STDES-65ACFADP test report

Introduction

This document reports the functional, thermal, EMI, and efficiency measurements results for the STDES-65ACFADP 65 W active clamp flyback adaptor reference design for USB Type-C™ PD source applications. This reference design meets CoC Tier 2 and DoE Level 6 efficiency requirements with a peak efficiency of 93.7% at full load.

The STDES-65ACFADP adopts the planar transformer technology, with an integrated GaN-based solution and digital control.

The reference design main devices are:

- ST-ONE: a programmable digital controller for the active clamp flyback primary high-low side GaN HEMT control plus a secondary synchronous rectifier MOSFET control and USB-PD control;
- MASTERGAN2: a high-voltage enhancement mode GaN with a half-bridge configuration and integrated gate driver.

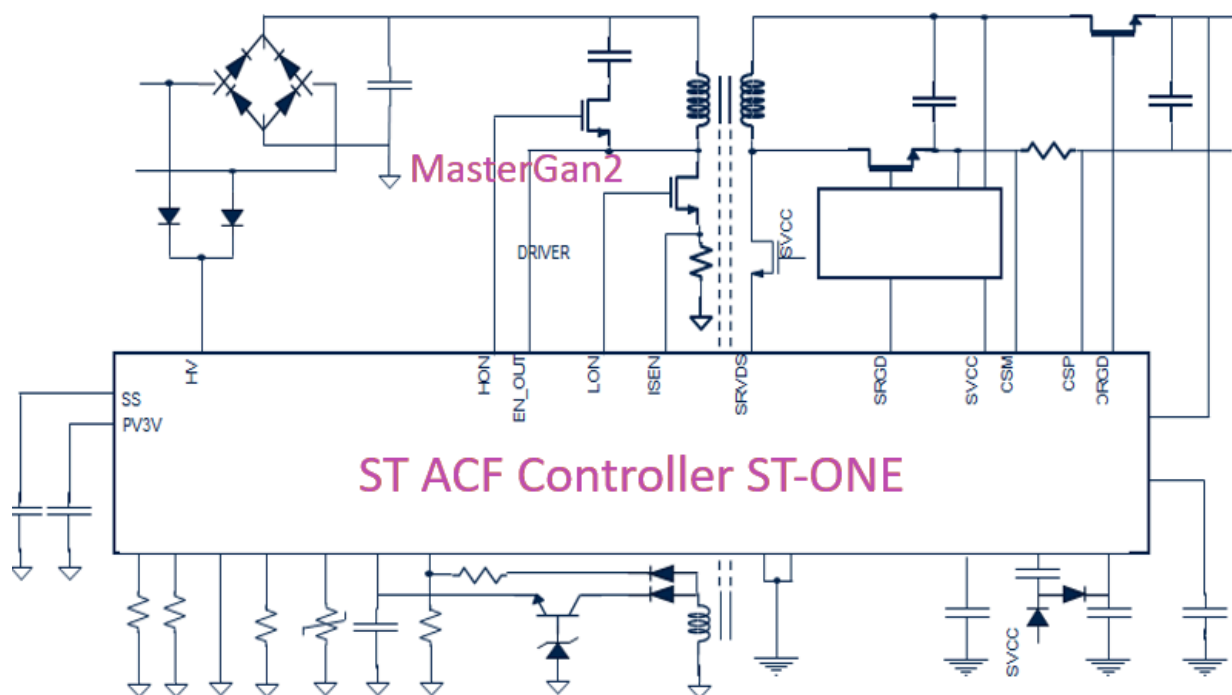The STDES-65ACFADP is a fully assembled reference design developed for performance evaluation only, not available for sale.

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For further information contact your local STMicroelectronics sales office.

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1 Overview

The STDES-65ACFADP main features are:

- Universal input mains range: 90 Vac to 264 Vac - frequency 47 Hz to 63 Hz
- Output voltage range: 5 V_{DC} - 20 V_{DC}
- PD output:
  – Five fixed PDOs: 5 V@3 A, 9 V@3 A, 12 V@3 A, 15 V@3 A, 20 V@3.25 A
- Output power: 20 V - 3.25 A, 65 W max.
- Form factor: 54 mm (L)*31 mm (W)*25 mm (H)
- Efficiency: meets CoC Tier 2 and DoE Level 6 efficiency requirements, with a peak efficiency of 93.7% at 230 Vac 65 W
- Digital control for ACF primary and secondary sides
- Integrated GaN IC MASTERGAN2
- Compact, simplified PCB layout, and bill of material reduction
- EMC compliant: CISPR32B/EN55032B
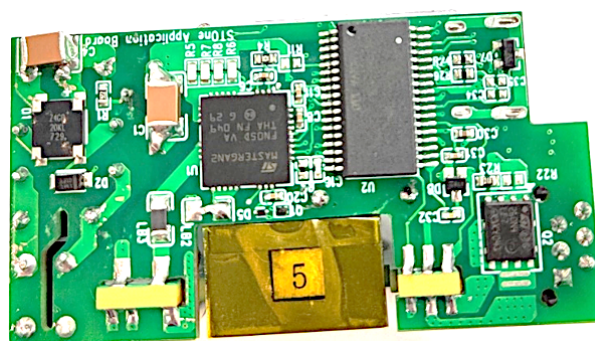- Planar transformer technology to achieve high-power density

Figure 1. STDES-65ACFADP architecture block diagram

Figure 2. STDES-65ACFADP reference design - top side
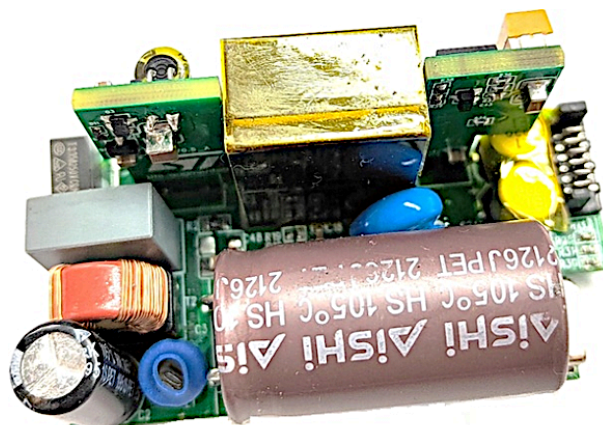
Figure 3. STDES-65ACFADP reference design - bottom side

Fully assembled board developed for
performance evaluation only,
not available for sale

2 Specifications

Table 1. STDES-65ACFADP electrical specifications

Symbol	Parameter	Test conditions	Minimum	Nominal	Maximum	Unit
		Input parameters				
V_{IN}	Input line voltage		90	115/230	264	Vrms
f_{LINE}	Input line frequency		47	50/60	63	Hz
P_{STBY}	No load input power (5 V_{OUT})	V_{IN} = 115 V_{RMS}, I_{OUT} = 0 A		50		mW
		V_{IN} = 230 V_{RMS}, I_{OUT} = 0 A		80		
P_{STBY}	No load input power (9 V_{OUT})	V_{IN} = 115 V_{RMS}, I_{OUT} = 0 A		170		mW
		V_{IN} = 230 V_{RMS}, I_{OUT} = 0 A		180		
P_{STBY}	No load input power (12 V_{OUT})	V_{IN} = 115 V_{RMS}, I_{OUT} = 0 A		220		mW
		V_{IN} = 230 V_{RMS}, I_{OUT} = 0 A		260		
P_{STBY}	No load input power (15 V_{OUT})	VIN = 115 V_{RMS}, I_{OUT} = 0 A		280		mW
		VIN = 230 V_{RMS}, I_{OUT} = 0 A		290		
P_{STBY}	No load input power (20 V_{OUT})	V_{IN} = 115 V_{RMS}, I_{OUT} = 0 A		180		mW
		V_{IN} = 230 V_{RMS}, I_{OUT} = 0 A		220		
		Output parameters - 5 V setting				
V_{OUT}	Output voltage	V_{IN} = 90 V_{RMS}~264 V_{RMS} I_{OUT} = 0 A~3 A		5		V
V_{ripple}	Output voltage ripple	Peak-to-peak value with 20 MHz bandwidth		180	250	mV
I_{OUT}	Output current		0		3	A
P_{OUT}	Continuous output power		0		15	W
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 115 V_{AC} and measured at the on-board USB Type-C™ receptacle		90.2		%
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 230 V_{AC} and measured at the on-board USB Type-C™ receptacle		88.4		%
		Output parameters - 9 V setting				
V_{OUT}	Output voltage	V_{IN} = 90 V_{RMS}~264 V_{RMS} I_{OUT} = 0 A~3 A		9		V
V_{ripple}	Output voltage ripple	Peak-to-peak value with 20 MHz bandwidth		152	250	mV
I_{OUT}	Output current		0		3	A
P_{OUT}	Continuous output power		0		27	W
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 115 V_{AC} and measured at the on-board USB Type-C™ receptacle		91.2		%
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 230 V_{AC} and measured at the on-board USB Type-C™ receptacle		90.3		%
		Output parameters - 12 V setting				
V_{OUT}	Output voltage	V_{IN} = 90 V_{RMS}~264 V_{RMS}		12		V

Symbol	Parameter	Test conditions	Minimum	Nominal	Maximum	Unit
		I_{OUT} = 0 A~3 A				
V_{ripple}	Output voltage ripple	Peak-to-peak value with 20 MHz bandwidth		180	250	mV
I_{OUT}	Output current		0		3	A
P_{OUT}	Continuous output power		0		36	W
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 115 V_{AC} and measured at the on-board USB Type-C™ receptacle		91.7		%
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 230 V_{AC} and measured at the on-board USB Type-C™ receptacle		91.5		%
Output parameters - 15 V setting						
V_{OUT}	Output voltage	V_{IN} = 90 V_{RMS}~264 V_{RMS} I_{OUT} = 0 A~3 A		15		V
V_{ripple}	Output voltage ripple	Peak-to-peak value with 20 MHz bandwidth		164	250	mV
I_{OUT}	Output current		0		3	A
P_{OUT}	Continuous output power		0		45	W
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 115 V_{AC} and measured at the on-board USB Type-C™ receptacle		91.7		%
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 230 V_{AC} and measured at the on-board USB Type-C™ receptacle		91.8		%
Output parameters - 20 V setting						
V_{OUT}	Output voltage	V_{IN} = 90 V_{RMS}~264 V_{RMS} I_{OUT} = 0 A~3.25 A		20		V
V_{ripple}	Output voltage ripple	Peak-to-peak value with 20 MHz bandwidth		268	300	mV
I_{OUT}	Output current		0		3.25	A
P_{OUT}	Continuous output power		0		65	W
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 115 V_{AC} and measured at the on-board USB Type-C™ receptacle		91.7		%
η_{ave}	Four-point average efficiency 25%, 50%, 75%, and 100% load	At 230 V_{AC} and measured at the on-board USB Type-C™ receptacle		92.1		%
Ambient and EMI parameters						
T_{AMB}	Ambient temperature	Free convection sea level	0	25	40	°C
EMI	Conducted EMI		Meets CISPR32B /EN55032			

3 Test setup

3.1 Test conditions and equipment

- 1 x STDES-65ACFADP reference design
- 1 x 61604A programmable AC source by Chroma
- 1 x 63600-5 DC E-load by Chroma
- 1 x WT500 power analyzer by YOKOGAWA
- 1 x MSO44 mixed signal oscilloscope by Tektronix
- 1 x 8845A 6-1/2 digit precision multimeter by FLUKE
- 1 x P-NUCLEO-USB002 kit (sink emulator) to connect to the USB Type-C™ output to adjust the output voltage
- Ambient temperature = 25°C

Figure 4. STDES-65ACFADP test setup
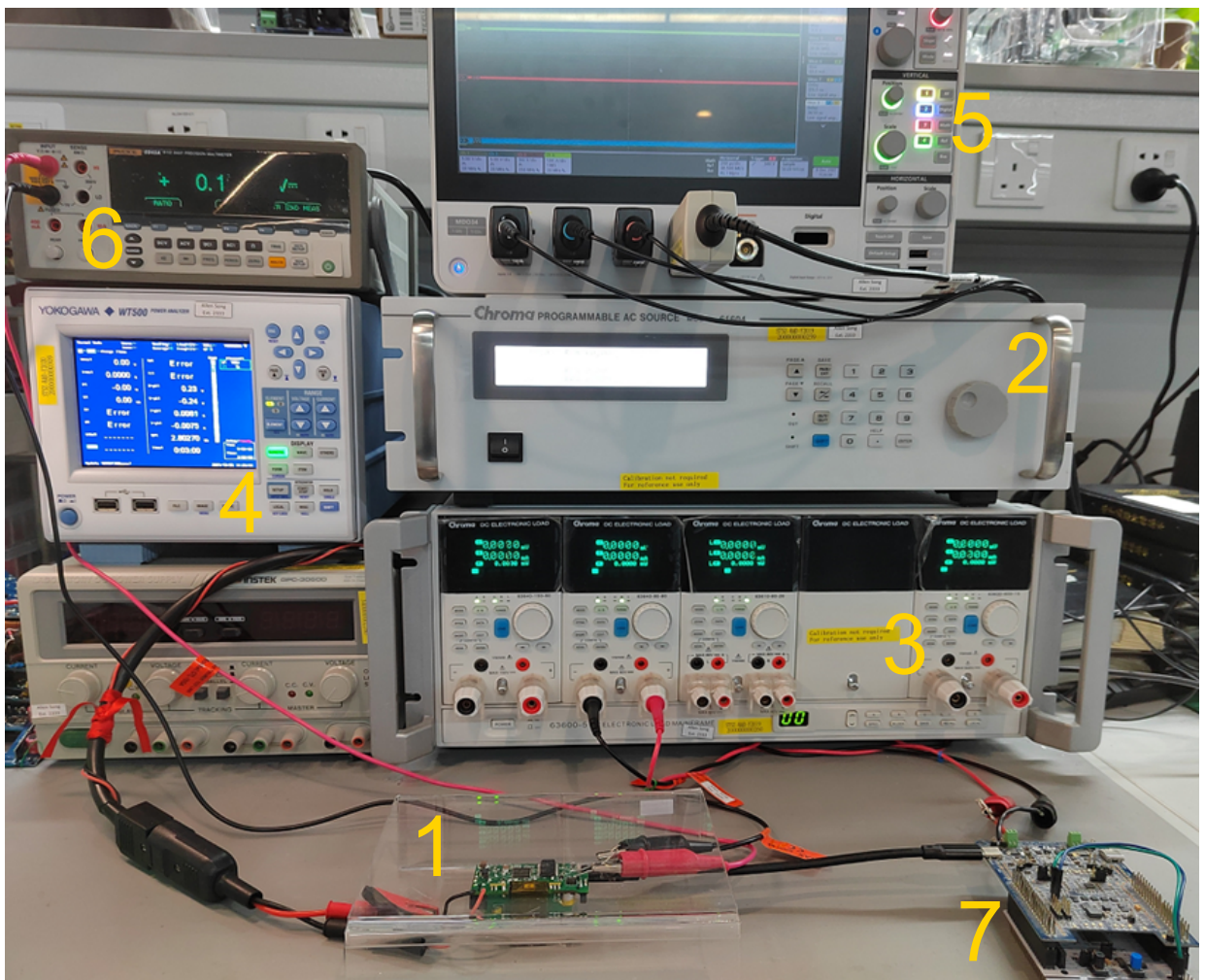
3.2 Procedure

Follow the steps below to test the reference design.

Step 1. Connect the STDES-65ACFADP USB Type-C™ output to the P-NUCLEO-USB002 kit via a USB Type-C™ cable.

Step 2. Connect the P-NUCLEO-USB002 to a PC computer via a USB Type-A cable.

Step 3. Connect the AC source to the STDES-65ACFADP AC input L/N cables.

Step 4. Power up the STDES-65ACFADP with a 110 V_{AC} or 230 V_{AC} input to start the test.

Step 5. Adjust the output voltage through the P-NUCLEO-USB002.

Step 6. Adjust the output current through the E-load.

4 Measurements/waveforms/test data

4.1 Efficiency test results

We tested the STDES-65ACFADP efficiency at 115 V_{AC} and 230 V_{AC} with different output voltages (5, 9, 12, 15, and 20 V).

The obtained results show that our reference design meets the EU CoC Rev.05 Tier 2 and DoE Level 6 requirements with an adequate margin.

4.1.1 Efficiency at 115 V_{AC} input

Figure 5. STDES-65ACFADP efficiency at 115 V_{AC} input
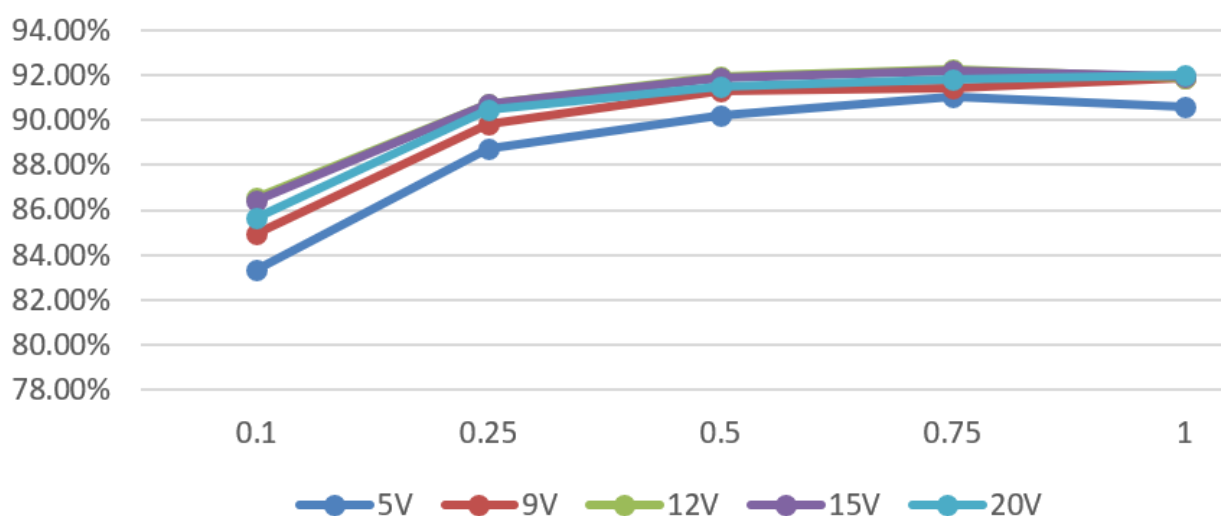
Table 2. STDES-65ACFADP efficiency at 115 V_{AC} input with different input voltages

Condition	Percentage of full loading	5 V	9 V	12 V	15 V	20 V
EU CoC Rev.05-Tier2 limit for 10% loading	-	72.48%	77.30%	78.30%	78.85%	78.85%
115 V_{AC} 60 Hz input	10%	83.33%	84.92%	86.56%	86.45%	85.64%
	25%	88.70%	89.83%	90.73%	90.73%	90.45%
	50%	90.18%	91.32%	91.91%	91.89%	91.86%
	75%	91.05%	91.39%	92.25%	92.21%	91.90%
	100%	90.58%	91.90%	91.88%	91.95%	92.40%
Four-point average		90.13%	91.11%	91.69%	91.70%	91.65%
EU CoC Rev.05-Tier2 limit	-	81.84%	87.30%	88.30%	88.85%	88.85%

4.1.2 Efficiency at 230 V$_{AC}$ input

Figure 6. STDES-65ACFADP efficiency at 230 V$_{AC}$ input
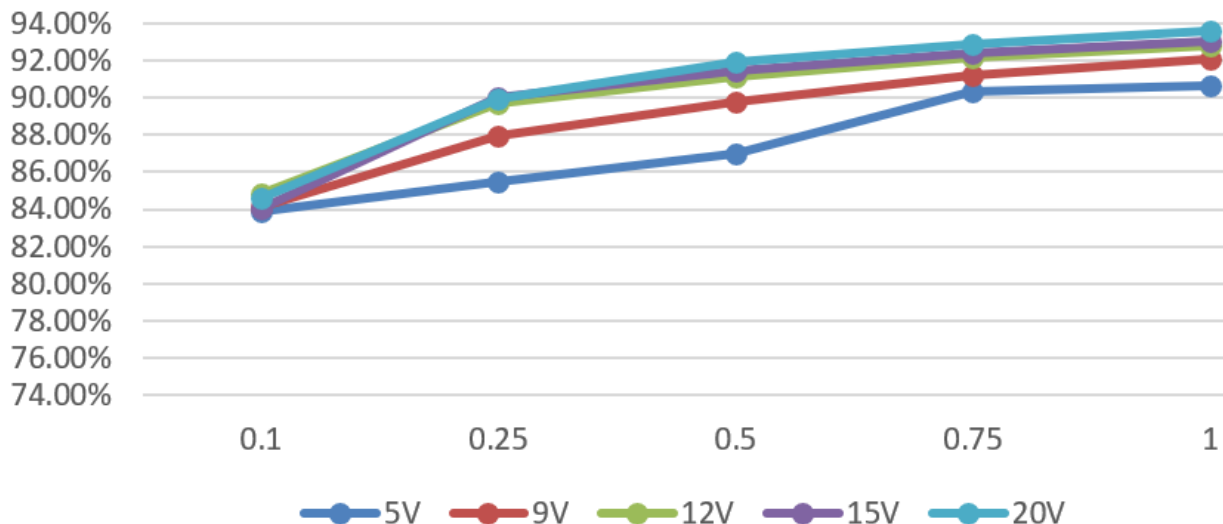
Table 3. STDES-65ACFADP efficiency at 230 V$_{AC}$ input with different input voltages

Condition	Percentage of full loading	5 V	9 V	12 V	15 V	20 V
EU CoC Rev.05-Tier2 limit for 10% loading	-	72.48%	77.30%	78.30%	78.85%	78.85%
230 V$_{AC}$ 50 Hz input	10%	83.87%	84.14%	84.80%	84.07%	84.58%
	25%	85.46%	87.90%	89.68%	90.00%	89.91%
	50%	86.99%	89.74%	91.12%	91.43%	91.95%
	75%	90.29%	91.20%	92.19%	92.42%	92.83%
	100%	90.65%	92.11%	92.76%	93.01%	93.70%
Four-point average		88.35%	90.24%	91.44%	91.72%	92.10%
EU CoC Rev.05-Tier2 limit	-	81.84%	87.30%	88.30%	88.85%	88.85%

4.2 Load and line regulation test results

Table 4. Load and line regulation at 5 V$_{OUT}$

Loading (%)	115 V$_{AC}$ (V)	230 V$_{AC}$ (V)	SPEC limit (V)	
0	5.10	5.11	4.85	5.15
10	4.88	4.89		
20	4.87	4.88		
33	4.93	4.91		
50	5.02	5.01		
75	5.02	5.02		
83	5.02	5.03		
100	5.02	5.03		

Table 5. Load and line regulation at 9 V$_{OUT}$

Loading (%)	115 V$_{AC}$ (V)	230 V$_{AC}$ (V)	SPEC limit (V)	
0	9.08	9.09		
10	9.07	9.08		
25	9.06	9.09	8.73	9.27
50	9.07	9.07		
75	9.06	9.05		
100	9.02	9.02		

Table 6. Load and line regulation at 12 V$_{OUT}$

Loading (%)	115 V$_{AC}$ (V)	230 V$_{AC}$ (V)	SPEC limit (V)	
0	12.05	12.08		
10	11.85	11.86		
20	11.87	11.87	11.64	12.36
50	11.88	11.89		
75	11.87	11.90		
100	11.85	11.88		

Table 7. Load and line regulation at 15 V$_{OUT}$

Loading (%)	115 V$_{AC}$ (V)	230 V$_{AC}$ (V)	SPEC limit (V)	
0	15.08	15.08		
10	15.06	15.09		
25	15.05	15.04	14.55	15.45
50	15.06	15.06		
75	15.05	15.06		
100	15.02	15.00		

Table 8. Load and line regulation at 20 V$_{OUT}$

Loading (%)	115 V$_{AC}$ (V)	230 V$_{AC}$ (V)	SPEC limit (V)	
0	20.05	20.06		
10	20.03	20.03		
25	20.02	20.03	19.4	20.6
50	20.01	20.02		
75	20.01	20.01		
100	20.00	20.00		

4.3 Ripple and noise

4.3.1 Test setup of the V$_{OUT}$ ripple and noise

To test the V$_{OUT}$ ripple and noise, we added a 10 µF electrolytic capacitor and a 100 nF ceramic capacitor at the end of the USB Type-C™ cable, as shown below.

Figure 7. **STDES-65ACFADP ripple and noise test setup**

4.3.2 Ripple and noise test results

Figure 8. **Ripple and noise at 115 V$_{AC}$ input: 5 V$_{OUT}$/3 A V$_{peak-peak}$ = 180 mV**
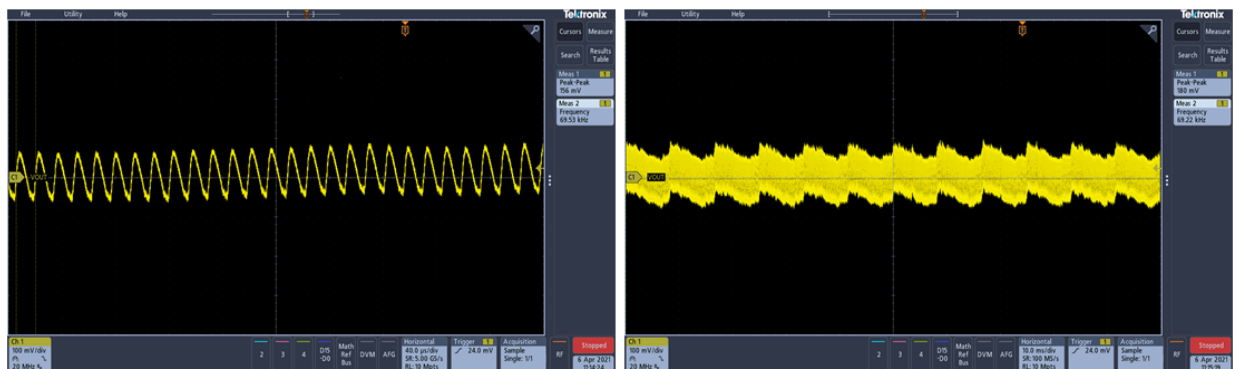
Figure 9. **Ripple and noise at 230 V$_{AC}$ input: 5 V$_{OUT}$/3 A V$_{peak-peak}$ = 140 mV**
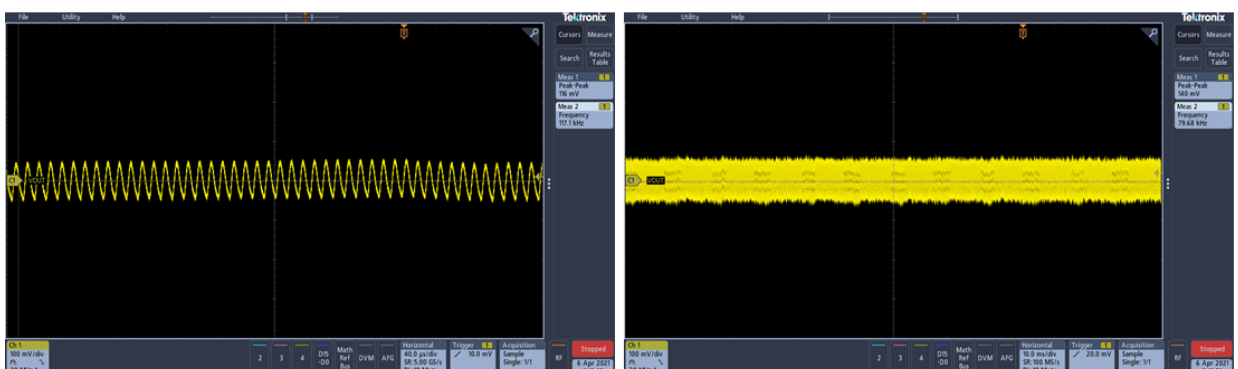
Figure 10. Ripple and noise at 115 V$_{AC}$ input: 9 V$_{OUT}$/3 A V$_{peak-peak}$ = 152 mV
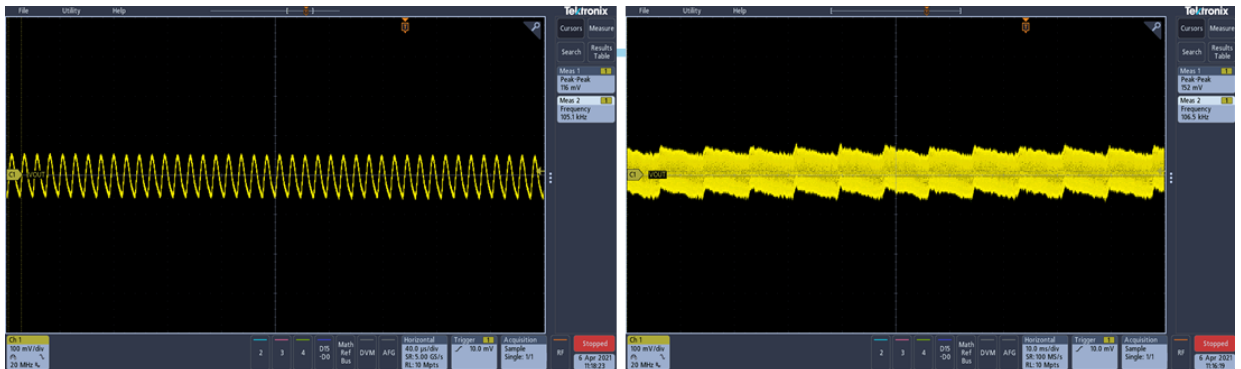
Figure 11. Ripple and noise at 230 V$_{AC}$ input: 9 V$_{OUT}$/3 A V$_{peak-peak}$ = 175 mV
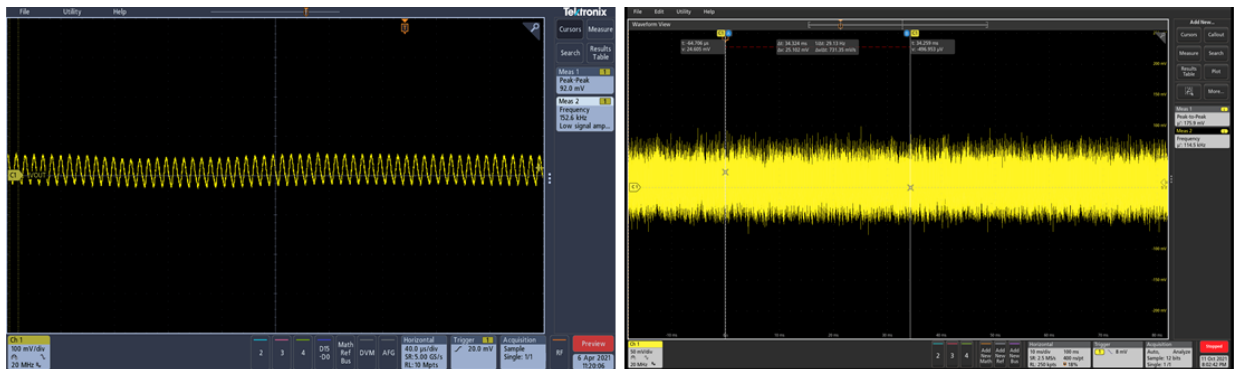
Figure 12. Ripple and noise at 115 V$_{AC}$ input: 12 V$_{OUT}$/3 A V$_{peak-peak}$ = 180 mV
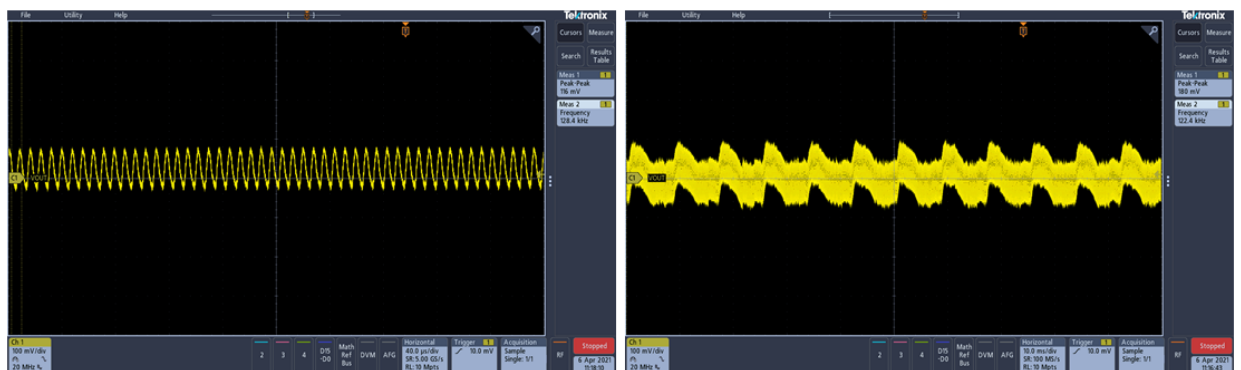
Figure 13. Ripple and noise at 230 V$_{AC}$ input: 12 V$_{OUT}$/3 A V$_{peak-peak}$ = 199 mV
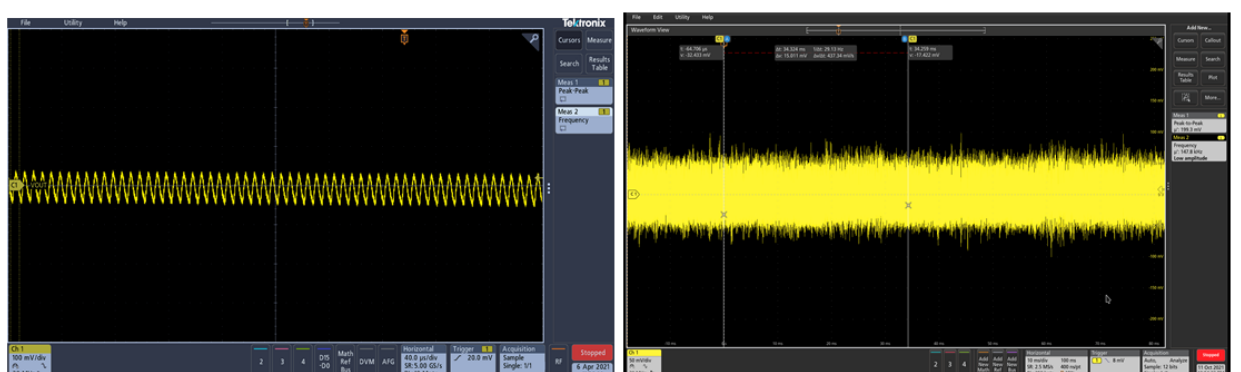
Figure 14. Ripple and noise at 115 V$_{AC}$ input: 15 V$_{OUT}$/3 A V$_{peak-peak}$ = 184 mV
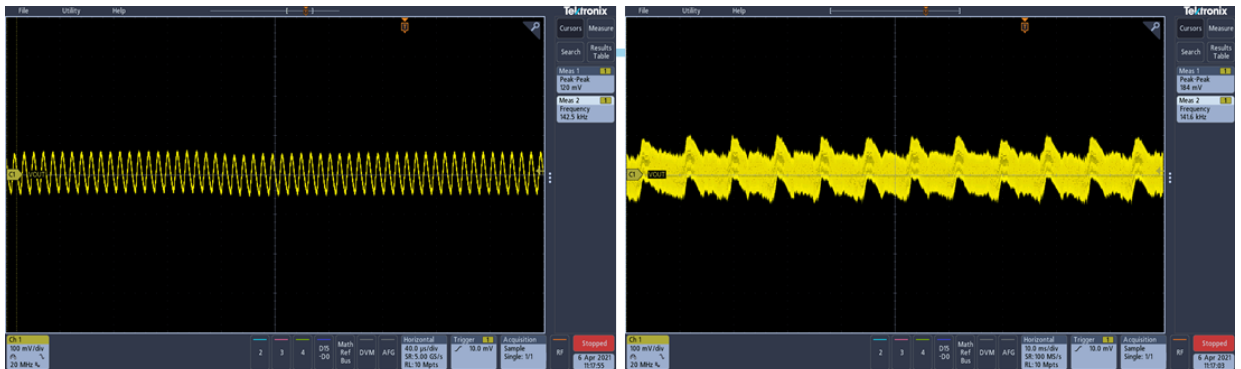
Figure 15. Ripple and noise at 230 V$_{AC}$ input: 15 V$_{OUT}$/3 A V$_{peak-peak}$ = 203 mV
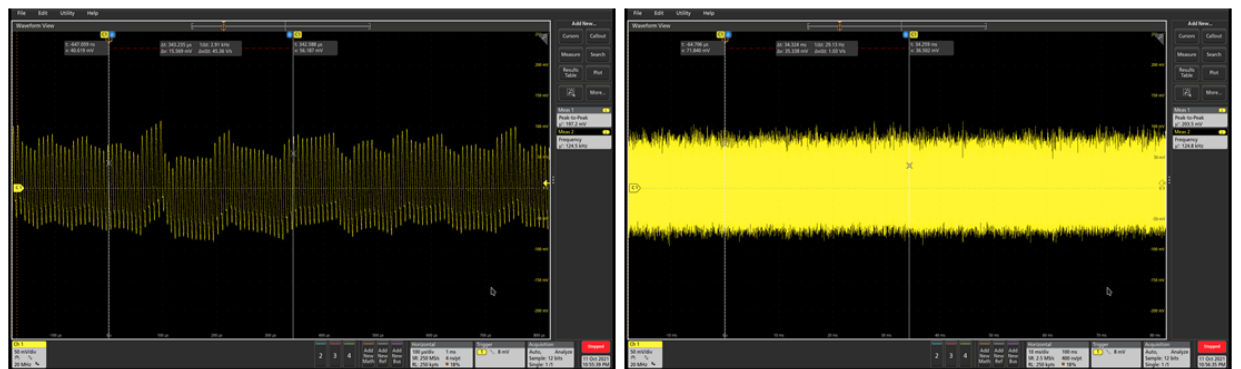
Figure 16. Ripple and noise at 115 V$_{AC}$ input: 20 V$_{OUT}$/3.25 A V$_{peak-peak}$ = 268 mV
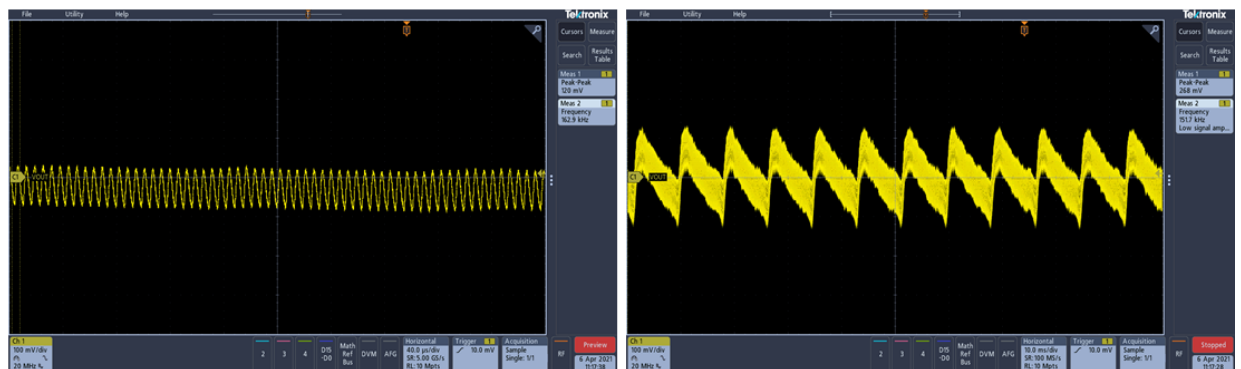
Figure 17. Ripple and noise at 230 V$_{AC}$ input: 20 V$_{OUT}$/3.25 A V$_{peak-peak}$ = 263 mV
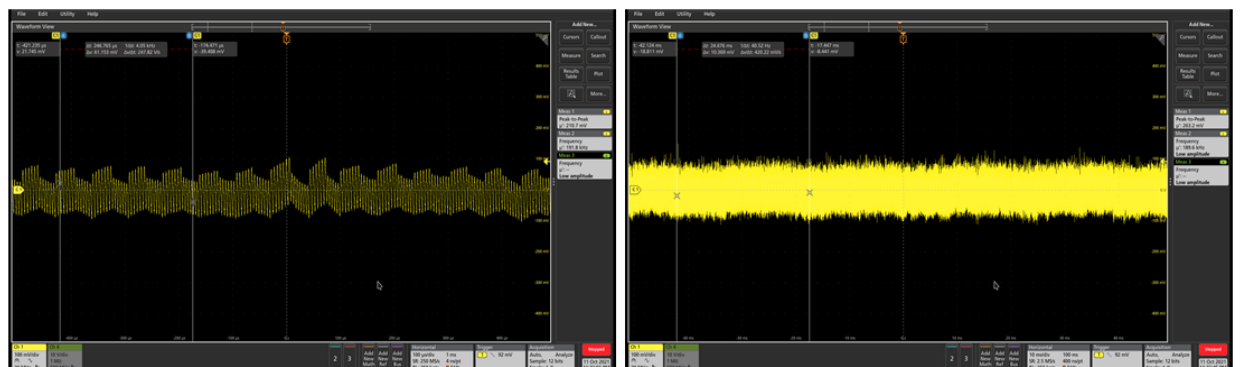
4.4 Typical waveforms

4.4.1 Startup

Figure 18. Startup waveform

- Yellow line: CH1 for low side GaN Vds
- Light blue line: CH2 for low side GaN Vgs
- Purple line: CH3 for clamp GaN Vgs

4.4.2 Normal operation

Figure 19. Primary side typical waveform: normal operation with 230 V$_{IN}$ 20 V$_{OUT}$/1.5 A

- Yellow line: CH1 for low side GaN Vds
- Light blue line: CH2 for low side GaN Vgs
- Purple line: CH3 for clamp GaN Vgs
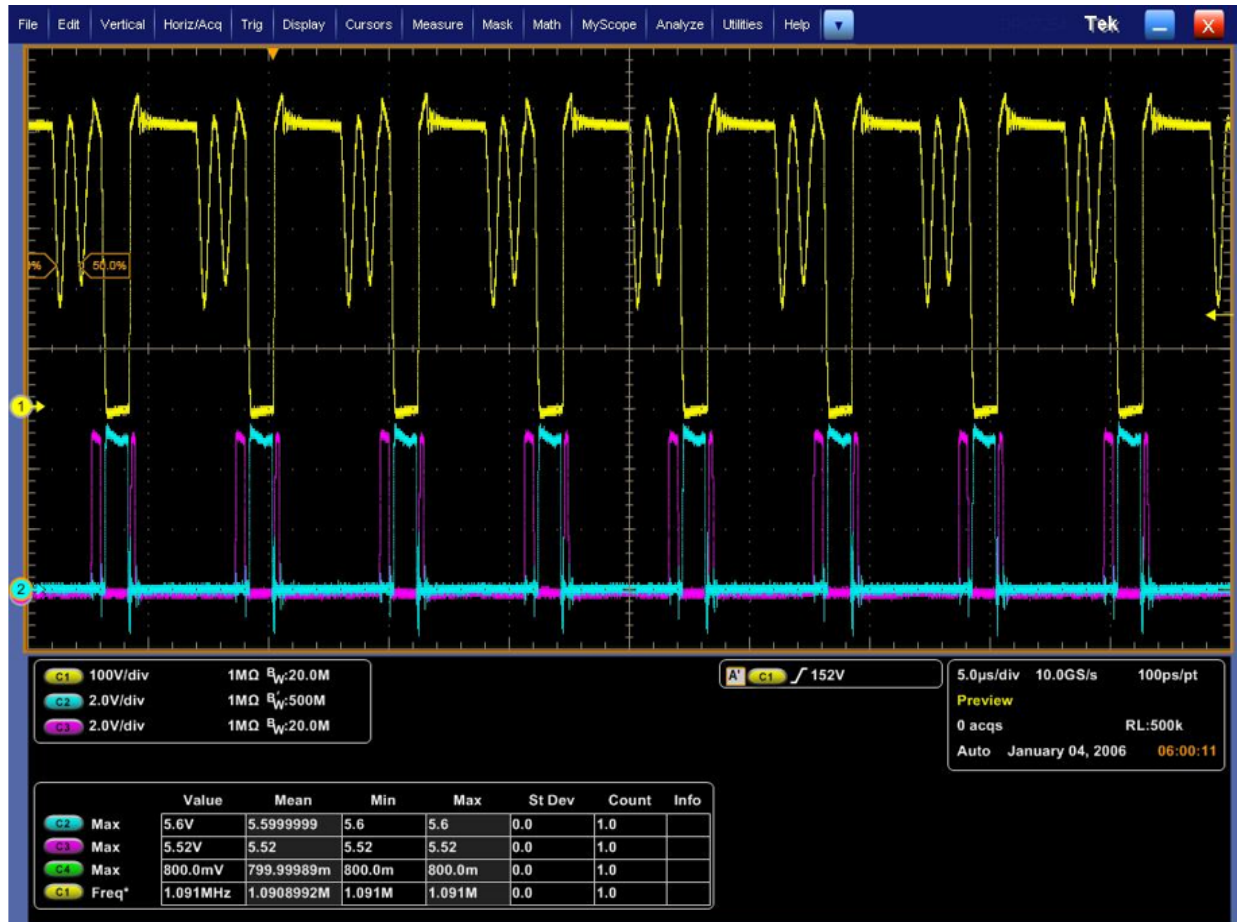
Figure 20. Secondary SR MOSFET Vds at 20 V 3.25 A

- Yellow line: CH1 for SR MOSFET Vds
- Light blue line: CH2 for low side GaN Vds
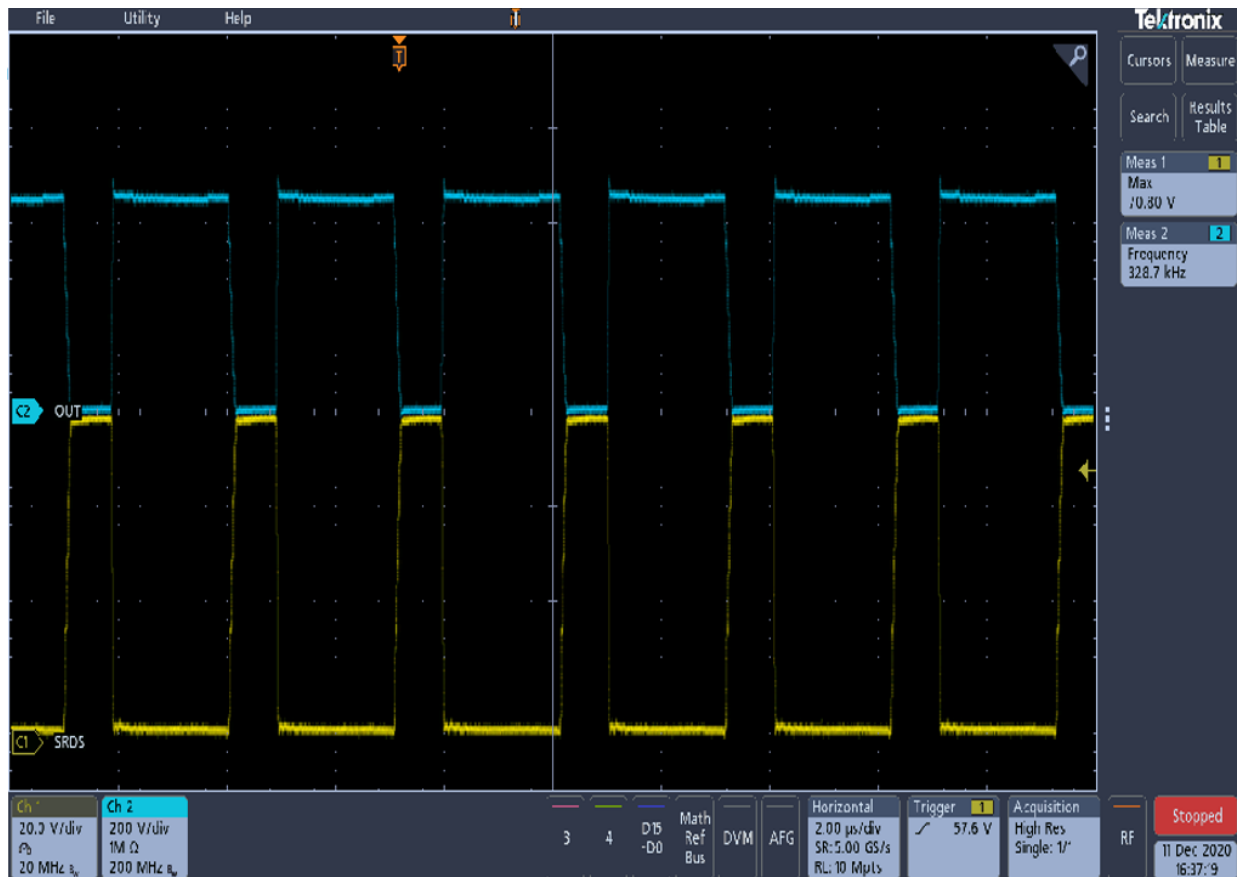
4.4.3 Normal operation, valley-skipping, and burst modes

To improve the efficiency at a medium load, the controller enters in valley-skipping mode when the switching frequency increases above a programmable value.

While in valley-skipping mode, the output load further decreases. If the frequency drops below about 20 KHz, the system enters the burst mode.

Figure 21. Normal operation mode
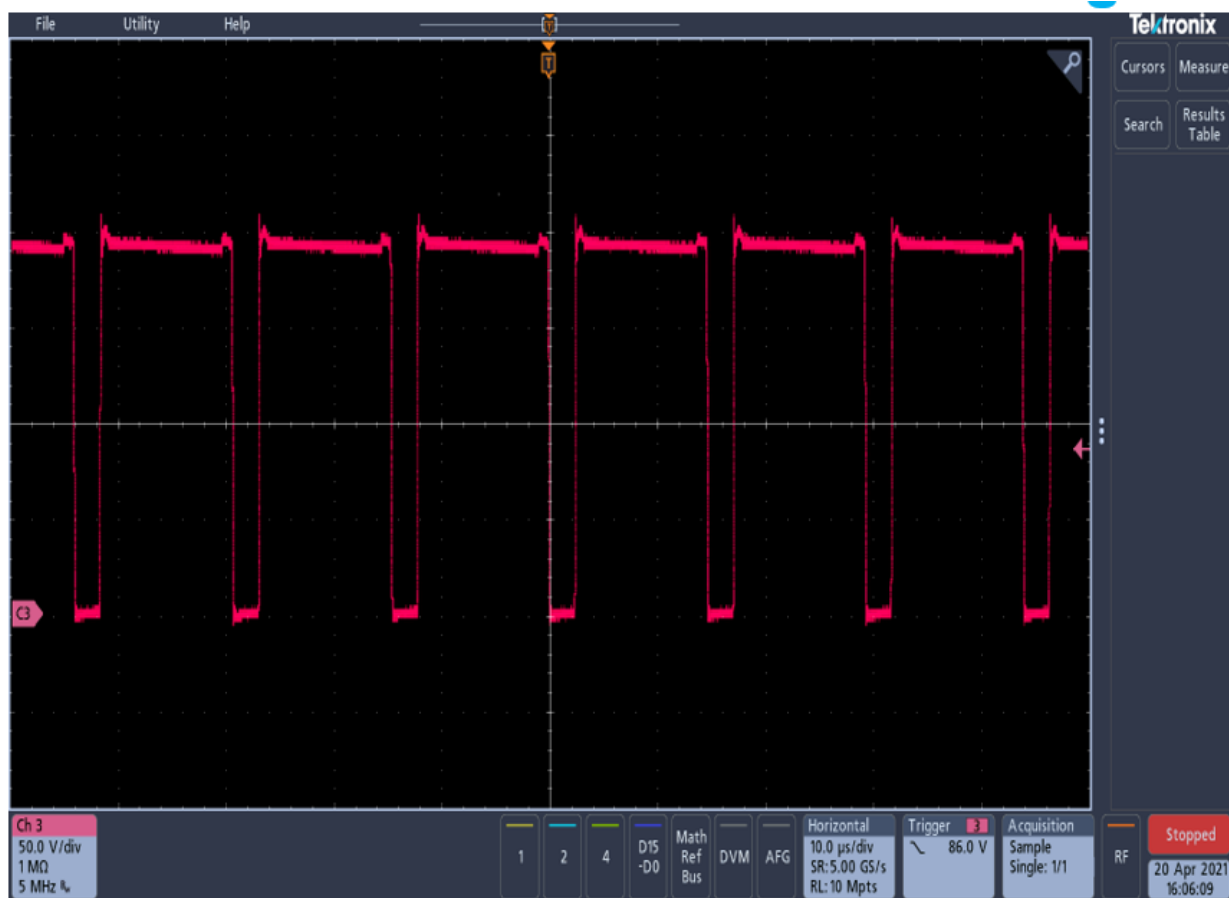
Figure 22. Valley-skipping mode
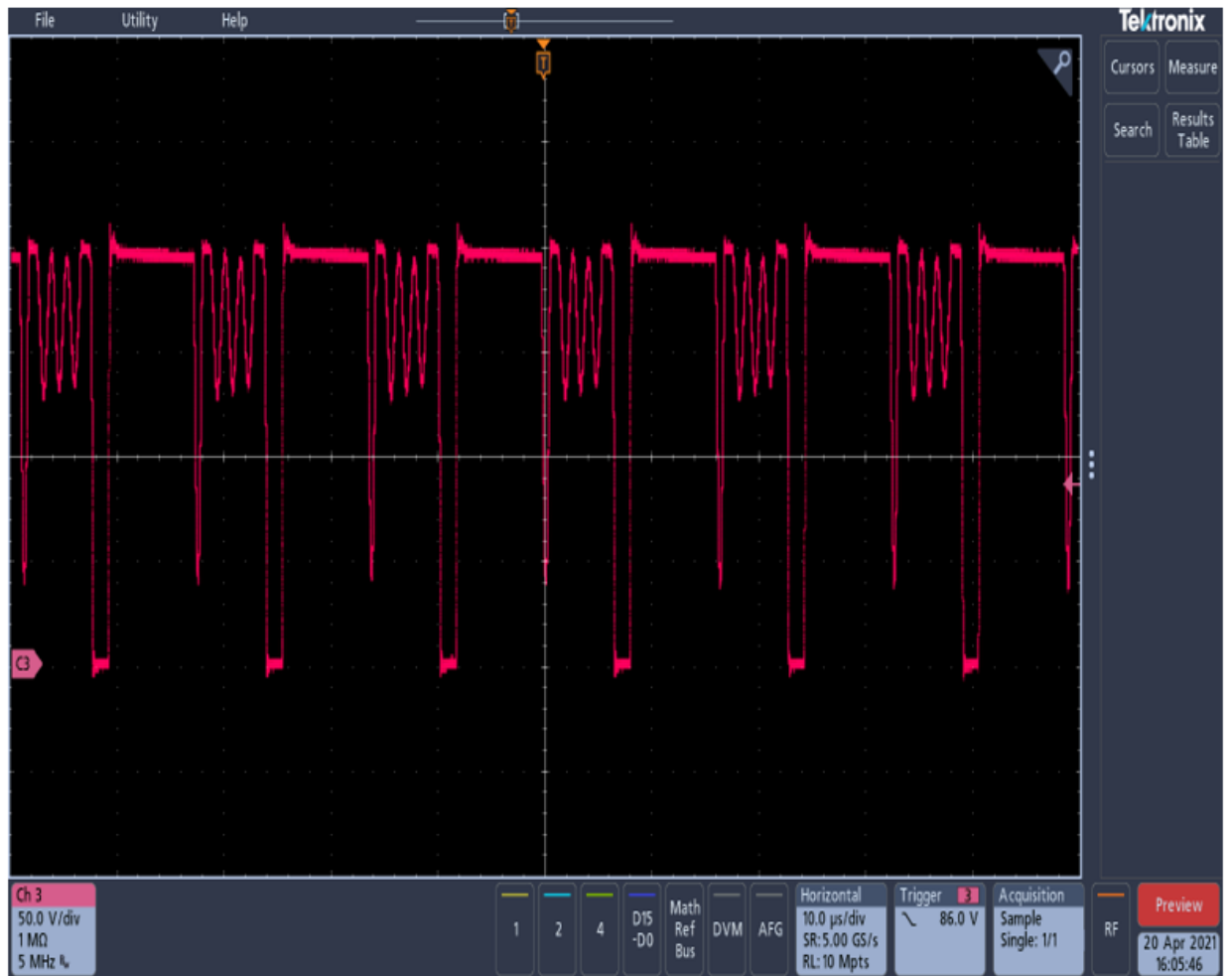
Figure 23. Burst mode
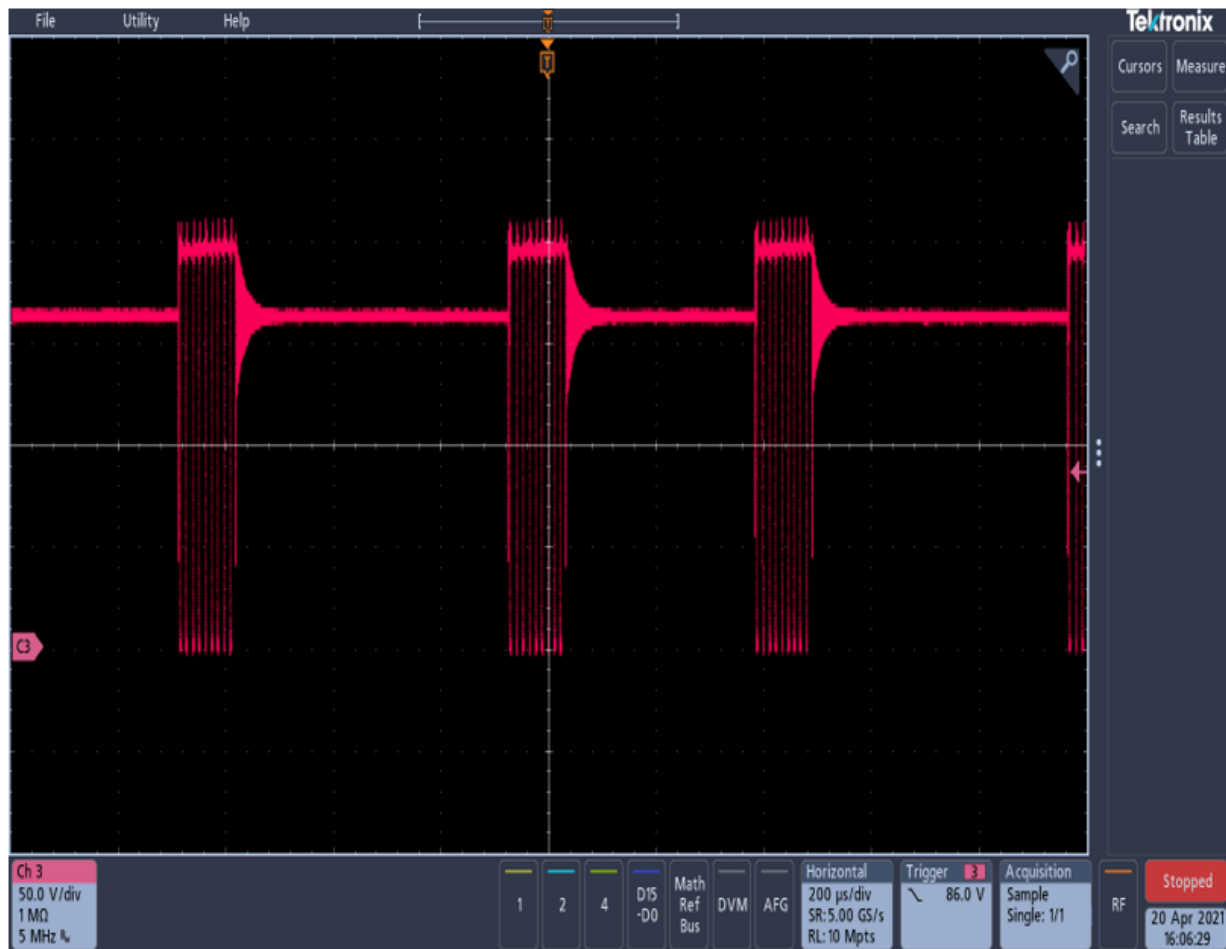
4.4.4 Thermal performance

Table 9. Key components temperature at 20 V_{OUT}/3.25 A, T_a = 25°C

Devices	115 V_{AC}	230 V_{AC}
	Maximum temperature	Maximum temperature
MASTERGAN2	86.5	84
ST-ONE	75.1	74.3
Transformer	78.6	79.4
SR MOS	83.2	79.4
Bridge diode	100	74.5

Figure 24. Thermal performance of the key components at 20 V/3.25 A, 115 V$_{AC}$ input
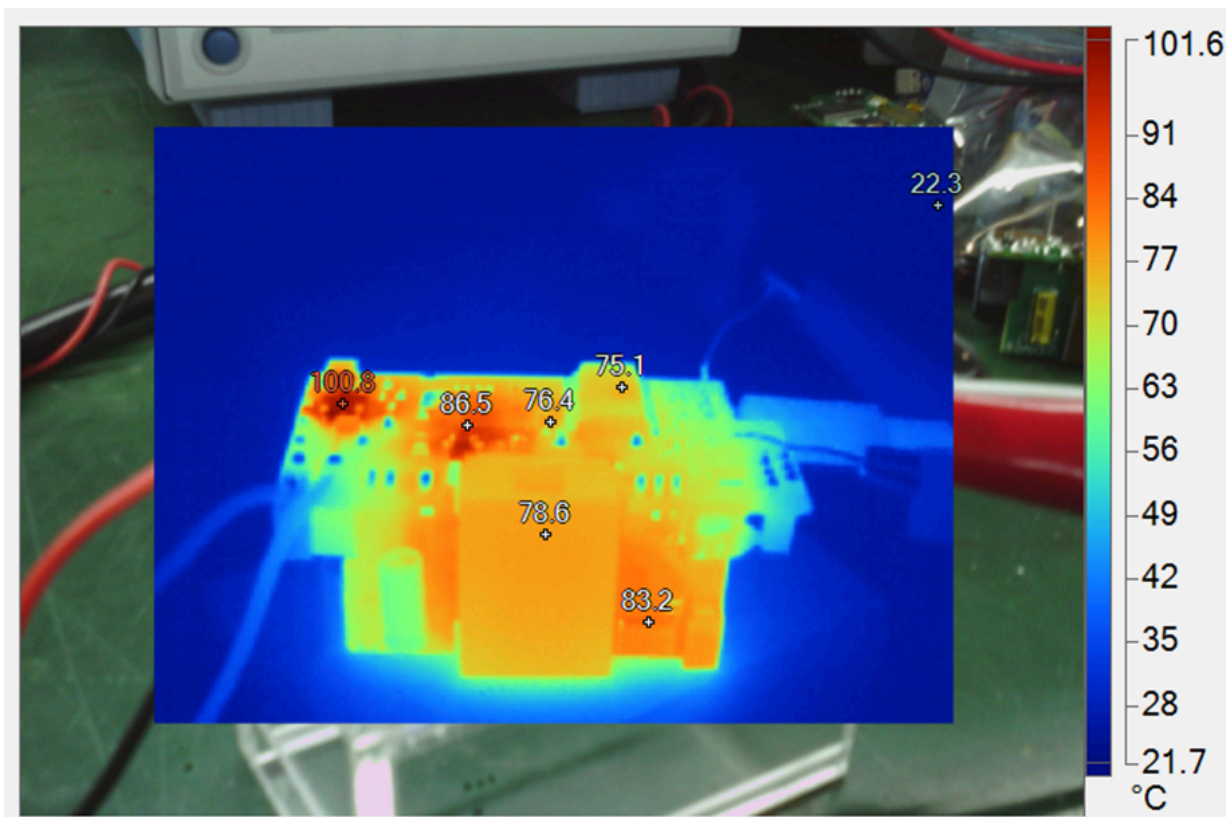
Figure 25. Thermal performance of the key components at 20 V/3.25 A, 230 V$_{AC}$ input
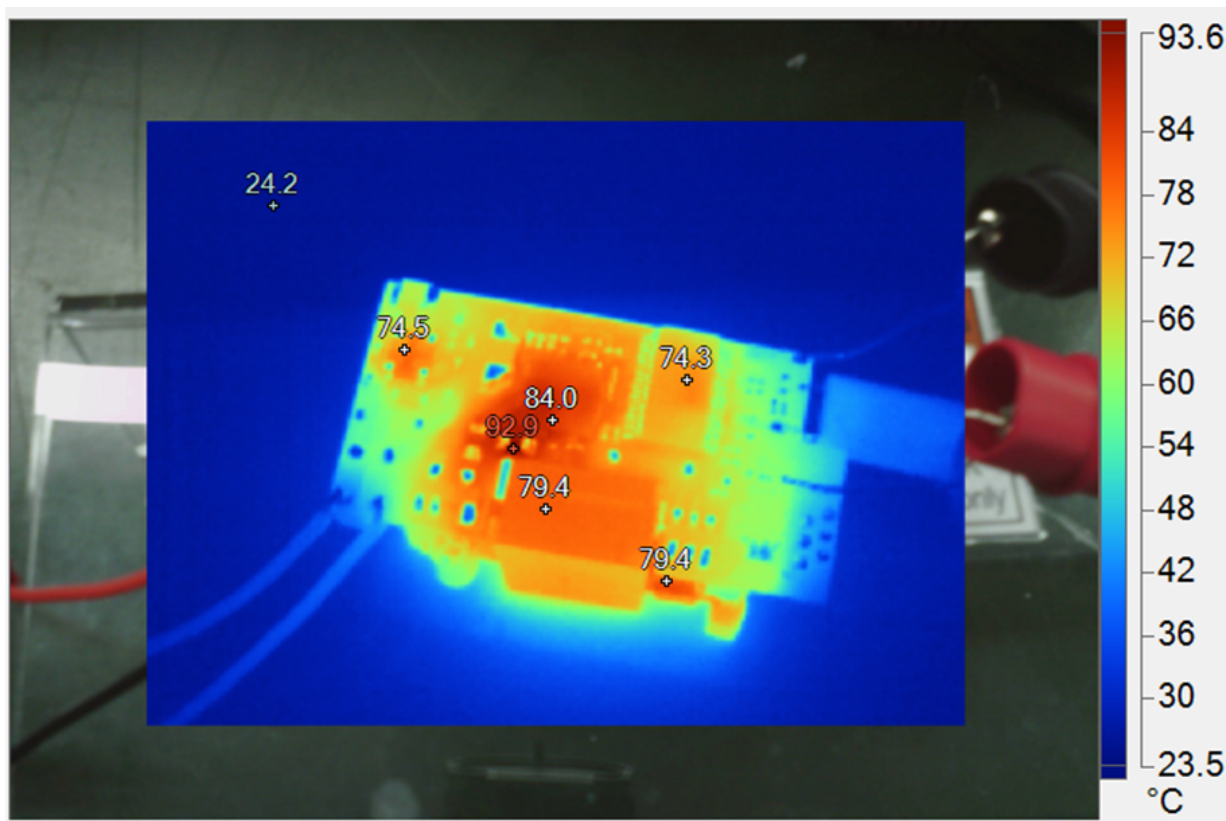
4.4.5 EMI performance

Figure 26. EMI-CE at 115 V$_{AC}$ input, 20 V/3.25 A - L line

Site Conduction #1

Limit: (CE)EN55032 class B_QP

EUT: 65W ACF Quick Charger

Phase: *L1*

Power: AC 120V/60Hz

Temperature: 22.8

Humidity: 48 %
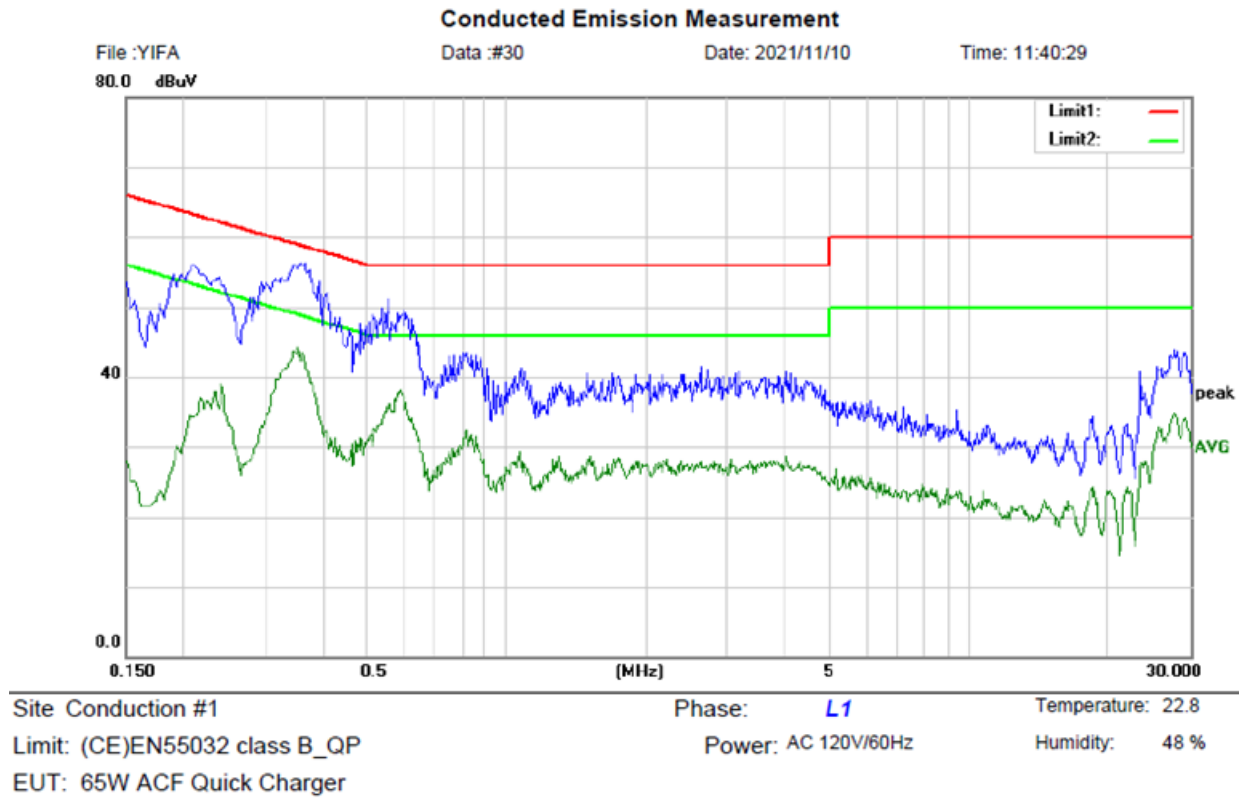
Figure 27. EMI-CE at 115 V$_{AC}$ input, 20 V/3.25 A - N line

Site Conduction #1

Limit: (CE)EN55032 class B_QP

EUT: 65W ACF Quick Charger

Phase: *N*

Power: AC 120V/60Hz

Temperature: 22.8

Humidity: 48 %
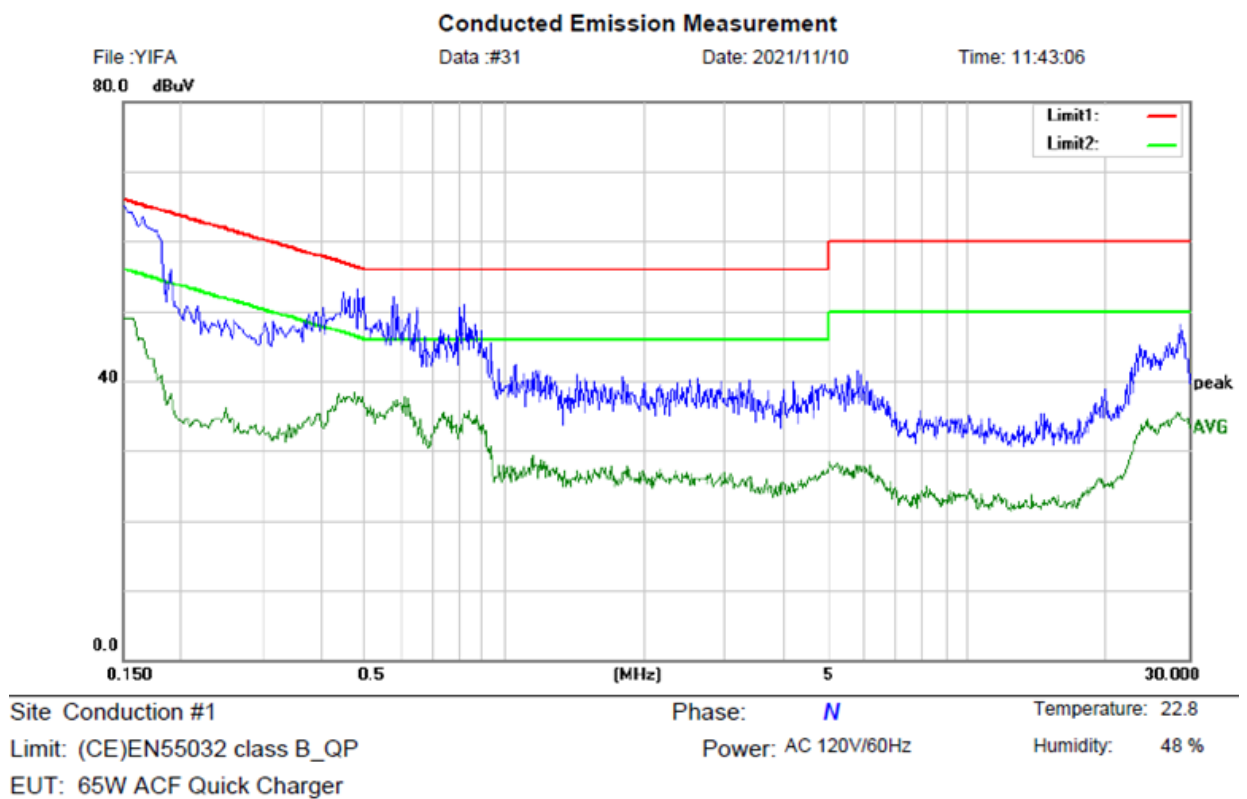
Figure 28. EMI-CE at 230 V$_{AC}$ input, 20 V/3.25 A - L line

Site Conduction #1
Limit: (CE)EN55032 class B_QP
EUT: 65W USB PD adaptor
Phase: L1
Power: AC 230V/50Hz
Temperature: 22.8
Humidity: 48 %
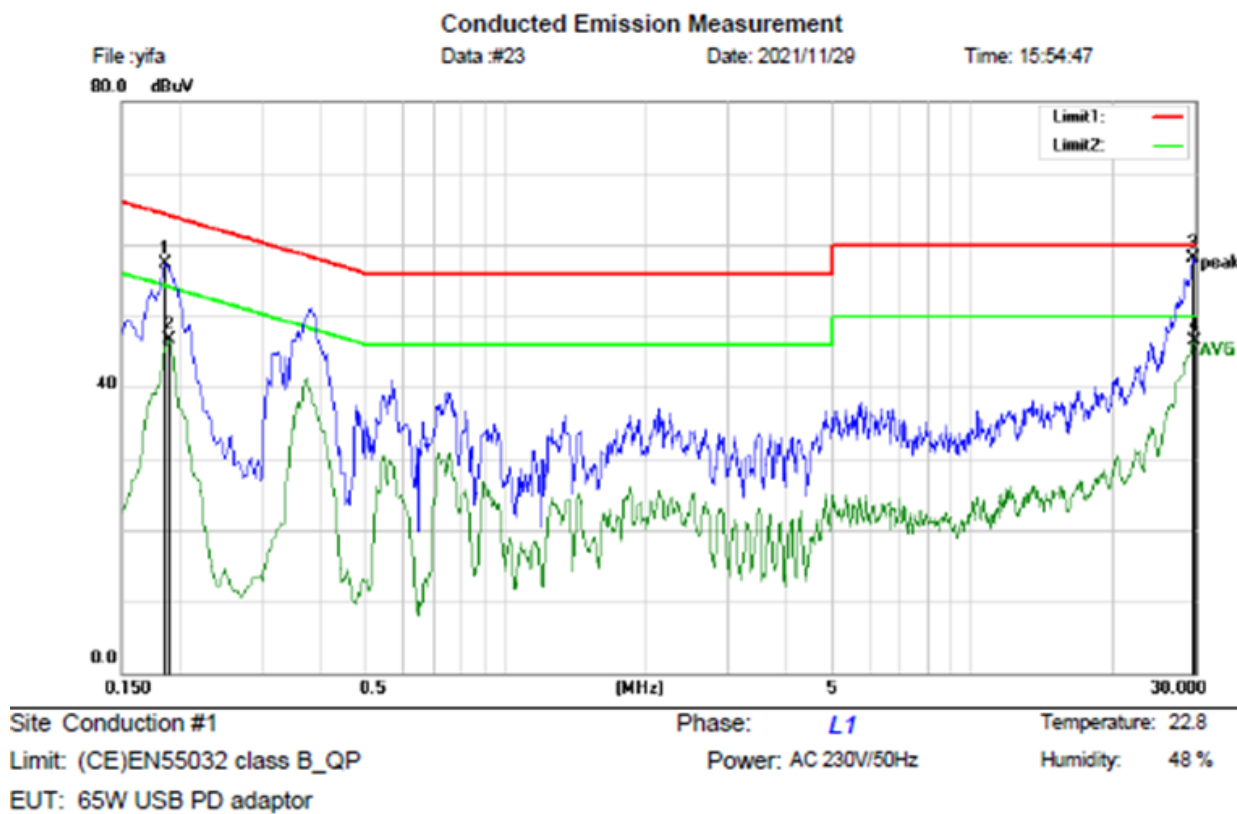
Figure 29. EMI-CE at 230 V$_{AC}$ input, 20 V/3.25 A - N line

Site Conduction #1
Limit: (CE)EN55032 class B_QP
EUT: 65W USB PD adaptor
Phase: N
Power: AC 230V/50Hz
Temperature: 22.8
Humidity: 48 %
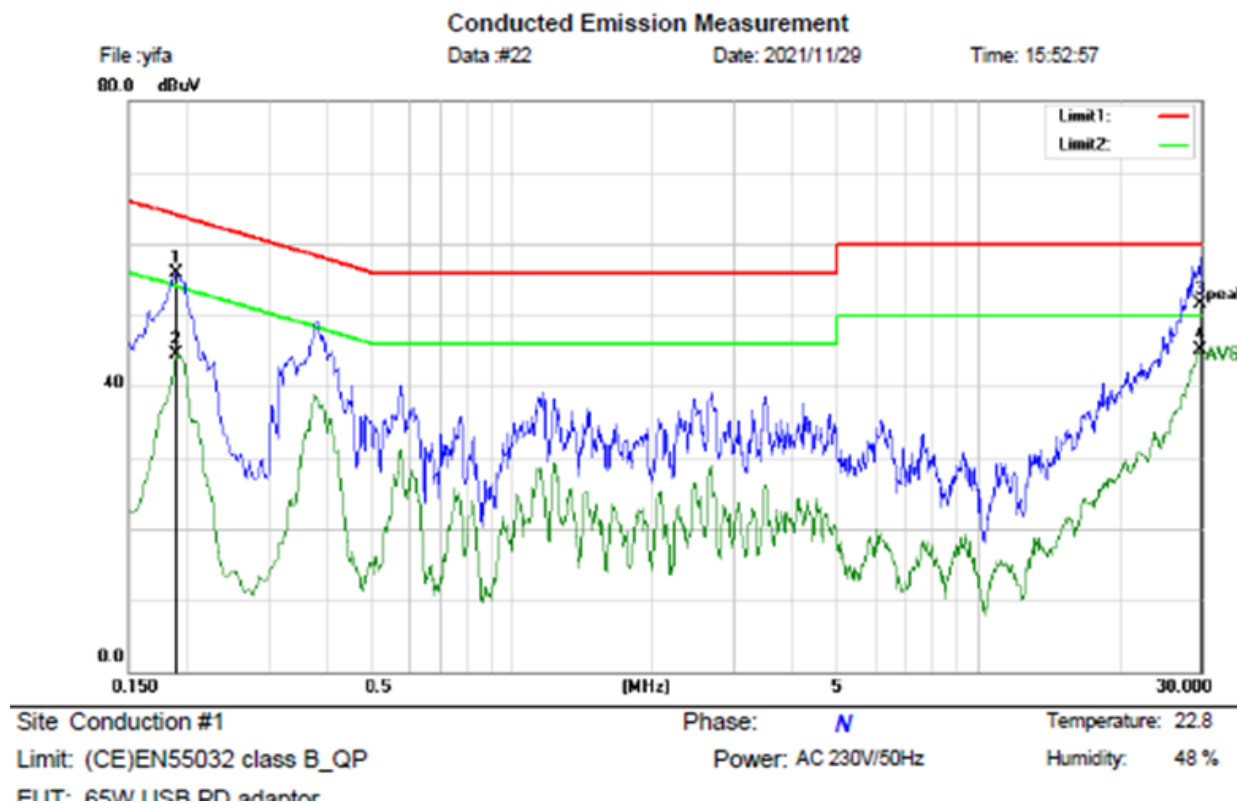
Figure 30. STDES-65ACFADP circuit schematic - power board

Figure 31. STDES-65ACFADP circuit schematic - control board
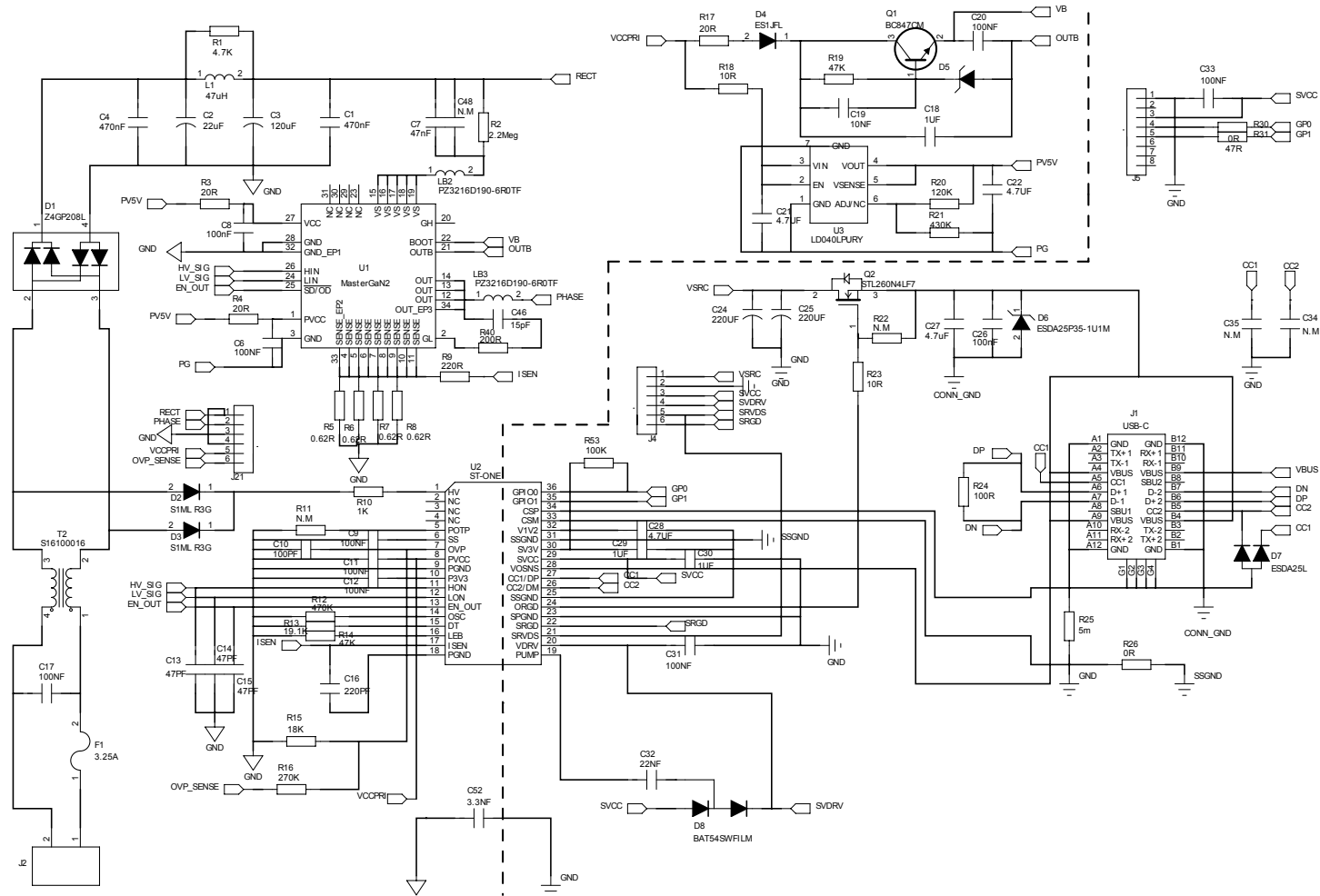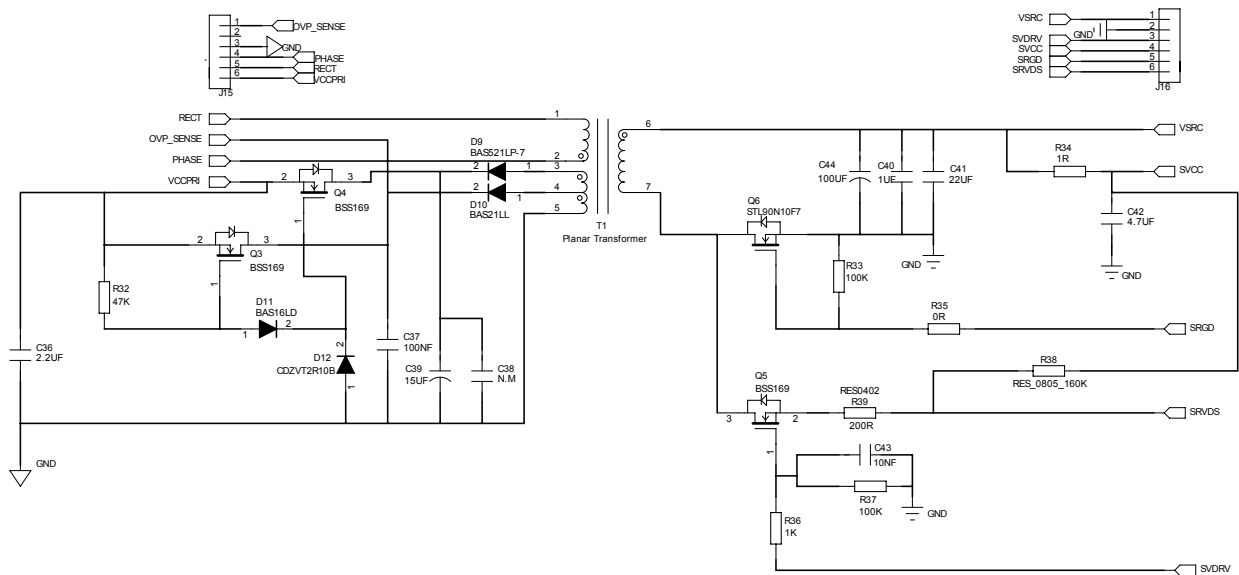
6 Bill of materials

Table 10. STDES-65ACFADP bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	1	Table 11. Power board	-	Power board	ST	Not available for separate sale
2	1	Table 12. Control board	-	Control board	ST	Not available for separate sale

Table 11. Power board bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	1	C7	1206 47 nF ±10% X7R 250 V, 1206	Ceramic capacitor	TDK	C3216X7R2E473KT020U
2	2	C4, C1	1812 0.47 µF ±10% 450 V, 1812	Ceramic capacitors	TDK	CGA8N4X7T2W474K230KA
3	2	C26, C21	0805 4.7 µF ±10% 50 V, 0805	Ceramic capacitors	TDK	C2012X7R1H475K125AC
4	2	C24, C25	SMD,6.3x7.7 mm 220 µF 25 V	E-CAP SMD	LELON	VZT221M1ETR- 0607
5	8	C6, C9, C11, C12, C31, C20, C33, C8	0402 100 nF ±10% 25 V X7R, 0402	Ceramic capacitors	Wuerth	885012205085
6	3	C13, C14, C15	0402 47 pF 5% 50 V, 0402	Ceramic capacitors	Wuerth	885012005059
7	1	C19	0402 10 nF ±10% 25 V, 0402	Ceramic capacitor	Wuerth	885012205050
8	1	C28	0402 4.7 µF ±20% 6.3 V, 0402	Ceramic capacitor	Wuerth	885012105008
9	1	C10	0402 100 pF ±10% 50 V, 0402	Ceramic capacitor	Wurth	885012205055
10	1	C29	0402 1 µF ±20% 10 V, 0402	Ceramic capacitor	Wuerth	885012105012
11	1	C30	0402 1 µF ±10% 35 V, 0402	Ceramic capacitor	TDK	C1005X5R1V105K050BC
12	1	C16	0402 220pF 5% 50V, 0402,	Ceramic capacitor	Wuerth	885012005063
13	1	C32	0402 22nF 10% 25V, 0402,	Ceramic capacitors	Wuerth	885012205052
14	1	C18	0603 47nF(473) ±10% 100V, 0603,	Ceramic capacitors	YAGEO	CC0603KRX7R0BB473
15	1	C22	0805 4.7 µF ±20% 25 V, 0805	Ceramic capacitor	Wuerth	885012107018

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
16	1	C46	1206 15 pF (150) ±5% 630 V, 1206	Ceramic capacitor	YAGEO	CC1206JKNPOCBN150
17	1	R1	0603 4.7 KΩ ±1%, 0603	Resistor	YAGEO	0603WAF4701T5E
18	1	R2	0805 2.2 MΩ ±1%, 0805	Resistor	YAGEO	RC0805FR-072M2L
19	3	R3, R4, R17	0603 20 Ω ±1%, 0603	Resistors	YAGEO	RC0603FR-0720RL
20	1	R9	0402 220 Ω ±1%, 0402	Resistor	YAGEO	RC0402FR-07220RL
21	1	R24	0402 100 Ω ±1%, 0402	Resistor	YAGEO	RC0402FR-07100RL
22	5	R26, R30	0402 0 Ω ±1%, 0402	Resistors	YAGEO	RC0402FR-070RL
23	3	R5, R6, R7, R8	0603 0.62 R ±1%, 0603	Resistors	ROHM	UCR03EVPFLR620
24	1	R25	0603 5 mR ±1%, 0603	Resistor	Panasonic	ERJ3LWFR005V
25	1	R10	0603 1 KΩ ±1%, 0603	Resistor	YAGEO	RC0603FR-071KL
26	2	R14, R19	0402 47 KΩ ±1%, 0402	Resistors	YAGEO	RC0402FR-0747KL
27	1	R13	0402 19.1KΩ ±1%, 0402,	Resistors	YAGEO	RC0402FR-0719K1L
28	1	R15	0402 18 KΩ ±1%, 0402	Resistor	YAGEO	RC0402FR-0718KL
29	1	R16	0402 270KΩ ±1%, 0402,	Resistors	YAGEO	RC0402FR-07270KL
30	1	R53	0603 100 K ±1%, 0603	Resistor	YAGEO	RC0603FR-07100KL
31	1	R20	0402 120 KΩ ±1%, 0402	Resistor	YAGEO	RC0402FR-07120KL
32	1	R40	0603 200 Ω ±1%, 0603	Resistor	YAGEO	RC0603FR-07200RL
33	2	R18, R23	0603 10 Ω ±1%, 0603	Resistors	YAGEO	RC0603FR-0710RL
34	1	R21	0402 430 KΩ ±1%, 0402	Resistor	YAGEO	RC0402FR-07430KL
35	1	R12	0402 470 KΩ ±1%, 0402	Resistor	YAGEO	RC0402FR-07470KL
36	1	R31	0402 47 Ω ±1%, 0402	Resistor	YAGEO	RC0402FR-0747RL
37	1	U1	MASTERGAN2, VFQFPN 9X9X1.0 31L pitch 0.6 mm	High-power density 600 V half-bridge driver with two enhancement mode GaN HEMTs	ST	MASTERGAN2
38	1	U2	STONE, QSOP36	Digital controller	ST	ST-ONE

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
39	1	U3	LDO40LPURY, DFN6 3x3	400 mA, 38 V low-dropout regulator with 45 µA quiescent current	ST	LDO40LPURY
40	1	D1	Z4GP208L-HF 800 V-2 A	Bridge	COMCHIP	Z4GP208L-HF
41	2	D2, D3	S1ML 1000 V - 1 A, SMA-2	Diode	Taiwan Semi	S1ML R3G
42	1	D4	ES1JFL, SOD-123FL	Diode	On Semiconductor	ES1JFL
43	1	D5	CDZVT2R6.2B 6.2 V - 100 mW, SOD-923	Zener	ROHM	CDZVT2R6.2B
44	1	D6	ESDA25P35-1 U1M, QFN-2L	High-power transient voltage suppressor	ST	ESDA25P35-1U1M
45	1	D7	ESDA25L, SOT-23-3L	Dual TRANSIL array for ESD protection	ST	ESDA25L
46	1	D8	BAT54SWFILM, SOT-323	signal diode	ST	BAT54SWFILM
47	1	J1	USB-C-MOLEX	Connector	Molex	2012670005
48	1	Q1	BC847CM SOT883_BEC_T, SOT-883	NPN transistor	Nexperia USA Inc.	BC847CM,315
49	1	Q2	STL260N4LF7, PowerFLAT 5x6	N-channel 40 V, 0.00085 ohm typ., 50 A STripFET F7 power MOSFET	ST	STL260N4LF7
50	2	LB2, LB3	206 size 6 A, 1206	Ferrite beads	Sunlord	PZ3216D190-6R0TF
51	1	T2	4 mH 1.2 A 200 mΩ	Common mode choke	Wurth Elektronik	S16100016
52	1	C3	120 µF 400 V	E-CAP	Aishi	EHS2GM121L30OT
53	1	C2	22 µF, 400 V	E-CAP	Aishi	ERK2GM220F16OT
54	1	F1	3.15 A	Fuse	LittelFuse	39213150000
55	1	C17	220 nF 275 V_{AC}	X-CAP	SRD	MP2224K27C5R6LC
56	1	L1	10 µH 1.85 A	Inductor	Wurth Elektronik	744779100
57	1	J5	I²C programming CONN_MOLEX	CONN_MOLEX	MOLEX	90325-0006
58	1	C52	3.3 nF	Y1 capacitor	STE	Q11F1D332MN0B0S0N0

Table 12. Control board bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	1	C42	0805 50 V 4.7 µF ±10% X7R, 0805	Ceramic capacitor	TDK	C2012X7R1H475K
2	1	C40	0603 1 µF ±10% 50 V X7R, 0603	Ceramic capacitor	TAIYO YUDEN	UMK107AB7105KA-T
3	1	C41	1206 22 µF ±20% 35 V, 1206	Ceramic capacitor	TDK	C3216X5R1V226M160AC
4	1	C43	0402 10 nF ±10% 25 V X7R, 0402	Ceramic capacitor	Wuerth	885012205050
5	1	C38	1210 2.2 µF ±10% 100 V, 1210	Ceramic capacitor	Walsin	1210B225K101CT
6	1	C37	0603 100 nF ±10% 100 V X7R, 0603	Ceramic capacitor	Wuerth	885012206120
7	1	C36	0805 22 µF ±20% 25 V X5R, 0805	Ceramic capacitor	SAMSUNG	CL21A226MAQNNNE
8	1	C44	1206 100 µF ±20% 25 V, 1206	Polymer solid electrolytic capacitor	KEMET	T521D107M025ATE060
9	1	D9	325 V SOD-882	Signal diode	Nexperia	BAS521LP-7
10	1	D10	200 V SOD-882	Signal diode	Nexperia	BAS21LLYL
11	1	D11	100 V SOD-882	Signal diode	NXP	BAS16LD
12	1	D12	10 V - 100 mW SOD-923	Zener diode	ROHM	CDZVT2R10B
13	1	Q5	250 V 30Ω, SOT23	N-channnel transistor	INFINEON	BSS139H6327XTSA1
14	2	Q3, Q4	100 V 12 Ω, SOT23	N-channnel transistor	INFINEON	BSS169H6327XTSA1
15	1	Q6	STL90N10F7, PowerFLAT 5x6	N-channel 100 V, 0.007 ohm typ., 70 A STripFET F7 power MOSFET	ST	STL90N10F7
16	1	R39	0402 200 Ω ±1%, 0402	Resistor	YAGEO	RC0402FR-07200RL
17	2	R33, R37	0402 100KΩ ±1%, 0402,	Resistors	YAGEO	RC0402FR-07100KL
18	1	R38	0402 160KΩ ±1%, 0402,	Resistors	YAGEO	RC0402FR-07160KL
19	1	R36	0402 1 KΩ ±1%, 0402	Resistor	YAGEO	RC0402JR-071KL
20	1	R35	0402 0 Ω 1%, 0402	Resistor	YAGEO	RC0402FR-070RL
21	1	R32	0402 47 KΩ ±1%, 0402	Resistor	YAGEO	RC0402FR-0747KL
22	1	R34	0402 1 Ω ±5%, 0402	Resistor	YAGEO	AC0402JR-071RL
23	1	C39	THT 100 V 15 µF	E-CAP	Ymin	LKMB1102A150MF

7 Conclusions

The test results shown demonstrate the good performances achieved by the STDES-65ACFADP.

The reference design shows a peak efficiency of ~ 93.7%. It also meets CoC Tier 2 and DoE Level 6 efficiency requirements for average efficiency.

The soft-switching architecture based on the zero voltage switching (ZVS) is achieved. The switching losses are then minimized.

The controller features a ZVS active clamp flyback with low RMS current, which allows reaching a very high performance. The reduction of switching and conduction losses, the elimination of the reverse recovery loss thanks to the MASTERGAN2, and the optimized power consumption makes the reference design is highly efficient. The secondary losses are minimized through the digital control of the optimized synchronous rectification.

The highly integrated MASTERGAN2 IC enhances the application robustness. The digital controller is optimized for the high frequency driver optimized for GaN for a fast, effective, and simplified layout.

The STDES-65ACFADP also achieves a good thermal performance.

Appendix A Reference design warnings, restrictions and disclaimer

Important: *The reference design is not a complete product. It is intended exclusively for evaluation in laboratory/ development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical/mechanical components, systems and subsystems.*

Danger: *Exceeding the specified reference design ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings, contact an STMicroelectronics field representative prior to connecting interface electronics, including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the reference design and/or interface electronics. During normal operation, some circuit components may reach very high temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified in the reference design schematic diagrams.*

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Revision history

Table 13. Document revision history

Date	Revision	Changes
20-Jun-2022	1	Initial release.

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