CoolGaN™ BDS-based H4 PFC evaluation board with isolated bias supply

EVAL_1K6W_H4_GaN_BDS

About this document

Scope and purpose

EVAL_1K6W_H4_GaN_BDS is an evaluation board solution designed for configurations using two devices connected in a back-to-back arrangement, featuring CoolGaN™ bidirectional switches (BDS) with several gate driving solutions, including a single-channel isolated gate driver IC (EiceDRIVER™ 1EDB7275F), and a configurable isolated bias supply enabled by a simple single-channel non-isolated gate driver IC (EiceDRIVER™ 1EDN7511B).

This evaluation board is compatible with Infineon system solution EVAL_1K6W_PSU_CFD7_QD, which is a server power supply composed of a continuous conduction mode (CCM) bridgeless power factor corrector (PFC) with back-to-back arrangement and a half-bridge LLC DC-DC resonant converter.

This document provides the board using CoolGaN™ BDS, CoolMOS™ MOSFETs, and CoolSiC™ Schottky diodes in top-side-cooled SMD package (TOLT and D-DPAK). It further details the specifications and the main results obtained from testing the PFC stage of a 1600 W server power supply. In addition, it covers the CoolGaN™ BDS gate-drive circuit design including schematic and PCB layout.

Intended audience

This document is intended for power electronics engineers and designers interested in learning how to design the BDS gate-drive circuit and integrate Infineon's configurable isolated bias-supply circuit to simplify the BDS power-supply design. It includes a demonstrating the performance of CoolGaN™ BDS 650 V G5 IGLT65R055B2 with 1.6 kW CCM PFC stage of EVAL_1K6W_PSU_CFD7_QD.

About this product group

Target applications

- 1-phase string inverter solutions
- 3-phase string inverter solutions
- Microinverter solutions
- Motor control
- Server power supply unit (PSU)

Product family

Infineon's CoolGaN™ solution offers unmatched quality that operates at higher switching speeds resulting in lower power losses, higher efficiency paving the way for smaller, and lighter power supplies with the same power supplies with the same size but increased power capability.

About this product group

Evaluation Board

This board is to be used during the design-in process for evaluating and measuring characteristic curves, and for checking datasheet specifications.

Note: PCB and auxiliary circuits are NOT optimized for final customer design.

Safety precautions

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

Table 1 Safety precautions

	**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.*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

Table of contents

1 Introduction

Based on the EVAL_1K6W_PSU_CFD7_QD platform [1], the power board has been modified by replacing the original two back-to-back CoolMOS™ switches with a CoolGaN™ bidirectional switch (BDS), as shown in Figure 1 and Figure 2. The gate-drive implementation adopts the circuit design from KIT_1EDB_AUX_GaN [2] and DEMO_AC_ZVS_HVBDS [3]. The following sections provide an overview and description of the modified board.

Replacing the original two back-to-back CoolMOS™ switches with an IGLT65R055B2 CoolGaN™ BDS reduces the power-loop area. To use CoolMOS™ G7 devices in the LLC stage, it lowers the losses and improve figures of merit [4], [5]. Additionally, the CoolSiC™ G6 diode's lower forward voltage reduces diode losses [4]. These lower losses, combined with improved thermal resistance, which offsets the smaller heat-spreading area compared with leaded packages, and the low profile of the top-side-cooled SMD packages; enabling the PFC and half-bridge switches to share the same heatsink. This board is vertically placed in the central part of the PSU in front of the fan (highlighted pink area in Figure 3. In this case, five parts are soldered to the power board and share the same heatsink, which is attached by using pressure clips.

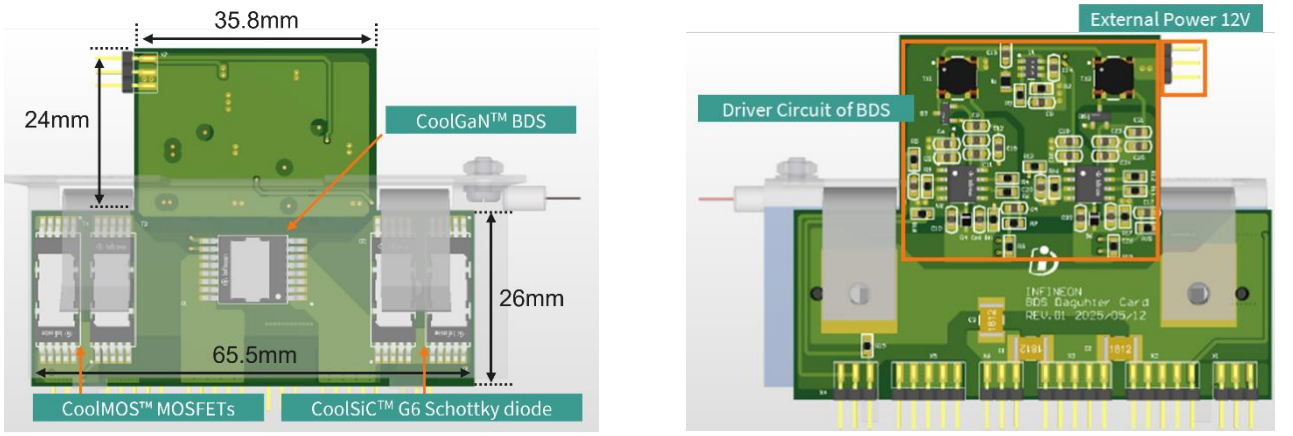


Figure 1 EVAL_1K6W_H4_GaN_BDS board to replace power board PFC and HB LLC

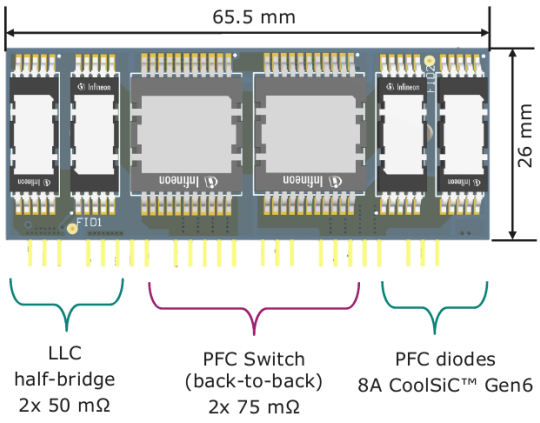


Figure 2 Power board PFC and HB LLC of EVAL_1K6W_PSU_CFD7_QD platform

1 Introduction

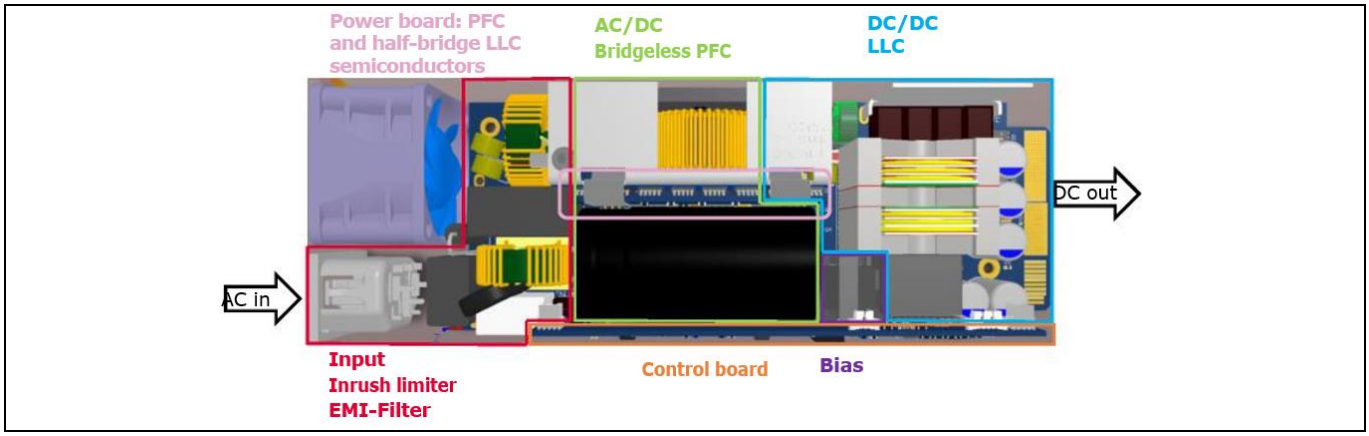


Figure 3 Power board of EVAL_1K6W_PSU_CFD7_QD platform

1.1 EZDrive: Gate driver circuit

The EZDrive gate driver circuit is the typical design choices for CoolGaN™ switches. For design rules, see [6] and for optimizing PCB layout for CoolGaN™ power transistors in SMPS applications, see [7]. The following figure shows the driver circuit for the evaluation boards (EVBs).

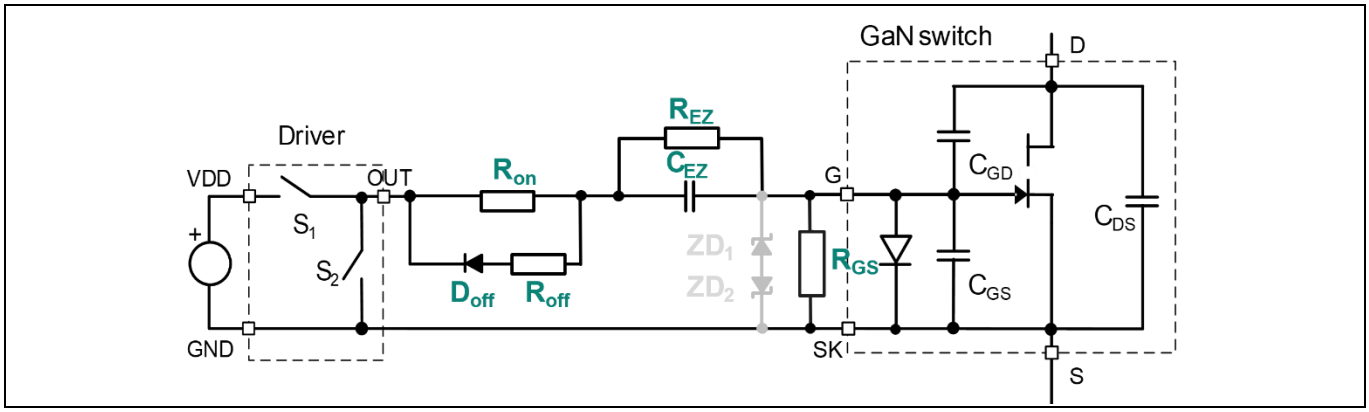
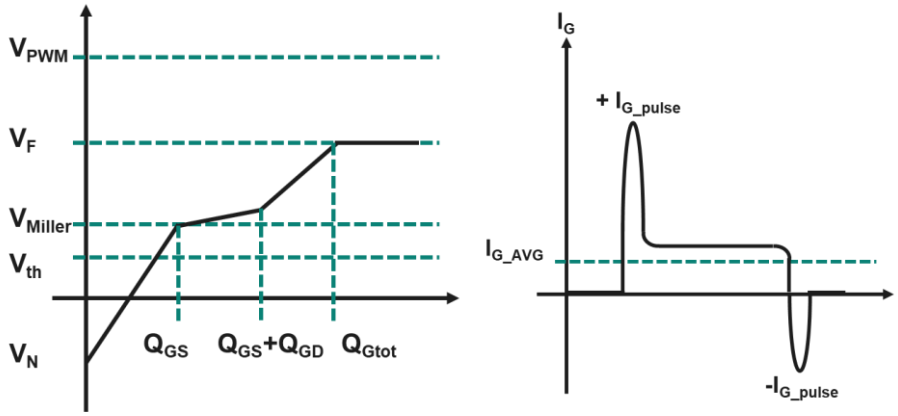


Figure 4 Typical EZDrive interface circuit for Infineon CoolGaN™ transistor

The definition of parameters shown in Figure 4 ([6], [7]) are as follows:

- **R_{on}, R_{off}:** Transient switching speed dV/dt tuning resistor
- **R_{EZ}:** Keeps the steady-state gate current I_{ss}
- **R_{GS}:** Resistor to reduce the gate-source voltage to 0 V when the input signal is open-circuited. Sets V_{GS} to OFF bias (0 V/−V), bleeds leakage/Miller charge
- **C_{EZ}:** Coupling capacitor as a charge pump to provide fast-switching transient as well as negative gate bias
- **ZD_1, ZD_2:** Zener diode to clamp the positive and negative gate voltage

1 Introduction



Typical switching waveform for GIT GaN transistor

Figure 5 Typical switching waveform for GIT GaN devices

2 EVAL_1K6W_H4_GaN_BDS board

The EVAL_1K6W_H4_GaN_BDS demonstration board is based on the EVAL_1K6W_PSU_CFD7_QD power board, with the back-to-back devices in the PFC section modified, as highlighted in green in Figure 6.

It requires a 12 V supply for VDDI. Figure 7 shows EVAL_1K6W_H4_GaN_BDS functional block diagram.

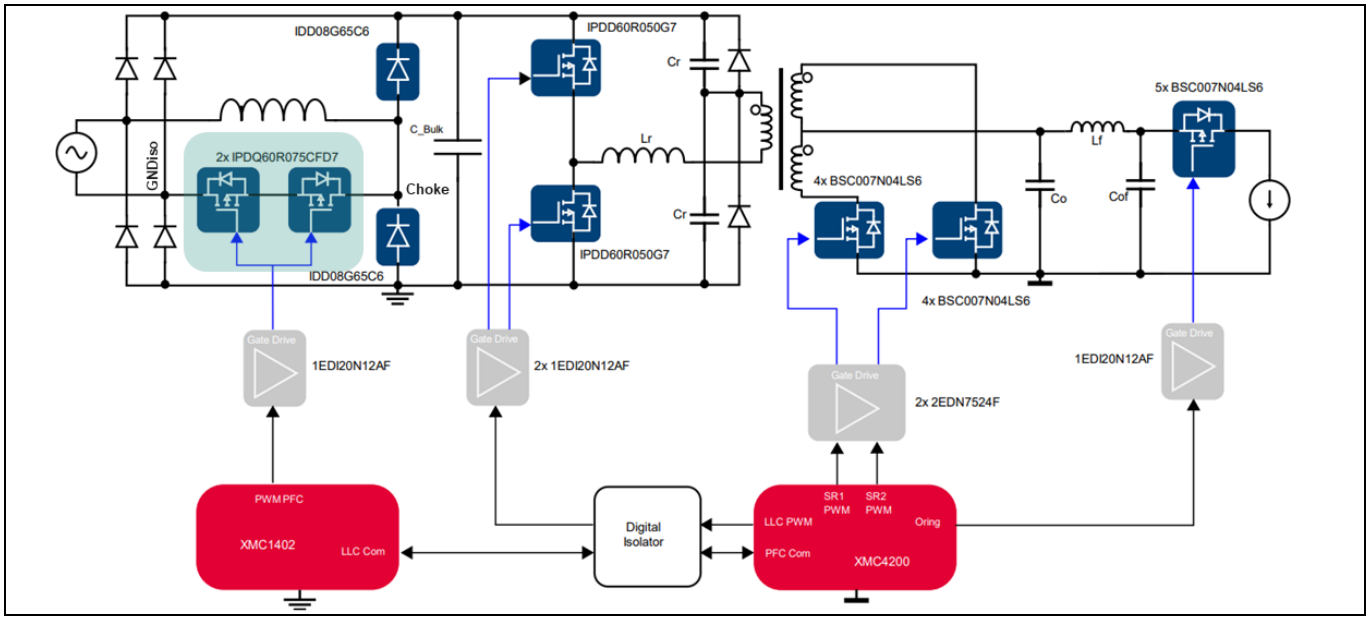


Figure 6 Simplified diagram of 1600 W Titanium server PSU with D-DPAK and Q-DPAK TSC (EVAL_1K6W_PSU_CFD7_QD)

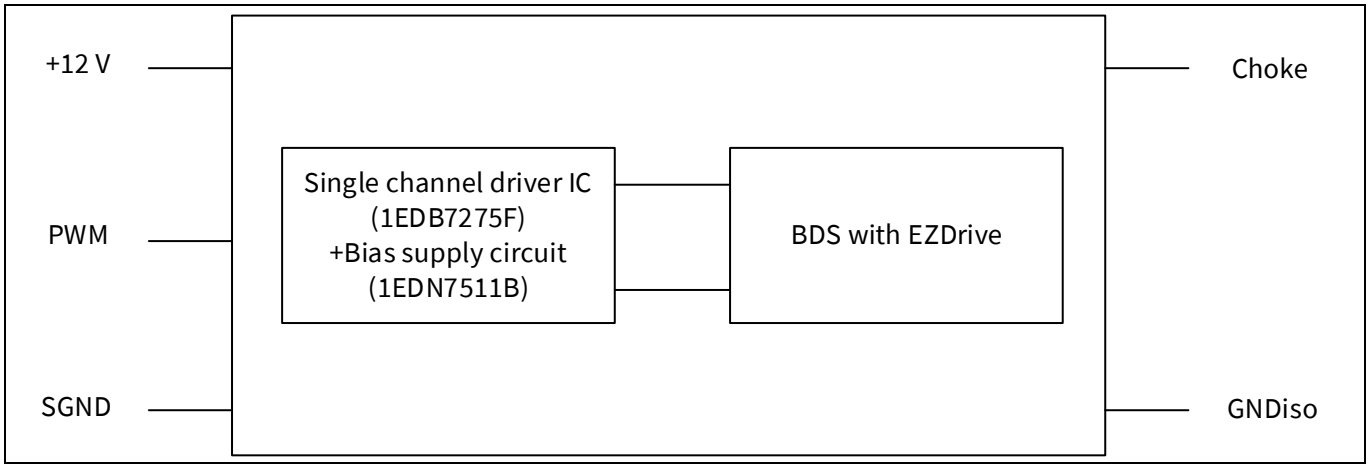


Figure 7 EVAL_1K6W_H4_GaN_BDS boardfunctional block

2 EVAL_1K6W_H4_GaN_BDS board

2.1 Connections and operating instruction

Table 2 Connection

Label	Description
VDDI	Connect the external 12 V to this pin

Note: Ensure that VDDI is provided before turning on supplies.

2.2 Schematics

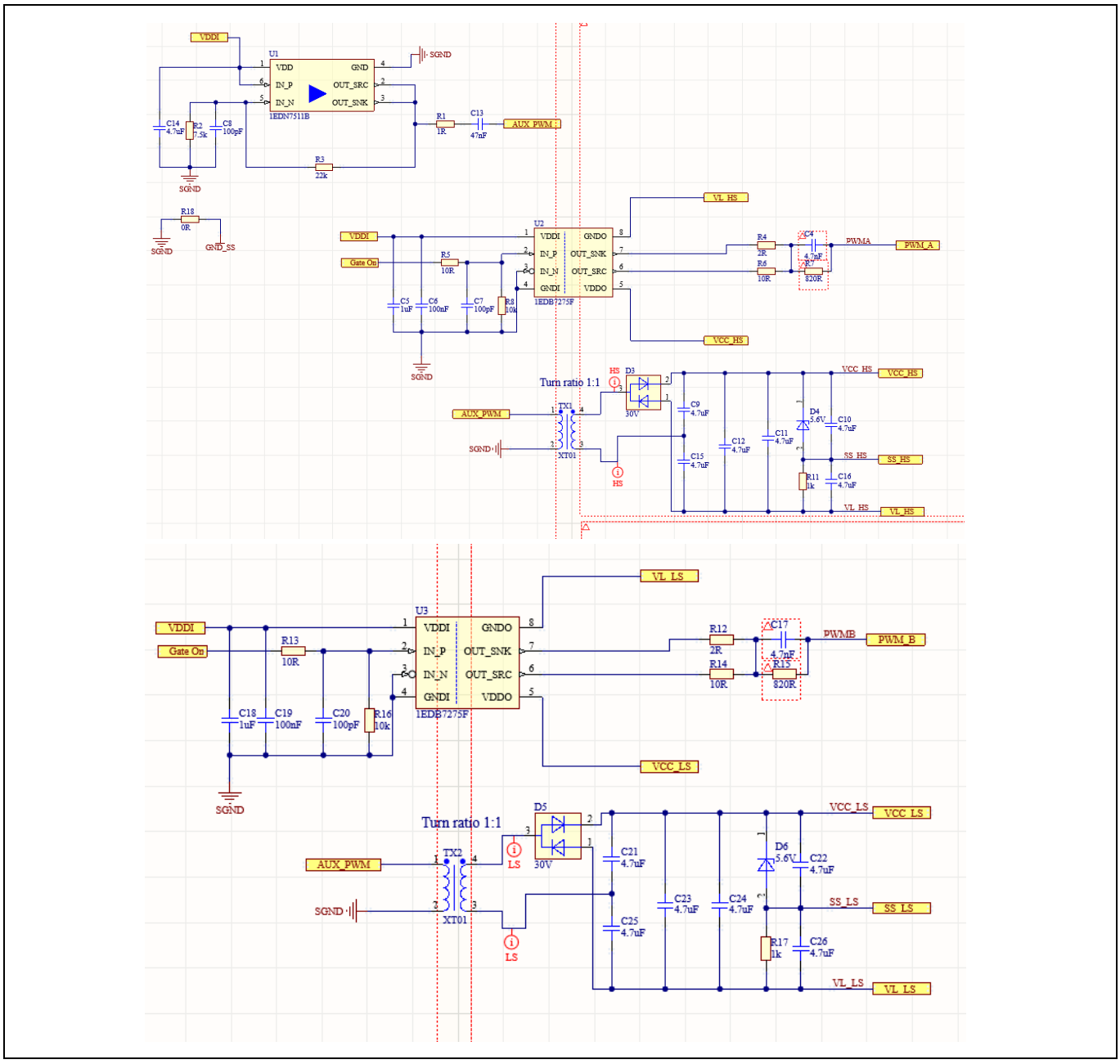


Figure 8 Schematic of the auxiliary supplies and gate drivers

2 EVAL_1K6W_H4_GaN_BDS board

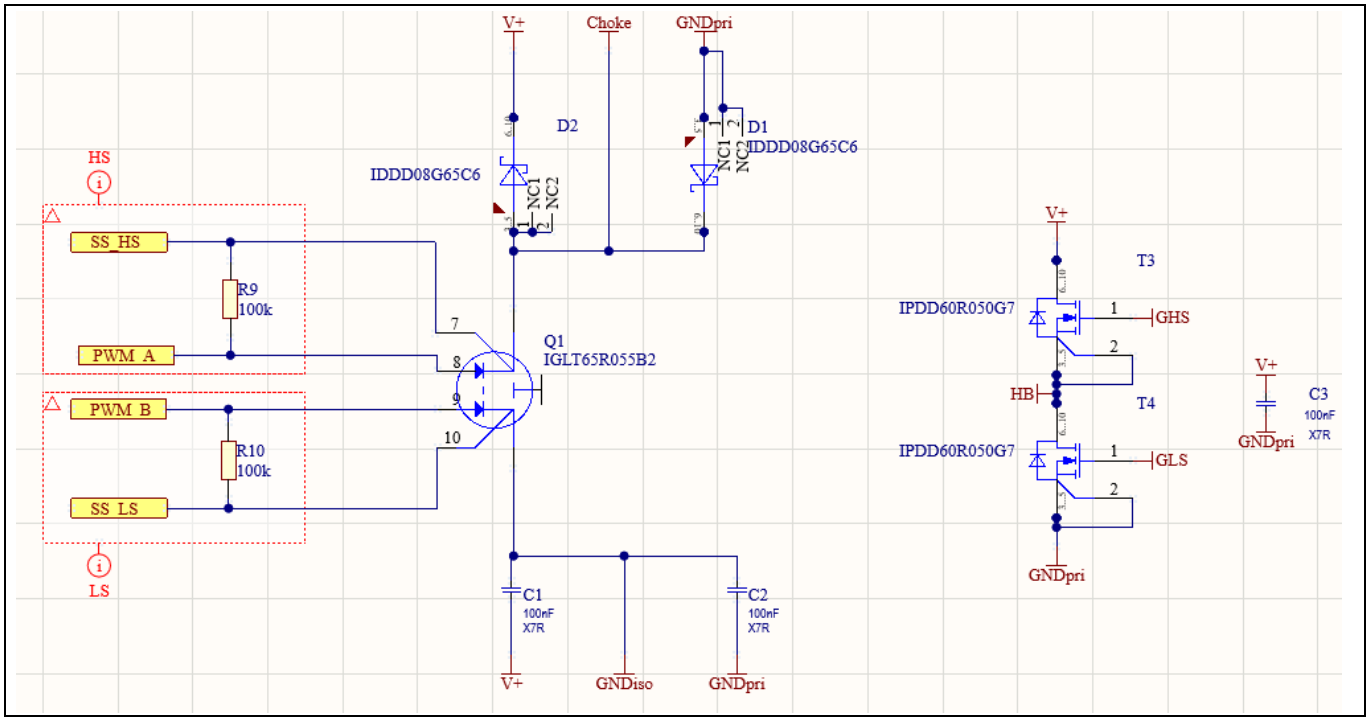


Figure 9 Schematic of the power components

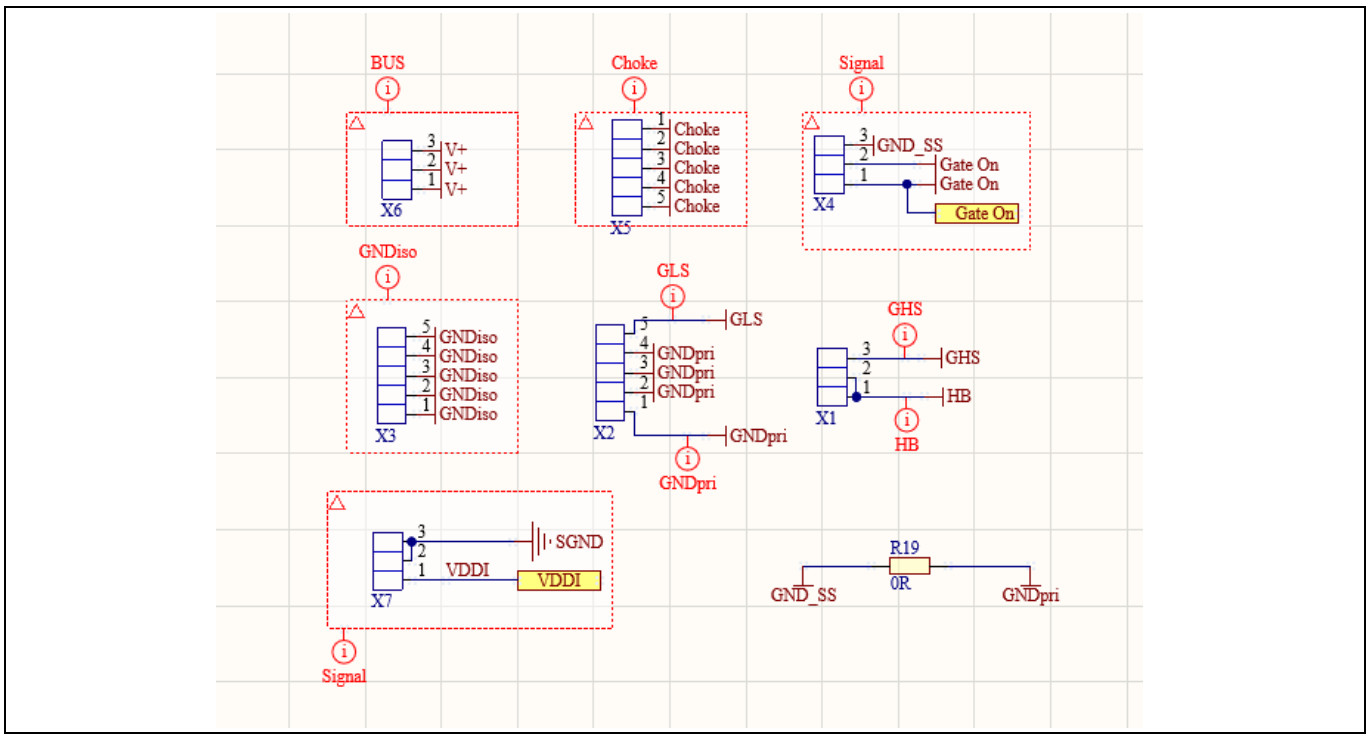


Figure 10 Schematic of the connectors

2.3 Layout

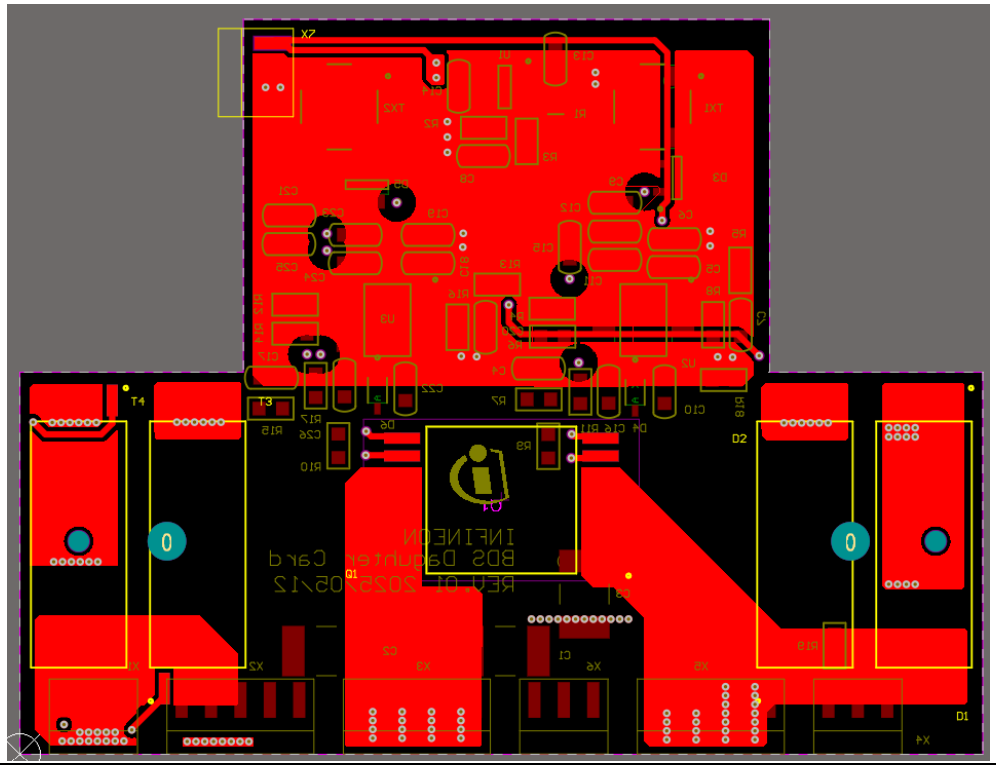


Figure 11 EVAL_1K6W_H4_GaN_BDS board – Top layer (layer 1)

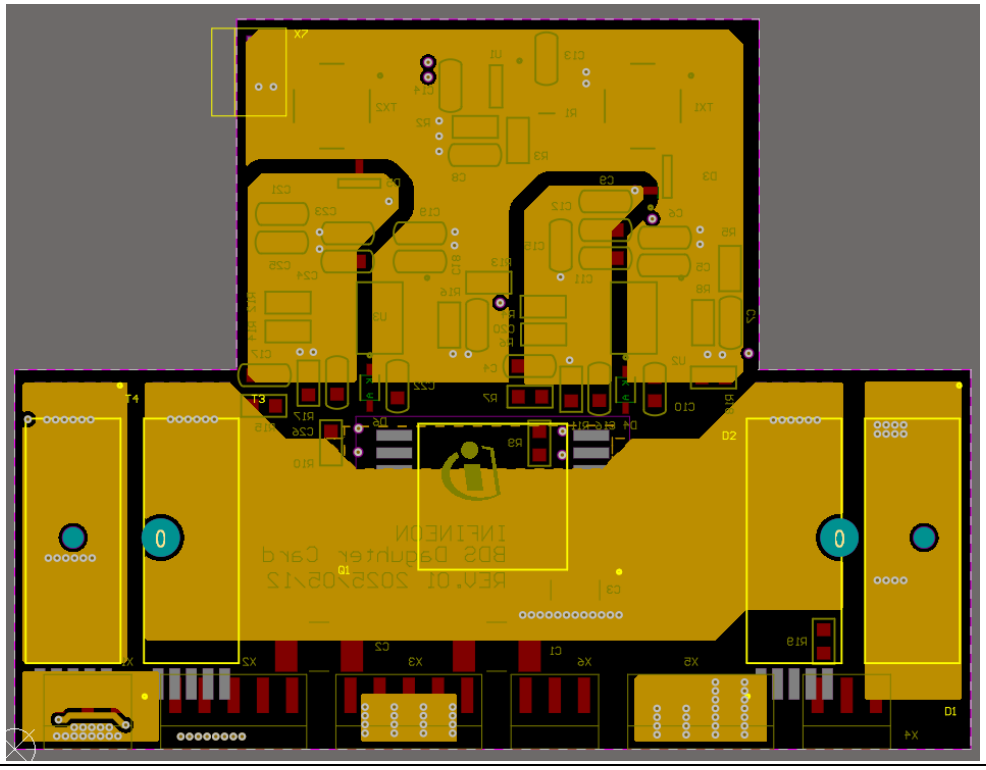


Figure 12 EVAL_1K6W_H4_GaN_BDS board – Layer 2

2 EVAL_1K6W_H4_GaN_BDS board

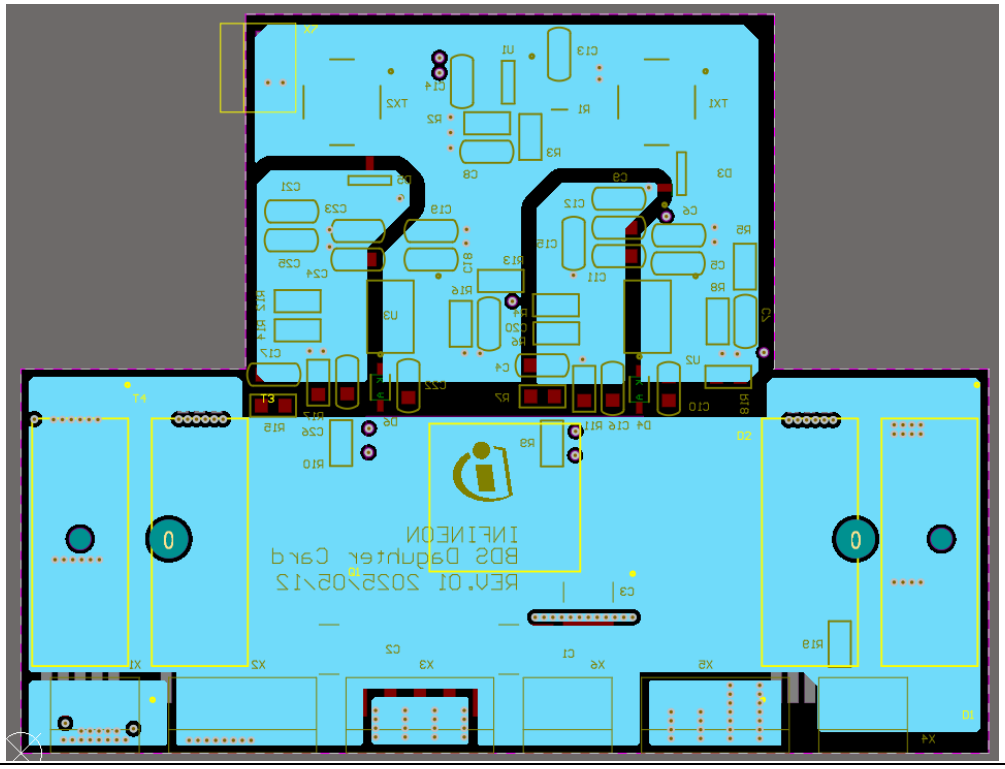


Figure 13 EVAL_1K6W_H4_GaN_BDS board – Layer 3

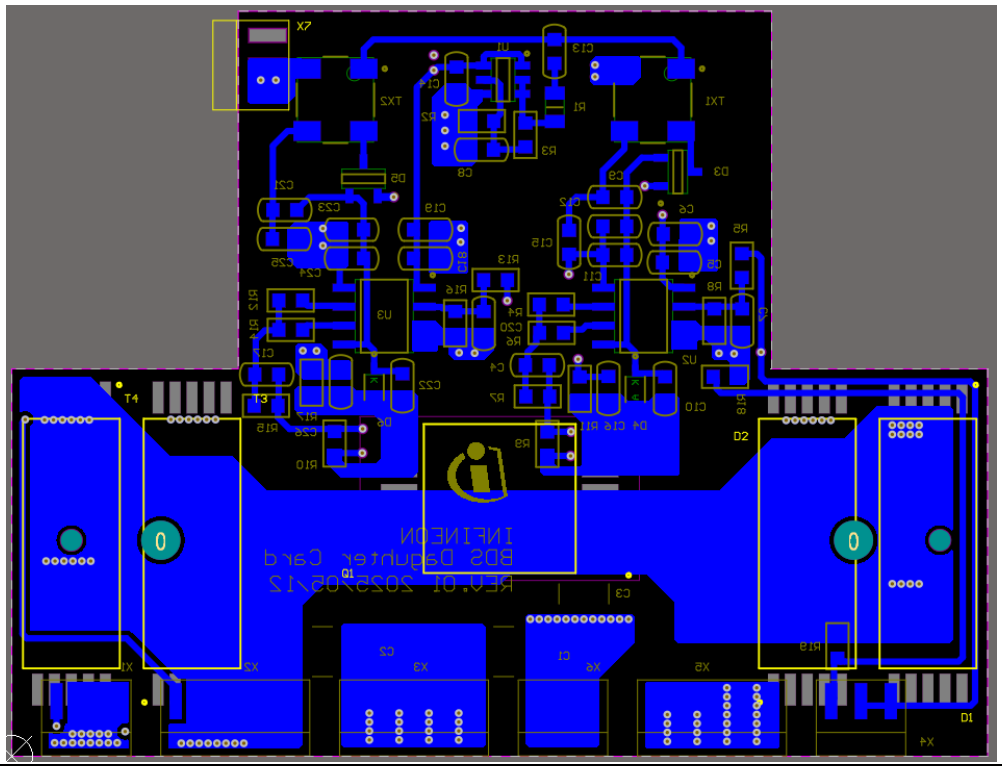


Figure 14 EVAL_1K6W_H4_GaN_BDS board – Bottom layer (layer 4)

2.4 Bill of materials (BOM)

Table 3 Bill of materials

Designator	Value	Tolerance	Voltage	Description	Comment
C1, C2, C3	100 nF	X7R	630 V	630 V, X7R, 1812 capacitor ceramic	SMD
C4, C17	3.3 nF	NP0	50 V	50 V, NP0, 0603 (1608)	SMD
C5, C18	1 µF	X7R	25 V	50 V, NP0, 0603 (1608)	SMD
C6, C19	100 nF	X7R	25 V	25 V, X7R, 0603 (1608)	SMD
C7, C8, C20	100 pF	NP0	50 V	50 V, NP0, 0603 (1608)	SMD
C9, C10, C11, C12, C14, C15, C16, C21, C22, C23, C24, C25, C26	4.7 µF	X5R	25 V	50 V, X5R, 0603 (1608)	SMD
C13	47 nF	X7R	25 V	25 V, X7R, 0603 (1608)	SMD
'D1, D2	IDDD08G65C6	–	650 V	6th generation CoolSiC™ 650 V SiC Schottky diode D3, D5	SMD
D3, D5	BAT5404E6327HTSA1	–	30 V	Silicon Schottky diode	SMD
D4, D6	MM3Z5V6T1G	–	5.6 V	Zener voltage regulator 300 mW MM3Z5V6T1G	SMD
Q1	IGLT65R055B2	–	650 V	BDS	SMD
R1	1R	–	1R	1R/0805	SMD
R2	7.5k	–	7.5k	7.5k/0603	SMD
R3	22k	–	22k	22k/0603	SMD
R4, R5, R6, R12, 13, R14	10R	–	10R	10R/0603	SMD
'R7, R15	820R	–	820R	820R/0603	SMD
R8, R16	10k	–	10k	10k/0603	SMD
R9, R10	100k	–	100k	100k/0603	SMD
R11, R17	1k	–	1k	1k/0603	SMD
R18, R19	0R	–	0R	0R/0603	SMD
T3, T4	IPDD60R050G7	–	600 V	600 V CoolMOS™ G7 power transistor	SMD

2 EVAL_1K6W_H4_GaN_BDS board

Designator	Value	Tolerance	Voltage	Description	Comment
TX1, TX2	XT01	–	–	ICE components / XT01 / 2.25 kV	SMD
U1	1EDN7511B	–	–	EiceDRIVER™, fast single channel 4 A/8 A low-side gate driver, UVLO - 4.2 V	SMD
U2, U3	1EDB7275F	–	–	Single-channel isolated gate-driver ICs	SMD
X1, X4, X6, X7	MMT-103-01-L-SH	–	–	Pin header 3 pole	SMD
X2, X3, X5	MMT-105-01-L-SH	–	–	Pin header 5 pole	SMD

3 Measurement results

3.1 Measurement suggestion

A long ground wire introduces unwanted inductance into the probe measurement path. This results in overshoot and ringing, associated with the rising and falling edges of the signals. Minimizing the length of the ground loop is especially important for CoolGaN™, which has very fast rise and fall times, affected by the probe's ground inductance. The following are a few examples of measurement setups.

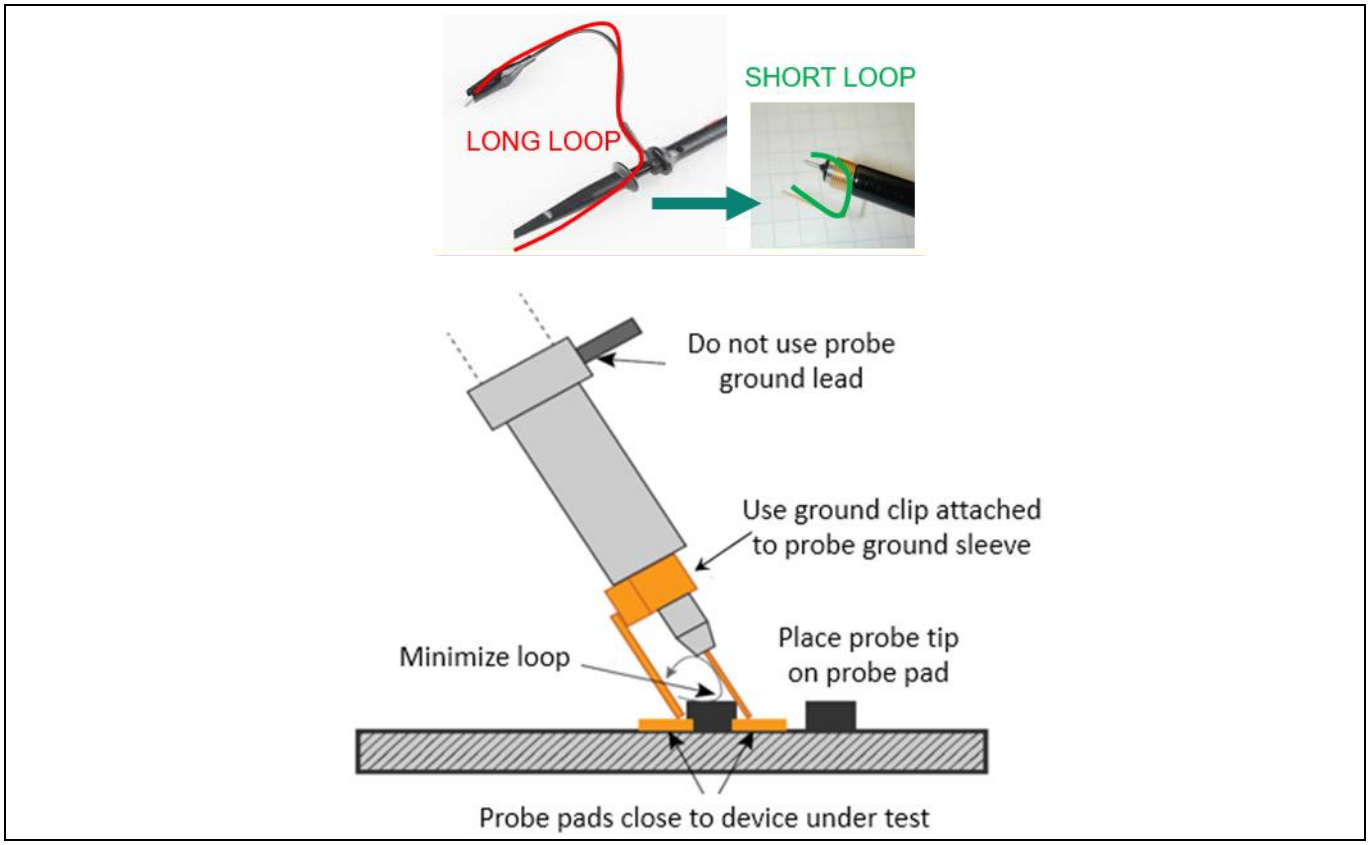


Figure 15 Examples of the scope probe with a short ground clip

3.2 Double pulse test with the evaluation board

The double pulse test (DPT) is the most commonly used and effective test for verifying switching performance. It is highly recommended to verify the power stage switching performance before powering up the system, as GaN is more sensitive.

- Should emulate high-power switching conditions without generating heat
- A safer test: Hard failures usually do not happen even with bad design
- Increase confidence for new users of CoolGaN™

For proper setup and connections for double pulse testing as shown in Figure 16, provide DC power supply connections. The inductor also connects to the terminal block (V_{DC+} and V_{SW}). It is recommended to use the high current with minimal inductance reduction for the inductor (L), as it can handle high pulse current without being saturated. No load is required for double pulse testing. The inductor energy is dissipated in the freewheeling diode.

3 Measurement results

Test conditions:

- **DUT:** IGLT65R055B2
- **Diode:** IDDD08G65C6
- **Cin:** 100 µF
- $\mathbf{V_{dc}}$: 400 V
- $\mathbf{I_{SS}}$: 16 A
- $\mathbf{V_{GS}}$: Depends on the driver solution (12 V/–3 V, 6 V/0 V, and 4 V/–3 V, etc.) and with RC or EZDrive circuit
- **L**: 1 mH
- $\mathbf{T_J}$: 25°C

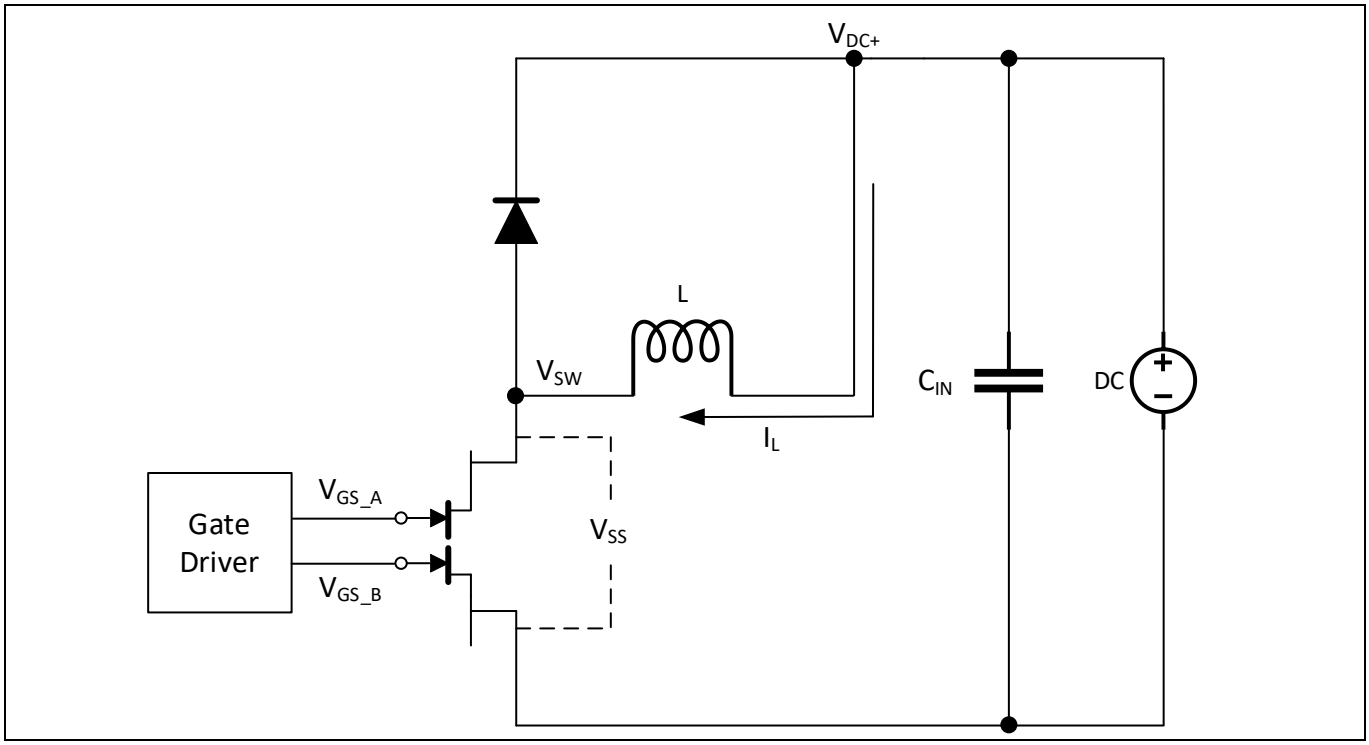


Figure 16 Double pulse test setup

This example shows how to set up the board for double-pulse testing. The test waveforms are shown in Figure 17. In the first pulse, CoolGaN™ BDS turns on and ramps the inductor current to the target value. It then turns off, and the current freewheels through the SiC diode. The second pulse captures the hard-switched turn-on at the leading edge (at the test current) and continues the ramp to a higher current level.

CoolGaN™ BDS performs especially well in double pulse tests, as the freewheeling diode has very low reverse-recovery behavior. Double-pulse testing is usually done one burst at a time (rather than continuously) to minimize power dissipation while quickly evaluating voltage and current limits. Table 4 lists the oscilloscope channels for Figure 17, Figure 18.

3 Measurement results

Table 4 Description of oscilloscope channels

Channel	Description
CH 1 (yellow)	Low-side GaN gate-to-source signal, 5 V/div
CH 2 (cyan)	Low-side GaN drain-to-source signal, 100 V/div
Ch 3 (red)	Inductor current, 10 A/div

Measured peak V_{DS} = 500 V, V_{GS} = 3.6 V. Reliable hard-switching with IGLT65R055B2 to achieve the target current.

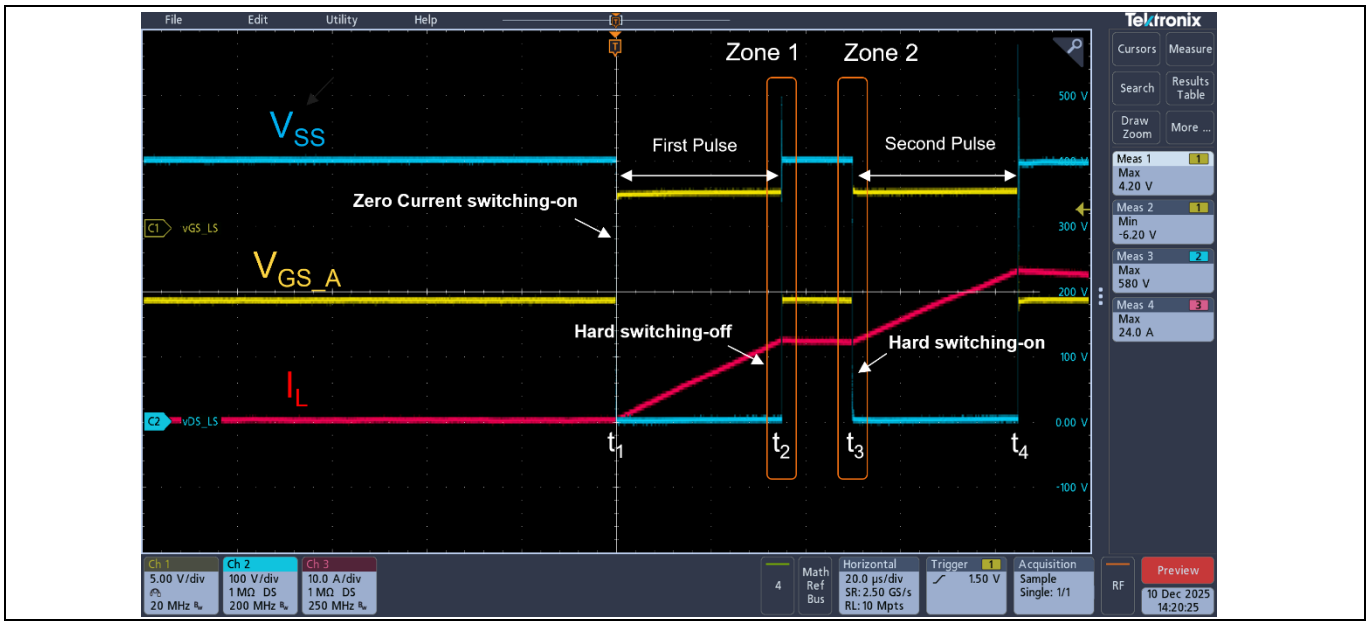


Figure 17 Double pulse test waveform with single-channel isolated driver IC and isolated standby aux power circuit

Figure 18 Double pulse test waveform in zone 1 and zone 2

3.3 Typical operating waveform

System operating with CoolGaN™ BDS in H4 PFC of EVAL_1K6W_PSU_CFD7_QD.

The H4 PFC switching frequency is 65 kHz.

Figure 19 to Figure 22 show the steady-state waveforms at 100% load for the IGLT65R055B2 at an input voltage of 176 VAC.

Figure 23 to Figure 26 show the steady-state waveforms at 100% load for the IGLT65R055B2 at an input voltage of 230 VAC.

Table 5 lists the oscilloscope channels for Figure 19, Figure 20, Figure 21, Figure 22, Figure 23, Figure 24, Figure 25, and Figure 26.

Table 5 Description of oscilloscope channels

Channel	Description
CH 1 (blue)	BDS gate A to kelvin source signal, 5 V/div
CH 2 (cyan)	AC input voltage, 250 V/div
CH3 (magenta)	BDS source to source voltage, 250 V/div
Ch 4 (green)	AC input current, 10 A/div

AC-ZVS BDS demonstration board configuration for H4 PFC:

- V_{ACin} = 176 VAC
- F_{grid} = 60 Hz
- f_{sw} = 65 kHz
- V_{out} = 400V
- P_{load} = 1600 W

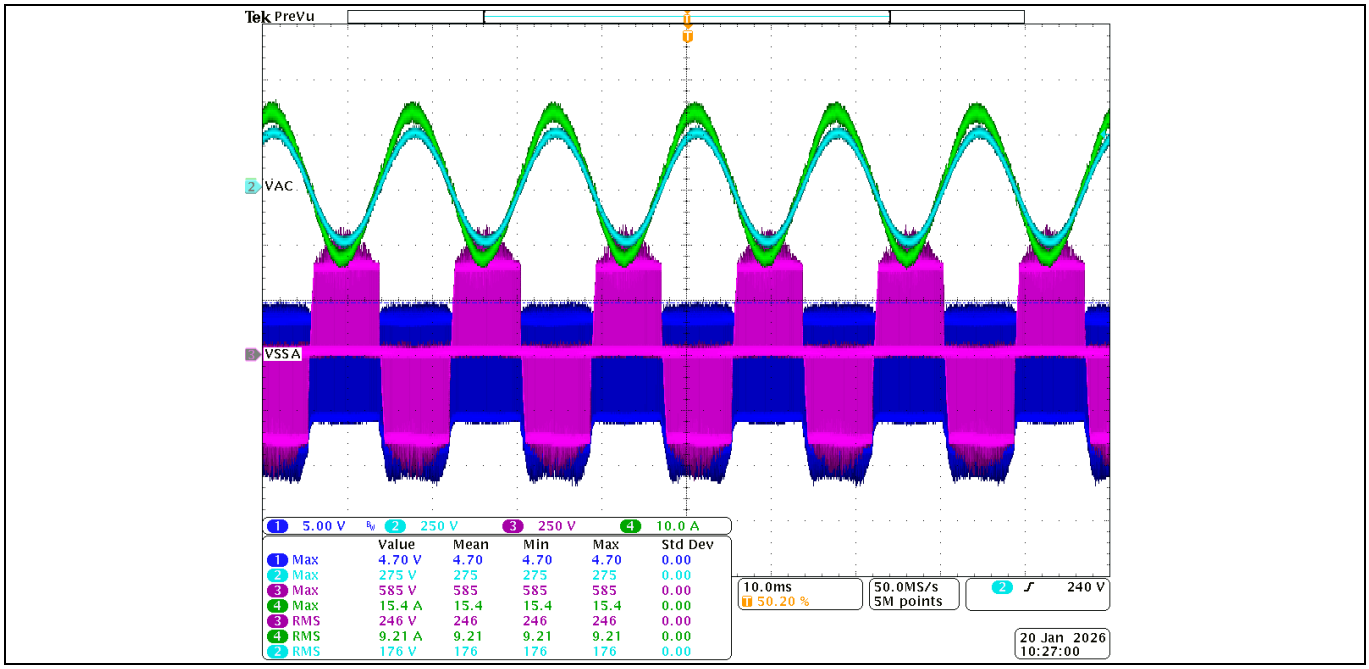


Figure 19 Typical operating waveform at 176 VAC

3 Measurement results

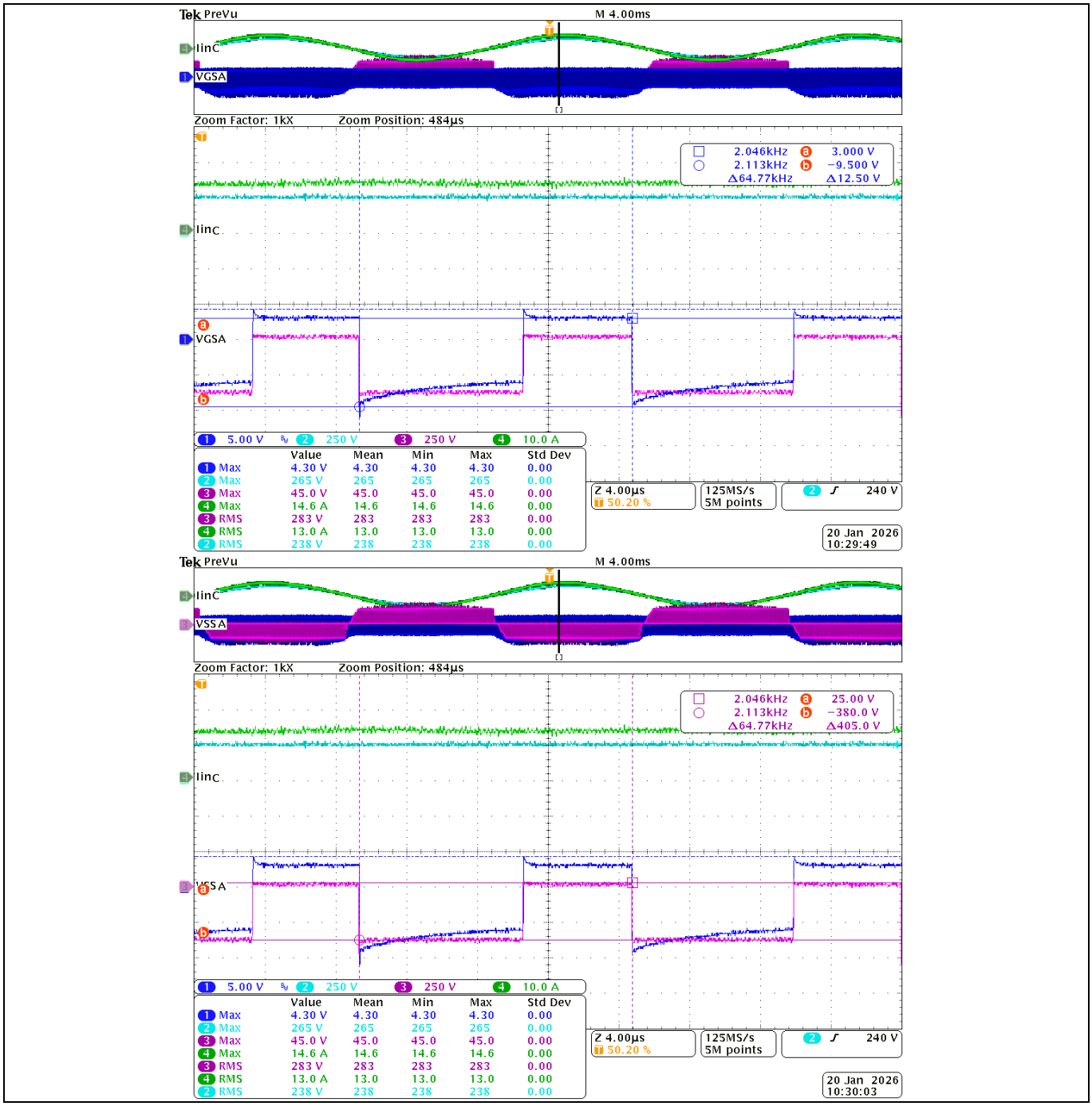


Figure 20 Peak of the positive half-cycle at 176 VAC, zoom in

3 Measurement results

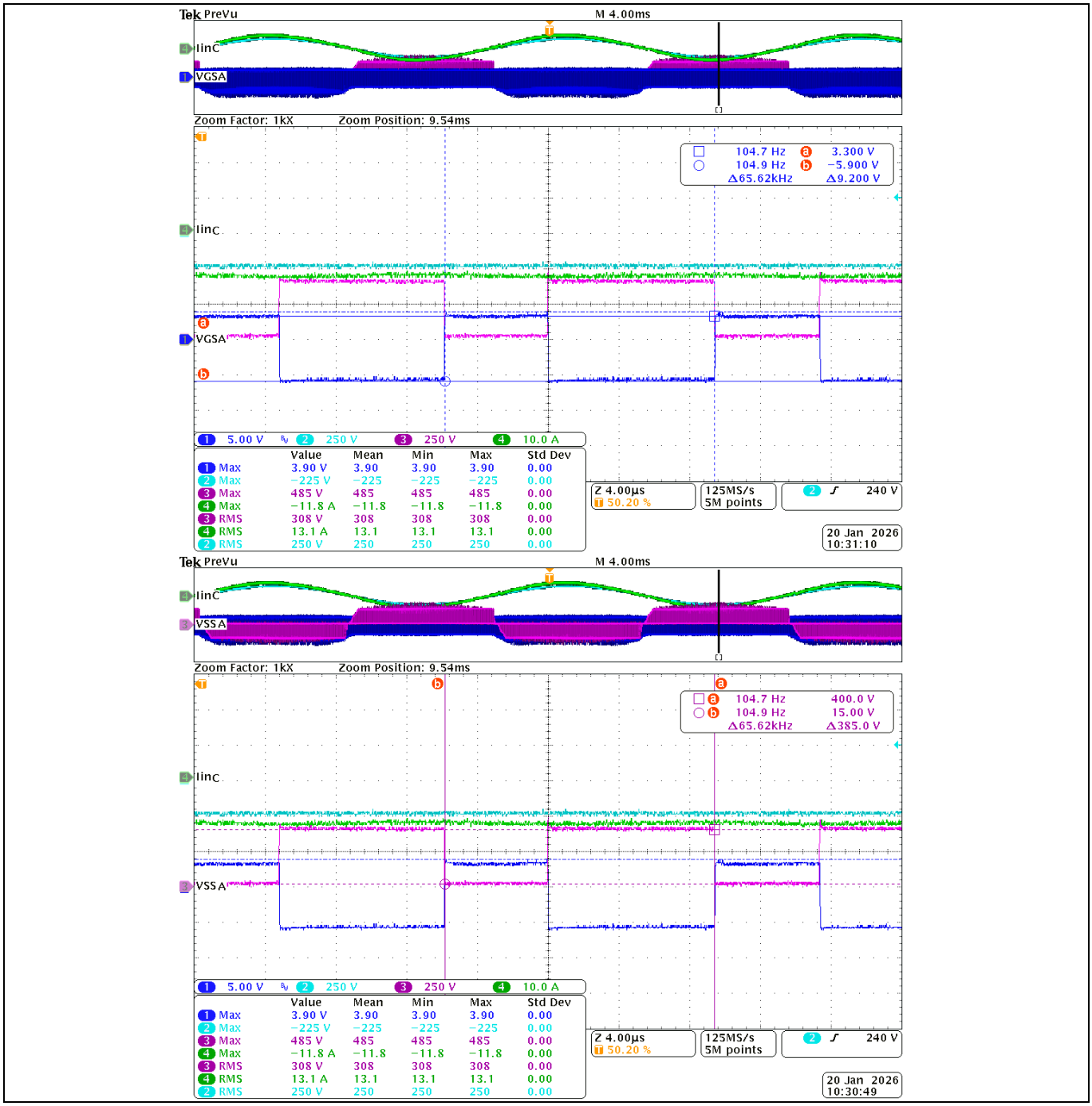


Figure 21 Peak of the negative half-cycle at 176 VAC, zoom in

3 Measurement results

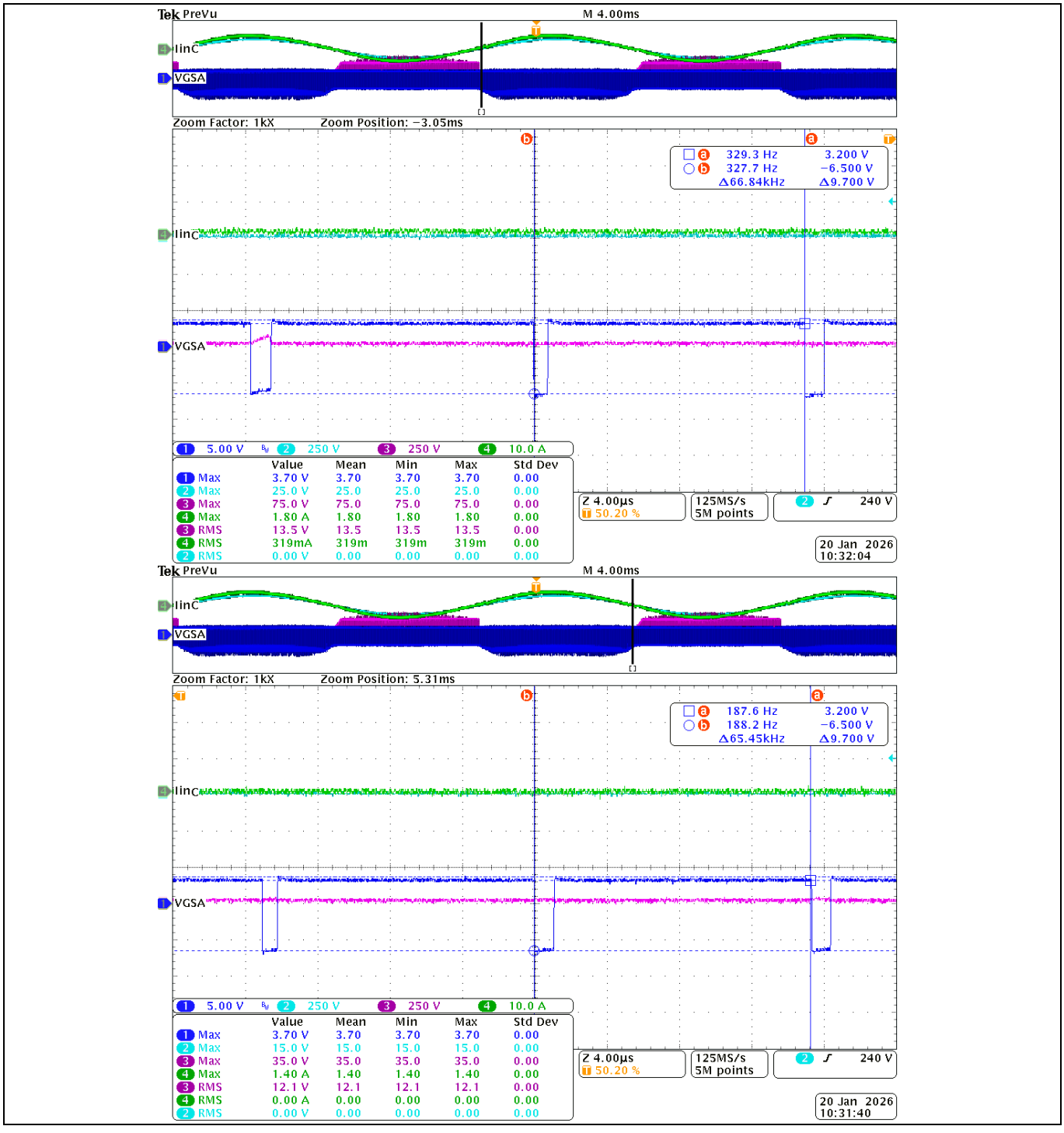


Figure 22 Zero-crossing point at 176 VAC, zoom in

3 Measurement results

AC-ZVS BDS demonstration board configuration for H4 PFC:

- V_{ACin} = 230 VAC
- F_{grid} = 60 Hz
- f_{sw} = 65 kHz
- V_{out} = 400 V
- P_{load} = 1600 W

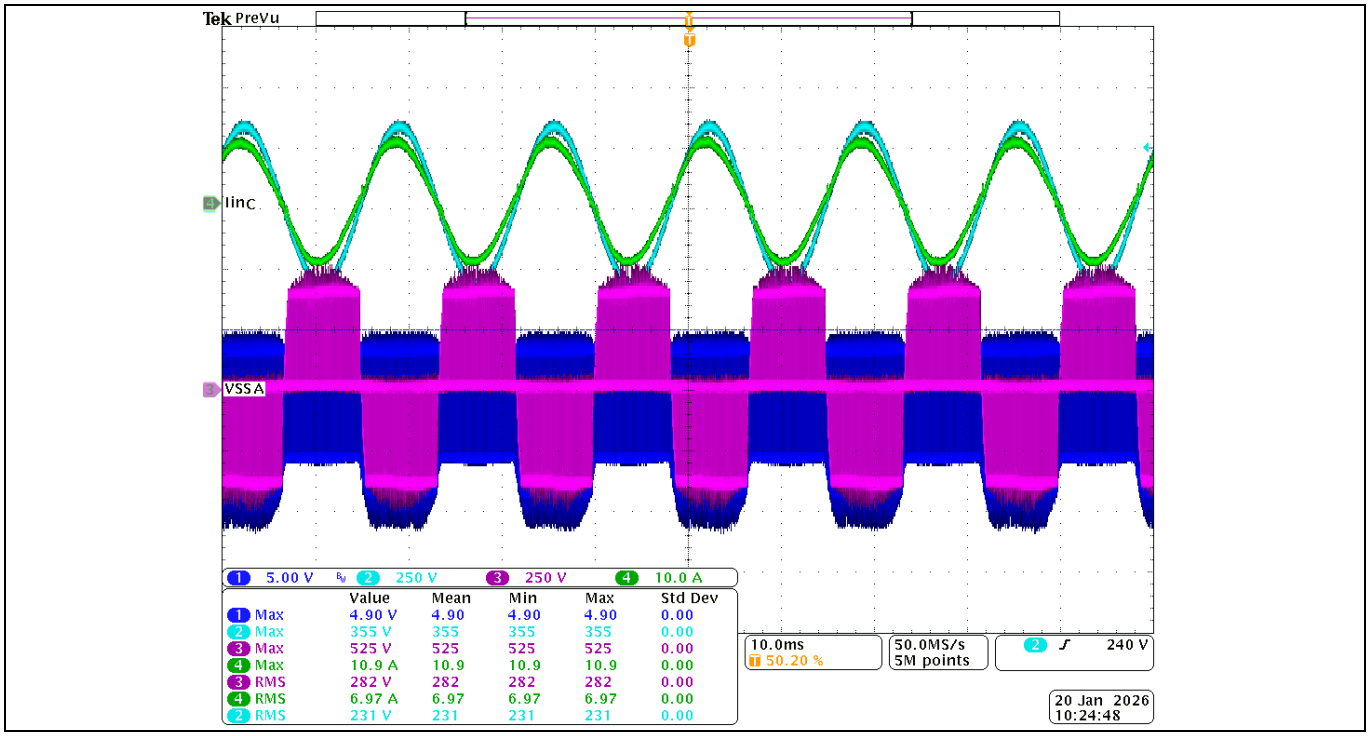


Figure 23 Typical operating waveform at 230 VAC

3 Measurement results

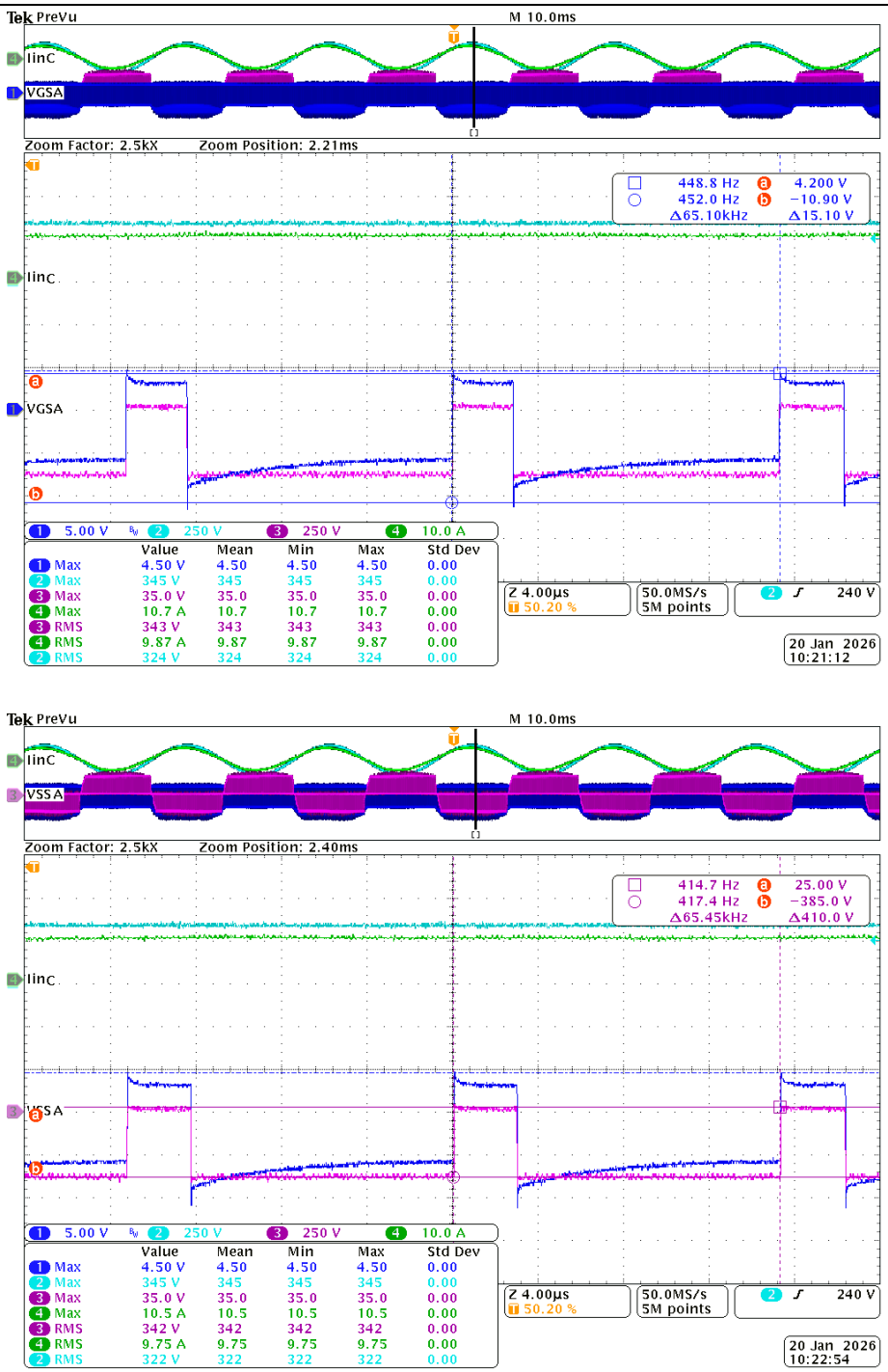


Figure 24 Peak of positive half-cycle at 230 VAC

3 Measurement results

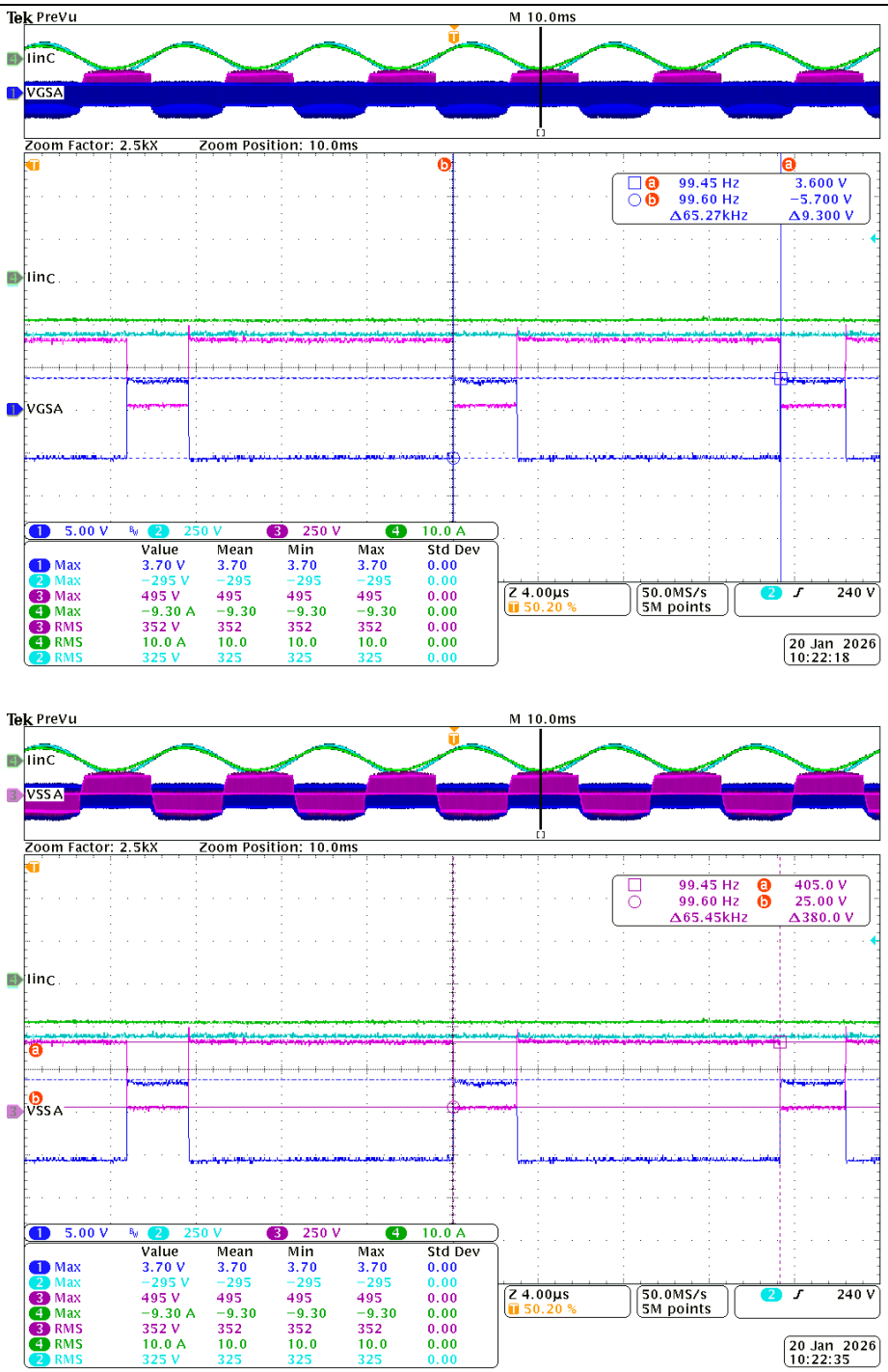


Figure 25 Peak of the negative half-cycle at 230 VAC

3 Measurement results

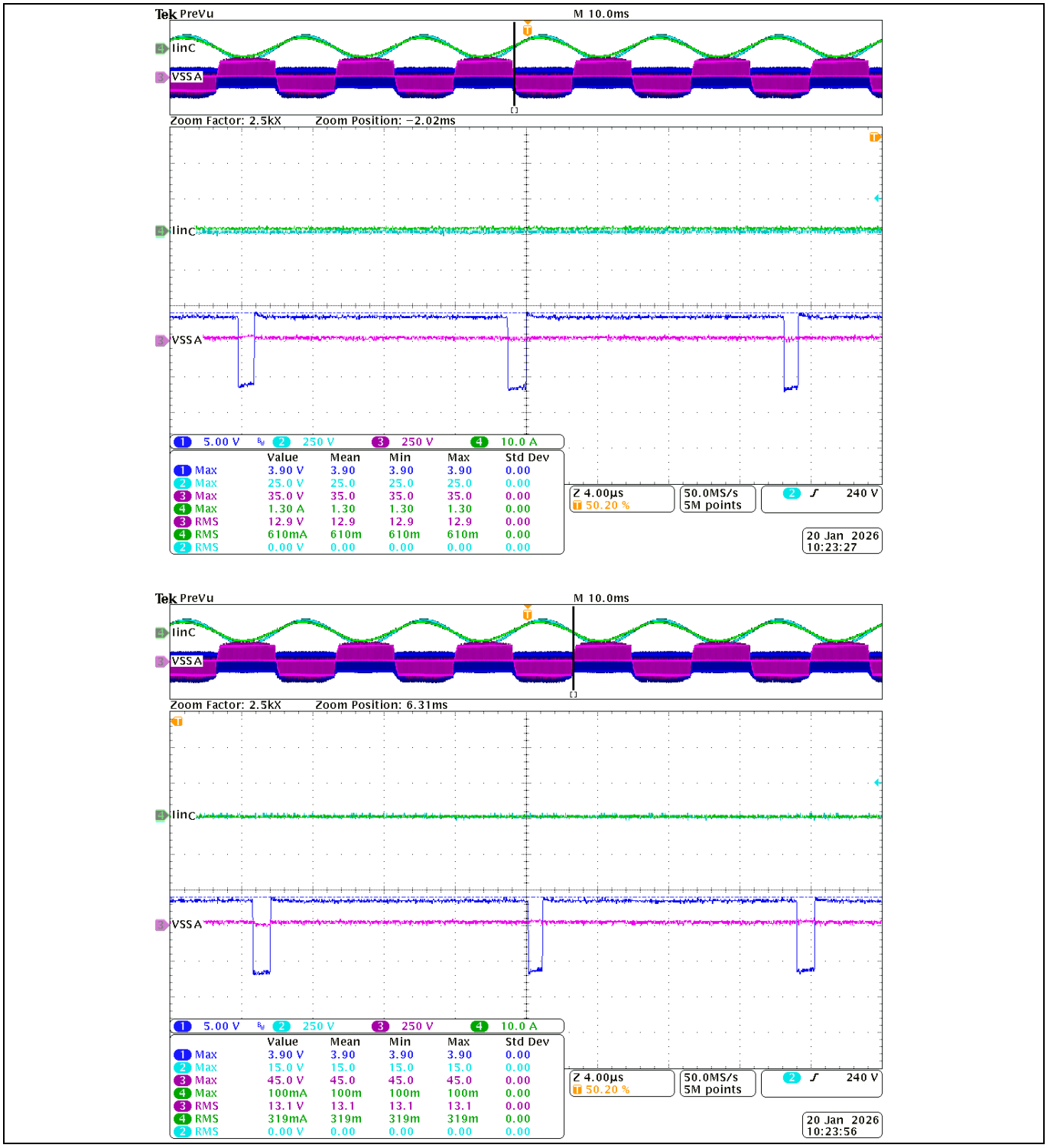


Figure 26 Zero-crossing point at 230 VAC

References

[1] Infineon Technologies AG: *1.6 kW Titanium PSU with CoolMOS™ 600 V CFD7, Q-DPAK, and XMC™*; Available online

[2] Infineon Technologies AG: *Isolated gate driver IC with a configurable isolated bias supply for GaN HEMTs*; Available online

[3] Infineon Technologies AG: *CoolGaN™ bidirectional switch 650 V G5 demo board user guide*; Available online

[4] Infineon Technologies AG: *CoolMOS™ G7 and CoolSiC™ G6 will come in a new top-side cooling package the DDPAK. A new option of integration*; Available online

[5] Infineon Technologies AG: *600 V CoolMOS™ CFD7 comes in a new top-side cooling package the QDPAK. A further option for integration*; Available online

[6] Infineon Technologies AG: *Whitepaper – Gate drive configurations for GaN power transistors*; Available online

[7] Infineon Technologies AG: *Optimizing PCB layout for CoolGaN™ power transistors in SMPS applications*; Available online

Revision history

Document revision	Date	Description of changes
V 1.0	2026-02-11	Initial release

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Safety & Operating Instructions:
Customer shall check the Evaluation Board for any physical damage which may have occurred during transport. If customer detects any damages or defects in the Evaluation Board, customer shall not connect the Evaluation Board to a power source. Customer shall contact Infineon for further support. If customer observes unusual operating behavior during the evaluation process, customer shall immediately shut off the power supply to the Evaluation Board and consult Infineon for support.
Customer shall not touch the Evaluation Board during operation and keep a safe distance.
Customer shall not touch the Evaluation Board after disconnecting the power supply, several components may still store electrical voltage and can discharge through physical contact. Several parts, like heat sinks and transformers, may still be very hot. Allow the components to cool before touching or servicing.
The electrical installation must be completed in accordance with the appropriate safety requirements.