65 W PAG2P-2S HF ZVS low profile PA board test report

Product_sales code – REF_65W_HFZVS_LP_PAG2

Devices – CYPAP212A1-14SXI and CYPAS211A1-32LQXQ

About this document

Scope and purpose

This document provides power management test results of the 65 W PAG2P-2S HF ZVS low profile PA solution demo board. The tests were performed on REV2 board, that 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 engineers and FAEs using the EZ-PD™ PAG2P/PAG2S HF QR zero-voltage switching low profile adapter REF_65W_HFZVS_LP_PAG2 hardware.

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Note: *Please note the following warnings regarding the hazards associated with development systems.*

Table 1 Safety precautions

	**Warning:** *The DC link potential of this board is up to 1000 VDC. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death.*
	**Warning**: *The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *The evaluation or reference board is connected to the grid input during testing. Hence, high-voltage differential probes must be used when measuring voltage waveforms by oscilloscope. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

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1 Introduction

This test report captures the performance of power adapter generation 2 – secondary controller (PAG2S) and primary controller (PAG2P) high-frequency quasi-resonant zero-voltage switching flyback (QR-ZVS) based on USB PD, 65 W adapter solution demo kit. This is a highly power-dense form-factor (26 W/in^3) and an efficient (>94%) adapter solution kit.

EZ-PD™ PAG2P power adapter generation 2 primary CYPAP212A1-14SXI 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 pulse-width modulator (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 and responding to 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), PWM, and zero-voltage switching (ZVS) control. PAG2S is targeted towards USB-C power adapters and it fits well into the high-efficiency AC-DC flyback designs with USB PD and other standard charging protocols. PAG2S also supports the 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 amplifies (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 advantage over the traditional primary side control, with programmable secondary SR FET ON time to ensure that primary FET achieves ZVS during the turn on, hence achieving optimized efficiency.

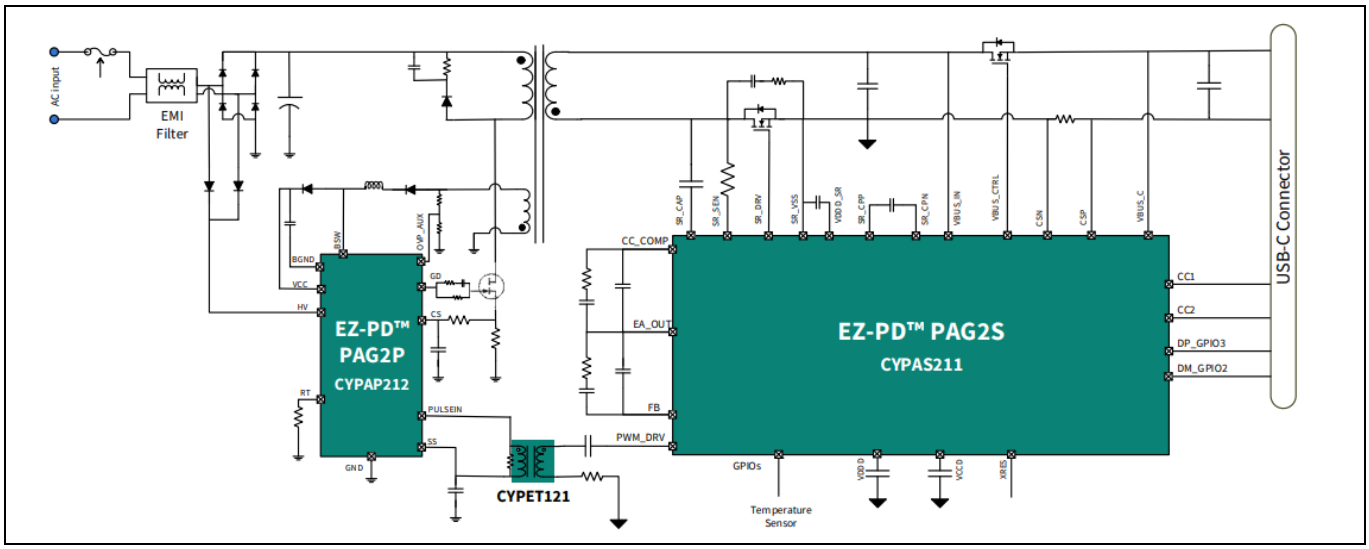


Figure 1 Application diagram for a power adapter in a secondary-side controlled flyback converter topology along with ZVS operation

2 Test setup

2.1 DUT (device under test)

65 W PAG2P-2S HF ZVS LP adapter solution demo board.

Table 2 DUT hardware and software configurations

DUT contents	Description	Remarks
Hardware – configuration		
65 W PAG2P+PAG2S HF ZVS LP solution board	Rev 2	–
Firmware		
Firmware repo	zvs_hf_lp_ver2.hex	

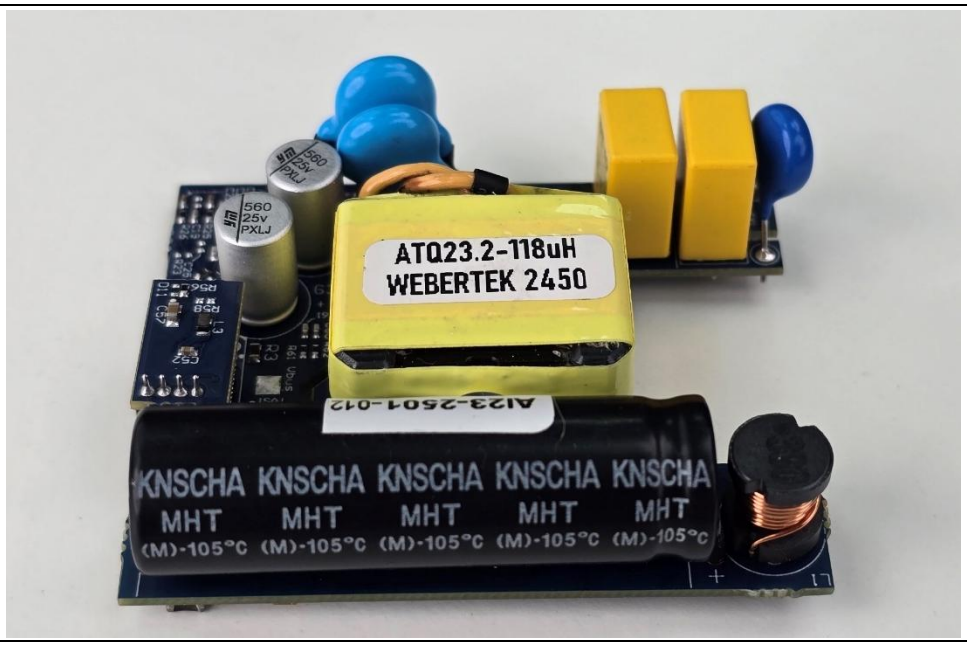


Figure 2 Isometric view of the 65W HF ZVS LP solution board



Dimensions (in mm): 54.5 x 45.1 x 16.25

Figure 3 Top and bottom view of the 65W HF ZVS LP solution board

2.2 DUT setup

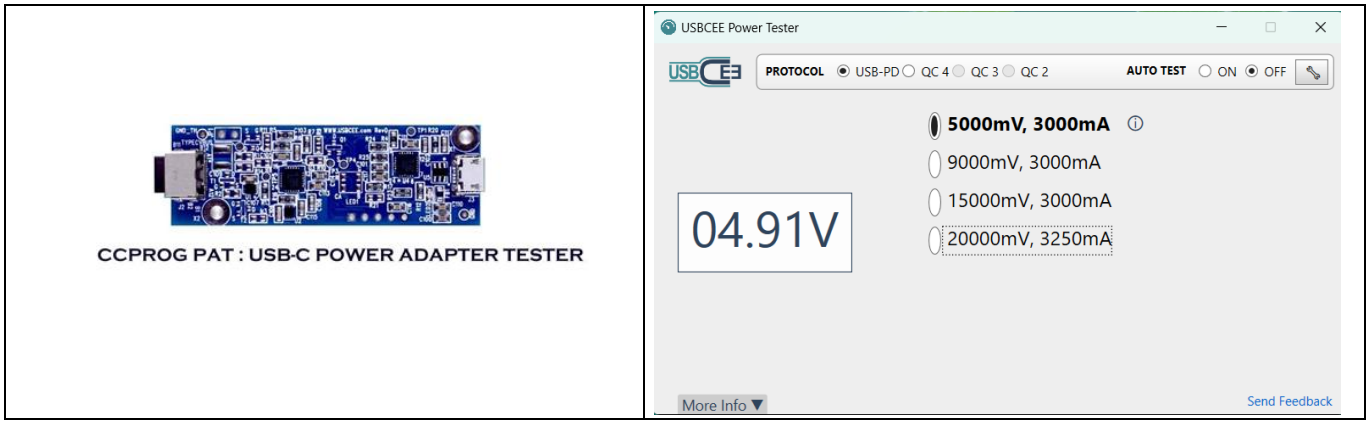


Figure 4 Physical CCGPROG PAT and USBCEE Power Tester UI

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 UI does a PDO discovery and displays the same on the UI. In this case, the solution kit is pre-configured with 4 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

You can either choose the suitable pre-configured PDO or configure a new one using Infineon's USB EZ-PD™ Configuration Utility. For the tests in the following sections, the pre-configured PDOs are used.

To know more about PAT tester, visit USBCEE.

Type C-C cable (1 meter long) used: Type-C cable being used for all the tests mentioned in this report is 3027003-01M. Fore more information, see [7].

2.3 Test equipment

The test equipment used to measure the efficiency, ripple, regulation, and transient response are shown in Table 3.

Table 3 Test equipment details

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

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 4 Efficiency and no-load consumption results

Parameter	**Standard (Minimum value)**		**Unit**	**Test condition**	**Test result**	
	DoE Level-6	**CoCv5 Tier 2**	**–**	**–**	**115 Vac 60 Hz**	**230 Vac 50 Hz**
Four-point average efficiency (Average of 25%, 50%, 75%, 100% load)	81.39	81.84	%	Vo = 5 Vdc, Io = 3 A	91.47	91.22
	86.62	87.30	%	Vo = 9 Vdc, Io = 3 A	93.14	92.77
	87.73	88.85	%	Vo = 15 Vdc, Io = 3 A	93.21	93.69
	88	89	%	Vo = 20 Vdc, Io = 3.25 A	93.68	94.02
CoCv5 Tier2 10% load efficiency	–	72.48	%	Vo = 5 Vdc, Io = 0.3 A	87.33	81.62
	–	77.30	%	Vo = 9 Vdc, Io = 0.3 A	89.22	87.58
	–	78.85	%	Vo = 15 Vdc, Io = 0.3 A	88.97	87.72
	–	79	%	Vo = 20 Vdc, Io = 0.325 A	89.55	89.05
–	**Standard (Maximum value)**		**–**	**–**	**Test result**	
Parameter	**DoE Level-6**	**CoCv5 Tier 2**		**Test condition**	**115 Vac 60 Hz**	**230 Vac 50 Hz**
No load power consumption	100	75	mW	No USB sink attached	25 mW	29 mW
	–	–	–	USB sink attached (output 5 V,0 A)	60 mW	60 mW

- **Peak efficiency**: **94.69%** (At 265 Vac-63 Hz, 15 V-3 A)
- **Full load efficiency at 230 Vac**: **94.66%** (At 230 Vac-50 Hz, 20 V-3.25 A)
- **Full load efficiency at 115 Vac**: **94.05%** (At 115 Vac-60 Hz, 20 V-3.25 A)
- **Full load efficiency at 90 Vac**: **92.68%** (At 90 Vac-47 Hz, 20 V-3.25 A)

Note:

1. *V-out for efficiency calculations is measured across Vbus_C at board end with 10 minutes warmup*
2. *Variation of ±0.5% in efficiency can be observed across units*

Power management test results

Table 5 EuP Lot6 V1[1]

Parameter	Test condition	Max pin (mW)	Test result			
			115 Vac 60 Hz		230 Vac 50 Hz	
			Pin (mW)	Efficiency (%)	Pin (mW)	Efficiency (%)
Efficiency at 250 mW load	Vo = 5 Vdc Io = 50 mA	500	326	76.67	337	74.02
Efficiency at 250 mW load	Vo = 9 Vdc Io = 27.78 mA	500	359	69.77	366	68.47
Efficiency at 250 mW load	Vo = 15 Vdc Io = 16.67 mA	500	342	73.19	348	71.97
Efficiency at 250 mW load	Vo = 20Vdc Io = 12.5 mA	500	355	70.63	357	70.18

Table 6 EuP Lot6 V2[1]

Parameter	Test condition	Max pin (mW)	Test result			
			115 Vac 60 Hz		230 Vac 50 Hz	
			Pin (mW)	Efficiency (%)	Pin (mW)	Efficiency (%)
Efficiency at 180 mW load	Vo = 5 Vdc Io = 36 mA	300	249	72.16	253	71.06
Efficiency at 180 mW load	Vo = 9 Vdc Io = 20 mA	300	283	63.71	287	62.83
Efficiency at 180 mW load	Vo = 15 Vdc Io = 12 mA	300	267	67.58	271	66.61
Efficiency at 180 mW load	Vo = 20 Vdc Io = 9 mA	300	277	64.93	281	64.08

[1] Following pin data is the average number taken over the duration of 5 minutes for each test condition.

Power management test results

Table 7 EuP Lot6 V2 (Customer requirements)[2]

Parameter	Test condition	Max pin (mW)	Test result			
			115 Vac 60 Hz		230 Vac 50 Hz	
			Pin (mW)	Efficiency (%)	Pin (mW)	Efficiency (%)
Efficiency at 150 mW load	Vo = 5 Vdc Io = 30 mA	280	217	69.07	219	68.47
Efficiency at 150 mW load	Vo = 9 Vdc Io = 16.67 mA	280	251	59.91	254	58.89
Efficiency at 150 mW load	Vo = 15 Vdc Io = 10 mA	280	236	63.80	238	63.33
Efficiency at 150 mW load	Vo = 20 Vdc Io = 7.5 mA	280	243	62.39	246	60.89

Table 8 Efficiency from 0.1 W to 1 W at 90 Vac 47 Hz for 20 V output[3]

S. No.	Vac	Frequency	Pin	V-out	I-out	Po	Efficiency
1	90	47	0.149	20.024	0.004	0.075	50.591
2	90	47	0.306	20.024	0.009	0.184	59.984
3	90	47	0.414	20.025	0.014	0.275	66.371
4	90	47	0.528	20.024	0.019	0.383	72.603
5	90	47	0.627	20.024	0.024	0.475	75.802
6	90	47	0.746	20.024	0.029	0.584	78.259
7	90	47	0.833	20.023	0.034	0.677	81.259
8	90	47	0.985	20.024	0.039	0.784	81
9	90	47	1.058	20.024	0.044	0.876	82.804
10	90	47	1.16	20.024	0.049	0.976	84.11

[2] Following pin data is the average number taken over the duration of 5 minutes for each test condition.

[3] Following data has been taken by automation system where instantaneous readings (AND NOT AVERAGE) are taken from all the instruments/equipment.

Power management test results

Table 9 Efficiency from 1 W to 10 W load at 90 Vac 47 Hz for 20 V output[3]

S. No.	Vac	Frequency	Pin	V-out	I-out	Po	Efficiency
1	90	47	1.162	20.021	0.049	0.984	84.689
2	90	47	2.242	20.022	0.099	1.986	88.577
3	90	47	3.316	20.021	0.149	2.988	90.118
4	90	47	4.388	20.02	0.199	3.99	90.927
5	90	47	5.444	20.02	0.249	4.991	91.681
6	90	47	6.507	20.02	0.299	5.985	91.976
7	90	47	7.615	20.019	0.349	6.986	91.74
8	90	47	8.67	20.019	0.399	7.98	92.04
9	90	47	9.72	20.019	0.449	8.981	92.394
10	90	47	10.78	20.019	0.499	9.983	92.604

Table 10 Efficiency from 10 W to 65 W load at 90 Vac 47 Hz for 20 V output[3]

S. No.	Vac	Frequency	Pin	V-out	I-out	Po	Efficiency
1	90	47	10.82	20.02	0.499	9.988	92.315
2	90	47	16.16	20.019	0.749	14.995	92.788
3	90	47	21.46	20.016	0.999	19.991	93.155
4	90	47	26.94	20.013	1.249	24.994	92.777
5	90	47	32.38	20.012	1.499	29.998	92.644
6	90	47	37.77	20.009	1.749	34.99	92.64
7	90	47	43.12	20.007	1.999	39.991	92.744
8	90	47	48.32	20.005	2.249	44.991	93.111
9	90	47	53.67	20.003	2.499	49.982	93.129
10	90	47	59.2	20	2.749	54.98	92.871
11	90	47	64.5	19.998	2.999	59.975	92.985
12	90	47	70	19.995	3.249	64.961	92.802

Table 11 Efficiency from 0.1 W to 1 W load at 115 Vac 60 Hz for 20 V output[3]

S. No.	Vac	Frequency	Pin	V-out	I-out	Po	Efficiency
1	115	60	0.123	20.027	0.004	0.075	51
2	115	60	0.348	20.027	0.009	0.183	52.705
3	115	60	0.451	20.026	0.014	0.275	60.991
4	115	60	0.984	20.026	0.019	0.383	65
5	115	60	0.661	20.026	0.024	0.475	71.918
6	115	60	0.784	20.026	0.029	0.584	74.445
7	115	60	0.875	20.027	0.034	0.677	77.427
8	115	60	1.015	20.028	0.039	0.785	77.296
9	115	60	1.727	20.027	0.044	0.876	79
10	115	60	1.208	20.027	0.049	0.975	80.735

Power management test results

Table 12 Efficiency from 1 W to 10 W load at 115 Vac 60 Hz for 20 V output[3]

S. No.	Vac	Frequency	Pin	V-out	I-out	Po	Efficiency
1	115	60	1.215	20.025	0.049	0.983	80.893
2	115	60	2.299	20.024	0.099	1.984	86.305
3	115	60	3.34	20.023	0.149	2.986	89.413
4	115	60	4.42	20.024	0.199	3.988	90.231
5	115	60	5.49	20.023	0.249	4.989	90.866
6	115	60	6.92	20.022	0.299	5.982	91
7	115	60	7.66	20.022	0.349	6.985	91.182
8	115	60	8.7	20.021	0.398	7.978	91.701
9	115	60	9.01	20.02	0.448	8.979	92
10	115	60	10.81	20.02	0.499	9.981	92.327

Table 13 Efficiency from 10 W to 65 W load at 115 Vac 60 Hz for 20 V output[3]

S. No.	Vac	Frequency	Pin	V-out	I-out	Po	Efficiency
1	115	60	12	20.019	0.499	9.988	90
2	115	60	16.3	20.017	0.749	14.994	91.987
3	115	60	21.8	20.015	0.999	19.991	91.701
4	115	60	27.4	20.012	1.249	24.993	91.217
5	115	60	32.45	20.01	1.499	29.997	92.44
6	115	60	37.64	20.008	1.749	34.988	92.955
7	115	60	42.57	20.006	1.999	39.989	93.936
8	115	60	47.89	20.004	2.249	44.99	93.945
9	115	60	53.39	20.002	2.499	49.979	93.612
10	115	60	58.5	19.999	2.749	54.977	93.977
11	115	60	63.8	19.996	2.999	59.97	93.996
12	115	60	67.8	19.994	3.249	64.957	94

Table 14 Efficiency from 0.1 W to 1 W load at 230 Vac 50 Hz for 20 V output[3]

S. No.	Vac	Frequency	Pin	V-out	I-out	Po	Efficiency
1	230	50	0.15	20.027	0.004	0.074	49.484
2	230	50	0.31	20.027	0.009	0.183	59.09
3	230	50	0.47	20.027	0.014	0.275	58.456
4	230	50	0.63	20.027	0.019	0.383	60.856
5	230	50	0.75	20.027	0.024	0.475	63.307
6	230	50	0.82	20.027	0.029	0.583	71.136
7	230	50	0.86	20.027	0.034	0.677	78.676
8	230	50	1.13	20.027	0.039	0.783	81
9	230	50	1.04	20.026	0.044	0.875	84.178
10	230	50	1.14	20.027	0.049	0.975	85.557

Power management test results

Table 15 Efficiency from 1 W to 10 W load at 230 Vac 50 Hz for 20 V output[3]

S. No.	Vac	Frequency	Pin	V-out	I-out	Po	Efficiency
1	230	50	1.33	20.024	0.049	0.982	84
2	230	50	2.34	20.024	0.099	1.984	84.806
3	230	50	3.45	20.023	0.149	2.986	86.565
4	230	50	4.56	20.023	0.199	3.988	87.456
5	230	50	5.7	20.022	0.249	4.989	87.53
6	230	50	6.77	20.022	0.299	5.982	88.368
7	230	50	7.83	20.022	0.349	6.984	89.198
8	230	50	8.79	20.02	0.398	7.978	90.761
9	230	50	9.82	20.02	0.448	8.979	91.433
10	230	50	10.84	20.019	0.499	9.98	92.071

Table 16 Efficiency from 10 W to 65 W load at 230 Vac 50 Hz for 20 V output[3]

S. No.	Vac	Frequency	Pin	V-out	I-out	Po	Efficiency
1	230	50	10.87	20.019	0.499	9.988	91.885
2	230	50	16.01	20.018	0.749	14.995	93.658
3	230	50	21.37	20.015	0.999	19.991	93.548
4	230	50	26.63	20.013	1.249	24.995	93.86
5	230	50	32	20.011	1.499	29.998	93.743
6	230	50	37.21	20.009	1.749	34.99	94.034
7	230	50	42.41	20.006	1.999	39.989	94.292
8	230	50	47.63	20.004	2.249	44.99	94.456
9	230	50	52.88	20.001	2.499	49.977	94.51
10	230	50	58.25	19.999	2.749	54.976	94.379
11	230	50	63.37	19.996	2.999	59.969	94.634
12	230	50	68.65	19.994	3.249	64.957	94.621

Power management test results

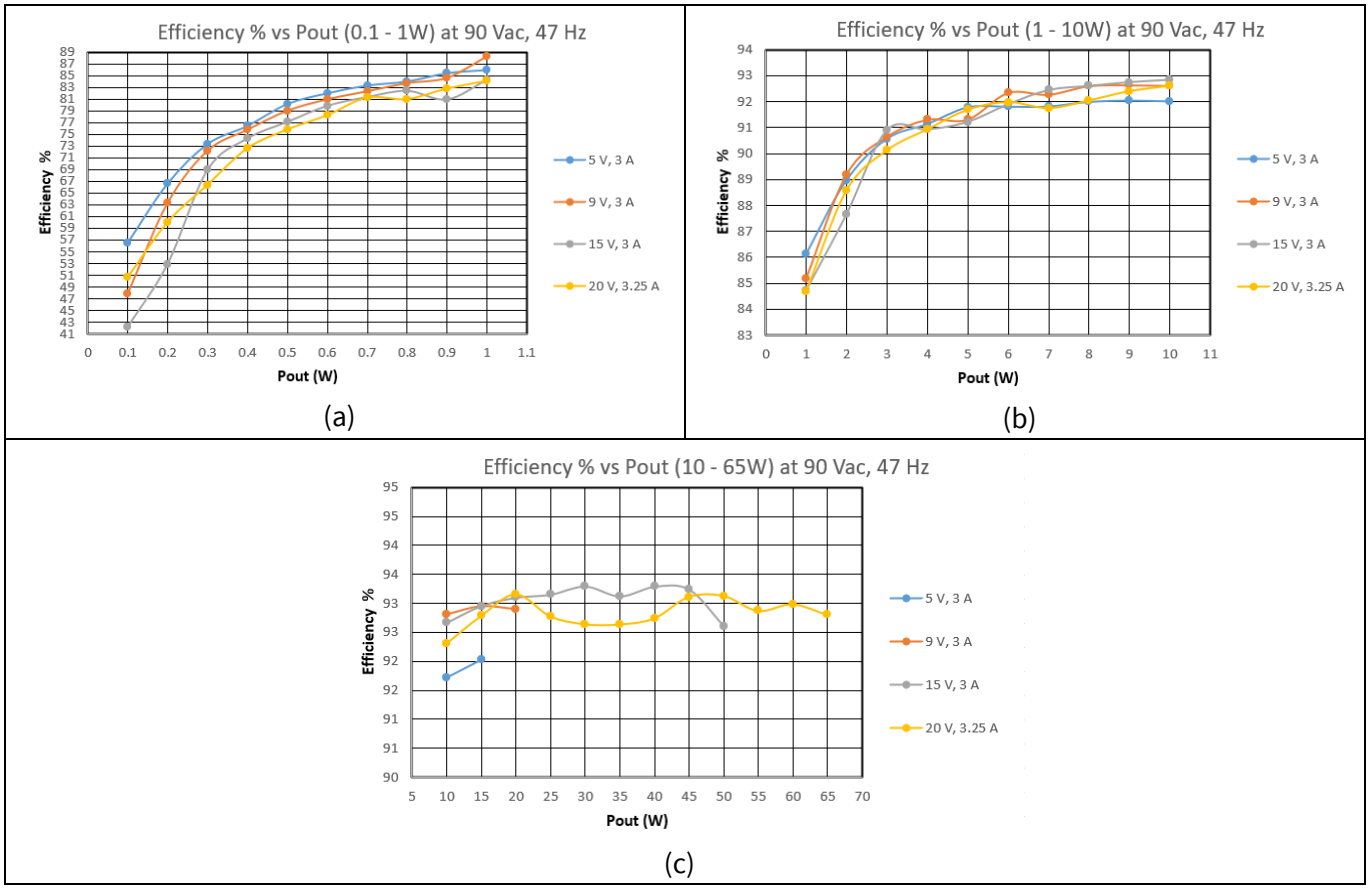


Figure 5 **(a) Efficiency with 0.1 to 1 W load at 90 Vac, 47 Hz; (b) Efficiency with 1 to 10 W load at 90 Vac, 47 Hz; (c) Efficiency with 10 W to 65 W load at 90 Vac, 47 Hz**

Power management test results

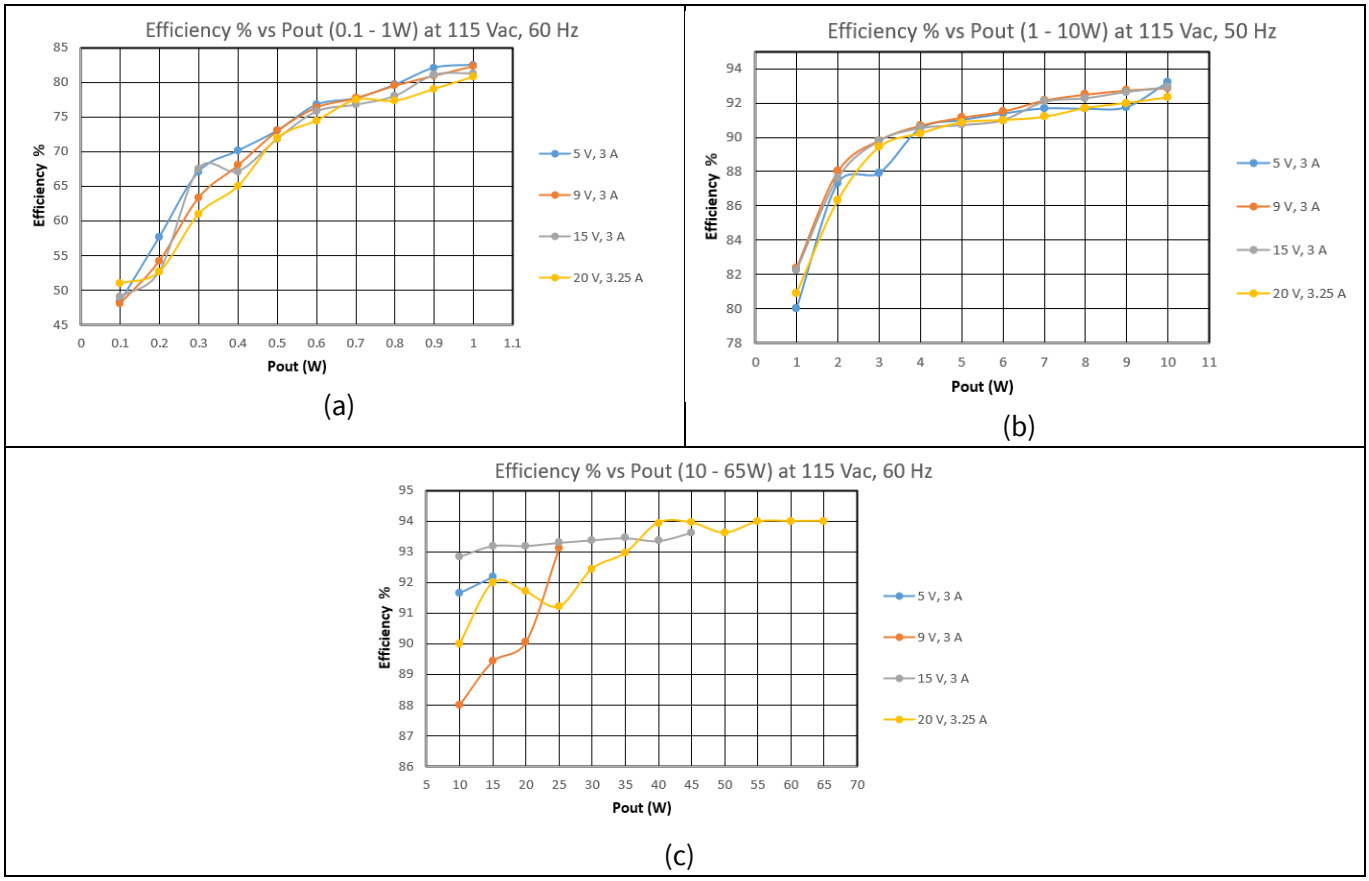


Figure 6 **(a) Efficiency with 0.1 to 1 W load at 115 Vac, 60 Hz; (b) Efficiency with 1 to 10 W load at 115 Vac, 60 Hz; (c) Efficiency with 10 W to 65 W load at 115 Vac, 60 Hz**

Power management test results

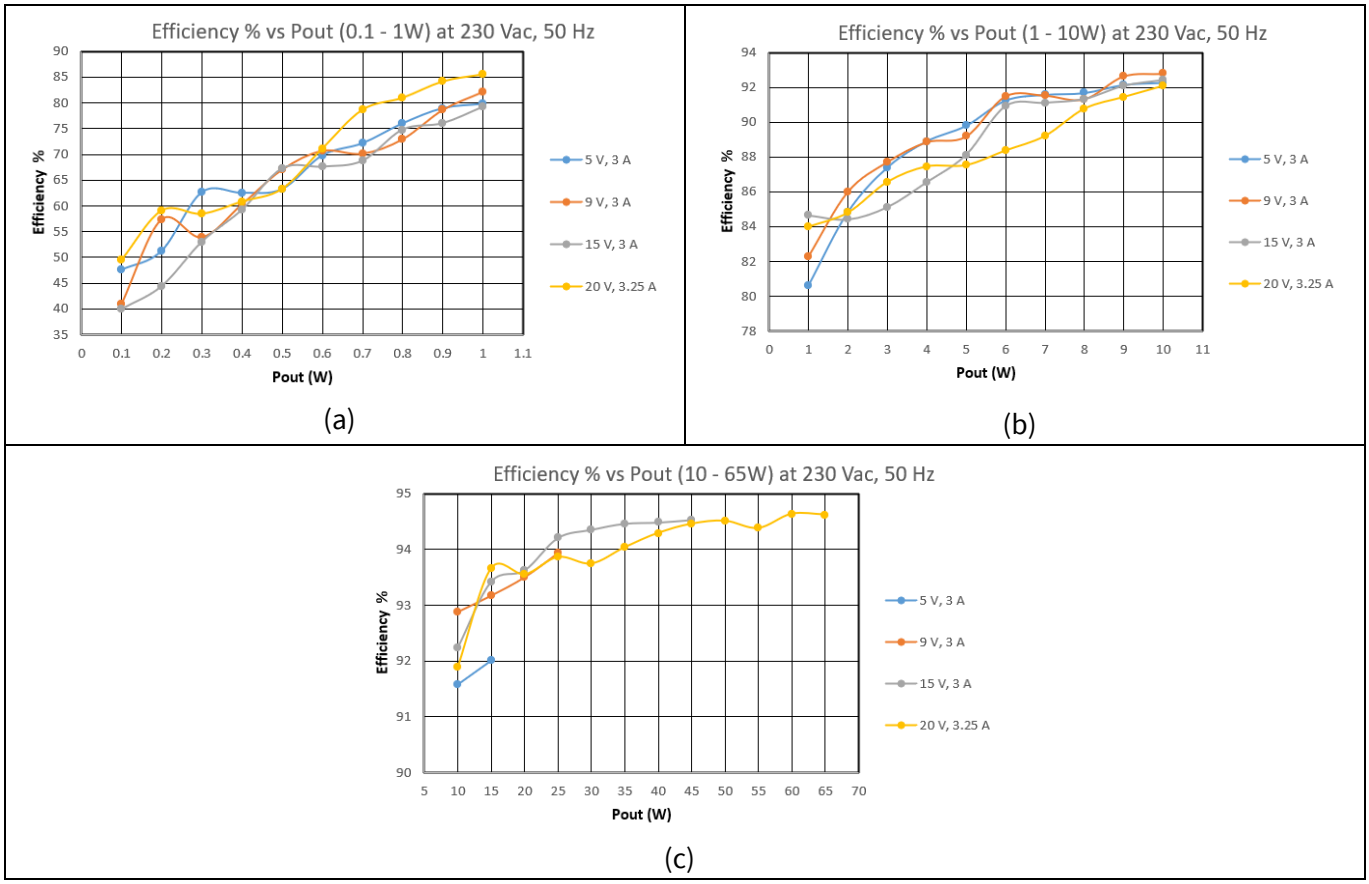


Figure 7 **Efficiency with 0.1 to 1 W load at 230 Vac, 50 Hz; (b) Efficiency with 1 to 10 W load at 230 Vac, 50 Hz; (c) Efficiency with 10 W to 65 W load at 230 Vac, 50 Hz**

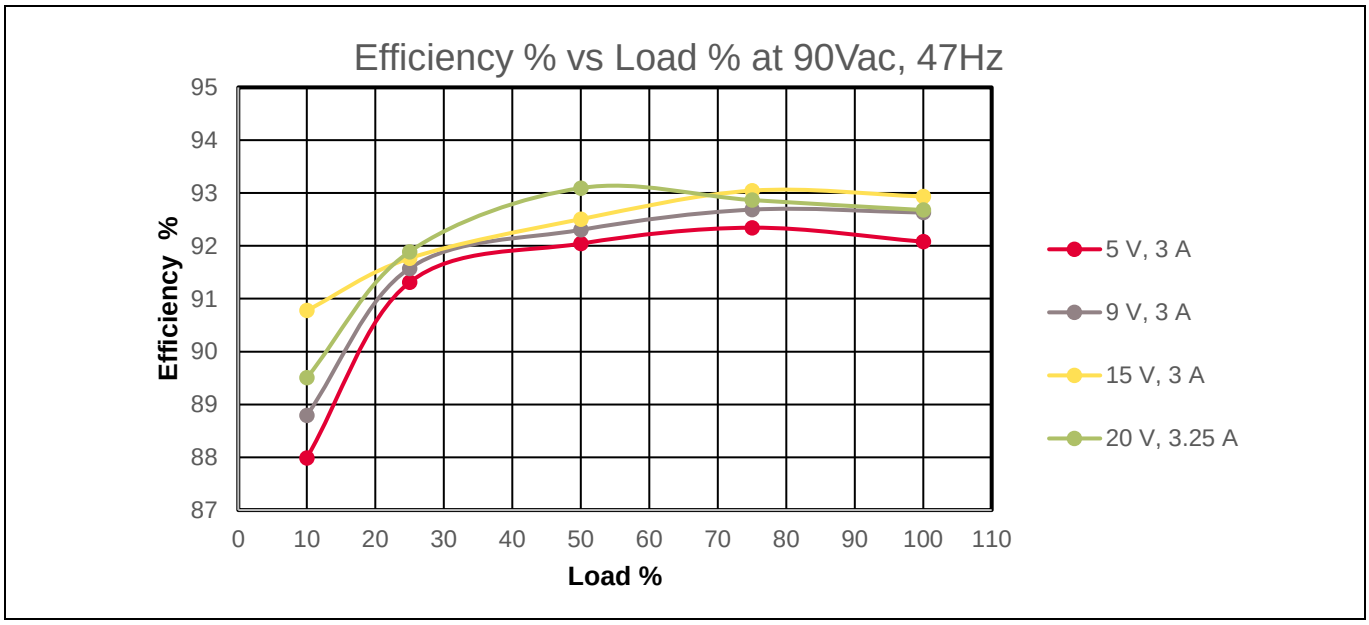


Figure 8 **Efficiency at 90 Vac, 47 Hz**

Power management test results

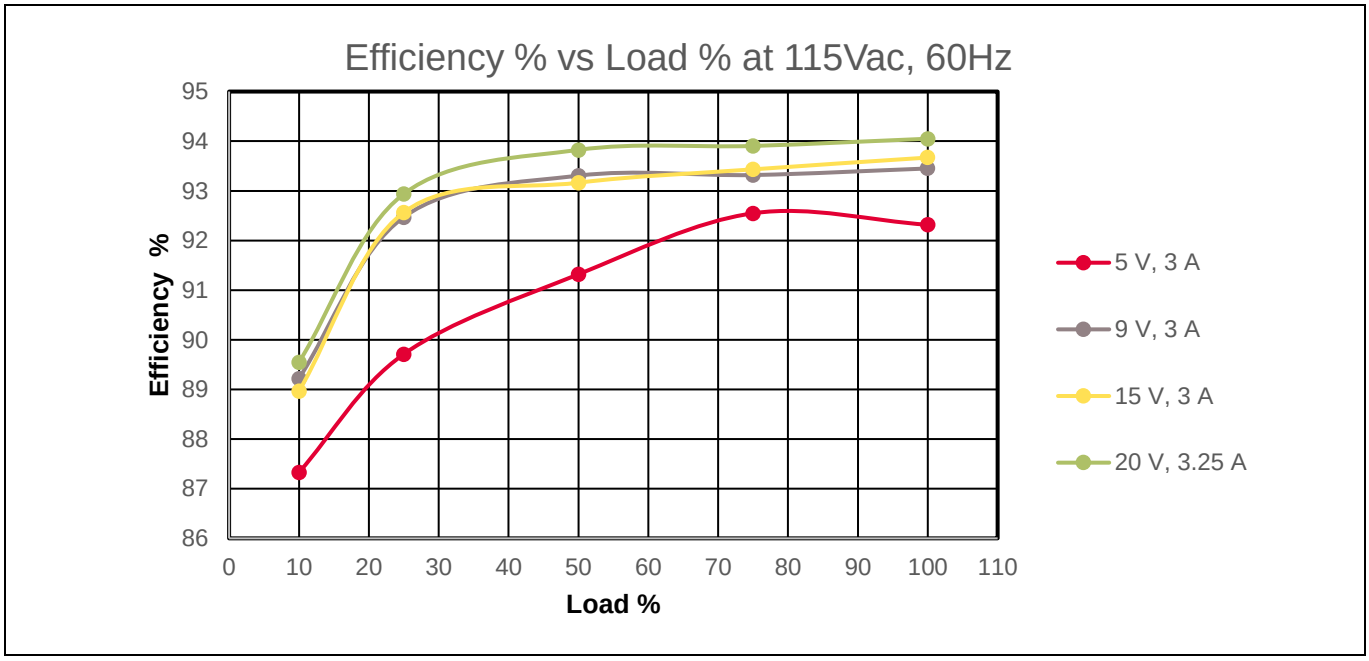


Figure 9 Efficiency at 115 Vac, 60 Hz

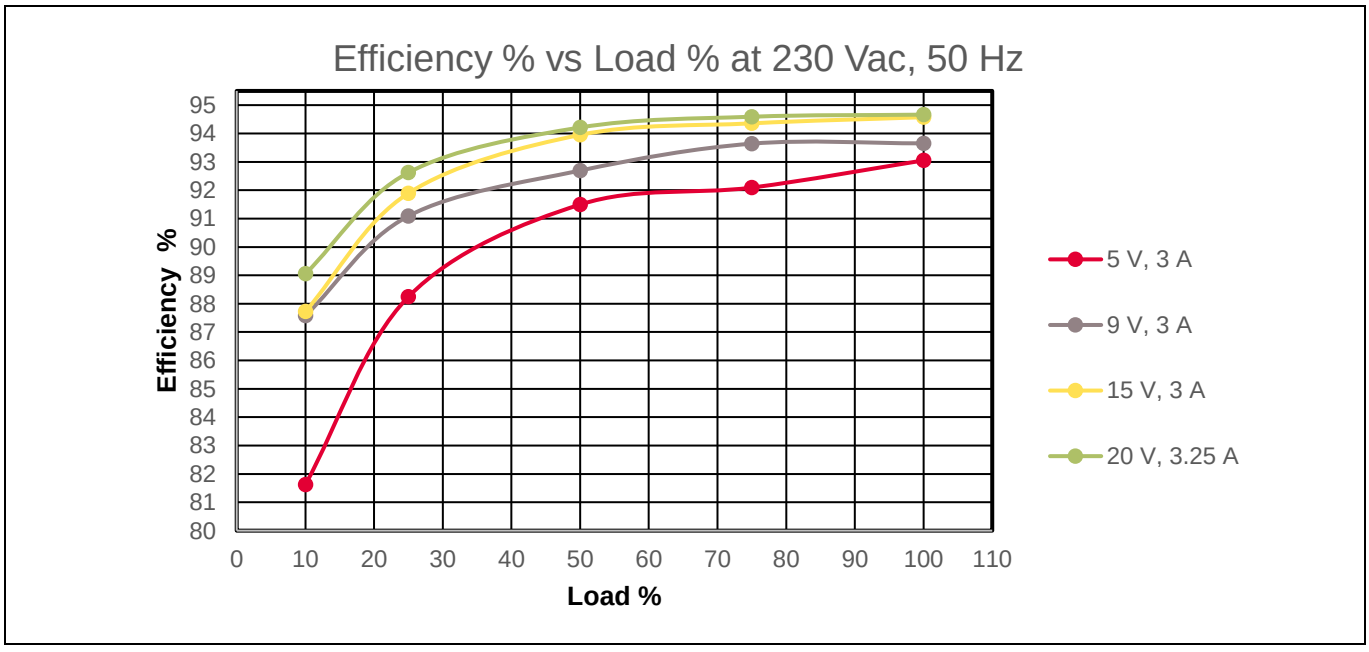


Figure 10 Efficiency at 230 Vac, 50 Hz

Power management test results

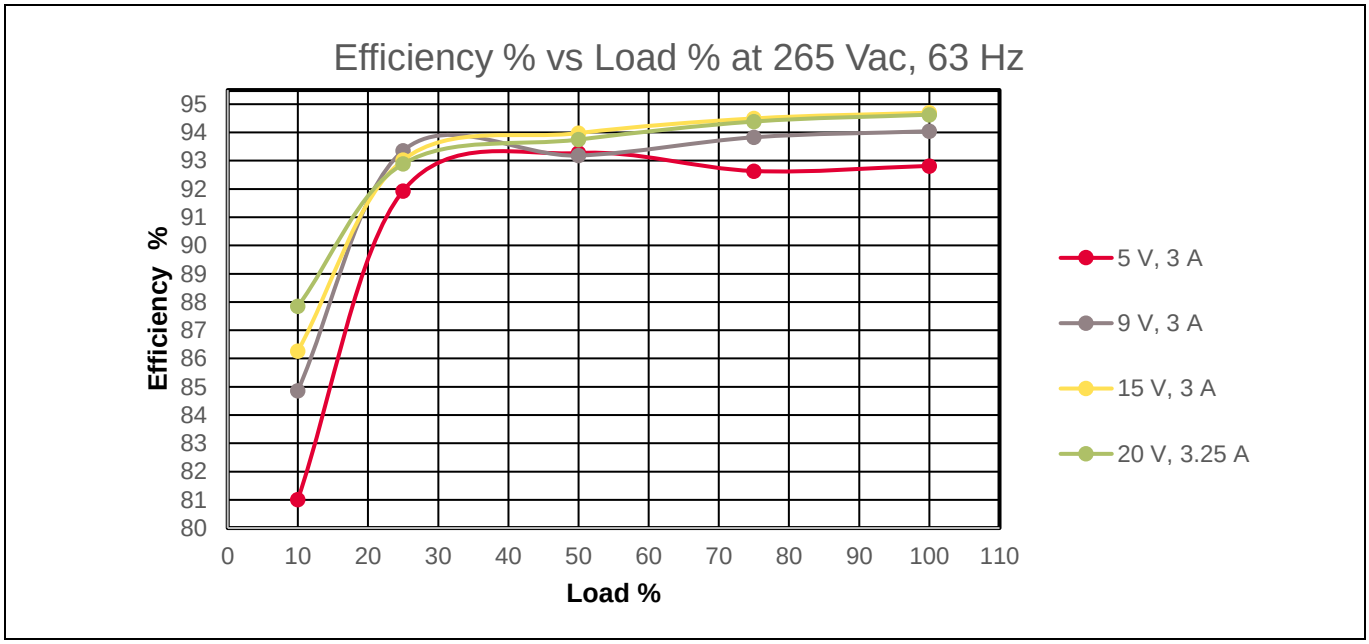


Figure 11 Efficiency at 265 Vac, 63 Hz

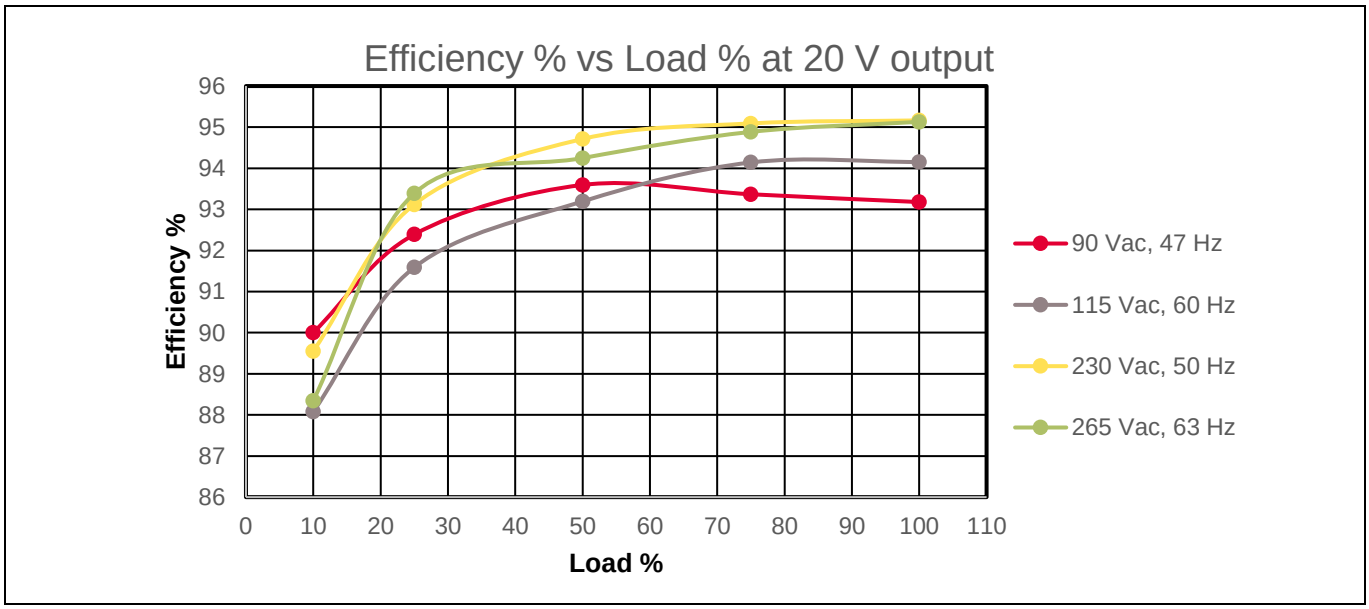


Figure 12 Efficiency at 20 V output for different line conditions

Power management test results

Table 17 Full load efficiency at different line conditions

S. No.	Vac (V)	Freq (Hz)	Pin	V-out (V)	I-out (A)	Po (W)	Efficiency (%)	4-pt. average efficiency (%)	CoC T2	DOE 6	Full load switching frequency (kHz)
1	90	47	7.24	20.031	0.324	6.4801	89.50	–	79	–	102
2	90	47	17.66	20.024	0.8104	16.2278	91.89	92.63	89	88	
3	90	47	34.970	20.018	1.6235	32.4993	93.0946				
4	90	47	52.420	20.007	2.4369	48.7555	92.8676				
5	90	47	70.320	19.999	3.2485	64.9676	92.6782				
6	115	60	7.349	20.041	0.3284	6.5808	89.55	–	79	–	162
7	115	60	17.47	20.034	0.8104	16.2362	92.938	93.68	89	88	
8	115	60	34.65	20.025	1.6235	32.5105	93.825				
9	115	60	51.94	20.018	2.4365	48.774	93.905				
10	115	60	69.12	20.009	3.2489	65.007	94.05				
11	230	50	7.28	20.040	0.3235	6.4831	89.05	–	79	–	129
12	230	50	17.53	20.034	0.8104	16.2365	92.6212	94.02	89	88	
13	230	50	34.5	20.052	1.6231	32.5033	94.2125				
14	230	50	51.56	20.017	2.4365	48.771	94.5908				
15	230	50	68.68	20.010	3.2498	65.016	94.6645				
16	265	63	7.38	20.040	0.3235	6.483	87.85	–	79	–	132
17	265	63	17.48	20.035	0.8104	16.237	93.13	93.91	89	88	
18	265	63	34.690	20.027	1.6239	32.5211	94.10				
19	265	63	51.68	20.017	2.4369	48.779	94.38				
20	265	63	68.69	20.007	3.2489	65.016	94.62				

Note: CoC Tier 2 limit for 4-pt average is 89% and 10% load is 79%.

3.2 Standby power consumption

Table 18 Standby power consumption across line conditions

Vin (Vac)	105 Vac, 47 Hz	115 Vac, 60 Hz	230 Vac, 50 Hz	240 Vac, 63 Hz
Input power (mW)	25 mW	25 mW	29 mW	29 mW

Note: There should be 15 minutes of warmup time before starting to measure standby power.

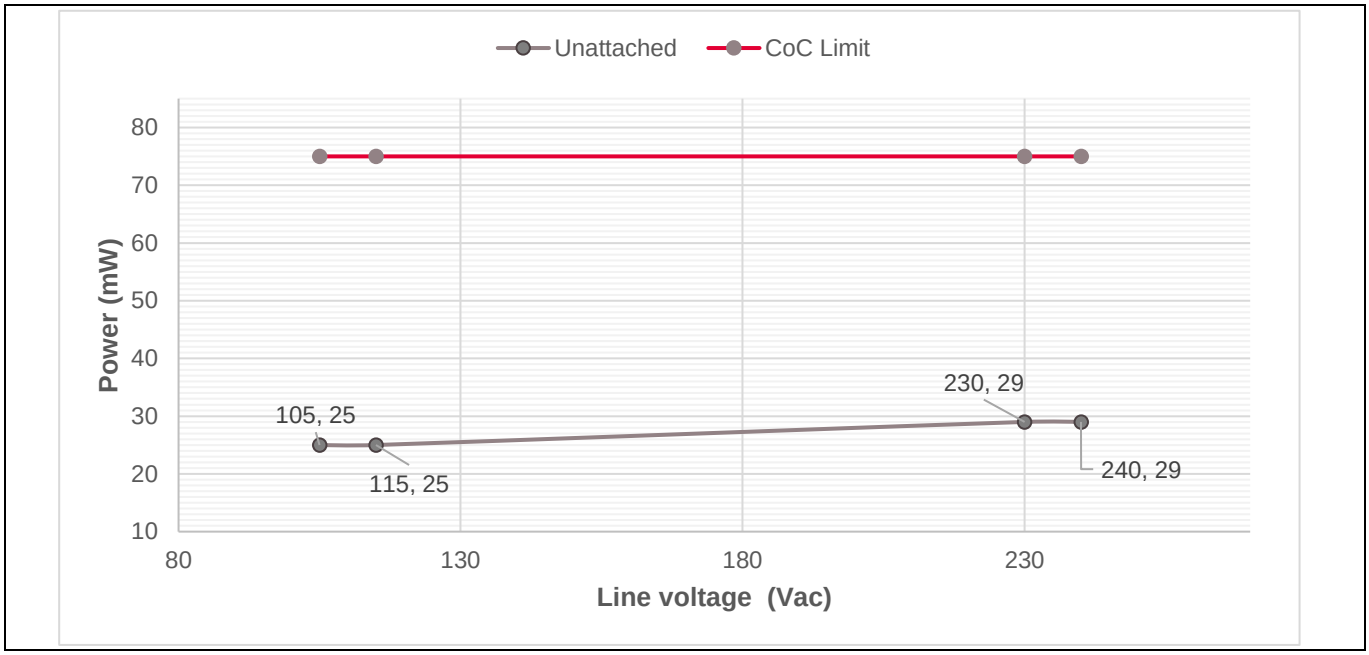


Figure 13 Standby power consumption

Note: The measurement was taken using Yokogawa WT310E power meter with line filter ON after 10 minutes.

3.3 Output voltage ripple peak-peak

Note: Ripple measurement is done at board end using Teledyne LeCroy probe adapter PK6-5MM-105.

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

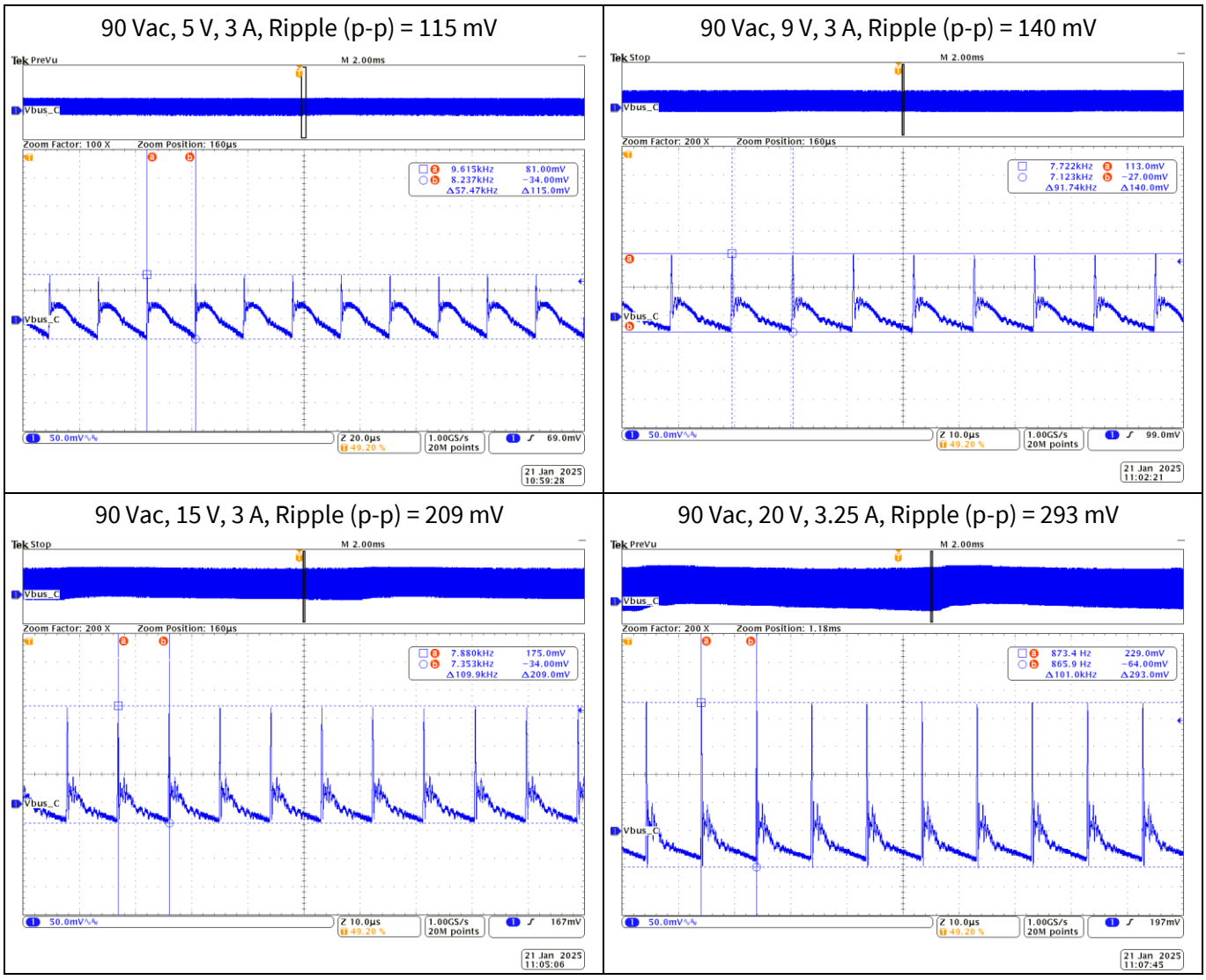


Figure 14 Ripple at 90 Vac 47 Hz (CH1: Vbus_C)

Power management test results

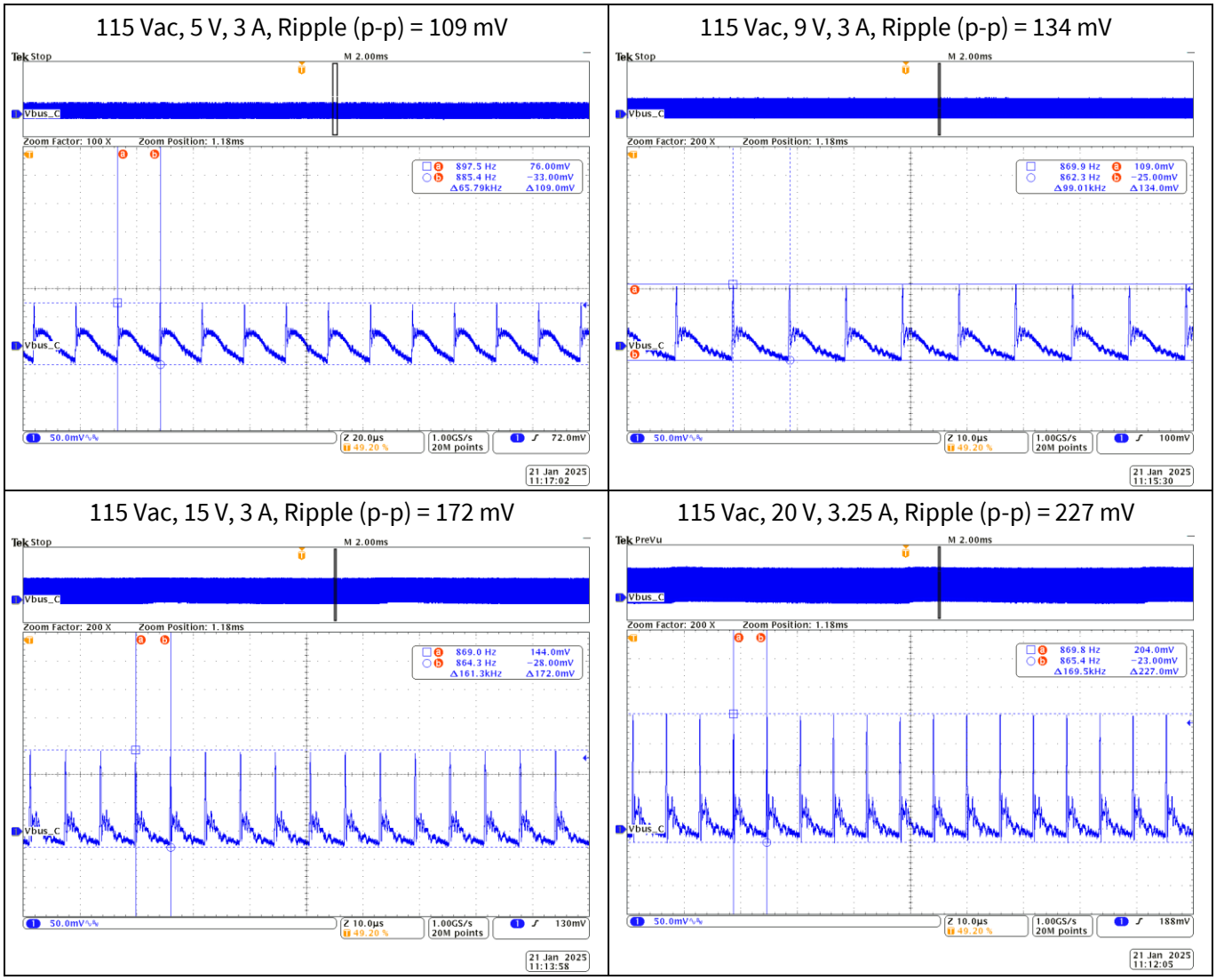


Figure 15 Ripple at 115 Vac 60 Hz (CH1: Vbus_C)

Power management test results

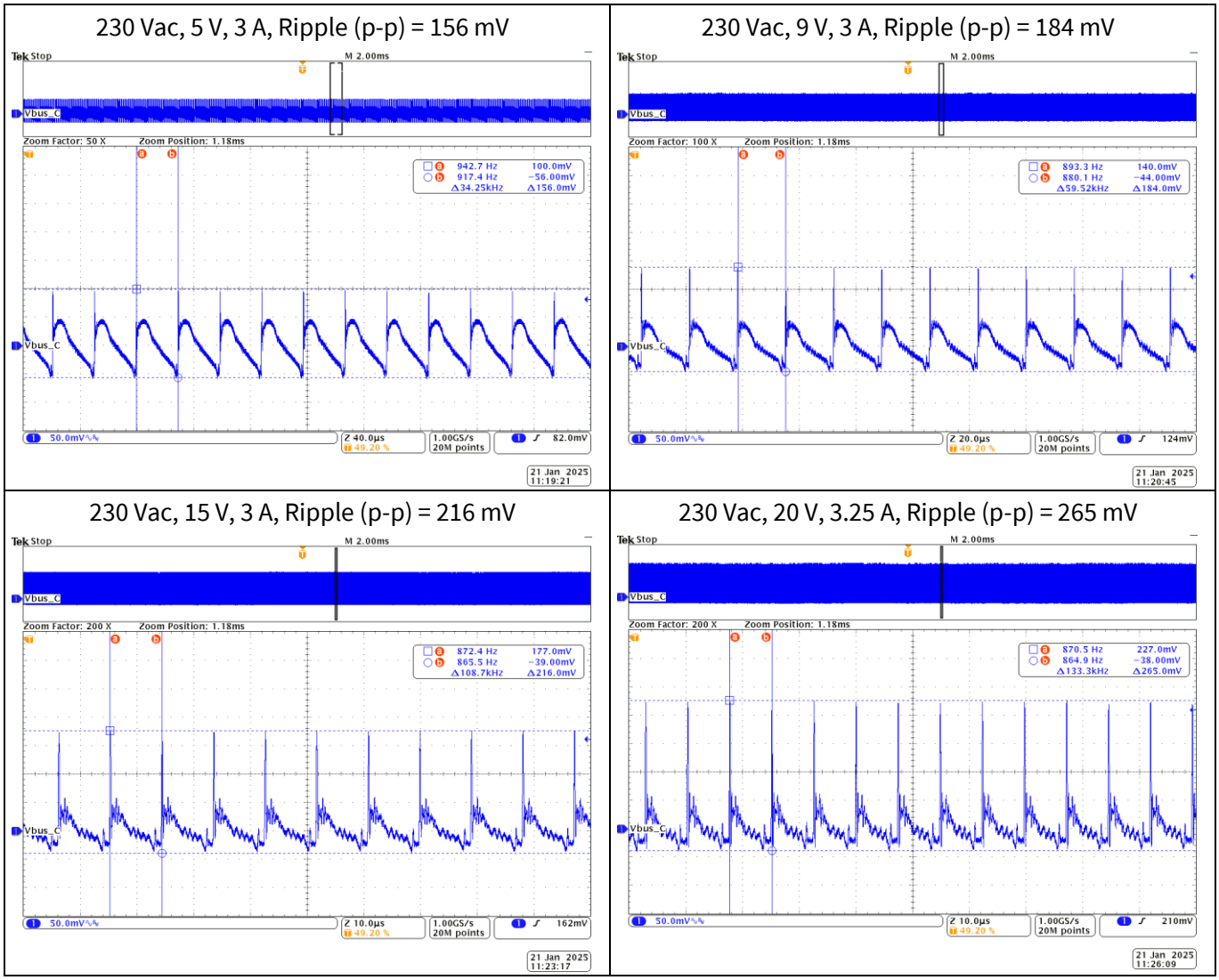


Figure 16 Ripple at 230 Vac 50 Hz (CH1: Vbus_C)

Power management test results

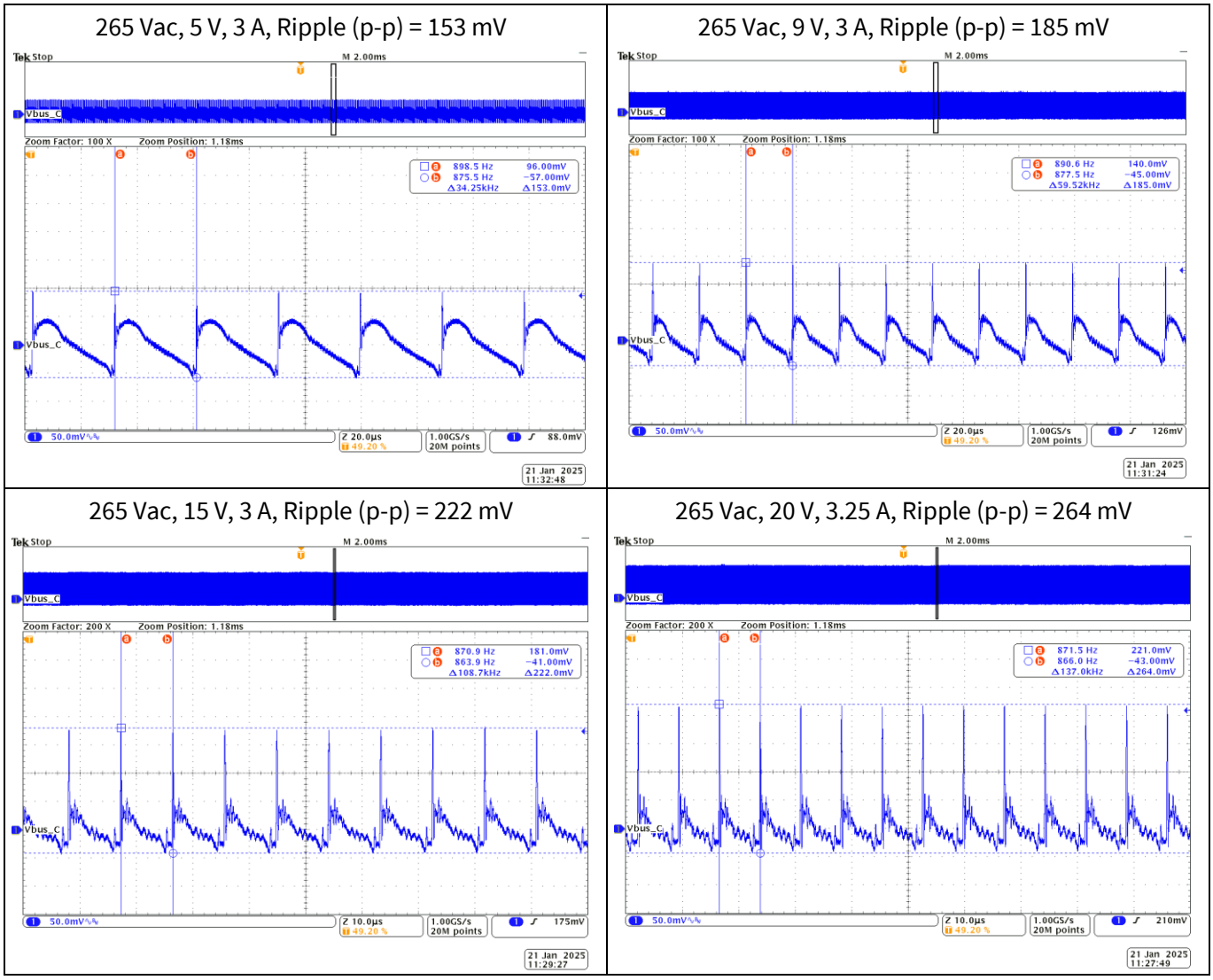


Figure 17 Ripple at 265 Vac 63 Hz (CH1: Vbus_C)

3.4 Output dynamic response settling time

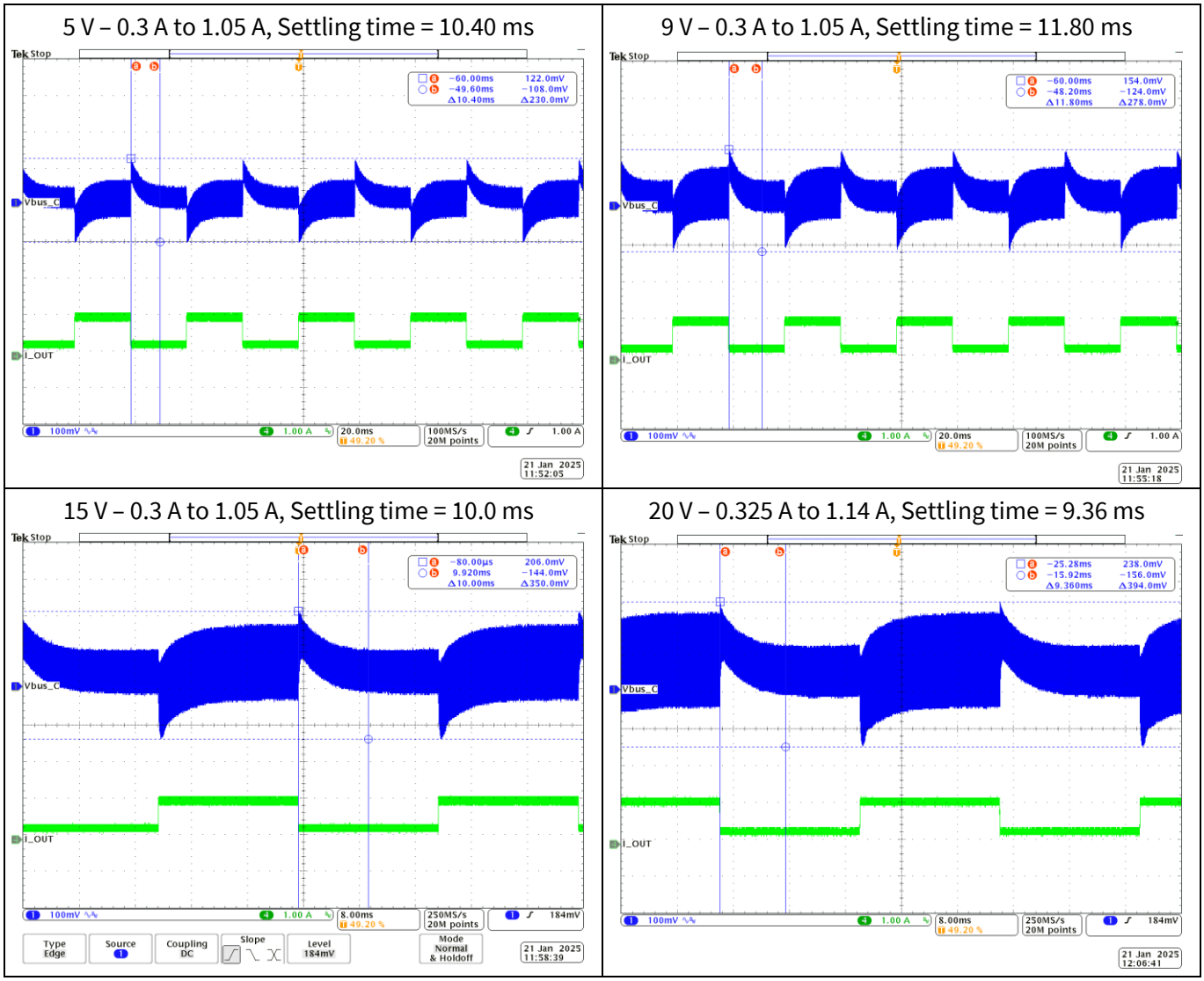


Figure 18 Settling time for 115 Vac, 60 Hz load transition 10% to 35% load (CH1: Vbus_C, CH4: Iout)

Power management test results

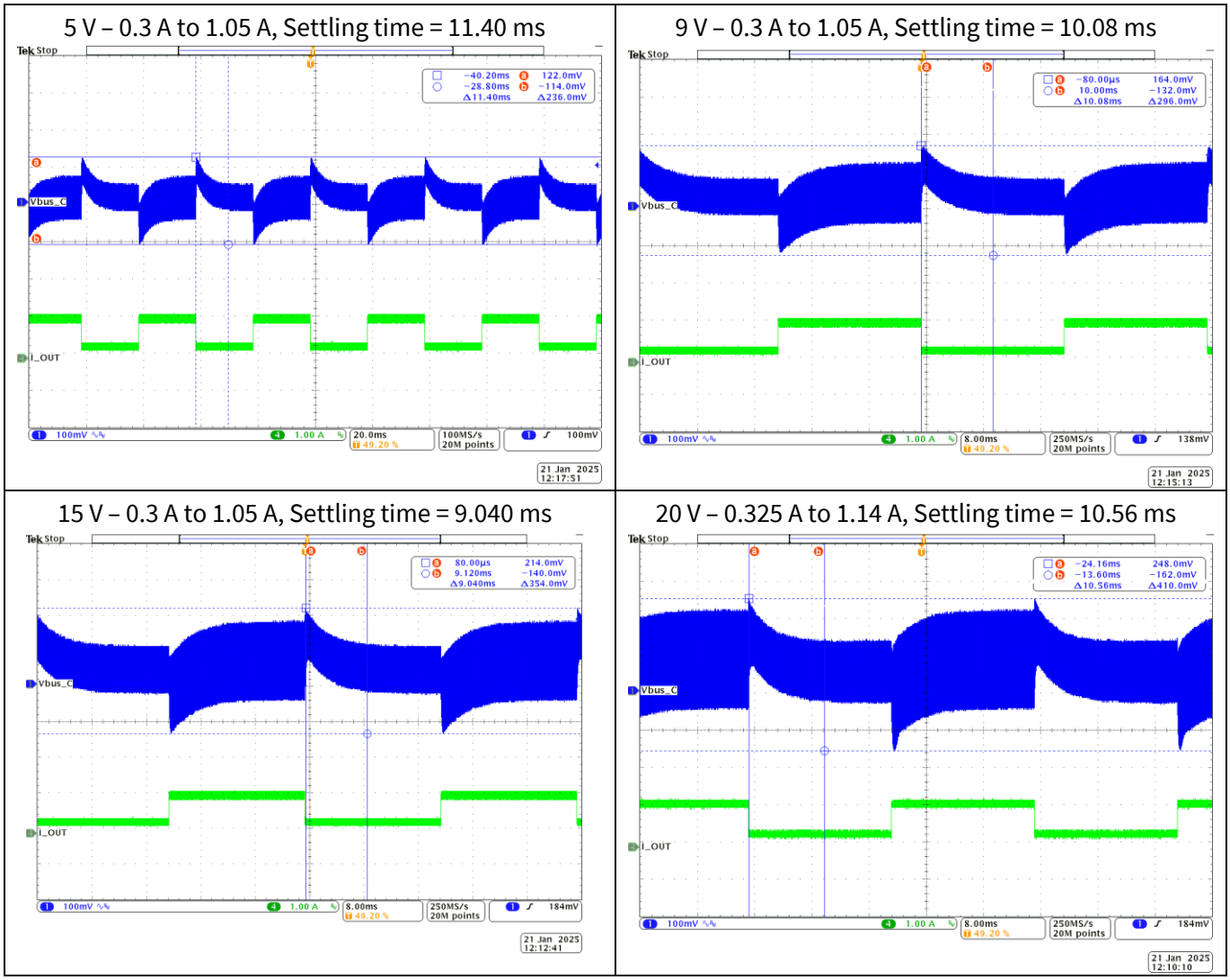


Figure 19 Settling time for 230 Vac, 50 Hz load transition 10% to 35% load (CH1: Vbus_C, CH4: Iout)

Power management test results

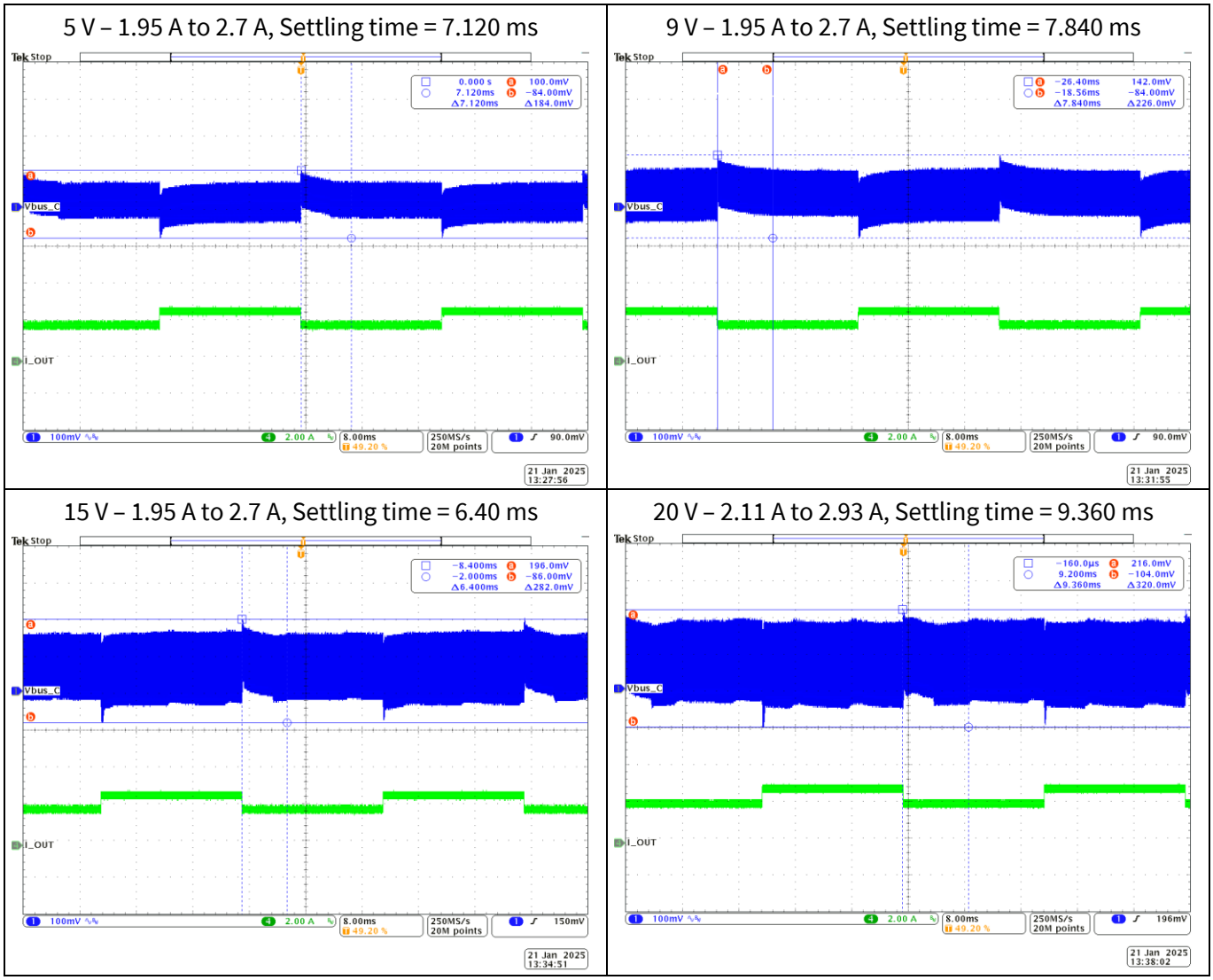


Figure 20 Settling time for 115 Vac, 60 Hz load transition 65% to 90% load (CH1: Vbus_C, CH4: Iout)

Power management test results

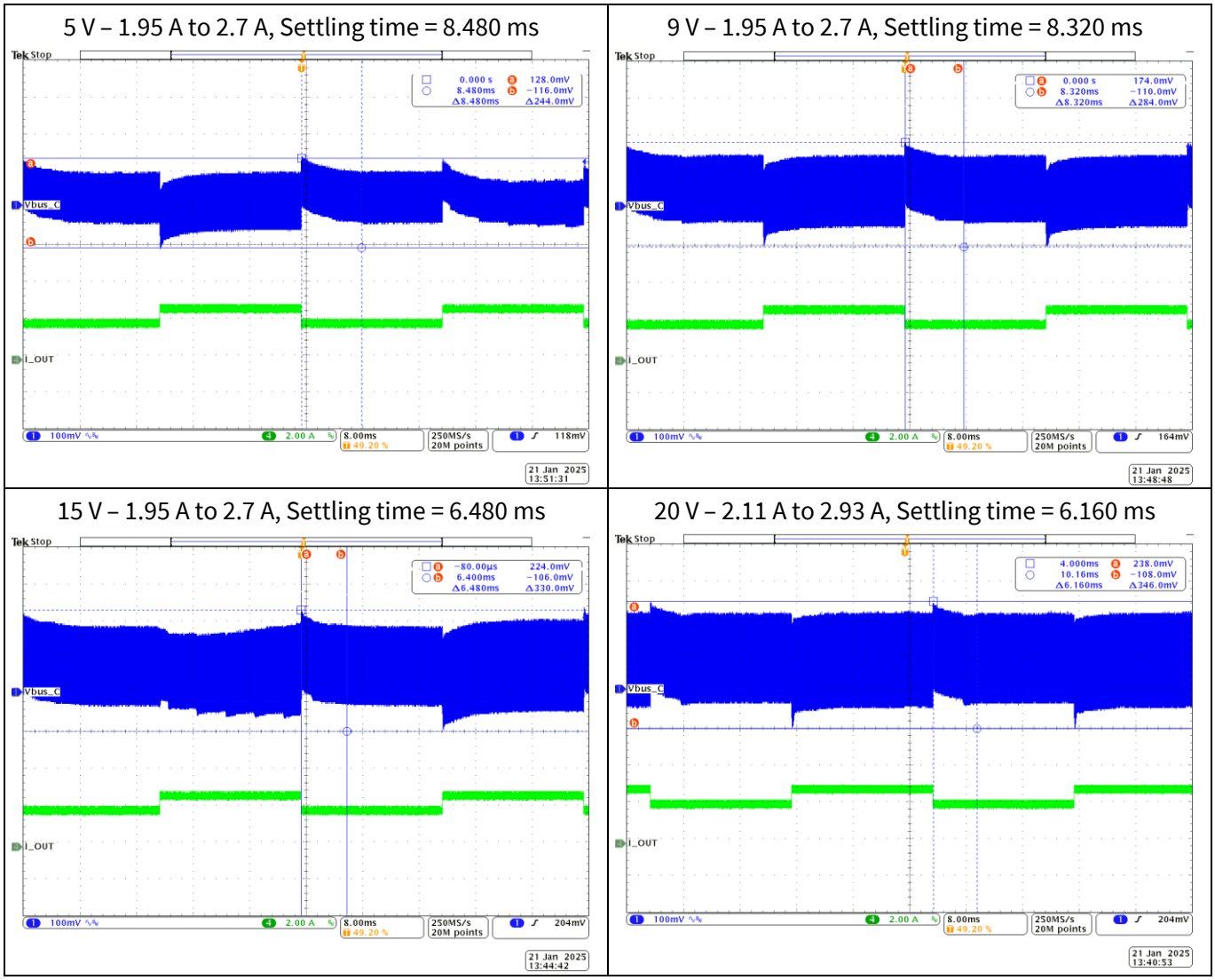


Figure 21 Settling time for 230 Vac, 50 Hz load transition 65% to 90% load (CH1: Vbus_C, CH4: Iout)

Power management test results

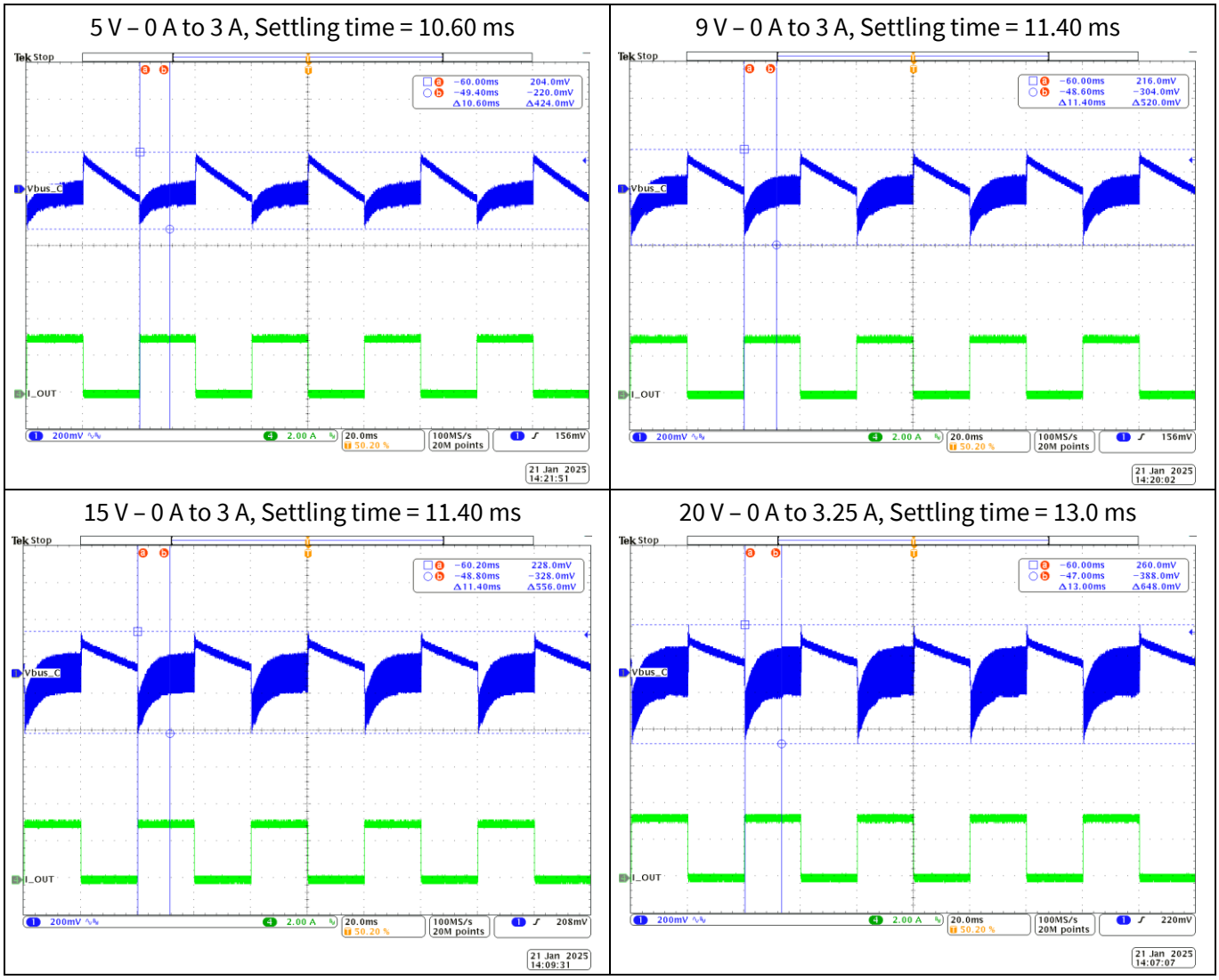


Figure 22 Settling time for 115 Vac, 60 Hz load transition 0% to 100% load (CH1: Vbus_C, CH4: Iout)

Power management test results

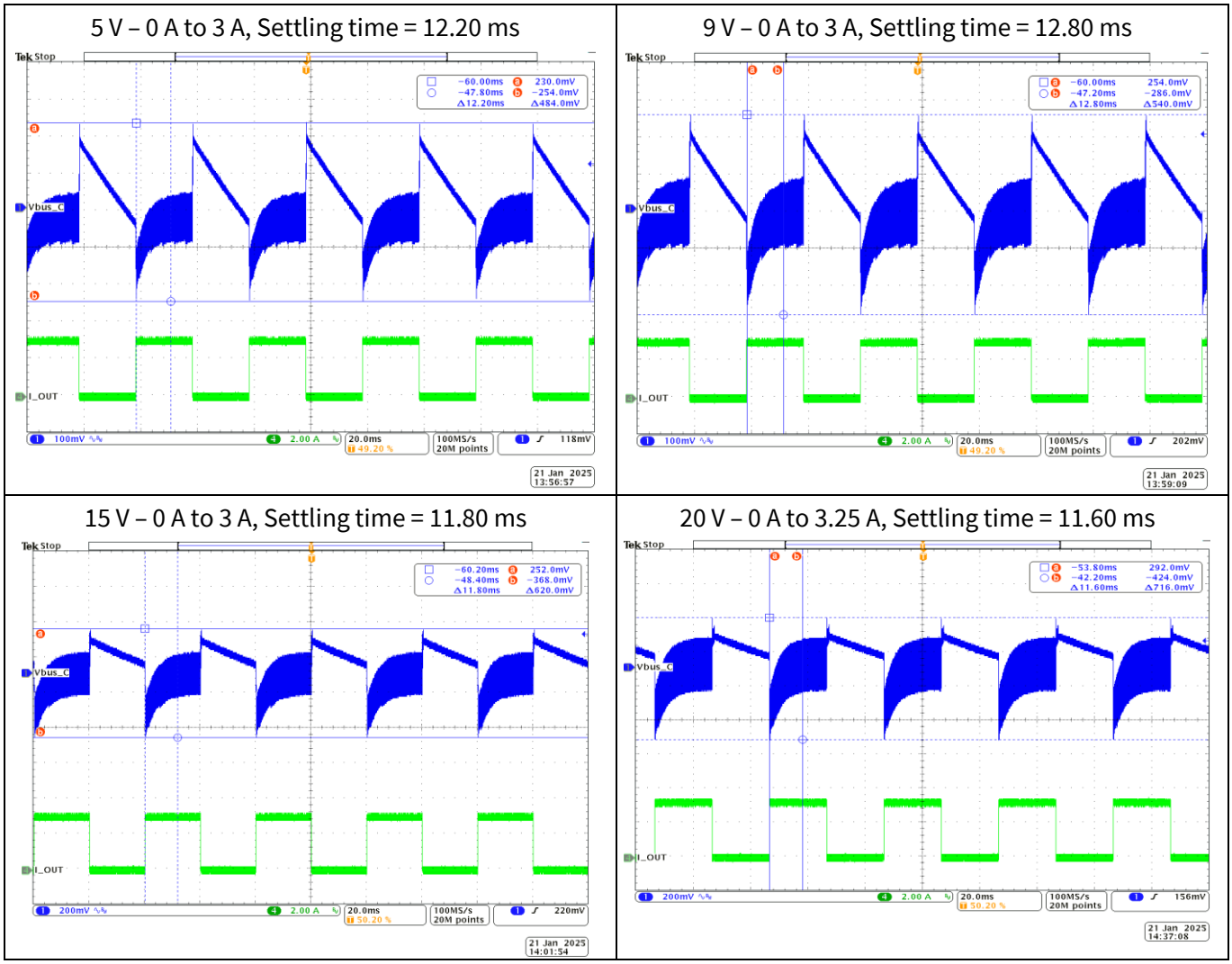
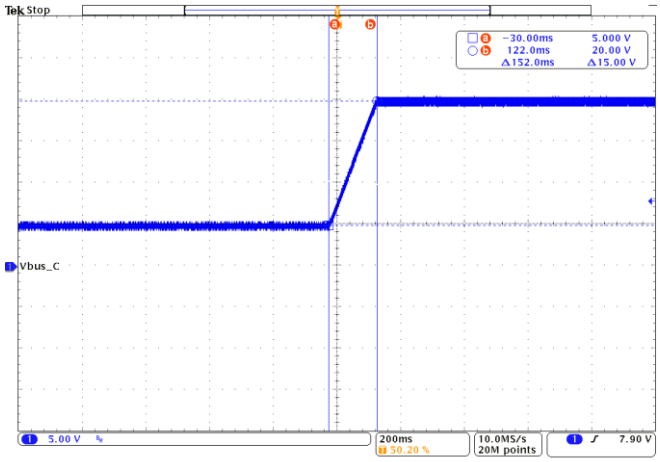


Figure 23 Settling time for 230 Vac, 50 Hz load transition 0% to 100% load (CH1: Vbus_C, CH4: Iout)

3.5 Output voltage transfer transition

Vout = 5 V to 20 V, Iout = 0 A
Transition time: 152 ms
Slew rate: 0.0987 mV/s



Vout = 20 V to 5 V, Iout = 0 A
Transition time: 152 ms
Slew rate: -0.0987 mV/s

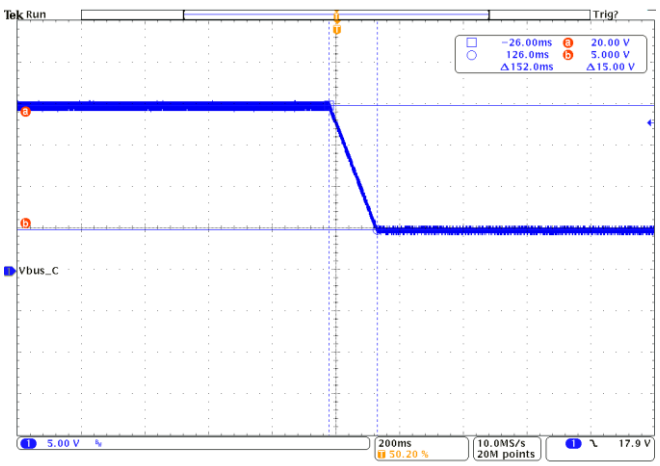
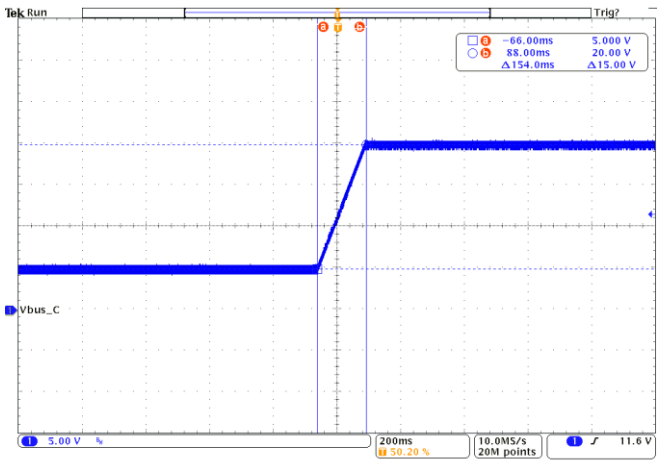


Figure 24 Output voltage transition at no load for 115 Vac, 60 Hz; (CH1: Vbus_C)

Vout = 5 V to 20 V, Iout = 0 A
Transition time: 154 ms
Slew rate: 0.0974 mV/s



Vout = 20 V to 5 V, Iout = 0 A
Transition time: 150 ms
Slew rate: -0.1000 mV/s

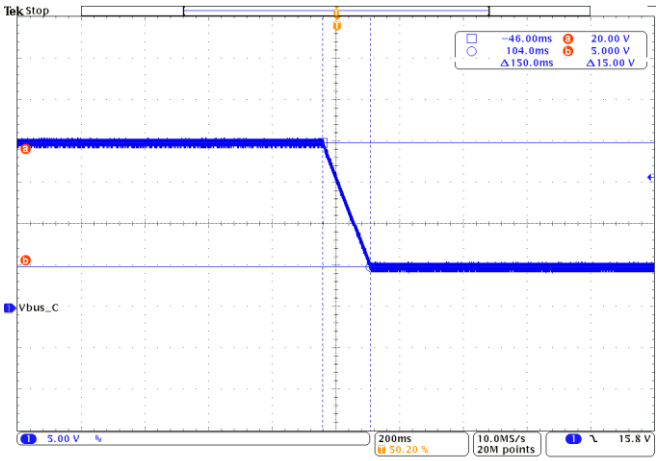
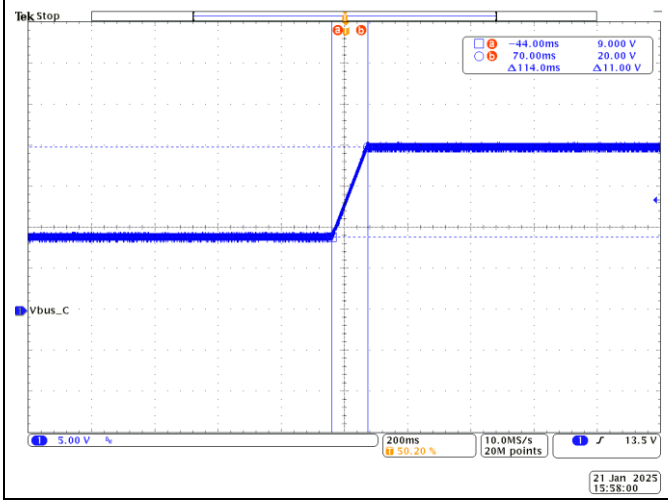


Figure 25 Output voltage transition at no load for 230 Vac, 50 Hz; (CH1: Vbus_C)

Power management test results

Vout = 9 V to 20 V, Iout = 0 A
Transition time: 114 ms
Slew rate: 0.0965 mV/s



Vout = 20 V to 9 V, Iout = 0 A
Transition time: 118 ms
Slew rate: -0.0932 mV/s

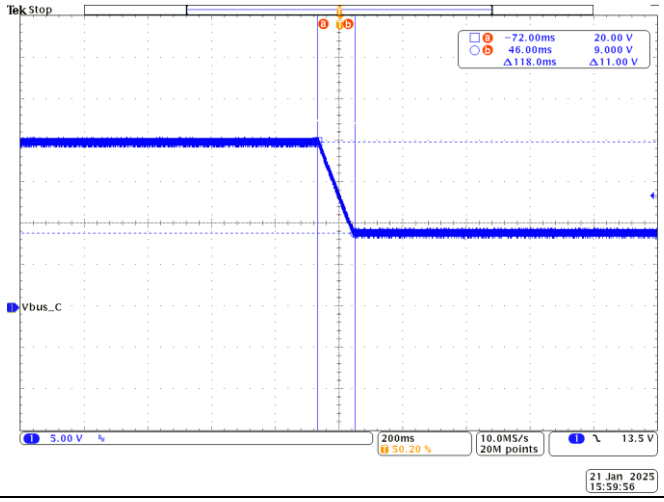
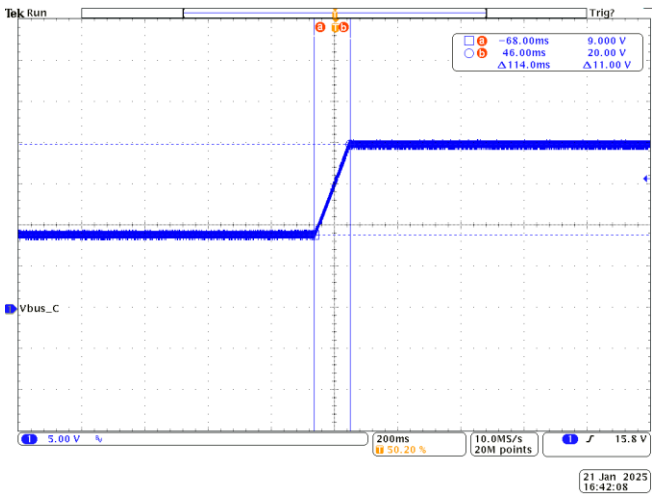


Figure 26 Output voltage transition at no load for 115 Vac, 60 Hz; (CH1: Vbus_C)

Vout = 9 V to 20 V, Iout = 0 A
Transition time: 114 ms
Slew rate: 0.0965 mV/s



Vout = 20 V to 9 V, Iout = 0 A
Transition time: 114 ms
Slew Rate: -0.0965 mV/s

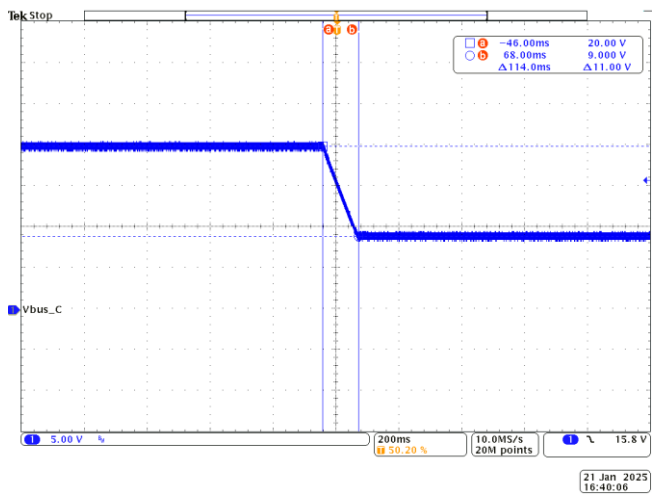
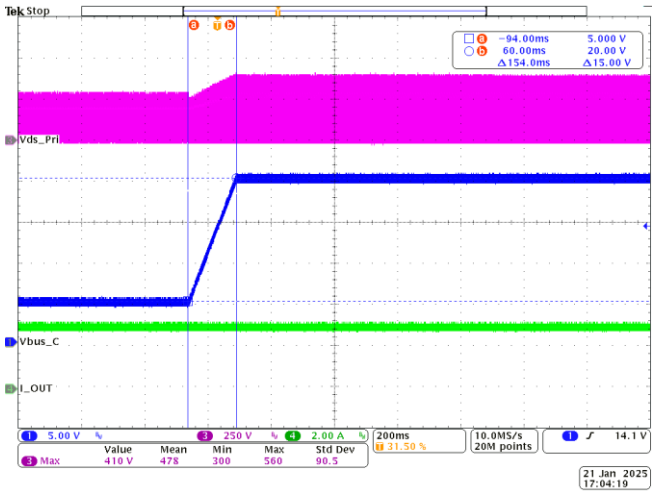


Figure 27 Output voltage transition at no load for 230 Vac, 50 Hz; (CH1: Vbus_C)

Power management test results

Vout = 5 V to 20 V, Iout = 3 A
Transition time: 154 ms
Slew rate: 0.0974 mV/s



Vout = 20 V to 5 V, Iout = 3 A
Transition time: 154 ms
Slew rate: -0.0974 mV/s

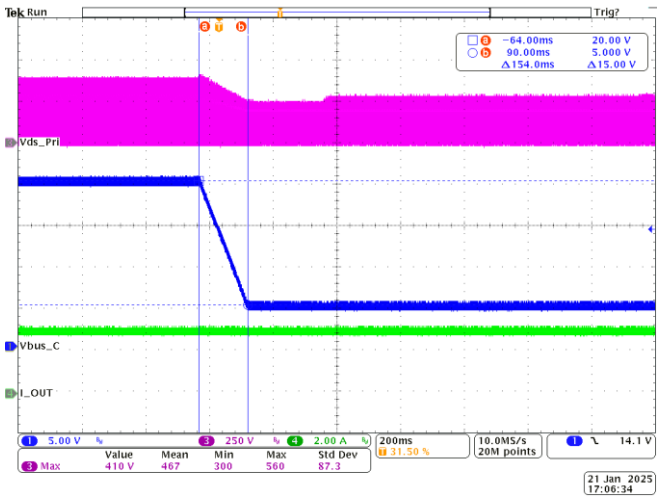
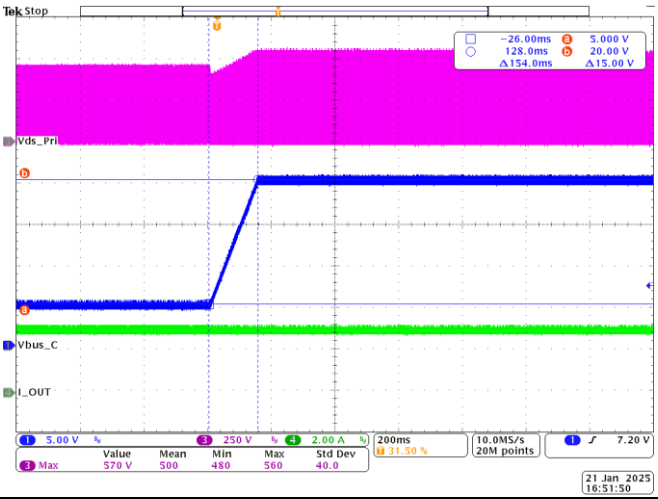


Figure 28 Output voltage transition at full load for 115 Vac, 60 Hz; (CH1: Vbus_C, CH3: Vds_Pri, CH4: Iout)

Vout = 5 V to 20 V, Iout = 3 A
Transition time: 154 ms
Slew rate: 98.67 V/s



Vout = 20 V to 5 V, Iout = 3 A
Transition time: 156 ms
Slew rate: -0.0962 mV/s

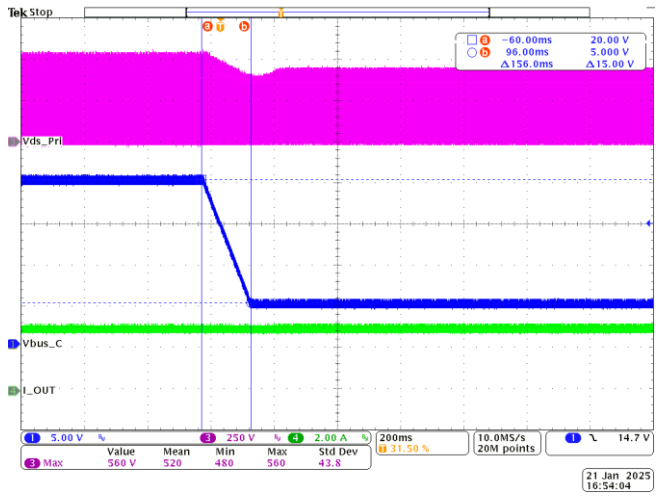
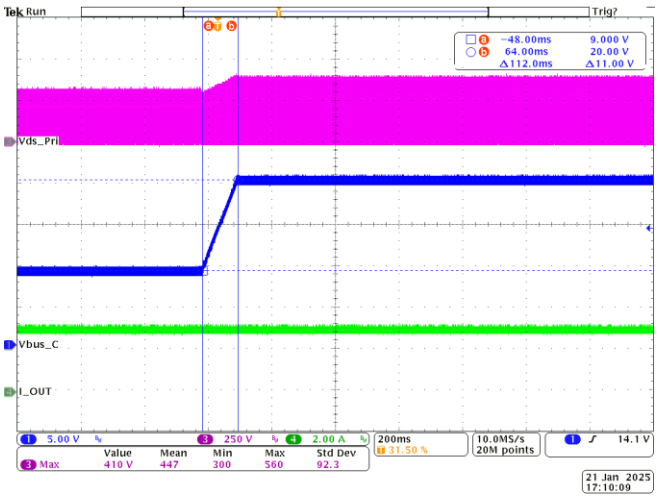


Figure 29 Output voltage transition at full load for 230Vac, 50Hz; (CH1: Vbus_C, CH3: Vds_Pri, CH4: Iout)

Power management test results

Vout = 9 V to 20 V, Iout = 3 A
Transition time: 112 ms
Slew rate: 0.0982 mV/s



Vout = 20 V to 9 V, Iout = 3 A
Transition time: 114 ms
Slew rate: -0.0965 mV/s

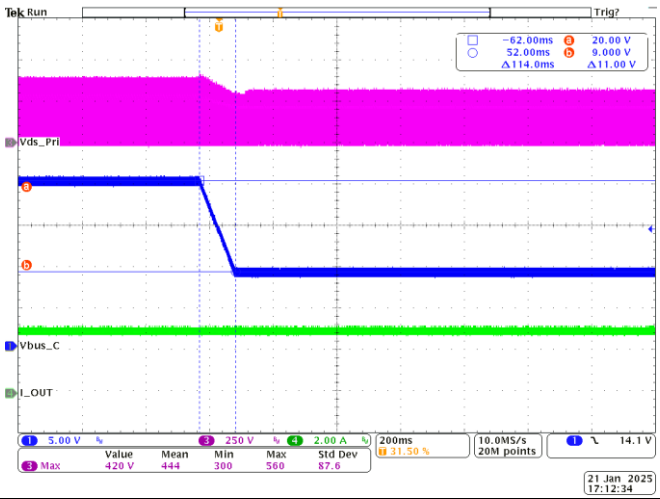
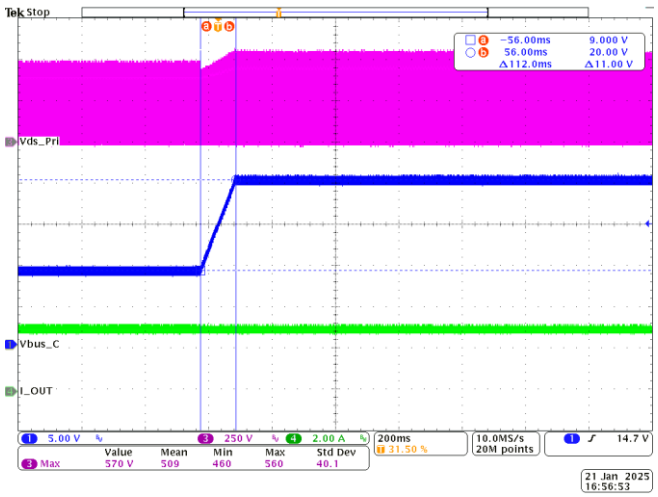


Figure 30 Output voltage transition at full load for 115Vac, 60Hz; (CH1: Vbus_C, CH3: Vds_Pri, CH4: Iout)

Vout = 9 V to 20 V, Iout = 3 A
Transition time: 112 ms
Slew rate: 0.0982 mV/s



Vout = 20V to 9V, Iout = 3A
Transition time: 112ms
Slew rate: -0.0982V/s

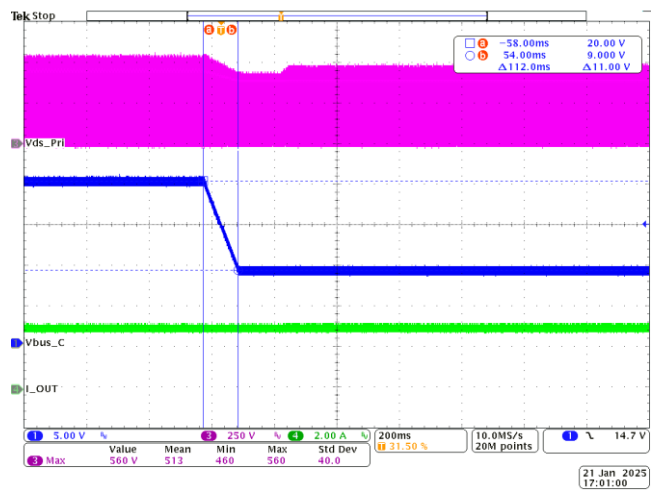
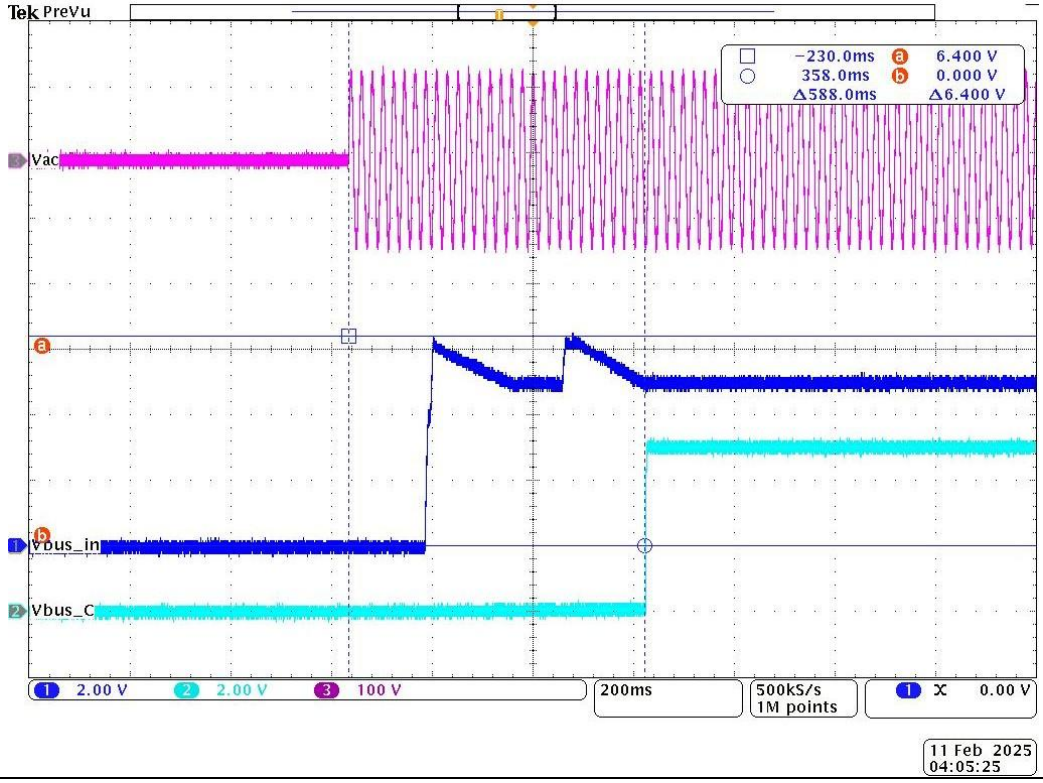


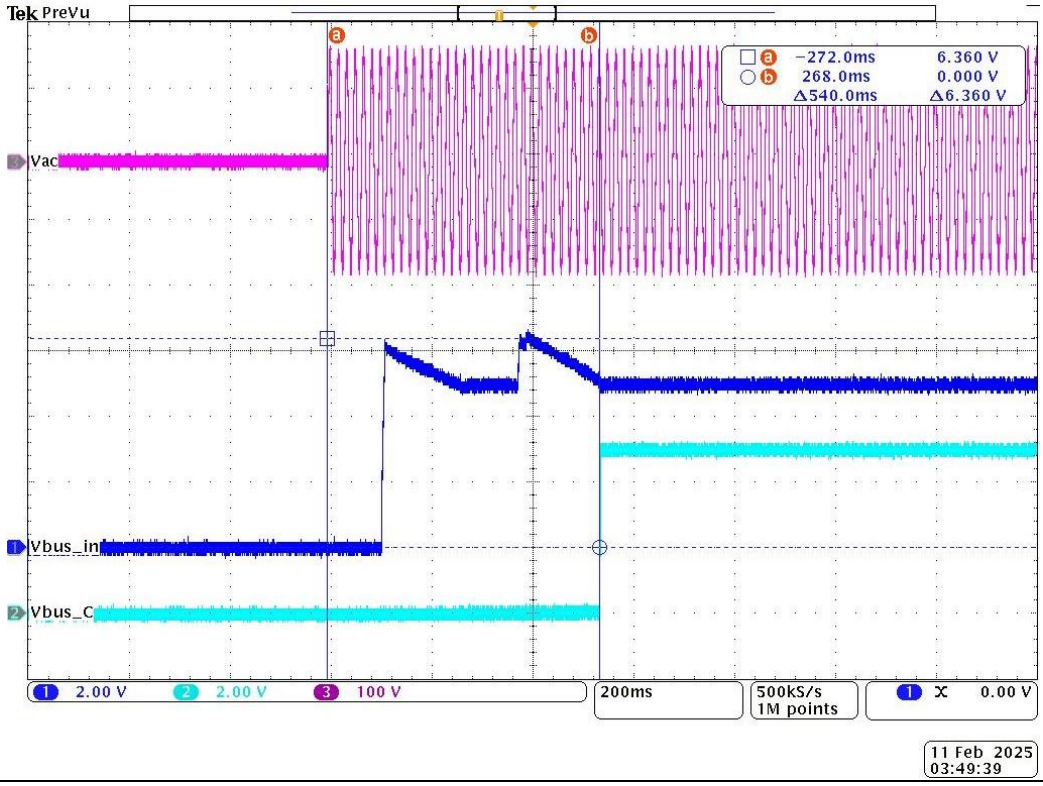
Figure 31 Output voltage transition at full load for 230 Vac, 50 Hz; (CH1: Vbus_C, CH3: Vds_Pri, CH4: Iout)

3.6 Start-up turn-on delay and Vbus_in overshoot

90 Vac, 47 Hz, Vout = 5 V, Iout = 0 A, start-up turn-on delay time = 588.0 ms, Vbus_in overshoot = 6.4 V

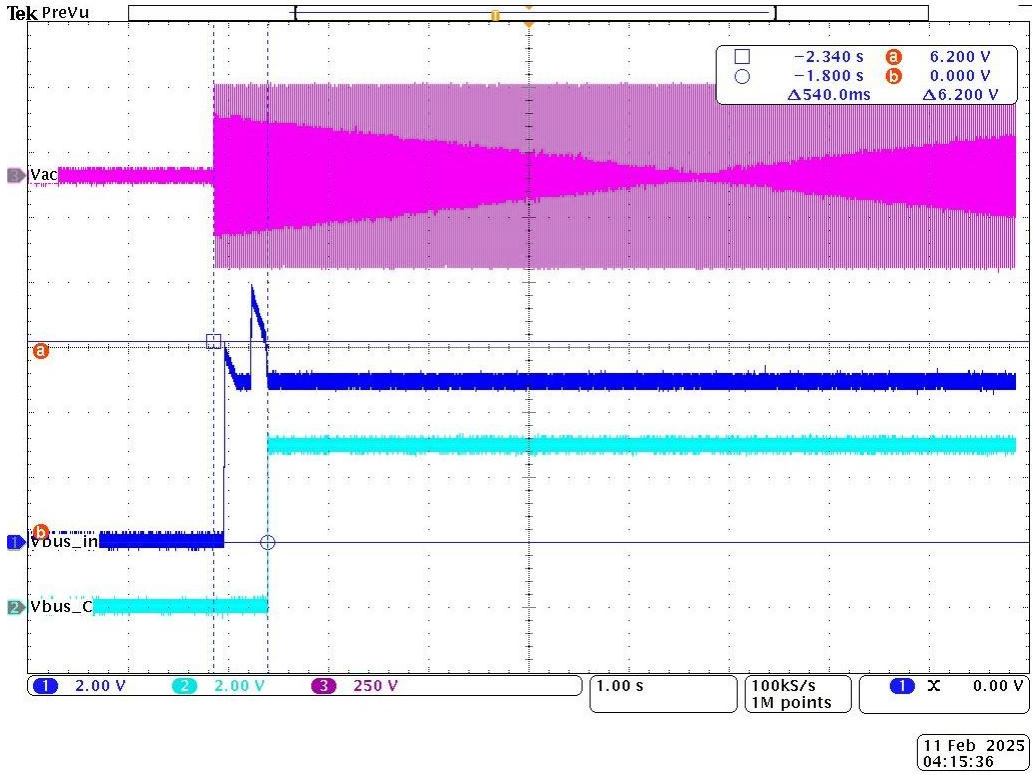


115 Vac, 60 Hz, Vout = 5 V, Iout = 0 A, start-up turn-on delay time = 540 ms, Vbus_in overshoot = 6.360 V



Power management test results

230 Vac, 50 Hz, Vout = 5 V, Iout = 0 A, start-up turn-on delay time = 540.0 ms, Vbus_in overshoot = 6.20 V



265 Vac, 63 Hz, Vout = 5 V, Iout = 0 A, start-up turn-on delay time = 539.0 ms, Vbus_in overshoot = 6.160 V

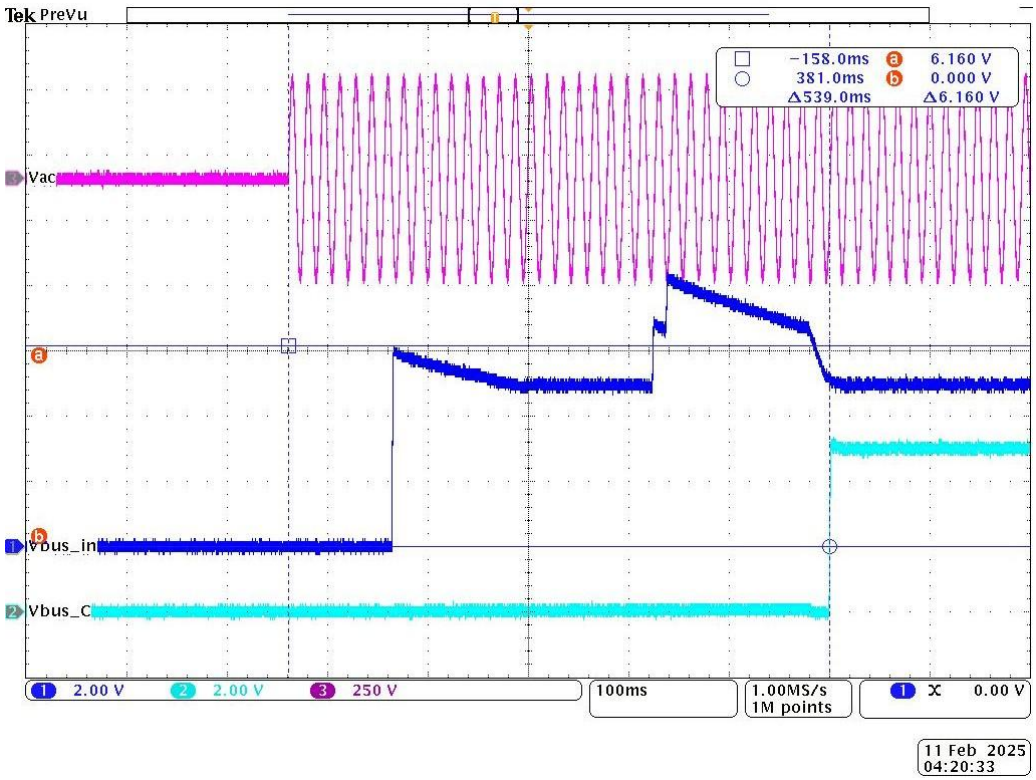
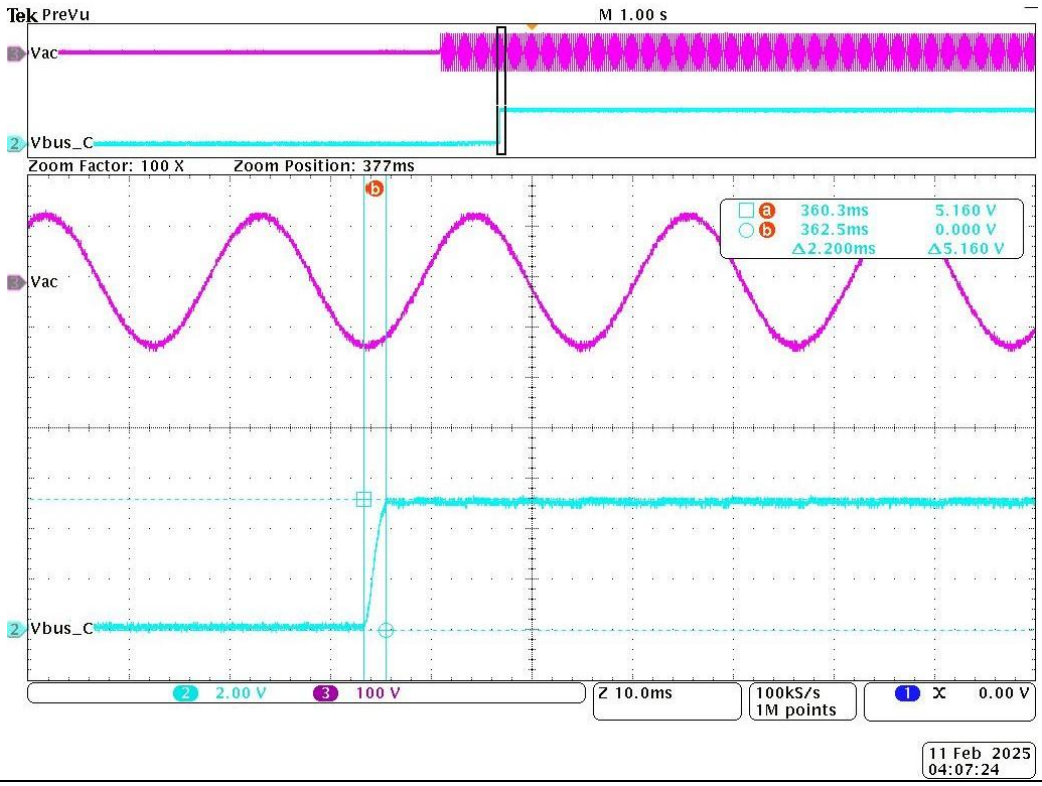


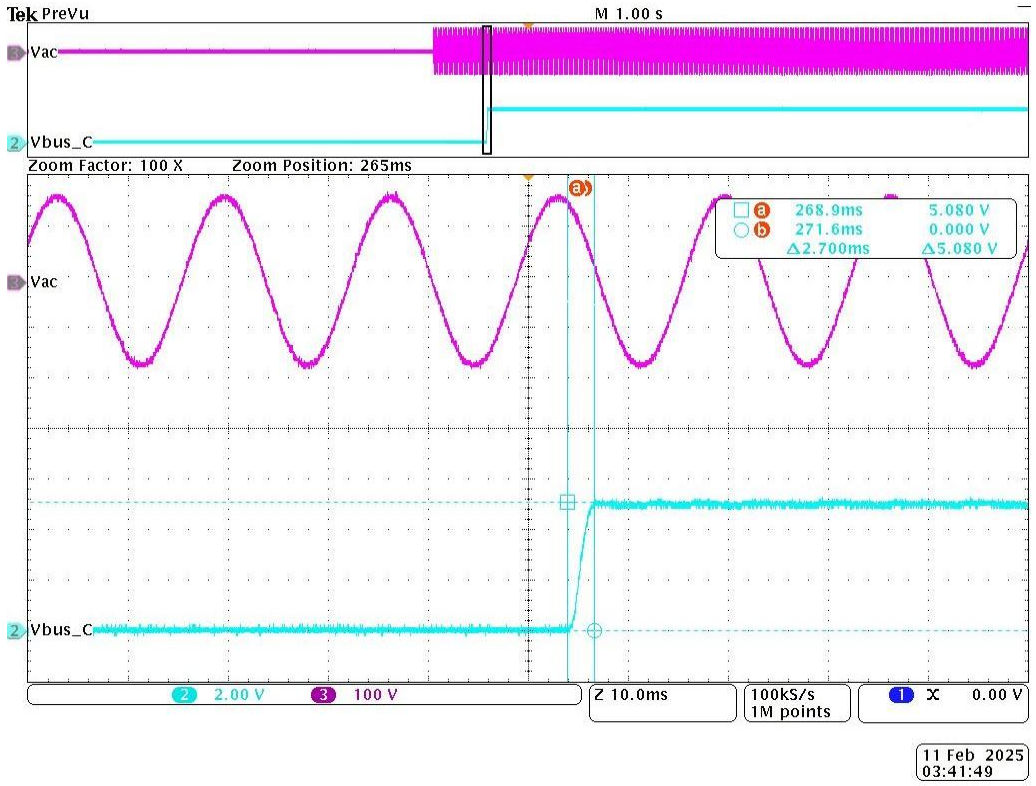
Figure 32 Start-up turn-on delay at various AC inputs (CH1: Vbus_in, CH2: Vbus_C CH3: Vin_AC)

3.7 Start-up rise time

Vout = 5 V, Iout = 0 A, start-up rise time at 90 Vac, 47 Hz = 2.20 ms

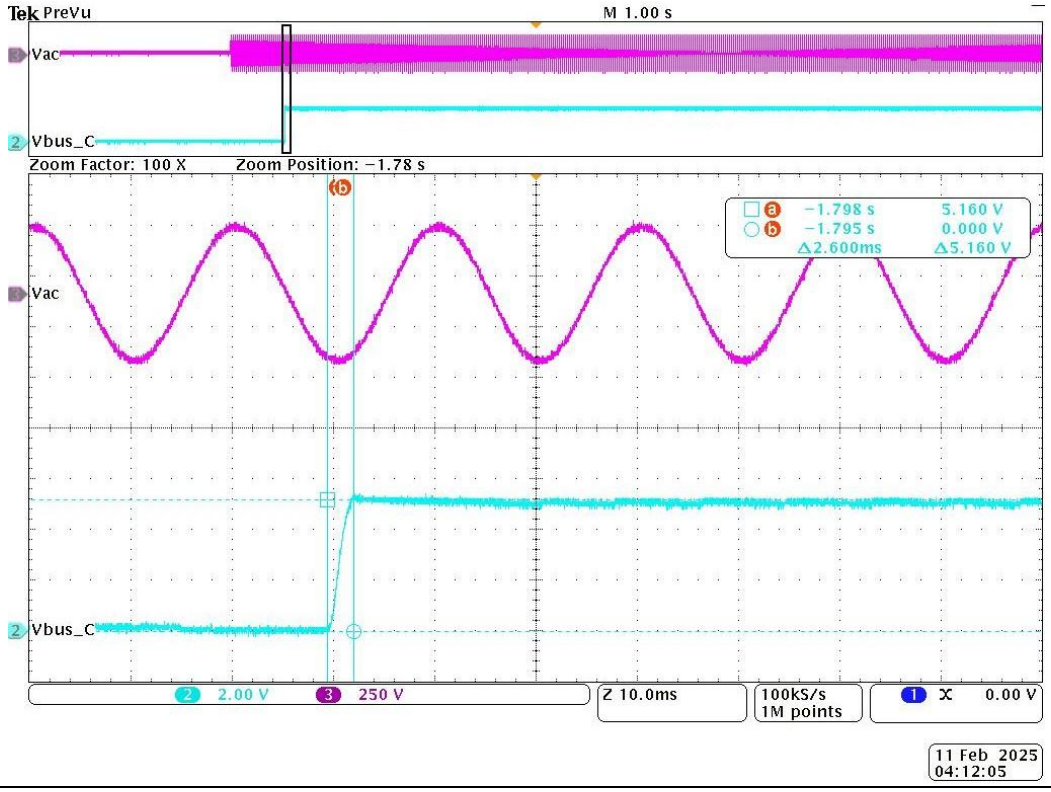


Vout = 5 V, Iout = 0 A, start-up rise time at 115 Vac, 60 Hz = 2.70 ms



Power management test results

Vout = 5 V, Iout = 0 A, start-up rise time at 230 Vac, 50 Hz = 2.6 ms



Vout = 5 V, Iout = 0 A, start-up rise time at 265 Vac, 63 Hz = 2.280 ms

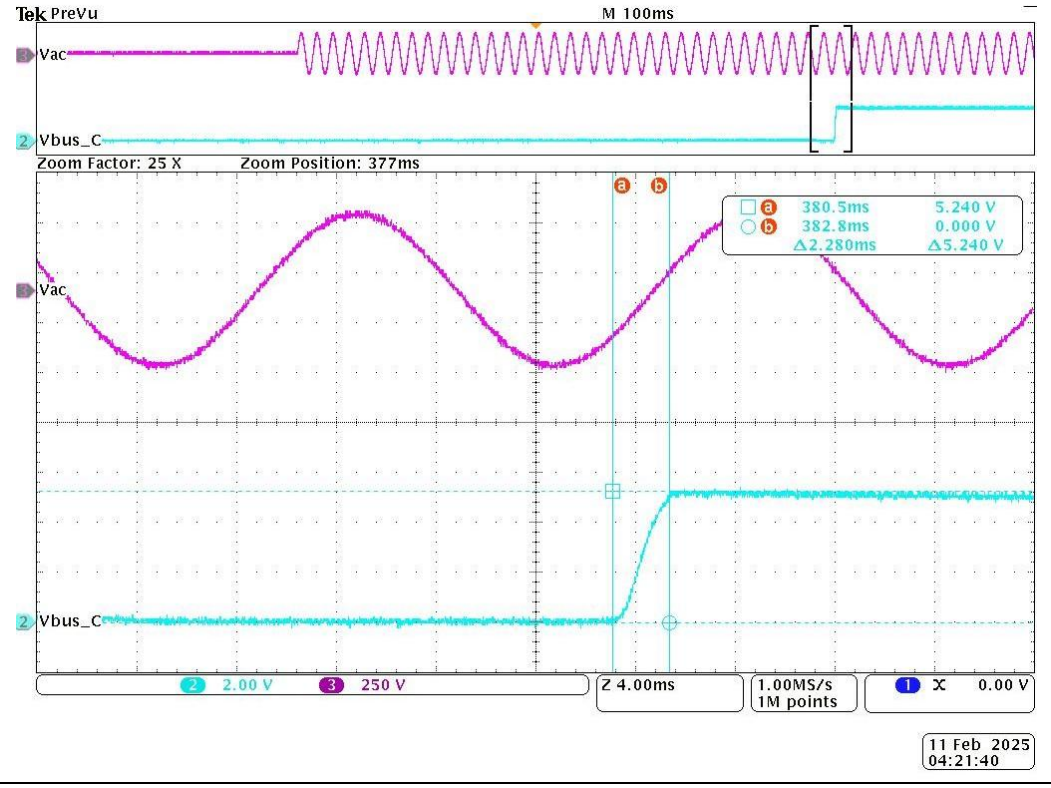
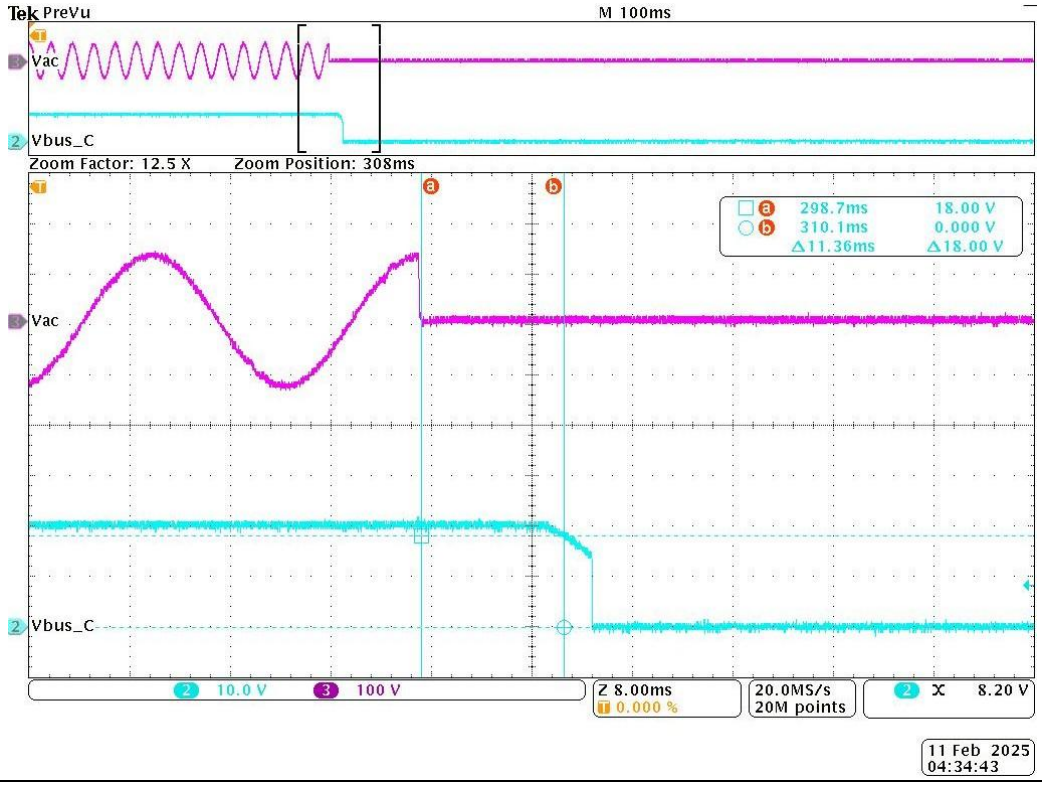


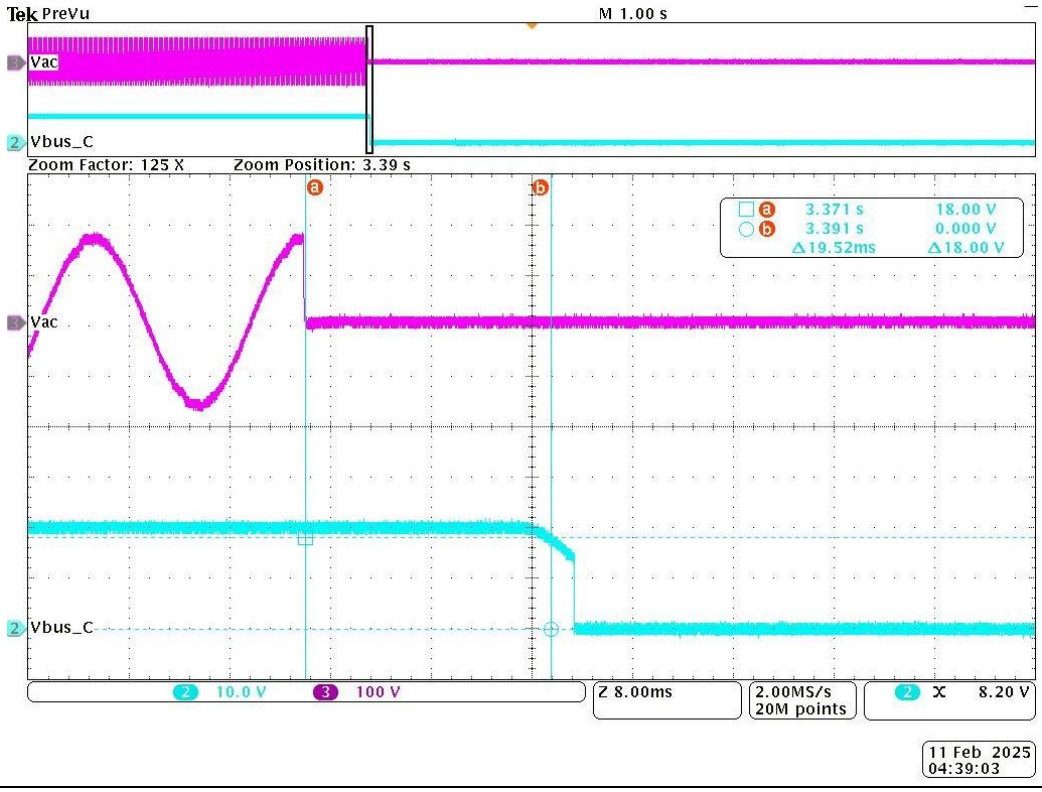
Figure 33 Start-up rise-time at various AC inputs (CH2: Vbus_C, CH3: Vin_AC)

3.8 Hold-up time

Vout = 20 V, Iout = 3.25 A, hold-up time at 90 Vac, 47 Hz = 11.36 ms

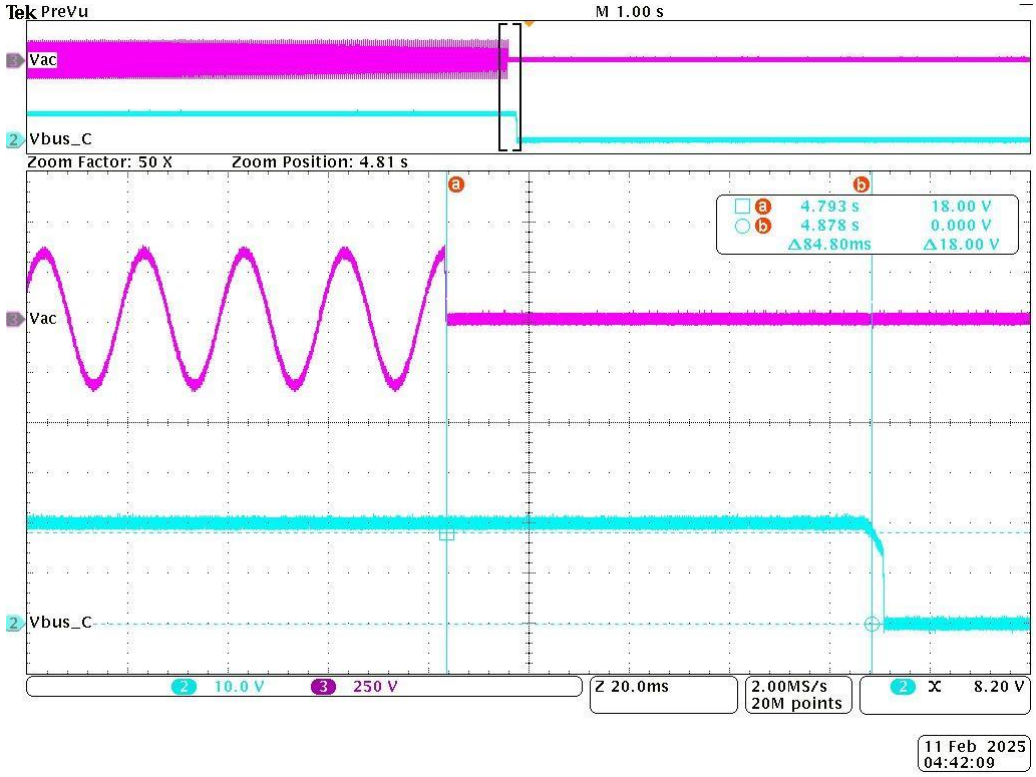


Vout = 20 V, Iout = 3.25 A, hold-up time at 115 Vac, 60 Hz = 19.52 ms



Power management test results

Vout = 20 V, Iout = 3.25 A, hold-up time at 230 Vac, 50 Hz = 84.80 ms



Vout = 20 V, Iout = 3.25 A, hold-up time at 265 Vac, 63 Hz = 114.0 ms

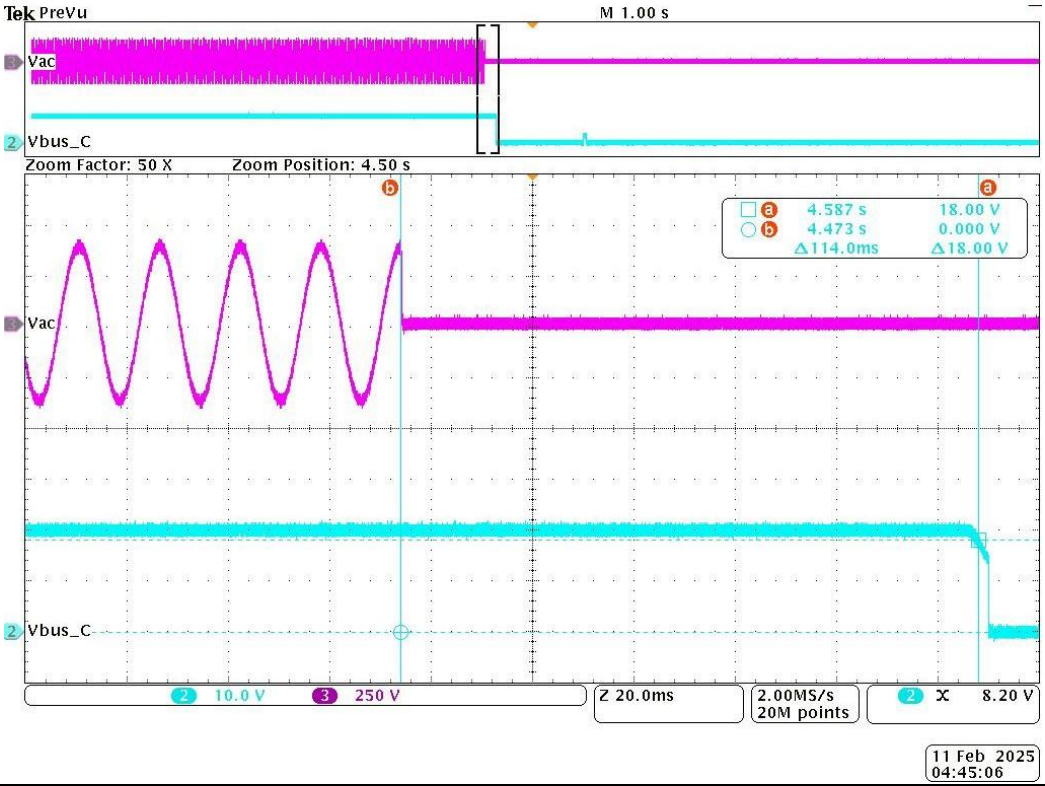
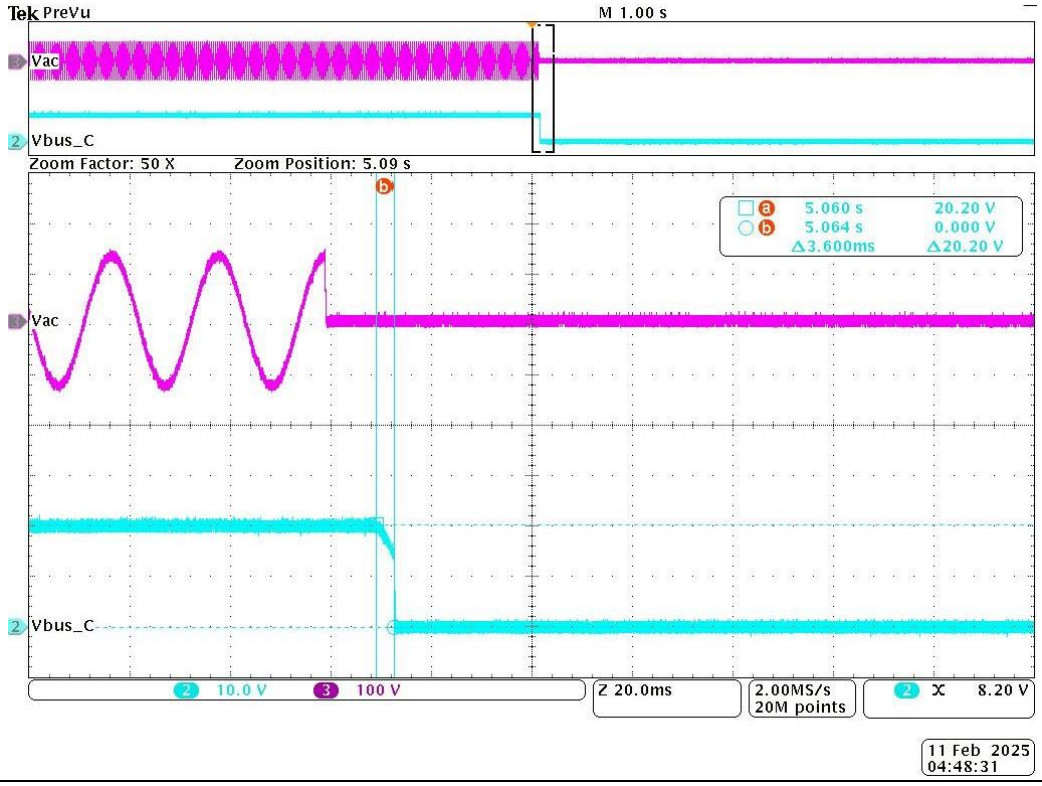


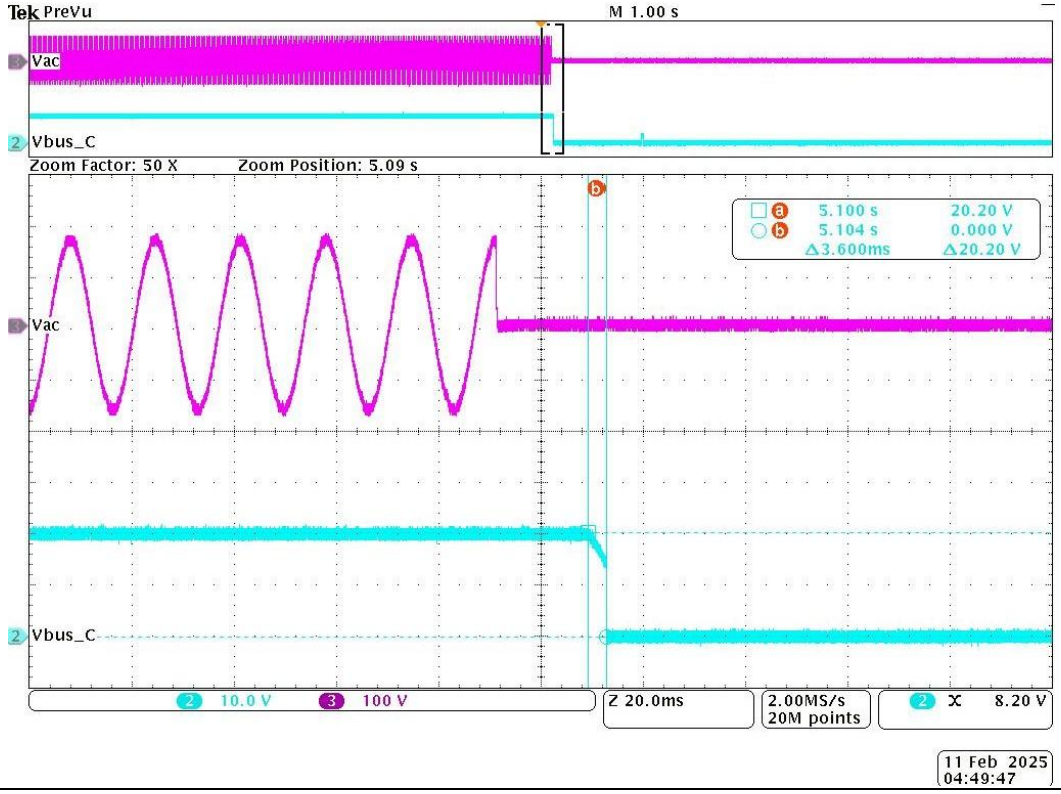
Figure 34 Hold-up time at various AC inputs (CH2: Vbus_C, CH3: Vin_AC)

3.9 Shutdown fall time

Vout = 20 V, Iout = 3.25 A, shutdown fall time at 90 Vac, 47 Hz = 3.600 ms

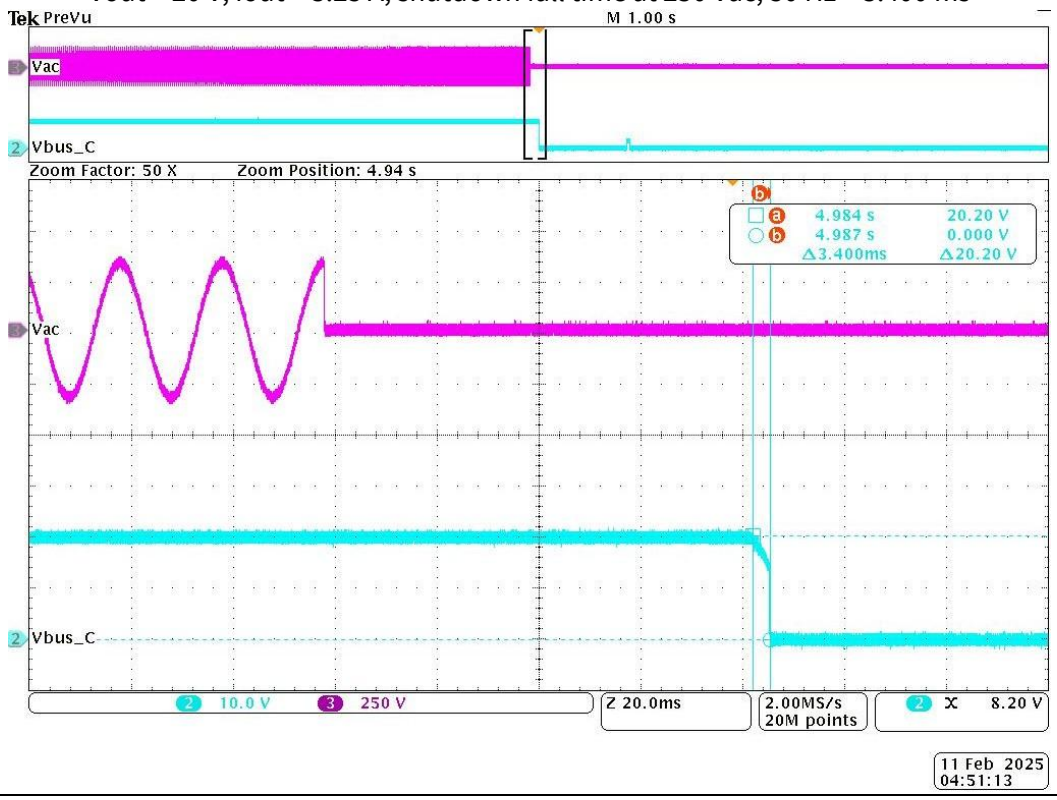


Vout = 20 V, Iout = 3.25 A, shutdown fall time at 115 Vac, 60 Hz = 3.600 ms



Power management test results

Vout = 20 V, Iout = 3.25 A, shutdown fall time at 230 Vac, 50 Hz = 3.400 ms



Vout = 20 V, Iout = 3.25 A, shutdown fall time at 265 Vac, 63 Hz = 114.0 ms

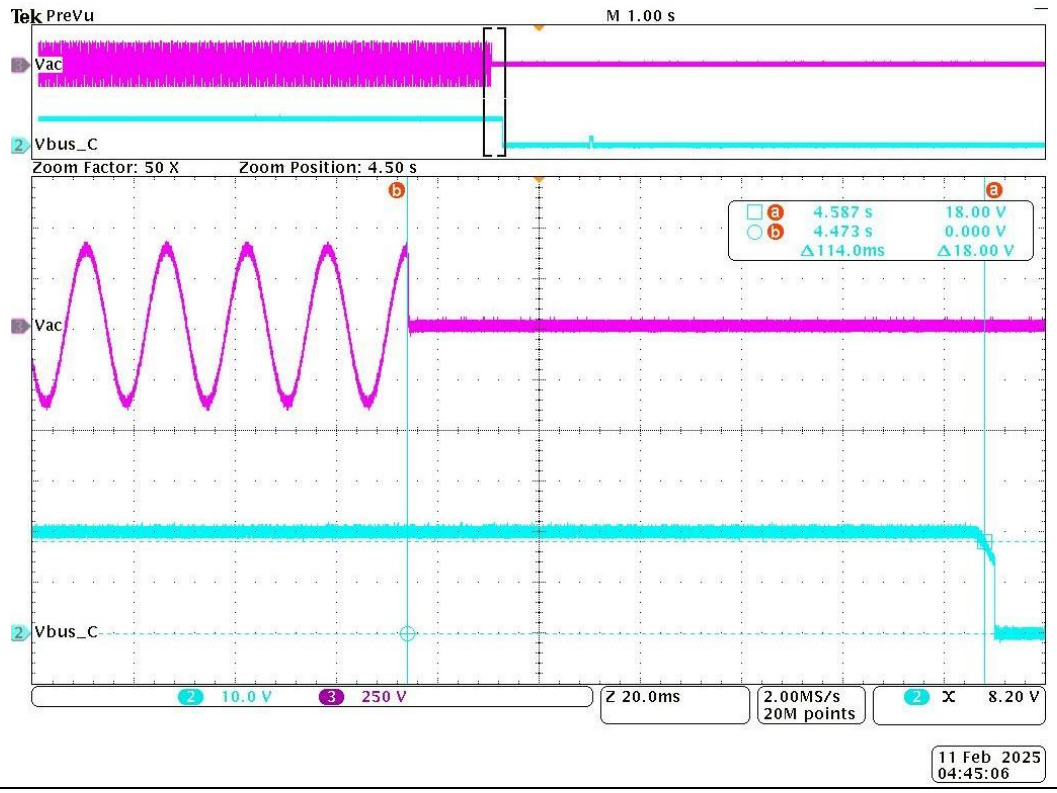
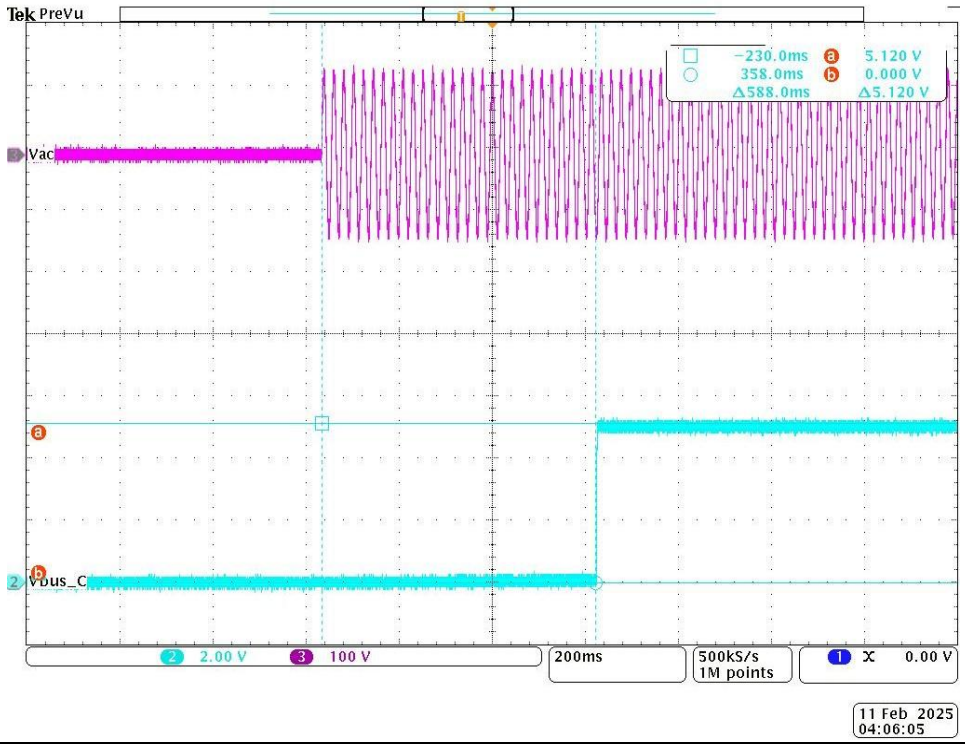


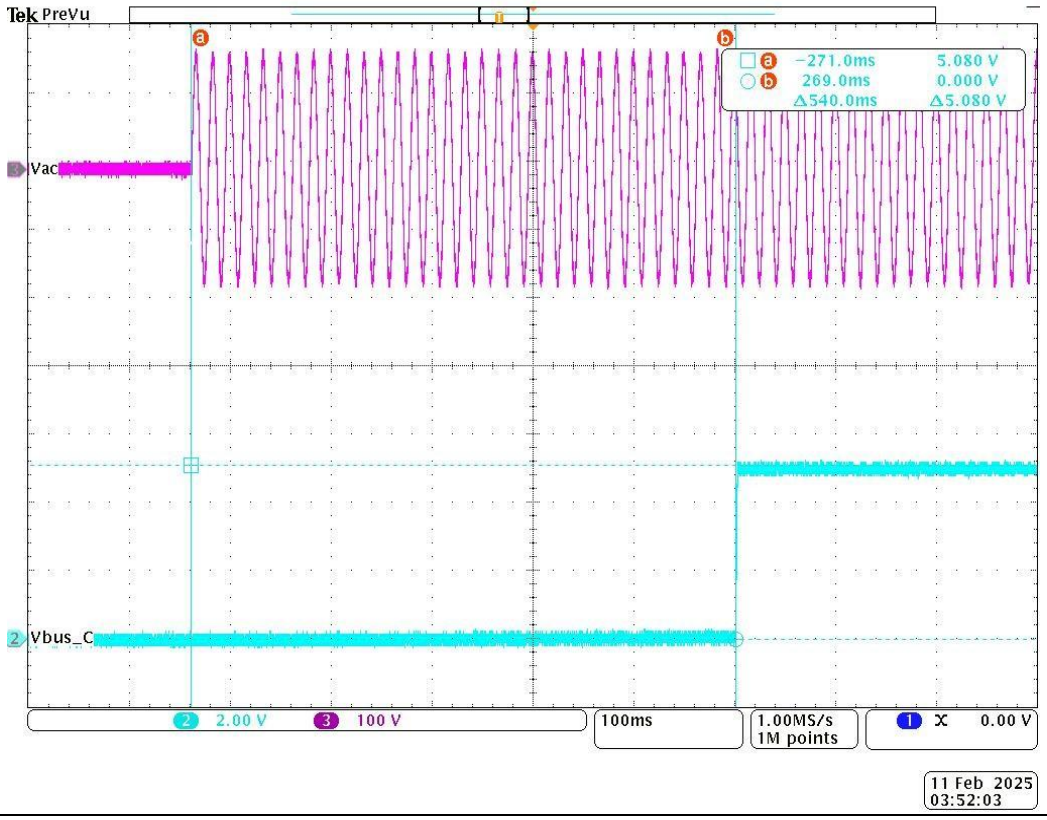
Figure 35 Shutdown fall time at various AC inputs (CH2: Vbus_C, CH3: Vin_AC)

3.10 Start-up turn-on delay

Vout = 5 V, Iout = 3 A, start-up delay time at 90 Vac, 47 Hz = 588.0 ms

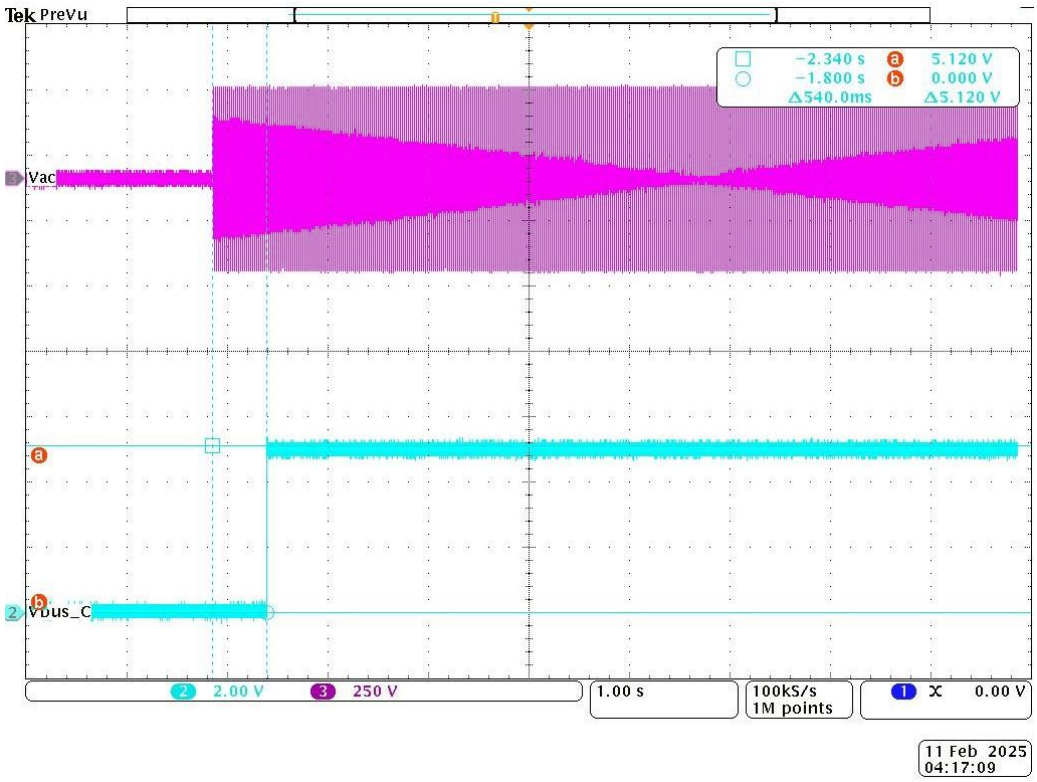


Vout = 5 V, Iout = 3 A, start-up delay time at 115 Vac, 60 Hz = 540.0 ms



Power management test results

Vout = 5 V, Iout = 3 A, start-up delay time at 230 Vac, 50 Hz = 540.0 ms



Vout = 5 V, Iout = 3 A, start-up delay time at 265 Vac, 63 Hz = 539.0 ms

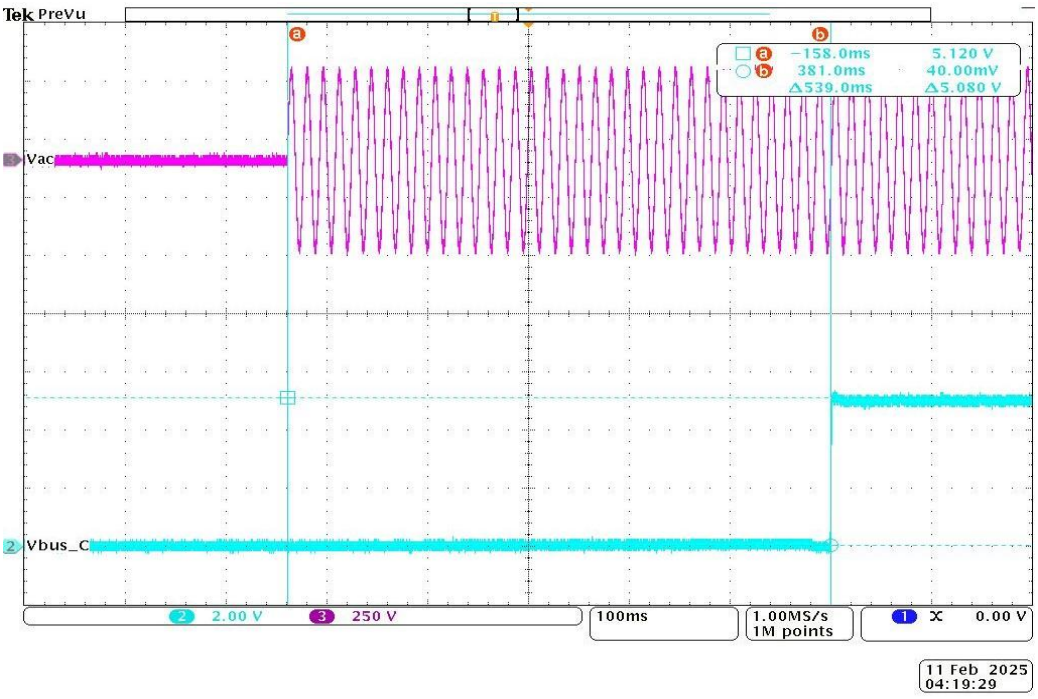


Figure 36 Start-up turn-on delay time at various voltages (CH2: Vbus_C, CH3: Vac)

3.11 Switch voltage stress

Test condition: Vin = 90 Vac, 47 Hz, Vout = 20 V, Iout = 3.25 A.

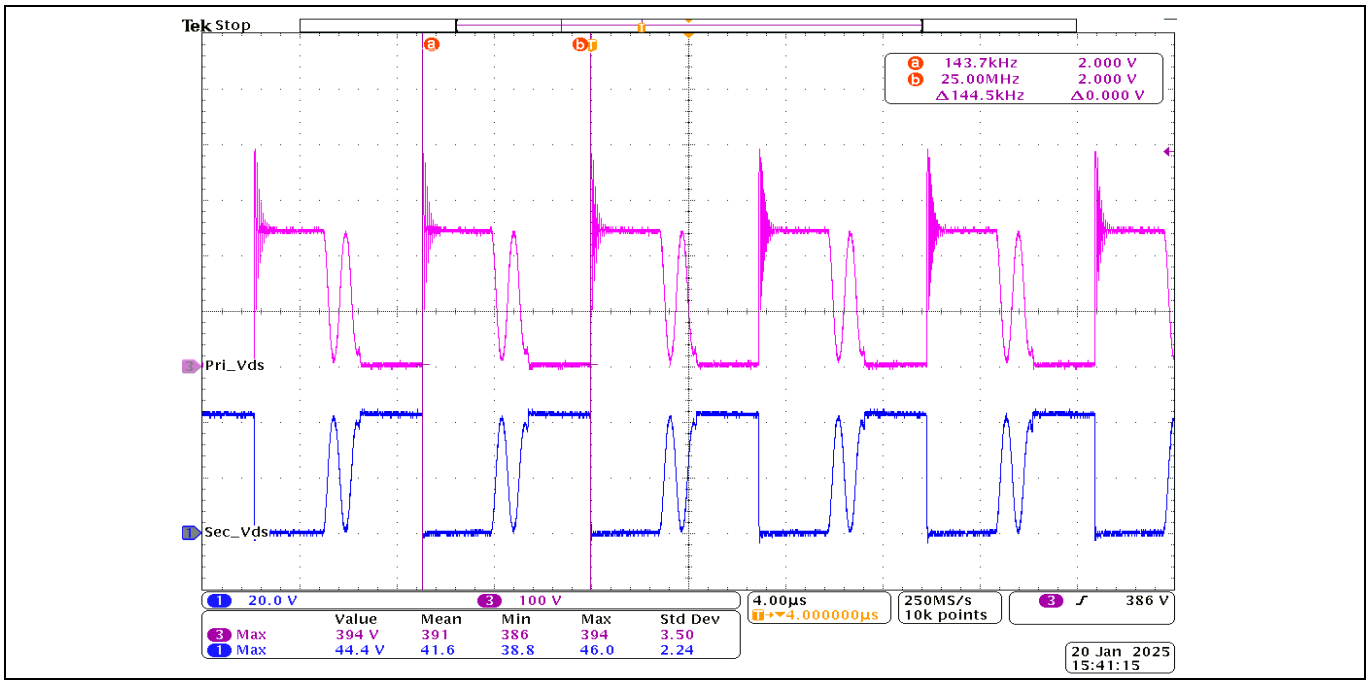


Figure 37 Switch voltage stress on primary and secondary FET (CH3: Vds_pri, CH1: Vds_sec)

Test condition: Vin = 115 Vac, 60 Hz, Vout = 20 V, Iout = 3.25 A.

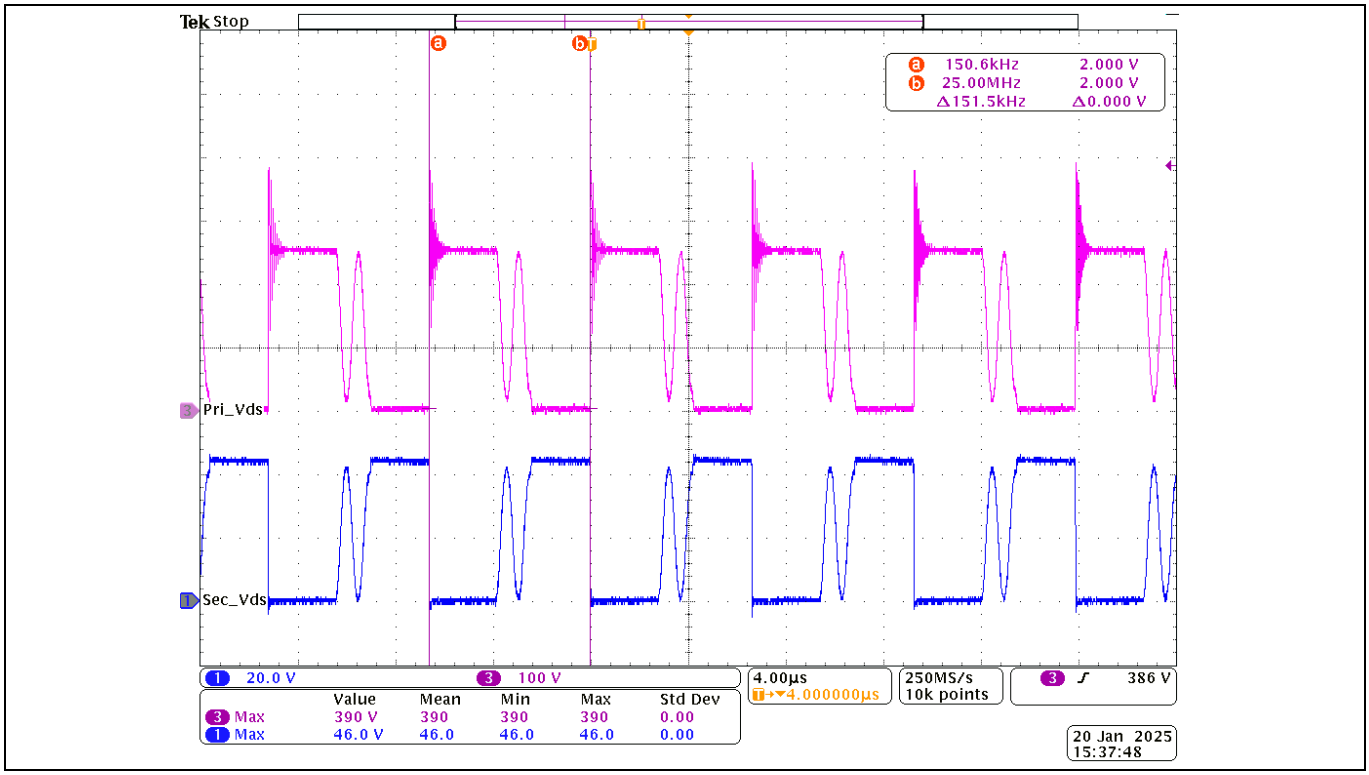


Figure 38 Switch voltage stress on primary and secondary FET (CH3: Vds_pri, CH1: Vds_sec)

Power management test results

Test condition: Vin = 230 Vac, 50 Hz, Vout = 20 V, Iout = 3.25 A.

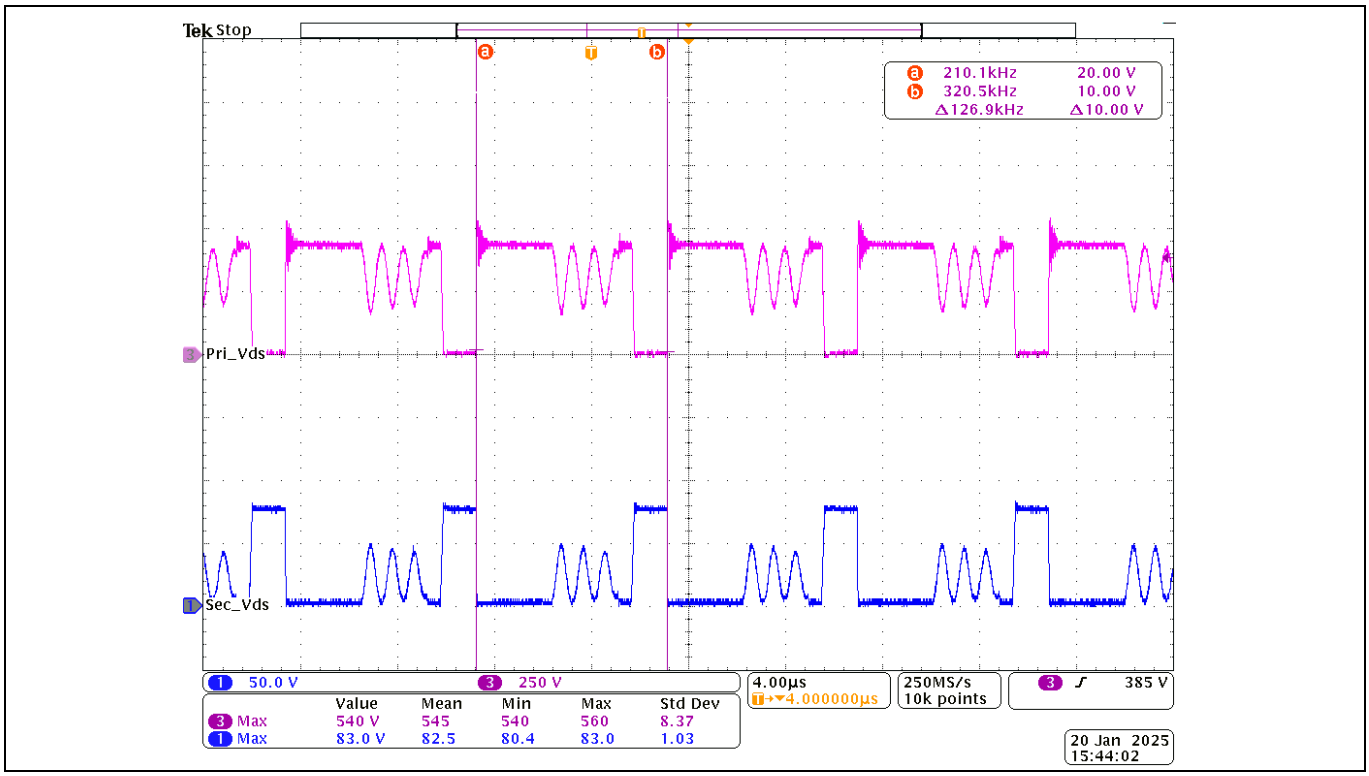


Figure 39 Switch voltage stress on primary and secondary FET (CH3: Vds_pri, CH1: Vds_sec)

Test condition: Vin = 265 Vac, 63 Hz, Vout = 20 V, Iout = 3.25 A.

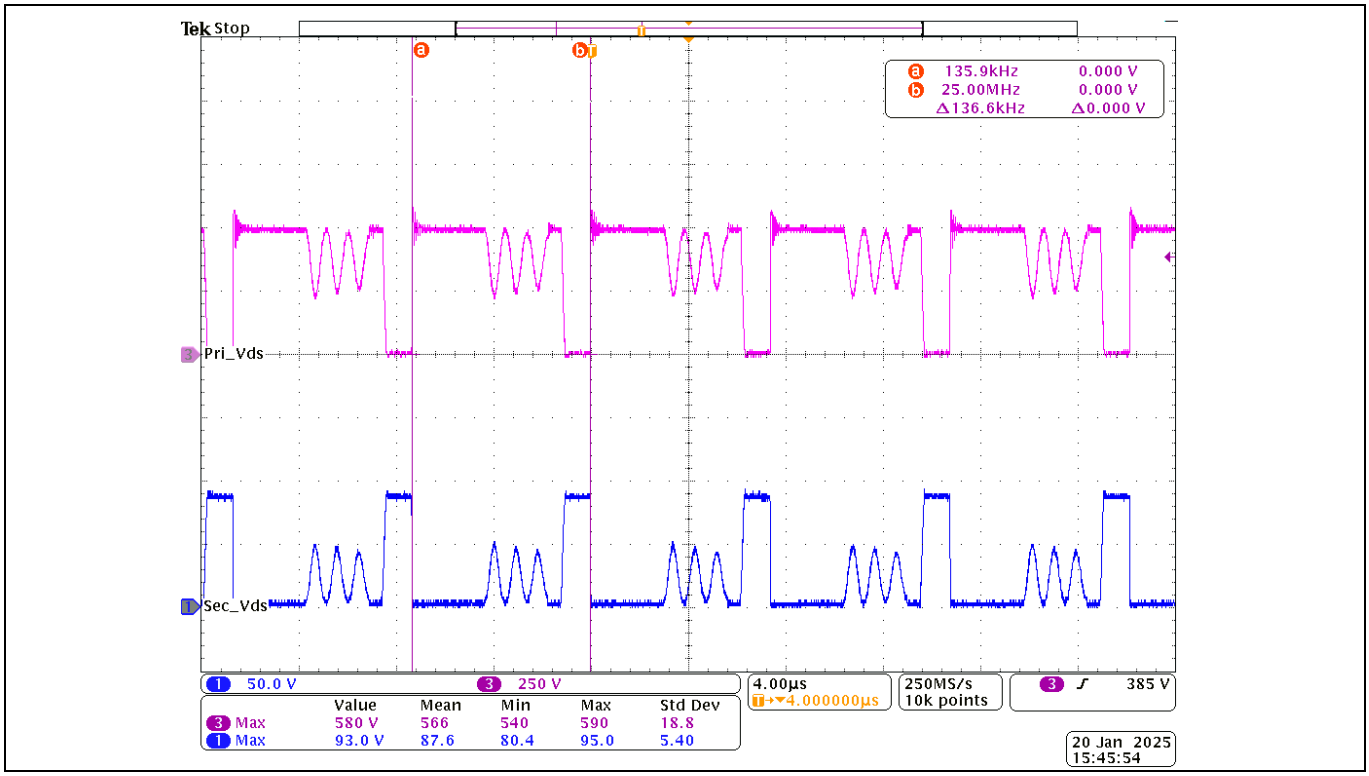


Figure 40 Switch voltage stress on primary and secondary FET (CH3: Vds_pri, CH1: Vds_sec)

Power management test results

Test condition: Vin = 265 Vac, 63 Hz, Vout = 20 V, Iout = 0 A.

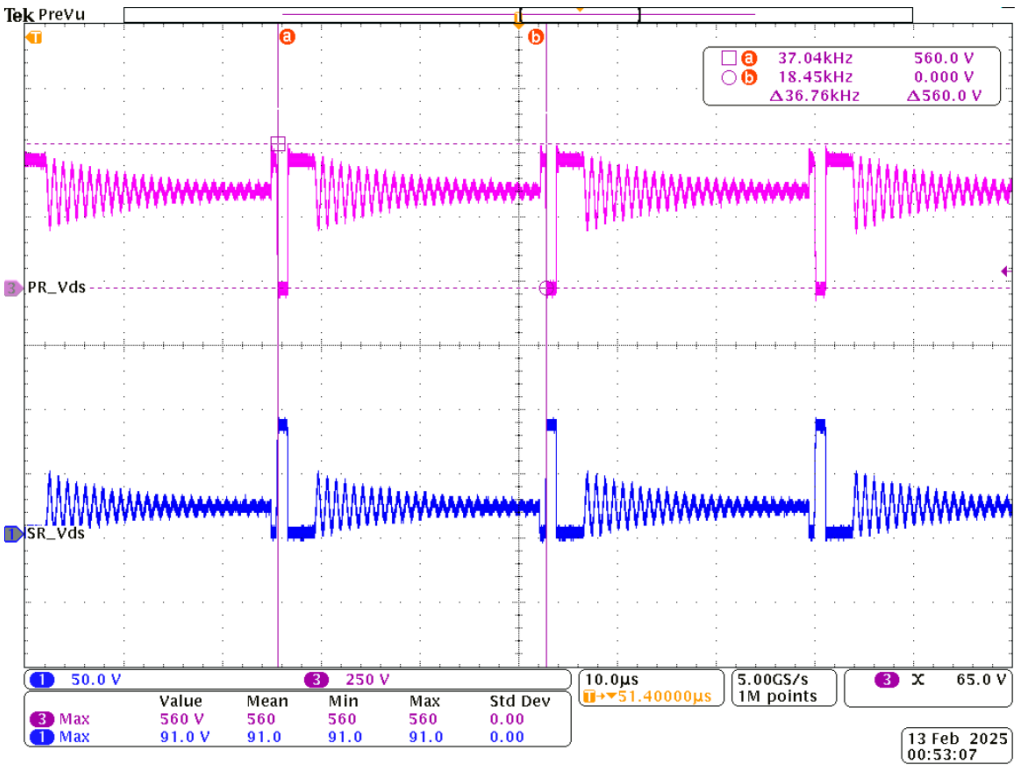
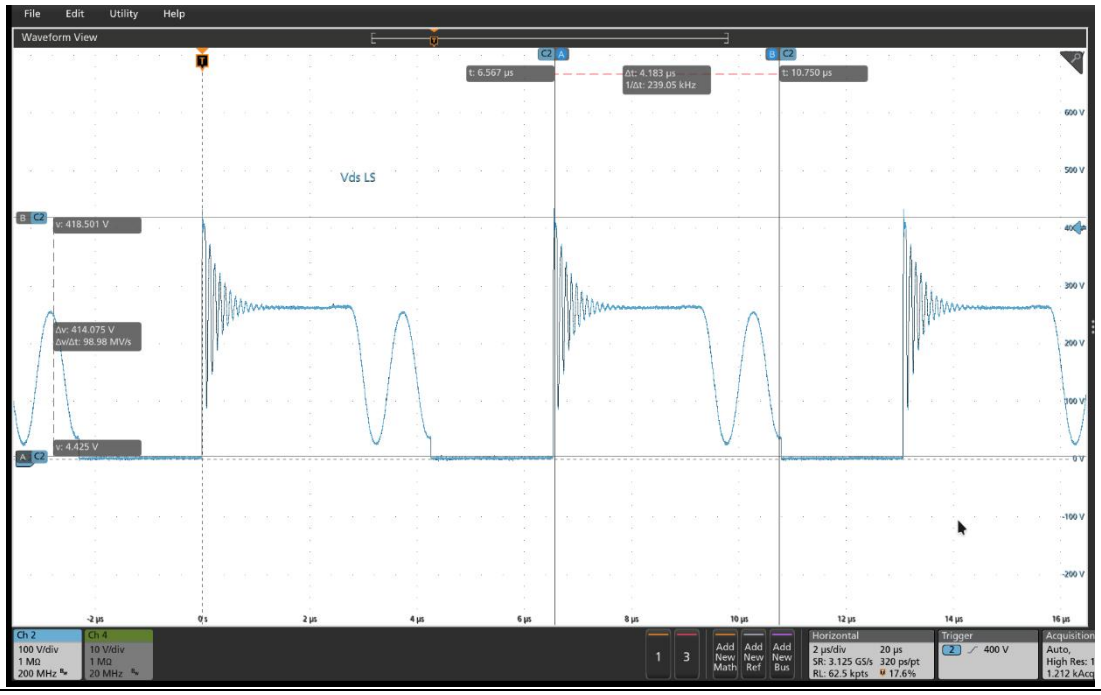


Figure 41 Switch voltage stress on primary and secondary FET (CH3: Vds_pri, CH1: Vds_sec)

3.12 QR and ZVS operation

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

Vac = 115 V, Vout = 20 V, Iout = 3.25 A, Mode = QR, Valley No = 2



Vac = 115 V, Vout = 20 V, Iout = 2.2 A, Mode = QR, Valley No = 3

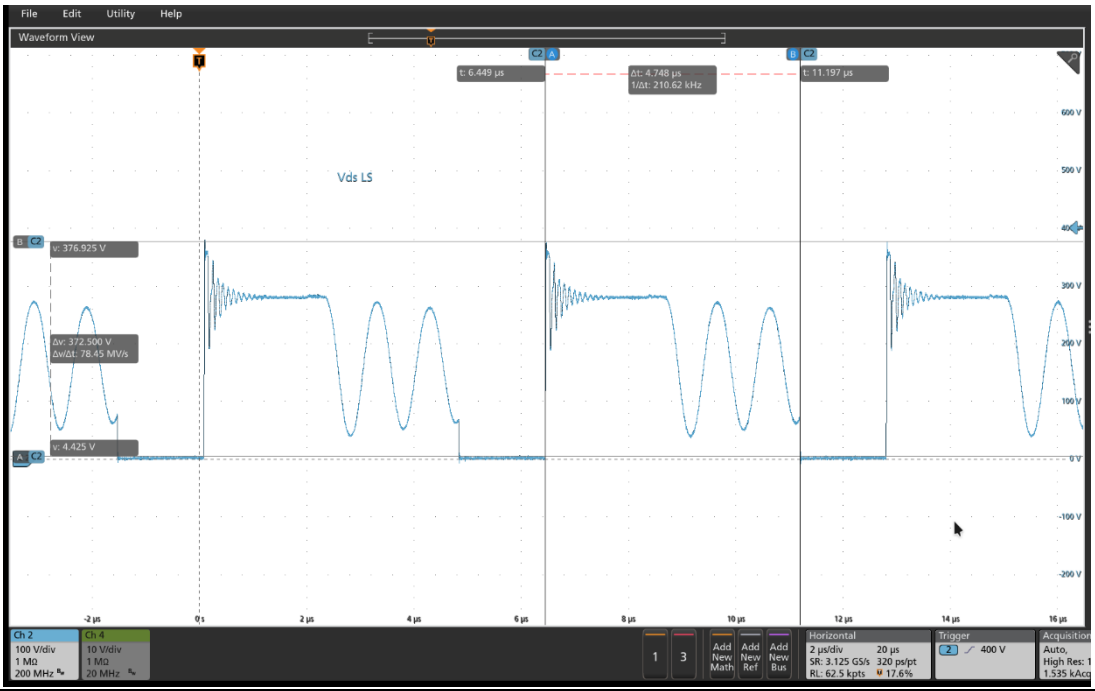
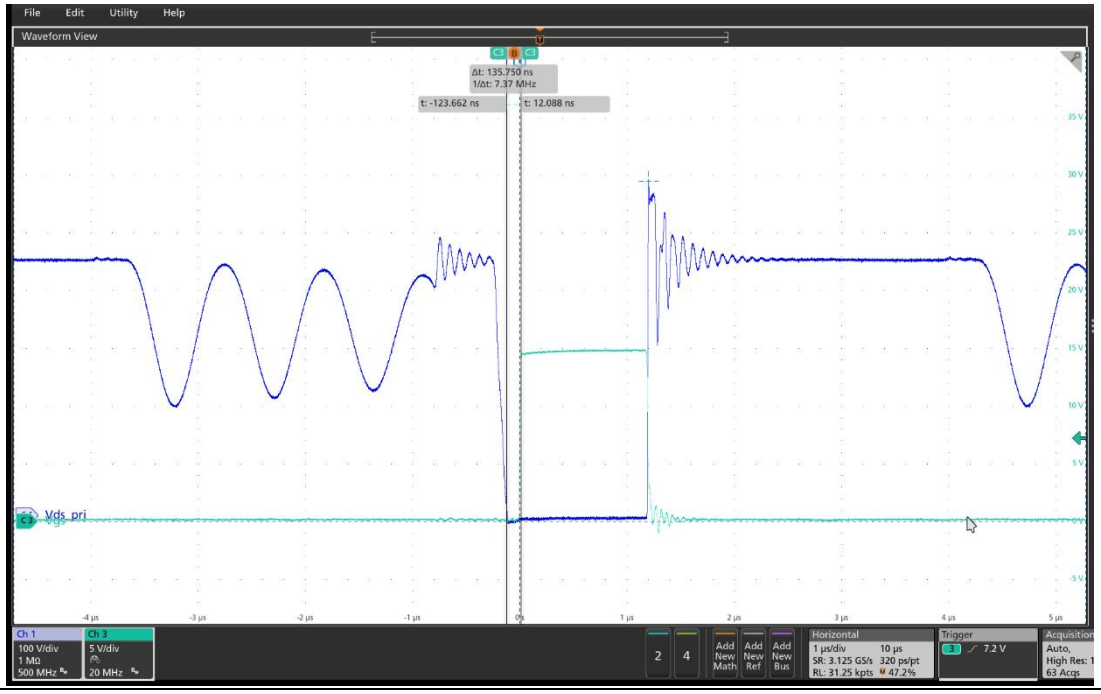


Figure 42 Primary Vds at 115 Vac, 60 Hz

Power management test results

Vac = 230 V, Vout = 20 V, Iout = 3.25 A, Mode = ZVS, ZVS pulse width = 550 ns, dead-time = 200 ns



Vac = 230 V, Vout = 20 V, Iout = 1 A, Mode = ZVS, ZVS pulse width = 550 ns, dead-time = 200 ns

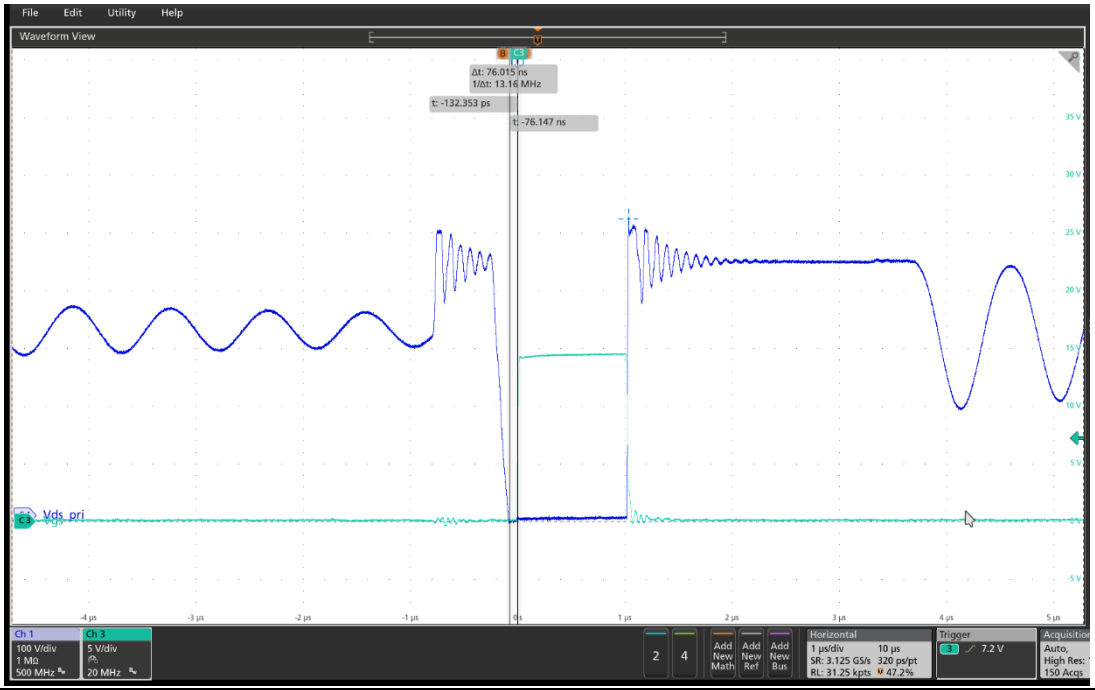
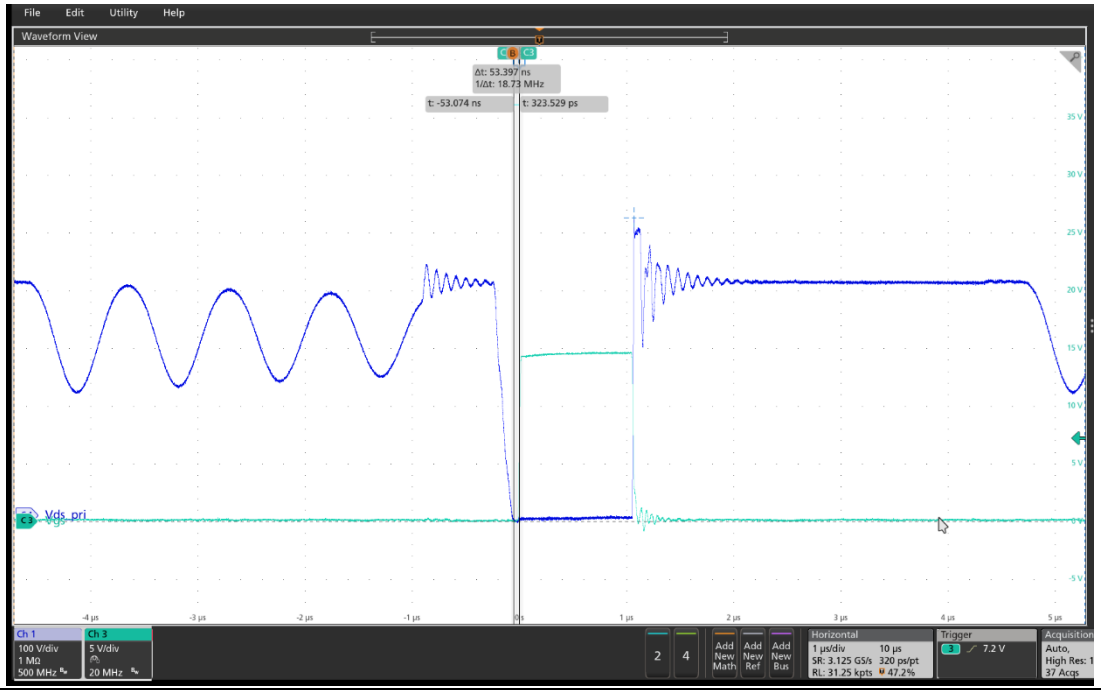


Figure 43 Primary Vds and Vgs for 20 V output at 230 Vac, 50 Hz (CH1: Vds_pri, CH3: GDL)

Power management test results

Vac = 230 V, Vout = 15 V, Iout = 3 A, Mode = ZVS, ZVS pulse width = 650 ns, dead-time = 200 ns



Vac = 230 V, Vout = 15 V, Iout = 1 A, Mode = ZVS, ZVS pulse width = 650 ns, dead-time = 200 ns

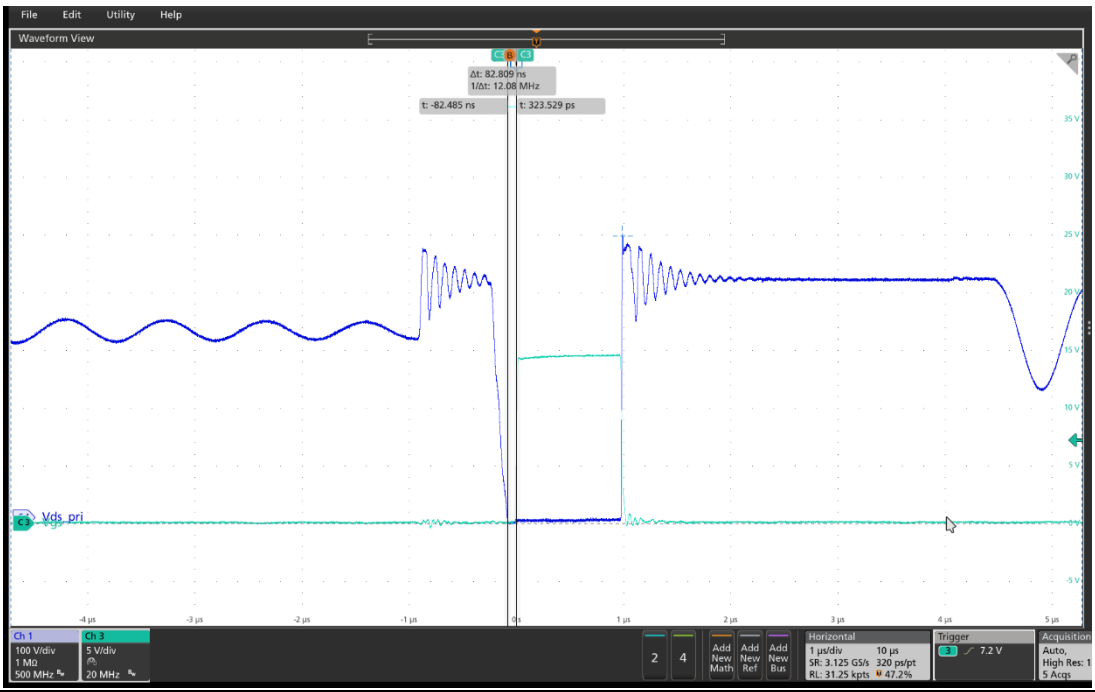
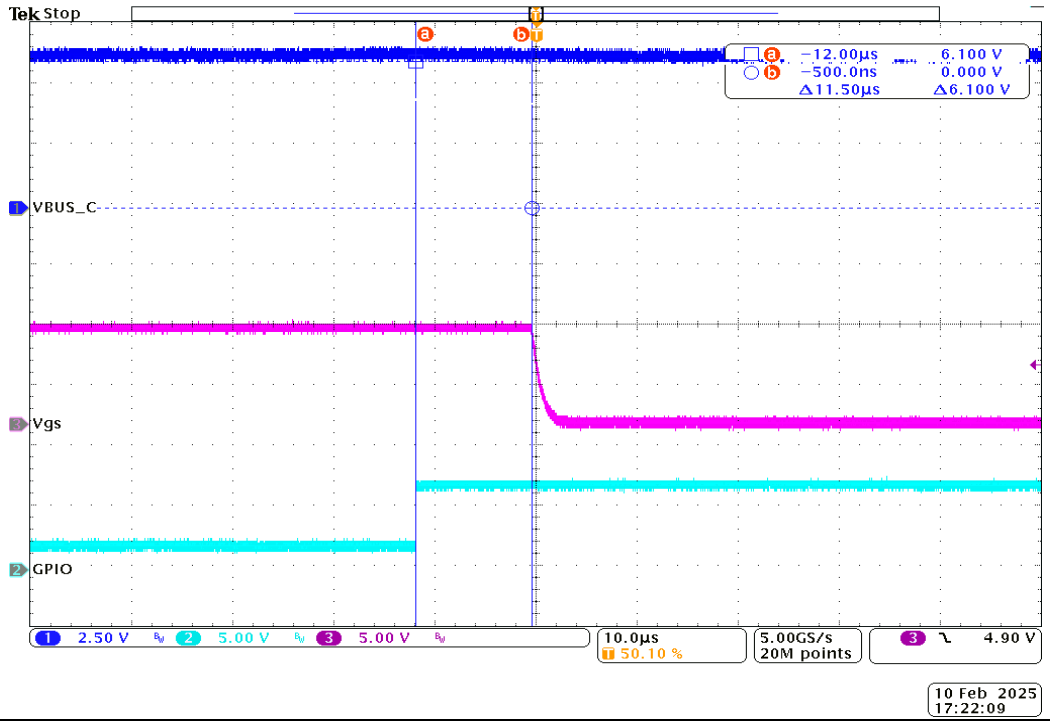


Figure 44 Primary Vds and Vgs for 15 V output at 230 Vac, 50 Hz (CH1: Vds_pri, CH3: GDL)

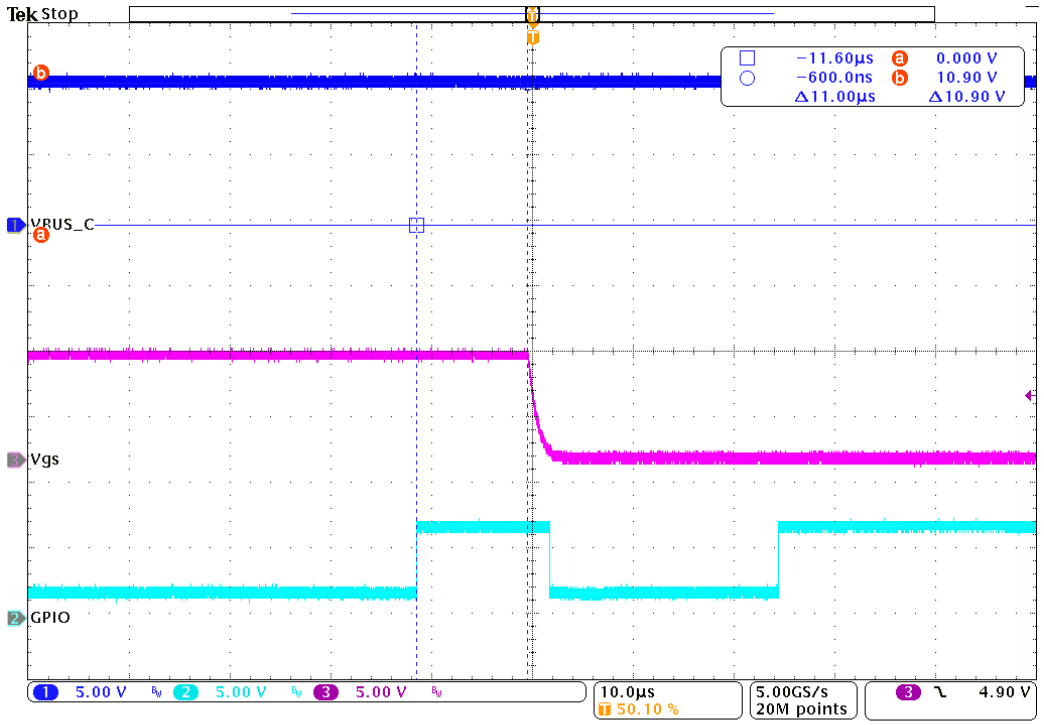
3.13 Overvoltage protection (OVP)

OVP tested at 115 Vac 60 Hz.

Vout = 5 V, OVP_limit = 6.1 V, OVP response time = 11.5 µs



Vout = 9 V, OVP_limit = 10.9 V, OVP response time = 11 µs



Power management test results

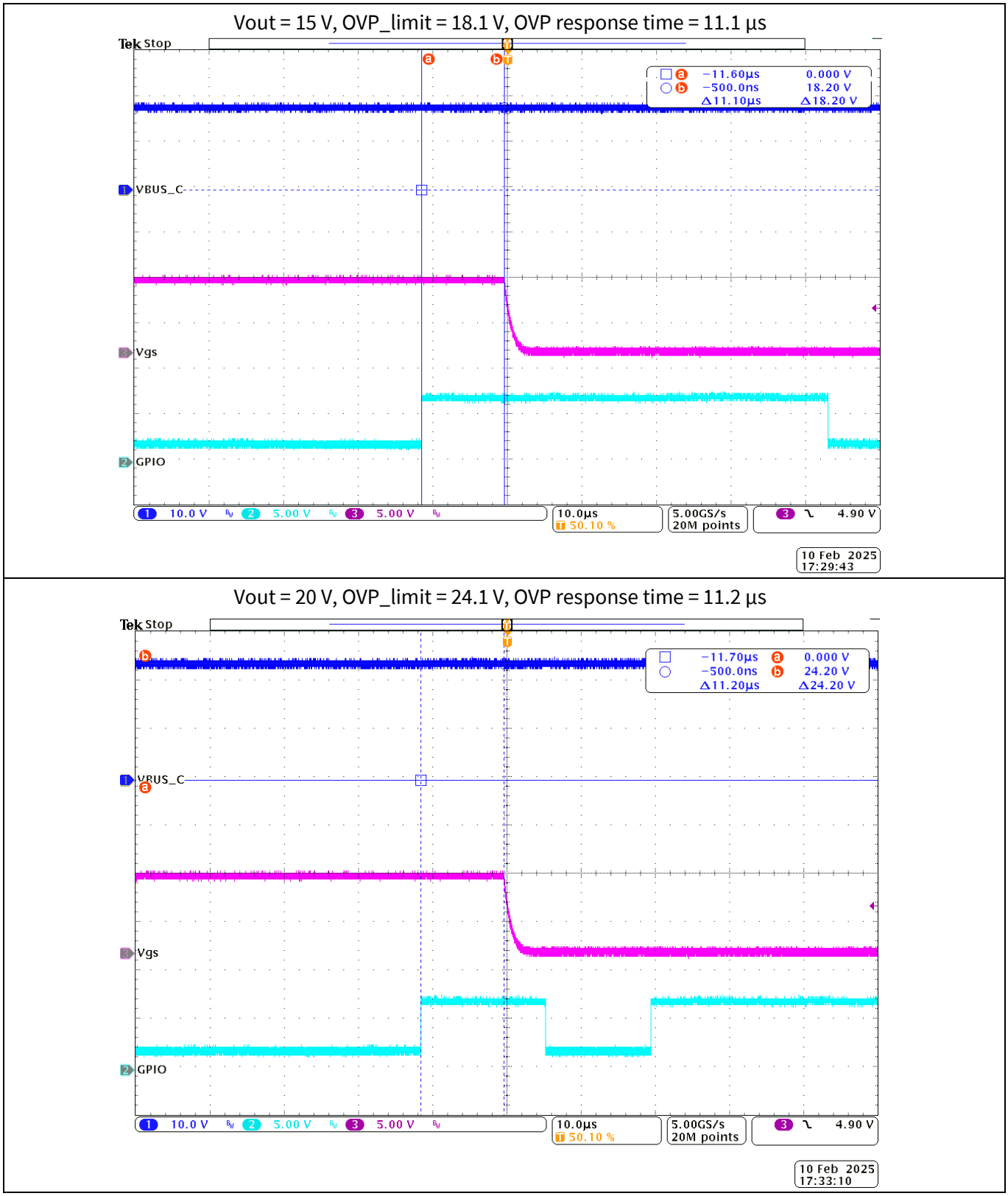


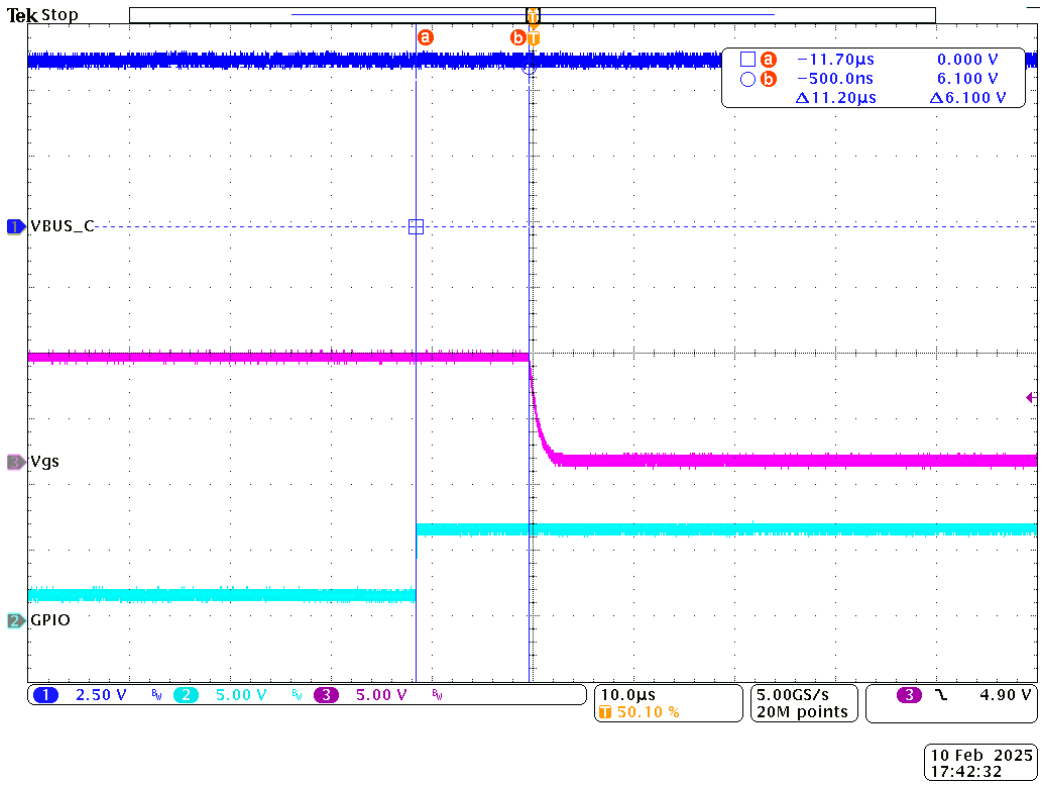
Figure 45 OVP at 115 Vac, 60 Hz (CH3: NFET[4]; CH2: GPIO9; CH1: Vbus_C)[4]

[4] NFET - Provider FET(Q2) gate to source waveform.

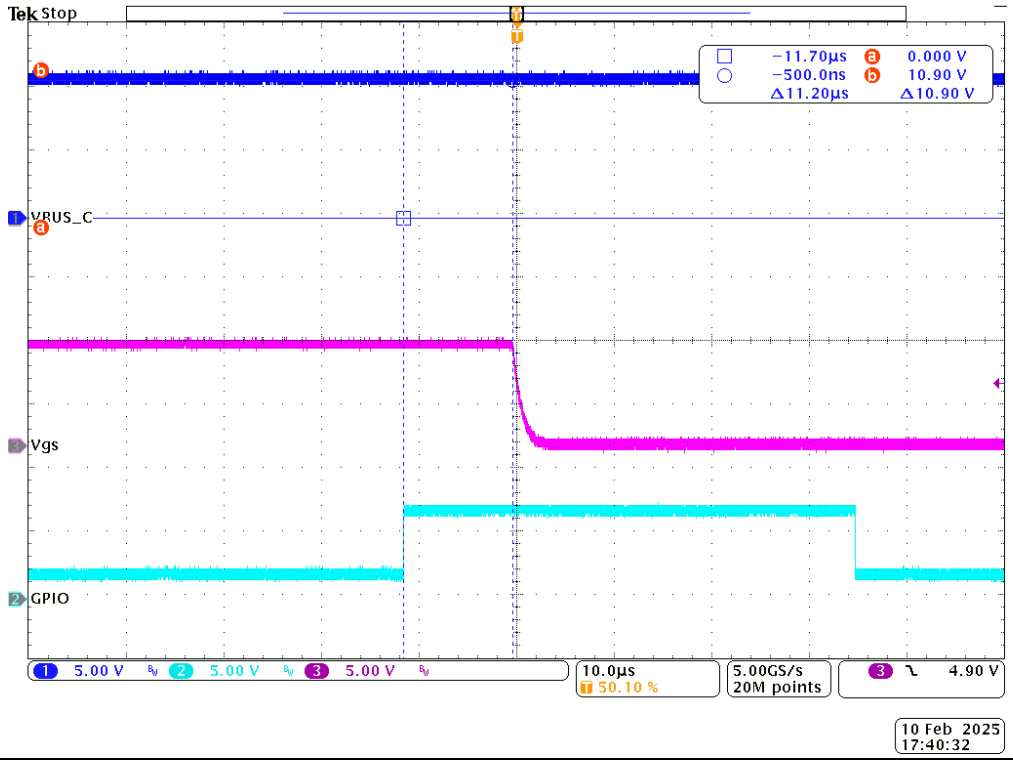
Power management test results

OVP tested at 230 Vac 50 Hz.

Vout = 5 V, OVP_limit = 6.1 V, OVP response time = 11.2 µs

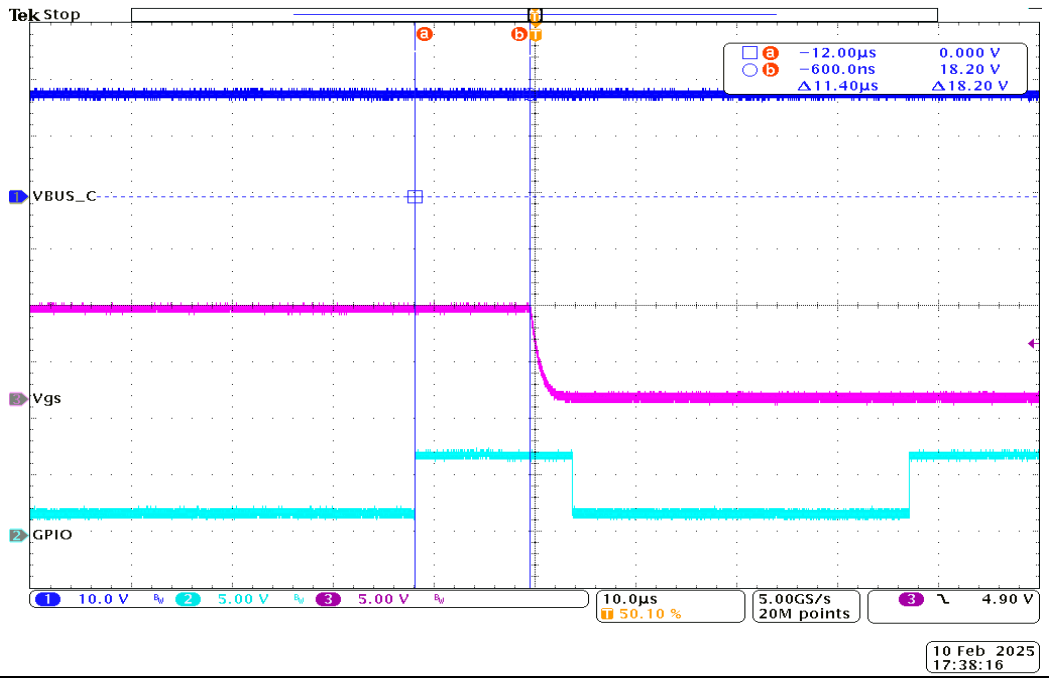


Vout = 9 V, OVP_limit = 10.9 V, OVP response time = 11.2 µs



Power management test results

Vout = 15 V, OVP_limit = 18.2 V, OVP response time = 11.4 µs



Vout = 20 V, OVP_limit = 24.2 V, OVP response time = 11.3 µs

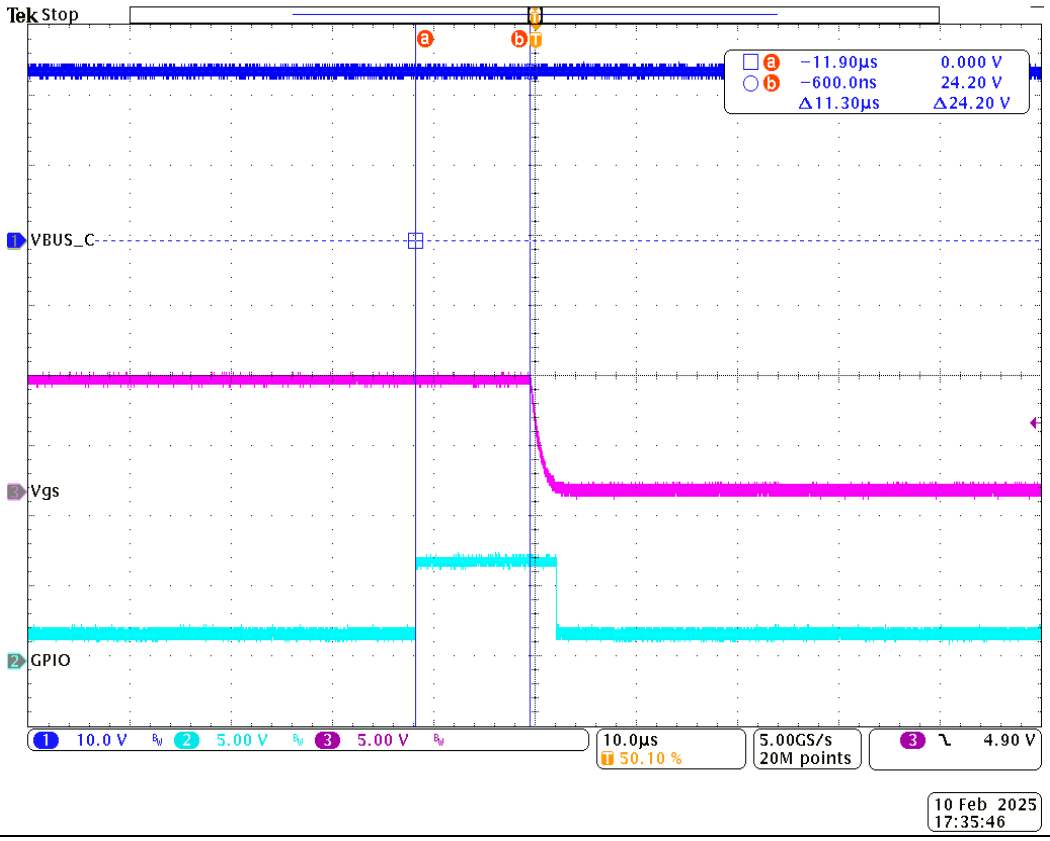


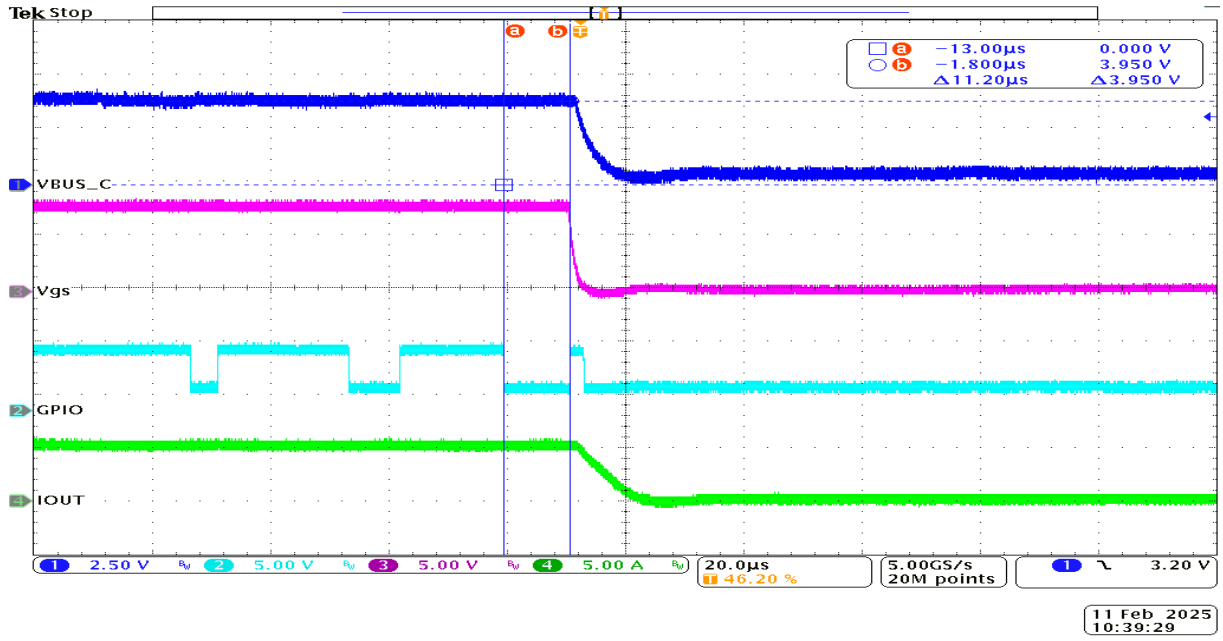
Figure 46 OVP at 230 Vac, 50 Hz (CH3: NFET[5]; CH2: GPIO9; CH1: Vbus_C)

[5] NFET - Provider FET(Q2) gate to source waveform.

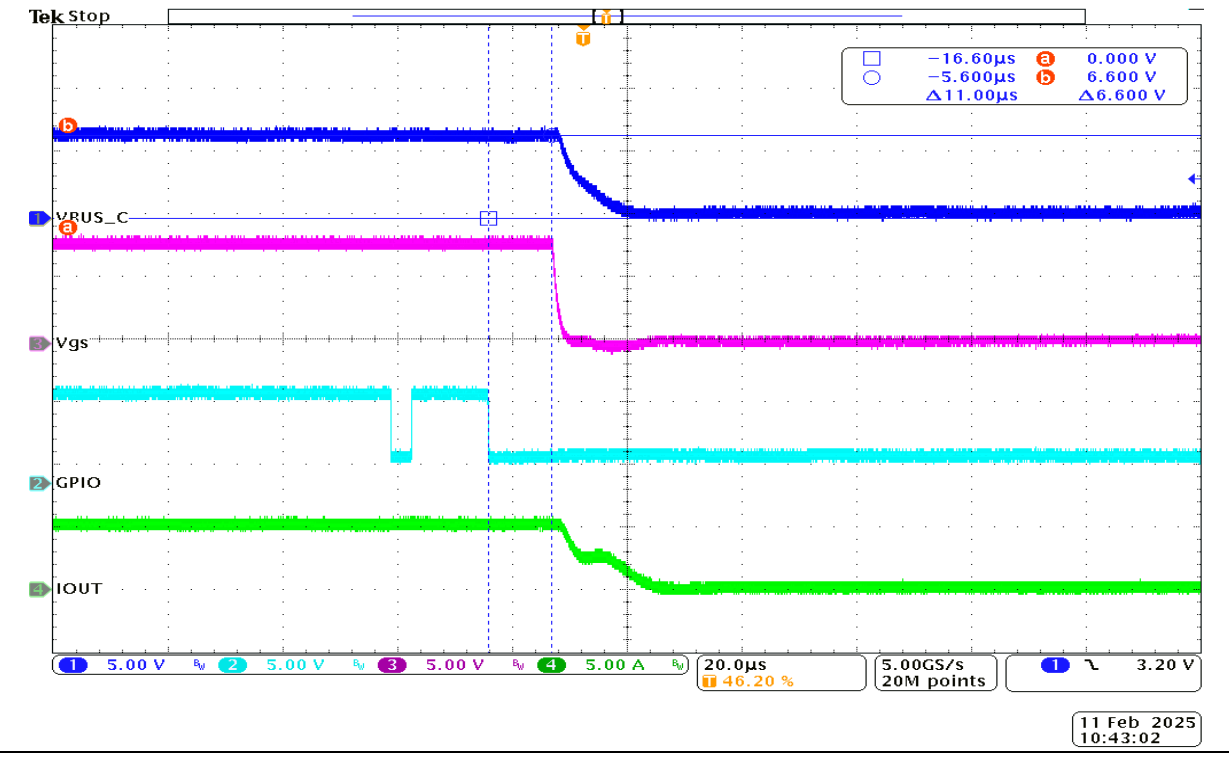
3.14 Undervoltage protection (UVP)

UVP tested at 115 Vac 60 Hz.

Vout = 5 V, UVP_limit = 3.95 V, UVP response time = 11.2 µs



Vout = 9 V, UVP_limit = 6.6 V, UVP response time = 11 µs



Power management test results

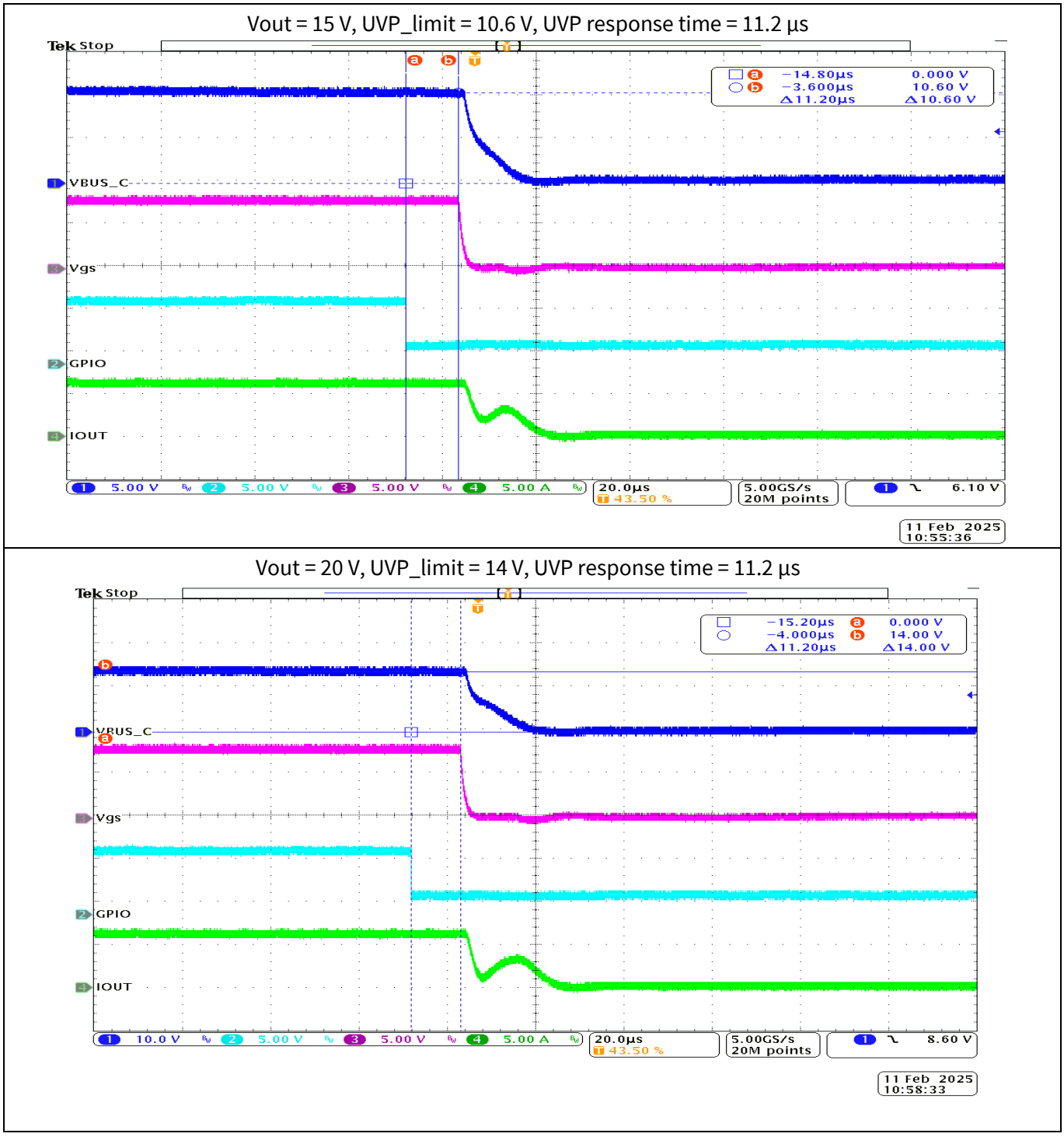


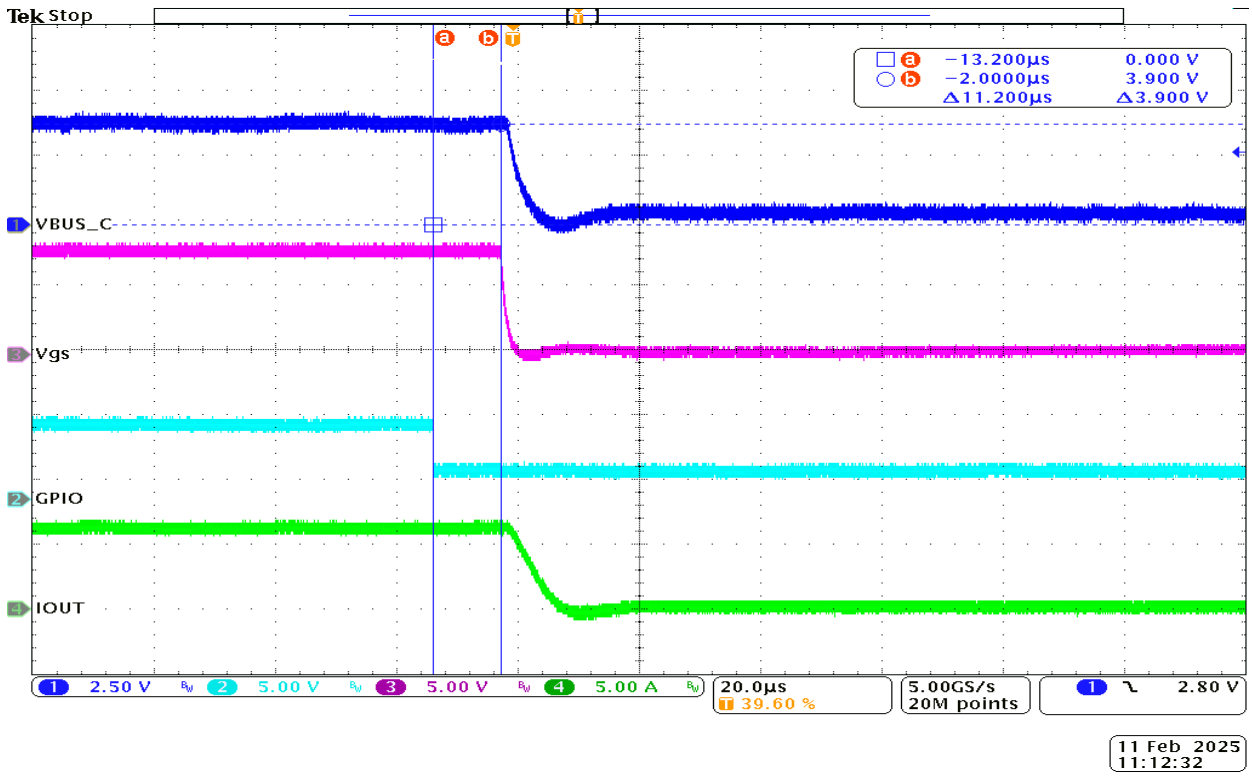
Figure 47 UVP at 115 Vac, 60 Hz (CH4: Iout; CH2: GPIO9; CH1: Vbus_C; CH3: NFET[6])

[6] **NFET - Provider FET(Q1) gate to source waveform.**

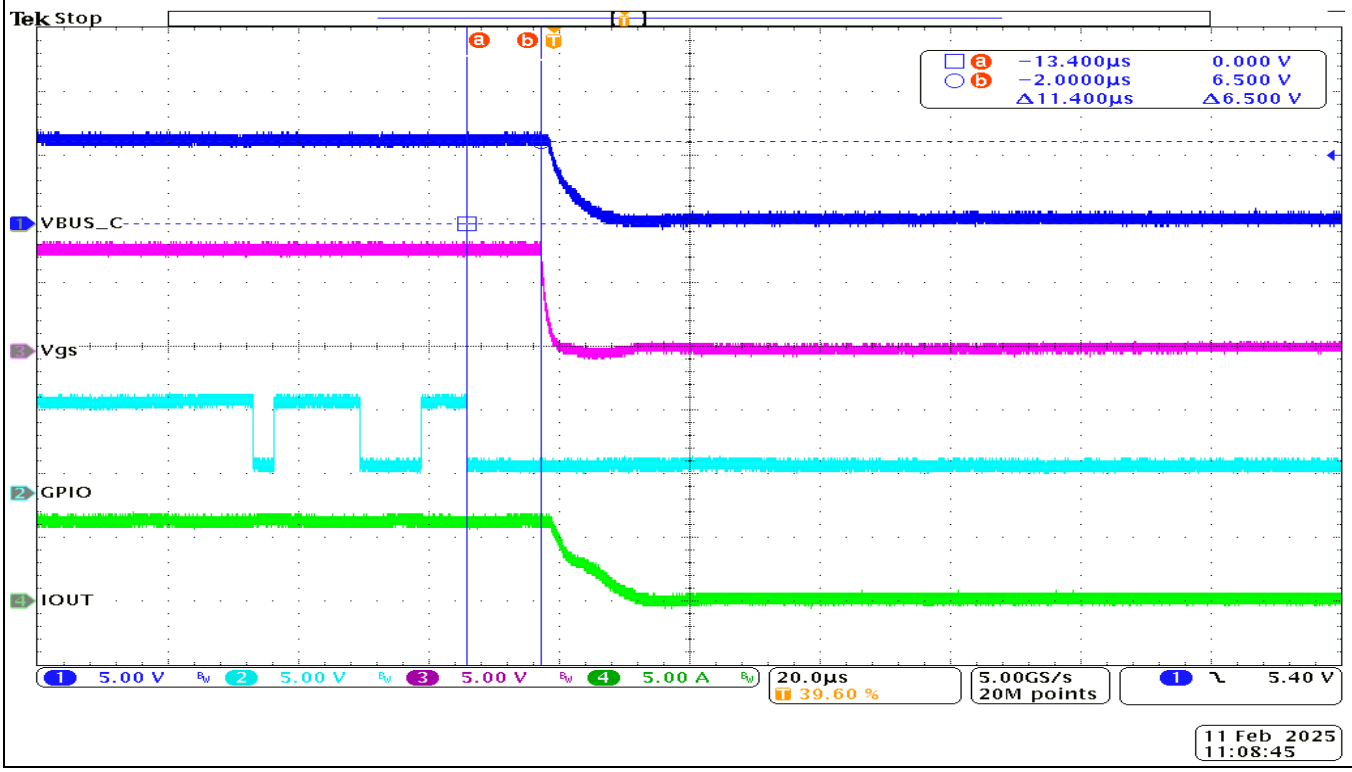
Power management test results

UVP tested at 230 Vac 50 Hz.

Vout = 5 V, UVP_limit = 3.9 V, UVP response time = 11.2 µs



Vout = 9 V, UVP_limit = 6.5 V, UVP response time = 11.4 µs



Power management test results

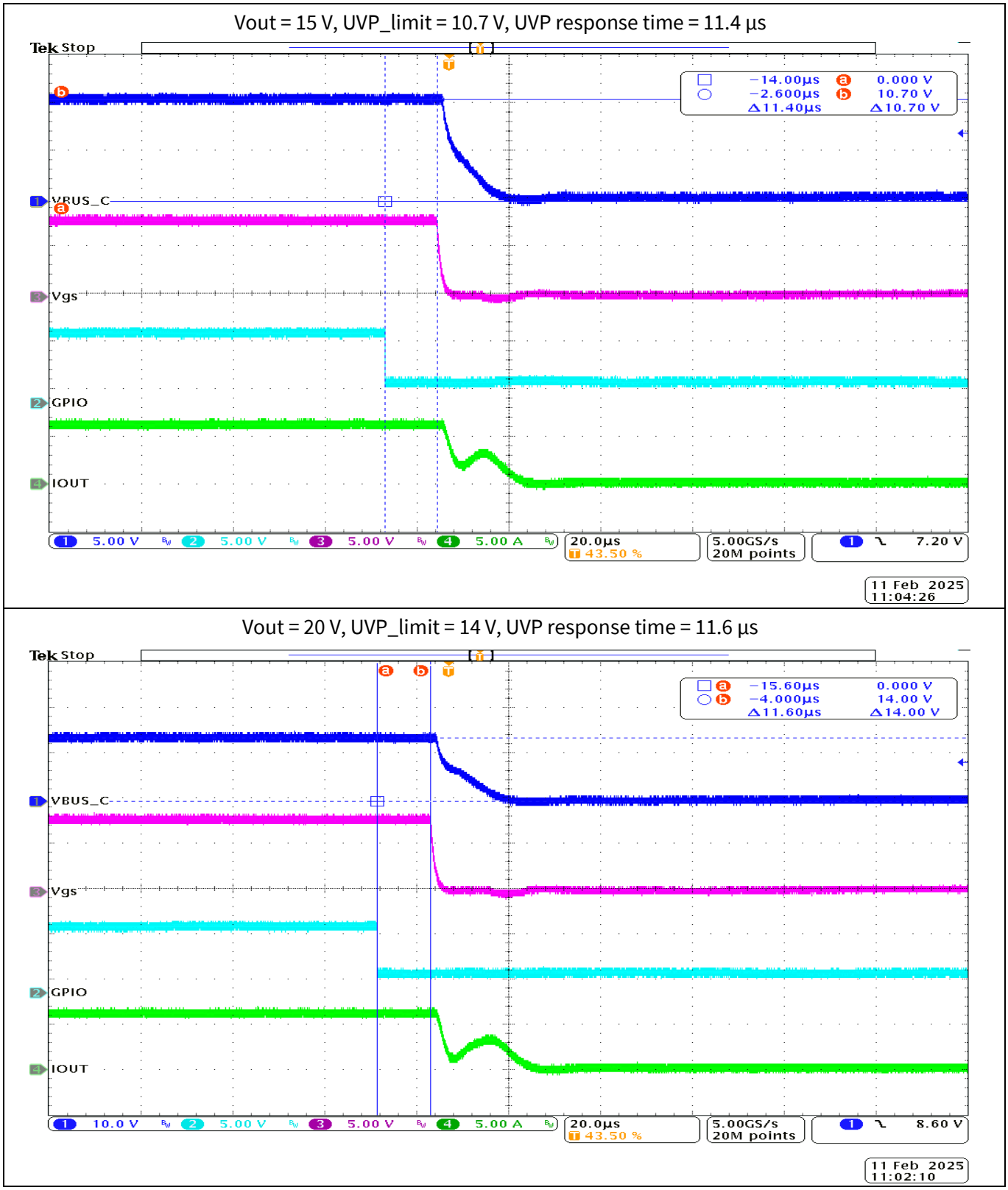


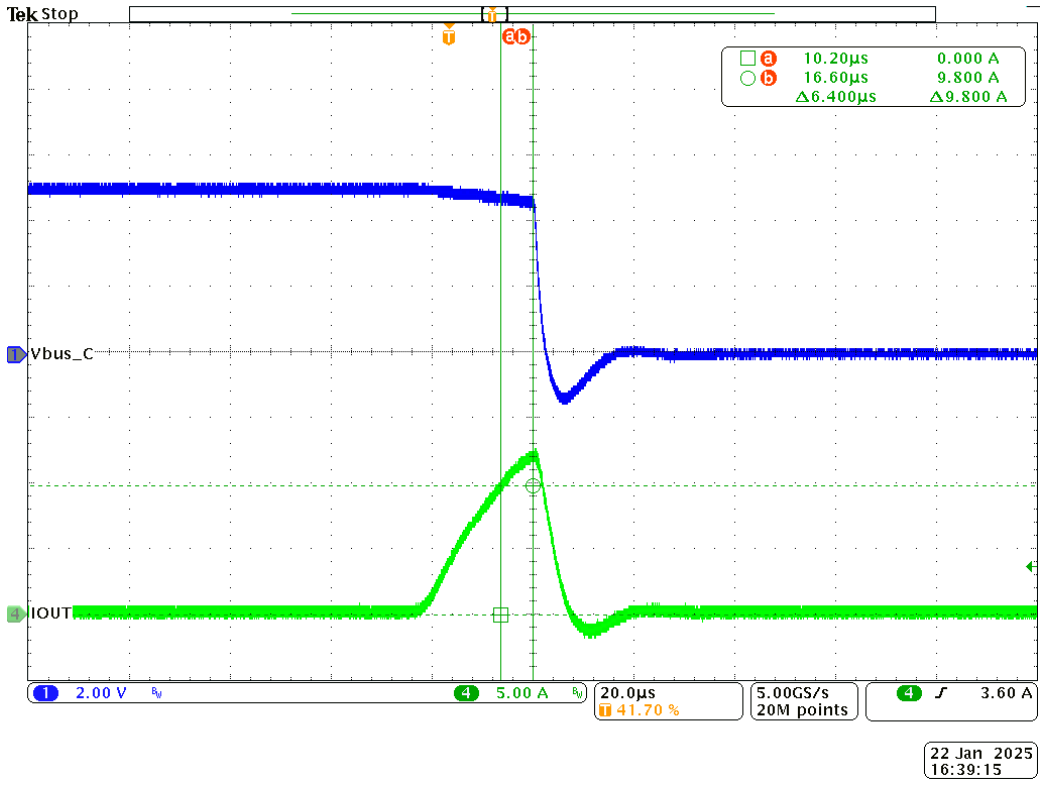
Figure 48 UVP at 230 Vac, 50 Hz (CH4: Iout; CH2: GPIO9; CH1: Vbus_C; CH3: NFET[7])

[7] **NFET - Provider FET(Q1) gate to source waveform.**

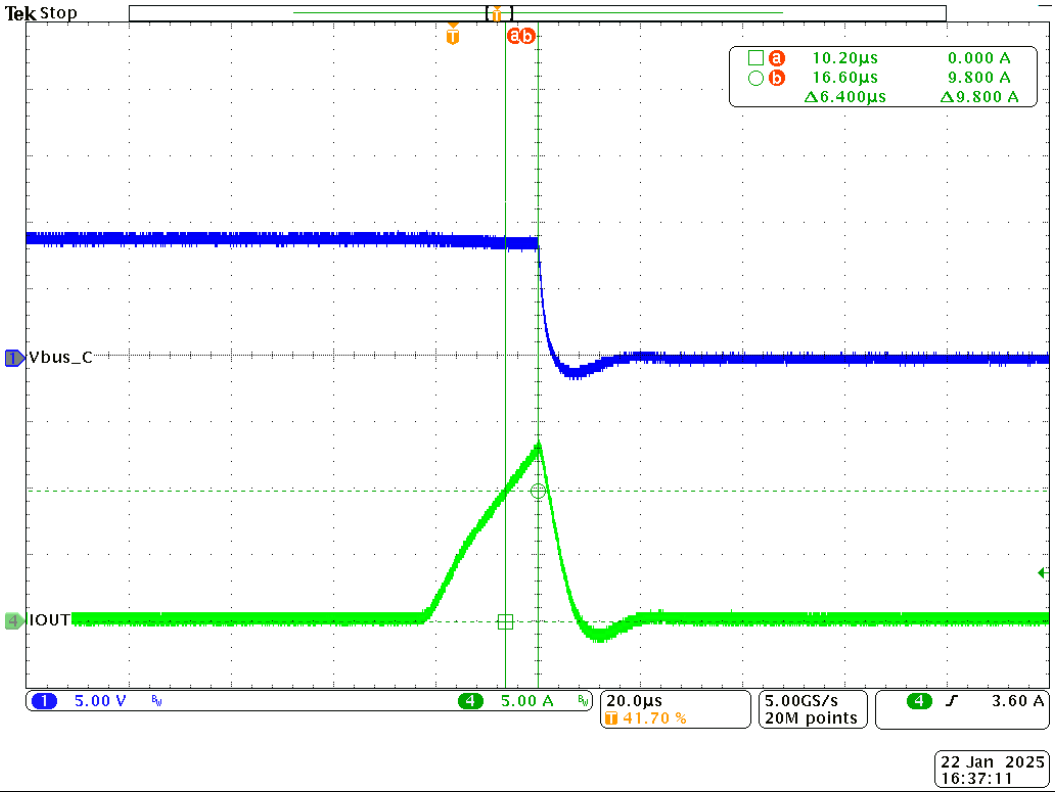
3.15 Short-circuit protection (SCP)

SCP tested at 115 Vac 60 Hz.

Fixed PDO = 5 V, 3 A; SCP trip point = 9.8 A; SCP response time = 6.40 µs

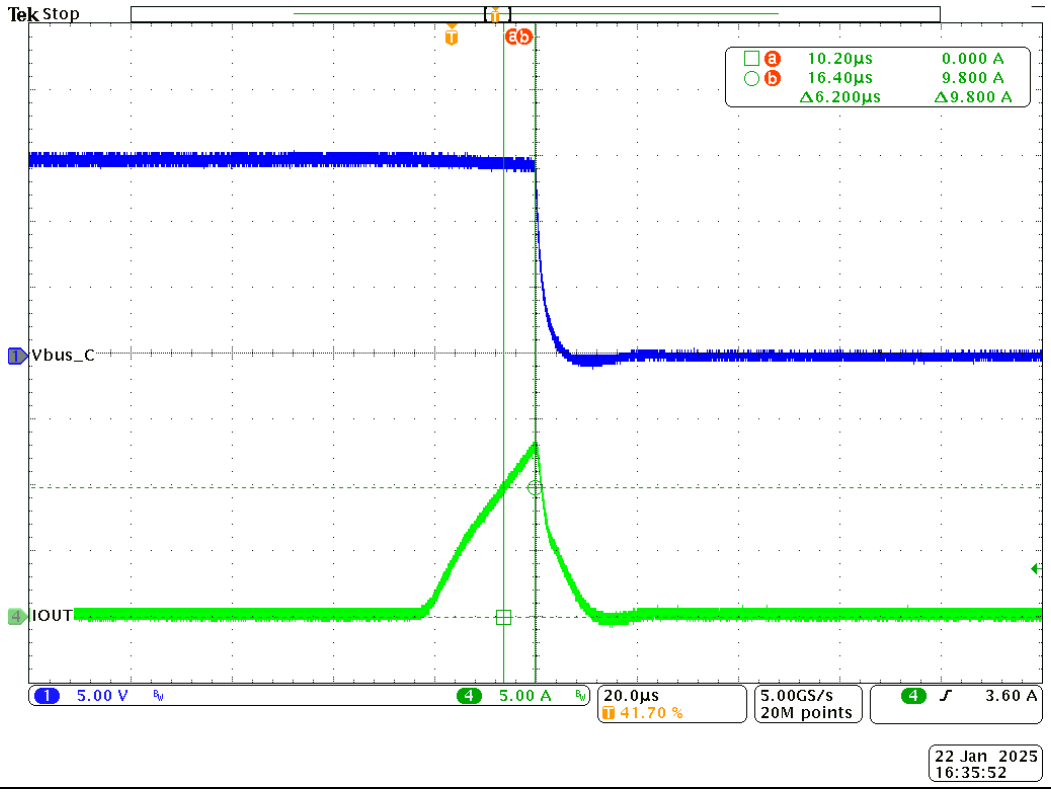


Fixed PDO = 9 V, 3 A; SCP trip point = 9.8 A; SCP response time = 6.40 µs



Power management test results

Fixed PDO = 15 V, 3 A; SCP trip point = 9.8 A; SCP response time = 6.20 µs



Fixed PDO = 20 V, 3.25 A; SCP trip point = 9.8 A; SCP response time = 6.40 µs

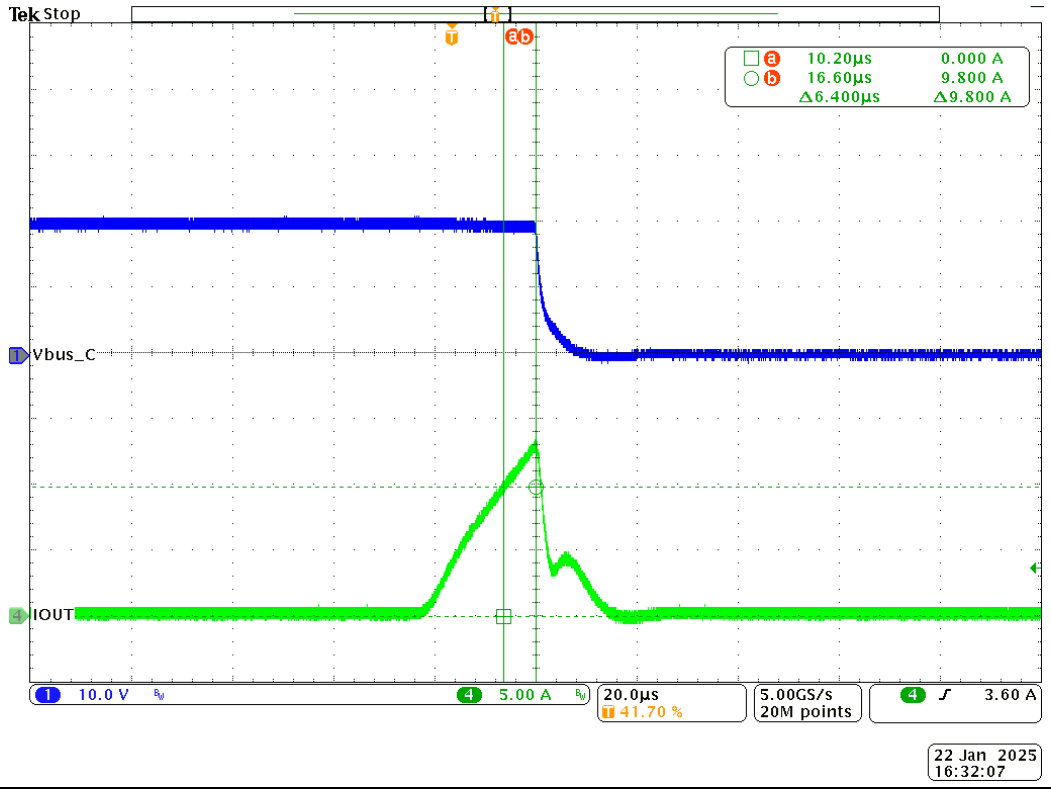
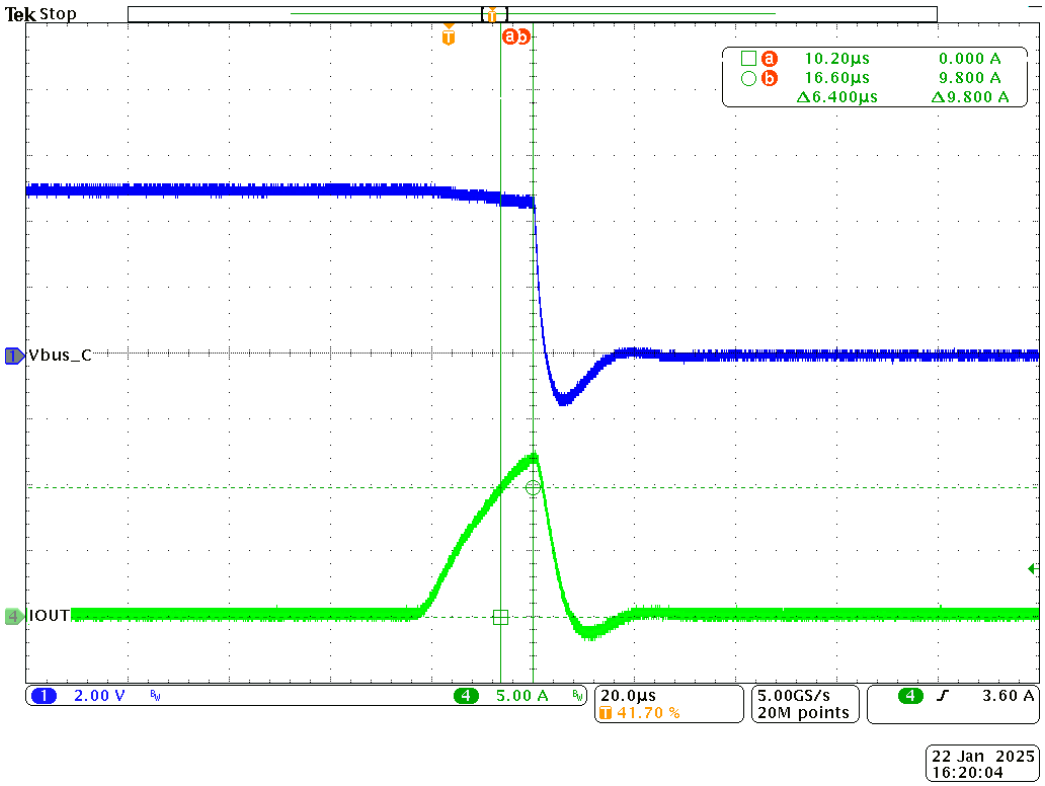


Figure 49 SCP at 115 Vac, 60 Hz (CH1: Vbus_C; CH4: Iout)

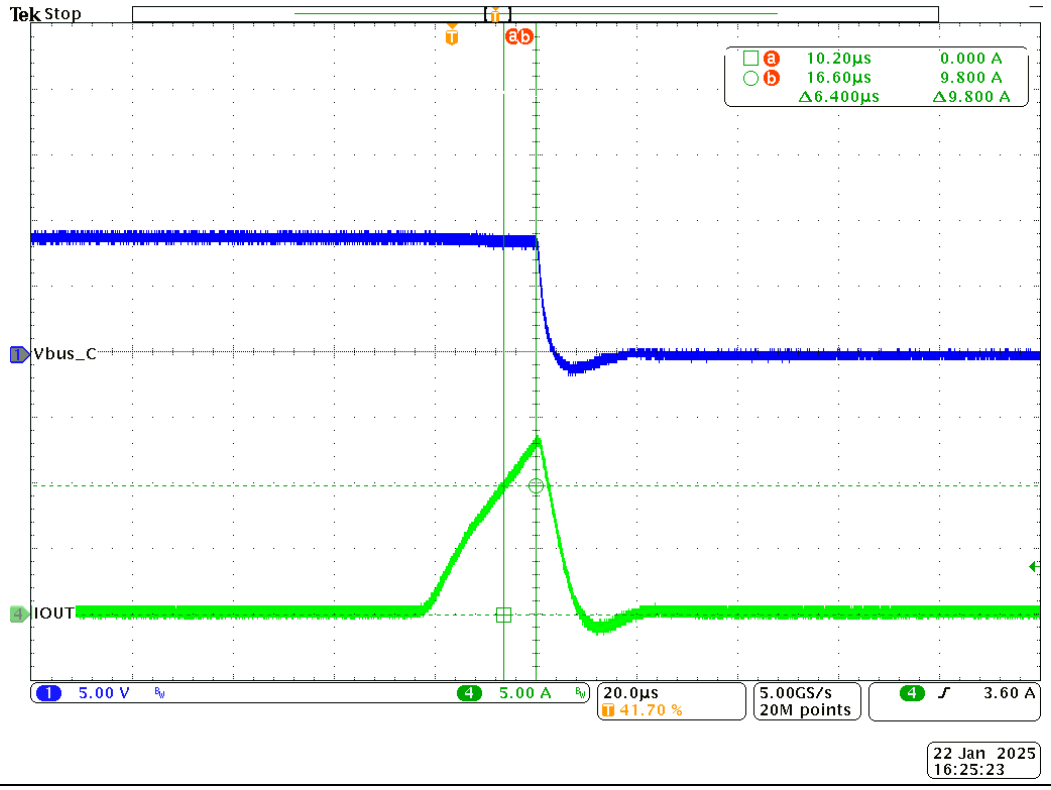
Power management test results

SCP tested at 230 Vac 50 Hz.

Fixed PDO = 5 V, 3 A; SCP trip point = 9.8 A; SCP response time = 6.40 µs



Fixed PDO = 9 V, 3 A; SCP trip point = 9.8 A; SCP response time = 6.40 µs



Power management test results

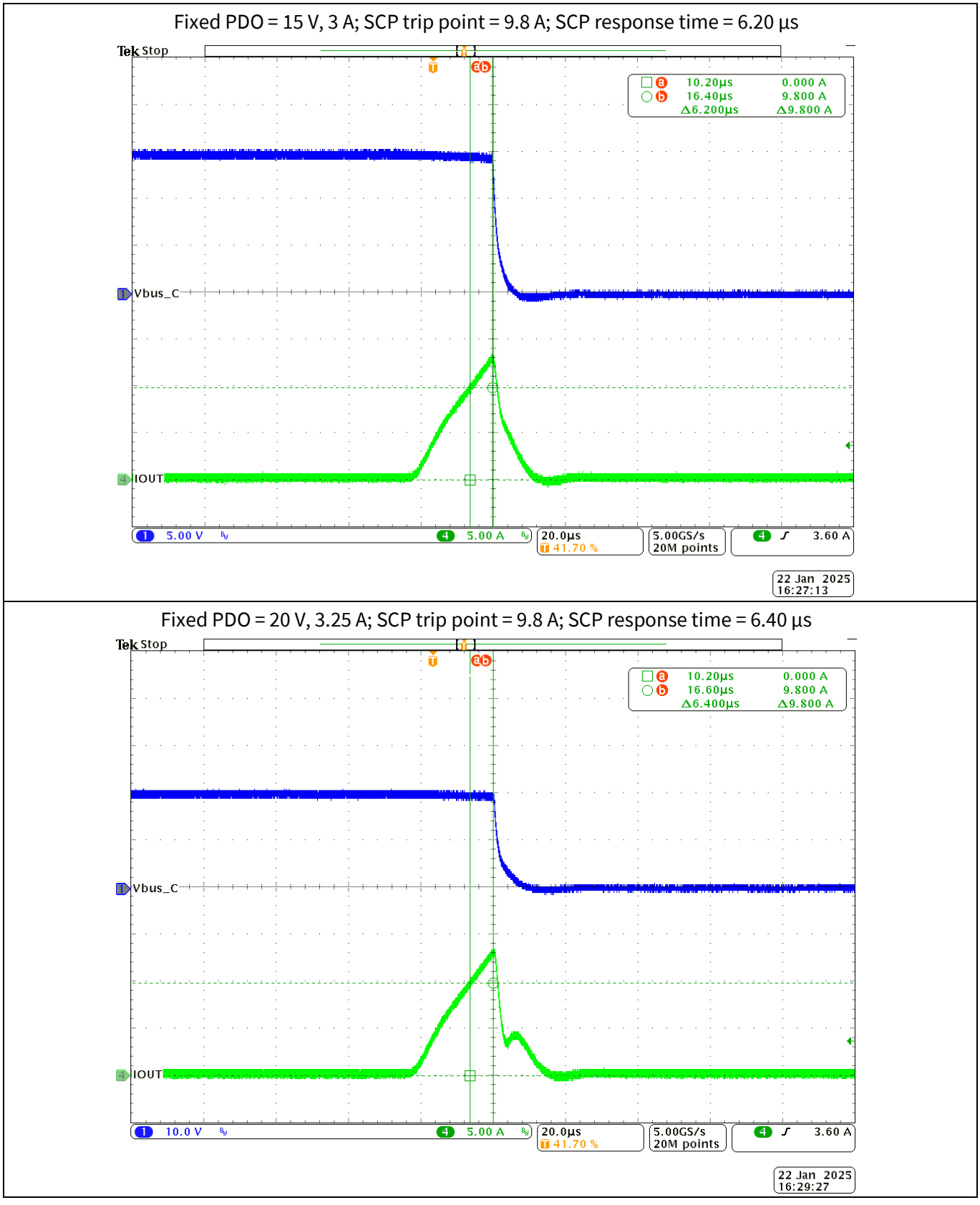
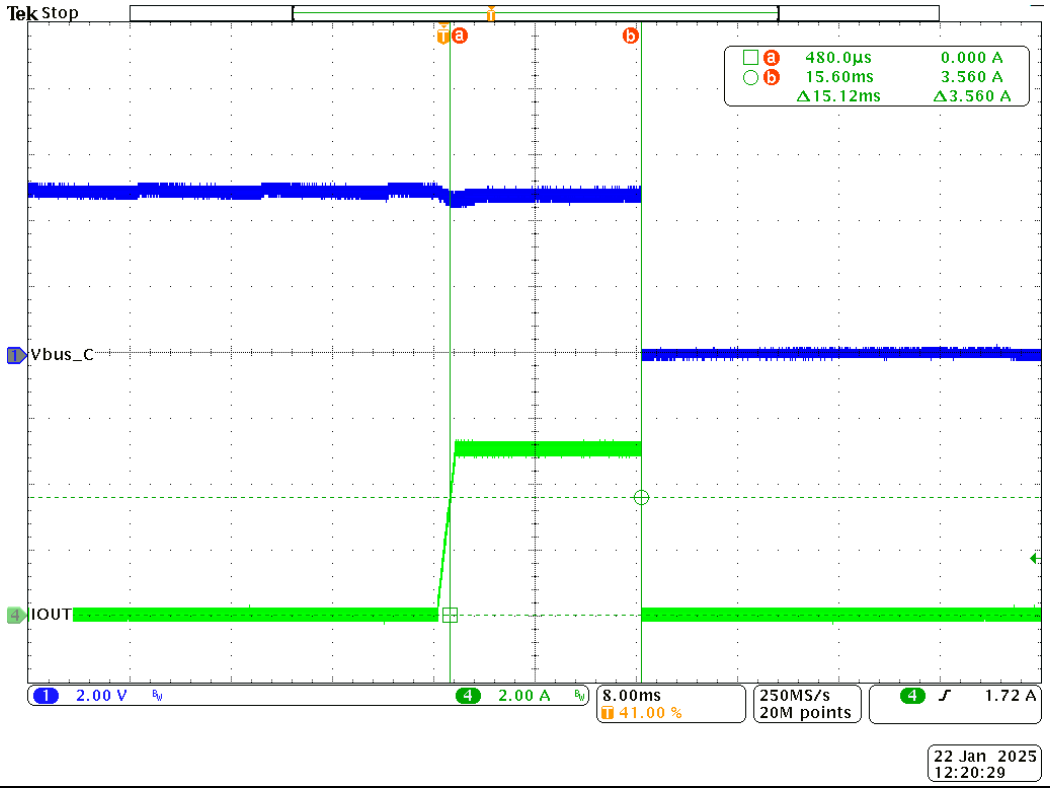


Figure 50 SCP at 230 Vac, 50 Hz (CH1: Vbus_C; CH4: Iout)

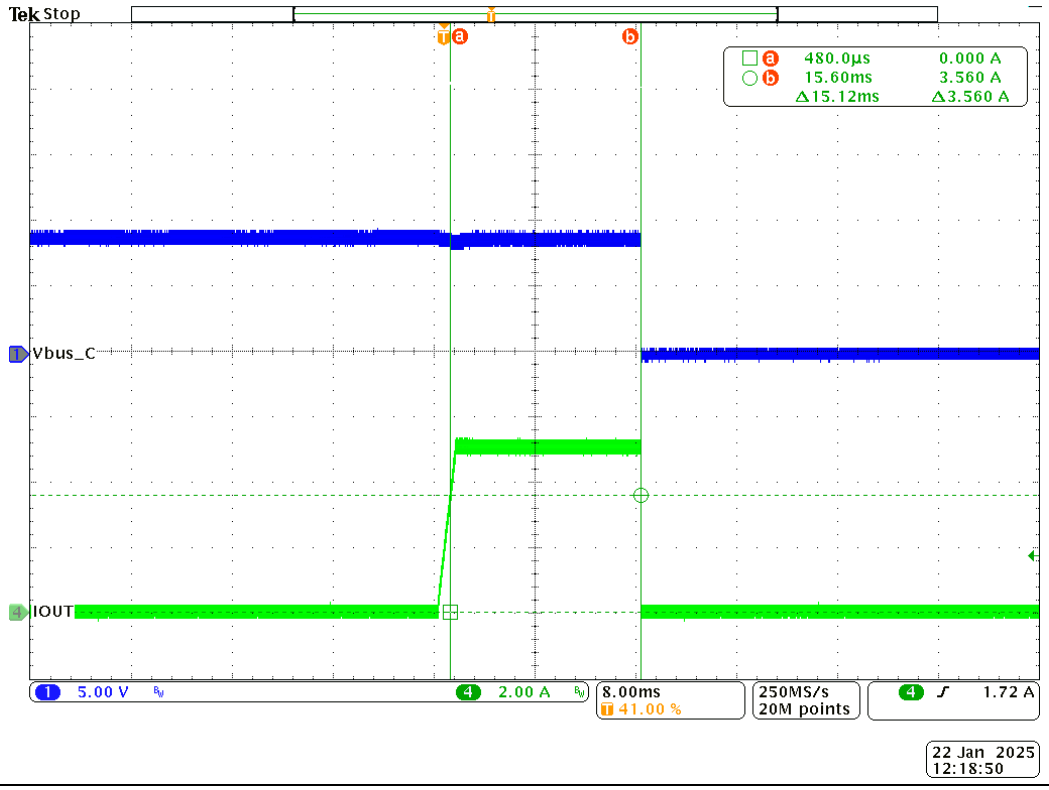
3.16 Overcurrent protection (OCP)

OCP tested at 115 Vac 60 Hz.

Fixed PDO = 5 V, 3 A; OCP trip point = 3.56 A; OCP response time = 15.12 ms

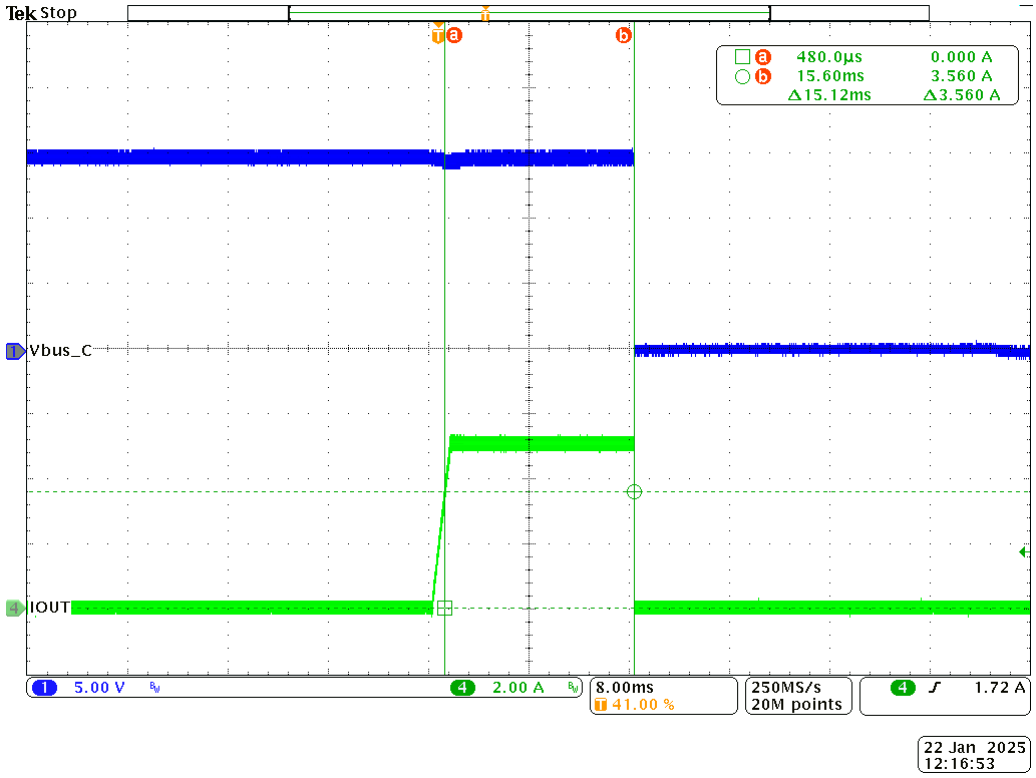


Fixed PDO = 9 V, 3 A; OCP trip point = 3.56 A; OCP response time = 15.12 ms



Power management test results

Fixed PDO = 15 V, 3 A; OCP trip point = 3.56 A; OCP response time = 15.12 ms



Fixed PDO = 20 V, 3.25 A; OCP trip point = 3.86 A; OCP response time = 15.04 ms

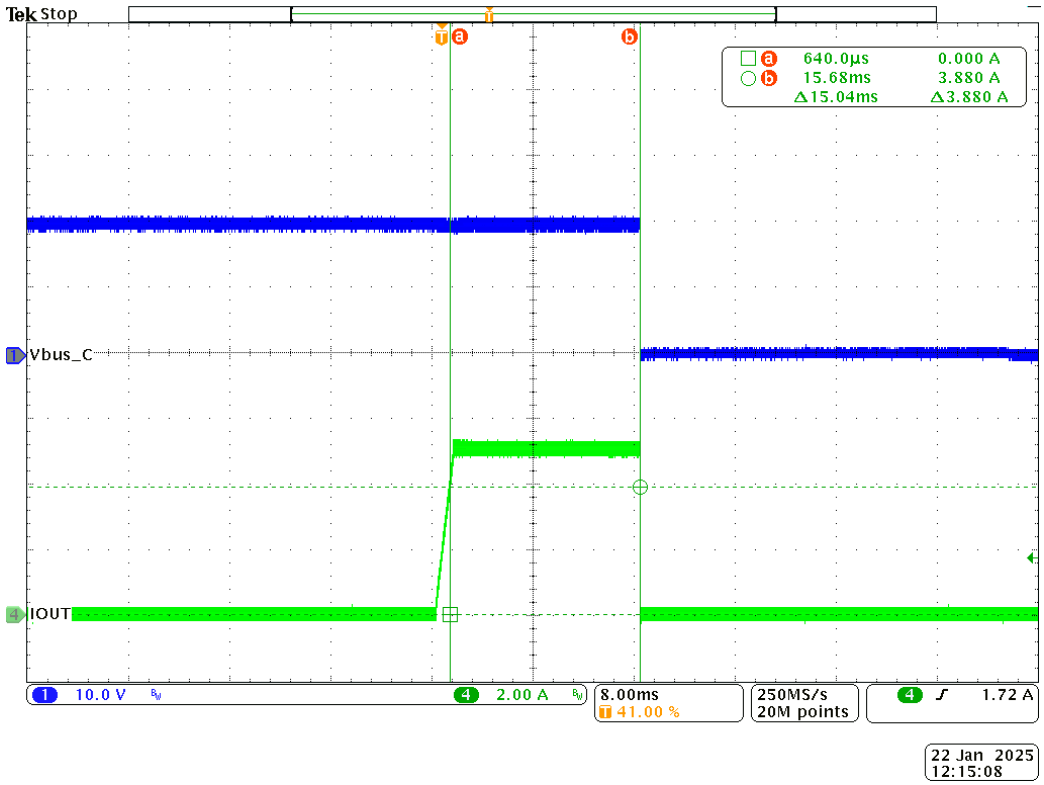
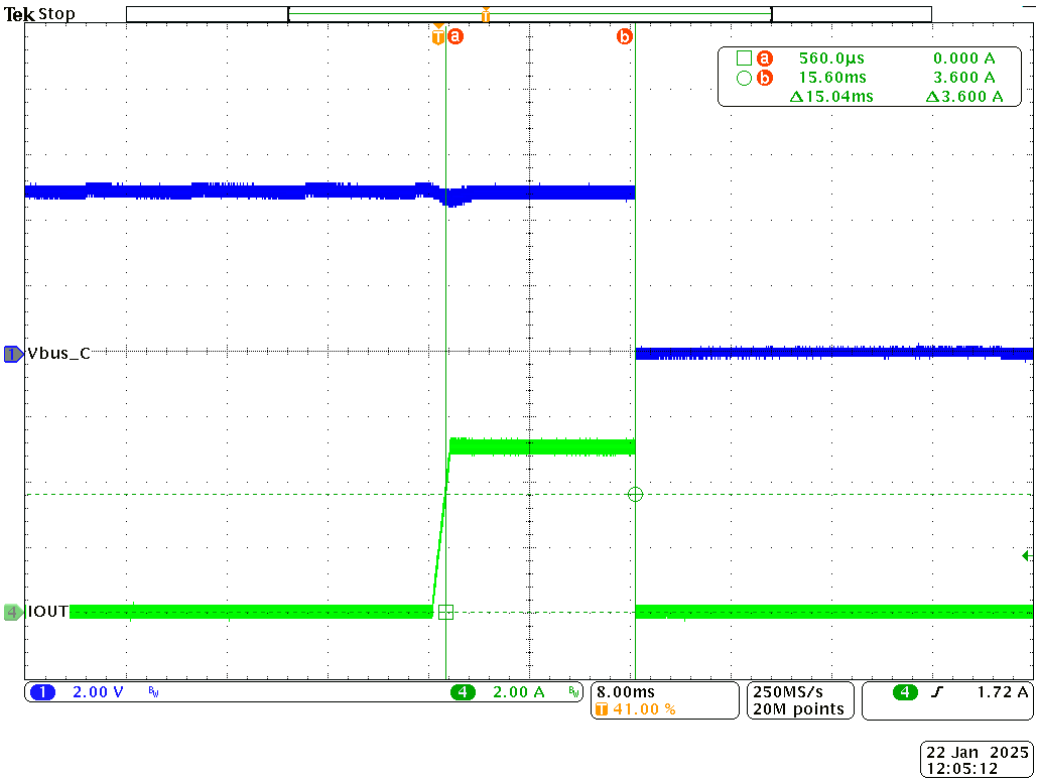


Figure 51 OCP at 115 Vac, 60 Hz (CH1: Vbus_C; CH4: Iout)

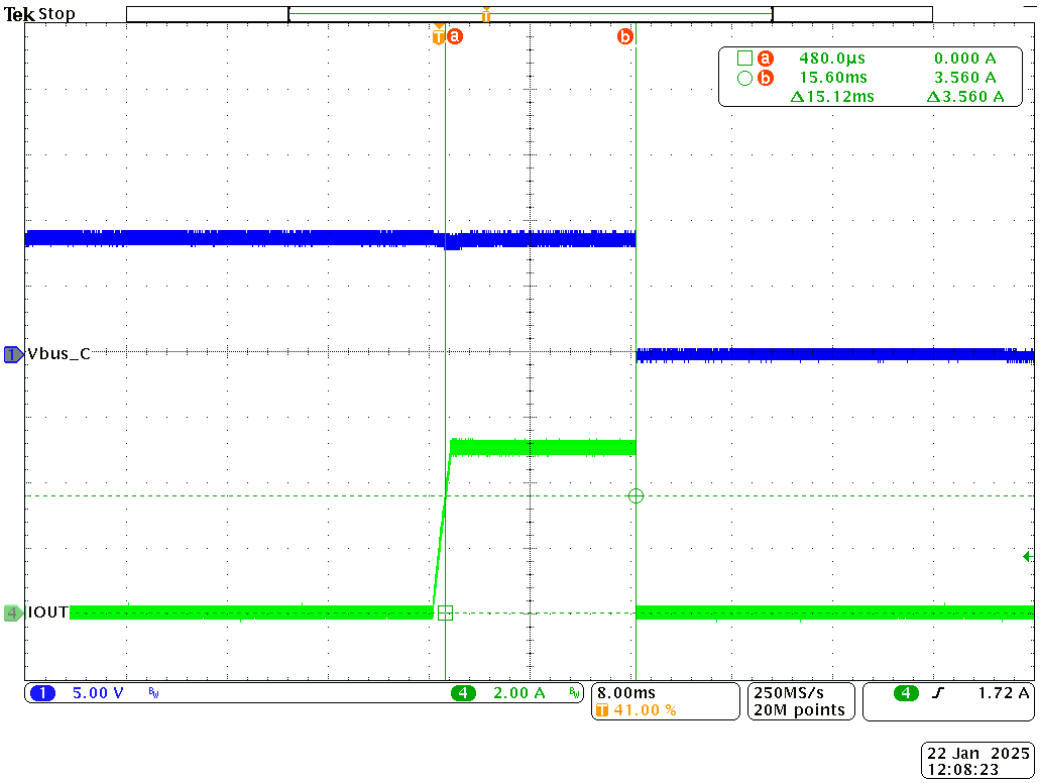
Power management test results

OCP tested at 230 Vac 50 Hz.

Fixed PDO = 5 V, 3 A; OCP trip point = 3.59 A; OCP response time = 15.04 ms

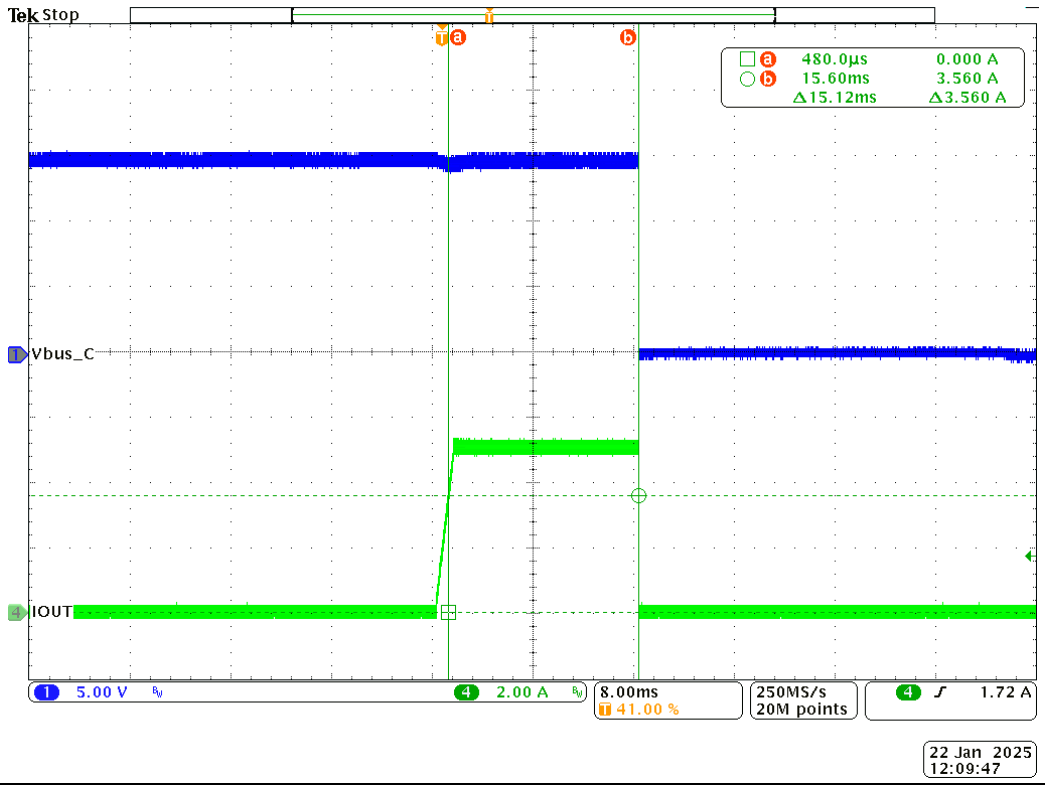


Fixed PDO = 9 V, 3 A; OCP trip point = 3.57 A; OCP response time = 15.12 ms



Power management test results

Fixed PDO = 15 V, 3 A; OCP trip point = 3.57 A; OCP response time = 15.12 ms



Fixed PDO = 20 V, 3.25 A; OCP trip point = 3.86 A; OCP response time = 15.04 ms

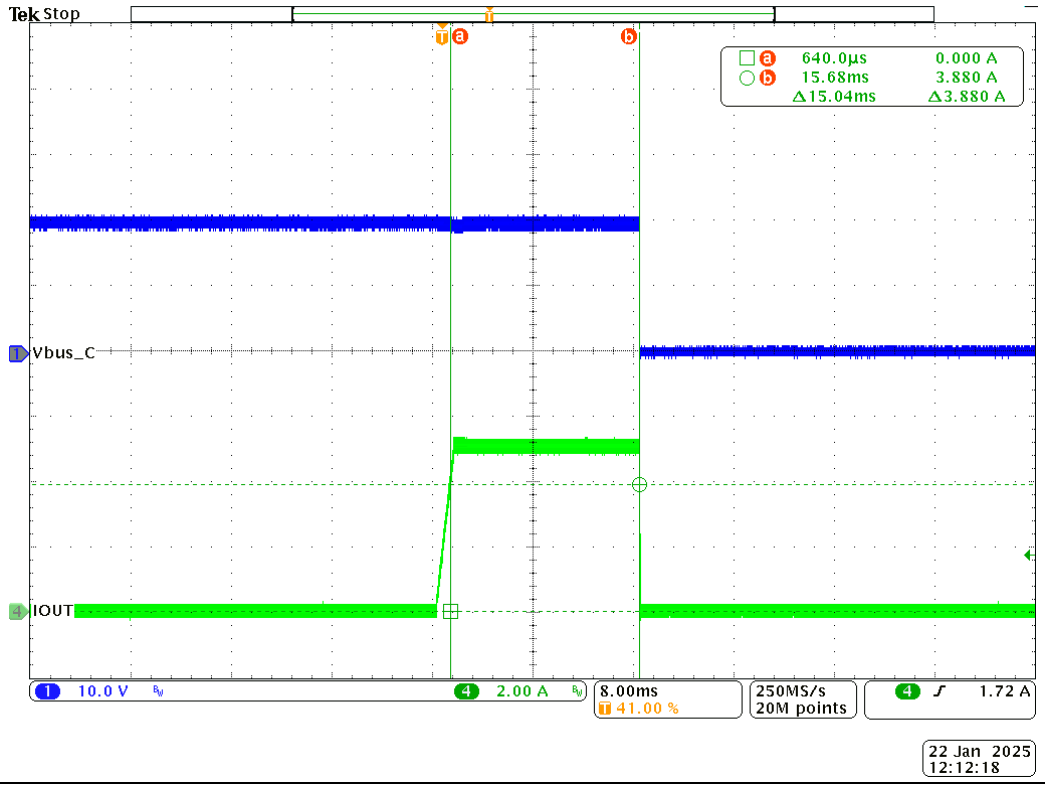


Figure 52 OCP at 230 Vac, 50 Hz (CH1: Vbus_C; CH4: Iout)

3.17 Thermal stress

- **Test condition**: Vin_ac = 90 Vac-47 Hz, Vout = 20 V, Iout = 3.25 A
- **Lab ambient temperature**: 24°C and in open frame
- **Run time**: 60 minutes

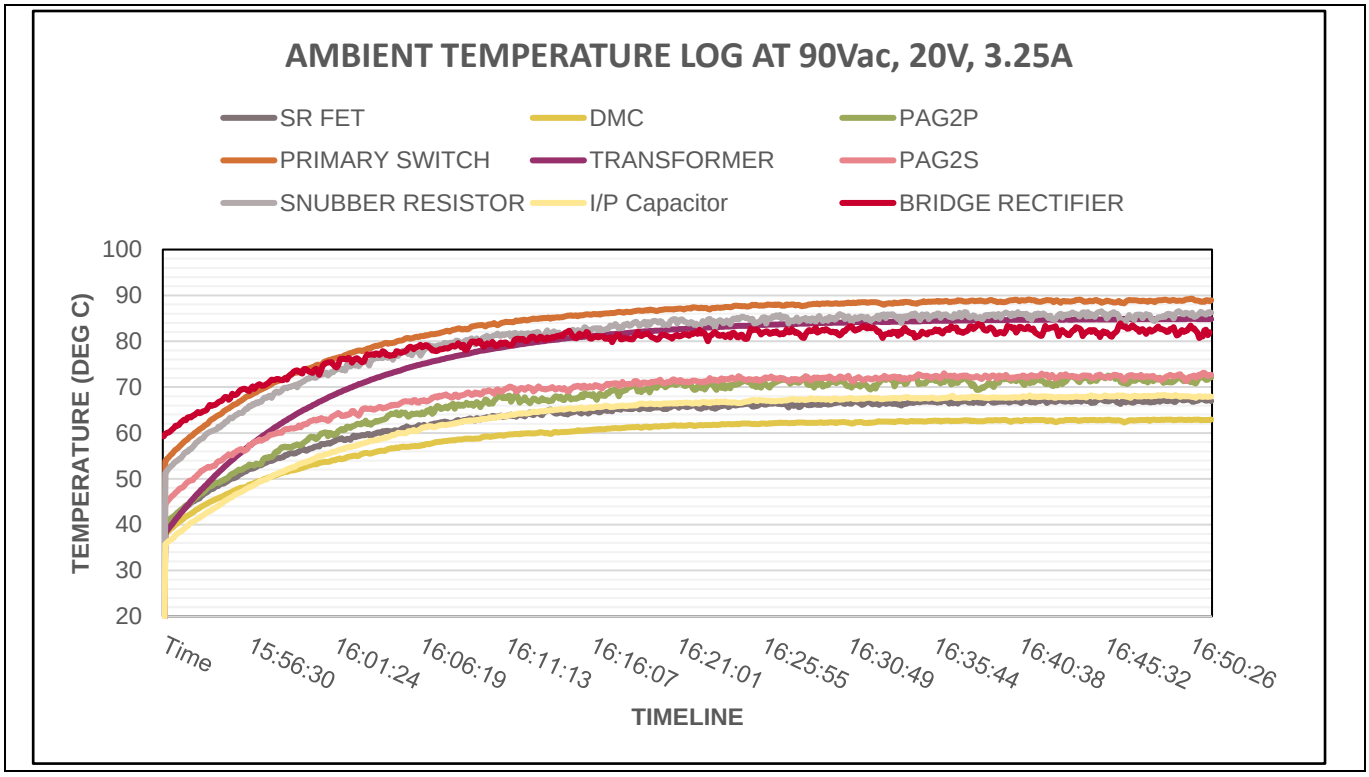


Figure 53 Thermal data logging of various components with time at 90 Vac-47 Hz, 20 V, 3.25 A

Table 19 Thermal data logging of various components at the end of 60 minutes at 90 Vac-47 Hz, 20 V, 3.25 A

Sl. No.	Component	Max temp in 24°C at the end of 60 minutes
1	Bridge rectifier – DB1	81.993
2	SR FET – Q4	66.966
3	DMC – L1	62.936
4	Transformer – T1	84.832
5	PAG2P (primary IC) – U2	72.128
6	PAG2S (secondary IC) – U3	72.673
7	Primary switch – Q3	88.957
8	Snubber resistor – R4	86.188
9	I/P capacitor (electrolytic) – C2	67.917

Power management test results

- **Test condition**: Vin_ac = 265 Vac-63 Hz, Vout = 20 V, Iout = 3.25 A
- **Lab ambient temperature**: 24°C and in open frame
- **Run time**: 60 minutes

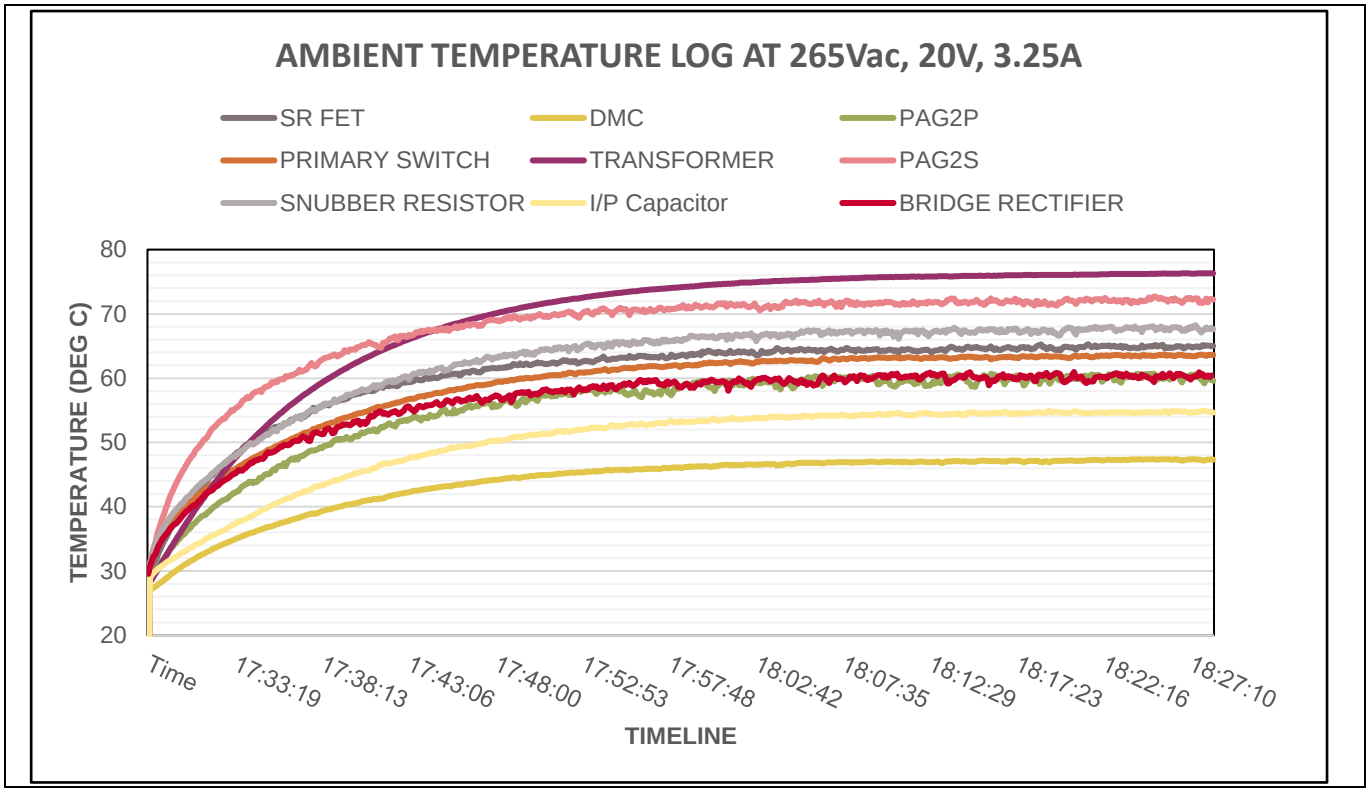


Figure 54 **Thermal data logging of various components with time at 265 Vac-63 Hz, 20 V, 3.25 A**

Table 20 **Thermal data logging of various components at the end of 60 minutes at 265 Vac-63 Hz, 20 V, 3.25 A**

Sl. No.	Component	Max temp in 24°C at the end of 60 minutes
1	Bridge rectifier – DB1	60.406
2	SR FET – Q4	64.987
3	DMC – L1	47.347
4	Transformer – T1	76.296
5	PAG2P (primary IC) – U2	59.585
6	PAG2S (secondary IC) – U3	72.21
7	Primary switch – Q3	63.589
8	Snubber resistor – R4	67.602
9	I/P capacitor (electrolytic) – C2	54.644

Power management test results

- **Test condition**: Vin_ac = 115 Vac-60 Hz, Vout = 20 V, Iout = 3.25 A
- **Lab ambient temperature**: 0°C and in open frame
- **Run time**: 60 minutes

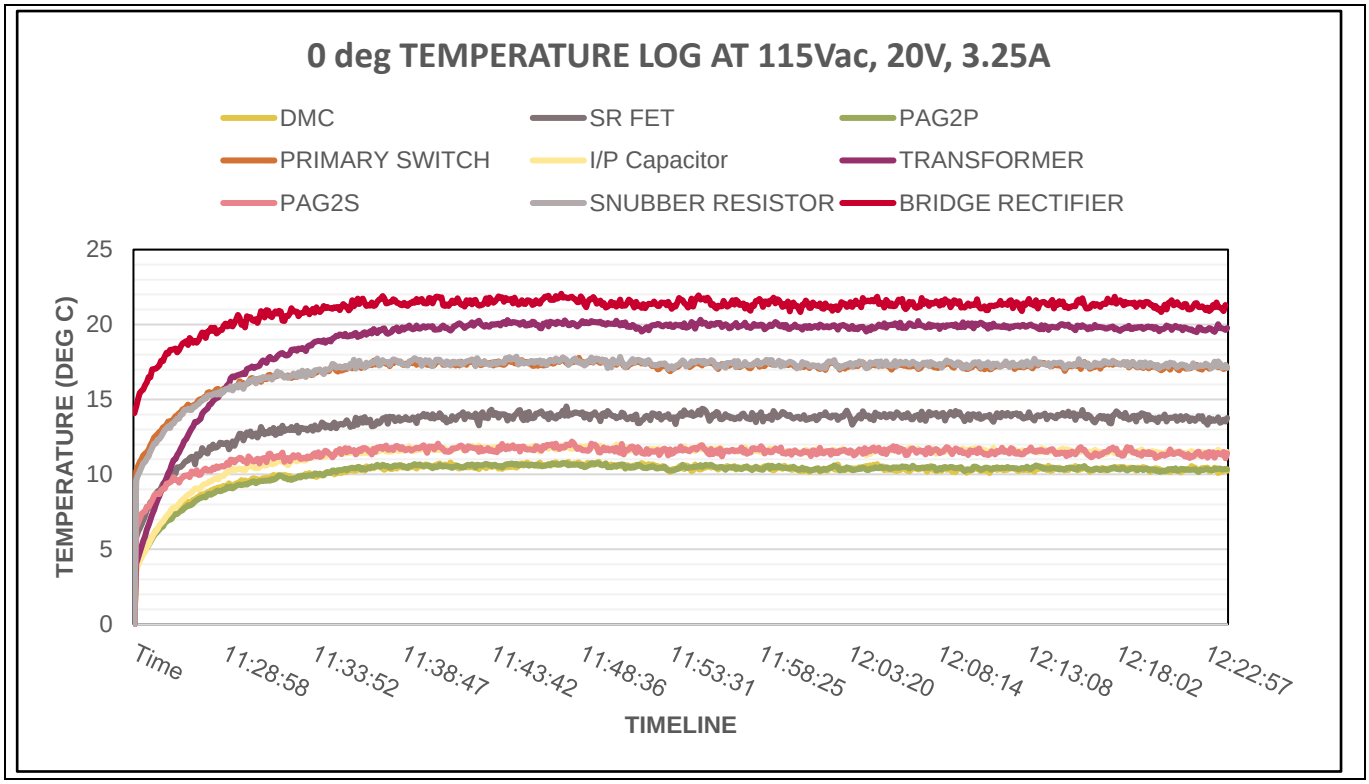


Figure 55 Thermal data logging of various components with time at 115 Vac-60 Hz, 20 V, 3.25 A

Table 21 Thermal data logging of various components at the end of 60 minutes at 115 Vac-60 Hz, 20 V, 3.25 A

Sl. No.	Component	Max temp in 0^0C at the end of 60mins
1	Bridge rectifier – DB1	21.312
2	SR FET – Q4	13.768
3	DMC – L1	10.23
4	Transformer – T1	19.763
5	PAG2P (primary IC) – U2	10.342
6	PAG2S (secondary IC) – U3	11.415
7	Primary switch – Q3	17.125
8	Snubber resistor – R4	17.127
9	I/P capacitor (electrolytic) – C2	11.504

Power management test results

- **Test condition**: Vin_ac = 230 Vac-50 Hz, Vout = 20 V, Iout = 3.25 A
- **Lab ambient temperature**: 0°C and in open frame
- **Run time**: 60 minutes

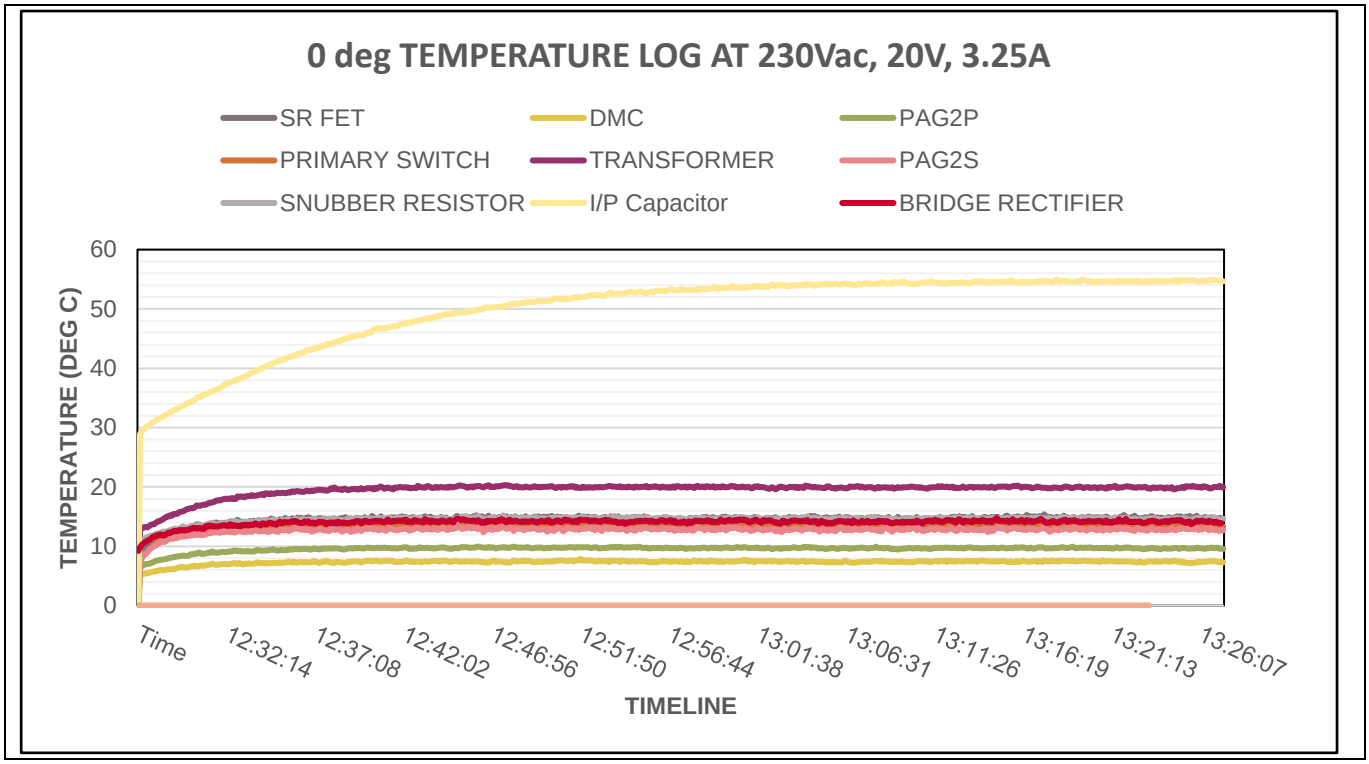


Figure 56 Thermal data logging of various components with time at 230 Vac-50 Hz, 20 V, 3.25 A

Table 22 Thermal data logging of various components at the end of 60 minutes at 230 Vac-50 Hz, 20 V, 3.25 A

Sl. No.	Component	Max temp in 0^0C at the end of 60 minutes
1	Bridge rectifier – DB1	13.942
2	SR FET – Q4	14.634
3	DMC – L1	7.297
4	Transformer – T1	19.958
5	PAG2P (primary IC) – U2	9.563
6	PAG2S (secondary IC) – U3	12.669
7	Primary switch – Q3	13.348
8	Snubber resistor – R4	14.62
9	I/P capacitor (electrolytic) – C2	54.644

Power management test results

- **Test condition:** Vin_ac = 115 Vac-60 Hz, Vout = 20 V, Iout = 3.25 A
- **Lab ambient temperature:** 50°C and in open frame
- **Run time:** 60 minutes

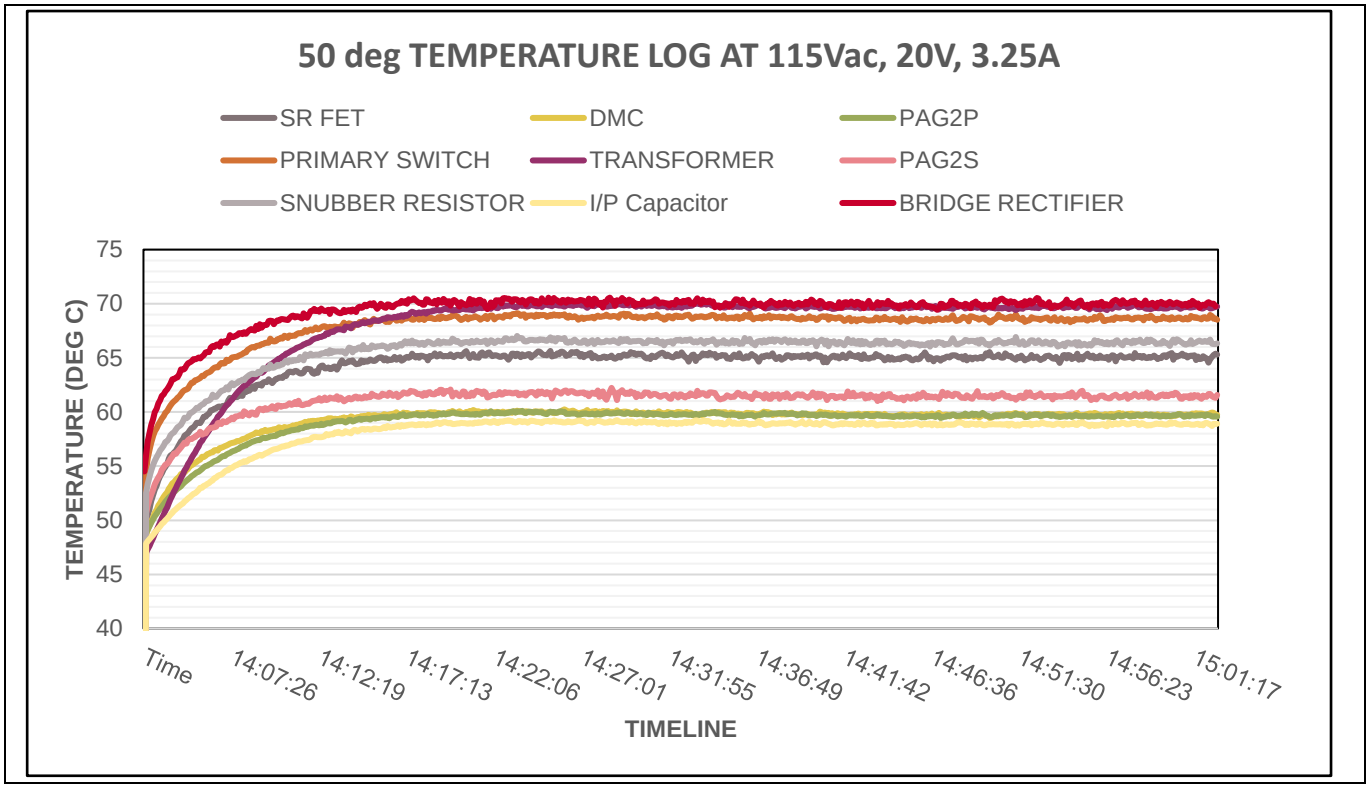


Figure 57 Thermal data logging of various components with time at 115 Vac-60 Hz, 20 V, 3.25 A

Table 23 Thermal data logging of various components at the end of 60 minutes at 115 Vac-60 Hz, 20 V, 3.25 A

Sl. No.	Component	Max temp in 50°C at the end of 60 minutes
1	Bridge rectifier – DB1	69.765
2	SR FET – Q4	65.306
3	DMC – L1	59.74
4	Transformer – T1	69.721
5	PAG2P (primary IC) – U2	59.564
6	PAG2S (secondary IC) – U3	61.578
7	Primary switch – Q3	68.522
8	Snubber resistor – R4	66.338
9	I/P capacitor (electrolytic) – C2	58.908

Power management test results

- **Test condition**: Vin_ac = 230 Vac-50 Hz, Vout = 20 V, Iout = 3.25 A
- **Lab ambient temperature**: 50°C and in open frame
- **Run time**: 60 minutes

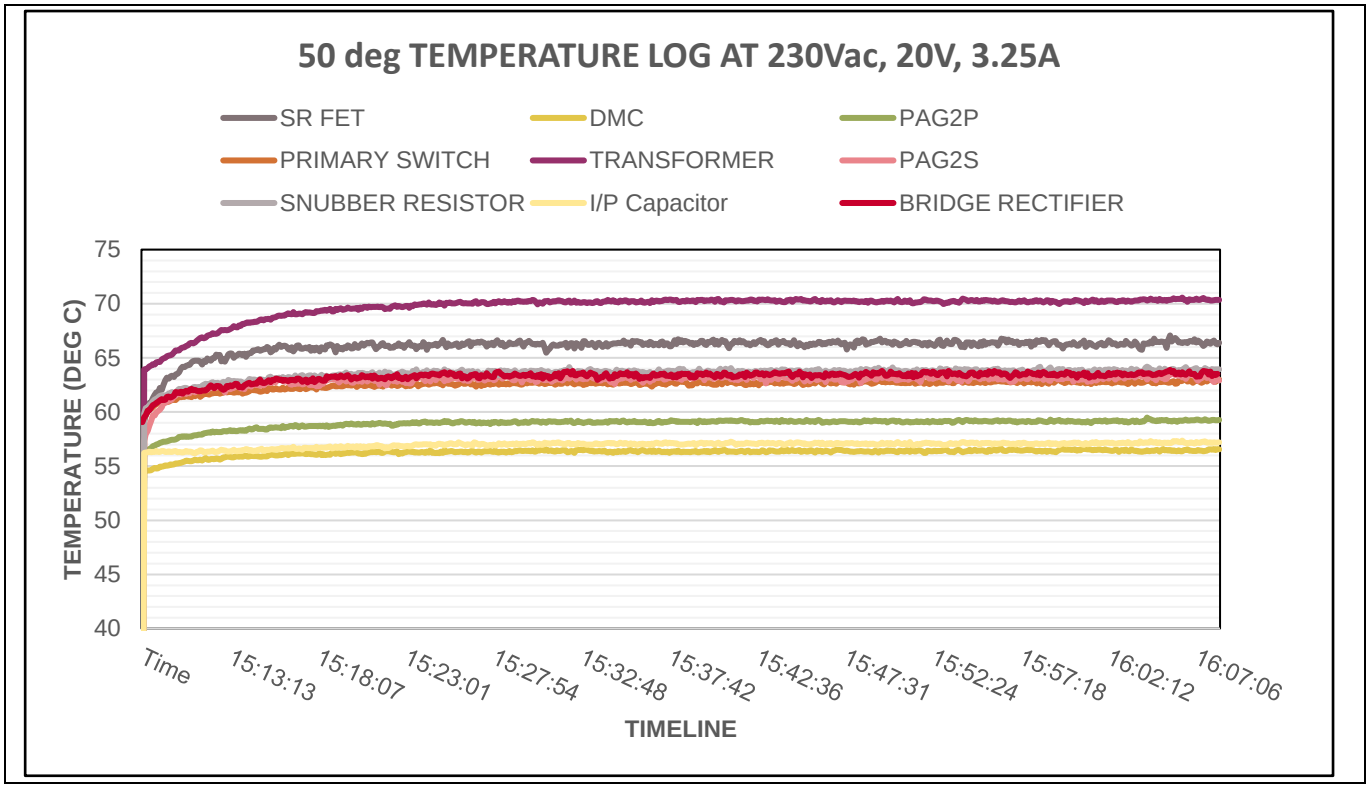


Figure 58 **Thermal data logging of various components with time at 230 Vac-50 Hz, 20 V, 3.25 A**

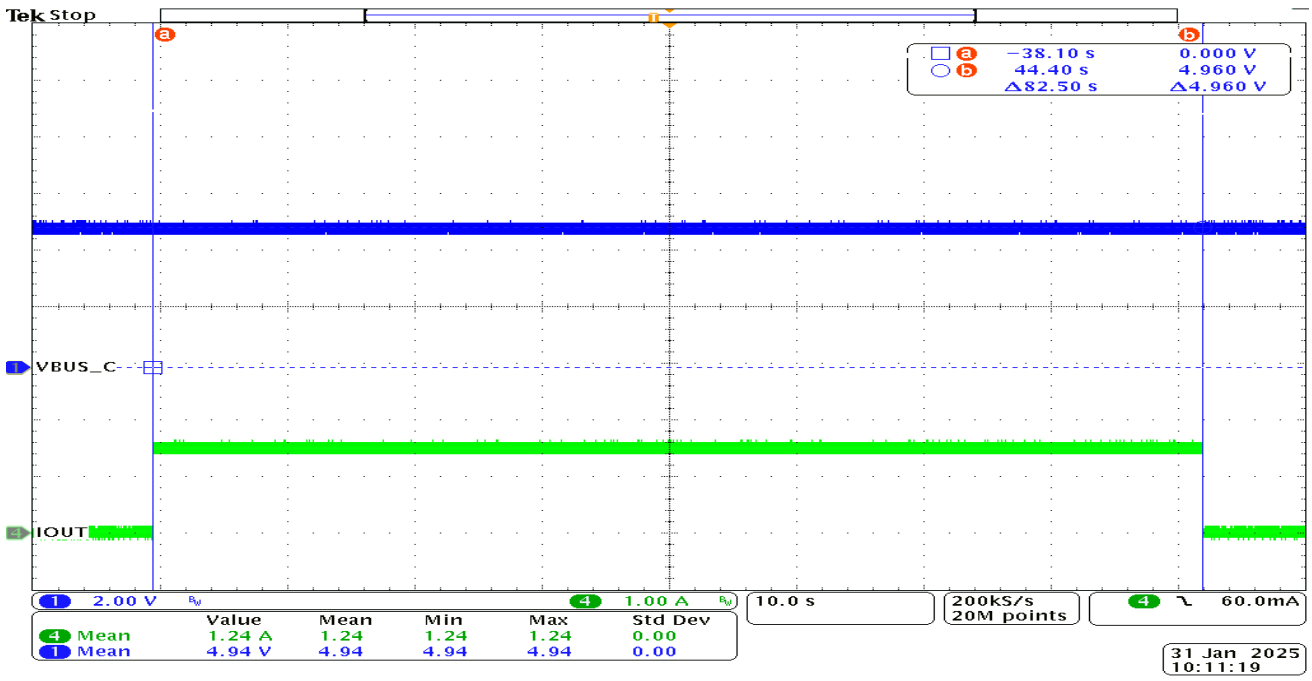
Table 24 **Thermal data logging of various components at the end of 60 minutes at 230 Vac-50 Hz, 20 V, 3.25 A**

Sl. No.	Component	Max temp in 50°C at the end of 60 minutes
1	Bridge rectifier – DB1	63.518
2	SR FET – Q4	66.406
3	DMC – L1	56.559
4	Transformer – T1	70.364
5	PAG2P (primary IC) – U2	59.258
6	PAG2S (secondary IC) – U3	62.901
7	Primary switch – Q3	62.994
8	Snubber resistor – R4	63.951
9	I/P capacitor (electrolytic) – C2	57.19

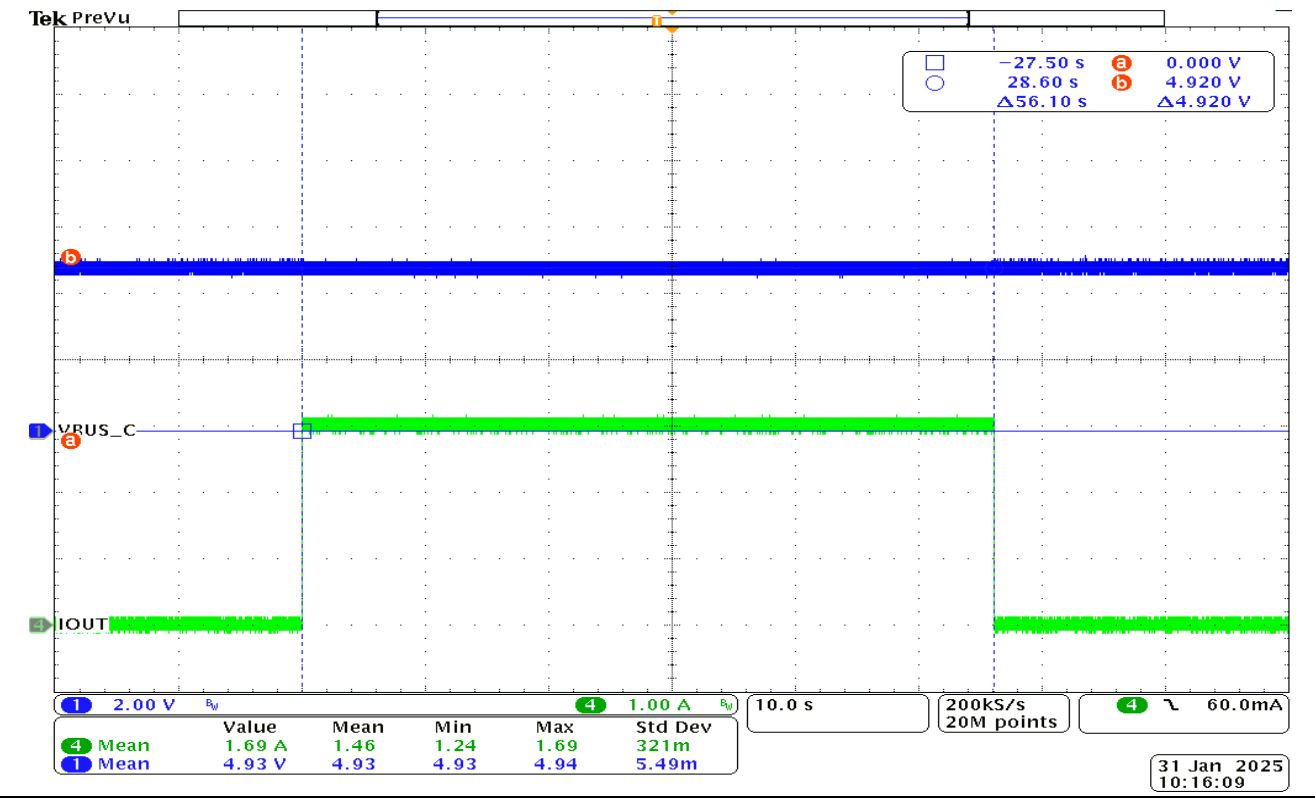
3.18 Limited power supply test (LPS)

3.18.1 LPS voltage test

Line condition: 115 Vac, 60 Hz; Output: 5 V, 1.5 A



Line condition: 115 Vac, 60 Hz; Output: 5 V, 3 A



Power management test results

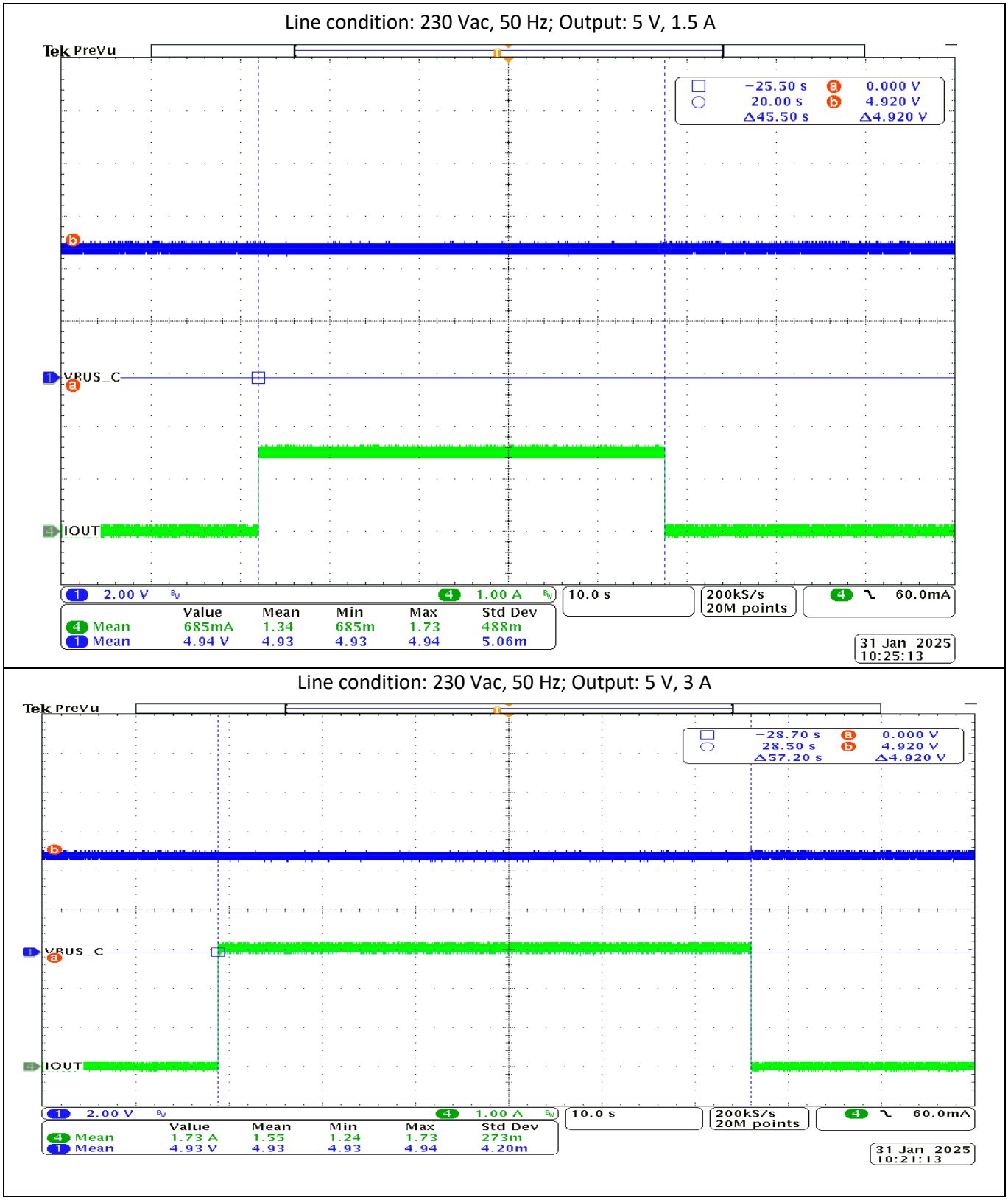


Figure 59 LPS Voltage Step at different conditions

3.18.2 LPS current test

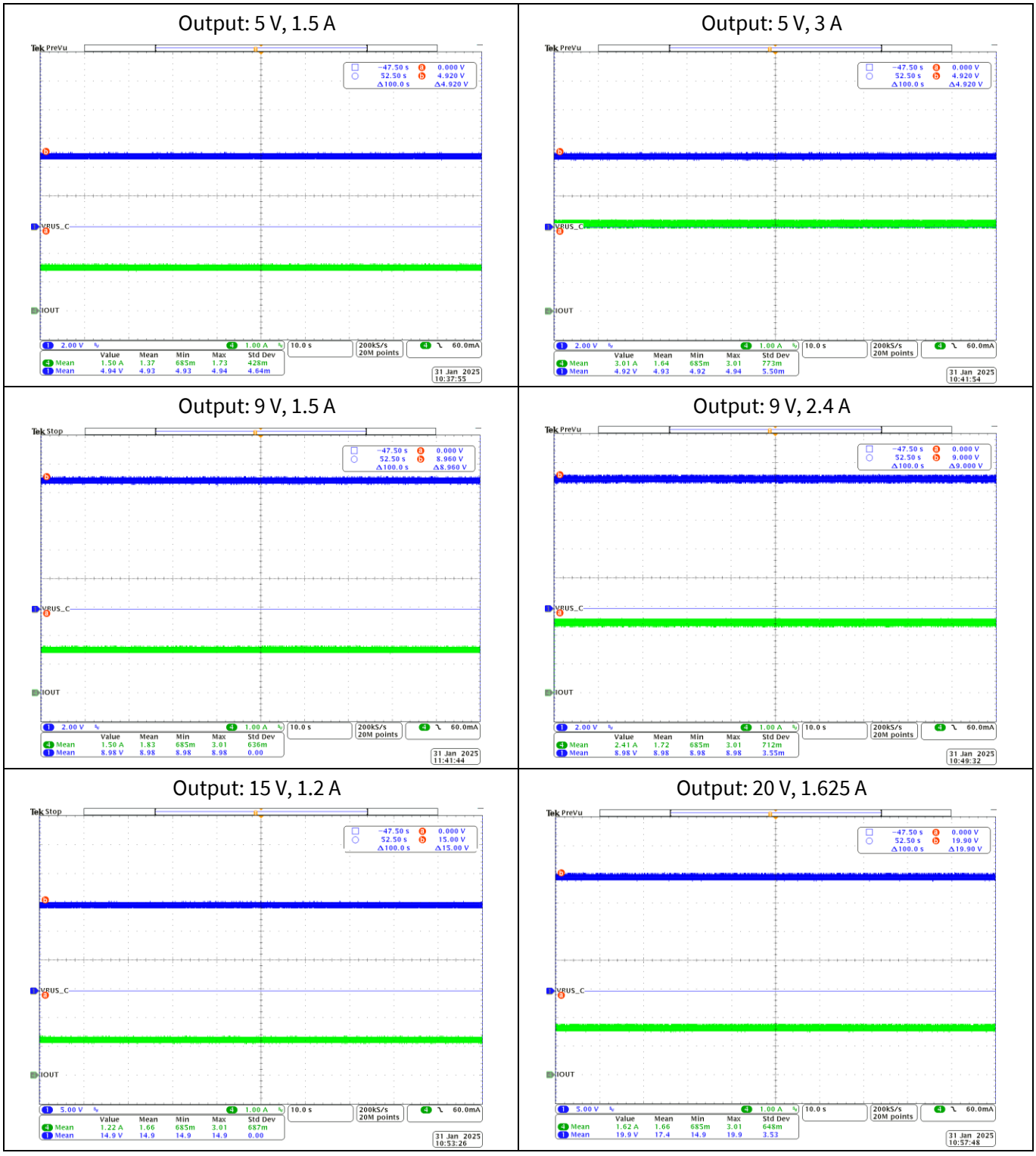
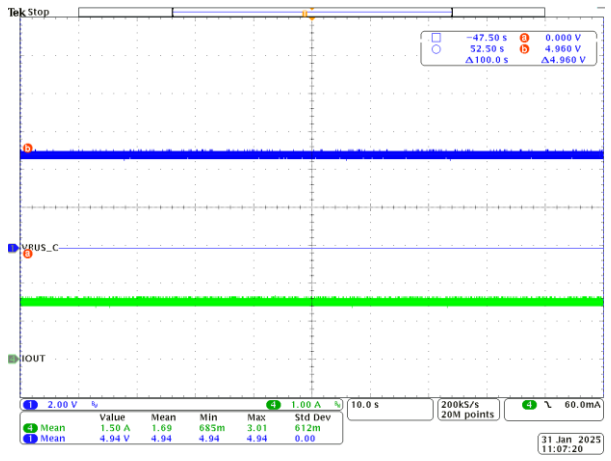


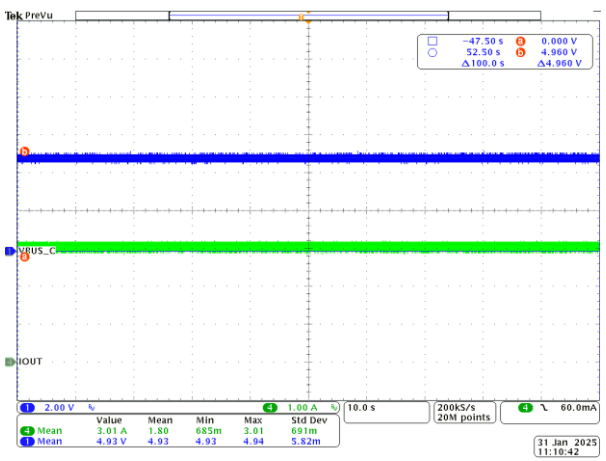
Figure 60 Line condition: 115 Vac, 60 Hz

Power management test results

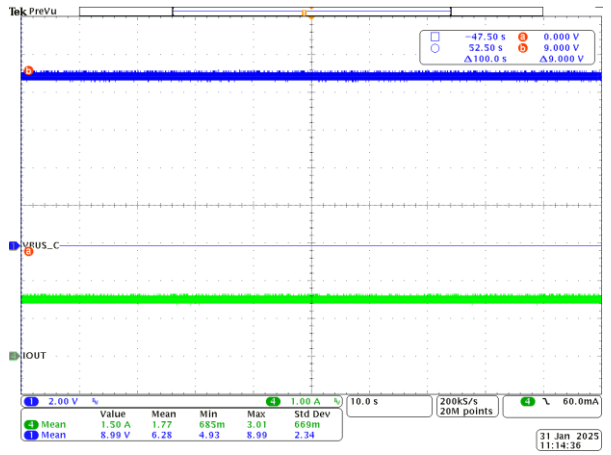
Output: 5 V, 1.5 A



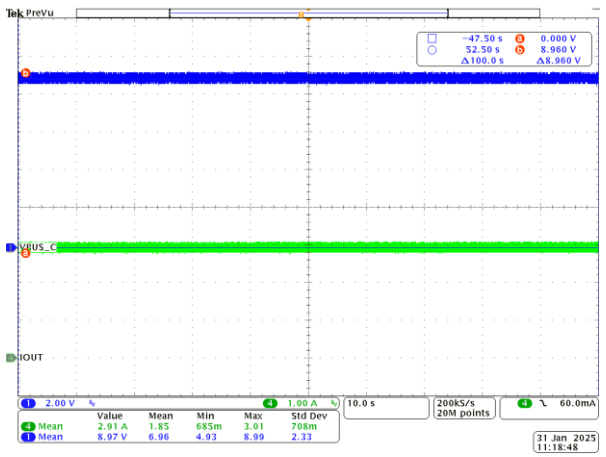
Output: 5 V, 3 A



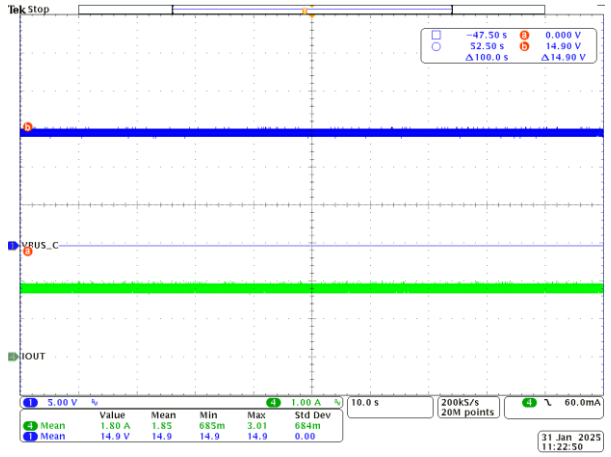
Output: 9 V, 1.5 A



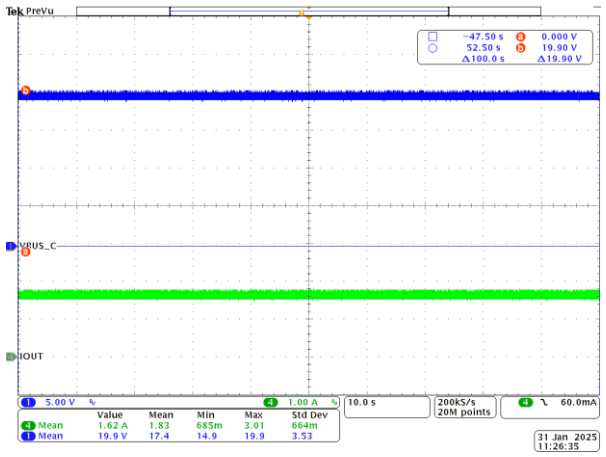
Output: 9 V, 2.9 A



Output: 15 V, 1.8 A



Output: 20 V, 1.625 A



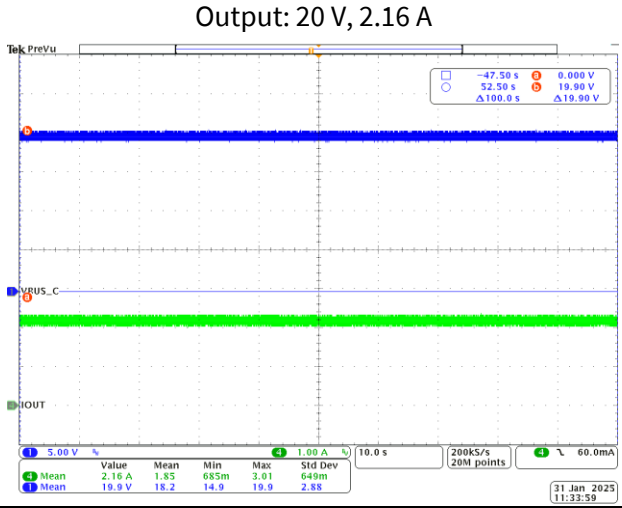


Figure 61 Line condition: 230 Vac, 50 Hz

3.19 EMI/EMC

3.19.1 Conducted emission (CE)

- **Requirements:** Class B CISPR 32, EN55032 - 4dB margin at 115/230 Vac
- **Remarks:** The CE results are captured on 3 different boards to ensure repeatability and consistency in results

A reference picture is shown in Figure 62.

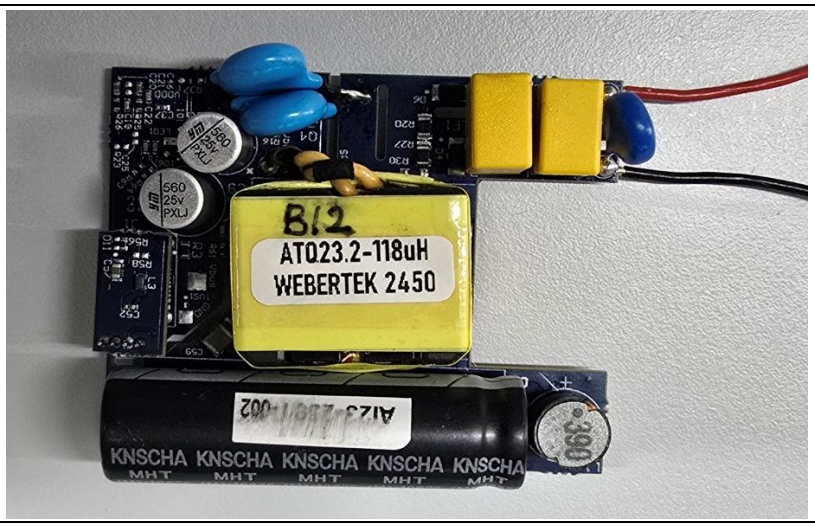


Figure 62 DUT image for CE setup

Power management test results

Conducted emission L1 at 230 Vac 50 Hz.

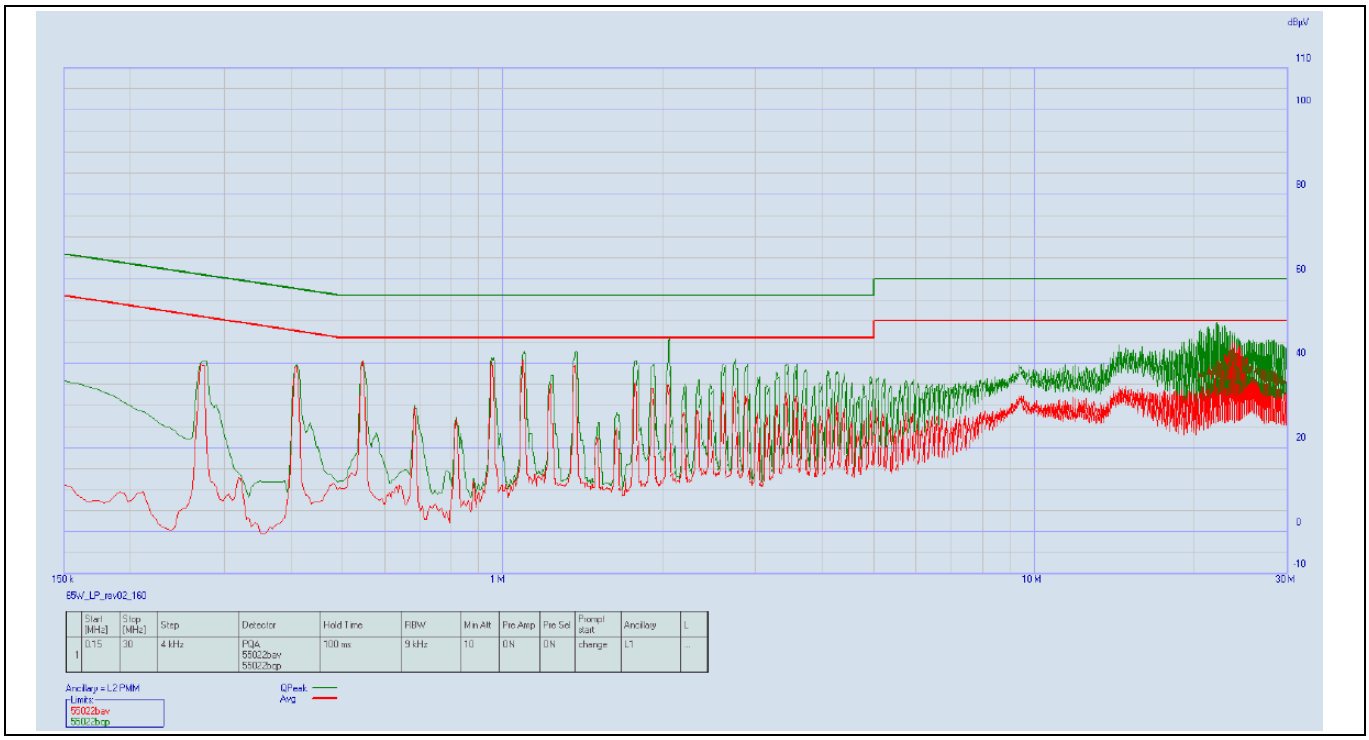


Figure 63 CE at 230 Vac 20 V full load with trace L1

```
65W_LP_rev02_160 29-01-2025 12:02:10
Rel. SW 2.37 (June 2019)
Rel. FW 2.64 23/08/18
Margin: 6 dB
```

	Frequency [MHz]	Avg [dBµV]	Limit 55022bav [dBµV]	Delta [dB]	QPeak [dBµV]	Limit 55022bqp [dBµV]	Delta [dB]
1	0.546	40.54	46.00	-5.46	40.68	56.00	---
2	0.954	40.63	46.00	-5.37	41.34	56.00	---
3	1.09	40.65	46.00	-5.35	41.73	56.00	---
4	1.094	40.79	46.00	-5.21	42.07	56.00	---
5	23.454	45.04	50.00	-4.96	46.32	60.00	---
6	23.59	44.89	50.00	-5.11	46.00	60.00	---
7	23.726	44.03	50.00	-5.97	45.37	60.00	---
8	24.138	44.05	50.00	-5.95	45.22	60.00	---

Figure 64 Frequencies and margin for CE at 230 Vac with trace L1

Average: ~5 dB pass; QP: >5 dB pass

Power management test results

Conducted emission L2 at 230 Vac 50 Hz.

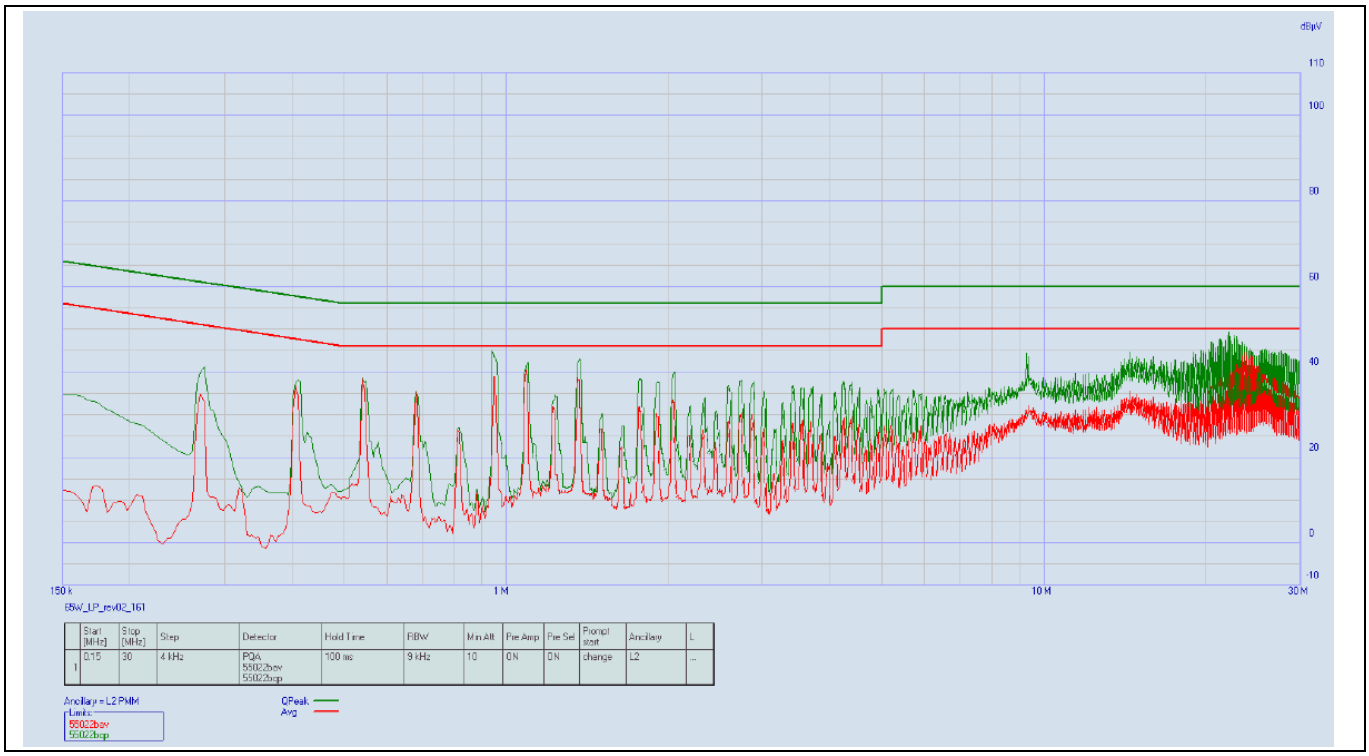


Figure 65 CE at 230 Vac 20 V full load with trace L2

```
65W_LP_rev02_161 29-01-2025 12:16:57
Rel. SW 2.37 (June 2019)
Rel. FW 2.64 23/08/18
Margin: 6 dB

     Frequency    Avg          Limit        Delta        QPeak        Limit        Delta
                               55022bav                              55022bqp
     [MHz]        [dBµV]       [dBµV]       [dB]         [dBµV]       [dBµV]       [dB]

   1  1.086          40.33        46.00        -5.67        41.29        56.00         ---
   2 23.45           44.68        50.00        -5.32        45.73        60.00         ---
   3 23.582          44.25        50.00        -5.75        45.26        60.00         ---
```

Figure 66 Frequencies and margin for CE at 230 Vac with trace L2

Average: ~5 dB pass; QP: >5 dB pass

Power management test results

Conducted emission L1 at 115 Vac 50 Hz.

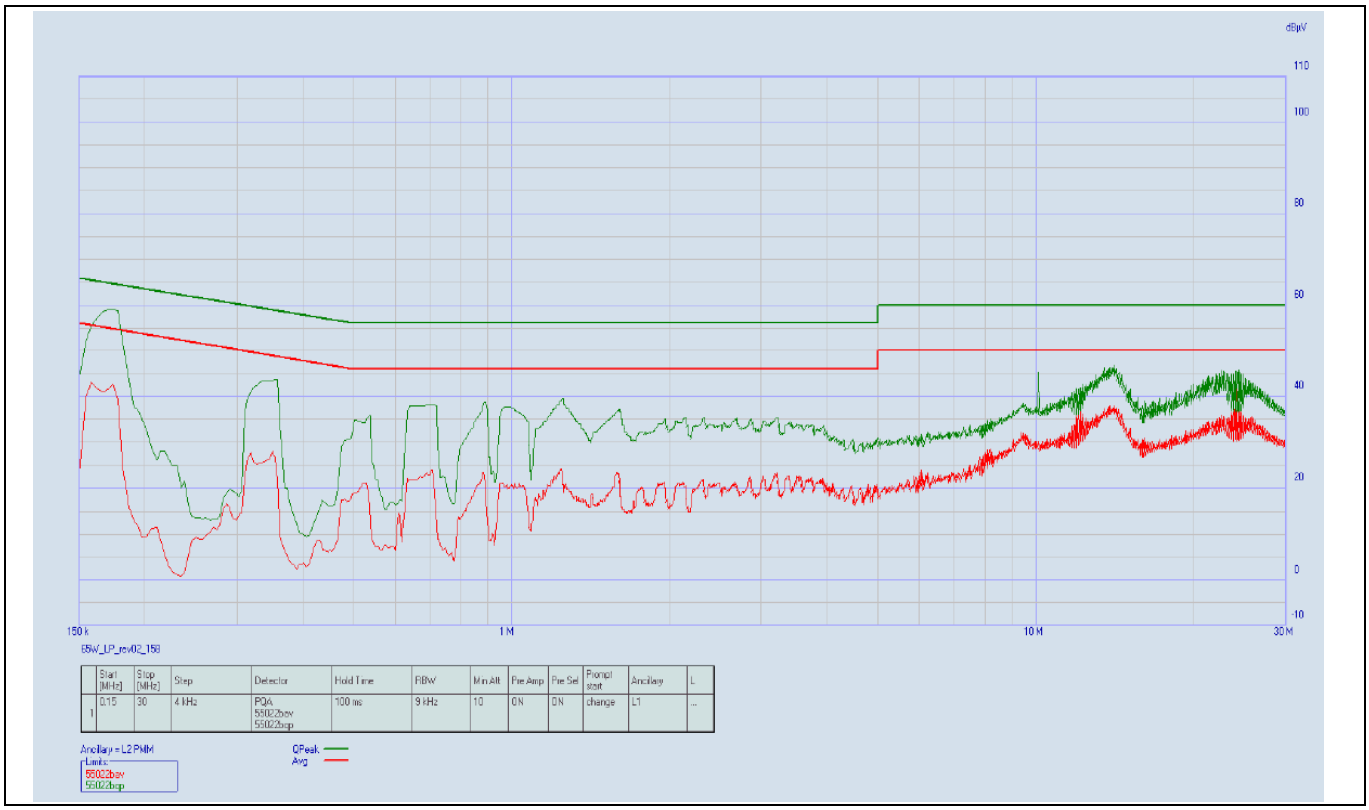


Figure 67 CE at 115 Vac 20 V full load with trace L1

```
65W_LP_rev02_158 29-01-2025 11:30:43
Rel. SW 2.37 (June 2019)
Rel. FW 2.64 23/08/18
Margin: 7 dB

     Frequency    Avg          Limit        Delta        QPeak        Limit        Delta
                               55022bav                              55022bqp
     [MHz]        [dBµV]       [dBµV]       [dB]         [dBµV]       [dBµV]       [dB]

1    0.166          41.02        55.16        ---          58.55        65.16       -6.61
2    0.17           41.52        54.96        ---          59.01        64.96       -5.95
3    0.174          42.80        54.77        ---          58.95        64.77       -5.82
4    0.178          39.28        54.58        ---          58.72        64.58       -5.86
```

Figure 68 Frequencies and margin for CE at 115 Vac with trace L1

Average: >5 dB pass; QP: ~6 dB pass

Power management test results

Conducted emission L2 at 115 Vac 50 Hz.

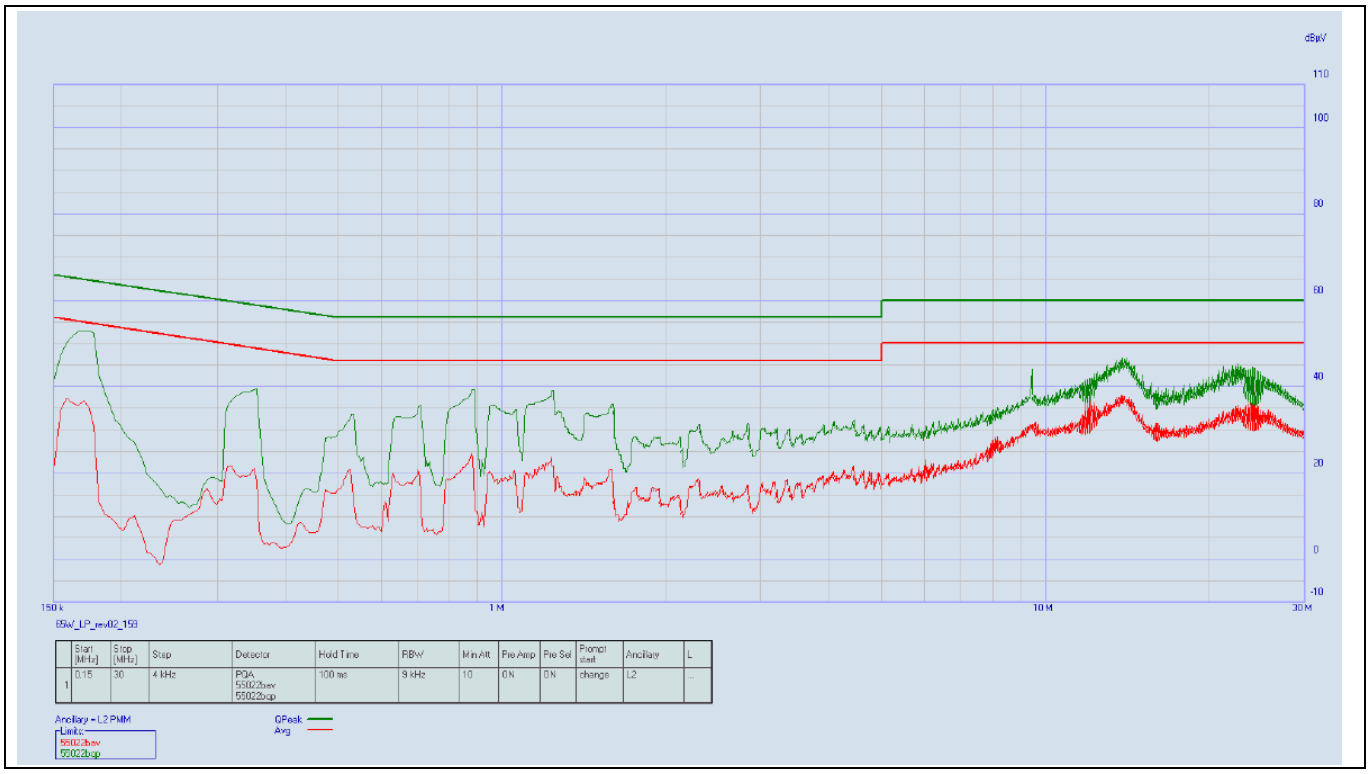


Figure 69 CE at 115 Vac 20 V full load with trace L2

```
65W_LP_rev02_159 29-01-2025 11:46:18
Rel. SW 2.37 (June 2019)
Rel. FW 2.64 23/08/18
Margin: 10 dB

     Frequency    Avg          Limit        Delta        QPeak        Limit        Delta
                               55022bav                               55022bqp
     [MHz]        [dBµV]       [dBµV]       [dB]         [dBµV]       [dBµV]       [dB]

   1 24.01          40.29        50.00         -9.71        41.77        60.00         ---
   2 24.014         40.48        50.00         -9.52        42.96        60.00         ---
```

Figure 70 Frequencies and margin for CE at 115 Vac with trace L2

Average: >5 dB pass; QP: >6 dB pass

3.19.2 Surge

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

The surge set-up was modified to prevent coupling between the DMC and electrolytic capacitor. It was observed that without this rework the Vds across the primary FET crosses 700 V which can cause a failure.

During debug it was observed that providing this **EMI absorber sheet from Würth Elektronik (P/N: 30403S)** between DMC and capacitor terminals, placing the DMC slightly away (and higher) from the capacitor terminals and providing copper shield on the exposed leads of DMC help pass surge of +/- 1 kV. The DUT is shown in Figure 71.

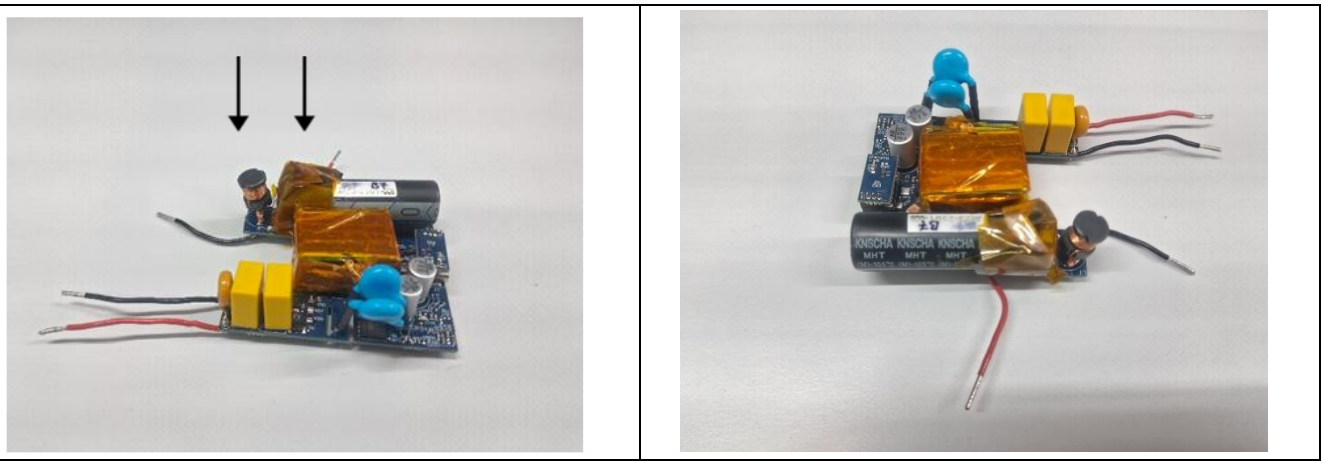


Figure 71 Device set-up for surge test

Test condition:

- Vac: 230 Vac, 50 Hz, Vo = 20 V, Io = 3.25 A
- **Combination wave surge:** ±1 kV DM at 0°, 90° and 270° - 5 pulses each with 60 s interval between pulses

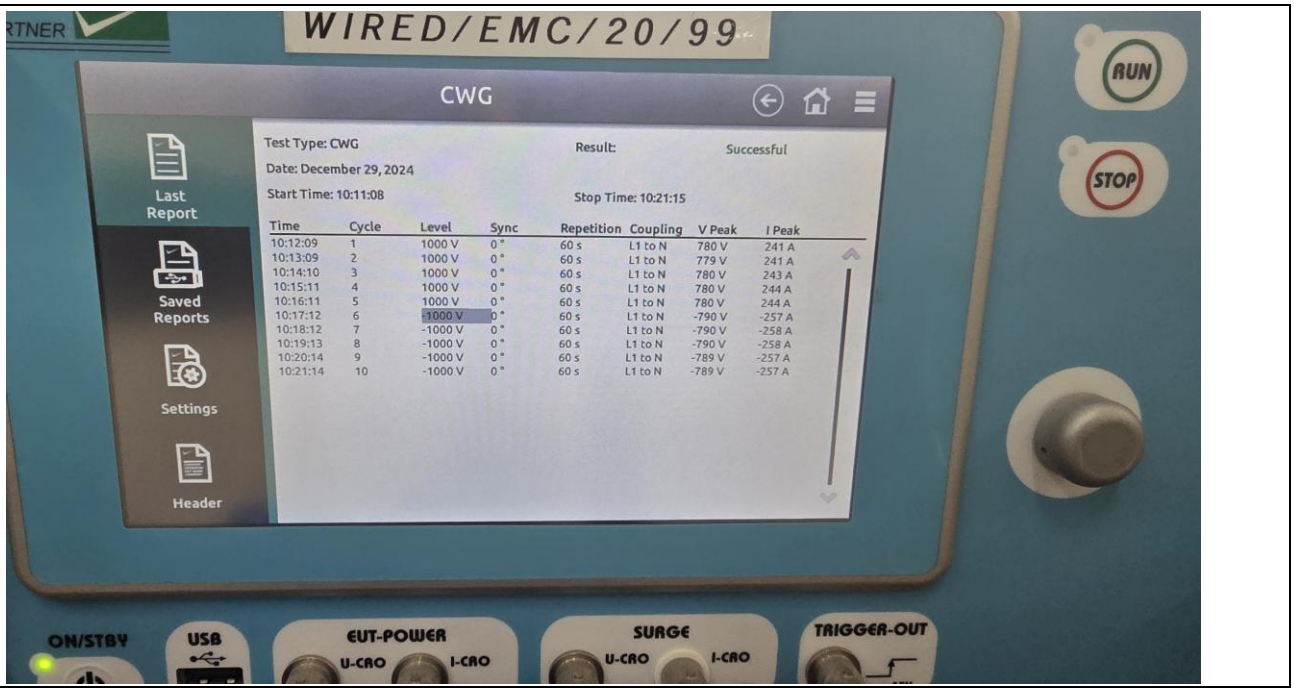


Figure 72 Surge test report for ±1 kV DM at 0°

Power management test results

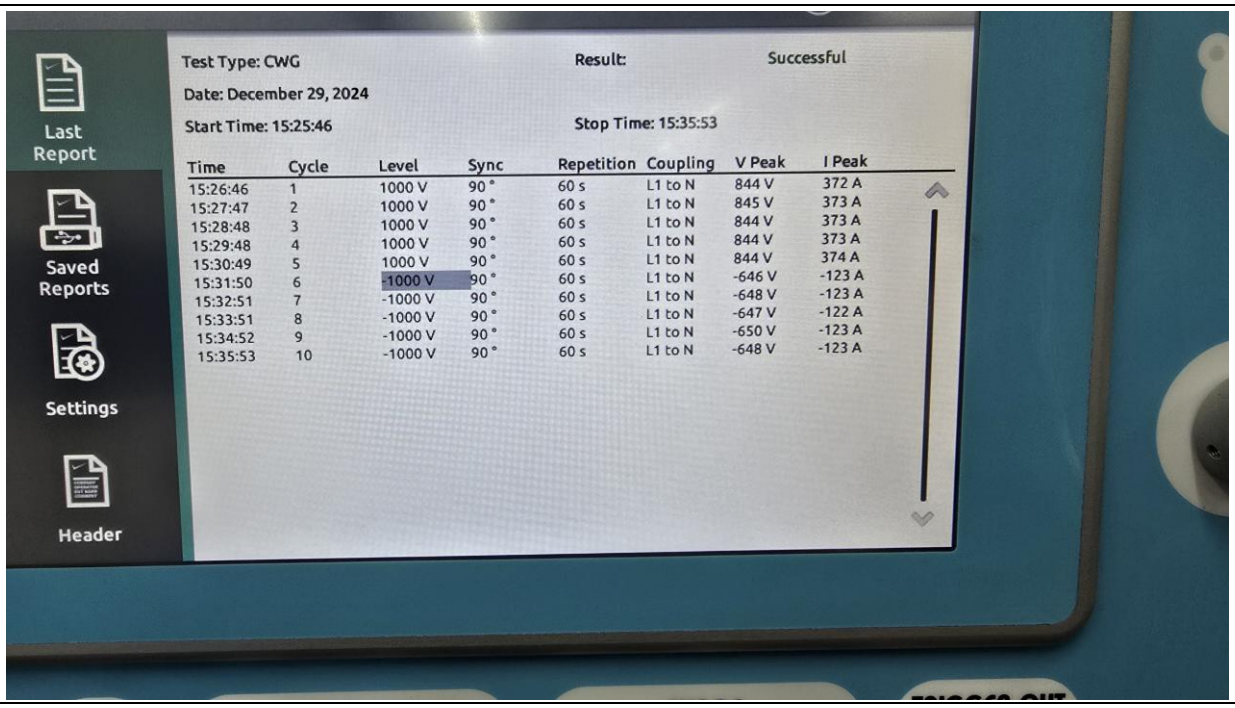


Figure 73 Surge test report for ±1 kV DM at 90°

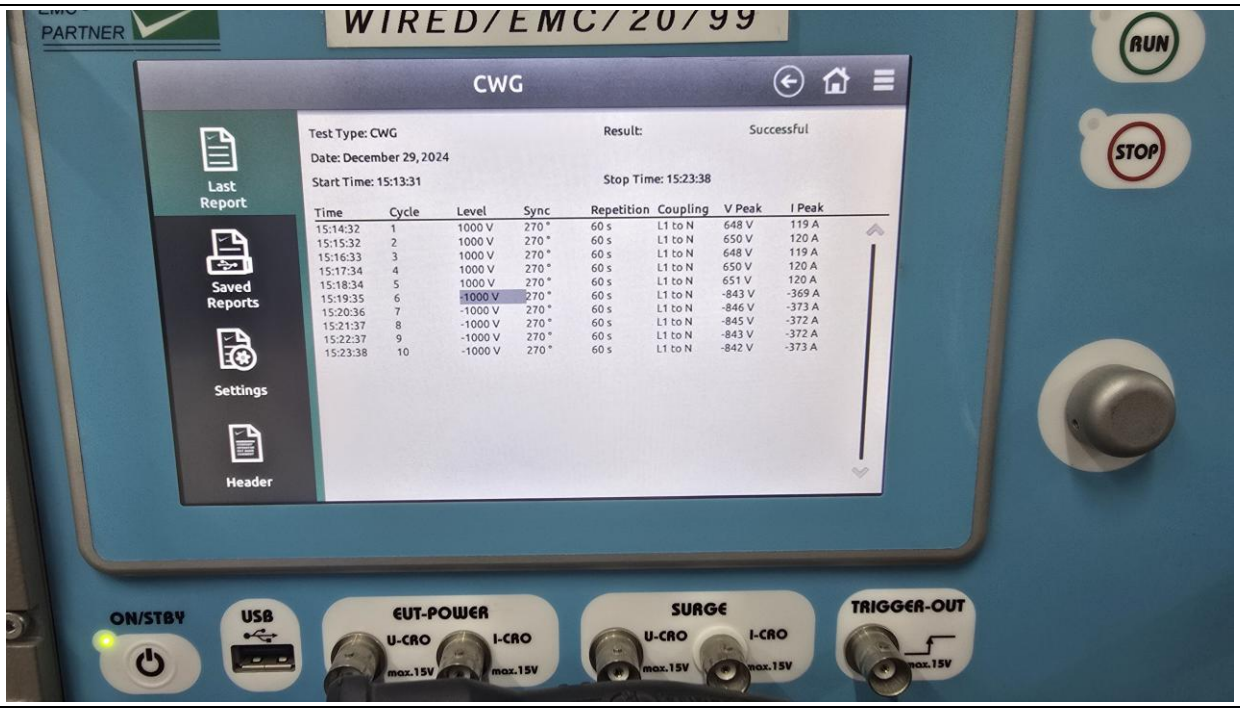


Figure 74 Surge test report for ±1 kV DM at 270°

3.19.3 ESD

Requirements: IEC61000-4-2 level 4; ± 8 kV contact, ±15 kV air, criteria A

Test condition:

- Indirect contact discharge
  - **Input:** 230 Vac, 50 Hz
  - **Output:** Vo = 20 V, Io = 3.25 A
  - **Indirect contact discharge:** 10 pulses each of +/-8 kV, vertical and horizontal plane tested in all orientations



Figure 75 Device set-up for ESD test

- Air discharge

As per IEC61000-4-2, air discharge is applicable where contact discharge test is not possible. This test was performed in TUV laboratory, and it was evident that the passing of air discharge test is greatly dependent on multiple factors such as type and material of enclosure, potting material used, thickness of enclosure, conformal coating on the board, etc,. The test image of the setup is shown in Figure 76. The board passed +/- 15 kV air discharge at 20 V, 3.25 A output.

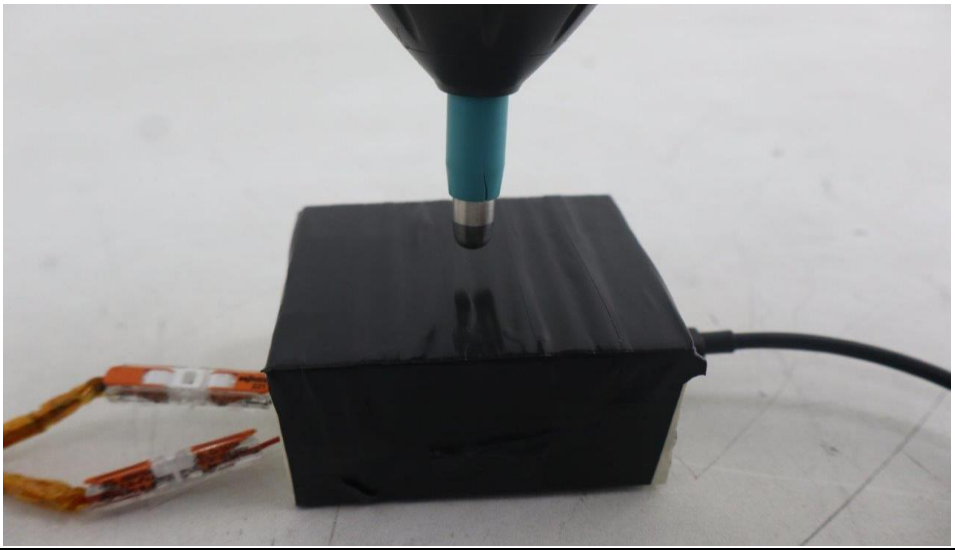
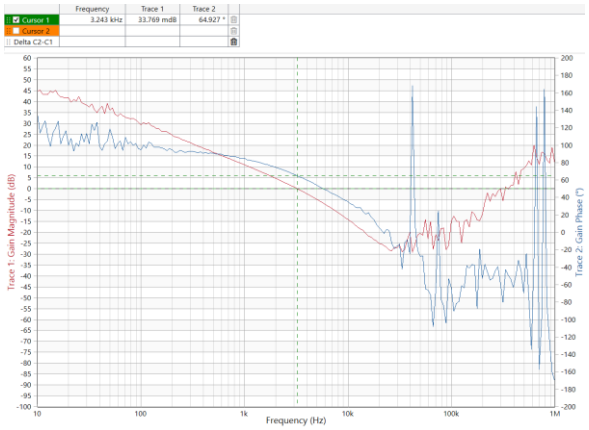


Figure 76 Setup image for air discharge

3.20 Bode stability

PDO: 5 V, 3 A



PDO: 20 V, 3.25 A

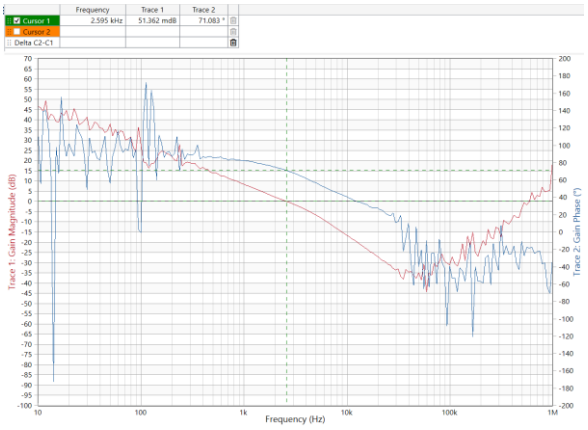
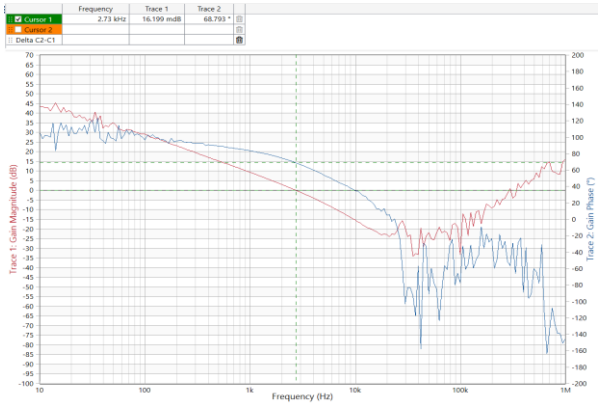


Figure 77 Loop stability at 115 Vac, 60 Hz

PDO: 5V, 3A



PDO: 20 V, 3.25 A

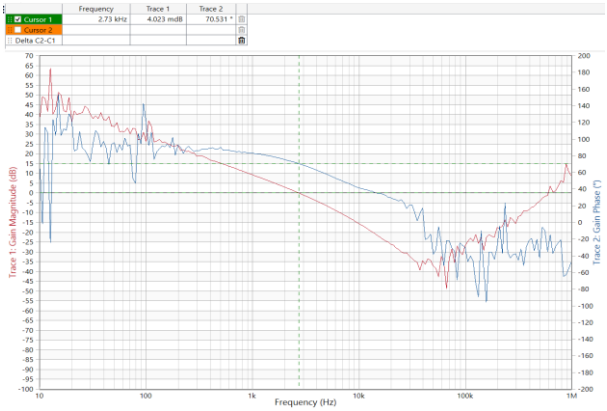


Figure 78 Loop stability at 230 Vac, 50 Hz

Power management test results

Table 25 Loop stability data for all output conditions

Vin	Vout	Load current	Cross over frequency (Hz)	Phase margin
115 Vac	5 V	3 A	3.243 k	64.927
	9 V	3 A	3.083 k	67.215
	15 V	3 A	2.991 k	68.113
	20 V	3.25 A	2.595 k	71.083
	5 V	0.6 A	1.412 k	78.294
	9 V	0.6 A	1.188 k	79.976
	15 V	0.6 A	989.91	80.829
	20 V	0.65 A	912.75	82.288
230 Vac	5 V	3 A	2.73 k	68.793
	9 V	3 A	2.73 k	70.003
	15 V	3 A	2.786 k	70.008
	20 V	3.25 A	2.73 k	70.531
	5 V	0.6 A	1.455 k	78.588
	9 V	0.6 A	1.2 k	80.25
	15 V	0.6 A	1.031 k	81.153
	20 V	0.65 A	894.42	82.174

3.21 Maximum input current in steady state

Vout = 20 V, Iout = 3.25 A

Input rms current (from power meter) = 1.276 A, Input peak current = 6.5 A

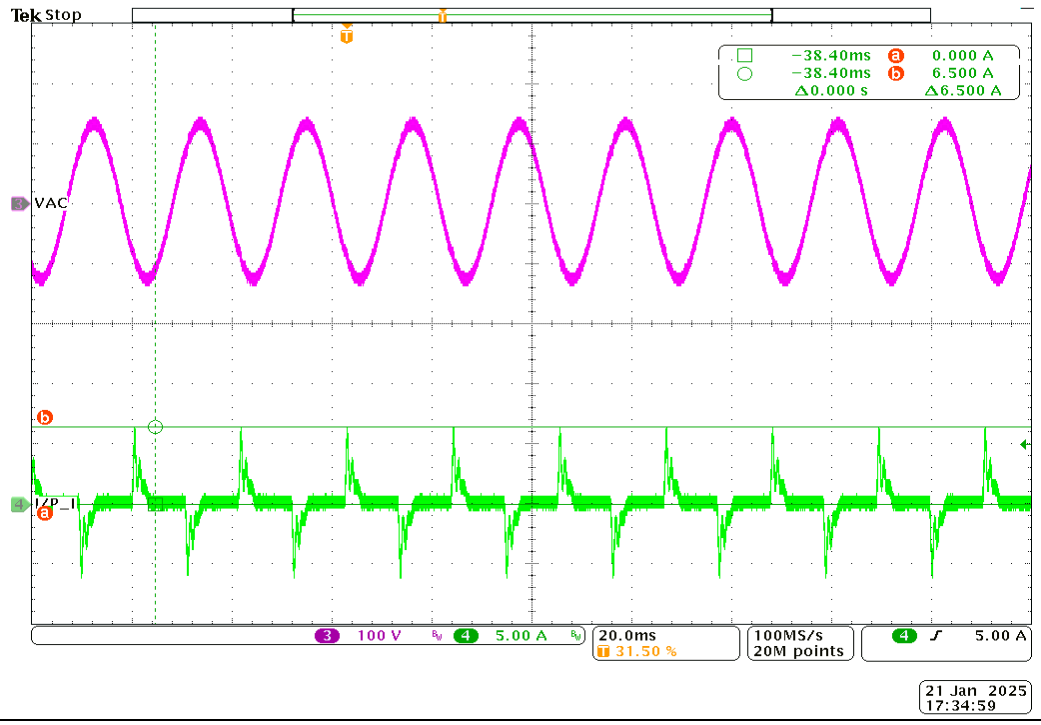


Figure 79 Input current at steady state, 90 Vac, 47 Hz (CH3: Vac, CH4: Ia

3.22 Inrush current at cold start

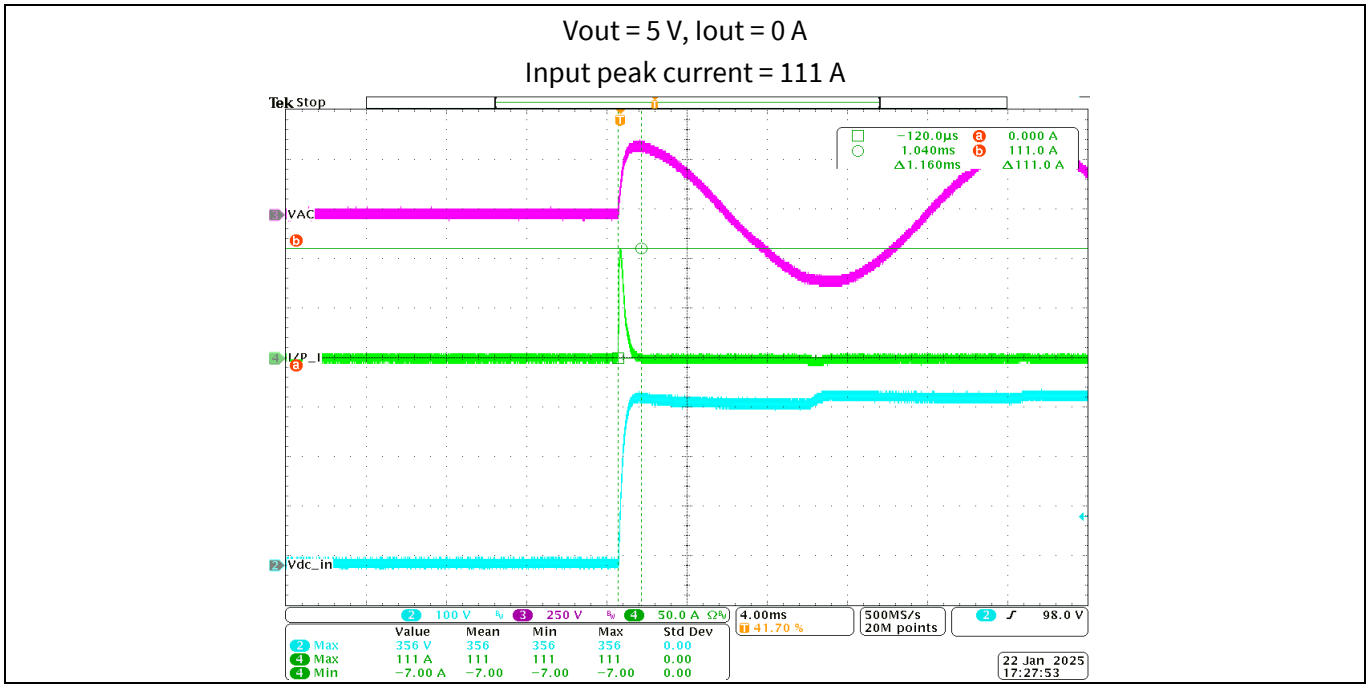


Figure 80 Inrush current at cold start 230 Vac, 50 Hz (CH2: Vdc_in CH3: Vac, CH4: Iac)

3.23 Capacitive hot-plug

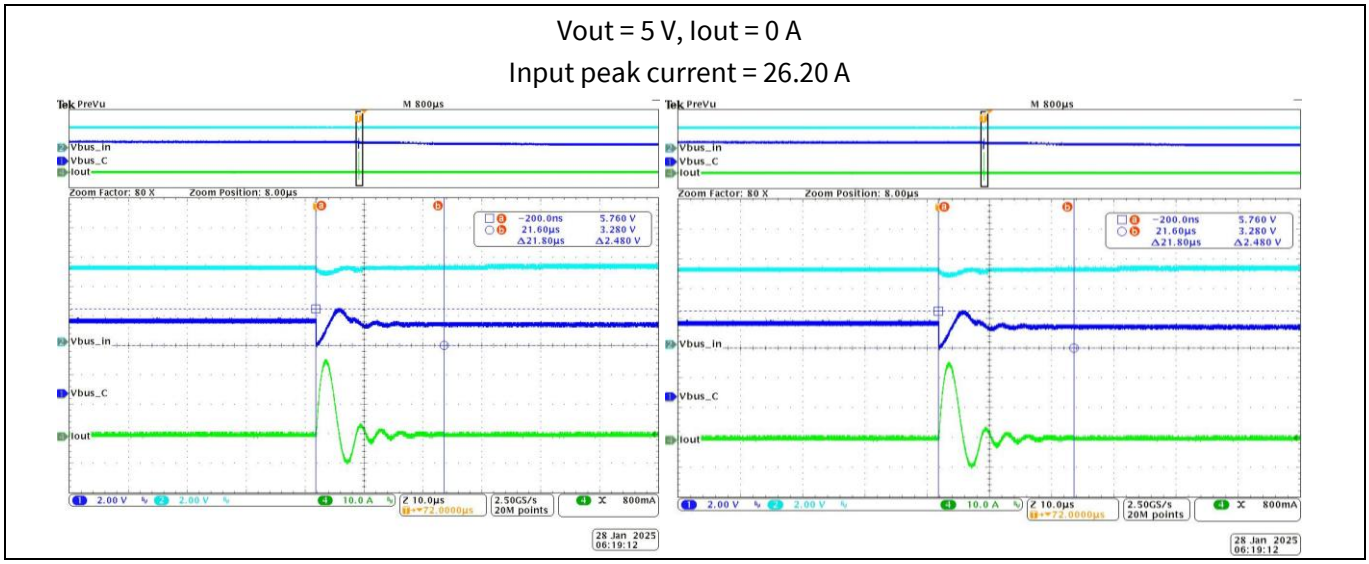


Figure 81 Capacitive hot-plug 115 Vac, 60 Hz (CH1: Vbus_C, CH2: Vbus_in, CH4: Iout)

3.24 Brownout recovery

Table 26 Brownout data

Test condition	Result	
Vo = 5 Vdc, Io = 0 A (No load)	UVLO falling	76.0 Vac
	UVLO rising	77.1 Vac
Vo = 20 Vdc, Io = 3.25 A (Full load)	UVLO falling	75.0 Vac
	UVLO rising	77.4 Vac

3.25 X-Cap discharge

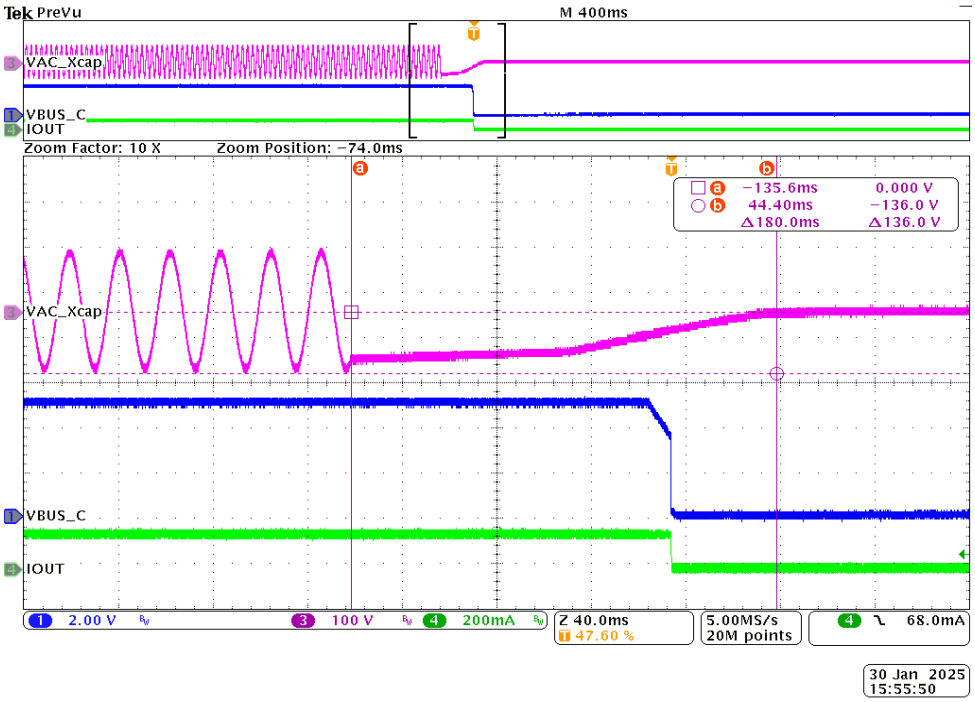


Figure 82 X-cap discharge at 90 Vac, 47 Hz (CH1: Vbus_C, CH3: Vac, CH4: Iout)

Power management test results

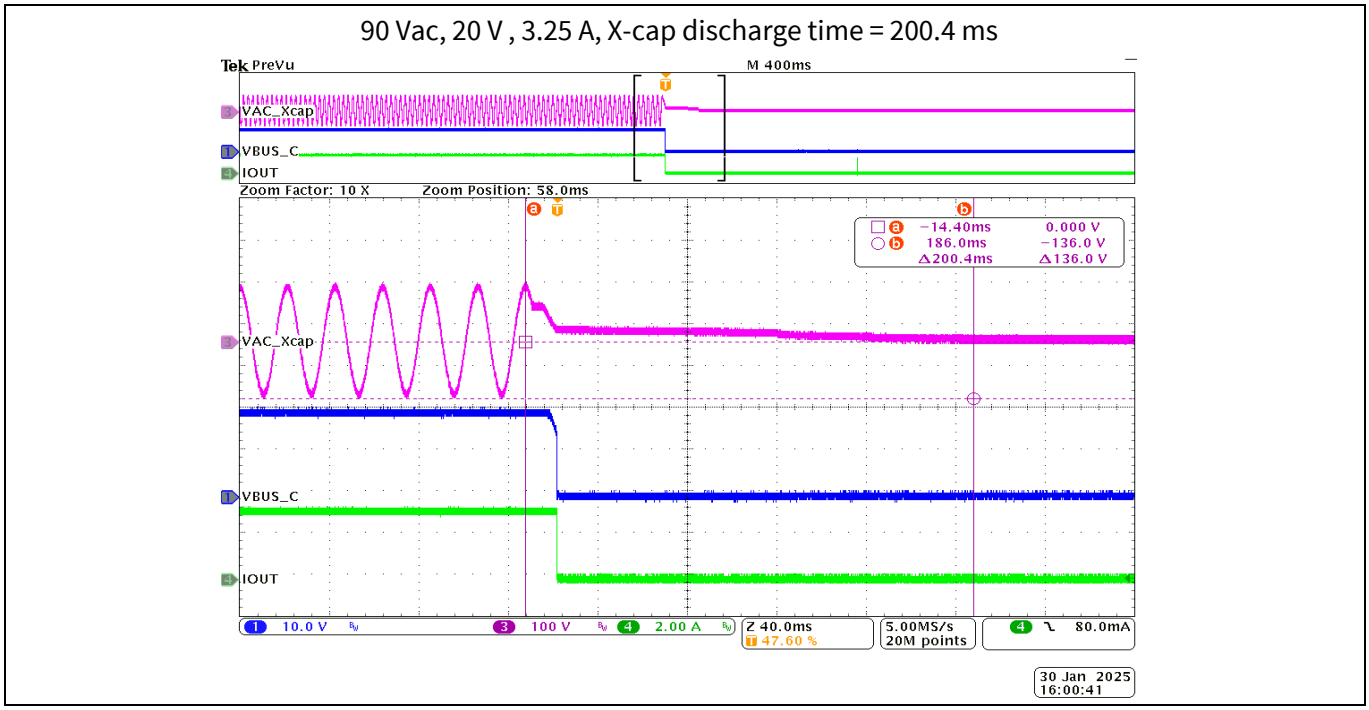


Figure 83 X-cap discharge at 265 Vac, 63 Hz (CH1: Vbus_C, CH3: Vac, CH4: Iout)

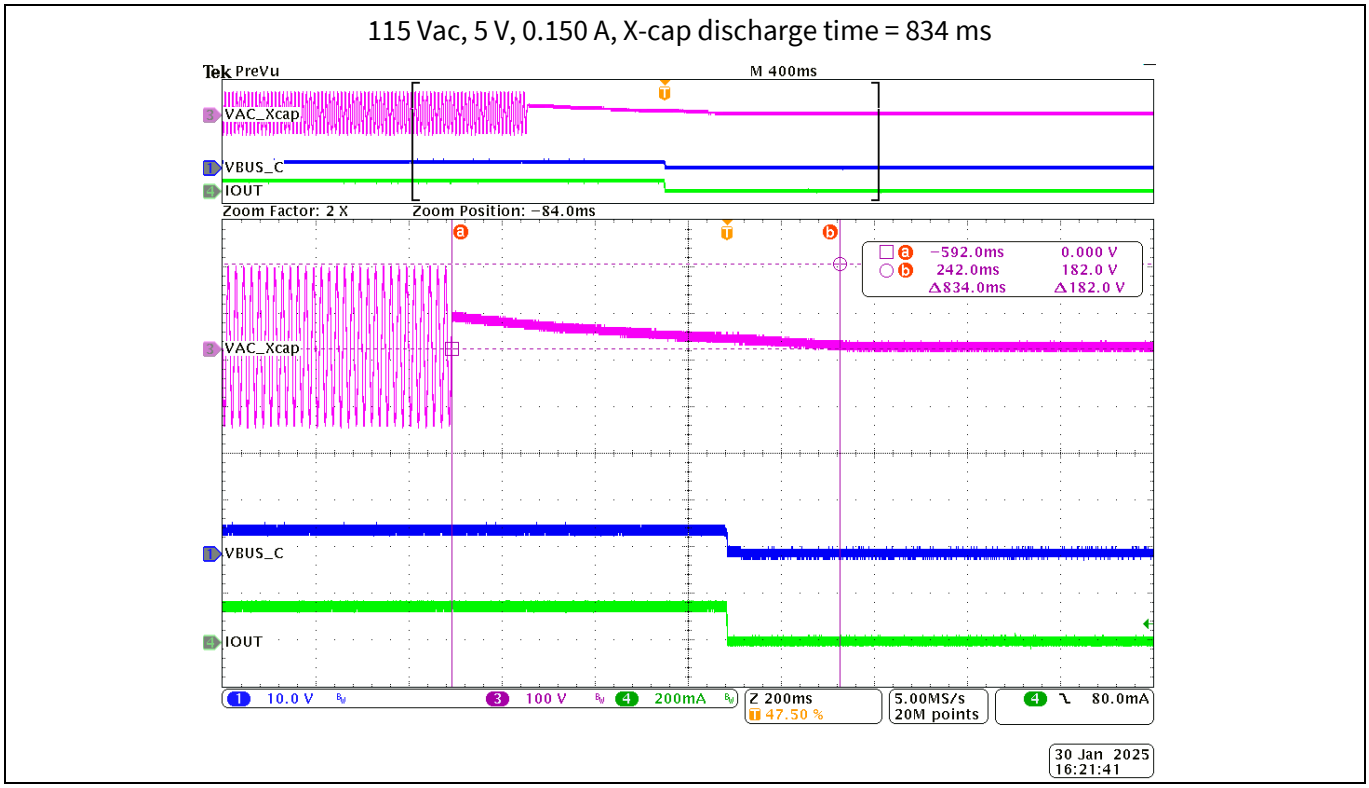


Figure 84 X-cap discharge at 115 Vac, 60 Hz (CH1: Vbus_C, CH3: Vac, CH4: Iout)

Power management test results

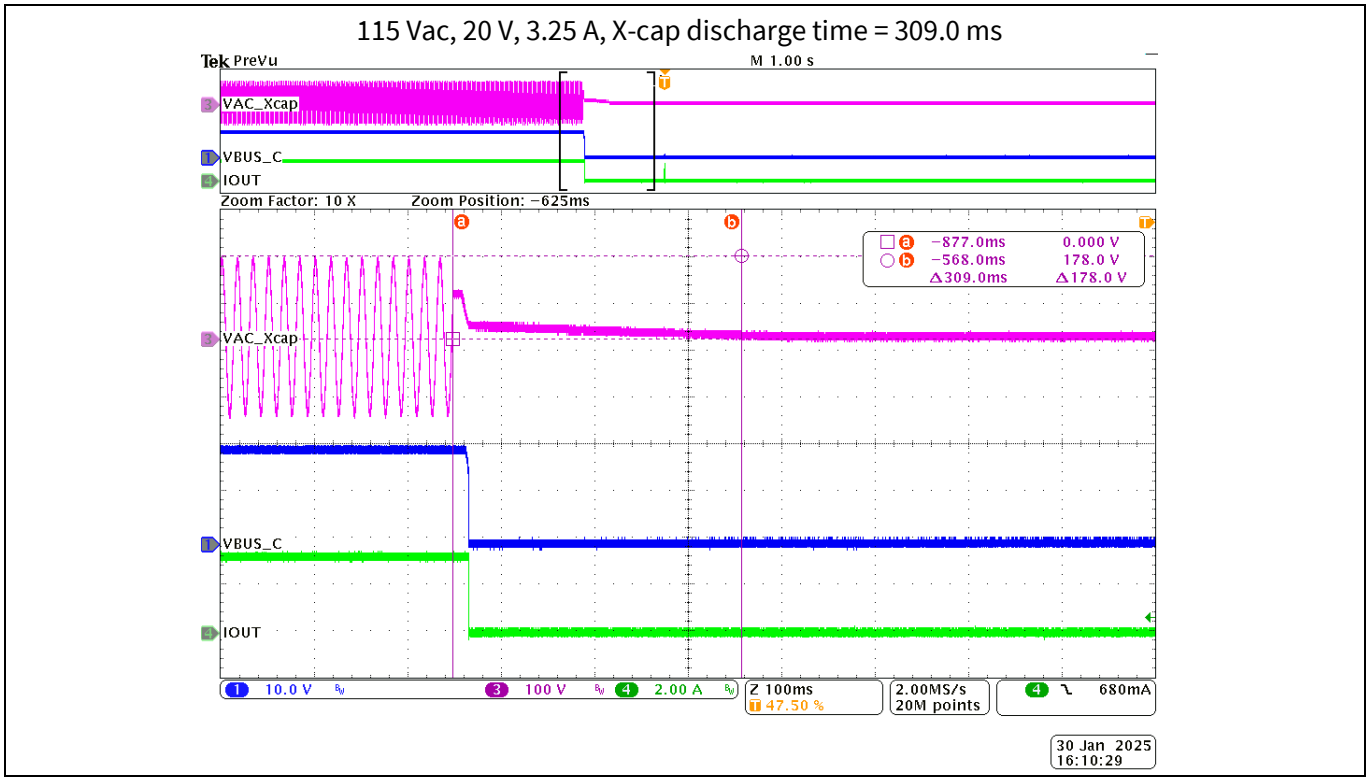


Figure 85 X-cap discharge at 115 Vac, 60 Hz (CH1: Vbus_C, CH3: Vac, CH4: Iout)

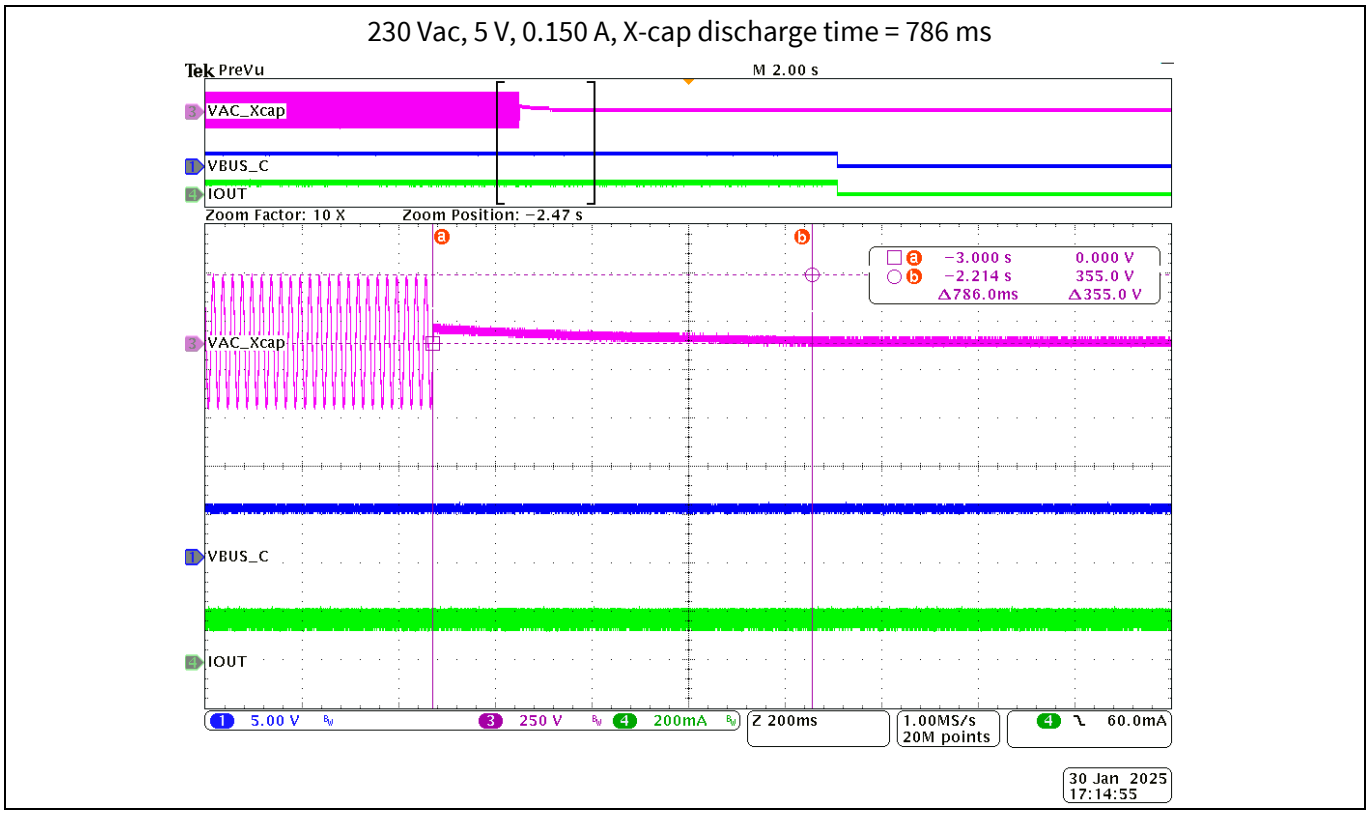


Figure 86 X-cap discharge at 230 Vac, 50 Hz (CH1: Vbus_C, CH3: Vac, CH4: Iout)

Power management test results

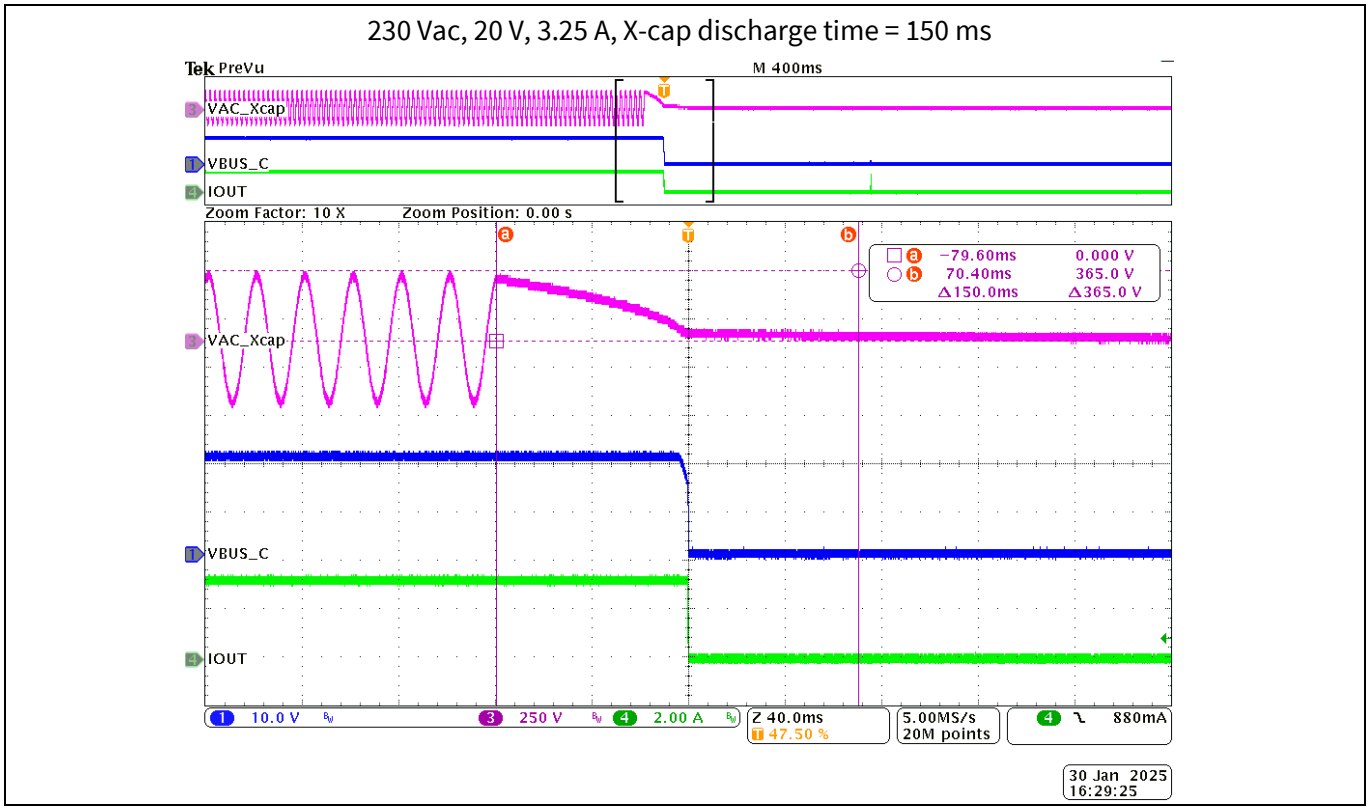


Figure 87 X-cap discharge at 230 Vac, 60 Hz (CH1: Vbus_C, CH3: Vac, CH4: Iout)

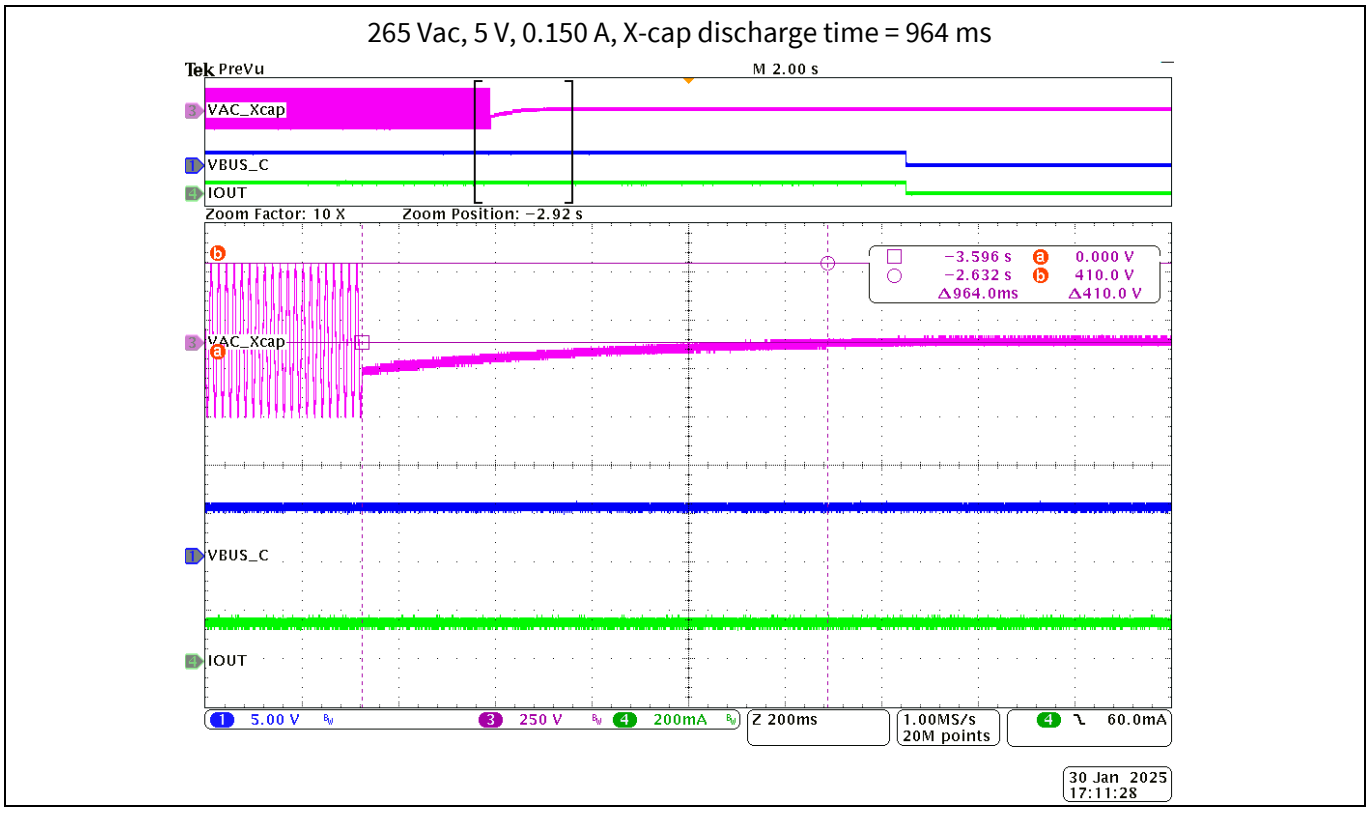


Figure 88 X-cap discharge at 265 Vac, 63 Hz (CH1: Vbus_C, CH3: Vac, CH4: Iout)

Power management test results

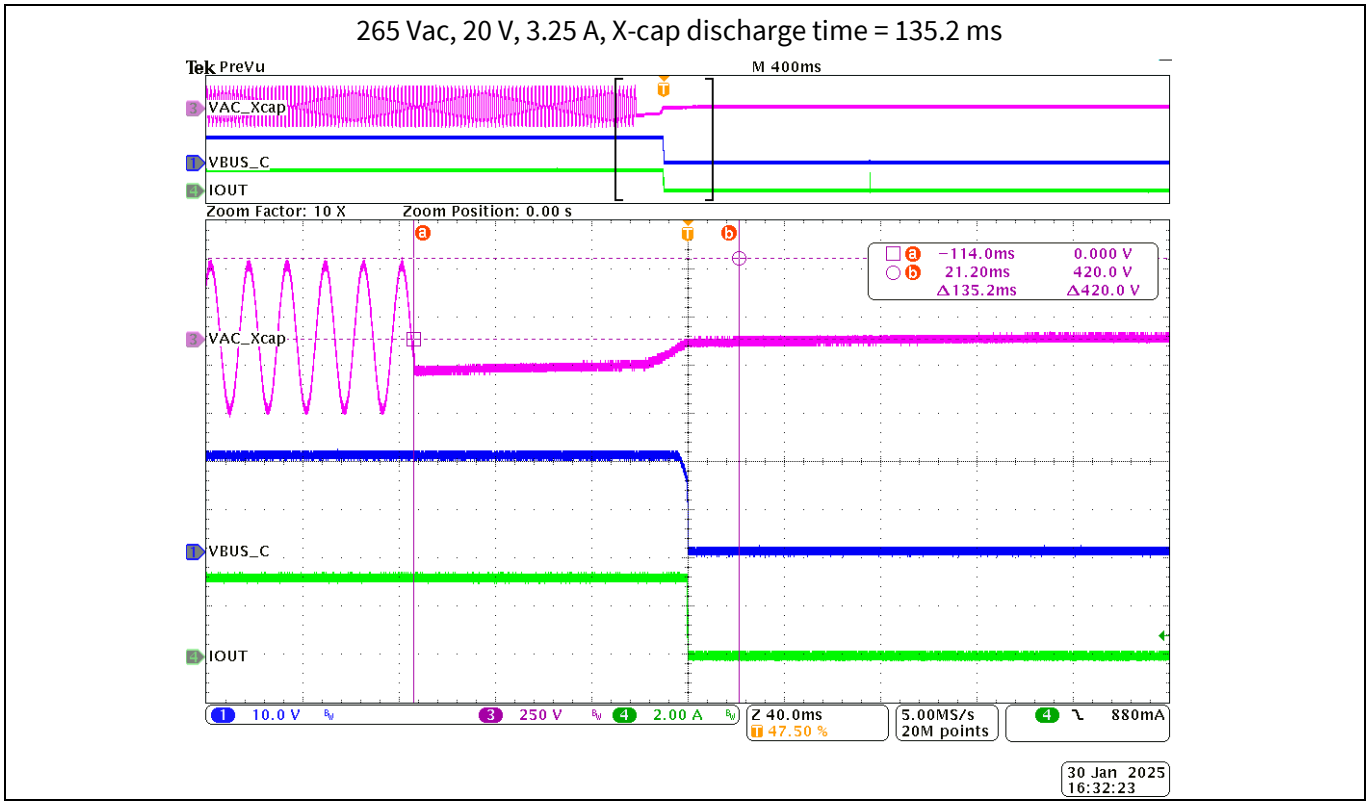


Figure 89 X-cap discharge at 265 Vac, 63 Hz (CH1: Vbus_C, CH3: Vac, CH4: Iout)

3.26 Vo steady state response with line transition

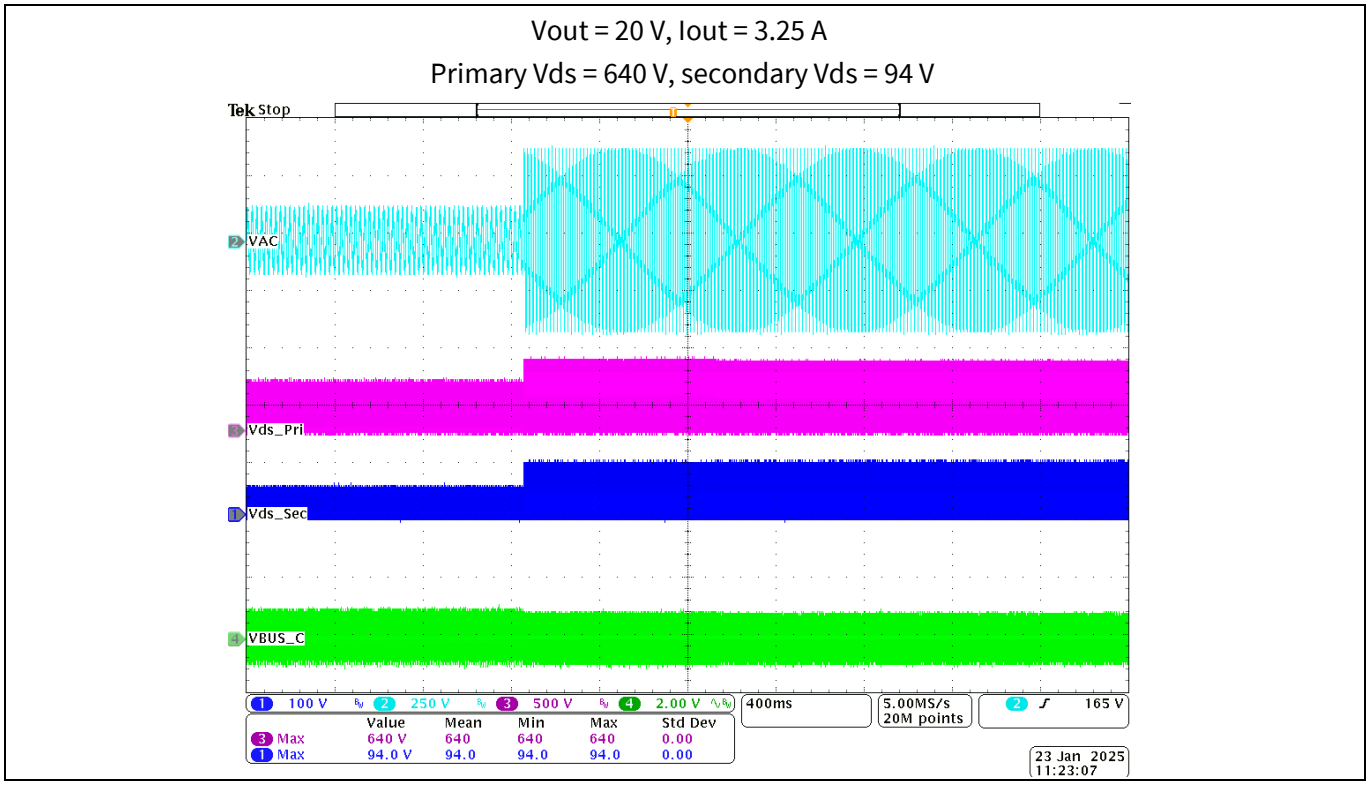


Figure 90 Line transition from 90 Vac, 50 Hz to 265 Vac, 50 Hz (CH1: Vds_sec, CH2: Vac, CH3: Pri_Vds, CH4: Vbus_C)

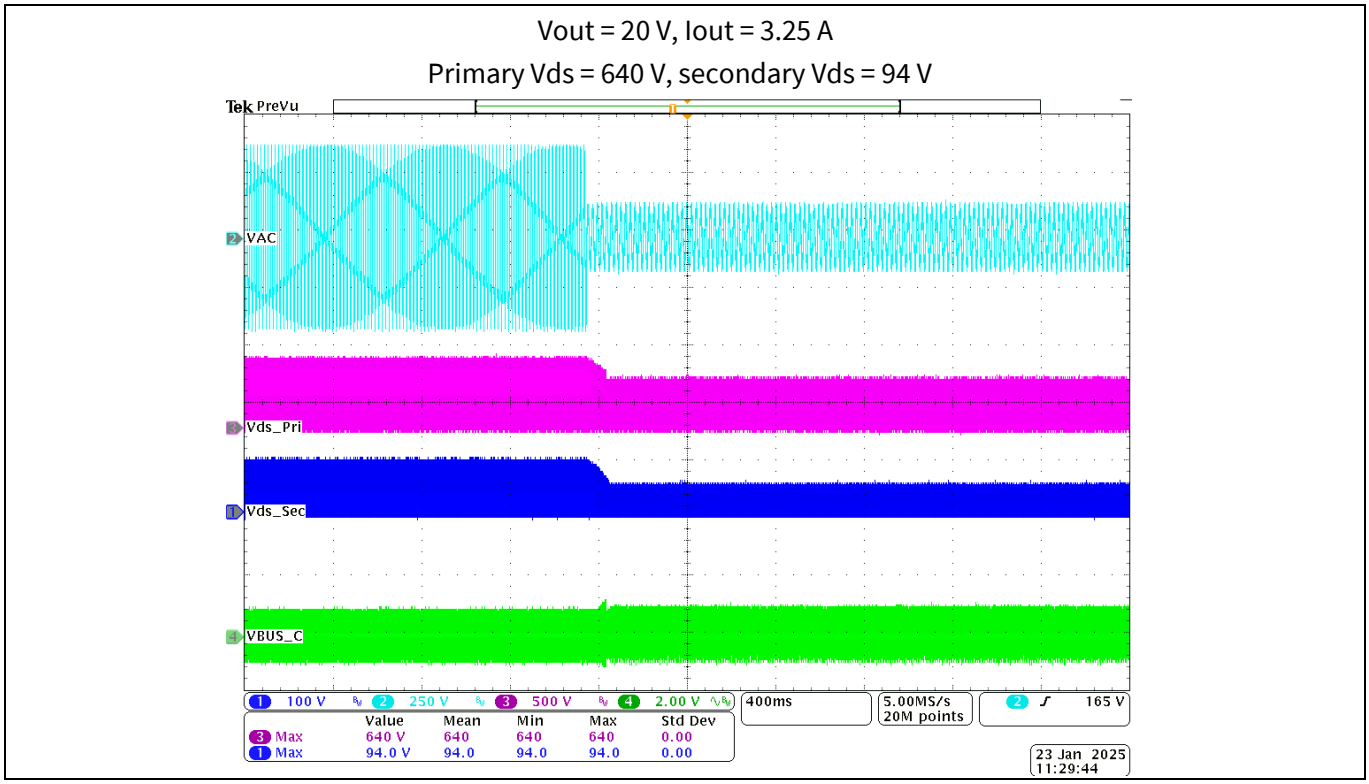


Figure 91 Line transition from 265 Vac, 50 Hz to 90 Vac, 50 Hz (CH1: Vds_sec, CH2: Vac, CH3: Pri_Vds, CH4: Vbus_C)

3.27 Hipot test

Test condition:

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

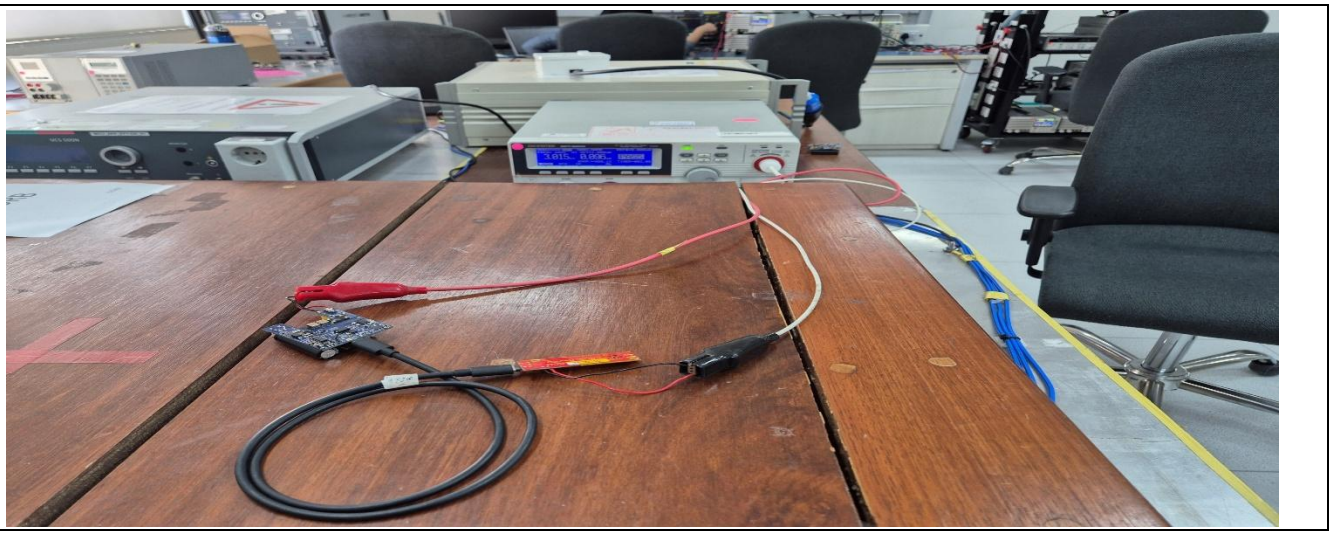


Figure 92 Hipot test setup

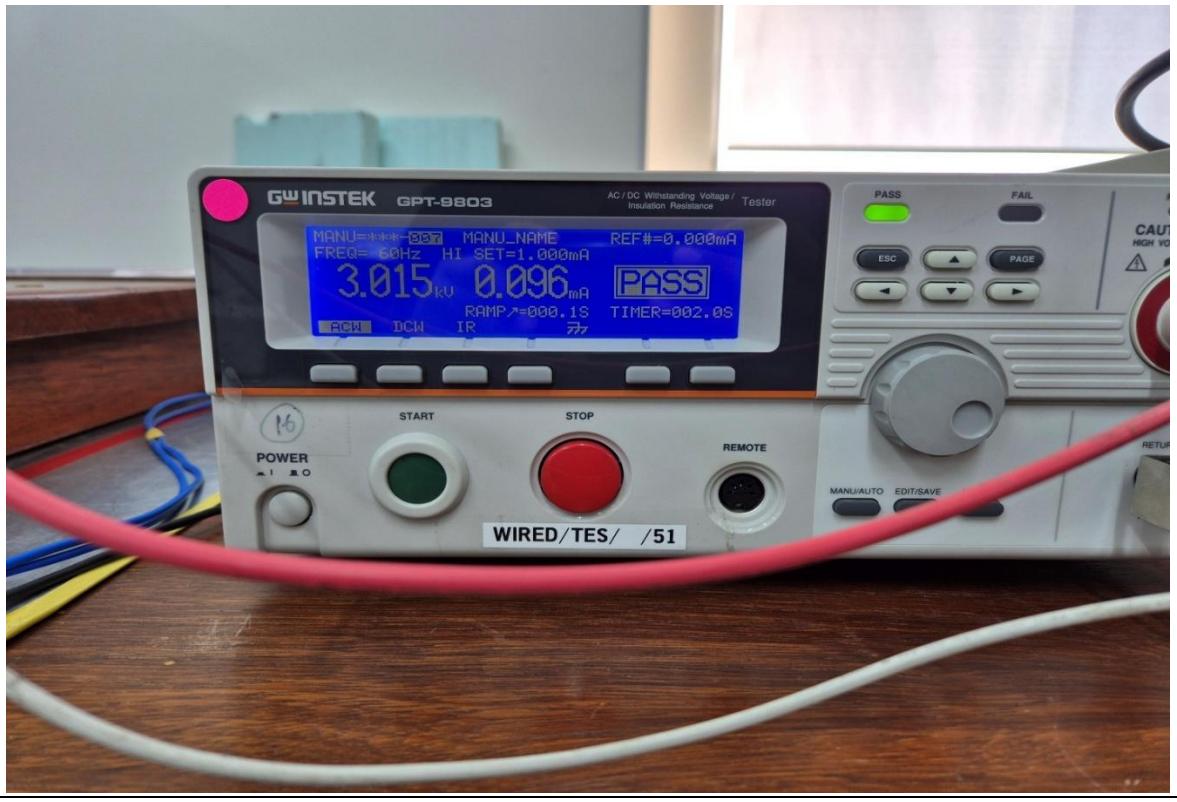


Figure 93 Hipot test result

4 USB PD source test results (using QuadraMAX)

4.1 Test setup

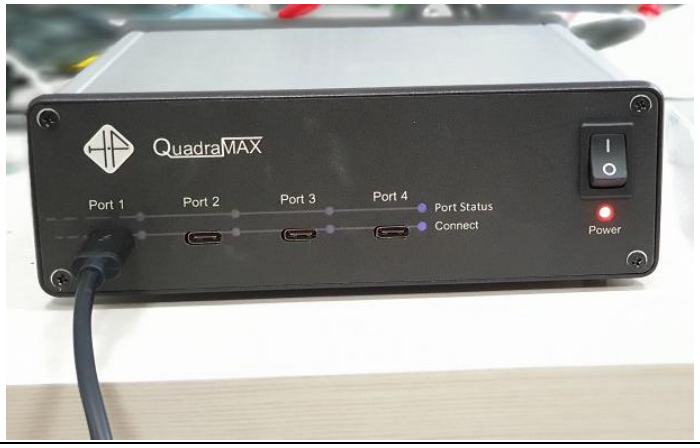


Figure 94 QuadraMAX tester

- **QuadDraw version:** 0.9.8930
- **QM#156 HWRev:** 1.4.4 FWST:0.1.1378 FWCCG1:0.11

4.2 Test results

Test Input voltage conditions: 15 Vac, 60 Hz and 230 Vac, 50 Hz

Table 27 QuadraMAX test results

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

5 Additional stress tests

5.1 Peak overload test

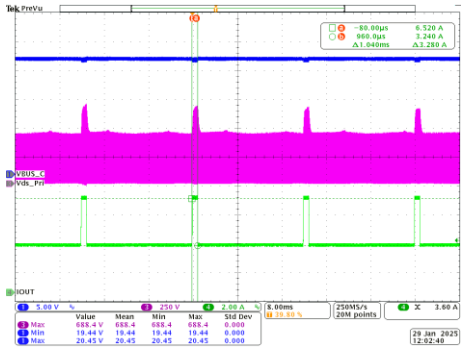
- **Test condition**: Vin: 90 Vac–47 Hz, 115 Vac–60 Hz, 230 Vac–50 Hz, Vo = 20 V, Io = dynamic
- **Lab ambient temperature**: 23°C and in open frame
- **Pass/Fail criteria:** ±10% of 20 V (18 V–22 V)

Test case 1

Vo = 20 V, 100% load (3.25 A) 19 ms – 200% load (6.5 A) 1 ms, slew rate = 500 mA/µs.

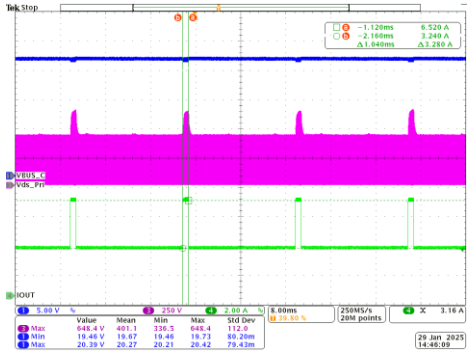
90 Vac–47 Hz, Vout = 20 V, Iout = 3.25 A, 19 ms–6.5 A, 1 ms

Vo max = 20.45 V, Vo min = 19.44 V



115 Vac–60 Hz, Vout = 20 V, Iout = 3.25 A, 19 ms–6.5 A, 1 ms

Vo max = 20.39 V, Vo min = 19.46 V



230 Vac–50 Hz, Vout = 20 V, Iout = 3.25 A, 19 ms–6.5 A, 1 ms

Vo max = 20.39 V, Vo min = 19.53 V

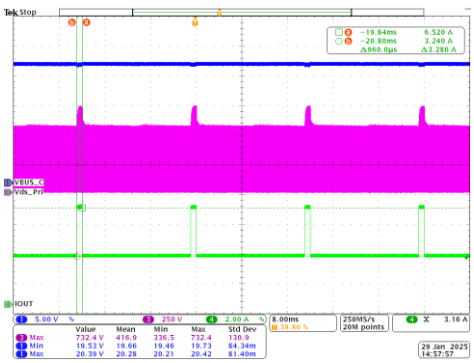


Figure 95 100% to 200% peak overload test at different line conditions (CH1: Vbus_C; CH3: Vds_Pri; CH4: Iout)

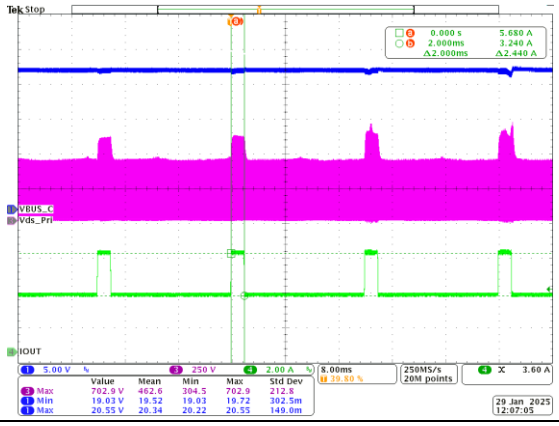
Additional stress tests

Test case 2

Vo = 20 V, 100% load (3.25 A) 18 ms–175% load (5.68 A) 2 ms, slew rate = 500 mA/µs.

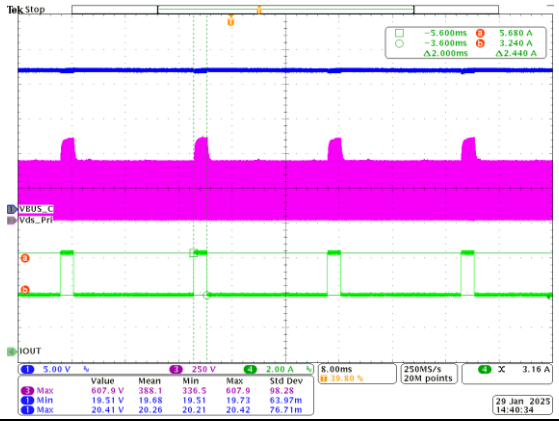
90 Vac–47 Hz, Vout = 20 V, Iout = 3.25 A, 18 ms–5.68A, 2 ms

Vo max = 20.55 V, Vo min = 19.03 V



115 Vac–60 Hz, Vout = 20 V, Iout = 3.25 A, 18 ms–5.68 A, 2 ms

Vo max = 20.41 V, Vo min = 19.51 V



230 Vac–50 Hz, Vout = 20 V, Iout = 3.25 A, 18 ms–5.68 A, 2 ms

Vo max = 20.40 V, Vo min = 19.57 V



Figure 96 100% to 175% peak overload test at different line conditions (CH1: Vbus_C; CH3: Vds_Pri; CH4: Iout)

Additional stress tests

Test case 3

Vo = 20 V, 100% load (3.25 A) 10ms–150% load (4.87 A) 10 ms, slew rate = 500 mA/µs.

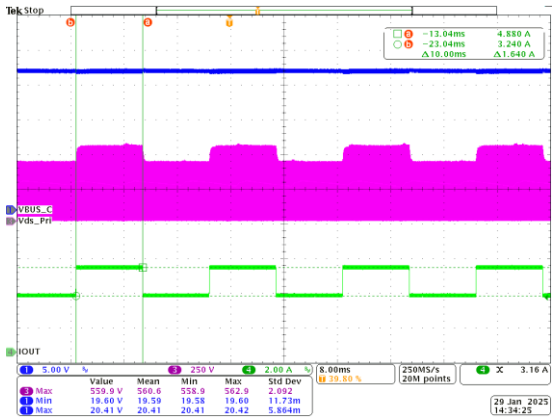
90 Vac–47 Hz, Vout = 20 V, Iout = 3.25 A,10 ms–4.87 A, 10 ms

Vo max = 20.61 V, Vo min = 19.12 V



115 Vac–60Hz, Vout = 20 V, Iout = 3.25 A,10 ms–4.87 A, 10 ms

Vo max = 20.41 V, Vo min = 19.60 V



230 Vac–50 Hz, Vout = 20 V Iout = 3.25 A,10 ms–4.87 A, 10 ms

Vo max = 20.38 V, Vo min = 19.61 V

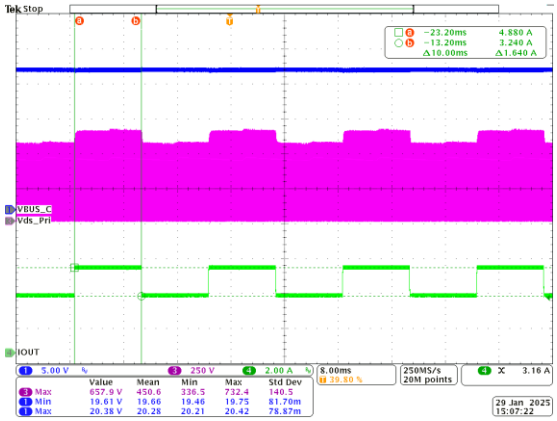


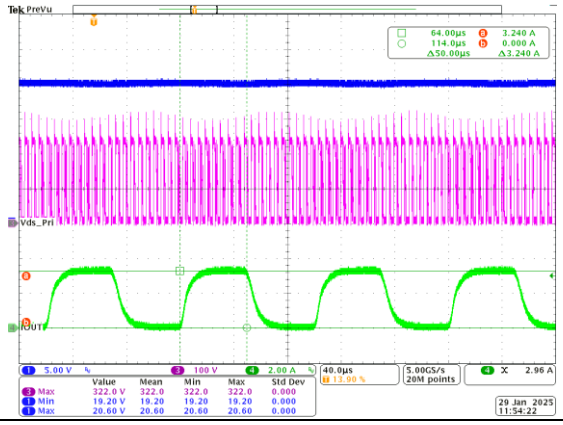
Figure 97 100% to 150% peak overload test at different line conditions (CH1: Vbus_C; CH3: Vds_Pri; CH4: Iout)

Additional stress tests

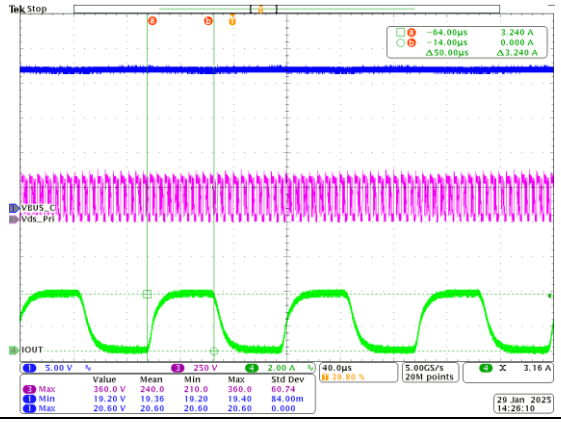
Test case 4

Vo = 20 V, 0% load (0 A) 50 µs – 100% load (3.25 A) 50 µs, slew rate = 500 mA/µs.

90 Vac–47 Hz, Vout = 20 V, Iout = 0 A,50 µs–3.25 A, 50 µs
Vo max = 20.60 V, Vo min = 19.20 V



115 Vac–60 Hz, Vout = 20 V, Iout = 0 A, 50 µs–3.25 A, 50 µs
Vo max = 20.60 V, Vo min = 19.20 V



230 Vac–50 Hz, Vout = 20 V, Iout = 0 A, 50 µs–3.25 A, 50 µs
Vo max = 20.80 V, Vo min = 19.20 V

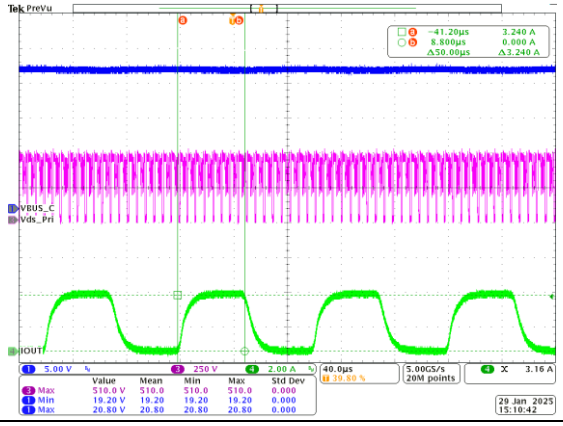


Figure 98 0% to 100% peak overload test at different line conditions (CH1: Vbus_C; CH3: Vds_Pri; CH4: Iout)

5.2 Stress test 1

Test condition: Vac = 90 Vac to 265 Vac, 50 Hz, Vout = 5 V Fixed, Iout = 0.1 A to 3 A; Run duration = 8 hours.

The DUT undergoes 8-hour burn-in test where the programmable AC supply is programmed to toggle from 90 Vac to 265 Vac every 10 seconds, Vout = 5 V Fixed with load pulsing from 0.1 A to 3 A every 10 ms with slewrate = 150 mA/ µs.

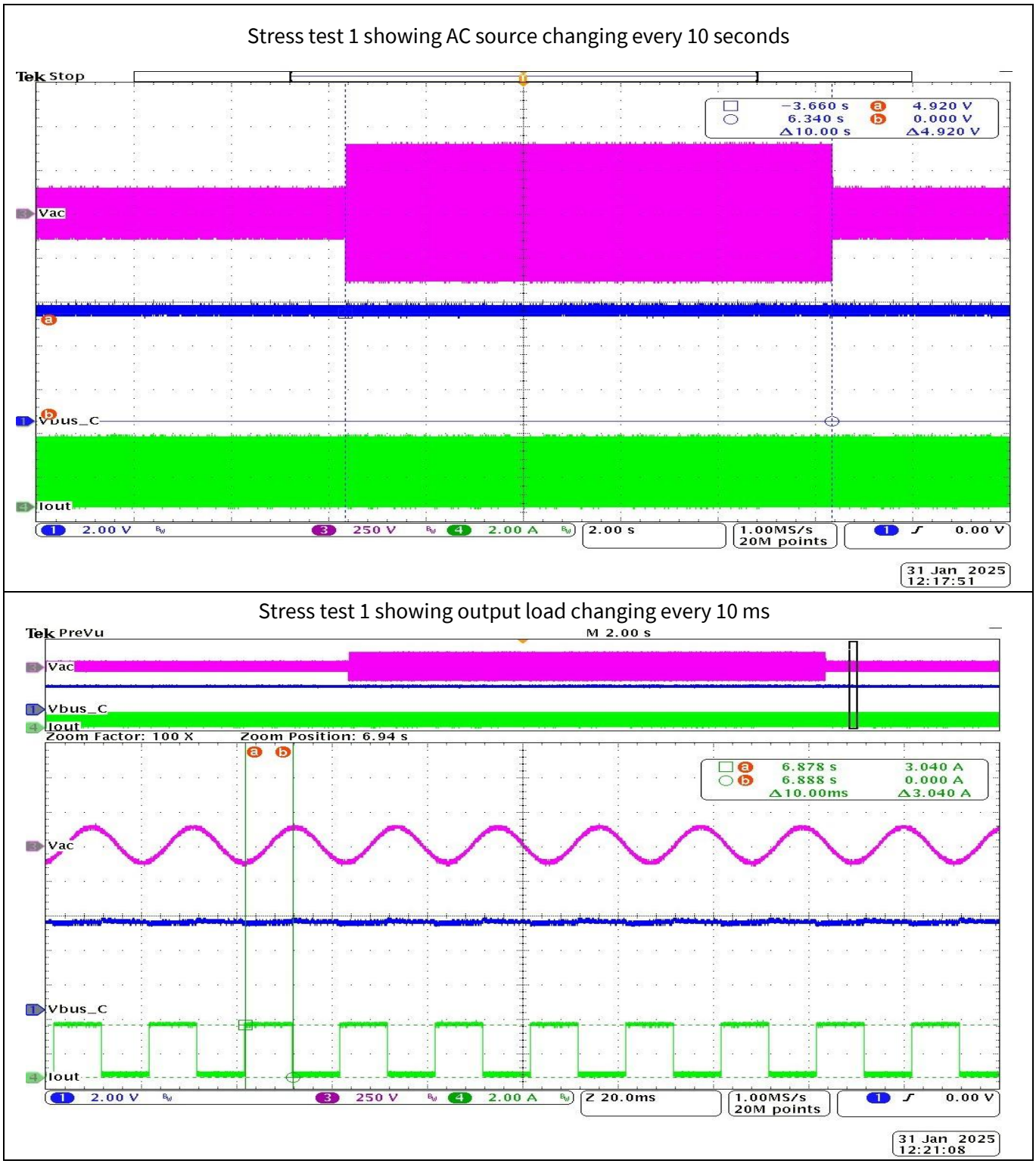


Figure 99 Stress test 1 (CH1: Vbus_C, CH3: Iout, CH4: Vac)

5.3 Stress test 2

Test condition: Vac = 90 Vac to 265 Vac, 50 Hz, Vout = 5 V-9 V-15 V- 20 V- 15 V- 9 V-5 V, Iout = 0.1 to 3 A.

Run duration: 8 hours

The DUT undergoes 8-hour burn-in test where the programmable AC power supply is programmed to toggle Voltage from 90 Vac to 265 Vac every 10 seconds each and Vout = 5 V-9 V-15 V-20 V-15 V-9 V-5 V Fixed PDO contract every 1 second each and load pulsing from 0.1 A to 3 A every 10 ms with slew rate = 150 mA/µs.

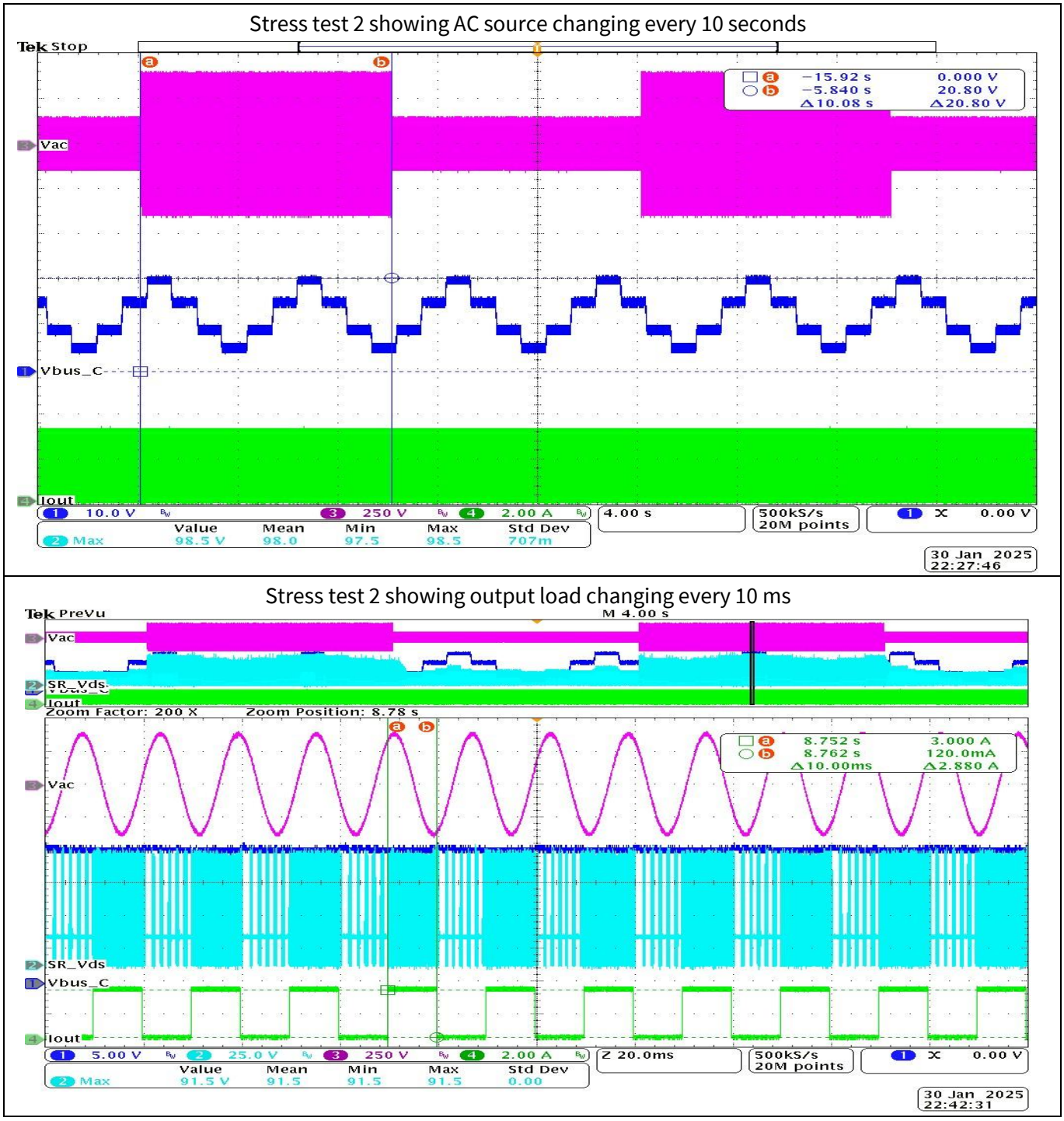


Figure 100 Stress test 2 (CH1: Vbus_C, CH2: SR_Vds, CH3: Vac, CH4: Iout)

6 Appendix

6.1 Schematics

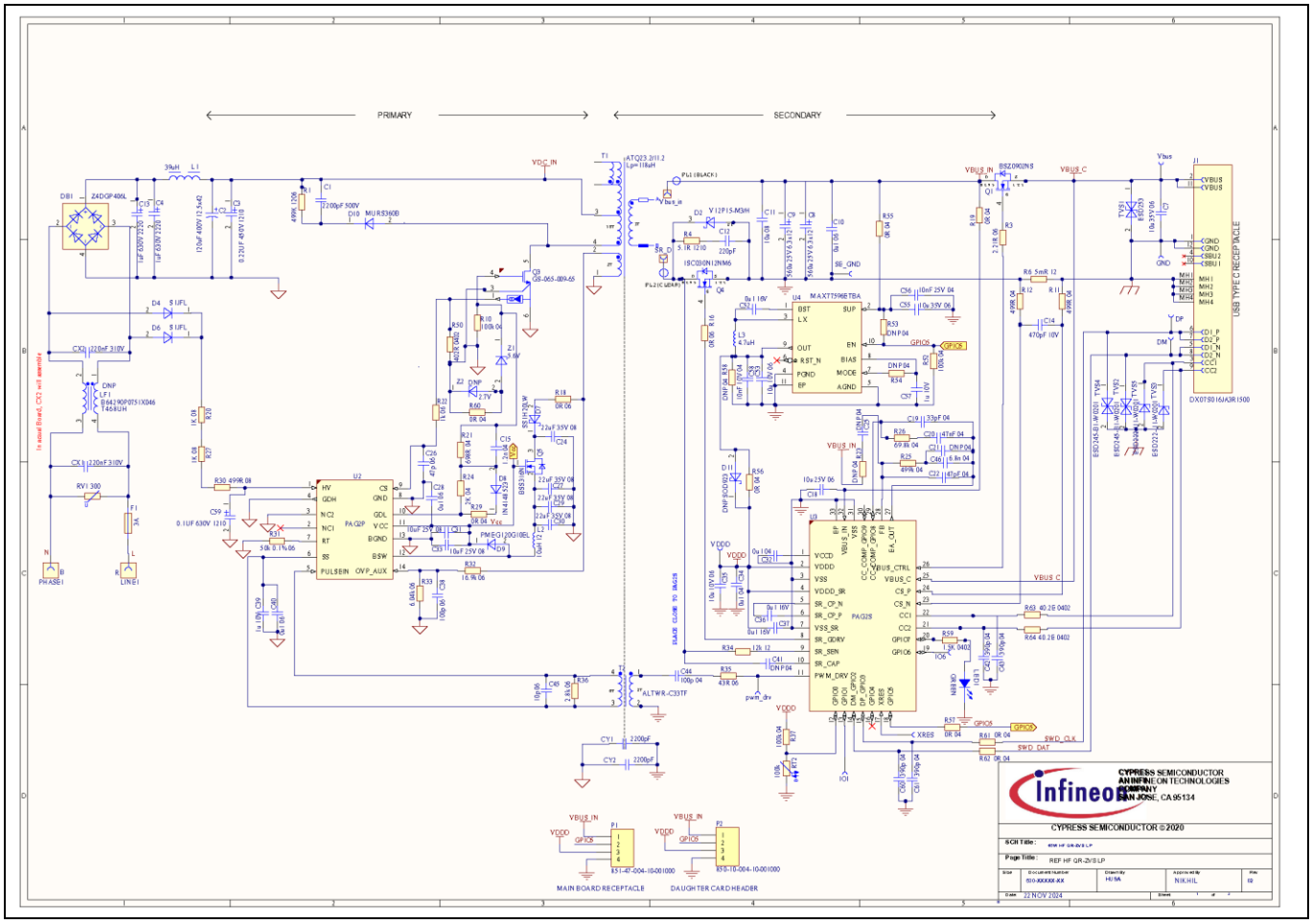


Figure 101 Schematic diagram of 65W PAG2P_PAG2S_HF ZVS_LP Rev2 Board

Appendix

6.2 Bill of materials (BOM)

Quantity	Designator	Comment	Manufacturer order Number	Manufacturer
1	C1	2200pF 500V	CC1206KKX7RBBB222	YAGEO
1	C3	0.22UF 450V 1210	C3225X7T2W224K200AA	TDK Corporation
2	C7, C55	10u 35V 06	GRM188R6YA106MA73D	Murata, Murata Electronics
1	C10	0u1 06	CGA3E2X8R1E104K080AA	TDK Corporation
1	C11	10u 08	GRM21BR61H106KE43K	Murata
1	C12	220pF	CC1206KRX7RABB221	YAGEO
1	C14	470pF 10V	C0603C471K8RACTU	KEMET
1	C15	1.2n 04	CC0402KRX7R9BB122	YAGEO
1	C18	10u 25V 06	CL10A106MA8NRNC	Samsung Electro-Mechanics
1	C19	33pF 04	KGM05ACG1E330FH	KYOCERA AVX
1	C20	47nF 04	GRM155R71E473JA88D	Murata Electronics
1	C21	DNP 04	DNP	Murata
1	C22	47pF 04	CBR04C470F3GAC	KEMET
4	C24, C27, C29, C30	22uF 35V 08	C2012X5R1V226M125AC	TDK
1	C26	47p 06	GRM1885C1H470GA01	Murata
1	C28	0u1 06	06035C104JAT2A	AVX
2	C31, C33	10uF 25V 08	GRM21BR61E106KA73	Murata
2	C32, C34	0u1 04	GRM152R61A104KE19	Murata
2	C35, C53	10u 10V 06	ZRB18AD71A106KE01L	Murata
3	C36, C37, C52	0u1 16V	GCM155R71C104KA55	Murata
1	C38	100p 06	06033A101JAT2A	AVX
2	C39, C57	1u 10V	CC0603JRX7R6BB105	YAGEO
1	C40	0u1 06	C0603C104J8RAC	Kemet
4	C42, C43, C60, C61	390p 04	CC0402JRNPO8BN391	YAGEO
1	C44	100p 04	GRM1555C1E101JA01	Murata
1	C45	10p 06	C0603C100K5GACAUTO	Kemet
1	C46	6.8n 04	GRM155R71E682JA01	Murata
1	C56	10nF 25V 04	GRM155R71E103JA01	Murata
1	C58	10nF 10V 04	GRM155R61A103KA01	Murata
1	C59	0.1UF 630V 1210	C1210C104KBRACTU	KEMET
2	CY1, CY2	2200pF	DE1E3RA222MN4AQ01F	Murata Electronics
1	D2	V12P15-M3/H	V12P15-M3/H	Vishay General Semiconductor - Diodes Division

Appendix

Quantity	Designator	Comment	Manufacturer order Number	Manufacturer
2	D4, D6	S1JFL	S1JFL	ON Semiconductor
1	D7	SS220LW	SS220LW	Taiwan Semiconductor
1	D8	1N4148 523	1N4148WT-7	Diodes Incorporated
1	D9	PMEG120G10EL	PNE20010ERX	Nexperia
1	D10	MURS360B	MURS360B	Diodes Incorporated
1	D11	DNP SOD923	NSR05F40NXT5G	Onsemi
1	DB1	Z4DGP406L	Z4DGP406L-HF	Comchiptech
1	F1	3A	TR1-2410TD3-R	Eaton - Electronics division
1	J1	DX07S016JA3R1500	DX07S016JA3R1500	JAE
1	L2	10uH 12	LSQCA322525T100KR	Taiyo Yuden
1	L3	4.7uH	LSBHB1608KKT4R7M	Taiyo Yuden
1	LED1	GREEN	LTST-C191KGKT	Lite-On Inc.
1	P1	851-47-004-10-001000	851-47-004-10-001000	Mill-Max Manufacturing Corp.
1	P2	850-10-004-10-001000	850-10-004-10-001000	Mill-Max Manufacturing Corp.
1	R1	499K 1206	ERJ-P08F4993V	Panasonic Electronic Components
1	R3	2.21R 06	CRCW06032R21FK	Vishay
1	R4	5.1R 1210	ERJ-14YJ5R1U	Panasonic
1	R6	5mR 12	CSRF1206FT5L00	Stackpole Electronics
2	R10, R52	100k 04	RC0402FR-07100KL	YAGEO
2	R11, R12	499R 04	CRCW0402499RFK	Vishay
2	R16, R18	0R 06	CRCW06030000Z0EA	Vishay
1	R19	0R 04	RC0402FR-070RL	YAGEO
2	R20, R27	1K 08	CRCW08051K00FKEAHP	Vishay
1	R21	698R 04	ERJ-2RKF6980X	Panasonic Electronic Components
1	R22	1k 06	AC0603JR-071KL	YAGEO
1	R24	2K 04	ERJ-2RKF2001X	Panasonic Electronic Components
1	R25	499k 04	CRCW0402499KFK	Vishay
1	R26	69.8k 04	CRCW040269K8FK	Vishay
4	R29, R60, R61, R62,	0R 04	RC0402JR-070RL	YAGEO
1	R30	499R 08	CRCW0805499RFKEAHP	Vishay
1	R31	50k 0.1% 06	RT0603BRD0750KL	YAGEO
1	R32	16.9k 06	CRCW060316K9FK	Vishay
1	R33	6.04k 06	CRCW06036K04FK	Vishay

Appendix

Quantity	Designator	Comment	Manufacturer order Number	Manufacturer
1	R34	12k 12	SDR03EZPF1202	ROHM Semiconductor
1	R35	43R 06	CRCW060343R0FK	Vishay
1	R36	2.8k 06	MCR03EZPFX2801	ROHM Semiconductors
1	R37	100k 04	CRCW0402100KFK	Vishay
1	R50	402R 0402	CRCW0402402RFKED	Vishay Dale
3	R55, R56, R57	0R 04	CRCW04020000Z0	Vishay
2	R63, R64	40.2E 0402	ERJ-2RKF40R2X	Panasonic Electronic Components
1	R59	1.5K 0402	AC0402JR-071K5L	Vishay
1	RT2	100k	NCU18WF104J60RB	Murata
1	RV1	300V	820473011	Würth Elektronik
1	U4	MAX77596ETBA	MAX77596ETBA+	Analog Devices
1	Z1	5.6V	DZ9F5V6S92	Diodes Incorporated
1	LF1	B64290P0751X046	B64290P0751X046	EPCOS/TDK
1	C25	DNP 04	GRM1555C1E101JA01	Murata
1	C41	DNP 04	GRM1555C1E100JA01	Murata
1	R23	DNP 04	CPF0402B49K9E1	TE Connectivity
3	R53, R54, R58	DNP 04	RC0402FR-07100KL	Yageo
1	LINE1	R	5000	Keystone Electronics Corp.
1	PHASE1	B	5001	Keystone Electronics Corp.
2	SR_D, Vbus_in	-	-	-
12	DM, DP, GND, IO1, IO5, IO6, IO7, pwm_drv, SE_GND, Vbus, VDDD, XRES	1:2		
1	-	WE-FAS EMI Flexible Absorber Sheet	30403S	Würth Elektronik
Infineon supplied components to Innovatech				
2	C8, C9	560u 25V 6.3x12	NPX 560uF 25V 6.3 x 12	Sh-ymin
1	C2	120uF 400V 12.5x42	MHT400V120UF87EC0448	KNSCHA
2	C4, C13	1uF 630V 2220	FS55X105K631EHG	Prosperity Dielectrics Co. Ltd

Appendix

Quantity	Designator	Comment	Manufacturer order Number	Manufacturer
1	CX1	220nF 310V	PX224K2C0702T	KYET
1	CX2	220nF 310V	PX224K2C0702T	KYET
1	L1	39uH	7447720390	Würth Elektronik
1	Q1	BSZ0902NS	BSZ0902NS	Infineon Technologies
1	Q3	GS-065-009-65	GS-065-009-65	Infineon Technologies
1	Q4	ISC030N12NM6	ISC030N12NM6	Infineon Technologies
1	Q5	BSS316N	BSS316N H6327	Infineon Technologies
1	T1	ATQ23.2/11.2	ATQ23.2/11.2	Better Magnetic
1	T2	ALTWR-C33TF	ALTWR-C33TF	Sunlord
1	TVS1	ESD253	ESD253-B1-W0201	Infineon Technologies
2	TVS3, TVS5	SZESD7241N2T5G	ESD222-U1-W0201	Infineon Technologies
2	TVS2, TVS4	ESD245-B1-W0201	ESD245-B1-W0201	Infineon Technologies
1	U2	PAG2P	CYPAP212A1-14SXI	Infineon Technologies
1	U3	PAG2S	CYPAS212A1-32LQXQ	Infineon Technologies
Bag and Tag				
2	C4, C13	1uF 500V 2220	C2220X105K501T	Holy Stone Enterprise Co., Ltd.
1	Z2	2.7V	DZ9F2V7S92-7	Diodes Incorporated
Accessories				
1	ACC1	30403S	30403S	Würth Elektronik

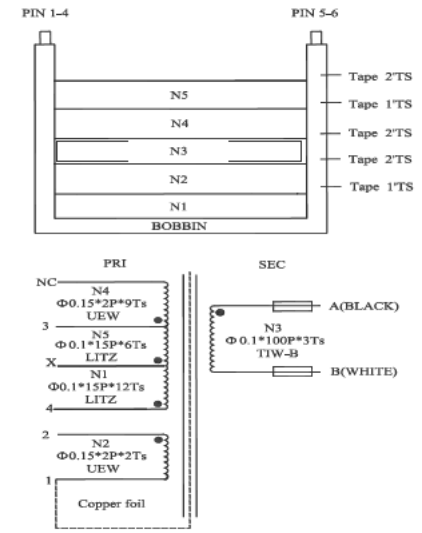
Appendix

6.3 Transformer specification (T1)

PROPRIETARY

Outline Dimension and Winding Configuration

1. Schematic:

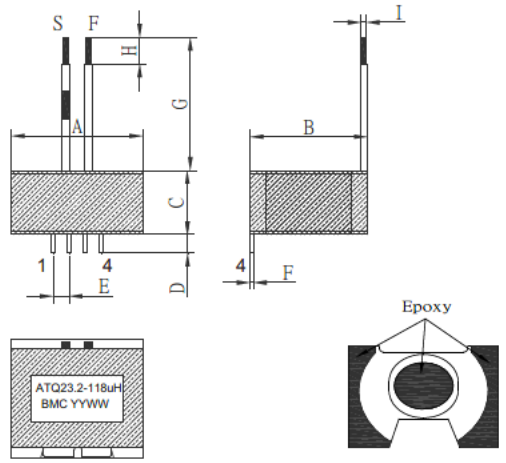


Note: 1. ● Winding start. ▭ Teflon tube

3.Electrical Characteristic

1.	Inductance test :	@100KHz/1.0V
	PIN(4-3)=118uH±10%	
2	Leakage Inductance test :	@100KHz/1.0V
	PIN(4-3)=6.0uH MAX	Short others pin
3	DC Resistance	@25℃
	PIN(2-1)=70mΩ MAX	
	PIN(4-3)=160mΩ MAX	
	PIN(BLK-WHT)=8mΩ MAX	
4	Turns test	'@20KHz/1.0V
	NP:PIN(4-3)=18T'S	
	NS:PIN(2-1)=2T'S	
	NS:PIN(BLK-WHT)=3T'S	
4	Dielectric Strength	
	PRI to SEC AC 3750V 50Hz/60Hz 1mA for 2 seconds	
	SEC to CORE AC 2000V 50Hz/60Hz 1mA for 2 seconds	

2. Appearance size chart:



Sym.	Nom(mm)	±Tol.
A	27.5	MAX
B	27.0	MAX
C	14.5	MAX
D	3.5	0.5
E	3.0	0.5
F	SQ0.6	0.1
G	25.0	2.0
H	5.0	2.0
I	3.0	MAX

Note: 1.Gap core connection dough epoxy resin （研磨铁芯结合面中柱点胶）（如上图）

2..Core is secured with tape 2T'S.（包2圈铁芯固定胶布）

3.Note : Add cross copper shields to the cores and ground to pin 1. Horizontal copper shield is 3mm width and vertical copper shield is 11mm.

Description			Issued Date	Page Nr.
			07/18/2024	2-1
Cust.Code-Part Nr.	Rev.	Engineering	Checked By	Approved By
ATQ23.2-118uH	0.0	BMC Enginnering LiZhiXie	BMC Enginnering HengChengLi	BMC Enginnering XiaoPingWang
Better Magnetics Nr.	BMC Rev.			
EF-247004	A			

Appendix

PROPRIETARY

Material List



All materials listed are in compliance with RoHS requirements

No.	Name	Description	Rating	Approval	Maker
1	Core	Ferrite core ATQ23.2/11/19 NH97 LP10A or equivalent			LIANFENG ✓ NEW CONDA ✓
2	Bobbin	Phenolic PM-9630 UL 94V-0	150℃	E41429	SUMITOMO ✓
3	Wire	Polyurethane enamelled copper Wire UEW MW75-C Ø0.1*15P LITZ WIRE Ø0.15 UEW	 130℃ 130℃	 E339217 E201757	 WEIHAN ✓ PACIFIC ✓
		Triple insulated wire TIW-B Ø0.1X100P or equivalent	130℃	E357240	KAIZHONGHEDONG
4	Tape	Polyester tape #1350F-1 or #CT280	 130℃ 130℃	 E17385 E165111	 3M YA HUA ✓
5	Copper foil	0.05(T)*11mm 0.05(T)*3mm			HAIYU DETAI ✓
6	Epoxy	2050 2041			CHENGGE ✓ CHENGGE ✓
7	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			07/18/2024	2-2
Cust.Code-Part Nr.	Rev.	Engineering	Checked By	Approved By
ATQ23.2-118uH	0.0	BMC Enginnering LiZhiXie	BMC Enginnering HengChengLi	BMC Enginnering XiaoPingWang
Better Magnetics Nr.	BMC Rev.			
EF-247004	A			

✓

Figure 102 ATQ23.2-118 µH (NH97)

Appendix

6.4 Inductor specification (L1)

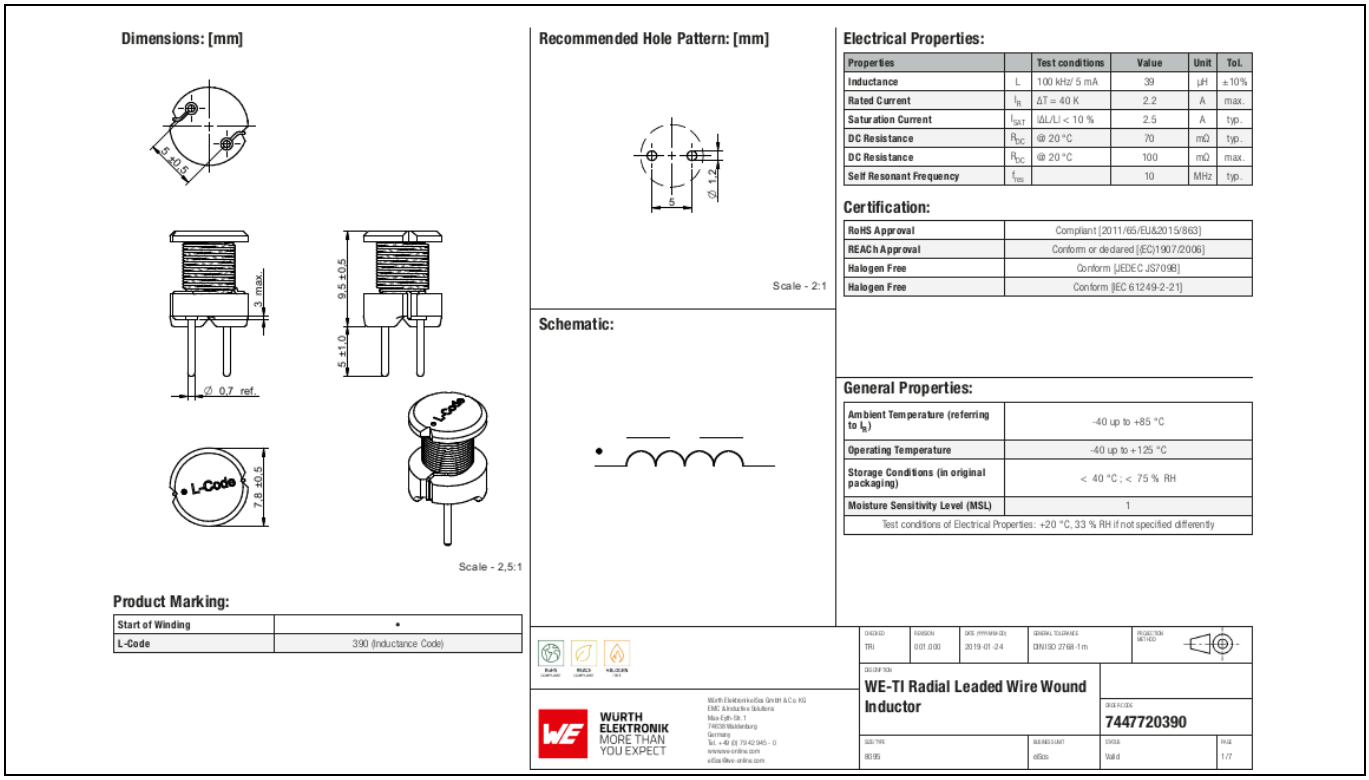


Figure 103 WE-TI Radial Leaded Wire Wound Inductor

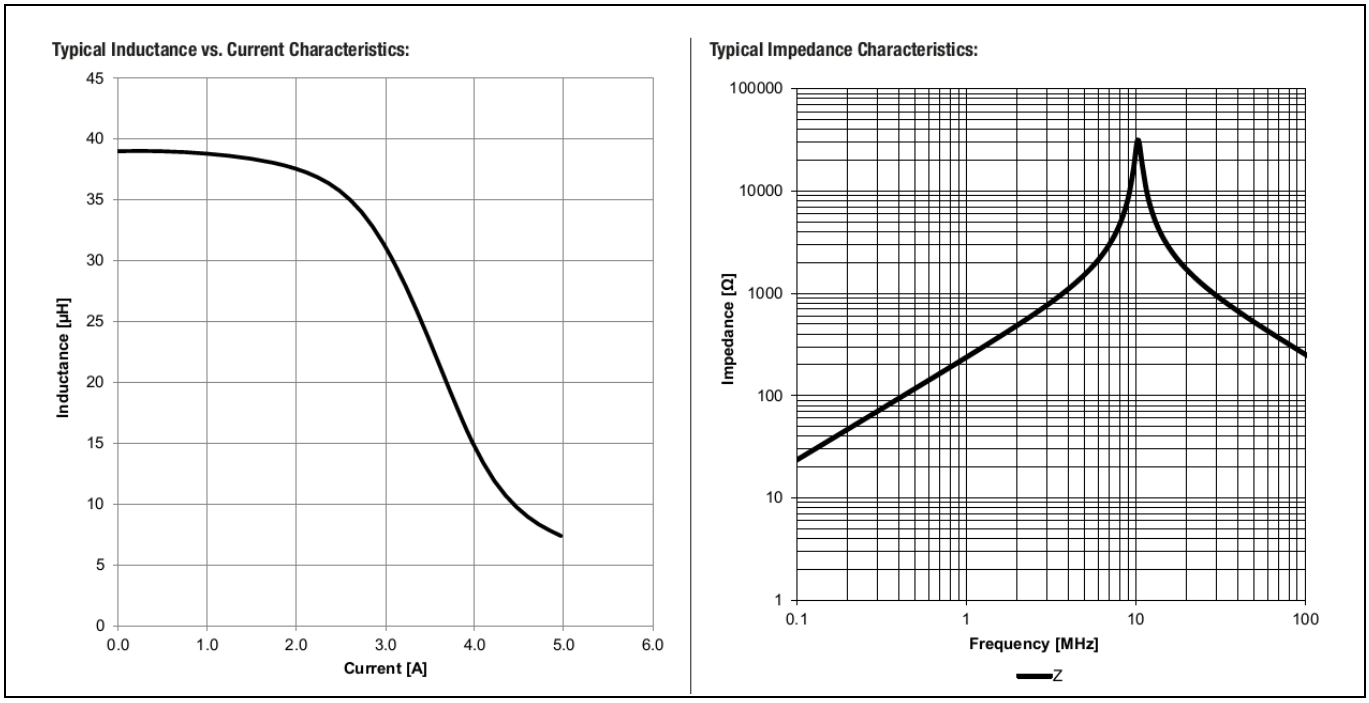


Figure 104 L1 FIXED IND 39 µH, 2.2 A, and 100 mohm

Appendix

6.5 Pulse transformer specification (T2)

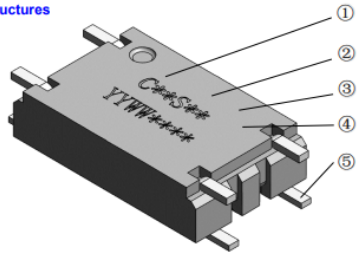
Sunlord www.sunlordinc.com

Proposal Of Pulse Transformer For Automobiles(ALTWR-C33TF)

Issued By	Checked By	Prepared By
Xiangping Qu	Xiangping Qu	Liangming Bin
2023/1/16	2023/1/16	2023/1/16

Note: This is a preliminary proposal for communication.The product reliability is being test,and the final product P/N, Structure, Shape and Dimensions, Electrical Characteristics may be changed. You are requested to confirm and approve our spec.

1.Structures

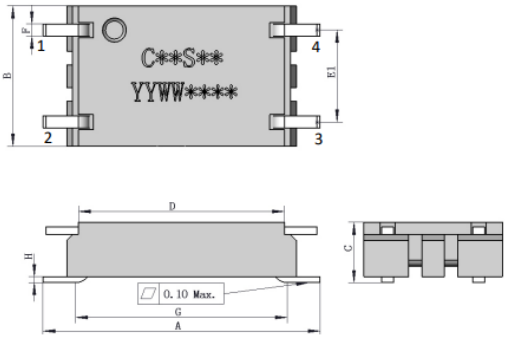


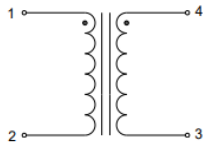
No.	Part Name	Material
①	Case	Plastics
②	Glue	Silicon Glue
③	Core	Ferrite soft magnetism
④	Wire	Polyurethane system enameled copper wire
⑤	Terminal	Cu+Ni+Sn plating

2.Shape and dimensions (mm)

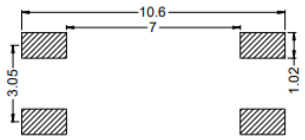
Unit:mm

Items	A	B	C	D Ref.	E1	F	G Ref.	H Ref.
Sunlord Design	9.3±0.30	4.90 Max.	2.00+0.20/ -0.10	6.9±0.50	3.05±0.13	0.50±0.13	7.10	0.25





Topological diagram



Recommend pad patterm (mm)

Shenzhen Sunlord Electronics Co.,Ltd. Page1/2

Figure 105 Pulse transformer specification

6.6 PCB layout

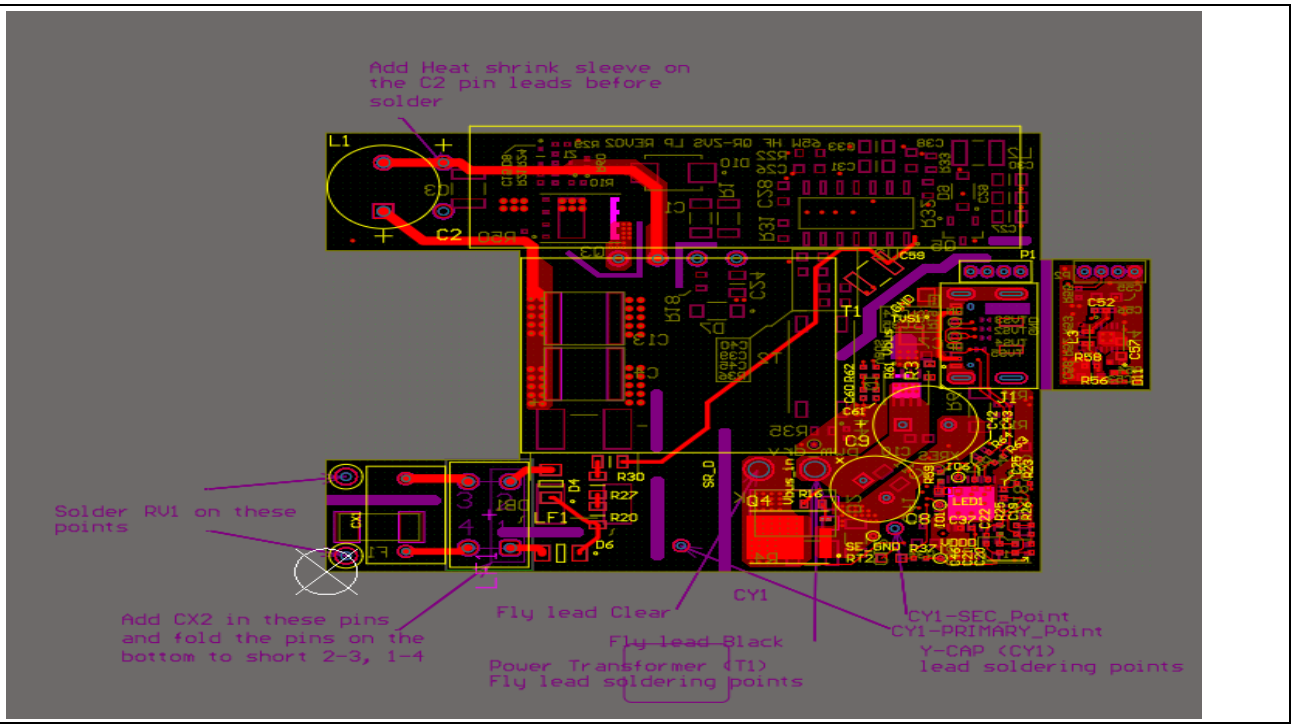


Figure 106 Top side copper layer 1

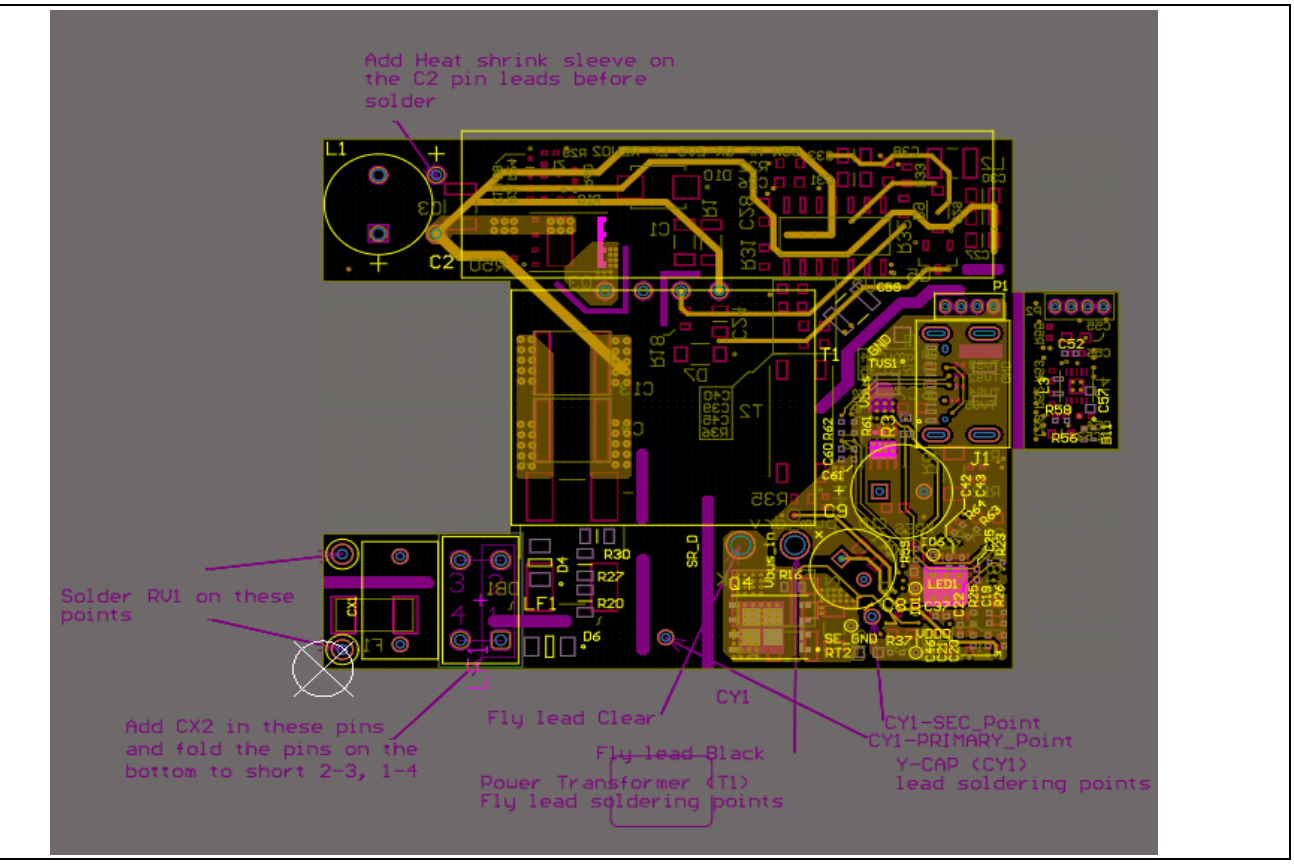


Figure 107 Inner layer – layer 2

Appendix

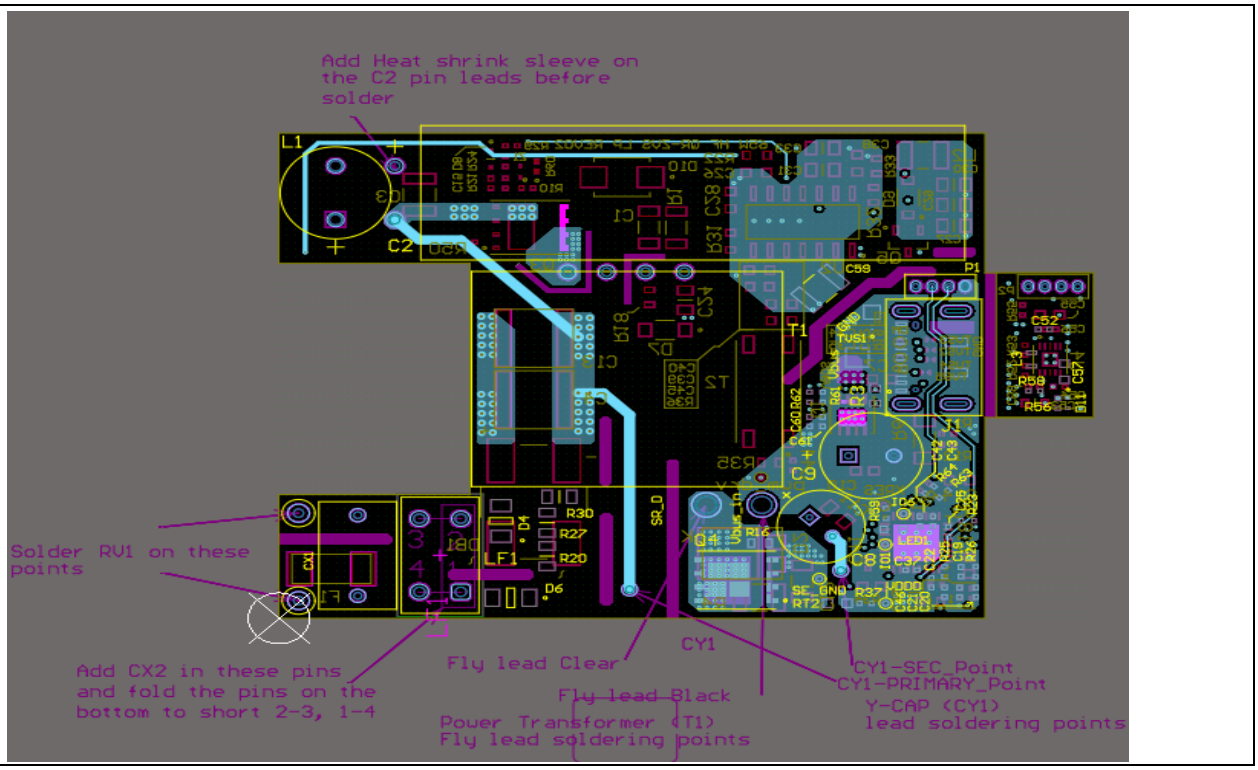


Figure 108 Inner layer – layer 3

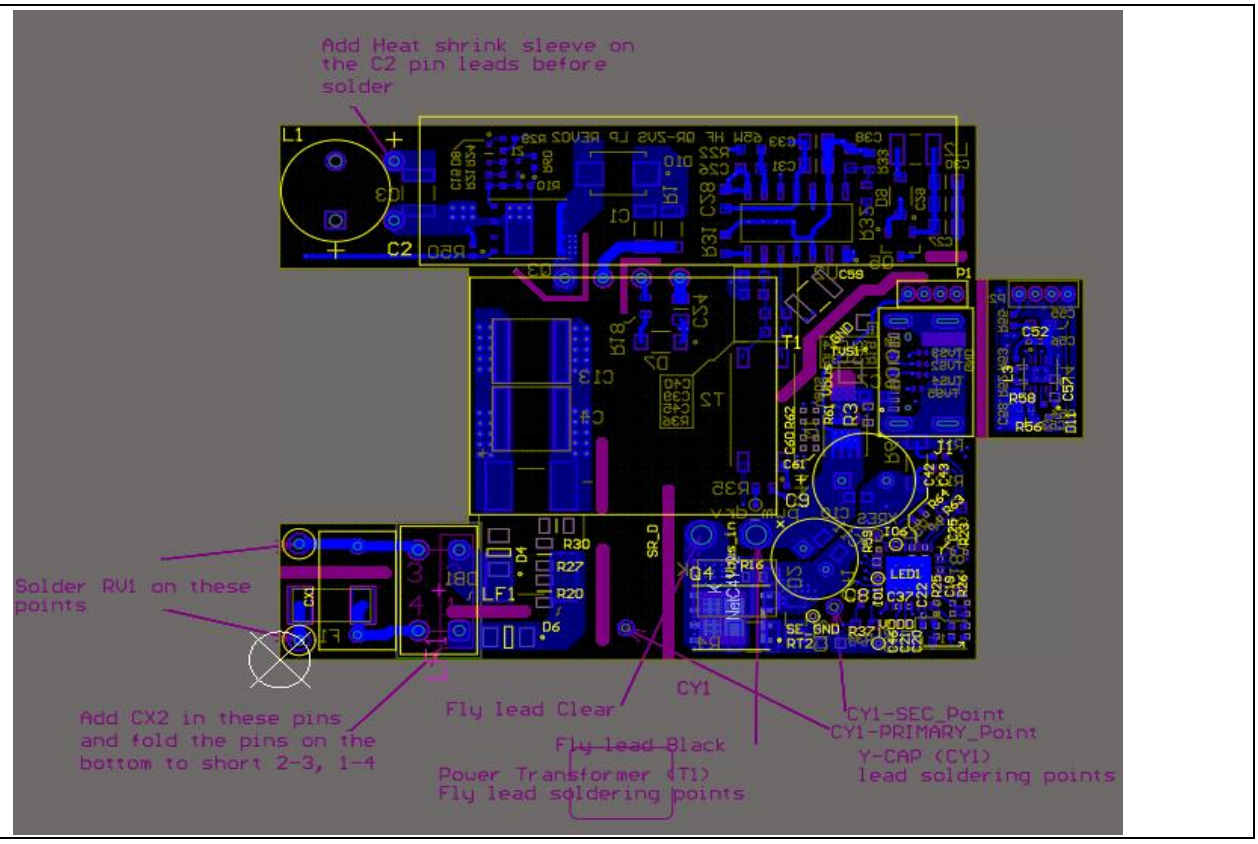


Figure 109 Bottom solder copper – layer 4

Appendix

6.7 EZ-PD™ Configuration Utility

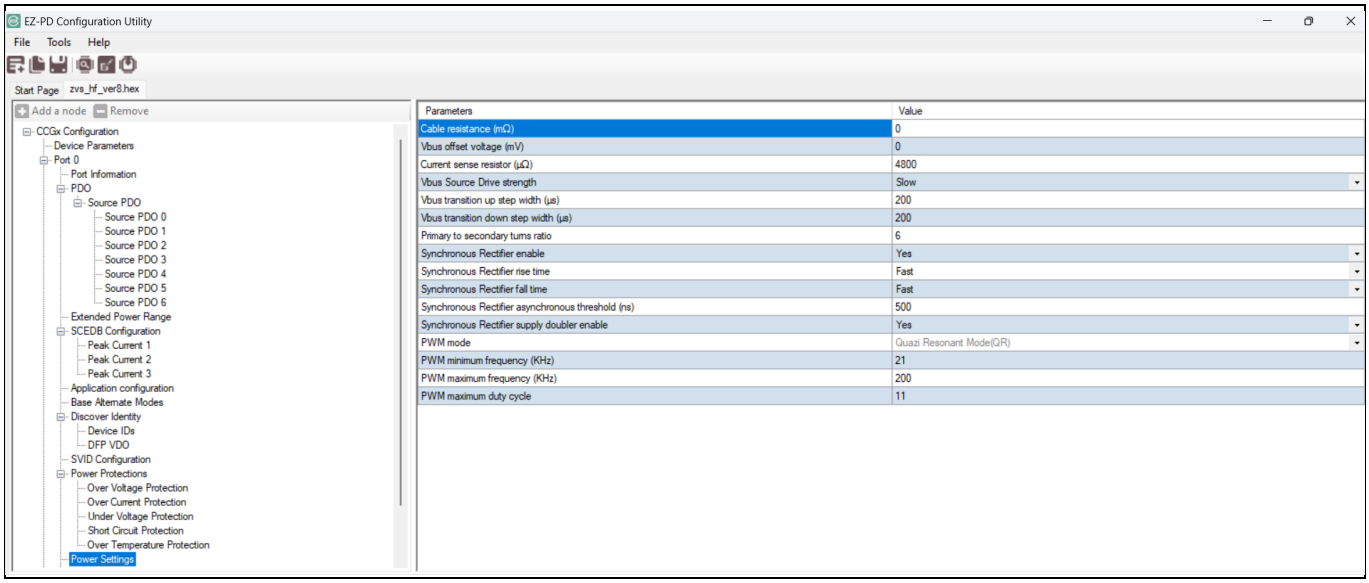


Figure 110 EZ-PD™ Configuration Utility

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 graphical user interface (GUI) of EZ-PD™ Configuration Utility allows users to intuitively select and configure the parameters for their application.

Following table shows the default configured values with respect to power settings and power protections.

Table 28 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	Enable for all voltages
PWM mode	Quasi resonant mode (QR)
PWM minimum frequency (kHz)	21

Appendix

Parameters	Values
PWM maximum frequency (kHz)	200
PWM maximum duty cycle at Minimum frequency (%)	18
Power protections	
Overvoltage protection	
Enable	Yes
Mode	OVP using dedicated comparator
OVP threshold (%)	20
Debounce period (µs)	10
Retry count	2
Overcurrent protection	
Enable	Yes
OCP threshold (%)	20
Debounce period (ms)	15
Retry count	2
Undervoltage protection	
Enable	Yes
Mode	UVP using dedicated comparator hardware detects trips and turns off FETs
UVP threshold (%)	70
Debounce period (µs)	10
Retry count	2
Shortcircuit protection	
Enable	Yes
Sense resistance (milli ohms)	0
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

References

[1] Infineon Technologies AG: *EZ-PD™ Configuration Utility*; Available online

[2] Infineon Technologies AG: *EZ-PD™ PAG2P primary-side start-up controller*; Available online

[3] Infineon Technologies AG: *EZ-PD™ PAG2S integrated USB PD and secondary-side ACF controller*; Available online

[4] Infineon Technologies AG: *65 W PAG2P-2S HF-ZVS PA (REF_65W_HFZVS_PAG2_PA) adapter board test report*; Available online

[5] USB Implementers Forum, Inc.: *Document library;* Available online

[6] USB Implementers Forum, Inc.: *USB Type-C and connector specification (Release 2.2)*; Available online

[7] Qualtek Electronics Corp.: *3027003-01M USB 3.1(C)/M - USB 3.1 (C) specification;* Available online

Abbreviations and definitions

Table 29 Abbreviations

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
Io/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 adaptor tester
PDO	Power delivery output
PPS	Programmable power supply
SCP	Short-circuit protection
USB PD	Universal Serial Bus Power Delivery
VBUS_C/V_{OUT}	Output voltage of the DUT
V_{AC}/V_{IN_AC}	Input DC voltage to the DUT
ZVS	Zero-voltage switching

Revision history

Document revision	Date	Description of changes
**	2025-04-16	Initial release

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Document reference

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