XDP™ XDPS2222: PFC + hybrid flyback combo IC for 240 W USB PD form factor reference design

About this document

Scope and purpose

This document presents information about the 240 W USB Power Delivery (PD) reference design, which is a form-factor board for a wall charger using a novel controller XDP™ digital power XDPS2222 for power factor correction (PFC) + hybrid flyback (HFB), a CoolGaN™ device IGLD60R190D1 as the main switch, a CoolMOS™ C7 superjunction MOSFET IPP65R065C7 as the PFC switch, and EZ-PD™ CCG3PA CYPD3175 for USB PD extended power range (EPR) control. The document presents the performance data of the reference design board.

Intended audience

The intended audiences for this document are users of the 240 W reference design board and design engineers of PFC + HFB converters using the XDP™ XDPS2222.

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Safety precautions

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 V DC. 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 heatsink 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 ESD 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 XDP™ XDPS2222 overview

The XDP™ XDPS2222 controller is a highly integrated device including the valley-switching PFC controller, the HFB controller, and three gate drivers for the main switches. The internal handshaking between the PFC and HFB controller and the adaptive bus voltage setting makes this controller perfect for applications with wide AC input and very wide output voltage range, such as USB PD adapters and battery chargers. For detailed information about this control IC, see the datasheet [1].

A short summary of the product, its main features, the IC pin layout, and the main benefits for the customer is given below.

1.1 Product highlights

- Digital combo controller for PFC boost and DC-DC hybrid flyback in DSO-14 (150 mil) package
- Novel zero-voltage switching (ZVS) hybrid flyback (asymmetrical half-bridge) topology for ultra-high system efficiency
- Integrated gate drivers supporting GaN and Si switches
- 600 V high-voltage start-up cell for fast V_{CC} charging
- Burst-mode operation for lowest no-load standby power
- Adaptive PFC bus voltage and PFC enable/disable control to maximize average and light-load efficiency
- Supports extra-wide output voltage range system designs and USB PD EPR 48 V
- Configurable parameters for protection modes and system performance
- MFIO communication pin configurable as external overtemperature protection (ExtOTP) or ZCD divider switching for high-resolution output voltage sensing
- Pb-free lead plating, halogen-free (according to IEC61249-2-21), RoHS compliant

1.2 PFC control

- Configurable PFC QRM operation for improved average efficiency
- Pulse skipping for improved light-load efficiency
- Automatic PFC disable/enable control depending on operating conditions
- Adaptive PFC bus voltage level following operating conditions

1.3 Hybrid flyback control

- Peak current-mode control for robust and fast input and load control
- ZVS operation of high-side and low-side switch (with ZVS pulse insertion in DCM)
- Configurable multimode operation for improved average and light-load efficiency

1.4 IC pin configuration

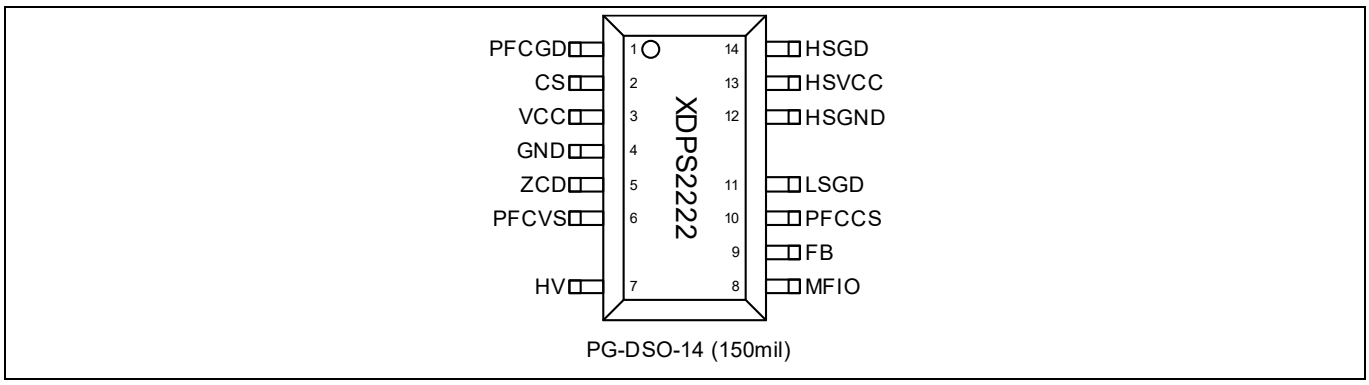


Figure 1 XDP™ XDPS2222 pin configuration

1.5 Main customer benefits

1.5.1 Low bill of materials

- PFC + HFB control with gate drivers in one 14-pin DSO package for direct driving of CoolMOS™, CoolGaN™, and legacy GaN Systems transistors
- Integrated start-up cell for V_{CC} initial charge-up
- Potential transformer size reduction compared to other flyback topologies

1.5.2 High system performance

- High system efficiency
- High power density design
- Low standby power

1.5.3 Unique controller in the market

- The most suitable controller for applications with wide AC input and wide output voltage range, such as USB PD EPR adapters and battery chargers
- Embedded digital core supporting configurable parameters for optimum system performance
- Ease of design, enabling a platform design approach by using one controller for multiple designs and applications

2 Board hardware

2.1 Overview

The 240 W USB PD form factor reference design uses the XDP™ digital combo controller XDPS2222, CoolGaN™ device IGLD60R190D1, CoolMOS™ device IPP65R065C7, and the EZ-PD™ controller CCG3PA CYPD3175. It targets applications of USB PD charger adapters, such as smartphones and mobile computers, with a very wide input range and a very wide output voltage range.

Figure 2 shows the top view of the complete board system, consisting of a main power board, an input EMI filter board, output capacitors board, and an USB PD-EPR board. The AC input connection points are assembled as loop test-points located on the bottom side of the input EMI board. The output connector is the USB Type-C connector located on the USB PD EPR board.

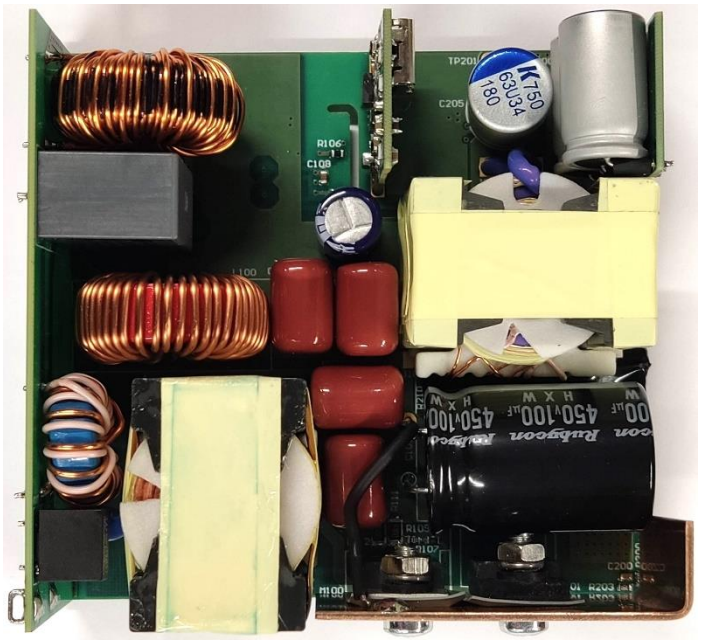


Figure 2 240 W USB PD reference design board

2.1.1 Input electrical requirements

Table 2 lists the electrical requirements for the input.

Table 2 Input electrical requirements

Parameter	Symbol	Value			Unit	Condition
		Min.	Typ.	Max.		
AC voltage	V AC	90	–	264	V_{RMS}	Maximum range
		100	–	240	V_{RMS}	Operating range
AC frequency	f_{AC}	47	–	63	Hz	–
Brown-in	–	–	88	–	V	–
Brown-out	–	–	75	–	V	–
X-capacitor discharge time	–	–	–	1	s	–

2.1.2 Output electrical requirements

Table 3 is showing the output electrical requirements.

Table 3 Output electrical requirements

Parameter	Symbol	Value			Unit	Condition
		Min.	Typ.	Max.		
Output voltage	V_{out}	–	5	–	V	Mean value of the standard fixed USB PD EPR voltages, at 115 V and 230 V AC input
		–	9	–	V	
		–	15	–	V	
		–	20	–	V	
		–	28	–	V	
		–	36	–	V	
		–	48	–	V	
Output current	I_{out}	0	3	–	A	V_{out} = 5 V, 9 V, 15 V
		0	5	–	A	V_{out} greater than 15 V
Start-up time	–	–	–	1.5	s	5 V output at cold start-up

2.1.3 Key components

The following Infineon components are used on the board.

Table 4 Key components

Item	Component
PFC + HFB controller	XDP™ XDPS2222
USB PD controller	EZ-PD™ CCG3PA CYPD3175
Active bridge switches	IPL60R065P7
PFC switch	IPP65R065C7
HFB switches	IGLD60R190D1
SR MOSFET	ISC073N12LM6
V_{CC} regulator switch	BSS169

2.1.4 Board and PCB information

The board and PCB information are summarized in Table 5.

Table 5 Board dimensions and power density

Item	Value	Unit
Dimensions	75 x 70 x 30	mm
Power density	≈ 25	W / in^3
PCB	6	Layers

2.2 Reference design board system

The system consists of the main power board, an input EMI filter board, an output capacitors board, and an USB PD-EPR board. Both the PFC and HFB stages are controlled by the combo controller XDP™ XDPS2222, one of Infineon's XDP™ digital controllers. At the output side, Infineon's USB PD EZ-PD™ controller CCG3PA CYPD3175 is used for the communication with the end device and output voltage management as well as driving the safety switch at the output. In the following sections, the schematics of these boards are shown, while the bills of materials (BOMs) of the boards can be found in Section 4.1.

2.2.1 Reference design board schematics

The schematics of the main power board, input EMI filter board, output capacitors board, and USB PD-EPR board are shown in Figure 3, Figure 4, and Figure 5.

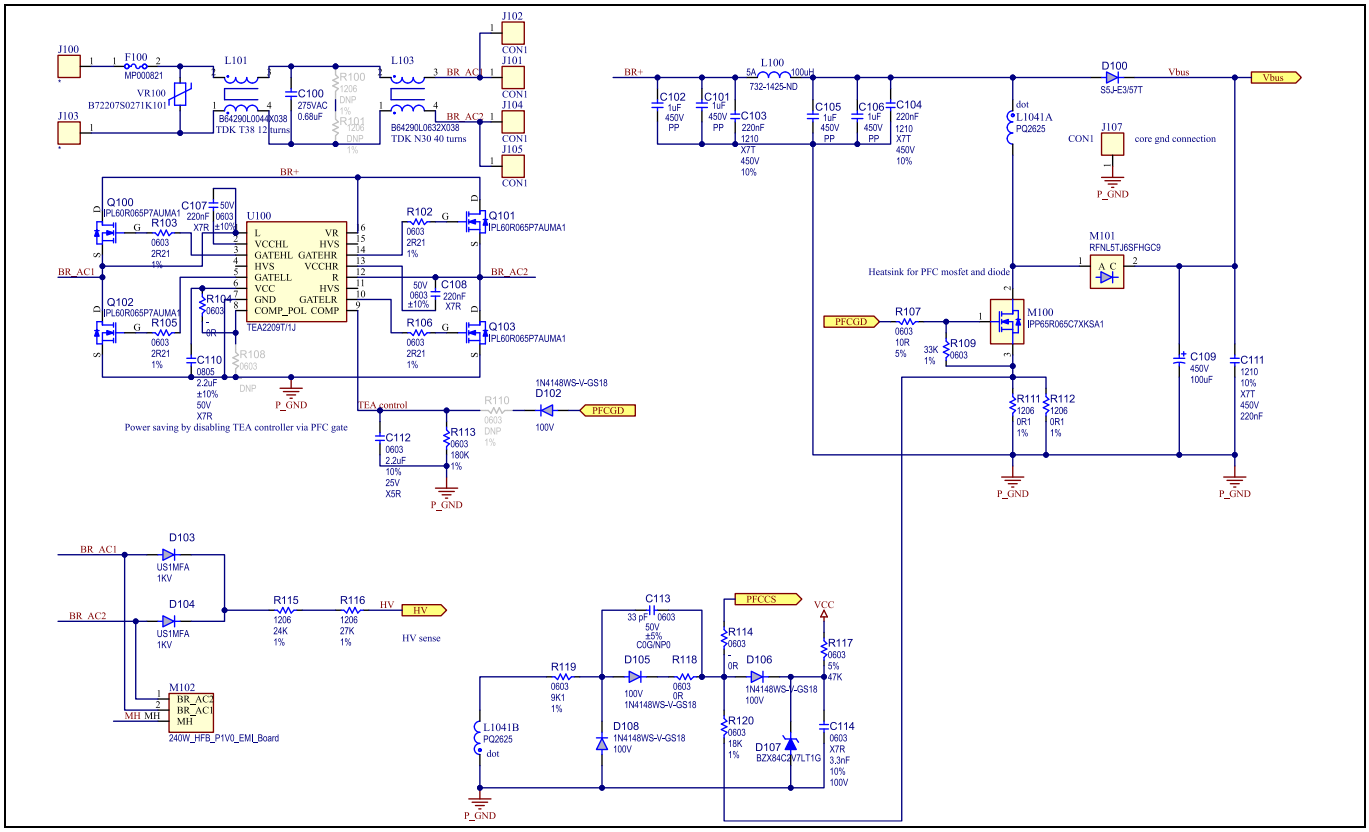


Figure 3 PFC stage schematic

Figure 3 shows the power circuitry of the AC input and PFC stage, including the input protection, EMI filter, and the start-up cell external circuit (D103, D104, R115, and R116). The PFC zero-crossing detection (ZCD) and current sensing (CS) signals are combined into a single signal, PFCCS, which is connected to IC pin PFCCS. The voltage at the PFC auxiliary winding, which is coupled to the PFC main inductance (L1041), is processed by the circuit and D108 is for the negative clamping, and the network D106, D107, C114, and R117 limits the positive voltage of the ZCD signal. Per resistor R120, the ZCD signal is effectively decoupled from the PFC CS resistors R111 and R112, which provides the CS signal to the control IC. A CoolMOS™ device with attached heatsink is used as the PFC main switch, M100, and it is driven directly by the XDP™ XDPS2222 from the PFCGD pin through the gate resistor R107.

The HFB is based on a half-bridge structure as shown in Figure 4.

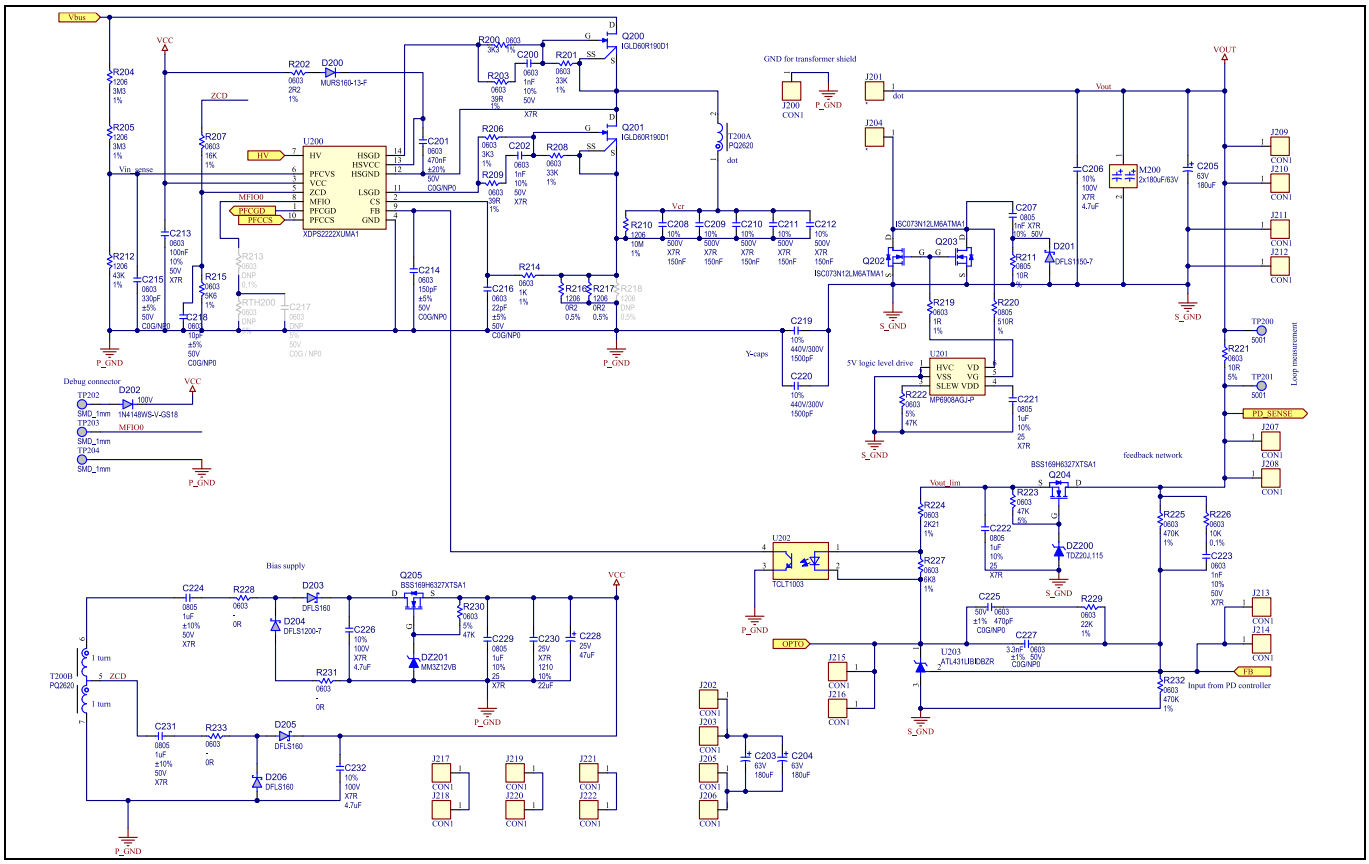


Figure 4 HFB stage schematic

The transformer's T200 primary winding is connected to the half-bridge switching node at one end and to the resonant capacitors (C208 to C212) at the other end. The shunt resistors (R216 to R217) are used to sense the current through the transformer primary winding for HFB peak current regulation. For accurate switching timing, the signal from the auxiliary winding (Vaux1) is used. It generates a ZCD signal using devices R207 and R215. The resistors R204, R205, and R212 are used for the PFC voltage sensing. The test points T202 to T204 are used for the parameter configuration via UART communication and debugging.

The MFIO pin functionality is set to ExtOTP in this design. An example of the other functionality of the MFIO pin is implemented and used for ZCD resistor divider switching for the output voltage sensing feature is described in 240 W USB PD evaluation board with PFC + hybrid flyback combo IC XDP™ XDPS2222 [2].

The USB PD-EPR board is based on the EZ-PD™ controller CYPD3175, as shown in Figure 5.

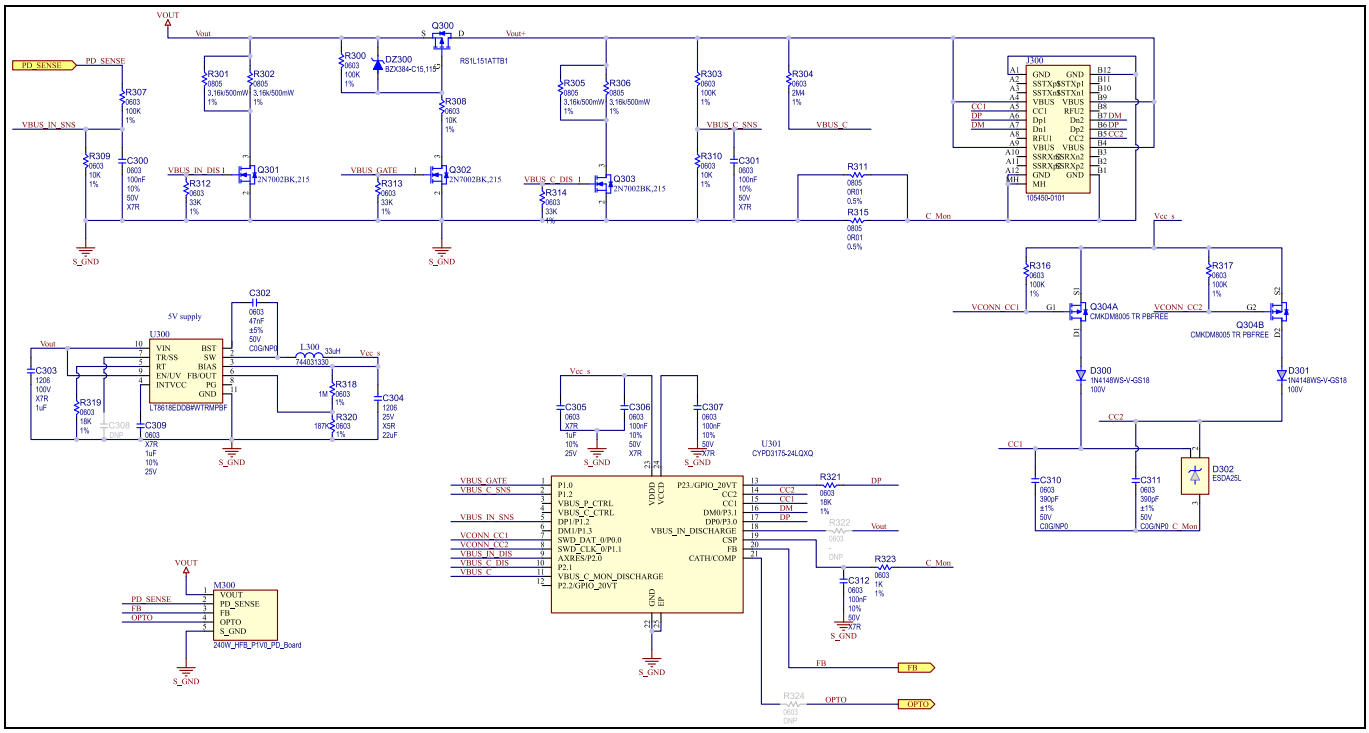


Figure 5 USB PD-EPR board schematic

A buck converter (U300) is used to generate the required supply voltage for the controller CYPD3175. The circuit consisting of Q304A, Q304B, D300, D301, R316, and R317 provides the required voltage at the communication lines CC1 and CC2. The controller CYPD3175 senses both the input voltage V_{out} (VOUT from the point of view of the EPR board) and output voltage (V_{out+}), where the “on” or “off” of the output voltage at the Type-C connector is controlled by the load switch Q300. The output current at the Type-C connector is sensed by shunt resistors R311 and R315, filtered by the elements of R323 and C312, and then fed to the PD control IC. The controller CYPD3175 communicates with the end device via the communication lines CC1 and CC2, sets the output voltage level of the HFB accordingly through the signal FB, and controls the load switch Q300 for supplying the end device. For the output voltage falling transition, the bus discharge paths before and after the safety switch (R301, R302, Q301, and R305, R306, Q303) may be activated by the PD controller.

2.2.2 Reference design PCB layout design

The 240 W USB PD form factor reference design PCB layout design information is depicted as follows in Figure 6 to Figure 11.

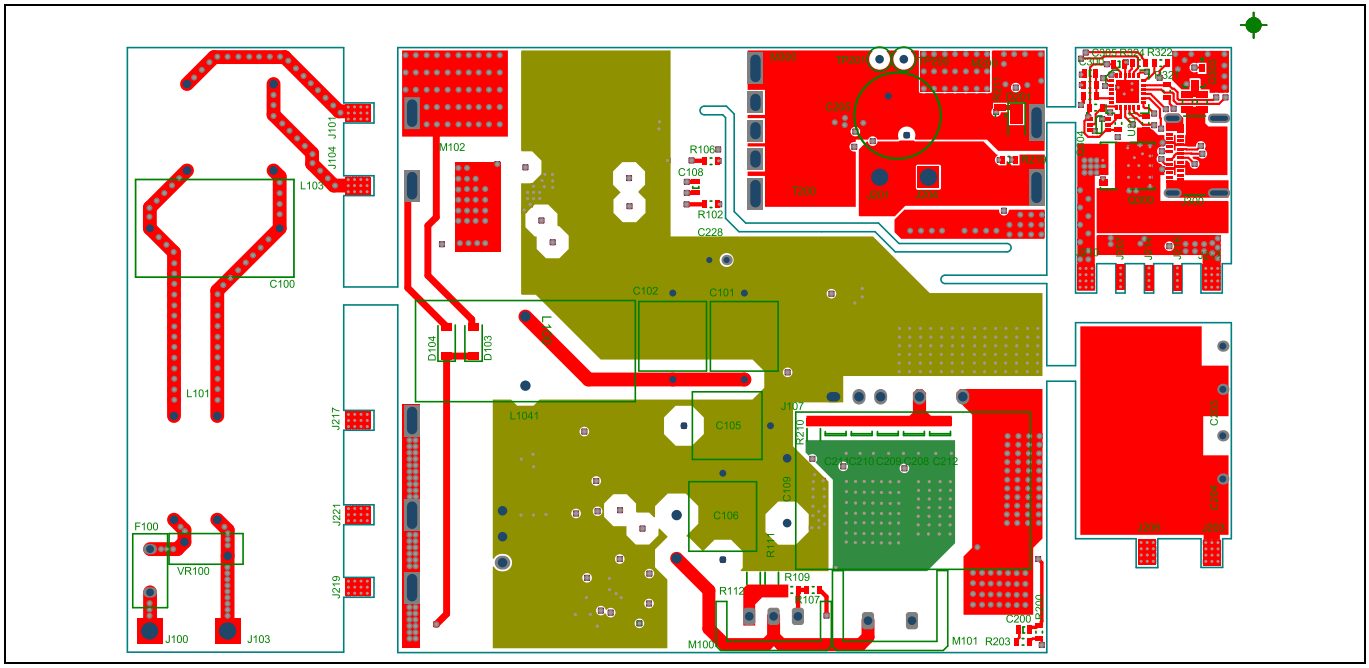


Figure 6 240 W USB PD reference design board layout – top layer

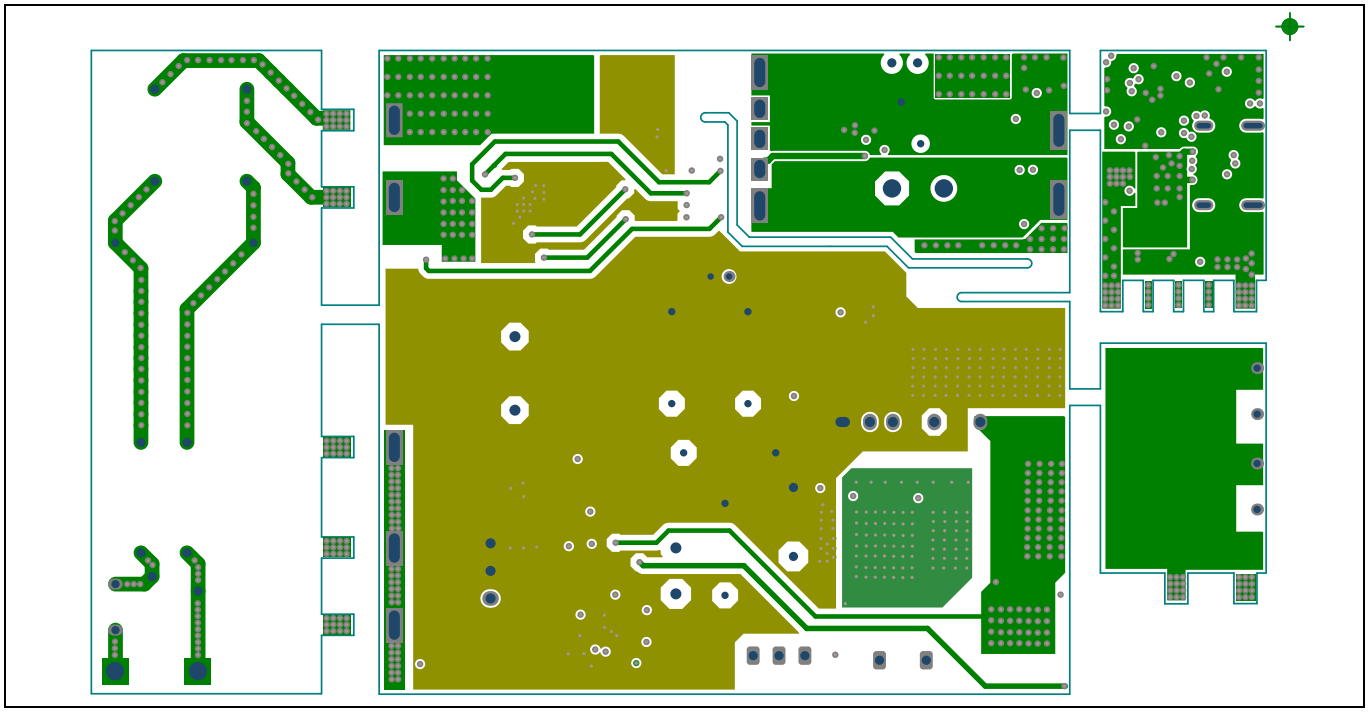


Figure 7 240 W USB PD reference design board layout – layer 2 (internal layer 1)

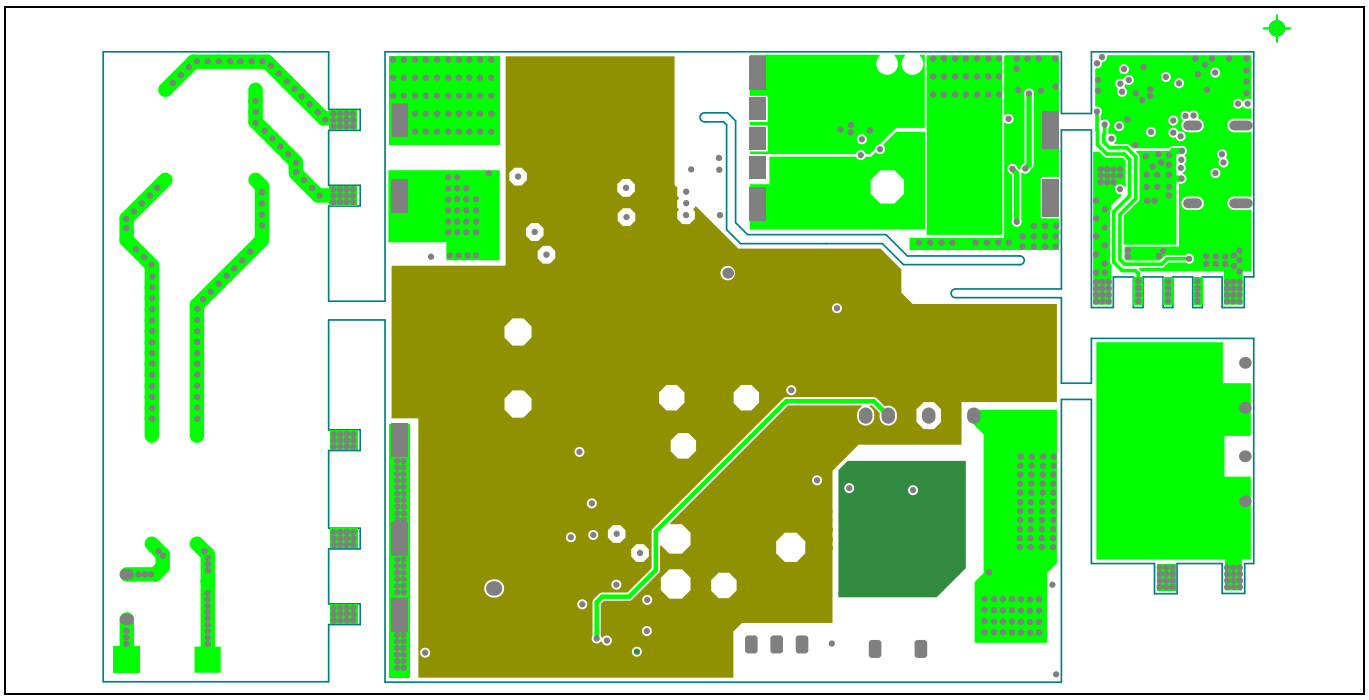


Figure 8 240 W USB PD reference design board layout – layer 3 (internal layer 2)

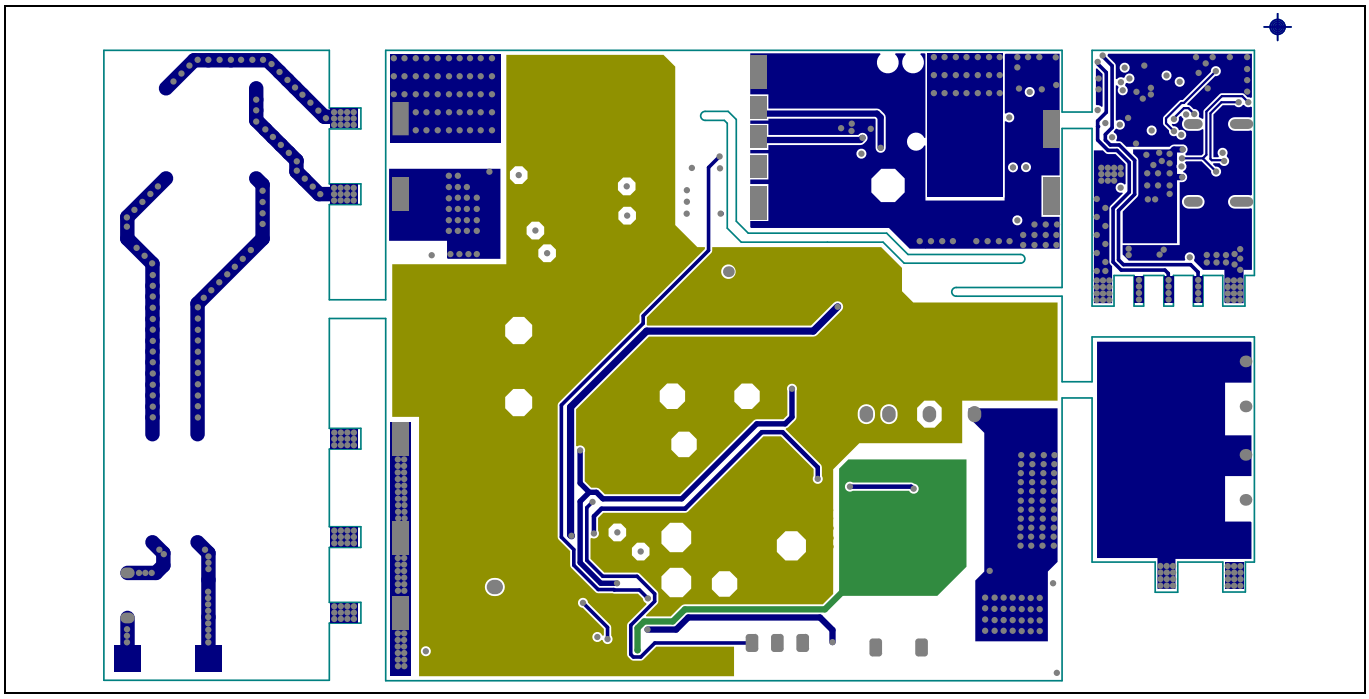


Figure 9 240 W USB PD reference design board layout – layer 4 (internal layer 3)

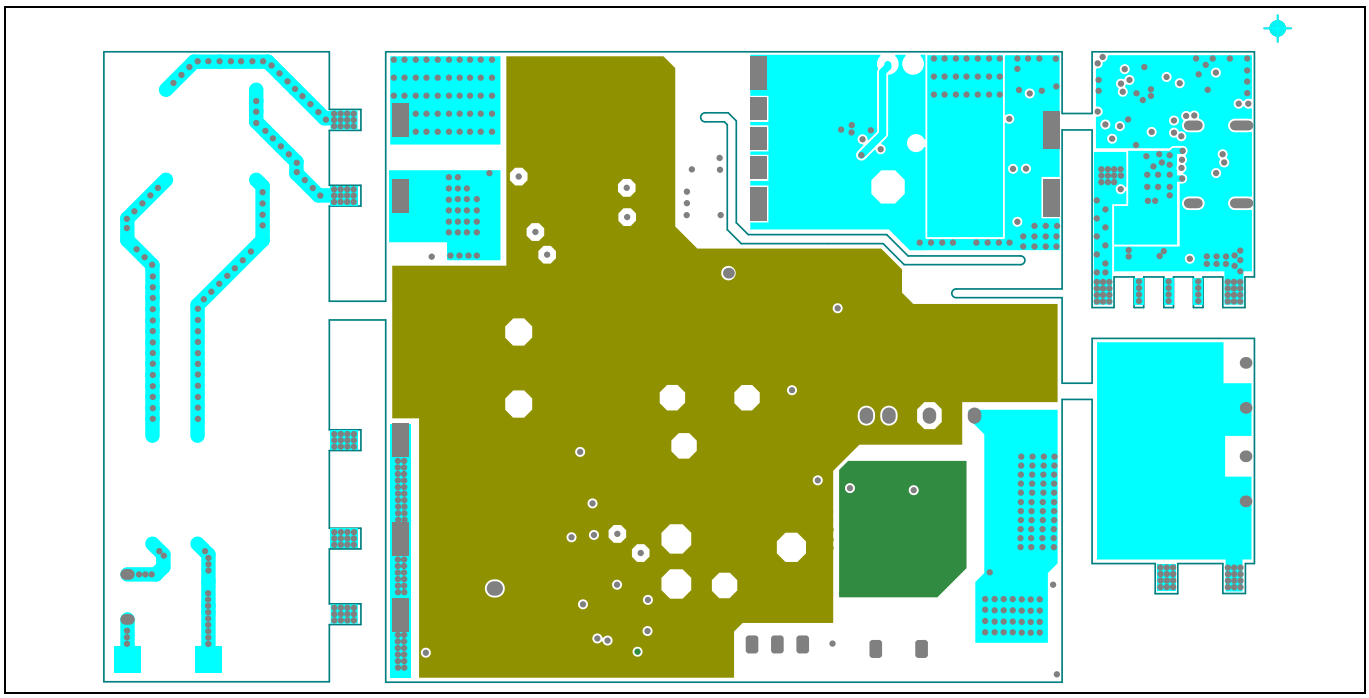


Figure 10 240 W USB PD reference design board layout – layer 5 (internal layer 4)

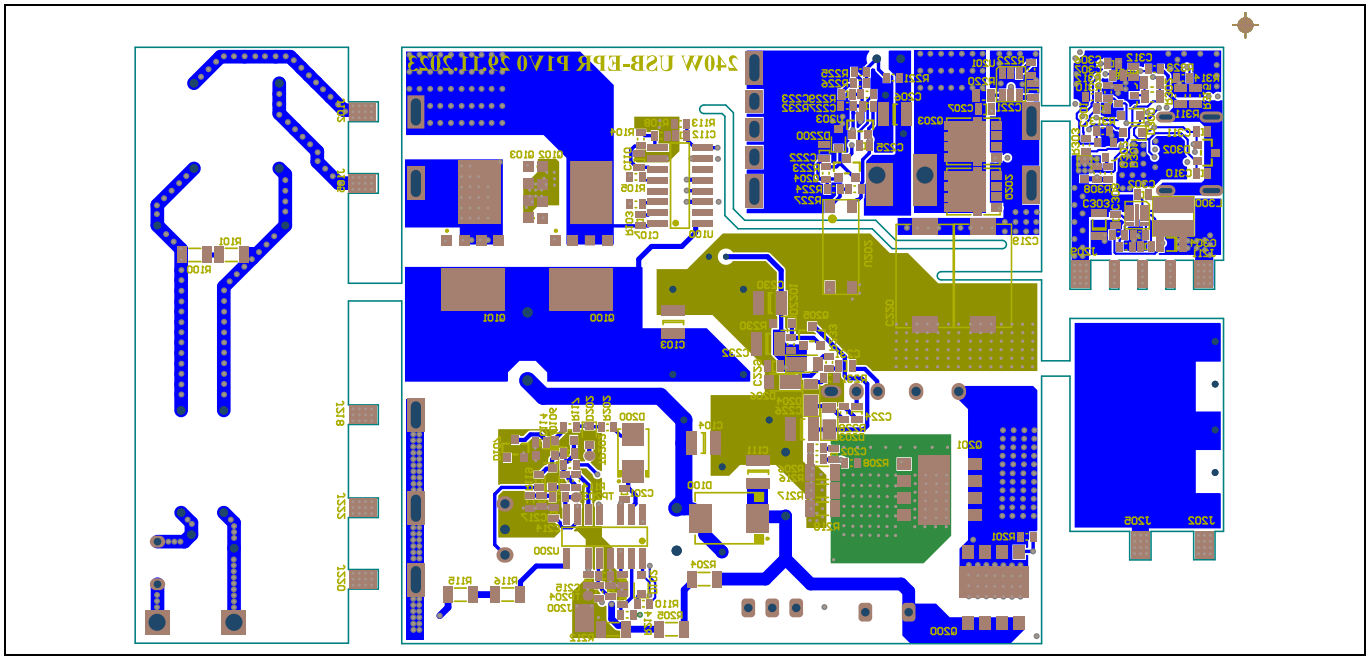


Figure 11 240 W USB PD reference design board layout – bottom layer

3 System performance

The key measurement results are illustrated in the following sections.

3.1 Efficiency and standby power

Four-point average efficiency of the board measured at the Type-C connector is shown in Table 6.

Table 6 Efficiency as a percentage, measured at the Type-C connector

V AC (V)	I_{out} / V_{out} (V)	100 percent	75 percent	50 percent	25 percent	Average
115	5	88.53%	89.27%	88.74%	86.94%	88.37%
	9	88.52%	87.14%	87.00%	84.62%	86.81%
	15	90.95%	89.21%	87.00%	81.92%	87.27%
	20	93.45%	94.14%	92.91%	85.38%	91.47%
	28	94.18%	93.89%	92.81%	85.95%	91.70%
	36	95.41%	94.68%	93.52%	87.72%	92.83%
	48	94.82%	94.78%	93.90%	88.44%	92.62%
230	5	86.67%	86.54%	86.06%	84.33%	85.90%
	9	91.68%	91.37%	90.25%	88.71%	90.50%
	15	93.14%	92.03%	89.22%	87.61%	90.49%
	20	93.39%	95.38%	94.71%	91.48%	93.74%
	28	94.77%	94.49%	93.13%	88.00%	92.60%
	36	94.95%	95.43%	94.22%	88.61%	93.30%
	48	95.91%	95.46%	94.42%	88.31%	93.22%

The average efficiency at low line input is illustrated in Figure 12.

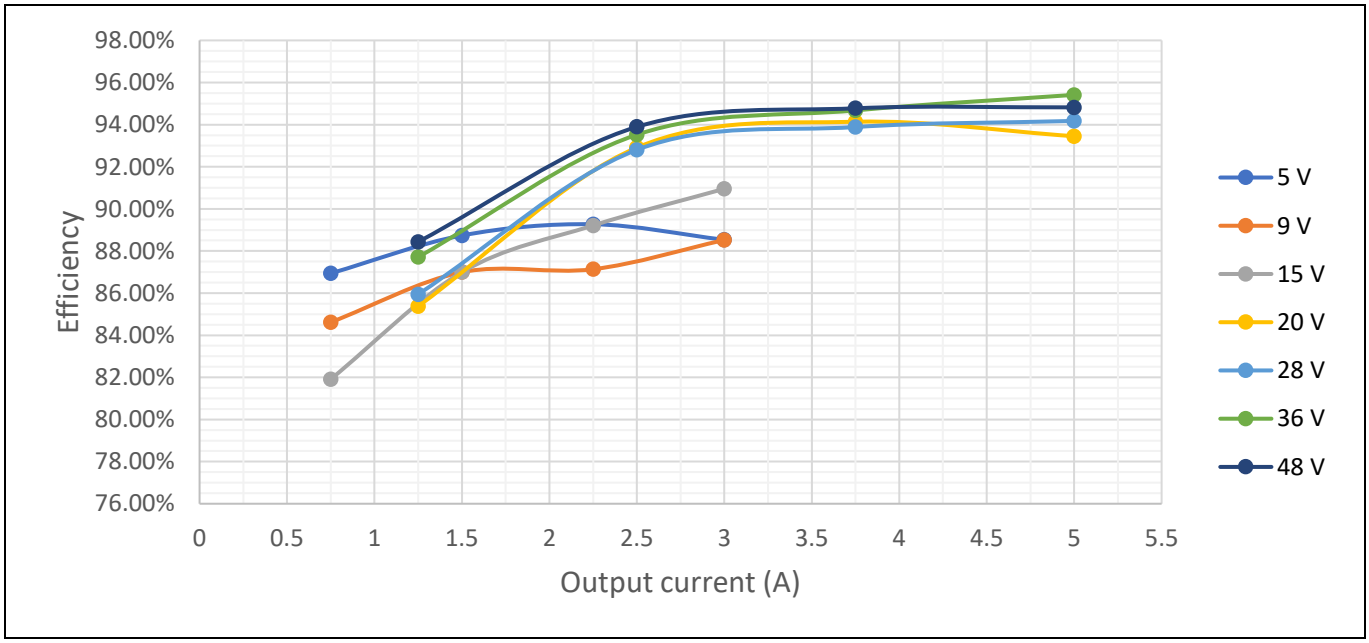


Figure 12 Efficiency vs. load at 115 V AC input

System performance

The average efficiency at high line input is illustrated in Figure 13.

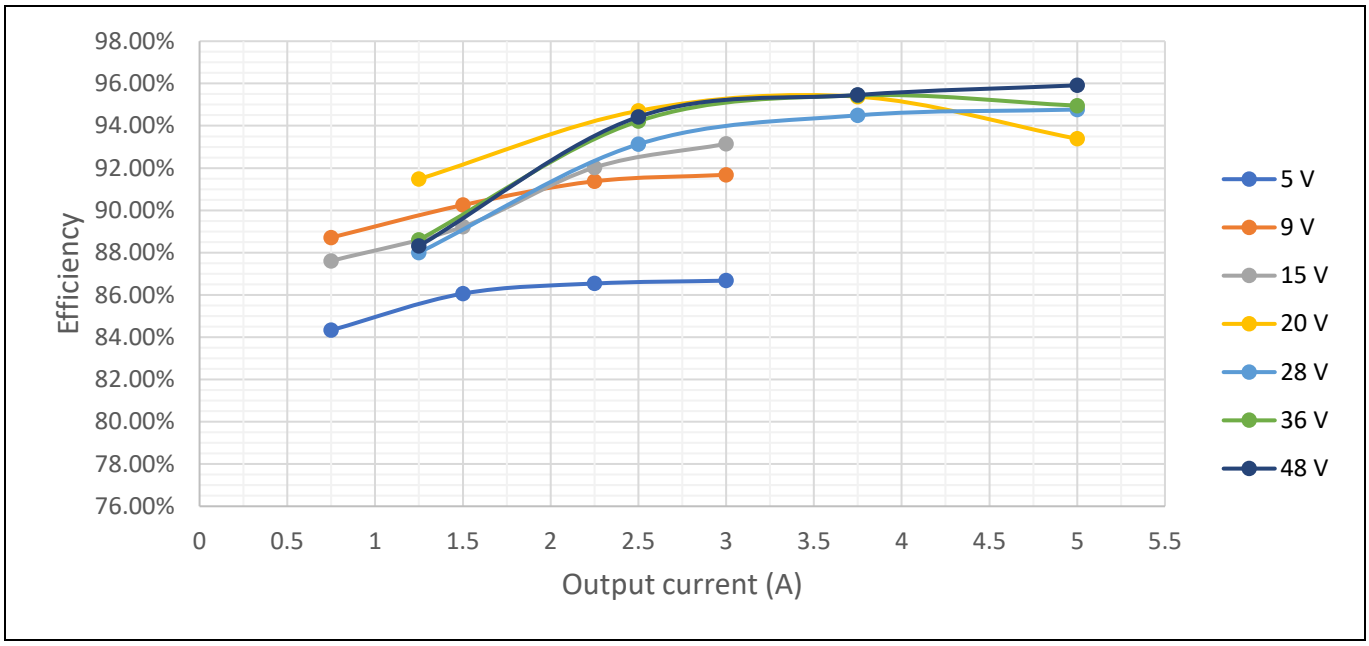


Figure 13 Efficiency vs. load at 230 V AC input

System standby input power is measured, and the results are shown in Table 7. For this measurement no load is connected to the output, the USB Type C cable is unplugged.

Table 7 Standby input power measurements

V AC (V) / Measurement	115	230
Total standby input power	101 mW	190 mW

3.2 Conducted EMI emissions measurement

The EMI measurement results for the full output power of 240 W meaning 48 V, 5 A output are presented in this section. The average (AVG) and quasi-peak (Q-Peak) tests were performed at both lowline (115 V AC) and high line (230 V AC), and each measurement is done on both live (L) and neutral (N) phases.

Figure 14 to Figure 17 show the conducted EMI scan plots.

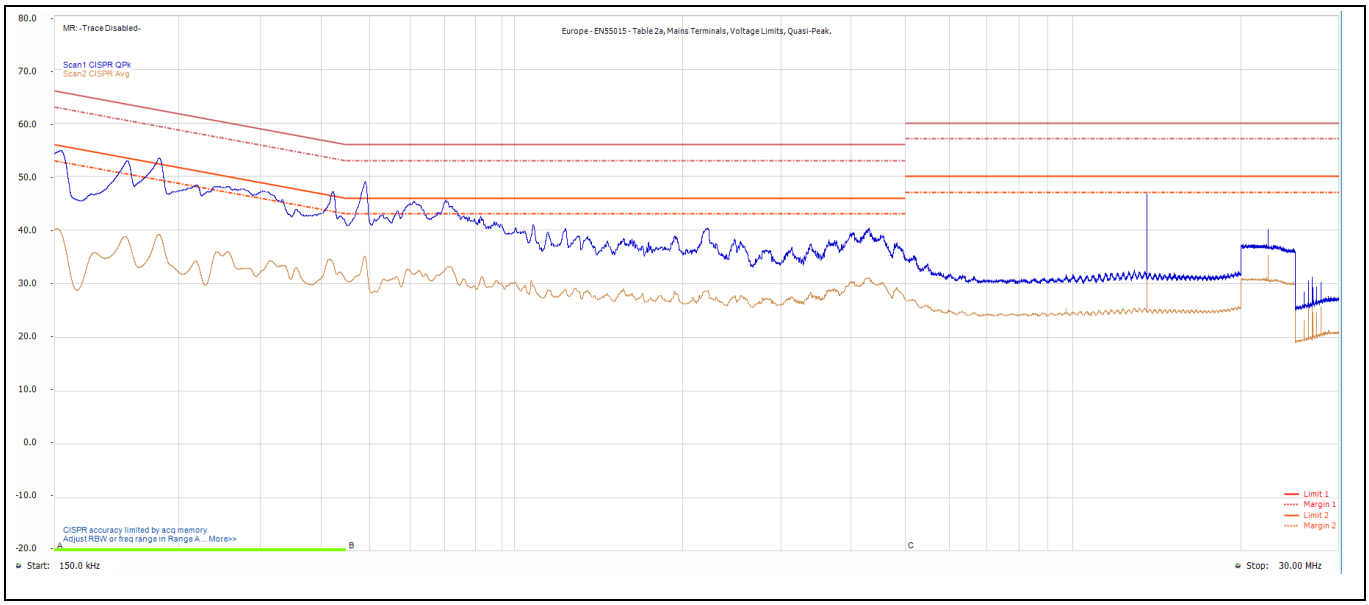


Figure 14 Q-peak and AVG conducted EMI test result plot for 115 V AC input and N phase

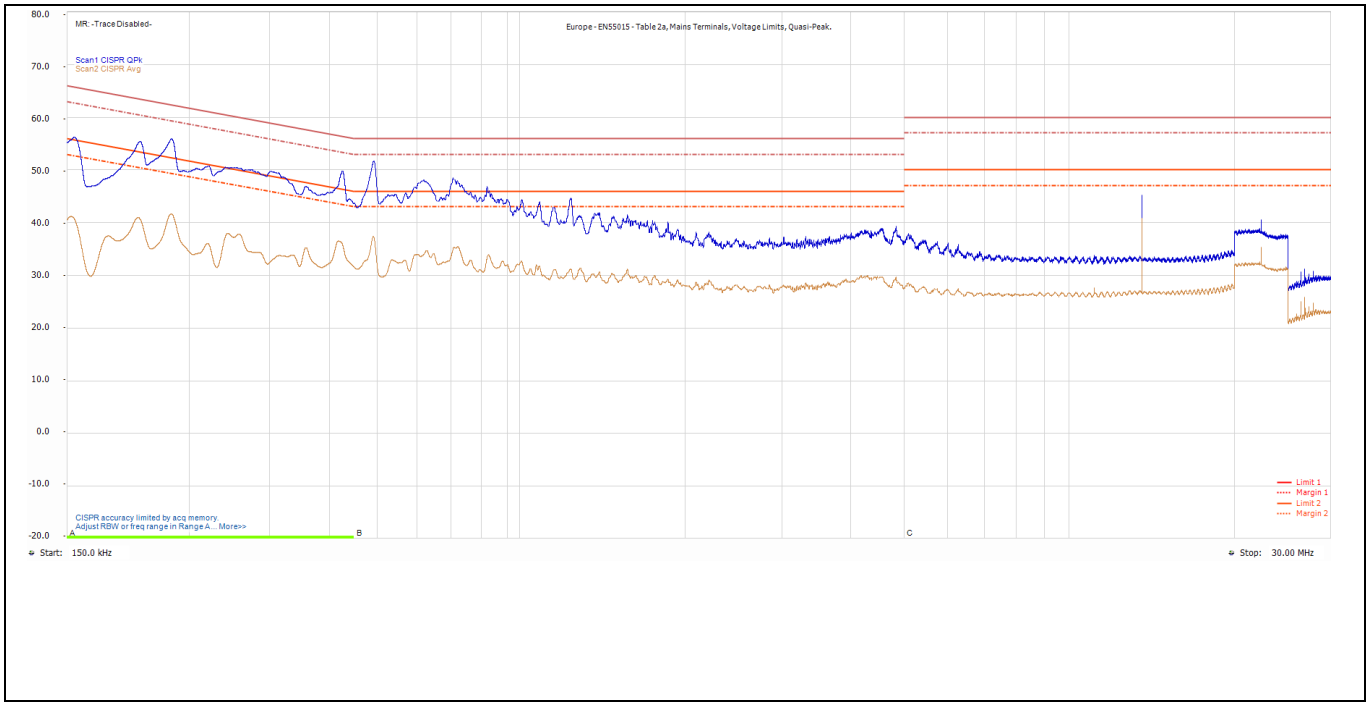


Figure 15 Q-peak and AVG conducted EMI test result plot for 115 V AC input and L phase

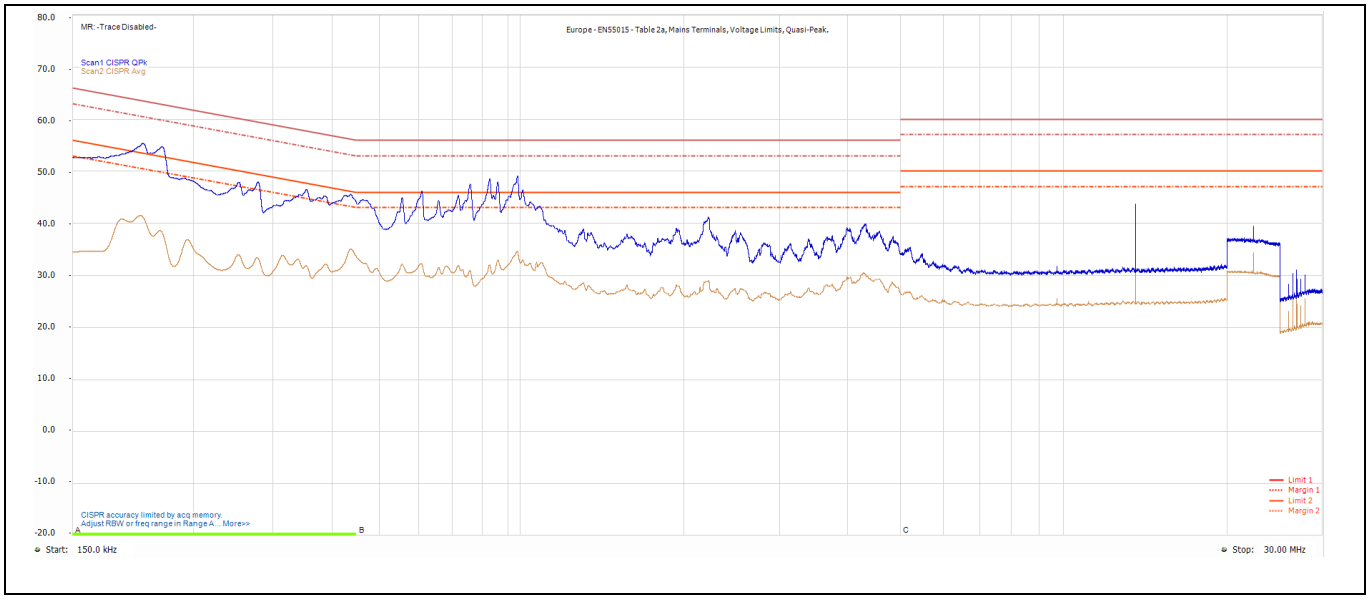


Figure 16 Q-peak and AVG conducted EMI test result plot for 230 V AC input on N phase

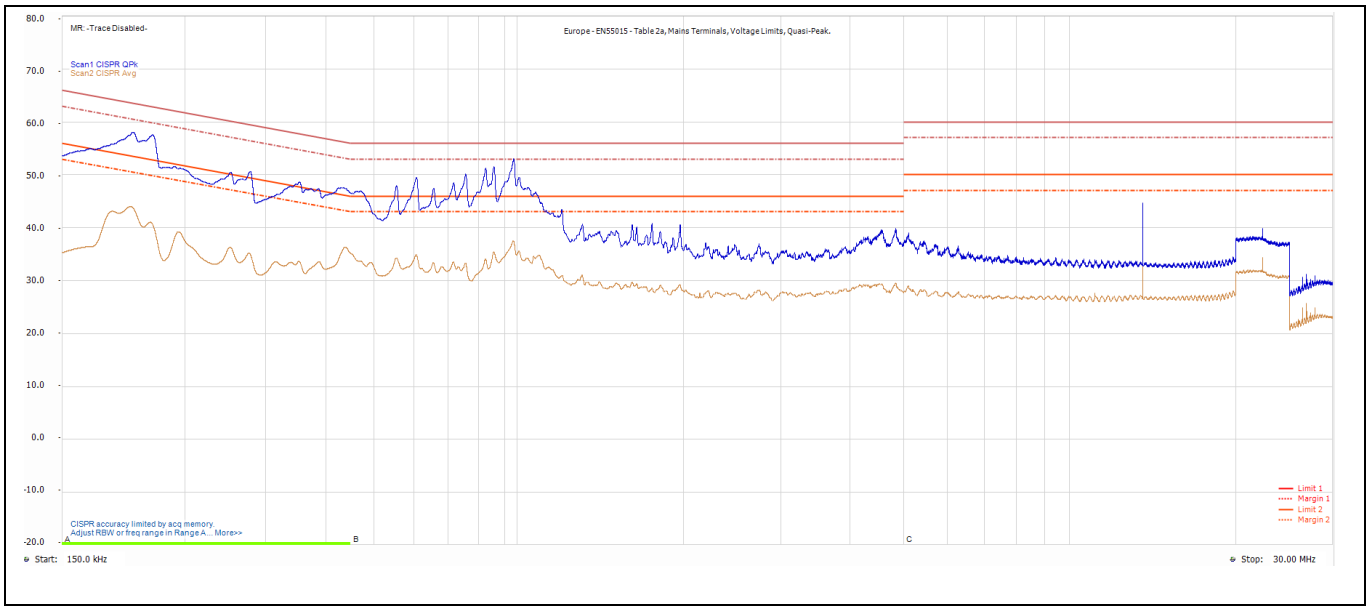
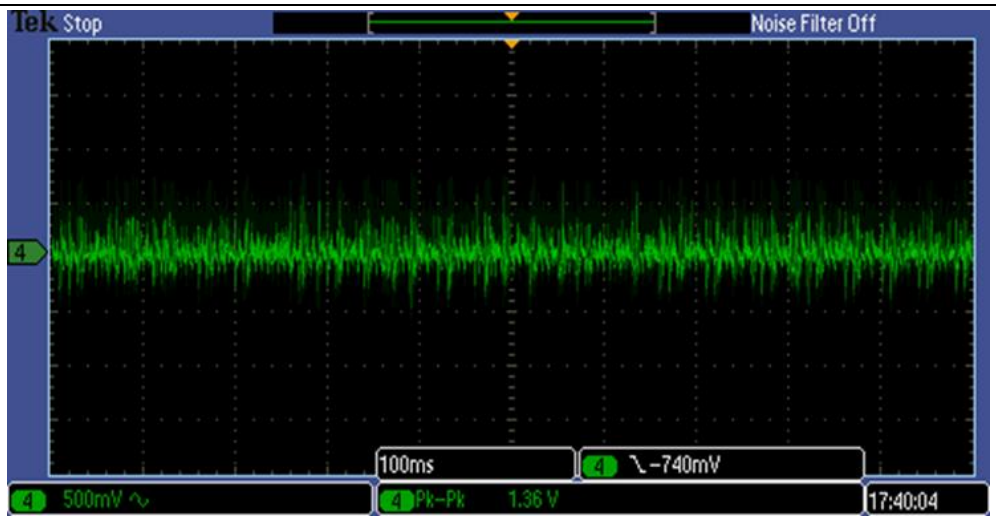


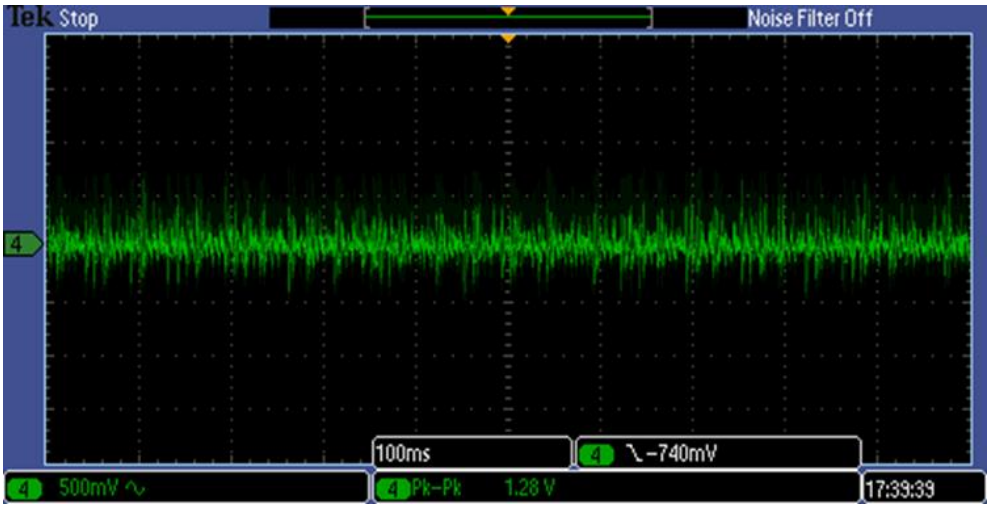
Figure 17 Q-peak and AVG conducted EMI test result plot for 230 V AC input and L phase

3.3 Output voltage ripple

The output voltage ripple was measured at the output capacitors and the results are showing a peak-to-peak value of 1.36 V for 115 V AC input and 48 V and 5 A output. The same measurement for 230 V AC input and 48 V and 5 A output indicates a peak-to-peak value of 1.28 V. The output voltage ripple measurements are presented in Figure 18.



a)



b)

Figure 18 Output voltage ripple waveform and measurement: a) 115 V AC input, 48 V 5A output; b) 230 V AC input, 48 V 5 A output

3.4 PFC performance

The power factor correction measurements were performed at 115 V AC and 230 V AC for both full power and 75 W input power and the values are presented in Table 8.

Table 8 Power factor measurement

V AC (V) / P_{in} (W)	115	230
250	0.973	0.921

The measurements show low harmonics current, as displayed in Figure 19.

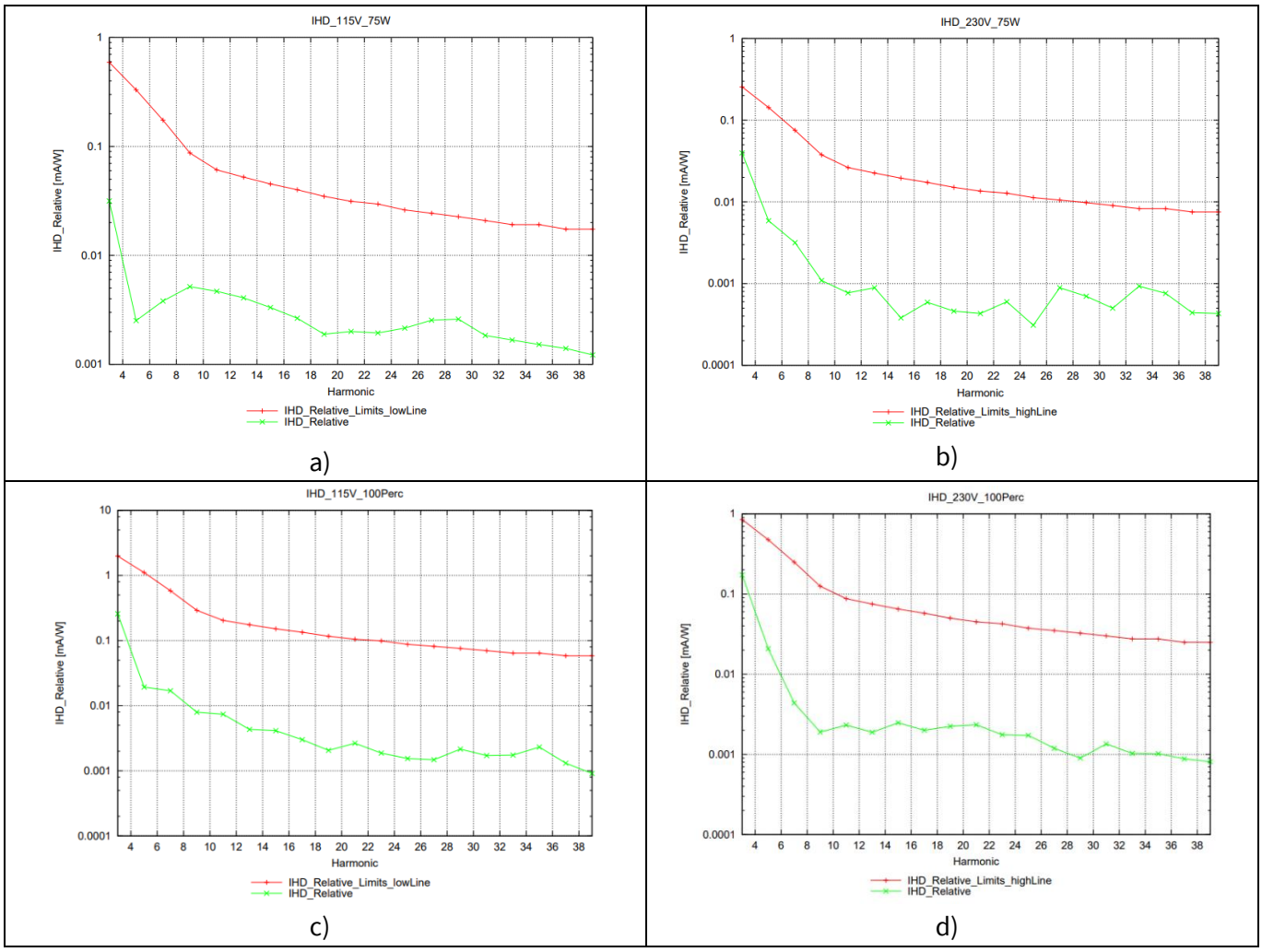


Figure 19 Harmonics current (green line) and its limit from IEC 61000-3-2 (red line): a) 115 V AC, 75 W, b) 230 V AC, 75 W, c) 115 V AC, 240 W, and d) 230 V AC, 240 W

3.5 Thermal measurement

The following images in Figure 21 are the infrared (IR) thermal images of the board at 90 V AC input and 48 V and 5 A output (full power 240 W) after 1-hour burn-in time and at around 25°C ambient temperature.

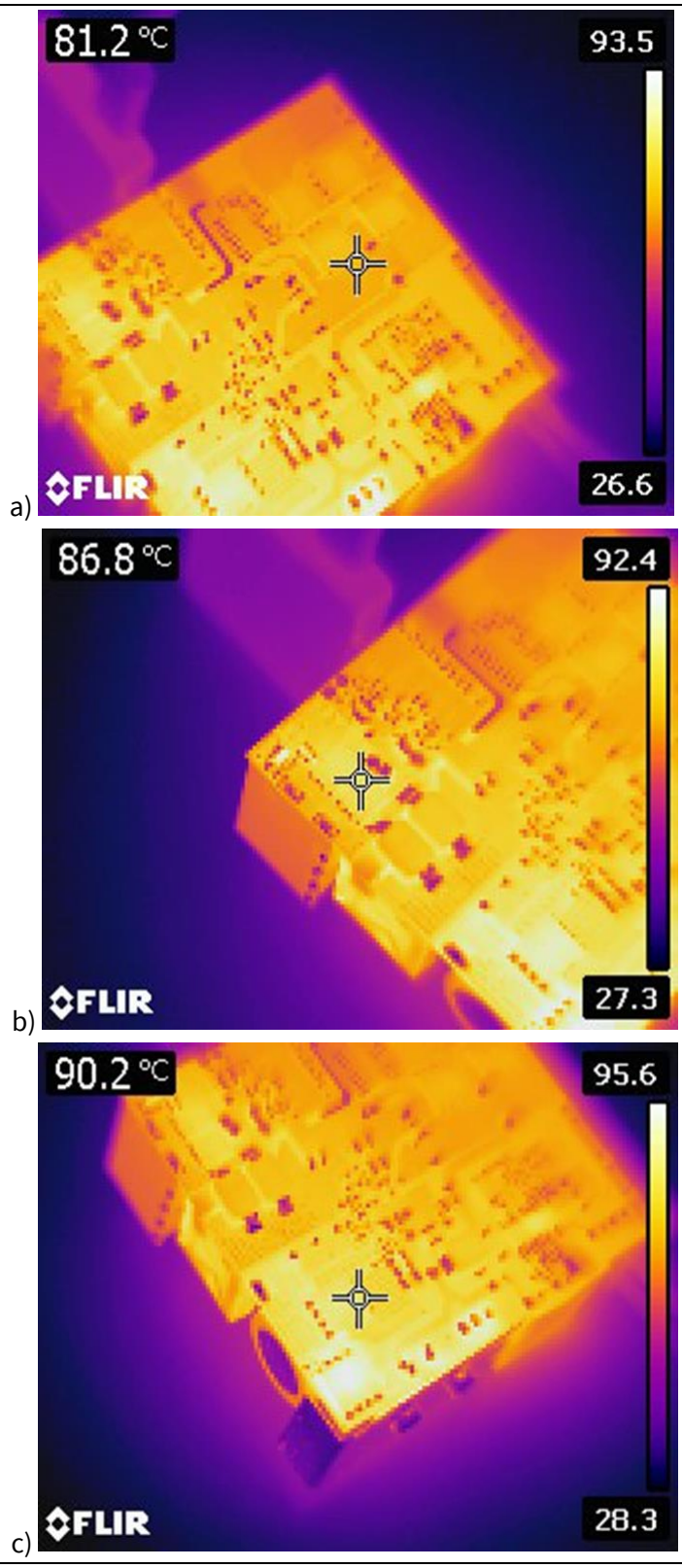
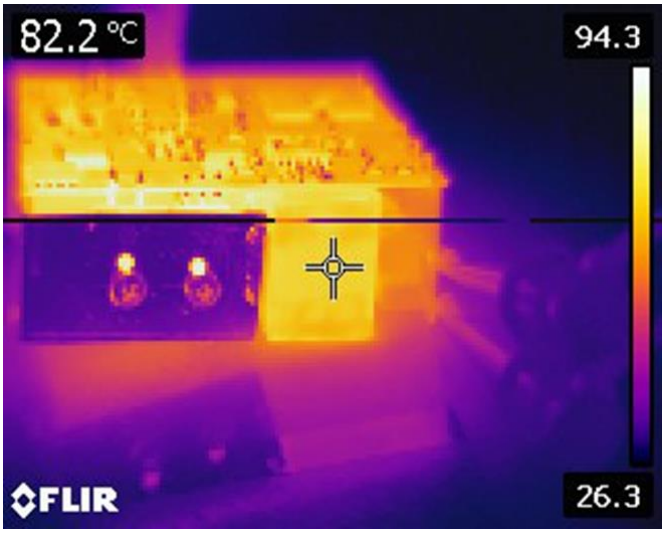
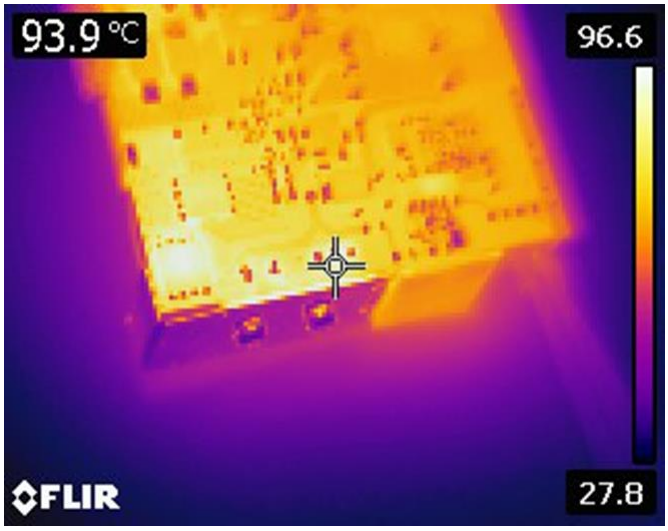


Figure 20 Thermal measurement: a) PCB, b) SR MOSFET, and c) GaN device

d)


e)


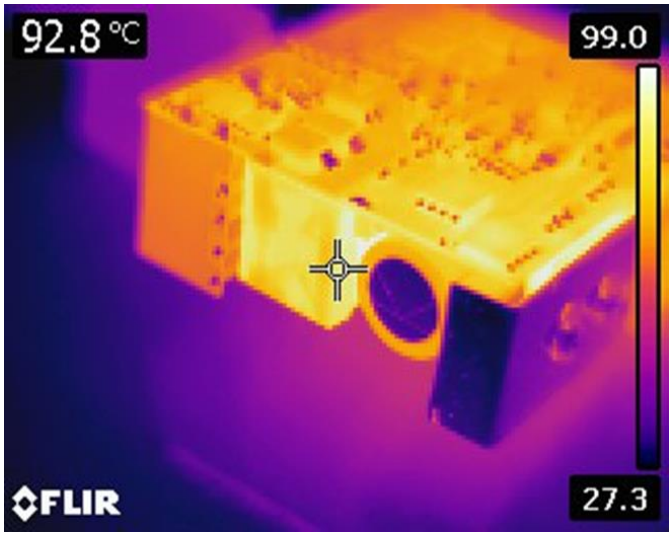
f)


Figure 21 Thermal measurement: d) PFC inductor, e) PFC MOSFET, and f) Transformer

The measurements show that the device with the highest temperature captured on the board is the PFC MOSFET, reaching a temperature of 93.9°C.

4 Appendices

This section describes the following information:

- BOMs of the boards
- Information on the magnetic devices

4.1 Bills of materials of the boards

This section presents the complete reference design BOM. While the given component voltage class shows its required operating voltage, some components on the board may have higher specification values due to component availability. Unless otherwise indicated in the BOM, 5 percent or better tolerance applies to the standard SMD resistors, and X7R or better or higher voltage class applies to the standard ceramic capacitors.

Table 9 BOM of all the boards in the system

No.	Quantity	Designator	Description
1	1	C100	0.68 µF/ 275VAC/ MKP_B32922C3684/ /20%
2	4	C101, C102, C105, C106	1 µF / 450 V/ CAP_PP_W8H12L12_Pitch_10 mm/ /10%
3	3	C103, C104, C111	220 nF/ 450 V/ CAP_C_1210/ /10%
4	2	C107, C108	220 µF / 50 V/ CAP_C_0603/ /±10%
5	1	C109	100 µF / 450 V/ RAD CAN 18x27 mm Horizontal Left/ /20%
6	1	C110	2.2 µF / 50 V/ CAP_C_0805/ /±10%
7	1	C112	2.2 µF / 25 V/ CAP_C_0603/ /10%
8	1	C113	33 pF/ 50 V/ CAP_C_0603/ /±5%
9	1	C114	3.3 nF/ 100 V/ CAP_C_0603/ /10%
10	3	C200, C202, C223	1 nF/ 50 V/ CAP_C_0603/ /10%
11	1	C201	470 nF/ 50 V/ CAP_C_0603/ /±20%
12	2	C203, C204	180 µF/ 63 V/ RAD CAN 10X16 Horizontal/ /20%
13	1	C205	180 µF/ 63 V/ RAD CAN 10x16 mm/ /20%
14	3	C206, C226, C232	4.7 µF/ 100 V/ CAP_C_1210/ /10%
15	1	C207	1 nF/ 50 V/ CAP_C_0805/ /10%
16	5	C208, C209, C210, C211, C212	150 nF/ 500 V/ CAP_C_1210/ /10%
17	6	C213, C300, C301, C306, C307, C312	100 nF/ 50 V/ CAP_C_0603/ /10%
18	1	C214	150 pF/ 50 V/ CAP_C_0603/ /±5%
19	1	C215	330 pF/ 50 V/ CAP_C_0603/ /±5%
20	1	C216	22 pF/ 50 V/ CAP_C_0603/ /±5%
21	1	C218	10 pF/ 50 V/ CAP_C_0603/ /±5%
22	2	C219, C220	1500 pF/ 440V/300V/ Murata_DK11XEA470K86RAH01/ /10%
23	3	C221, C222, C229	1 µF/ 25/ CAP_C_0805/ /10%
24	2	C224, C231	1 µF/ 50 V/ CAP_C_0805/ /±10%

Appendices

No.	Quantity	Designator	Description
25	1	C225	470 pF/ 50 V/ CAP_C_0603/ /±1%
26	1	C227	3.3 nF/ 50 V/ CAP_C_0603/ /±1%
27	1	C228	47 µF/ 25 V/ RAD CAN 5x11 mm/ /20%
28	1	C230	22 µF/ 25 V/ CAP_C_1210_H_2_5/ /10%
29	1	C302	47 nF/ 50 V/ CAP_C_0603/ /±5%
30	1	C303	1 µF/ 100 V/ CAP_C_1206/ /10%
31	1	C304	22 µF/ 25 V/ CAP_C_1206/ /10%
32	2	C305, C309	1 µF/ 25 V/ CAP_C_0603/ /10%
33	2	C310, C311	390 pF/ 50 V/ CAP_C_0603/ /±1%
34	1	D100	S5J-E3/57T/ / DO-214AB_SMC/ /
35	7	D102, D105, D106, D108, D202, D300, D301	1N4148WS-V-GS18/ / SOD-323/ /
36	2	D103, D104	US1MFA/ / SOD-123/ /
37	1	D107	BZX84C2V7LT1G/ / SOT-23-3/ /
38	1	D200	MURS160-13-F/ / DO-214AA_SMB/ /
39	1	D201	DFLS1150-7/ / PowerDI123/ /
40	3	D203, D205, D206	DFLS160/ / PowerDI123/ /
41	1	D204	DFLS1200-7/ / PowerDI123/ /
42	1	D302	ESDA25L/ / SOT-23-3/ /
43	1	DZ200	TDZ20J,115/ 20 V/ sod-323/ /
44	1	DZ201	MM3Z12VB/ 12 V/ sod-323/ /
45	1	DZ300	BZX384-C15,115/ 15 V/ sod-323/ /
46	1	F100	MP000821/ / Fuse_Multicomp_MP0008xx/ /
47	4	J100, J103, J201, J204	/ / CON1_THT_D2.5H2/ /
48	1	J300	105450-0101/ / MOLEX_USB_C_105450-0101/ /
49	1	L100	100 µH/ / WE_7447070/ /20%
50	1	L101	/ / 240 W_HF_CM_Custom_Horizontal_12.5x5/ /
51	1	L103	/ / 240 W_LF_CM_Custom_Vertical_22x12/ /
52	1	L300	33 µH/ / WE-TPC_3.8x3.8/ /30%
53	1	L1041	PQ2620/25/ / PQ2625_PFC_Ind/ /
54	1	M100	IPP65R065C7XKSA1/ / Infineon CoolMOS™ C7 SJ MOSFET TO220/ /
55	1	M101	RFNL5TJ6SFHGC9 / / TO220_Diode / /
56	1	M102	240 W_HFB_P1V0_EMI_Board
57	1	M200	2x180 µF/63 V/ / 2x180 µF_10x16_Rad_Can_Cap_PCB/ /
58	1	M300	240 W_HFB_P1V0_PD_Board
59	4	Q100, Q101, Q102, Q103	IPL60R065P7AUMA1/ / Infineon 600 V CoolMOS™ P7/ /VDSS 600 V/ PG-VSON-4/ /

Appendices

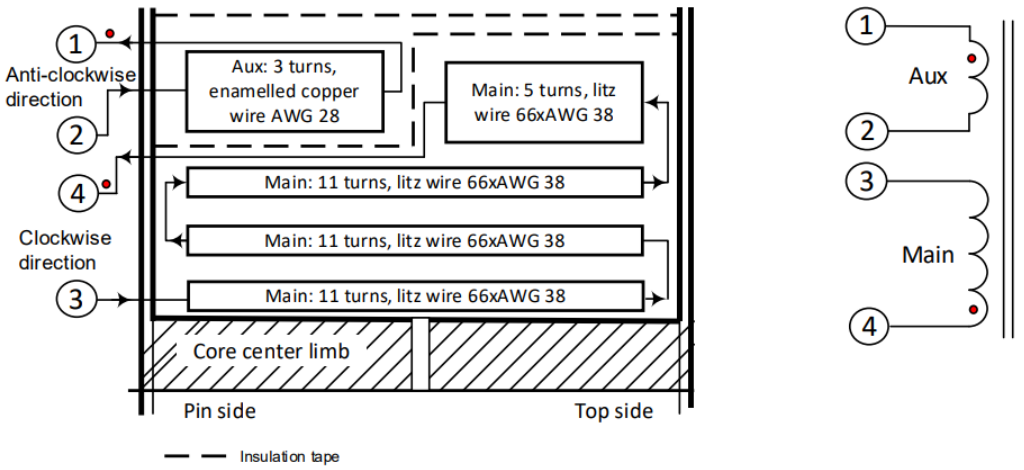
No.	Quantity	Designator	Description
60	2	Q200, Q201	IGLD60R190D1/ Infineon 600 V CoolGaN™/ PG-LSON-8-1 8x8/ /
61	2	Q202, Q203	ISC073N12LM6ATMA1/ Infineon 120 V OptiMOS™ 6 / DFN5 5X6, 1.27P (SO-8FL)/ /
62	2	Q204, Q205	BSS169H6327XTSA1/ 100 V/ SOT-23-3-GSD/ /
63	1	Q300	RS1L151ATTB1/ / DFN5 5X6, 1.27P (SO-8FL)/ /
64	3	Q301, Q302, Q303	2N7002BK,215/ 60 V/ SOT23-3L-GSD/ /
65	1	Q304	CMKDM8005 TR PBFREE/ 20 V/ SOT-363-GDS_Double/ /
66	4	R102, R103, R105, R106	2R21/ / RES_C_0603/ /1%
67	6	R104, R114, R118, R228, R231, R233	0R/ / RES_C_0603/ /-
68	2	R107, R221	10R/ / RES_C_0603/ /5%
69	6	R109, R201, R208, R312, R313, R314	33K/ / RES_C_0603/ /1%
70	3	R120, R319, R321	18K/ / RES_C_0603/ /1%
71	2	R111, R112	0R1/ / RES_C_1206/ /1%
72	1	R113	180K/ / RES_C_0603/ /1%
73	1	R115	24K/ / RES_C_1206/ /1%
74	1	R116	27K/ / RES_C_1206/ /1%
75	4	R117, R222, R223, R230	47K/ / RES_C_0603/ /5%
76	1	R119	9K1/ / RES_C_0603/ /1%
77	2	R200, R206	3K3/ / RES_C_0603/ /1%
78	1	R202	2R2/ / RES_C_0603/ /1%
79	2	R203, R209	39R/ / RES_C_0603/ /1%
80	2	R204, R205	3M3/ / RES_C_1206/ /1%
81	1	R207	16K/ / RES_C_0603/ /1%
82	1	R210	10M/ / RES_C_1206/ /1%
83	1	R211	10R/ / RES_C_0805/ /%
84	1	R212	43K/ / RES_C_1206/ /1%
85	1	R226	10K/ / RES_C_0603/ /0.1%
86	2	R214, R323	1K/ / RES_C_0603/ /1%
87	1	R215	5K6/ / RES_C_0603/ /1%
88	2	R216, R217	0R2/ / RES_C_1206/ /0.5%
89	1	R219	1R/ / RES_C_0603/ /1%
90	1	R220	510R/ / RES_C_0805/ /%
91	1	R224	2K21/ / RES_C_0603/ /1%
92	2	R225, R232	470K/ / RES_C_0603/ /1%
93	1	R227	6K8/ / RES_C_0603/ /1%
94	1	R229	22K/ / RES_C_0603/ /1%

Appendices

No.	Quantity	Designator	Description
95	5	R300, R303, R307, R316, R317	100K/ / RES_C_0603/ /1%
96	4	R301, R302, R305, R306	3K16/ / RES_C_0805/ 500mW/1%
97	1	R304	2M4/ / RES_C_0603/ /1%
98	3	R308, R309, R310	10K/ / RES_C_0603/ /1%
99	2	R311, R315	0R01/ / RES_C_0805/ /0.5%
100	1	R318	1M/ / RES_C_0603/ /1%
101	1	R320	187K/ / RES_C_0603/ /1%
102	1	T200	/ / PQ2620_240 W_Custom_Transformer/ /
103	2	TP200, TP201	5001/ / Keystone_TP_THT_1mm/ /
104	1	U100	TEA2209T/1J/ / SOIC16/ /
105	1	U200	XDPS2222XUMA1/ / Infineon XDP™ digital power combo controller PFC + hybrid flyback/ /SOIC16_XPDS2221/ /
106	1	U201	MP6908AGJ-P/ /SR controller/ /TSOT-23-6/ /
107	1	U202	TCLT1003/ / Vishay_TCLT100/ /
108	1	U203	ATL431LIBIDBZR/ / SOT-23-3/ /
109	1	U300	LT8618EDDB#WTRMPBF/ / WFDFN10/ /
110	1	U301	CYPD3175-24LQXQ/ / QFN-24_4X4_RF6886/ /
111	1	VR100	B72207S0271K101/ / EPCOS_VR_B722_Series_B72207S0271K101/ /

4.2 Information on the magnetic devices

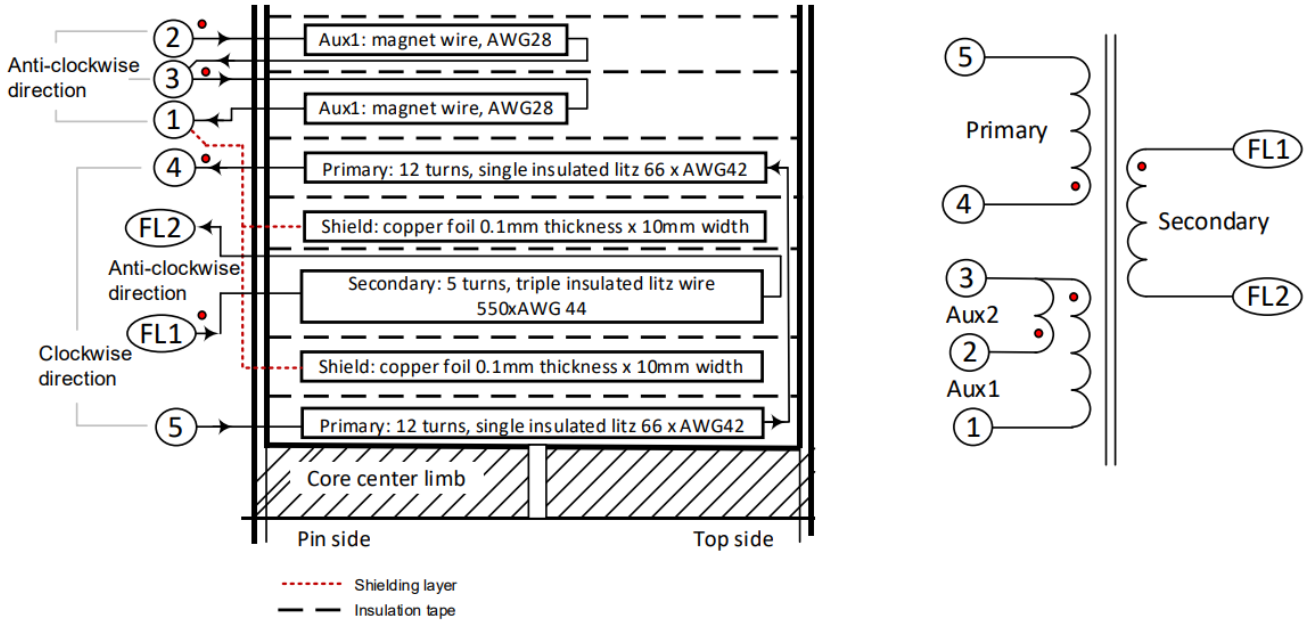
This section presents the information about the PFC choke and the HFB transformer is shown in Figure 22 and Figure 23. Both the choke and transformer are built using PQ26/25 and PQ26/20 cores with 3C95 ferrite material and custom bobbins. The air gap in the center leg of the cores is adjusted in such way that the main inductance for the PFC choke is 180 µH and the primary inductance of the hybrid flyback transformer is 200 µH. Both magnetic devices are shielded with an outside copper band around the core connected to GND/PGND. The PFC choke has an additional copper band over the windings.



Winding	Symbol	Turns	Wire	Construction
Main	Nmain	38	Litz wire, 66 x AWG 38	Close winding
Aux	Naux	3	Magnet wire, AWG 28	Close winding

Device	Core		Pin assignment	
	Type	Material	Pin	Signal
Lpfc	PQ26/25	3C95 Ferroxcube ferrite or similar	1	GND
			2	ZCD
			3	PFC DRAIN
			4	VIN+

Figure 22 PFC choke specification



Winding layer	Symbol	Turns	Wire proposal	Construction
Primary part 1	Np1	12 turns	Single insulated litz wire, 66 x AWG 42	Close winding
Shield 1	Nsh2	1 turn	Copper foil, 0.1mm thickness, 10mm width	Space winding
Secondary	Ns	5 turns	Triple insulated litz wire, 550 x AWG 44	Close winding
Shield 2	Nsh2	1 turn	Copper foil, 0.1mm thickness, 10mm width	Space winding
Primary part 2	Np2	12 turns	Single insulated litz wire, 66 x AWG 42	Close winding
Aux1	Na1	1 turn	Magnet wire, AWG 28	Close winding
Aux2	Na2	2 turns	Magnet wire, AWG 28	Close winding

Device	Core		Pin assignment	
	Type	Material	Pin	Signal
Thfb	PQ26/20	3C95 Ferroxcube ferrite or similar	1	PGND
			2	LDO INPUT
			3	ZCD
			4	VCR
			5	PSW
			FL1	VOUT
			FL2	SSW

Figure 23 HFB transformer specification

References

[1] Infineon Technologies AG: *XDPS2222 PFC + hybrid flyback – combo controller*, Datasheet (Rev. 1.0); 2023-03-29; Available online.

[2] Infineon Technologies AG: *240 W USB PD evaluation board with PFC + hybrid flyback combo IC XDP™ XDPS2222*; Available online.

Revision history

Document revision	Date	Description of changes
V 1.0	2024-03-06	Initial release
V 1.1	2024-09-24	Updated the output discharge resistors on USB PD board

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