1600 W Titanium server power supply with 600 V CoolMOS™ G7 in DDPAK and digital control by XMC™

EVAL_1K6W_PSU_G7_DD

About this document

Scope and purpose

This document introduces a complete Infineon system solution for a 1600 W server PSU which achieves 80 Plus Titanium standard. The EVAL_1K6W_PSU_G7_DD board is a server power composed of a Continuous Conduction Mode (CCM) bridgeless Power Factor Corrector (PFC) with bi-directional switch and a half-bridge LLC DC-DC resonant converter. This document shows the board using CoolMOS™ MOSFETs and CoolSiC™ Schottky diodes in a top-side cooled SMD package (DDPAK) as well as the specifications and the main results obtained during the test of the 1600 W server PSU.

The Infineon components used in the 1600 W server PSU are:

- 600 V CoolMOS™ G7 superjunction (SJ) MOSFET and 650 V CoolSiC™ G6 Schottky diode
- 40 V OptiMOS™ 6 MOSFET
- 1EDI20N12AF isolated and 2EDN7524F non-isolated gate drivers (EiceDRIVER™)
- XMC1402 and XMC4200 microcontrollers
- ICE2QR2280G CoolSET™ Quasi Resonant (QR) flyback controller

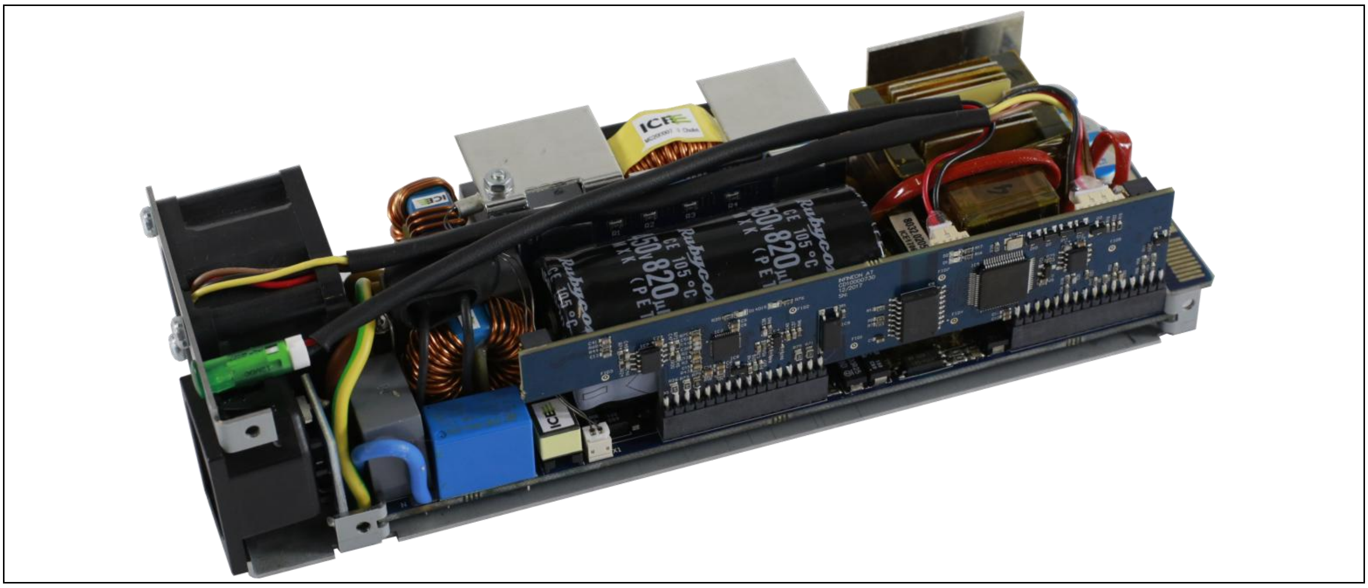

Figure 1 1600 W Titanium server power supply

Intended audience

For design engineers, technicians, and developers of electronic systems.

Keypoints

- Describes a 1600 W server PSU design achieving 80 Plus Titanium efficiency with increased power density using DDPAK SMD packages
- Explains system architecture combining bridgeless PFC and half-bridge LLC stages with digital control via XMC™ microcontrollers
- Demonstrates thermal, EMI, and dynamic performance under steady-state and transient conditions for high-line operation in data center servers
- Highlights integration of CoolMOS™ G7 and CoolSiC™ G6 in top-side cooled DDPAK for reduced losses and shared heat sink mounting
- Provides design insights on protection schemes, burst mode behavior, and layout strategies for optimized commutation loops and reliability

About this product family

Product family

Infineon's CoolMOS™ is a high-voltage N-channel silicon power MOSFET that is designed to provide excellent thermal performance, lowest switching and conduction power losses, and optimal RDS(on) for increased system efficiency, supporting a range of application from low power levels to high power levels.

Target applications

- Consumer electronics
- Industrial applications
- Home appliances
- Server
- Telecom
- Renewables

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1 Background and system description

The trend in SMPS in recent years has been toward increased power density with optimized cost. Achieving this higher power density, high efficiency is a key parameter, since heat dissipation must be minimized. The 800 W server PSU developed with Infineon [1], [2] is a good example of the achievable efficiency levels, out-performing 80 Plus Platinum efficiency.

However, if higher power is needed with the same form factor, thus increasing the power density, even higher efficiency is required to further reduce the heat dissipation and make the design thermally feasible.

Keeping this in mind, this document introduces a 1600 W server PSU which complies with 80 Plus Titanium efficiency, as shown in Figure 2. The 1600 W PSU keeps the same form factor as the previously presented 800 W server PSU. Therefore, the power density is increased to 44 W/in^3 in the design shown.

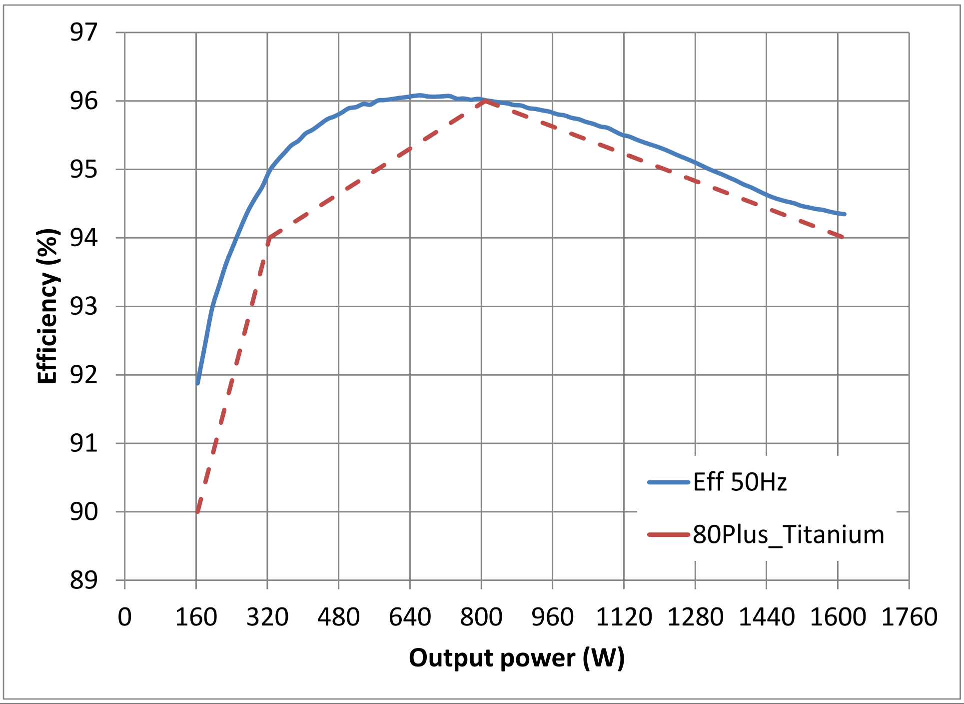

Figure 2 Measured efficiency of the 1600 W server PSU, complying with the Titanium efficiency standard

The efficiency shown can be achieved by using the best-in-class 600 V CoolMOS™ G7 together with 650 V CoolSiC™ G6 Schottky diodes. The outstanding performance of these semiconductor technologies, together with the innovative DDPAK SMD package with top-side cooling, enables a different system thinking, as further presented in [3] and explained in this application note. Due to production variations, efficiency variations in the range of 0.1 percent to 0.2 percent can be seen in the result shown.

The 1600 W server PSU is a system solution (PFC + LLC) developed with Infineon power semiconductors as well as Infineon drivers and microcontrollers. The Infineon devices used in the implementation of the 1600 W server PSU are:

- 150 mΩ 600 V CoolMOS™ G7 (IPDD60R150G7) and 8A 650 V CoolSiC™ G6 Schottky diodes (IDDD08G65C6), all with DDPAK package, for PFC

- 50 mΩ 600 V CoolMOS™ G7 DDPAK package (IPDD60R050G7) and 7 mΩ 40 V OptiMOS™ 6 in Super SO-8 package (BSC007N04LS6) for LLC
- 0.7 mΩ 40 V OptiMOS™ 6 in Super SO-8 package (BSC007N04LS6) as O-ring switch
- 1EDI20N12AF isolated and 2EDN7524F non-isolated gate drivers (EiceDRIVER™)
- ICE2QR2280G QR flyback controller with integrated 800 V CoolMOS™ for the bias auxiliary supply
- XMC1402 (PFC) and XMC4200 (LLC) microcontrollers for control implementation

This document will describe the system and board of the 1600 W server SMPS, as well as the specifications and main test results. For further information on Infineon semiconductors, see Infineon website, as well as the Infineon evaluation board search, and the different websites for the different implemented components:

- CoolMOS™ power MOSFETs
- OptiMOS™ power MOSFETs
- CoolSiC™ Schottky diodes
- Gate driver ICs
- QR CoolSET™
- XMC™ microcontrollers

1.1 System description

The EVAL_1K6W_PSU_G7_DD design consists of a bridgeless PFC with bi-directional switch [4] as the AC-DC stage and a half-bridge LLC with Synchronous Rectification (SR) as the DC-DC stage (Figure 3). The power supply has been designed to comply with the requirements of data center server operation.

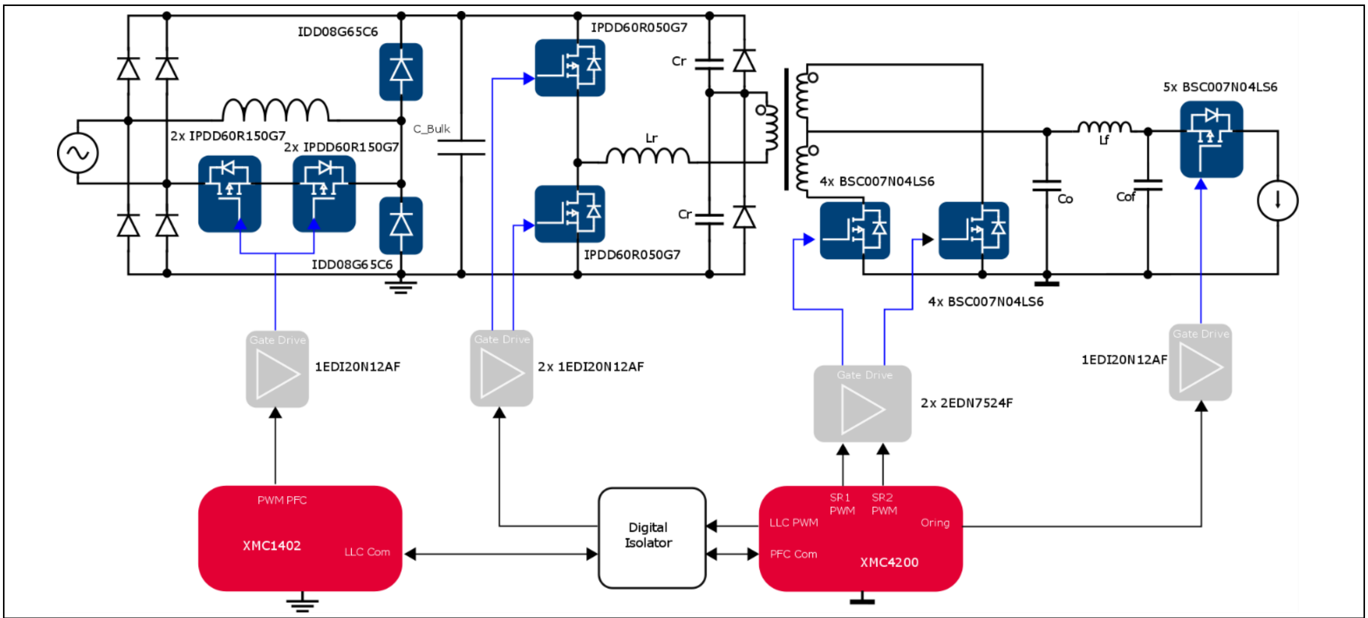

Figure 3 1600 W Titanium server PSU (EVAL_1K6W_PSU_G7_DD) – simplified diagram showing the topologies implemented and the Infineon semiconductors used

The PFC stage is operated exclusively at high line (176 V_{rms} minimum, 230 V_{rms} nominal) in CCM with a 65 kHz switching frequency. The bulk capacitance is designed to comply with the hold-up time, as shown in Table 1. The PFC function to achieve bulk voltage control at an adequate level for the DC-DC converter, while demanding high-quality current from the grid, is implemented in an Infineon XMC1402 microcontroller. Further details on PFC control implementation in the XMC™ 1000 family are available in the application notes of other Infineon PSU and PFC evaluation boards [1], [2], [5], and [6].

The DC-DC stage is an LLC resonant topology with center-tapped transformer and SR. The resonant frequency of the implemented resonant tank is 160 kHz and the operating switching frequency is allowed to move in the range from 52 kHz to 300 kHz. The targeted output voltage is 12.2 V with a nominal output current of 132 A. The LLC control is implemented in an XMC4200 Infineon microcontroller, which includes voltage regulation, burst mode operation, output overcurrent protection (OCP), overvoltage protection (OVP), and timer configuration for CoolMOS™ and OptiMOS™ safe operation. Further details about the digital control implementation of LLC in the XMC™ 4000 family can be found in [1], [2], and [7].

O-ring switches are mounted for efficiency consideration of the full system solution. However, no advance O-ring function is included in the control implementation. Furthermore, an I²C channel is reserved in the secondary controller, which enables PM-Bus communication.

1.2 Board description

Figure 4 shows the placement of different sections of the EVAL_1K6W_PSU_G7_DD server PSU with Infineon DDPAK semiconductors. The board shown is 19.3 cm long, with a width of 7 cm and a height of 4.4 cm.

Immediately after the AC input connector, the fuse, NTC inrush current limiter, and input relay are placed, followed by a two-stage EMI filter. The middle section of the board contains the AC-DC stage, including the bulk capacitor. Finally, the DC-DC converter, O-ring switches, and output connector are positioned on the right. In addition, the bias converter generates the required supplies for the driving and control circuitry. The control board is placed along the side of the power supply.

In addition, a host board to be connected to the output connector is attached. This board includes power connectors, a sensing point for the output voltage, and a switch for remote on-off. Furthermore, it offers the possibility of externally supplying the fan, as explained in [1].

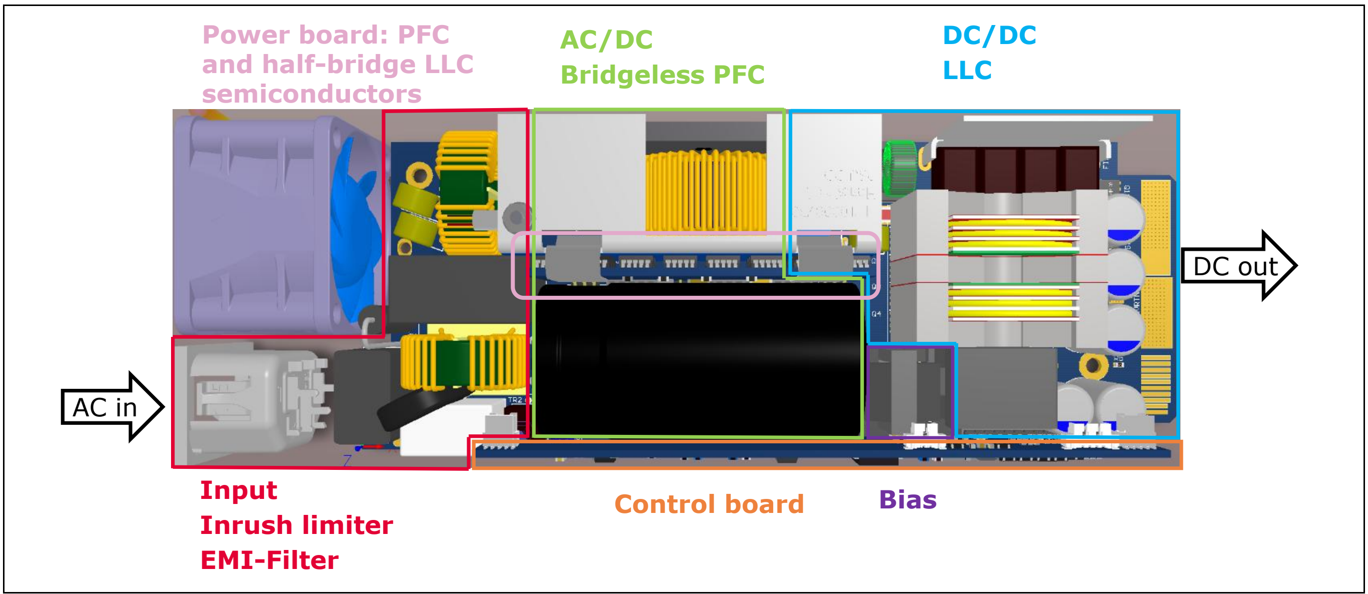

Figure 4 **Placement of the different sections in the 1600 W PSU with Infineon DDPAK CoolMOS™ and CoolSiC™**

1.3 DDPAK power board

The use of the top-side cooled DDPAK package enables different system thinking and the inclusion of SMD packages in high-power SMPS applications [3]. The previously shown placement of the 1600 W PSU is a good example of this system thinking and SMD integration.

The use of CoolMOS™ G7 transistors in both PFC and LLC allows loss reduction due to an E_{oss} and $R_{DS(on)}$ reduction [3]. Furthermore, the forward voltage in the CoolSiC™ G6 diode is reduced, contributing to lower diode losses [3]. The lower losses together with an improved thermal resistance, which compensates the lower dissipation area in respect to leaded packages, and the low profile of the top-side cooled SMD package, enable mounting of the PFC and half-bridge switches to share the same heatsink.

The use of a power board (Figure 5) enables a high-power density design, while having optimized commutation loops and therefore, low parasitic inductances. This power board, which mounts the PFC CoolMOS™ G7 switches and CoolSiC™ G6 Schottky diodes, together with the LLC CoolMOS™ G7 half-bridge switches, is vertically placed in the central part of the PSU in front of the fan (the pink area in Figure 4). In this case, eight parts are soldered to the power board and share the same heatsink, which is attached by using pressure clips as shown in Figure 5.

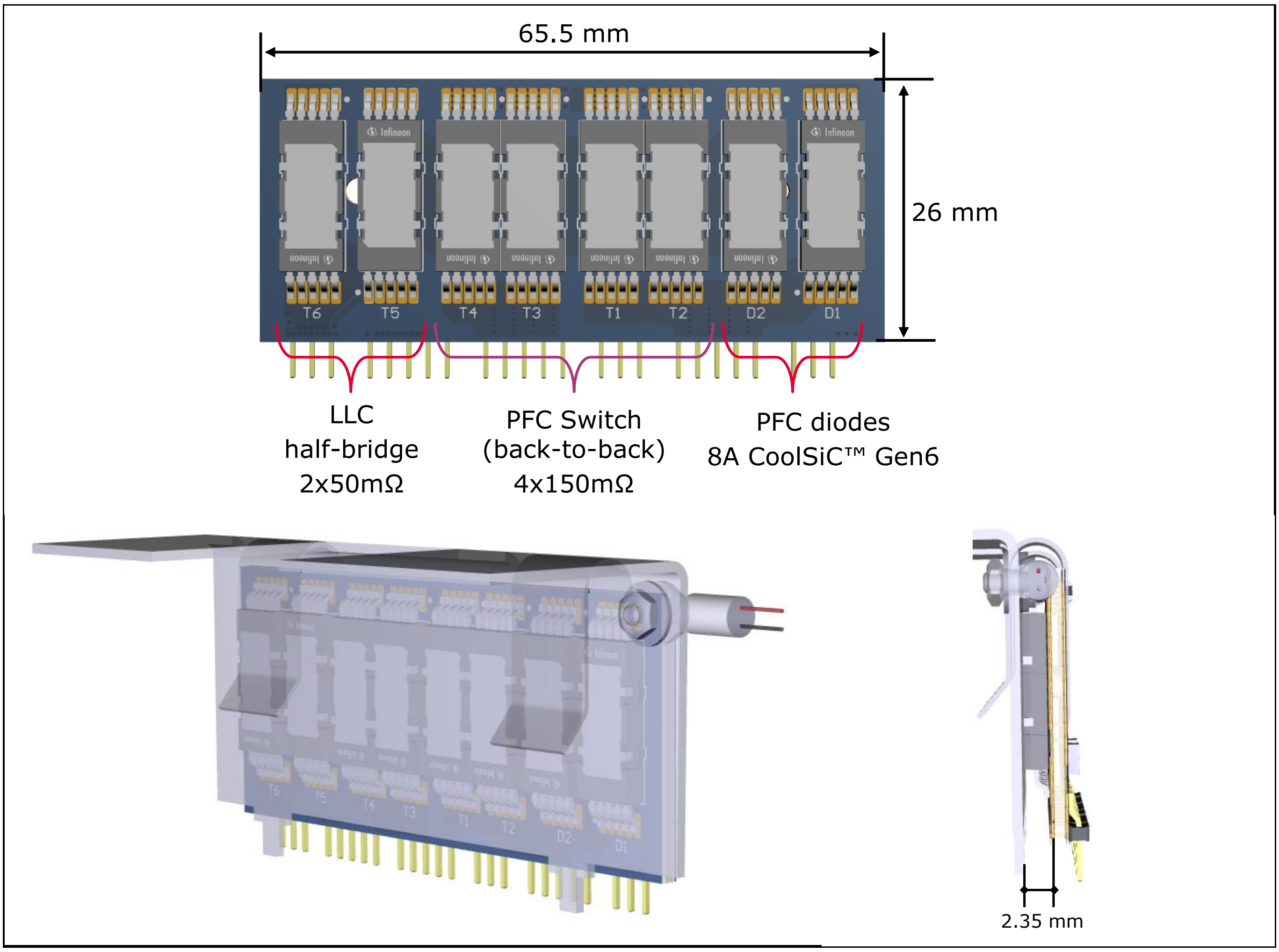

Figure 5 Power board mounting Infineon DDPAK semiconductors for the PFC and half-bridge LLC

2 Specification and test results

This chapter presents the specifications, performance, and behavior of the 1600 W server PSU developed using CoolMOS™ G7 in a DDPAK package. Table 1 shows the demonstrator performance and specifications under several steady-state and dynamic conditions.

Table 1 Summary of specifications and test conditions for the 1600 W PSU

<table>
<tr><th colspan="2">Test</th><th>Conditions</th><th colspan="2">Specification</th></tr>
<tr><td colspan="2">Efficiency test</td><td>230 V_{rms}, 50 Hz/60 Hz, 10 percent to 100 percent load</td><td colspan="2">80 Plus Titanium efficiency
η_{pk} = 96 percent at 800 W (50 percent load)</td></tr>
<tr><td colspan="2">Current THD</td><td>230 V_{rms}, 50 Hz/60 Hz, 10 percent to 100 percent load</td><td colspan="2">THDi less than 10 percent from 20 percent load</td></tr>
<tr><td colspan="2">Power factor</td><td>230 V_{rms}, 50 Hz/60 Hz, 10 percent to 100 percent load</td><td colspan="2">PF more than 0.95 from 20 percent load</td></tr>
<tr><td colspan="2">Output voltage</td><td></td><td colspan="2">12.2 V</td></tr>
<tr><td colspan="2">Steady-state V_{out} ripple</td><td>230 V_{rms}, 50 Hz/60 Hz, 10 percent to 100 percent load</td><td colspan="2">$|\Delta V_{out}|$ less than 120 $mV_{pk\text{-}pk}$</td></tr>
<tr><td colspan="2">Inrush current</td><td>230 V_{rms}, 50 Hz/60 Hz, measured on the first AC cycle</td><td colspan="2">I_{in_peak} less than 30 A</td></tr>
<tr><td rowspan="2">Power line disturbance</td><td>AC lost (hold-up time)</td><td>230 V_{rms}, 50 Hz, 10 ms at 100 percent load, 20 ms at 50 percent load</td><td rowspan="2">$|\Delta V_{out}|$ less than 240 mV_{pk}</td><td rowspan="2">No damage:
* PSU soft start if bulk voltage under 310 V
* PSU soft start if V AC out of range for certain time</td></tr>
<tr><td>Voltage sag</td><td>200 V_{rms}, 50Hz/60Hz, different sag conditions, 100 percent load</td></tr>
<tr><td colspan="2">Brown-out</td><td></td><td colspan="2">174 V on; 168 V off</td></tr>
<tr><td colspan="2" rowspan="2">Load transient</td><td>1 A ↔ 66 A, 0.5 A/µs</td><td colspan="2" rowspan="2">$|\Delta V_{out}|$ less than 240 mV_{pk}</td></tr>
<tr><td>66 A ↔ 133 A, 0.5 A/µs</td></tr>
<tr><td colspan="2" rowspan="4">OCP</td><td>30 s at 141 A</td><td colspan="2" rowspan="3">LLC off
Resume of operation requires bulk voltage to drop under 310 V</td></tr>
<tr><td>10 s at 149 A</td></tr>
<tr><td>1 ms at 168 A</td></tr>
<tr><td>Output terminals in short-circuit</td><td colspan="2">Detection within switching cycle.
Resumption of operation requires bulk voltage to drop under 310 V</td></tr>
<tr><td colspan="2">EMI conducted</td><td>230 V_{rms}, 50Hz, full load, resistive load, lab set-up</td><td colspan="2">Complies with Class B limits</td></tr>
</table>

2.1 Performance and steady-state waveforms

In this chapter, the steady-state waveforms are presented together with the efficiency and the power factor (PF) and THD achieved in the 1600 W server PSU presented in this application note. The PSU operates only in high line (from 176 V to 265 V line voltage) with a nominal input voltage of 230 V_{rms}. Therefore, the efficiency is presented for this nominal voltage. As shown in Figure 6, the Infineon 1600 W PSU with DDPAK CoolMOS™ G7 and CoolSiC™ G6 achieves Titanium efficiency.

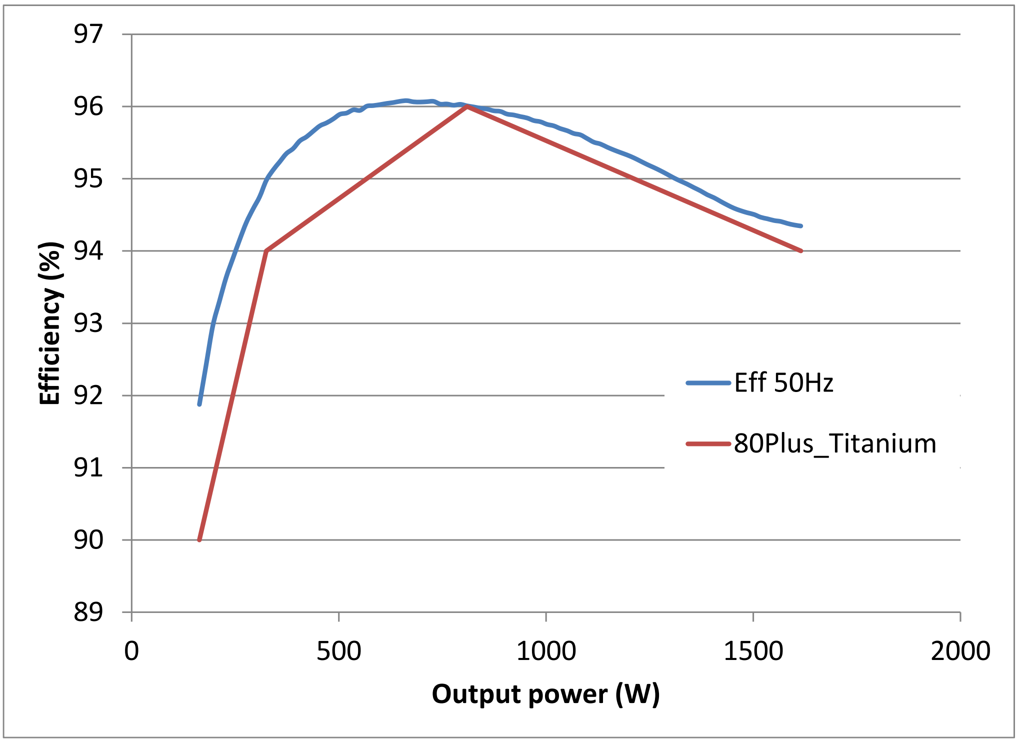

Figure 6 **Measured efficiency at 230 V 50 Hz input voltage**

Figure 7 depicts the measured PF and THD. The achieved PF is over 0.95 when the output power is higher than the 20 percent of the nominal output power, i.e., 320 W, for both 50 Hz and 60 Hz input voltage. In case of the THD, the distortion is under 10 percent for output power over the 20 percent level for both 50 Hz and 60 Hz input voltage.

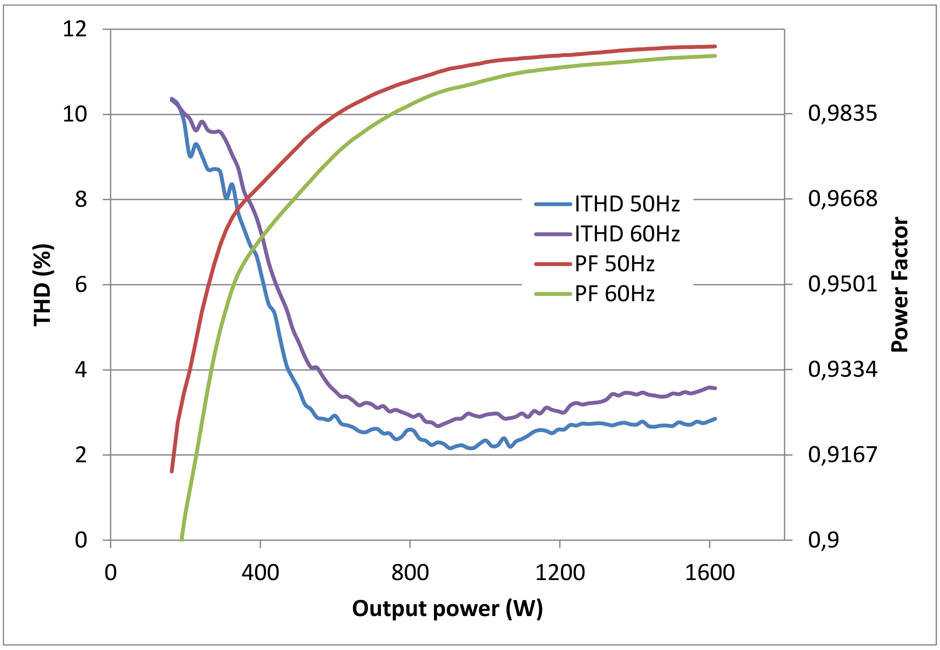

Figure 7 **Measured THD and power factor at 230 V input voltage for both 50 Hz and 60 Hz**

The main waveforms of the PSU are presented for different output power levels for 50 Hz (Figure 8) and 60 Hz (Figure 9) at nominal input voltage. As it can be seen, the input current exhibits low distortion according to the previously presented curve, and the output voltage ripple remains within the specified ±120 mV range.

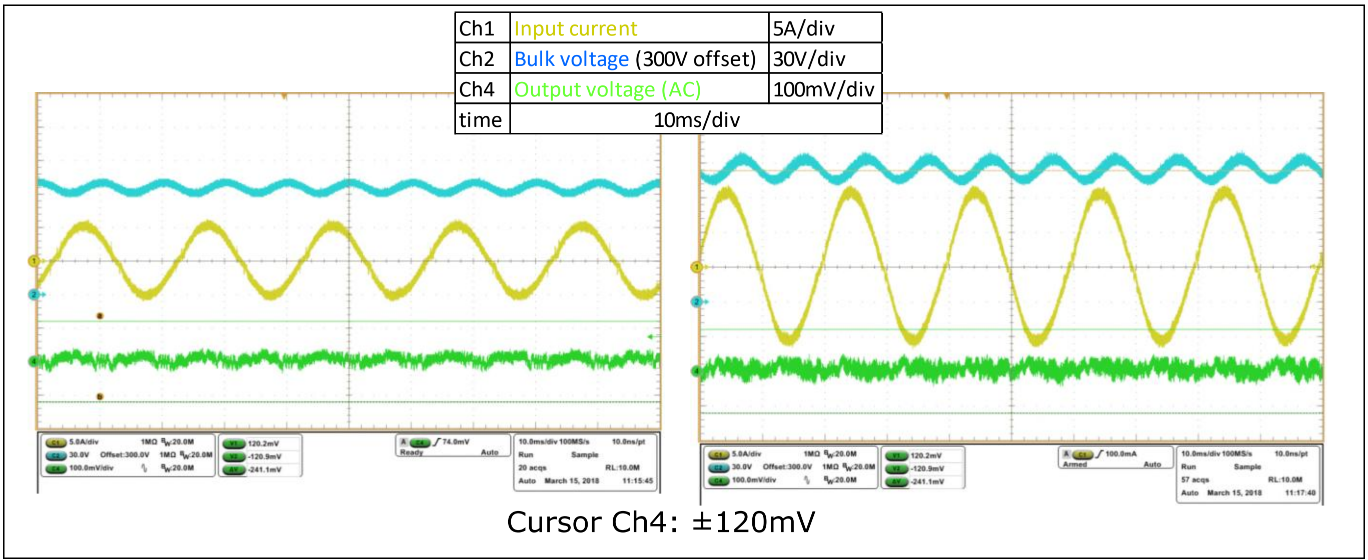

Figure 8 **Steady-state waveforms at 230 V 50 Hz for 50 percent load (left) and 100 percent load (right)**

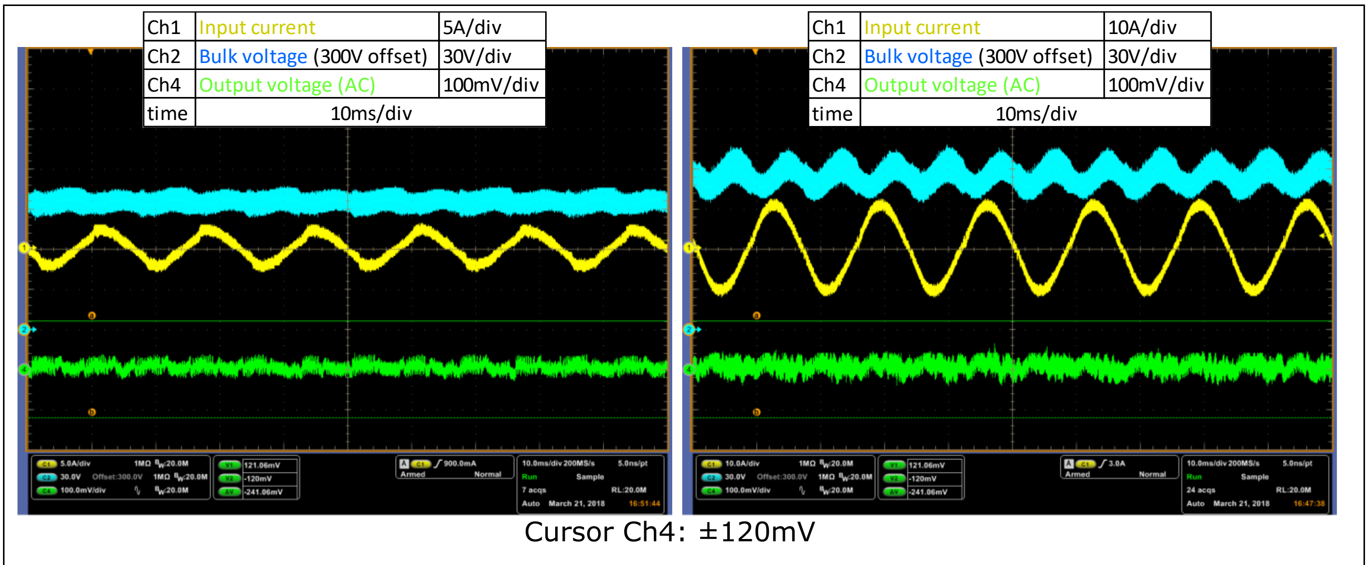

Figure 9 **Steady-state waveforms at 230 V 60 Hz for 20 percent load (left) and 100 percent load (right)**

2.2 Inrush current

In the PSU, the inrush current when connecting to the AC source is limited with NTC. This resistor is short-circuited by a parallel relay before start-up, if the input and output voltage conditions to start the PFC are met. The inrush current is measured at the first AC cycle, and it is independent on the output load. In Figure 10, the full-load start-up of the server PSU is presented, and the inrush current is highlighted. According to the measurement, the inrush current is significantly under the specified 30 A in Table 1.

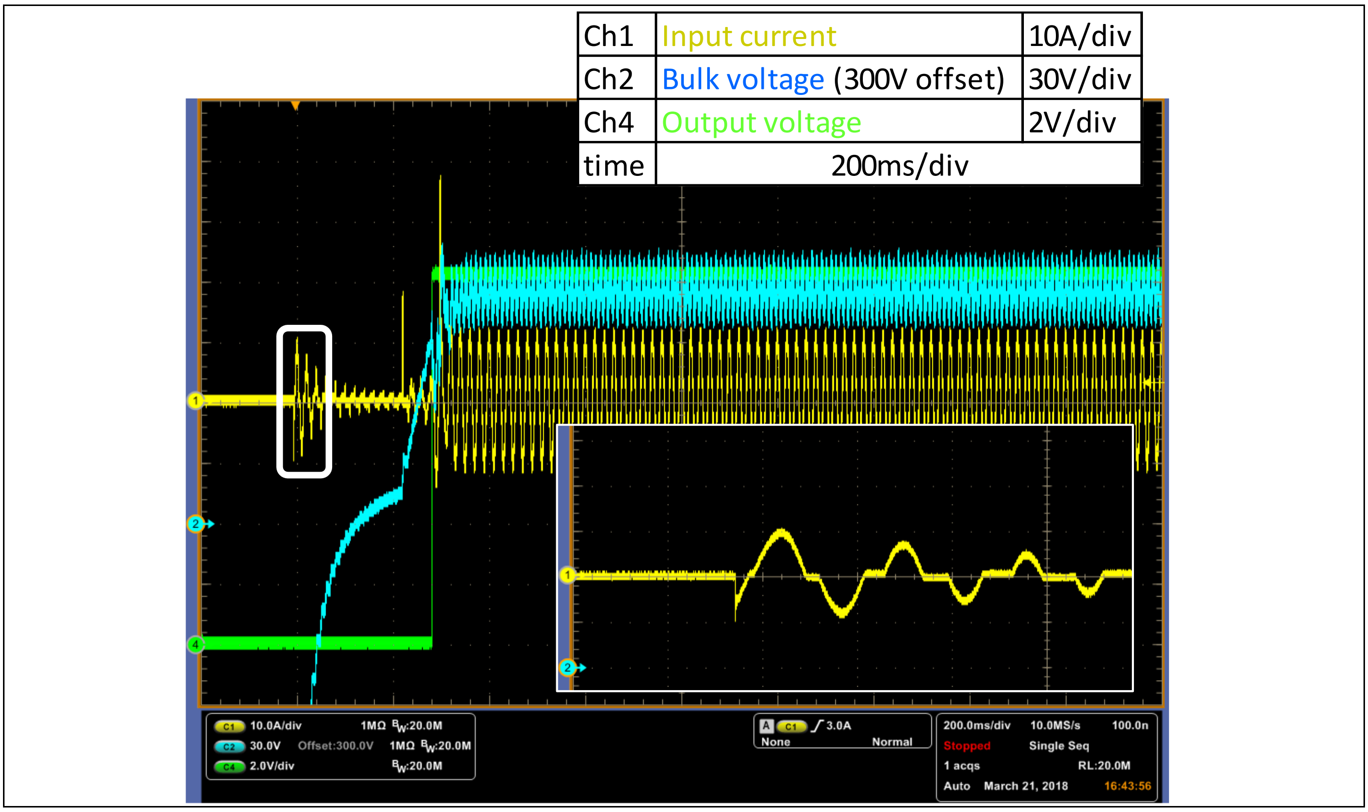

Figure 10 Inrush current of the 1600 W server PSU at full-load start-up

2.3 Power line disturbance

Two main line disturbance conditions can occur when connected to the grid. On one side, the AC can be lost during a certain time – Line Cycle Drop Out (LCDO) – and, on the other side, the AC voltage can suddenly decrease to an abnormal value – voltage sag. This section introduces the test conditions for both disturbances as well as the SMPS performance when those conditions are applied using a programmable AC source.

2.3.1 Line cycle drop-out

The 1600 W power supply operates exclusively in high line. Therefore, the AC LCDO capability is tested from 230 V to 0 V. Different timing, related to the specified hold-up time and line frequency are applied as shown in Table 2. The test results (Figure 11 and Figure 12) show that the output voltage is within the specified dynamic variation regardless of the start angle of the voltage drop-out. In case the drop-out is longer than specified, output voltage regulation can be lost, and even a turn-off and restart of the unit is possible if the bulk voltage falls to 310 V.

Table 2 Applied voltage cycles for LCDO test at different loads with 50 Hz AC input voltage

		1st to 10th time (100 ms period)	
Applied voltage	230 V AC	0 V AC	230 V AC
Timing at different load conditions	50 percent load	20 percent (20 ms)	80 percent (80 ms)
	100 percent load	10 percent (10 ms)	90 percent (90 ms)

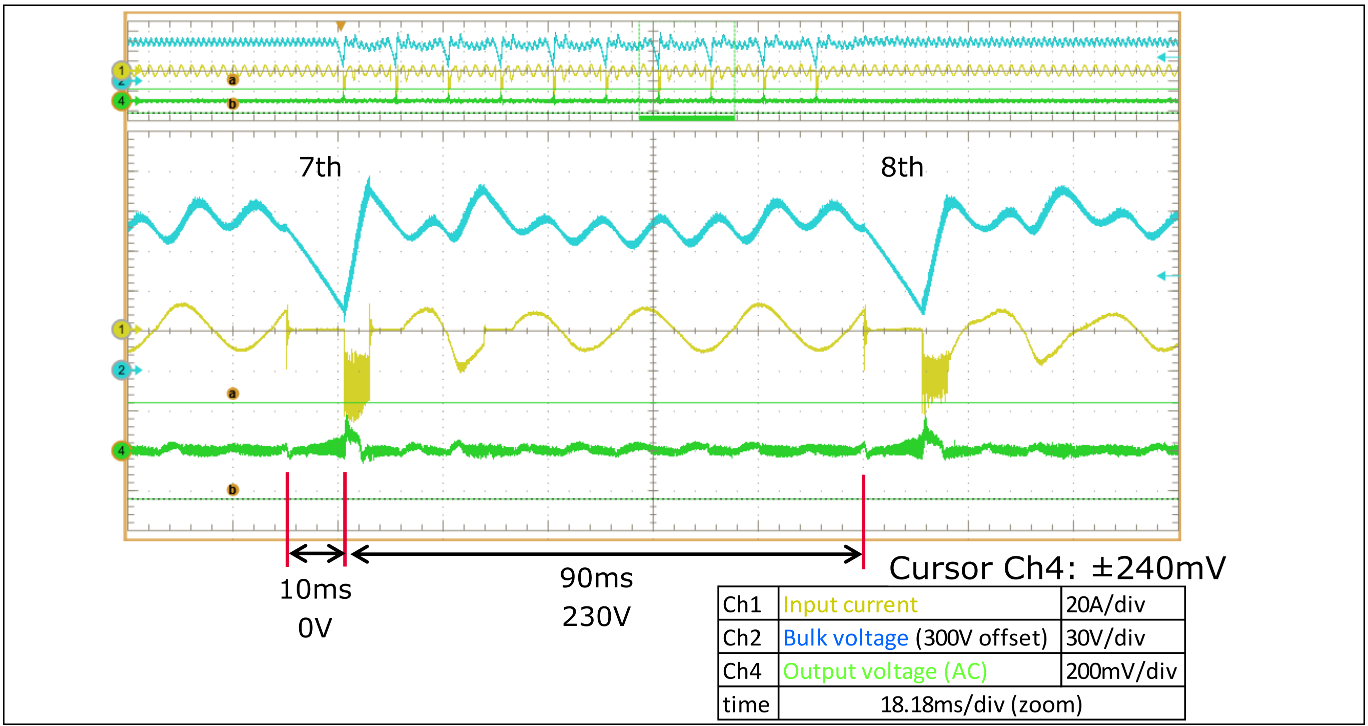

Figure 11 **Detail of the 7th and 8th repetition in a 10 ms LCDO test at 230 V AC, 50 Hz and 100 percent load with a starting angle of 45 degrees**

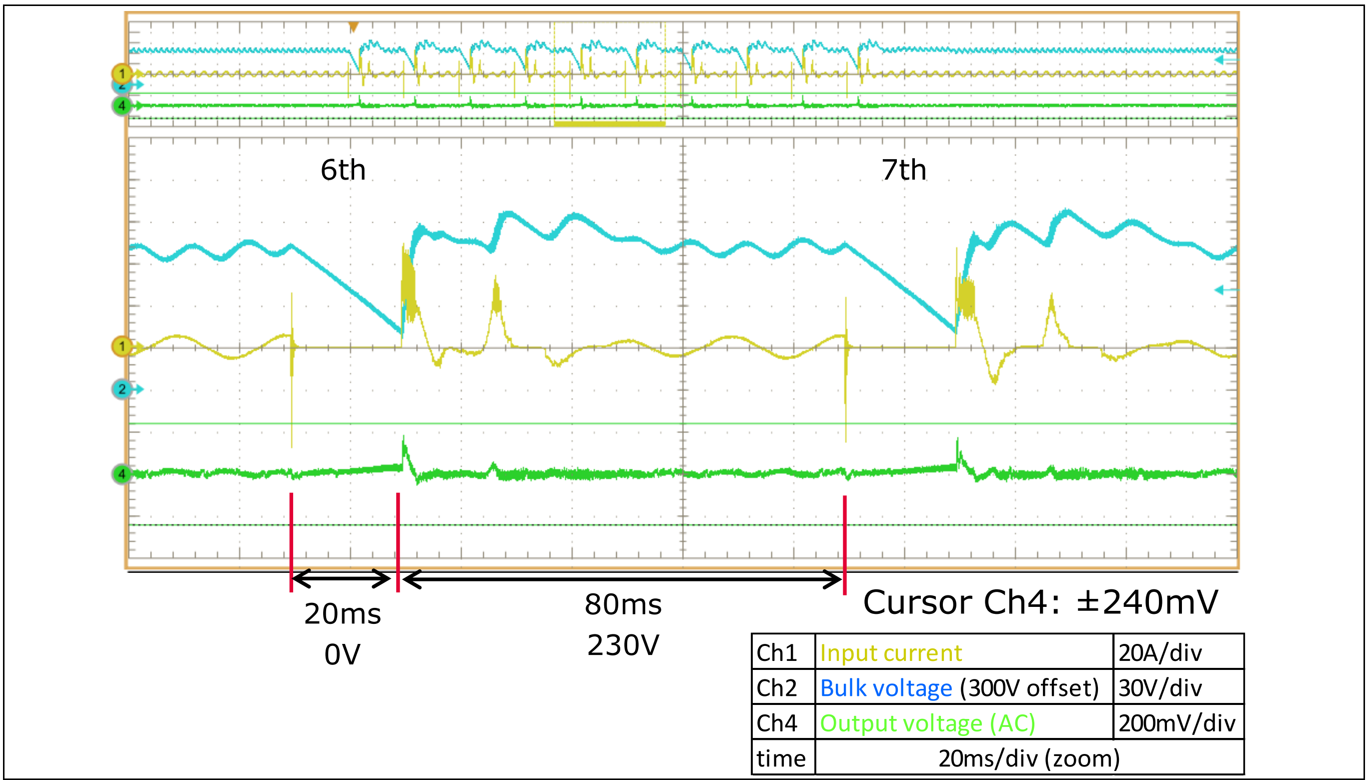

Figure 12 **Detail of the 6th and 7th repetition in a 20 ms LCDO test at 230 V AC, 50 Hz and 50 percent load with a starting angle of 90 degrees**

2.3.2 Voltage sag

For high-line, two different voltage sag conditions (Table 3) are considered and tested. Figure 13 shows the PSU behavior with voltage sag according to Table 3. As can be seen, the output voltage is not affected by the input voltage variation. However, if the voltage sag lasts longer than specified in the table, the power supply turns off and restarts with soft start after idle time. Figure 14 shows this behavior when a voltage sag to 150 V is applied for longer than 2 s.

Table 3 Voltage sag conditions applied in the 1600 W PSU test

		1st to 10th time	
	Steady AC input	**Voltage sag (time)**	**Period**
AC input	200 V AC	130 V AC (0.5 s)	5 s
	200 V AC	150 V AC (2 s)	20 s

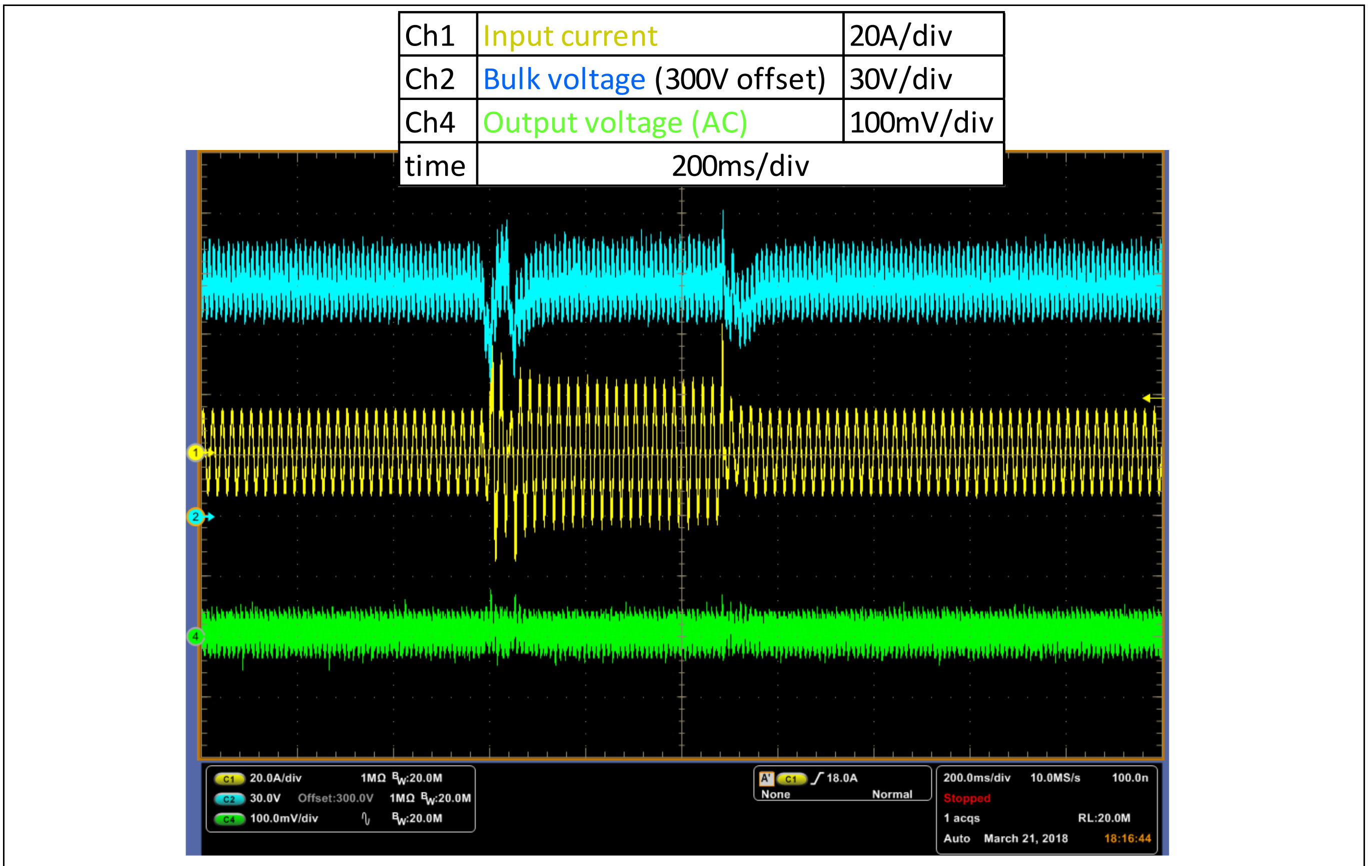

Figure 13 Main waveforms during a 500 ms and 130 V_{rms} voltage sag at full load

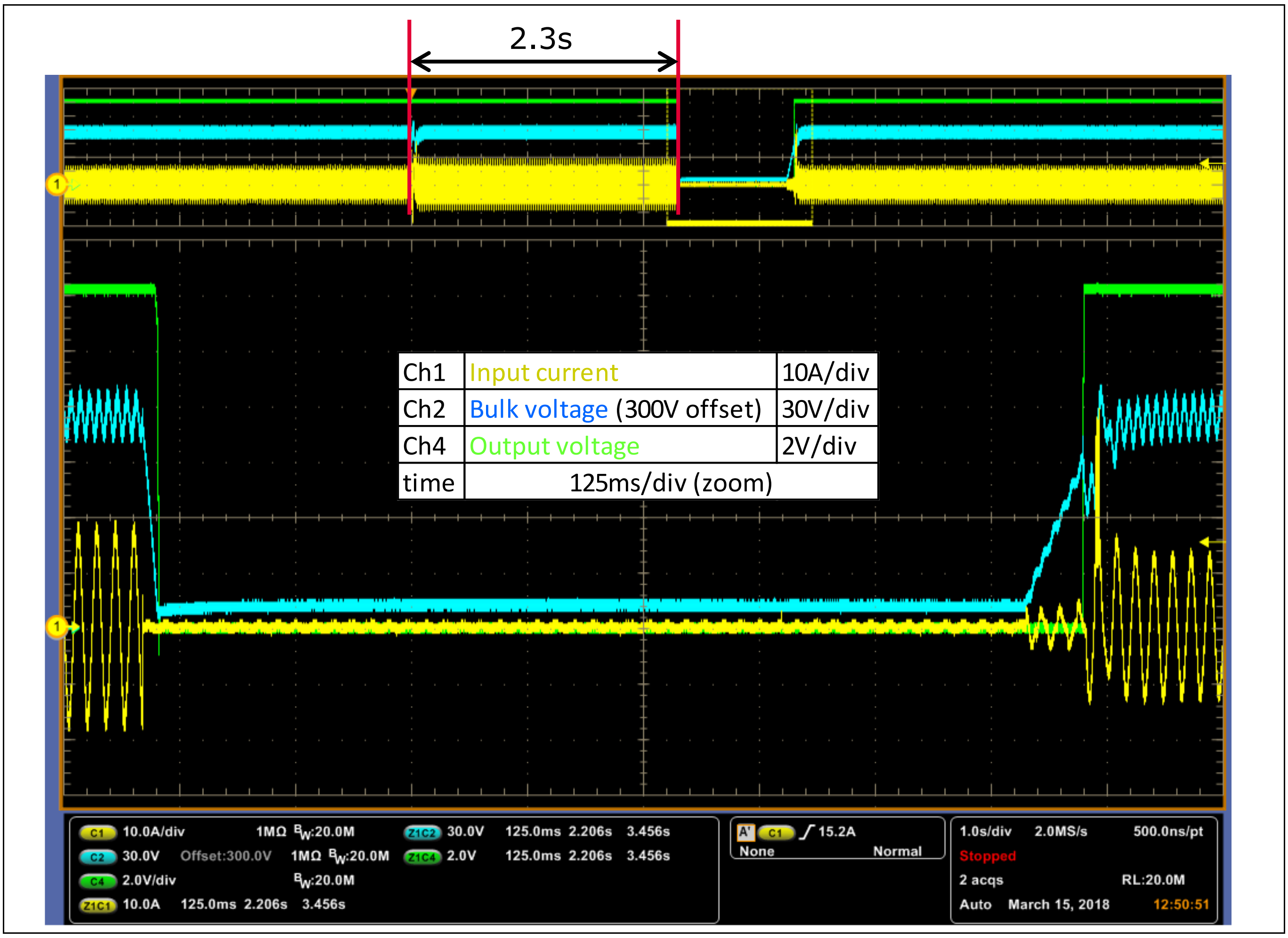

Figure 14 SMPS resumes operation after 150 V_{rms} voltage sag applied for 3.5 seconds at full load

2.4 Output voltage dynamic behavior

In addition to power line disturbance, two other dynamic perturbances can affect the performance of the power supply shown: load and input voltage variation.

2.4.1 Load transient response

As specified in Table 1, light-load (1 A) to half-load (66 A) and half-load to full-load (132 A) with 0.5 A/µs steps are considered. Figure 15 and Figure 16 show two examples for the different load steps at different frequency ratios. In all the tested cases, the output voltage dynamic ripple is within ±240 mV of the steady-state voltage of 12.2 V.

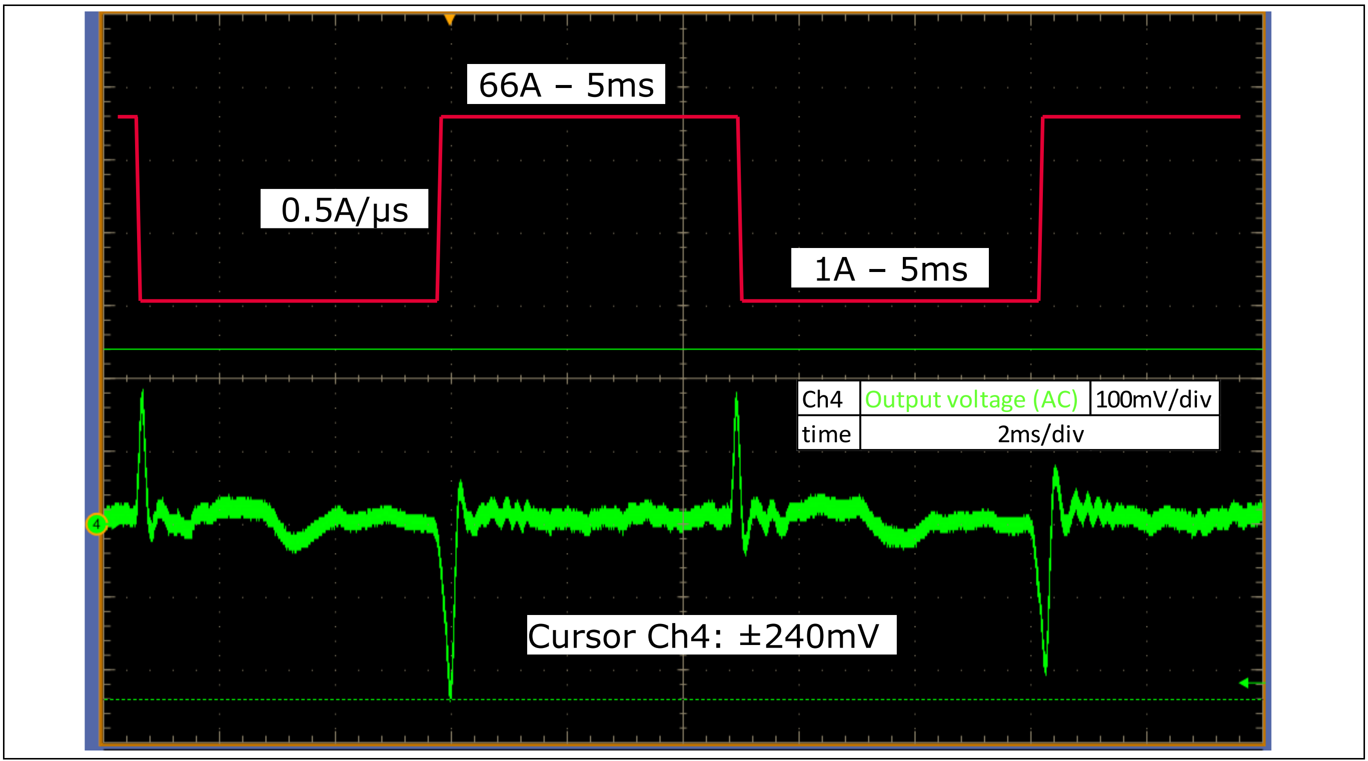

Figure 15 **Output voltage response to 1 A to 66 A dynamic load steps with 0.5 A/µs current slope every 5 ms**

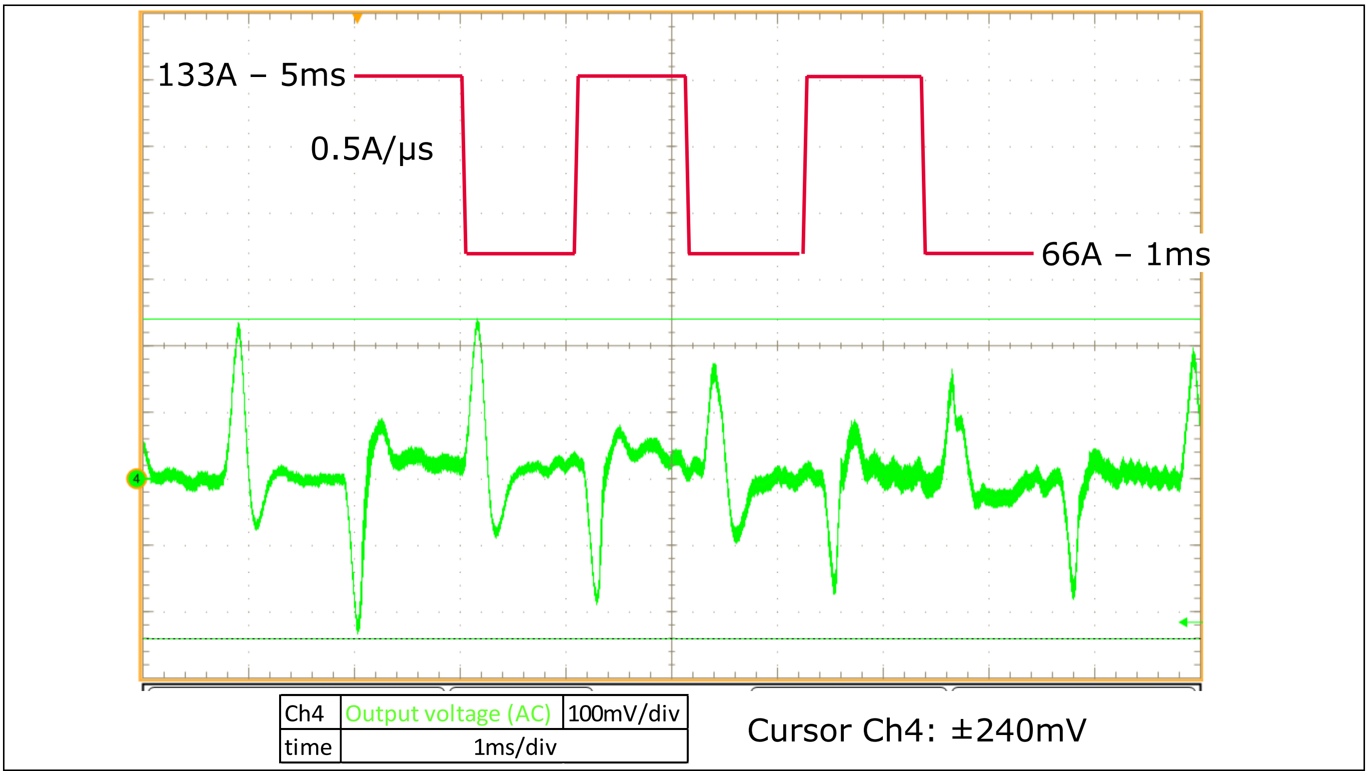

Figure 16 **Output voltage response to 132 A to 66 A dynamic load steps with 0.5 A/µs current slope every 1 ms**

2.4.2 Input voltage variation

Input voltage variations, as seen in the power line disturbance section, modify the bulk voltage and ultimately affect the output voltage ripple. This can occur as well when the input voltage varies even within the normal operation range, as shown in Figure 17.

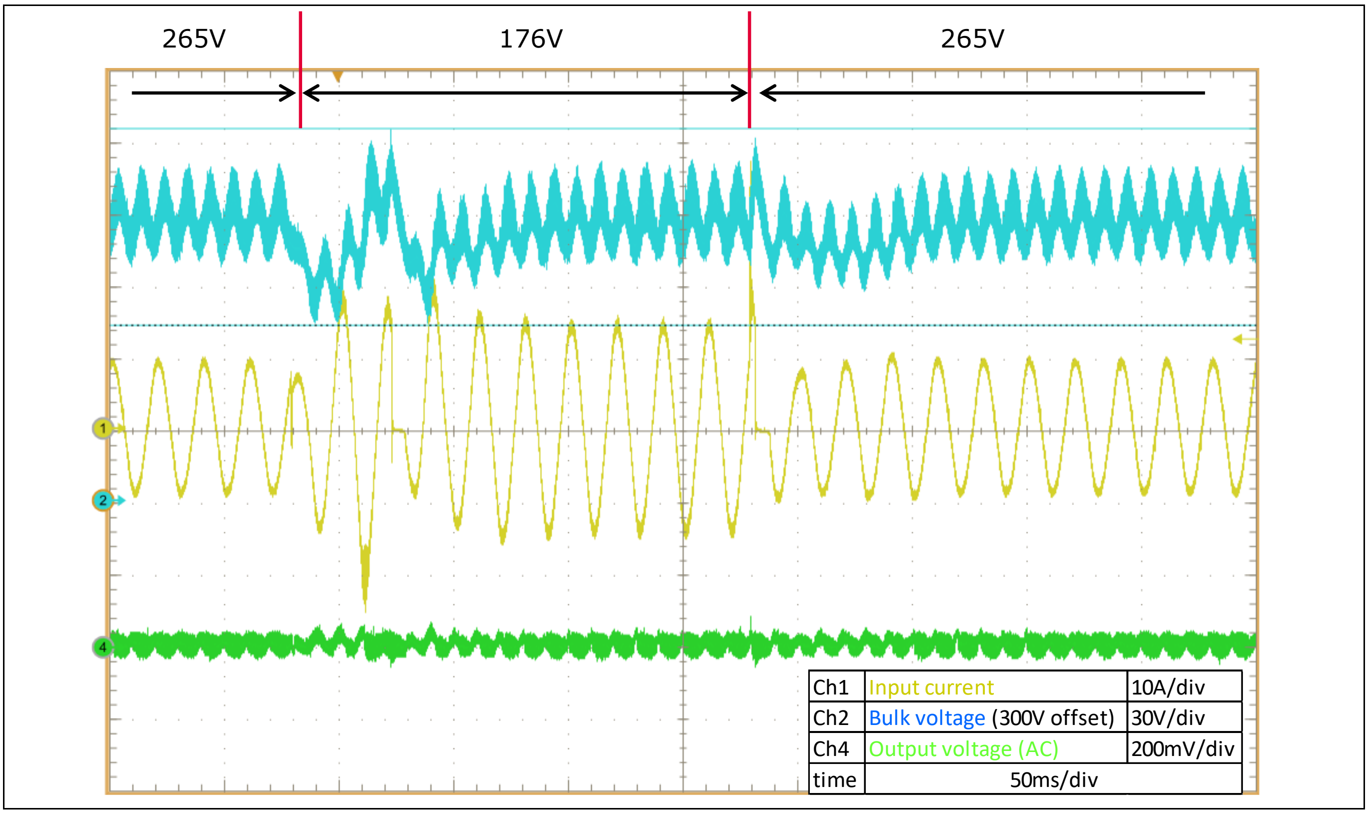

Figure 17 Maximum (265 V_{rms}) to minimum (176 V_{rms}) line voltage variation at full-load operation

2.4.3 Burst mode

The DC-DC stage of the 1600 W PSU goes into burst mode operation in light- or no-load conditions, and in those dynamic conditions where the output voltage regulation is lost due to maximum frequency limitation (300 kHz). Figure 18 shows the output voltage ripple for no-load operation of the PSU when the LLC converter is in burst mode.

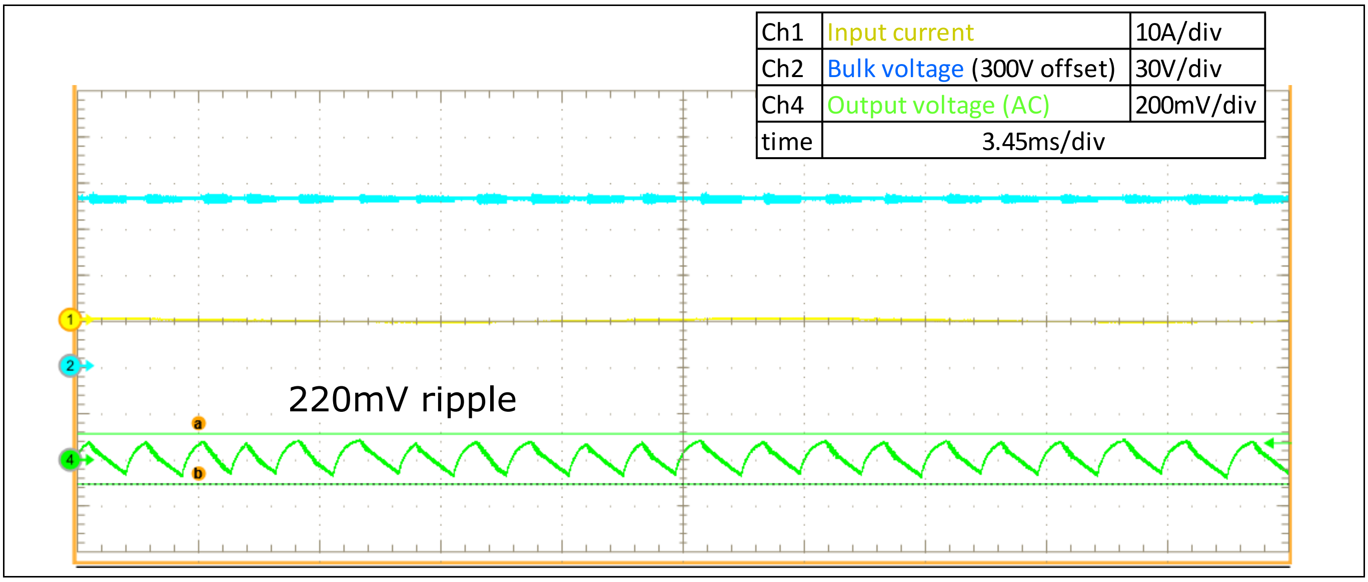

Figure 18 Output voltage ripple in burst mode at no-load operation

2.5 Protections

Both stages in the 1600 W server PSU implement protections to ensure robust and reliable operation.

In the case of PFC, the brown-out protection considers the possible voltage sag as already introduced. Furthermore, average and peak inductor current limitations are implemented, as well as bulk voltage monitoring for both undershoot and overshoot.

Regarding the LLC, apart from switching frequency limitation (52kHz to 300kHz), two main protections are implemented: overcurrent and overvoltage.

2.5.1 Over Current Protection (OCP)

The programmed OCP levels, together with the maximum allowed time for each level, are introduced in Table 1. Figure 19 shows the unit reaction to a 155 A load current. LLC shuts down and the bulk voltage must go under 310 V to allow a PSU restart.

In addition, a fast short-circuit protection is implemented by comparing the resonant current with a fixed level, set to 56 A. This enables detection of a very heavy overload within a few switching cycles. The power supply can also be restarted when the bulk voltage decreases under 310 V after a short-circuit fault.

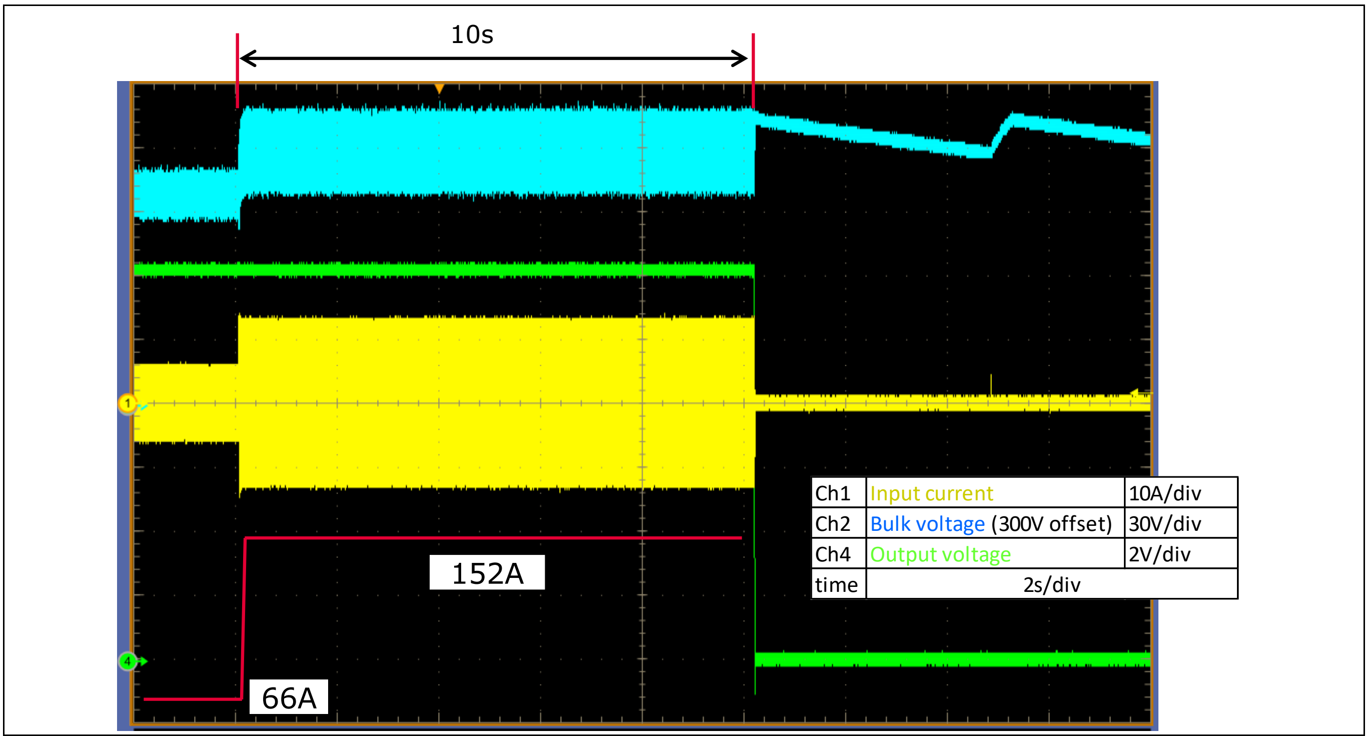

Figure 19 LLC converter of the 1600 W SMPS shutdown due to 155 A OCP

2.5.2 Over Voltage Protection (OVP)

In case of control issues in the DC-DC stage of the power supply, OVP is set to 14 V. Figure 20 shows the mentioned protection when the LLC is operated with a modified control loop, which is allowing the output voltage to reach the OVP level.

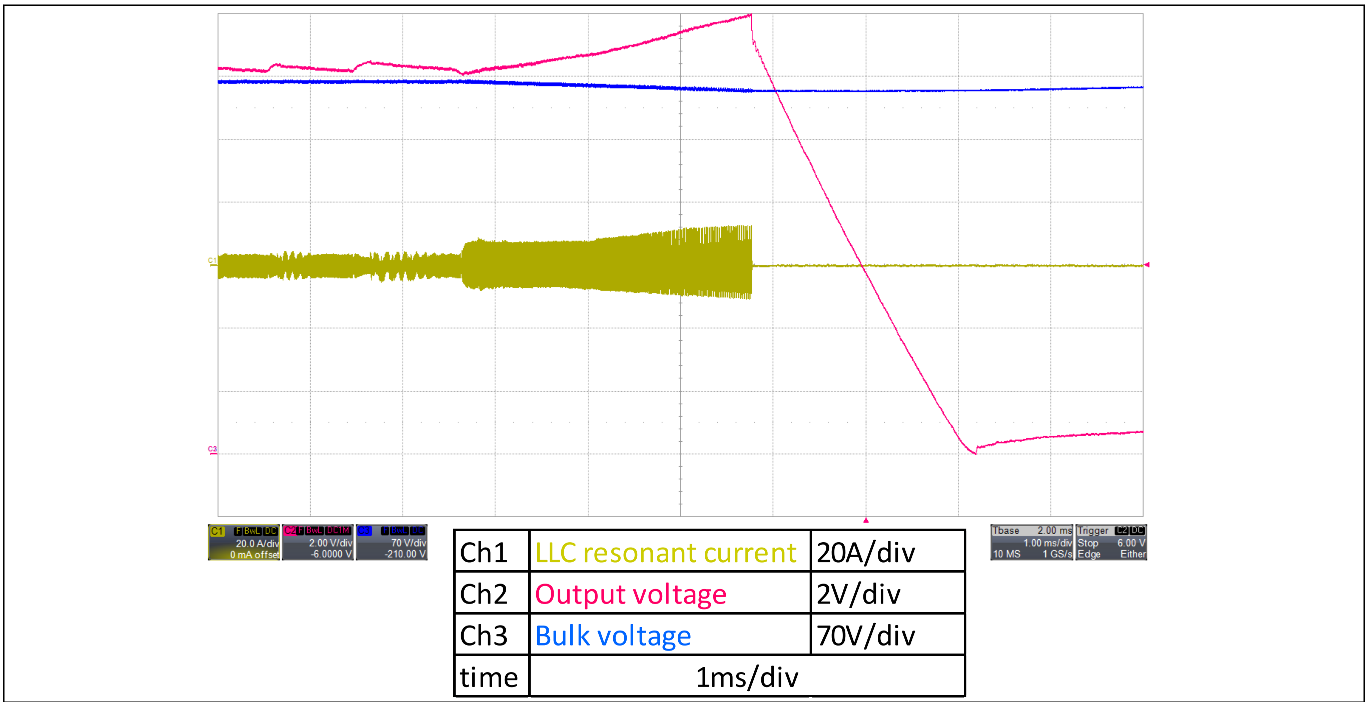

Figure 20 OVP triggered in the PSU with a modified control loop

2.6 Conducted EMI

The high-power-density 1600 W server PSU with DDPAK includes an EMI filter to comply with the electromagnetic emission standards. In this case, the conducted EMI complies with Class B limits, as shown in Figure 21. Pure resistive load is used for the conducted EMI test, and the converter runs at nominal output power with nominal (230 V) input voltage at 50 Hz.

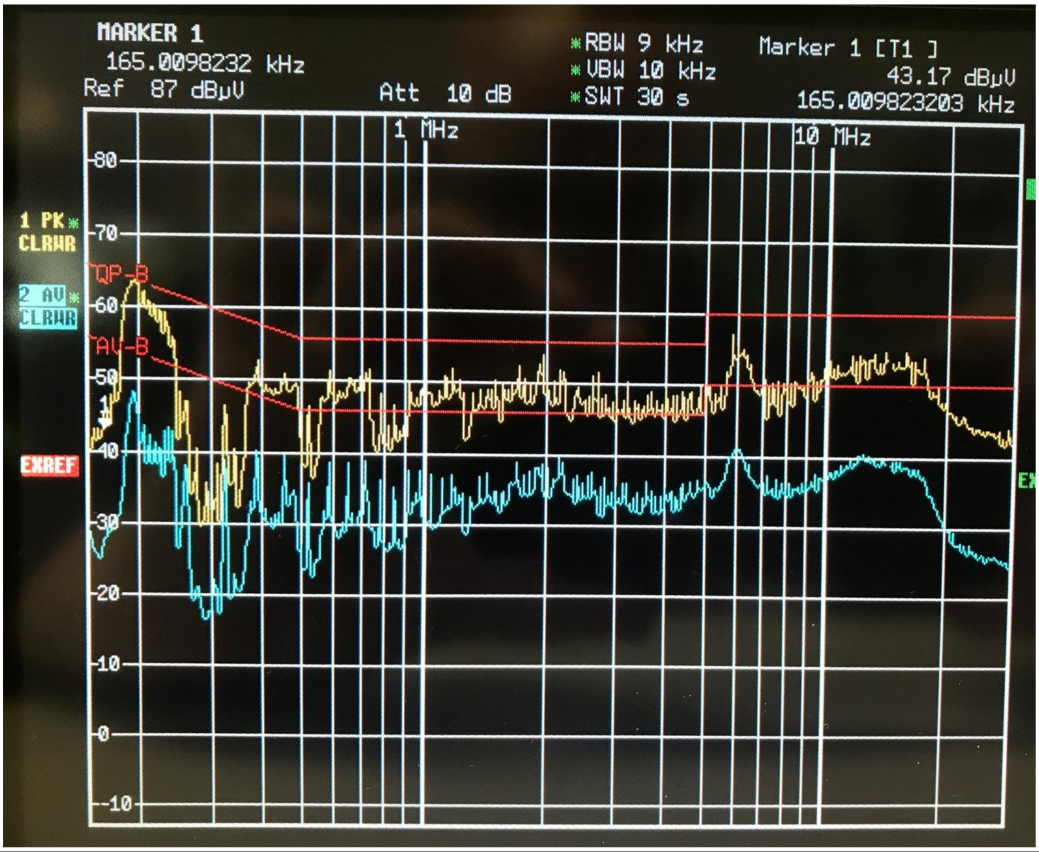

Figure 21 **Measured EMI conducted emissions (yellow: quasi-peak, blue: average) at 230 V AC input and 1600 W output resistive load**

2.7 Thermal measurements

A long-time test has been run with attached Type K thermocouplers to the main devices of the EVAL_1K6W_PSU_G7_DD board. The test has been run for nominal input voltage (230 V_{rms}) as well as the minimum input voltage (176 V_{rms}), which is the worst case for the PFC operation. In both cases, nominal load (132 A at 12.2 V output) has been applied during the test at room temperature. The tested unit was enclosed, and the fan was controlled by the secondary side controller and supplied from the server power supply output.

Therefore, the results presented in this section provide the thermal performance of the 1600 W server power supply with Infineon semiconductors introduced in this document at room temperature.

The monitored parts in the thermal test are:

- PFC switch: the four switches have been monitored with similar results. The presented measurement corresponds to the hottest device during the test
- PFC diode: in this case, one of the two SiC diodes has been measured

- PFC choke
- Diode bridge: current flows through part of the input diode bridge during PFC diode conduction
- LLC half-bridge
- LLC transformer
- LLC synchronous rectifiers: the measurement of a sampled device from both SR branches is shown
- O-ring switch: as in the SR case, one of the paralleled devices has been sampled in these measurements

Figure 22 shows the temperature evolution of the sensed points for nominal input and load conditions. It can be seen that the maximum temperature is obtained in the SR due to high current in the secondary side. The measured maximum temperature is 84°C at room temperature, which provides sufficient margin in case the ambient temperature increases.

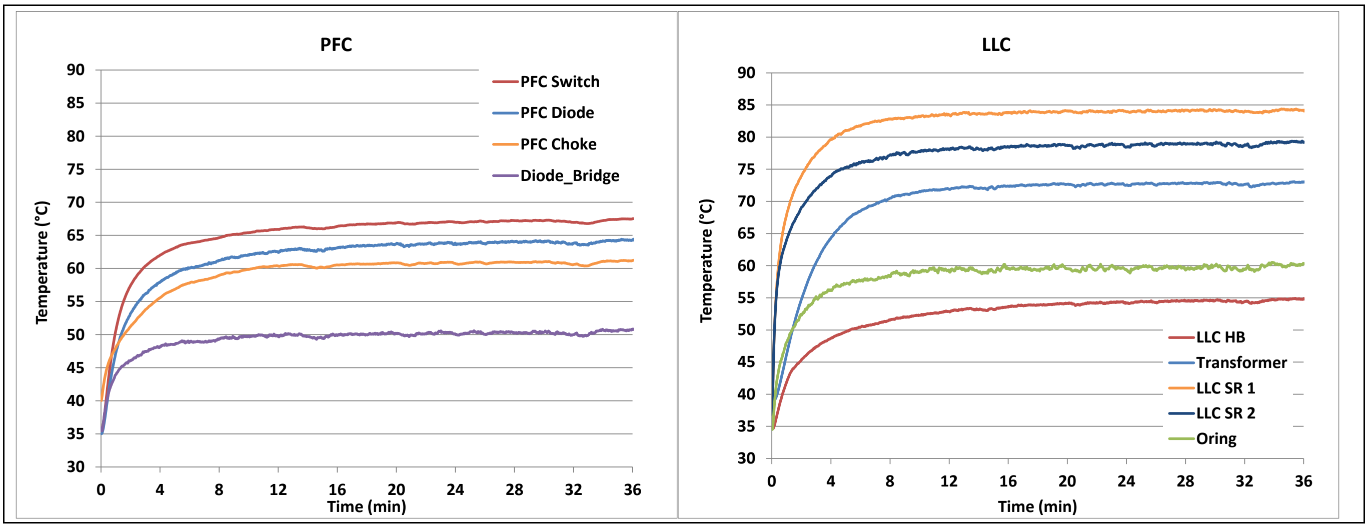

Figure 22 Temperature evolution with operation time in EVAL_1K6W_PSU_G7_DD under nominal input and load conditions at room temperature

In the case of minimum input voltage operation (176 V_{rms}), the thermal behavior is presented in Figure 23. The LLC temperatures are very consistent with those presented for nominal conditions, since the PFC is regulating the bulk voltage for the DC-to-DC converter. However, the measured temperatures in the PFC section have increased considerably with respect to the nominal input voltage. This temperature increase is due to the higher input current for the reduced input voltage. Nevertheless, although the PFC choke is the hot spot of the power supply, together with the SR, the maximum temperature is the same as previously presented, and there is still margin for higher ambient temperature operation.

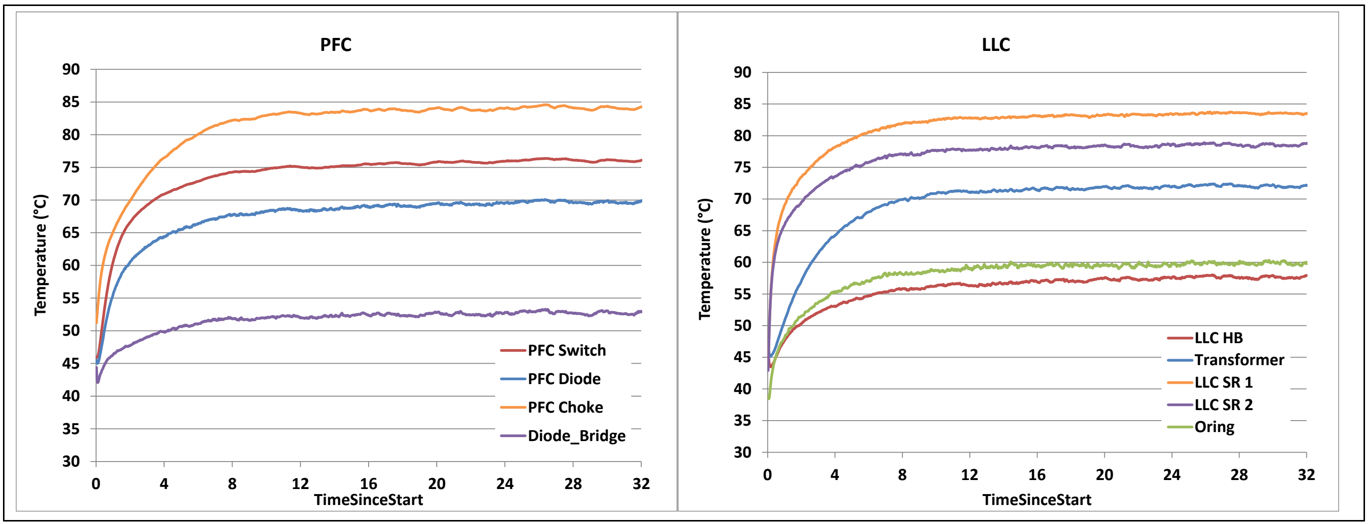

Figure 23 Temperature evolution with operation time in EVAL_1K6W_PSU_G7_DD under minimum input and nominal load conditions, at room temperature

3 Summary

This document presents a 1600 W server PSU (EVAL_1K6W_PSU_G7_DD board) which complies with the 80 Plus Titanium efficiency standard: efficiency is over 96 percent at 50 percent load. The achieved power density is 44 W/in^3, which is enabled using SMD packages.

The new DDPAK package is utilized in a power board, which allows reduced commutation loops. Furthermore, the combination of this package with CoolMOS™ G7 and CoolSiC™ G6 diode technologies enables mounting all semiconductors in the same heatsink and obtains a high-power density. In addition, the use of the power board approach will, in future, enable the testing of new SMD packages, such as QDPAK.

This server PSU also allows the implementation and testing of future Infineon devices and technologies. Further modifications of the power supply shown will be possible by updating different Infineon products such as 2EDF isolated drivers for LLC stage, fifth-generation CoolSET™ in the bias supply or CoolMOS™ S7 as relay replacement. OptiMOS™ 6 information will be available soon. Please check the Infineon website for more information.

4 Schematics

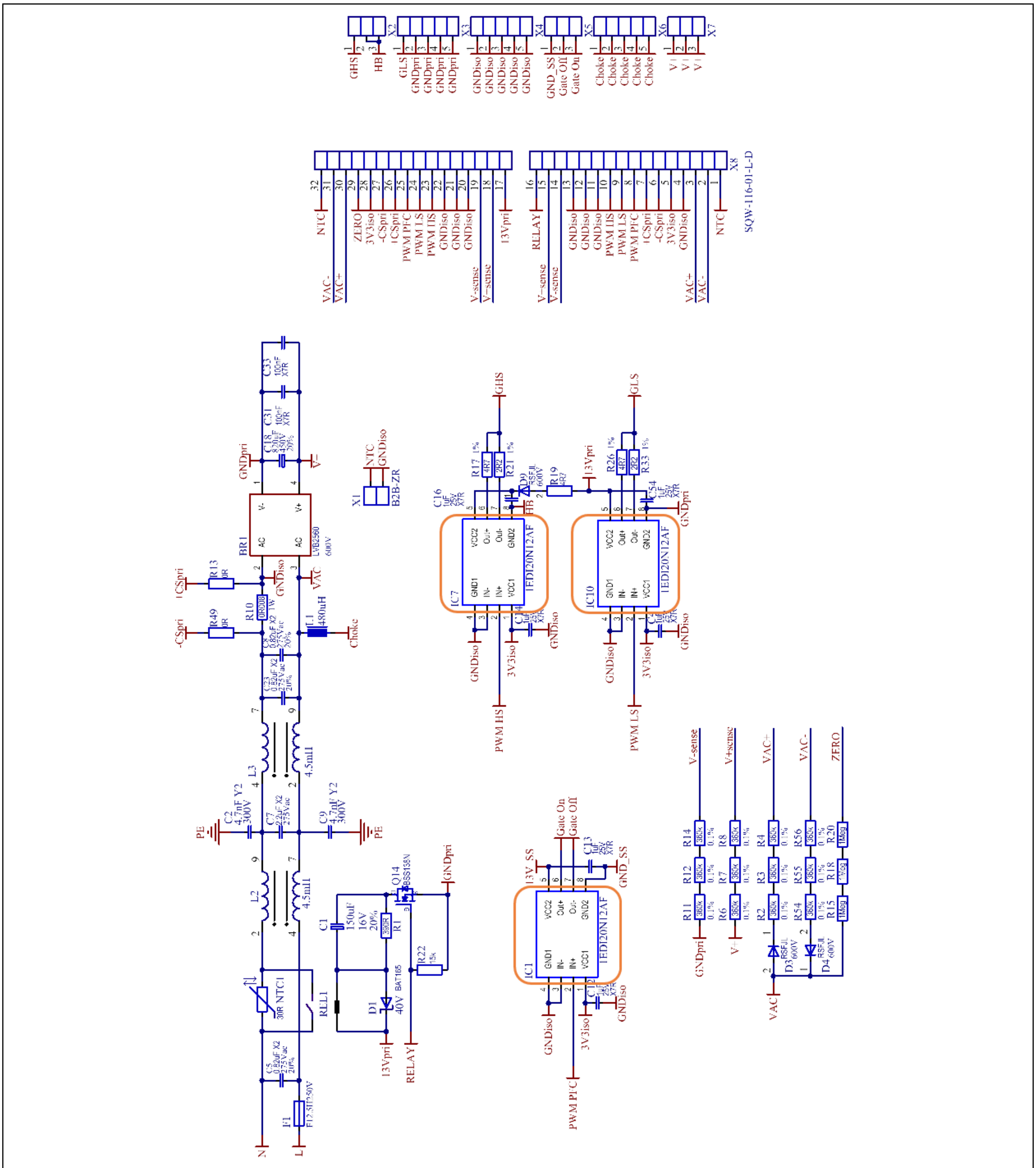

Figure 24 **PFC schematic of the 1600 W PSU, which includes the NTC, power board and primary-side control board connectors, as well as the PFC and LLC half-bridge drivers (highlighted in orange). The PFC switch and diode are on the power board**

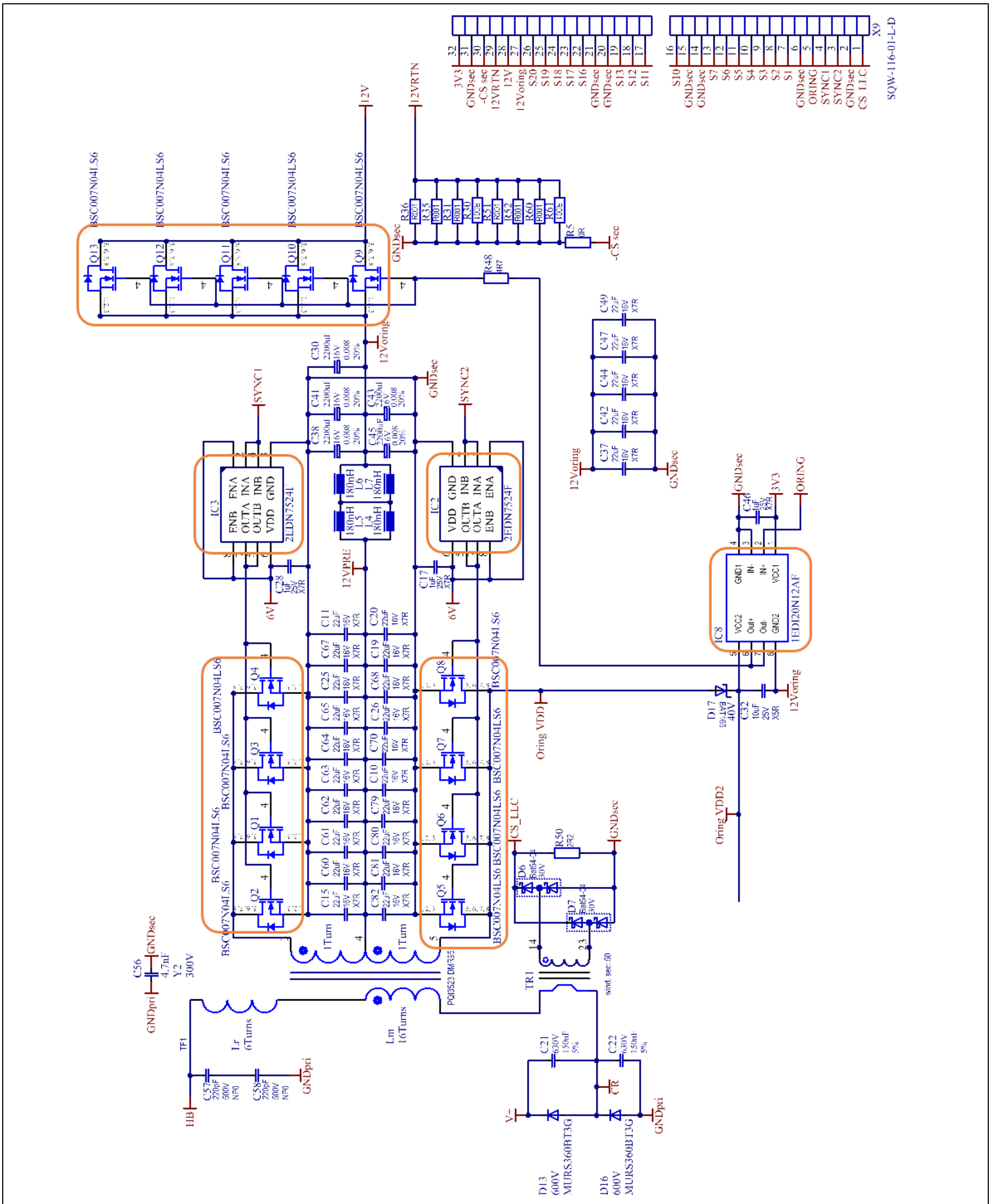

Figure 25 **LLC schematic of the 1600 W PSU with the secondary-side control board connector. The primary-side switches and drivers are on the power board and shown in the PFC schematic. Infineon products are highlighted in orange**

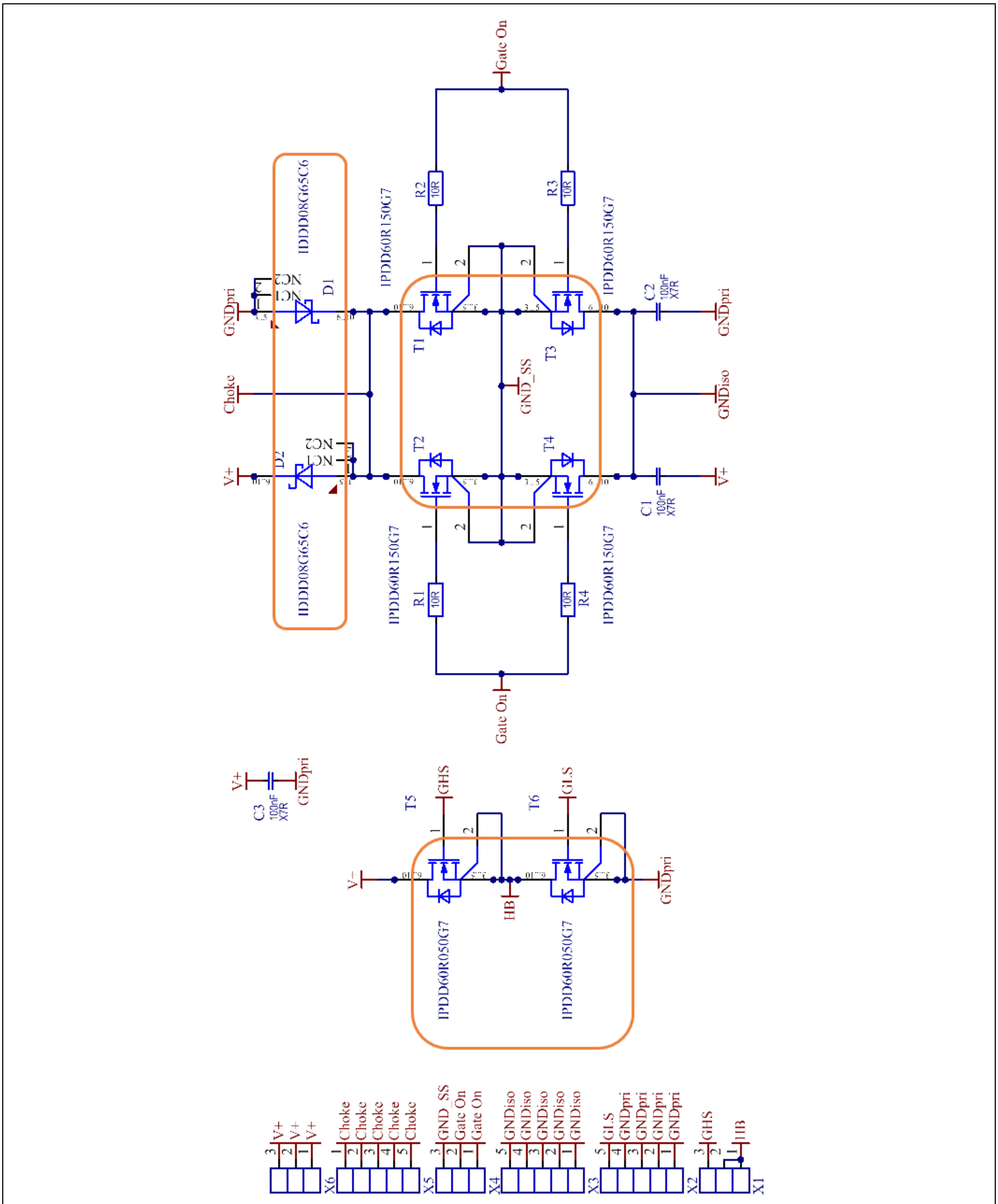

Figure 26 **Power board schematic for the main semiconductors of the 1600 W server PSU. The highlighted parts are the Infineon DDPAK MOSFETs and diodes**

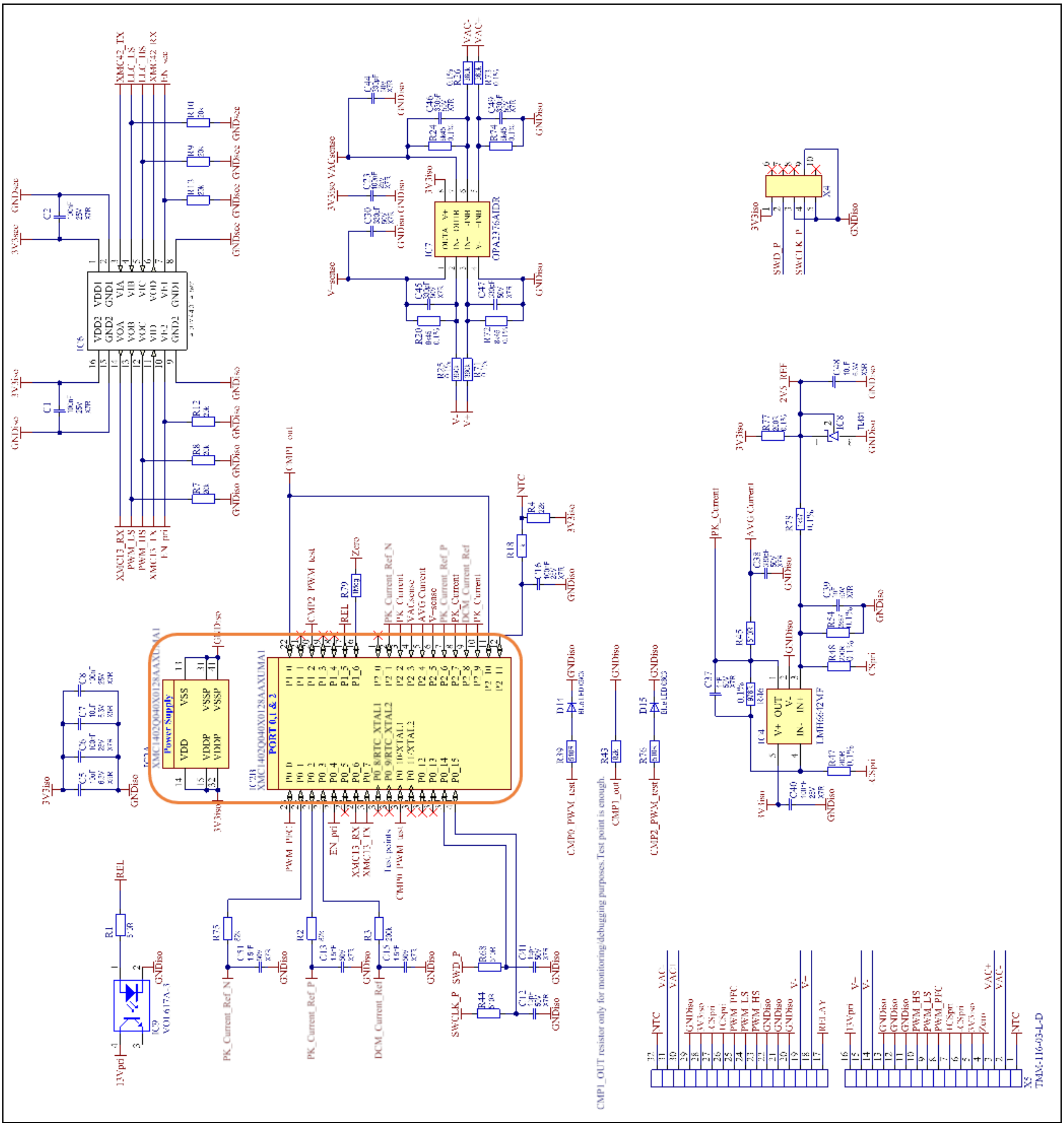

Figure 27 Primary-side controller (XMC1402 highlighted) schematic, including the digital isolator for primary-secondary communication

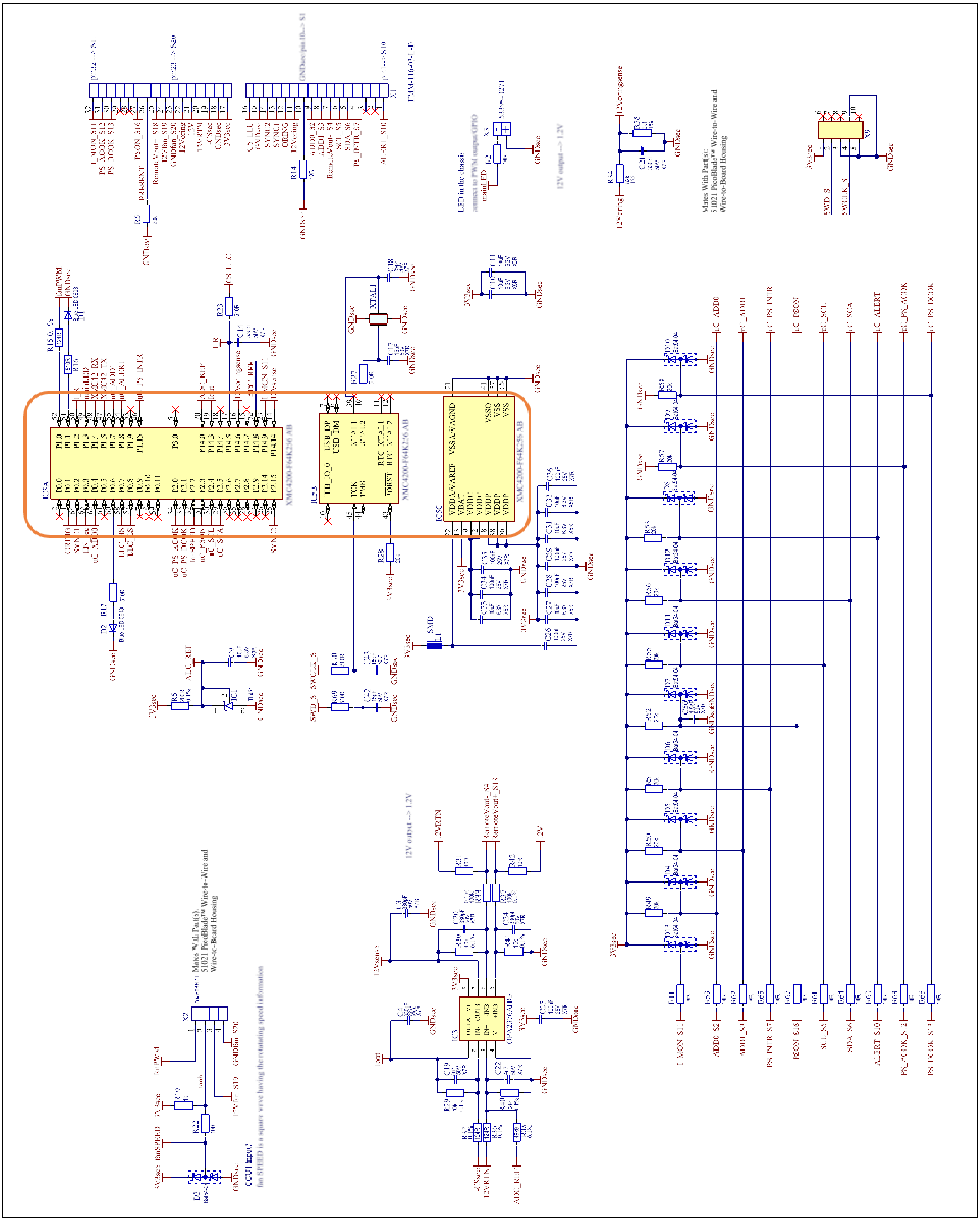

Figure 28 **Secondary-side controller (XMC4200 highlighted) schematic, including the signaling for the PSU output connector**

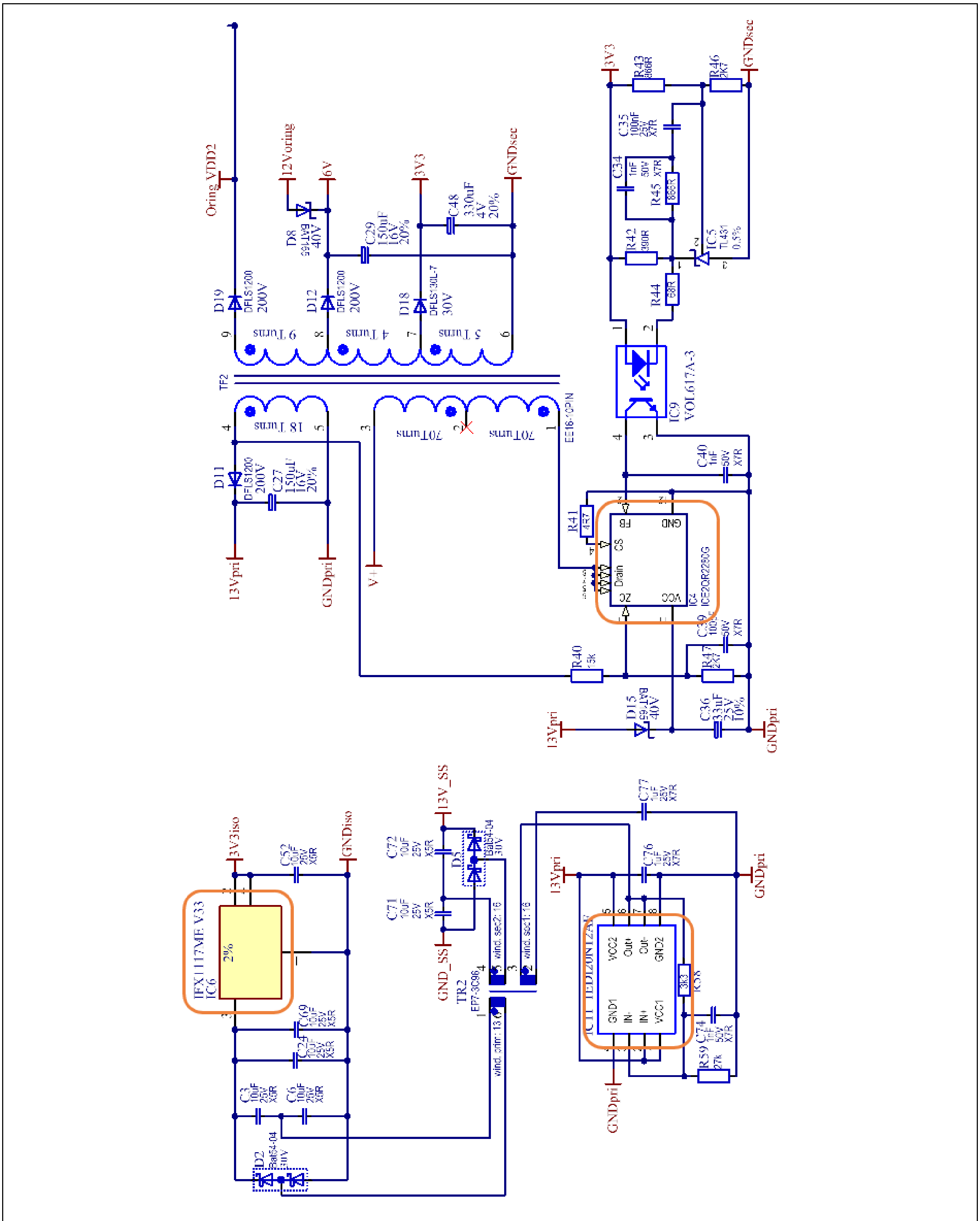

Figure 29 Auxiliary power supply (bias) of the 1600 W server PSU. The implemented Infineon components are highlighted in orange

5 Bill of materials (BoM)

Table 4 Main board components

Designator	Value	Tolerance	Voltage	Description	Comment
IC2, IC3	**2EDN7524F**			**Integrated circuit**	**SMD**
IC1, IC7, IC8, IC10, IC11	**1EDI20N12AF**			**Integrated circuit**	**SMD**
IC4	**ICE2QR2280G**			**Integrated circuit**	**SMD**
IC6	**IFX1117ME V33**	**2 percent**	**15 V**	**Integrated circuit**	**SMD**
NTC1	30 R	20 percent		NTC resistor	THT
R1	390 R	1 percent		Resistor	SMD
R10	0R008	1 percent		Resistor	SMD
R42	390 R	1 percent		Resistor	SMD
R44	68 R	1 percent		Resistor	SMD
R58	3k3	1 percent		Resistor	SMD
R59	27 k	1 percent		Resistor	SMD
R2, R3, R4, R6, R7, R8, R11, R12, R14, R54, R55, R56	360 k	0.1 percent		Resistor	SMD
R22, R40	15 k	1 percent		Resistor	SMD
R43, R45	866 R	1 percent		Resistor	SMD
R46, R47	2K7	1 percent		Resistor	SMD
R15, R18, R20	1 Meg	1 percent		Resistor	SMD
R21, R33, R50	2R2	1 percent		Resistor	SMD
R5, R13, R49	0 R	1 percent		Resistor	SMD
R17, R19, R26, R41, R48	4R7	1 percent		Resistor	SMD
R30, R31, R35, R36, R51, R52, R60, R61	R001	1 percent		Resistor	SMD
REL1	OJE-SS-112HM		12 V	Relay	THT
Q14	BSS138N		60 V	MOSFET	SMD
Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13	BSC007N04LS6		40 V	MOSFET	SMD
L1	480 µH			Magnetic	THT
TF1	PQI3523 DMR95			Magnetic	THT
TF2	EE16-10PIN			Magnetic	THT
TR1				Magnetic	THT
TR2	EP7-3C96			Magnetic	THT
L2, L3	4.5 mH			Magnetic	THT
L4, L5, L6, L7	180 nH			Magnetic	SMD
IC5	TL431	0.5 percent		Integrated circuit	SMD
IC9	VOL617A-3			Integrated circuit	SMD

Designator	Value	Tolerance	Voltage	Description	Comment
F1	F12.5H250V			Fuse	THT
D1, D8, D15, D17	BAT165		40 V	Schottky diode	SMD
D2, D5, D6, D7	BAT54-04		30 V	Schottky diode	SMD
BR1	LVB2560		600 V	Bridge diode	THT
D18	DFLS130L-7		30 V	Diode	SMD
D13, D16	MURS360BT3G		600 V	Diode	SMD
D11, D12, D19	DFLS1200		200 V	Diode	SMD
D3, D4, D9	RSFJL		600 V	Diode	SMD
X1	B2B-ZR			Connector	THT
X8, X9	SQW-116-01-L-D			Connector	THT
C18	820 µF	20 percent	450 V	Polarized capacitor	THT
C36	33 µF	10 percent	25 V	Polarized capacitor	SMD
C48	330 µF	20 percent	4 V	Polarized capacitor	SMD
C1, C27, C29	150 µF	20 percent	16 V	Polarized capacitor	SMD
C30, C38, C41, C43, C45	2200 µF	20 percent	16 V	Polarized capacitor	THT
C7	2.2 µF X2	20 percent	275 V AC	Foil capacitor	THT
C21, C22	150 nF	5 percent	630 V	Foil capacitor	THT
C5, C8, C23	0.82 µF X2	20 percent	275 V AC	Foil capacitor	THT
C35	100 nF	X7R	25 V	Ceramic capacitor	SMD
C39	100 pF	X7R	50 V	Ceramic capacitor	SMD
C4, C12, C13, C14, C16, C17, C28, C46, C54, C76, C77	1 µF	X7R	25 V	Ceramic capacitor	SMD
C31, C33	100 nF		500 V	Ceramic capacitor	SMD
C57, C58	220 pF	NP0	500 V	Ceramic capacitor	SMD
C10, C11, C15, C19, C20, C25, C26, C37, C42, C44, C47, C49, C60, C61, C62, C63, C64, C65, C67, C68, C70, C79, C80, C81, C82	22 µF	X7R	16 V	Ceramic capacitor	SMD
C2, C9, C56	4.7 nF	Y2	300 V	Ceramic capacitor	THT
C34, C40, C74	1 nF	X7R	50 V	Ceramic capacitor	SMD
C3, C6, C24, C32, C52, C69, C71, C72	10 µF	X5R	25 V	Ceramic capacitor	SMD

Table 5 Power board components

Designator	Value	Tolerance	Voltage	Description	Comment
T5, T6	**IPDD60R050G7**			**600 V CoolMOS™ G7 power transistor, 600 V (VDS)**	**SMD**
T1, T2, T3, T4	**IPDD60R150G7**			**600 V CoolMOS™ G7 power transistor, 600 V (VDS)**	**SMD**
D1, D2	**IDDD08G65C6**			**650 V CoolSiC™ G6 Schottky diode**	**SMD**
R1, R2, R3, R4	10 R	1 percent		Resistor	SMD
C1, C2, C3	100 nF		500 V	Ceramic capacitor	SMD
X1, X4, X6	MMT-103-01-L-SH			Connector	SMD
X2, X3, X5	MMT-105-01-L-SH			Connector	SMD

Table 6 Control board components

Designator	Value	Tolerance	Voltage	Description	Comment
IC2	**XMC1402-Q040X0128AAXUMA1**			**Integrated circuit**	**SMD**
IC5	**XMC4200-F64K256AB**			**Integrated circuit**	**SMD**
C1, C2, C6, C8, C16, C23, C25, C26, C28, C29, C34, C35, C36, C40	100 nF	X7R	25 V	Ceramic capacitor	SMD
C3, C4, C14, C20, C21, C24, C30, C38, C44, C45, C46, C47, C49	330 pF	X7R	50 V	Ceramic capacitor	SMD
C5, C7, C9, C10, C11, C27, C31, C32, C33, C48	10 µF	X5R	6.3 V	Ceramic capacitor	SMD
C12, C17, C18, C41, C42, C43	15 pF	X7R	50 V	Ceramic capacitor	SMD
C13, C15, C50, C51	1.5 nF	X7R	50 V	Ceramic capacitor	SMD
C19, C22	4 n7	X7R	50 V	Ceramic capacitor	SMD
C37, C39	1 nF	X7R	50 V	Ceramic capacitor	SMD
D1, D2, D14, D15	Blue LED 0603			LED diode	SMD
D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13	BAT54-04			Diode	SMD
IC1, IC8	TL431			Integrated circuit	SMD

Designator	Value	Tolerance	Voltage	Description	Comment
IC3, IC7	OPA2376AIDR			Integrated circuit	SMD
IC4	LMH6642MF			Integrated circuit	SMD
IC6	ADUM4401ARWZ			Integrated circuit	SMD
IC9	VOL617A-3			Integrated circuit	SMD
L1	Ferrite bead 60 Ω at 100 mHz			Magnetic	SMD
R1, R16, R17, R23, R27, R39, R44, R45, R68, R69, R70, R76	510 R	1 percent		Resistor	SMD
R2, R34, R43, R75	82 k	1 percent		Resistor	SMD
R3	200 k	1 percent		Resistor	SMD
R4	22 k	1 percent		Resistor	SMD
R5, R47, R48, R77	200 R	0.1 percent		Resistor	SMD
R6, R7, R8, R9, R10, R12, R13, R28, R49, R50, R51, R52, R53, R55, R56, R57, R58	20 k	1 percent		Resistor	SMD
R11, R14, R21, R22, R31, R42, R59, R60, R61, R62, R63, R64, R65, R66, R67	10 R	1 percent		Resistor	SMD
R15, R32, R36	124 R	0.1 percent		Resistor	SMD
R18, R19	1 k	1 percent		Resistor	SMD
R20, R24, R72, R74	8k45	0.1 percent		Resistor	SMD
R25, R26, R71, R73	360 k	0.1 percent		Resistor	SMD
R29, R30, R41	10 k	0.1 percent		Resistor	SMD
R33, R37	100 k	0.1 percent		Resistor	SMD
R35	49k9	0.1 percent		Resistor	SMD
R38	9k1	1 percent		Resistor	SMD
R40	12k4	0.1 percent		Resistor	SMD
R46	976 R	0.1 percent		Resistor	SMD
R54	2k87	0.1 percent		Resistor	SMD

Designator	Value	Tolerance	Voltage	Description	Comment
R78	1k47	0.1 percent		Resistor	SMD
R79	1 Meg	1 percent		Resistor	SMD
X1, X5	TMM-116-03-L-D			Connector	SMD
X2	53398-0471			Connector	SMD
X3	53398-0271			Connector	SMD
X4, X9				Connector	SMD
XTAL1	12 MHz			Crystal oscillator	SMD

6 Related resources

- CoolMOS™ packages
- Developer Community

References

[1] Infineon Technologies AG: *800 W Platinum® server power supply, using 600 V CoolMOS™ C7 and digital control with XMC™*; Available online

[2] Infineon Technologies AG: *800 W Platinum® server power supply, using 600 V CoolMOS™ P7 and digital control with XMC™*; Available online

[3] Infineon Technologies AG: *CoolMOS™ G7 and CoolSiC™ G6 will come in a new top-side cooling package – the DDPAK*; Available online

[4] L. Huber, Y. Jang and M. M. Jovanovic, "Performance Evaluation of Bridgeless PFC Boost Rectifiers," in IEEE Transactions on Power Electronics, vol. 23, no. 3, pp. 1381-1390, May 2008; Available online

[5] Infineon Technologies AG: *PFC demo board – system solution. High power density 800 W 130kHz Platinum server design*; Available online

[6] Infineon Technologies AG: *High-efficiency 3 kW bridgeless dual-boost PFC demo board*; Available online

[7] Infineon Technologies AG: *3 kW dual-phase LLC demo board, using 600 V CoolMOS™ CFD7 and digital control by XMC4400*; Available online

Revision history

Document revision	Date	Description of changes
V 1.1	2018-05-02	Section 2.7 with thermal measurements added
V 1.2	2025-12-15	

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