

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

About this document

Scope and purpose

This document provides power management test results of the 65 W PAG2P-2S HF ZVS REV3 Solution Demo Board. The tests were performed on REV3 ZVS board, which is equipped with Infineon CYPAP212A1-14SXI on the primary and CYPAS211A1-32LQXQ on the secondary section of the converter.

Intended audience

This document is intended for customers and FAEs using the EZ-PD™ PAG2P/PAG2S QR zero voltage switching REF_65W_HFZVS_PAG2_PA hardware.

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Introduction

1 Introduction

This test report captures the performance of PAG2S (Power Adapter Generation 2 – Secondary controller) and PAG2P (Primary controller) high-frequency quasi-resonant zero-voltage switching (QR-ZVS) flyback based on USB PD, 65 W adapter solution demo kit. This is a highly power-dense form-factor (32 W/inch³) and an efficient (>94 percent) adapter solution kit.

EZ-PD™ PAG2P CYPAP212A1-14SXI (Power Adapter Generation 2 Primary) is Infineon's second generation integrated primary-side start-up controller for AC/DC applications targeting the mobile power adapter segment. PAG2P interfaces with the AC mains rectified output on the primary side and receives the necessary PWM signal from the secondary side to provide a regulated output voltage. PAG2P is designed to complement a secondary controlled AC/DC flyback converter topology. In this topology, voltage and current regulation is performed by the secondary controller (PAG2S). PAG2P is responsible for providing the start-up function, driving the primary side FET as well as responding to the fault conditions.

EZ-PD™ PAG2S CYPAS211A1-32LQXQ is an integrated secondary-side PWM controller and USB Power Delivery (USB PD) controller. PAG2S integrates secondary side synchronous rectifier (SR), pulse-width modulator (PWM), and zero voltage switching (ZVS) control. PAG2S is targeted towards the USB-C power adapters and fits well into the high-efficiency AC-DC flyback designs with USB PD and other standard charging protocols. PAG2S also supports USB PD Extended Power Range (EPR) mode.

Figure 1 shows the application diagram for a power adapter implementing a secondary-side controlled synchronous flyback converter topology. PAG2S modulates the pulse width of the primary MOSFET in voltage control mode. PAG2S engages the internal error amplifiers (EA) and a programmable ramp generator to determine the pulse width of PWM. The PWM signal is transferred from the secondary to the primary side through a pulse edge transformer.

In this topology, PAG2S integrates three key features: secondary-side PWM control, charging protocol control, and fault protection. This approach of integrating the ZVS on the secondary side has advantages over the traditional primary side control in the following ways:

- Programmable high side ON time to reach true ZVS operation to achieve optimized efficiency.

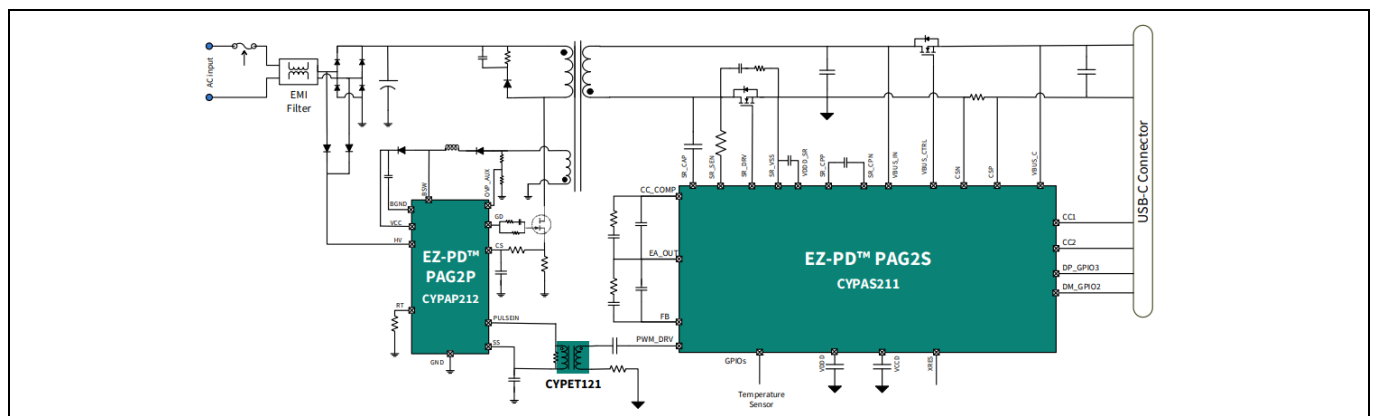


Figure 1 Application diagram for a power adapter in a secondary side controlled flyback converter topology along with ZVS operation

Test setup

2 Test setup

2.1 Device under test (DUT)

Table 1 65 W PAG2P-2S HFZVS Solution Demo Board hardware and software configurations

DUT contents	Description	Remarks
Hardware – configuration		
PAG2P + PAG2S HFZVS 65W Solution Board V3	Rev 3	–
Firmware		
Firmware repo	zvs_hf_pa_ver1.hex	

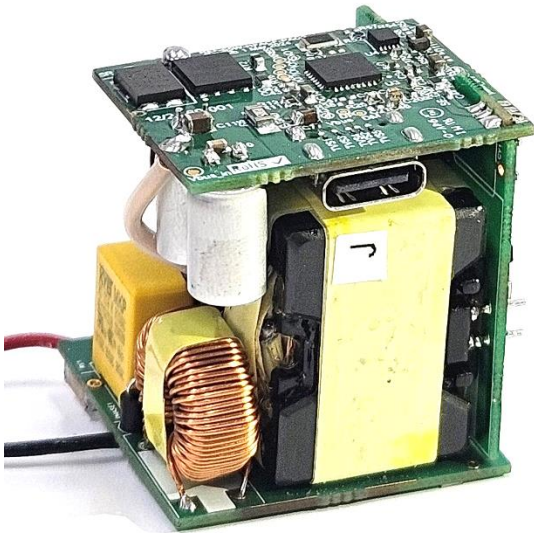


Figure 2 Isometric view of 65 W PAG2P-2S HFZVS Solution Demo Board



Dimensions (in mm): 34.29 x 31.97 x 30.46

Figure 3 Top view of 65 W PAG2P-2S HFZVS Solution Demo Board

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Test setup

2.2 DUT setup

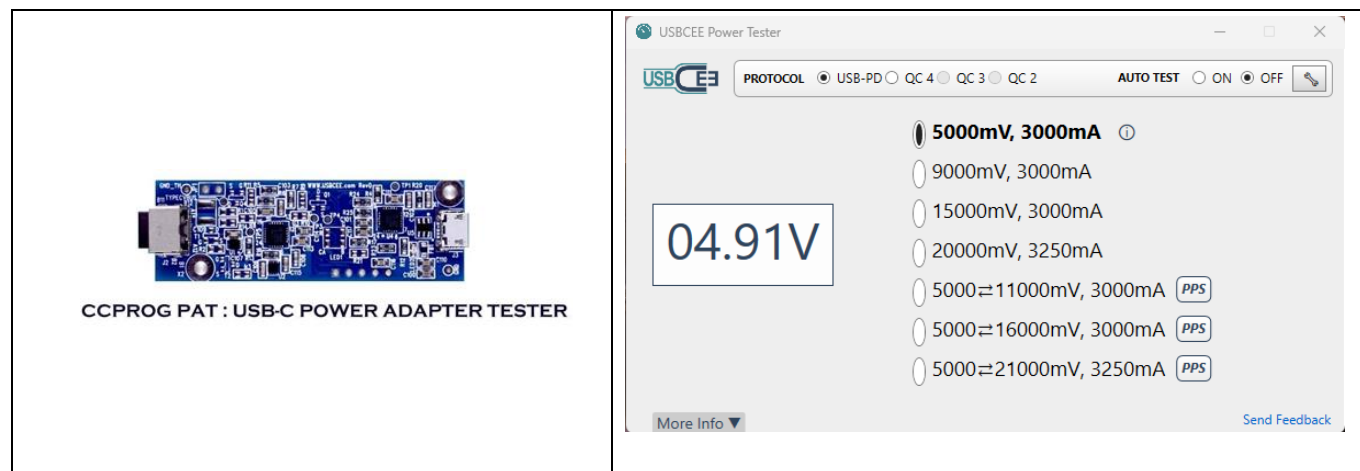


Figure 4 Physical CCGPROG PAT and USBCEE Power Tester UI

The DUT is connected to PAT i.e., Power Adapter Tester (CCPROG PAT) using a USB Type-C cable. Once a successful connection is established, PAT does a PDO discovery and displays the same on the UI. In this case, the solution kit is pre-configured with seven PDOs:

- PDO 1: 5 V, 3 A FIXED
- PDO 2: 9 V, 3 A FIXED
- PDO 3: 15 V, 3 A FIXED
- PDO 4: 20 V, 3.25 A FIXED
- PDO 5: 5 V to 11 V, 3 A PPS
- PDO 6: 5 V to 16 V, 3 A PPS
- PDO 7: 5 V to 21 V, 3.25 A PPS

One can either choose the suitable pre-configured PDO or configure a new one using Infineon's [EZ-PD™ Configuration Utility](#). For the tests in the following sections, we use the pre-configured PDOs.

To know more about PAT tester, visit [USBCEE](#).

2.3 Test equipment

The test equipment used to measure the efficiency, ripple, regulation, and transient response are shown in [Table 2](#).

Table 2 Test equipment details

Test setup	Description
Oscilloscope name	Tektronix MDO4104C/MSO 44
Power meter	Yokogawa WT310E
Digital multimeter (V_o and I_o)	Keysight 34465 A
Programmable AC source	Chroma 61501/61502
Electronic load	Chroma 63113 A/ 63103
Thermal camera	Flir E75
Automation software	LabVIEW/Python

Power management test results

3 Power management test results

Note: All the tests mentioned in this report are carried-out under open-frame condition.

3.1 Efficiency and no-load consumption

Table 3 Efficiency and no-load consumption results

Parameter	Standard (Minimum value)		Unit	Test condition	Test result	
	DoE Level-6	CoCv5 Tier 2			115 V _{AC} 60 Hz	230 V _{AC} 50 Hz
Four-point average efficiency (Average of 25%, 50%, 75%, 100% load)	81.39	81.84	%	V _O = 5 V _{DC} , I _O = 3 A	92.38	93.13
	86.62	87.30	%	V _O = 9 V _{DC} , I _O = 3 A	93.40	94.12
	87.73	88.85	%	V _O = 15 V _{DC} , I _O = 3 A	93.78	94.33
	88	89	%	V _O = 20 V _{DC} , I _O = 3.25 A	94.02	94.14
CoCv5 Tier2 10% load efficiency	–	72.48	%	V _O = 5 V _{DC} , I _O = 0.3 A	89.88	89.32
	–	77.30	%	V _O = 9 V _{DC} , I _O = 0.3 A	91.91	91.86
	–	78.85	%	V _O = 15 V _{DC} , I _O = 0.3 A	92.54	90.32
	–	79	%	V _O = 20 V _{DC} , I _O = 0.325 A	91.93	90.66
Parameter	Standard (Maximum value)		Unit	Test condition	Test result	
	DoE Level-6	CoCv5 Tier 2			115 V _{AC} 60 Hz	230 V _{AC} 50 Hz
No load power consumption	100	75	mW	No USB sink attached	24 mW	28 mW
	–	–	–	USB sink attached	60 mW	60 mW

Note:

1. Peak Efficiency: 94.72% (At 265 V_{AC} - 63 Hz, 15 V - 3 A)
2. Full load Efficiency at 230 V_{AC}: 94.58% (At 230 V_{AC} - 50 Hz, 20 V - 3.25 A)
3. Full load Efficiency at 115 V_{AC}: 94.03% (At 115 V_{AC} - 60 Hz, 20 V - 3.25 A)
4. Full load Efficiency at 90 V_{AC}: 92.74% (At 90 V_{AC} - 47 Hz, 20 V - 3.25 A)
5. V_{OUT} for efficiency calculations is measured across V_{BUS_C} at board end with 10 minutes warmup.
6. Variation of ±0.5% in efficiency can be observed across units.

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Power management test results

Table 4 lists the instruments used to capture the efficiency data.

Table 4 Instruments used to capture efficiency data

Instruments	Model number
AC source	GWInstek ASR2100
Power meter (V_{IN} and PIN)	Hioki PW3335
I_{OUT} measurement shunt	Vishay Y14730R00500B0R
Electronic load	GWInstek PEL-3021
Data logger (V_{BUS} , and I_{OUT})	Keysight 34970 A

Table 5 EuP Lot6 V1

Parameter	Test condition	Max Pin (mW)	Test result			
			115 V _{AC} 60 Hz		230 V _{AC} 50 Hz	
			Pin (mW)	Efficiency (%)	Pin (mW)	Efficiency (%)
Efficiency at 250 mW load	$V_o = 5 V_{DC}$ $I_o = 50 \text{ mA}$	500	317	79.0	325	77.0
Efficiency at 250 mW load	$V_o = 9 V_{DC}$ $I_o = 27.78 \text{ mA}$		346	72.2	346	72.2
Efficiency at 250 mW load	$V_o = 15 V_{DC}$ $I_o = 16.67 \text{ mA}$		333	74.9	333	74.9
Efficiency at 250 mW load	$V_o = 20 V_{DC}$ $I_o = 12.5 \text{ mA}$		356	70.3	356	70.3

Table 6 EuP Lot6 V2

Parameter	Test condition	Max Pin (mW)	Test result			
			115 V _{AC} 60 Hz		230 V _{AC} 50 Hz	
			Pin (mW)	Efficiency (%)	Pin (mW)	Efficiency (%)
Efficiency at 180 mW load	$V_o = 5 V_{DC}$ $I_o = 36 \text{ mA}$	300	242	74.5	251	71.8
Efficiency at 180 mW load	$V_o = 9 V_{DC}$ $I_o = 20 \text{ mA}$		270	66.8	270	66.8
Efficiency at 180 mW load	$V_o = 15 V_{DC}$ $I_o = 12 \text{ mA}$		258	69.9	258	69.9
Efficiency at 180 mW load	$V_o = 20 V_{DC}$ $I_o = 9 \text{ mA}$		281	64.2	280	64.4

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Power management test results

Table 7 Efficiency from 1% to 10% load at 90 V_{AC} 47 Hz for 20 V output

Load %	V _{AC}	Frequency	Pin	V _{OUT}	I _{OUT}	P _o	Efficiency
1	90	47	0.800	20.015	0.033	0.661	82.68%
2			1.520	20.017	0.067	1.333	87.69%
3			2.200	20.016	0.098	1.971	89.57%
4			2.900	20.018	0.131	2.629	90.64%
5			3.590	20.018	0.163	3.268	91.03%
6			4.310	20.017	0.197	3.939	91.38%
7			4.990	20.018	0.229	4.579	91.76%
8			5.690	20.018	0.261	5.234	91.99%
9			6.400	20.018	0.294	5.895	92.10%
10			7.090	20.020	0.327	6.550	92.39%

Table 8 Efficiency from 10% to 100% load at 90 V_{AC} 47 Hz for 20 V output

Load %	V _{AC}	Frequency	Pin	V _{OUT}	I _{OUT}	P _o	Efficiency
10	90	47	7.090	20.015	0.327	6.543	92.29%
20			14.050	20.014	0.653	13.075	93.06%
30			21.070	20.012	0.980	19.611	93.07%
40			28.010	20.008	1.306	26.129	93.28%
50			34.990	20.007	1.632	32.653	93.32%
60			41.960	20.003	1.959	39.179	93.37%
70			49.000	19.999	2.285	45.690	93.25%
80			56.050	19.996	2.611	52.215	93.16%
90			63.080	19.994	2.937	58.726	93.10%
100			70.340	19.992	3.264	65.247	92.76%

Table 9 Efficiency from 1% to 10% load at 115 V_{AC} 60 Hz for 20 V output

Load %	V _{AC}	Frequency	Pin	V _{OUT}	I _{OUT}	P _o	Efficiency
1	115	60	0.790	20.024	0.033	0.664	84.09%
2			1.510	20.023	0.066	1.331	88.16%
3			2.200	20.022	0.098	1.971	89.59%
4			2.900	20.023	0.131	2.627	90.59%
5			3.590	20.021	0.163	3.267	91.01%
6			4.310	20.023	0.197	3.941	91.43%
7			4.990	20.022	0.229	4.575	91.69%
8			5.700	20.022	0.261	5.234	91.82%
9			6.390	20.021	0.294	5.893	92.22%
10			7.100	20.023	0.327	6.546	92.19%

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Power management test results

Table 10 Efficiency from 10% to 100% load at 115 V_{AC} 60 Hz for 20 V output

Load %	V _{AC}	Frequency	Pin	V _{OUT}	I _{OUT}	P _o	Efficiency
10	115	60	7.080	20.016	0.327	6.547	92.48%
20			13.980	20.013	0.653	13.077	93.54%
30			20.900	20.011	0.980	19.608	93.82%
40			27.790	20.008	1.306	26.132	94.03%
50			34.700	20.006	1.632	32.657	94.11%
60			41.600	20.003	1.959	39.180	94.18%
70			48.530	20.000	2.285	45.694	94.16%
80			55.320	19.997	2.611	52.222	94.40%
90			62.330	19.993	2.937	58.727	94.22%
100			69.380	19.991	3.264	65.247	94.04%

Table 11 Efficiency from 1% to 10% load at 230 V_{AC} 50 Hz for 20 V output

Load %	V _{AC}	Frequency	Pin	V _{OUT}	I _{OUT}	P _o	Efficiency
1	230	50	0.800	20.026	0.033	0.658	82.23%
2			1.510	20.026	0.066	1.323	87.62%
3			2.190	20.026	0.098	1.968	89.86%
4			2.890	20.024	0.131	2.623	90.76%
5			3.570	20.024	0.163	3.268	91.54%
6			4.290	20.025	0.197	3.936	91.75%
7			5.130	20.023	0.228	4.574	89.15%
8			5.800	20.023	0.261	5.232	90.20%
9			6.480	20.023	0.294	5.890	90.90%
10			7.160	20.022	0.327	6.542	91.37%

Table 12 Efficiency from 10% to 100% load at 230 V_{AC} 50 Hz for 20 V output

Load %	V _{AC}	Frequency	Pin	V _{OUT}	I _{OUT}	P _o	Efficiency
10	230	50	7.200	20.016	0.327	6.551	90.99%
20			13.970	20.014	0.653	13.079	93.62%
30			20.860	20.010	0.980	19.610	94.01%
40			27.740	20.006	1.306	26.132	94.20%
50			34.570	20.004	1.632	32.651	94.45%
60			41.410	20.000	1.959	39.174	94.60%
70			48.260	19.997	2.285	45.689	94.67%
80			55.130	19.995	2.611	52.213	94.71%
90			61.970	19.990	2.937	58.721	94.76%
100			68.840	19.987	3.264	65.232	94.76%

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Power management test results

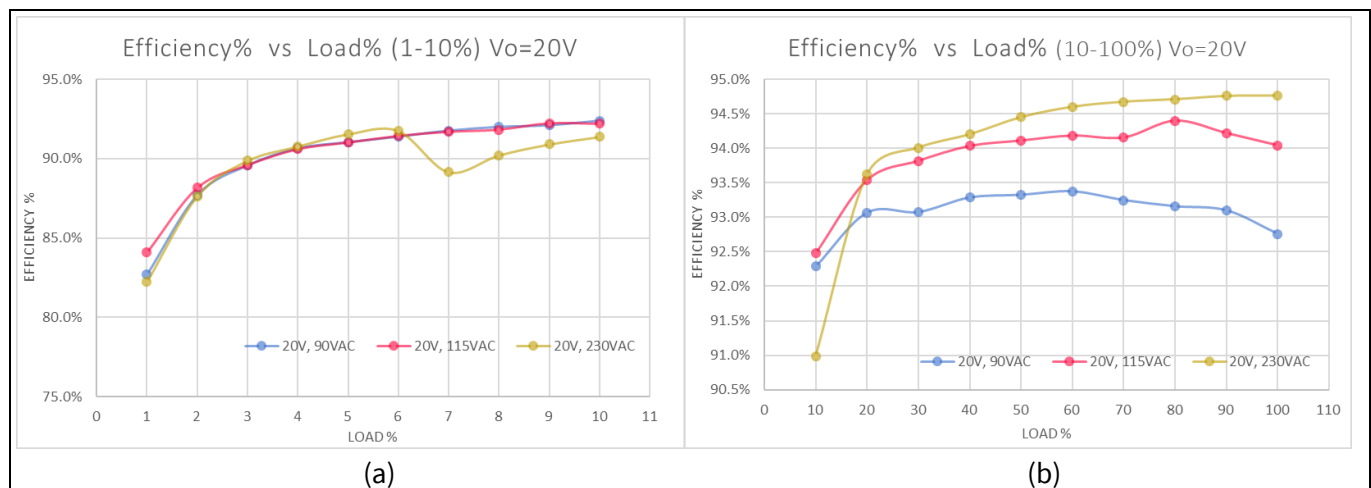


Figure 5 (a) Efficiency with 1% to 10% load for 20 V output; (b) Efficiency with 10% to 100% load for 20 V output

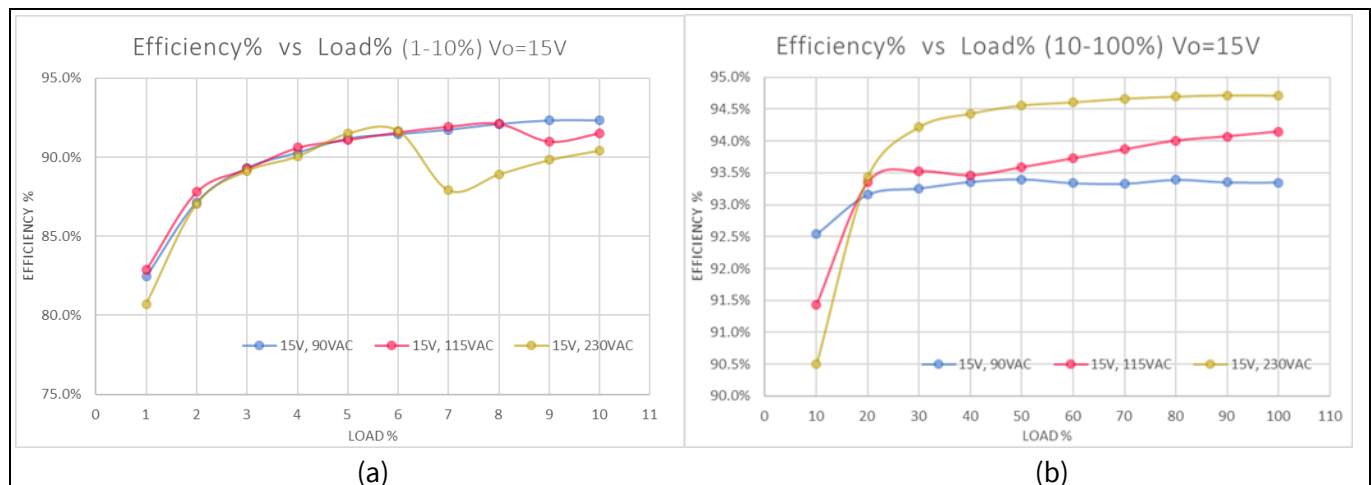


Figure 6 (a) Efficiency with 1% to 10% load for 15 V output; (b) Efficiency with 10% to 100% load for 15 V output

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Power management test results

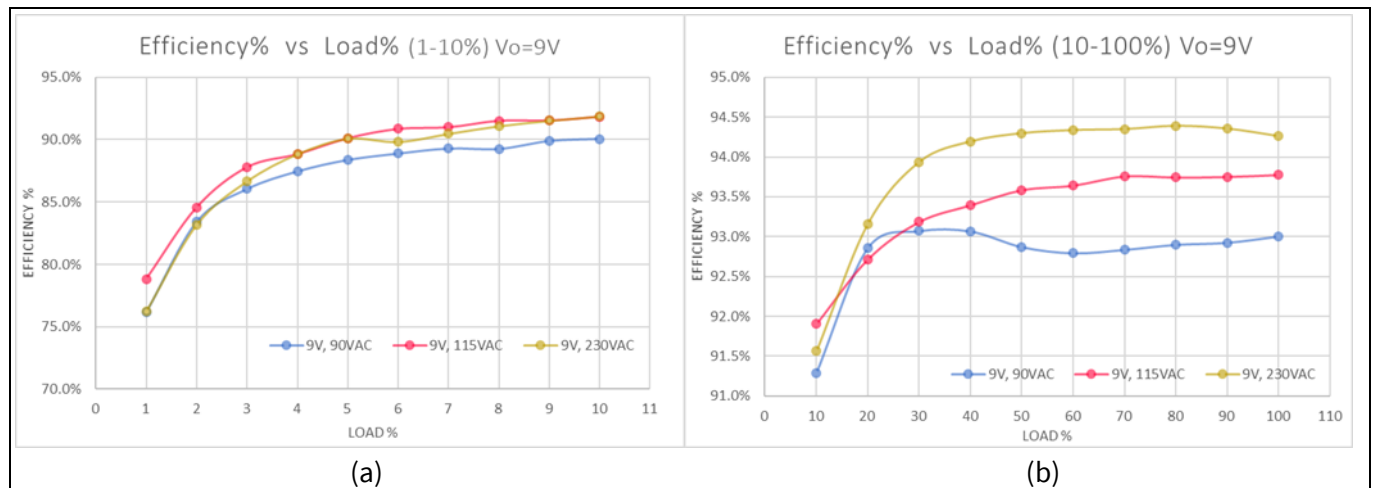


Figure 7 (a) Efficiency with 1% to 10% load for 9 V output; (b) Efficiency with 10% to 100% load for 9 V output

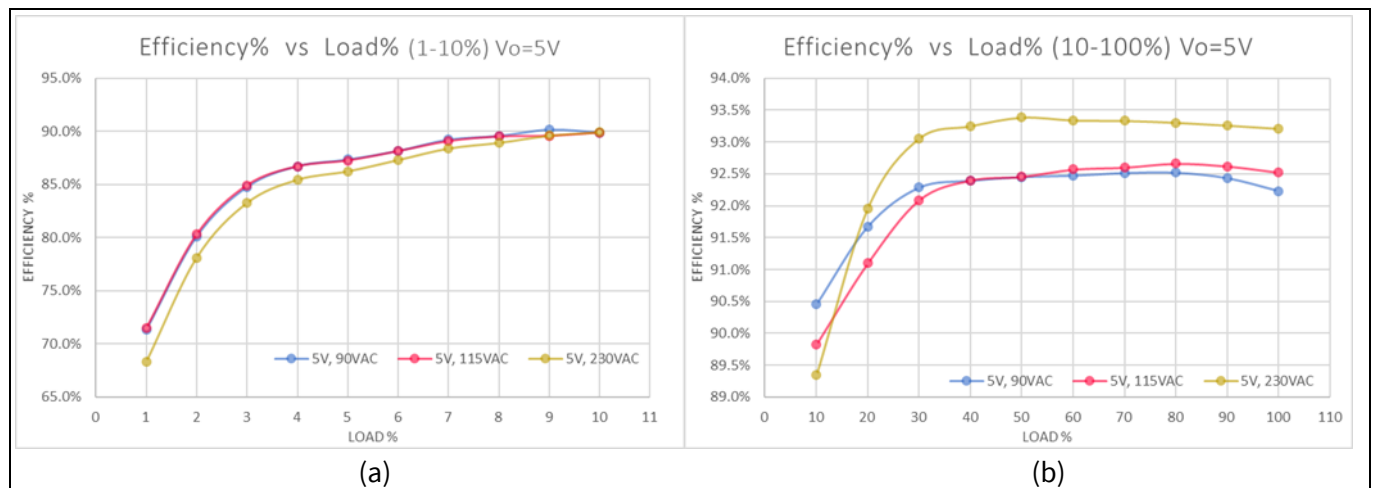


Figure 8 (a) Efficiency with 1 to 10% load for 5 V output; (b) Efficiency with 10 to 100% load for 5 V output

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Power management test results

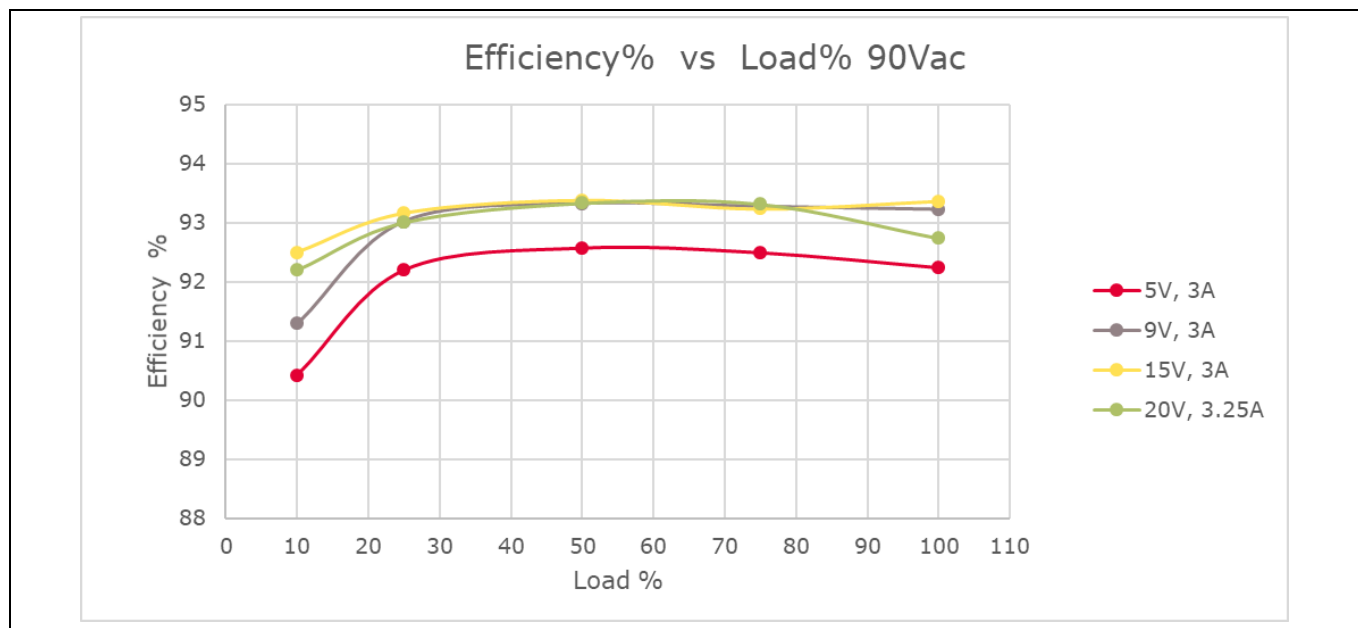


Figure 9 Efficiency at 90 V_{AC}, 47 Hz

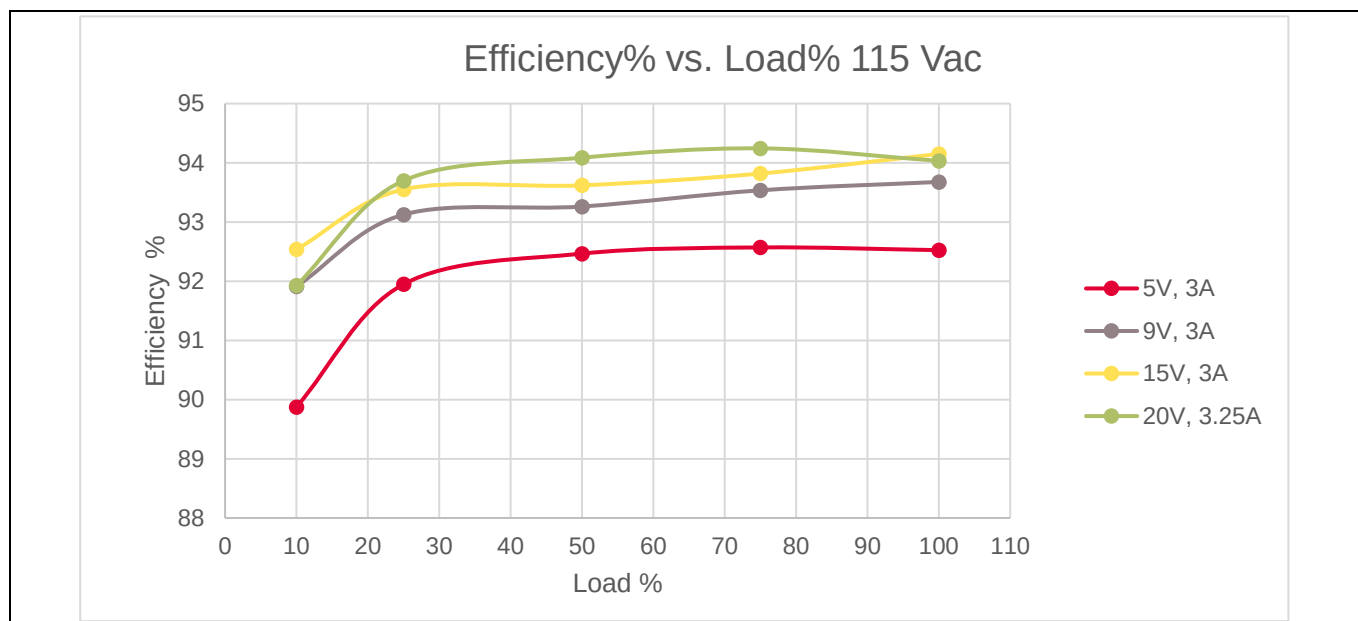


Figure 10 Efficiency at 115 V_{AC}, 60 Hz

Power management test results

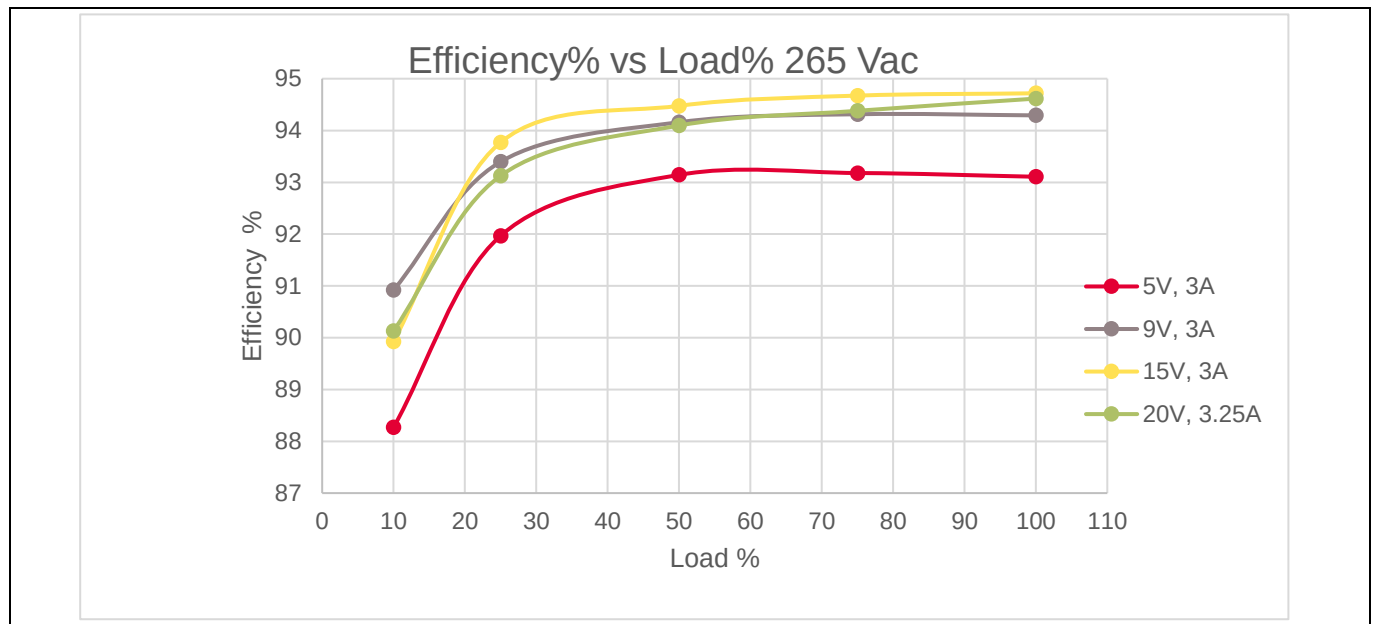


Figure 11 Efficiency at 265 V_{AC}, 63 Hz

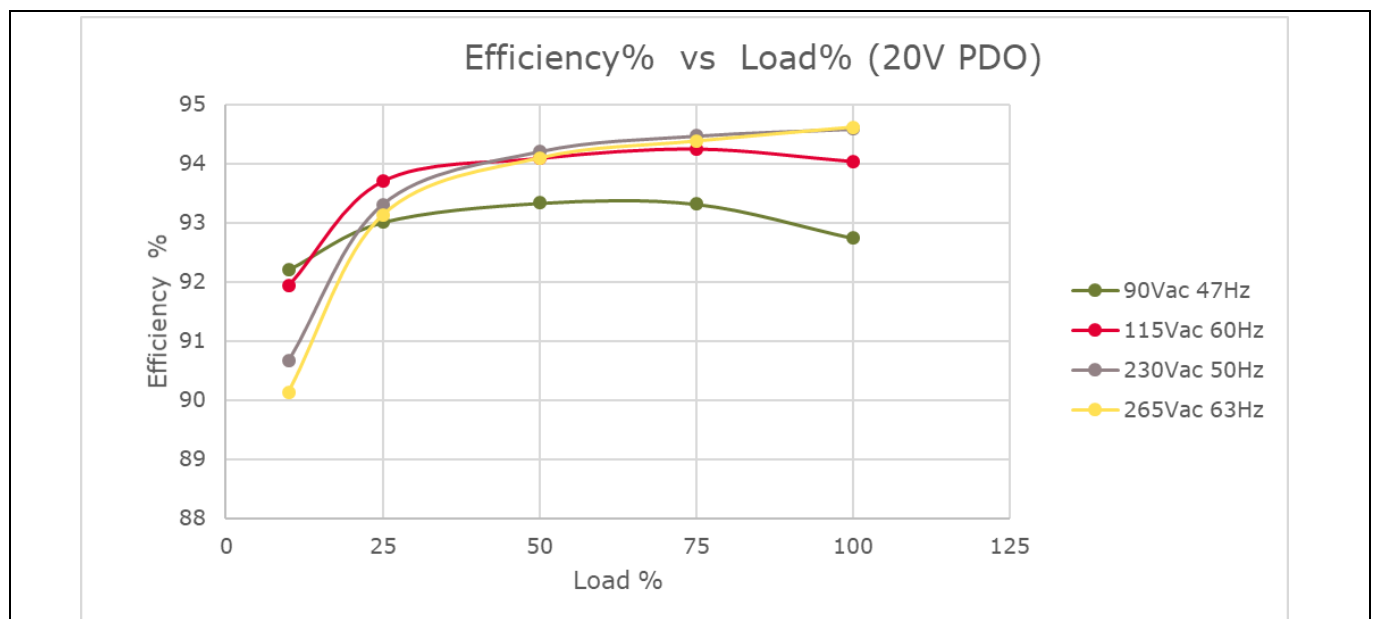


Figure 12 Efficiency at different line conditions for 20 V PDO

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Power management test results

Table 13 Full load efficiency at different line condition

Sl. no.	V _{AC} (V)	Freq (Hz)	P _{in}	V _{OUT} (V)	I _{OUT} (A)	P _o (W)	Efficiency (%)	4-pt Average Efficiency (%)	CoC T2	DOE 6	Full load switching frequency (kHz)
1	90	47	7.100	20.008	0.327	6.546	92.20	–	79	–	102
2	90	47	17.550	20.004	0.816	16.322	93.00	93.10	89	88	
3	90	47	34.970	19.997	1.632	32.638	93.33				
4	90	47	52.420	19.990	2.447	48.915	93.31				
5	90	47	70.320	19.984	3.263	65.213	92.74				
6	115	60	7.120	20.010	0.327	6.545	91.93	–	79	–	162
7	115	60	17.420	20.006	0.816	16.322	93.70	94.02	89	88	
8	115	60	34.690	19.998	1.632	32.639	94.09				
9	115	60	51.910	19.991	2.447	48.922	94.24				
10	115	60	69.360	19.985	3.264	65.221	94.03				
11	230	50	7.220	20.009	0.327	6.546	90.66	–	79	–	129
12	230	50	17.490	20.005	0.816	16.320	93.31	94.14	89	88	
13	230	50	34.650	19.998	1.632	32.642	94.20				
14	230	50	51.790	19.990	2.447	48.924	94.47				
15	230	50	68.950	19.984	3.263	65.215	94.58				
16	265	63	7.260	20.010	0.327	6.544	90.13	–	79	–	132
17	265	63	17.530	20.006	0.816	16.325	93.13	94.05	89	88	
18	265	63	34.690	19.999	1.632	32.642	94.10				
19	265	63	51.840	19.991	2.448	48.927	94.38				
20	265	63	68.930	19.983	3.264	65.219	94.62				

1. CoC Tier 2 limit for 4-pt Average is 89%
2. CoC Tier 2 limit for 10% load is 79%

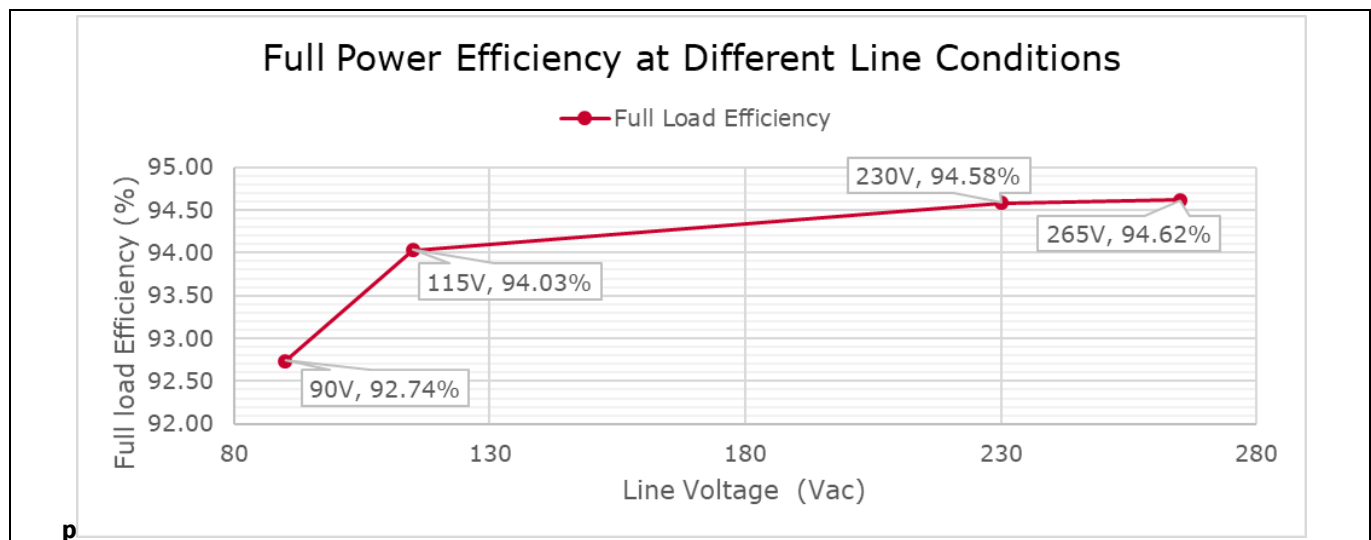


Figure 13 Full power efficiency at different line conditions

Power management test results

3.2 Standby power consumption

Table 14 Standby power consumption across line conditions

V_{IN} (V _{AC})	90 V _{AC} , 47 Hz	115 V _{AC} , 60 Hz	230 V _{AC} , 50 Hz	265 V _{AC} , 63 Hz
Input Power (mW)	24 mW	24 mW	28 mW	28 mW

Note: There should be 15 minutes of warmup time before measuring standby power.

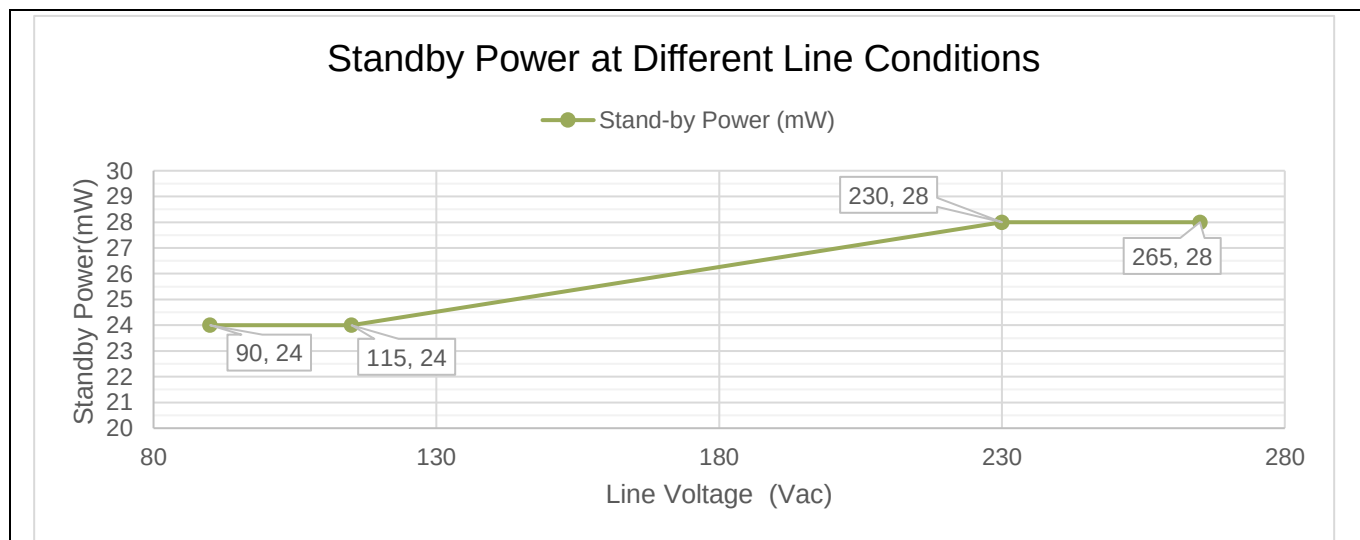


Figure 14 Standby power consumption

Note: The measurement was taken using WTVIEWERfree software with line filter ON.

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Power management test results

3.3 Output voltage ripple peak-peak

Note: Ripple measurement is done at board end using LeCroy probe adapter [pk6-5 mm-105](#).

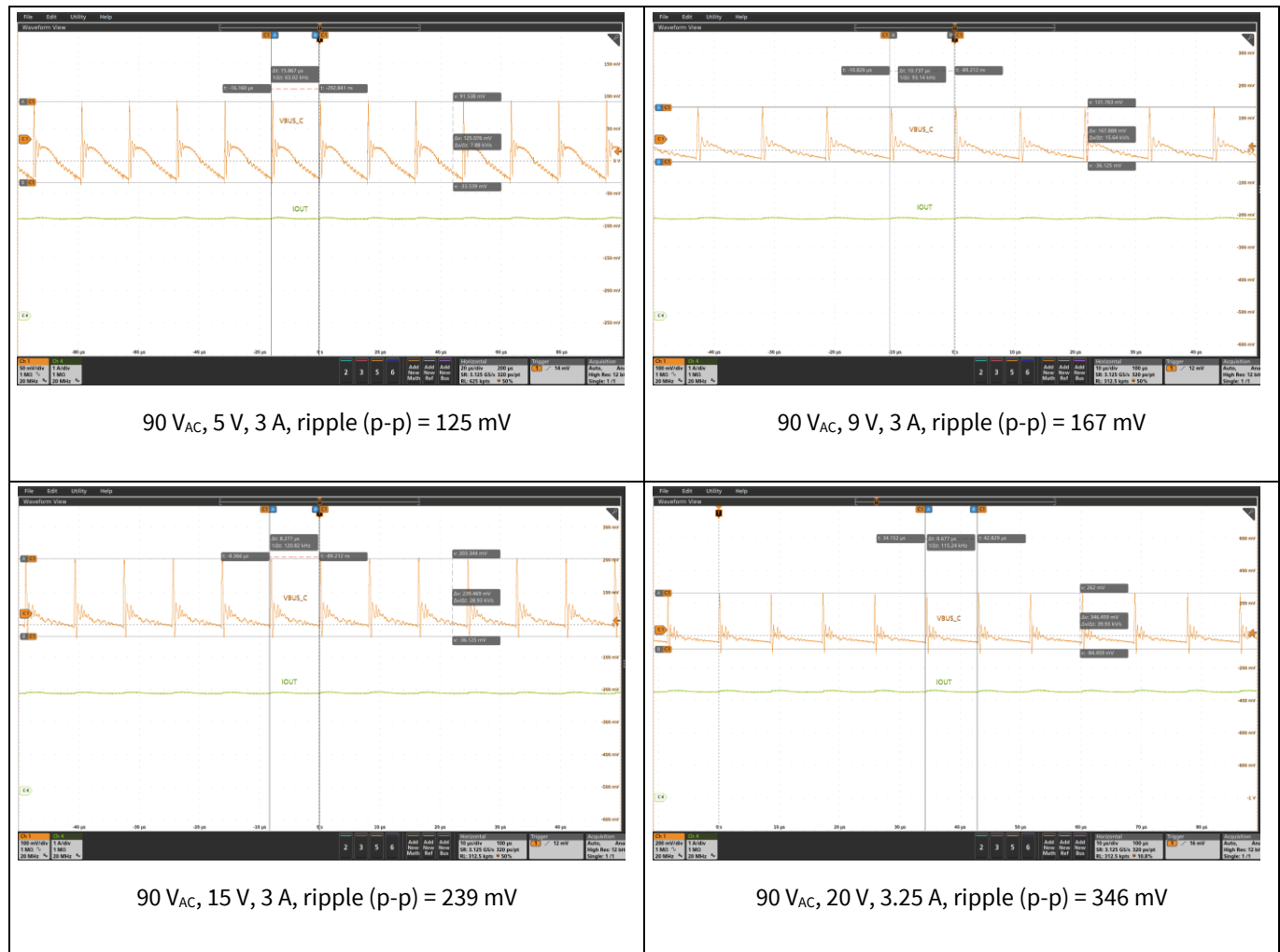


Figure 15 Ripple at 90 V_{AC} 47 Hz (CH1: V_{BUS_C}, CH4: I_{OUT})

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Power management test results

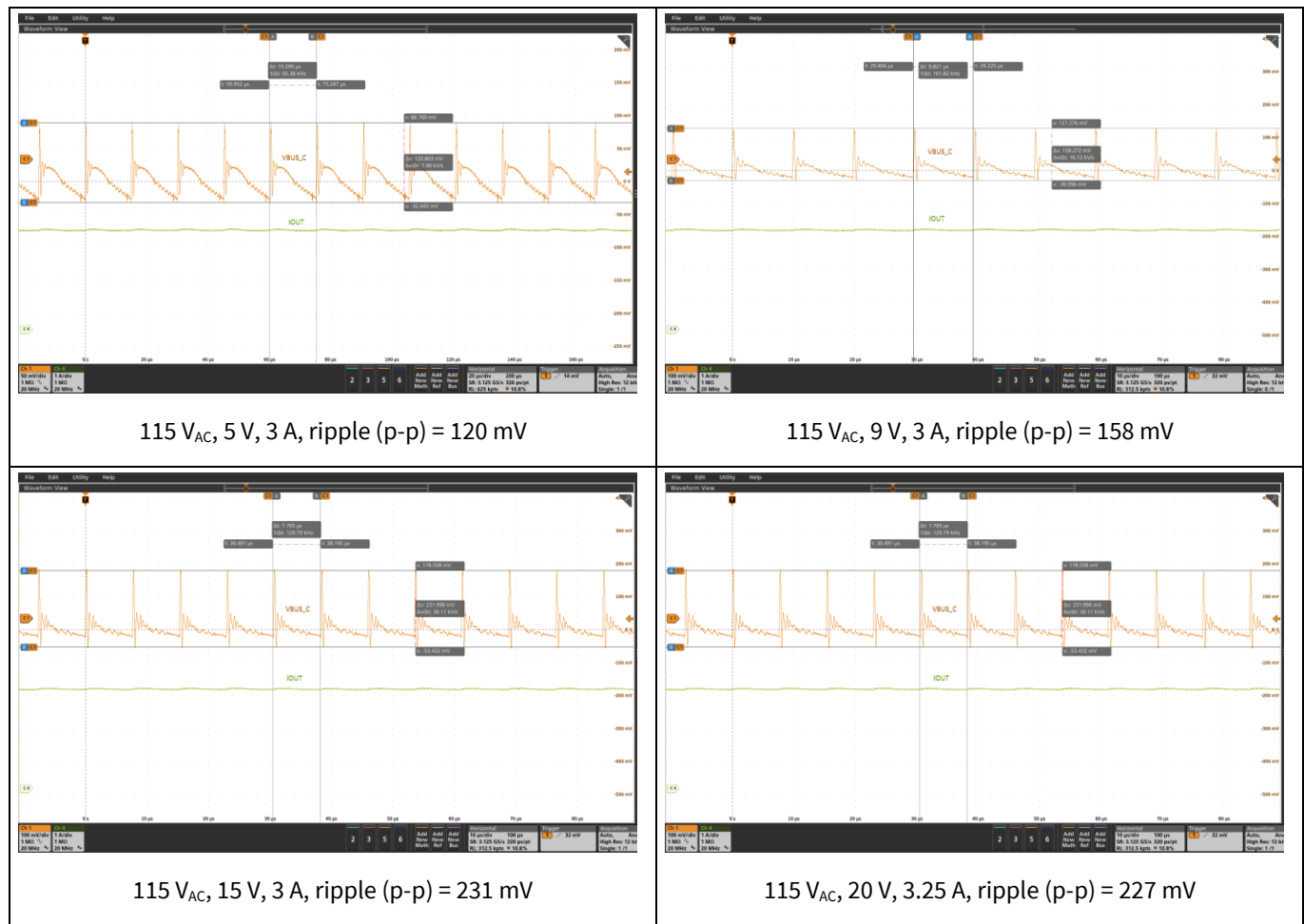


Figure 16 Ripple at 115 V_{AC} 60 Hz (CH3: V_{BUS_C}, CH4: I_{OUT})

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Power management test results

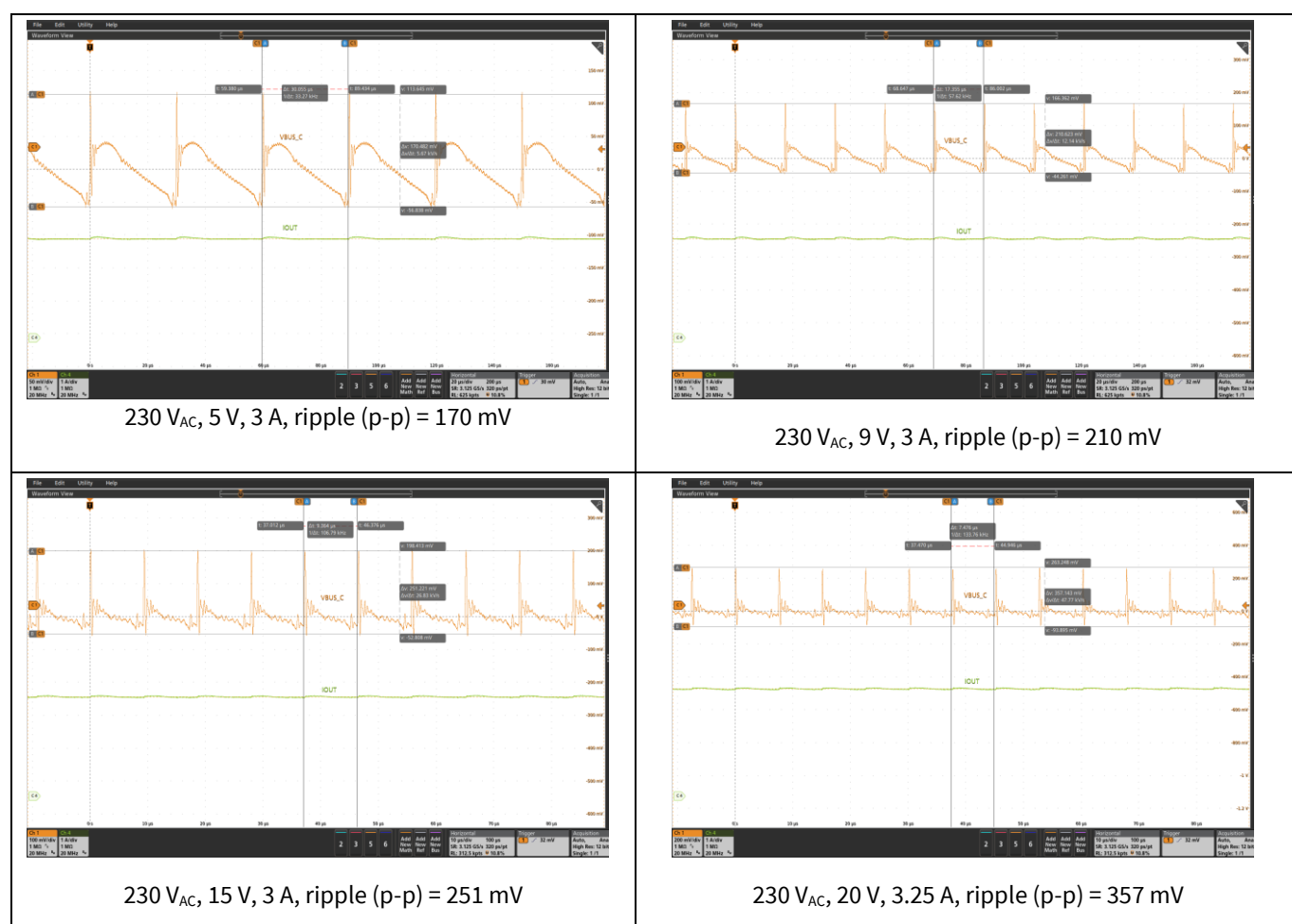


Figure 17 Ripple at 230 V_{AC} 50 Hz (CH1: V_{BUS_C}, CH4: I_{OUT})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

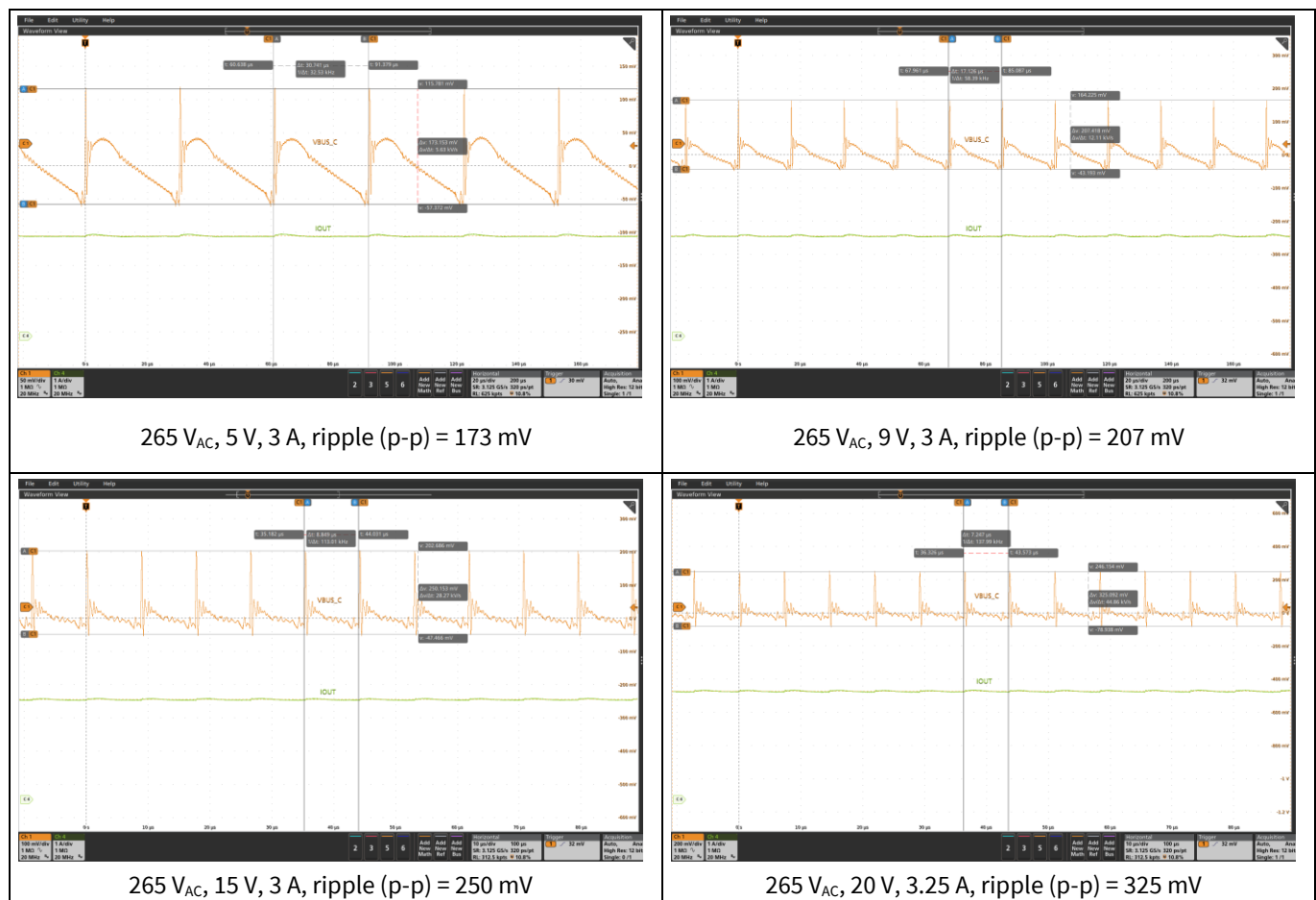


Figure 18 Ripple at 265 V_{AC} 63 Hz (CH1: V_{BUS_C} , CH4: I_{OUT})

Note: Waveforms have been taken by keeping the oscilloscope in 20 MHz bandwidth limitation.

Power management test results

3.4 Output dynamic response settling time

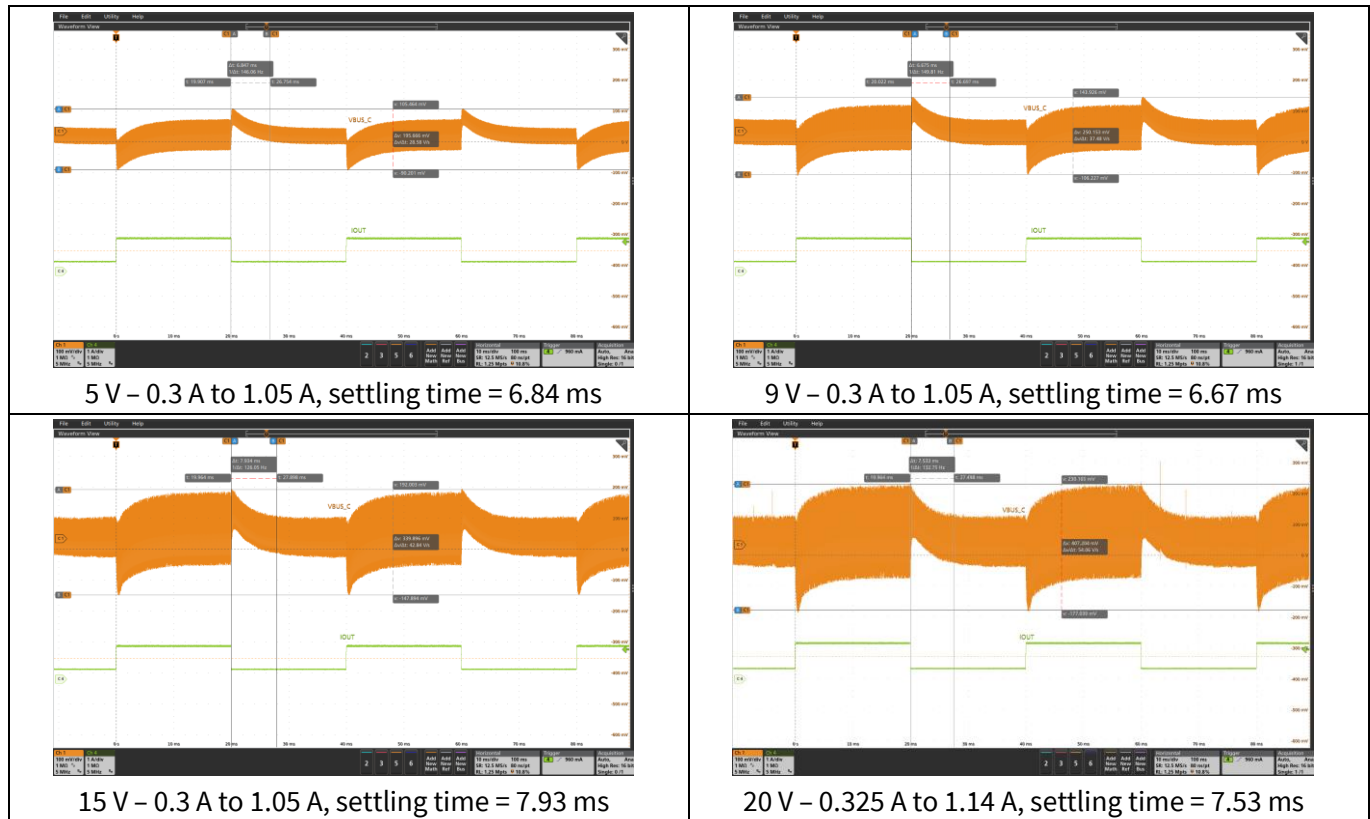


Figure 19 Settling time for 115 V_{AC}, 60 Hz load transition 10% to 35% load (CH1: V_{BUS_C}, CH4: I_{OUT})

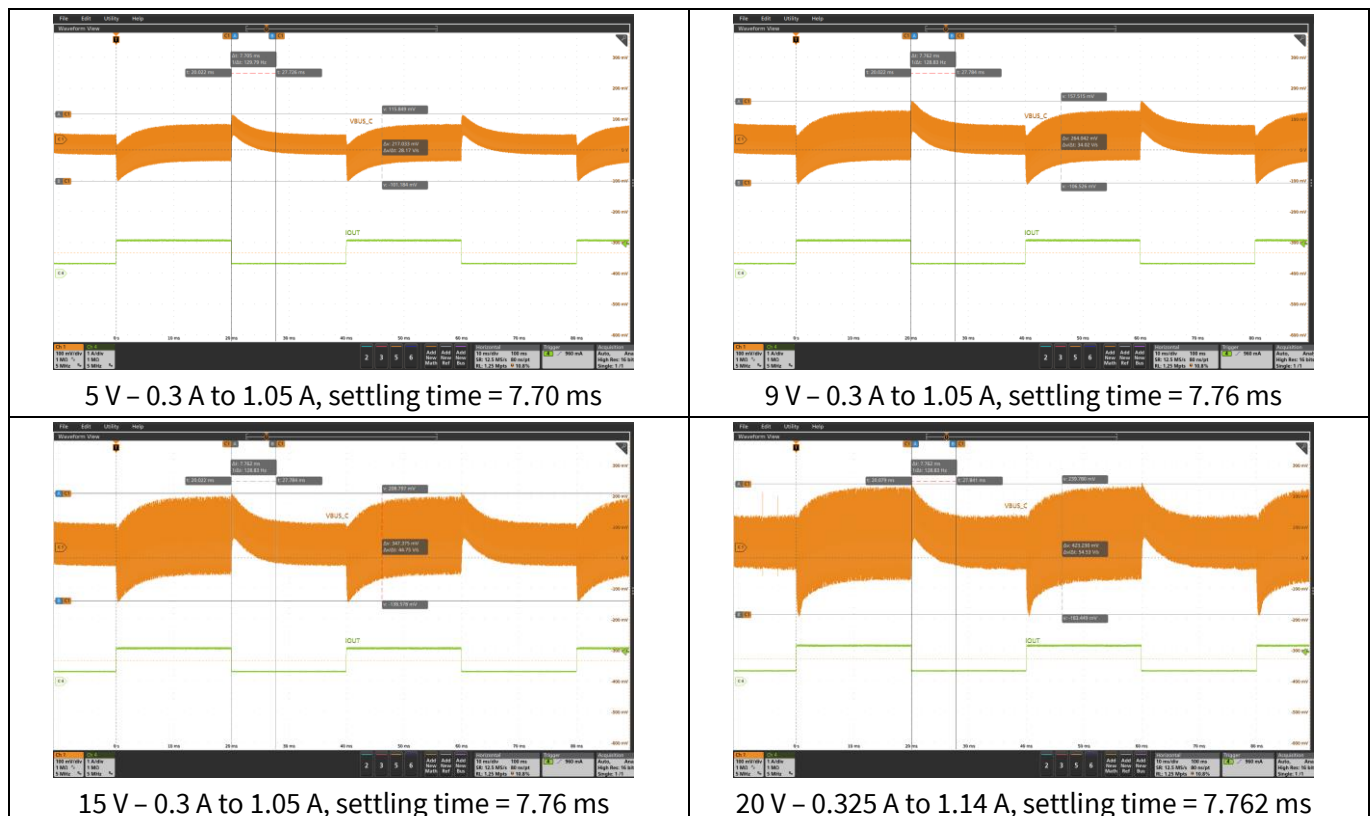


Figure 20 Settling time for 230 V_{AC}, 50 Hz load transition 10% to 35% load (CH1: V_{BUS_C}, CH4: I_{OUT})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

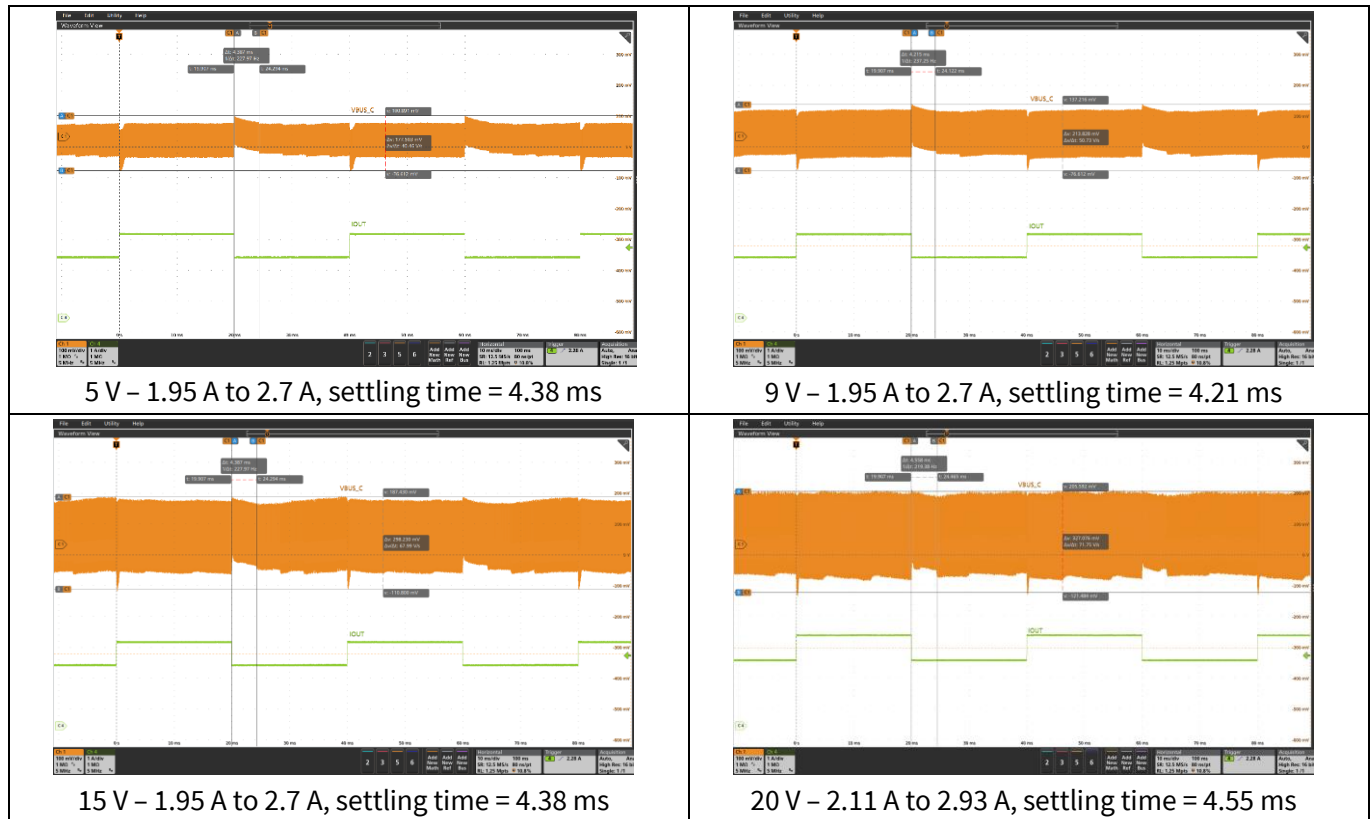


Figure 21 Settling time for 115 V_{AC}, 60 Hz load transition 65% to 90% load (CH1: V_{BUS_C}, CH4: I_{OUT})

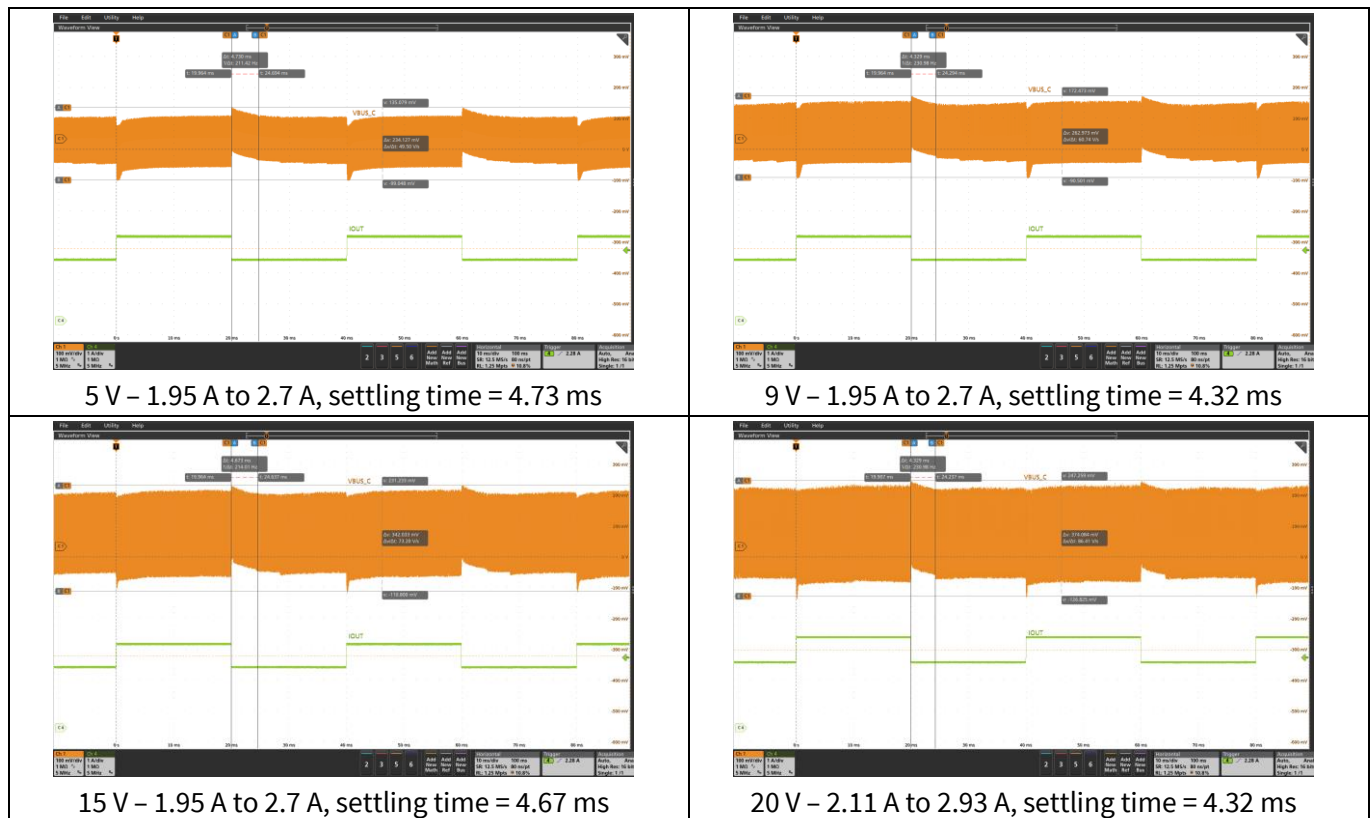


Figure 22 Settling time for 230 V_{AC}, 50 Hz load transition 65% to 90% load (CH1: V_{BUS_C}, CH4: I_{OUT})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

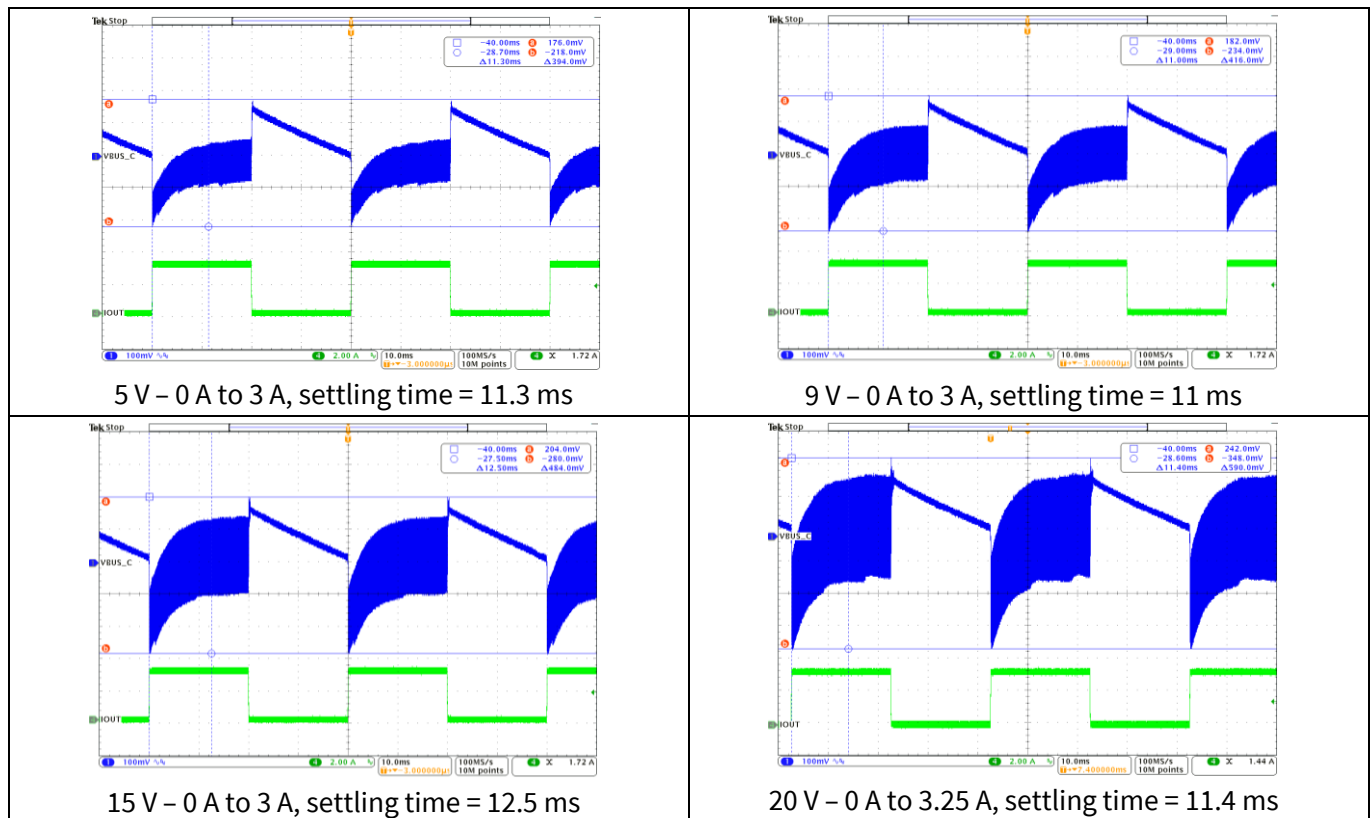


Figure 23 Settling time for 115 V_{AC}, 60 Hz load transition 0% to 100% load (CH1: V_{BUS_C}, CH4: I_{OUT})

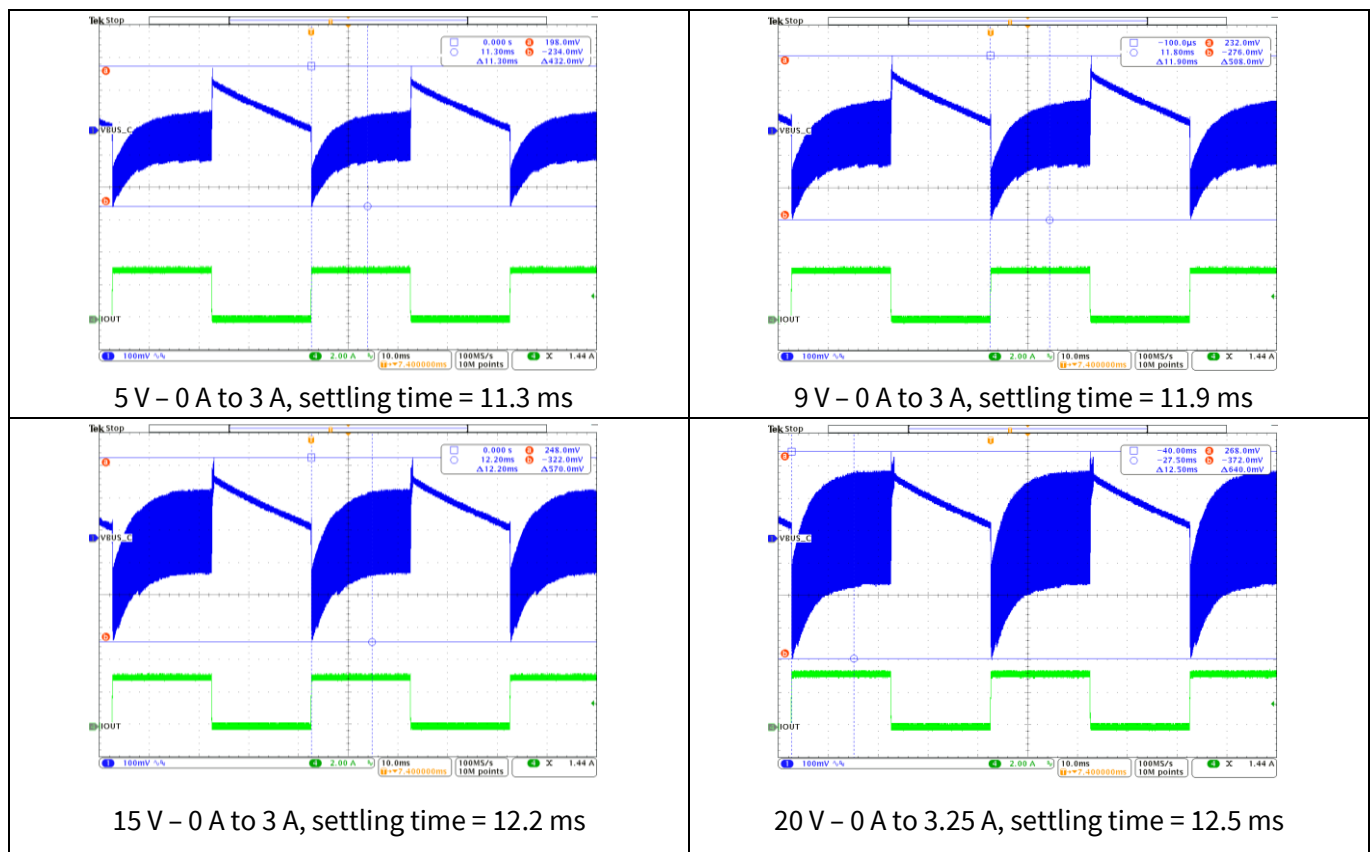


Figure 24 Settling time for 230 V_{AC}, 50 Hz load transition 0% to 100% load (CH1: V_{BUS_C}, CH4: I_{OUT})

Power management test results

3.5 Output voltage transfer transition

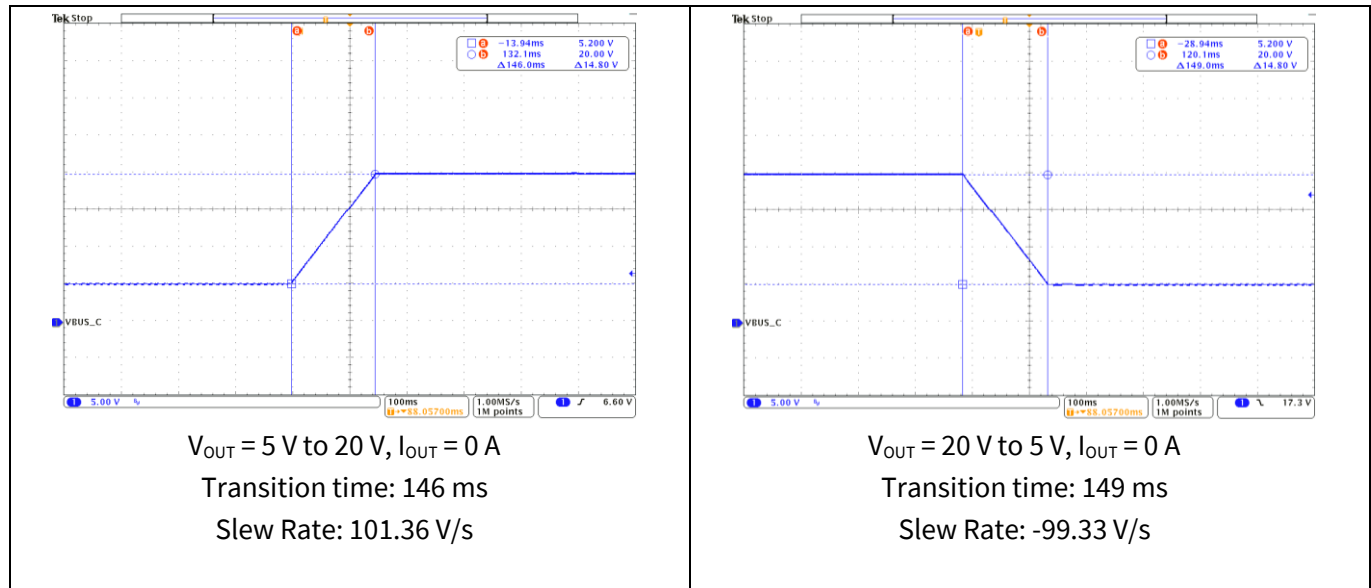


Figure 25 Output voltage transition at no load for 115 V_{AC}, 60 Hz; (CH1: V_{BUS_C})

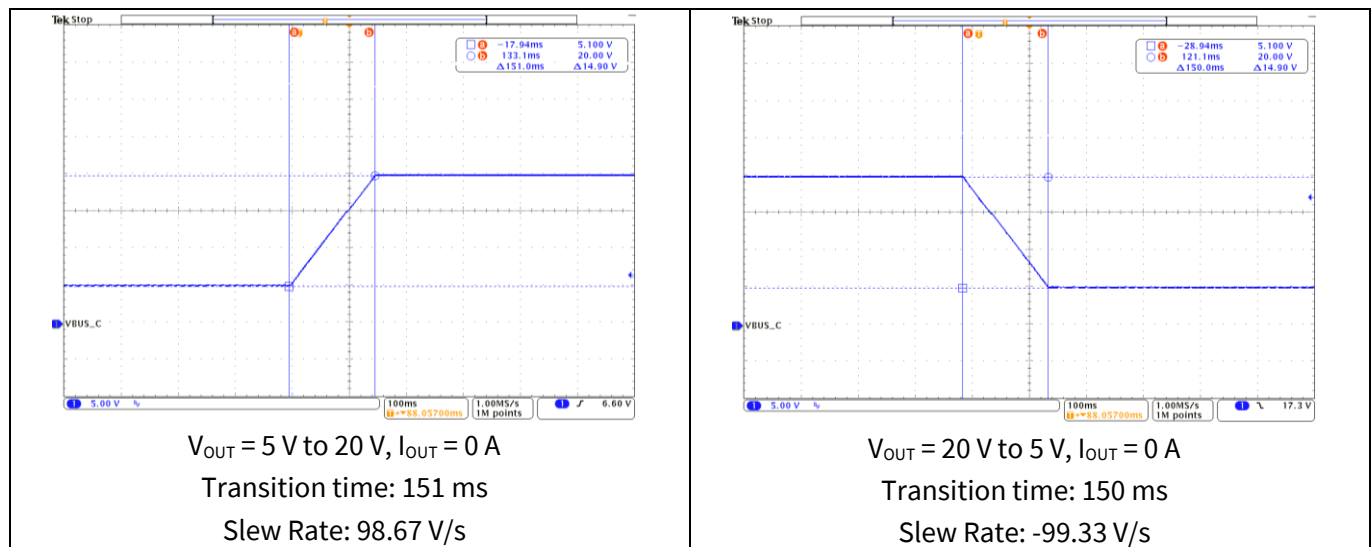


Figure 26 Output voltage transition at no load for 230 V_{AC}, 50 Hz; (CH1: V_{BUS_C})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

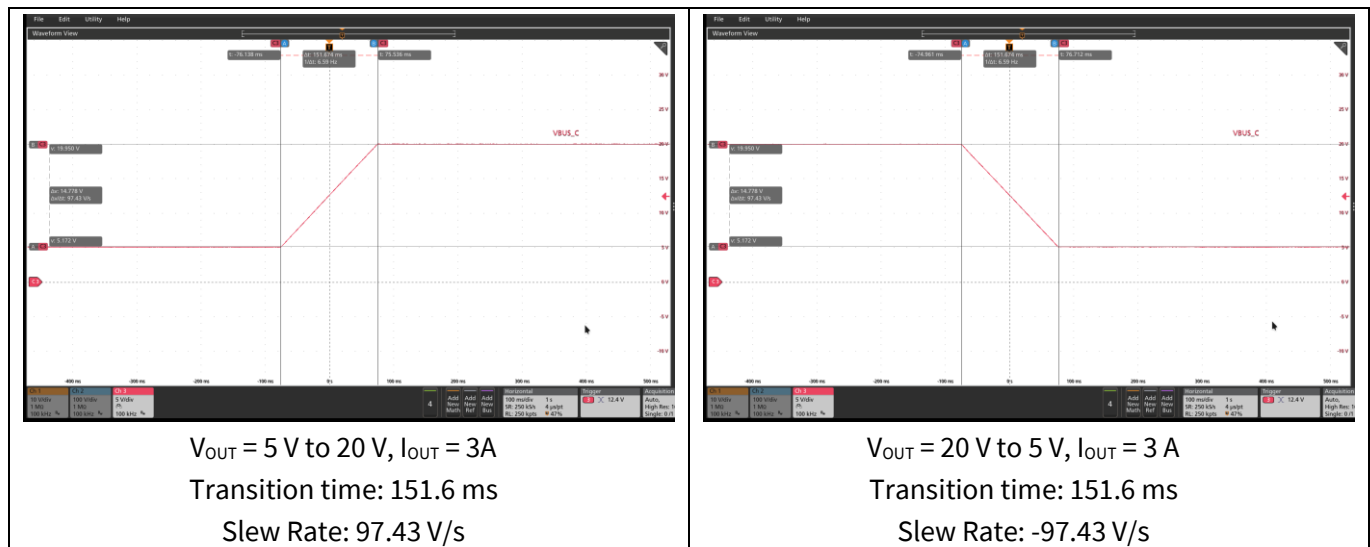


Figure 27 Output voltage transition at 3 A load for 115 V_{AC}, 60 Hz; (CH3: V_{BUS_C})

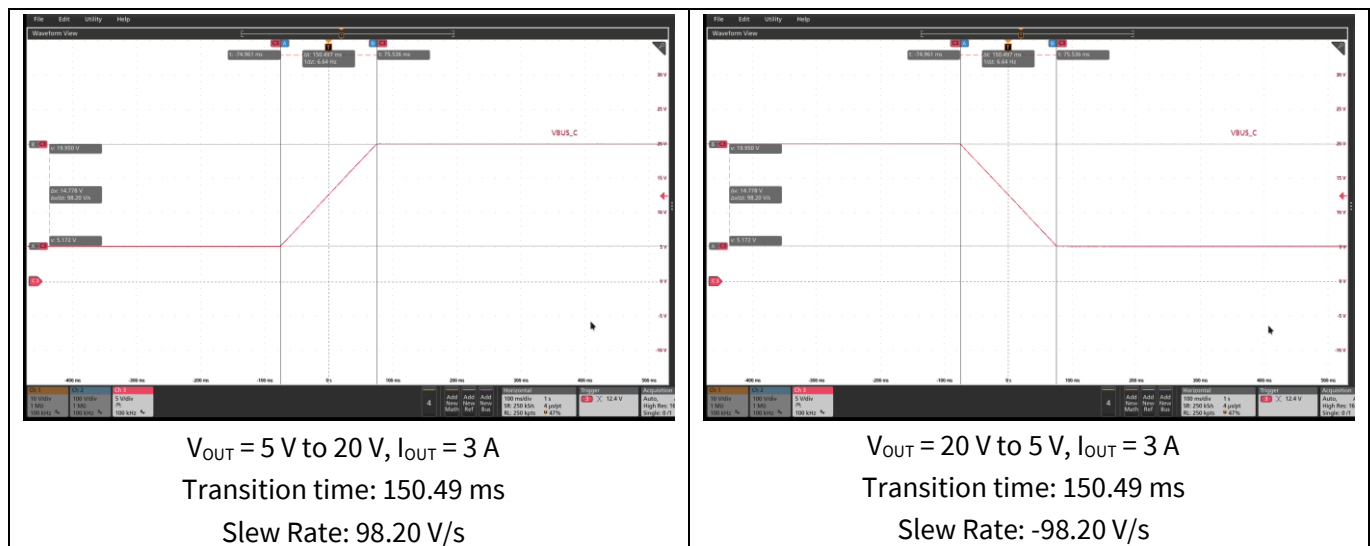


Figure 28 Output voltage transition at 3 A load for 230 V_{AC}, 50 Hz; (CH3: V_{BUS_C})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

3.6 Start-up turn-on delay and startup rise time

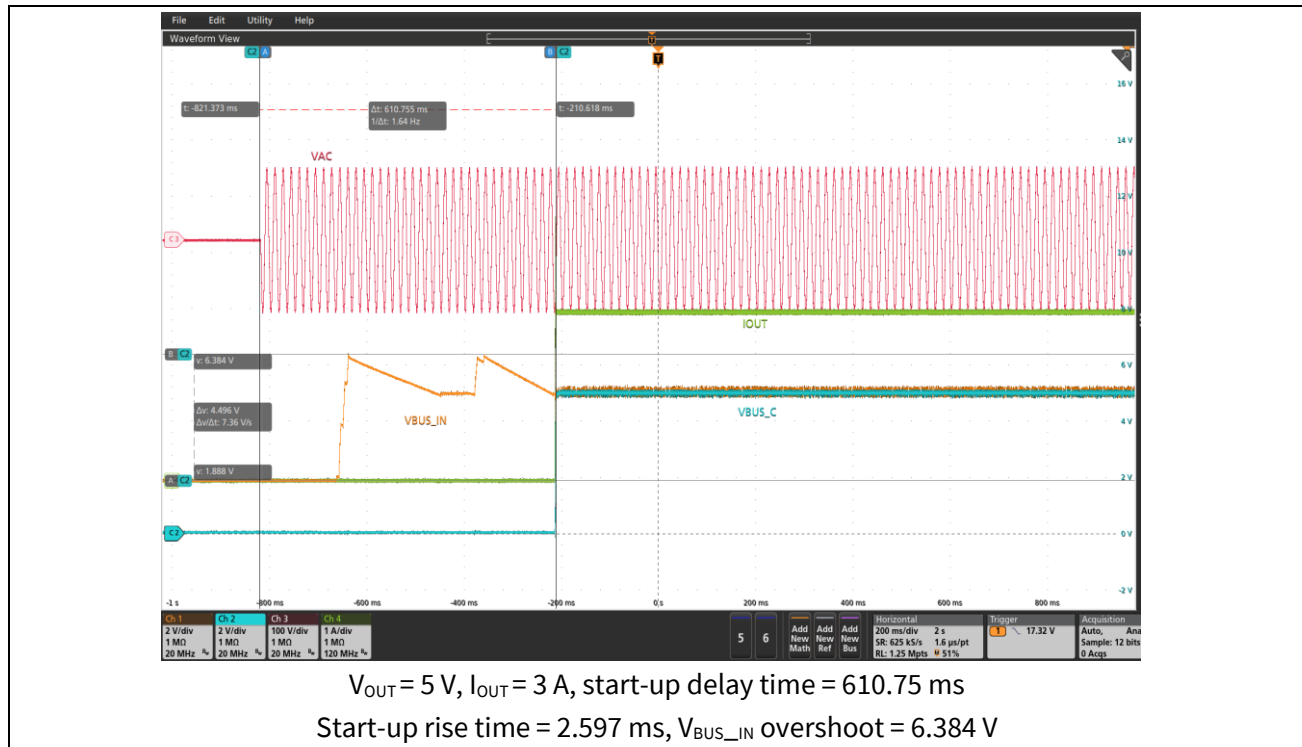


Figure 29 Start-up turn-on delay at 90 V_{AC}, 47 Hz (CH1: V_{BUS_IN}, CH2: V_{BUS_C}, CH3: V_{AC}, CH4: I_{OUT})

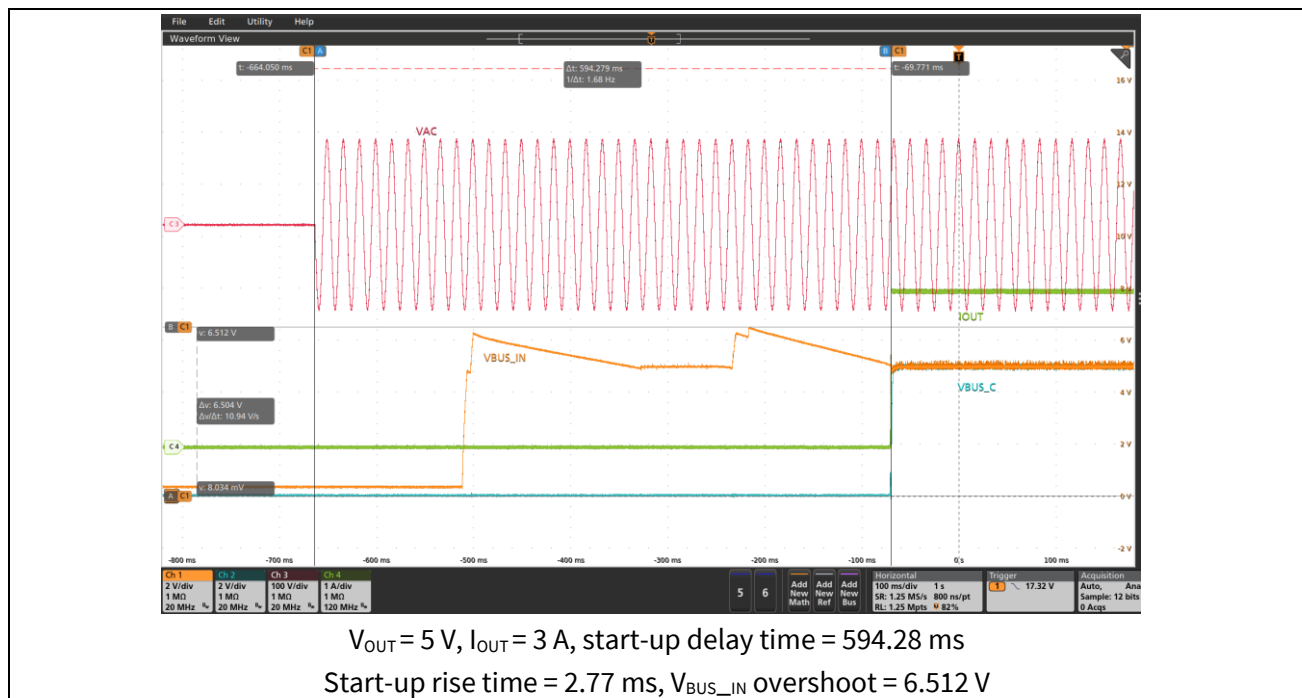


Figure 30 Start-up turn-on delay at 115 V_{AC}, 60 Hz (CH1: V_{BUS_C}, CH2: V_{BUS_IN}, CH3: V_{AC}, CH4: I_{OUT})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

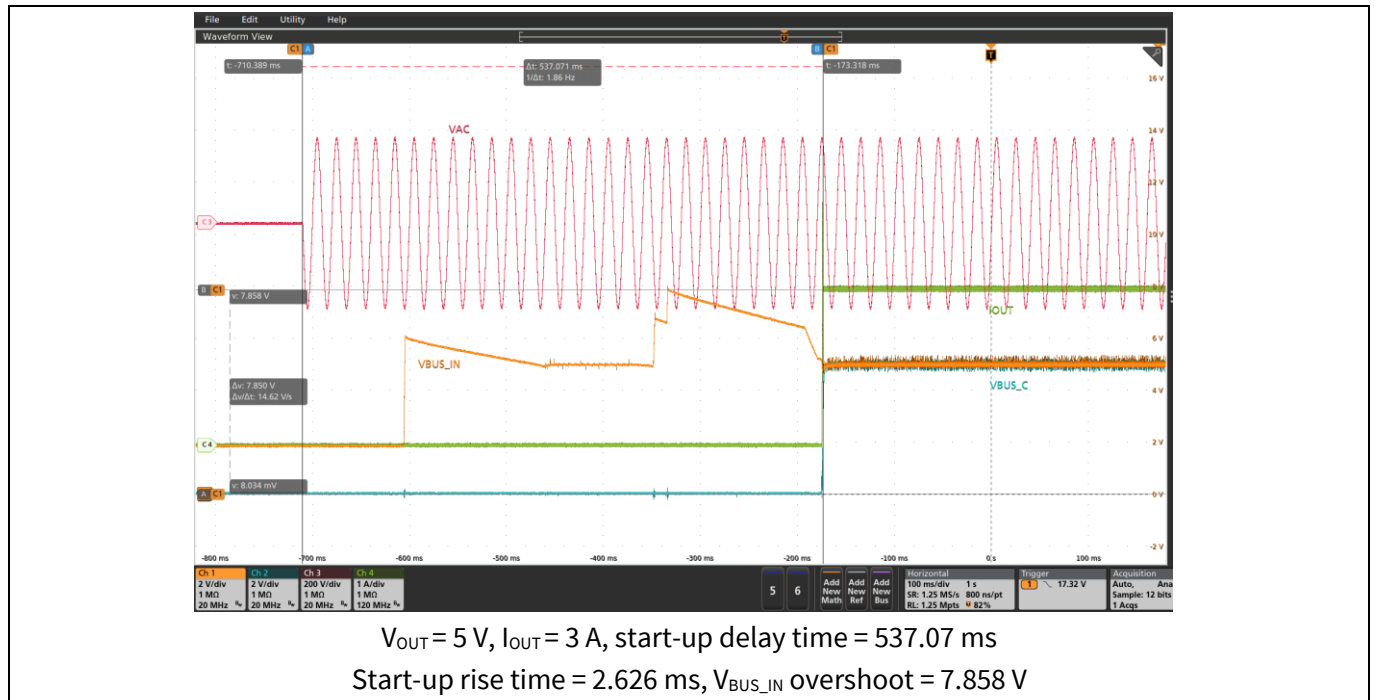


Figure 31 Start-up turn-on delay at 230 V_{AC}, 50 Hz (CH1: V_{BUS_IN}, CH2: V_{BUS_C}, CH3: V_{AC}, CH4: I_{OUT})

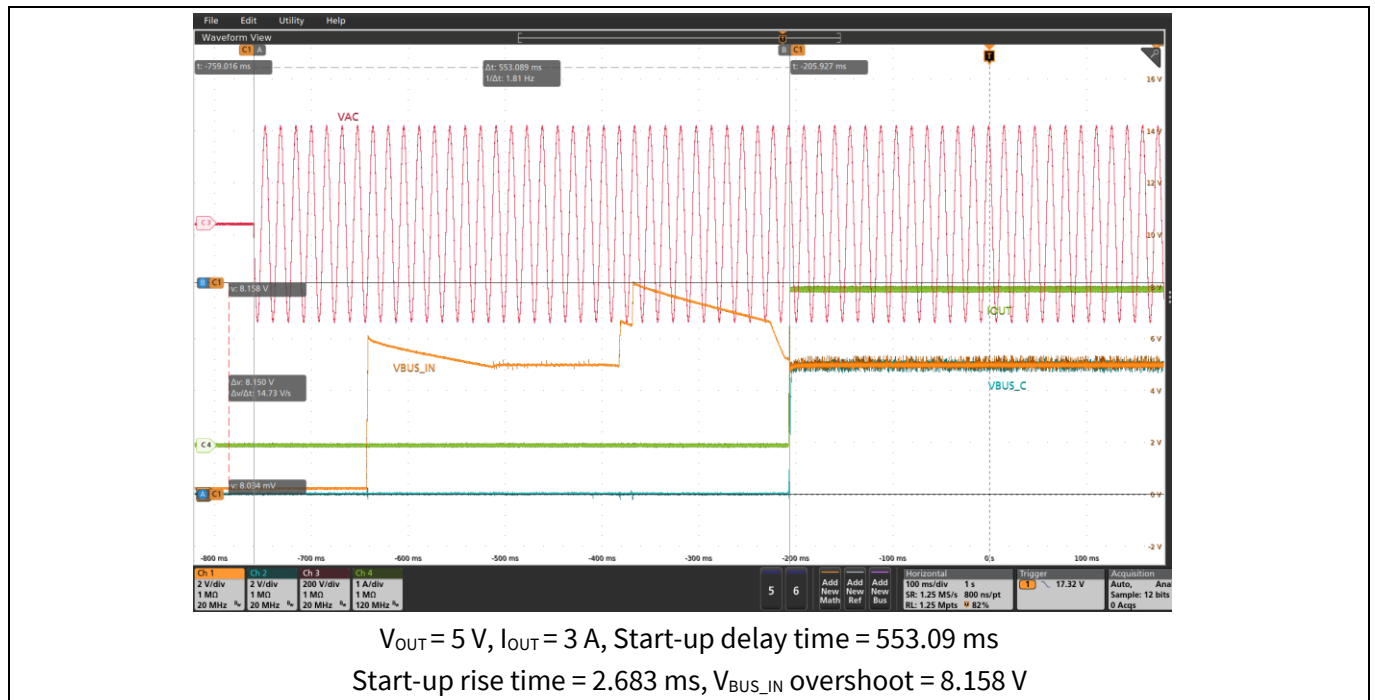


Figure 32 Start-up turn-on delay at 265 V_{AC}, 63 Hz (CH1: V_{BUS_IN}, CH2: V_{BUS_C}, CH3: V_{AC}, CH4: I_{OUT})

Power management test results

3.7 Hold-up time

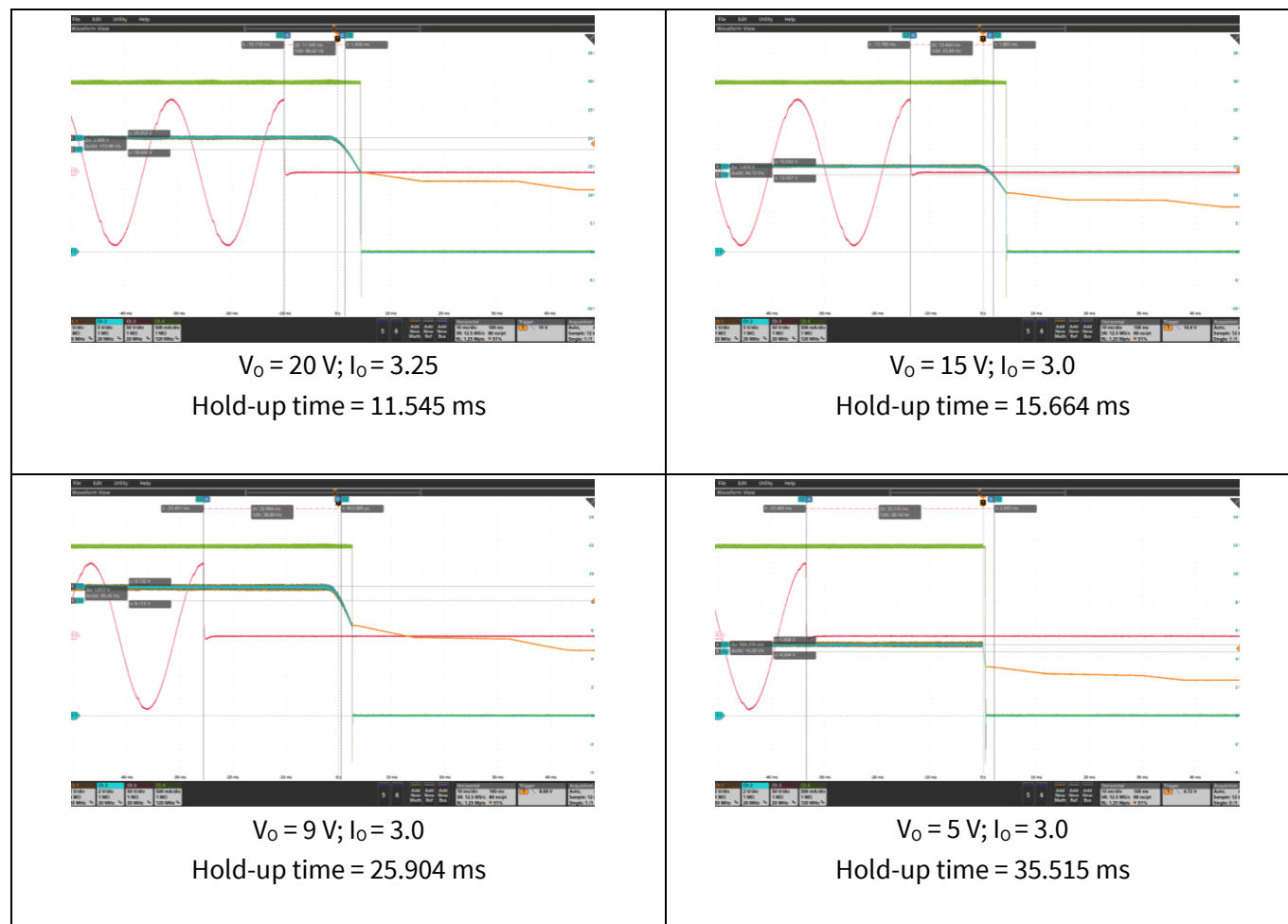


Figure 33 Hold-up time at 90 V_{AC}, 47 Hz (CH1: V_{BUS_IN}, CH2: V_{BUS_C}, CH3: V_{IN_AC}, CH4: I_{OUT})

Power management test results

3.8 Shut-down fall time

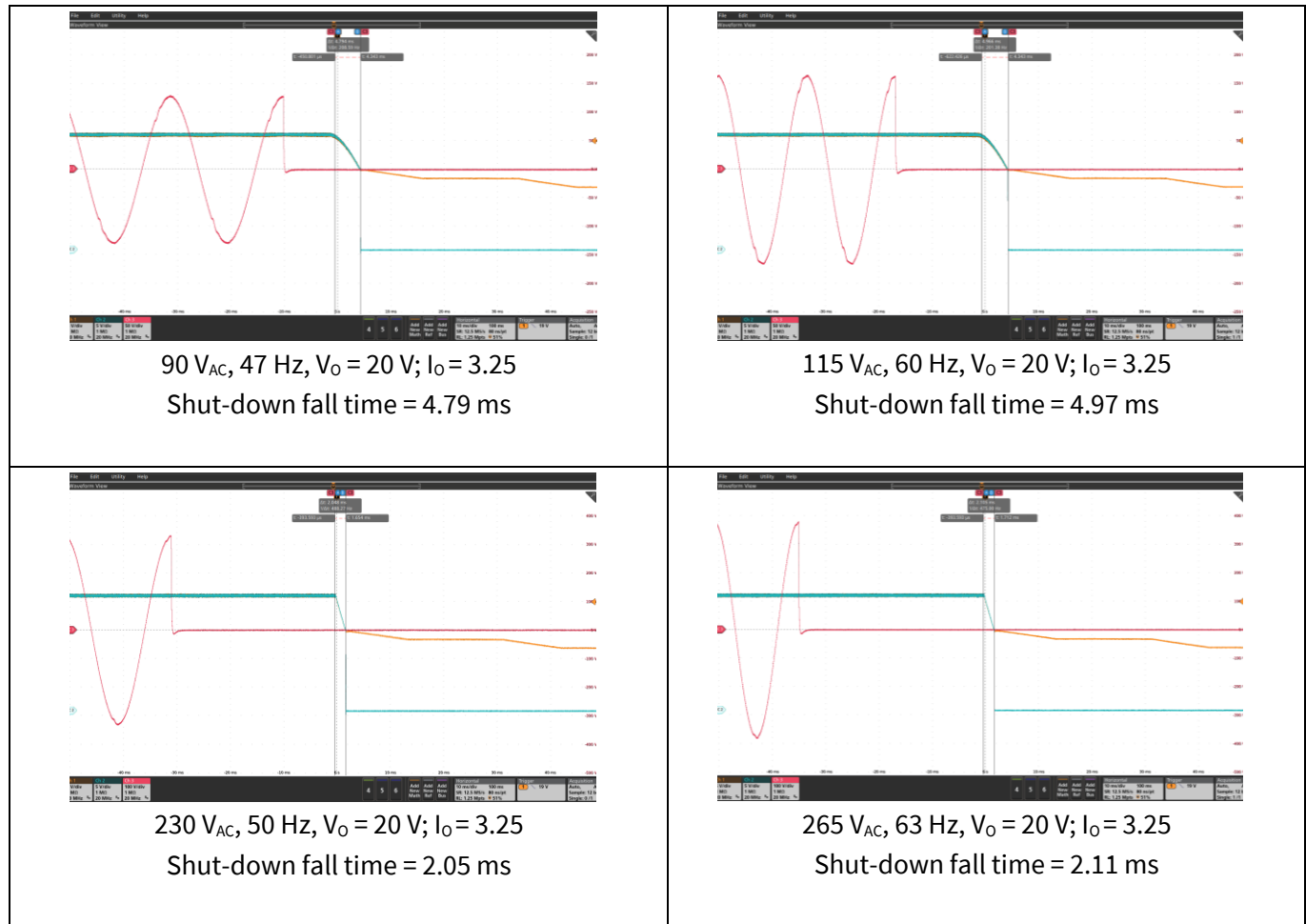


Figure 34 Shut-down fall time at different line conditions for 20 V, 3.25 A (CH1: V_{BUS_IN}, CH2: V_{BUS_C}, CH3: V_{IN_AC})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

3.9 Switch voltage stress

Test Condition: $V_{IN} = 265 V_{AC}$, 63 Hz, $V_{OUT} = 20 V$, $I_{OUT} = 3.25 A$

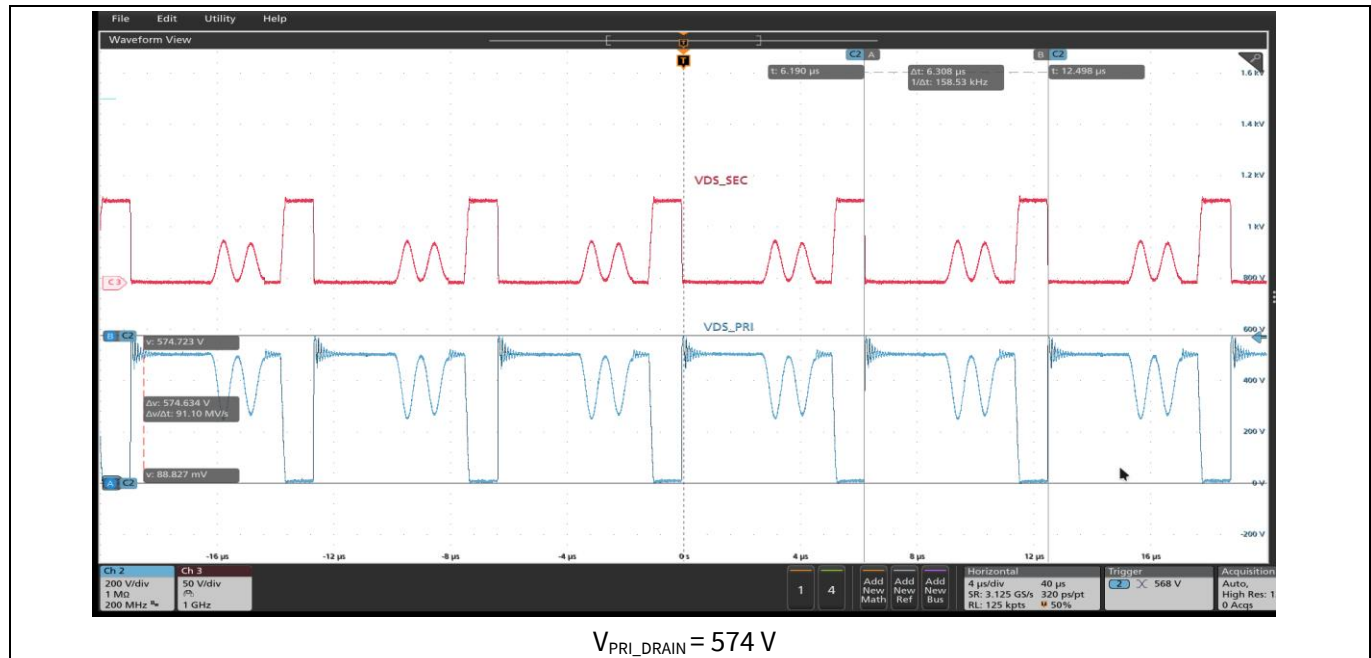


Figure 35 Switch voltage stress on primary FET (CH2: V_{PRI_DRAIN} , CH3: V_{SR_SEC})

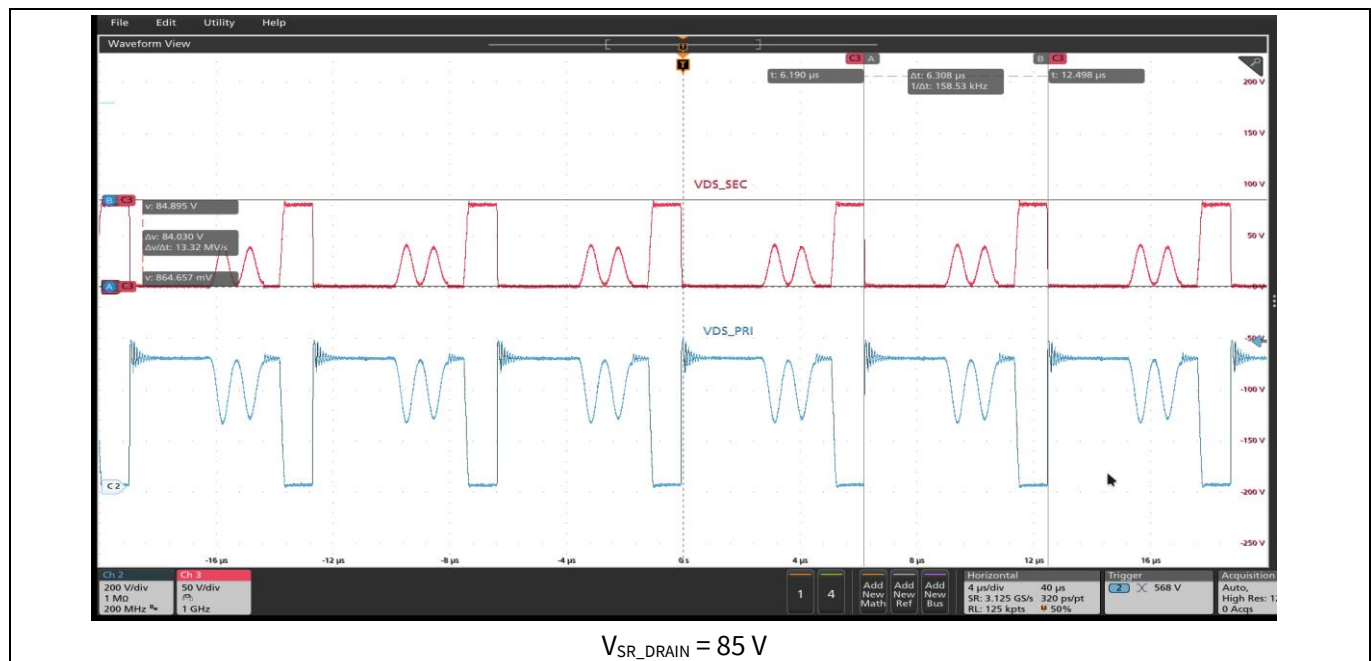


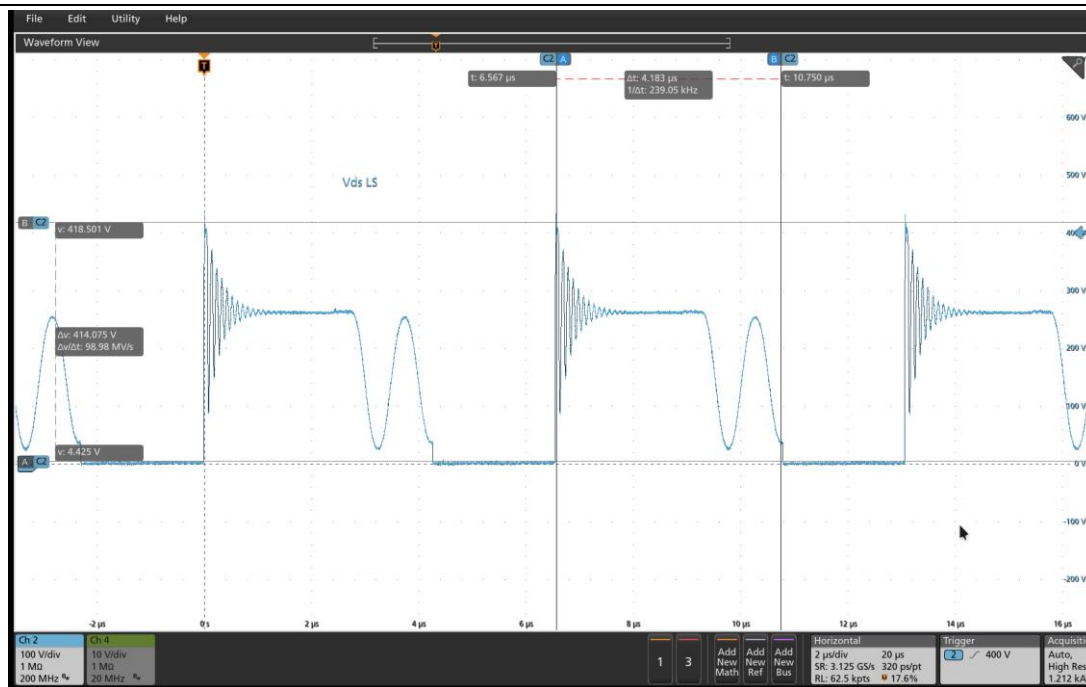
Figure 36 Switch voltage stress on secondary FET

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

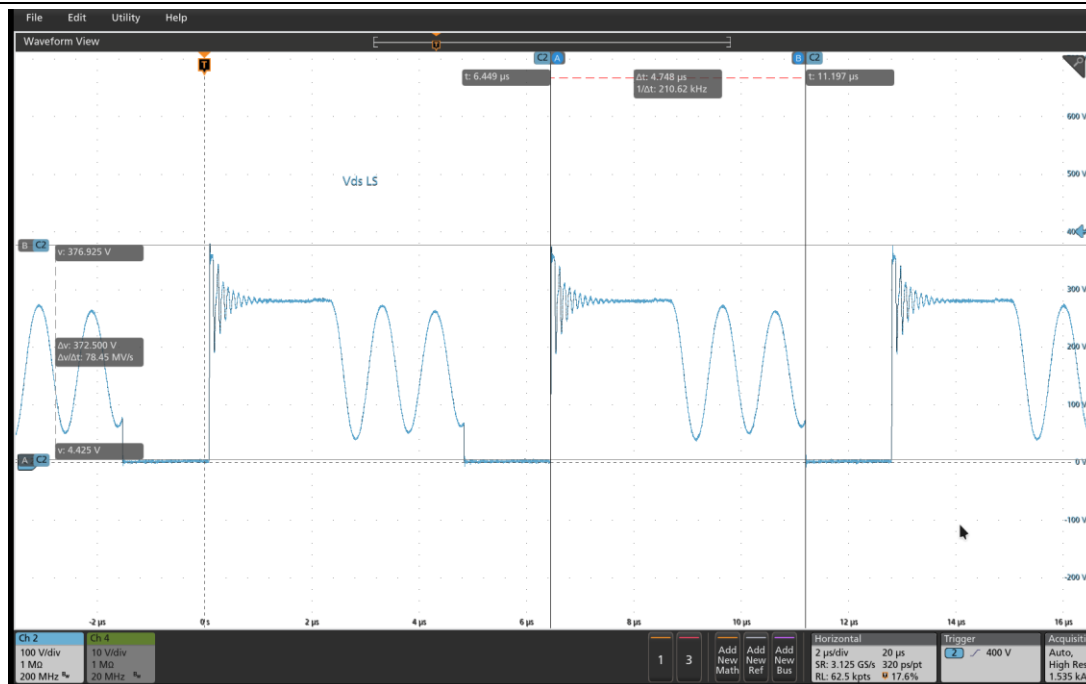
Power management test results

3.10 QR and ZVS operation

The system is designed to work in QR mode at low line ($<150 V_{AC}$) and in QR-ZVS mode in high line ($>150 V_{AC}$) to achieve the maximum possible efficiency.



$V_{AC} = 115 V$, $V_{OUT} = 20 V$, $I_{OUT} = 3.25 A$, Mode = QR, Valley No = 2

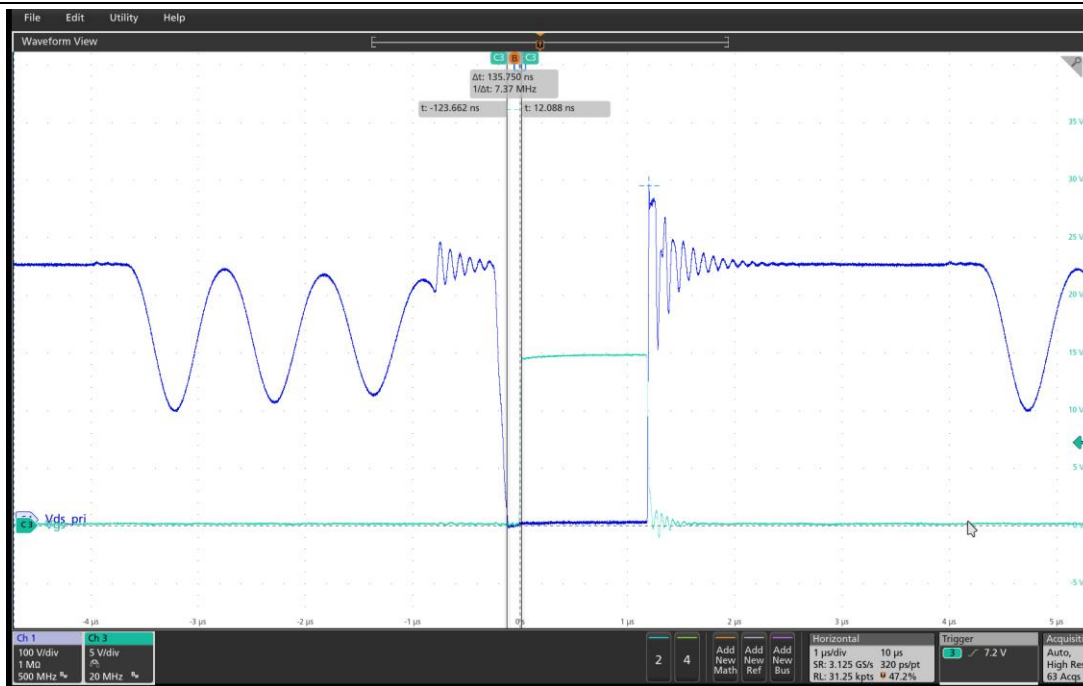


$V_{AC} = 115 V$, $V_{OUT} = 20 V$, $I_{OUT} = 2.2 A$, Mode = QR, Valley No = 3

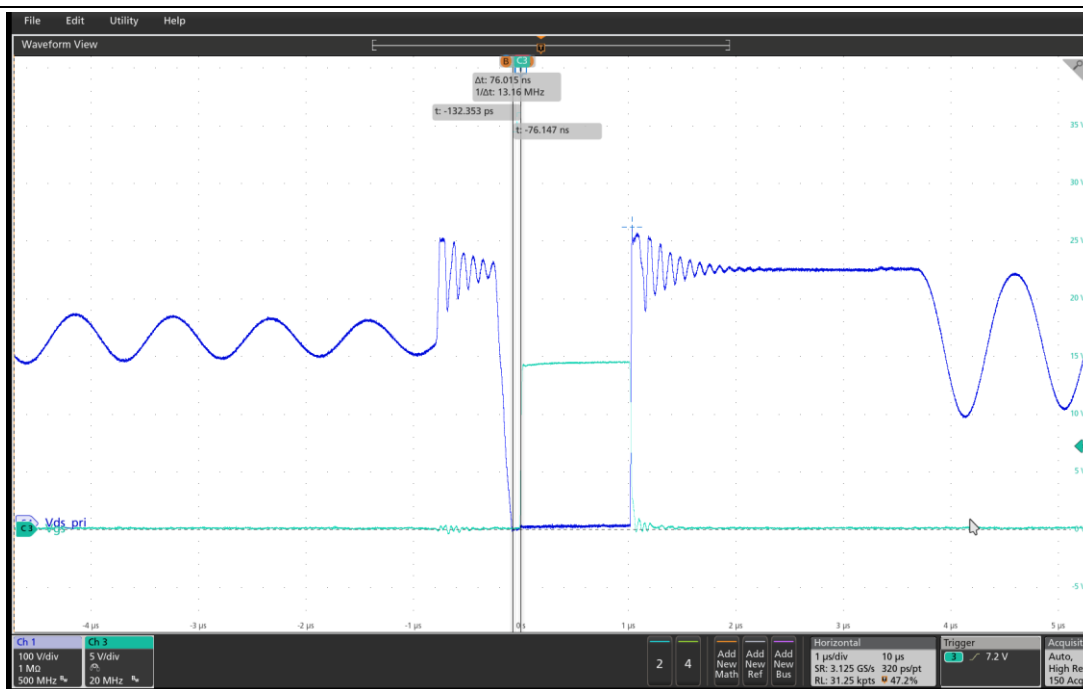
Figure 37 Primary V_{DS} at 115 V_{AC} , 60 Hz

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results



$V_{AC} = 230$ V, $V_{OUT} = 20$ V, $I_{OUT} = 3.25$ A, Mode = ZVS, ZVS pulse width = 550 ns, Dead time = 200 ns

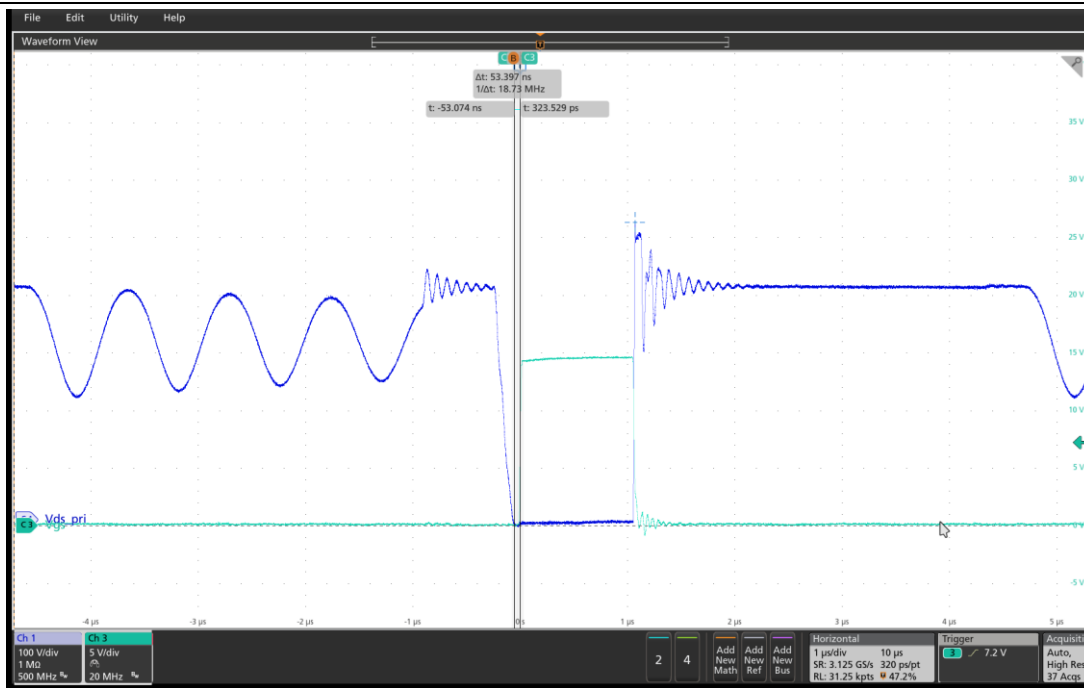


$V_{AC} = 230$ V, $V_{OUT} = 20$ V, $I_{OUT} = 1$ A, Mode = ZVS, ZVS pulse width = 550 ns, Dead time = 200 ns

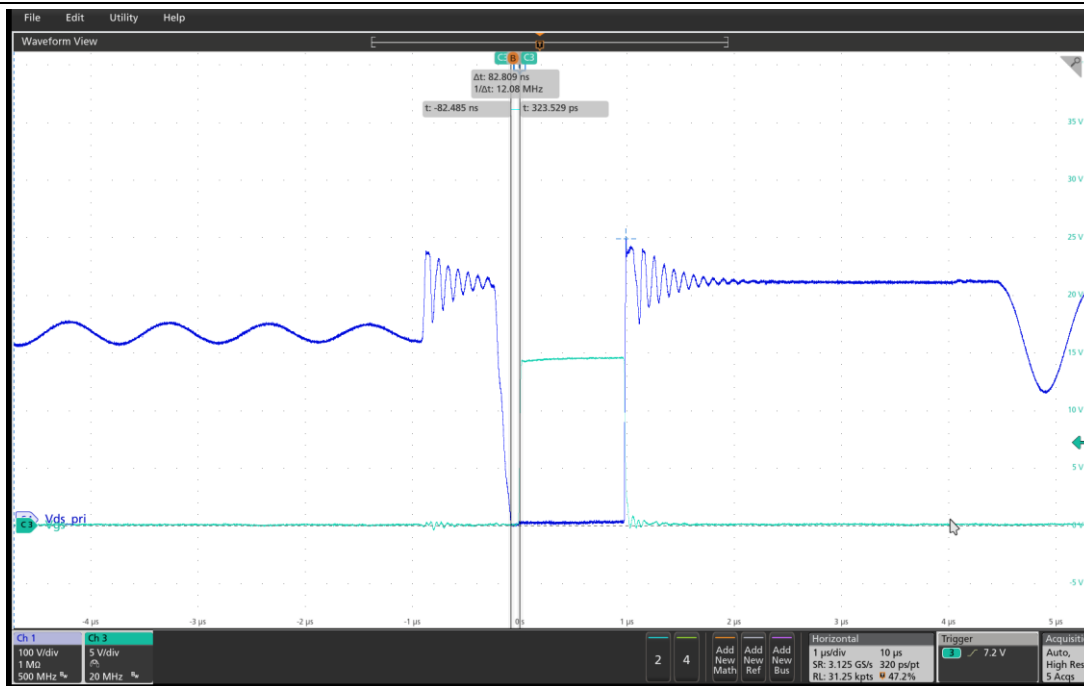
Figure 38 Primary V_{DS} and V_{GS} for 20 V output at 230 V_{AC} , 50 Hz (CH1: V_{DS_PRI} , CH3: GDL)

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results



$V_{AC} = 230\text{ V}$, $V_{OUT} = 15\text{ V}$, $I_{OUT} = 3\text{ A}$, Mode = ZVS, ZVS pulse width = 65 ns, Dead time = 200 ns

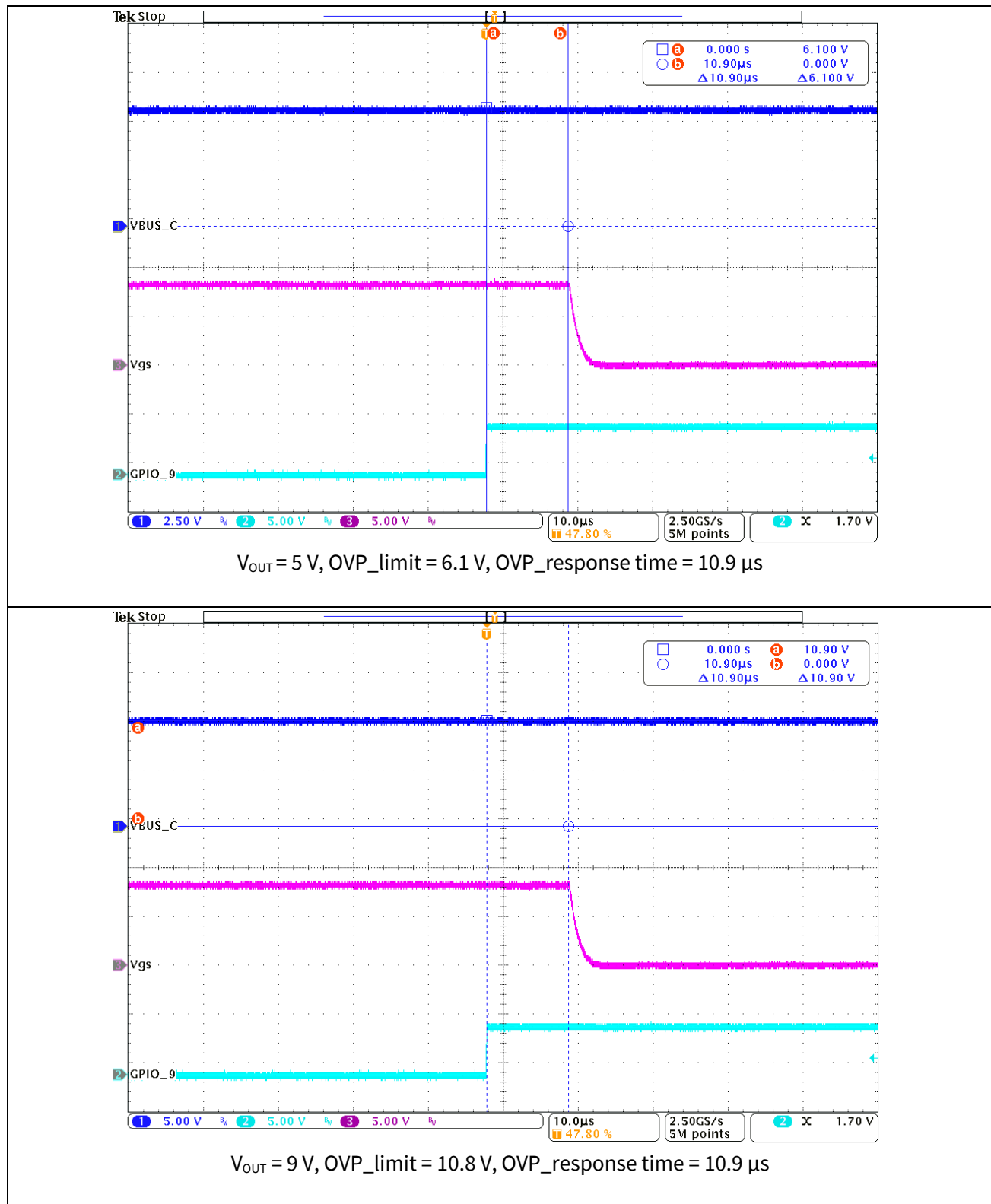


$V_{AC} = 230\text{ V}$, $V_{OUT} = 15\text{ V}$, $I_{OUT} = 1\text{ A}$, Mode = ZVS, ZVS pulse width = 650 ns, Dead time = 200 ns

Figure 39 Primary V_{DS} and V_{GS} for 15 V output at 230 V_{AC} , 50 Hz (CH1: V_{DS_PRI} , CH3: GDL)

Power management test results

3.11 Overvoltage protection (OVP)



65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

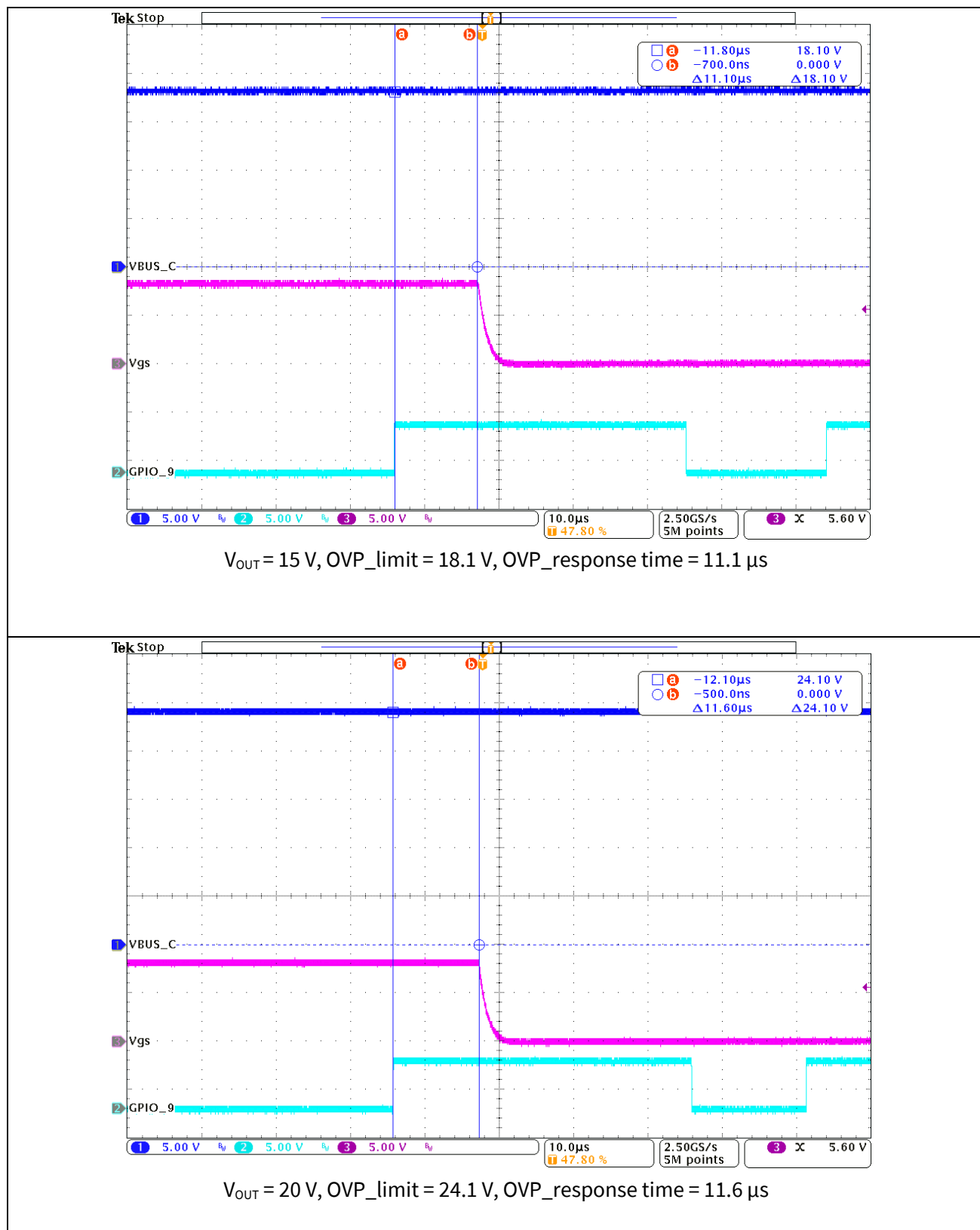


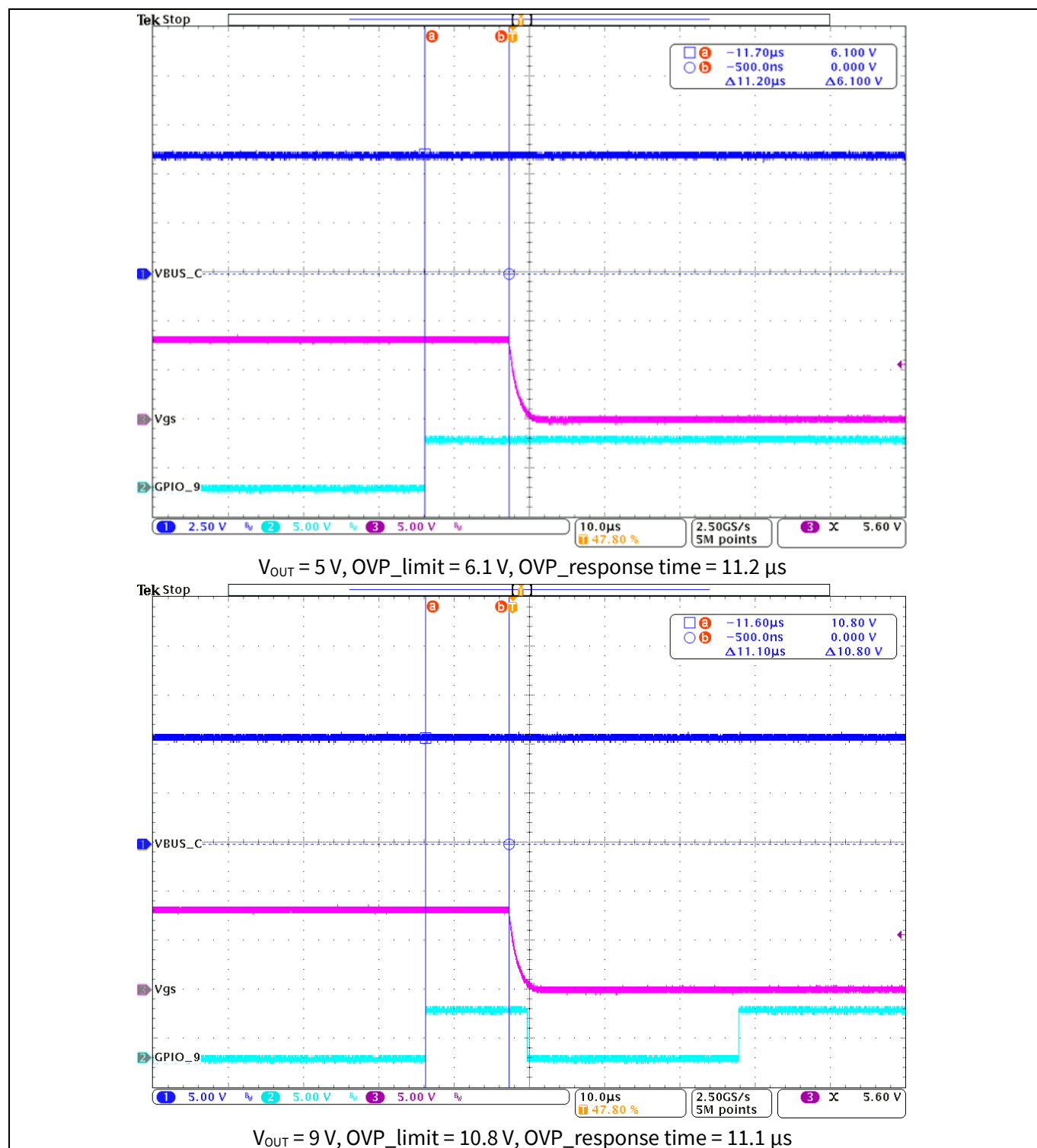
Figure 40 OVP at 115 V_{AC}, 60 Hz (CH3: NFET¹; CH2: GPIO9; CH1: V_{BUS_C})

¹ NFET - Provider FET(Q2) Gate to source waveform.

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results



65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

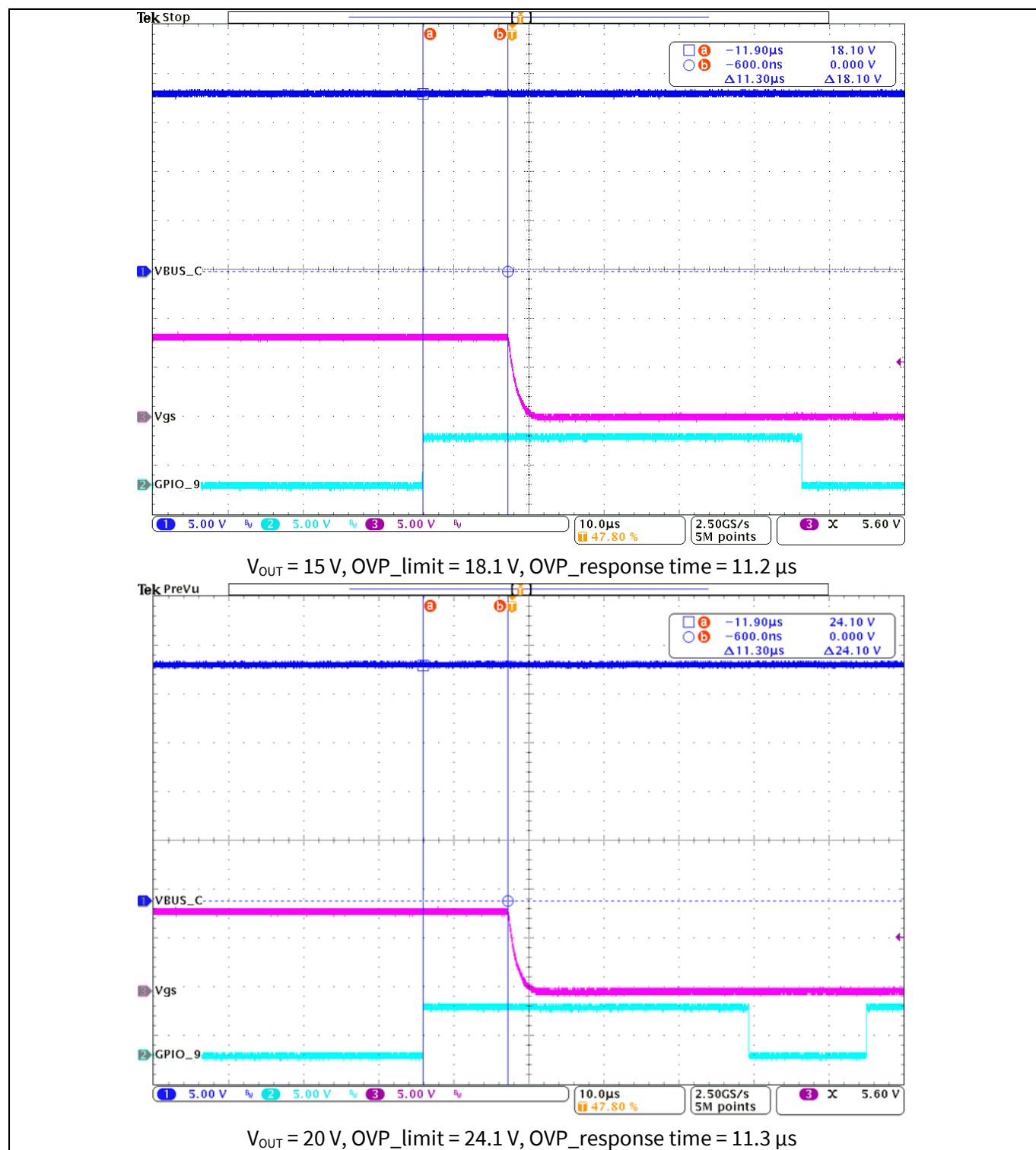


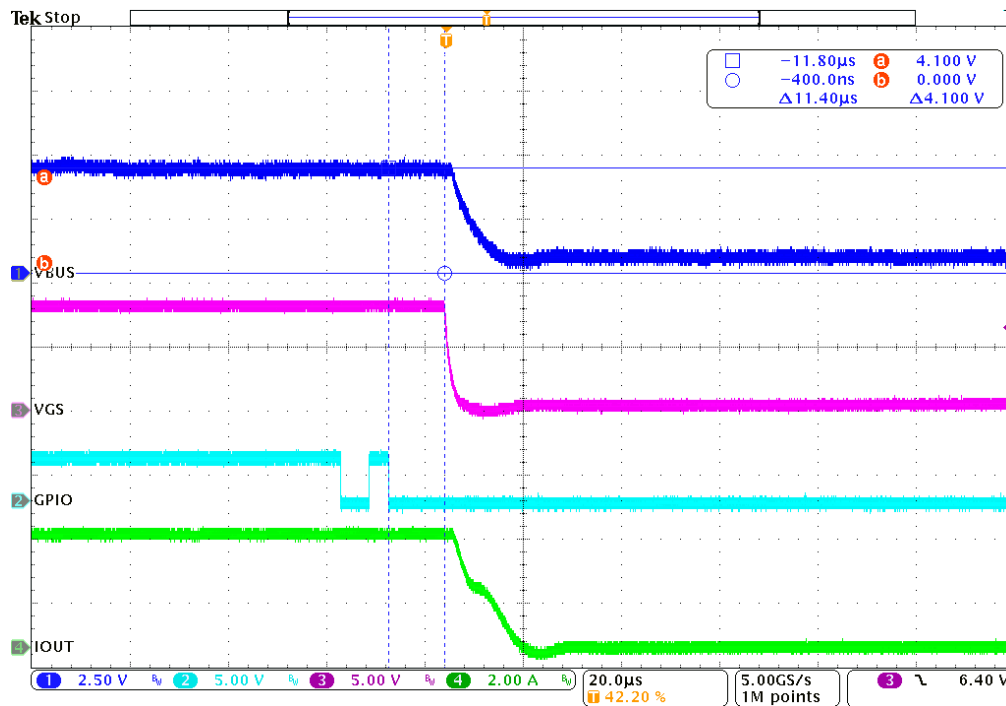
Figure 41 OVP at 230 V_{AC}, 50 Hz (CH3: NFET¹; CH2: GPIO9; CH1: V_{BUS_c})

¹ NFET - Provider FET(Q2) Gate to source waveform.

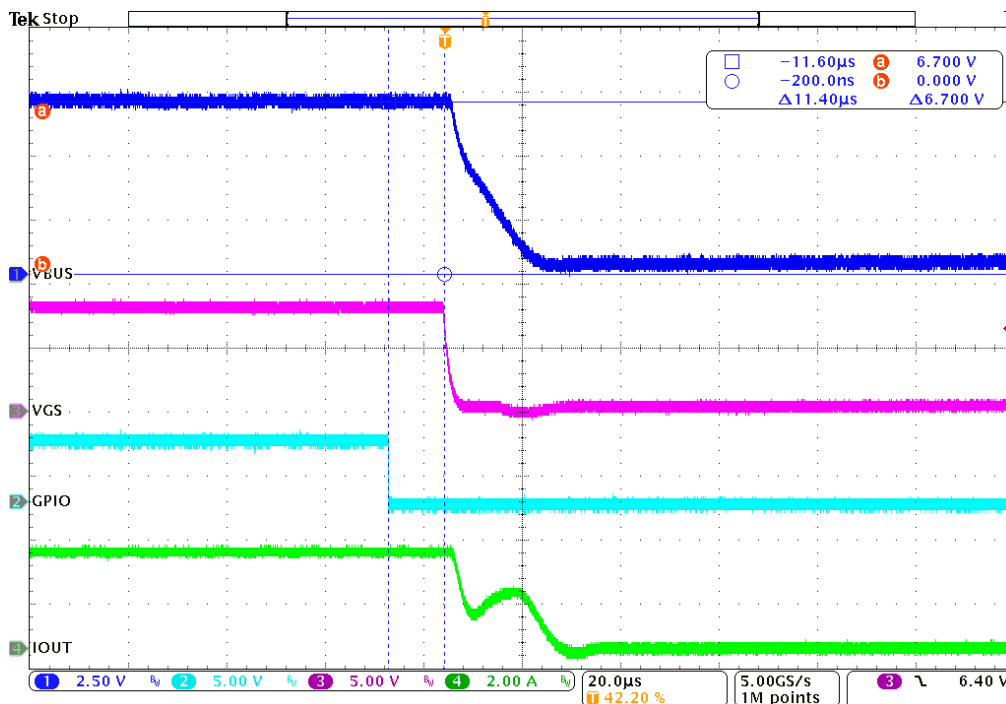
Power management test results

3.12 Undervoltage protection (UVP)

UVP tested at 115 V_{AC} 60 Hz



V_{OUT} = 5 V, UVP_limit = 4.1 V, UVP_response time = 11.4 μs



V_{OUT} = 9 V, UVP_limit = 6.7 V, UVP_response time = 11.4 μs

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

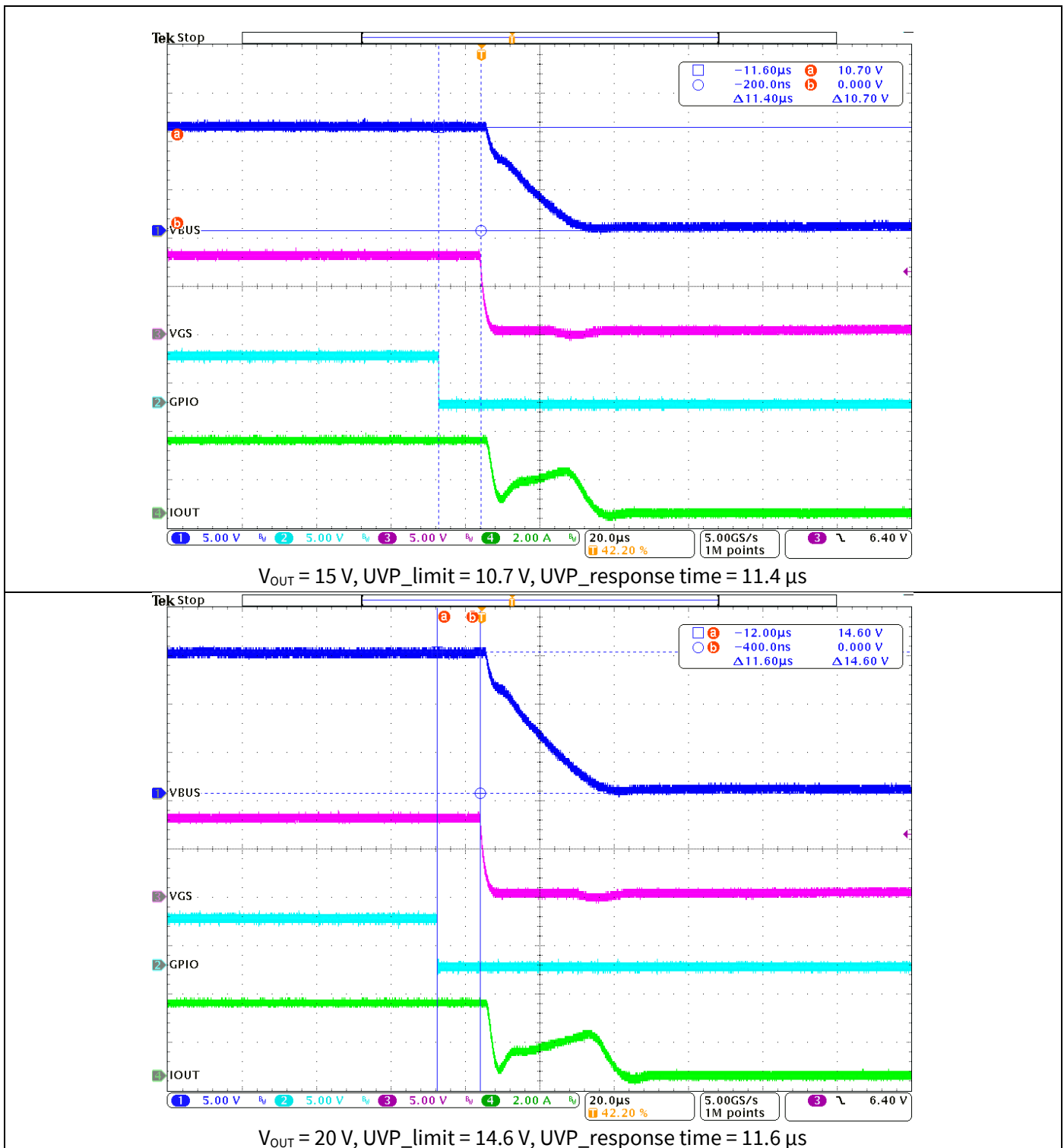


Figure 42 UVP at 115 V_{AC} , 60 Hz (CH4: I_{OUT} ; CH2: GPIO9; CH1: V_{BUS_C} ; CH3: NFET¹)

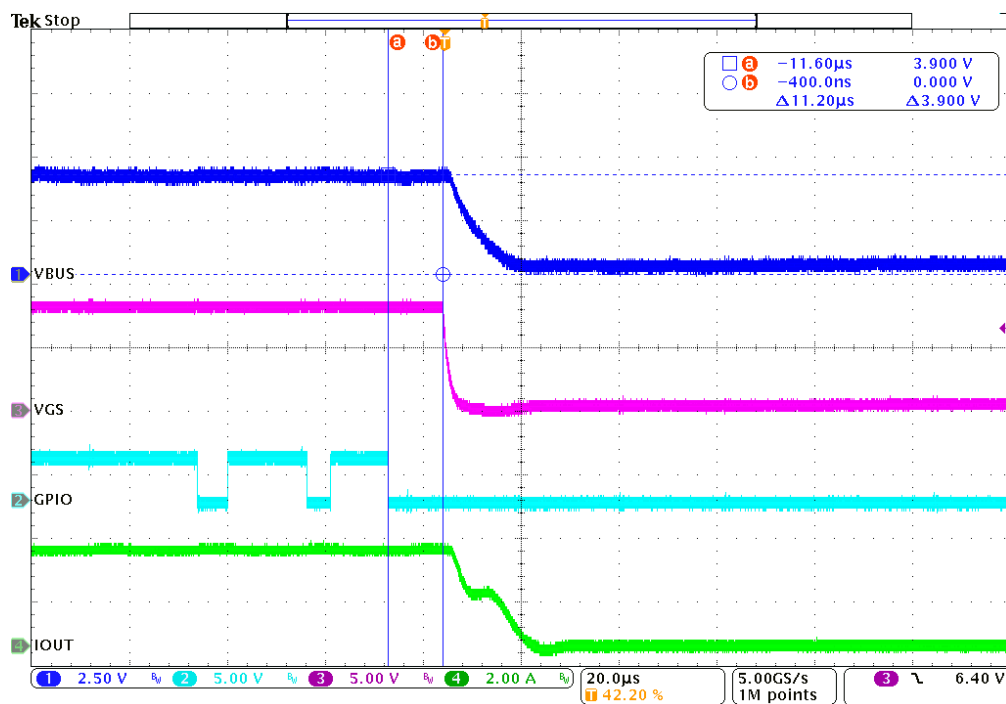
¹ NFET - Provider FET(Q1) Gate to source waveform.
Test report

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

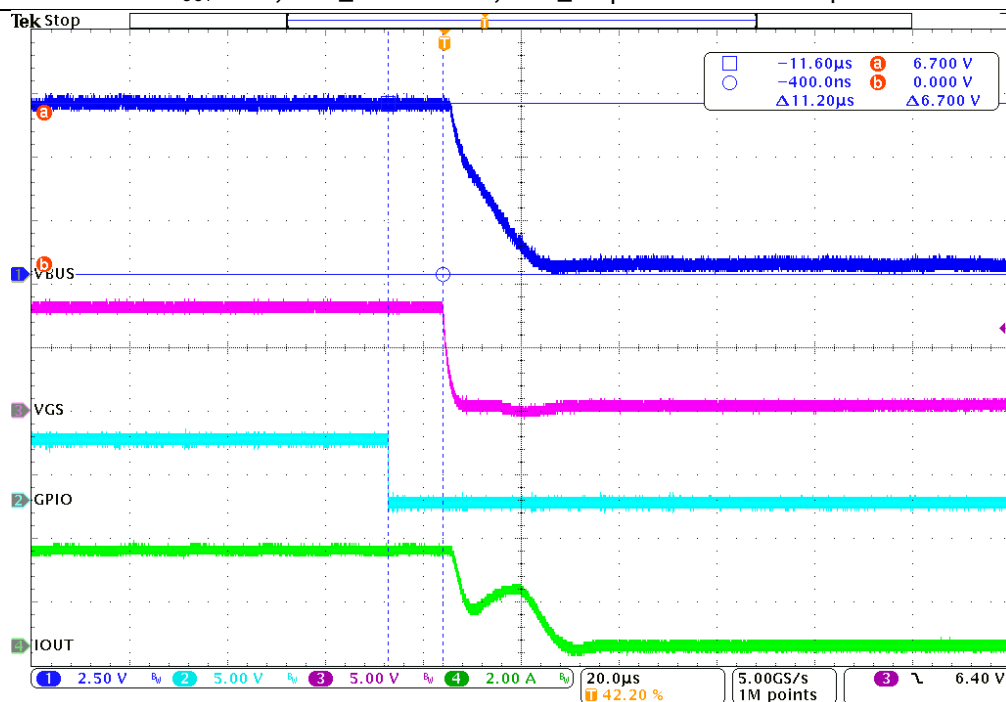


Power management test results

UVP tested at 230 VAC 50 Hz



$V_{OUT} = 5\text{ V}$, UVP_limit = 3.9 V, UVP_response time = 11.2 μs



$V_{OUT} = 9\text{ V}$, UVP_limit = 6.7 V, UVP_response time = 11.2 μs

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

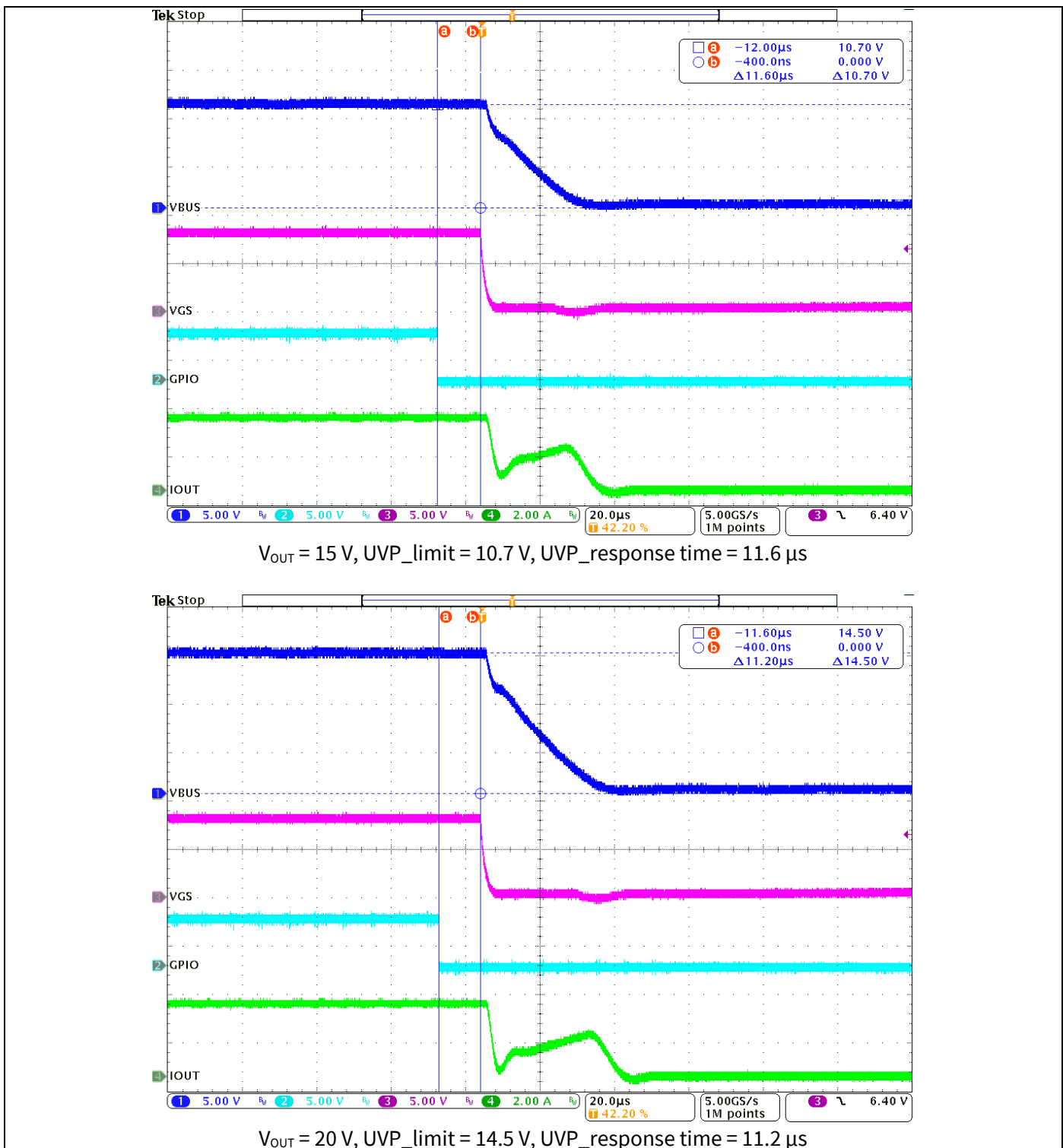


Figure 43 UVP at 230 V_{AC}, 50 Hz (CH4: I_{OUT}; CH2: GPIO9; CH1: V_{BUS_C}; CH3: NFET¹)

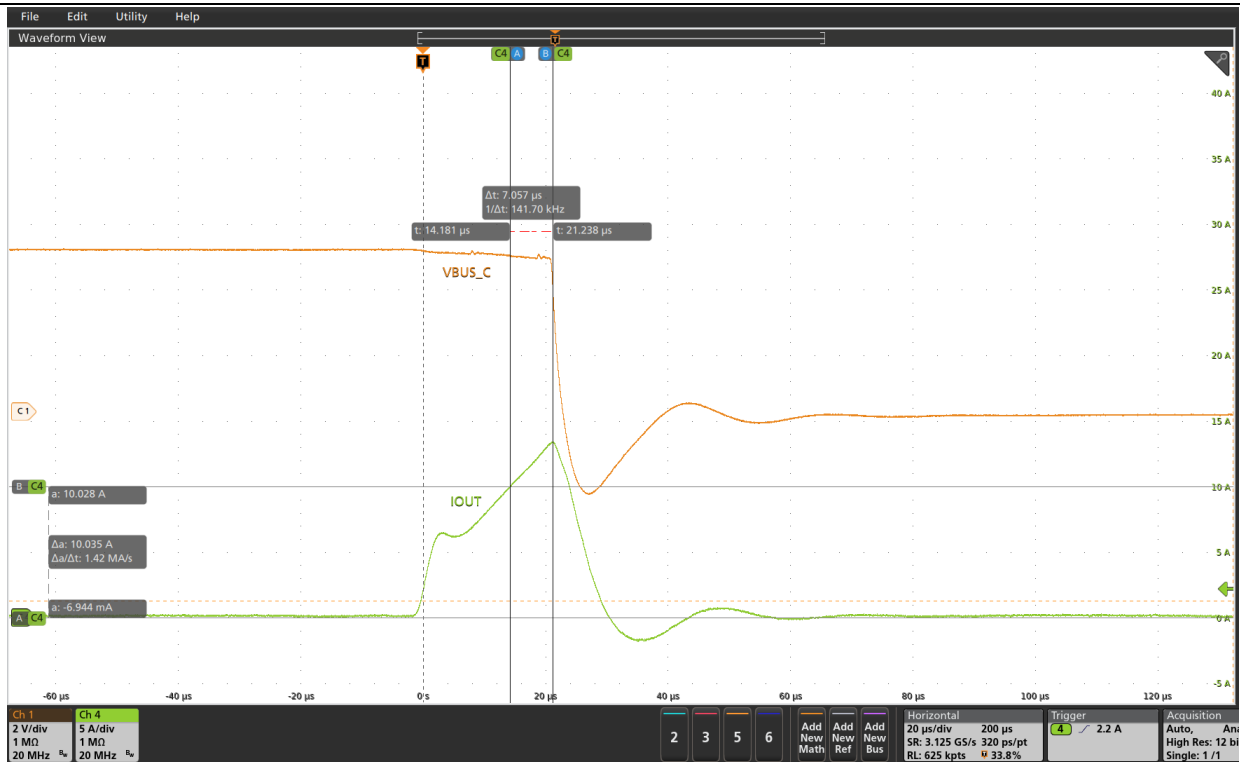
¹ NFET - Provider FET(Q1) Gate to source waveform.

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

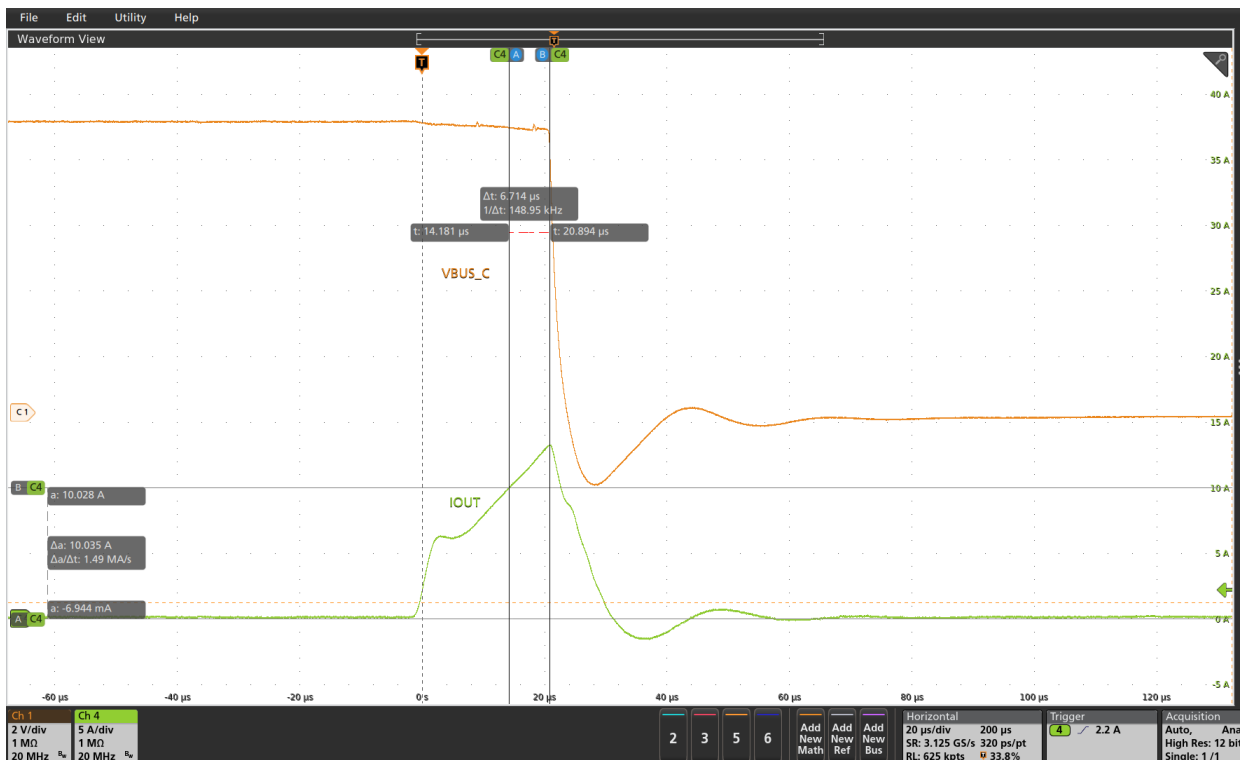
Power management test results

3.13 Short-circuit protection (SCP)

SCP tested at 115 V_{AC} 60 Hz



Fixed PDO = 5 V, 3 A; SCP_trip point = 10 A; SCP_response time = 7.05 µs



Fixed PDO = 9 V, 3 A; SCP_trip point = 10 A; SCP_response time = 6.7 µs

The screenshot displays a current transient on an oscilloscope. The top trace, labeled **VBUS_C** (orange), shows a voltage signal that remains relatively flat before a sharp drop and subsequent recovery. The bottom trace, labeled **IOUT** (green), shows the current response, which rises to a peak of approximately 10.035 A before settling back to a baseline of -6.944 mA. Key measurement points on the IOUT trace include a peak value of 10.028 A and a slope of 1.55 MA/s. The horizontal scale is 20 μs/div, and the vertical scale is 5 A/div. The trigger is set to 2.2 A.

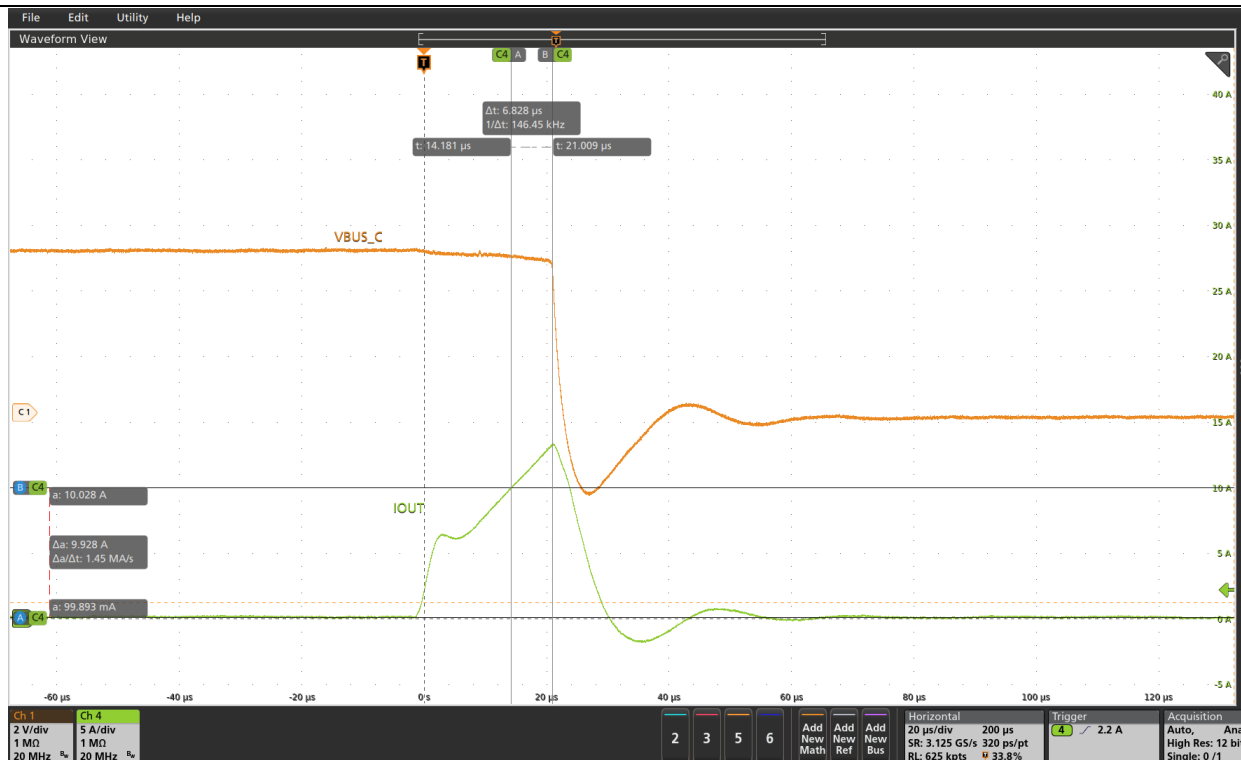
The screenshot displays two waveforms on a digital oscilloscope. The top trace, labeled **VBUS_C** (orange), shows a voltage signal that drops from a steady state of approximately 15V to about 14.5V, then gradually recovers. The bottom trace, labeled **IOUT** (green), shows a current signal that spikes from 0A to a peak of approximately 10.035A before settling back to 0A. The scope's horizontal scale is 200 µs/div, and the vertical scale is 5 A/div. The trigger is set to 2.2 A. The acquisition mode is set to Auto, and the resolution is 12 bits.

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

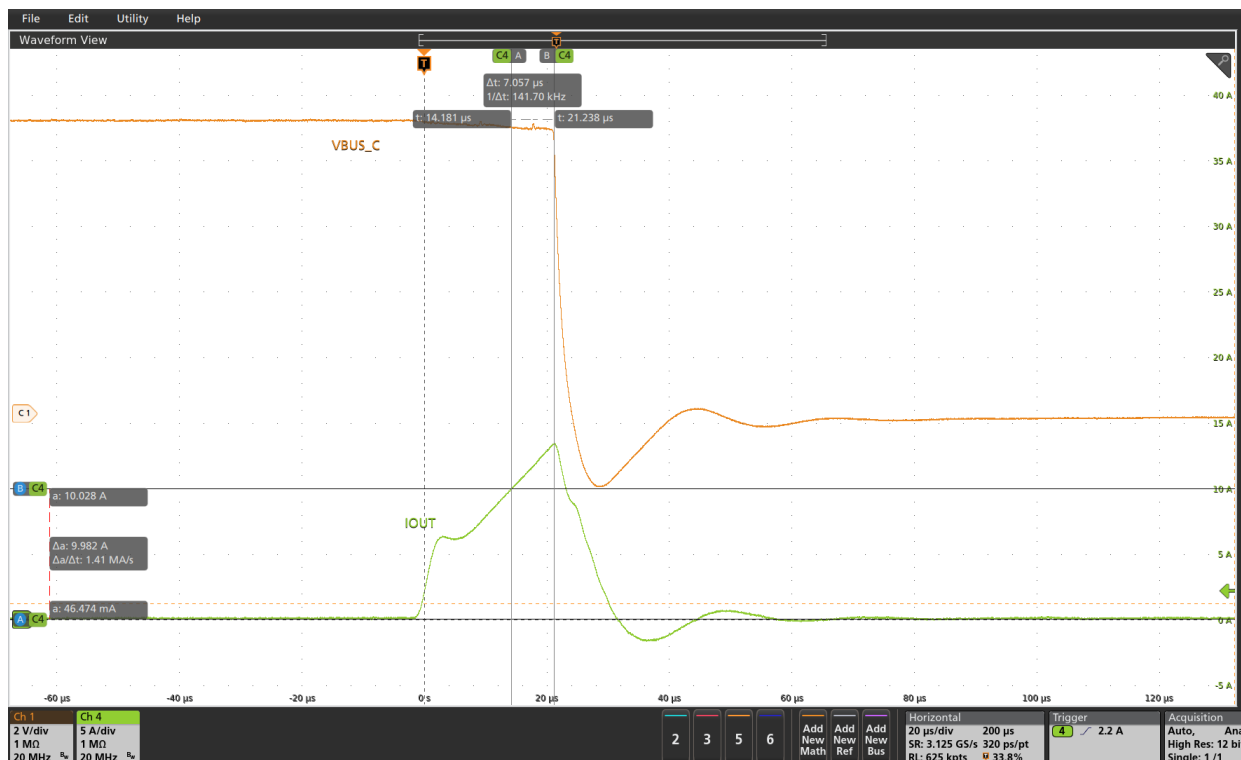


Power management test results

SCP tested at 230 V_{AC} 50 Hz



Fixed PDO = 5 V, 3 A; SCP_trip point = 10 A; SCP_response time = 6.8 μs

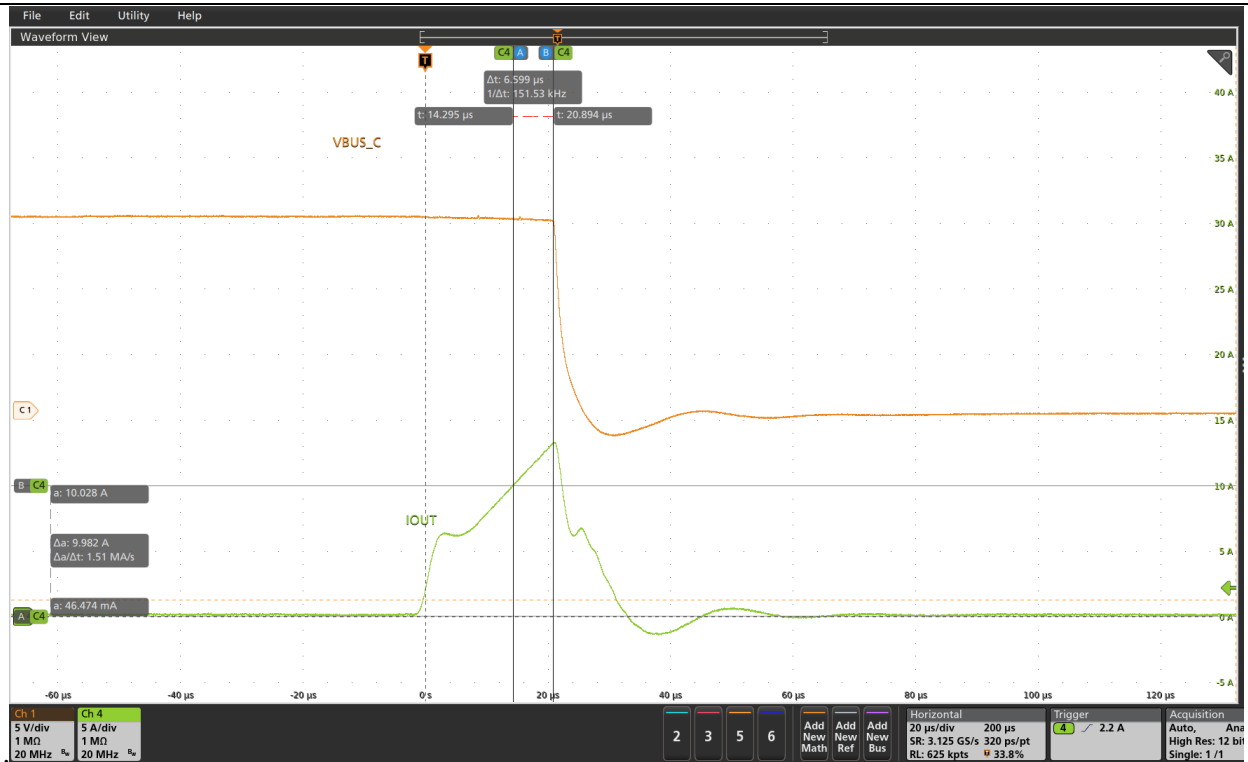


Fixed PDO = 9 V, 3 A; SCP_trip point = 10 A; SCP_response time = 7.05 μs

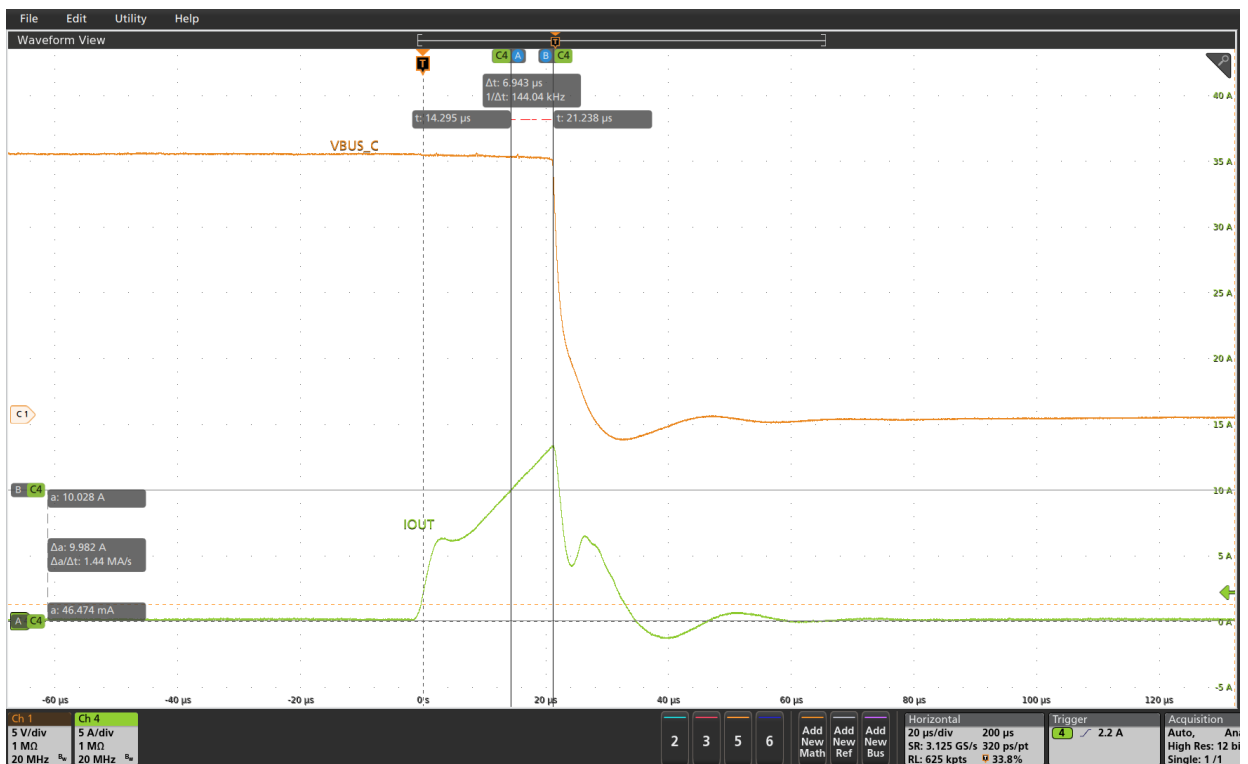
65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results



Fixed PDO = 15 V, 3 A; SCP_trip point = 10 A; SCP_response time = 6.6 μs



Fixed PDO = 20 V, 3.25 A; SCP_trip point = 10 A; SCP_response time = 6.94 μs

Figure 45 SCP at 230 V_{AC}, 50 Hz (CH1: V_{BUS_C}; CH4: I_{OUT})

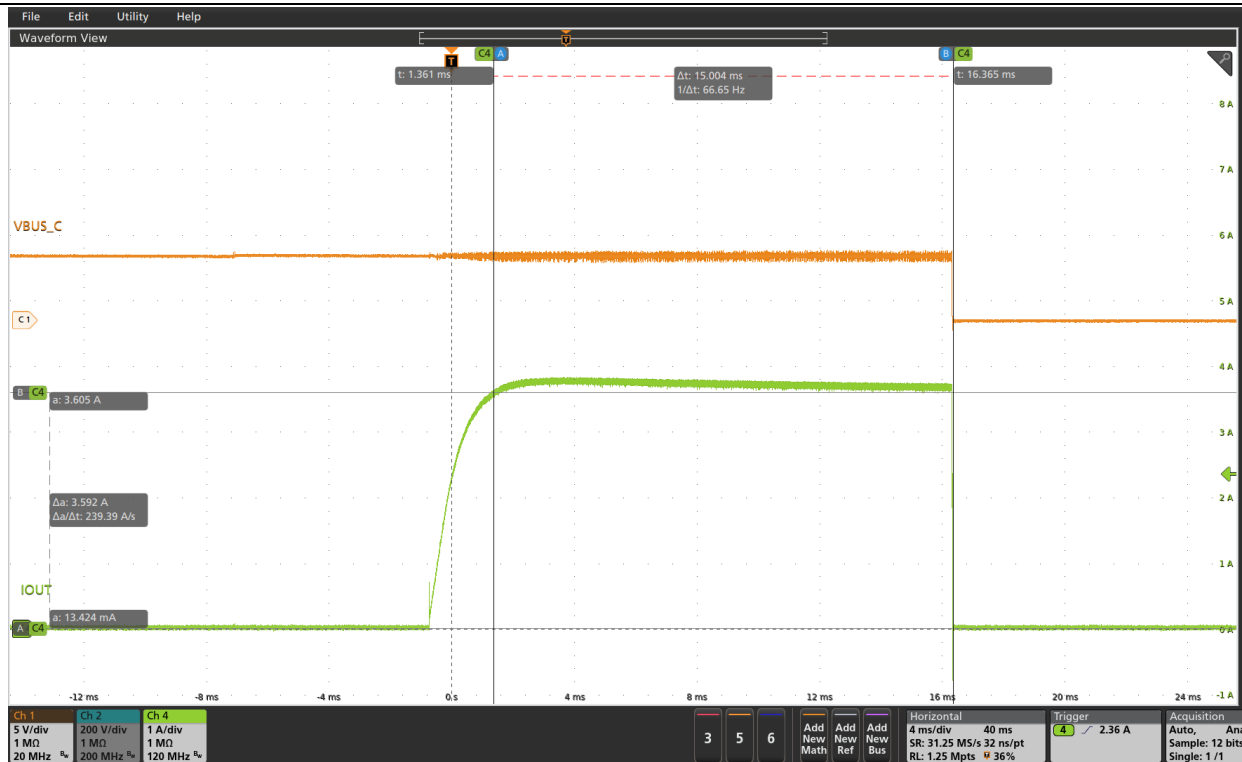
65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



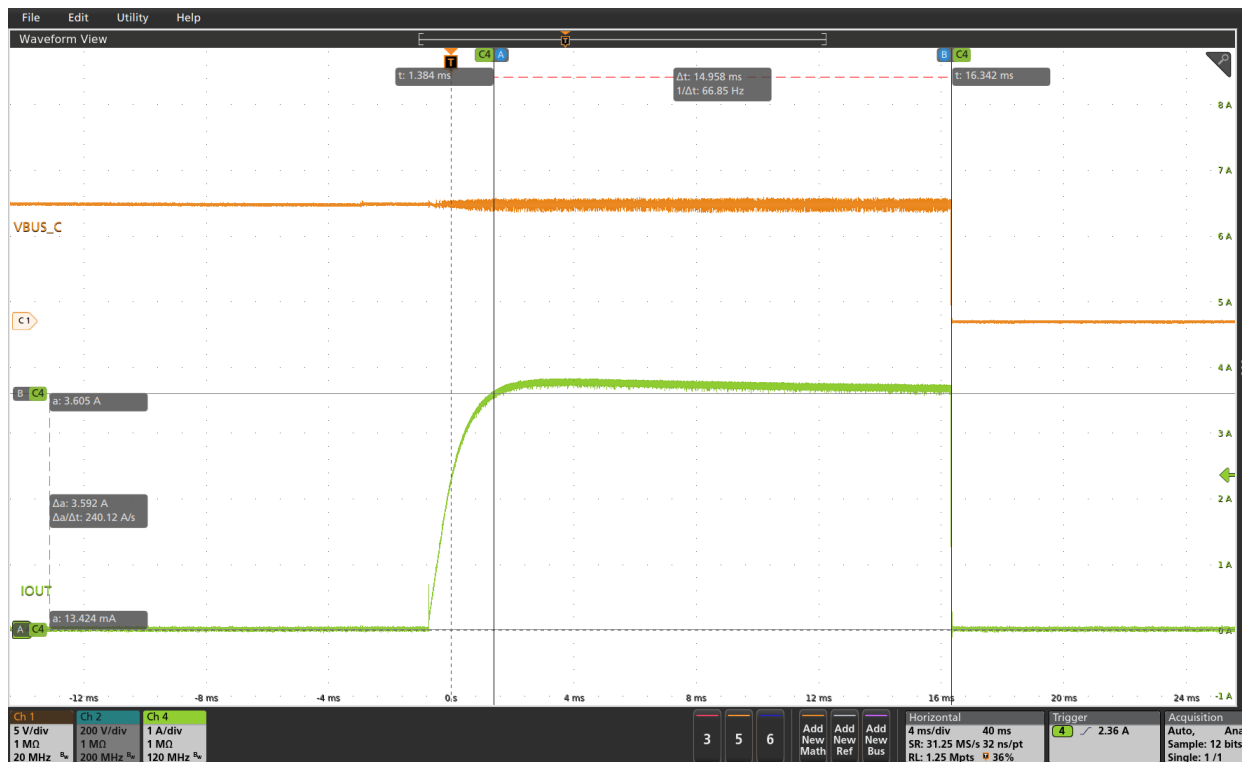
Power management test results

3.14 Overcurrent protection (OCP)

OCP tested at 115 V_{AC} 60 Hz



Fixed PDO = 5 V, 3 A; OCP_trip point = 3.605 A; OCP_response time = 15 ms

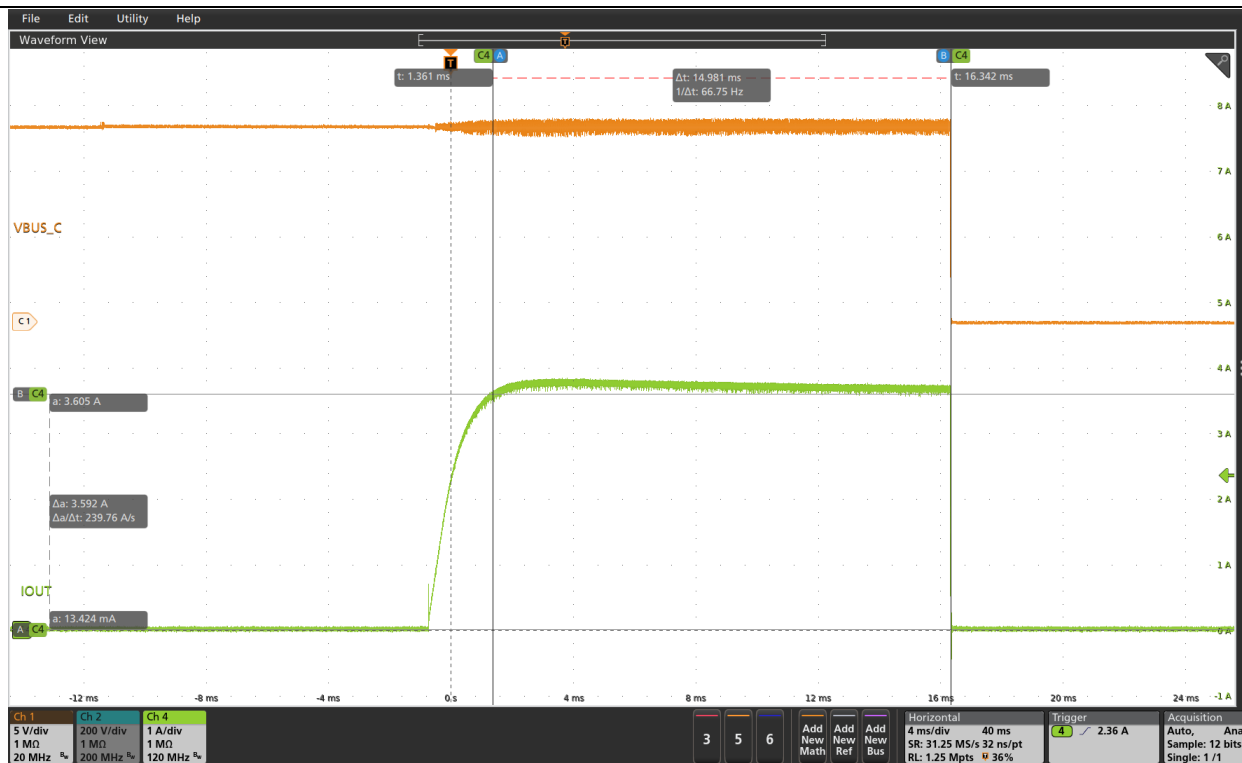


Fixed PDO = 9 V, 3 A; OCP_trip point = 3.605 A; OCP_response time = 14.95 ms

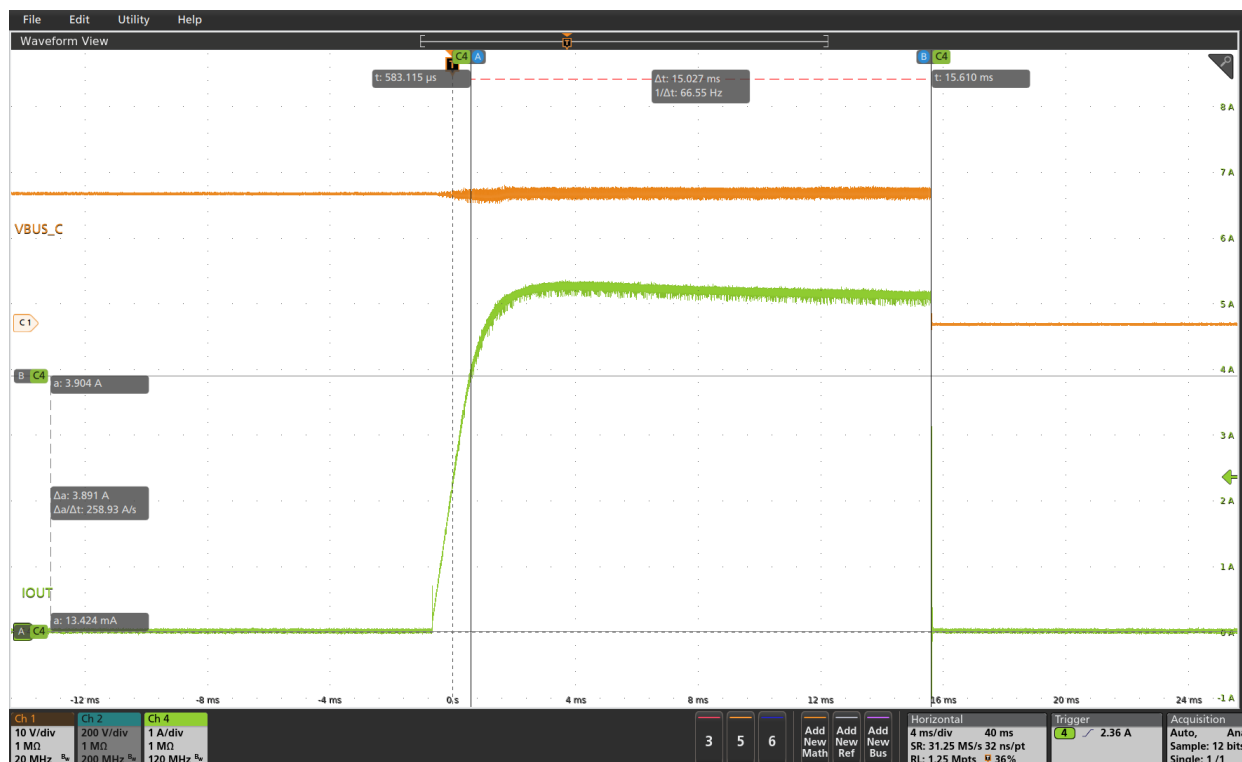
65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results



Fixed PDO = 15 V, 3 A; OCP_trip point = 3.605 A; OCP_response time = 14.98 ms



Fixed PDO = 20 V, 3.25 A; OCP_trip point = 3.90 A; OCP_response time = 15 ms

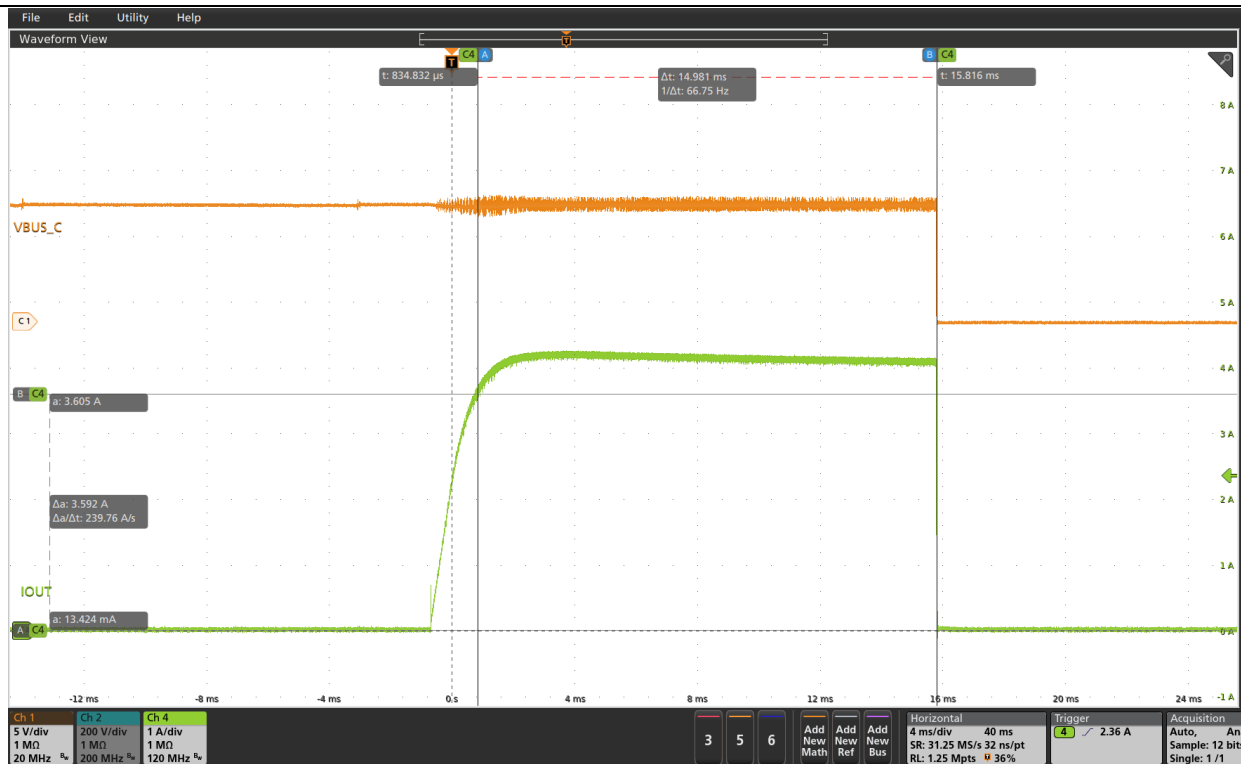
Figure 46 OCP at 115 V_{AC}, 60 Hz (CH1: V_{BUS_C}; CH4: I_{OUT})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

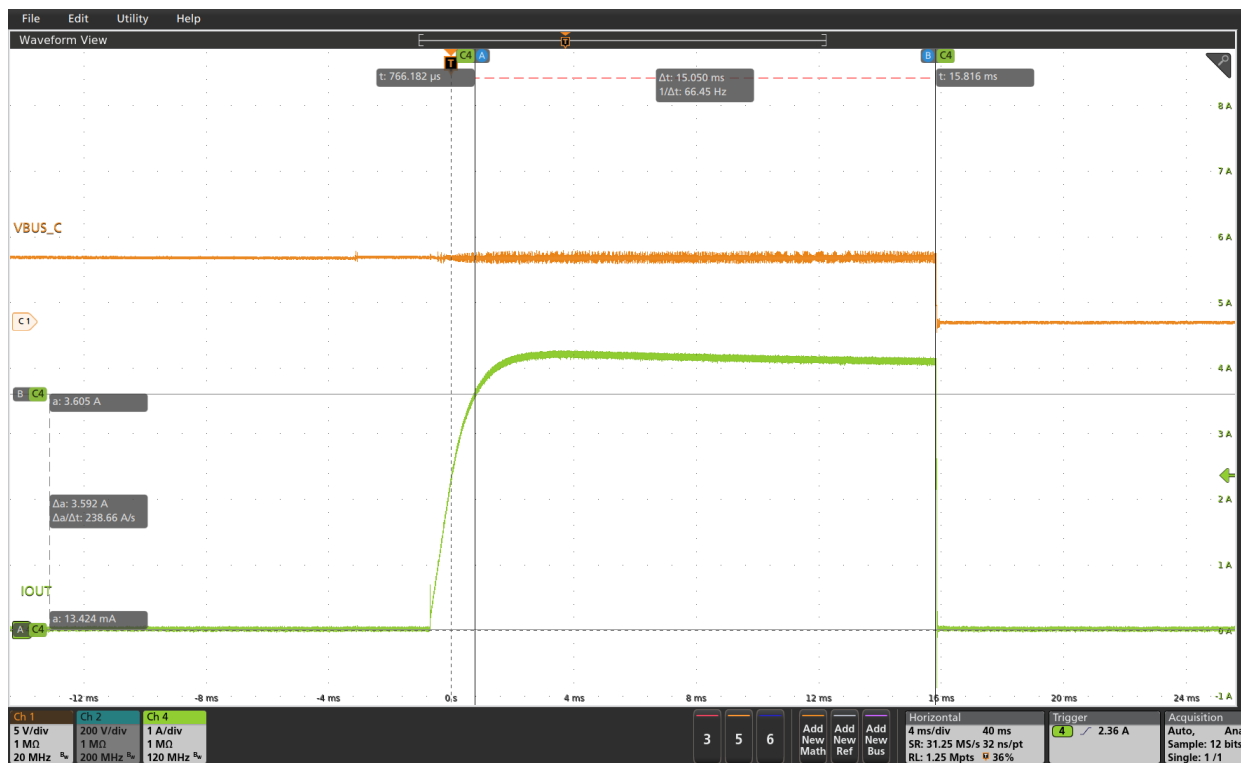


Power management test results

OCP Tested at 230 V_{AC} 50 Hz



Fixed PDO = 5 V, 3 A; OCP_trip point = 3.605 A; OCP_response time = 15 ms



Fixed PDO = 9 V, 3 A; OCP_trip point = 3.605 A; OCP_response time = 14.98 ms

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

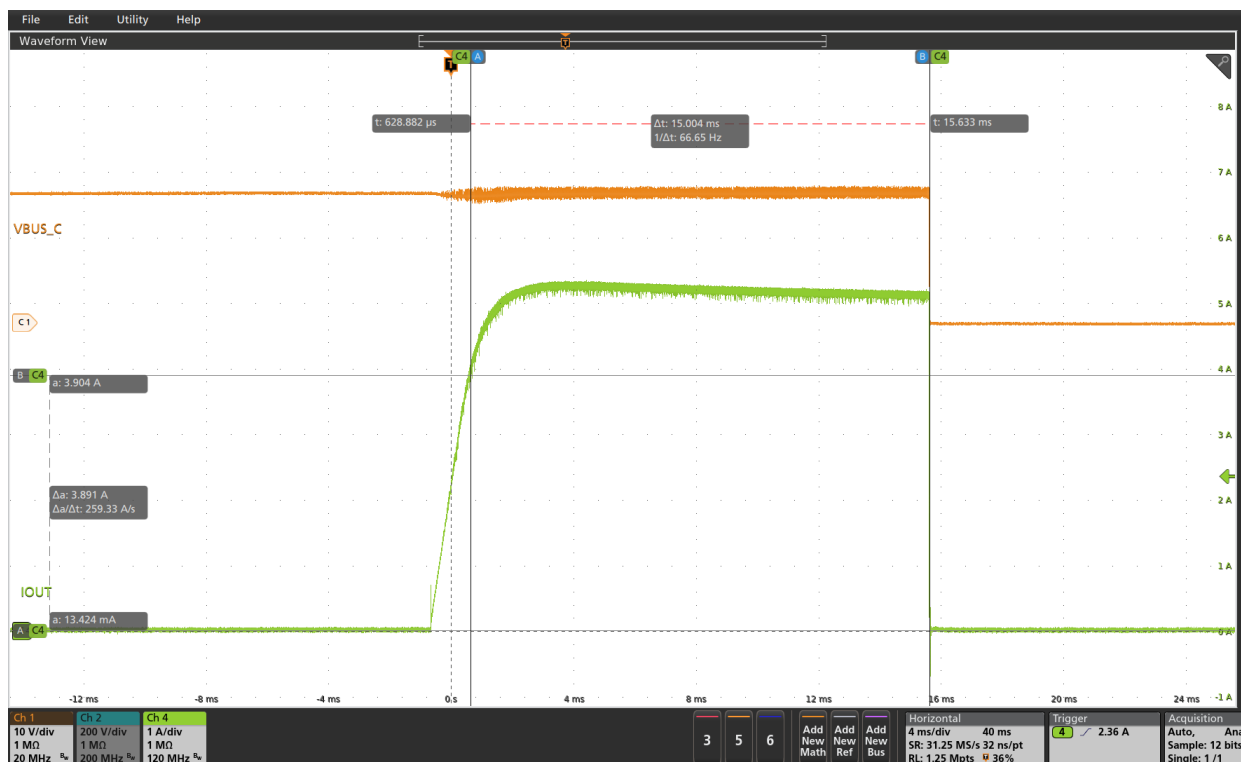
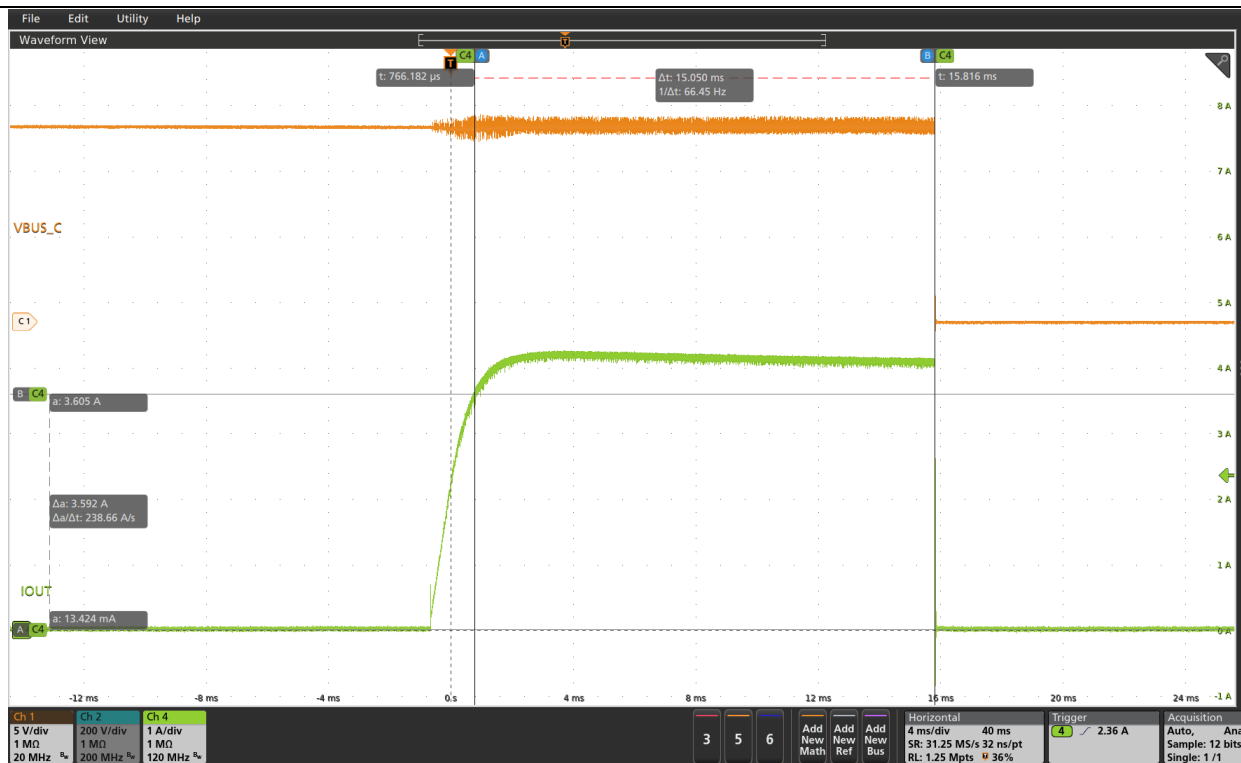


Figure 47 OCP at 230 V_{AC}, 50 Hz (CH1: V_{BUS_C}; CH4: I_{OUT})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

3.15 Peak overload test

- **Test condition:** V_{IN} : 90 V_{AC}, 47 Hz, 115 V_{AC} – 60 Hz, 230 V_{AC} – 50 Hz, V_O = 20 V, I_O = Dynamic
- **Lab ambient temperature:** 23°C and in open frame
- **Pass/Fail criteria:** $\pm 10\%$ of 20 V (18 V – 22 V)

Test case 1

V_O = 20 V, 100% load (3.25 A) 19 ms – 200% load (6.5 A) 1 ms; Slew rate = 500 mA/ μ s

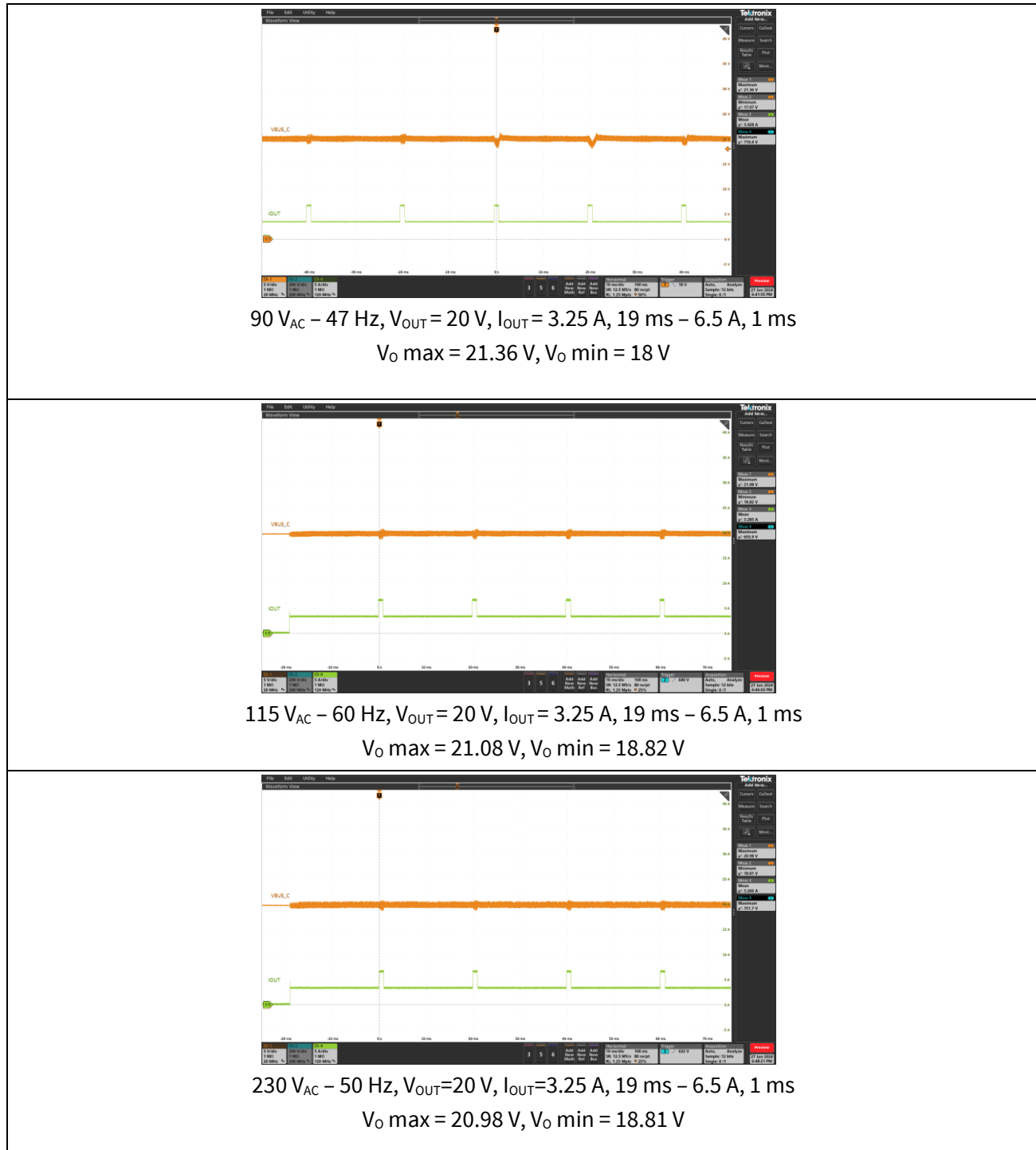


Figure 48 100% to 200% peak over load test at different line conditions (CH1: V_{BUS_C} ; CH4: I_{OUT})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

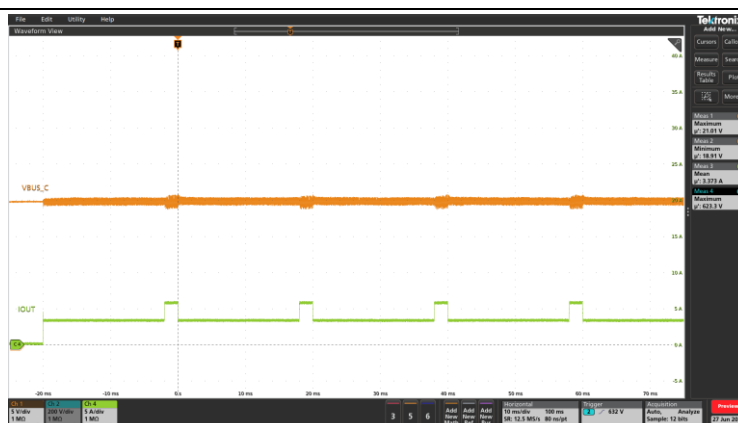
Power management test results

Test case 2

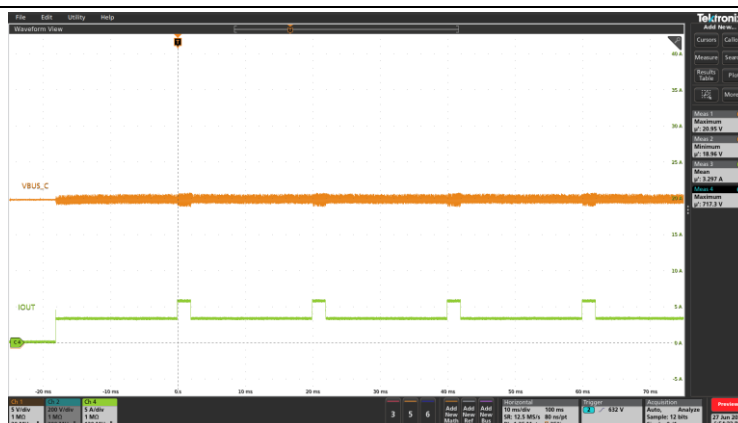
$V_0 = 20\text{ V}$, 100% load (3.25 A) 18 ms – 175% load (5.68 A) 2 ms; Slew rate = 500 mA/ μs



90 V_{AC} – 47 Hz, $V_{OUT} = 20\text{ V}$, $I_{OUT} = 3.25\text{ A}$, 18 ms – 5.68 A, 2 ms
 $V_0\text{ max} = 21.32\text{ V}$, $V_0\text{ min} = 18.13\text{ V}$



115 V_{AC} – 60 Hz, $V_{OUT} = 20\text{ V}$, $I_{OUT} = 3.25\text{ A}$, 18 ms – 5.68 A, 2 ms
 $V_0\text{ max} = 21.01\text{ V}$, $V_0\text{ min} = 18.91\text{ V}$



230 V_{AC} – 50 Hz, $V_{OUT} = 20\text{ V}$, $I_{OUT} = 3.25\text{ A}$, 18 ms – 5.68 A, 2 ms
 $V_0\text{ max} = 20.95\text{ V}$, $V_0\text{ min} = 18.96\text{ V}$

Figure 49 100% to 175% peak over load test at different line conditions (CH1: V_{BUS_C} ; CH4: I_{OUT})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

Test case 3

$V_0 = 20\text{ V}$, 100% load (3.25 A) 10 ms – 150% load (4.87 A) 10 ms; Slew rate = 500 mA/ μs

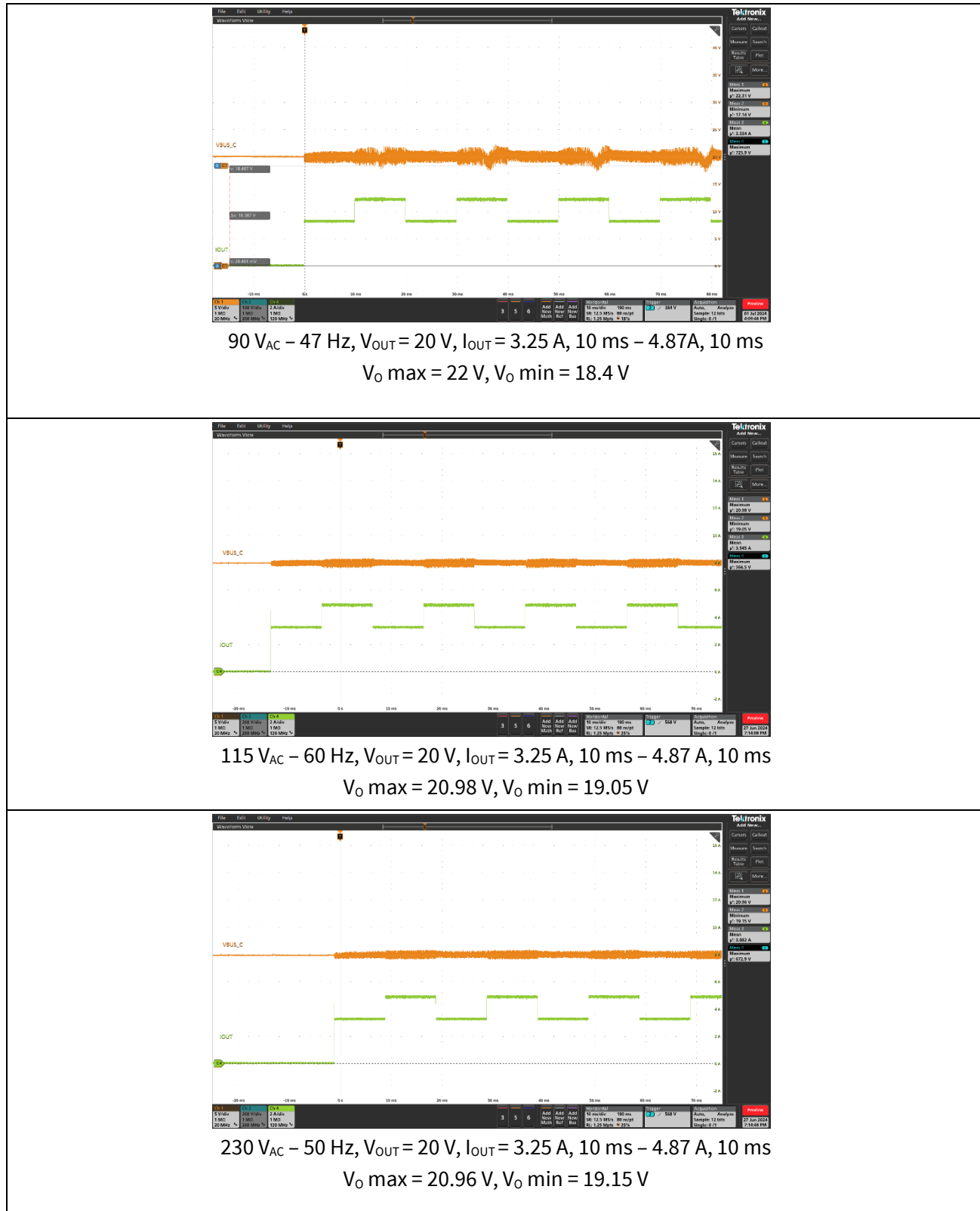


Figure 50 100% to 150% peak over load test at different line conditions (CH1: V_{BUS_C} ; CH4: I_{OUT})

Power management test results

3.16 Thermal stress

- **Test condition:** $V_{IN_AC} = 90\text{ V}_{AC}$ - 47 Hz, $V_{OUT} = 20\text{ V}$, $I_{OUT} = 3.25\text{ A}$
- **Lab ambient temperature:** 24°C and in open frame
- **Run time:** 60 minutes

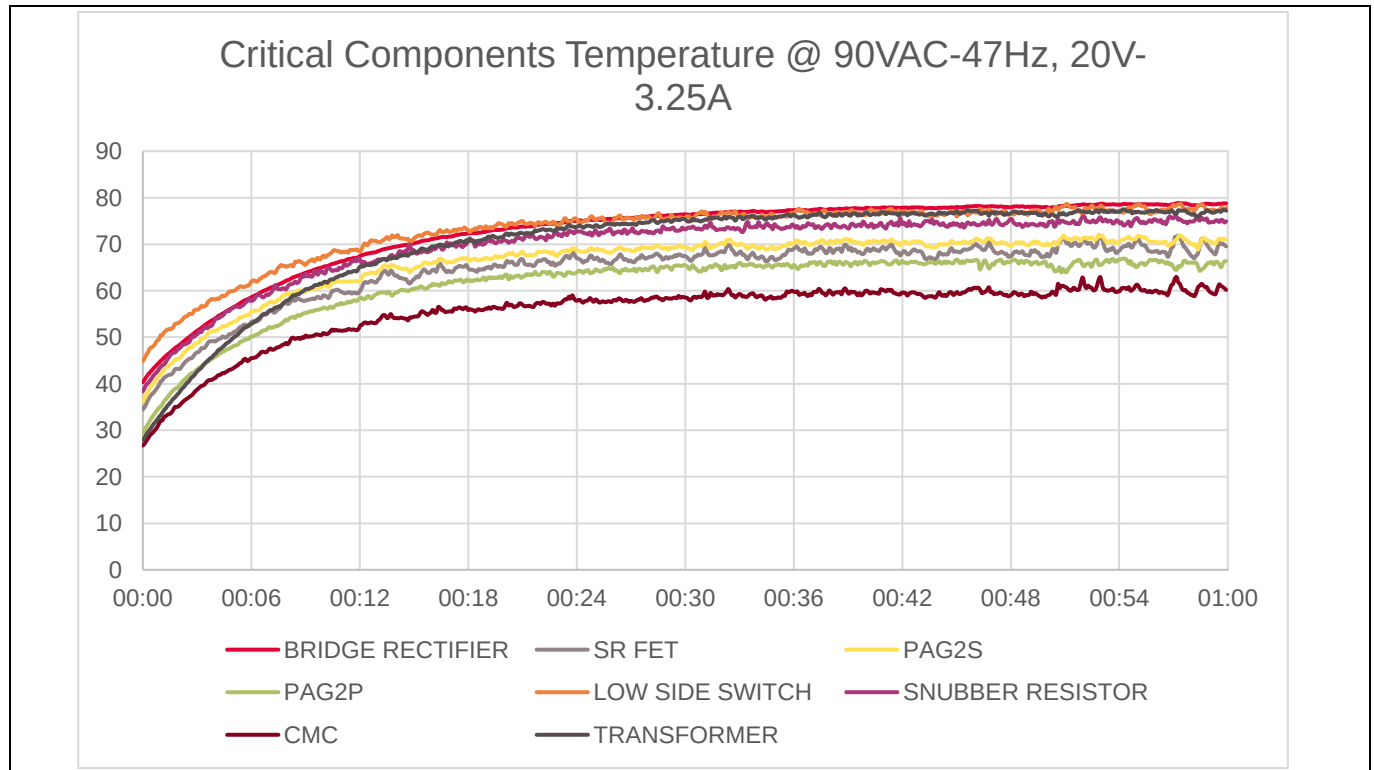


Figure 51 Thermal data logging of various components with time at 90 V_{AC}, 47 Hz, 20 V, 3.25 A

Table 15 Thermal data logging of various components at the end of 60 mins at 90 V_{AC}, 47 Hz, 20 V, 3.25 A

Sl. No.	Component	Max. temp in °C at the end of 60 mins
1	Bridge rectifier	78.16
2	SR FET	69.53
3	CMC	60.18
4	Transformer	77.21
5	PAG2P (Primary IC)	66.37
6	PAG2S (Secondary IC)	71.01
7	Low side switch	77.80
8	Snubber resistor	74.91

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

- **Test condition:** $V_{IN_AC} = 115 V_{AC} - 60 \text{ Hz}$, $V_{OUT} = 20 V$, $I_{OUT} = 3.25 A$
- **Lab ambient temperature:** 24°C and in open frame
- **Run time:** 60 minutes

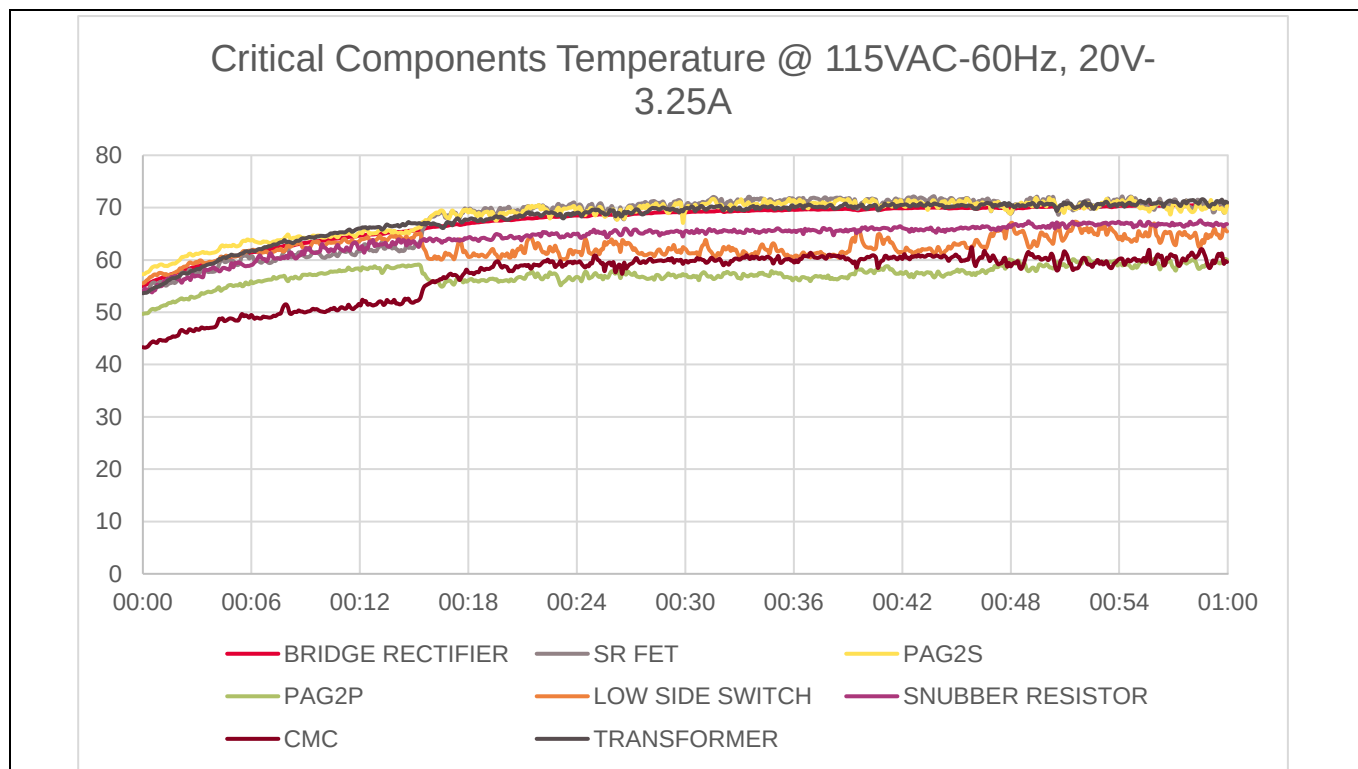


Figure 52 Thermal data logging of various components with time at 115 V_{AC}, 60 Hz, 20 V, 3.25 A

Table 16 Thermal data logging of various components at the end of 60 mins at 115 V_{AC}, 60 Hz, 20 V, 3.25 A

Sl. No.	Component	Max. temp in °C at the end of 60 mins
1	Bridge rectifier	70.38
2	SR FET	70.96
3	CMC	59.60
4	Transformer	70.96
5	PAG2P (Primary IC)	60.00
6	PAG2S (Secondary IC)	70.36
7	Low side switch	65.43
8	Snubber resistor	66.84

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

- **Test condition:** $V_{IN_AC} = 230\text{ V}_{AC}$, 50 Hz, $V_{OUT} = 20\text{ V}$, $I_{OUT} = 3.25\text{ A}$
- **Lab ambient temperature:** 24°C and in open frame
- **Run time:** 60 minutes

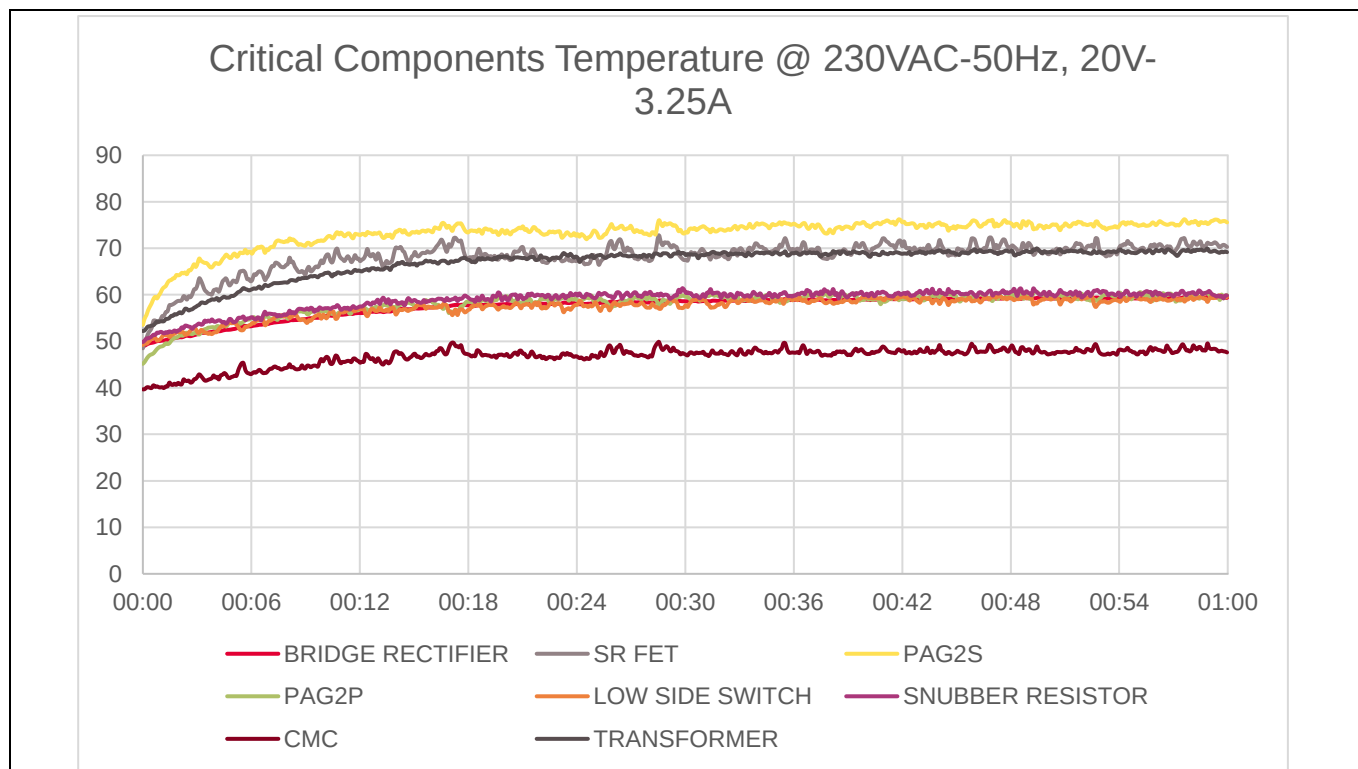


Figure 53 Thermal data logging of various components with time at 230 V_{AC}, 50 Hz, 20 V, 3.25 A

Table 17 Thermal data logging of various components at the end of 60 mins at 230 V_{AC}, 50 Hz, 20 V, 3.25 A

Sl. No.	Component	Max. temp in °C at the end of 60 mins
1	Bridge rectifier	59.34
2	SR FET	70.28
3	CMC	47.60
4	Transformer	69.16
5	PAG2P (Primary IC)	59.89
6	PAG2S (Secondary IC)	75.57
7	Low side switch	59.56
8	Snubber resistor	59.84

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

- **Test condition:** $V_{IN_AC} = 265 V_{AC}$ -63 Hz, $V_{OUT} = 20 V$, $I_{OUT} = 3.25 A$
- **Lab ambient temperature:** 24°C and in open frame
- **Run time:** 60 minutes

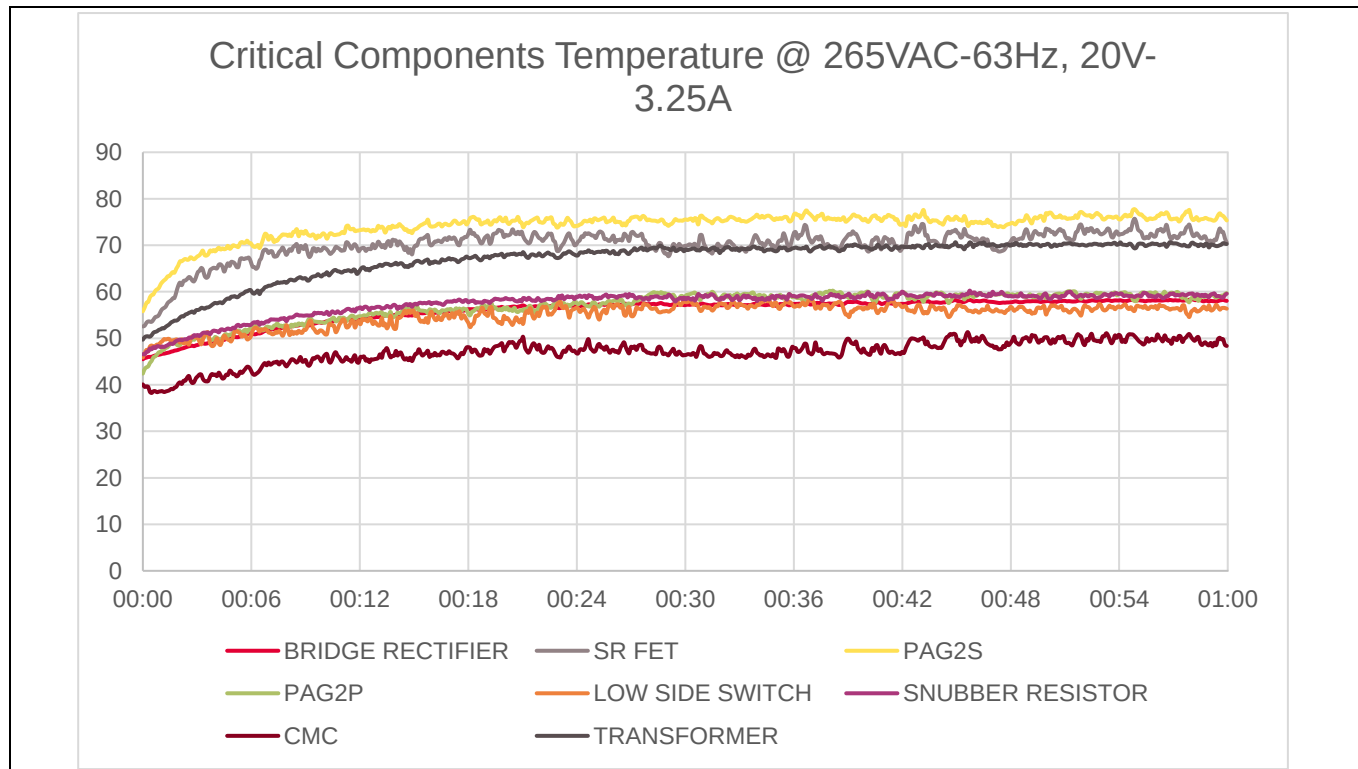


Figure 54 Thermal data logging of various components with time at 265 V_{AC}, 63 Hz, 20 V, 3.25 A

Table 18 Thermal data logging of various components at the end of 60 mins at 265 V_{AC}, 63 Hz, 20 V, 3.25 A

Sl. No.	Component	Max. temp in °C at the end of 60 mins
1	Bridge rectifier	58.04
2	SR FET	70.58
3	CMC	48.35
4	Transformer	70.26
5	PAG2P (Primary IC)	59.70
6	PAG2S (Secondary IC)	75.34
7	Low side switch	56.36
8	Snubber resistor	59.58

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

3.17 EMI/EMC

3.17.1 Conducted emission

Requirements: Class B CISPR 32, EN55032 – 4 dB margin @115/230 V_{AC}

Remarks: Refer to [Figure 55](#) for the CE results that are captured with an additional shield on the Transformer and CMC.

Conducted emission L1 at 230 V_{AC} 50 Hz:

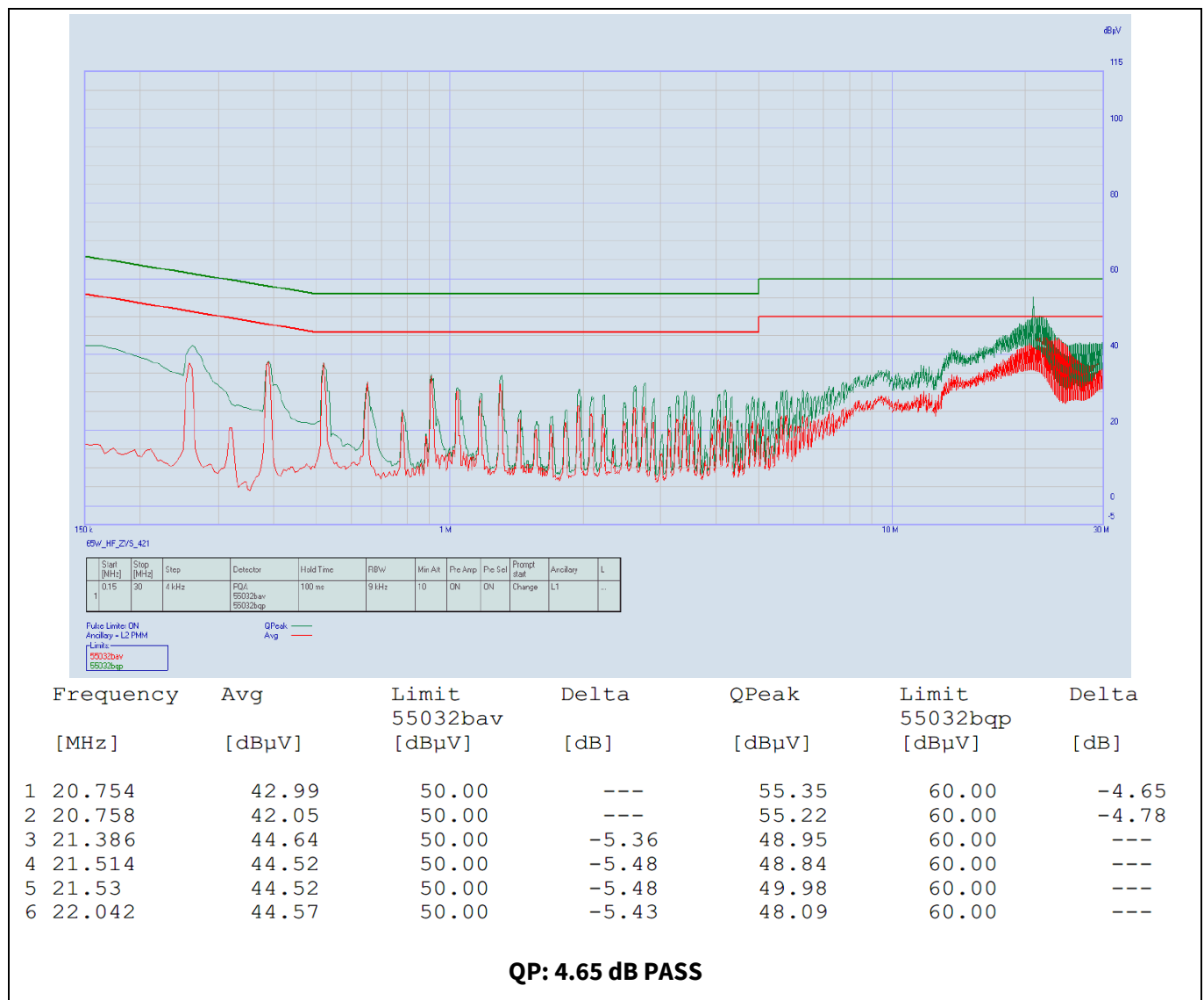


Figure 55 CE at 230 V_{AC} 20 V full load with trace L1

[Click or tap here to enter text.](#)

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

Conducted emission L2 at 230 V_{AC} 50 Hz

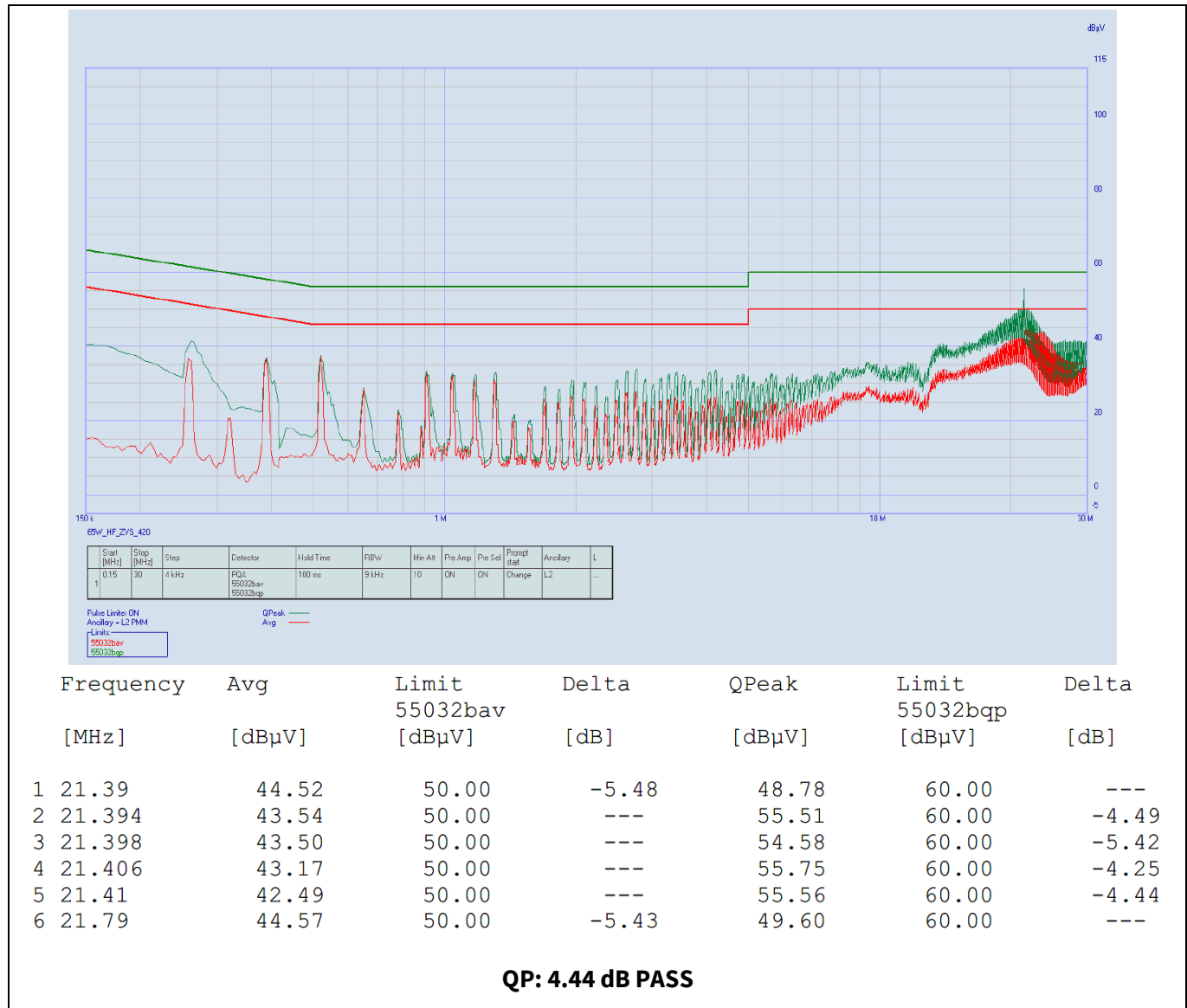


Figure 56 CE at 230 V_{AC} 20 V full load with trace L2

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

Conducted emission L1 at 115 V_{AC} 60 Hz

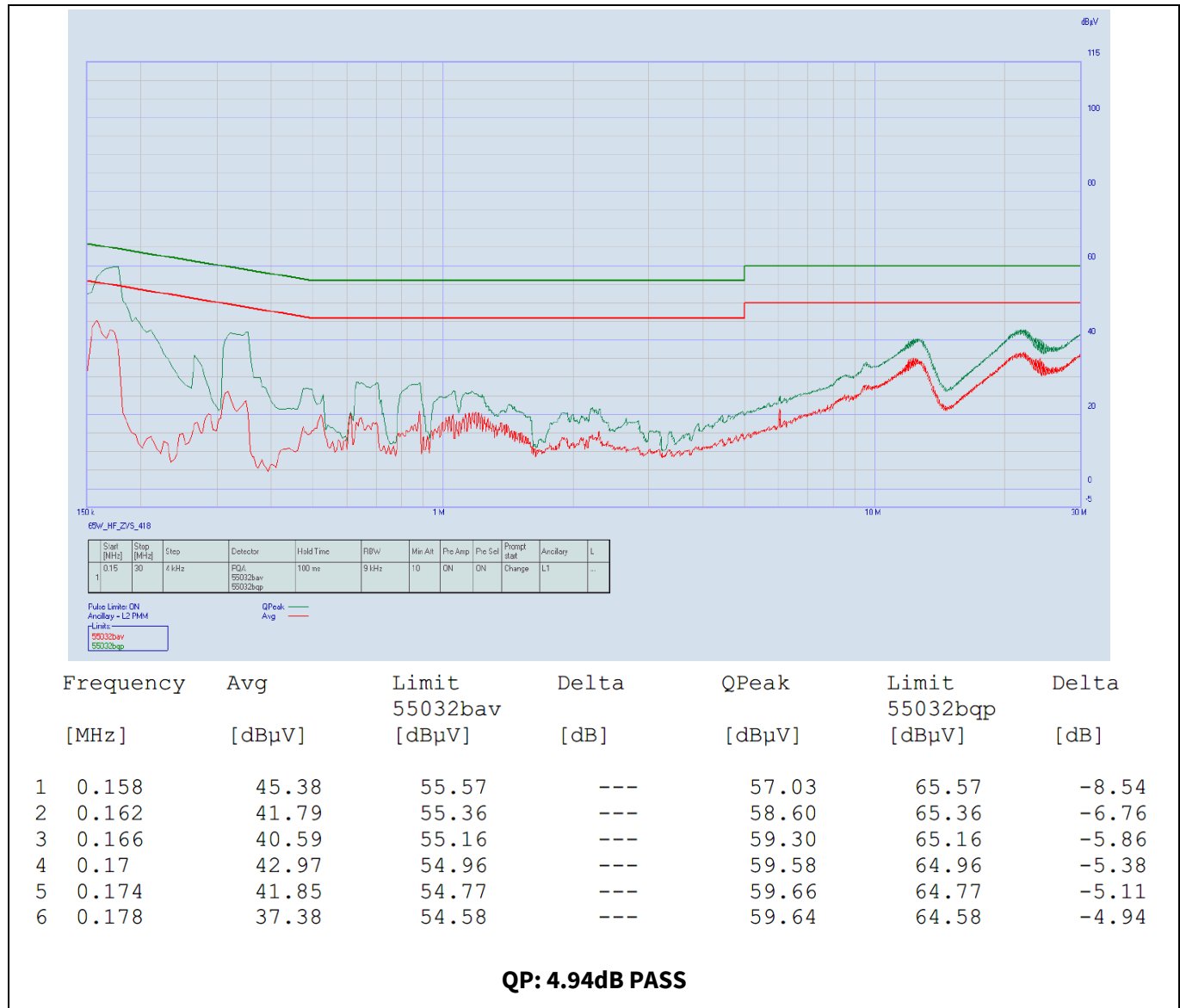


Figure 57 CE at 115 V_{AC} 20 V full load with trace L1

Click or tap here to enter text.

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

Conducted emission L2 at 115 V_{AC} 60 Hz

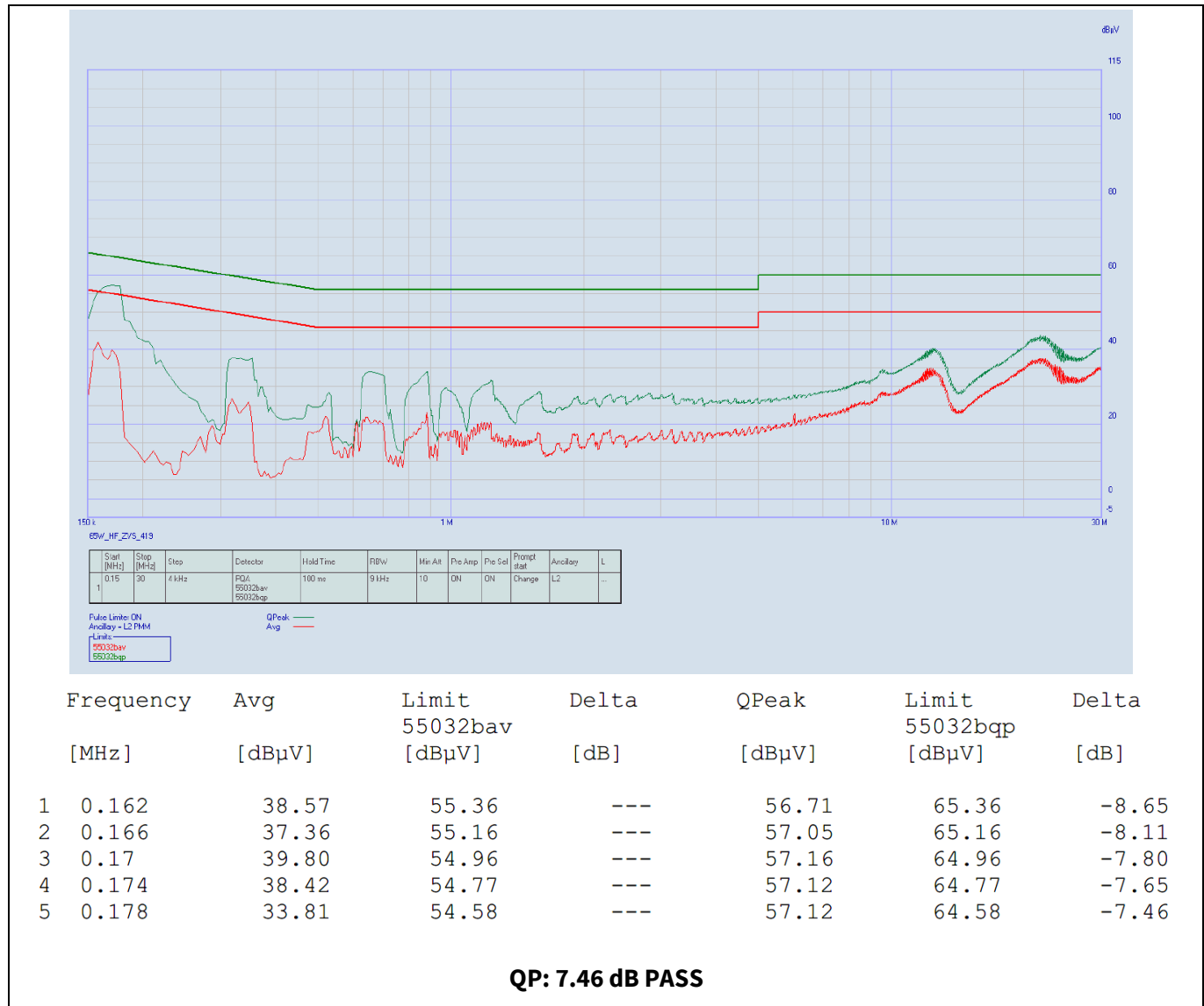


Figure 58 Frequencies and margin for CE at 115 V_{AC} with trace

Click or tap here to enter text.

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

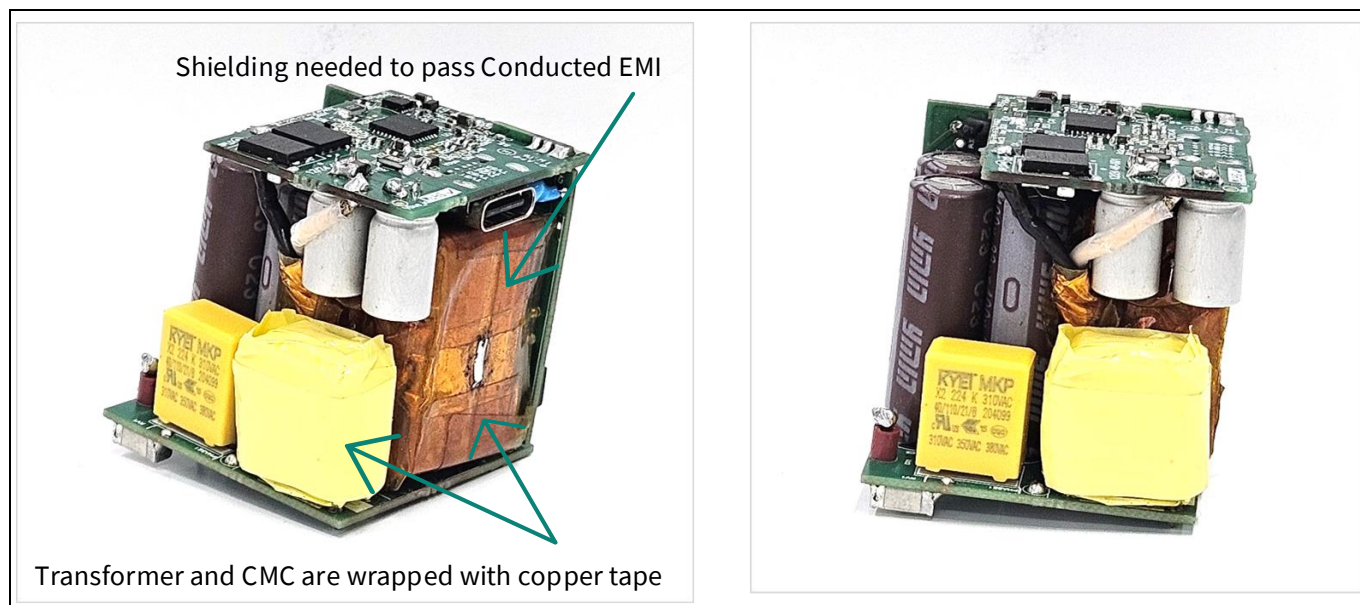


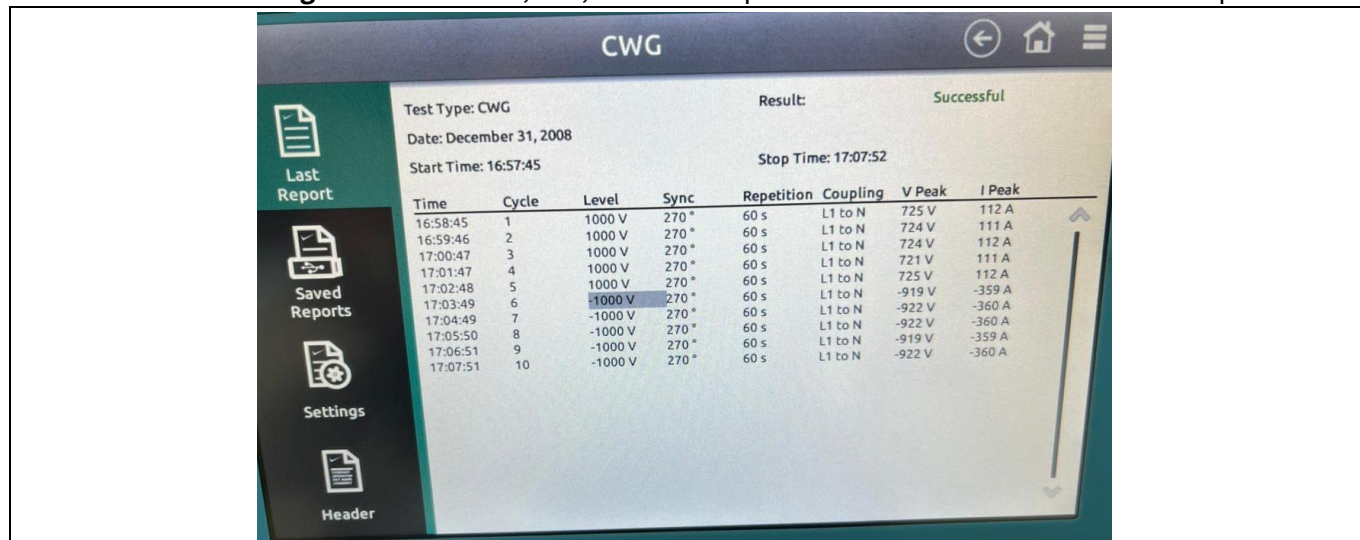
Figure 59 DUT Images with CE modifications

3.17.2 Surge

Requirements: IEC61000-4-5, ± 1 kV DM and ± 2 kV CM, Criteria B (auto-recovery)

Test Condition: V_{AC} : 230 V_{AC}, 50 Hz, V_0 = 20 V, I_0 = 3.25 A

Combination wave surge: ± 1 kV DM at 0°, 90°, and 270° - 5 pulses each with 60 s interval between pulses



Time	Cycle	Level	Sync	Repetition	Coupling	V Peak	I Peak
16:58:45	1	1000 V	270°	60 s	L1 to N	725 V	112 A
16:59:46	2	1000 V	270°	60 s	L1 to N	724 V	111 A
17:00:47	3	1000 V	270°	60 s	L1 to N	724 V	112 A
17:01:47	4	1000 V	270°	60 s	L1 to N	721 V	111 A
17:02:48	5	1000 V	270°	60 s	L1 to N	725 V	112 A
17:03:49	6	-1000 V	270°	60 s	L1 to N	-919 V	-359 A
17:04:49	7	-1000 V	270°	60 s	L1 to N	-922 V	-360 A
17:05:50	8	-1000 V	270°	60 s	L1 to N	-922 V	-360 A
17:06:51	9	-1000 V	270°	60 s	L1 to N	-919 V	-359 A
17:07:51	10	-1000 V	270°	60 s	L1 to N	-922 V	-360 A

Figure 60 Surge test report for ± 1 kV DM at 270°

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

3.17.3 ESD

Requirements: IEC61000-4-2 level 4; ± 8 kV contact, ± 16 kV air, Criteria A

Test Condition: V_{AC} : 230 V_{AC} , 50 Hz, $V_O = 20$ V, $I_O = 3.25$ A, 10 pulse each, vertical, and horizontal plane with all orientations.

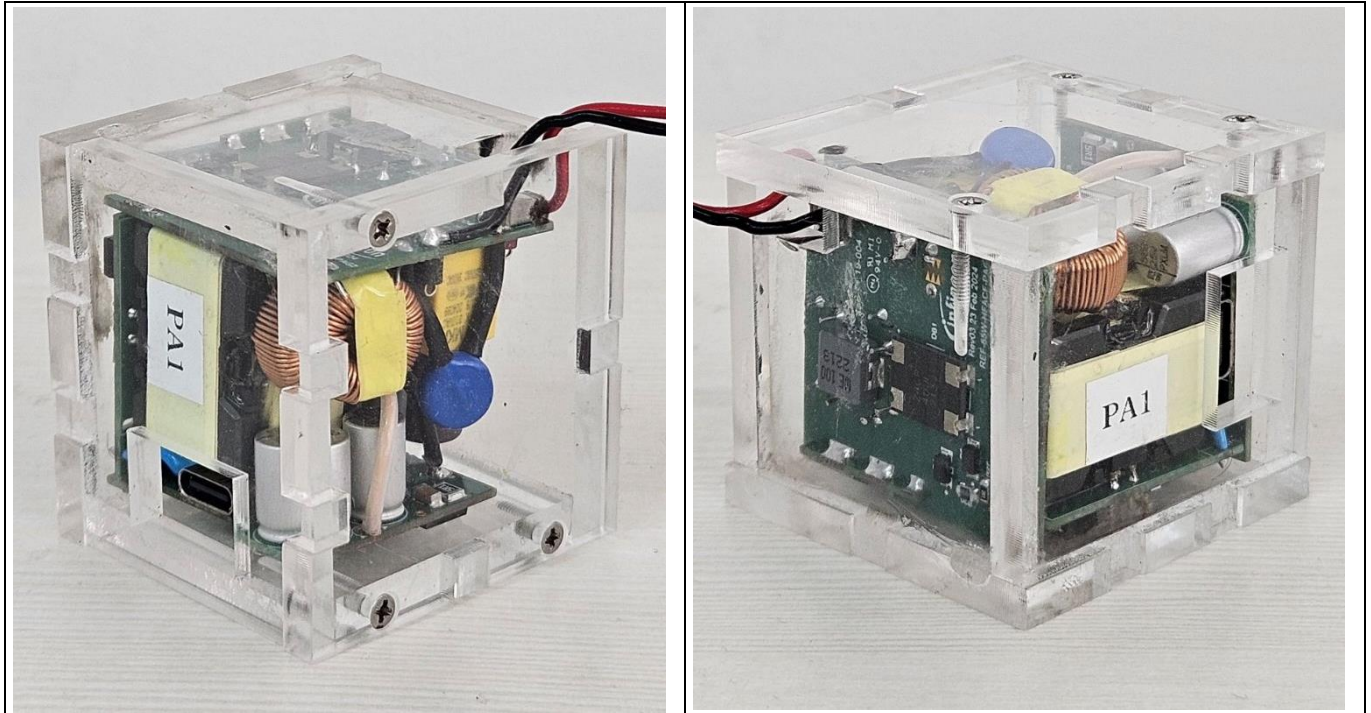


Figure 61 Device set-up for ESD test

3.18 Bode stability

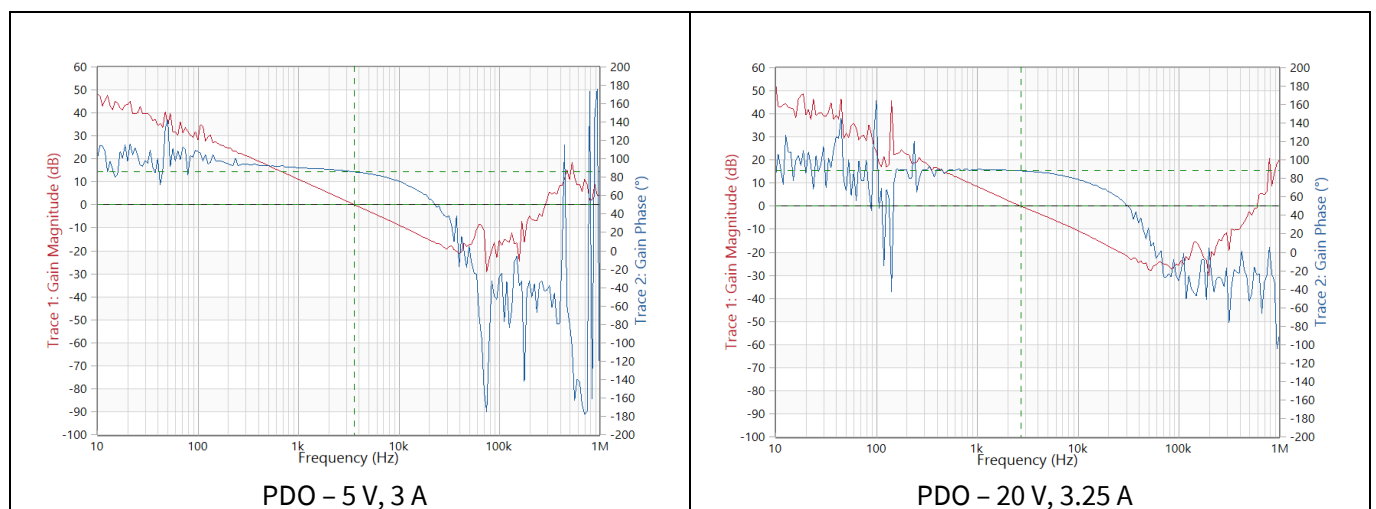


Figure 62 Loop stability at 115 V_{AC} , 60 Hz

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Power management test results

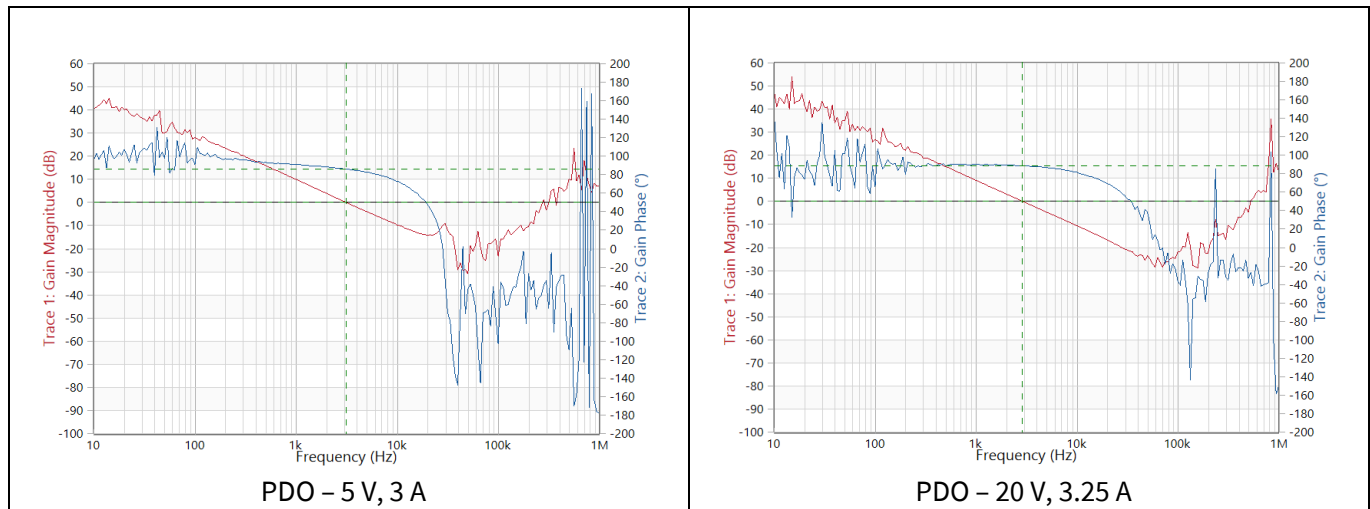


Figure 63 Loop stability at 230 V_{AC}, 50 Hz

Table 19 Loop stability data for all output conditions

V _{IN}	V _{OUT}	Load current	Cross over frequency (Hz)	Phase margin
115 V _{AC}	5 V	3 A	3.626 k	85.86
	9 V	3 A	3.31 k	87.01
	15 V	3 A	2.901 k	87.62
	20 V	3.25 A	2.702 k	88.37
115 V _{AC}	5 V	0.6 A	1.47 k	88.38
	9 V	0.6 A	1.188 k	88.54
	15 V	0.6 A	970.03 k	88.06
	20 V	0.65 A	912.75 k	88.04
230 V _{AC}	5 V	3 A	3.115 k	86.05
	9 V	3 A	2.901 k	88.1
	15 V	3 A	2.991 k	88.27
	20 V	3.25 A	2.872 k	88.48
230 V _{AC}	5 V	0.6 A	1.729 k	62.83
	9 V	0.6 A	1.729 k	70.54
	15 V	0.6 A	1.031 k	88.39
	20 V	0.65 A	931.46 k	88.05

Power management test results

3.19 Maximum input current in steady state

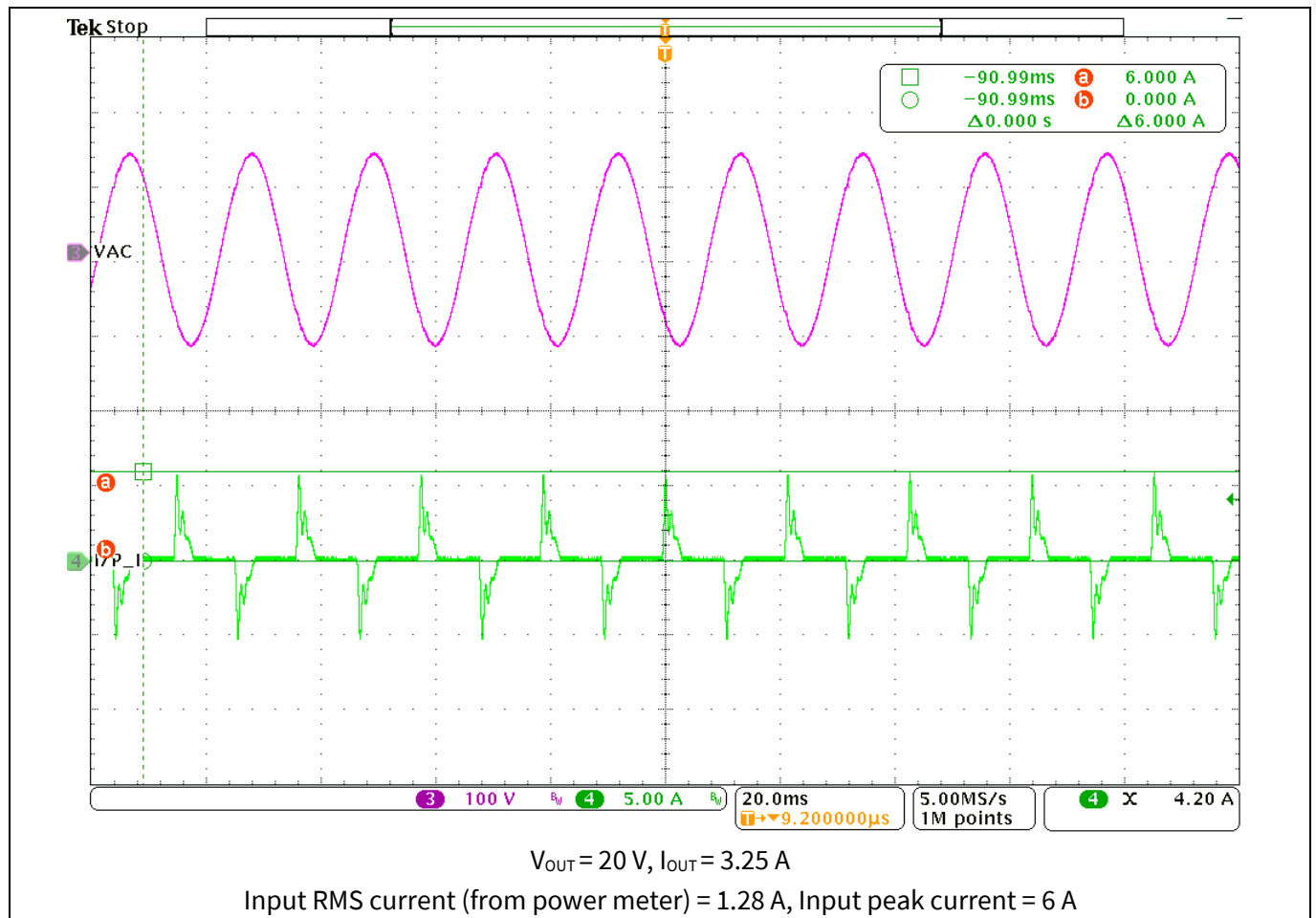


Figure 64 Input current at steady state, 90 V_{AC}, 47 Hz (CH3: V_{AC}, CH4: I_{AC})

Power management test results

3.20 Inrush current at cold start

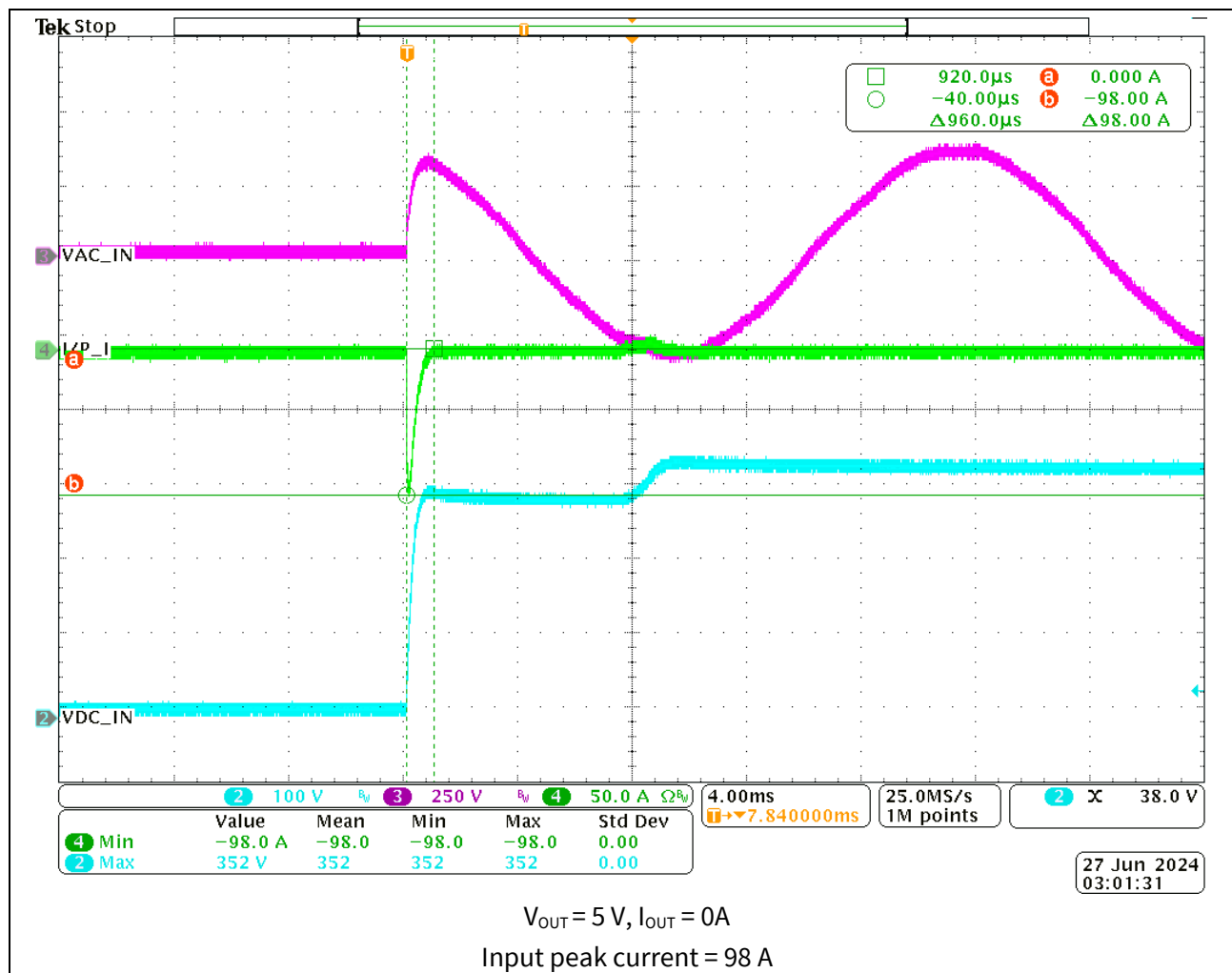


Figure 65 Inrush current at cold start 230 V_{AC}, 50 Hz (CH2: V_{DC_IN} CH3: V_{AC}, CH4: I_{AC})

3.21 Brown-out recovery

Table 20 Brown-out data

Test condition	Result	
$V_O = 5\text{ V}_{DC}$, $I_O = 0\text{ A}$ (No load)	UVLO falling	74.2 V _{AC}
	UVLO rising	75.8 V _{AC}
$V_O = 20\text{ V}_{DC}$, $I_O = 3.25\text{ A}$ (Full load)	UVLO falling	75.3 V _{AC}
	UVLO rising	76.5 V _{AC}

Power management test results

3.22 X-cap discharge

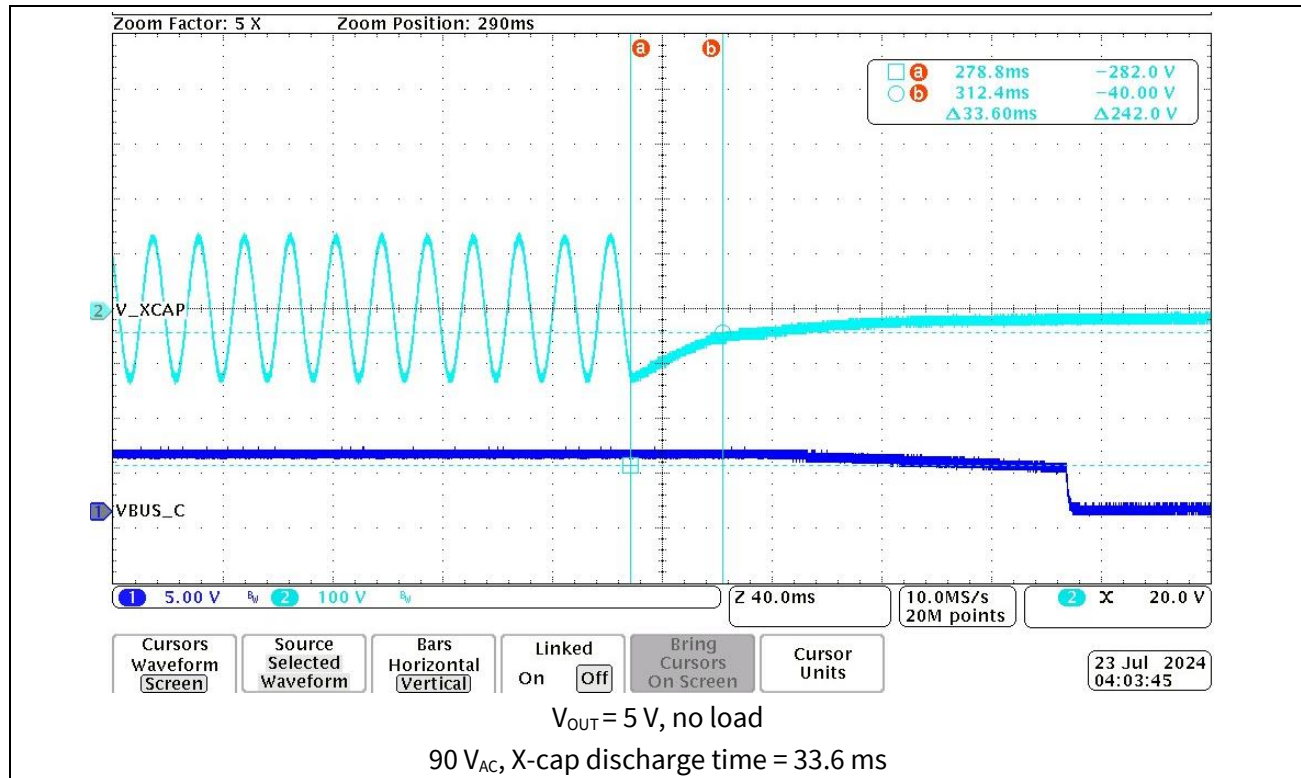


Figure 66 X-cap discharge at 90 V_{AC}, 47 Hz (CH1: V_{BUS_C}, CH2: V_{AC})

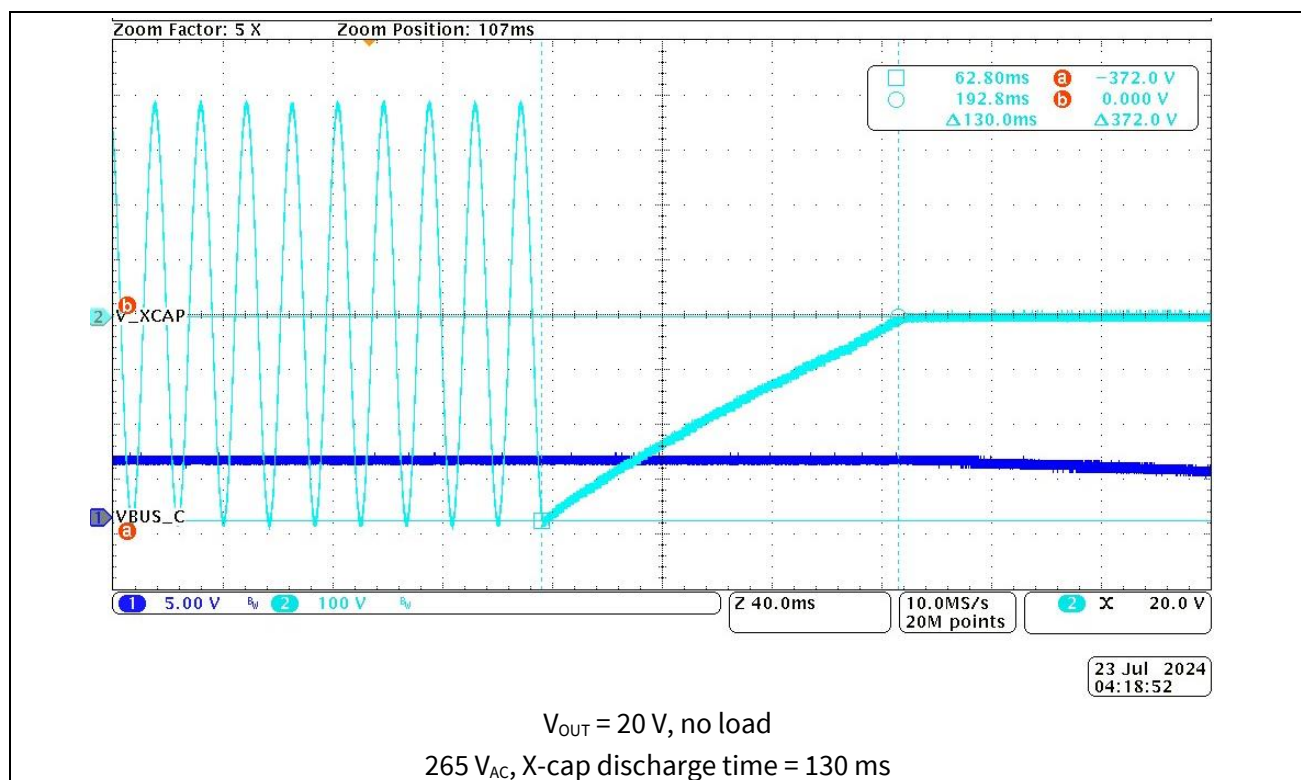


Figure 67 X-cap discharge at 265 V_{AC}, 63 Hz (CH1: V_{BUS_C}, CH2: V_{AC})

Power management test results

3.23 V_o steady state response with line transition

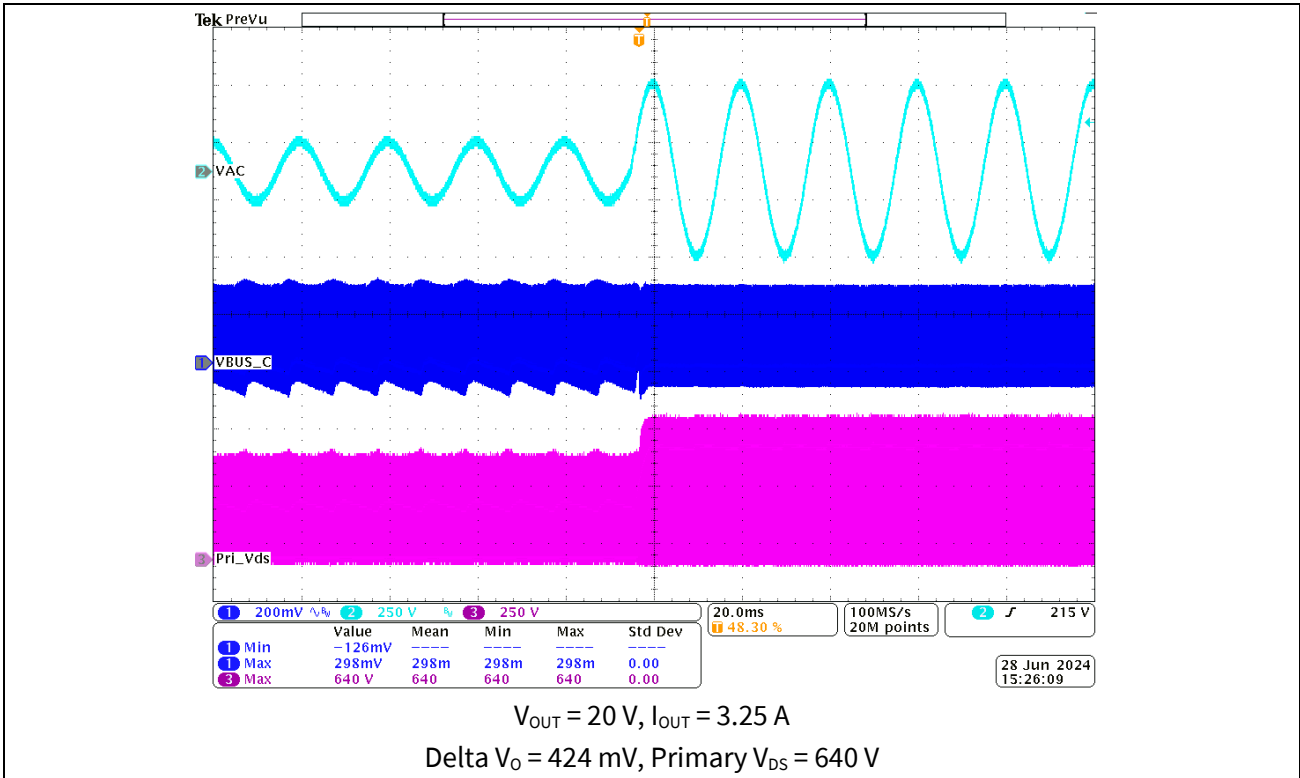


Figure 68 Line transition from 90 V_{AC} , 50 Hz to 265 V_{AC} , 50 Hz (CH1: V_{BUS_C} , CH2: V_{AC} , CH3: Pri_V_{DS})

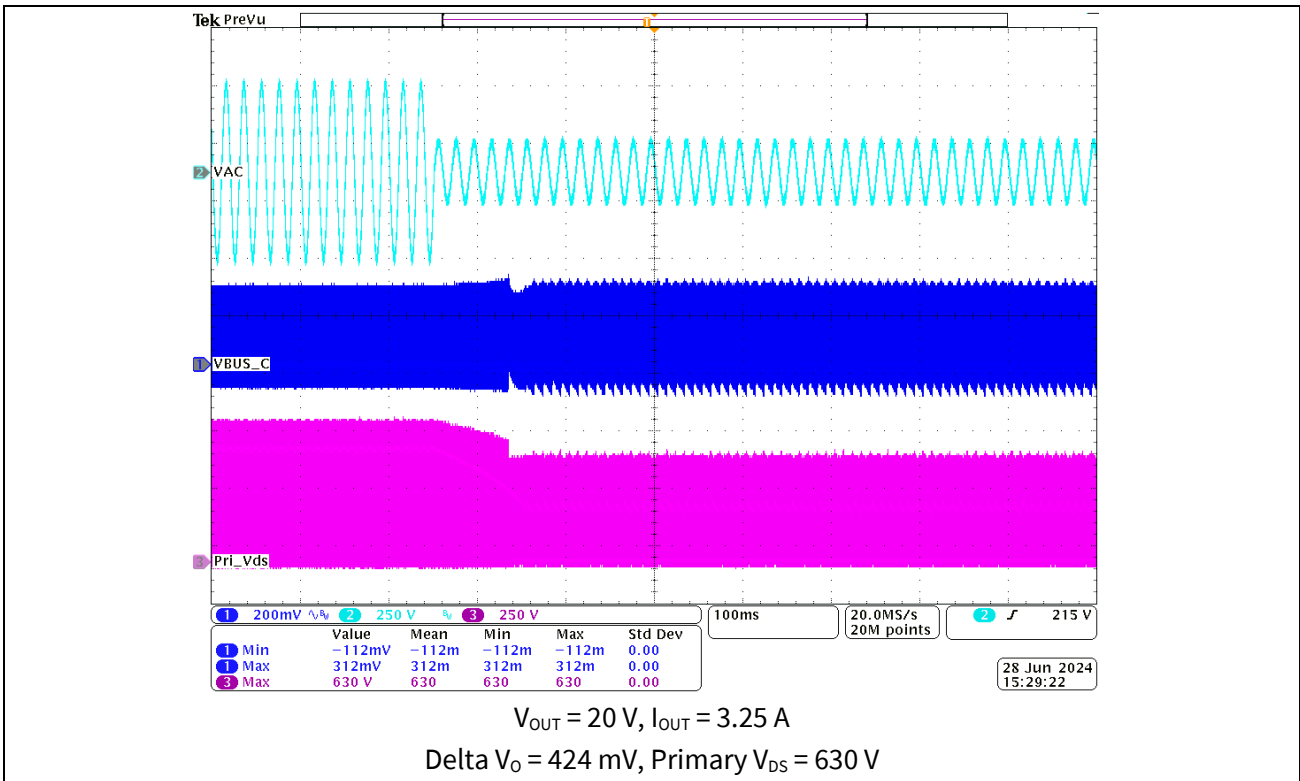


Figure 69 Line transition from 265 V_{AC} , 50 Hz to 90 V_{AC} , 50 Hz (CH1: V_{BUS_C} , CH2: V_{AC} , CH3: Pri_V_{DS})

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Power management test results

3.24 Hi-POT test

Test Condition: Mode: ACW, Voltage: 3 kV, Timer: 2 s, Hi-SET: 1 mA, Lo-SET: 0 mA

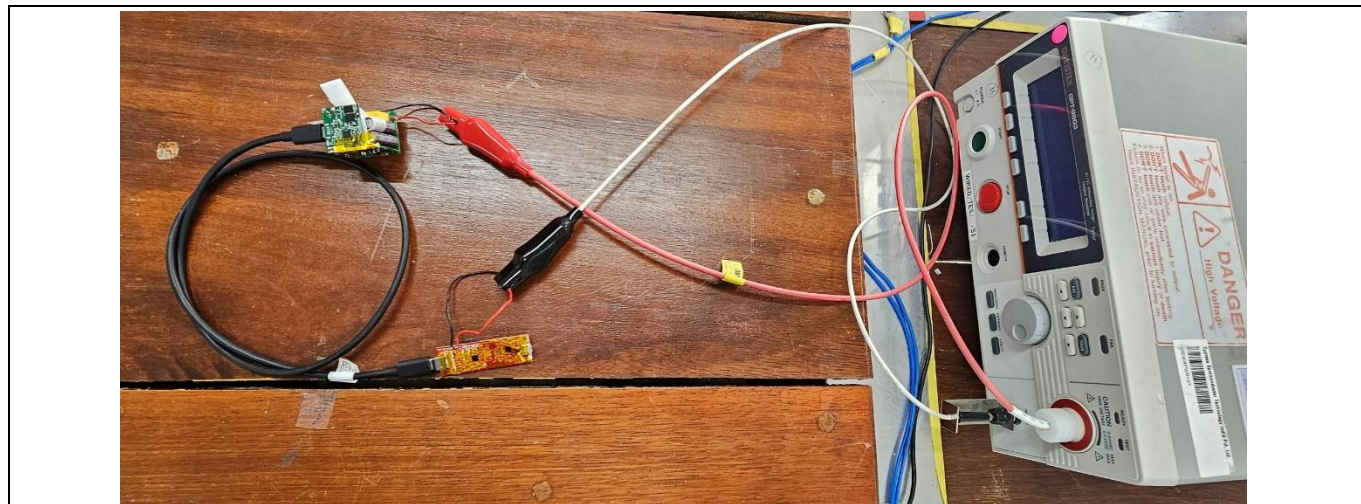


Figure 70 Hi-POT test setup



Figure 71 Hi-POT test result

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

USB PD source test results (using QuadraMAX)

4 USB PD source test results (using QuadraMAX)

4.1 Test setup



Figure 72 QuadraMAX tester

- QuadDraw Version: 0.9.8594
- QM#108 HW Rev: 1.4.4 FWST:0.0.1376 FWCCG1:0.10

4.2 Test results

Test input voltage conditions: 115 V_{AC}, 60 Hz, and 230 V_{AC}, 50 Hz

Table 21 QuadraMAX test results

Test	Description	Result
TD SPT.1	Load test	Pass
TD SPT.2	Capabilities test	Pass
TD SPT.3	Hard reset test	Pass

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report

Appendix

5 Appendix

5.1 Schematic

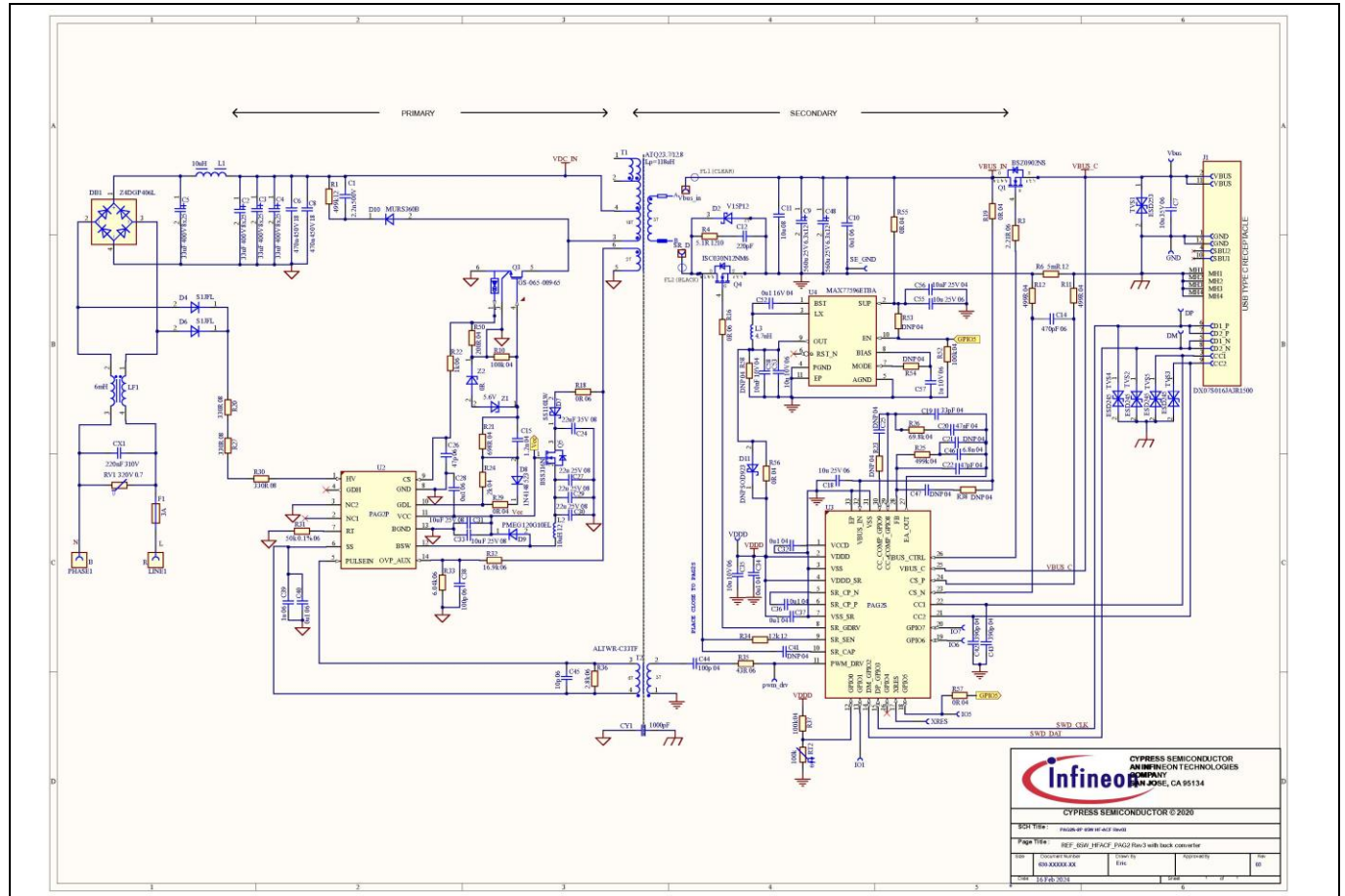


Figure 73 Schematic diagram of 65 W PAG2P_PAG2S_HF ZVS_Rev3_GaN system_SCH

Appendix

5.2 Bill of materials (BOM)

Table 22 Bill of materials

Designator	Quantity	Comment	Value	Manufacturer order number	Manufacturer
C1	1	2200pF 500V	2200pF 500V	CC1206KKX7RBBB222	YAGEO
C2, C3, C4, C5	4	33uF 400V 8x25	33uF 400V 8x25	KCX 33u1F 400V 8X25	Rubycon
C6, C8	2	470n 450V 18	470n 450V 18	CGA8N4X7T2W474M230KA	TDK Corporation
C7	1	10u 35V 06	10u 35V 06	GRM188R6YA106MA73D	Murata
C9, C48	2	560u 25V 6.3x12	560u 25V 6.3x12	NPX 560uF 25V 6.3 x 12	Sh-ymin
C10	1	0u1 06	0u1 06	CGA3E2X8R1E104K080AA	TDK Corporation
C11	1	10u 08	10u 08	GRM21BR61H106KE43K	Murata
C12	1	220pF	220pF	1206B221K201CT	Walsin Technology
C14	1	470pF 06	470pF 06	GRM188R71H471KA01D	Murata
C15	1	1.2n 04	1.2n 04	GRM155R71H122JA01	Murata
C18	1	10u 25V 06	10u 25V 06	885012106031	Würth Elektronik
C19	1	33pF 04	33pF 04	GRM1555C1E330GA01	Murata
C20	1	47nF 04	47nF 04	GRM155R61C473JA01	Murata
C22	1	4.7pF 04	4.7pF 04	GRM1555C1H4R7BA01D	Murata
C24	1	22uF 35V 08	22uF 35V 08	C2012X5R1V226M125AC	TDK
C26	1	47p 06	47p 06	GRM1885C1H470GA01	Murata
C27, C29, C30	3	22u 25V 08	22u 25V 08	GRM21BR61E226ME44	Murata
C28	1	0u1 06	0u1 06	06035C104JAT2A	AVX
C31, C33	2	10uF 25V 08	10uF 25V 08	GRM21BR61E106KA73	Murata
C32, C34	2	0u1 04	0u1 04	GRM152R61A104KE19	Murata
C35	1	10u 10V 06	10u 10V 06	ZRB18AD71A106KE01L	Murata
C36, C37	2	0u1 04	0u1 04	GCM155R71C104KA55	Murata
C38	1	100p 06	100p 06	06033A101JAT2A	AVX
C39	1	1u 06	1u 06	GRM185R61A105KE26	Murata
C40	1	0u1 06	0u1 06	C0603C104J8RAC	Kemet
C42, C43	2	390p 04	390p 04	GRM1555C1E391JA01	Murata
C44	1	100p 04	100p 04	GRM1555C1E101JA01	Murata
C45	1	10p 06	10p 06	C0603C100K5GACAUTO	Kemet
C46	1	6.8n 04	6.8n 04	GRM155R71E682JA01	Murata
C52	1	0u1 16V 04	0u1 16V 04	GCM155R71C104KA55	Murata

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Appendix

Designator	Quantity	Comment	Value	Manufacturer order number	Manufacturer
C53	1	10u 10V 06	10u 10V 06	ZRB18AD71A106KE01L	Murata
C55	1	10u 25V 06	10u 25V 06	885012106031	Würth Elektronik
C56	1	10nF 25V 04	10nF 25V 04	GRM155R71E103JA01	Murata
C57	1	1u 10V 06	1u 10V 06	GRM185R61A105KE26	Murata
C58	1	10nF 10V 04	10nF 10V 04	GRM155R61A103KA01	Murata
CX1	1	220nF 310V	220nF 310V	PX224K2C0702T	KYET
CY1	1	1000pF	1000pF	DE1E3RA102MN4AN01F	Murata
D2	1	V15P12	V15P12	V15P12-M3/H	Vishay
D8	1	1N4148 523	1N4148 523	1N4148WT-7	Diodes Incorporated
D4, D6	2	S1JFL	S1JFL	S1JFL	ON Semiconductor
D10	1	MURS360B	MURS360B	MURS360BT3G	ON Semiconductor
D7	1	SS110LW	SS110LW	SS110LW	Taiwan Semiconductor
D9	1	PMEG120G10E L	PMEG120G10E L	PMEG120G10ELRX	Nexperia
DB1	1	Z4DGP406L	Z4DGP406L	Z4DGP406L-HF	Comchip Technology
DM, DP, GND, IO1, IO5, IO6, IO7, pwm_drv, SE_GND, Vbus, VDDD, XRES	12	Test pad	Test pad	-	-
F1	1	3A	3A	TR1-2410TD3-R	Bussmann
J1	1	DX07S016JA3R 1500	DX07S016JA3R 1500	DX07S016JA3R1500	JAE
L1	1	10uH	10uH	74437346100	Würth Elektronik
L2	1	10uH 12	10uH 12	LSQCA322525T100KR	Taiyo Yuden
L3	1	4.7uH	4.7uH	LSBHB1608KKT4R7M	Taiyo Yuden
LF1	1	6mH	6mH	B64290L0044X038	EPCOS
LINE1	1	R	R	5000	Keystone Electronics Corp.
PHASE1	1	B	B	5001	Keystone Electronics Corp.

65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report



Appendix

Designator	Quantity	Comment	Value	Manufacturer order number	Manufacturer
Q1	1	BSZ0902NS	BSZ0902NS	BSZ0902NS	Infineon Technologies
Q3	1	GS-065-009-65	GS-065-009-65	GS-065-009-65	Infineon Technologies
Q4	1	ISC030N12NM6	ISC030N12NM6	ISC030N12NM6	Infineon Technologies
Q5	1	BSS316N	BSS316N	BSS316N H6327	Infineon Technologies
R1	1	499k 13	499k 13	ERJ-P08F4993V	Panasonic
R10	1	100k 04	100k 04	RC0402FR-07100KL	Yageo
R3	1	2.21R 06	2.21R 06	CRCW06032R21FK	Vishay
R4	1	5.1R 1210	5.1R 1210	ERJ-14YJ5R1U	Panasonic
R6	1	5mR 12	5mR 12	CSRF1206FT5L00	Stackpole Electronics
R11, R12	2	499R 04	499R 04	CRCW0402499RFK	Vishay
R24	1	2k 04	2k 04	CRCW04022K00FKEDC	Vishay
R16, R18	2	0R 06	0R 06	CRCW06030000Z0EA	Vishay
R29	1	0R 04	0R 04	RC0402JR-070RL	Yageo
R19	1	0R 04	0R 04	RC0402FR-070RL	Yageo
R20, R27, R30	3	330R 08	330R 08	CRCW0805330RFKEAHP	Vishay
R21	1	698R 04	698R 04	CRCW0402698RFKEDC	Vishay
R22	1	1k 06	1k 06	AC0603JR-071KL	Yageo
R25	1	499k 04	499k 04	CRCW0402499KFK	Vishay
R26	1	69.8k 04	69.8k 04	CRCW040269K8FK	Vishay
R31	1	50k 0.1% 06	50k 0.1% 06	RT0603BRD0750KL	Yageo
R32	1	16.9k 06	16.9k 06	CRCW060316K9FK	Vishay
R33	1	6.04k 06	6.04k 06	CRCW06036K04FK	Vishay
R34	1	12k 12	12k 12	CRCW120612K0FK	Vishay
R35	1	43R 06	43R 06	CRCW060343R0FK	Vishay
R36	1	2.8k 06	2.8k 06	MCR03EZPFX2801	ROHM Semiconductors
R37	1	100k 04	100k 04	CRCW0402100KFK	Vishay
R50	1	200R 04	200R 04	CRCW0402200RFK	Vishay
R52	1	100k 04	100k 04	RC0402FR-07100KL	Yageo
R55, R56, R57	3	0R 04	0R 04	CRCW04020000Z0	Vishay
RT2	1	100k	100k	NCU18WF104J60RB	Muata
RV1	1	320V 0.7	320V 0.7	B72207S2321K101	Epcos

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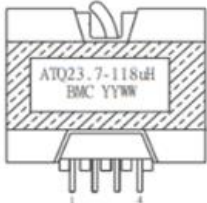


Appendix

Designator	Quantity	Comment	Value	Manufacturer order number	Manufacturer
SR_D, Vbus_in	2	Test pad	Test pad	-	-
T1	1	ATQ23.7/12.8	ATQ23.7/12.8	ATQ23.7/12.8	Better Magnetic
T2	1	ALTWR-C33TF	ALTWR-C33TF	ALTWR-C33TF	Sunlord
TVS1	1	ESD253	ESD253	ESD253-B1-W0201	Infineon Technologies
TVS2, TVS3, TVS4, TVS5	4	ESD245	ESD245	ESD245-B1-W0201	Infineon Technologies
U2	1	PAG2P	PAG2P	CYPAP212A1-14SXI	Infineon Technologies
U3	1	PAG2S	PAG2S	CYPAS212A1-32LQXQ	Infineon Technologies
U4	1	MAX77596ETB A	MAX77596ETBA	MAX77596ETBA+	Analog Devices
Z1	1	5.6V	5.6V	DZ9F5V6S92	Diodes Incorporated
Z2	1	0R 04	0R 04	RC0402FR-070RL	Yageo

Appendix

5.3 Transformer specification (T1)

PROPRIETARY Material List					
					
All materials listed are in compliance with RoHS requirements					
No.	Name	Description	Rating	Approval	Maker
1	Core	Ferrite core ATQ23.7/12.8/17.8 NH97 or equivalent			LIANFENG
2	Bobbin	Phenolic PM-9630 UL 94V-0	150℃	E41429	SUMITOMO ✓
3	Wire	Polyurethane enamelled copper Wire UEW MW75-C Ø0.1*20P, Ø0.1*15P Ø0.16	130℃	E339217	WEIHAN ✓
		Triple insulated wire TIW-B Ø0.1X80P or equivalent	130℃	E201757	PACIFIC ✓
			130℃	E357240	KAIZHONGHEDONG
4	Tape	Polyester tape #1350F-1 or #CT280	130℃ 130℃	E17385 E165111	3M YA HUA ✓
5	Tube	CB-HFT ND-LL	125℃ 200℃	E180908 E350651	CHANGYUAN NANDIAN ✓
6	Copper foil	0.05(T)*8mm 0.05(T)*3mm			HAIYU ✓ DETAI
7	Epoxy	2050 2041			CHENGGE ✓ CHENGGE ✓
8	Varnish	BC-359 WP-2952F-2G(Y)	180℃ 130℃	E317427 E72979	DOLPH ✓ HITACHI
Description			Issued Date		Page Nr.
Note: denotes the material used for the sample			09/13/2023		2-2
Cust.Code-Part Nr.		Rev.	Engineering		Checked By
ATQ23.7-118uH		0.0			Approved By
Better Magnetics Nr.		BMC Rev			
EF-239002		A			

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5.4 Inductor specification (L1)

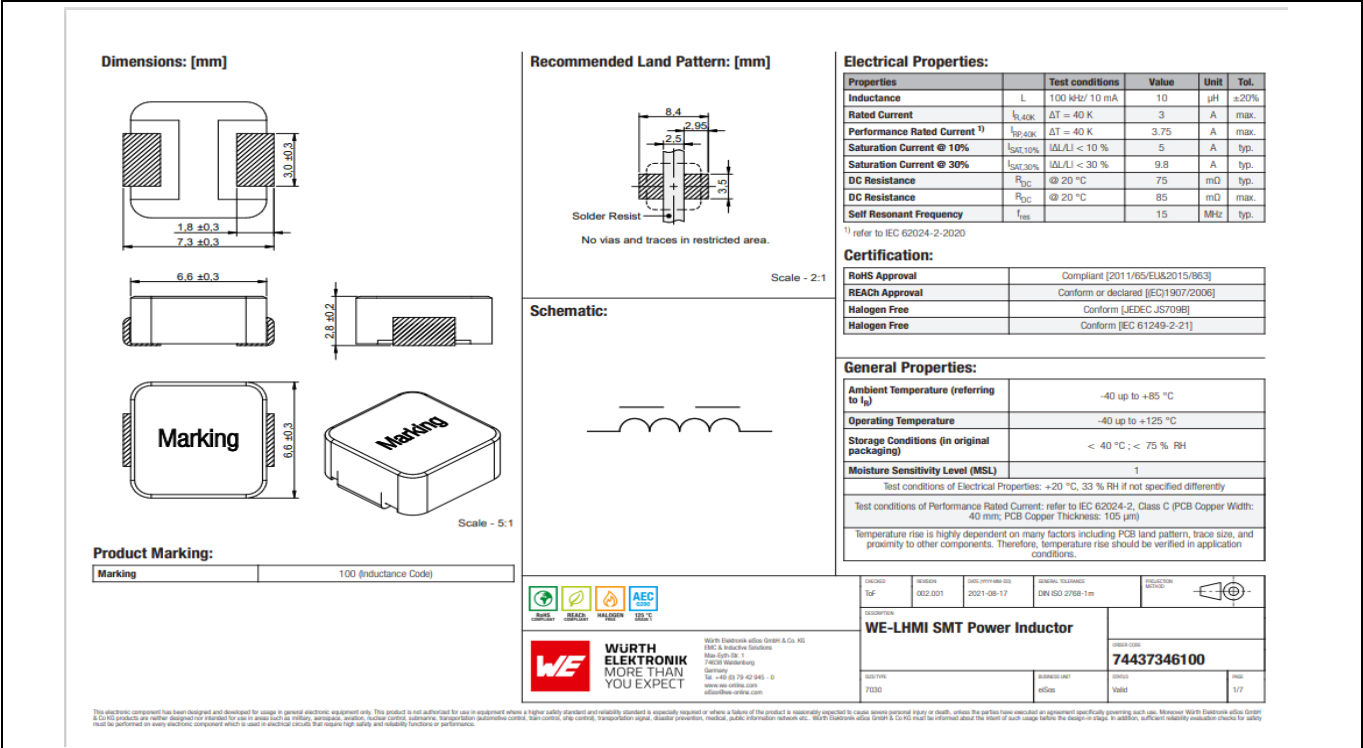


Figure 75 FIXED IND 10UH 3A 85 MOHM SMD Würth Elektronik

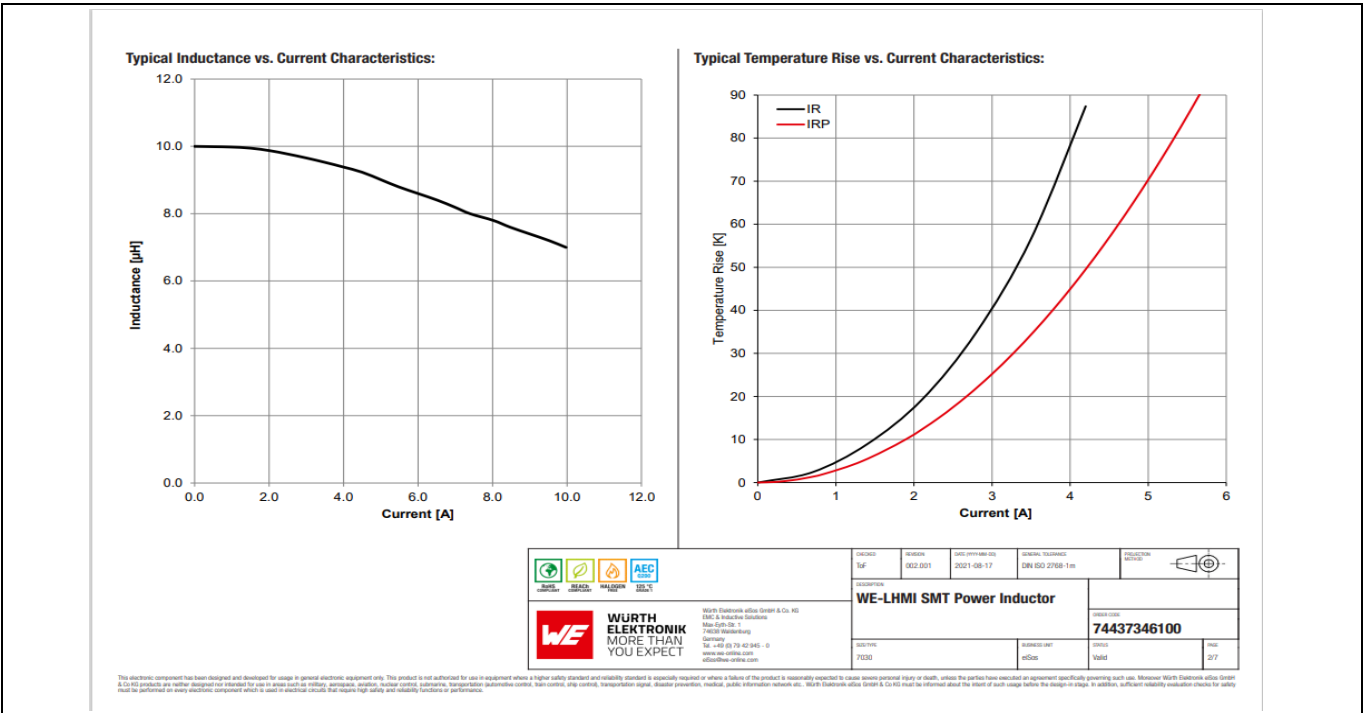


Figure 76 L1 FIXED IND 10UH 3A 85 MOHM SMD Würth Elektronik inductor specifications

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Appendix

5.5 Common mode choke specification (LF2)

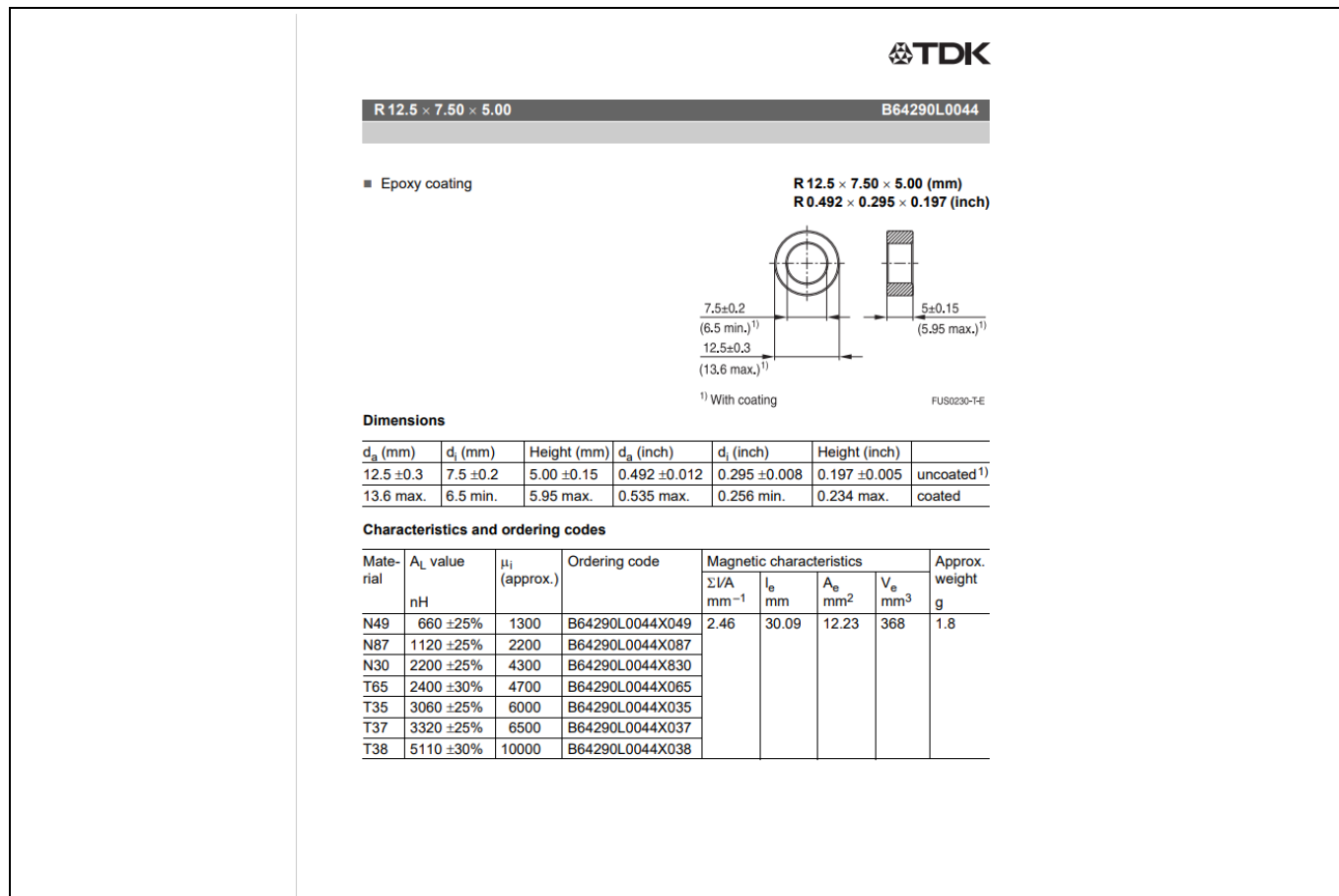


Figure 77 Common mode chock specification

Remarks: Material: T38, Turns: 30, L = 4.6 mH, R_{dc} = 66 mohm

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Appendix

5.6 Pulse transformer specification (T2)

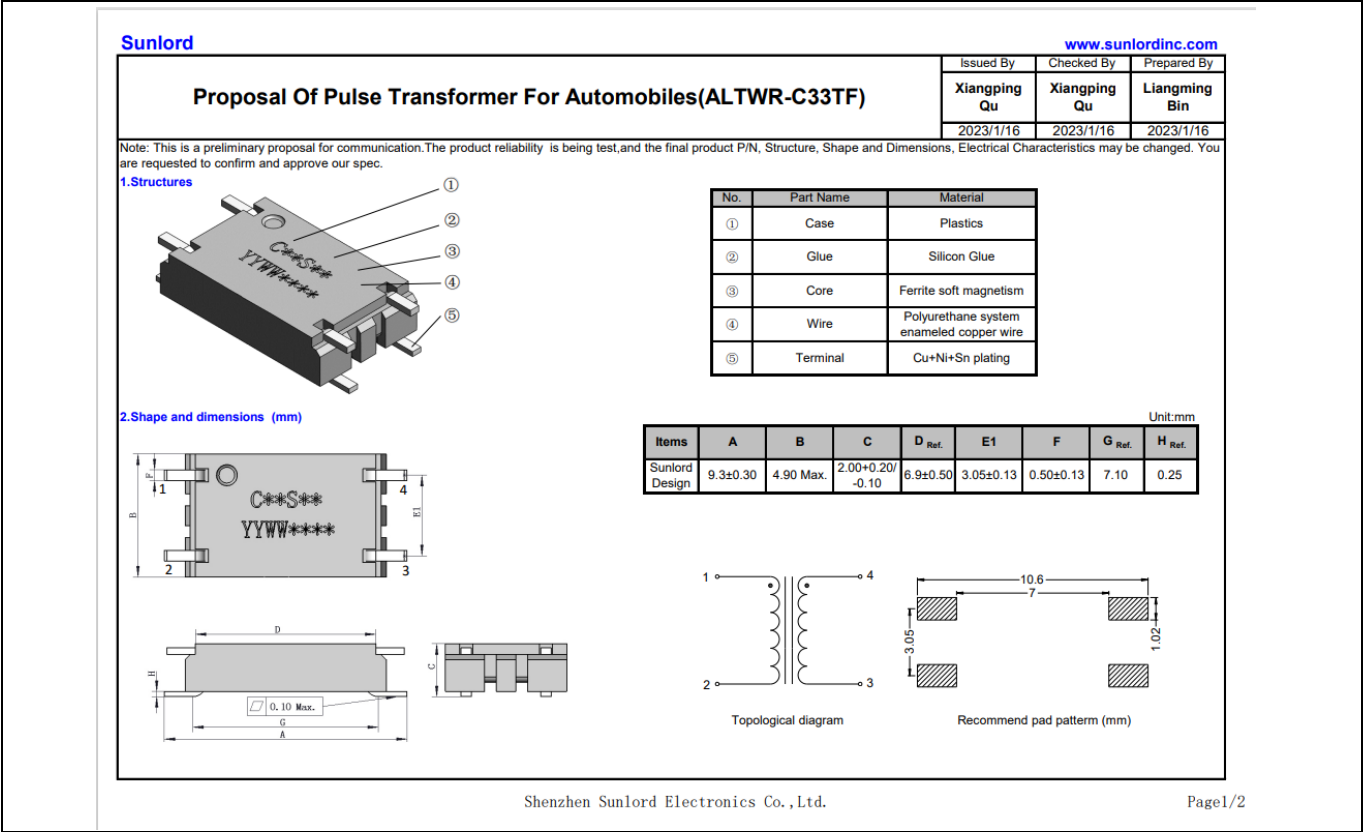


Figure 78 Pulse transformer specification

Appendix

5.7 PCB layout

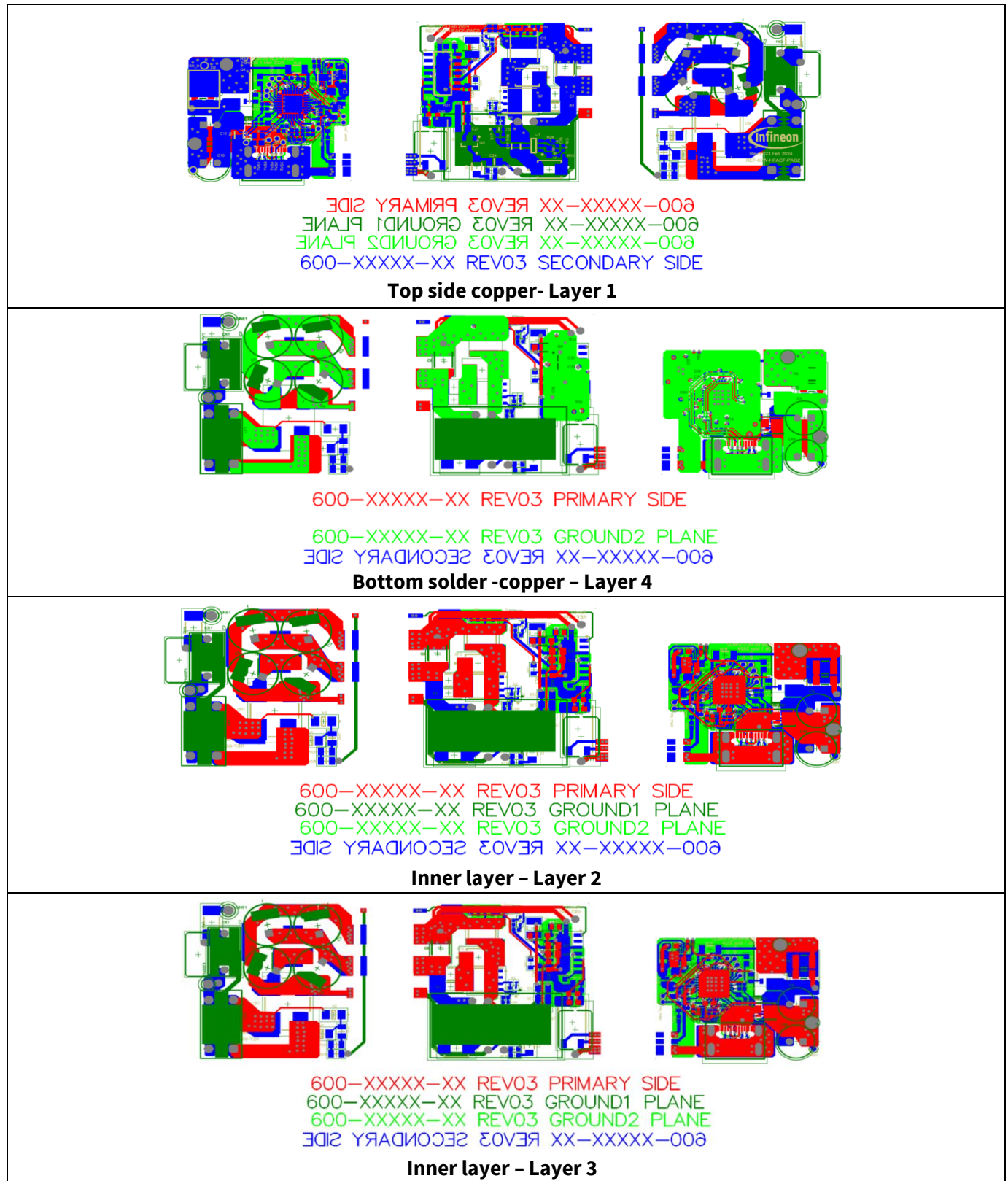


Figure 79 PCB layout

Appendix

5.8 EZ-PD™ Configuration Utility

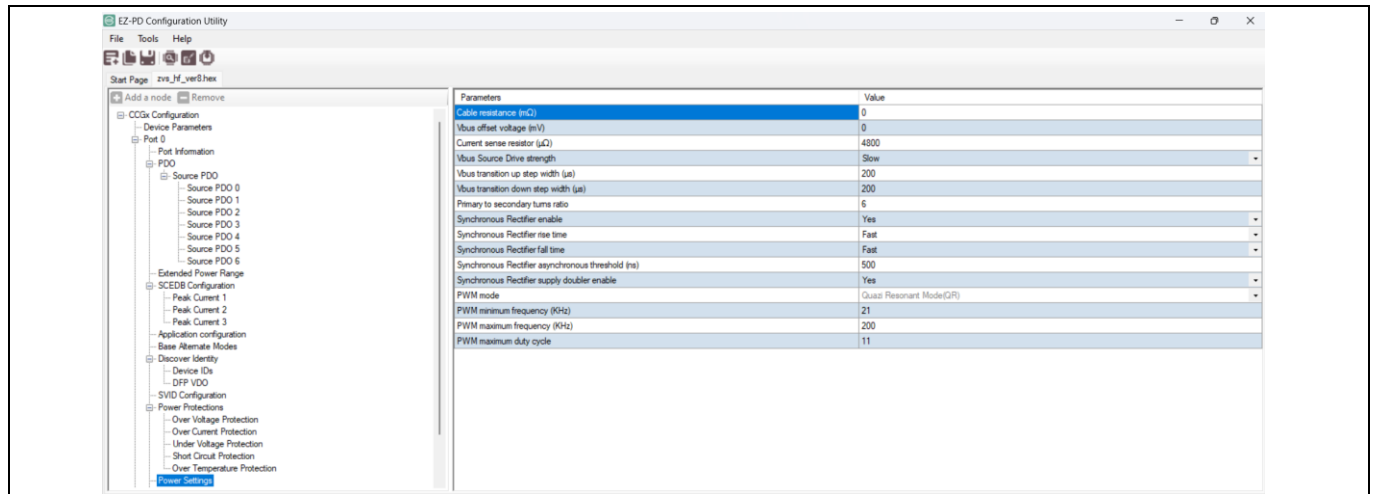


Figure 80 EZ-PD™ Configuration Utility

The Infineon's EZ-PD™ PAG2S controller is a highly configurable and programmable solution. The chip can be configured using parameters stored in the internal flash memory. These parameters are to be chosen and programmed by Infineon customers according to their use cases and requirements.

The GUI of EZ-PD™ Configuration Utility allows users to intuitively select and configure the parameters for their application.

Table 23 lists the default configured values with respect to Power Settings and Power Protections.

Table 23 Default configuration values

Parameters	Values
Power settings	
Cable resistance (mΩ)	0
Vbus offset voltage (mV)	0
Current sense resistor (μΩ)	4800
Vbus source drive strength	Slow
Vbus transition up step width (μs)	200
Vbus transition down step width (μs)	200
Primary to secondary turns ratio	6
Synchronous rectifier enable	Yes
Synchronous rectifier rise time	Fast
Synchronous rectifier fall time	Fast
Synchronous rectifier async threshold (ns)	500
Synchronous rectifier doubler enable	Yes
PWM mode	Quasi Resonant Mode (QR)
PWM minimum frequency (kHz)	21
PWM maximum frequency (kHz)	200
PWM maximum duty cycle at Minimum frequency (%)	11

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Appendix

Parameters	Values
Power protections	
Overvoltage protection	
Enable	Yes
OVP threshold (%)	20
Debounce period (μs)	10
Retry count	2
Overcurrent protection	
Enable	Yes
OCP threshold (%)	20
Debounce period (ms)	10
Retry count	2
Undervoltage protection	
Enable	Yes
UVP threshold (%)	70
Debounce period (μs)	10
Retry count	2
Short-circuit protection	
Enable	Yes
SCP threshold (%)	40
Debounce period (μs)	2
Retry count	2
Overtemperature protection	
Enable	Yes
Thermistor type 1	NTC
Cut-off value 1	255
Restart value 1	909
Debounce period(ms)	10
Enable thermistor 2	Yes
Thermistor type 2	NTC
Cut-off value 2	255
Restart value 2	909

Acronyms

Acronyms

Table 24 **Acronyms**

Abbreviation	Definition
CC-CV	Constant current - constant voltage
CE	Conducted emission
CH'x'	Oscilloscope channel numbers
CR Mode	Constant resistance mode in electronic load
DCM	Discontinuous current mode
DP/DM	USB data positive/data negative lines
DUT/EUT	Device under test/equipment under test
FET	MOSFET (Metal Oxide Semiconductor Field Effect Transistor)
GUI	Graphical User Interface
HF	High frequency
I_o/I_{OUT}	Output current of the DUT
NGDO	NFET gate driver output
OCP	Overcurrent protection
OVP	Overvoltage protection
P-P	Peak-to-peak
PAT	Power adapter tester
PDO	Power Delivery output
PPS	Programmable power supply
SCP	Short-circuit protection
USB PD	Universal Serial Bus Power Delivery
V_{BUS_C}/V_{OUT}	Output voltage of the DUT
V_{AC}/V_{IN_AC}	Input DC voltage to the DUT
ZVS	Zero voltage switching

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- [3] Infineon Technologies AG: *EZ-PD™ Configuration Utility*; [Available online](#)
- [4] Infineon Technologies AG: *EZ-PD™ PAG2S-QZ integrated USB PD and secondary-side QR-ZVS CONTROLLER* (Document Number: 002-37216 Rev. *C), 2023-12-21; [Available online](#)
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Revision history

Revision history

Document revision	Date	Description of changes
**	2024-10-18	Initial release
*A	2024-10-28	Updated title

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Edition 2024-10-28

Published by

Infineon Technologies AG
81726 Munich, Germany

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Document reference

002-40640 Rev. *A

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