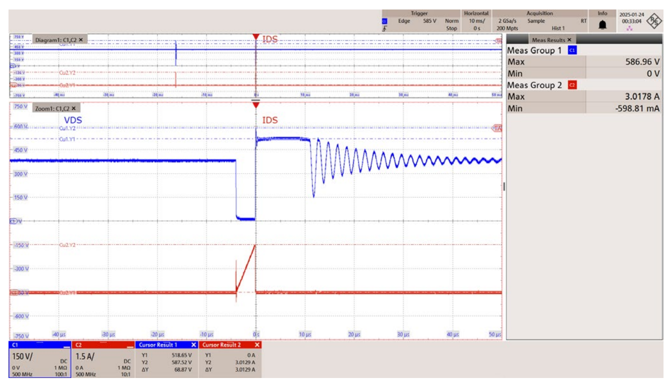


Figure 50 – 265 VAC 50 Hz.
CH1: V_{DS}, 150 V / div., 10 ms / div.
CH2: I_{DS}, 1.5 A / div., 10 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 587 V
$I_{DS(MAX)}$ = 3.02 A

12.2.2 Primary MOSFET VDS and IDS at Start-up Operation

12.2.2.1 Full Load

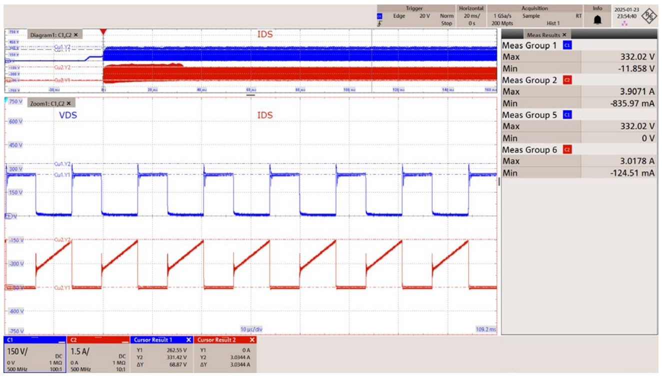


Figure 51 – 85 VAC 60 Hz.
CH1: V_{DS}, 150 V / div., 20 ms / div.
CH2: I_{DS}, 1.5 A / div., 20 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 332 V
$I_{DS(MAX)}$ = 3.91 A

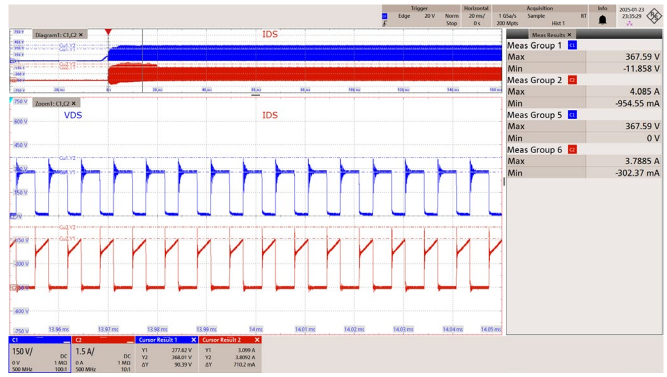


Figure 52 – 115 VAC 60 Hz.
CH1: V_{DS}, 150 V / div., 20 ms / div.
CH2: I_{DS}, 1.5 A / div., 20 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 368 V
$I_{DS(MAX)}$ = 4.09 A

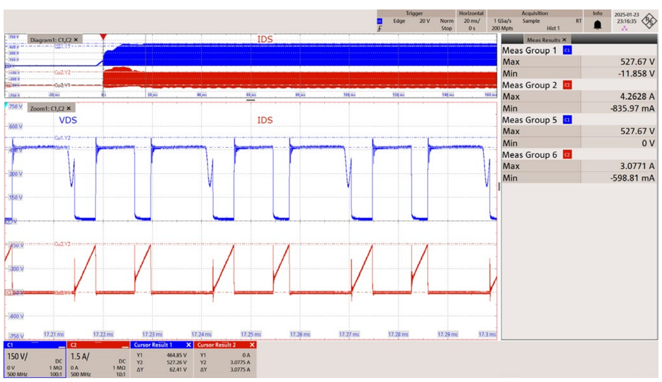


Figure 53 – 230 VAC 50 Hz.
CH1: V_{DS}, 150 V / div., 20 ms / div.
CH2: I_{DS}, 1.5 A / div., 20 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 528 V
$I_{DS(MAX)}$ = 4.26 A

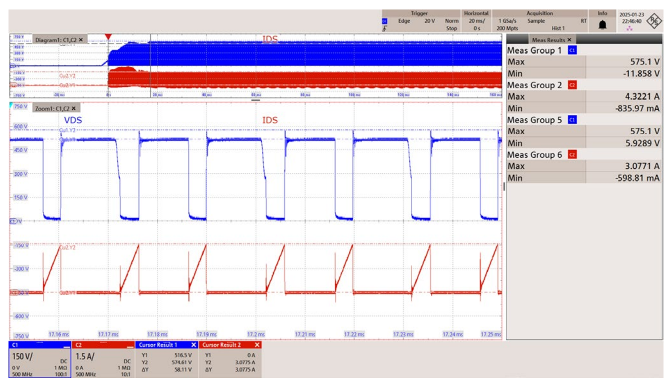


Figure 54 – 265 VAC 50 Hz.
CH1: V_{DS}, 150 V / div., 20 ms / div.
CH2: I_{DS}, 1.5 A / div., 20 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 575 V
$I_{DS(MAX)}$ = 4.32 A

12.2.2.2 No Load

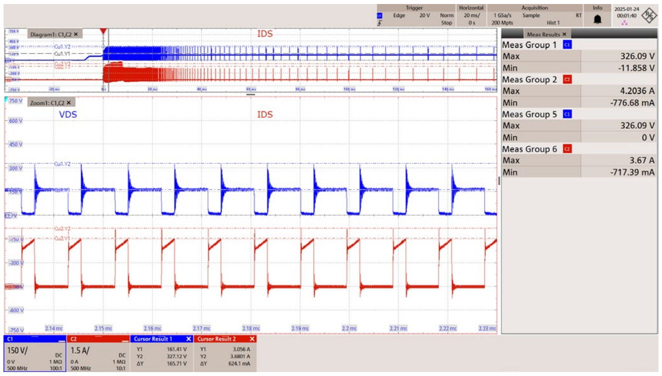


Figure 55 – 85 VAC 60 Hz.
CH1: V_{DS}, 150 V / div., 20 ms / div.
CH2: I_{DS}, 1.5 A / div., 20 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 326 V
$I_{DS(MAX)}$ = 4.20 A

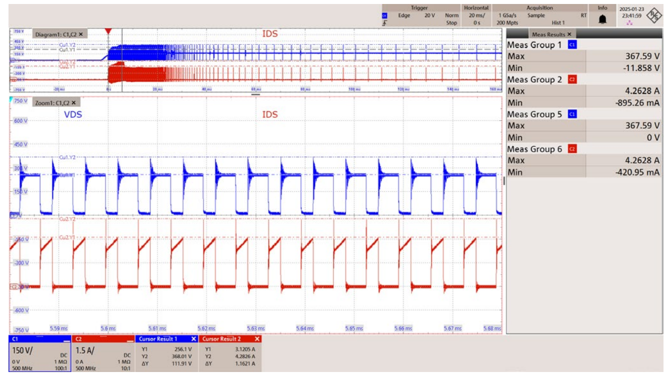


Figure 56 – 115 VAC 60 Hz.
CH1: V_{DS}, 150 V / div., 20 ms / div.
CH2: I_{DS}, 1.5 A / div., 20 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 368 V
$I_{DS(MAX)}$ = 4.26 A

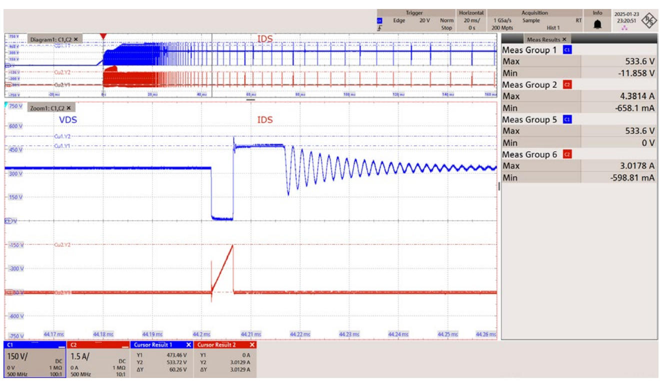


Figure 57 – 230 VAC 50 Hz.
CH1: V_{DS}, 150 V / div., 20 ms / div.
CH2: I_{DS}, 1.5 A / div., 20 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 534 V
$I_{DS(MAX)}$ = 4.38 A

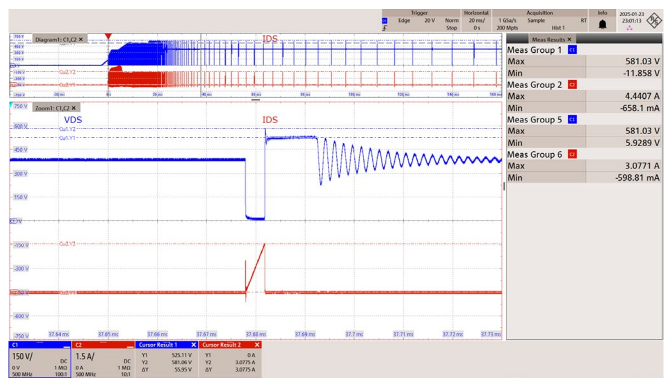


Figure 58 – 265 VAC 50 Hz.
CH1: V_{DS}, 150 V / div., 20 ms / div.
CH2: I_{DS}, 1.5 A / div., 20 ms / div.
Zoom: 10 µs / div.
$V_{DS(MAX)}$ = 581 V
$I_{DS(MAX)}$ = 4.44 A

12.2.3 Freewheeling Diode Voltage at Normal Operation

12.2.3.1 Full Load

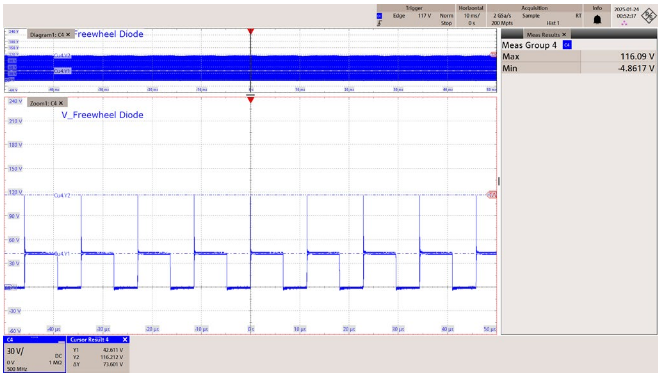


Figure 59 – 85 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 10 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 116 V

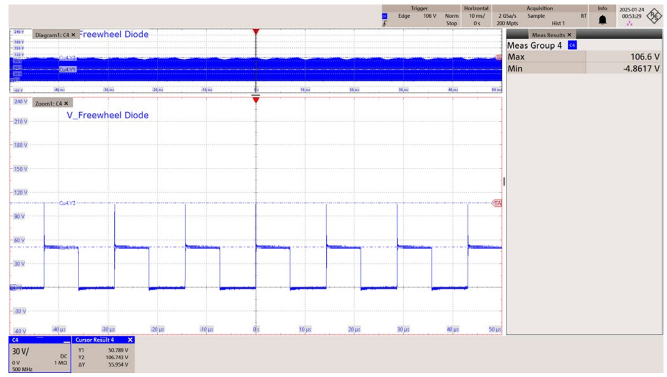


Figure 60 – 115 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 10 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 107 V

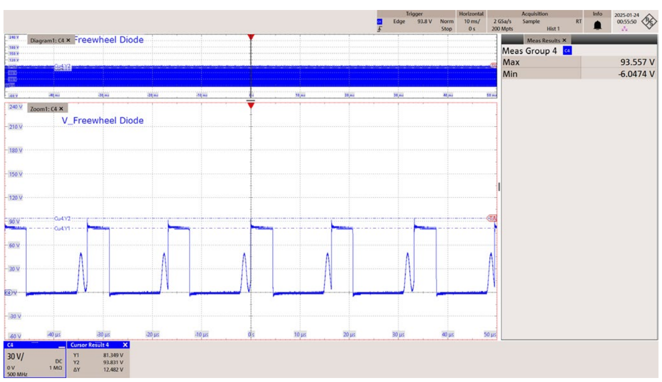


Figure 61 – 230 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 10 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 93.6 V

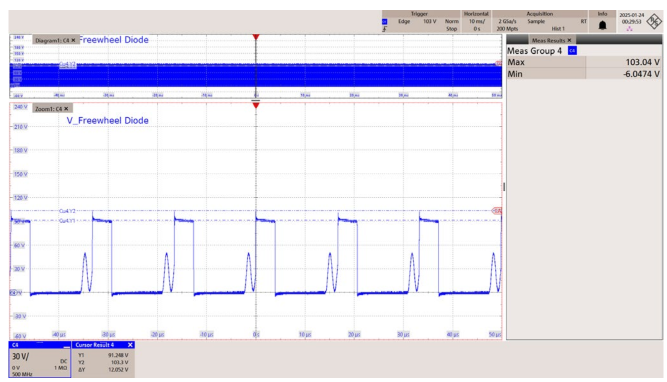


Figure 62 – 265 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 10 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 103 V

12.2.3.2 No Load

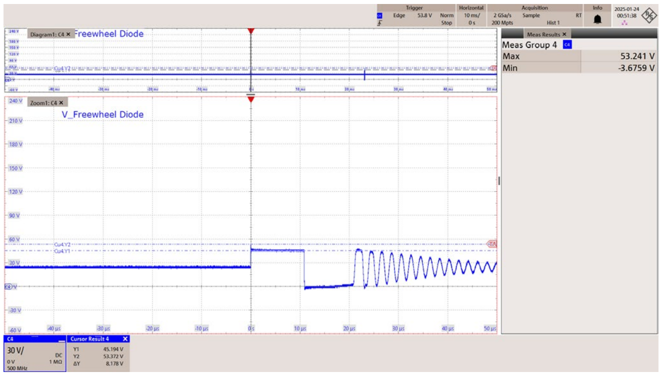


Figure 63 – 85 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 10 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 53.2 V

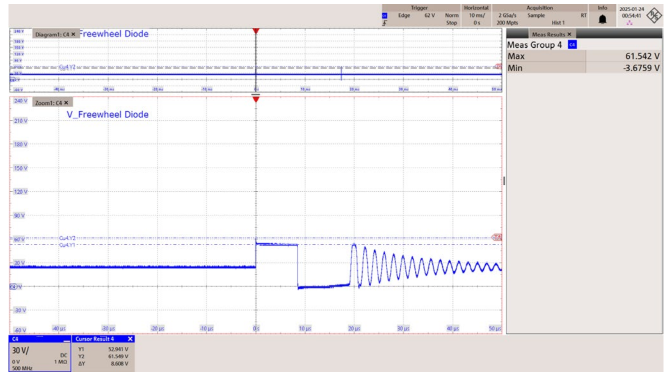


Figure 64 – 115 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 10 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 61.5 V

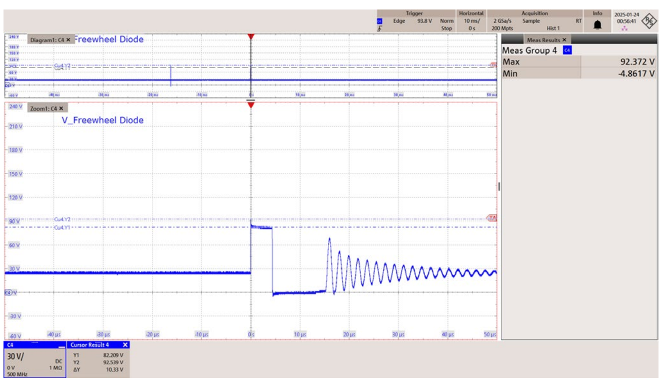


Figure 65 – 230 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 10 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 92.4 V

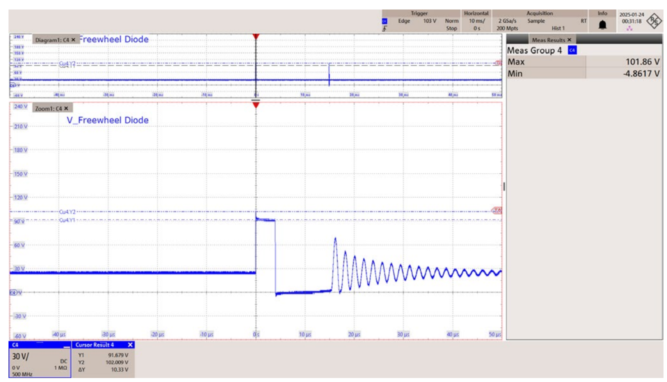


Figure 66 – 265 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 10 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 102 V

12.2.4 Freewheeling Diode Voltage and Current at Start-Up

12.2.4.1 Full Load

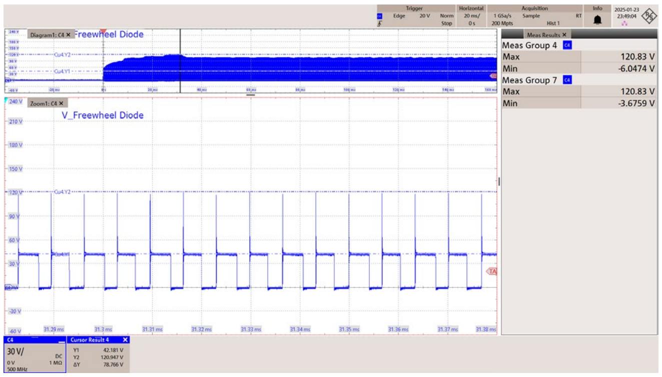


Figure 67 – 85 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 121 V

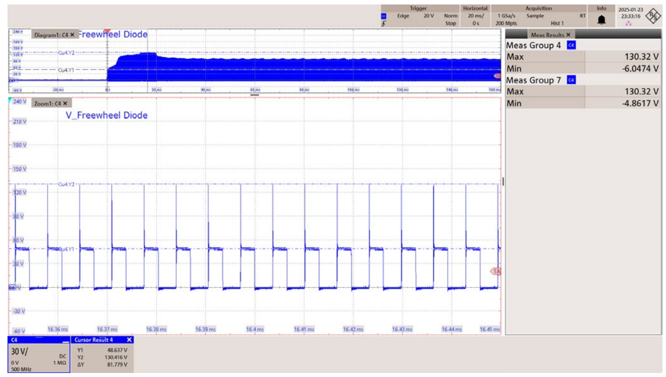


Figure 68 – 115 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 130 V

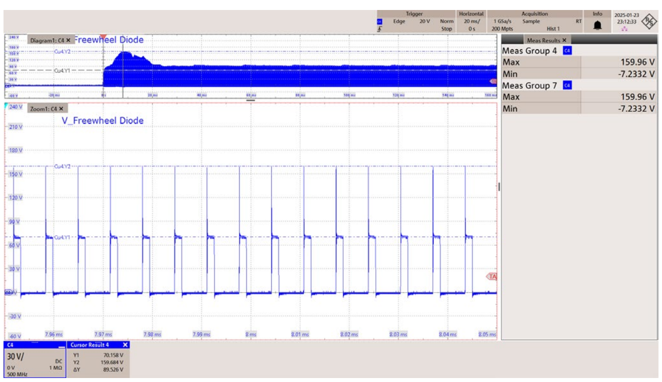


Figure 69 – 230 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 160 V

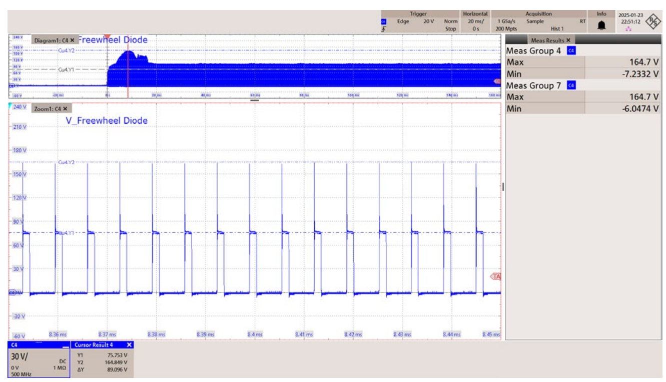


Figure 70 – 265 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 165 V

12.2.4.2 No Load

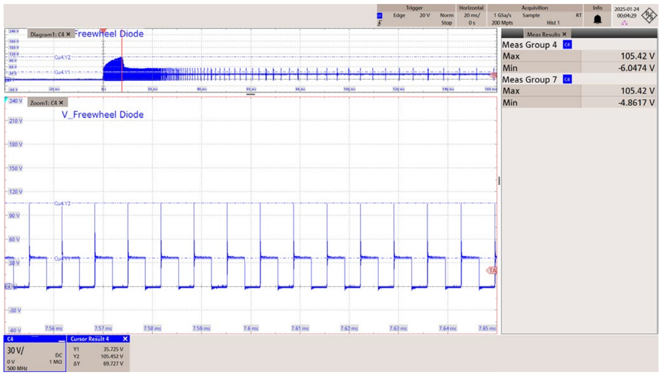


Figure 71 – 85 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 105 V

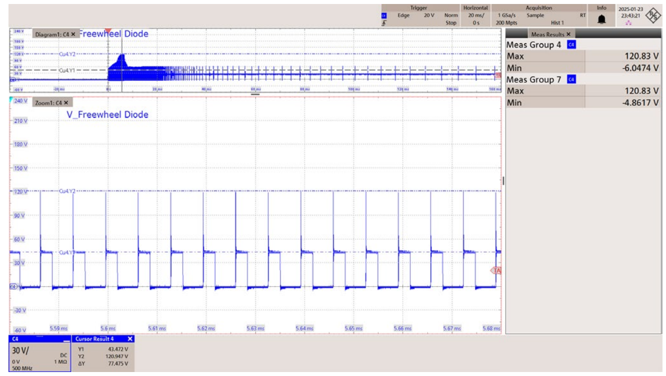


Figure 72 – 115 VAC 60 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 121 V

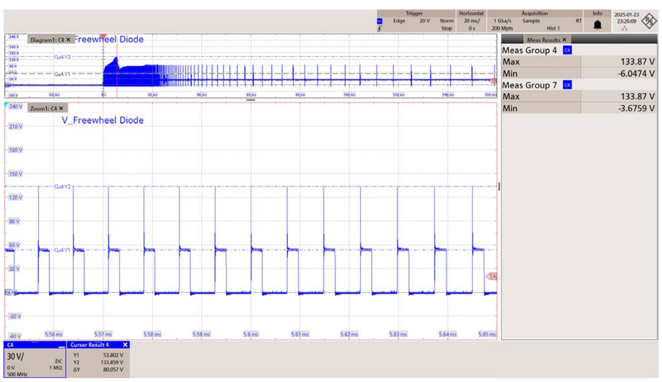


Figure 73 – 230 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 134 V

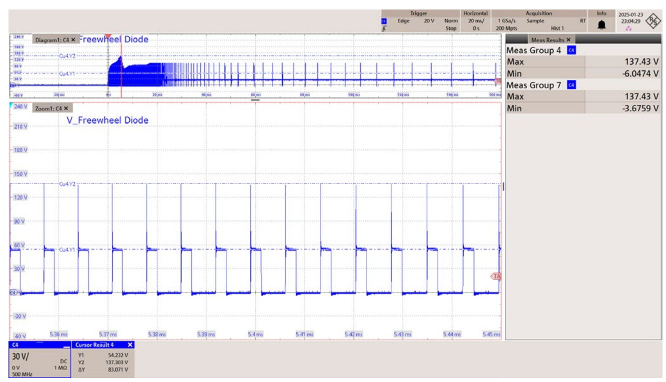


Figure 74 – 265 VAC 50 Hz.
CH1: $V_{FreewheelDiode}$, 30 V / div., 20 ms / div.
Zoom = 10 µs /div.
$V_{FreewheelDiode(MAX)}$ = 137 V

12.3 Output Voltage Ripple

12.3.1 Ripple Measurement Technique

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

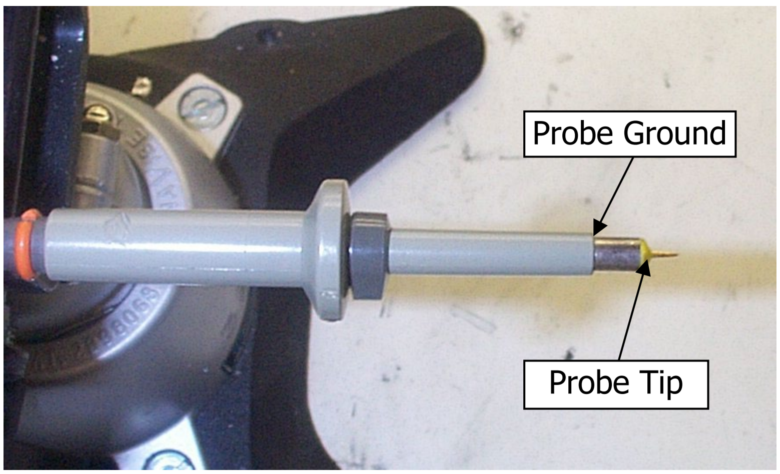


Figure 75 – Oscilloscope Probe Prepared for Ripple Measurement. (Probe cover and Ground Lead Removed.)

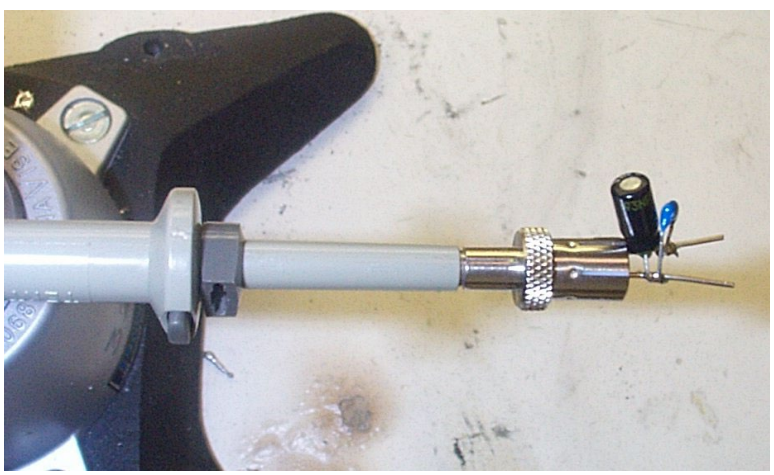


Figure 76 – Oscilloscope Probe with Probe Master (**www.probemaster.com**) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added.)

12.3.2 Measurement Results

Note: All ripple measurements were taken at PCB end.

12.3.2.1 100% Load Condition

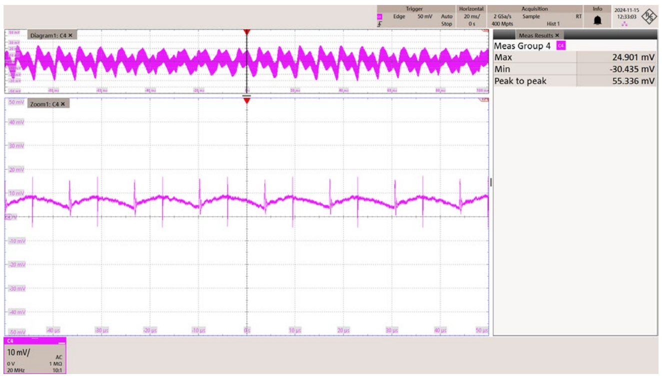


Figure 77 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 55.3 mV

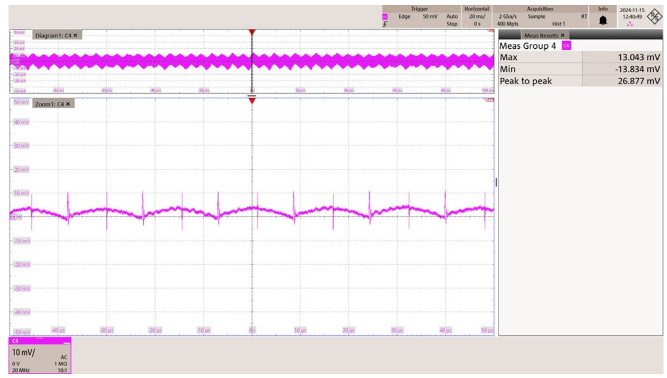


Figure 78 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 26.9 mV

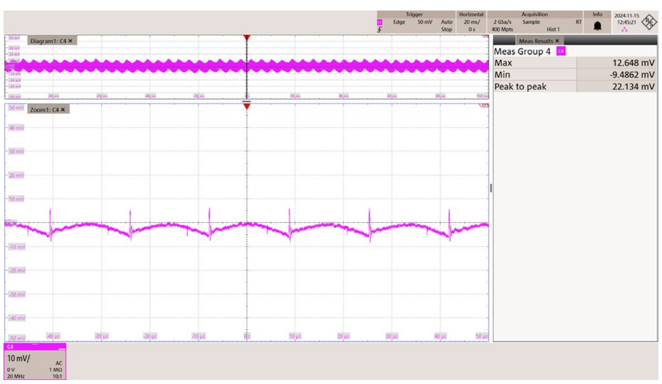


Figure 79 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 22.1 mV

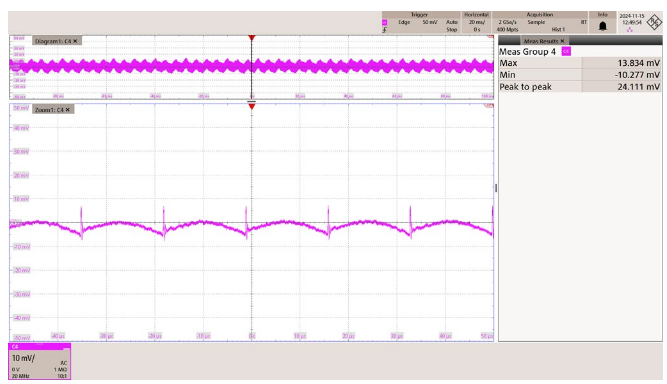


Figure 80 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 24.1 mV

12.3.2.2 75% Load Condition

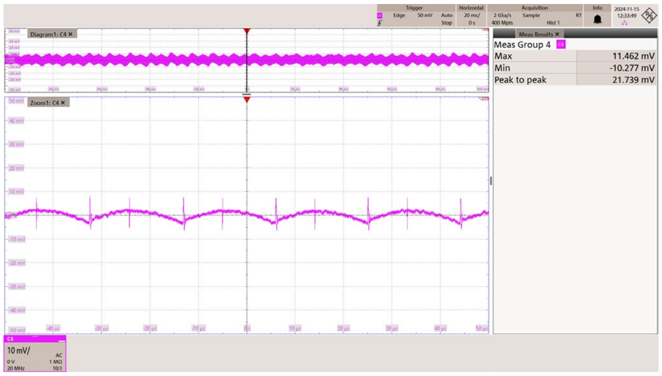


Figure 81 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 μs / div.
Output Ripple = 21.7 mV

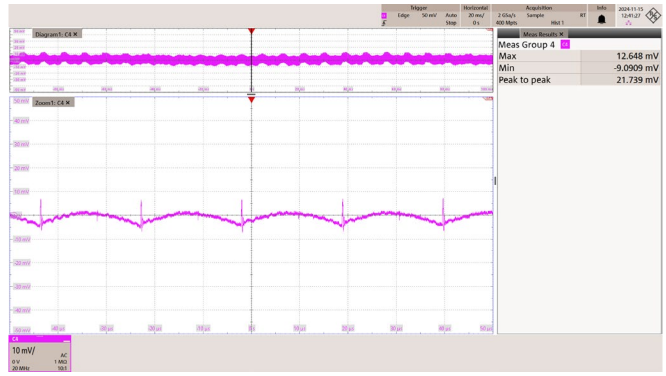


Figure 82 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 μs / div.
Output Ripple = 21.7 mV

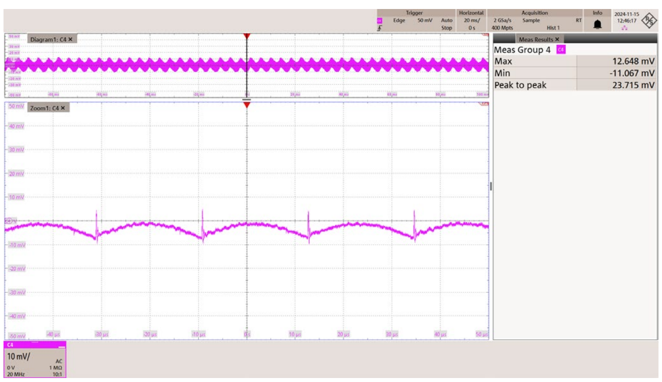


Figure 83 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 μs / div.
Output Ripple = 23.7 mV

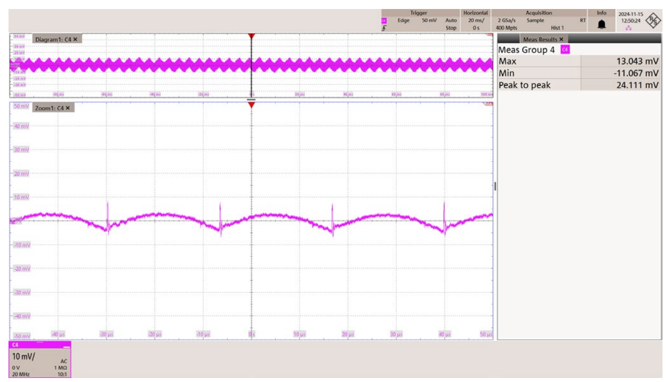


Figure 84 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 μs / div.
Output Ripple = 24.1 mV

12.3.2.3 50% Load Condition

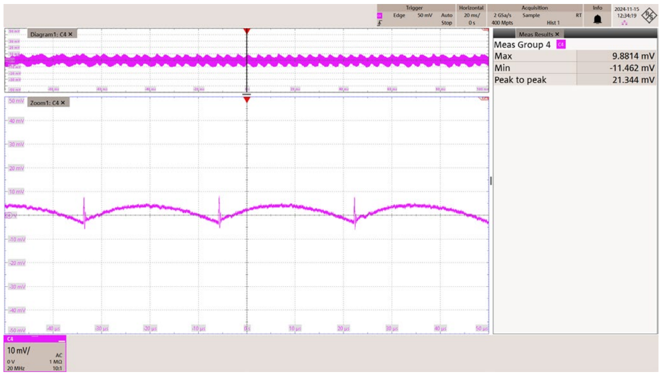


Figure 85 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 21.3 mV

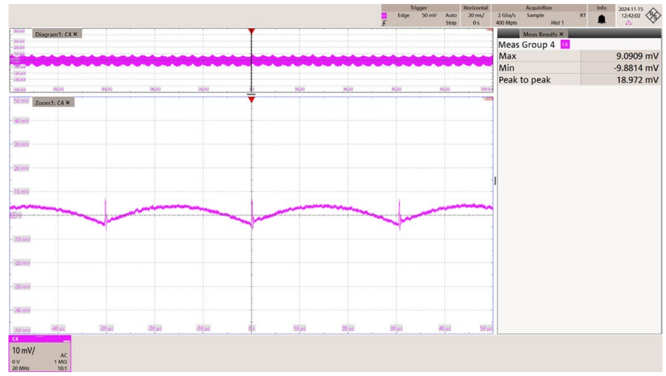


Figure 86 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 19.0 mV

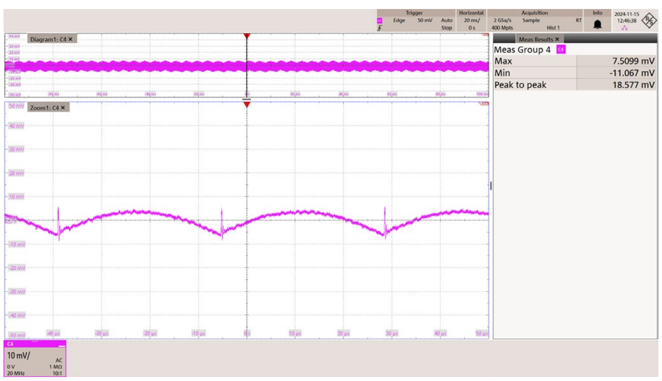


Figure 87 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 18.6 mV

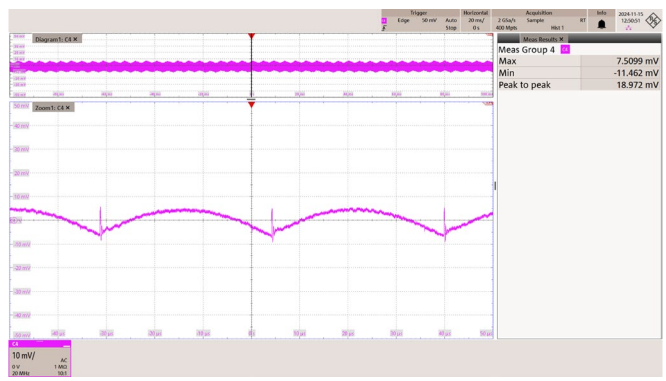


Figure 88 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 10 µs / div.
Output Ripple = 19.0 mV

12.3.2.4 25% Load Condition

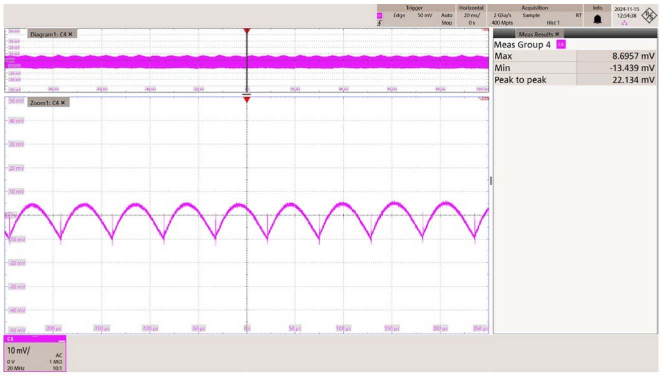


Figure 89 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 50 µs / div.
Output Ripple = 22.1 mV

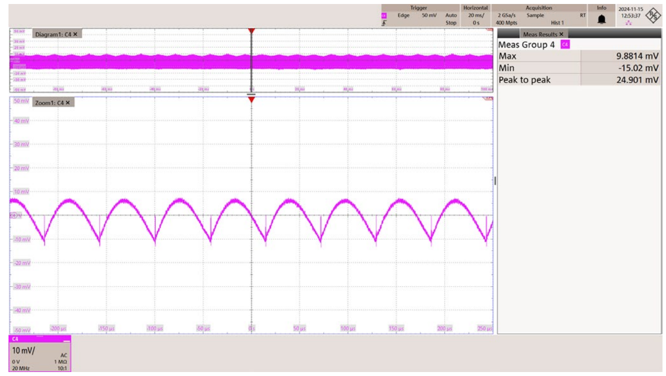


Figure 90 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 50 µs / div.
Output Ripple = 24.9 mV

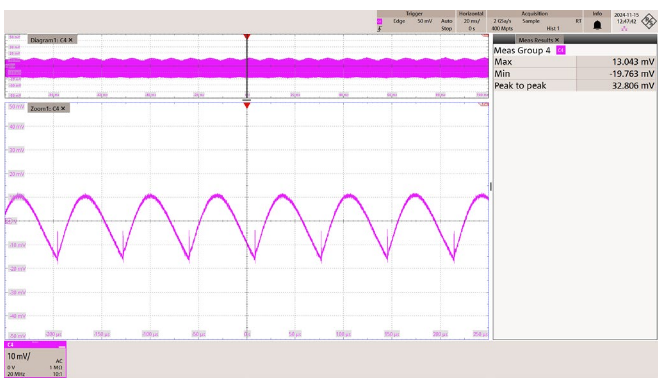


Figure 91 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 50 µs / div.
Output Ripple = 32.8 mV

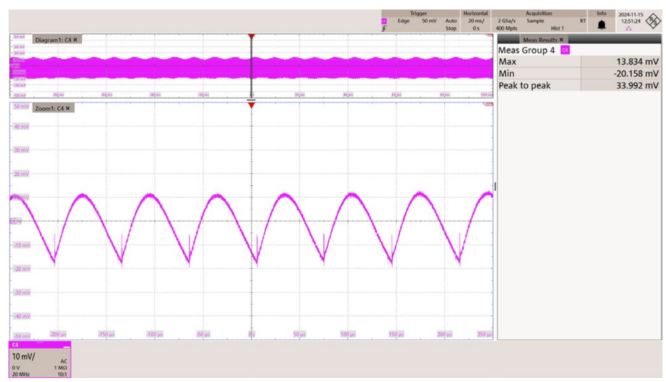


Figure 92 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 50 µs / div.
Output Ripple = 34.0 mV

12.3.2.5 10% Load Condition

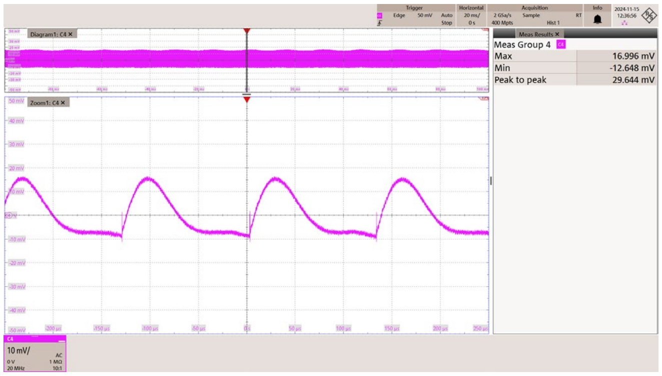


Figure 93 – 85 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 50 µs / div.
Output Ripple = 29.6 mV

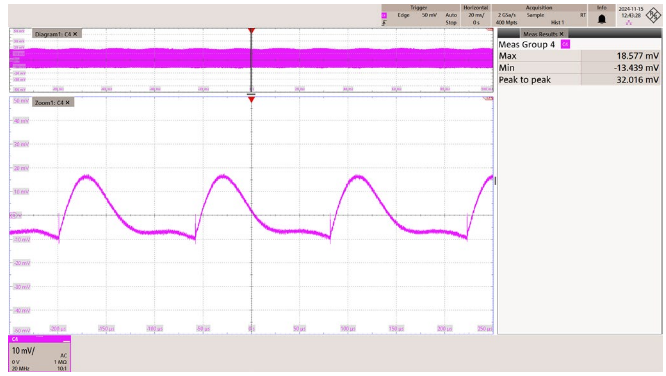


Figure 94 – 115 VAC 60 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 50 µs / div.
Output Ripple = 32.0 mV

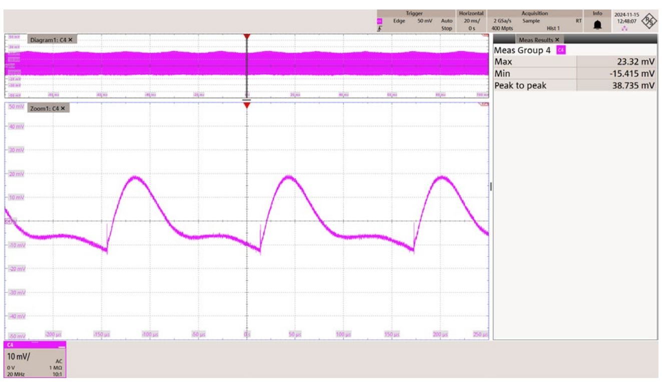


Figure 95 – 230 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 50 µs / div.
Output Ripple = 38.7 mV

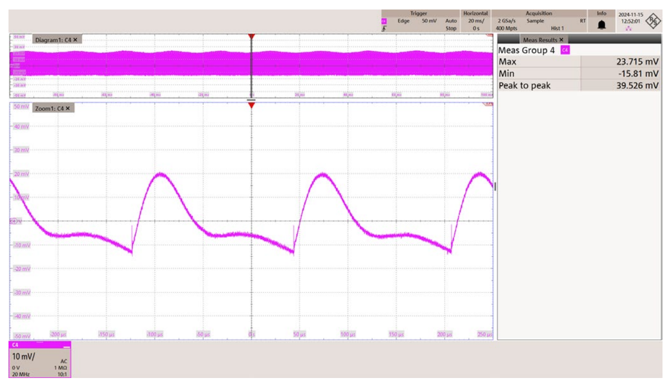


Figure 96 – 265 VAC 50 Hz.
CH4: V_{Ripple}, 10 mV / div., 20 ms / div.
Zoom: 50 µs / div.
Output Ripple = 39.5 mV

12.3.3 Output Ripple Voltage Graph

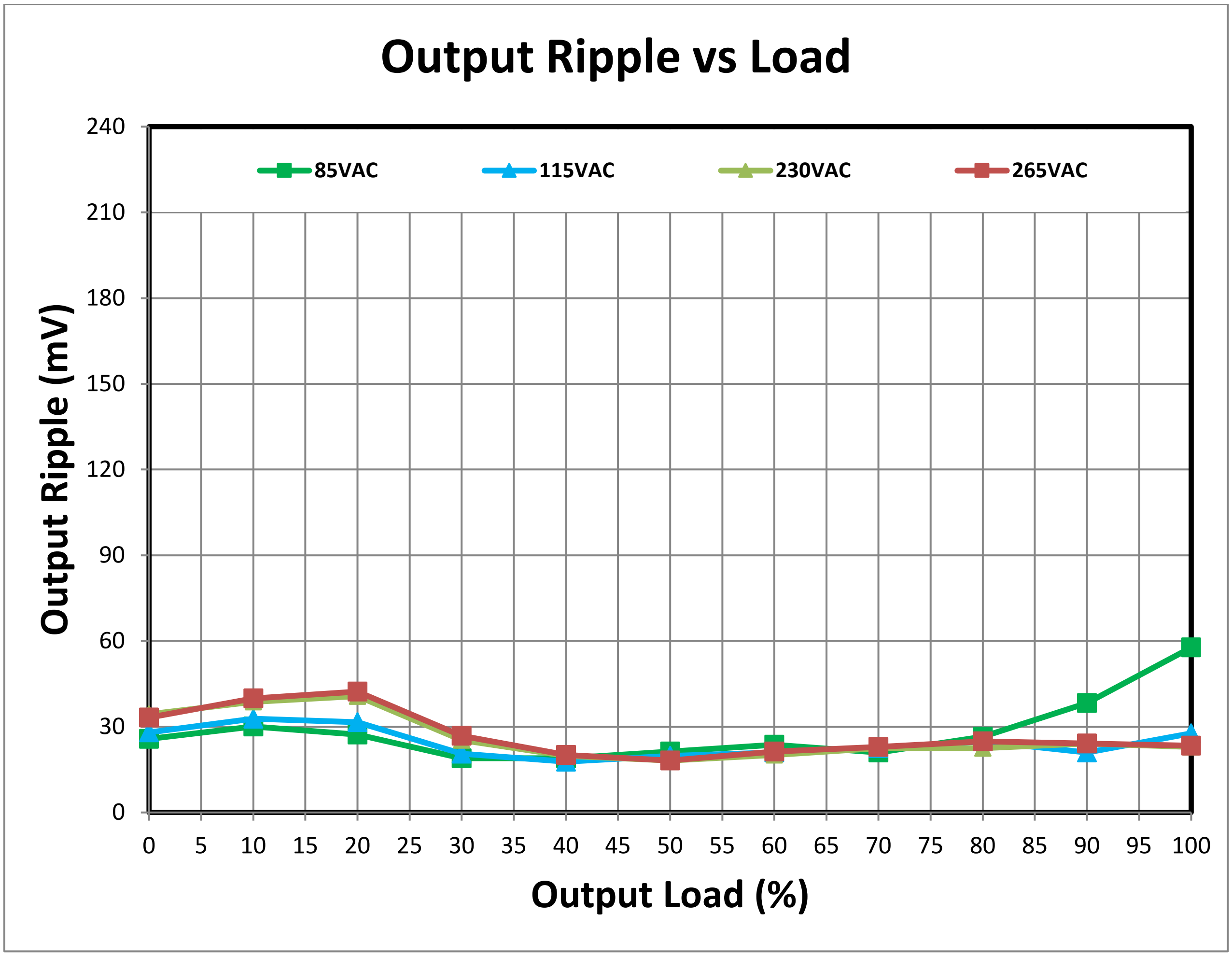


Figure 97 – Voltage Ripple (Measured at PCB End at Room Temperature).

13 Thermal Performance

13.1 25 °C Ambient Thermals

13.1.1 85 VAC Full Load at 25 °C Ambient

Test result after 2 hours running continuously at 85 VAC full load.

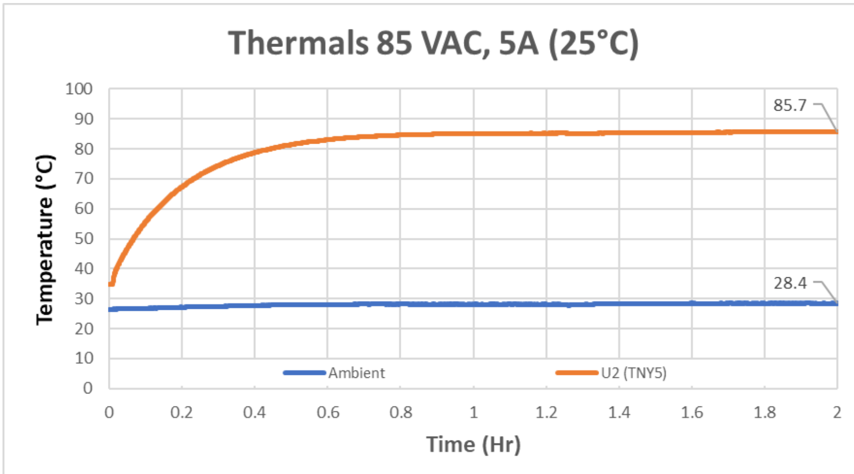


Figure 98 – 85 VAC 60 Hz. TNY5077E Thermals.

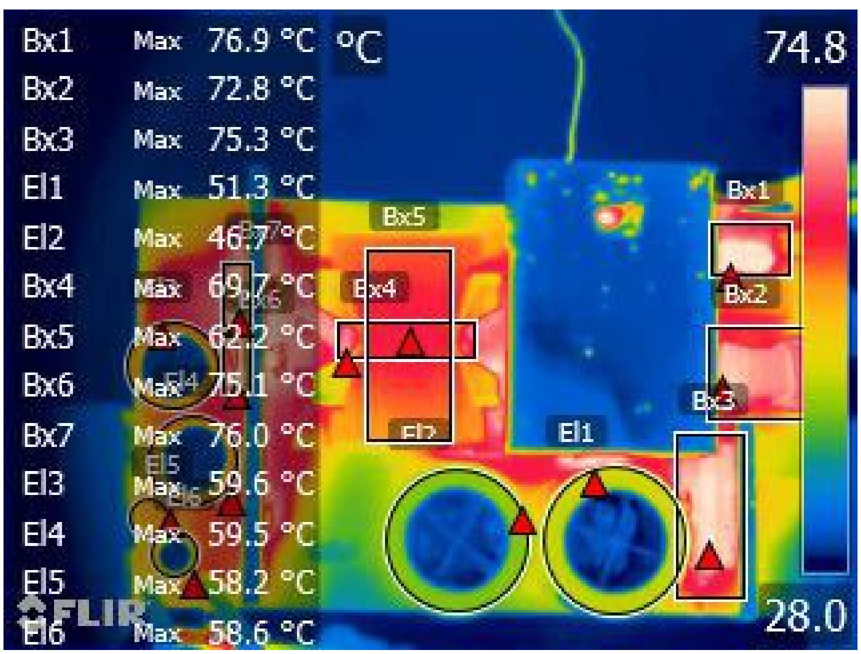


Figure 99 – 85 VAC 60 Hz. Top Side Discrete Component Thermals.

Component		Actual Temperature	Temperature (Normalized to 25 ˚C)
Ambient		28.0	25
TNY5077E (U1)		85.7	82.3
Bx1	CMC (L1)	76.9	73.9
Bx2	CMC (L2)	72.8	69.8
Bx3	Bridge Rectifier (BR1)	75.3	72.3
El1	Bulk Capacitor (C2)	51.3	48.3
El2	Bulk Capacitor (C16)	46.7	43.7
Bx4	TRF Winding (T1)	69.7	66.7
Bx5	TRF Core (T1)	62.2	59.2
Bx6	Freewheeling Diode (D4)	75.1	72.1
Bx7	Freewheeling Diode (D6)	76.0	73.0
El3	Output Capacitor (C9)	59.6	56.6
El4	Output Capacitor (C10)	59.5	56.5
El5	Output Inductor (L3)	58.2	55.2
El6	Output Capacitor (C14)	58.6	55.6

13.1.2 265 VAC Full Load at 25 °C Ambient

Test result after 1 hour running continuously at 265 VAC full load.

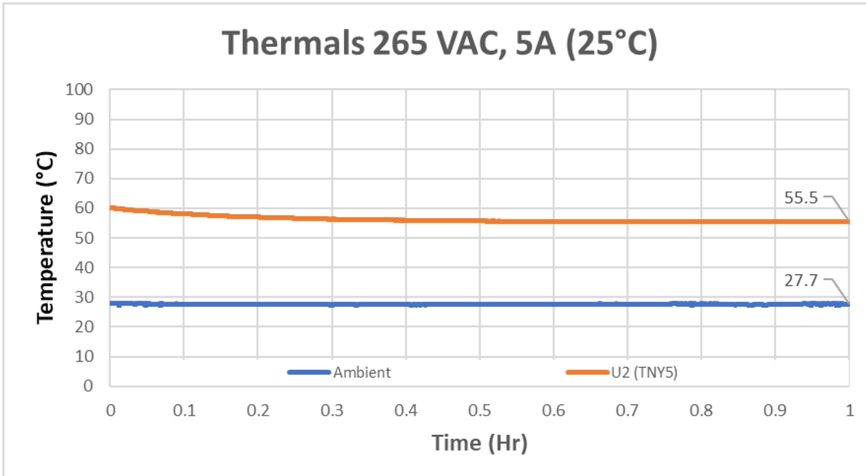


Figure 100 – 265 VAC 50 Hz. TNY5077E Thermals.

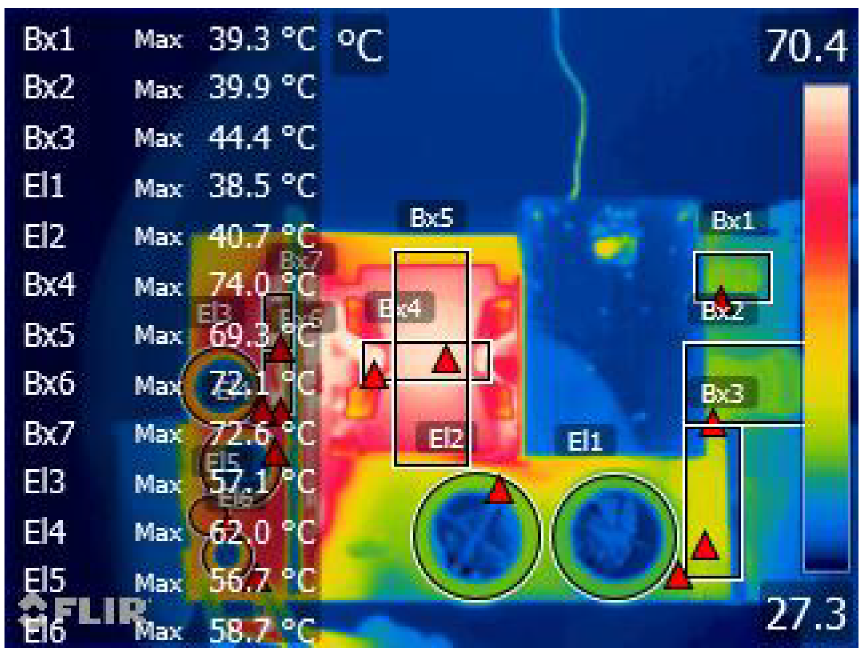


Figure 101 – 265 VAC 50 Hz. Top Side Discrete Component Thermals.

Component		Actual Temperature	Temperature (Normalized to 25 ˚C)
Ambient		27.3	25
TNY5077E (U1)		55.5	52.8
Bx1	CMC (L1)	39.3	37.0
Bx2	CMC (L2)	39.9	37.6
Bx3	Bridge Rectifier (BR1)	44.4	42.1
El1	Bulk Capacitor (C2)	38.5	36.2
El2	Bulk Capacitor (C16)	40.7	38.4
Bx4	TRF Winding (T1)	74.0	71.7
Bx5	TRF Core (T1)	69.3	67.0
Bx6	Freewheeling Diode (D4)	72.1	69.8
Bx7	Freewheeling Diode (D6)	72.6	70.3
El3	Output Capacitor (C9)	57.1	54.8
El4	Output Capacitor (C10)	62.0	59.7
El5	Output Inductor (L3)	56.7	54.4
El6	Output Capacitor (C14)	58.7	56.4

14 Fault Condition

14.1 Output Short-Circuit Protection

14.1.1 Start-Up Short

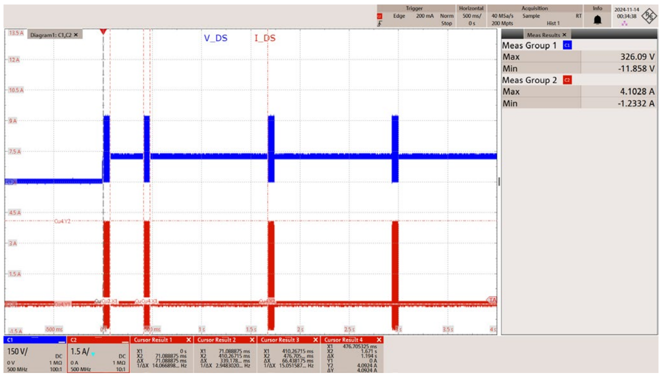


Figure 102 – 85 VAC 60 Hz. Output Short.
CH1: V_{DS}, 150 V / div., 500 ms / div.
CH2: I_{DS}, 1.5 A / div., 500 ms / div.
$V_{DS(MAX)}$ = 326 V
$I_{DS(MAX)}$ = 4.10 A
t_{AR_ON} = 71.1 ms
t_{AR_OFF} = 1.19 s

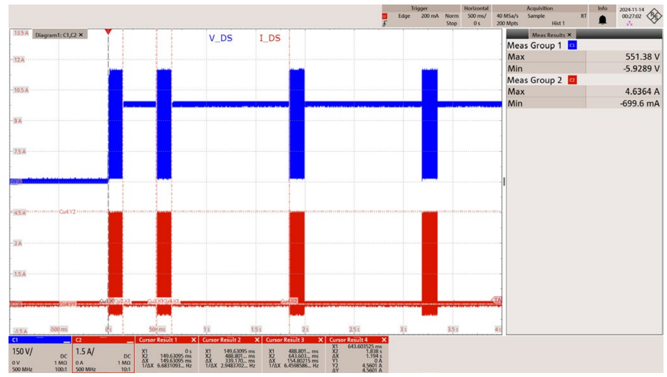


Figure 103 – 265 VAC 50 Hz Output Short.
CH1: V_{DS}, 150 V / div., 500 ms / div.
CH2: I_{DS}, 1.5 A / div., 500 ms / div.
$V_{DS(MAX)}$ = 551 V
$I_{DS(MAX)}$ = 4.64 A
t_{AR_ON} = 150 ms
t_{AR_OFF} = 1.19 s

14.1.2 Running Short

14.1.2.1 Full Load To Short

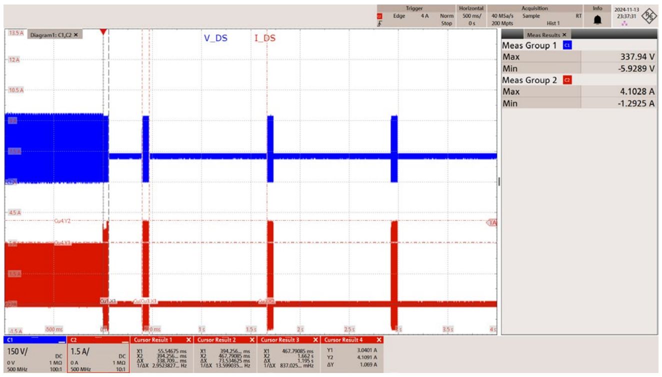


Figure 104 – 85 VAC 60 Hz. Output Short.
CH1: V_{DS}, 150 V / div., 500 ms / div.
CH2: I_{DS}, 1.5 A / div., 500 ms / div.
$V_{DS(MAX)}$ = 338 V
$I_{DS(MAX)}$ = 4.10 A
t_{AR_ON} = 73.5 ms
t_{AR_OFF} = 1.2 s

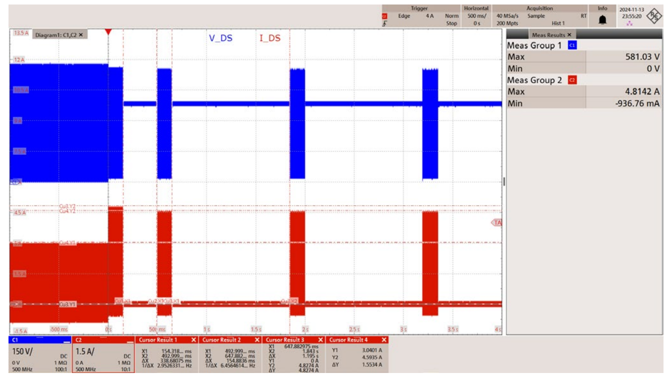


Figure 105 – 265 VAC 50 Hz. Output Short.
CH1: V_{DS}, 150 V / div., 500 ms / div.
CH2: I_{DS}, 1.5 A / div., 500 ms / div.
$V_{DS(MAX)}$ = 581 V
$I_{DS(MAX)}$ = 4.81 A
t_{AR_ON} = 155 ms
t_{AR_OFF} = 1.2 s

14.1.2.2 No Load To Short

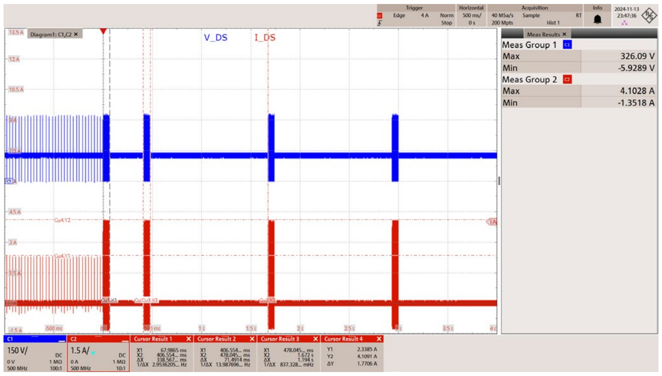


Figure 106 – 85 VAC 60 Hz. Output Short.
CH1: V_{DS}, 150 V / div., 500 ms / div.
CH2: I_{DS}, 1.5 A / div., 500 ms / div.
$V_{DS(MAX)}$ = 326 V
$I_{DS(MAX)}$ = 4.10 A
t_{AR_ON} = 71.5 ms
t_{AR_OFF} = 1.19 s

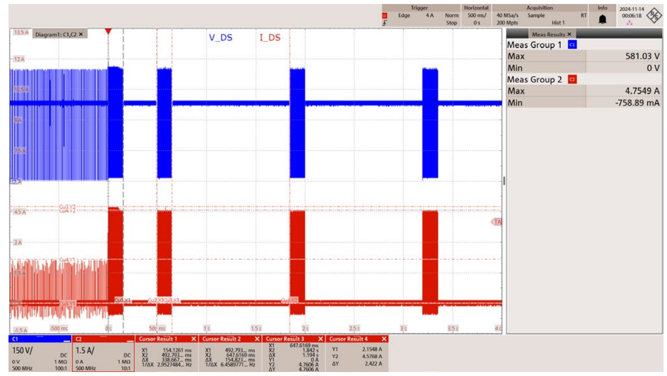


Figure 107 – 265 VAC 50 Hz. Output Short.
CH1: V_{DS}, 150 V / div., 500 ms / div.
CH2: I_{DS}, 1.5 A / div., 500 ms / div.
$V_{DS(MAX)}$ = 581 V
$I_{DS(MAX)}$ = 4.75 A
t_{AR_ON} = 155 ms
t_{AR_OFF} = 1.19 s

14.2 Over Temperature Protection

IC's case temperature was measured using thermocouple.

14.2.1 OTP at 85 VAC

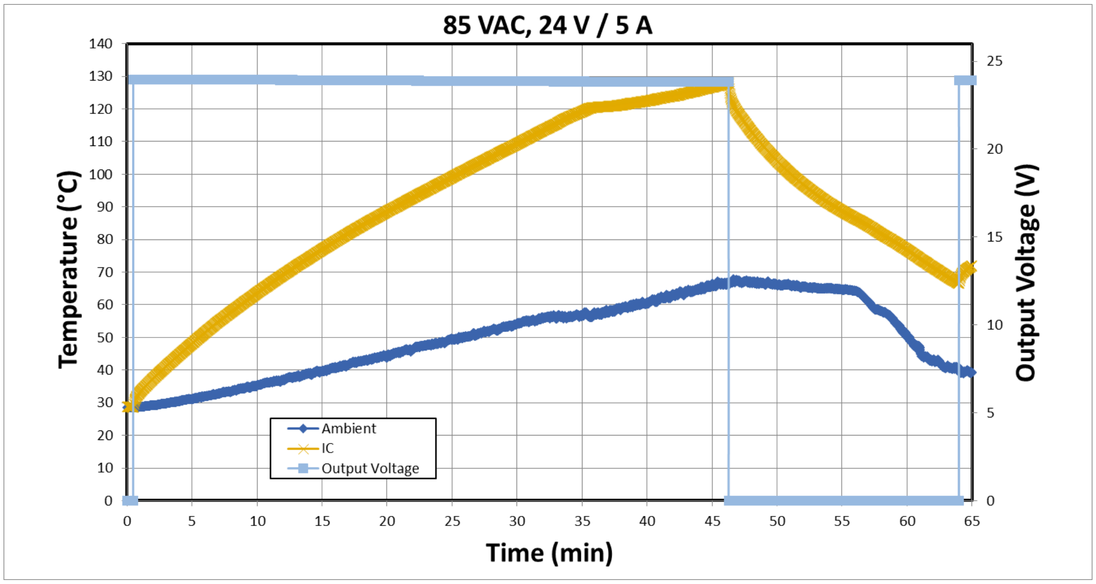


Figure 108 – 85 VAC, Io = 5 A (100% load)
OTP: 128 ºC
OTP recovery: 66.5 ºC
Hysteresis: 61.5 ºC

14.2.2 OTP at 265 VAC

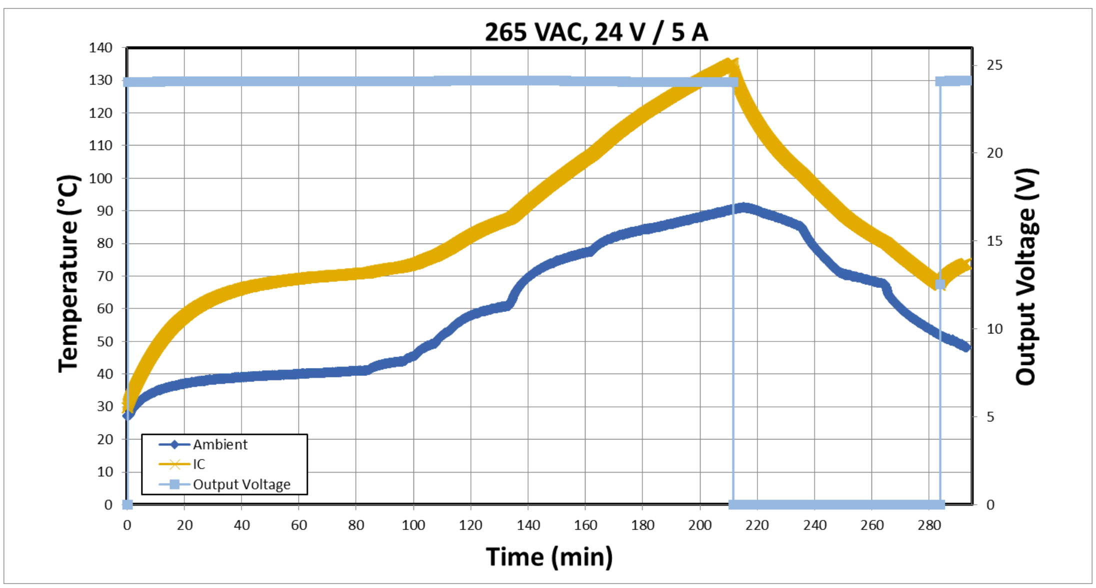


Figure 109 – 265 VAC, Io = 5 A (100% load)
OTP: 135 ºC
OTP recovery: 67.5 ºC
Hysteresis: 67.5 ºC

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. Input voltage set at 115 VAC and 230 VAC.
4. 24 V RLOAD resistance is 4.8 ohms.

Figure 110 – EMI Test Set-up.

15.2 Output Float

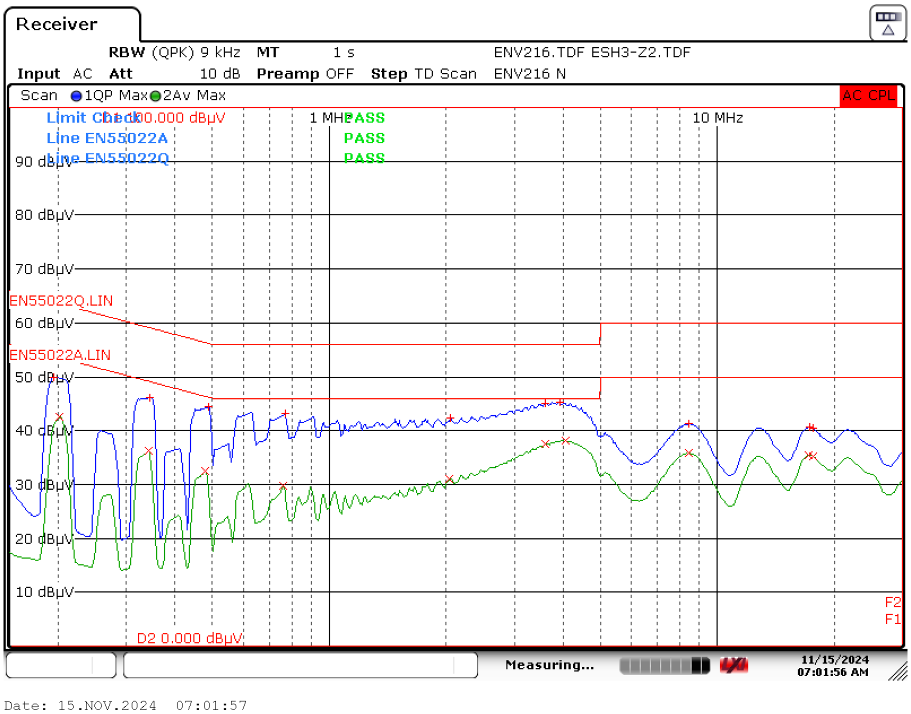


Figure 111 – 115 VAC 60 Hz.
Line and Neutral Output Float Scan

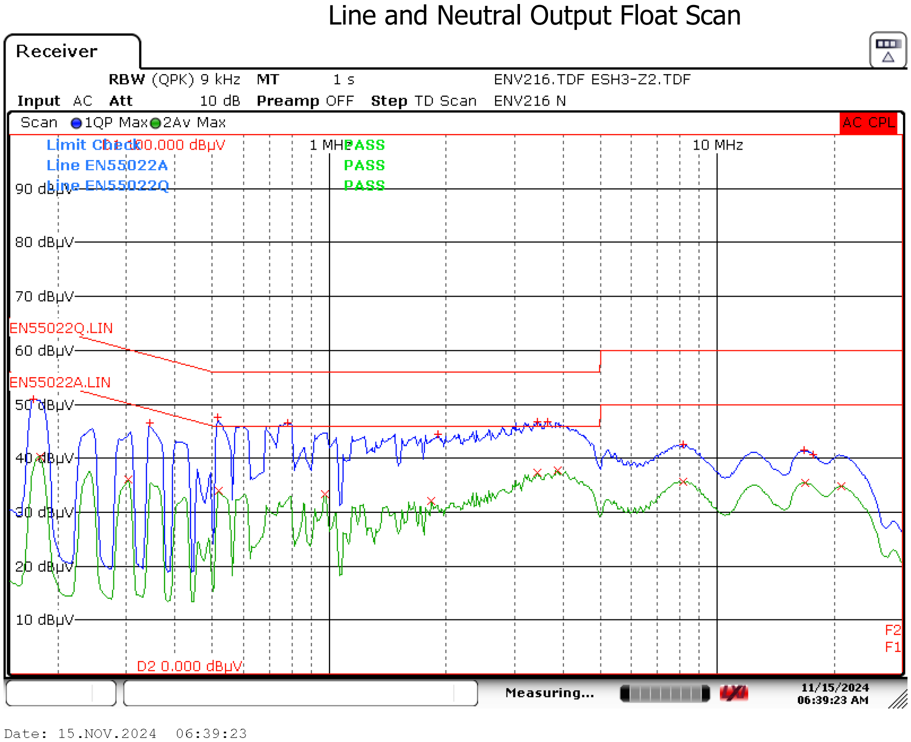


Figure 112 – 230 VAC 60 Hz.
Line and Neutral Output Float Scan

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 nominal lines. Output was loaded at full load and operation was verified following each surge event.

16.1 Differential Mode Surge

16.1.1 115 VAC

DM Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (º)	Test Result (Pass/Fail)
+2000	115	L to N	0	Pass
-2000	115	L to N	0	Pass
+2000	115	L to N	90	Pass
-2000	115	L to N	90	Pass
+2000	115	L to N	180	Pass
-2000	115	L to N	180	Pass
+2000	115	L to N	270	Pass
-2000	115	L to N	270	Pass

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

16.1.2 230 VAC

DM Surge Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (º)	Test Result (Pass/Fail)
+2000	230	L to N	0	Pass
-2000	230	L to N	0	Pass
+2000	230	L to N	90	Pass
-2000	230	L to N	90	Pass
+2000	230	L to N	180	Pass
-2000	230	L to N	180	Pass
+2000	230	L to N	270	Pass
-2000	230	L to N	270	Pass

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

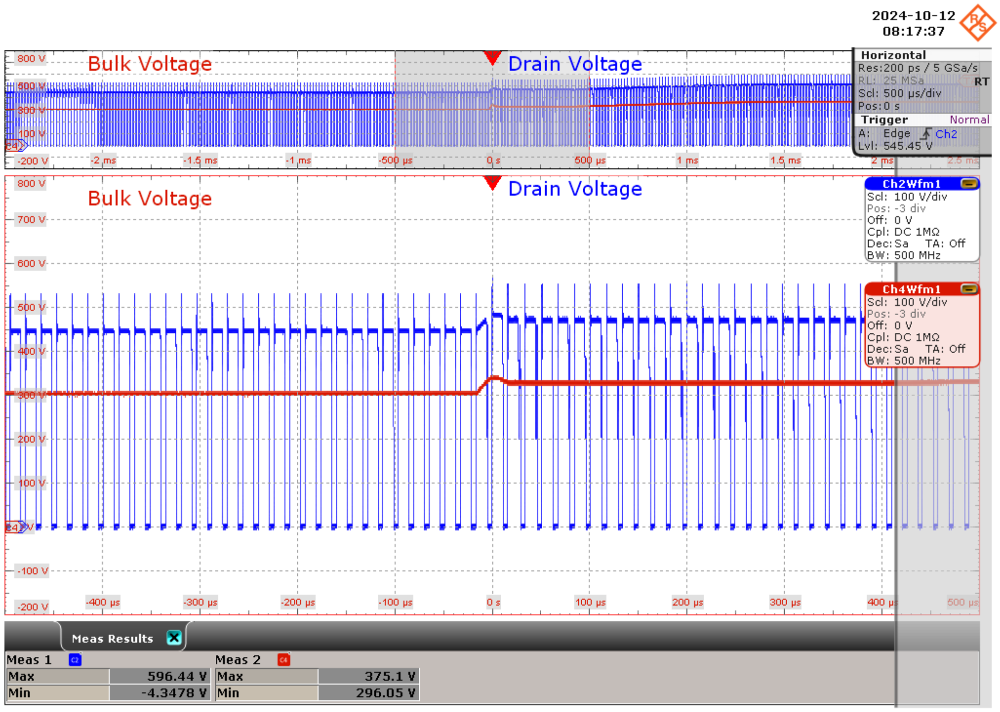


Figure 113 – Differential Mode Surge Input AC and V_{DS} Waveform.

Ch2: V_{DS}, 100 V / div., 500 µs / div.

Ch1: Bulk Voltage, 100 V / div., 500 µs / div.

Zoom: 100 µs / div.

$V_{DS(MAX)}$: 596 V.

16.2 Common Mode Ring Wave Surge

16.2.1 115 VAC

Surge Voltage	Input Voltage	Phase Angle	IEC Coupling	Generator Impedance	Number Strikes	Result
+4000 V	115	0º	L,N → PE	12Ω	10	Pass
–4000 V	115	0º	L,N → PE	12Ω	10	Pass
+4000 V	115	90º	L,N → PE	12Ω	10	Pass
–4000 V	115	90º	L,N → PE	12Ω	10	Pass
+4000 V	115	270º	L,N → PE	12Ω	10	Pass
–4000 V	115	270º	L,N → PE	12Ω	10	Pass
+6000 V	115	0º	L,N → PE	12Ω	10	Pass
–6000 V	115	0º	L,N → PE	12Ω	10	Pass
+6000 V	115	90º	L,N → PE	12Ω	10	Pass
–6000 V	115	90º	L,N → PE	12Ω	10	Pass
+6000 V	115	270º	L,N → PE	12Ω	10	Pass
–6000 V	115	270º	L,N → PE	12Ω	10	Pass

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

16.2.2 230 VAC

Surge Voltage	Input Voltage	Phase Angle	IEC Coupling	Generator Impedance	Number Strikes	Result
+4000 V	230	0º	L,N → PE	12Ω	10	Pass
–4000 V	230	0º	L,N → PE	12Ω	10	Pass
+4000 V	230	90º	L,N → PE	12Ω	10	Pass
–4000 V	230	90º	L,N → PE	12Ω	10	Pass
+4000 V	230	270º	L,N → PE	12Ω	10	Pass
–4000 V	230	270º	L,N → PE	12Ω	10	Pass
+6000 V	230	0º	L,N → PE	12Ω	10	Pass
–6000 V	230	0º	L,N → PE	12Ω	10	Pass
+6000 V	230	90º	L,N → PE	12Ω	10	Pass
–6000 V	230	90º	L,N → PE	12Ω	10	Pass
+6000 V	230	270º	L,N → PE	12Ω	10	Pass
–6000 V	230	270º	L,N → PE	12Ω	10	Pass

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

17 EFT

Output was loaded at full load and operation was verified following each surge event.

17.1 115 VAC

Surge Voltage	Phase Angle	IEC Coupling	Frequency	Burst Time	Reception Time	Step Duration	Result
+4000 V	0º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
–4000 V	0º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
+4000 V	0º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
–4000 V	0º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
+4000 V	90º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
–4000 V	90º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
+4000 V	90º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
–4000 V	90º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
+4000 V	180º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
–4000 V	180º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
+4000 V	180º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
–4000 V	180º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
+4000 V	270º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
–4000 V	270º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
+4000 V	270º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
–4000 V	270º	L to N	100 kHz	750 µs	300 ms	120 s	Pass

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

17.2 230 VAC

Surge Voltage	Phase Angle	IEC Coupling	Frequency	Burst Time	Reception Time	Step Duration	Result
+4000 V	0º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
–4000 V	0º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
+4000 V	0º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
–4000 V	0º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
+4000 V	90º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
–4000 V	90º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
+4000 V	90º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
–4000 V	90º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
+4000 V	180º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
–4000 V	180º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
+4000 V	180º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
–4000 V	180º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
+4000 V	270º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
–4000 V	270º	L to N	5 kHz	15 ms	300 ms	120 s	Pass
+4000 V	270º	L to N	100 kHz	750 µs	300 ms	120 s	Pass
–4000 V	270º	L to N	100 kHz	750 µs	300 ms	120 s	Pass

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

18 ESD

All ESD strikes were applied at end of 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
-8.8	24 V	10	PASS
+8.8	GND	10	PASS
-8.8	GND	10	PASS

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

Passed ±16.5 kV air discharge

Air Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+16.5	24 V	10	PASS
-16.5	24 V	10	PASS
+16.5	GND	10	PASS
-16.5	GND	10	PASS

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

19 Revision History

Date	Author	Revision	Description and Changes	Reviewed
11-Mar-25	RPL/KCP/JA	A	Initial Release.	Apps & Mktg

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

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