XDP™ XDPS2221E: PFC + hybrid-flyback combo IC with CoolGaN™ for 100 W adapter evaluation board

About this document

Scope and purpose

This document provided information about the 100 W adapter evaluation board, showcasing the XDP™ digital power XDPS2221E controller for power factor correction (PFC) + hybrid-flyback (HFB) and CoolGaN™ device in single-output adapter. The system solution includes the following components:

- CoolMOS™ P7 devices in the active-bridge rectification
- CoolGaN™ Drive 700 V G5 IGI70N140A2MS device as PFC switch
- CoolGaN™ Transistor Dual 650 V G5 IGI65D1414A3M as half-bridge switching device

The system is referred as an ‘evaluation design’ for a few reasons: It is designed for the functional demonstration not the highest power density consideration.

Although the power stage is equivalent to the existing 140 W reference design ‘REF_XDPS2221_140W1’, the transformer and PFC choke can be further optimized for better efficiency and power density. With an improved transformer design, an efficiency of more than 94% at a 90 V AC input can be easily achieved for an output power of 140 W (one output board design at 28 V and 5 A condition). For more information about the reference boards, see the References section. The document presents the performance data and design information of the evaluation board. This design exhibits a very low standby power (< 80 mW), which meets the DoE Level VII power supply efficiency requirements.

Intended audience

The intended audiences for this document are switched-mode power supply design engineers and users of this 100 W evaluation board.

Keypoints

Adapter, high-efficiency, hybrid flyback, CoolGaN™

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

	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™ XDPS2221E overview

The XDP™ XDPS2221E controller is an easy- to-use IC, a highly integrated device that includes the multimode PFC controller, the hybrid-flyback (HFB) controller, and three gate drivers for the PFC switch and hybrid-flyback switches. The high level of integration for both PFC and HFB stages make this controller the perfect choice for wide input – wide output applications. One such application is the USB PD adapter and the battery chargers as presented in this document. For detailed information about the control IC, see the datasheet [1].

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 integrated start-up cell for internal biasing and fast VCC charging
- Burst-mode operation for lowest no-load standby power and tiny load requirements
- Adaptive PFC bus voltage and PFC enable/disable control to maximize average and light-load efficiency
- Comprehensive set of protections
- Configurable parameters for protection modes and system performance
- MFIO communication pin configurable as active bridge rectification enable (ACT_EN) or external signal feed for over-temperature (OTP_NTC)
- Pb-free lead plating, halogen-free (according to IEC61249-2-21), and 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
- Zero voltage switching (ZVS) operation of high-side and low-side switch (with ZVS pulse insertion in Discontinuous Conduction Mode)
- Configurable multimode operation for improved average and light-load efficiency

1.4 IC pin configuration

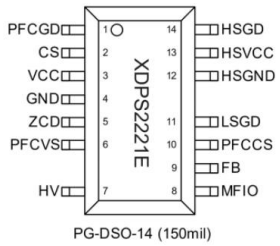


Figure 1 IC pin configuration

1.4.1 Low BILL of materials

- PFC + HFB control with gate drivers in one 14-pin DSO package for direct driving of CoolMOS™ and CoolGaN™
- Integrated start-up cell for VCC initial charge-up
- Potential transformer size reduction compared to other flyback topologies

1.4.2 High system performance

- High system efficiency
- High power density design
- Independent enable and disable control of active bridge controller and PFC stage to guarantee low power consumption in no-and light-load conditions
- Great efficiency in tiny load conditions and low standby power to meet DOE Level VII

1.4.3 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

1.4.4 Selected (system) control features

The following innovative features enable high system efficiency throughout all line, load conditions, ensuring no-load power consumption:

- The hybrid-flyback topology is used as an isolated DC-DC stage, featuring implemented control features and operation modes such as continuous resonant mode (CRM), zero-voltage resonant valley switching (ZV- RVS), and burst mode
- The adaptive PFC stage output voltage and hybrid-flyback output voltage are adjusted based on the AC-input voltage to USB-PD output voltage ratio, ensuring optimum performance and high system efficiency
- The output DC-DC buck stage can operate in bypass mode, allowing it to be bypassed in cases where the requested USB-PD voltage matches the adapted hybrid-flyback voltage

2 IGI70N140A2MS overview

IGI70N140A2MS combines a 140 mΩ CoolGaN™ Drive, it adopts gate injection transistor (GIT) with an integrated smart gate driver for layout's ease of use, providing advanced current sensing protection features with low standby power consumption. Lossless current sense technology provides shunt-less and lossless current sensing readout, which enables cycle-by-cycle overcurrent protection (OCP) and latched short circuit protection (SCP). Along with undervoltage lock-out (UVLO) and overtemperature protection (OTP), the device is protected to operate within its safe operating area (SOA). Sleep mode enables low power consumption in the standby state. The fast autowakeup is triggered by the PWM input after less than 200 ns. In low-to-medium power applications, it is thus ideally suited to support the design of high-density AC/DC chargers and adapters, utilizing the superior switching behavior of CoolGaN™ switches.

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

2.1 Product highlights

- 700 V 140 mΩ CoolGaN™ Drive, it adopts gate injection transistor (GIT) integrated with dedicated gate driver and protection features
- Fixed short circuit protection and programmable cycle-by-cycle over current protection
- Low consumption Sleep mode enables VCC quiescent current below 350 µA
- Integrated LDO supplies 5.25 V and 3 mA for digital isolator when used as high-side
- Digital PWM input signal with standard logic input levels compatible with digital controllers
- Wide supply voltage operating range (6.5 V to 24 V)
- Space saving 6x8 QFN package with exposed pad for effective PCB cooling

2.2 IC pin configuration

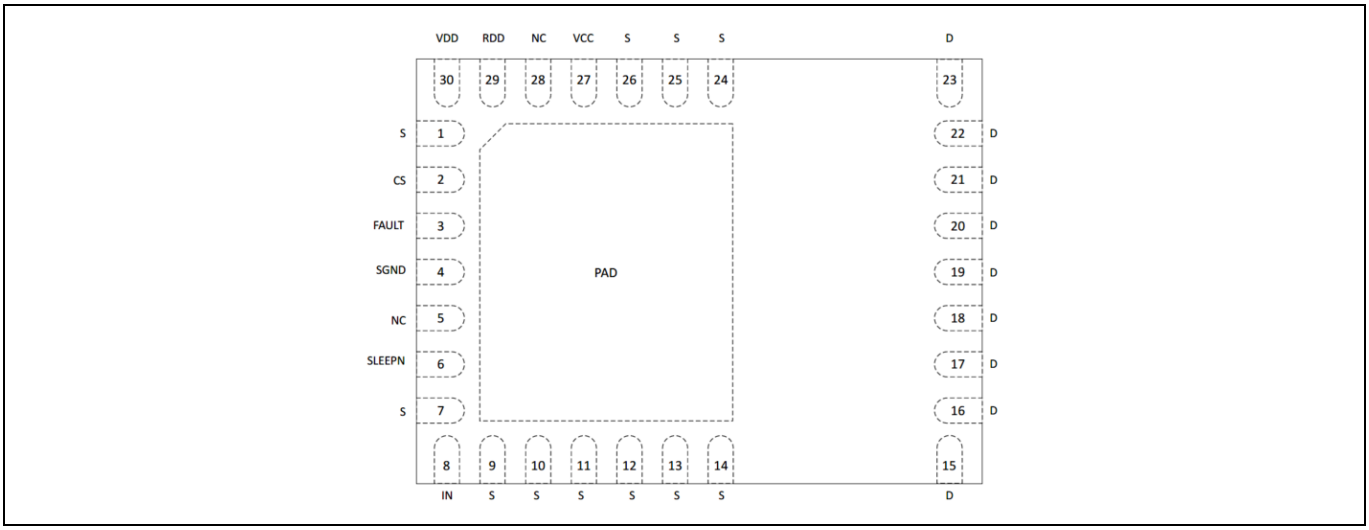


Figure 2 IGI70N140A2MS pin configuration

2.3 User benefits

2.3.1 High system performance

- High power density design
- Multiple protections (OCP/SCP/OTP) are included

- Great efficiency in tiny load conditions and low standby power to meet DOE Level VII

2.3.2 Lossless current sense technology

Real-time measurements of the current through the transistor are needed in many applications. A common solution is the use of a simple shunt resistor. While this method is inexpensive, it has several disadvantages. For example, larger PCB area, higher leakage inductance, and existing losses.

The lossless current sense technology provides a real-time current sensing method without having any of these
disadvantages. The drain current is sensed internally and is passed on to the CS pin as a current signal. This signal creates a voltage drop across the ROCP and RSENSE resistors that can be measured by the controller.
The lossless current sense feature can be disabled by leaving the CS pin open.

2.3.3 Low-power Sleep mode

When the SLEEPN pin is low and the IN pin is low, the device enters low-power Sleep mode automatically after a time interval of tSLEEP_EN. VCC current consumption is reduced to IVCCqu_SLEEP (maximum 350 µA). When SLEEPN pin or IN pin is switched to high, the device returns to normal operation after a time of tSLEEP_EXIT. During low-power Sleep mode, the lossless current sense feature is disabled.

3 Board hardware

3.1 Overview

The 100 W adapter evaluation board uses the XDP™ digital combo controller XDPS2221E, CoolGaN™ Transistor Dual IGI65D1414A3M device, and CoolGaN™ Drive IGI70N140A2MS device featuring high integrated adapter.

Figure 3 shows the top view of the complete board system, consisting of a main power board, an input active-bridge rectifier board, and VCC board. The AC input connection points are located on the bottom-left side and marked accordingly. JP 200 is the UART connector that may be used for the configuration of the XDP™ XDPS2221E or for reading MFIO pin signals.

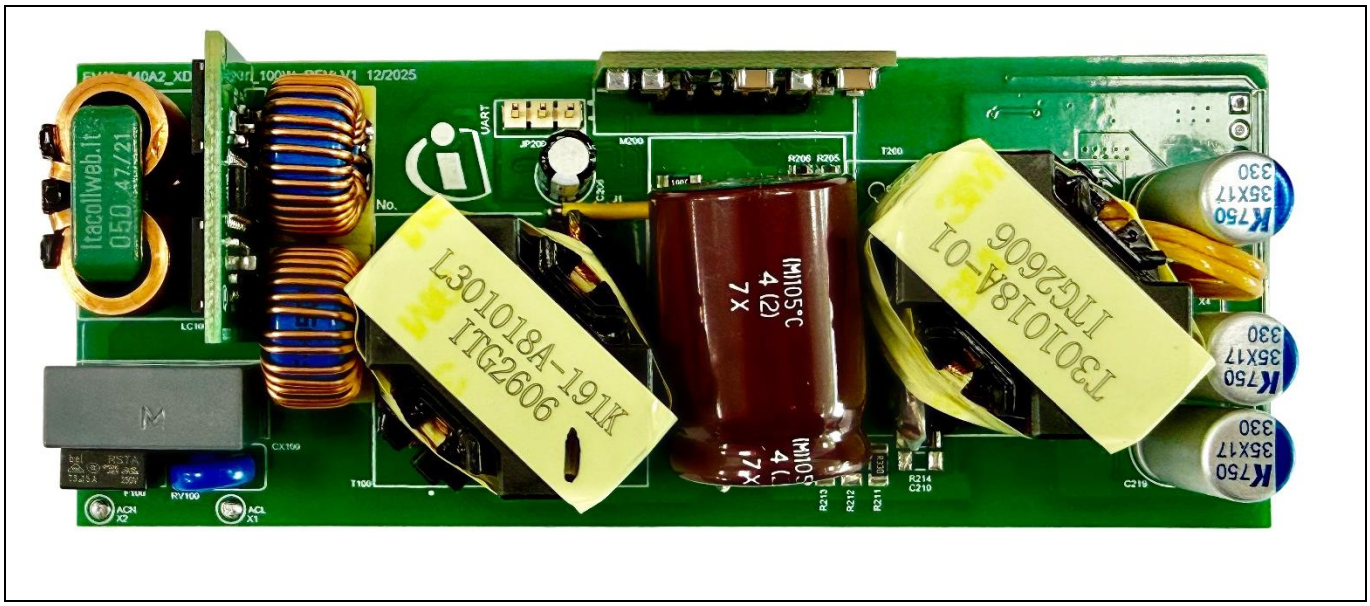


Figure 3 EVAL_100W _PFC_140AMS Evaluation Board

3.1.1 Input electrical requirements

Table 1 lists the electrical requirements for the input of the 100 W evaluation board.

Table 1 Input electrical requirement

Parameter	Symbol	Value			Unit	Condition
		Min.	Typ.	Max.		
AC	VAC	90	-	264	V_{RMS}	Maximum range
		100	-	240	V_{RMS}	Nominal range
AC frequency	f_{AC}	47	-	63	Hz	-
Brown-in	-	-	85	-	V	-
Brown-out	-	-	75	-	V	-
X-capacitor discharge time	-	-	-	1	s	-

3.1.2 Output electrical requirements

Table 2 Output electrical requirements

Parameter	Symbol	Value			Unit
		Min.	Typ.	Max.	
Output voltage	V_{OUT}	-	20	-	V
Output current	I_{OUT}	-	5	-	A
Start-up time	-	-	-	0.5	s

3.1.3 Key components

The following Infineon components are used on the board.

Table 3 Key component

Item	Component
PFC + HFB controller	XDP™ XDPS2221E
Active bridge switches	IPL60R085P7
PFC switch	CoolGaN™ Drive IGI70N140A2MS
HFB switches	CoolGaN™ Tranistor Dual IGI65D1414A3M
SR MOSFET	BSC034N10LS5
VCC regulator switch	BSS169

3.1.4 Board and PCB information

The board and PCB information are summarized in Table 4.

Table 4 Board dimensions and power density

Board	Item	Value	Unit
Power board	Dimension	114 x 45 x 25	mm
	Power density	≈ 12.5	W / in3
	PCB	2	Layers

3.2 Evaluation board system

The system consists of the main power board, an active bridge rectifier board, and a VCC bias board. The hybrid-flyback combo controller XDP™ XDPS2221E controls both the PFC and HFB stages. The CoolGaN™ Transistor Dual IGI65D1414A3M device was chosen, having both the high-side and low-side GaN switches integrated in one package.
The PFC switch, a CoolGaN™ Drive IGI70N140A2MS device, is based on a 140 mΩ e-mode GaN transistor with integrated intelligent gate driver and lossless current sense. Having the overcurrent protection integrated into IGI70N140A2MS, the PFC stage does not require any PFC shunt resistor. At the output side using ATL431 to get fixed output voltage management as well as controlling the regulation loop of the HFB.

In the following sections, the schematics and printed circuit board (PCB) layout design information of the boards are shown, while the bills of materials (BOMs) of the boards can be found in Section 4.1.

3.2.1 Evaluation board schematics

The schematics of all the boards of this evaluation board system are shown in Figure 4 to Figure 9.

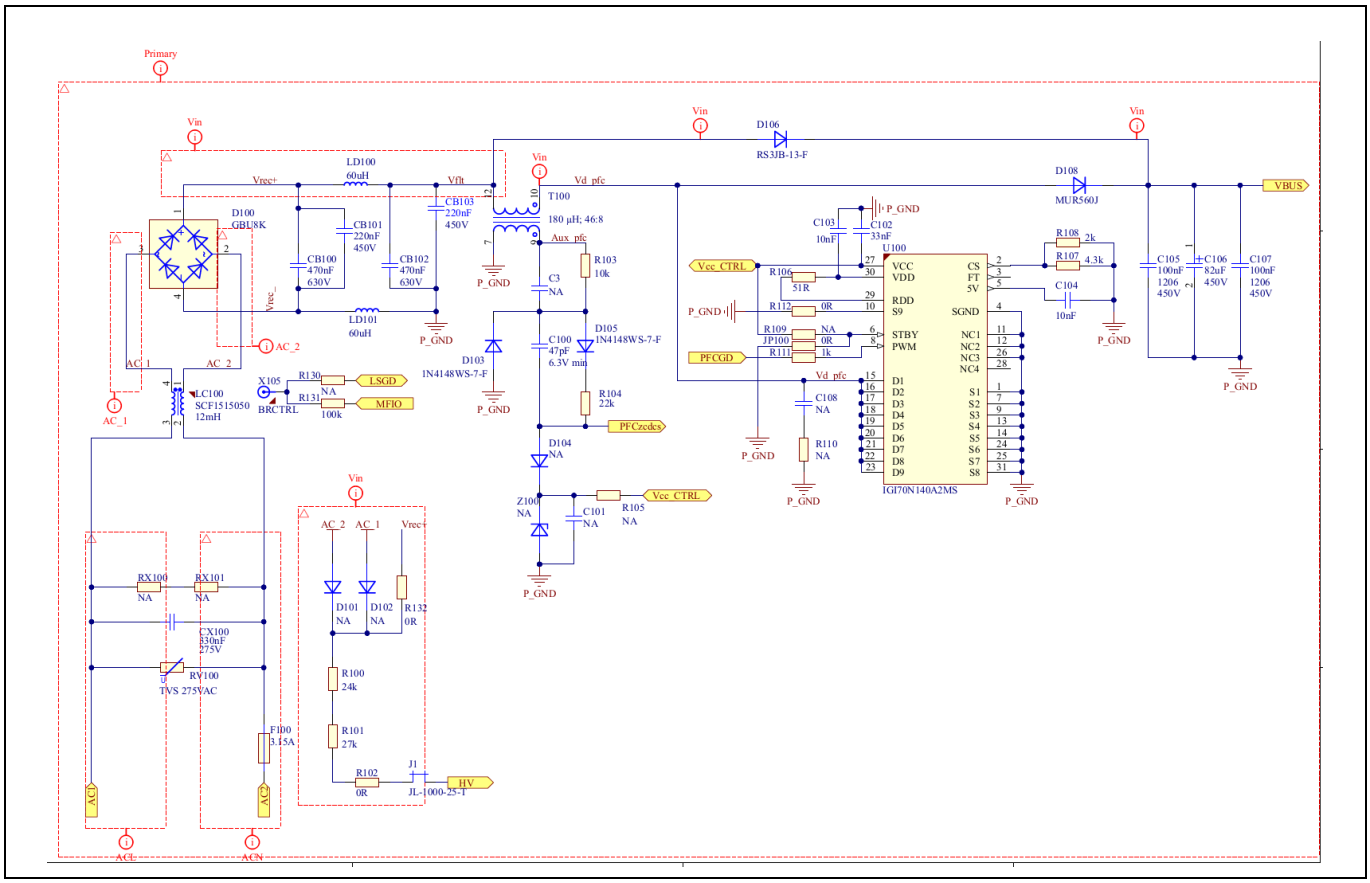


Figure 4 PFC stage schematic

Figure 4 shows the power circuitry of the AC input and PFC stage, including the input protection, EMI filter, and the start-up cell feed resistors R132, R100, R101, and R102. The PFC main switch U100 is the CoolGaN™ Drive IGI70N140A2MS that integrates a high-performance e-Mode GaN FET, gate drive, and lossless current sense. The CoolGaN™ Drive is driven directly by the XDP™ XDPS2221E from the PFCGD pin through R111. The PFC zero-crossing detection (ZCD) circuit is processing the Aux_pfc signal from the auxiliary winding of the PFC choke T100 via R103, D103, C100, D105, and R104. The resulting processed signal PFCzcdcs is sent to the PFCCS pin of the controller.

The active-bridge board is shown in Figure 5. It comprises the active-bridge controller U100 and the CoolMOS™ P7 IPL60R085P7 FETs Q100, Q101, Q102, and Q103. To save loss, U100 is disabled at no-load and at very light load conditions via BRCTRL signal generated by the MFIO pin of XDPS2221E. The MFIO pin is configured for ACT_EN function.

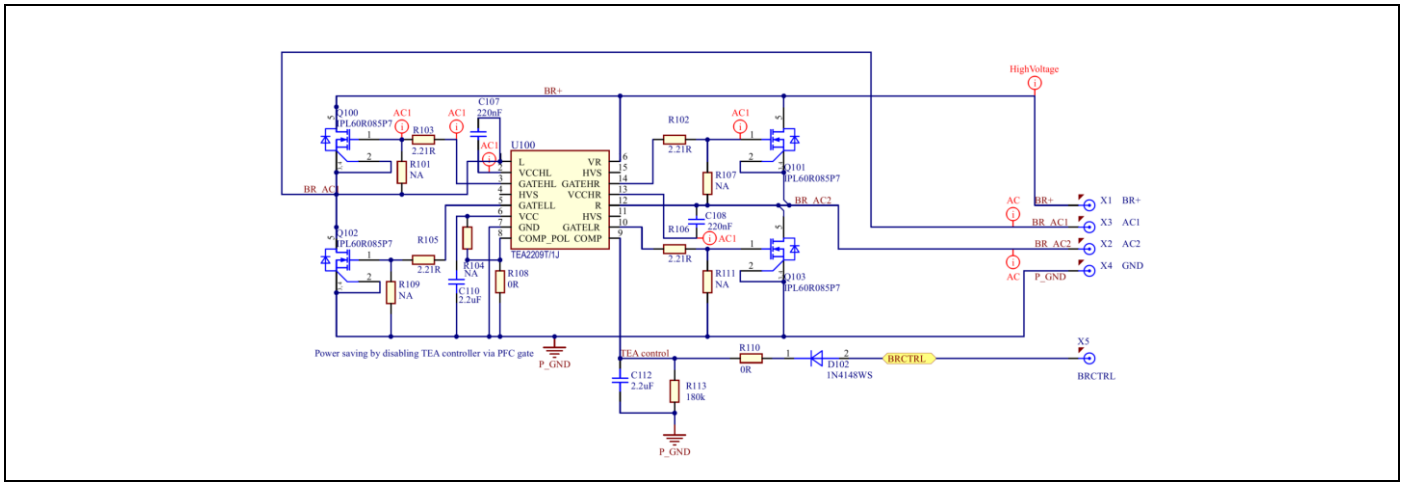


Figure 5 Active-bridge rectifier board schematic

The hybrid-flyback (HBF) DC to DC stage, which is based on a half-bridge structure, is controlled by XDP™ XDPS2221E combo IC, the application circuitry as shown in Figure 6.

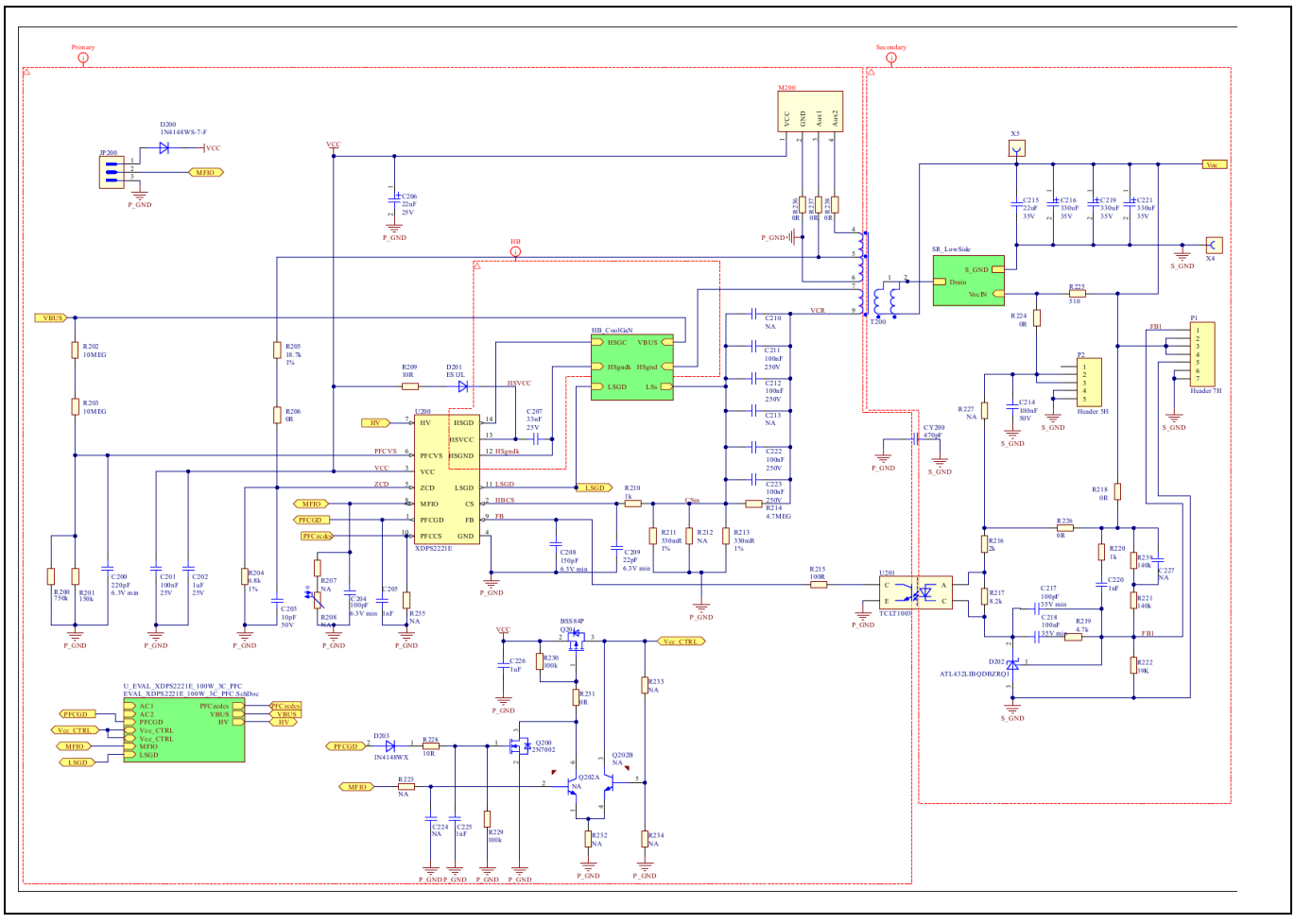


Figure 6 HBF stage schematics

The primary winding of the T200 transformer is connected to the half-bridge switching node at one end and to the resonant capacitors (C211, C212, C222, and C223) at the other end. The shunt resistors

(R211 and R213) are used to sense the current through the transformer's primary winding for HFB peak current regulation.

For accurate switching timing, the signal from the auxiliary winding (Na1: 5 to 6) is used. It generates a ZCD signal using devices R204 and R205. The resistors R200, R201, R202, and R203 are used for the PFC VBUS voltage
sensing. The JP200 connector is used for parameter configuration via UART communication and debugging.

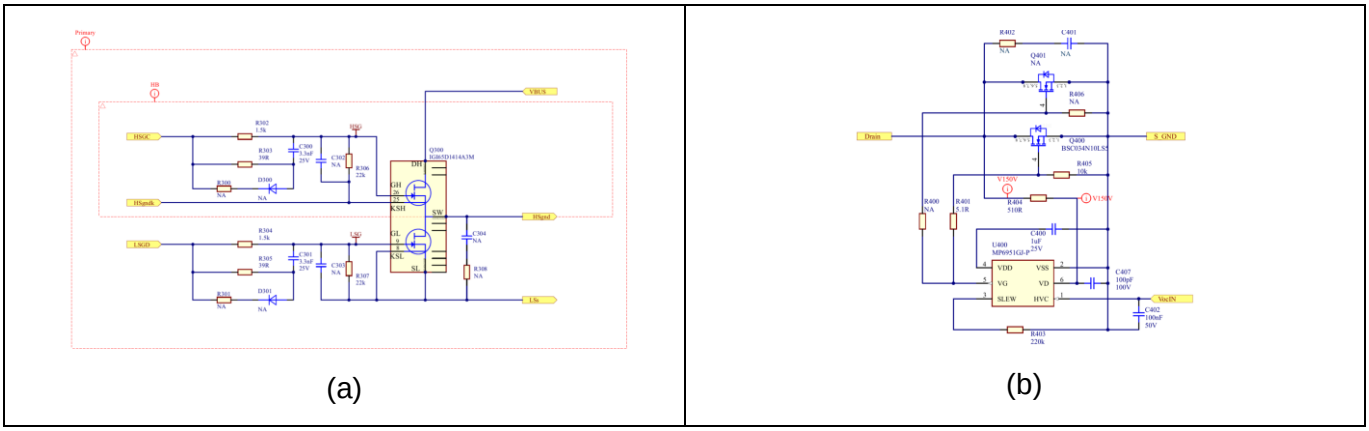


Figure 7 Schematics: a) half-bridge schematic (CoolGaN™ Transistor Dual), b) synchronous rectifier schematic

The half-bridge schematic and secondary side synchronous rectifier schematic are depicted in Figure 7.

In Figure 8, the schematic of the VCC supply board is shown. This bias supply is based on a charge pump circuit that is fed by Vaux1 and Vaux2 voltages generated by auxiliary windings Na1 and Na2.

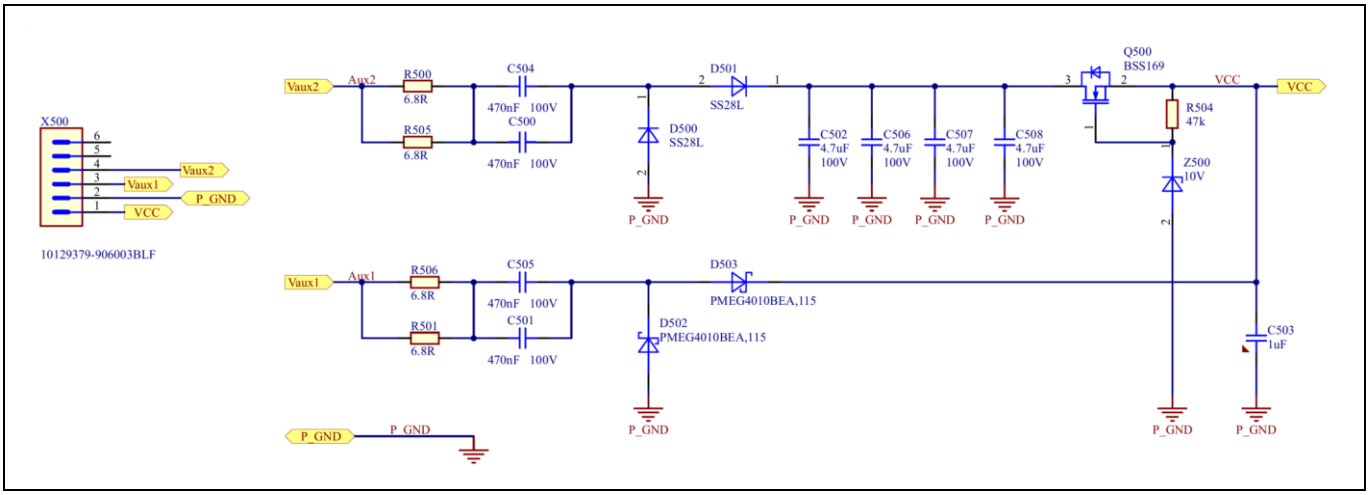


Figure 8 VCC supply board schematic

With a charge pump, this board supports an output voltage from 5~20 V with feedback loop adjustment.

3.2.2 Evaluation board PCB layout design

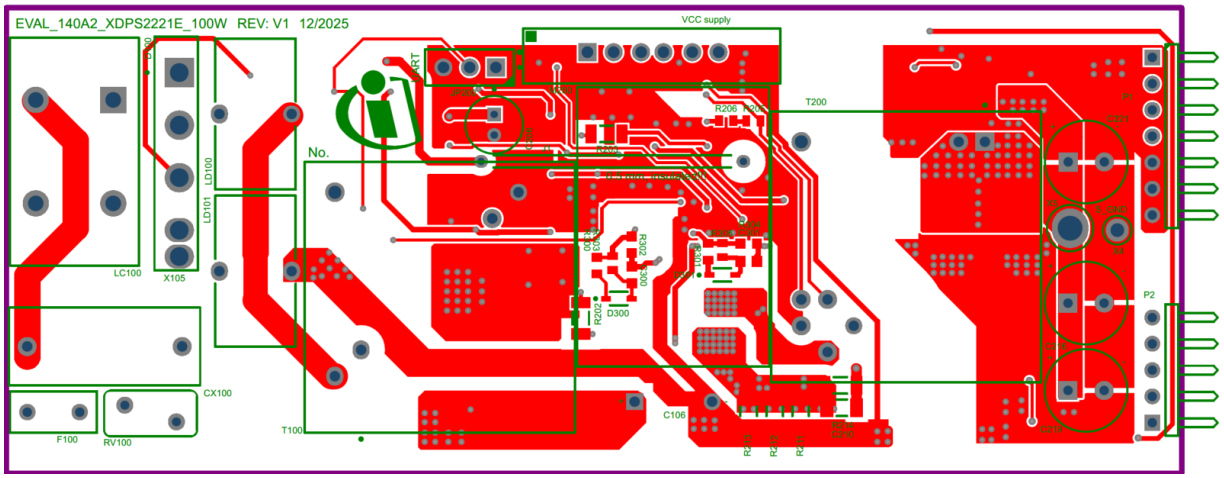


Figure 9 100 W power board layout – top layer

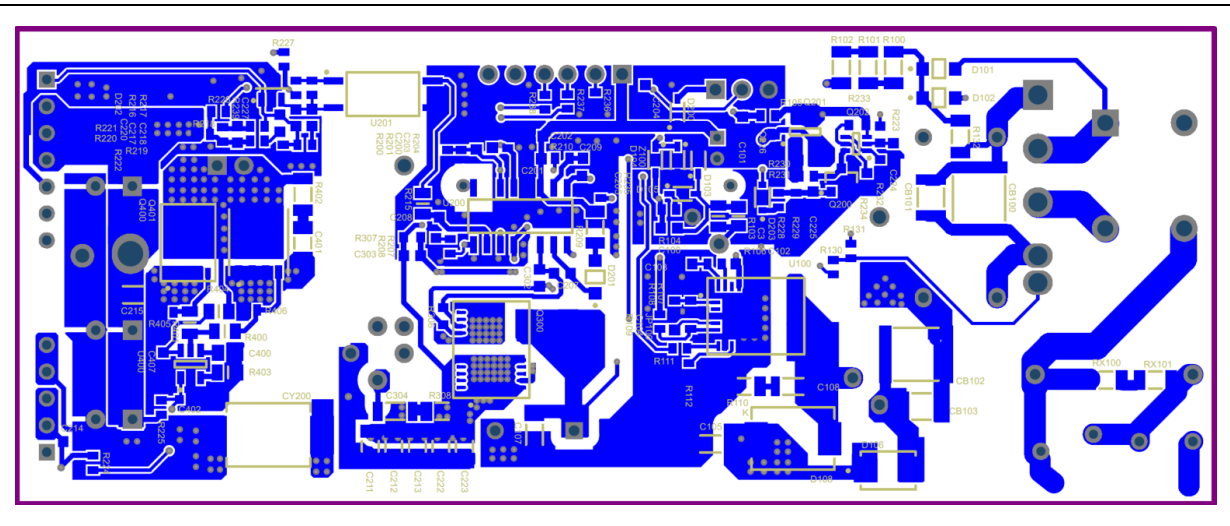


Figure 10 100 W power board layout – bottom layer

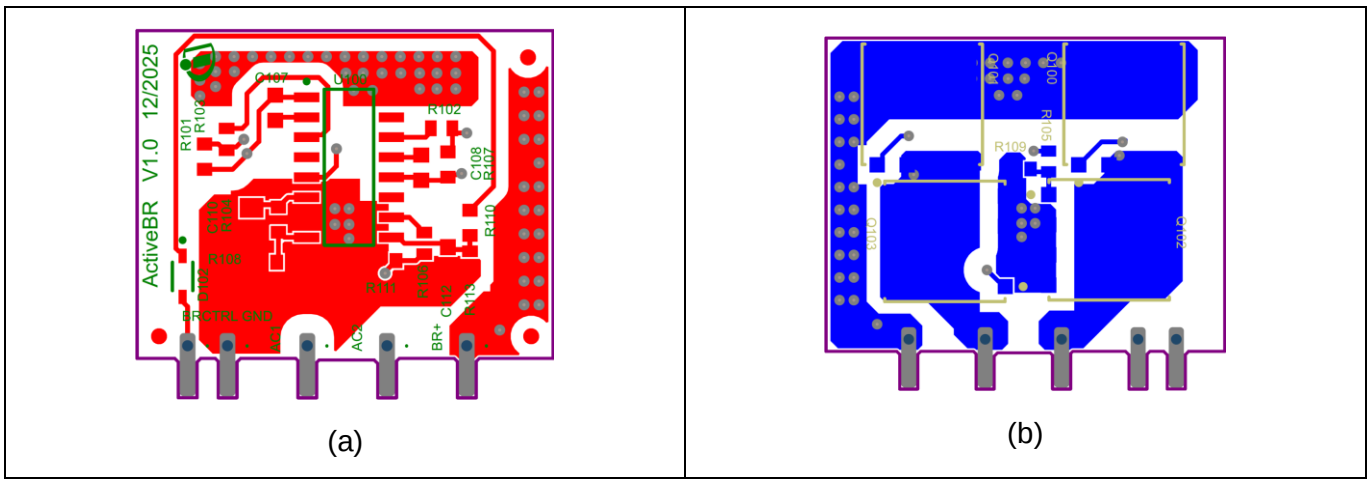
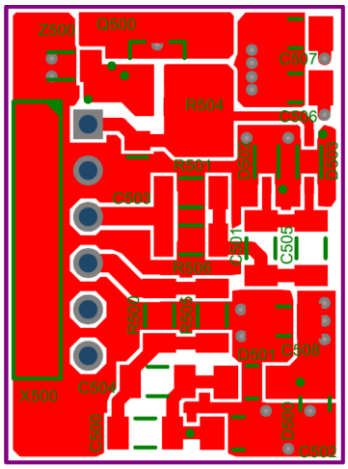


Figure 11 Active bridge rectifier board layout – a) top layer, b) bottom layer



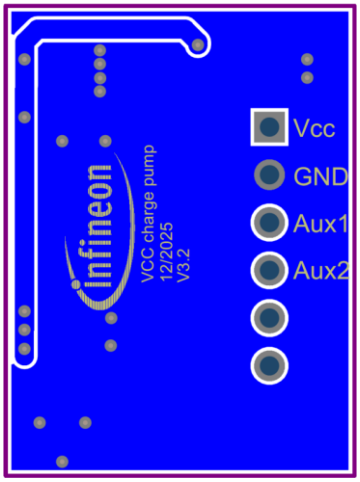


Figure 12 VCC supply board layout – a) top layer, b) bottom layer

4 System performance

The key measurement results are illustrated in the following sections.

4.1 Evaluation board system

The four-point average efficiency of the board measured is shown in Table 5. As can be seen in the table, the four-point average efficiency is high enough to meet stringent efficiency standards set by the DoE Level VII power supply conversion efficiency requirements.

Table 5 Efficiency as a percentage, measured at the output terminal

VAC(V)	Iout(A) / Vout(V)	100%	75%	50%	25%	Average	Average acc. DoE VII
115	20	94.79%	94.83%	94.06%	92.87%	94.14%	89%
230	20	95.22%	94.69%	93.24%	91.47%	93.66%	89%

The four-point efficiency at the lower- and higher-line input voltage, measured for 20 V output voltage, is shown in Figure 13.

Figure 13 Efficiency at 115/230 V AC

Table 6 Standby input power measurements

V AC(V)	90	115	230	264	DoE VII
No load Consumption(mW)	69.96	68.4048	75.522	74.964	150

System standby input power is measured, and the results are shown in Table 6. For standby input power.

4.2 Conducted EMI emissions measurement

The EMI measurement results for the full output power of 100 W are presented in this section. The average (AVG) and quasi-peak (Q-peak) tests were performed at both lowline (110 V AC) and high line (230 V AC), with Line (L) and neutral (N) conditions.

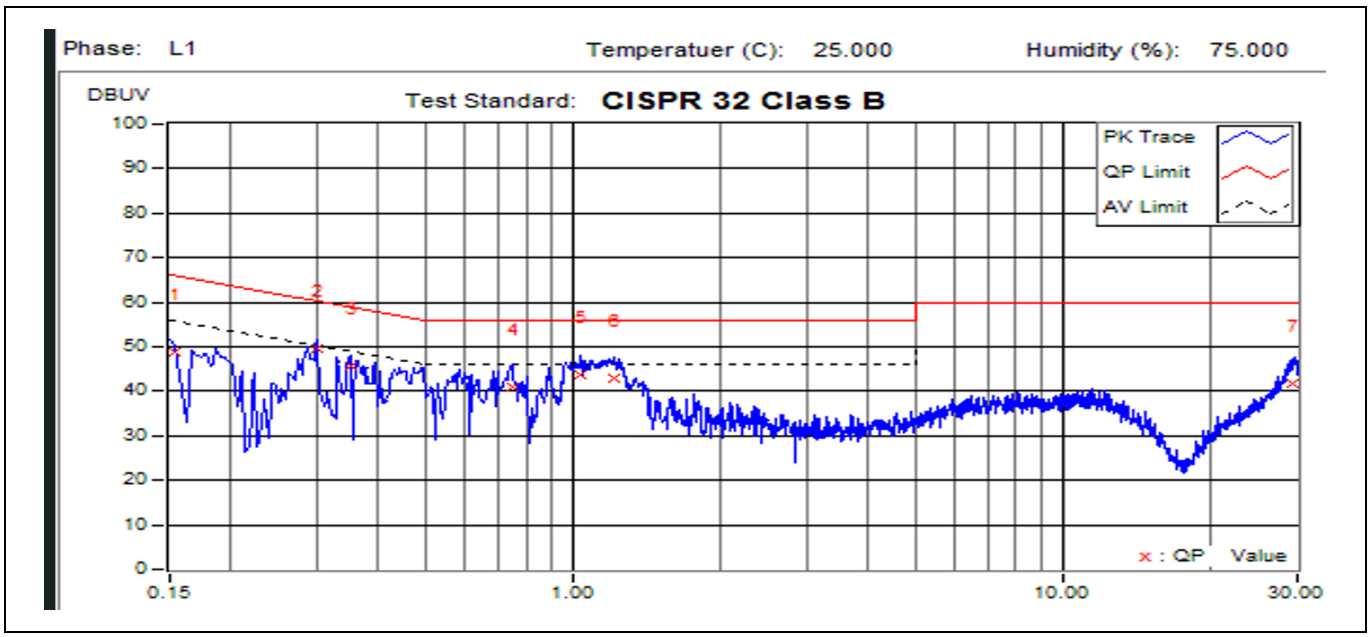


Figure 14 Q-peak and AVG conducted EMI test result plot for 110 V AC input and L phase

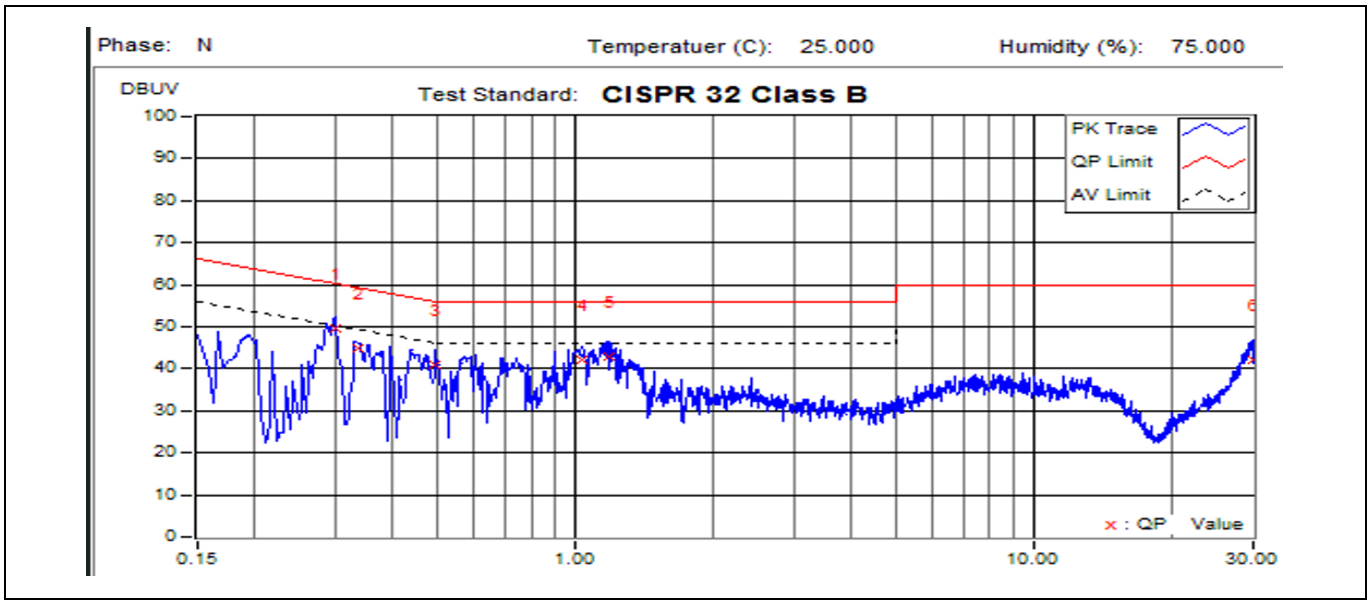


Figure 15 Q-peak and AVG conducted EMI test result plot for 110 V AC input and N phase

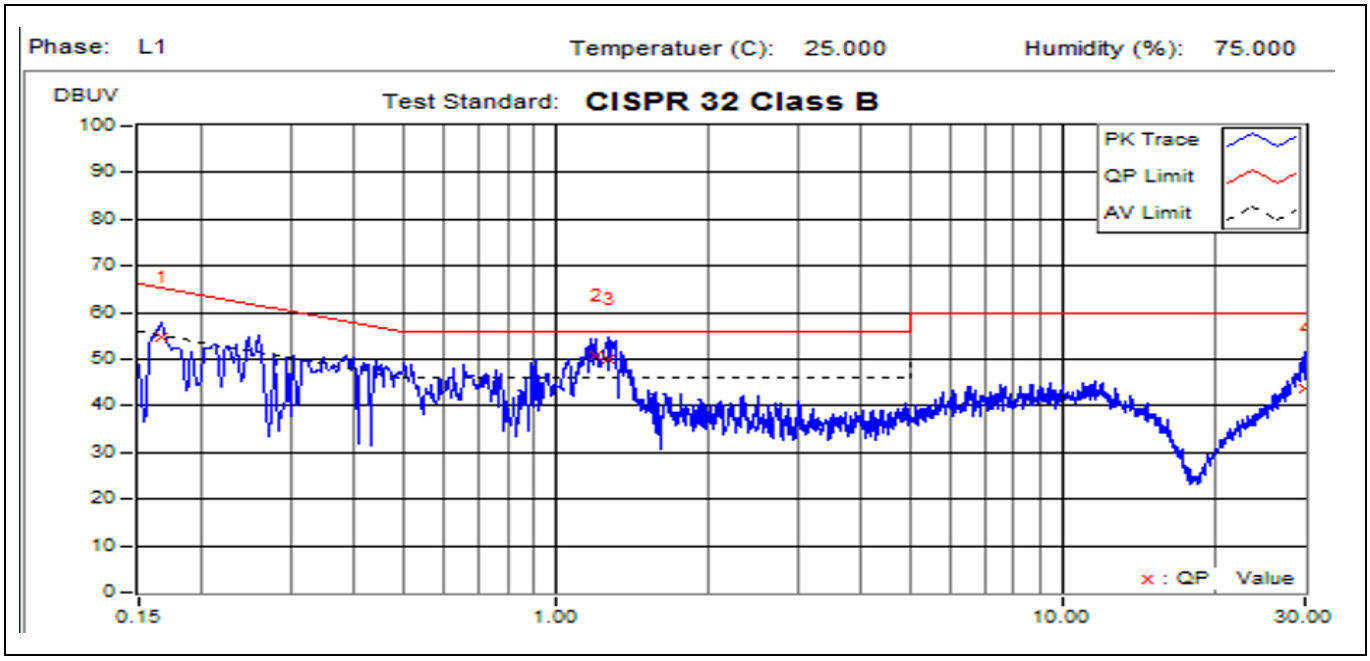


Figure 16 Q-peak and AVG conducted EMI test result plot for 230 V AC input and L phase

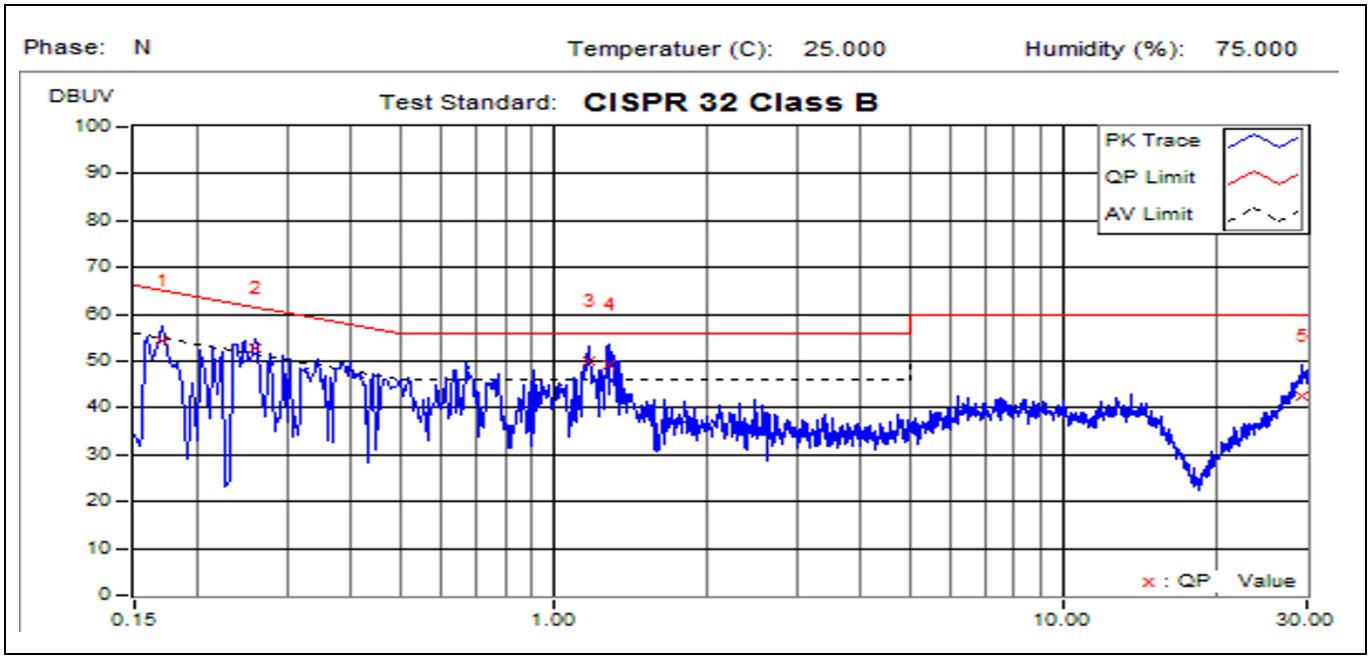


Figure 17 Q-peak and AVG conducted EMI test result plot for 230 V AC input and N phase

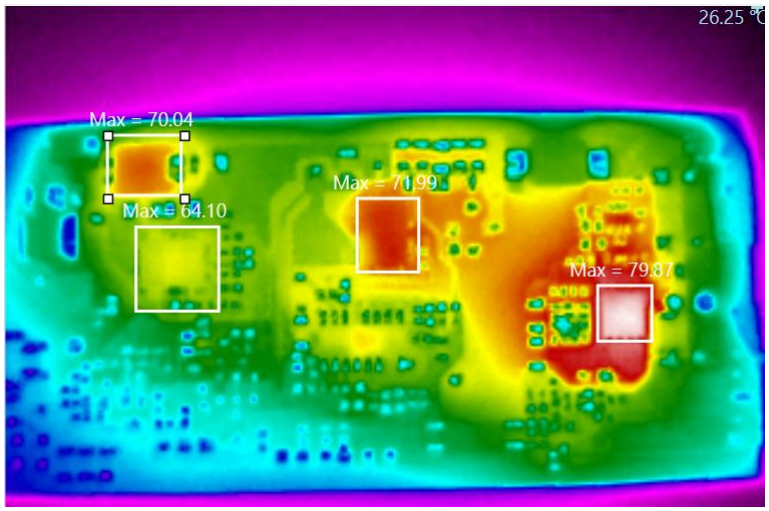
4.3 PFC performance

In this section, the PFC performance data is presented, which is quantified by the power factor, harmonic currents, and the total harmonic distortion measurements. The power factor measurements were performed at 115 VAC and 230 VAC for a load from 100% down to 25% with 25% steps. The results of this test are presented in Table 7.

Table 7 Power factor measurement

VAC(V) / Load (%)	115	230
25	95.6	76.35
50	98.75	91.58
75	99.4	95.68
100	99.6	97.35

4.4 Thermal measurement



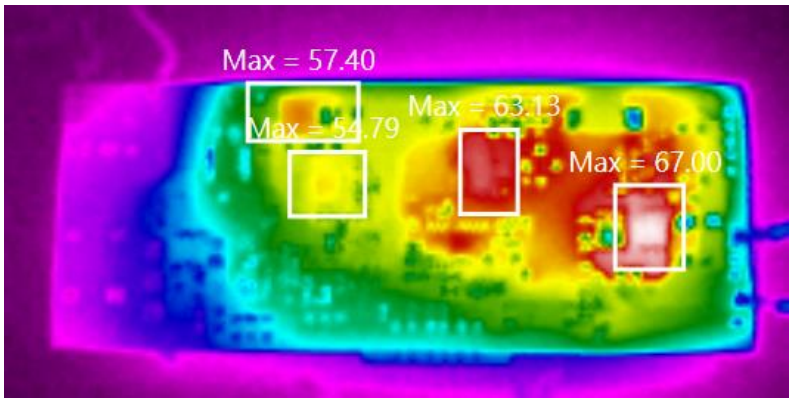
(a)

$T_{PFC\ Diode}$ = 70.04°C

$T_{PFC\ GaN}$ = 64.1°C

$T_{HBF\ GAN}$ = 71.99°C

T_{SR} = 79.87 °C



(b)

$T_{PFC\ Diode}$ = 57.4°C

$T_{PFC\ GaN}$ = 54.79°C

$T_{HBF\ GAN}$ = 63.13°C

T_{SR} = 67°C

Figure 18 Thermal images: a) 115 VAC bottom, b) 230 VAC bottom

At an ambient temperature of 20°C and DUT burn in 30 mins, the measurements show that the device with the highest temperature captured on the board is the SR MOSFET, reaching a temperature of 79.87 °C at 115 VAC input voltage. The temperature of the CoolGaN™ Transistor Dual device is reaching 71.99 °C at 115 VAC and the CoolGaN™ Drive device of 64.1 °C at the same input voltage.

5 Appendices

This section describes the following information:

- Bills of materials (BOMs) of the boards
- Information on magnetic devices

5.1 Bills of materials of the boards

This section provides the list of all the components used in the boards that are part of the evaluation board.
Each table is the complete BOM for each board in the system.
While the given component voltage class shows its required operating voltage, some components on the board may have higher specification values due to the component's 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 8 Power board BOM

No.	Quantity	Designator	Description	Part number	Manufacturer
1	1	C100	CAP / CERA / 47pF / 6V3 / 10% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	C0603C470K5GACAUTO	Kemet
2	2	C102, C207	CAP / CERA / 33nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	GRM188R71E333JA01	Murata
3	2	C103, C104	CAP / CERA / 10nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	GRM188R71E103JA01	Murata
4	2	C105, C107	CAP / CERA / 100nF / 450V / 10% / X7T (EIA) / -55°C to 125°C / 3.20mm L X 1.60mm W X 1.80mm H / SMD / -	C3216X7T2W104K160AA	TDK Corporation
5	1	C106	CAP / ELCO / 82uF / 450V / 20% / Aluminum electrolytic / -40°C to 105°C / Horizontal, 7.50mm pitch, 18.50mm L X 27.00mm W X 18.50mm H / THT / -	EKXQ451ELL820MM25S	Chemi-Con
6	1	C200	CAP / CERA / 220pF / 50V / 2% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	GRM1885C1H221GA01	Murata
7	1	C201	CAP / CERA / 100nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	GRM188R71E104JA01	Murata
8	1	C202	CAP / CERA / 1uF / 25V / 10% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	GRM188R71E105KA12	Murata

No.	Quantity	Designator	Description	Part number	Manufacturer
9	1	C203	CAP / CERA / 10pF / 50V / 2.5% / X8G (Murata) / -55°C to 150°C / 0603(1608) / SMD / -	GCM1885G1H100RA16	Murata
10	1	C204	CAP / CERA / 100pF / 50V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	GCM1885C1H101JA16	Murata
11	1	C205	CAP / CERA / 1nF / 25V / 10% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	885012206059	Wurth Elektronik
12	1	C206	CAP / ELCO / 22uF / 25V / 20% / Aluminum electrolytic / -40°C to 85°C / 2.00mm C X 0.50mm W 5.25mm Dia X 12.50mm H / THT / -	UVR1E220MDD	Nichicon
13	1	C208	CAP / CERA / 150pF / 50V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	GCM1885C1H151JA16	Murata
14	1	C209	CAP / CERA / 22pF / 50V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	GRM1885C1H220JA01	Murata
15	4	C211, C212, C222, C223	CAP / CERA / 100nF / 250V / 10% / X7R (EIA) / -55°C to 125°C / 1206(3216) / SMD / -	GRM31CR72E104KW03	Murata
16	2	C214, C218	CAP / CERA / 100nF / 50V / 10% / X8L (EIA) / -55°C to 150°C / 0603(1608) / SMD / -	GCM188L81H104KA57	Murata
17	1	C215	CAP / CERA / 22uF / 35V / 20% / X5R (EIA) / -55°C to 85°C / 1206(3216) / SMD / -	C3216X5R1V226M160AC	TDK Corporation
18	3	C216, C219, C221	CAP / ELCO / 330uF / 35V / 20% / Aluminum electrolytic / -55°C to 105°C / 3.50mm C X 0.60mm W 8.00mm Dia X 18.00mm H / THT / -	A750KW337M1VAAE020	Kemet
19	1	C217	CAP / CERA / 100pF / 50V / 2% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	GRM1885C1H101GA01	Murata
20	2	C220, C225	CAP / CERA / 1nF / 50V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	GRM1885C1H102JA01	Murata
21	1	C226	CAP / CERA / 1uF / 25V / 10% / X5R (EIA) / -55°C to 85°C / 0603(1608) / SMD / -	GRM185R61E105KA12	Murata
22	2	C300, C301	CAP / CERA / 3.3nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	GRM188R71E332JA01	Murata

Appendices

No.	Quantity	Designator	Description	Part number	Manufacturer
23	1	C400	CAP / CERA / 1uF / 25V / 10% / X7R (EIA) / -55°C to 125°C / 0805 / SMD / -	08053C105K4Z2A	AVX
24	1	C402	CAP / CERA / 100nF / 50V / 10% / X7R (EIA) / -55Â°C to 125°C / 603 / SMD / -	885012206095	Wurth Elektronik
25	1	C407	CAP / CERA / 100pF / 100V / 2% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	GRM1885C2A101GA01	Murata
26	2	CB100, CB102	CAP / CERA / 470nF / 630V / 10% / X7T (EIA) / -55°C to 125°C / 2220(5750) / SMD / -	CGA9P1X7T2J474K250KC	TDK Corporation
27	1	CB101	CAP / CERA / 220nF / 450V / 10% / X7T (EIA) / -55°C to 125°C / 3.20mm L X 2.50mm W X 2.20mm H / SMD / -	CGA6M4X7T2W224K200AA	TDK Corporation
28	1	CB103	CAP / CERA / 220nF / 450V / 10% / X7T (EIA) / -55°C to 125°C / 3.20mm L X 2.50mm W X 2.20mm H / SMD / -	CGA6M4X7T2W224K200AA	TDK Corporation
29	1	CX100	CAP / FILM / 330nF / 275V / 10% / MKP (Metallized Polypropylene) / -40°C to 105°C / 12.50mm C X 0.60mm W 15.00mm L X 8.50mm T X 14.50mm H / - / -	R46KI333040P0M	Kemet
30	1	CY200	CAP / CERA / 470pF / / 10% / B (JIS) / -40°C to 125°C / 5.10 mm Pitch, 2 pin, 8.00 mm L X 6.00 mm W X 2.50 mm H body / SMD / -	DK1B3EA471K86HBH01	Murata
31	3	D103, D105, D200	Surface Mount Fast Switching Diode, 75V	1N4148WS-7-F	Diodes Incorporated
32	1	D106	3.0A Surface Mount Fast Recovery Rectifier	RS3JB-13-F	Diodes Incorporated
33	1	D108	Ultrafast power diode	MUR560J	WeEn Semiconductors
34	1	D201	1A, 600V Surface Mount Super Fast Rectifier, Low-Power Loss, High Efficiency	ES1JL	Taiwan Semiconductor
35	1	D202	High-Bandwidth Low IQ Programmable Shunt Regulator, Inverter, and Motor Control Applications	ATL432LIBQDBZRQ1	Texas Instruments

No.	Quantity	Designator	Description	Part number	Manufacturer
36	1	D203	High-Speed Switching Diode	1N4148WX-TP	Micro Commercial Components
37	1	F100	RES / STD / - / - / - / - / -55°C to 125°C / 5.08mm C X 0.60mm W 8.35mm L X 4.00mm T X 8.10mm H / THT / -	RSTA 3.15-BULK SHORT	Bel Fuse Inc.
38	2	JP100, R112	RES / STD / 0R / - / 0% / - / -55°C to 155°C / 0603 / SMD / -	CRCW06030000Z0EA	Vishay
39	1	JP200	Through hole .025 SQ Post Header, 2.54mm pitch, 3 pin, vertical, single row	HTSW-103-07-G-S	Samtec
40	1	LC100	IND / STD / 12mH / 2.36A / 50% / -40°C to 125°C / 100mR / THT / inductor, THT, 4 pin, 22.00 mm L X 12.50 mm W X 20.00 mm H body / THT / -	SCF1515050	ITACOIL
41	2	LD100, LD101	IND / STD / 60uH / 4.1A / 20% / -40°C to 105°C / 40mR / THT / inductor, THT, 7 mm pitch, 2 pin, 16.00 mm L X 9.90 mm W X 16 mm H body / THT / -	7447023	Wurth Elektronik
42	1	Q200	OptiMOS Small-Signal-transistor	2N7002	Infineon
43	1	Q201	SIPMOS P-Channel Enhancement Small-Signal-transistor	BSS84PH6327XTSA2	Infineon
44	1	Q300	Half Bridge GaNFast Power IC	IGI65D1414A3M	Infineon
45	1	Q400	OptiMOS 5 Power-transistor, 100V	BSC034N10LS5	Infineon
46	1	R100	RES / STD / 24k / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	CRCW120624K0FK	Vishay
47	1	R101	RES / STD / 27k / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	CRCW120627K0FK	Vishay
48	2	R102, R132	RES / STD / 0R / - / 0% / - / -55°C to 155°C / 1206(3216) / SMD / -	CRCW12060000Z0EA	Vishay
49	1	R103	RES / STD / 10k / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805(2012) / SMD / -	CRCW080510K0FK	Vishay
50	1	R104	RES / STD / 22k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW060322K0FK	Vishay

No.	Quantity	Designator	Description	Part number	Manufacturer
51	1	R106	RES / STD / 51R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW060351R0FK	Vishay
52	1	R107	RES / STD / 4.3k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW06034K30FK	Vishay
53	2	R108, R216	RES / STD / 2k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW06032K00FK	Vishay
54	1	R111	RES / STD / 1k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW06031K00FK	Vishay
55	3	R131, R229, R230	RES / STD / 100k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW0603100KFK	Vishay
56	1	R200	RES / STD / 750k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW0603750KFK	Vishay
57	1	R201	RES / STD / 150k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW0603150KFK	Vishay
58	2	R202, R203	RES / STD / 10MEG / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206(3216) / SMD / -	CRCW120610M0FK	Vishay
59	1	R204	RES / STD / 6.8k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW06036K80FK	Vishay
60	1	R205	RES / STD / 18.7k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW060318K7FK	Vishay
61	8	R206, R218, R224, R226, R231, R236, R237, R238	RES / STD / 0R / - / 0% / - / -55°C to 155°C / 0603(1608) / SMD / -	CRCW06030000Z0EA	Vishay
62	1	R209	Thick Film Resistors - SMD General-Purpose Chip Resistor 1206, 10Ohms, 1%, 1/4W	RC1206FR-0710RL	YAGEO
63	1	R210	RES / STD / 1k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	CRCW06031K00FK	Vishay
64	2	R211, R213	RES / STD / 330mR / 500mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	CRM1206-FX-R330 E LF	Bourns
65	1	R214	RES / STD / 4.7MEG / 330mW / 5% / 200ppm/K / -55°C to 155°C	SG73P2BTTD475J	KOA Speer Electronics Inc.

No.	Quantity	Designator	Description	Part number	Manufacturer
			/ 3.20mm L X 1.60mm W X 0.70mm H / SMD / -		
66	1	R215	RES / STD / 100R / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805(2012) / SMD / -	CRCW0805100RFK	Vishay
67	1	R217	RES / STD / 8.2k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW06038K20FK	Vishay
68	1	R219	RES / STD / 4.7k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	CRCW06034K70FK	Vishay
69	1	R220	RES / STD / 1k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	CRCW06031K00FK	Vishay
70	2	R221, R239	Thick Film Resistors - SMD General-Purpose Chip Resistor 0603, 140kOhms, 1%, 1/10W	RC0603FR-07140KL	YAGEO
71	1	R222	Thick Film Resistors - SMD General-Purpose Chip Resistor 0603, 39kOhms, 1%, 1/10W	RC0603FR-07140KL	YAGEO
72	1	R225	Thick Film Resistors - SMD General-Purpose Chip Resistor 0603, 510Ohms, 1%, 1/10W	RC0603FR-07510RL	YAGEO
73	1	R228	RES / STD / 10R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW060310R0FKEA	Vishay
74	2	R302, R304	RES / - / 1.5k / 100mW / 1% / 100ppm/K / - / 0603(1608) / SMD / -	MCR03EZPFX1501	ROHM Semiconductors
75	2	R303, R305	RES / VAR / 39R / 125mW / 1% / 25ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW060339R0FK	Vishay
76	2	R306, R307	RES / STD / 22k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	RC0603FR-0722KL	Yageo
77	1	R401	RES / STD / 5.1R / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805(2012) / SMD / -	CRCW08055R10FK	Vishay
78	1	R403	RES / STD / 220k / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805(2012) / SMD / -	CRCW0805220KFK	Vishay
79	1	R404	RES / STD / 510R / 125mW / 1% / 100ppm/K / -55°C to 155°C / 0805(2012) / SMD / -	MC0805S8F5100T5E	Multicomp

No.	Quantity	Designator	Description	Part number	Manufacturer
80	1	R405	RES / STD / 10k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW060310K0FKEA	Vishay
81	1	RV100	Varistors 275VAC 10% 7mm StandarD	B72207S0271K101	Epcos
82	1	T100	190uH, N1:N2=46:9	L301018A-191K	ITG
83	1	T200	Np:Ns:Naux1:Naux2=21:3:1:2, RM10, Lp 230µH	T301018A-01	ITG
84	1	U100	GaN transistor with Integrated gate driver	IGI70N140A2MS	Infineon
85	1	U200	XDPS2221E/ / SOIC127P600X175-14N-1/	XDPS2221E	Infineon
86	1	U201	Optocoupler, Photo transistor Output	TCLT1003	Vishay
87	1	U400	Monolithic Power Systems (MPS) Fast Turn-Off Rectifier for Flyback Converter With Intelligent VDS Ringing Detection	MP6951GJ-P	Monolithic Power Systems

Table 9 Active bridge board BOM

No.	Quantity	Designator	Description	Part number	Manufacturer
1	2	R108, R110	RES / STD / 0R / 100mW / 1% / 200ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	RC0603FR-070RL	Yageo
2	1	D102	Small Signal Fast Switching Diode	1N4148WS	Vishay
3	1	R113	RES / STD / 180k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW0603180KFK	Vishay
4	4	R102, R103, R105, R106	RES / STD / 2.21R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603(1608) / SMD / -	CRCW06032R21FK	Vishay
5	1	C110	CAP / CERA / 2.2uF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 805(2012) / SMD / -	C2012X7R1H225K125AE	TDK Corporation
6	1	U100	IC ACTIVE BRIDGE CTRL SOIC16	TEA2209T/1J	NXP
7	1	C112	CAP / CERA / 2.2uF / 50V / 10% / X5R (EIA) / -55°C to 85°C / 603(1608) / SMD / -	GRT188R61H225KE13D	Murata

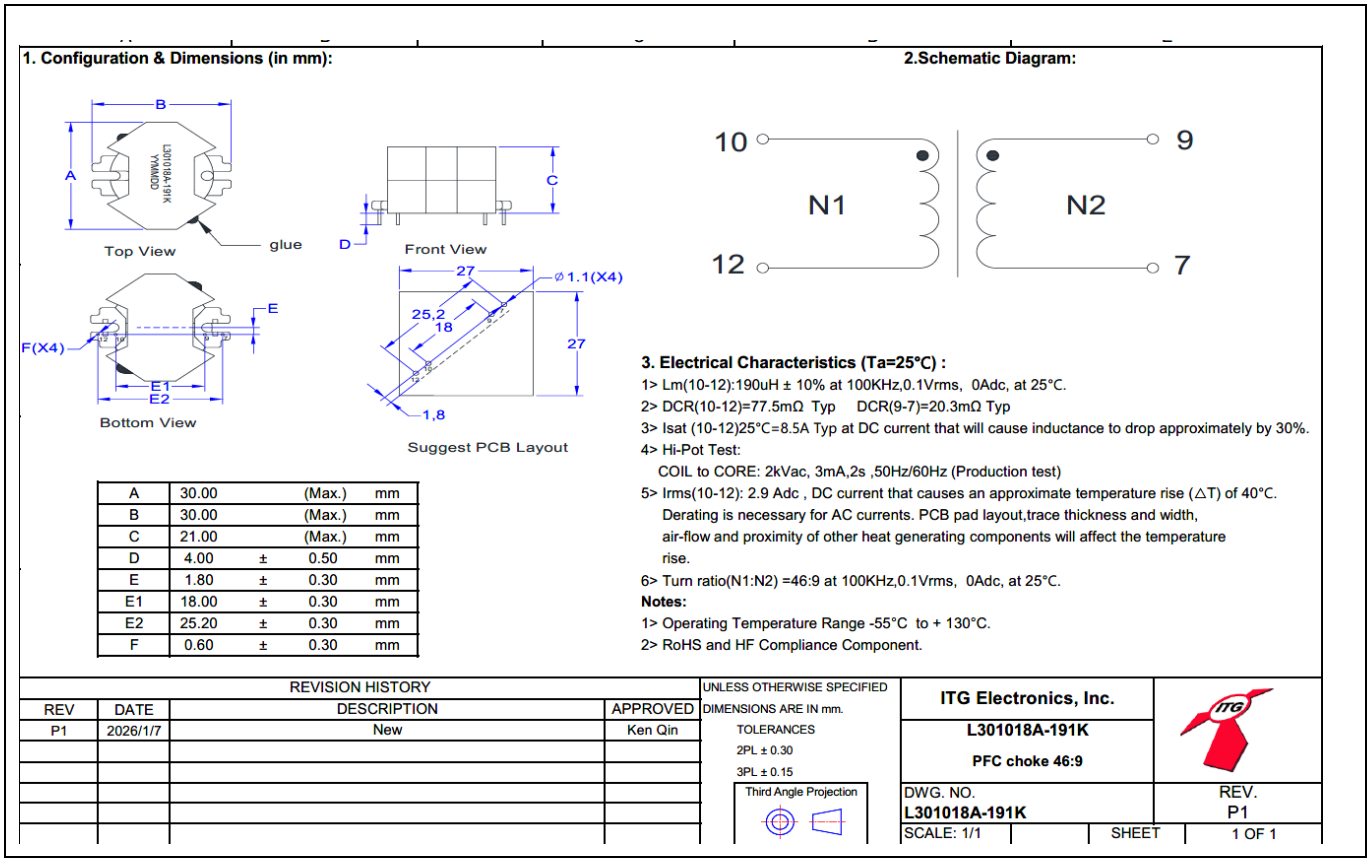
No.	Quantity	Designator	Description	Part number	Manufacturer
8	2	C107, C108	CAP / CERA / 220nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	GCM188R71H224KA64	Murata
9	4	Q100, Q101, Q102, Q103	600V CoolMOS P7 Power transistor	IPL60R085P7	Infineon

Table 10 VCC board BOM

No.	Quantity	Designator	Description	Part number	Manufacturer
1	4	C500, C501, C504, C505	CAP / CERA / 470nF / 100V / 10% / X7R (EIA) / -55°C to 125°C / 1206(3216) / SMD / -	12061C474K4Z2A	AVX
2	4	C502, C506, C507, C508	CAP / CERA / 4.7uF / 100V / 10% / X7S (EIA) / -55°C to 125°C / 1206 (3216) / SMD / -	GRM31CC72A475KE11L	Murata
3	1	C503	CAP / CERA / 1uF / 50V / 10% / X5R (EIA) / -55°C to 85°C / 0805(2012) / SMD / -	GRM219R61H105KA73	Murata
4	2	D500, D501	SUPER BARRIER RECTIFIER	SS28L	Multicomp
5	2	D502, D503	Very low VF MEGA Schottky barrier rectifier	PMEG4010BEA,115	Nexperia
6	1	Q500	SIPMOS Small-Signal-transistor	BSS169	Infineon
7	4	R500, R501, R505, R506	RES / STD / 6.8R / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206(3216) / SMD / -	CRCW12066R80FK	Vishay
8	1	R504	RES / STD / 47k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	CRCW060347K0FK	Vishay
9	1	X500	Connector, THT, 6pins, 2.54mm pitch, Board-to-Board	10129379-906003BLF	Amphenol
10	1	Z500	Zener Voltage Regulators 500 mW SOD-123 Surface Mount	BZT52-B10J	Nexperia

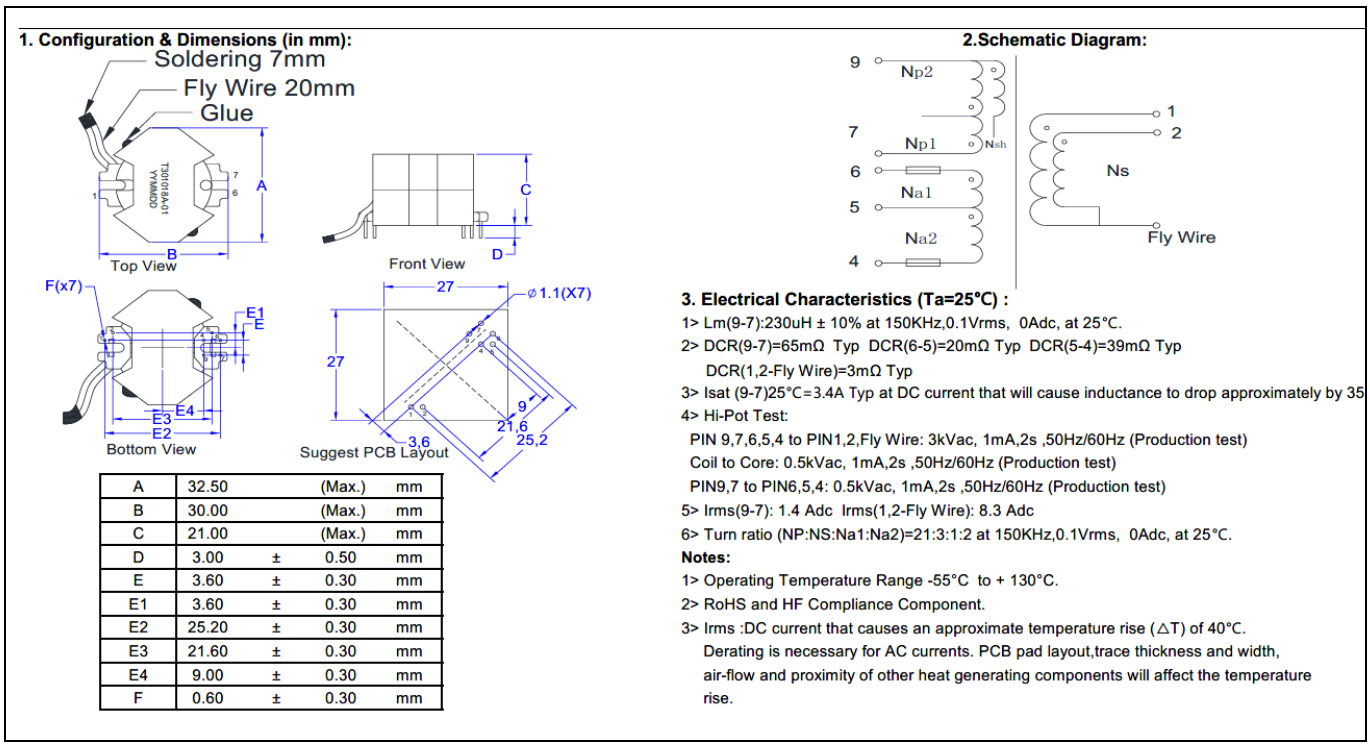
5.2 Information on magnetic components

This section provides information about the PFC choke and the HFB transformer. Figure 19 shows the PFC choke specification sheet, while Figure 20 illustrates the specification sheet of the transformer. Both the choke and transformer are built using RM10 cores with 3C95 Ferrite material and standard bobbins with some pins trimmed/removed. The air gap in the center leg of the cores is adjusted in
such way that the main inductance for the PFC choke is 190 µH and the primary inductance of the hybrid-flyback transformer is 230 µH. Both magnetic devices are varnished, and the transformer is connected to PGND. The transformer has a copper band for shielding, wrapped around and covering the windings and core legs.



A	30.00		(Max.)	mm
B	30.00		(Max.)	mm
C	21.00		(Max.)	mm
D	4.00	±	0.50	mm
E	1.80	±	0.30	mm
E1	18.00	±	0.30	mm
E2	25.20	±	0.30	mm
F	0.60	±	0.30	mm

Figure 19 PFC choke specification



A	32.50		(Max.)	mm
B	30.00		(Max.)	mm
C	21.00		(Max.)	mm
D	3.00	±	0.50	mm
E	3.60	±	0.30	mm
E1	3.60	±	0.30	mm
E2	25.20	±	0.30	mm
E3	21.60	±	0.30	mm
E4	9.00	±	0.30	mm
F	0.60	±	0.30	mm

Figure 20 HBF transformer specification

References

[1] Infineon Technologies AG: XDPS2221E PFC + Hybrid-flyback combo controller datasheet; Available online

[2] Infineon Technologies AG: REF_XDPS2221_140W1140 W reference board for ultrahigh power density in USB-C chargers with EPR and adapters product page; Available online

[3] Infineon Technologies AG: REF_XDPS2221_120W1 120 W reference board for 3 USB-C chargers with EPR and adapters product page; Available online

Revision history

Document revision	Date	Description of changes
1.00	2026-04-28	Initial release

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