Test Report: PMP41117

65W Dual-Port USB Power Delivery Charger With Self-Biasing GaN Flyback Converter Reference Design

Description

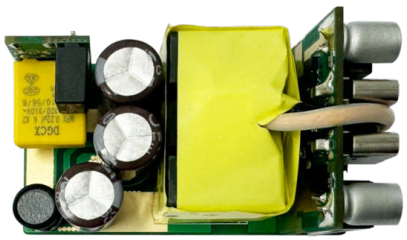
This reference design is a 65W, dual USB Type-C® port USB power delivery (PD) charger reference design with integrated flyback controller and Gallium nitride (GaN) power switch. This design can deliver 65W full rated power across 90VAC to 264VAC and meet efficiency standards and regulations such as DoE Level VI and CoC V5 Tier 2 efficiency standards for average efficiency across 25%, 50%, 75%, and 100% while also achieving low standby power consumption. The AC-DC stage flyback converter UCG28826 features VCC self-bias and simplifies the circuity by eliminating auxiliary winding as well as associated VCC rectifier circuity. The DC-DC stage buck converter TPS56837HA switching frequency runs at 500kHz which can minimize the buck stage size further, yielding to 2.3W per cubic centimeters power density.

Features

- Achieve 91.8% efficiency at 90VAC, single port
- 2.3W per cubic centimeter power density based on PCB size
- Meets DoE Level VI and CoC V5 Tier2 efficiency standards
- No load power consumption 23mW at 115VAC, 30mW at 230VAC
- Full independent power 65W on each USB port

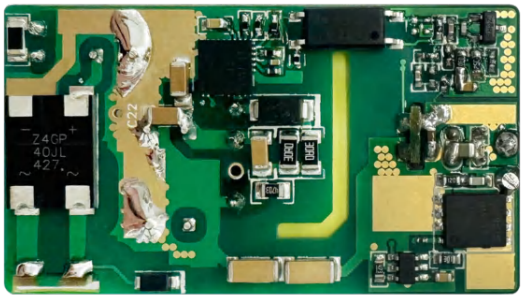
Applications

- USB AC/DC adapter
- USB wall power outlet
- Appliances

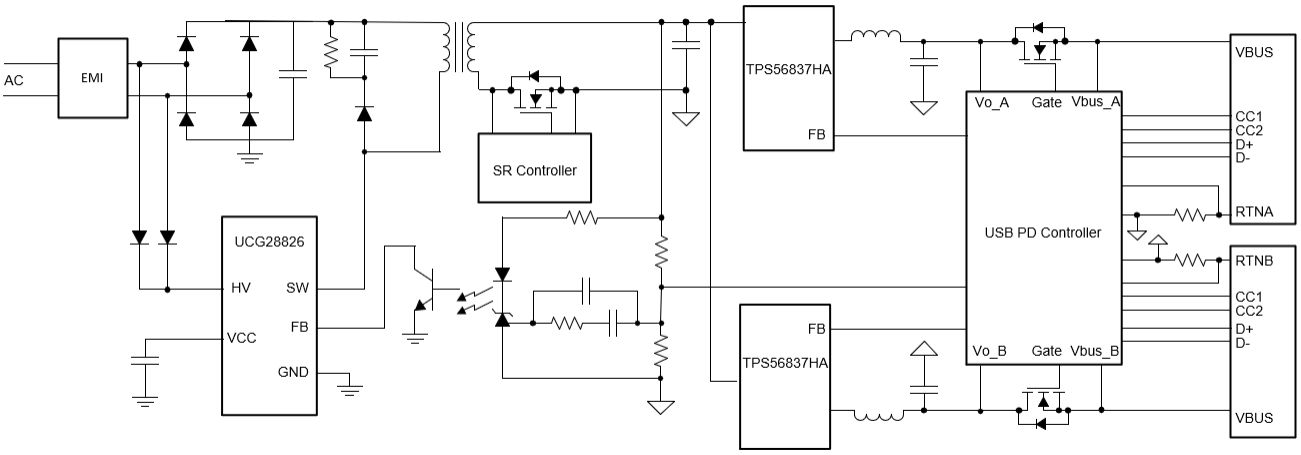


Top View

Angled View



Bottom View



System Block Diagram

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage range	90VAC-264VAC
Input voltage frequency	47HZ-60Hz
Output Power profile at single port (port1 or port2)	5V, 3A; 9V, 3A; 15V, 3A; 20V, 3A
Output Power profile at dual port (port1+port2)	5V, 3A; 5V, 3A
	5V, 3A; 9V, 3A
	5V, 3A; 15V, 3A
	5V, 3A; 20V, 2.25A
	9V, 3A; 9V, 3A
	9V, 2.25A; 15V, 3A
	9V, 2.25A; 20V, 2.25A
Maximum total output power	65W

1.2 Required Equipment

- AC Source: Chroma Model 61601
- Digital Power Meter: Yokogawa WT310
- Power-Z P240 Bi-directional Multi-protocol Power Supply
- DC source: GWinstek, GPS-3303C
- Bi-Directional Power Source: IT6010C-80-300
- Electronic load: Chroma, 6314A
- Oscilloscope: Tektronix, DPO 3054
- Infrared Thermal Camera: Fluke, TiS55
- Ture-RMS-Multimeter: Fluke, 287C

1.3 Dimensions

Board size: 27mm × 48mm × 22mm (open frame).

1.4 Test Setup

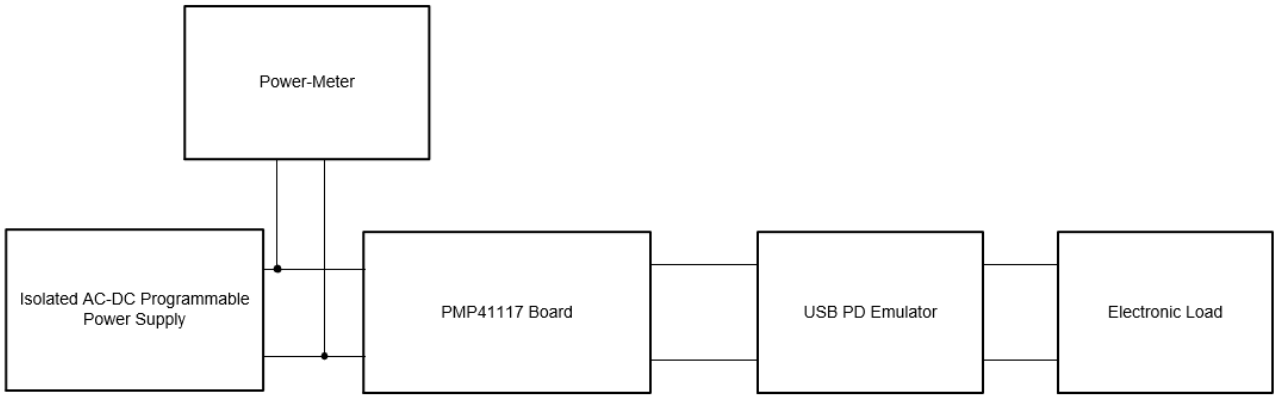


Figure 1-1. Test Setup

Figure 1-2. Test Setup Image

2 Testing and Results

2.1 Efficiency Graphs

Figure 2-1 through Figure 2-6 show the single port efficiency and power loss graphs.

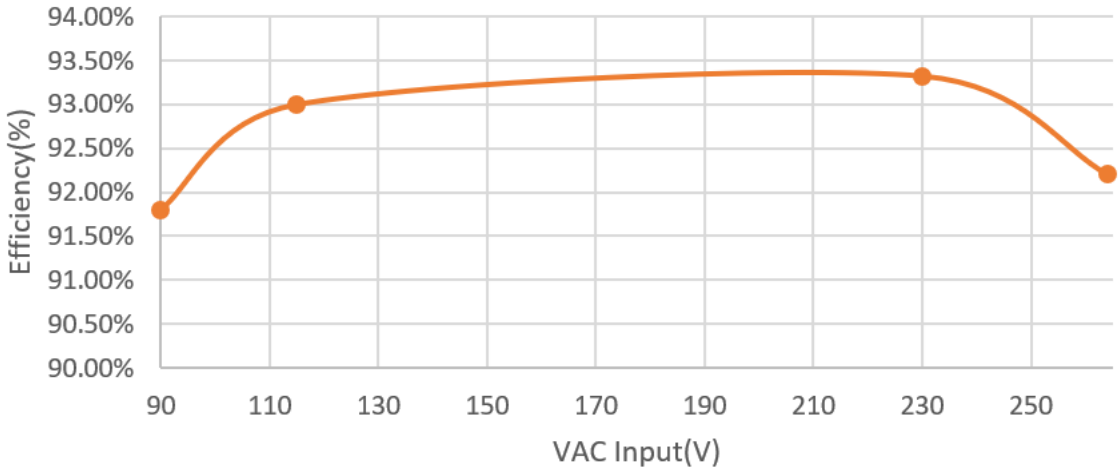


Figure 2-1. Single port, 20V_{out} Full Load Efficiency Versus AC Input

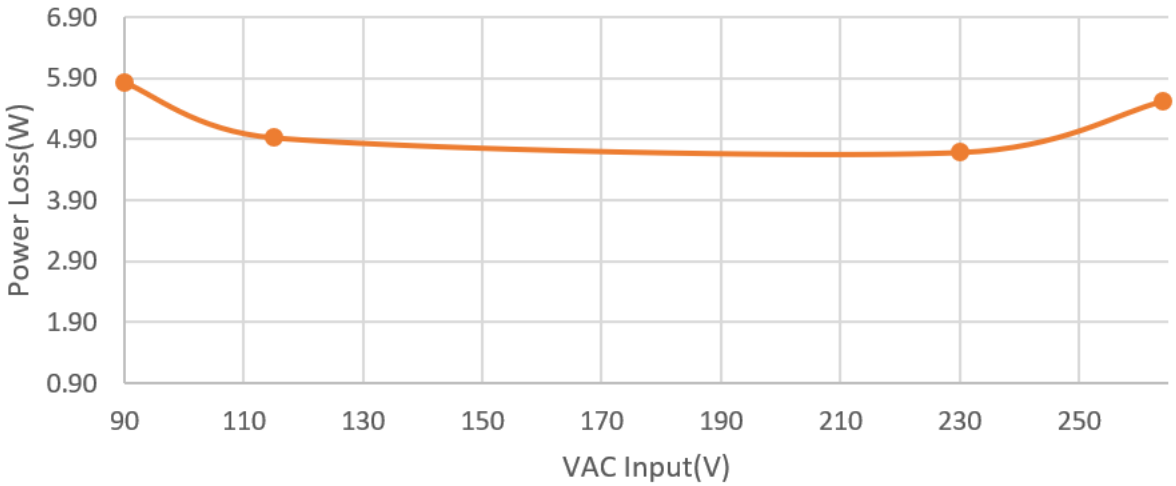


Figure 2-2. Single Port, 20V_{out} Full Load Power Loss Versus AC Input

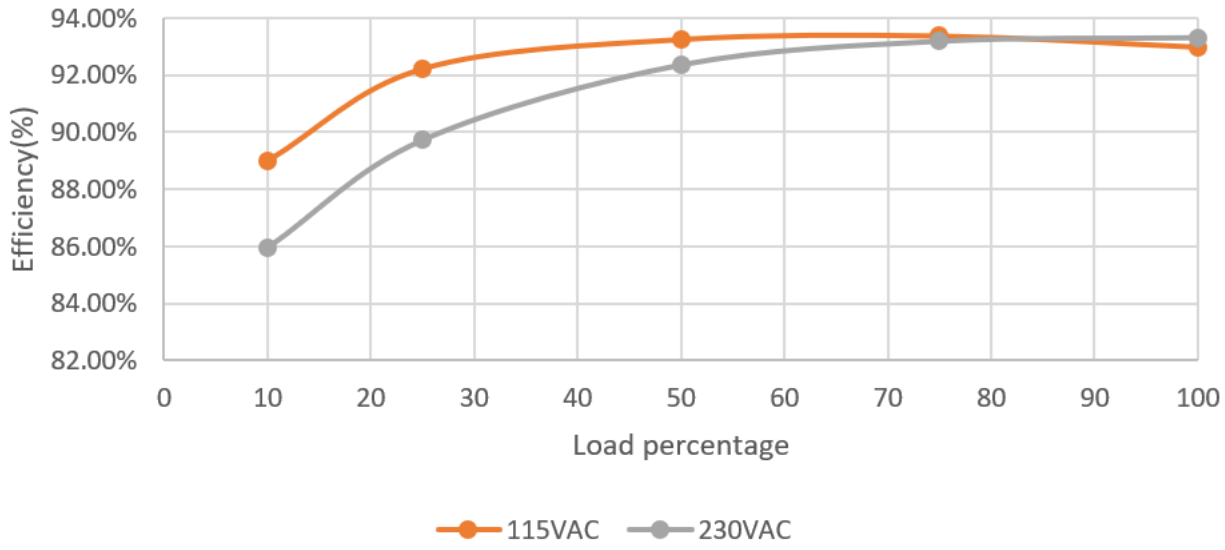


Figure 2-3. Single Port, 20V_{out} Efficiency Versus Load and AC Input Voltage

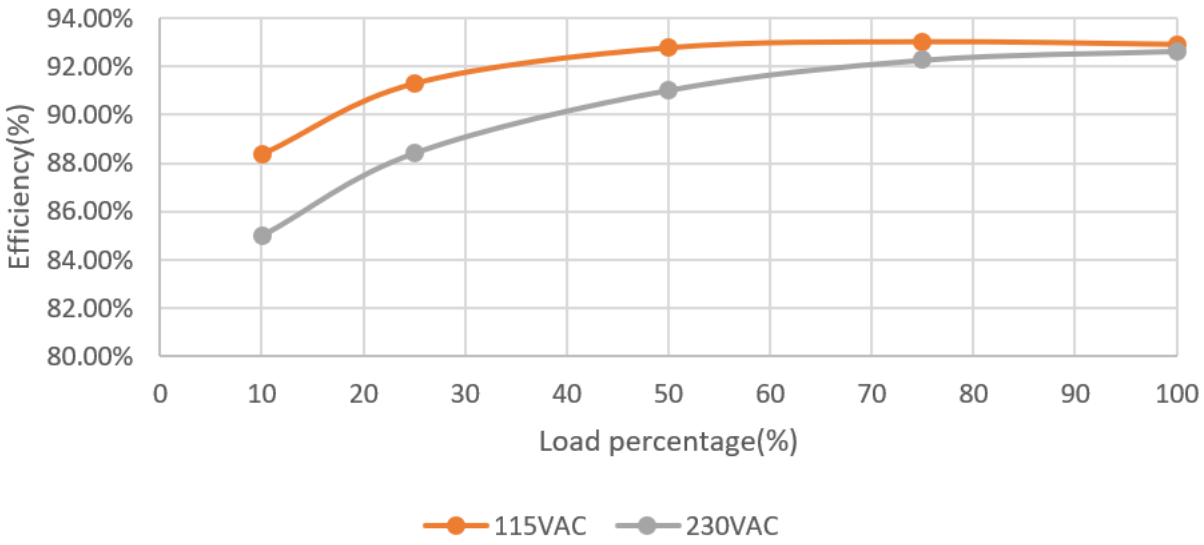


Figure 2-4. Single Port, 15V_{out} Efficiency Versus Load and Input Voltage

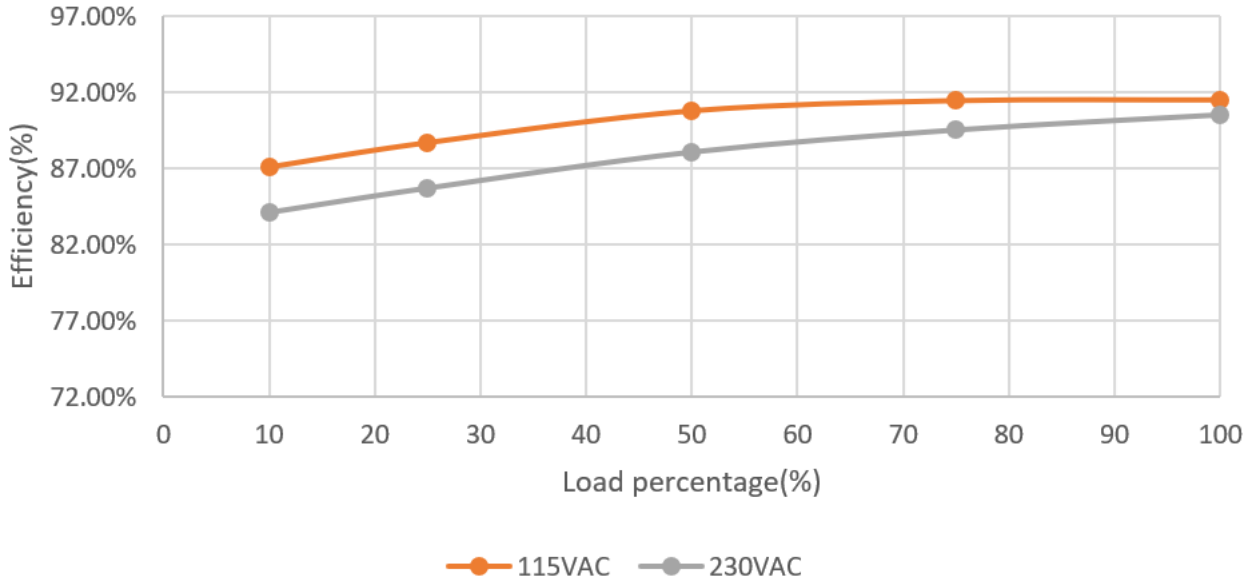


Figure 2-5. Single Port, 9V_{out} Efficiency Versus Load and Input Voltage

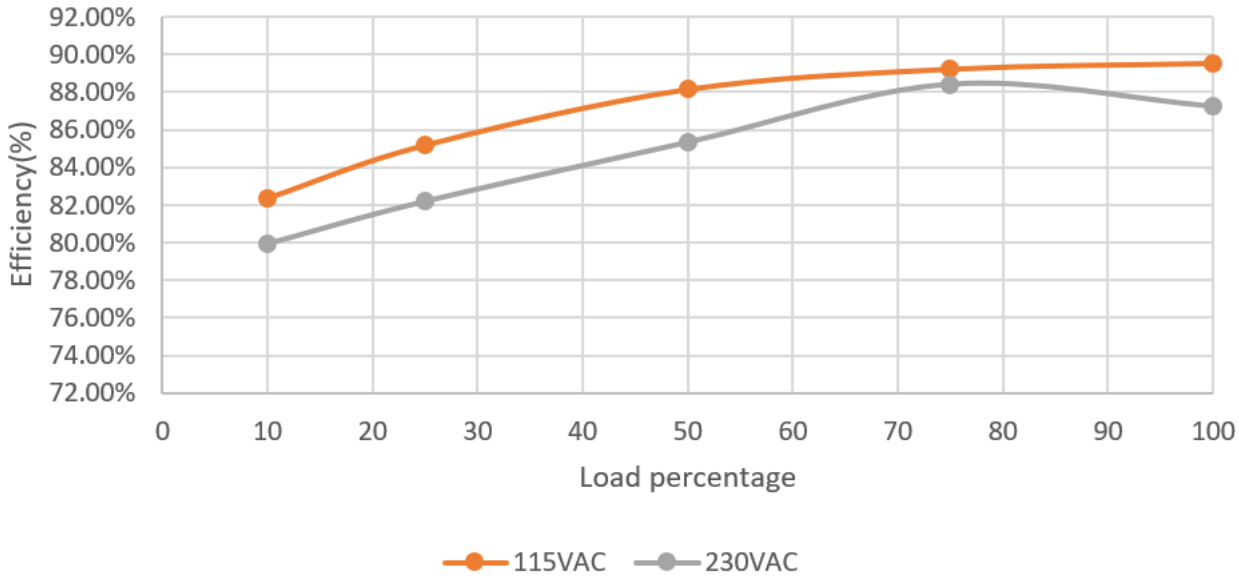


Figure 2-6. Single Port, 5V_{out} Efficiency Versus Load and Input Voltage

Figure 2-7 through Figure 2-10 show the dual port efficiency and power loss graphs.

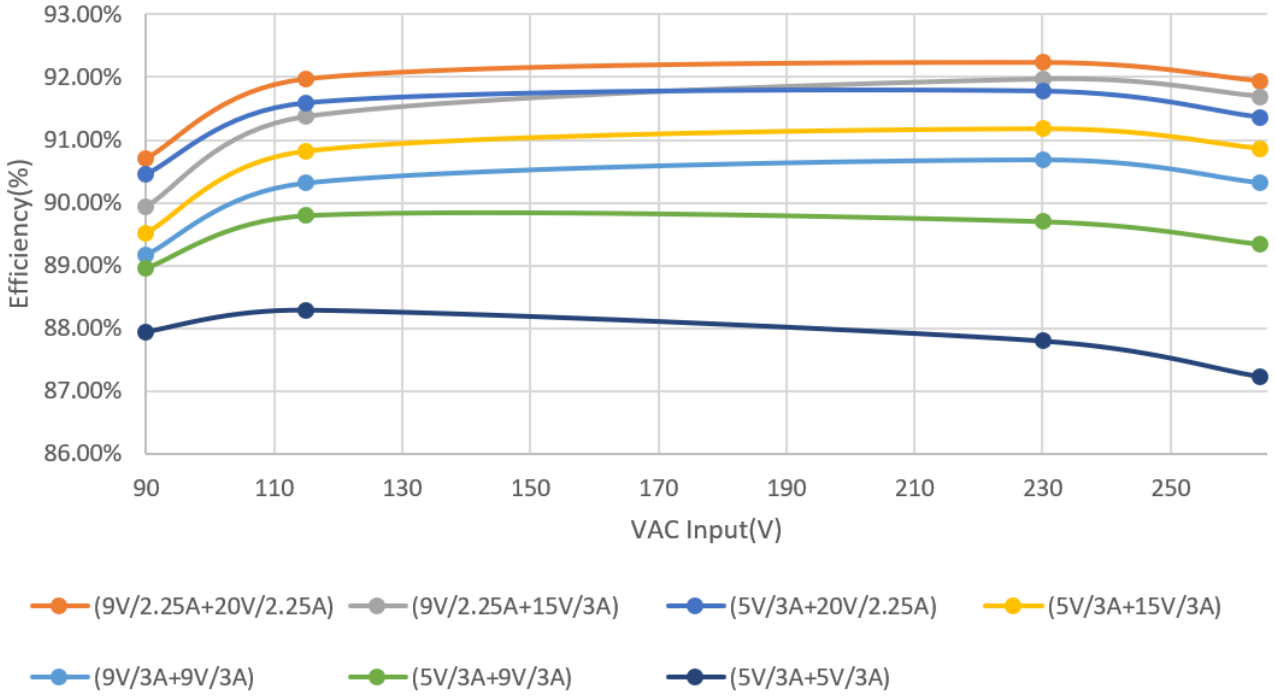


Figure 2-7. Dual Port Full Load Efficiency versus AC Input Voltage

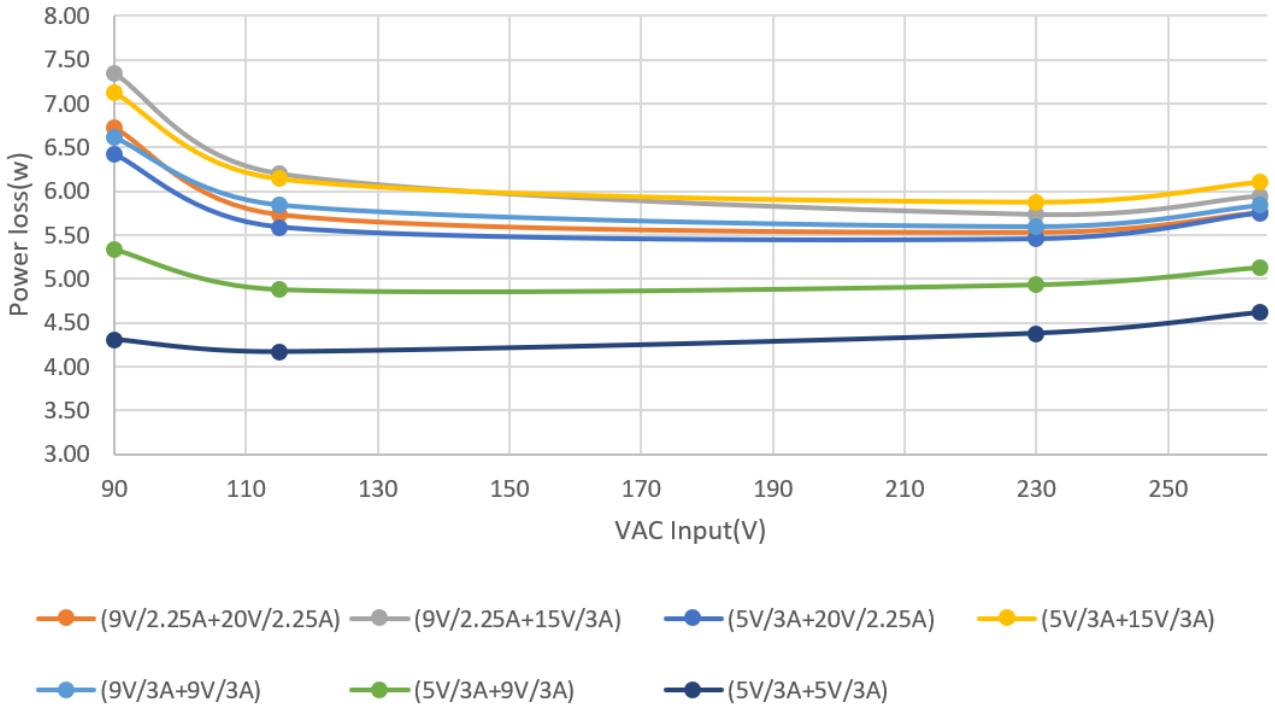


Figure 2-8. Dual Port Full Load Power Loss versus AC Input Voltage

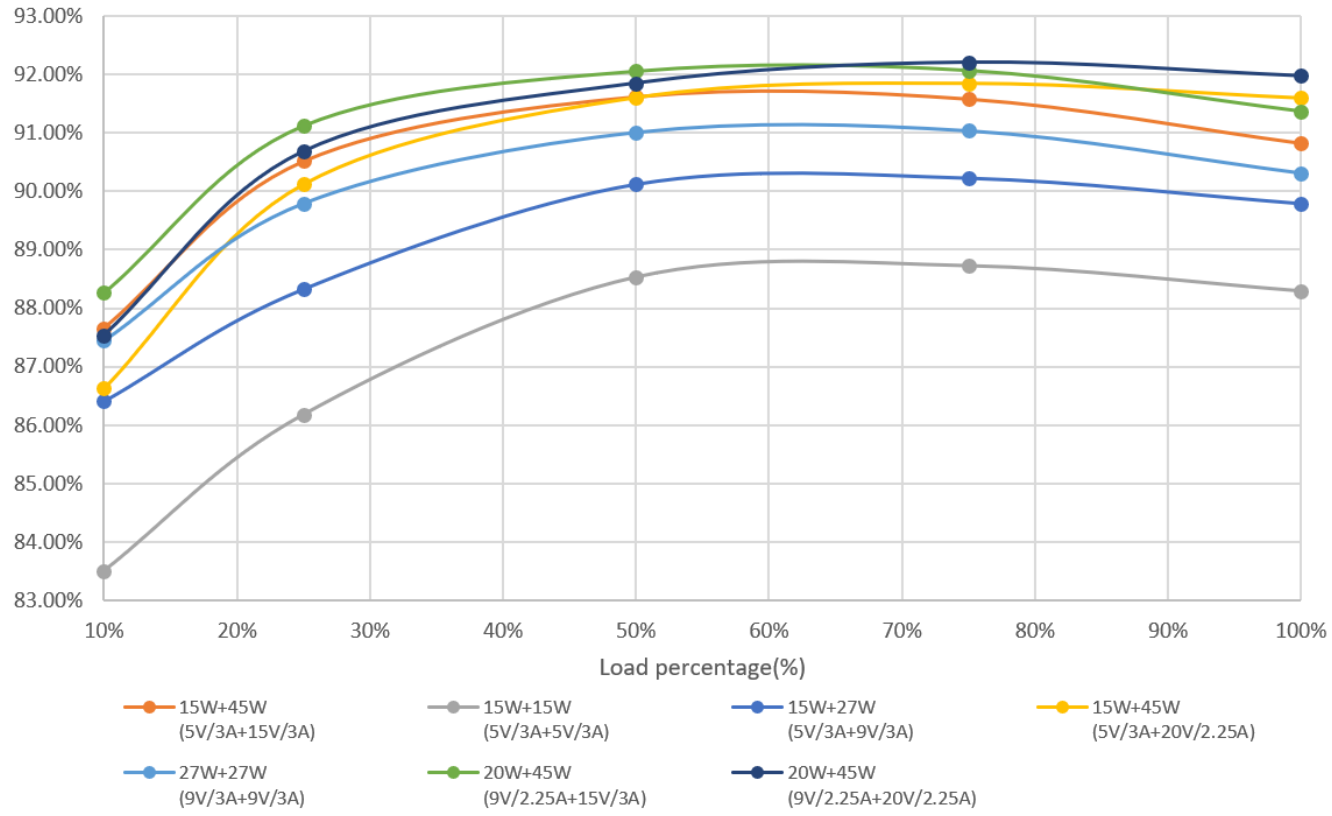


Figure 2-9. Dual Port Efficiency versus Load Percentage at 115VAC Input Voltage

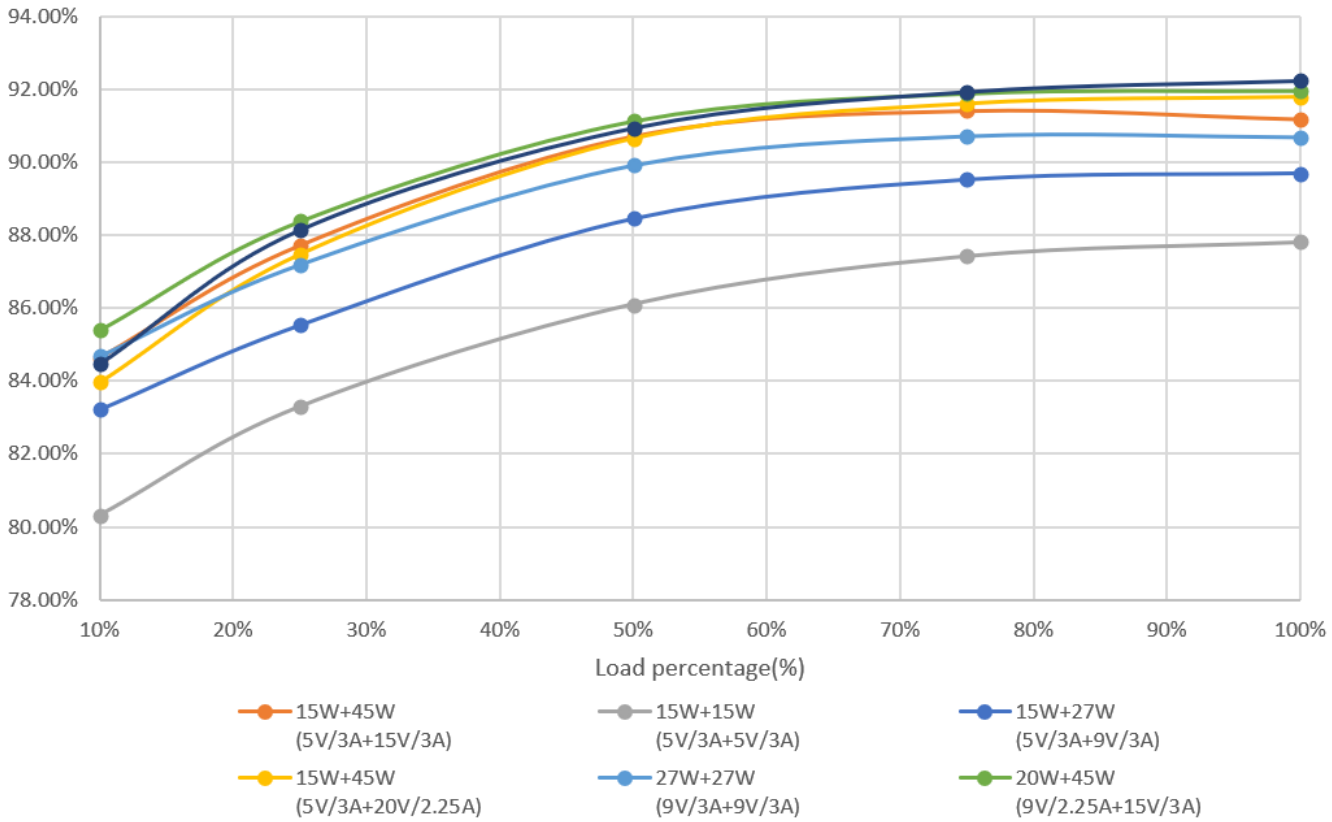


Figure 2-10. Dual Port Efficiency versus Load Percentage at 230VAC Input Voltage

2.2 Voltage Regulation

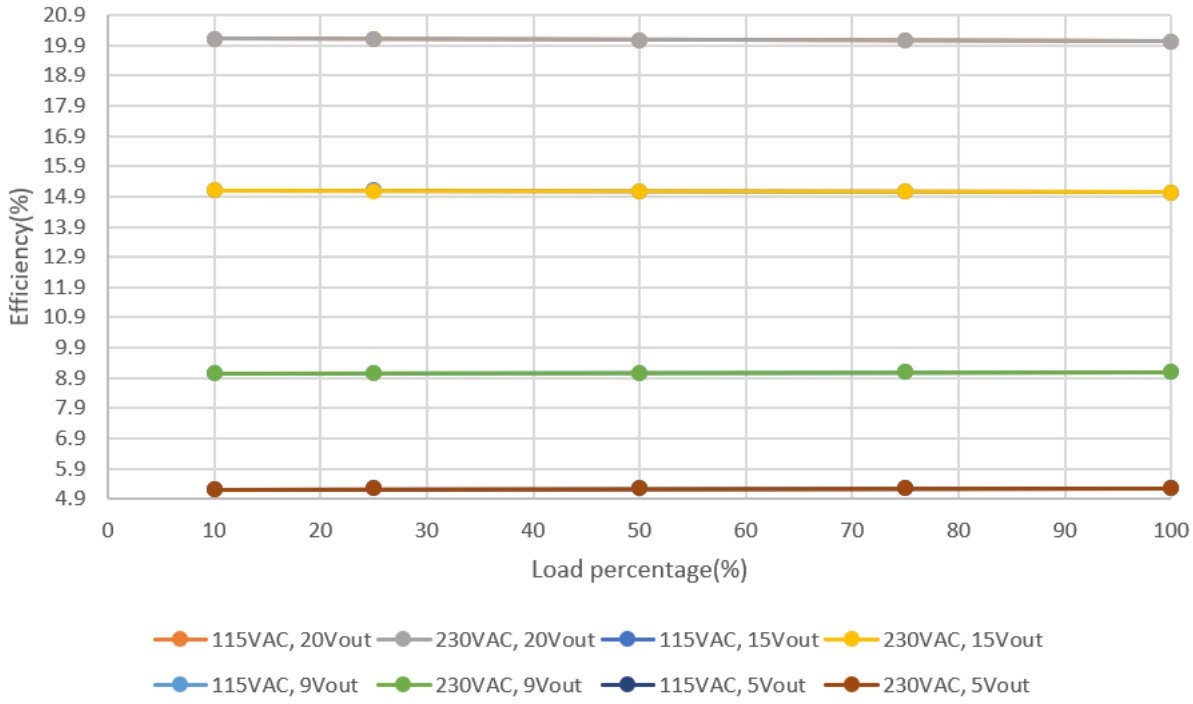


Figure 2-11. Voltage Regulation Versus Load and AC Input Voltage

2.3 No Load Power Consumption

Table 2-1. No Load Power Consumption Across AC Input

VAC_IN(V)	90	115	230	264
No load power consumption (mW)	19	23	30	33

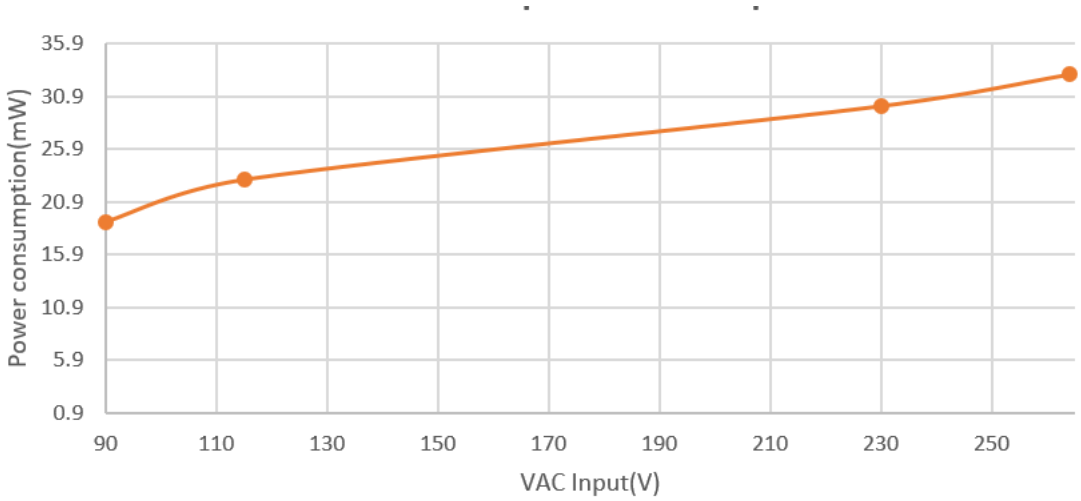


Figure 2-12. No Load Input Power Consumption versus AC Input Voltage

2.4 Efficiency Data

The following tables provide the single port efficiency data.

Table 2-2. Single Port, 20V_{out}, Full Load Efficiency and Power Loss

Test Condition	Vin_AC (V)	Efficiency	Power Loss (W)
Output:20V, 3.25A	90	91.80%	5.84
Output:20V, 3.25A	115	93.00%	4.93
Output:20V, 3.25A	230	93.32%	4.68
Output:20V, 3.25A	264	92.21%	5.53

Table 2-3. Single Port Four-Point Load Average Load Efficiency Across VAC Input Voltage

Test condition	115VAC	230VAC	DoE 6	Pass or Fail
25%, 50%, 75%, 100% load average efficiency at Output 20V, 3.25A	92.97%	92.15%	88%	Pass
25%, 50%, 75%, 100% load average efficiency at Output 15V, 3A	92.50%	91.09%	87.73%	Pass
25%, 50%,75%, 100% load average efficiency at Output 9V, 3A	90.61%	88.47%	86.62%	Pass
25%, 50%, 75%, 100% load average efficiency at Output 5V, 3A	88.03%	85.78%	81.39%	Pass

Table 2-4. 10% Load Efficiency Across VAC Input Voltage

Test Condition	115VAC	230VAC	CoC V5 Tier2	Pass or Fail
10% load at Output 20V, 3.25A	88.98%	85.94%	79%	Pass
10% load at Output 15V, 3A	88.35%	84.99%	78.85%	Pass
10% load at Output 9V, 3A	87.10%	84.09%	77.30%	Pass
10% load at Output 5V, 3A	82.38%	79.93%	74.50%	Pass

The following tables provide the dual port efficiency data.

Table 2-5. Dual Port Rated Full Load Efficiency and Power Loss Across AC Input Voltage

Test condition	VIN_AC(V)	Efficiency	Power Loss (W)
Port1 9V, 2.25A; Port2 20V, 2.25A	90	90.71%	6.73
Port1 9V, 2.25A; Port2 20V, 2.25A	115	91.97%	5.74
Port1 9V, 2.25A; Port2 20V ,2.25A	230	92.23%	5.54
Port1 9V, 2.25A; Port2 20V, 2.25A	264	91.94%	5.76
Port1 9V, 2.25A; Port2 15V, 3A	90	89.93%	7.35
Port1 9V, 2.25A; Port2 15V, 3A	115	91.37%	6.20
Port1 9V, 2.25A; Port2 15V, 3A	230	91.97%	5.73
Port1 9V, 2.25A; Port2 15V, 3A	264	91.69%	5.95
Port1 5V, 3A; Port2 20V, 2.25A	90	90.46%	6.42
Port1 5V, 3A; Port2 20V, 2.25A	115	91.59%	5.59
Port1 5V, 3A; Port2 20V, 2.25A	230	91.78%	5.45

Table 2-5. Dual Port Rated Full Load Efficiency and Power Loss Across AC Input Voltage (continued)

Test condition	VIN_AC(V)	Efficiency	Power Loss (W)
Port1 5V, 3A; Port2 20V, 2.25A	264	91.36%	5.75
Port1 5V, 3A; Port2 15V, 3A	90	89.51%	7.13
Port1 5V, 3A; Port2 15V, 3A	115	90.82%	6.15
Port1 5V, 3A; Port2 15V, 3A	230	91.18%	5.88
Port1 5V, 3A; Port2 15V,3A	264	90.87%	6.11
Port1 9V, 3A; Port2 9V, 3A	90	89.17%	6.62
Port1 9V, 3A; Port2 9V, 3A	115	90.31%	5.85
Port1 9V, 3A; Port2 9V, 3A	230	90.68%	5.60
Port1 9V,3A; Port2 9V,3A	264	90.32%	5.84
Port1 5V,3A; Port2 9V,3A	90	88.96%	5.33
Port1 5V, 3A; Port2 9V, 3A	115	89.79%	4.88
Port1 5V,3A; Port2 9V,3A	230	89.70%	4.94
Port1 5V, 3A; Port2 9V,3A	264	89.34%	5.13
Port1 5V,3A; Port2 5V,3A	90	87.95%	4.31
Port1 5V, 3A; Port2 5V, 3A	115	88.29%	4.17
Port1 5V, 3A; Port2 5V,3A	230	87.79%	4.38
Port1 5V, 3A; Port2 5V, 3A	264	87.22%	4.62

Table 2-6. Dual port four-point load average efficiency across VAC input voltage

Test condition	115	230	DoE VI	Pass or Fail
25%, 50%, 75%,100% load average efficiency at 9V, 2.25A ; 20V, 2.25A	91.67%	90.81%	86%	Pass
25%, 50%, 75%,100% load average efficiency at 9V, 2.25A ; 15V,3A	91.65%	90.84%	86%	Pass
25%, 50%, 75%,100% load average efficiency at 5V, 3A ; 20V, 2.25A	91.29%	90.37%	86%	Pass
25%, 50%, 75%,100% load average efficiency at 9V, 2.25A ; 15V, 3A	91.13%	90.25%	86%	Pass
25%, 50%, 75%, 100% load average efficiency at 9V, 3A ; 9V, 3A	90.54%	89.62%	84.13%	Pass
25%, 50%, 75%, 100% load average efficiency at 5V, 3A ; 9V, 3A	89.62%	88.30%	84.13%	Pass
25%, 50%, 75%, 100% load average efficiency at 5V, 3A ; 5V, 3A	87.93%	86.15%	81.60%	Pass

Note: Variation of ±0.3% in 4-point average efficiency and ±0.5% in 10% efficiency can be observed.

2.5 Thermal Images

Thermal tests were performed at room temperature, open frame, with 30-minute warm up.

Table 2-7 shows single port full load thermal test results.

Table 2-7. Single Port, 20V, Full Load Thermal Test Result at Room Temperature 25ºC

Temperature(°C)	Test Condition	
Components	**90VAC**	**264VAC**
AC Bridge	102	73
UCG28826	85	89
Transformer	78	79
Synchronous Rectifier MOSFET	82	81
Snubber	100	98
TPS56837HA	86	85
DCDC Buck Inductor	70	69

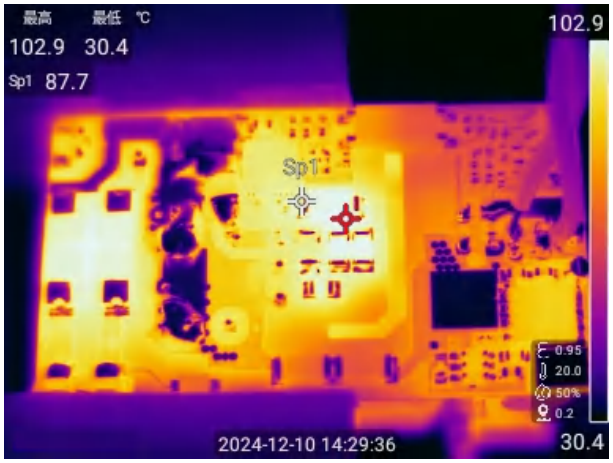


Figure 2-13. 90VAC, Single Port, 20V, Full Load, PCB Bottom Side

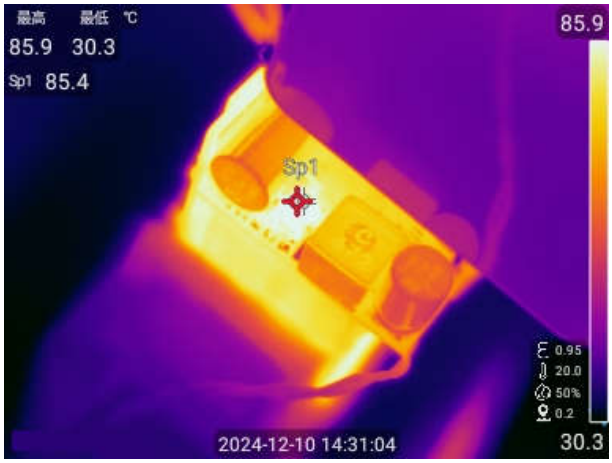


Figure 2-14. 90VAC, Single Port, 20V, Full Load, DCDC Board

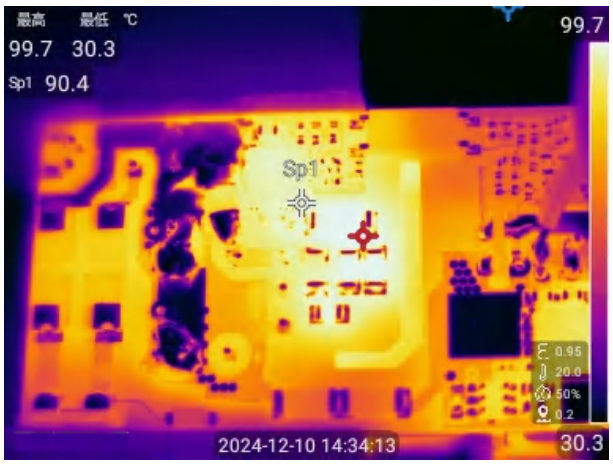


Figure 2-15. 264VAC, Single Port, 20V, Full Load, PCB Bottom Side

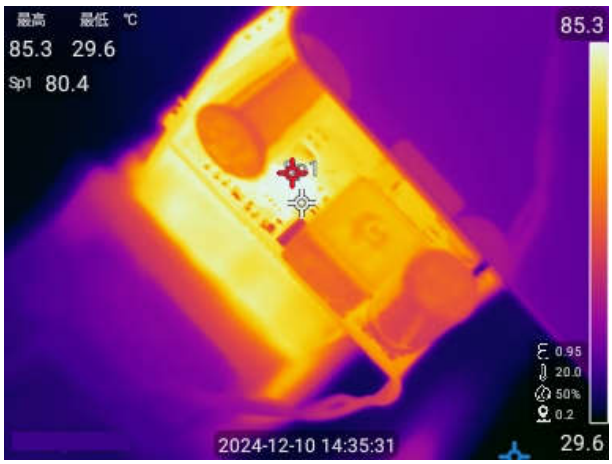


Figure 2-16. 264VAC, Single Port, 20V, Full Load, DCDC Board

Table 2-8 details the dual port full load thermal test results.

Table 2-8. Dual Port Full Load Thermal Test Results

Temperature(°C)	Thermal Test at 45W+20W, Port 1: 15V, 3A, Port2: 9V, 2.25A	
Components	**90VAC**	**264VAC**
AC Bridge	106	75
UCG28826	88	91
Transformer	79	76
Synchronous Rectifier MOSFET	89	87
Snubber	103	100
TPS56837HA_45W	94	91
DCDC Buck Inductor_45W	74	73
TPS56837HA_20W	92	89
DCDC Buck Inductor_20W	75	72

Figure 2-17 through Figure 2-21 show the dual port full load thermal test results with 45W+20W power profile thermal images.

Figure 2-17. 90VAC, Dual Port, 45W (15V, 3A) +20W (9V, 2.25A), Full Load, PCB Bottom Side

Figure 2-18. 90VAC, Dual Port, 45W (15V, 3A) +20W (9V, 2.25A), Full Load, DCDC Board

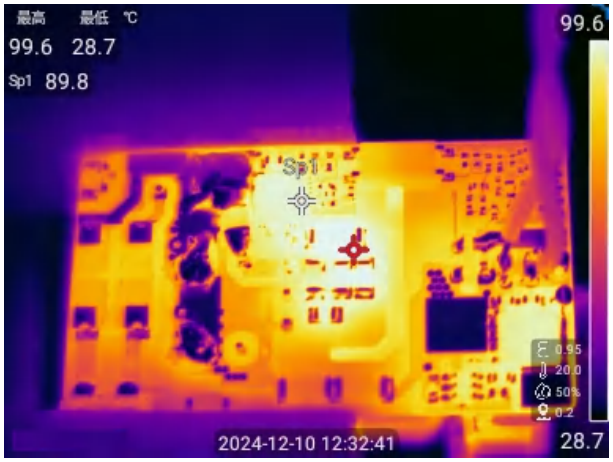


Figure 2-19. 264VAC, Dual Port, 45W (15V, 3A) +20W (9V, 2.25A), Full Load, PCB Bottom Side

Figure 2-20. 264VAC, Dual Port, 45W (15V, 3A) +20W (9V,2.25A), Full Load, DCDC Board

Figure 2-21. 90VAC, Dual Port, 45W (15V, 3A) +20W (9V, 2.25A), Full Load, PCB Bottom Side

2.6 EMI

The test was performed with resistive load, un-earthed condition.

EMI TEST REPORT

parameter

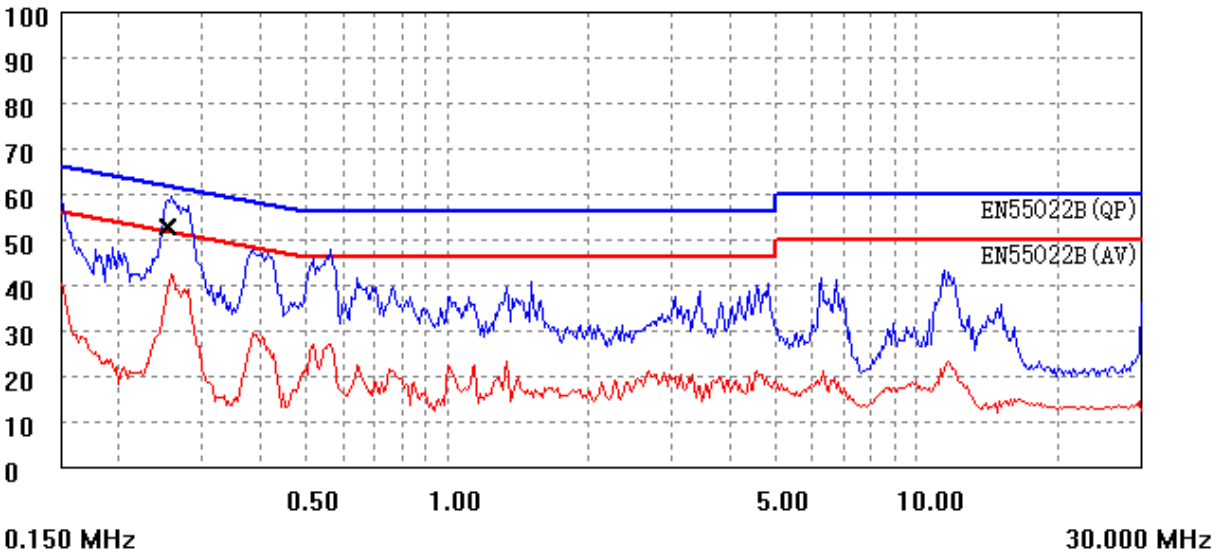
Organization:		Operator:		EUT:	
Place:		Time:	2024/12/4/15:13	Test equipment:	KH3932
Detector:	PK+AV	Test-time(ms):	30	SN:	320684
Limit:	EN55022B	Transductor(PK/AV):	PK / AV	JZ:	2,15,1038
Remark:					

freq, step

Start(MHz)	End(MHz)	Step(MHz)
0.150	2.000	0.002
2.000	10.000	0.010
10.000	30.000	0.025

scan result

dBuV



final test

	freq(MHz)	lev(dBuV)	Lim(dBuV)	Δ(lev-Lim)
(QP)	0.254	52.8	63.0	-10.2

Figure 2-22. 115VAC, 20V 3.25A, L Phase

EMI TEST REPORT

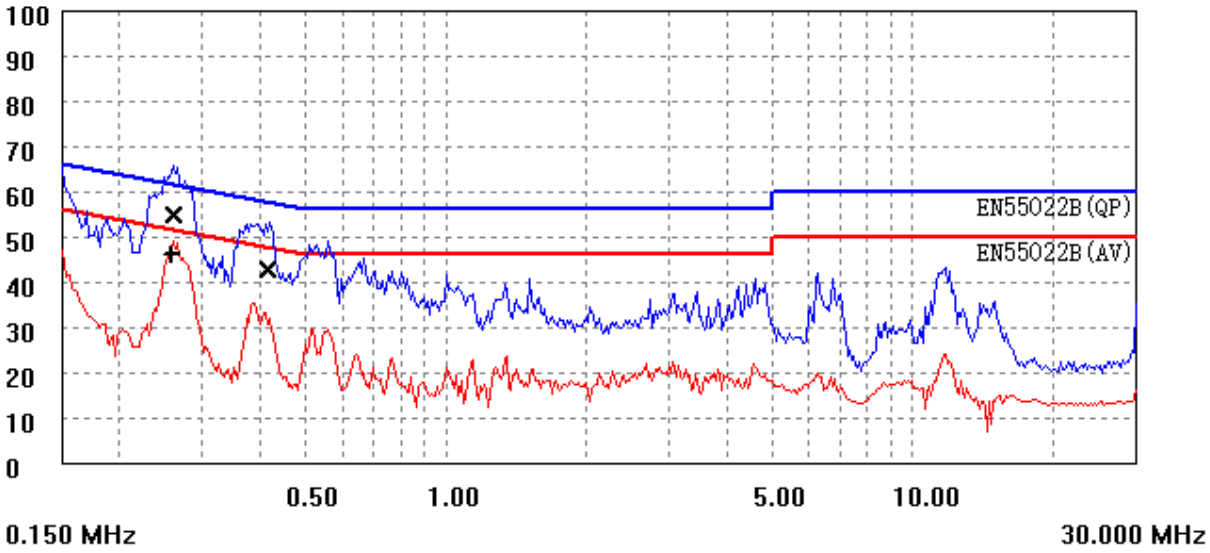
parameter

Organization:		Operator:		EUT:	
Place:		Time:	2024/12/4/15:08	Test equipment:	KH3932
Detector:	PK+AV	Test-time(ms):	30	SN:	320684
Limit:	EN55022B	Transductor(PK/AV):	PK / AV	JZ:	2,15,1036
Remark:					

freq, step

Start(MHz)	End(MHz)	Step(MHz)
0.150	2.000	0.002
2.000	10.000	0.010
10.000	30.000	0.025

scan result



final test

(QP)	freq(MHz)	lev(dBuV)	Lim(dBuV)	Δ(lev-Lim)
	0.261	54.7	62.8	-8.1
	0.414	42.7	58.5	-15.7
(AV)	freq(MHz)	lev(dBuV)	Lim(dBuV)	Δ(lev-Lim)
	0.259	45.9	52.9	-7.0

Figure 2-23. 115VAC, 20V 3.25A, N Phase

EMI TEST REPORT

parameter

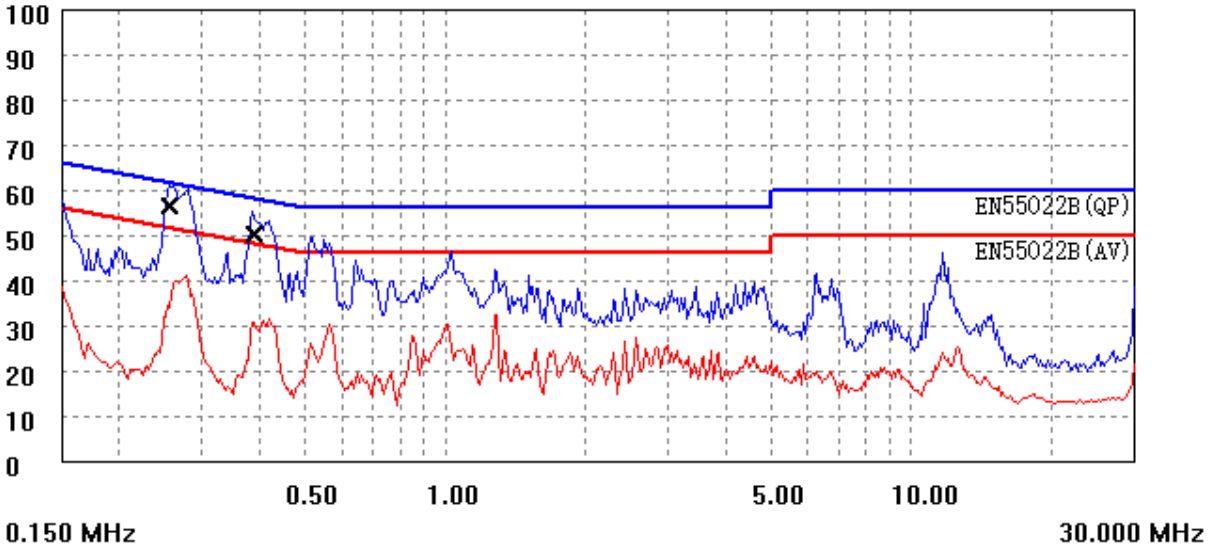
Organization:		Operator:		EUT:	
Place:		Time:	2024/12/4/15:24	Test equipment:	KH3932
Detector:	PK+AV	Test-time(ms):	30	SN:	320684
Limit:	EN55022B	Transductor(PK/AV):	PK / AV	JZ:	2,15,1036
Remark:					

freq, step

Start(MHz)	End(MHz)	Step(MHz)
0.150	2.000	0.002
2.000	10.000	0.010
10.000	30.000	0.025

scan result

dBuV



final test

[QP]	freq(MHz)	lev(dBuV)	Lim(dBuV)	Δ(lev-Lim)
	0.257	56.4	62.9	-6.6
	0.388	50.1	59.2	-9.1

Figure 2-24. 230VAC, 20V 3.25A, L Phase

EMI TEST REPORT

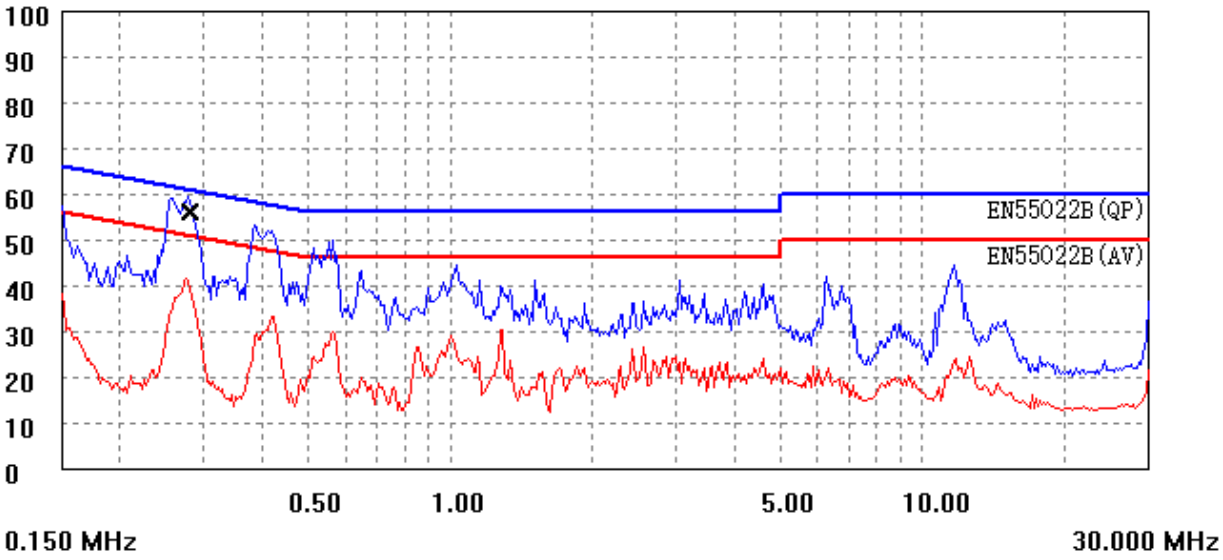
parameter

Organization:		Operator:		EUT:	
Place:		Time:	2024/12/4/15:18	Test equipment:	KH3932
Detector:	PK+AV	Test-time(ms):	30	SN:	320684
Limit:	EN55022B	Transductor(PK/AV):	PK / AV	JZ:	2,15,1033
Remark:					

freq, step

Start(MHz)	End(MHz)	Step(MHz)
0.150	2.000	0.002
2.000	10.000	0.010
10.000	30.000	0.025

scan result



final test

(QP)	freq(MHz)	lev(dBuV)	Lim(dBuV)	Δ(lev-Lim)
	0.281	56.0	62.3	-6.2

Figure 2-25. 230VAC, 20V 3.25A, N Phase

3 Waveforms

3.1 Start-Up and Shut Down Waveforms

The following waveforms show the start-up and shut down waveform at 90VAC, 264VAC input.

CH1: VAC Input, CH2:VOUT, CH3: Vout_ACDC, CH4: Iout

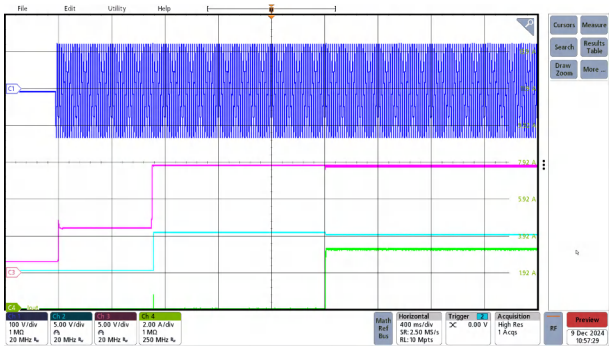


Figure 3-1. 90VAC, Start-up

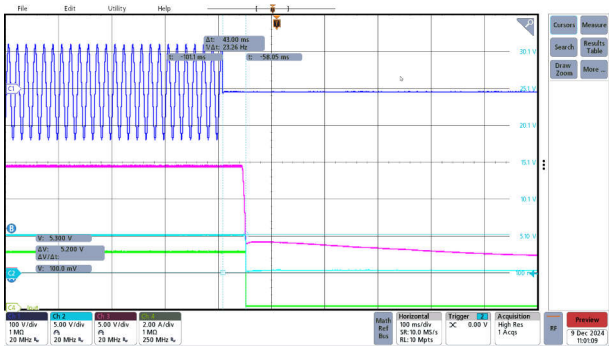


Figure 3-2. 90VAC, Shut Down

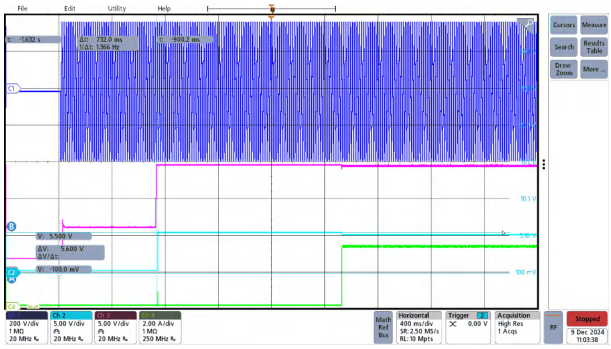


Figure 3-3. 264VAC, Start-Up

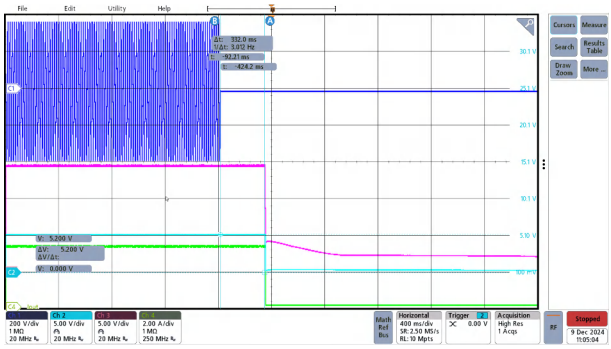


Figure 3-4. 264VAC, Shut Down

3.2 Voltage Transition

The following waveforms show the voltage transition per USB PD emulator request.

CH1: VAC Input, CH2:VOUT, CH3: Vout_ACDC, CH4: Iout

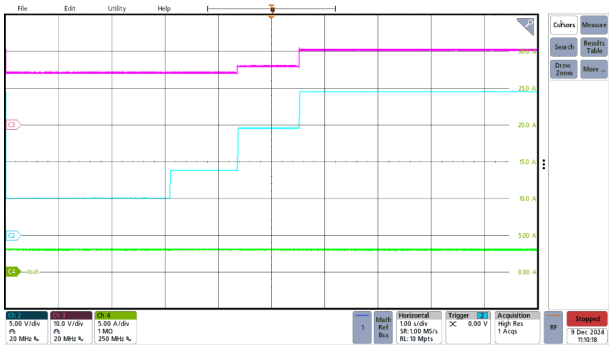


Figure 3-5. 115VAC, 5V to 9V, 15V, 20V Voltage Transition at Full Load

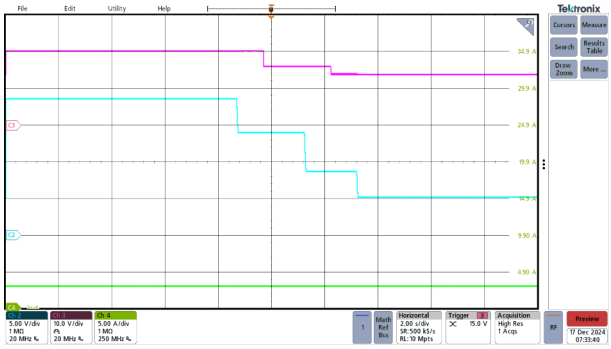


Figure 3-6. 115VAC, 20V to 15V, 9V, 5V Voltage Transition at Full Load

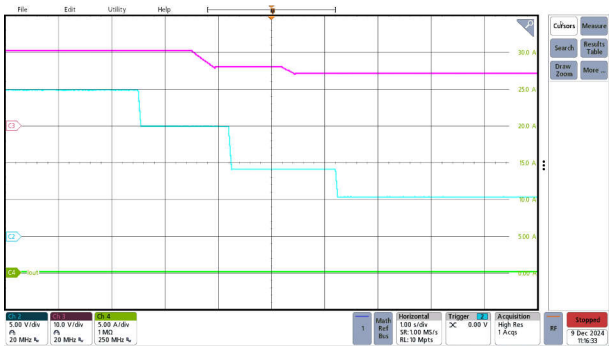


Figure 3-7. 115VAC, 20V to 5V Voltage Transition at Open Load

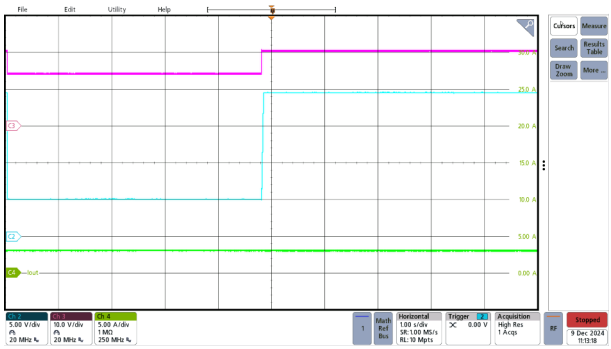


Figure 3-8. 115VAC, 5V to 20V Voltage Transition at Full Load

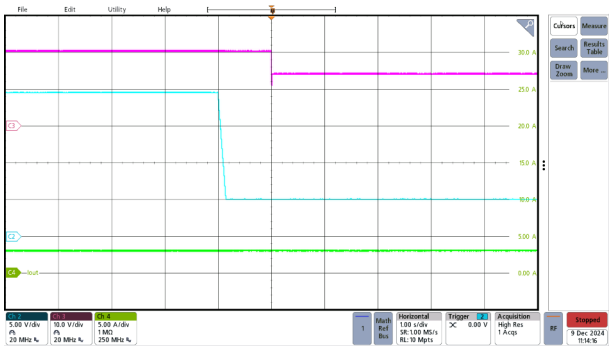


Figure 3-9. 115VAC, 20V to 5V Voltage Transition at Full Load

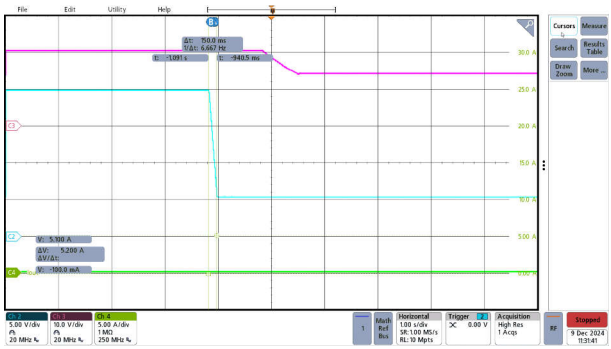


Figure 3-10. 115VAC, 20V to 5V Voltage Transition at Open Load

3.3 Switching Waveform

The following images are primary switching node and synchronous rectifier gate waveforms.

CH1: Vpri_ds, CH2: SR_Gate

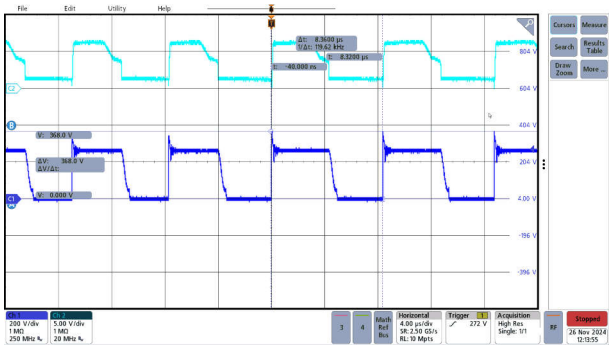


Figure 3-11. 115VAC, Vds_pri, VSR_gate, 20V, Full Load

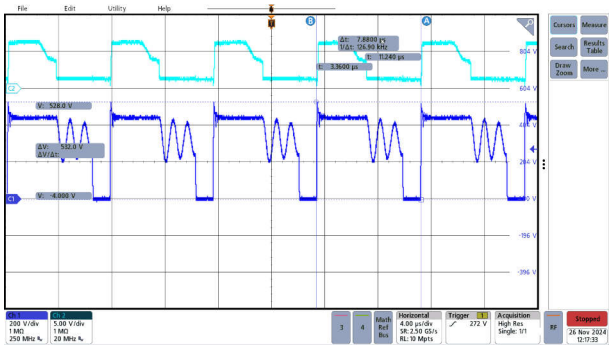


Figure 3-12. 230VAC, Vds_pri, VSR_gate, 20V, Full Load

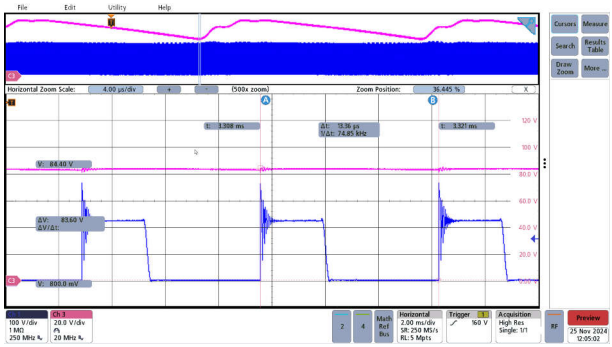


Figure 3-13. 90VAC, Full Load, Vds_pri, Vbus Valley 83V

The following images are 230VAC input ACDC switching node waveforms at different load conditions.

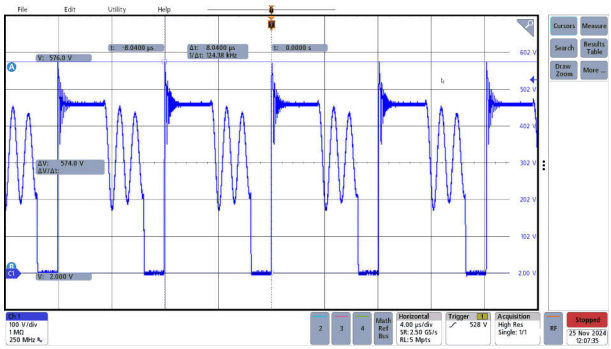


Figure 3-14. 230VAC, 20V, 3.25A, fsw = 125KHz

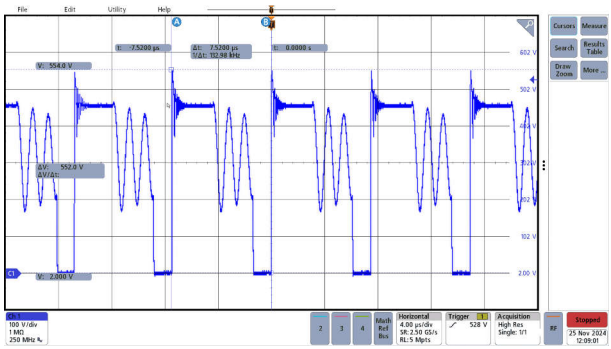


Figure 3-15. 230VAC, 20V, 75% Load, 2.45A, fsw = 133KHz

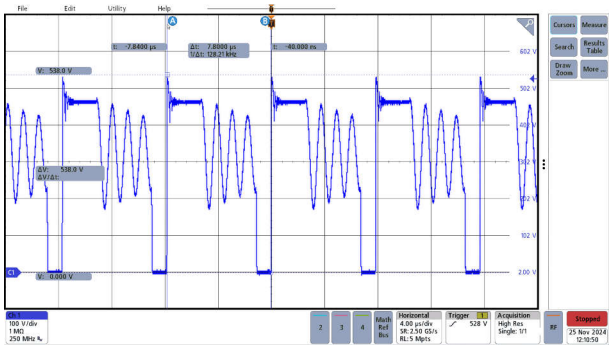


Figure 3-16. 230VAC, 20V, 50% Load, 1.6A, fsw = 128KHz

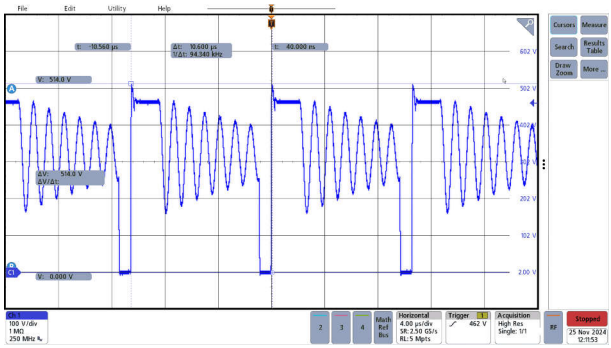


Figure 3-17. 230VAC, 20V, 25% Load 0.82A, fsw = 94KHz

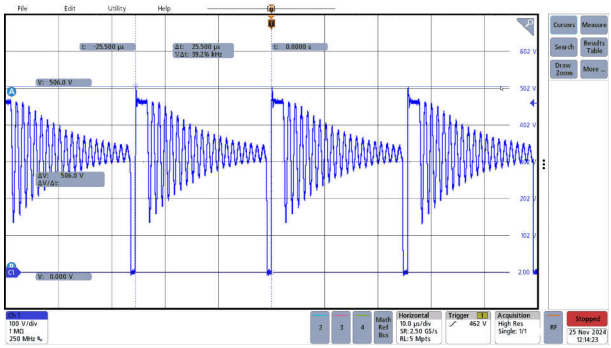


Figure 3-18. 230VAC, 10% Load 0.32A, fsw = 39KHz

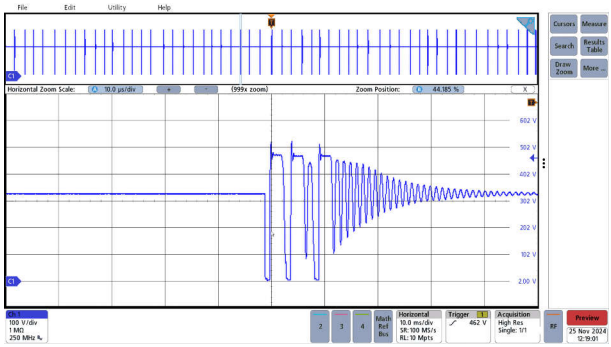


Figure 3-19. 230VAC, 20V, 200mW Load, Vds_pri

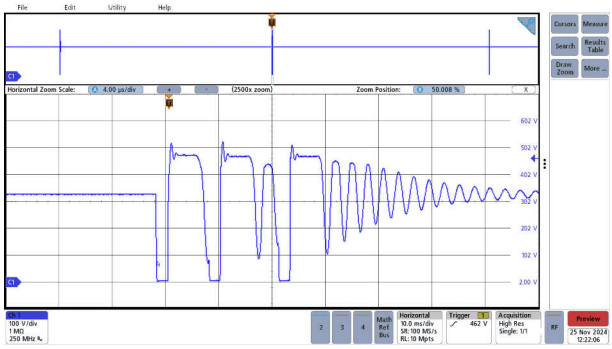


Figure 3-20. 230VAC, 20V, Open Load, Vds_pri

The following images are 115VAC input ACDC switching node waveforms at different load conditions.

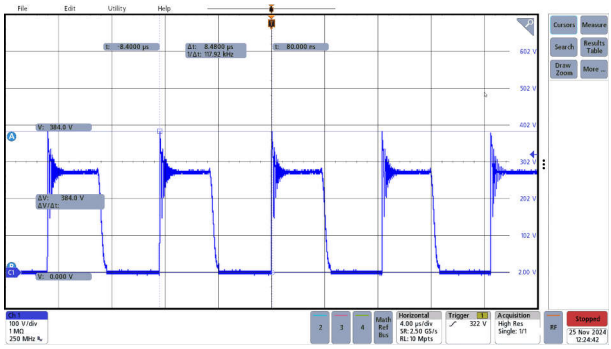


Figure 3-21. 115VAC, 20V, 3.25A Full Load, Vds_pri, fsw = 118KHz

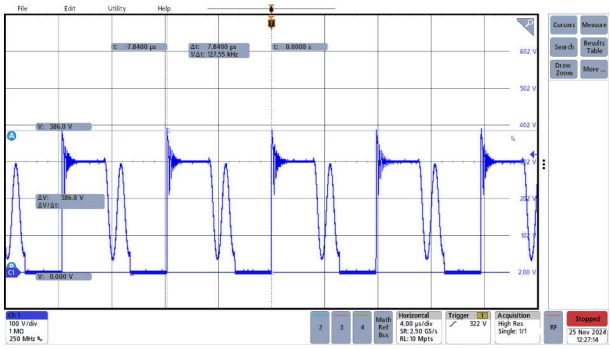


Figure 3-22. 115VAC, 20V, 2.45A 75% Load, Vds_pri, fsw = 127KHz

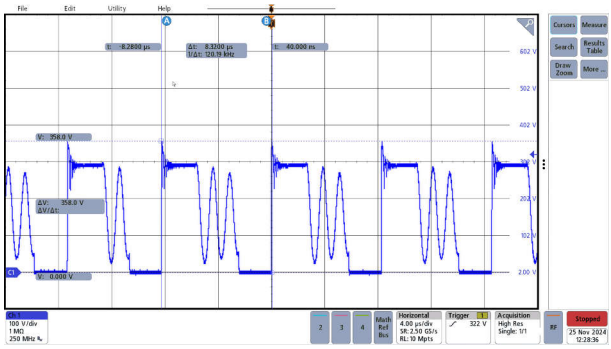


Figure 3-23. 115VAC, 20V, 1.8A 50% Load, Vds_pri, fsw = 120KHz

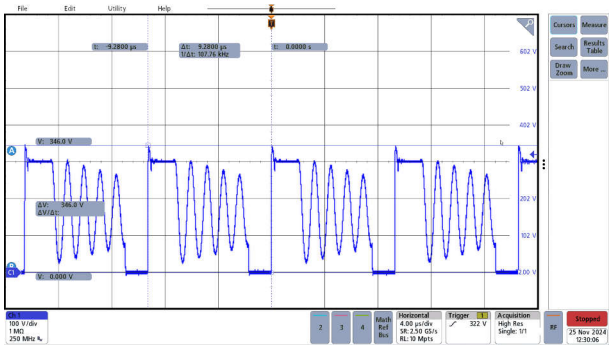


Figure 3-24. 115VAC, 20V, 0.82A 25% Load, Vds_pri, fsw = 107KHz

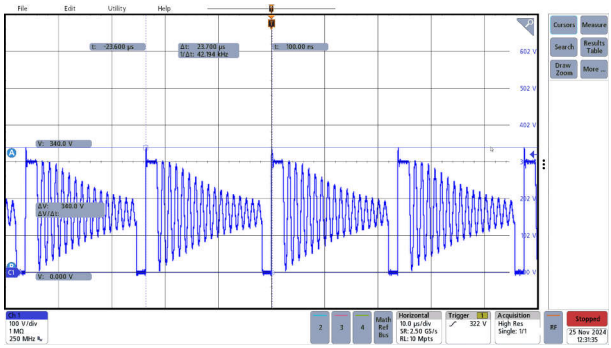


Figure 3-25. 115VAC, 20V, 0.32A 10% Load, Vds_pri, fsw = 42KHz

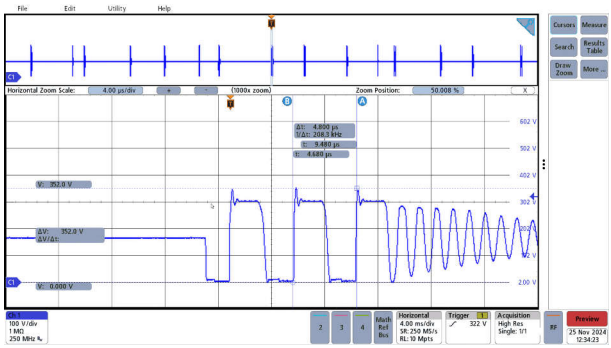


Figure 3-26. 115VAC, 20V, 200mW Load, Vds_pri

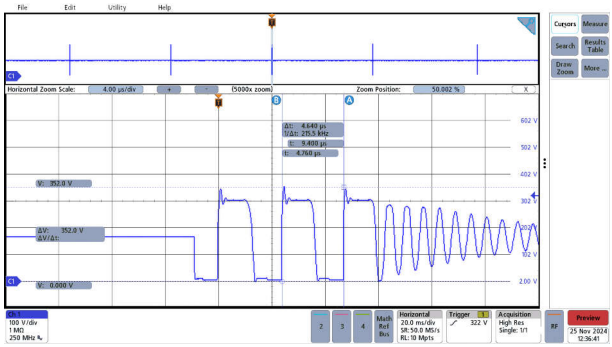


Figure 3-27. 115VAC, 20V, Open Load, Vds_pri, 3 Consecutive Switching Cycle to Achieve First Valley Switching

3.3.1 Voltage Stress at Normal Operation

Figure 3-28 and Figure 3-29 show the voltage stress on primary and secondary switches at 264VAC input, full load.

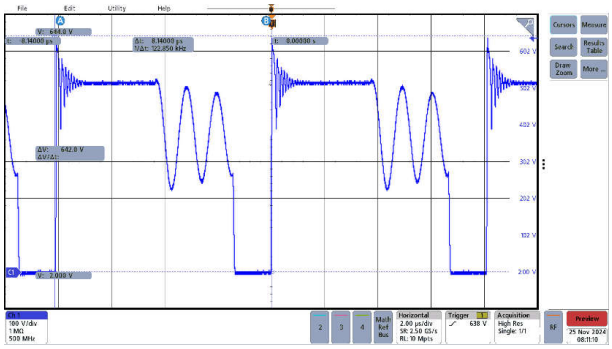


Figure 3-28. Vds_pri,264VAC, Full Load, Vds Voltage Stress 640V

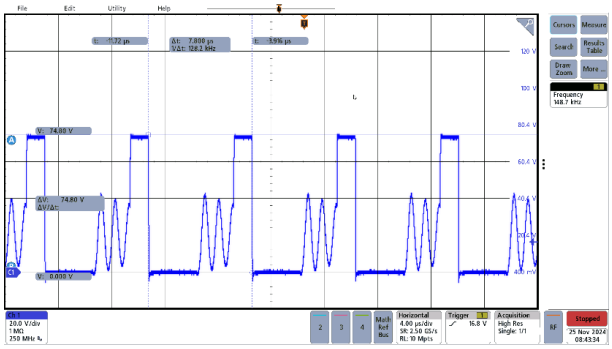


Figure 3-29. Vds_sr, 264VAC, Full Load, Vds Voltage Stress 74.8V

3.3.2 Voltage Stress at Start-Up

Figure 3-30 and Figure 3-31 show the voltage stress on primary side switches at 264VAC and 90VAC, full load start-up.

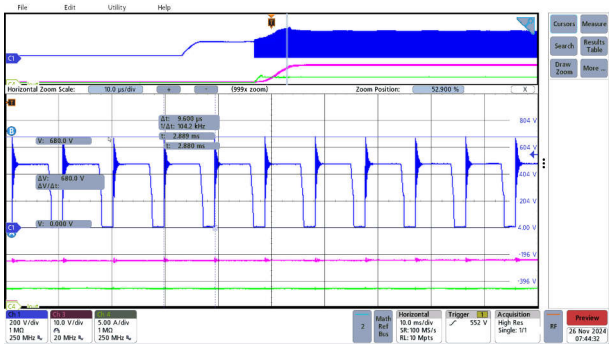


Figure 3-30. Start-Up Vds_pri,264VAC, Full Load, Vds Peak 680V

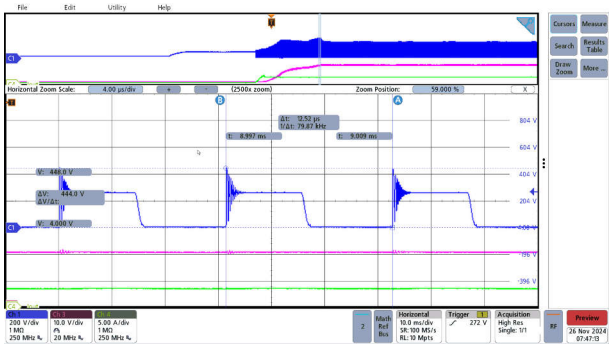


Figure 3-31. Start-Up Vds_pri, 90VAC, Full Load, Vds Peak 446V

3.3.3 VCC Self-Bias Voltage

Figure 3-32 through Figure 3-34 show the VCC voltage at different AC input and load conditions.

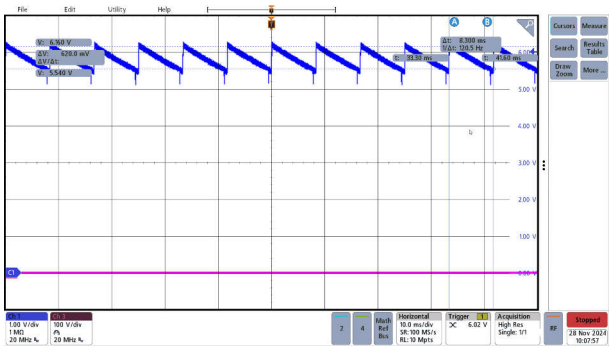


Figure 3-32. 90VAC, Open Load, VCC Charging Frequency 47Hz, fline 47Hz

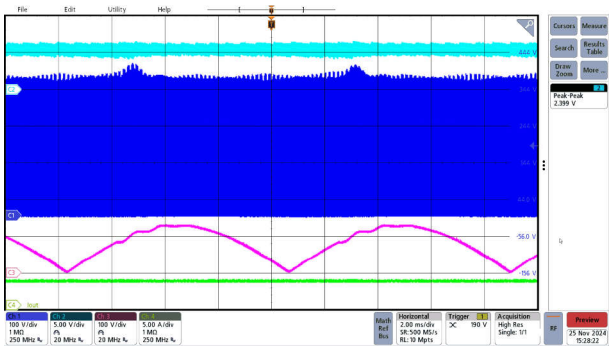


Figure 3-33. VCC Voltage, 90VAC, Full Load

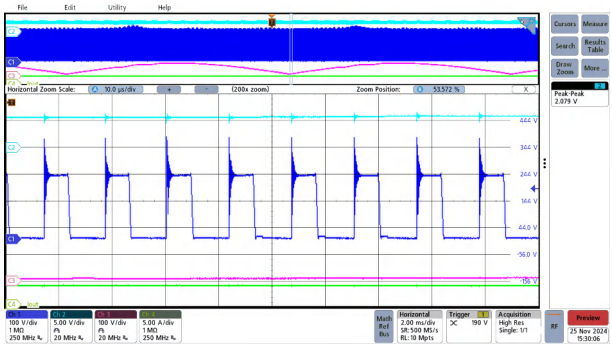


Figure 3-34. VCC Voltage, 90VAC, Full Load, Zoom In at VBUS Valley

Figure 3-35 through Figure 3-37 show the VCC voltage at open load and full load, 230VAC input.

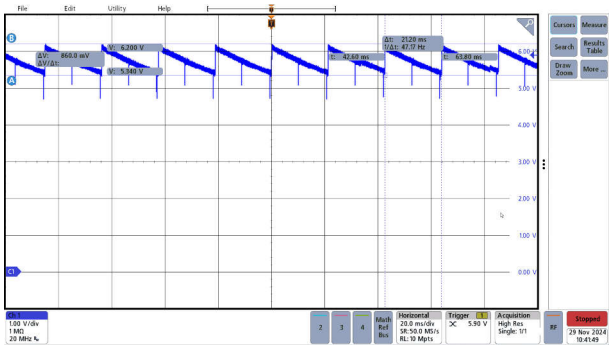


Figure 3-35. 264VAC, Open Load, VCC Charging Frequency 47Hz, fline 47Hz

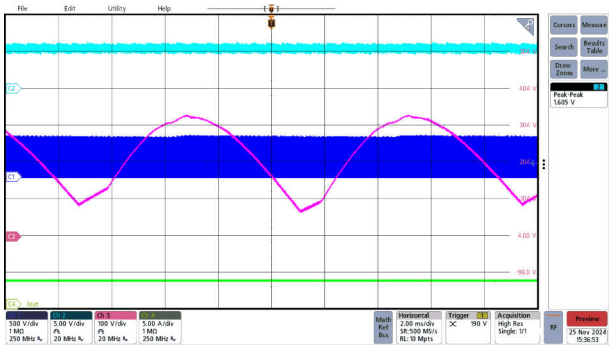


Figure 3-36. VCC Voltage, 230VAC, 20V, Full Load

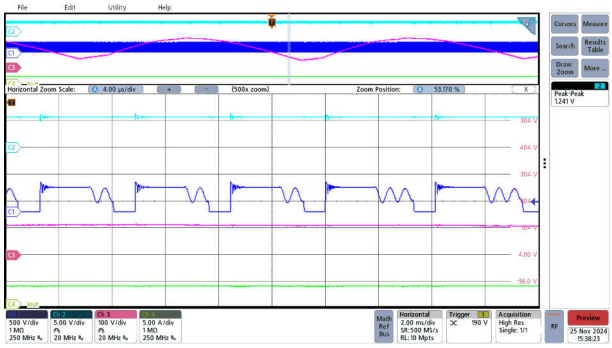


Figure 3-37. VCC Voltage, 230VAC, 20V, Full Load, Zoom In

3.3.4 X Cap Discharge

Figure 3-38 and Figure 3-39 show the X cap discharge at 230VAC and 264VAC, respectively.

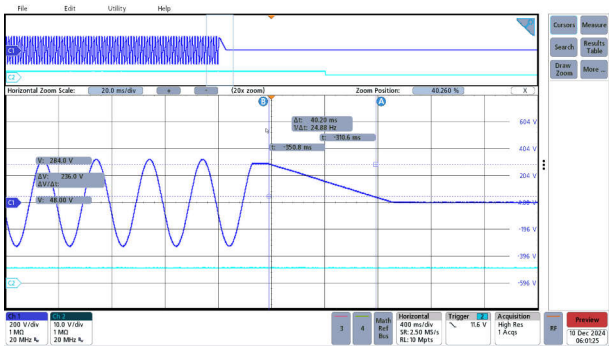


Figure 3-38. X Cap Discharge, 230VAC, 50Hz, 5V, 1A Load, 44ms X Cap Discharge Time

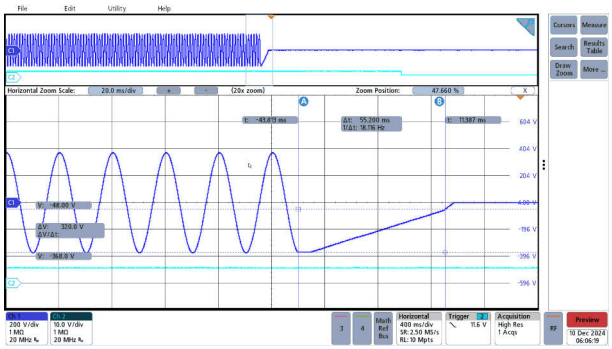


Figure 3-39. X Cap Discharge, 264VAC, 50Hz, 5V, 1A Load, 55ms X Cap Discharge Time

3.4 Ripple and Noise

Figure 3-40 through Figure 3-51 show the ripple and noise at full load, 50%, open load at 5V, 9V, 15V, and 20V conditions.

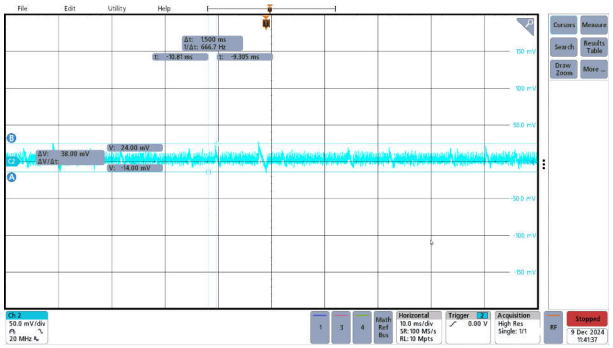


Figure 3-40. 5V, Open Load

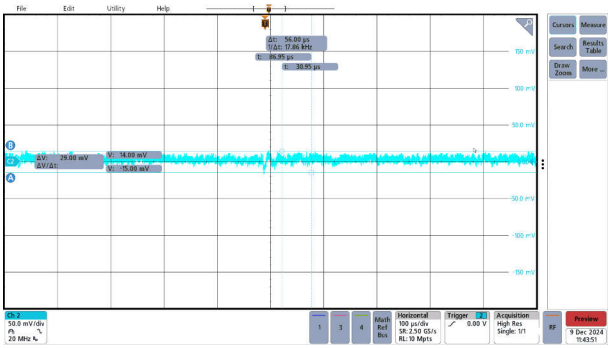


Figure 3-41. 5V, 50% Load, 1.5A

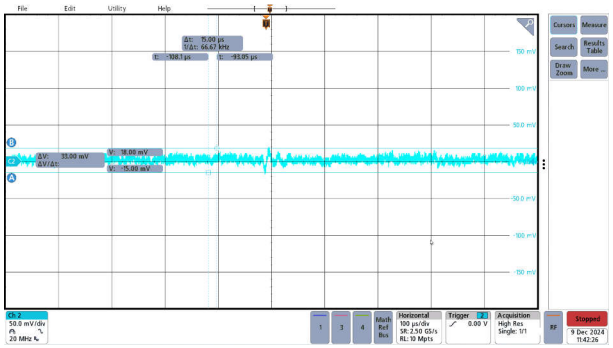


Figure 3-42. 5V, 100% Load, 3A

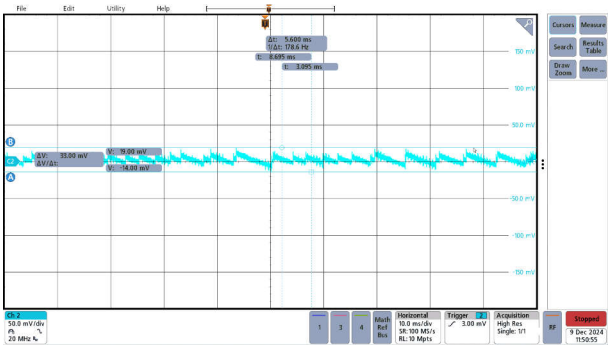


Figure 3-43. 9V, Open Load

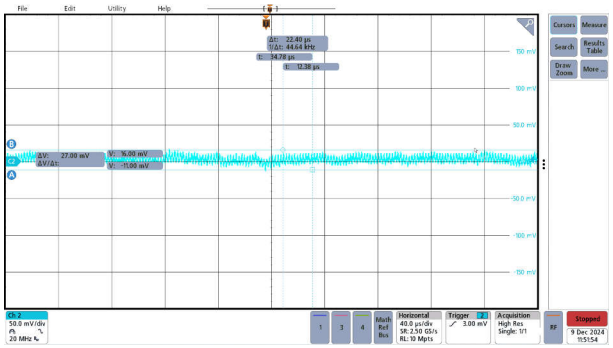


Figure 3-44. 9V, 50% Load, 1.5A

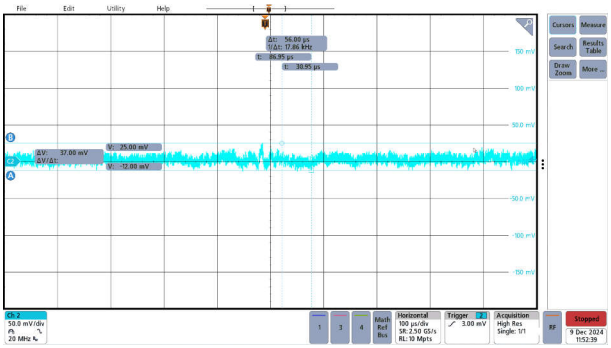


Figure 3-45. 9V, 100% Load, 3A

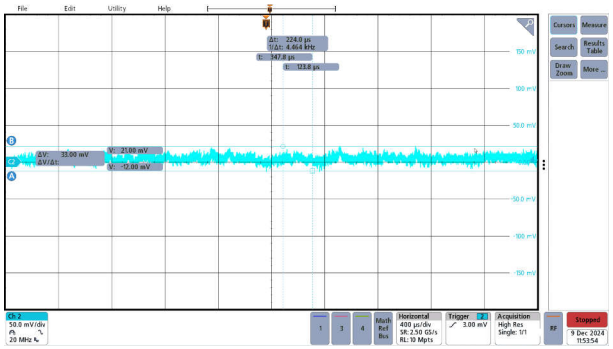


Figure 3-46. 15V, Open Load

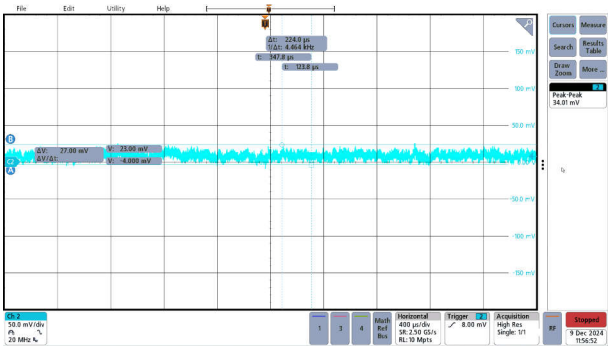


Figure 3-47. 15V, 50% Load, 1.5A

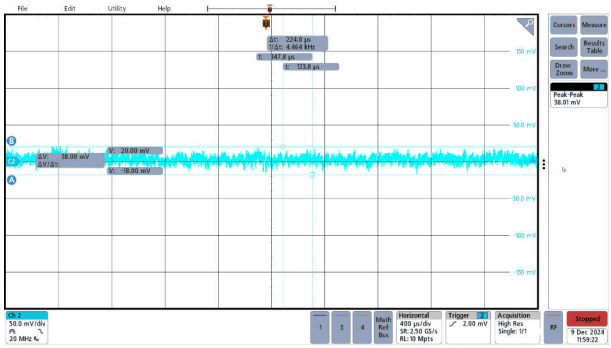


Figure 3-48. 15V, 100% Load, 3A

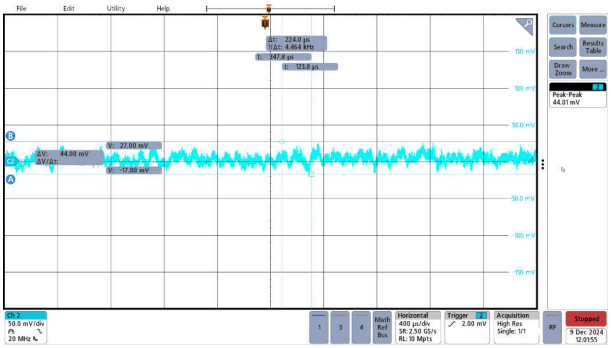


Figure 3-49. 20V, Open Load

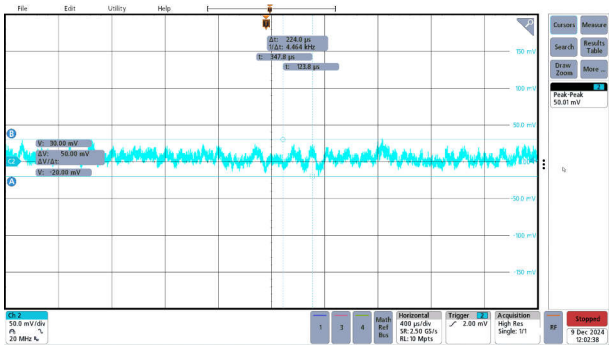


Figure 3-50. 20V, 50% Load, 1.5A

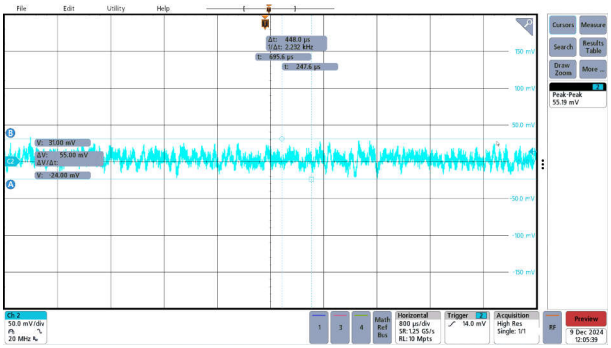


Figure 3-51. 20V, 100% Load, 3A

3.5 Load Transients

The load dynamic test was performed from 0.1A to full load for 5V, 9V, 15V, and 20V individually. The slew rate is set to 0.5A / µs. Output voltage was measured at the PCB end of the USB Type-C receptacle.

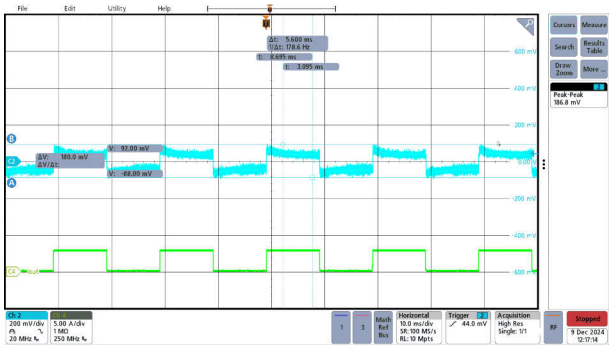


Figure 3-52. Load Transient, 115VAC, 5V, 0.1A to 3A Full Load

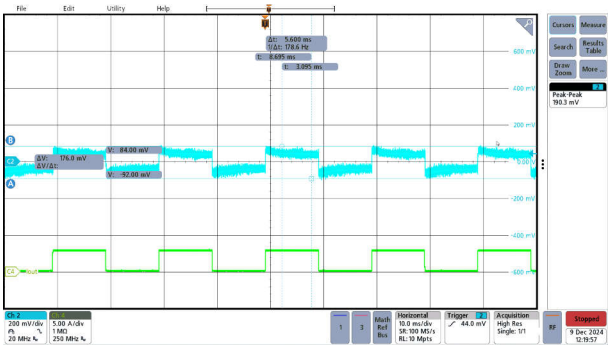


Figure 3-53. Load Transient, 115VAC, 9V, 0.1A to 3A Full Load

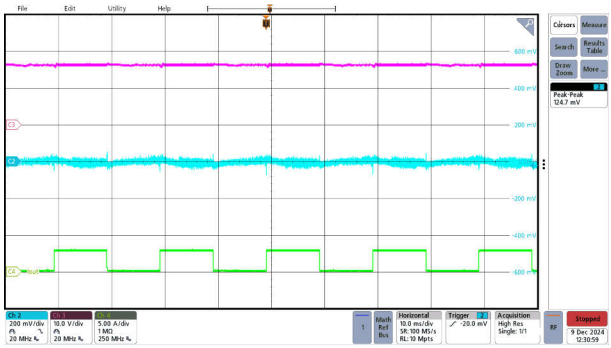


Figure 3-54. Load Transient, 115VAC, 15V, 0.1A to 3A Full Load

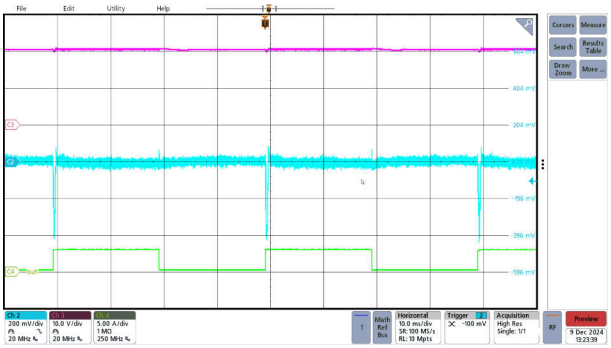


Figure 3-55. Load Transient, 115VAC, 20V, 0.1A to 3.25A Full Load

3.6 Overcurrent Protection

Overcurrent protection (OCP) was performed at the USB Type-C cable end and the test gradually increased the current of E-load at constant current (CC) mode for 5V, 9V, 15V, and 20V individually

OCP Test condition	Vout = 5V	Vout = 9V	Vout = 15V	Vout = 20V
OCP(A)	3.46	3.48	3.49	3.85

CH1: Vout, CH2: Vbuck_output, CH3: Vout_AC-DC, CH4: Iout

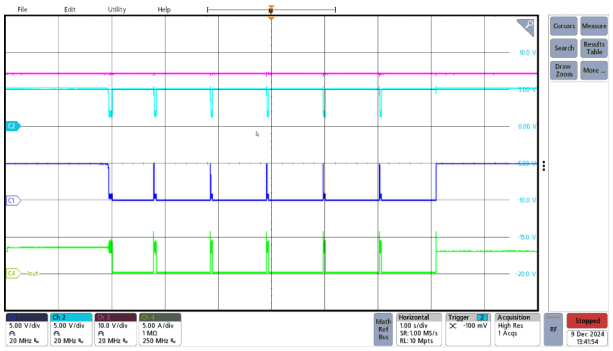


Figure 3-56. 5V, OCP Test

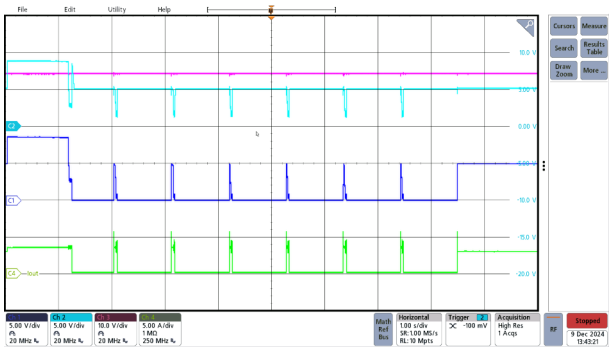


Figure 3-57. 9V, OCP Test

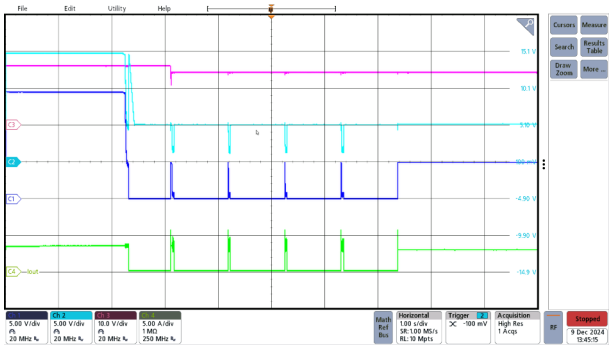


Figure 3-58. 15V, OCP Test

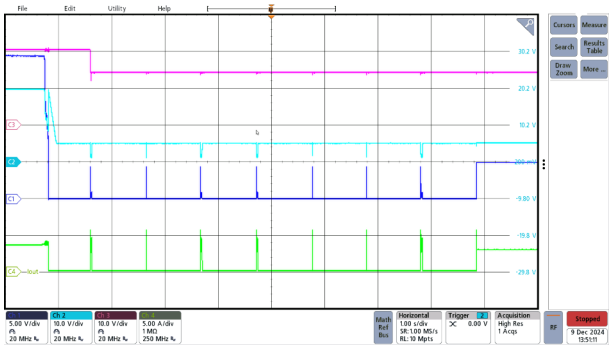


Figure 3-59. 20V, OCP Test

3.7 Short-Circuit Protection

Short-circuit testing was performed at the USB Type-C cable end.

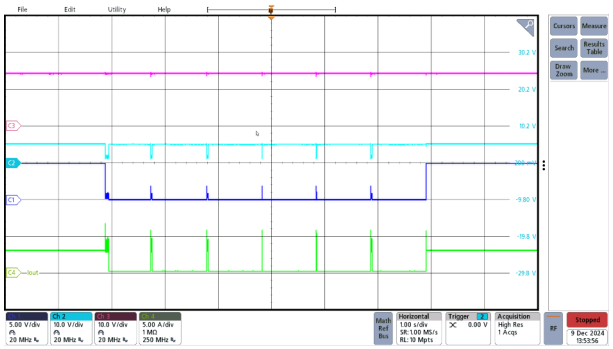


Figure 3-60. Short Circuit at PCB End and Recovery After Short Circuit Removed, 5V Output, 264VAC

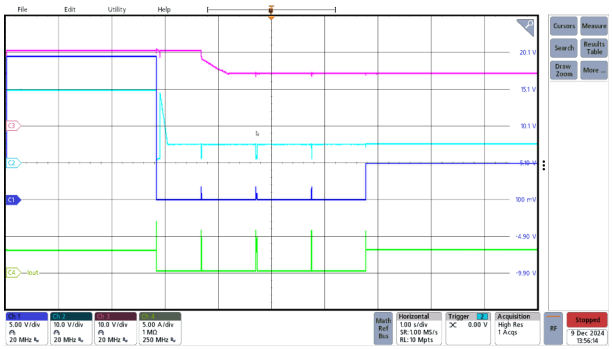


Figure 3-61. Short Circuit at PCB End and Recovery After Short Circuit Removed, 20V Output, 264VAC

3.8 Overvoltage Protection at AC-DC Output

By disconnect output feedback, Vout ramps up and UCG28826 SW pin senses the output voltage and once the sensed voltage triggers the overvoltage protection (OVP) threshold, the OVP protection is triggered.

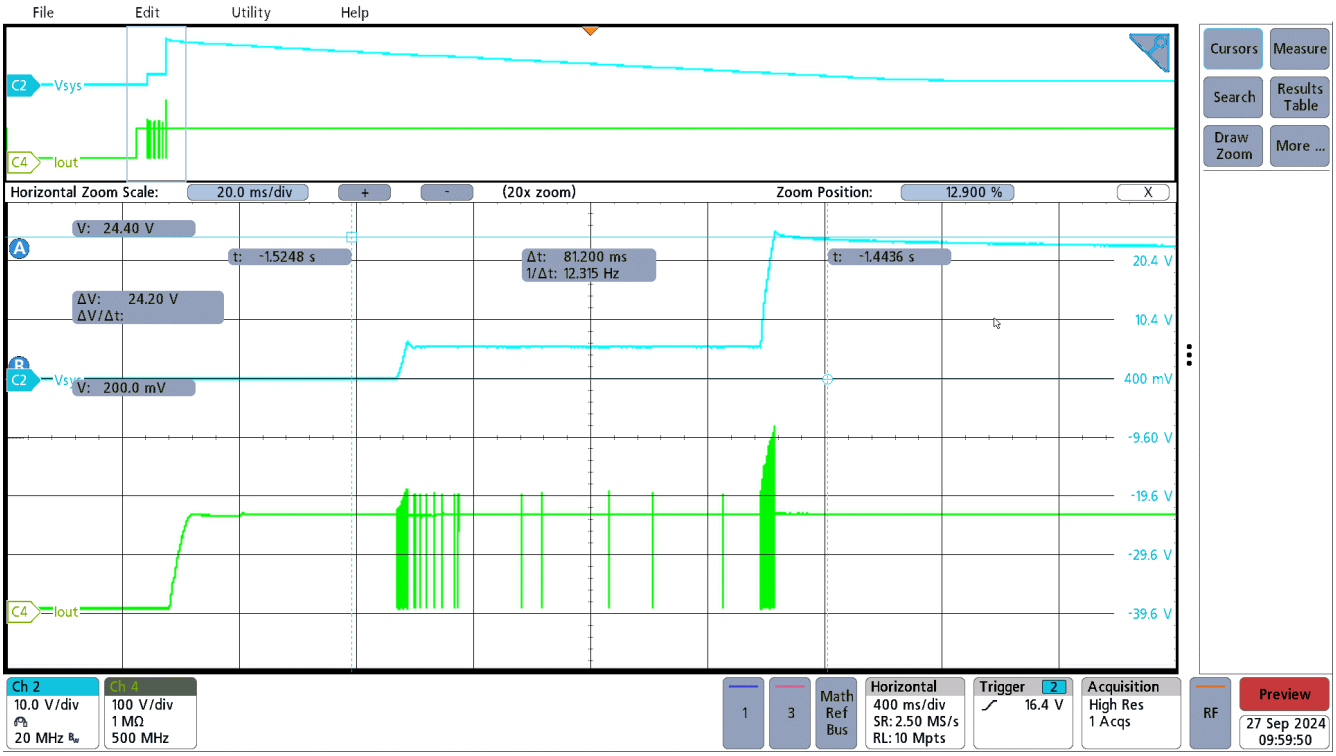


Figure 3-62. OVP, 264VAC, Open Load

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