Reference Design Report

Title	**26.5 W Dual Output Isolated Flyback Power Supply Using TNY5073K**
Specification	85 – 265 VAC Input; 12 V / 2 A Output and 5 V / 0.5 A Output
Application	Appliance
Author	Applications Engineering Department
Document Number	RDR-1016
Date	January 31, 2025
Revision	A

Summary and Features

- Up to 150 kHz switching frequency for small transformer.
- Dual output power supply
- >86% full load efficiency at 115 VAC and >87% full load efficiency at 230 VAC
- >85.5% average efficiency at 115 VAC and 230 VAC
- <50 mW no-load input power at 230 VAC
- Delivers 26.5 W output power from 85 VAC to 265 VAC
- Extensive protection features including
  - Line Under Voltage Protection
  - Line Over Voltage Protection
  - Over Temperature Protection (OTP)
  - Short Circuit Protection
  - Over Power Protection.
- Class B Conducted EMI with > 6 dB margin.

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

1 Introduction 5
2 Power Supply Specification 6
3 Schematic 7
4 Circuit Description 8
4.1 Input EMI Filtering and Rectification 8
4.2 TinySwitch-5 Primary 8
4.3 Output Rectification 9
4.4 Output Rectification 9
5 PCB Layout 10
5.1 PCB Specification 10
6 Bill of Materials 11
6.1 Electrical BOM 11
6.2 Mechanical BOM 12
7 Transformer Specification 13
7.1 Electrical Diagram 13
7.2 Electrical Specifications 13
7.3 Material List 13
7.4 Transformer Build Diagram 14
7.5 Transformer Instructions 14
7.6 Transformer Winding Illustrations 15
8 Design Spreadsheet 19
9 Performance Data 27
9.1 Full Load Efficiency vs. Line 27
9.2 Line Regulation 28
9.3 Efficiency vs. Load 29
9.4 Load Regulation 32
9.5 Average and 10% Efficiency 33
9.5.1 Average and 10% Efficiency at 115 VAC 33
9.5.2 Average and 10% Efficiency at 230 VAC 33
9.6 No-Load Input Power 34
9.7 Standby Input Power 35
9.7.1 Standby Efficiency 35
9.7.2 Standby Input Power 36
9.8 Cross Regulation 37
9.8.1 Cross Regulation with 12 V at Minimum Load and Varying 5 V Load 37
9.8.2 Cross Regulation with 12 V at Full Load and Varying 5 V Load 38
9.8.3 Cross Regulation with 5 V at Minimum Load and Varying 12 V Load 39
9.8.4 Cross Regulation with 5 V at Full Load and Varying 12 V Load 40
10 Waveforms 41
10.1 Switching Waveforms 41
10.1.1 Primary MOSFET Drain-Source Voltage and Current at Normal Operation 41
10.1.2 Primary MOSFET Drain-Source Voltage and Current at Start-up Operation 43
10.1.3 12V Freewheeling Diode Voltage at Normal Operation 45

10.1.4 12V Freewheeling Diode Voltage at Start-Up....47
10.1.5 5V Freewheeling Diode Voltage at Normal Operation....49
10.1.6 5V Freewheeling Diode Voltage at Start-Up....51
10.1 Output Start-up....53
10.1.1 Full Load CC Mode....53
10.1.2 Full Load CR Mode....54
10.1.3 No Load....55
10.2 Load Transient Response....56
10.2.1 Transient 5 V_{OUT} 10% - 100% Load and 12 V_{OUT} fixed at 10% Load....56
10.2.2 Transient 5 V_{OUT} 10% - 100% Load and 12 V_{OUT} fixed at 100% Load....57
10.2.3 Transient 12 V_{OUT} 10% - 100% Load and 5 V_{OUT} fixed at 10% Load....58
10.2.4 Transient 12 V_{OUT} 10% - 100% Load and V_{OUT} fixed at 100% Load....59
10.3 Output Voltage Ripple....60
10.3.1 Ripple Measurement Technique....60
10.3.2 Measurement Results....61
10.3.3 Output Ripple Voltage Graph....66
10.4 Thermal Performance....67
10.4.1 85 VAC Full Load at 25 °C Ambient....67
10.4.2 265 VAC Full Load at 25 °C Ambient....69
11 Fault Condition....71
11.1 Output Short-Circuit Protection....71
11.2 Overpower Protection....74
11.3 Over Temperature Protection....75
12 Conducted EMI....77
12.1 Test Set-up Equipment....77
12.1.1 Equipment and Load Used....77
12.2 Output Float....78
13 Line Surge....79
13.1 Differential Mode Surge....79
13.2 Common Mode Surge – Ring Wave....81
13.3 EFT Burst....82
14 ESD....83
15 Revision History....85

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

1 Introduction

This engineering report describes a flyback converter that provides an isolated nominal output voltage of 12 V at 2 A and 5 V at 500 mA from a wide input voltage range of 85 VAC to 265 VAC. This power supply utilizes the TNY5073K 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.

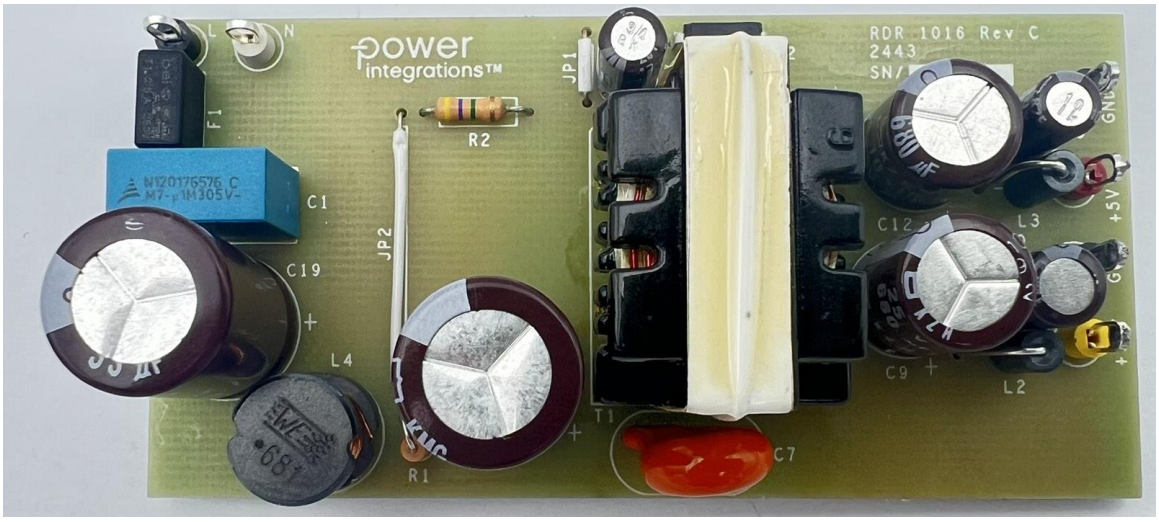


Figure 1 – Photograph, Top View.

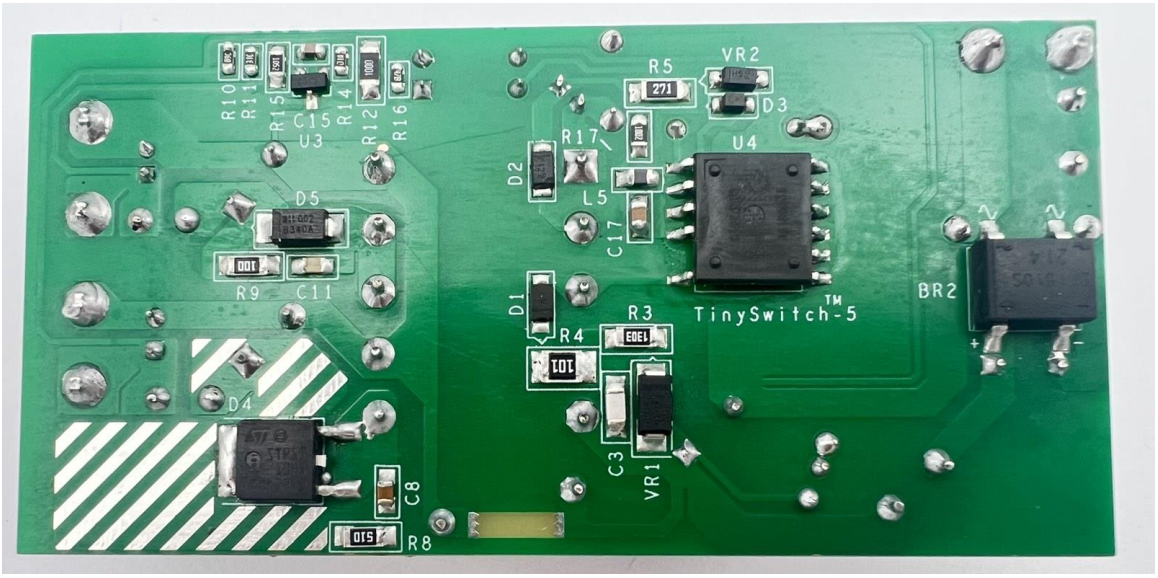


Figure 2 – Photograph, Bottom View.

2 Power Supply Specification

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

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	85		265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power (230 VAC)				50	mW	
Output1						
Output Voltage	V_{OUT1}	11.4	12	12.6	V	± 5% at Line/Load Voltage Regulation And ± 10 % at Load Transient Voltage Regulation. 20 MHz Bandwidth.
Output Ripple Voltage	$V_{RIPPLE1}$			150	mV	
Output Current	I_{OUT1}	0.2		2	A	
Output2						
Output Voltage	V_{OUT2}	4.75	5	5.25	V	± 5% at Line/Load Voltage Regulation And ± 10 % at Load Transient Voltage Regulation. 20 MHz Bandwidth.
Output Ripple Voltage	$V_{RIPPLE2}$			100	mV	
Output Current	I_{OUT2}	0.05		0.5	A	
Total Output Power						
Continuous Output Power	P_{OUT}			26.5	W	
Efficiency						
Full Load 115 VAC	$\eta_{115\ VAC}$	86			%	Measured at P_{OUT} 25 °C.
Full Load 230 VAC	$\eta_{230\ VAC}$	87			%	
Average efficiency at 25, 50, 75 and 100 % of P_{OUT}	η_{DOE}	85			%	Measured at Nominal Input 115 VAC and 230 VAC.
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Surge (Differential)				±1	kV	1.2/50 µs Surge, IEC 61000-4-5
Ring Wave (Common Mode)				±4	kV	
Electrical Fast Transient				±4	kV	
ESD – Air Discharge				±16.5	kV	
ESD – Contact Discharge				±8.8	kV	
Ambient Temperature	T_{AMB}	0		40	°C	Free Convection, Sea Level.

3 Schematic

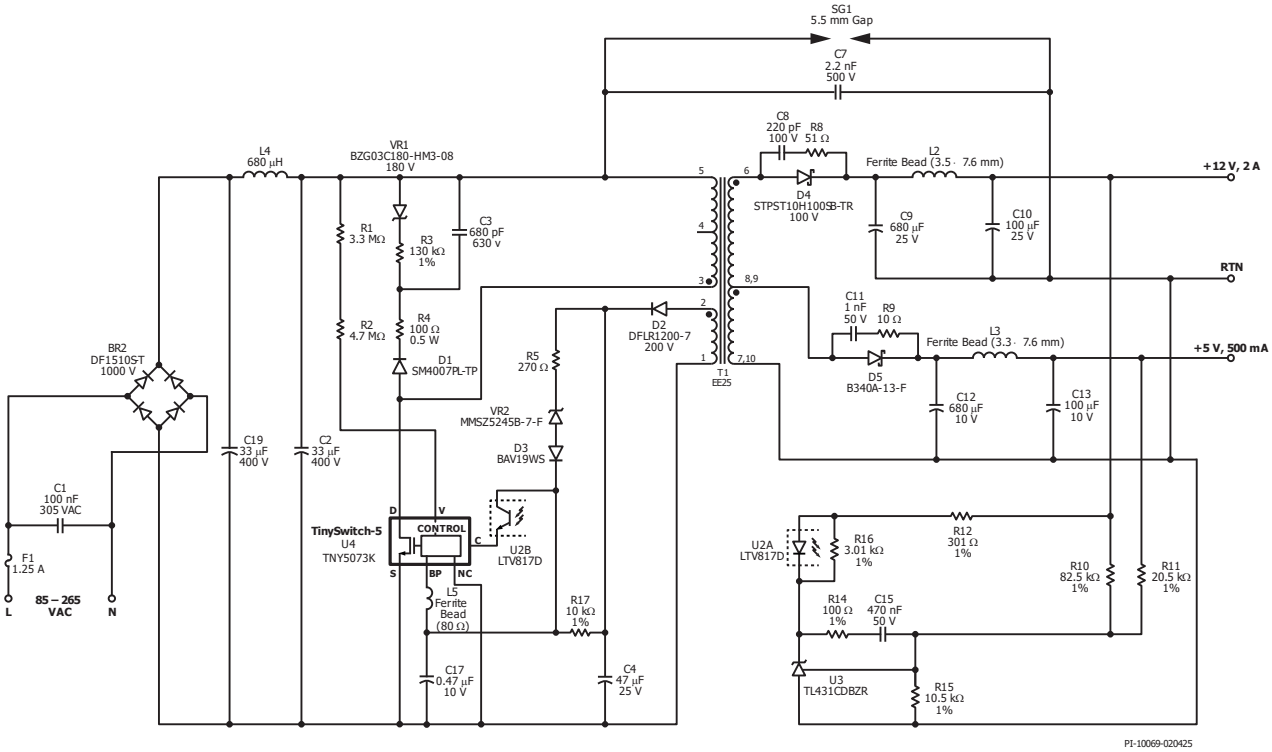


Figure 3 – Schematic.

4 Circuit Description

This power supply employs a TNY5073K off-line switcher, (U4), in a flyback configuration. IC U1 has an integrated 725 V power MOSFET. It regulates the output by adjusting the 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. Bulk Capacitors C19 and C2 together with differential mode choke L4 forms an EMI filter that attenuates both common mode and differential mode conducted EMI. BR2 converts the AC line voltage into the DC voltage seen across bulk capacitors C19 and C2.

4.2 TinySwitch-5 Primary

The TNY5073K device (U4) 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 C19 and C2, and the other side is connected to the DRAIN pin of U4. When the MOSFET turns off, the leakage inductance of the transformer induces a voltage spike on the drain node. The spike amplitude is limited by an RCDZ clamp network that consists of VR1, D1, R3, R4, and C3. Resistor R4 are used together with capacitor C3 to damp high frequency ringing and improve EMI. Y capacitor CY1, connected between the primary and secondary side helps improve EMI.

The TNY5073K regulates the output by adjusting the power MOSFET off-time duration in proportion to the current into its CONTROL pin. The power supply output voltage is sensed on the secondary side by shunt regulator U3 and provides a feedback signal to the primary side through optocoupler U2.

The line undervoltage and overvoltage is determined by the current supplied from resistors R1 and R2 to the V pin. R5, D3, and VR2 are used for output overvoltage protection. An increase in output voltage causes an increase in the bias winding voltage, sensed by VR2. Once VR2 is activated, it will inject current to the BP pin causing the IC U4 to shut down and enter auto-restart.

Bypass capacitor C17 serves as the selector for the maximum drain current (either standard or reduced) and is placed as physically close as possible to U4. C17 was used to select reduced current limit of the IC. At start-up, this capacitor is charged through the DRAIN (D) pin. Once it is charged, U4 begins to switch. Capacitor C4 stores enough energy to ensure the TinySwitch-5 IC is powered until the output reaches regulation. After start-up, the bias winding delivers current via diode D2 and R17 to charge capacitor C4 which in turn powers the controller. Resistor R17 is used to set the typical bias current of the IC U4. Ferrite bead L5 minimizes the noise coming to the BP Pin and should be placed close as possible to the IC.

4.3 Output Rectification

Schottky diodes D4 rectify the 12 V secondary winding output of T1. The output voltage is filtered by C9, L2, and C10. Resistor R8 and capacitor C8 snubs the voltage spike caused by the commutation of D4. Schottky diode D5 rectifies the 5 V secondary winding output of T1. The output voltage is filtered by C12, L3, and C13. Resistor R9 and capacitor C11 absorb the noise caused by the commutation of D5. A low voltage rating diode was achievable for D4 and D5 due to the flexibility of a higher turns ratio (higher VOR). This is realized due to the 725 V rating of the MOSFET in U4. This also further improves efficiency due to the low forward voltage drop (VF) of the low voltage diode.

4.4 Output Rectification

The reference IC, U3 or TL431CDBZR, is used to set the output voltage programmed via the feedback resistor divider R10, R11 and R15. The TL431CDBZR varies its cathode voltage to keep its input voltage constant (equal to 2.50 V, ±2.2%). As the cathode voltage changes, the current through the optocoupler LED and transistor within U2 changes. R12, R14 and C15 provide stable operation, while resistor R16 maintains minimum bias to U3.

5 PCB Layout

5.1 PCB Specification

- Layer: 1
- Board Thickness: 1.6 mm.
- Copper Thickness: 2 oz.
- Material: FR-4

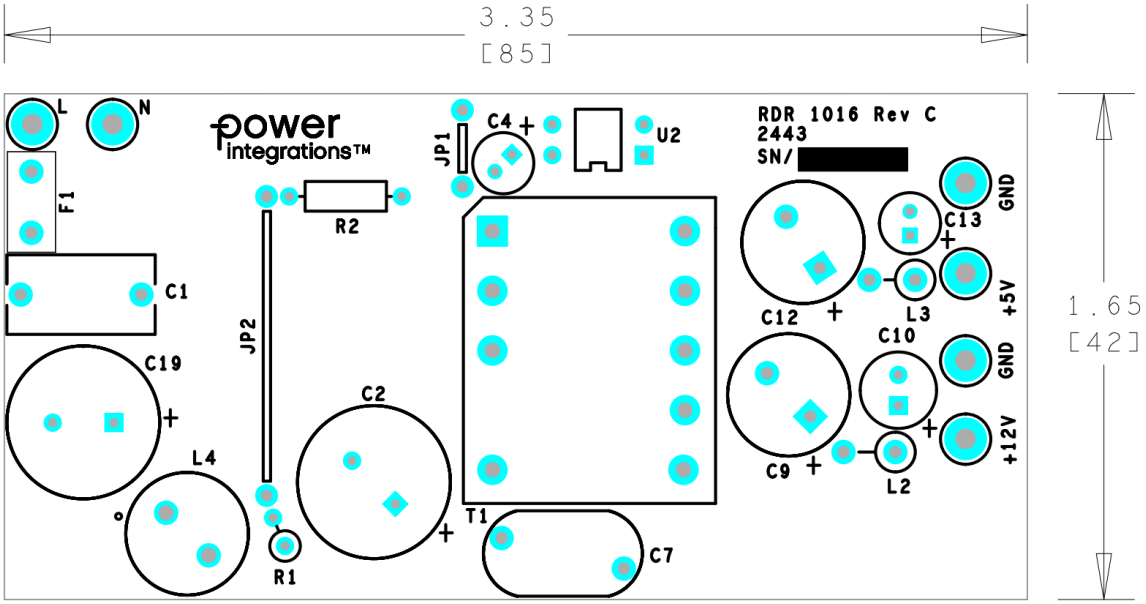


Figure 4 – Printed Circuit Board, Top View.

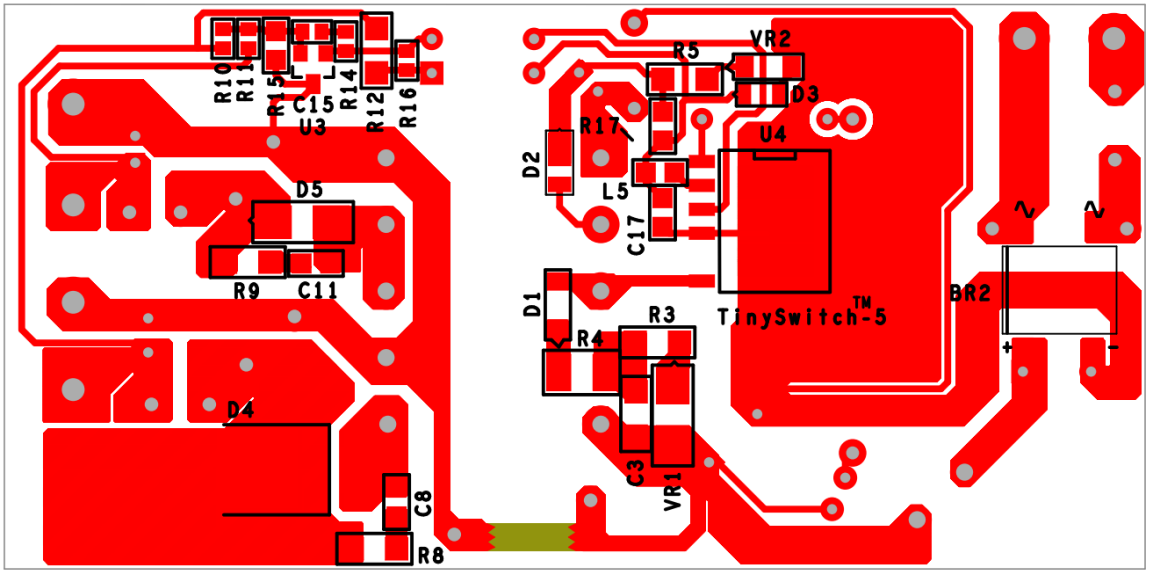


Figure 5 – Printed Circuit Board, Bottom View.

6 Bill of Materials

6.1 Electrical BOM

Item	Qty.	Ref Des	Description	Mfr. Part Number	Manufacturer
1	1	BR2	Bridge Rectifier, Single Phase, Standard, 1 kV, Surface Mount DF-S), DF-S,4-SMD	DF1510S-T	Diodes Incorporated
2	1	C1	100 nF, 305 VAC, Film, X2	B32921C3104M	Epcos
3	2	C2 C19	33 uF, 400 V, Electrolytic, Very Low ESR, 18 mOhm, (12.5 x 25)	EKMG401ELL330MK25S	Nippon Chemi-Con
			33 uF, 400 V, Electrolytic, (12.5 x 20)	EKMG401ELL330MK20S	Nippon Chemi-Con
4	1	C3	680 pF, 630 V, Ceramic, X7R, 1206	C1206C681KBRAC7800	Kemet
5	1	C4	47 uF, 25 V, Electrolytic, Very Low ESR, 300 mOhm, (5 x 11)	EKZE250ELL470ME11D	Nippon Chemi-Con
6	1	C7	2200 PF,±20%, 500 VAC (Y1),760VAC (X1), Ceramic, Y5U (E), RADIAL	440LD22-R	Vishay
7	1	C8	220 pF, 100 V, Ceramic, X7R, 0805	08051C221KAT2A	AVX
8	1	C9	680 uF, 25 V, Electrolytic, Very Low ESR, 32 mOhm, (10 x 16)	EKZH250EC3681MJ16S	Nippon Chemi-Con
9	1	C10	100 uF, 25 V, Electrolytic, Very Low ESR, 130 mOhm, (6.3 x 11)	EKZE250ELL101MF11D	Nippon Chemi-Con
10	1	C11	1 nF, 50 V, Ceramic, X7R, 0805	08055C102KAT2A	AVX Corp
11	1	C12	680 uF, 10 V, Electrolytic, Very Low ESR, 53 mOhm, (10 x 12.5)	EKZE100ELL681MJC5S	Nippon Chemi-Con
12	1	C13	100 uF, 10 V, Electrolytic, Very Low ESR, 300 mOhm, (5 x 11)	EKZE100ELL101ME11D	Nippon Chemi-Con
13	1	C15	0.47 µF, ±10%, 50 V, Ceramic Capacitor X7R, 0603 (1608 Metric)	CGA3E3X7R1H474K080AB	TDK Corporation
14	1	C17	0.47 uF, ±10%, 25 V, Ceramic Capacitor, X7R, 0805 (2012 Metric)	CGA4J2X7R1E474K125AA	TDK Corporation
15	1	D1	1000 V, 1 A, Standard Recovery, SOD-123FL	SM4007PL-TP	Micro Commercial Co.
16	1	D2	200 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1200-7	Diodes Inc
17	1	D3	100 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV19WS-7-F	Diode Inc.
18	1	D4	DIODE, SCHOTTKY, 10 A, 100 V, TO-252-3, DPak (2 Leads + Tab), SC-63	STPST10H100SB-TR	STMicroelectronics
19	1	D5	DIODE, SCHOTTKY, 40 V, 3A, SMA, DO-214AA	B340A-13-F	Diodes Incorporated
20	1	F1	FUSE, 1.25 A 250 VAC, Slow, 8.35 mm x 4.0 mm x 7.7 mm	RST 1.25-BULK	Bel Fuse Inc
21	2	L2 L3	3.5 mm x 7.6 mm, 75 Ohms at 25 MHz, 22 AWG hole, Ferrite Bead	2743004112	Fair-Rite
22	1	L4	680 µH Unshielded Wirewound Inductor 900 mA 790 mOhm Max Radial, Vertical Cylinder (Open)	7447480681	Wurth Electronics Inc
23	1	L5	80 Ohms at 100 MHz 1 Signal Line Ferrite Bead 0805 (2012 Metric) 300 mA 300 mOhm	EBMS201209K800	Max Echo
24	1	R1	RES, 3.3 M, 5%, 1/4 W, Carbon Film	CFR-25JB-3M3	Yageo
25	1	R2	RES, 4.7 M, 5%, 1/4 W, Carbon Film	CFR-25JB-4M7	Yageo
26	1	R3	RES, 130 k, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1303V	Panasonic
27	1	R4	RES, 100 , 5%, 1/2 W, Thick Film, 1210	ERJ-14YJ101U	Panasonic
28	1	R5	RES, 270 R, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J271V	Panasonic
29	1	R8	RES, 51 R, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J510V	Panasonic
30	1	R9	RES, 10 R, 5%, 2/3 W, Thick Film, 1206	ERJ-P08J100V	Panasonic
31	1	R10	RES, 82.5 k, 1%, 1/10 W, Thick Film, 0603	ERJ-3EKF8252V	Panasonic
32	1	R11	RES, 20.5 k, 1%, 1/10 W, Thick Film, 0603	ERJ-3EKF2052V	Panasonic
33	1	R12	RES, 301 R, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF3010V	Panasonic
34	1	R14	RES, 100 R, ±1%, ±100 ppm/°C, 1/10 W, Thick Film, 0603 (1608 Metric)	CRCW0603100RFKEA	Vishay Dale
35	1	R15	RES, 10.5 k, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1052V	Panasonic
36	1	R16	RES, 3.01 k, 1%, 1/10 W, Thick Film, 0603	ERJ-3EKF3011V	Panasonic
37	1	R17	RES, 10.0 k, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1002V	Panasonic
38	1	U2	Opto coupler, 35 V, CTR 300-600%, 4-DIP	LTV-817D	Liteon
39	1	U3	IC, Shunt Regulator Adj.,2.495 V, 2.2%, 100mA, 0 °C ~ 70 °C (TA), SOT23-3, TO-236-3, SC-59, SOT-23-3	TL431CDBZR	Texas Instruments
40	1	U4	TinySwitch-5, TNY5073K, eSOP-12P	TNY5073K	Power Integrations

41	1	VR1	Zener Diode 180 V 1.25 W ±6.39% Surface Mount DO-214AC (SMA)	BZG03C180-HM3-08	Vishay Semiconductors
42	1	VR2	DIODE ZENER 15 V 500 MW SOD123	MMSZ5245B-7-F	Diodes, Inc
43	1	T1	Bobbin, EE25, Vertical, 10 pins	YW-360-02B	Yih-Hwa Enterprises

6.2 Mechanical BOM

Item	Qty.	Ref Des	Description	Mfr. Part Number	Manufacturer
1	1	+5 V	Test Point, RED,THRU-HOLE MOUNT	5010	Keystone
2	1	+12 V	Test Point, YELLOW,THRU-HOLE MOUNT	5014	Keystone
3	3	GND , L	Test Point, BLK,THRU-HOLE MOUNT	5011	Keystone
4	2	JP1 JP2	Wire Jumper, Insulated, 24 AWG, 0.2 in	C2003A-12-02	Gen Cable
5	1	N	Test Point, WHT,THRU-HOLE MOUNT	5012	Keystone

7 Transformer Specification

7.1 Electrical Diagram

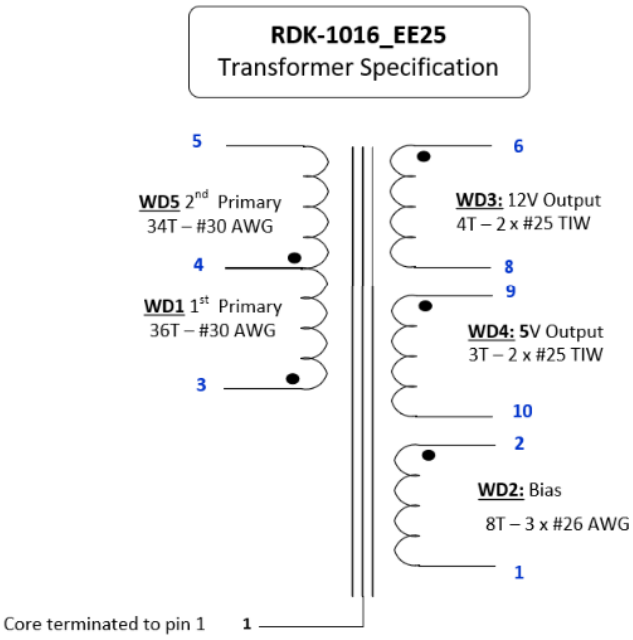


Figure 6 – Transformer Electrical Diagram.

7.2 Electrical Specifications

Parameter	Condition	Spec.
Nominal Primary Inductance	Measured at 1 V pk-pk and 100 kHz frequency, between pin 3 to pin 5, with all other Windings open.	1105.9 uH
Tolerance	Tolerance of Primary Inductance.	±5%
Leakage Inductance	Measured across primary winding with all other windings shorted.	< +3%

7.3 Material List

Item	Description
[1]	Core: EE25 TDK PC40
[2]	Bobbin: EE25, Vertical, 10 pins (Mfg PN: YW-360-02B, Mfg: Yih-Hwa Enterprises)
[3]	Magnet Wire: #30 AWG.
[4]	Magnet Wire: #26 AWG.
[5]	TIW Wire: #25 AWG.
[6]	Polyester Tape: 10.5 mm.
[7]	Polyester Tape: 7 mm.
[8]	Varnish: Dolph BC 359 or Equivalent.
[9]	Bus Wire: uninsulated 26 AWG

7.4 Transformer Build Diagram

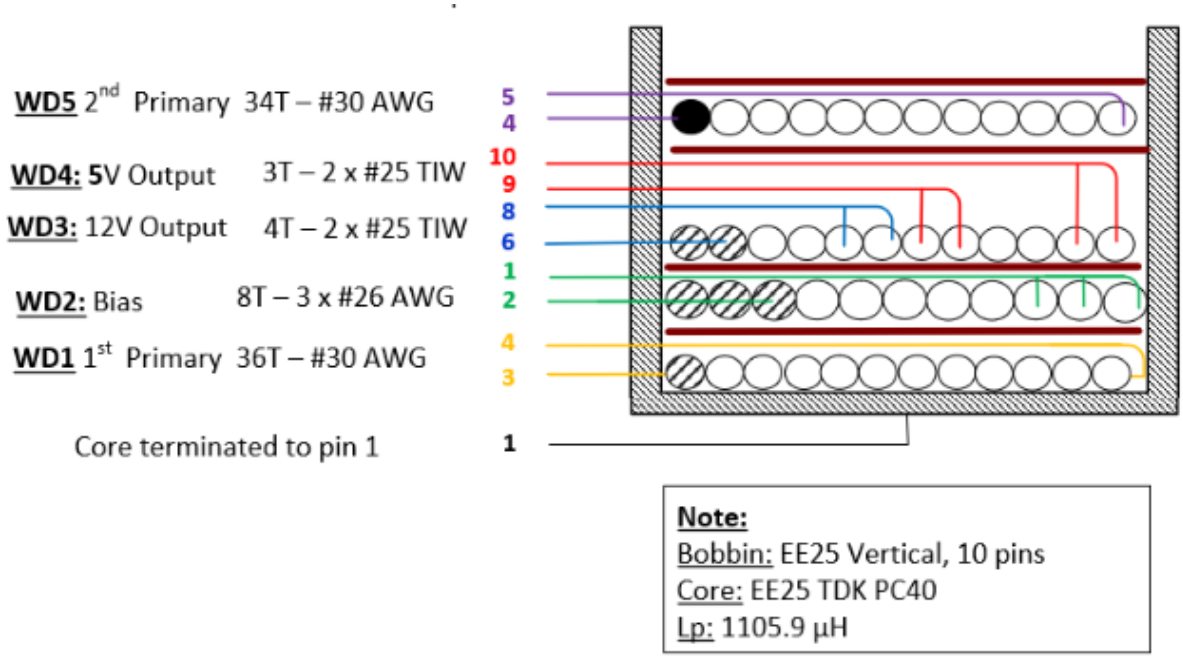
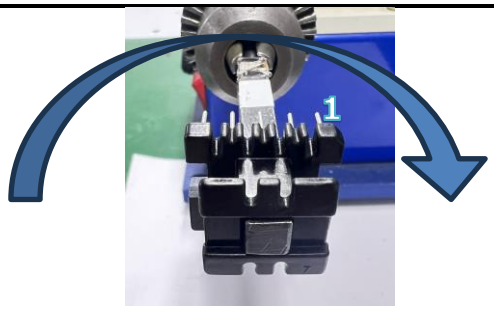
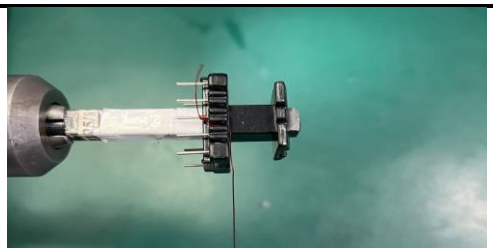
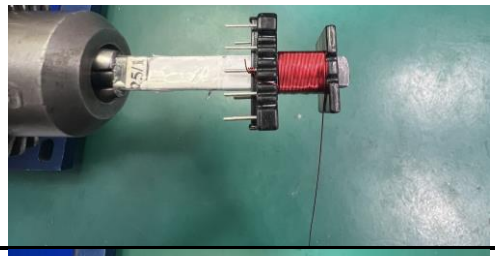
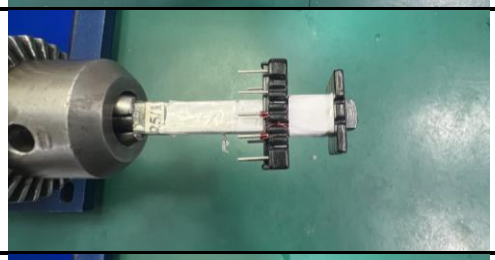
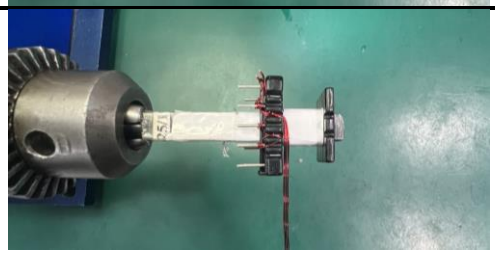


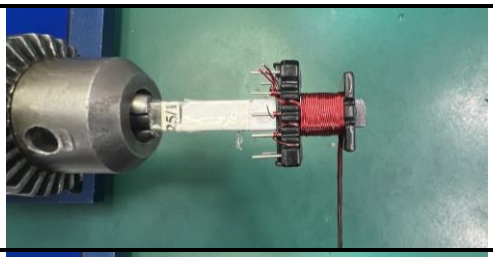
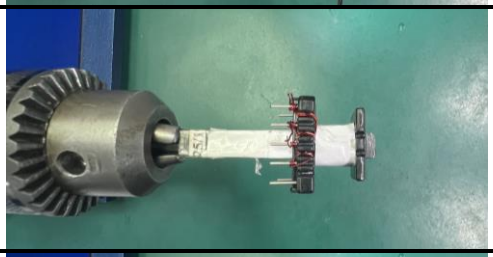
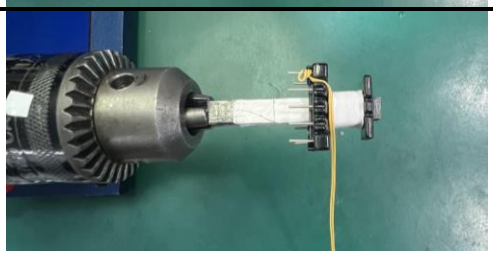
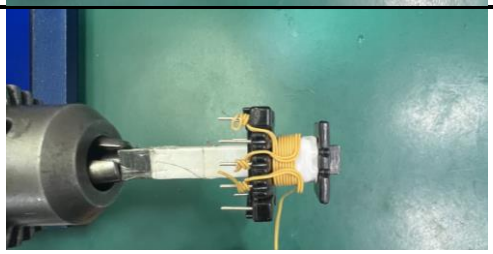
Figure 7 – Transformer Build Diagram.

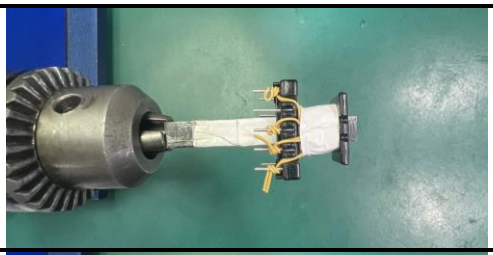
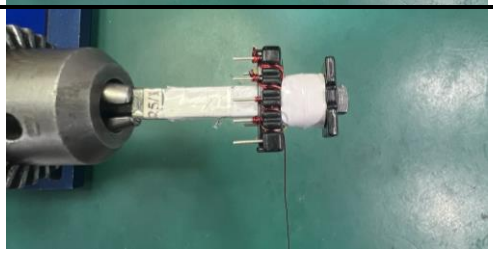
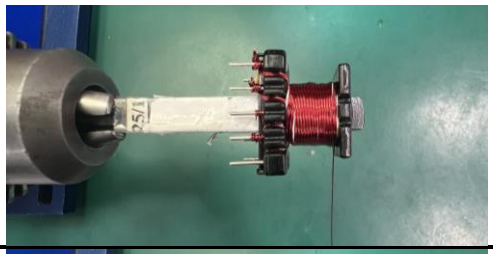
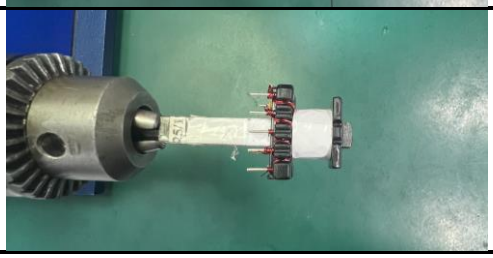
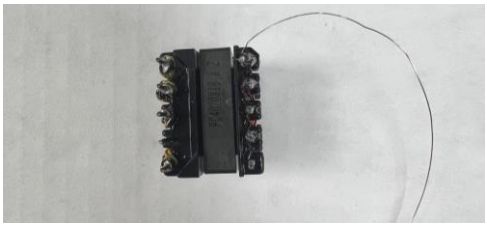
7.5 Transformer Instructions

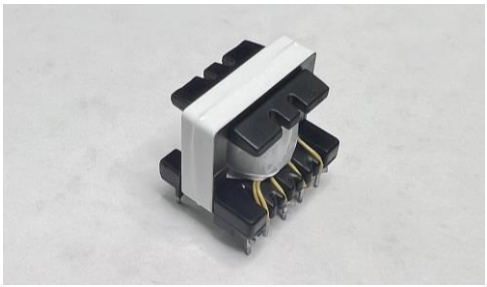
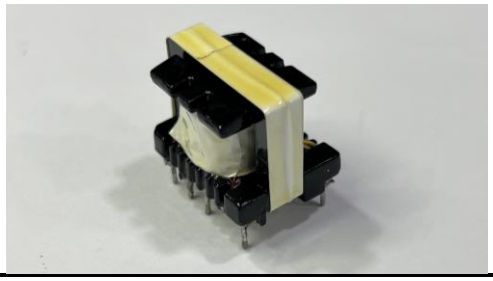
Bobbin Preparation	For the purposes of these instructions, Item [2] is oriented on winder such that pin 1 is located on the top right side facing the mandrel. Winding direction is clockwise.
WD1 1st Primary	Start at pin 3, wind 36 turns of wire Item [3] for the 1st layer. Finish WD1 at pin 4.
Insulation	Use 1 layer of tape Item [6] for insulation.
WD2 Bias	Prepare 3 strands of wire Item [4]. Start 3 strands of wire Item [4] at pin 2, wind 8 turns for 1 layer of winding. Finish WD2 at pin 1.
Insulation	Use 1 layer of tape Item [6] for insulation.
WD3 12 V Output	Prepare 2 strands of wire Item [5]. Start 2 strands of wire Item [5] at pin 6, wind 4 turns for 1 layer of winding. Finish at pin 8.
WD4 5 V Output	Prepare 2 strands of wire Item [5]. Start 2 strands of wire Item [5] at pin 9, wind 3 turns for 1 layer of winding. Finish at pin 10.
Insulation	Use 1 layer of tape Item [6] for insulation.
WD5 2nd Primary	Start at pin 4, wind 34 turns of wire Item [3] for the last layer winding. Finish WD5 at pin 5.
Insulation	Use 1 layer of tape Item [6] for insulation.
Grind Core, Solder and Cut Pin	Use Item [1], Gap Cores to get 1105.9 µH. Solder the wires to the leads of the bobbin and cut Pin 4. Solder a bus wire Item [9], start at pin 1, wrap the bus wire Item [9] around the core Item [1] for 1 revolution.
Finish	Wrap the core with 3 layers of tape Item [7]. Varnish the TRF with item [8].

7.6 Transformer Winding Illustrations

Bobbin Preparation		For the purposes of these instructions, Item [2] is oriented on winder such that pin 1 is located on the top right side facing the mandrel. Winding direction is clockwise.
WD1 1st Primary	 	Start at pin 3, wind 36 turns of wire Item [3] for the 1st layer. Finish WD1 at pin 4.
Insulation		Use 1 layer of tape Item [6] for insulation.
WD2 Bias		Prepare 3 strands of wire Item [4]. Start 3 strands of wire Item [4] at pin 2, wind 8 turns for 1 layer of winding. Finish WD2 at pin 1.

		
Insulation		Use 1 layer of tape Item [6] for insulation.
WD3 **12 V Output**	 	Prepare 2 strands of wire Item [5]. Start 2 strands of wire Item [5] at pin 6, wind 4 turns for 1 layer of winding. Finish at pin 8.
WD4 **5 V Output**	 	Prepare 2 strands of wire Item [5]. Start 2 strands of wire Item [5] at pin 9, wind 3 turns for 1 layer of winding. Finish at pin 10.

Insulation		Use 1 layer of tape Item [6] for insulation.
WD5 2nd Primary	 	Start at pin 4, wind 34 turns of wire Item [3] for the last layer winding. Finish WD5 at pin 5.
Insulation		Use 1 layer of tape Item [6] for insulation.
Grind Core, Solder and Cut Pin	 	Use Item [1], Gap Cores to get 1105.9 µH. Solder the wires to the leads of the bobbin and cut Pin 4. Solder a bus wire Item [9], start at pin 1, wrap the bus wire Item [9] around the core Item [1] for 1 revolution.

Finish	 	Wrap the core with 3 layers of tape Item [7]. Varnish the TRF with item [8].

8 Design Spreadsheet

	ACDC_TinySwitch5_Flyback_021825; Rev.0.2; Copyright Power Integrations 2025	**INPUT**	**OUTPUT**	**UNITS**	**TinySwitch5 Single/Multi Output Flyback Design Spreadsheet**
2	APPLICATION VARIABLES				Design Title
3	INPUT_TYPE	AC	AC		Input Type
4	VIN_MIN		85	V	Minimum AC input voltage
5	VIN_MAX		265	V	Maximum AC input voltage
6	VIN_RANGE		85-265	VAC	Range of AC input voltage
7	LINEFREQ		60	Hz	AC Input voltage frequency
8	CAP_INPUT	66.0	66.0	uF	Input capacitor
9	VOUT		12.00	V	Output voltage at the board
10	IOUT	2.208	2.208	A	Output current
11	POUT		26.50	W	Output power
12	EFFICIENCY		0.87		AC-DC efficiency estimate at full load given that the converter is switching at the valley of the rectified minimum input AC voltage
13	FACTOR_Z		0.50		Z-factor estimate
14	ENCLOSURE	OPEN FRAME	OPEN FRAME		Power supply enclosure
15					
16					
17					
18	PRIMARY CONTROLLER SELECTION				
19	DEVICE_SERIES	TNY5073	TNY5073		Generic device code
20	ILIMIT_MODE	STANDARD	STANDARD		Device current limit mode
21	PACKAGE_DEVICE	eSOP	eSOP		Device Package
22	DEVICE_CODE		TNY5073K		Actual device code
23	POUT_MAX		30	W	Power capability of the device based on thermal performance
24	RDSON_100DEG		6.38	Ω	Primary switch on time drain resistance at 100 degC
25	ILIMIT_MIN		0.741	A	Minimum current limit of the primary switch

26	ILIMIT_TYP		0.805	A	Typical current limit of the primary switch
27	ILIMIT_MAX		0.869	A	Maximum current limit of the primary switch
28	VDRAIN_BREAKDOWN		725	V	Device breakdown voltage
29	VDRAIN_ON_PRSW		2.02	V	Primary switch on time drain voltage
30	VDRAIN_OFF_PRSW		528.4	V	Peak drain voltage on the primary switch during turn-off. A 30V leakage spike voltage is assumed
31					
32					
33					
34	WORST CASE ELECTRICAL PARAMETERS				
35	FSWITCHING_MAX	119300	119300	Hz	Maximum switching frequency at full load and valley of the rectified minimum AC input voltage.
36	VOR	125.0	125.0	V	Secondary voltage reflected to the primary when the primary switch turns off
37	VMIN		92.12	V	Valley of the minimum input AC voltage at full load
38	KP		0.55		Measure of continuous/discontinuous mode of operation
39	MODE_OPERATION		CCM		Mode of operation
40	DUTYCYCLE		0.581		Primary switch duty cycle
41	TIME_ON		13.50	us	Primary switch on-time
42	TIME_ON_AT_FSWITCHING_MAX		4.87	us	Primary switch on-time at FSWITCHING_MAX
43	TIME_OFF		3.51	us	Primary switch off-time at 85VAC, 26.496W, and 119300Hz.
44	LPRIMARY_MIN		1050.6	uH	Minimum primary inductance

45	LPRIMARY_TYP		1105.9	uH	Typical primary inductance
46	LPRIMARY_TOL	5.0	5.0	%	Primary inductance tolerance
47	LPRIMARY_MAX		1161.2	uH	Maximum primary inductance
48					
49	PRIMARY CURRENT				
50	IPEAK_PRIMARY		0.850	A	Primary switch peak current
51	IPEDESTAL_PRIMARY		0.340	A	Primary switch current pedestal
52	IAVG_PRIMARY		0.316	A	Primary switch average current
53	IRIPPLE_PRIMARY		0.613	A	Primary switch ripple current
54	IRMS_PRIMARY		0.436	A	Primary switch RMS current
55					
56	SECONDARY CURRENT				
57	IPEAK_SECONDARY		8.502	A	Secondary winding peak current
58	IPEDESTAL_SECONDARY		3.397	A	Secondary winding current pedestal
59	IRMS_SECONDARY		3.701	A	Secondary winding RMS current
60					
61					
62					
63	TRANSFORMER CONSTRUCTION PARAMETERS				
64	CORE SELECTION				
65	CORE	EE25	EE25		Core selection. Refer to the 'Transformer Construction' tab to see the detailed report
66	CORE CODE		PC40EE25/ 19-Z		Core code
67	AE		40.00	mm^2	Core cross sectional area
68	LE		48.70	mm	Core magnetic path length
69	AL		2000	nH/turns ^2	Ungapped core effective inductance
70	VE		1950.0	mm^3	Core volume
71	BOBBIN		BE25-118CPFR		Bobbin

72	AW		44.10	mm^2	Window area of the bobbin
73	BW		9.80	mm	Bobbin width
74	MARGIN		0.0	mm	Safety margin width (Half the primary to secondary creepage distance)
75					
76	PRIMARY WINDING				
77	NPRIMARY		70		Primary turns
78	BPEAK		3720	Gauss	Peak flux density
79	BMAX		3493	Gauss	Maximum flux density
80	BAC		1238	Gauss	AC flux density (0.5 x Peak to Peak)
81	ALG		226	nH/turns ^2	Typical gapped core effective inductance
82	LG		0.198	mm	Core gap length
83					
84	PRIMARY BIAS WINDING				
85	NBIAS_PRIMARY		8	turns	Primary bias winding number of turns
86					
87	SECONDARY WINDING				
88	NSECONDARY	7	7	turns	Secondary winding number of turns
89					
90	SECONDARY BIAS WINDING				
91	NBIAS_SECONDARY		NA	turns	Secondary bias winding number of turns
92					
93					
94					
95	PRIMARY COMPONENTS SELECTION				
96	LINE UNDERVOLTAGE				
97	BROWN-IN REQURED		76.08	V	Required AC RMS/DC line voltage brown-in threshold
98	RLS		8.04	MΩ	Connect two 4.02 MOhm resistors to the V-pin for the required UV/OV threshold
99	BROWN-IN ACTUAL		63.5 - 78.6	V	Actual AC RMS/DC brown-in range
100	BROWN-OUT ACTUAL		55 - 67.9	V	Actual AC RMS/DC brown-out range

101					
102	LINE OVERVOLTAGE				
103	OVERVOLTAGE_LINE		285.4 - 355.2	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		56.38	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
111					
112					
113					
114	SECONDARY COMPONENTS				
115	VREF_REG	2.50	2.50	V	Reference voltage of the feedback
116	RFB_UPPER		38.30	kΩ	Upper feedback resistor (connected to the first output voltage)
117	RFB_LOWER		10.00	kΩ	Lower feedback resistor
118					
119	SECONDARY BIAS DIODE				
120	USE_SECONDARY_BIAS	AUTO	NO		Use secondary bias winding for the design
121	VBIAS_SECONDARY		NA	V	Rectified secondary bias voltage
122	VF_BIAS_SECONDARY		NA	V	Bias winding diode forward drop
123	VREVERSE_BIASDIODE_SECONDARY		NA	V	Bias diode reverse voltage (not accounting parasitic voltage ring)
124	CBIAS_SECONDARY		NA	uF	Bias winding rectification capacitor
125					
126					
127	MULTIPLE OUTPUT PARAMETERS				
128	OUTPUT 1				

129	VOUT1		12.00	V	Output 1 voltage
130	IOUT1	2.00	2.00	A	Output 1 current
131	POUT1		24.00	W	Output 1 power
132	VD1	0.60	0.60	V	Forward voltage drop of diode for output 1
133	NS1		7.00	turns	Number of turns for output 1
134	ISPEAK1		8.50	A	Instantaneous peak value of the secondary current for output 1
135	ISRMS1		3.353	A	Root-mean-squared value of the secondary current for output 1
136	ISRIPPLE1		2.691	A	Current ripple on the secondary waveform for output 1
137	PIV1_CALCULATED		58.96	V	Computed peak inverse voltage stress on the diode for output 1
138	OUTPUT_RECTIFIER1	AUTO	SB560		Recommended diode for output 1.
139	PIV1_RATING		60.00	V	Peak inverse voltage rating on the diode for output 1
140	TRR1		0.00	ns	Reverse recovery time of the diode for output 1
141	IFM1		5.00	A	Maximum forward continuous current of the diode for output 1
142	PLOSS_DIODE1		1.93	W	Maximum diode power loss for output 1
143					
144	OUTPUT 2				
145	VOUT2	5.00	5.00	V	Output 2 voltage
146	IOUT2	0.500	0.500	A	Output 2 current
147	POUT2		2.50	W	Output 2 power
148	VD2	0.40	0.40	V	Forward voltage drop of diode for output 2
149	NS2		3.00	turns	Number of turns for output 2
150	ISPEAK2		19.84	A	Instantaneous peak value of the secondary current for output 1

151	ISRMS2		0.838	A	Root mean squared value of the secondary current for output 2
152	ISRIPPLE2		0.673	A	Current ripple on the secondary waveform for output 2
153	PIV2		25.10	V	Computed peak inverse voltage stress on the diode for output 2
154	OUTPUT_RECTIFIER2	AUTO	1N5821		Recommended diode for output 2.
155	PIV2_RATING		30.00	V	Peak inverse voltage rating on the diode for output 2
156	TRR2		0.00	ns	Reverse recovery time of the diode for output 2
157	IFM2		3.00	A	Maximum forward continuous current of the diode for output 2
158	PLOSS_DIODE2		0.32	W	Maximum diode power loss for output 2
159					
160	OUTPUT 3				
161	VOUT3		0.00	V	Output 3 voltage
162	IOUT3		0.000	A	Output 3 current
163	POUT3		0.00	W	Output 3 power
164	VD3		N/A	V	Forward voltage drop of diode for output 3
165	NS3		N/A	turns	Number of turns for output 3
166	ISPEAK3		N/A	A	Instantaneous peak value of the secondary current for output 1
167	ISRMS3		N/A	A	Root mean squared value of the secondary current for output 3
168	ISRIPPLE3		N/A	A	Current ripple on the secondary waveform for output 3
169	PIV3		N/A	V	Computed peak inverse voltage stress on the diode for output 3

170	OUTPUT_RECTIFIER3	AUTO	N/A		Recommended diode for output 3.
171	PIV3_RATING		N/A	V	Peak inverse voltage rating on the diode for output 3
172	TRR3		N/A	ns	Reverse recovery time of the diode for output 3
173	IFM3		N/A	A	Maximum forward continuous current of the diode for output 3
174	PLOSS_DIODE3		N/A	W	Maximum diode power loss for output 2
175					
176	PO_TOTAL		26.50	W	The total power of all outputs does not add up to the total power of the design

9 Performance Data

9.1 Full Load Efficiency vs. Line

Test Condition: Soak for 15 minutes for each line.

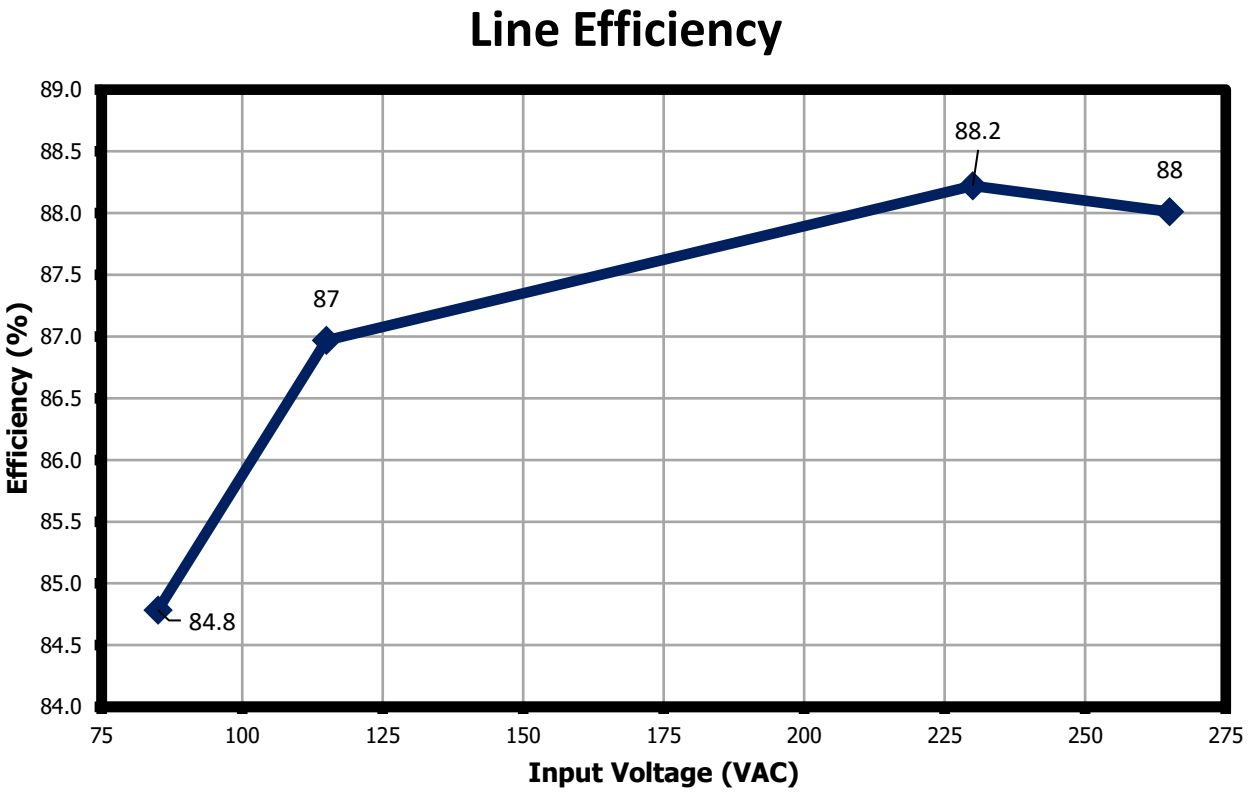


Figure 8 – Efficiency vs. Input Voltage.

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(V)	(A)	(W)	(%)	(%)
85	60	85	669	30.9	11.9	2	23.7	-1.15	4.98	0.5	2.49	-0.34	84.8
115	60	115	540	30.1	11.9	2	23.7	-1.21	4.98	0.5	2.49	-0.32	87
230	50	230	349	29.7	11.9	2	23.7	-1.19	4.99	0.5	2.50	-0.12	88.2
265	50	265	311	29.8	11.9	2	23.7	-1.23	4.99	0.5	2.50	-0.14	88

9.2 Line Regulation

Test Condition: Soak for 15 minutes for each line.

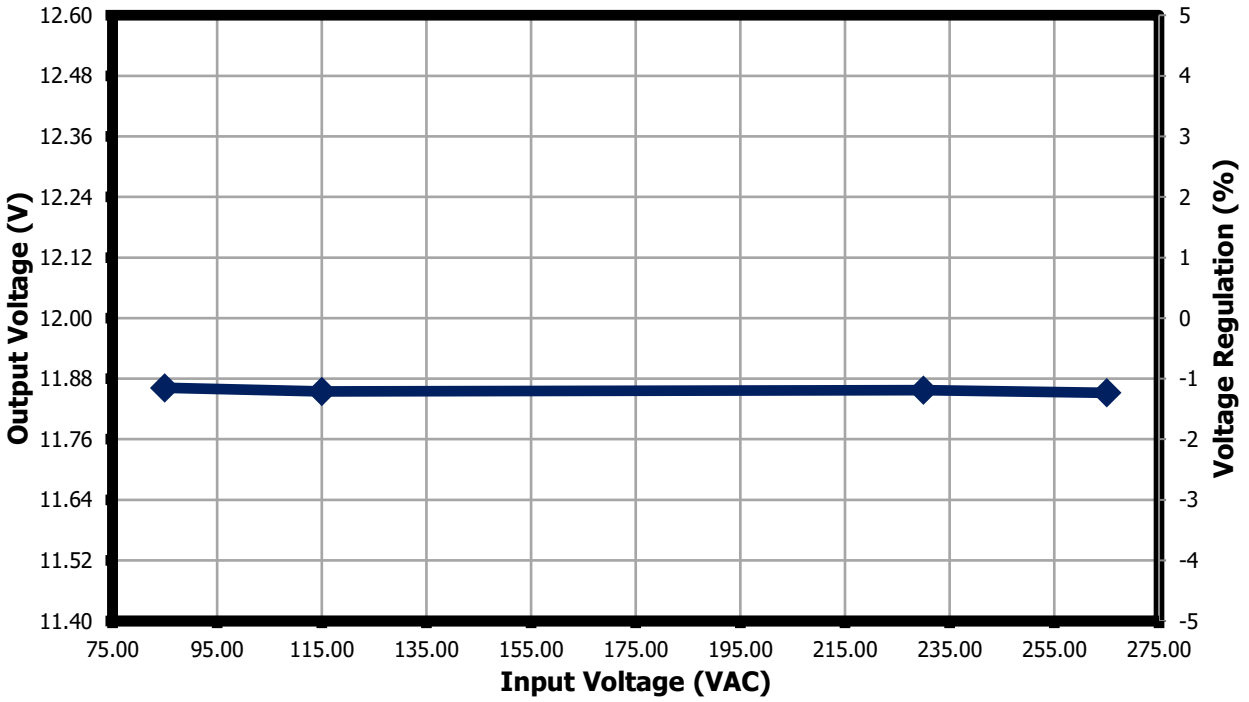


Figure 9 – 12 Output Voltage vs. Line Voltage.

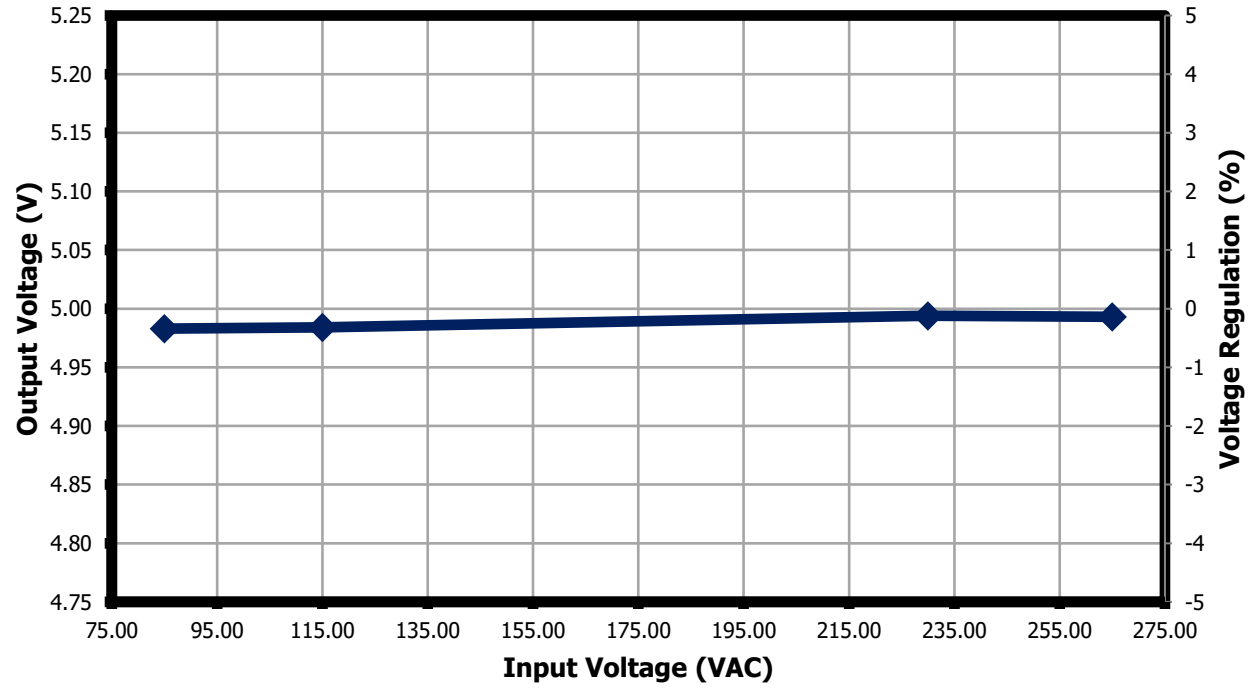


Figure 10 – 5 Output Voltage vs. Line Voltage.

9.3 Efficiency vs. Load

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

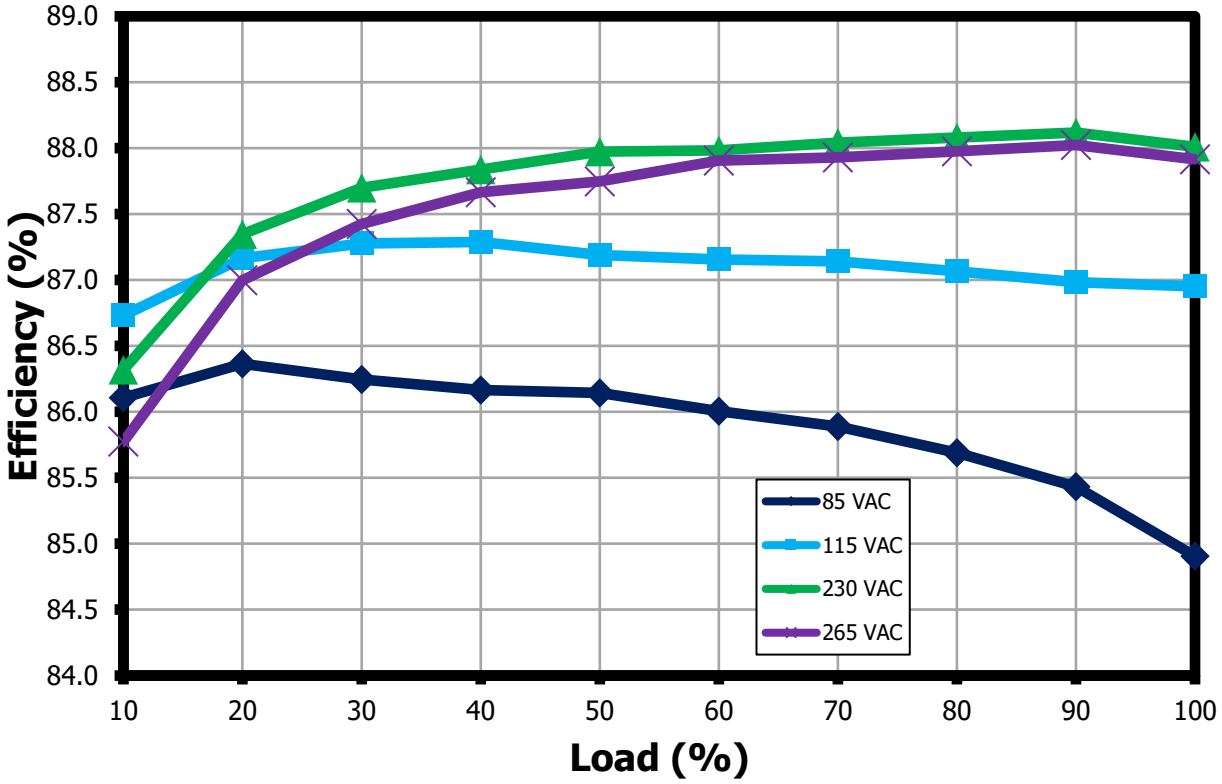


Figure 11 – Efficiency vs. Percentage Load.

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	12 V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	5 V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(V)	(A)	(W)	(%)	(%)
85	60	85	664	30.7	11.8	2	23.60	-1.63	4.95	0.5	2.47	-1.08	84.9
85	60	85	605	27.5	11.8	1.8	21.24	-1.63	4.95	0.45	2.23	-0.94	85.4
85	60	85	547	24.4	11.8	1.6	18.91	-1.50	4.96	0.4	1.99	-0.72	85.7
85	60	85	488	21.3	11.8	1.4	16.57	-1.32	4.98	0.35	1.74	-0.48	85.9
85	60	85	431	18.3	11.9	1.2	14.21	-1.25	4.98	0.3	1.49	-0.42	86
85	60	85	375	15.2	11.9	1.0	11.85	-1.23	4.98	0.25	1.25	-0.38	86.1
85	60	85	319	12.2	11.9	0.8	9.48	-1.20	4.98	0.2	1.00	-0.36	86.2
85	60	85	257	9.11	11.9	0.6	7.11	-1.18	150	0.15	0.75	-0.36	86.2
85	60	85	178	6.07	11.9	0.4	4.74	-1.15	4.98	0.1	0.50	-0.34	86.4
85	60	85	94	3.04	11.9	0.2	2.37	-1.12	4.98	0.05	0.25	-0.32	86.1

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	12 V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	5 V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(V)	(A)	(W)	(%)	(%)
115	60	115	536	29.9	11.8	2	23.6	-1.81	4.95	0.5	2.48	-0.94	87
115	60	115	496	27	11.8	1.8	21.2	-1.61	4.96	0.45	2.23	-0.74	87
115	60	115	456	24	11.8	1.6	18.9	-1.53	4.97	0.4	1.99	-0.64	87
115	60	115	416	21	11.8	1.4	16.6	-1.34	4.98	0.35	1.74	-0.40	87.1
115	60	115	373	18	11.8	1.2	14.2	-1.31	4.98	0.3	1.49	-0.38	87.2
115	60	115	318	15	11.9	1.0	11.8	-1.28	4.98	0.25	1.25	-0.36	87.2
115	60	115	259	12	11.9	0.8	9.48	-1.25	4.98	0.2	1.00	-0.34	87.3
115	60	115	199	9	11.9	0.6	7.11	-1.23	4.98	0.15	0.75	-0.34	87.3
115	60	115	138	6.01	11.9	0.4	4.74	-1.20	4.98	0.1	0.50	-0.32	87.2
115	60	115	74.2	3.02	11.9	0.2	2.37	-1.17	4.99	0.05	0.25	-0.30	86.7

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	12 V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	5 V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(V)	(A)	(W)	(%)	(%)
230	50	230	347	29.5	11.8	2	23.5	-1.99	4.95	0.5	2.48	-0.92	88
230	50	230	316	27	11.8	1.8	21.3	-1.57	4.98	0.45	2.24	-0.46	88.1
230	50	230	284	24	11.8	1.6	18.9	-1.53	4.98	0.4	1.99	-0.40	88
230	50	230	252	21	11.8	1.4	16.5	-1.47	4.98	0.35	1.74	-0.38	88
230	50	230	219	18	11.8	1.2	14.2	-1.44	4.98	0.3	1.49	-0.34	88
230	50	230	186	15	11.8	1.0	11.8	-1.41	4.98	0.25	1.25	-0.32	88
230	50	230	153	11.9	11.8	0.8	9.47	-1.37	4.99	0.2	1.00	-0.30	87.8
230	50	230	118	8.95	11.8	0.6	7.10	-1.34	4.99	0.15	0.75	-0.28	87.7
230	50	230	81.9	5.99	11.8	0.4	4.73	-1.32	4.99	0.1	0.50	-0.26	87.4
230	50	230	47	3.03	11.9	0.2	2.37	-1.28	4.99	0.05	0.25	-0.24	86.3

VAC	Freq	V_{IN}	I_{IN}	P_{IN}	12 V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	5 V_{OUT}	I_{OUT}	P_{OUT}	V_{REG}	Efficiency
(RMS)	(Hz)	(RMS)	(mA)	(W)	(V)	(A)	(W)	(%)	(V)	(A)	(W)	(%)	(%)
265	50	265	309	29.6	11.8	2	23.5	-2.04	4.96	0.5	2.48	-0.90	87.9
265	50	265	282	26.7	11.8	1.8	21.3	-1.61	4.98	0.45	2.24	-0.44	88
265	50	265	253	23.7	11.8	1.6	18.9	-1.56	4.98	0.4	1.99	-0.40	88
265	50	265	225	20.8	11.8	1.4	16.5	-1.52	4.98	0.35	1.74	-0.36	87.9
265	50	265	196	17.8	11.8	1.2	14.2	-1.47	4.98	0.3	1.49	-0.34	87.9
265	50	265	167	14.9	11.8	1.0	11.8	-1.47	4.98	0.25	1.25	-0.32	87.8
265	50	265	137	11.9	11.8	0.8	9.46	-1.41	4.99	0.2	1.00	-0.28	87.7
265	50	265	104	8.98	11.8	0.6	7.10	-1.37	4.99	0.15	0.75	-0.26	87.4
265	50	265	74.2	6.01	11.8	0.4	4.73	-1.34	4.99	0.1	0.50	-0.24	87
265	50	265	43.5	3.05	11.8	0.2	2.37	-1.31	4.99	0.05	0.25	-0.22	85.8

9.4 Load Regulation

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

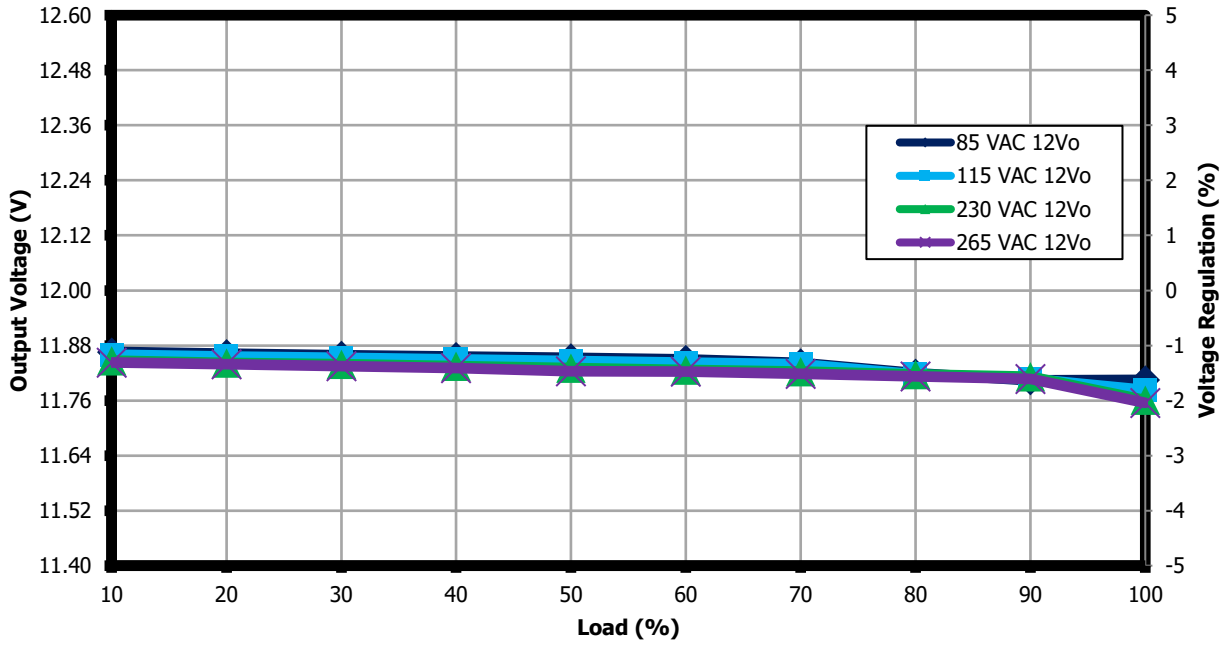


Figure 12 – 12 Output Voltage vs. Percent Load.

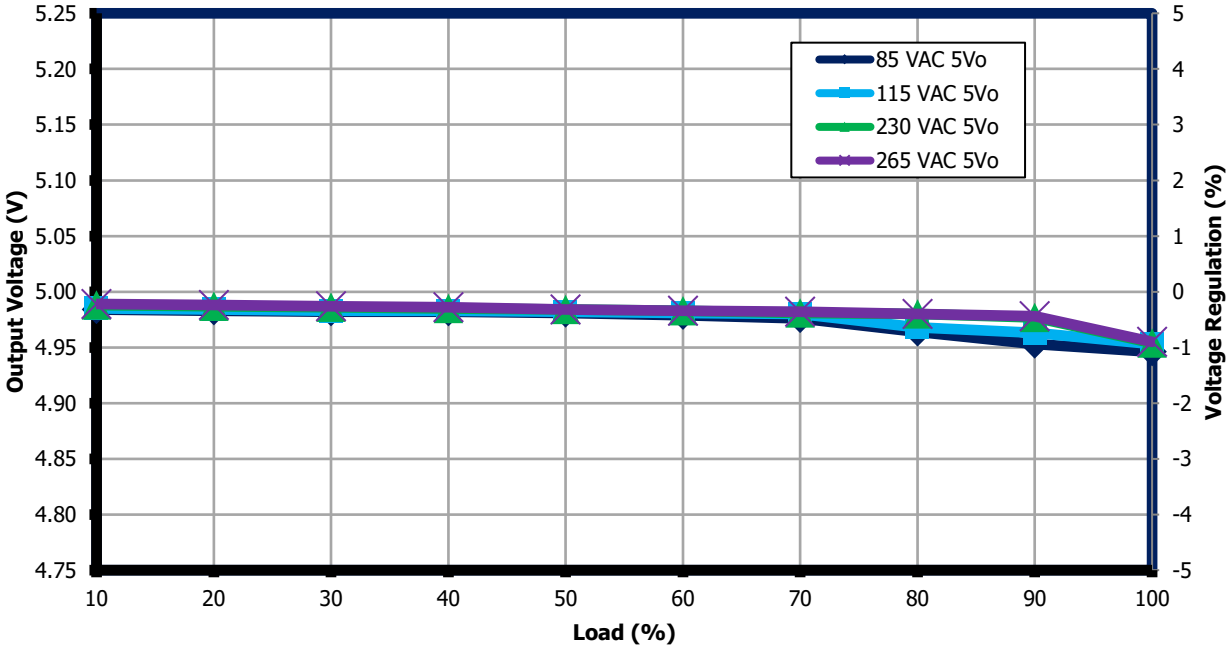


Figure 13 – 5 Output Voltage vs. Percent Load.

9.5 Average and 10% Efficiency

9.5.1 Average and 10% Efficiency at 115 VAC

Load	P_{IN}	12 V_{OUT} at PCB	I_{OUT}	P_{OUT}	5 V_{OUT} at PCB	I_{OUT}	P_{OUT}	Efficiency at PCB	Average Efficiency	DOE6 Limit
(%)	(W)	(V_{DC})	(A)	(W)	(V_{DC})	(A)	(W)	(%)	(%)	(%)
100	30.3	11.7	2	23.4	4.90	0.5	2.45	85.1	85.9	80.7
75	22.8	11.8	1.5	17.7	4.93	0.375	1.85	85.7		
50	15.3	11.8	1	11.8	4.96	0.25	1.24	86.2		
25	7.58	11.9	0.5	5.95	4.92	0.125	0.61	86.6		
10	3.04	11.9	0.2	2.39	5.01	0.05	0.25	87	---	---

9.5.2 Average and 10% Efficiency at 230 VAC

Load	P_{IN}	12 V_{OUT} at PCB	I_{OUT}	P_{OUT}	5 V_{OUT} at PCB	I_{OUT}	P_{OUT}	Efficiency at PCB	Average Efficiency	DOE6 Limit
(%)	(W)	(V_{DC})	(A)	(W)	(V_{DC})	(A)	(W)	(%)	(%)	(%)
100	29.9	11.7	2	23.4	4.91	0.5	2.46	86.4	86.7	80.7
75	22.5	11.8	1.5	17.6	4.94	0.375	1.85	86.7		
50	15	11.8	1	11.8	4.96	0.25	1.24	87		
25	7.54	11.9	0.5	5.93	4.92	0.125	0.61	87		
10	3.06	11.9	0.2	2.39	5.01	0.05	0.25	86.4	---	---

9.6 No-Load Input Power

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

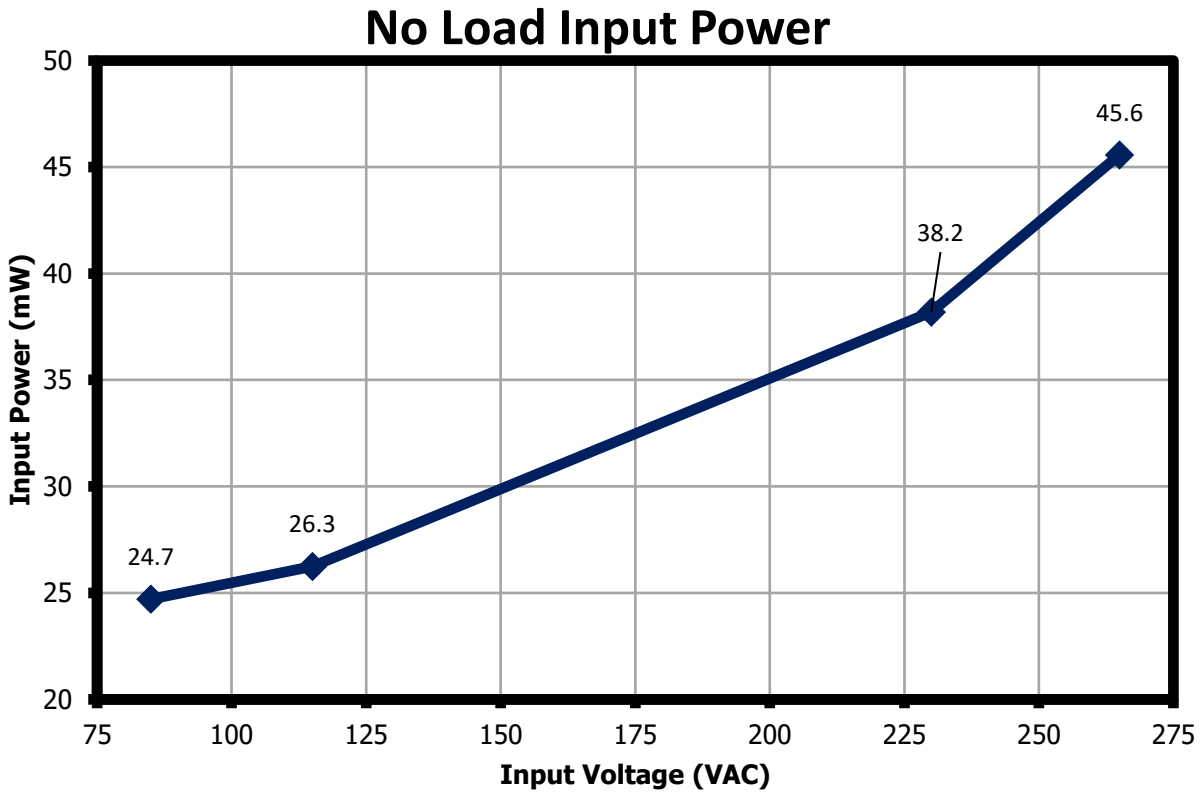


Figure 14 – No-Load Input Power vs. Line at Room Temperature.

VAC	Freq	V_{IN}	I_{IN}	P_{IN}
(RMS)	(Hz)	(RMS)	(mA)	(mW)
85	60	85	15.3	24.7
115	60	115	15.9	26.3
230	50	230	16.4	38.2
265	50	265	17	45.6

9.7 Standby Input Power

9.7.1 Standby Efficiency

Note: 12 V output and 5 V output are Loaded Simultaneously.

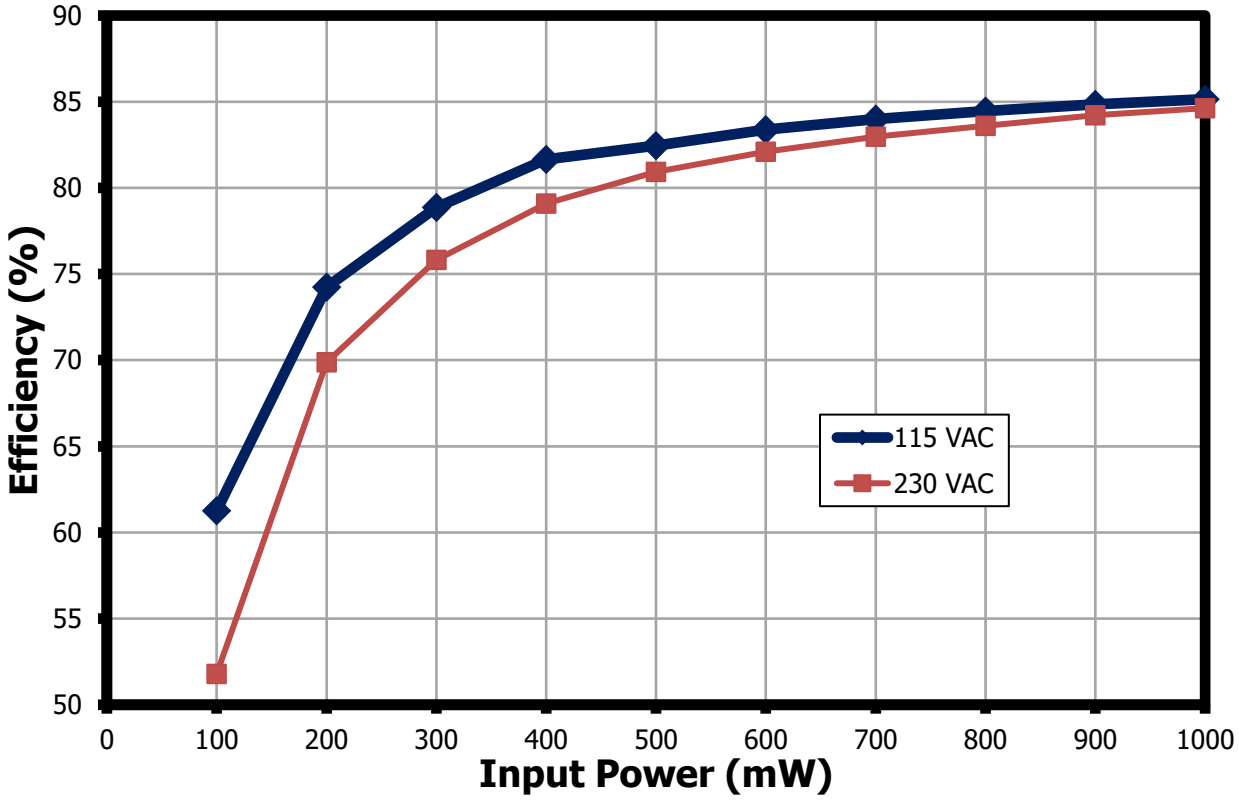


Figure 15 – Efficiency vs. Input Power

9.7.2 Standby Input Power

Note: 12 V output and 5 V output are Loaded Simultaneously.

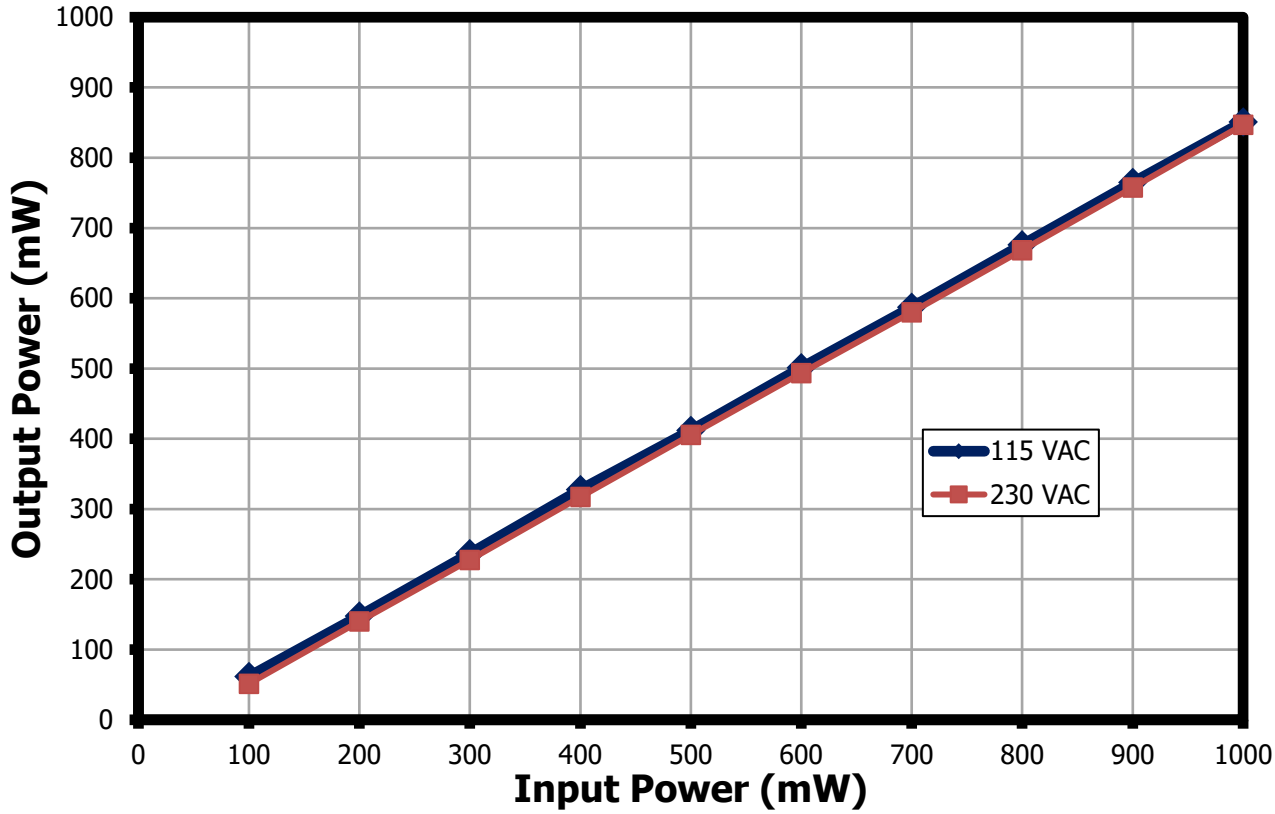


Figure 16 – Output Power vs. Input Power

9.8 Cross Regulation

9.8.1 Cross Regulation with 12 V at Minimum Load and Varying 5 V Load

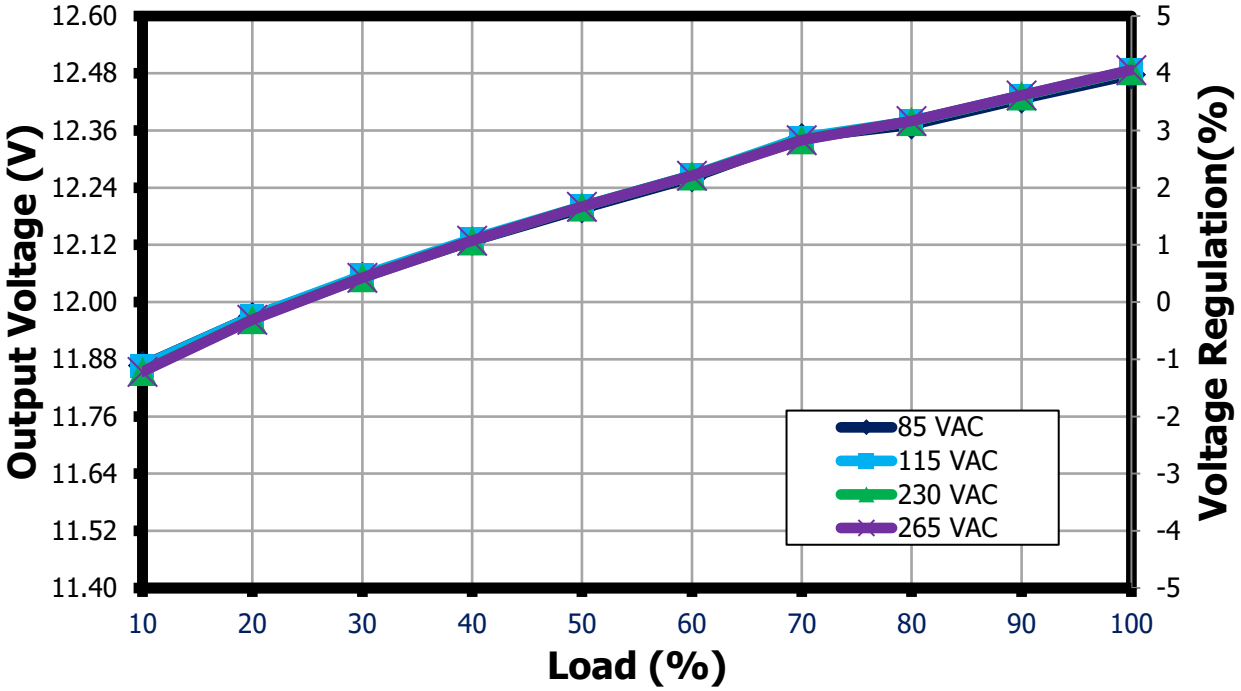


Figure 17 – 12 V Output Voltage vs. Percent Load.

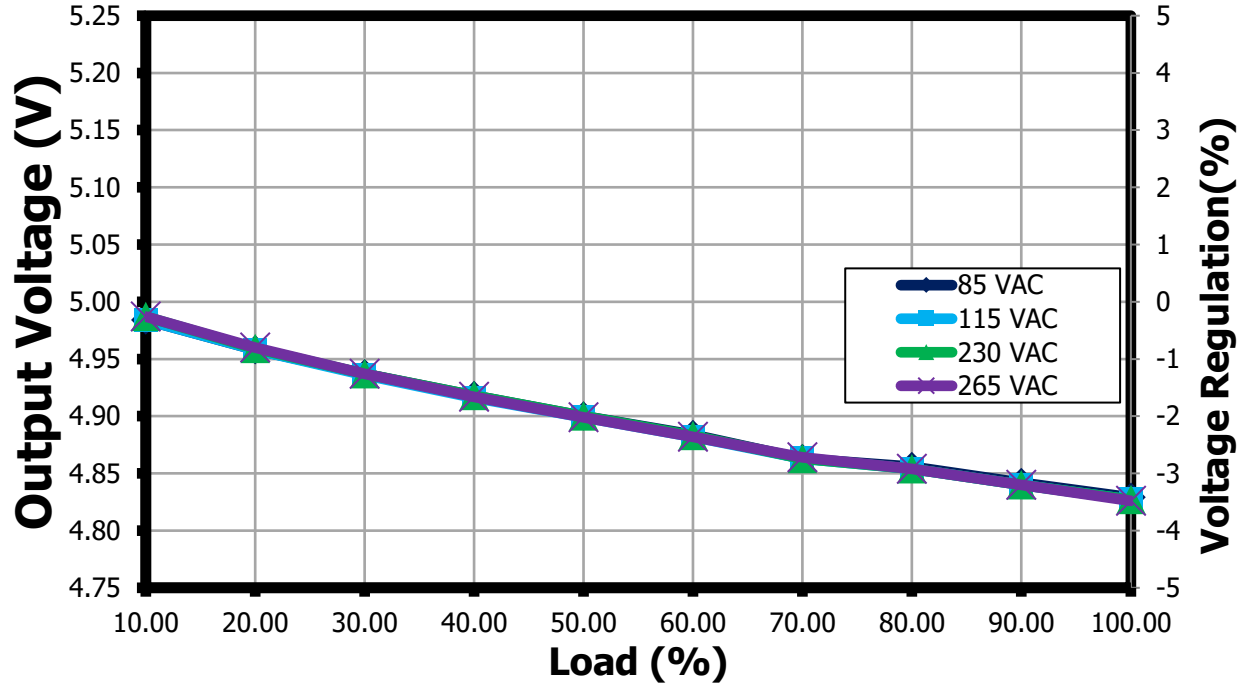


Figure 18 – 5 V Output Voltage vs. Percent Load.

9.8.2 Cross Regulation with 12 V at Full Load and Varying 5 V Load

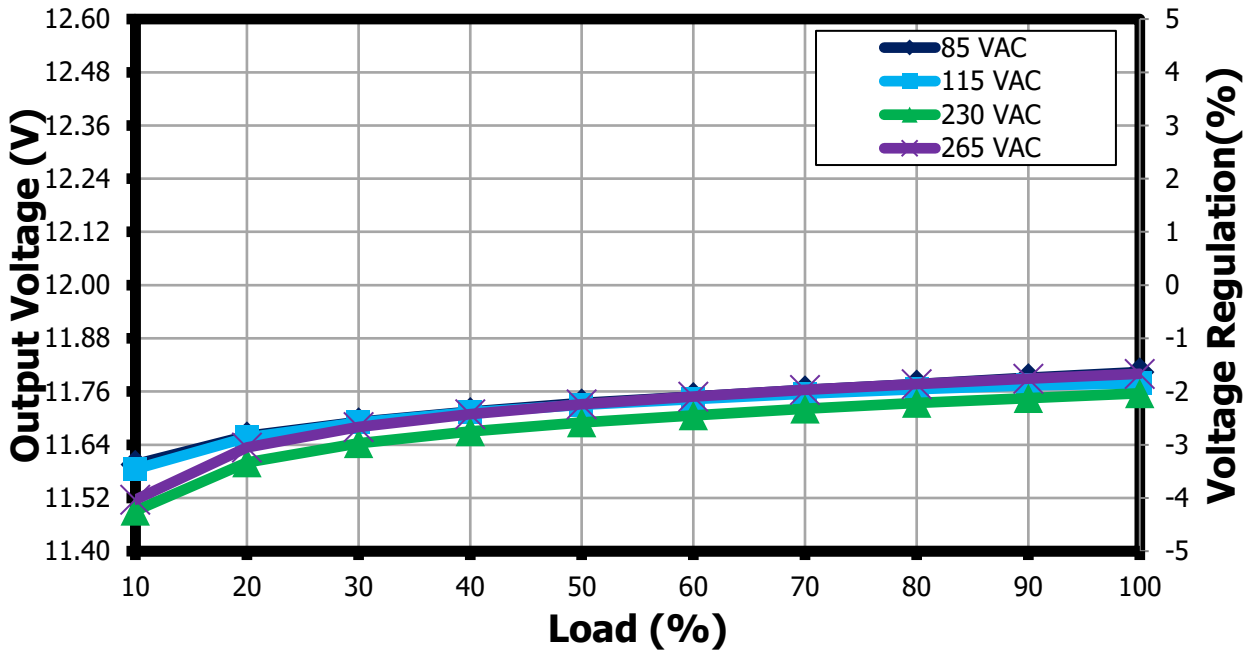


Figure 19 – 12 V Output Voltage vs. Percent Load.

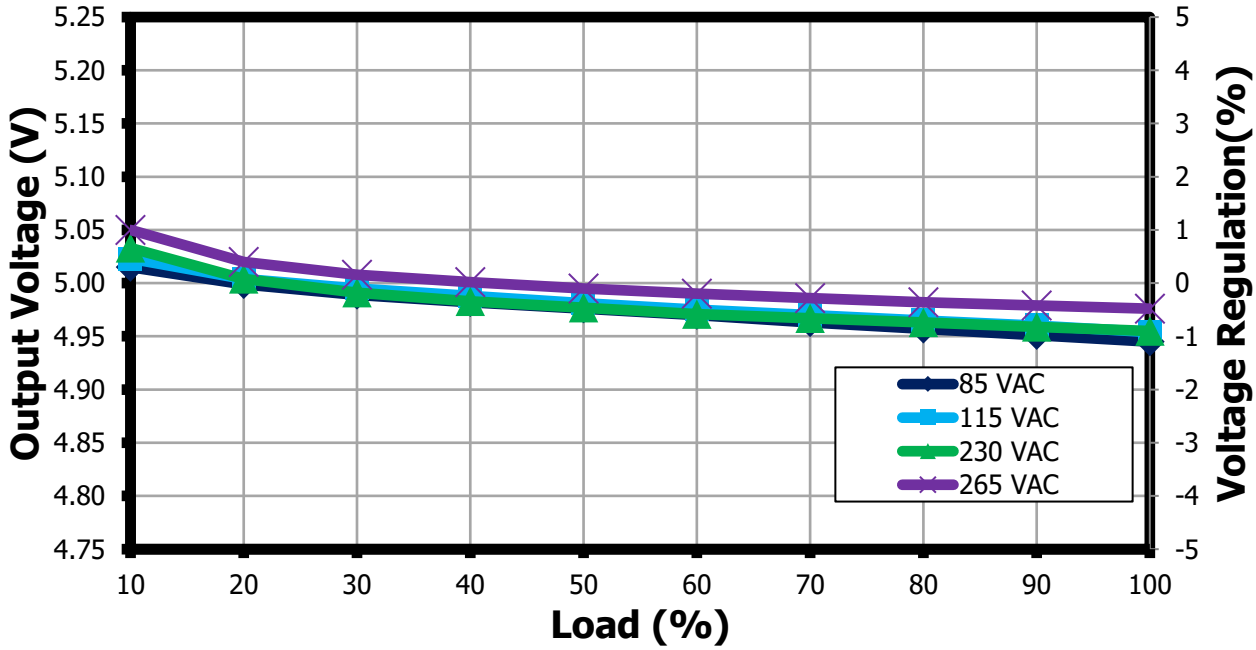


Figure 20 – 5 V Output Voltage vs. Percent Load.

9.8.3 Cross Regulation with 5 V at Minimum Load and Varying 12 V Load

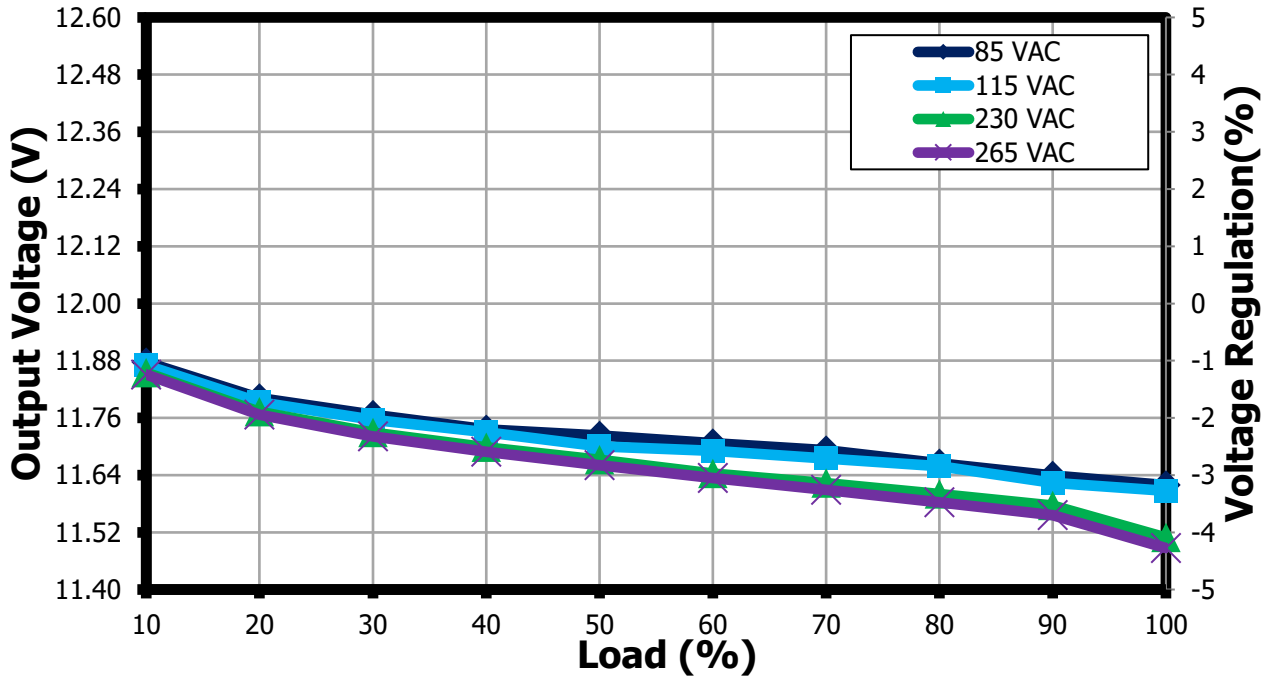


Figure 21 – 12 V Output Voltage vs. Percent Load.

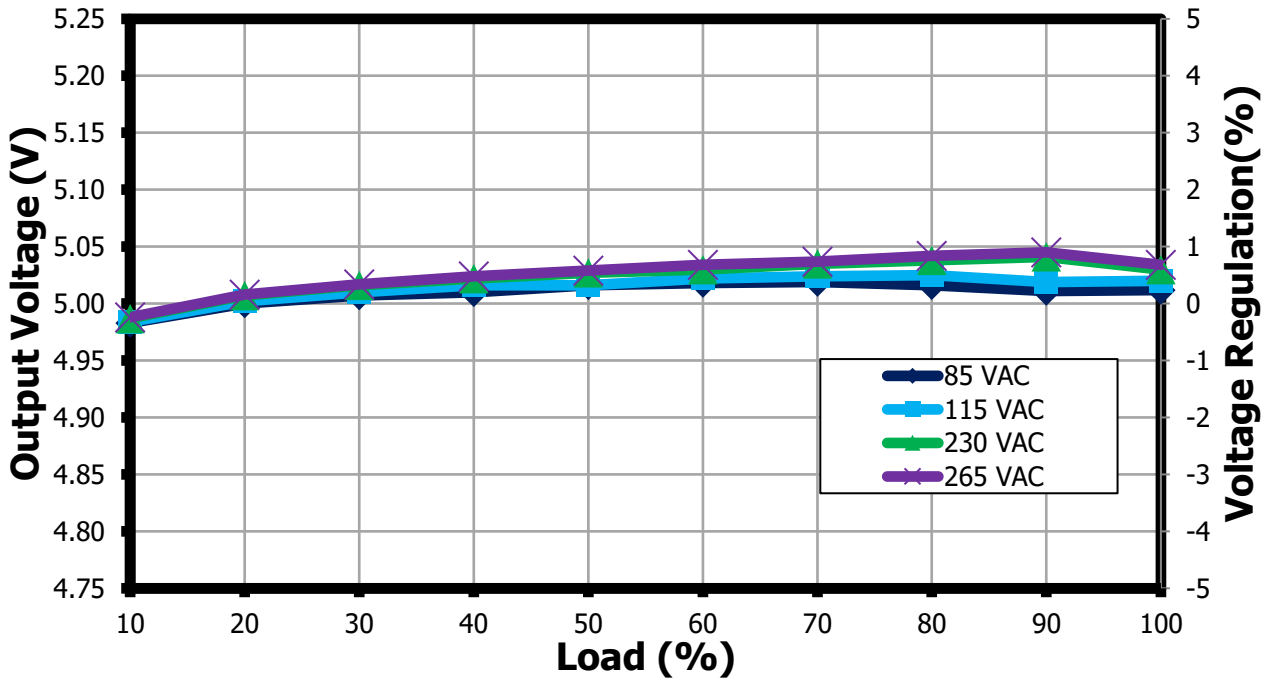


Figure 22 – 5 V Output Voltage vs. Percent Load.

9.8.4 Cross Regulation with 5 V at Full Load and Varying 12 V Load

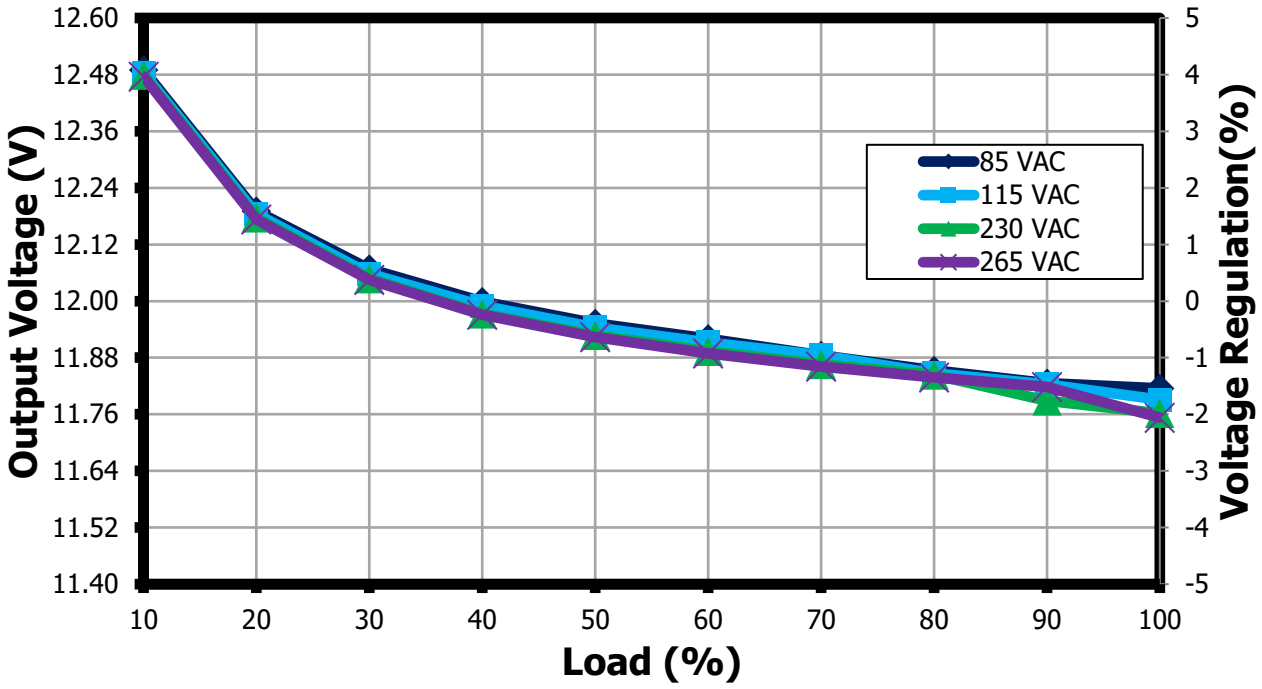


Figure 23 – 12 V Output Voltage vs. Percent Load.

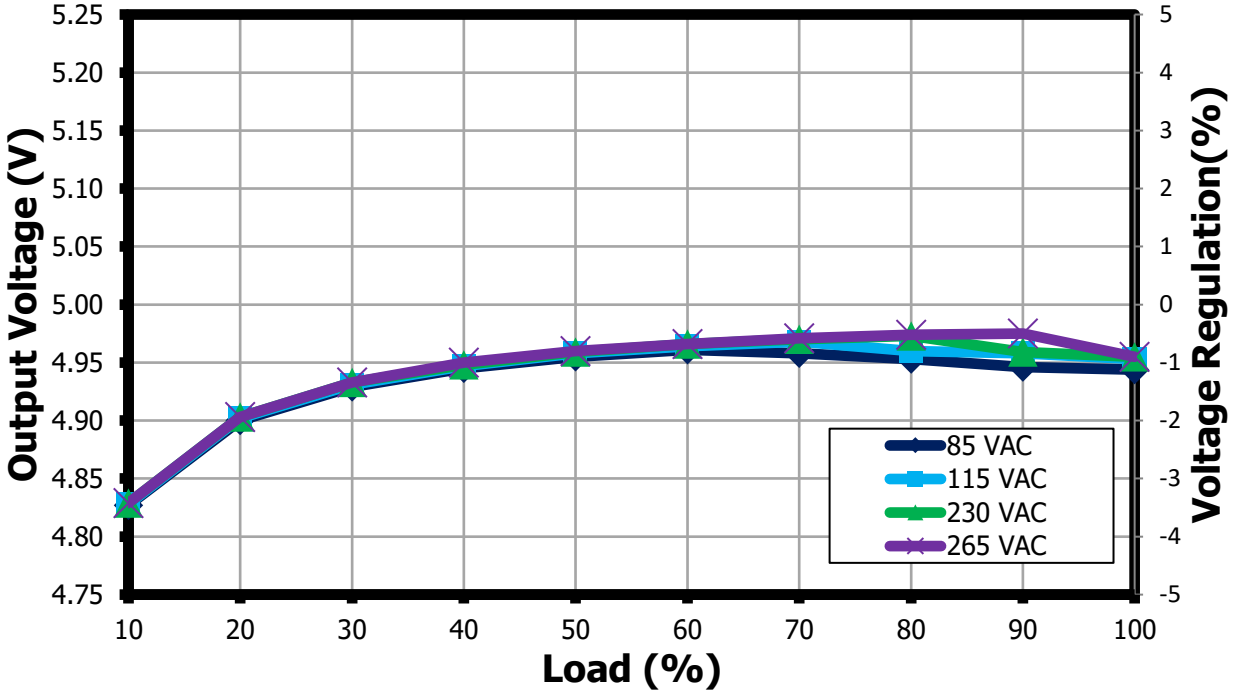


Figure 24 – 5 V Output Voltage vs. Percent Load.

10 Waveforms

10.1 Switching Waveforms

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

10.1.1.1 Full Load

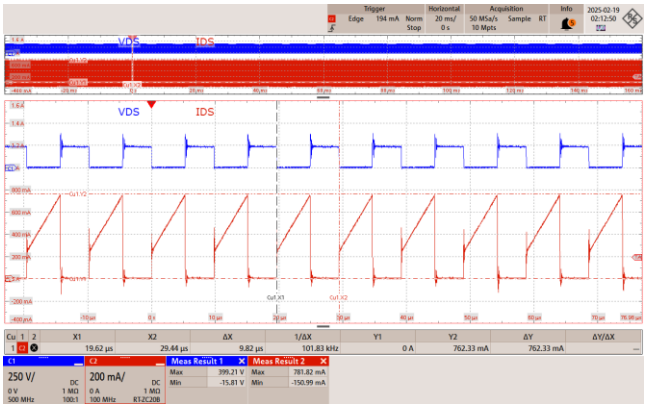


Figure 25 – 85 VAC 60 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Drain $Voltage_{(MAX)}$ = 399 V
Drain $Current_{(MAX)}$ = 782 mA

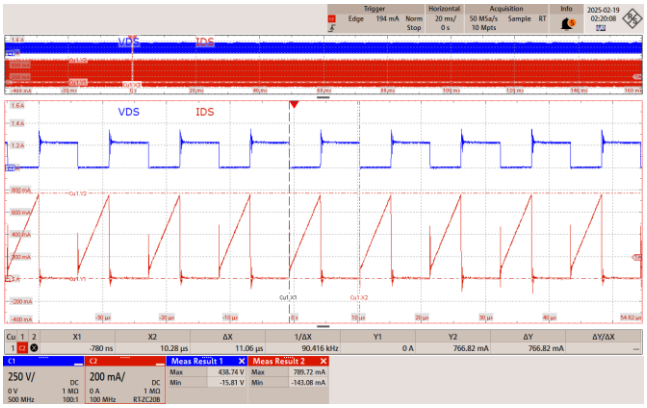


Figure 26 – 115 VAC 60 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Drain $Voltage_{(MAX)}$ = 439 V
Drain $Current_{(MAX)}$ = 790 mA

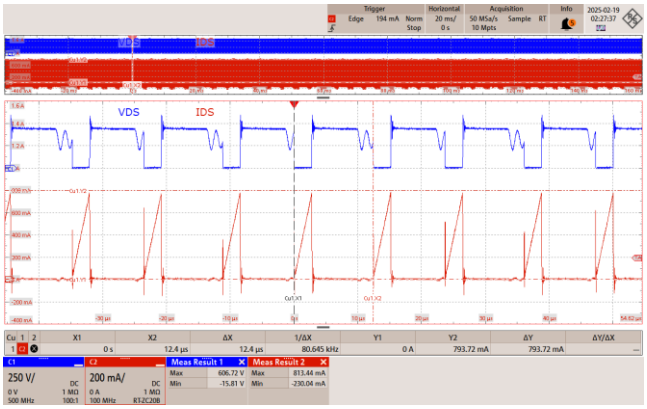


Figure 27 – 230 VAC 50 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Drain $Voltage_{(MAX)}$ = 607 V
Drain $Current_{(MAX)}$ = 813 mA

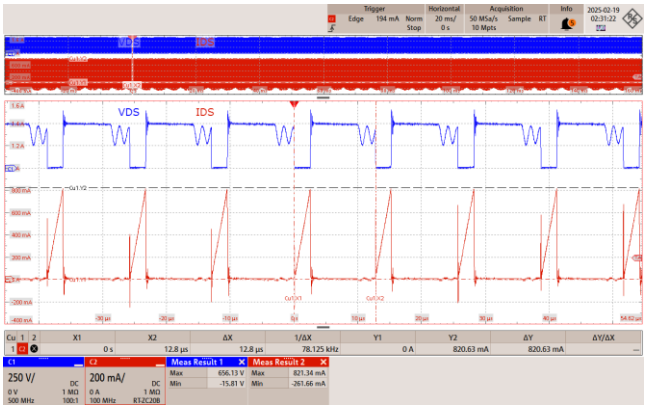


Figure 28 – 265 VAC 50 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Drain $Voltage_{(MAX)}$ = 656 V
Drain $Current_{(MAX)}$ = 821 mA

10.1.1.2 No Load

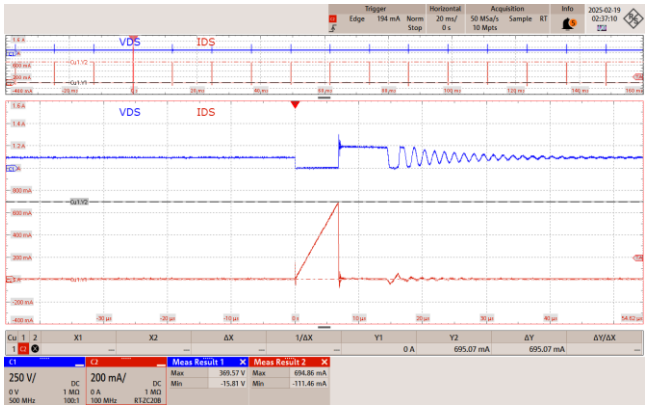


Figure 29 – 85 VAC 60 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Drain Voltage$_{(MAX)}$ = 370 V
Drain Current$_{(MAX)}$ = 695 mA

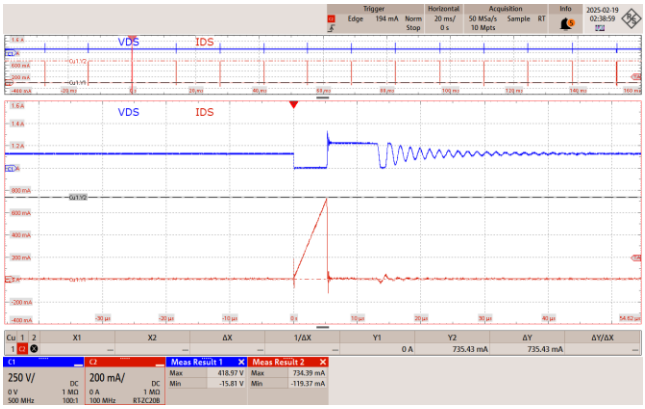


Figure 30 – 115 VAC 60 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Drain Voltage$_{(MAX)}$ = 419 V
Drain Current$_{(MAX)}$ = 734 mA

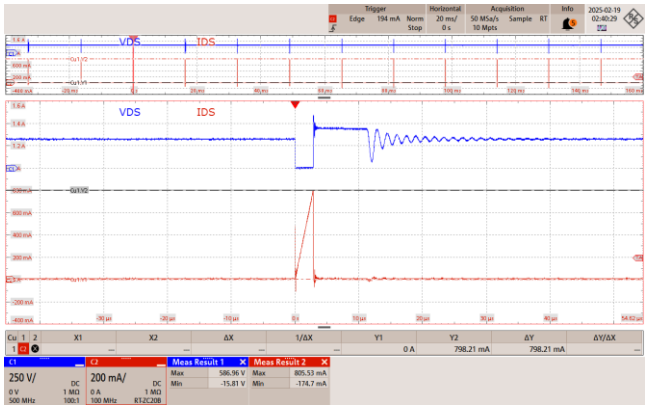


Figure 31 – 230 VAC 50 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Drain Voltage$_{(MAX)}$ = 587 V
Drain Current$_{(MAX)}$ = 806 mA

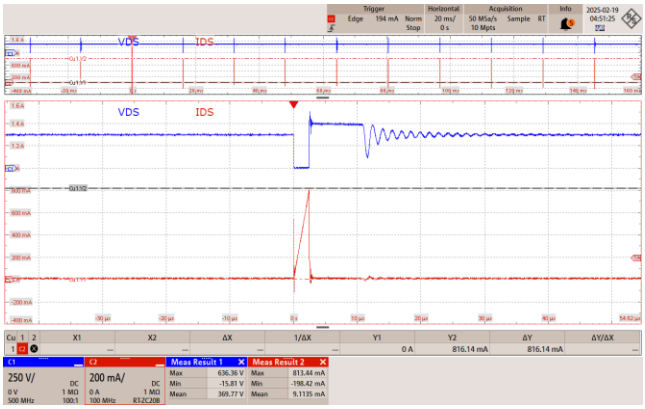


Figure 32 – 265 VAC 50 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 10 µs / div.
Drain Voltage$_{(MAX)}$ = 636 V
Drain Current$_{(MAX)}$ = 813 mA

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

10.1.2.1 Full Load

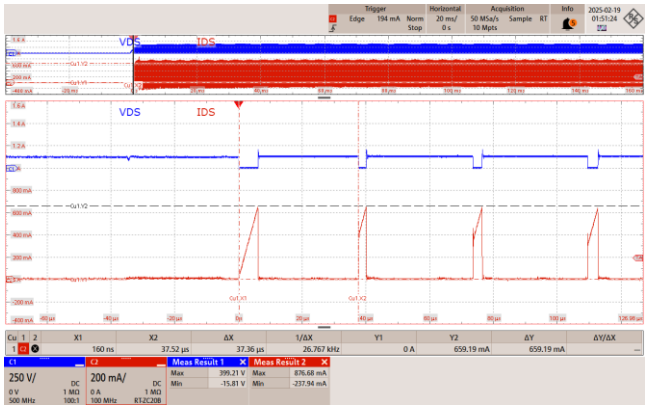


Figure 33 – 85 VAC 60 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 20 µs / div.
Drain Voltage$_{(MAX)}$ = 399 V
Drain Current$_{(MAX)}$ = 877 mA

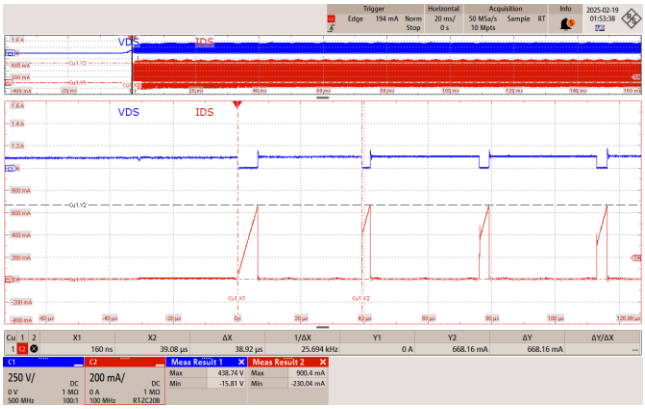


Figure 34 – 115 VAC 60 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 20 µs / div.
Drain Voltage$_{(MAX)}$ = 439 V
Drain Current$_{(MAX)}$ = 900 mA

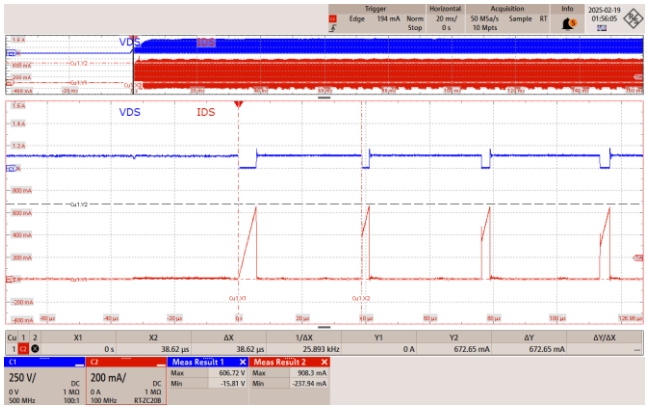


Figure 35 – 230 VAC 50 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 20 µs / div.
Drain Voltage$_{(MAX)}$ = 607 V
Drain Current$_{(MAX)}$ = 908 mA

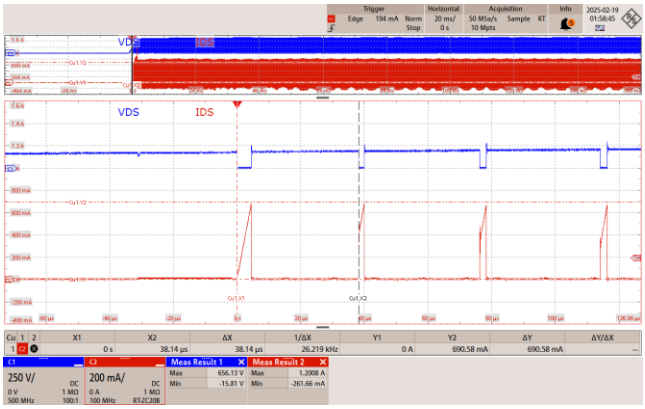


Figure 36 – 265 VAC 50 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 20 µs / div.
Drain Voltage$_{(MAX)}$ = 656 V
Drain Current$_{(MAX)}$ = 1.2 A

10.1.2.2 No Load

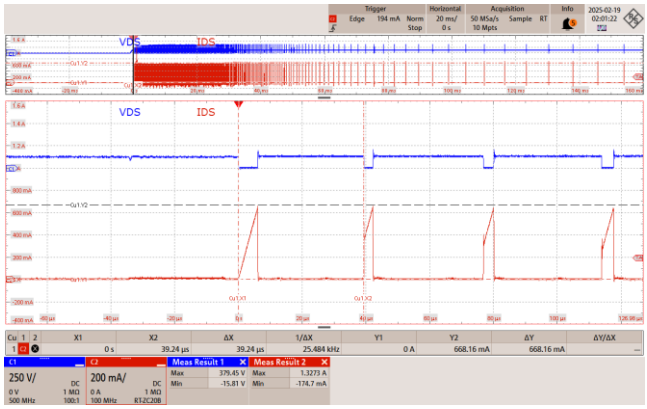


Figure 37 – 85 VAC 60 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 20 µs / div.
Drain Voltage$_{(MAX)}$ = 379 V
Drain Current$_{(MAX)}$ = 1.33 A

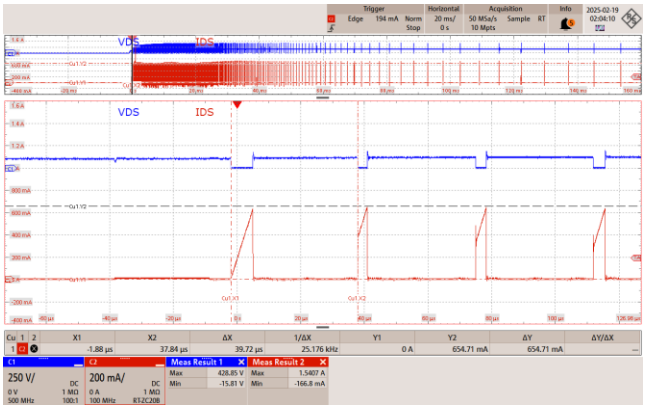


Figure 38 – 115 VAC 60 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 20 µs / div.
Drain Voltage$_{(MAX)}$ = 429 V
Drain Current$_{(MAX)}$ = 1.54 A

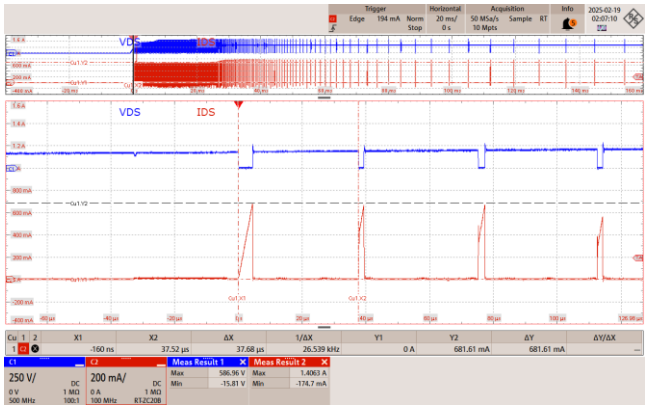


Figure 39 – 230 VAC 50 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 20 µs / div.
Drain Voltage$_{(MAX)}$ = 587 V
Drain Current$_{(MAX)}$ = 1.41 A

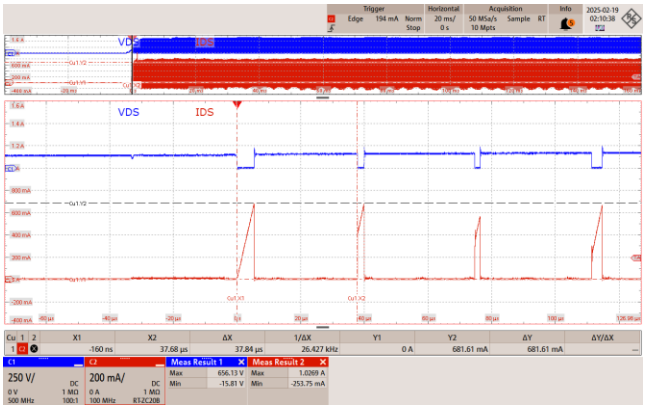


Figure 40 – 265 VAC 50 Hz.
CH1: V_{DS}, 250 V / div., 20 ms / div.
CH2: I_{DS}, 200 mA / div., 20 ms / div.
Zoom: 20 µs / div.
Drain Voltage$_{(MAX)}$ = 656 V
Drain Current$_{(MAX)}$ = 1.03 A

10.1.3 12V Freewheeling Diode Voltage at Normal Operation

10.1.3.1 Full Load

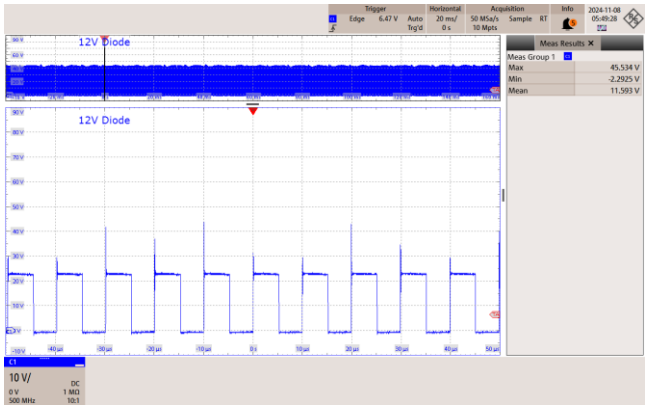


Figure 41 – 85 VAC 60 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 45.5 V

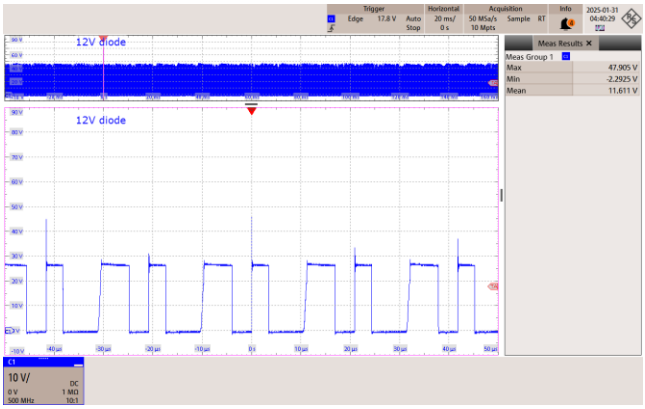


Figure 42 – 115 VAC 60 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 47.9 V

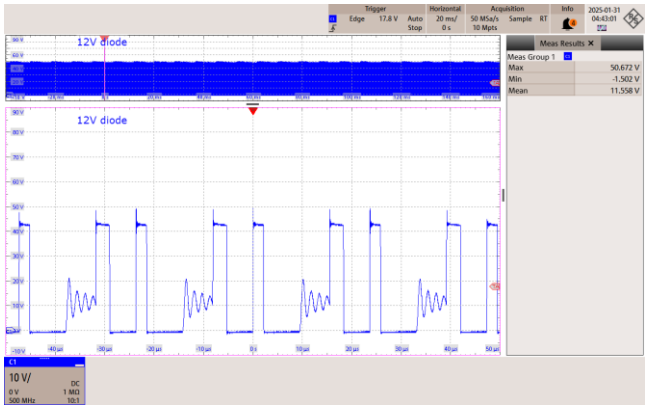


Figure 43 – 230 VAC 50 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 50.7 V

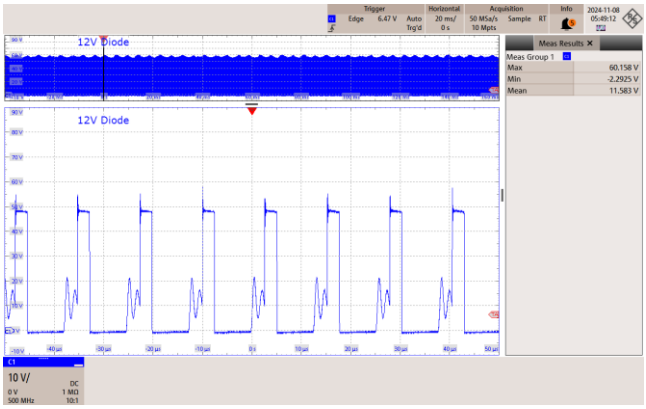


Figure 44 – 265 VAC 50 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 60.2 V

10.1.3.2 No Load

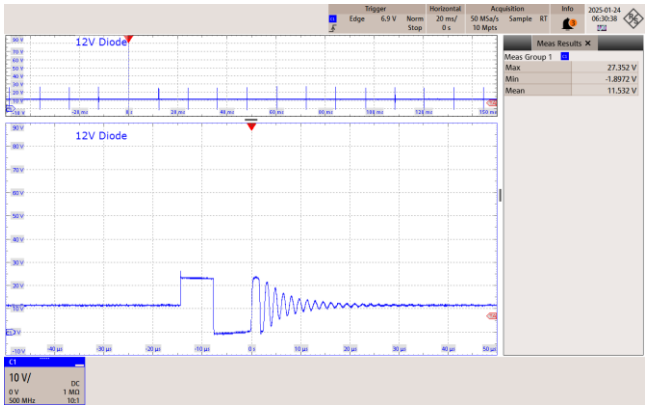


Figure 45 – 85 VAC 60 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 27.4 V

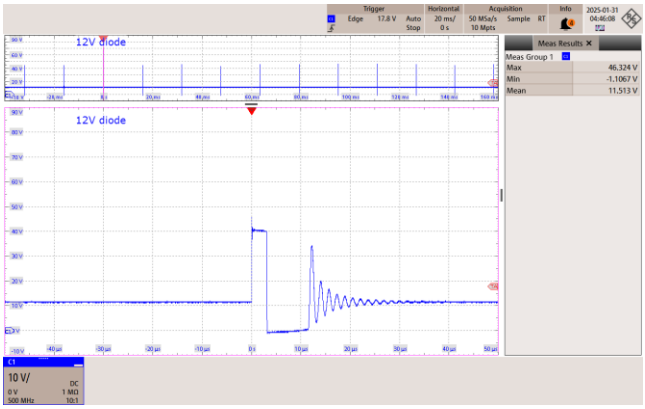


Figure 46 – 115 VAC 60 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 46.3 V

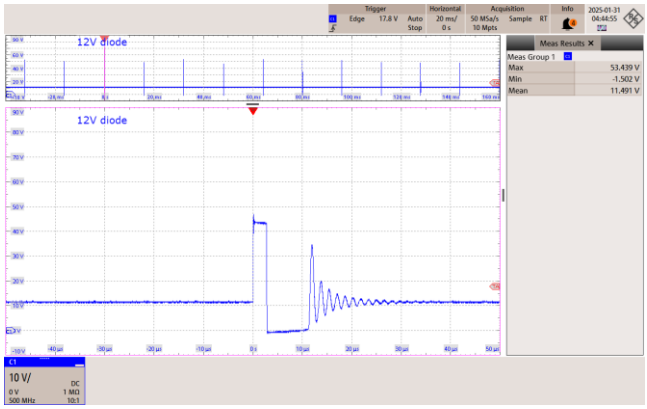


Figure 47 – 230 VAC 50 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 53.4 V

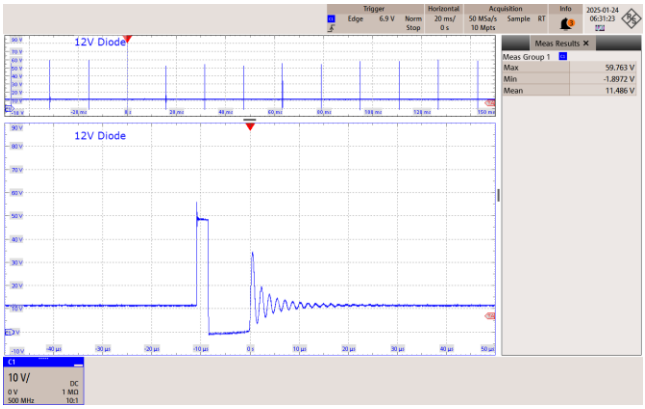


Figure 48 – 265 VAC 50 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 59.8 V

10.1.4 12V Freewheeling Diode Voltage at Start-Up

10.1.4.1 Full Load

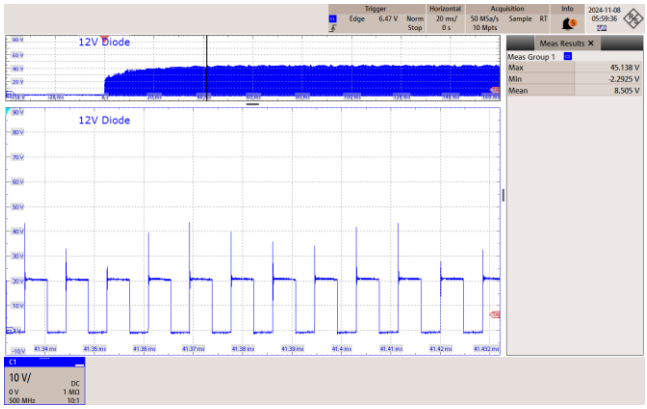


Figure 49 – 85 VAC 60 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 45.1 V

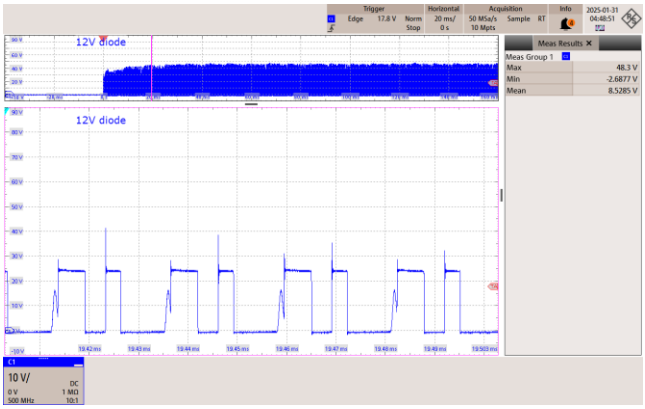


Figure 50 – 115 VAC 60 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 48.3 V

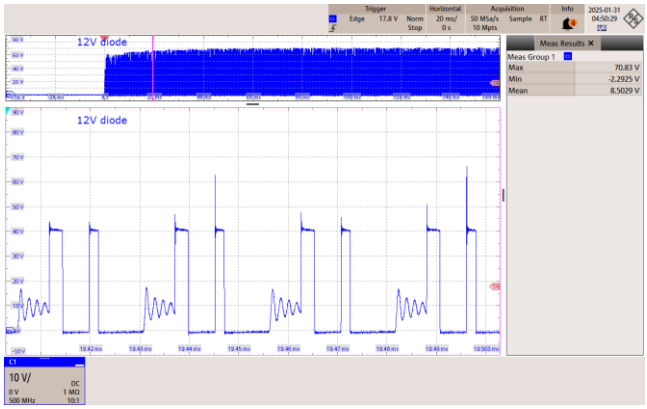


Figure 51 – 230 VAC 50 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 70.8 V

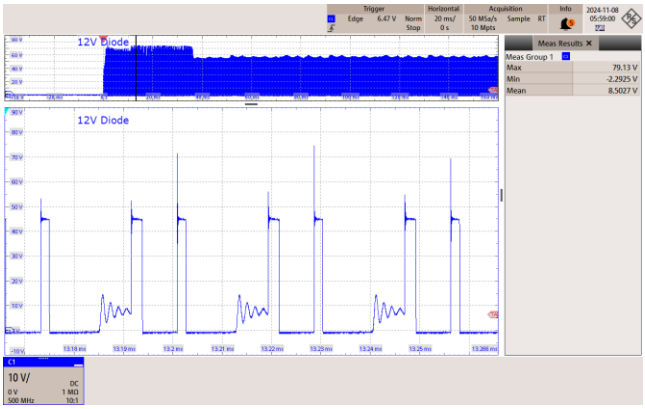


Figure 52 – 265 VAC 50 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 79.1 V

10.1.4.2 No Load

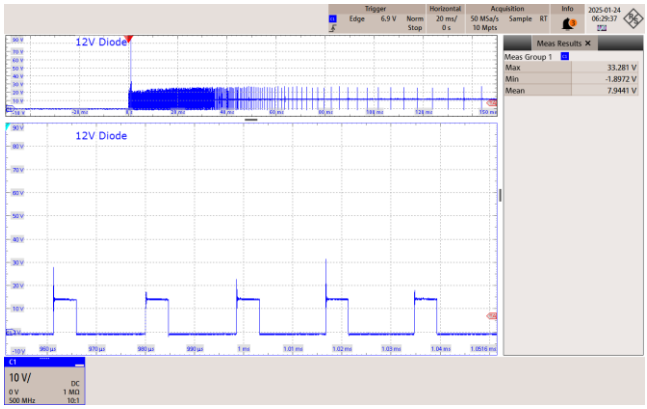


Figure 53 – 85 VAC 60 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 33.3 V

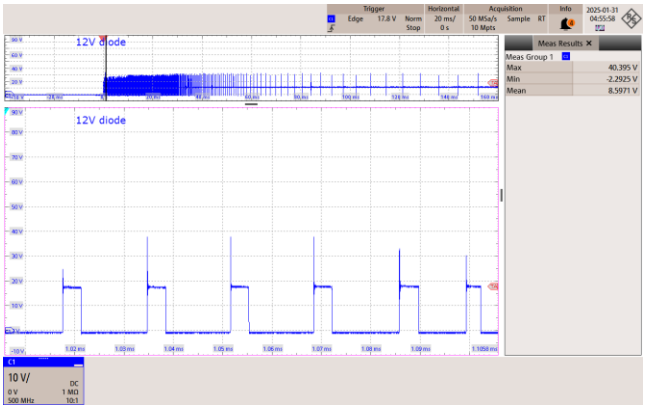


Figure 54 – 115 VAC 60 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 40.4 V

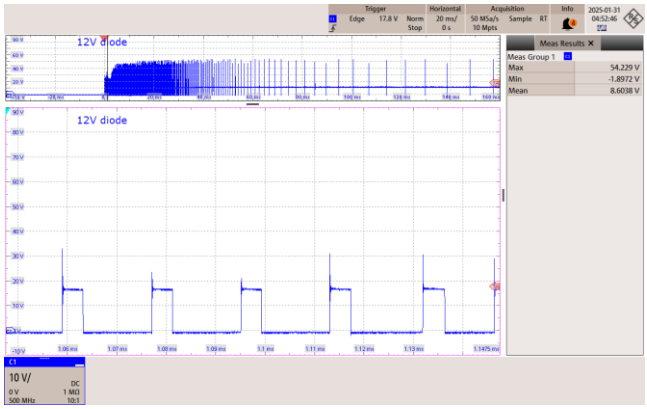


Figure 55 – 230 VAC 50 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 54.2 V

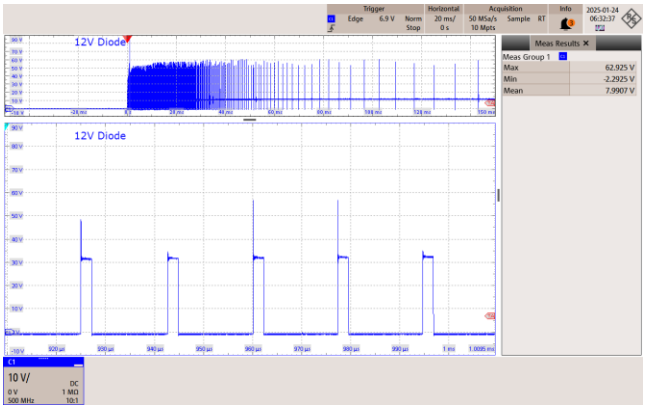


Figure 56 – 265 VAC 50 Hz.
CH1: 12 V Diode Voltage, 10 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 62.9 V

10.1.5 5V Freewheeling Diode Voltage at Normal Operation

10.1.5.1 Full Load

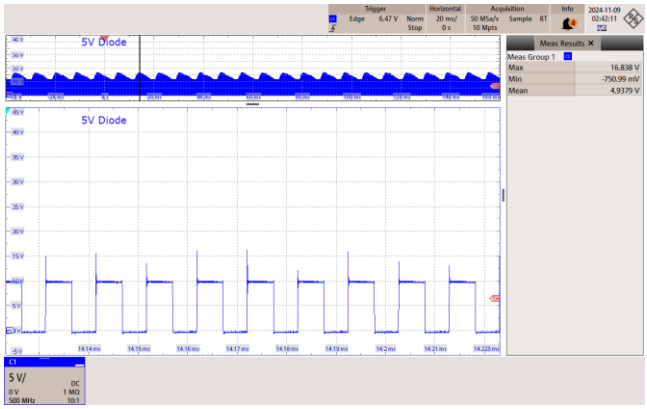


Figure 57 – 85 VAC 60 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 16.8 V

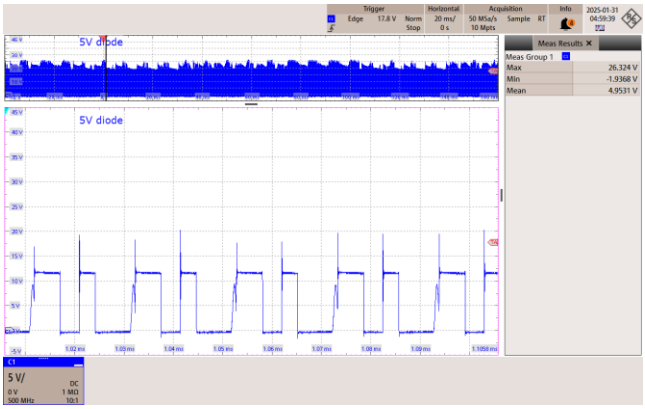


Figure 58 – 115 VAC 60 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 26.3 V

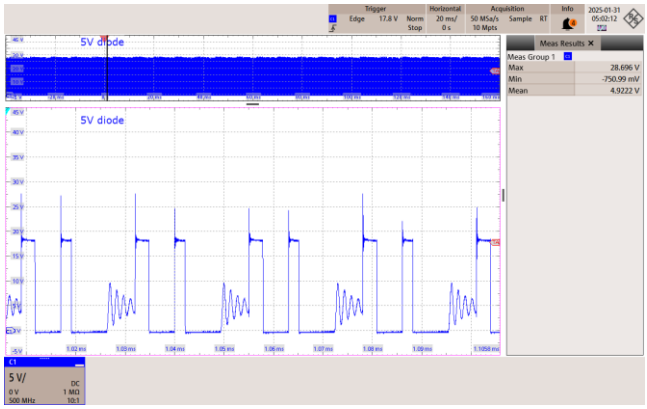


Figure 59 – 230 VAC 50 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 28.7 V

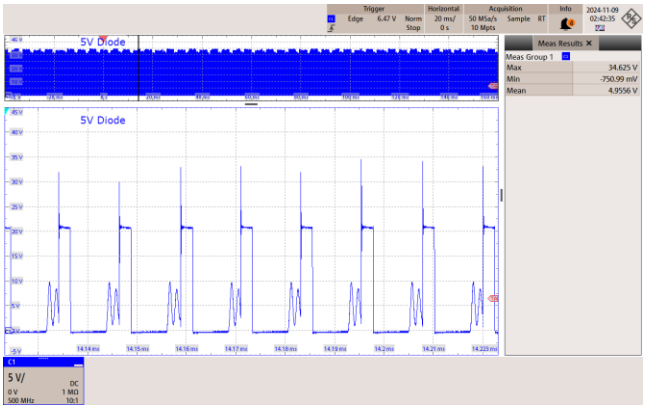


Figure 60 – 265 VAC 50 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 34.6 V

10.1.5.2 No Load

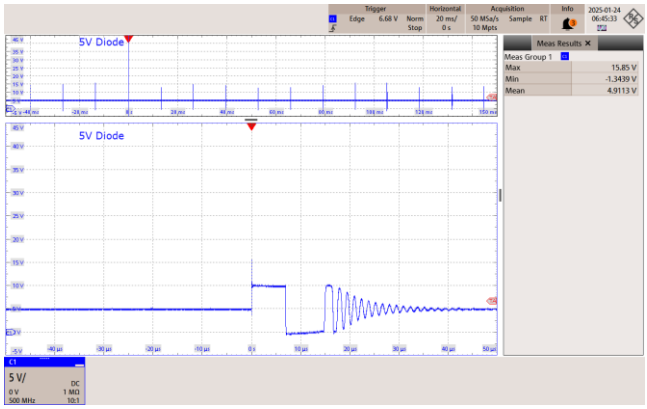


Figure 61 – 85 VAC 60 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 15.9 V

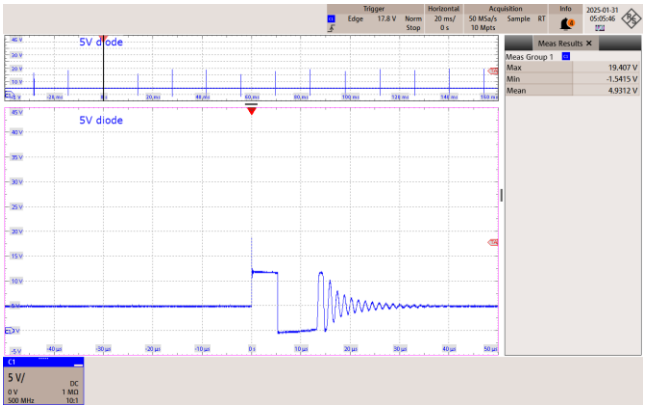


Figure 62 – 115 VAC 60 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 19.4 V

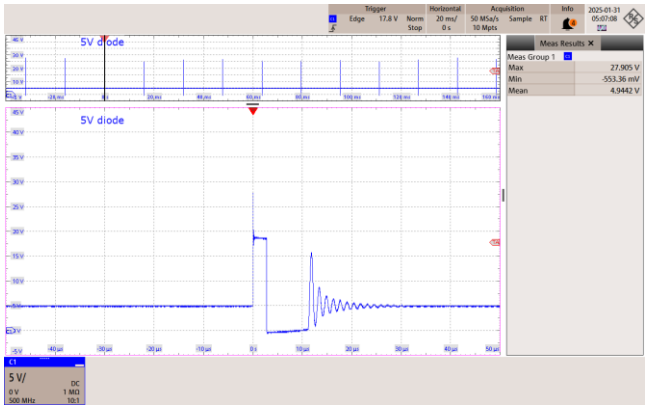


Figure 63 – 230 VAC 50 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 27.9 V

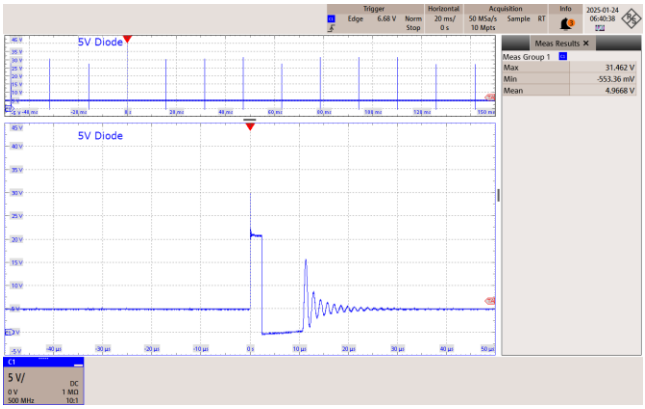


Figure 64 – 265 VAC 50 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 31.5 V

10.1.6 5V Freewheeling Diode Voltage at Start-Up

10.1.6.1 Full Load

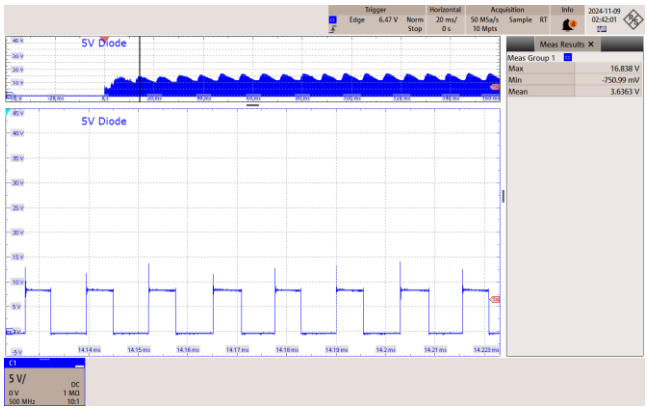


Figure 65 – 85 VAC 60 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 16.8 V

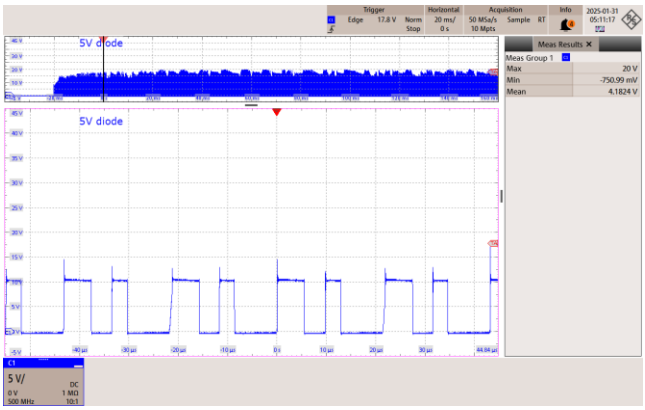


Figure 66 – 115 VAC 60 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 20 V

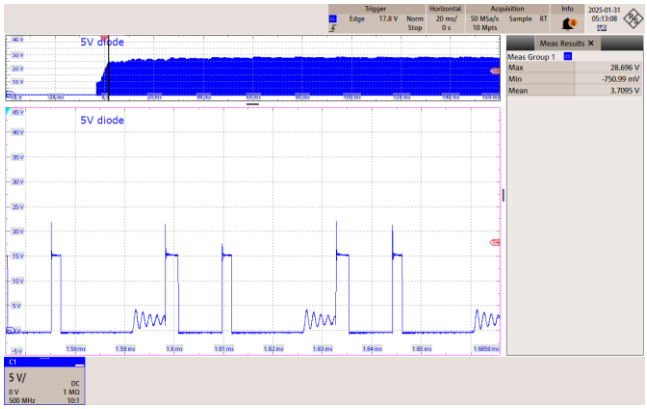


Figure 67 – 230 VAC 50 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 28.6 V

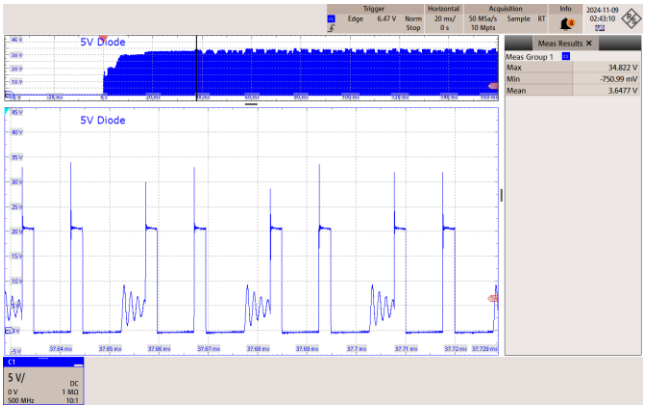


Figure 68 – 265 VAC 50 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 34.8 V

10.1.6.2 No Load

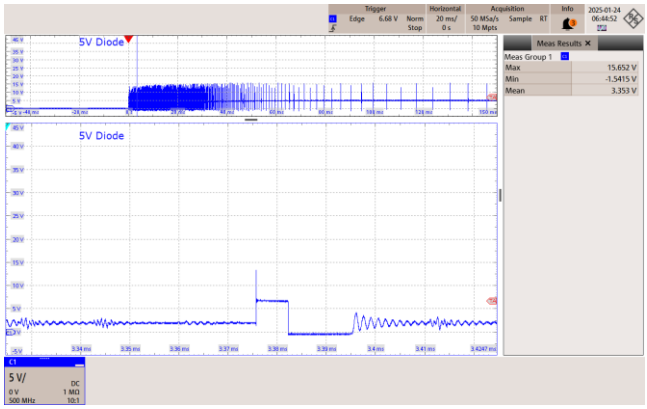


Figure 69 – 85 VAC 60 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 15.7 V

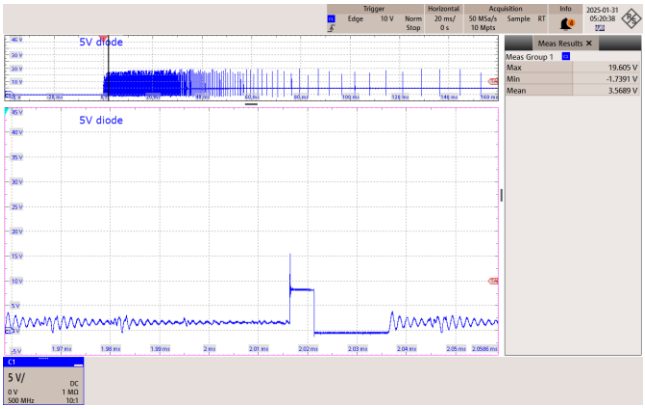


Figure 70 – 115 VAC 60 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 19.6 V

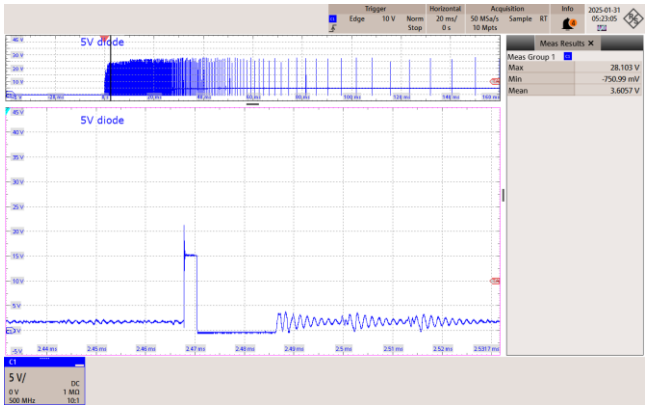


Figure 71 – 230 VAC 50 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 28.1 V

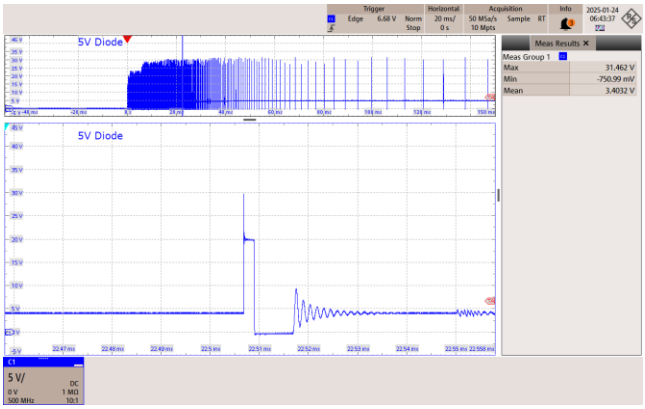


Figure 72 – 265 VAC 50 Hz.
CH1: 5 V Diode Voltage, 5 V / div., 20 ms / div.
Zoom : 10 µs / div.
Freewheel Diode Voltage$_{(MAX)}$ = 31.5 V

10.1 Output Start-up

10.1.1 Full Load CC Mode

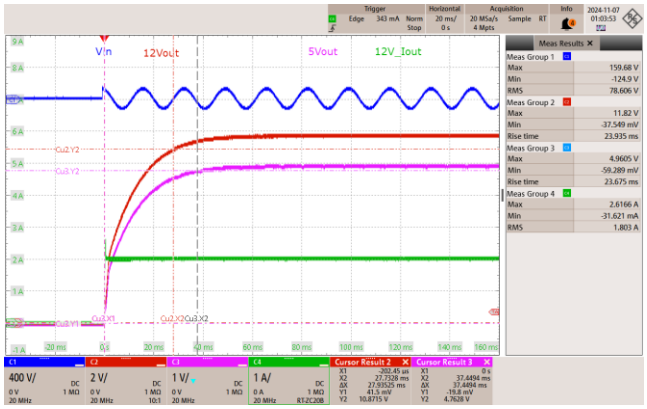


Figure 73 – 85 VAC 60 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 23.9 ms.
12 V_{OUT}_V_{MAX} = 11.8 V
5 V_{OUT}_Rise Time = 23.7 ms.
5 V_{OUT}_V_{MAX} = 4.96 V

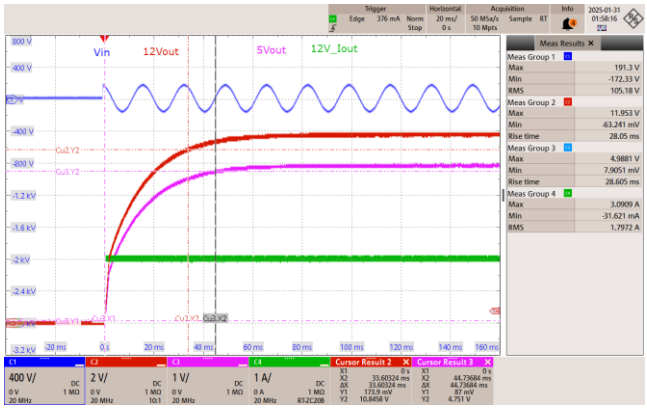


Figure 74 – 115 VAC 60 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 28.1 ms.
12 V_{OUT} _V_{MAX} = 12 V
5 V_{OUT}_Rise Time = 28.05 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

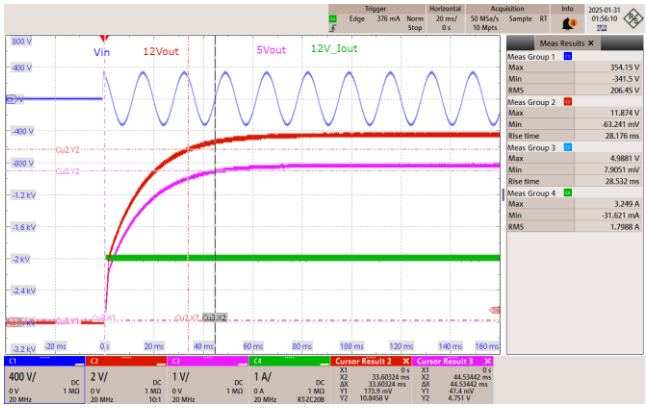


Figure 75 – 230 VAC 50 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 28.2 ms.
12 V_{OUT}_V_{MAX} = 11.9 V
5 V_{OUT}_Rise Time = 28.5 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

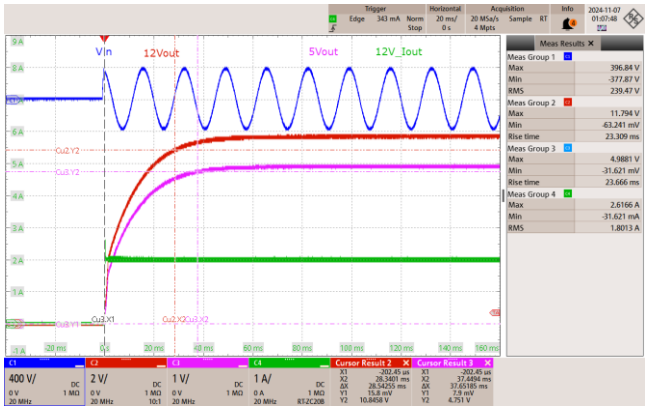


Figure 76 – 265 VAC 50 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT} _Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 23.3 ms.
12 V_{OUT}_V_{MAX} = 11.8 V
5 V_{OUT}_Rise Time = 23.7 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

10.1.2 Full Load CR Mode

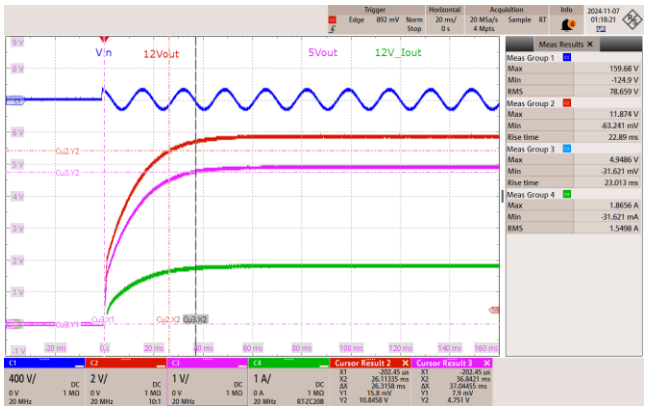


Figure 77 – 85 VAC 60 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 22.9 ms.
12 V_{OUT}_V_{MAX} = 11.9 V
5 V_{OUT}_Rise Time = 23 ms.
5 V_{OUT}_V_{MAX} = 4.95 V

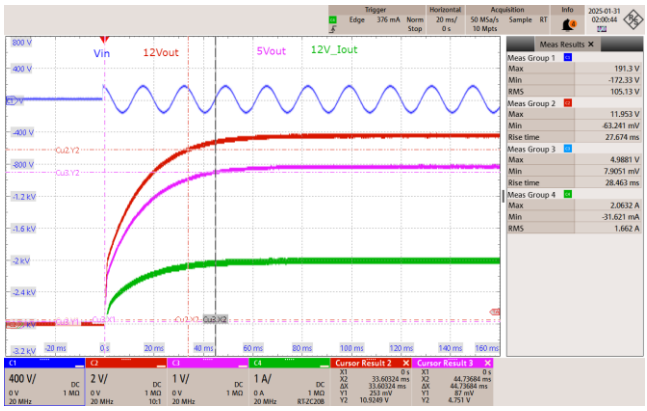


Figure 78 – 115 VAC 60 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 27.7 ms.
12 V_{OUT}_V_{MAX} = 12 V
5 V_{OUT}_Rise Time = 28.5 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

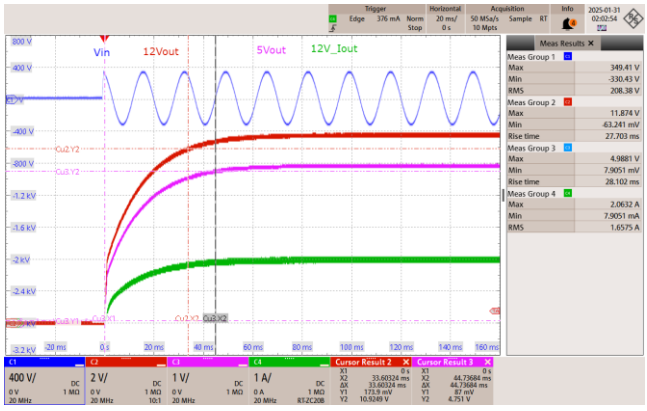


Figure 79 – 230 VAC 50 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 27.7 ms.
12 V_{OUT}_V_{MAX} = 11.9 V
5 V_{OUT}_Rise Time = 28.1 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

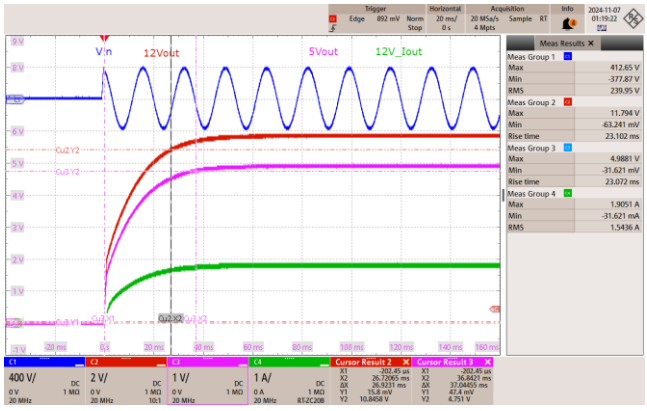


Figure 80 – 265 VAC 50 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 23.02 ms.
12 V_{OUT}_V_{MAX} = 11.8 V
5 V_{OUT}_Rise Time = 23.1 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

10.1.3 No Load

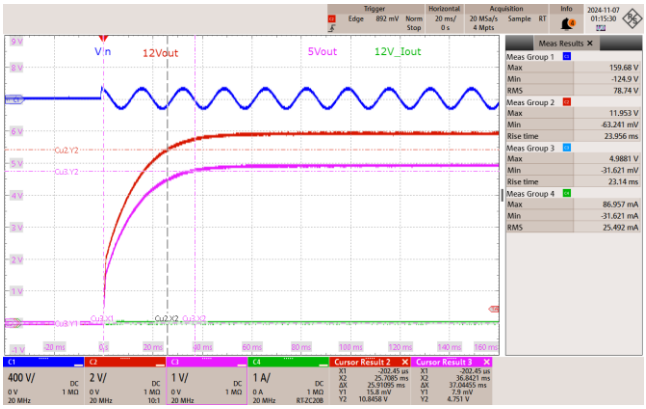


Figure 81 – 85 VAC 60 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 24 ms.
12 V_{OUT}_V_{MAX} = 12 V
5 V_{OUT}_Rise Time = 23.1 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

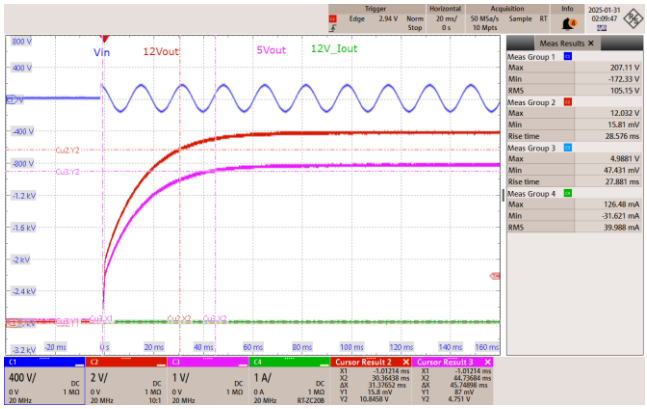


Figure 82 – 115 VAC 60 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 28.6 ms.
12 V_{OUT}_V_{MAX} = 12 V
5 V_{OUT}_Rise Time = 27.9 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

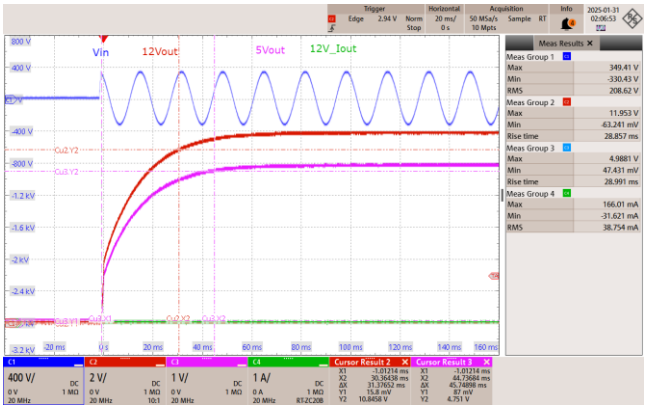


Figure 83 – 230 VAC 50 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 28.9 ms.
12 V_{OUT}_V_{MAX} = 12 V
5 V_{OUT}_Rise Time = 29 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

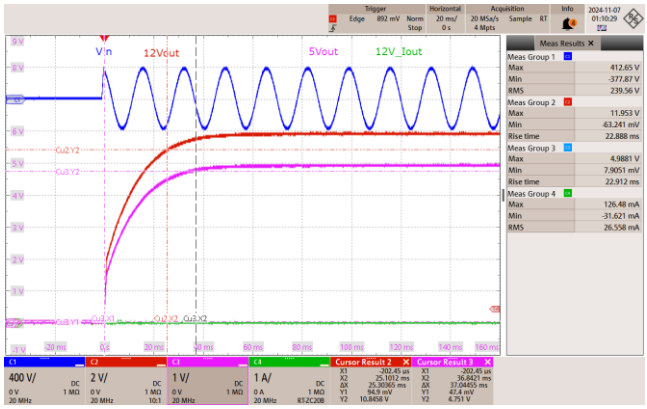


Figure 84 – 265 VAC 50 Hz.
CH1: Input Voltage, 400 V / div., 20 ms / div.
CH2: 12 V_{OUT}_Voltage, 2 V / div., 20 ms / div.
CH3: 5 V_{OUT}_Voltage, 1 V / div., 20 ms / div.
CH4: 12 V_Output Current, 1 A / div., 20 ms / div.
12 V_{OUT}_Rise Time = 22.9 ms.
12 V_{OUT}_V_{MAX} = 12 V
5 V_{OUT}_Rise Time = 22.9 ms.
5 V_{OUT}_V_{MAX} = 4.99 V

10.2 Load Transient Response

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

10.2.1 Transient 5 V_{OUT} 10% - 100% Load and 12 V_{OUT} fixed at 10% Load

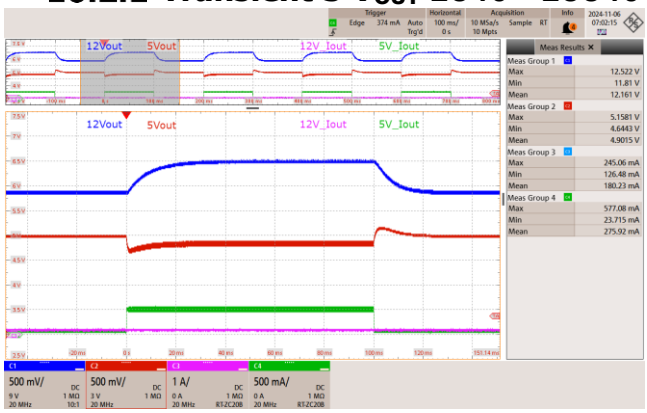


Figure 85 – 85 VAC 60 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 12.52 V
V_{MIN}: 11.8 V
5 V_{OUT}: V_{MAX}: 5.16 V
V_{MIN}: 4.64 V

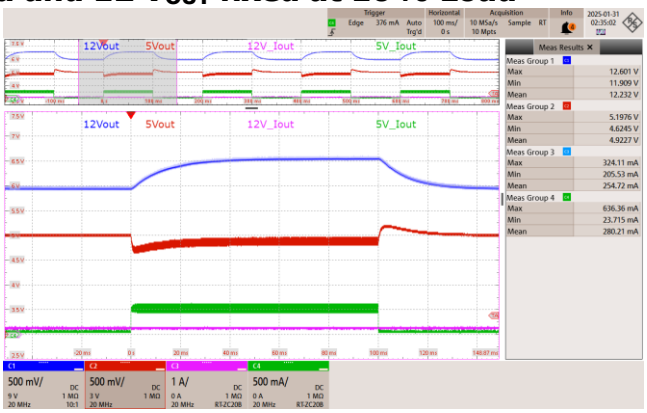


Figure 86 – 115 VAC 60 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 12.6 V
V_{MIN}: 11.9 V
5 V_{OUT}: V_{MAX}: 5.2 V
V_{MIN}: 4.62 V

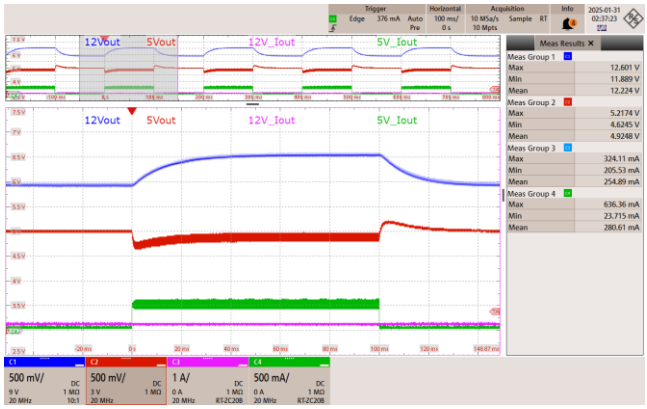


Figure 87 – 230 VAC 50 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12V_{OUT}: V_{MAX}: 12.6 V
V_{MIN}: 11.9 V
5 V_{OUT}: V_{MAX}: 5.22 V
V_{MIN}: 4.62 V

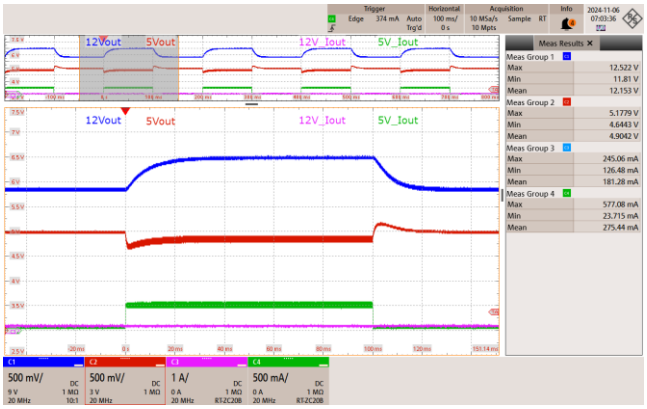


Figure 88 – 265 VAC 50 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12V_{OUT}: V_{MAX}: 12.6 V
V_{MIN}: 11.8 V
5 V_{OUT}: V_{MAX}: 5.18 V
V_{MIN}: 4.64 V

10.2.2 Transient 5 V_{OUT} 10% - 100% Load and 12 V_{OUT} fixed at 100% Load

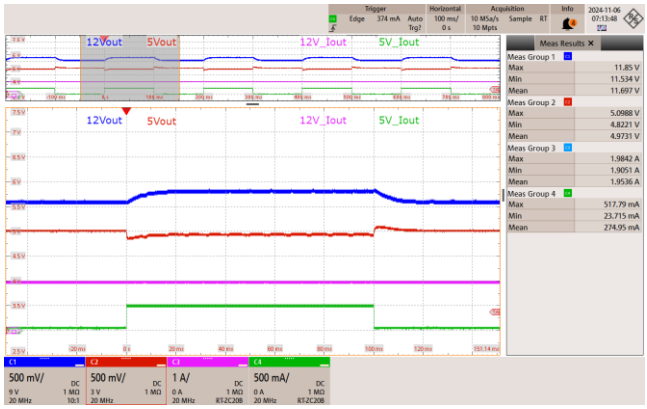


Figure 89 – 85 VAC 60 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 11.9 V
V_{MIN}: 11.5 V
5 V_{OUT}: V_{MAX}: 5.1 V
V_{MIN}: 4.82 V

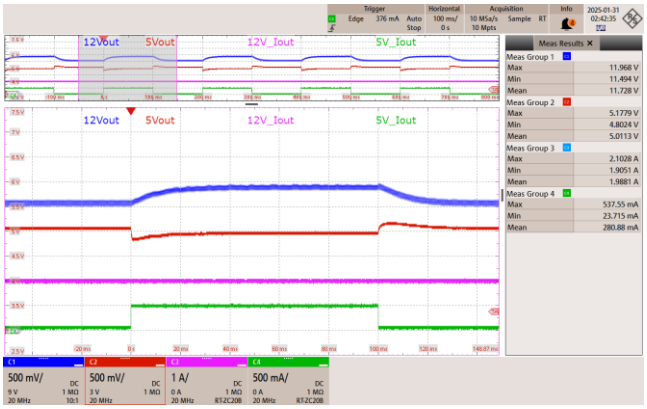


Figure 90 – 115 VAC 60 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20ms /div.
12 V_{OUT}: V_{MAX}: 12 V
V_{MIN}: 11.5 V
5 V_{OUT}: V_{MAX}: 5.2 V
V_{MIN}: 4.8 V

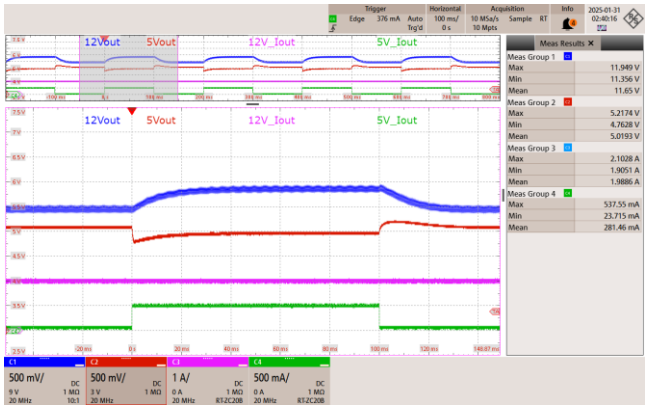


Figure 91 – 230 VAC 50 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 11.9 V
V_{MIN}: 11.4 V
5 V_{OUT}: V_{MAX}: 5.22 V
V_{MIN}: 4.76 V

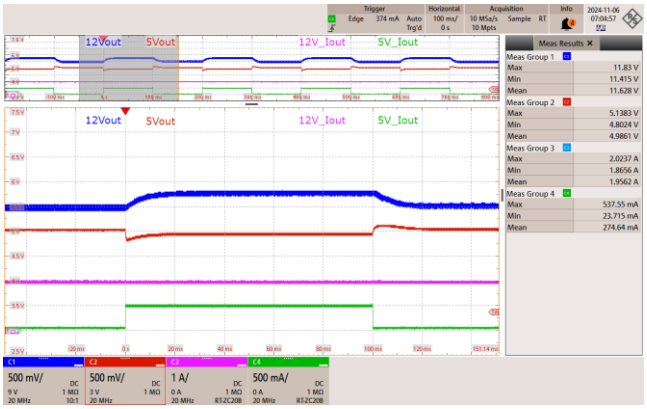


Figure 92 – 265 VAC 50 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 11.8 V
V_{MIN}: 11.4 V
5 V_{OUT}: V_{MAX}: 5.14 V
V_{MIN}: 4.8 V

10.2.3 Transient 12 V_{OUT} 10% - 100% Load and 5 V_{OUT} fixed at 10% Load

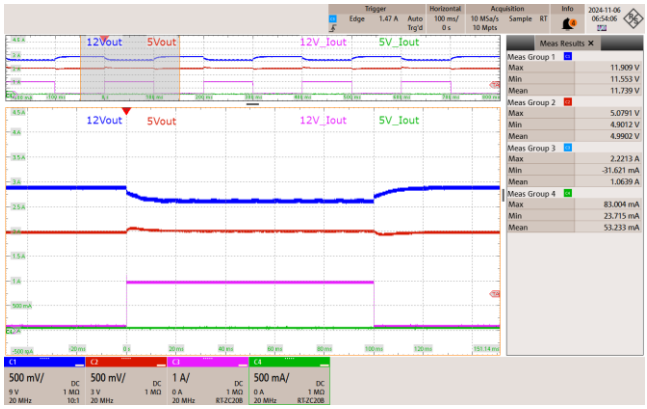


Figure 93 – 85 VAC 60 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 11.9 V
V_{MIN}: 11.5 V
5 V_{OUT}: V_{MAX}: 5.08 V
V_{MIN}: 4.9 V

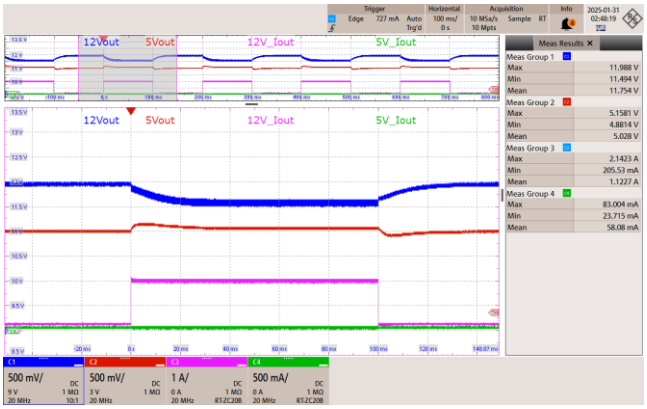


Figure 94 – 115 VAC 60 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 12 V
V_{MIN}: 11.5 V
5 V_{OUT}: V_{MAX}: 5.16 V
V_{MIN}: 4.88 V

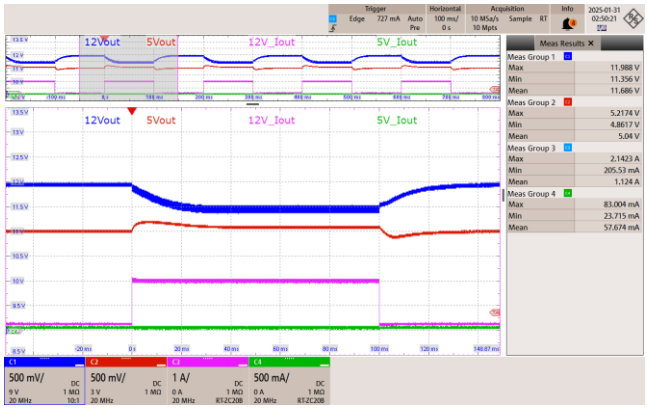


Figure 95 – 230 VAC 50 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT} _Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 12 V
V_{MIN}: 11.4 V
5 V_{OUT}: V_{MAX}: 5.22 V
V_{MIN}: 4.86 V

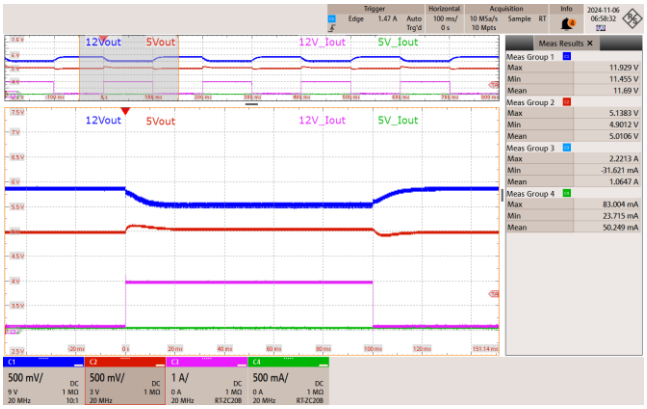


Figure 96 – 265 VAC 50 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 11.9 V
V_{MIN}: 11.5 V
5 V_{OUT}: V_{MAX}: 5.14 V
V_{MIN}: 4.9 V

10.2.4 Transient 12 V_{OUT} 10% - 100% Load and V_{OUT} fixed at 100% Load

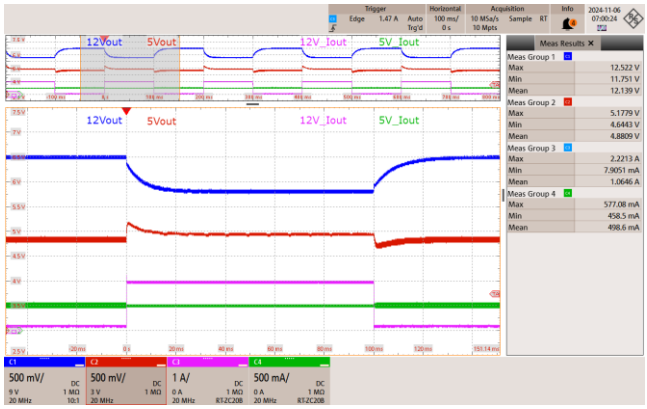


Figure 97 – 85 VAC 60 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: : 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 12.5 V
V_{MIN}: 11.8 V
5 V_{OUT}: V_{MAX}: 5.18 V
V_{MIN}: 4.64 V

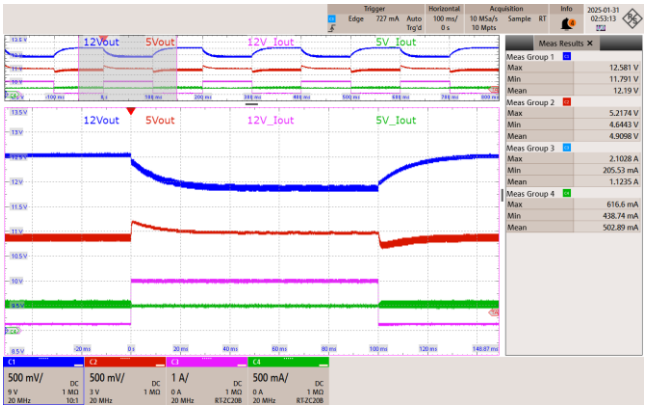


Figure 98 – 115 VAC 60 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: : 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 12.6 V
V_{MIN}: 11.8 V
5 V_{OUT}: V_{MAX}: 5.22 V
V_{MIN}: 4.64 V

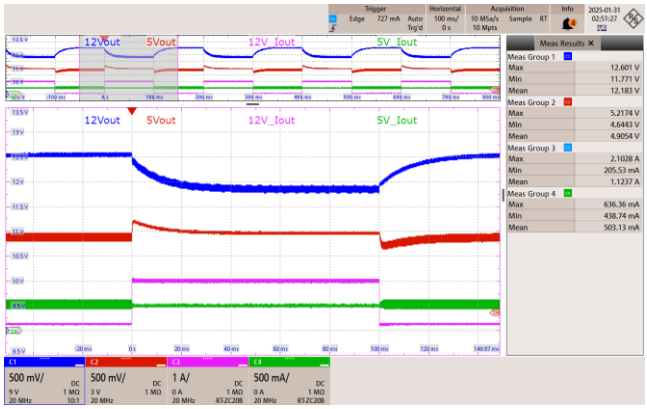


Figure 99 – 230 VAC 50 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 12.6 V
V_{MIN}: 11.8 V
5 V_{OUT}: V_{MAX}: 5.22 V
V_{MIN}: 4.64 V

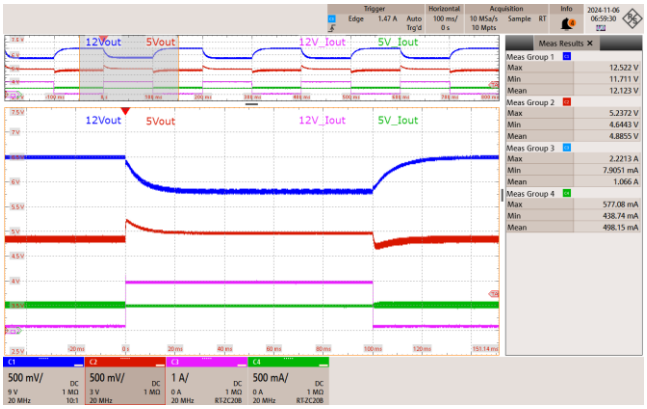


Figure 100 – 265 VAC 50 Hz.
CH1: 12 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH2: 5 V_{OUT}_Voltage, 500 mV / div., 100 ms / div.
CH3: 12 I_{OUT}_Current, 1 A / div., 100 ms / div.
CH4: 5 I_{OUT}_Current, 500 mA / div., 100 ms / div.
Zoom: 20 ms /div.
12 V_{OUT}: V_{MAX}: 12.6 V
V_{MIN}: 11.7 V
5 V_{OUT}: V_{MAX}: 5.24 V
V_{MIN}: 4.64 V

10.3 Output Voltage Ripple

10.3.1 Ripple Measurement Technique

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

The 4987BA probe adapter is 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).

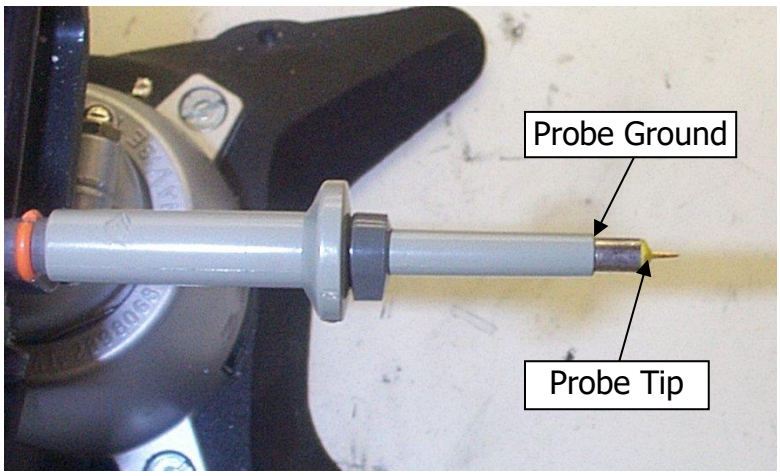


Figure 101 – Oscilloscope Probe Prepared for Ripple Measurement. (End Cap and Ground Lead Removed)

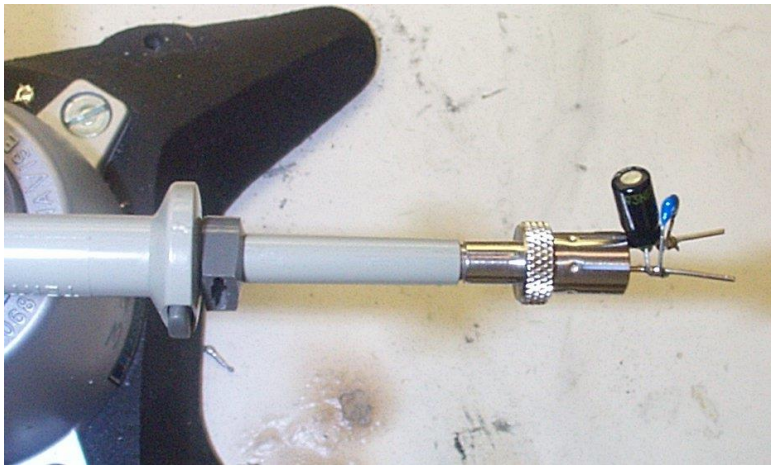


Figure 102 – Oscilloscope Probe with Probe Master (**www.probemaster.com**) 4987A BNC Adapter. (Modified with wires for ripple measurement, and two parallel decoupling capacitors added)

10.3.2 Measurement Results

Note: All ripple measurements were taken at PCB end.

10.3.2.1 100% Load Condition

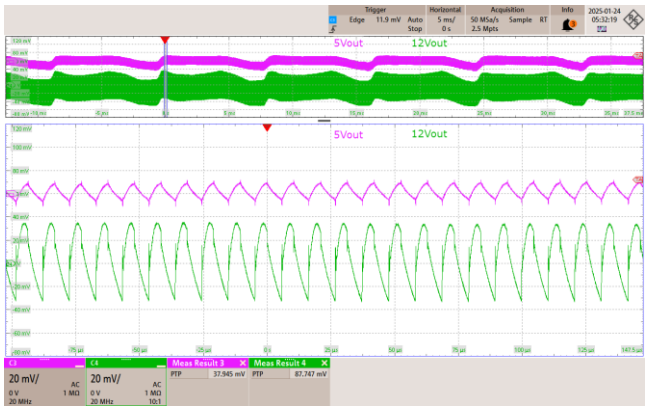


Figure 103 – 85 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 37.9 mV
12 V_Output Ripple = 87.8 mV

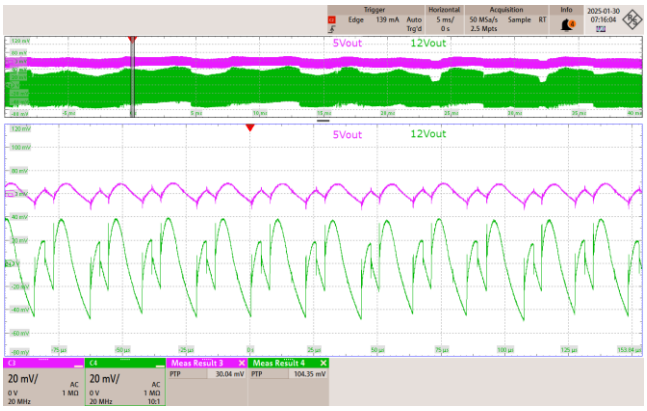


Figure 104 – 115 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 30 mV
12 V_Output Ripple = 105 mV

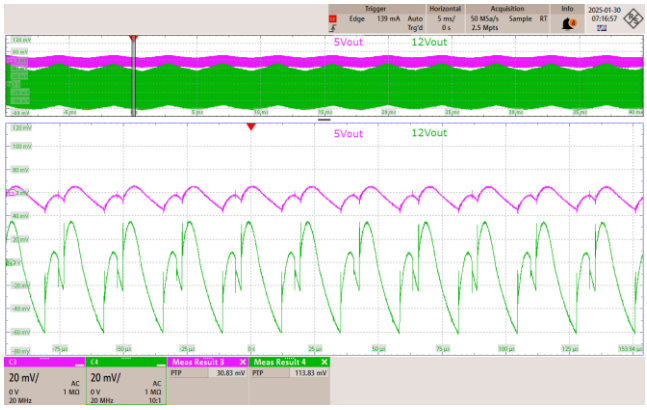


Figure 105 – 230 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 30.8 mV
12 V_Output Ripple = 114 mV

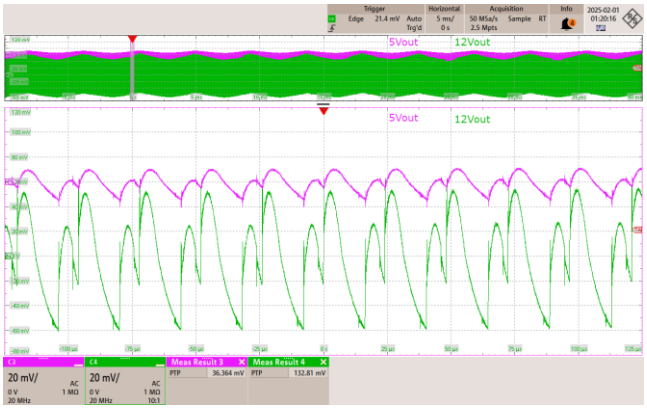


Figure 106 – 265 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 36.4 mV
12 V_Output Ripple = 133 mV

10.3.2.2 75% Load Condition

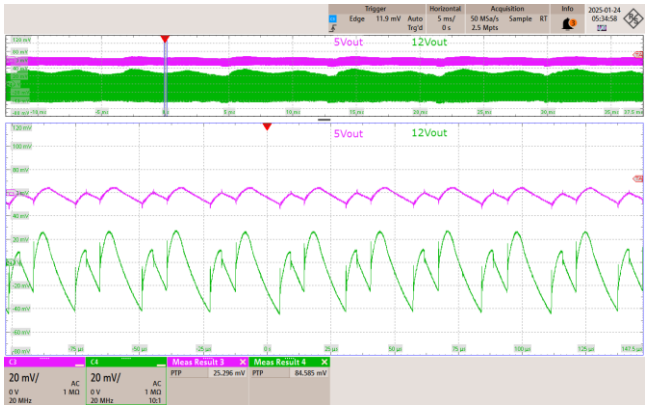


Figure 107 – 85 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 25.3 mV
12 V_Output Ripple = 84.6 mV

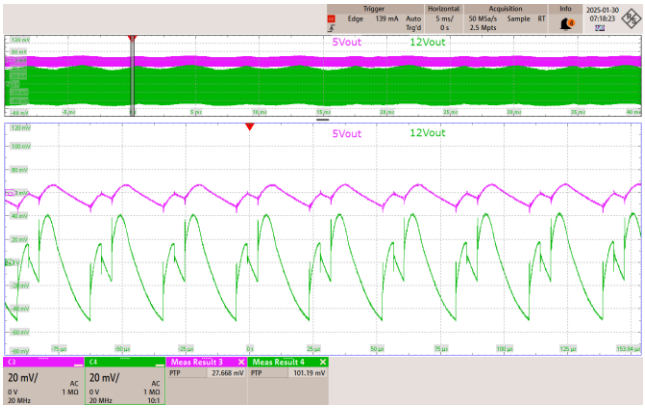


Figure 108 – 115 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 27.7 mV
12 V_Output Ripple = 101 mV

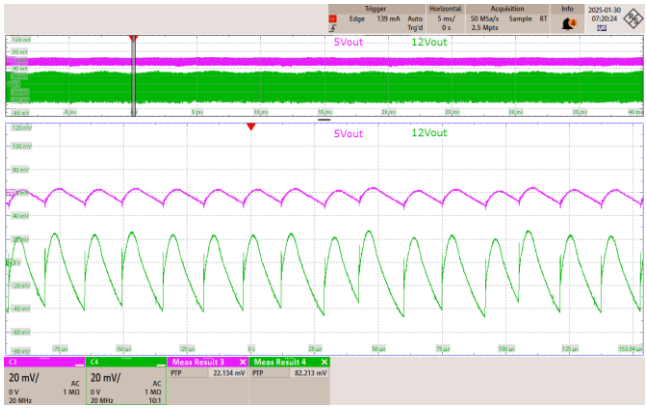


Figure 109 – 230 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 22.1 mV
12 V_Output Ripple = 82.2 mV

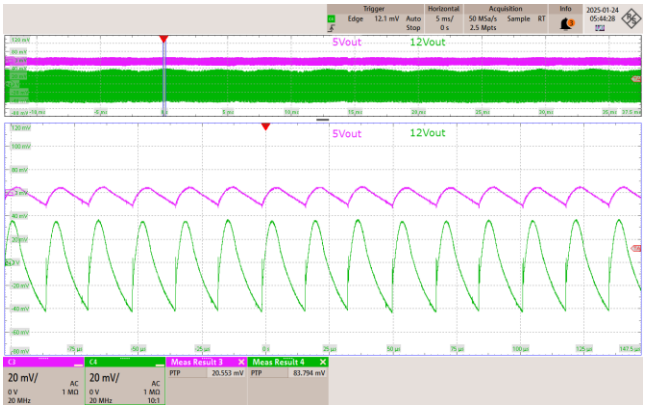


Figure 110 – 265 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 20.3 mV
12 V_Output Ripple = 83.8 mV

10.3.2.3 50% Load Condition

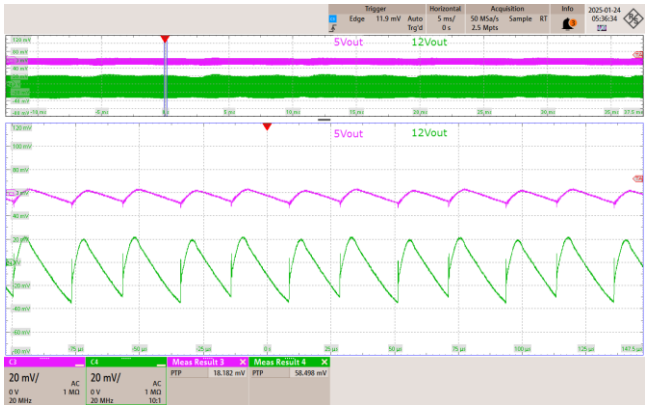


Figure 111 – 85 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 18. 2 mV
12 V_Output Ripple = 58.5 mV

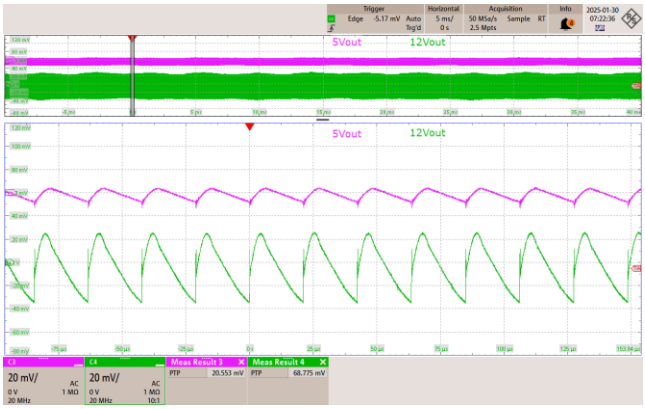


Figure 112 – 115 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 20.6 mV
12 V_Output Ripple = 68.8 mV

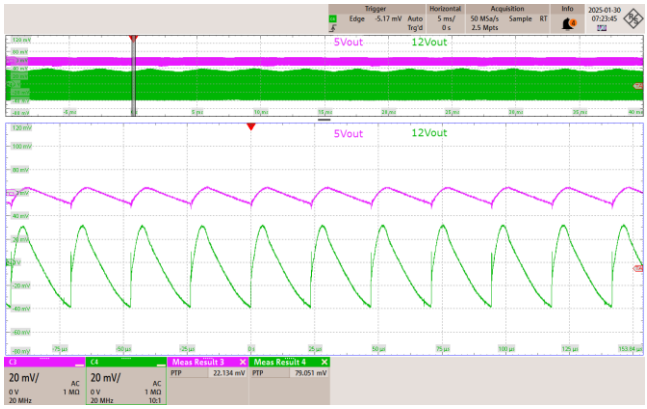


Figure 113 – 230 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 22.1 mV
12 V_Output Ripple = 79.1 mV

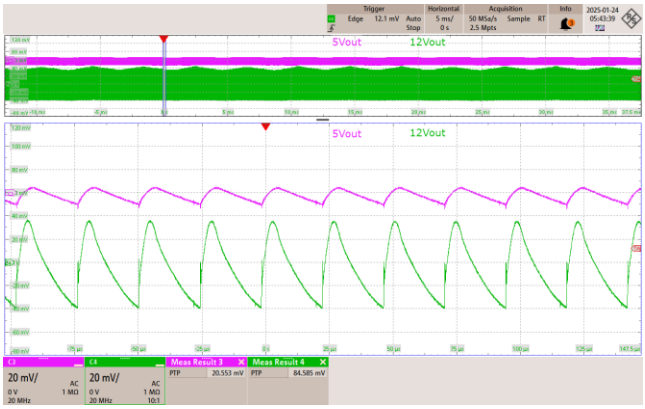


Figure 114 – 265 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 20.5 mV
12 V_Output Ripple = 84.6 mV

10.3.2.4 25% Load Condition

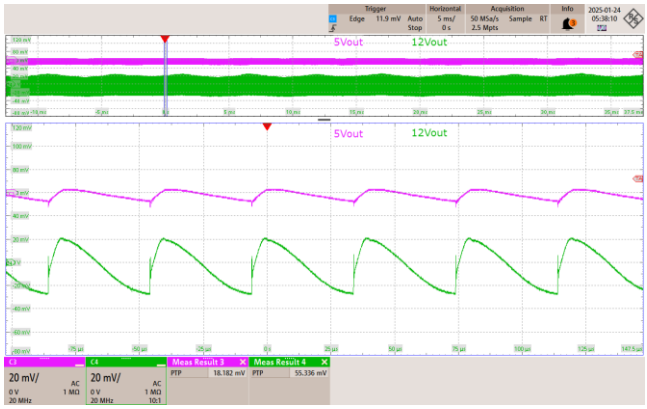


Figure 115 – 85 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 18.2 mV
12 V_Output Ripple = 55.3 mV

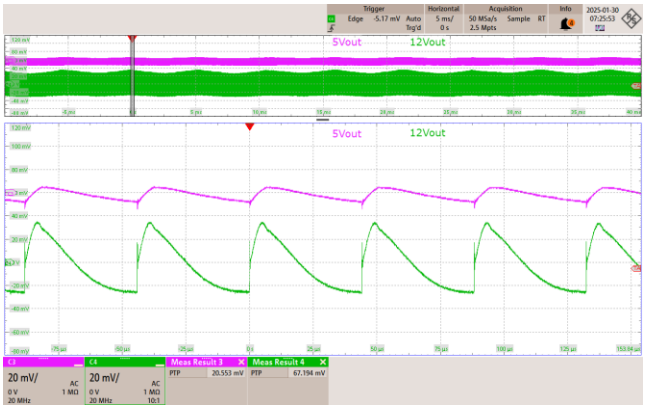


Figure 116 – 115 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 20.6 mV
12 V_Output Ripple = 67.2 mV

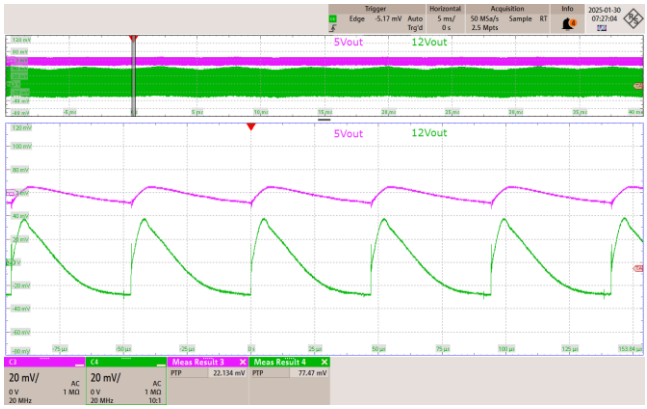


Figure 117 – 230 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 22.1 mV
12 V_Output Ripple = 77.5 mV

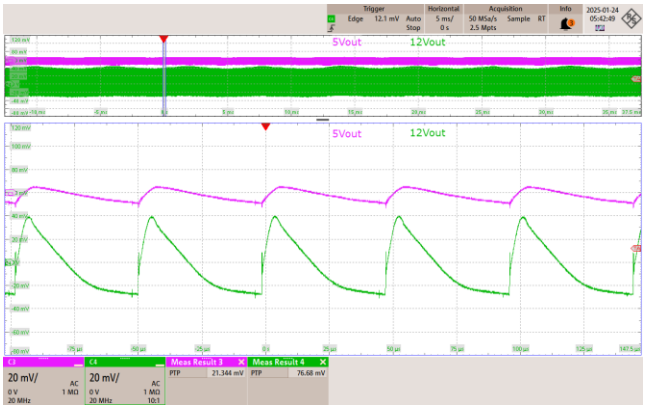


Figure 118 – 265 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 21.3 mV
12 V_Output Ripple = 76.7 mV

10.3.2.5 10% Load Condition

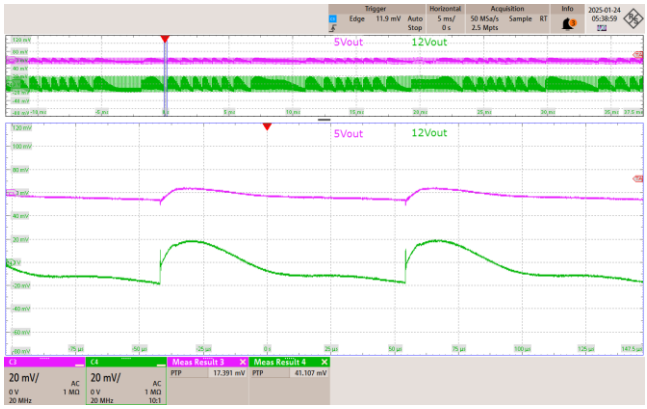


Figure 119 – 85 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 17.4 mV
12 V_Output Ripple = 41.1 mV

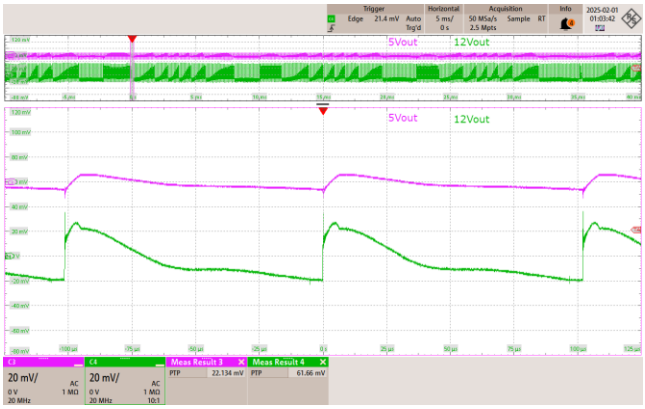


Figure 120 – 115 VAC 60 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 22.1 mV
12 V_Output Ripple = 61.7 mV

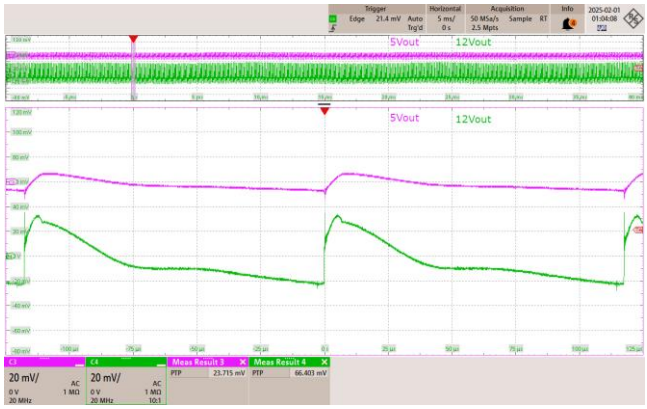


Figure 121 – 230 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 23.7 mV
12 V_Output Ripple = 66.4 mV

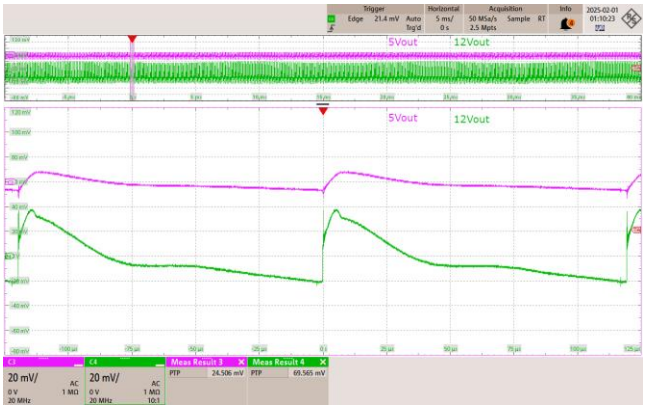


Figure 122 – 265 VAC 50 Hz.
CH3: 5 V_Output Ripple, 20 mV / div., 5 ms / div.
CH4: 12 V_Output Ripple, 20 mV / div., 5 ms / div.
Zoom: 25 µs / div.
5 V_Output Ripple = 24.5 mV
12 V_Output Ripple = 69.6 mV

10.3.3 Output Ripple Voltage Graph

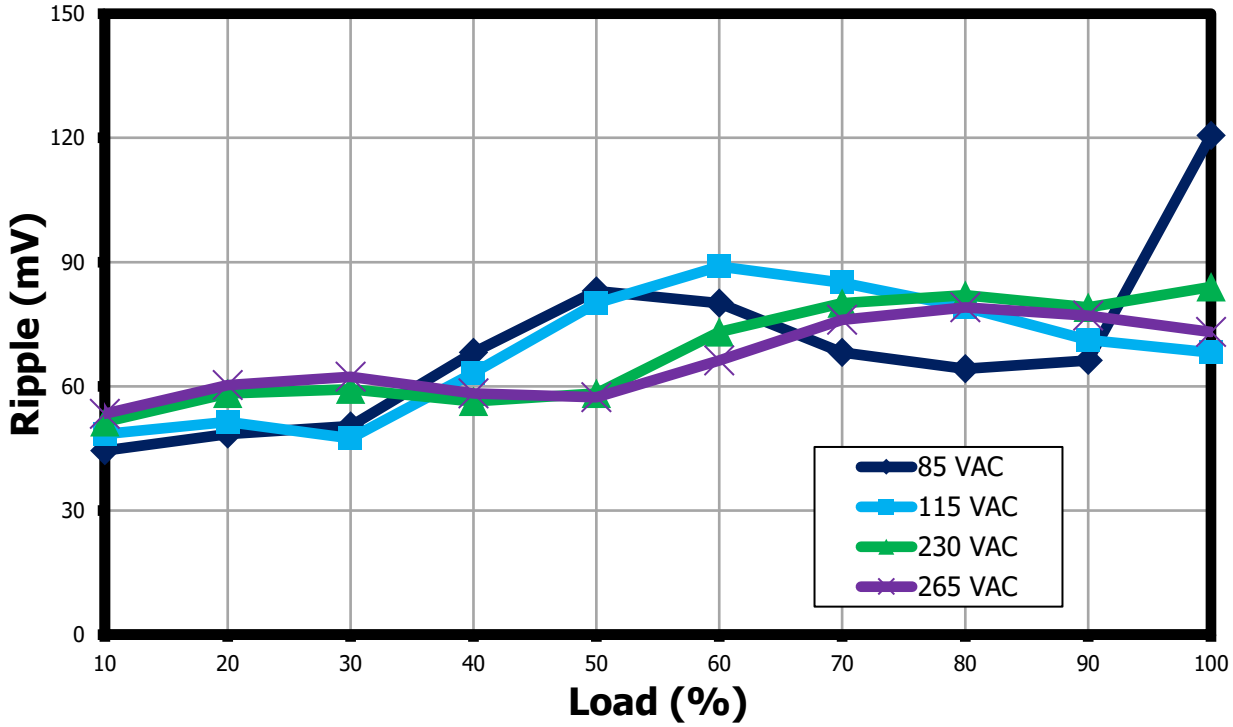


Figure 123 – 12 Voltage Ripple (Measured at PCB End at Room Temperature).

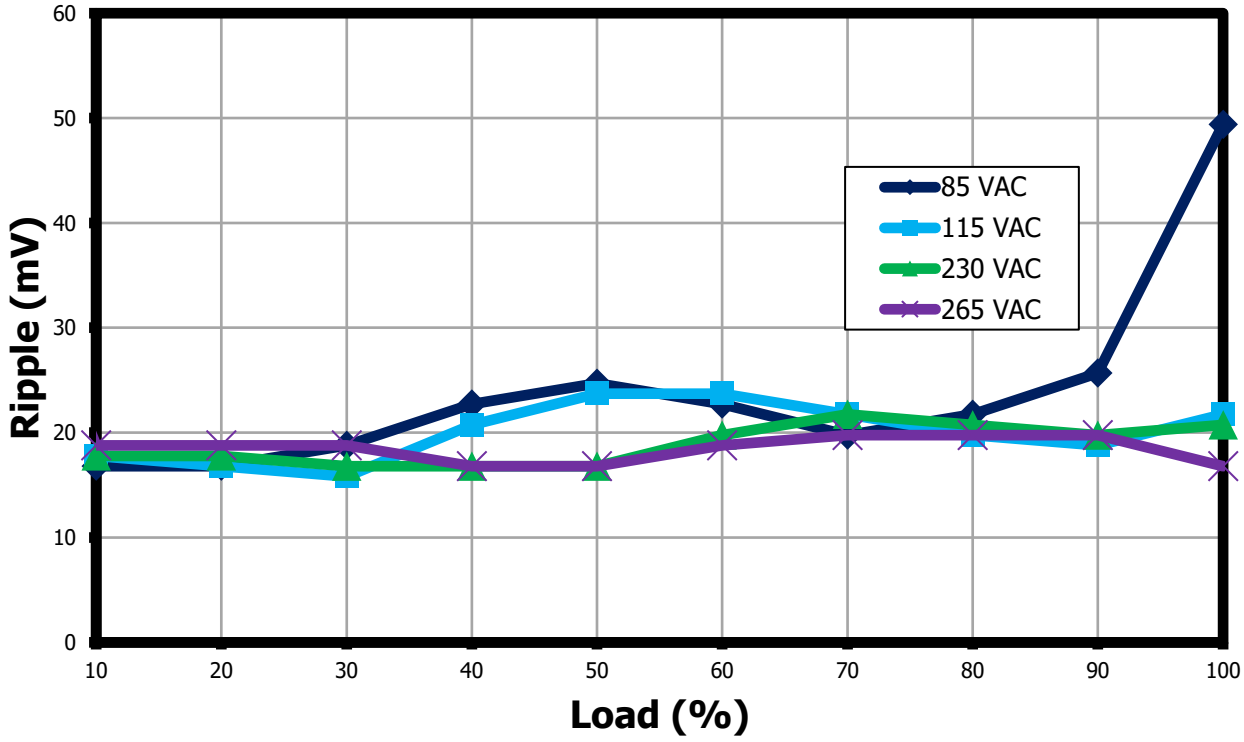


Figure 124 – 5 Voltage Ripple (Measured at PCB End at Room Temperature).

10.4 Thermal Performance

10.4.1 85 VAC Full Load at 25 °C Ambient

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

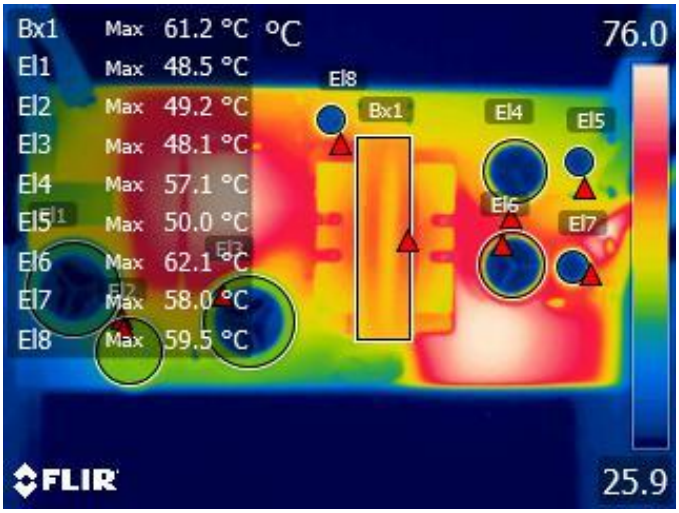


Figure 125 – 85 VAC 60 Hz Top Side Discrete Component Thermals.

Component	Temperature (°C)
Ambient	25.9
Transformer Core (T1)	61.2
Input Cap. 1(Cin19)	48.5
Diff. Mode Choke (L4)	49.2
Input Cap.2 (Cin2)	48.1
12 V_{OUT} Output Cap.1(Cout9)	57.1
12 V_{OUT} Output Cap.2(Cout10)	50.0
5 V_{OUT} Output Cap.1(Cout12)	62.1
5 V_{OUT} Output Cap.2(Cout13)	58.0
Bias Cap. (C4)	59.5

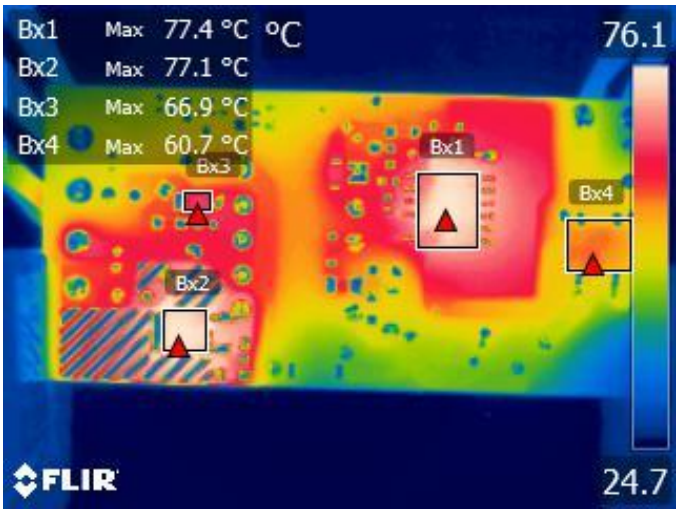


Figure 126 – 85 VAC 60 Hz Bottom Side Thermals.

Component	Temperature (°C)
Ambient	24.7
TNY50732K (U41)	77.4
12 V Secondary Diode (D4)	77.1
5 V Secondary Diode (D5)	66.9
BR Diode (BR2)	60.7

10.4.2 265 VAC Full Load at 25 °C Ambient

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

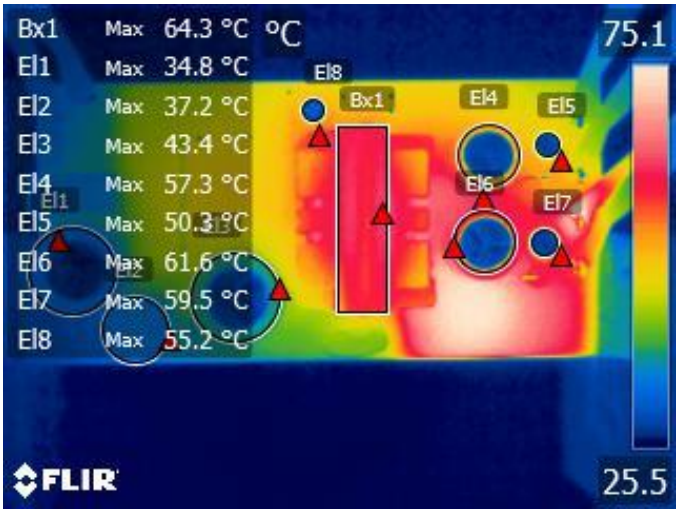


Figure 127 – 265 VAC 50 Hz Top Side Discrete Component Thermals.

Component	Temperature (°C)
Ambient	25.5
Transformer Core (T1)	64.3
Input Cap. 1(Cin19)	34.8
Diff. Mode Choke (L4)	37.2
Input Cap.2 (Cin2)	43.4
12 V_{OUT} Output Cap.1(Cout9)	57.3
12 V_{OUT} Output Cap.2(Cout10)	50.3
5 V_{OUT} Output Cap.1(Cout12)	61.6
5 V_{OUT} Output Cap.2(Cout13)	59.5
Bias Cap. (C4)	55.2

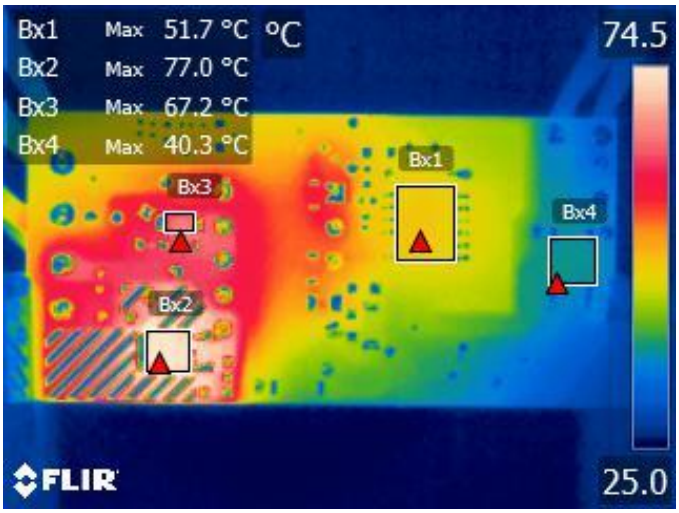


Figure 128 – 265 VAC 50 Hz Bottom Side Thermals.

Component	Temperature (°C)
Ambient	25.0
TNY50732K (U41)	51.7
12 V Secondary Diode (D4)	77.0
5 V Secondary Diode (D5)	67.2
BR Diode (BR2)	40.3

11 Fault Condition

11.1 Output Short-Circuit Protection

Figure 129 – 85 VAC 60 Hz 12 V Start-Up Output Short.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 12 V_V_{OUT}, 4 V / div., 400 ms / div.
CH4: 12 V_I_{OUT}, 1 A / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 350 V
Drain Current $_{(MAX)}$ = 830 mA
$t_{AR\_(OFF)1}$ = 337 ms
$t_{AR\_(OFF)2}$ = 1.21 s
$t_{AR(ON)}$ = 85.3 ms

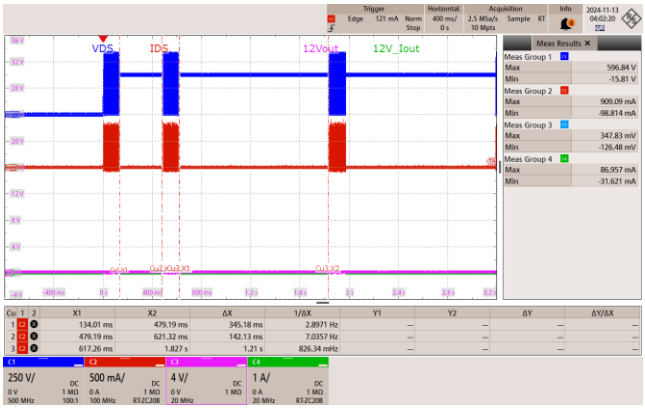


Figure 130 – 265 VAC 50 Hz 12 V Start-Up Output Short.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 12V_V_{OUT}, 4 V / div., 400 ms / div.
CH4: 12V_I_{OUT}, 1 A / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 597 V
Drain Current $_{(MAX)}$ = 909 mA
$t_{AR\_(OFF)1}$ = 345 ms
$t_{AR\_(OFF)2}$ = 1.21 s
$t_{AR(ON)}$ = 142 ms

Figure 131 – 85 VAC 60 Hz 5 V Start-Up Output Short.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 5 V_V_{OUT}, 2 V / div., 400 ms / div.
CH4: 5 V_I_{OUT}, 250 mA / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 350 V
Drain Current $_{(MAX)}$ = 810 mA
$t_{AR\_(OFF)1}$ = 345 ms
$t_{AR\_(OFF)2}$ = 1.21 s
$t_{AR(ON)}$ = 65 ms

Figure 132 – 265 VAC 50 Hz 5 V Start-Up Output Short.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 5 V_V_{OUT}, 2 V / div., 400 ms / div.
CH4: 5 V_I_{OUT}, 250 mA / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 597 V
Drain Current $_{(MAX)}$ = 870 mA
$t_{AR\_(OFF)1}$ = 341ms
$t_{AR\_(OFF)2}$ = 1.22 s
$t_{AR(ON)}$ = 85.2 ms

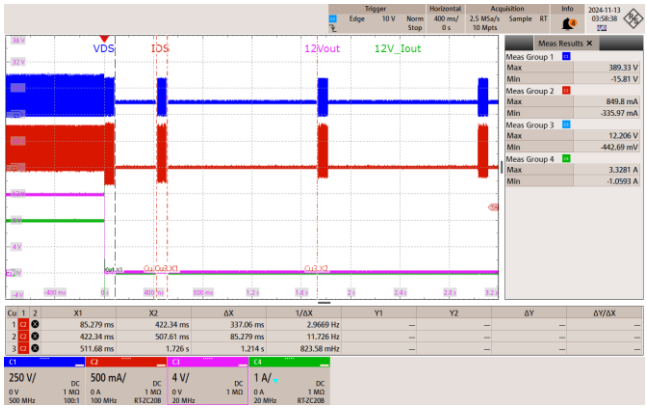


Figure 133 – 85 VAC 60 Hz 12 V Running Output Short.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 12 V_V_{OUT}, 4 V / div., 400 ms / div.
CH4: 12 V_I_{OUT}, 1 A / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 389 V
Drain Current $_{(MAX)}$ = 850 mA
$t_{AR\_(OFF)1}$ = 337 ms
$t_{AR\_(OFF)2}$ = 1.21 s
$t_{AR(ON)}$ = 85.3 ms

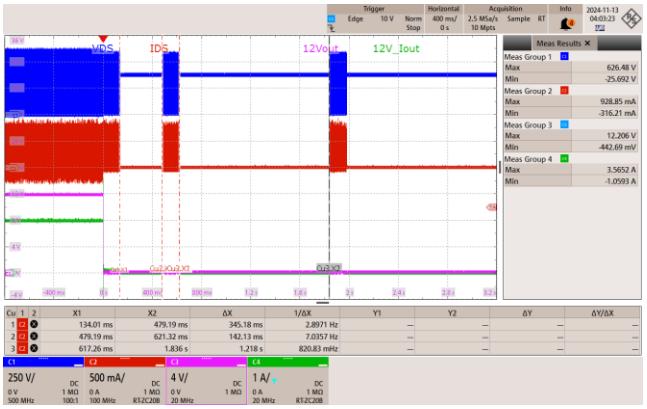


Figure 134 – 265 VAC 50 Hz. 12 V Running Output Short.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 12 V_V_{OUT}, 4 V / div., 400 ms / div.
CH4: 12 V_I_{OUT}, 1 A / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 626 V
Drain Current $_{(MAX)}$ = 929 mA
$t_{AR\_(OFF)1}$ = 345 ms
$t_{AR\_(OFF)2}$ = 1.22 s
$t_{AR(ON)}$ = 142 ms

Figure 135 – 85 VAC 60 Hz 5 V Running Output Short.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 5 V_V_{OUT}, 2 V / div., 400 ms / div.
CH4: 5 V_I_{OUT}, 250 mA / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 389 V
Drain Current $_{(MAX)}$ = 810 mA
$t_{AR\_(OFF)1}$ = 1.21 s
$t_{AR\_(OFF)2}$ = 1.21 s
$t_{AR(ON)}$ = 69 ms

Figure 136 – 265 VAC 50 Hz 5 V Running Output Short.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 5 V_V_{OUT}, 2 V / div., 400 ms / div.
CH4: 5 V_I_{OUT}, 250 mA / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 626 V
Drain Current $_{(MAX)}$ = 968 mA
$t_{AR\_(OFF)1}$ = 1.21 s
$t_{AR\_(OFF)2}$ = 1.21 s
$t_{AR(ON)}$ = 93.4 ms

11.2 Overpower Protection

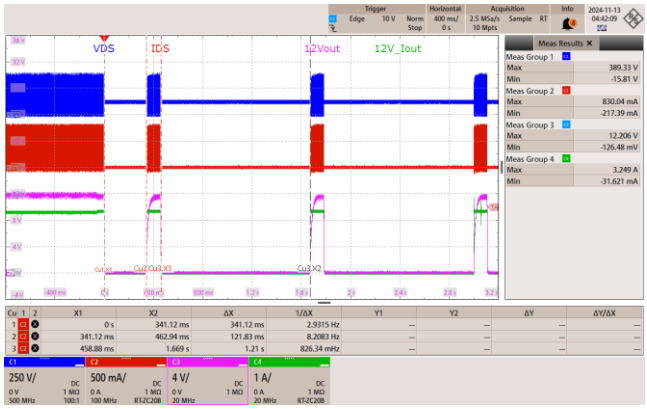


Figure 137 – 85 VAC 60 Hz 12 V / 2.3 A, 5 V / 0.575 A.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 12 V_V_{OUT}, 4 V / div., 400 ms / div.
CH4: 12 V_I_{OUT}, 1 A / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 389 V
Drain Current $_{(MAX)}$ = 830 mA
$t_{AR\_(OFF)1}$ = 341 ms
$t_{AR\_(OFF)2}$ = 1.24 s
$t_{AR(ON)}$ = 122 ms

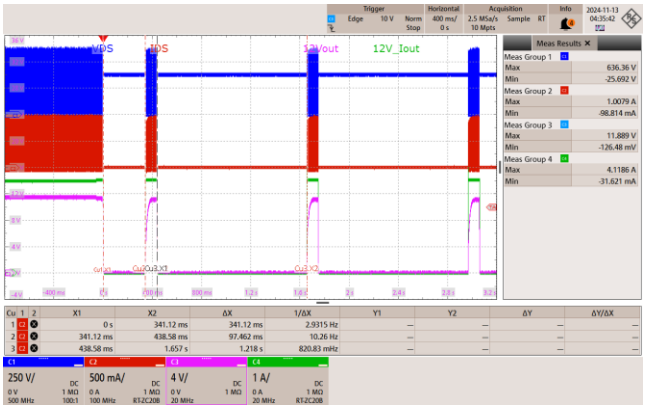


Figure 138 – 265 VAC 60 Hz. 12 V / 3.5 A, 5 V / 0.875 A.
CH1: Drain Voltage, 250 V / div., 400 ms / div.
CH2: Drain Current, 500 mA / div., 400 ms / div.
CH3: 12 V_V_{OUT}, 4 V / div., 400 ms / div.
CH4: 12 V_I_{OUT}, 1 A / div., 400 ms / div.
Drain Voltage $_{(MAX)}$ = 636 V
Drain Current $_{(MAX)}$ = 1.01 A
$t_{AR\_(OFF)1}$ = 341 ms
$t_{AR\_(OFF)2}$ = 1.22 s
$t_{AR(ON)}$ = 97.5 ms

11.3 Over Temperature Protection

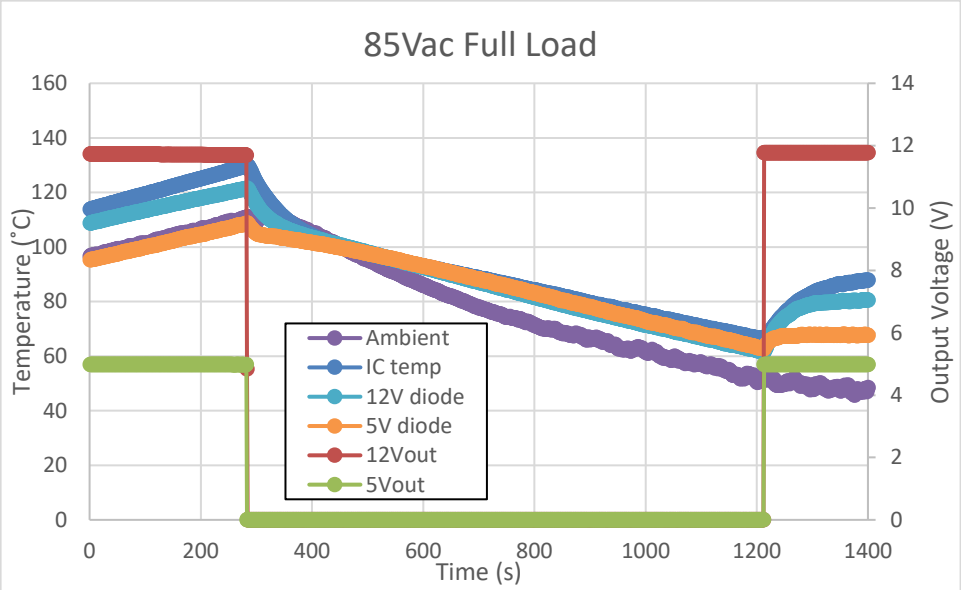


Figure 139 – 85 VAC 60 Hz Full Load OTP.

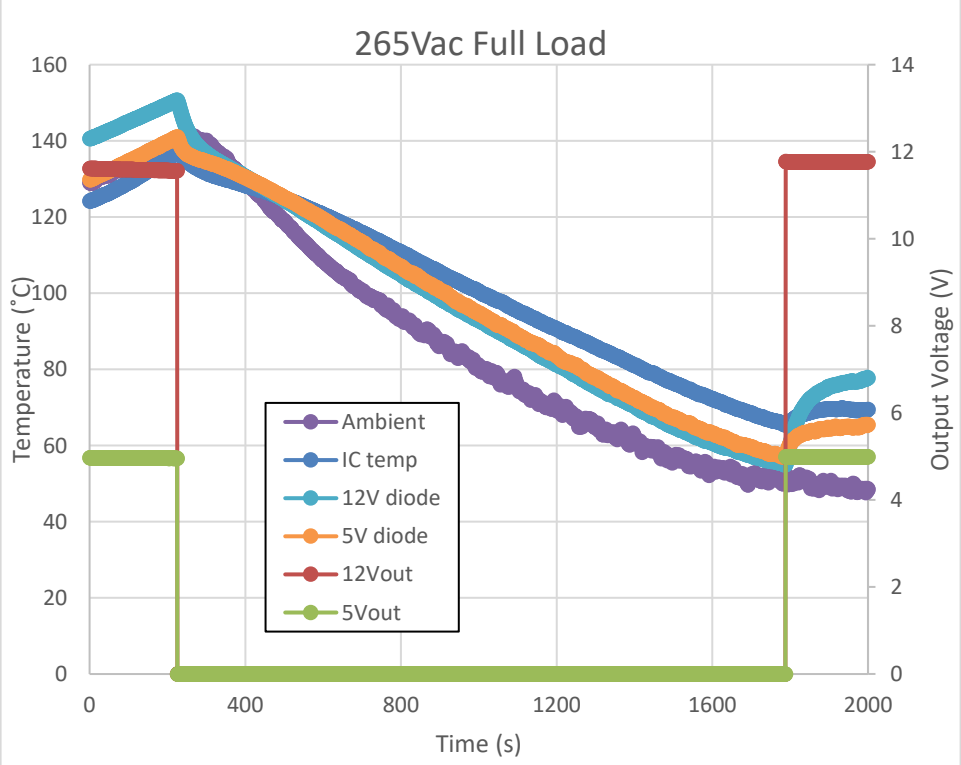


Figure 140 – 265 VAC 50 Hz Full Load OTP.

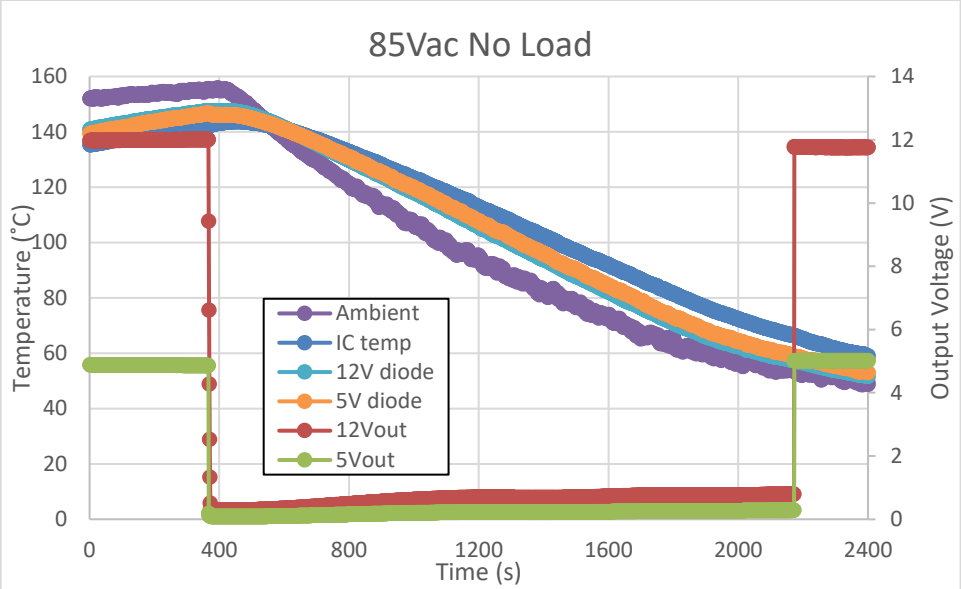


Figure 141 – 85 VAC 60 Hz No Load OTP.

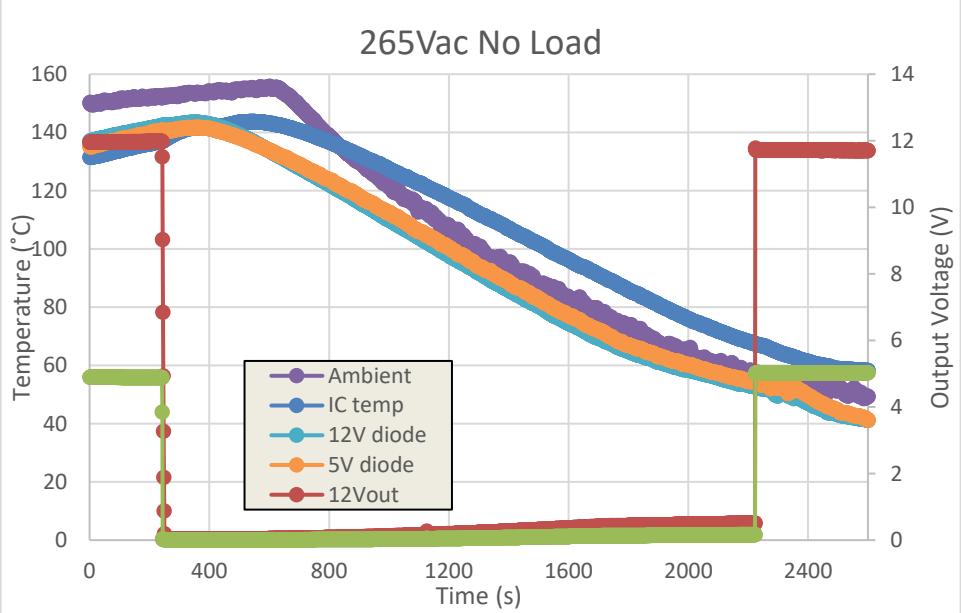


Figure 142 – 265 VAC 50 Hz No Load OTP.

Input (VAC) and Loading	IC Temperature (°C)	
	OTP Shutdown	Recover
85 VAC Full Load	123	66.4
265 VAC Full Load	137	65.5
85 VAC No Load	142	66.4
265 VAC No Load	137	67.4

12 Conducted EMI

Conducted emissions tests were performed at 115 VAC and 230 VAC at full load (12 V / 2 A and 5 V / 0.5 A). Measurements were taken with floating ground.

12.1 Test Set-up Equipment

12.1.1 Equipment and Load Used

1. Rohde and Schwarz ENV216 two-line V-network.
2. Rohde and Schwarz ESRP EMI test receiver.
3. Input voltage set at 115 VAC and 230 VAC.
4. 12 V R_{LOAD} resistance is 6 Ohms and 5 V R_{LOAD} resistance is 10 Ohms.

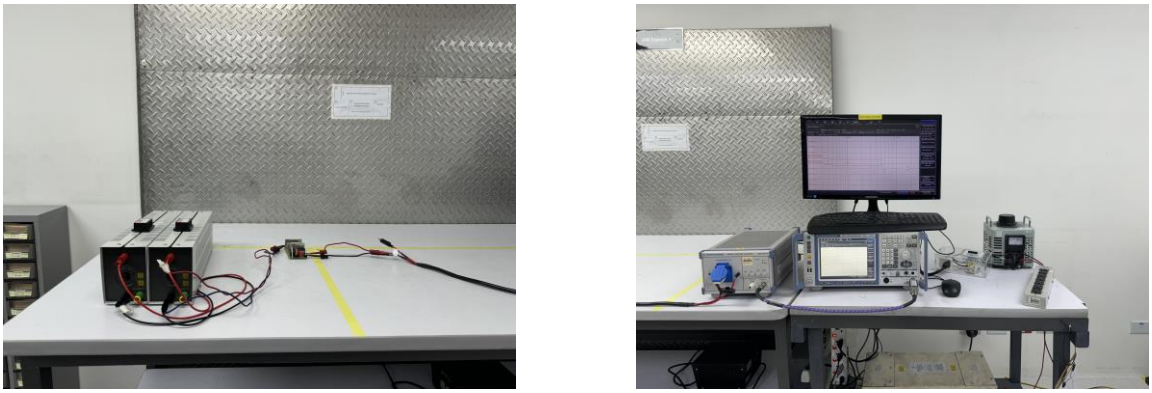


Figure 143 – EMI Test Set-up.

12.2 Output Float

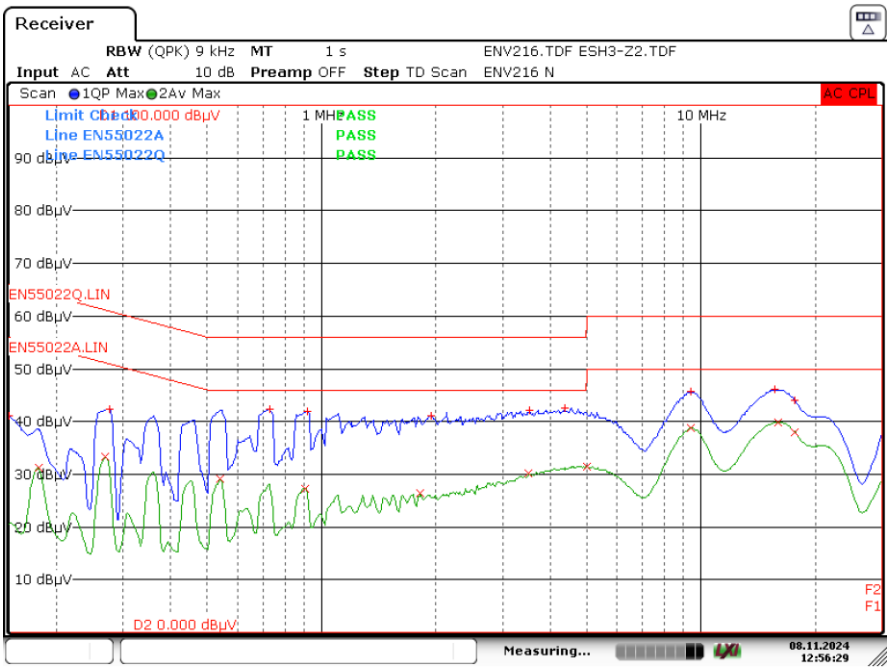


Figure 144 – 115 VAC 50 Hz.
Line / Neutral - Floating

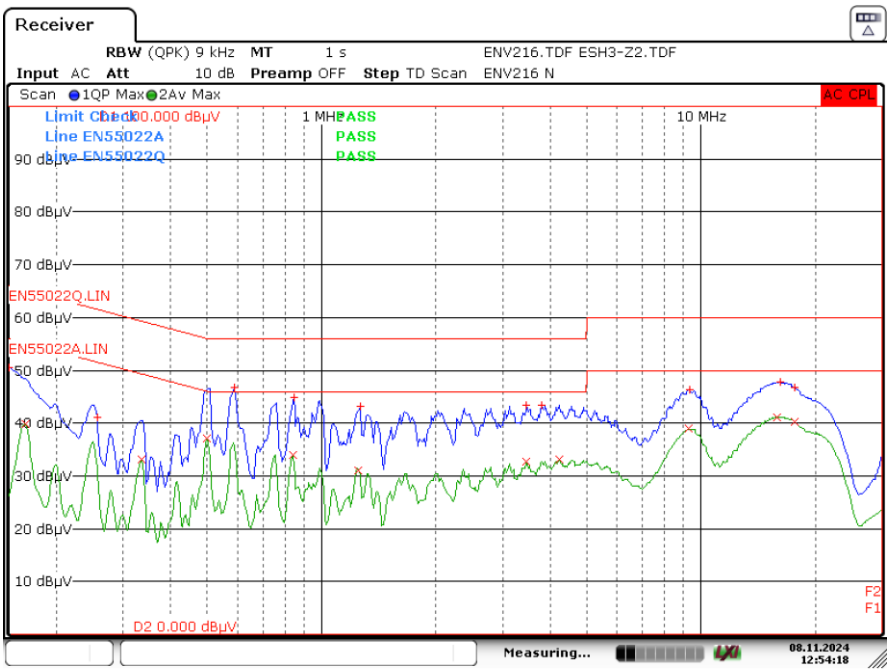


Figure 145 – 230 VAC 50 Hz.
Line / Neutral - Floating

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

13.1 Differential Mode Surge

DM Surge Level (kV)	Input Voltage (VAC)	Injection Location	Injection Phase (º)	Test Result (Pass/Fail)
+1	115	L to N	0	Pass
-1	115	L to N	0	Pass
+1	115	L to N	90	Pass
-1	115	L to N	90	Pass
+1	115	L to N	180	Pass
-1	115	L to N	180	Pass
+1	115	L to N	270	Pass
-1	115	L to N	270	Pass

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

DM Surge Level (kV)	Input Voltage (VAC)	Injection Location	Injection Phase (º)	Test Result (Pass/Fail)
+1	230	L to N	0	Pass
-1	230	L to N	0	Pass
+1	230	L to N	90	Pass
-1	230	L to N	90	Pass
+1	230	L to N	180	Pass
-1	230	L to N	180	Pass
+1	230	L to N	270	Pass
-1	230	L to N	270	Pass

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

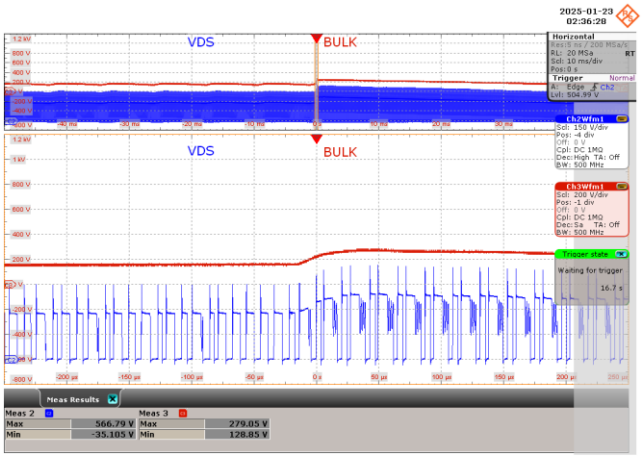


Figure 146 – 115 VAC 60 Hz +1kV_90°
CH2: Drain Voltage, 150 V / div., 10 ms / div.
CH3: Bulk Voltage, 200 V / div., 10 ms / div.
Zoom: 50 µs / div
V_{DS} Max Voltage = 567 V.

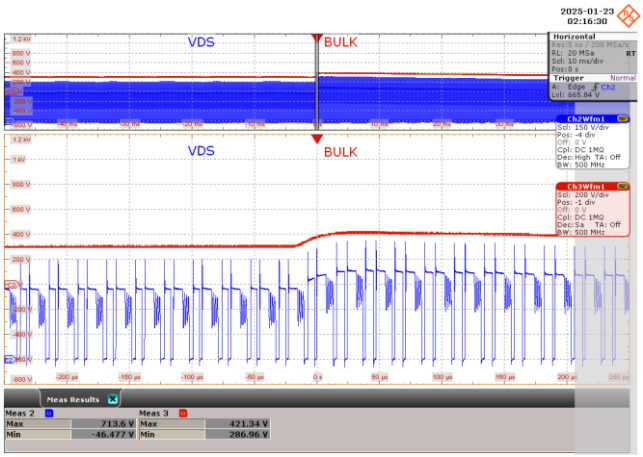


Figure 147 – 230 VAC 60 Hz +1kV_90°
CH2: Drain Voltage, 150 V / div., 10 ms / div.
CH3: Bulk Voltage, 200 V / div., 10 ms / div.
Zoom: 50 µs / div
V_{DS} Max Voltage = 714 V.

13.2 Common Mode Surge – Ring Wave

Surge Voltage (kV)	Phase Angle (º)	Input Voltage (VAC)	IEC Coupling	Generator Impedance (Ω)	Number of Strikes	Result
+4	0	115	L, N - PE	12	10	PASS
-4	0	115	L, N - PE	12	10	PASS
+4	90	115	L, N - PE	12	10	PASS
-4	90	115	L, N - PE	12	10	PASS
+4	270	115	L, N - PE	12	10	PASS
-4	270	115	L, N - PE	12	10	PASS

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

Surge Voltage (kV)	Phase Angle (º)	Input Voltage (VAC)	IEC Coupling	Generator Impedance (Ω)	Number of Strikes	Result
+4	0	230	L, N - PE	12	10	PASS
-4	0	230	L, N - PE	12	10	PASS
+4	90	230	L, N - PE	12	10	PASS
-4	90	230	L, N - PE	12	10	PASS
+4	270	230	L, N - PE	12	10	PASS
-4	270	230	L, N - PE	12	10	PASS

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

13.3 EFT Burst

EFT DM Surge Level (kV)	Input Voltage (VAC)	Injection Location	Injection Phase (º)	Frequency	T-Burst	T-Rep	Test Duration	Test Result
+4	115	L to N	0	5 kHz	15 ms	300 ms	120 s	Pass
-4	115	L to N	0	5 kHz	15 ms	300 ms	120 s	Pass
+4	115	L to N	0	100 kHz	750 µs	300 ms	120 s	Pass
-4	115	L to N	0	100 kHz	750 µs	300 ms	120 s	Pass
+4	115	L to N	90	5 kHz	15 ms	300 ms	120 s	Pass
-4	115	L to N	90	5 kHz	15 ms	300 ms	120 s	Pass
+4	115	L to N	90	100 kHz	750 µs	300 ms	120 s	Pass
-4	115	L to N	90	100 kHz	750 µs	300 ms	120 s	Pass
+4	115	L to N	180	5 kHz	15 ms	300 ms	120 s	Pass
-4	115	L to N	180	5 kHz	15 ms	300 ms	120 s	Pass
+4	115	L to N	180	100 kHz	750 µs	300 ms	120 s	Pass
-4	115	L to N	180	100 kHz	750 µs	300 ms	120 s	Pass
+4	115	L to N	270	5 kHz	15 ms	300 ms	120 s	Pass
-4	115	L to N	270	5 kHz	15 ms	300 ms	120 s	Pass
+4	115	L to N	270	100 kHz	750 µs	300 ms	120 s	Pass
-4	115	L to N	270	100 kHz	750 µs	300 ms	120 s	Pass

EFT DM Surge Level (kV)	Input Voltage (VAC)	Injection Location	Injection Phase (º)	Frequency	T-Burst	T-Rep	Test Duration	Test Result
+4	230	L to N	0	5 kHz	15 ms	300 ms	120 s	Pass
-4	230	L to N	0	5 kHz	15 ms	300 ms	120 s	Pass
+4	230	L to N	0	100 kHz	750 µs	300 ms	120 s	Pass
-4	230	L to N	0	100 kHz	750 µs	300 ms	120 s	Pass
+4	230	L to N	90	5 kHz	15 ms	300 ms	120 s	Pass

-4	230	L to N	90	5 kHz	15 ms	300 ms	120 s	Pass
+4	230	L to N	90	100 kHz	750 µs	300 ms	120 s	Pass
-4	230	L to N	90	100 kHz	750 µs	300 ms	120 s	Pass
+4	230	L to N	180	5 kHz	15 ms	300 ms	120 s	Pass
-4	230	L to N	180	5 kHz	15 ms	300 ms	120 s	Pass
+4	230	L to N	180	100 kHz	750 µs	300 ms	120 s	Pass
-4	230	L to N	180	100 kHz	750 µs	300 ms	120 s	Pass
+4	230	L to N	270	5 kHz	15 ms	300 ms	120 s	Pass
-4	230	L to N	270	5 kHz	15 ms	300 ms	120 s	Pass
+4	230	L to N	270	100 kHz	750 µs	300 ms	120 s	Pass
-4	230	L to N	270	100 kHz	750 µs	300 ms	120 s	Pass

14 ESD

All ESD strikes were applied at end of PCB with 230 VAC and 115 VAC input voltage and full load.

Passed ±8.8 kV contact discharge at 115 VAC

Contact Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+8.8	12 V	10	PASS
-8.8	12 V	10	PASS
+8.8	5 V	10	PASS
-8.8	5 V	10	PASS
+8.8	GND	10	PASS
-8.8	GND	10	PASS

Passed ±16.5 kV air discharge at 115 VAC

Air Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+16.5	12 V	10	PASS
-16.5	12 V	10	PASS
+16.5	5 V	10	PASS
-16.5	5 V	10	PASS
+16.5	GND	10	PASS
-16.5	GND	10	PASS

Passed ±8.8 kV contact discharge at 230 VAC

Contact Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+8.8	12 V	10	PASS
-8.8	12 V	10	PASS
+8.8	5 V	10	PASS
-8.8	5 V	10	PASS
+8.8	GND	10	PASS
-8.8	GND	10	PASS

Passed ±16.5 kV air discharge at 230 VAC

Air Discharge Voltage (kV)	Applied to	Number of Strikes	Test Result
+16.5	12 V	10	PASS
-16.5	12 V	10	PASS
+16.5	5 V	10	PASS
-16.5	5 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.

15 Revision History

Date	Author	Revision	Description and Changes	Reviewed
31-Jan-25	RN / RPA	A	Initial Release	Apps & Mktg

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

Power Integrations Worldwide Sales Support Locations

WORLD HEADQUARTERS
5245 Hellyer Avenue
San Jose, CA 95138, USA.
Main: +1-408-414-9200
Customer Service:
Worldwide: +1-65-635-64480
Americas: +1-408-414-9621
e-mail: usasales@power.com

CHINA (SHANGHAI)
Rm 2410, Charity Plaza, No. 88,
North Caoxi Road,
Shanghai, PRC 200030
Phone: +86-21-6354-6323
e-mail: chinasales@power.com

CHINA (SHENZHEN)
17/F, Hivac Building, No. 2, Keji Nan 8th Road, Nanshan District,
Shenzhen, China, 518057
Phone: +86-755-8672-8689
e-mail: chinasales@power.com

GERMANY (AC-DC/LED Sales)
Einsteinring 24
85609 Dornach/Aschheim
Germany
Tel: +49-89-5527-39100
e-mail: eurosales@power.com

GERMANY (Gate Driver Sales)
HellwegForum 1
59469 Ense
Germany
Tel: +49-2938-64-39990
e-mail: igbt-driver.sales@power.com

INDIA
#1, 14th Main Road
Vasanthanagar
Bangalore-560052
India
Phone: +91-80-4113-8020
e-mail: indiasales@power.com

ITALY
Via Milanese 20, 3rd. Fl.
20099 Sesto San Giovanni (MI) Italy
Phone: +39-024-550-8701
e-mail: eurosales@power.com

JAPAN
Yusen Shin-Yokohama 1-chome Bldg.
1-7-9, Shin-Yokohama, Kohoku-ku
Yokohama-shi,
Kanagawa 222-0033 Japan
Phone: +81-45-471-1021
e-mail: japansales@power.com

KOREA
RM 602, 6FL
Korea City Air Terminal B/D,
159-6
Samsung-Dong, Kangnam-Gu,
Seoul, 135-728 Korea
Phone: +82-2-2016-6610
e-mail: koreasales@power.com

SINGAPORE
51 Newton Road,
#19-01/05 Goldhill Plaza
Singapore, 308900
Phone: +65-6358-2160
e-mail: singaporesales@power.com

TAIWAN
5F, No. 318, Nei Hu Rd.,
Sec. 1
Nei Hu District
Taipei 11493, Taiwan R.O.C.
Phone: +886-2-2659-4570
e-mail: taiwansales@power.com

UK
Building 5, Suite 21
The Westbrook Centre
Milton Road
Cambridge
CB4 1YG
Phone: +44 (0) 7823-557484
e-mail: eurosales@power.com