EVAL-FFXMR20W2M1HX

2 kV CoolSiC™ EasyDUAL™ 2B Evaluation Board

User guide

UG-2024-22

About this document

The purpose of this board is to enable the evaluation of the FF6MR20W2M1H CoolSiC™ MOSFET module in combination with 1ED3890MC12M gate driver. The evaluation board allows users to evaluate the device performance via double-pulse measurements.

Scope and purpose

This user guide describes EVAL-FFXMR20W2M1HX evaluation board, its main features, key data, pin assignments, mechanical dimensions, and electrical interfaces. The board allows the user to characterize the modules for a DC-link up to 1500 V. The board has two variants:

1. EVAL-FFXMR20W2M1HS: EVAL-FFXMR20W2M1H Power board suitable for using a coaxial shunt for drain current measurement + EVAL-FFXMR20WXM1H gate driver board with 1ED3890MC12M gate driver
2. EVAL-FFXMR20W2M1HR: EVAL-FFXMR20W2M1H Power board equipped with holes suitable for a Rogowski coil for drain current measurement + EVAL-FFXMR20WXM1H gate driver board with 1ED3890MC12M gate driver

Intended audience

This document is intended for engineers who want to evaluate the performance of Infineon's latest 2kV FF6MR20W2M1H CoolSiC™ MOSFET module in combination with 1ED3890MC12M gate driver.

Evaluation board

This board will be used during design-in, for evaluation and measurement of device switching characteristics.

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

Figure 1 Realistic view of the EVAL-FFXMR20W2M1HS

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Safety precautions

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

Table 1 Safety precautions

	**Warning:** *The DC link potential of this board is up to 1500 VDC. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death. The board only offers functional isolation between the power and user interface*
	**Warning:** *The user must measure and check that the DC-link voltage has fallen to zero before touching the boards*
	**Caution:** *Only personnel familiar with power electronics 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:** *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 The evaluation board at a glance

The evaluation board EVAL-FFXMR20W2M1HX allows the customer to begin initial characterization measurements very quickly. Due to the usage of the EiceDRIVER™ 1ED38x0Mc12M and its flexible parameter setting options via I2C-BUS. This flexible parameter settings are provided by configuration registers accessible via I2C. These configuration options influence many thresholds and timing paramaters to optimize the circuit for its intended application. In addition to the flexible parameter setting options via I2C-BUS, the EiceDRIVER™ 1ED38x0Mc12M contains 16 status registers. These can also be read out via the I2C-BUS and can therefore provide information about various states of the driver stage. For more information we refer to the EiceDRIVER™ 1ED38x0Mc12M reference manual here.

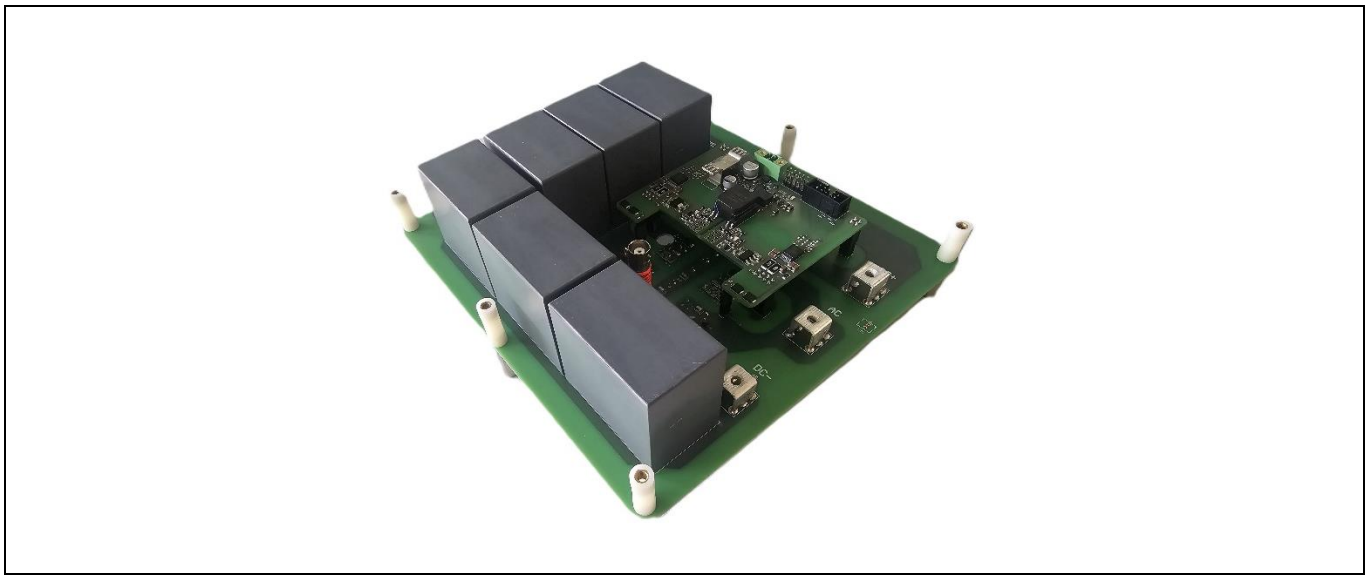

Figure 2 Realistic view of the EVAL-FFXMR20W2M1HS

1.1 Block diagram

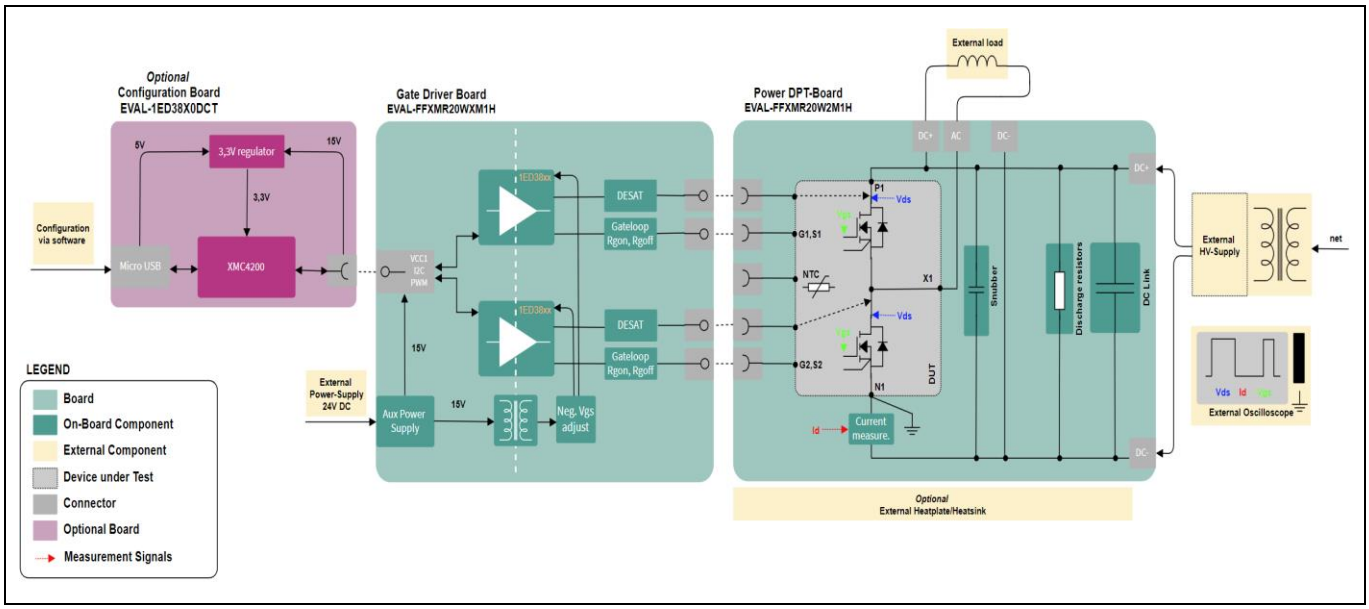

Figure 3 Complete evaluation system consisting of the 2 kV Easy 2B module power board, gate driver board and the additional EVAL-1ED38X0DCT as the control and configuration stage.

The evaluation board at a glance

The EVAL board EVAL-FFXMR20W2M1HX comprises the power board and the gate driver board shown in the figure 2 and 3. The two boards are connected together using board-to-board connectors. An additional microcontroller board EVAL-1ED38X0DCT that is purchased separately is used as the control stage to easily configure the gate drivers and generate the required PWM signals for double pulse testing (DPT).

Note: The microcontroller board EVAL-1ED38X0DCT is needed for operation. The board has to be purchased separately

Table 2 DPT board Specifications

Parameter	Minimum	Typical	Maximum	Unit
DC-link voltage	0	800	1500	V_{dc}
Current	Suitable only for DPT up to 400 A			
Recommended pulse width for the second pulse	2		10	µs

Table 3 Board variants

EVAL-FFXMR20W2M1HX	
EVAL-FFXMR20W2M1HS	**EVAL-FFXMR20W2M1HR**
EVAL-FFXMR20W2M1H Power board with pads suitable for a coaxial shunt for drain current measurement	EVAL-FFXMR20W2M1H Power board equipped with holes suitable for a Rogowski coil for drain current measurement
EVAL-FFXMR20WXM1H gate driver board with 1ED3890MC12M gate driver	EVAL-FFXMR20WXM1H gate driver board with 1ED3890MC12M gate driver

2 Power board

2.1 Features

There are two variants for the power board, the main difference is the method provided to measure the drain current of the MOSFET.

Table 4 Board variants

EVAL-FFXMR20W2M1HS	Pads suitable for a coaxial shunt placement
EVAL-FFXMR20W2M1HR	Holes suitable to be used with a Rogowski coil

Note: The boards don't come with the Rogowski coil or the coaxial shunt. The Rogowski coil and the coaxial shunt have to be purchased by the user separately.

Table 5 Coaxial shunt

Part number	Supplier
SSDN-005 M4x 12mm	Ing. Büro M. Billmann

The power board comes along with:

- 132 µF bulk film capacitance
- FF6MR20W2M1H pressed-in module
- Optional unpopulated 6 x 5.6 nF snubber ceramic capacitors
- Power connectors for external HV supply
- Power connectors for external inductor
- Signal connectors for gate-drive signals, active miller clamp and DESAT connections
- Through-hole and SMD test points for (V_{ds}, V_{gs}) measurements
- Optional unpopulated MMCX connectors for V_{gs}

2.1.1 EVAL-FFXMR20W2M1HS power board

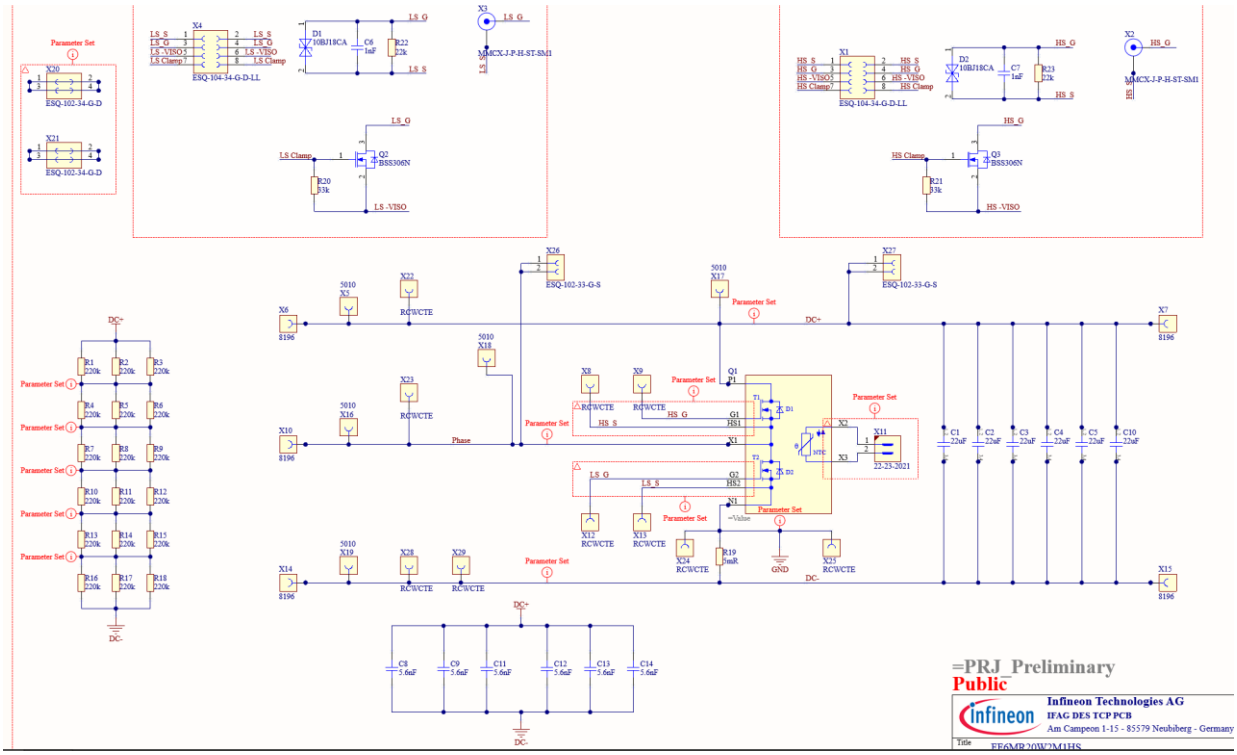

Figure 4 EVAL-FFXMR20W2M1HS schematics

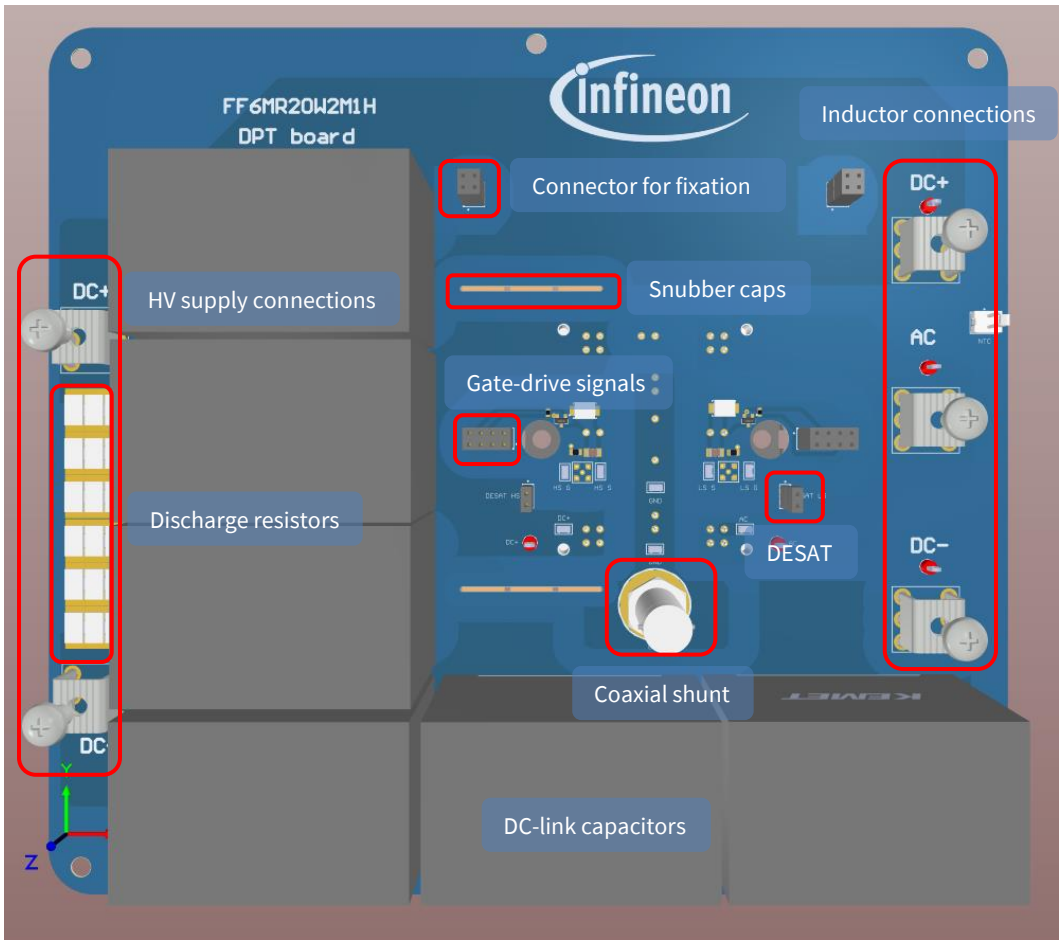

Figure 5 EVAL-FFXMR20W2M1HS power board

2.1.2 EVAL-FFXMR20W2M1HR power board

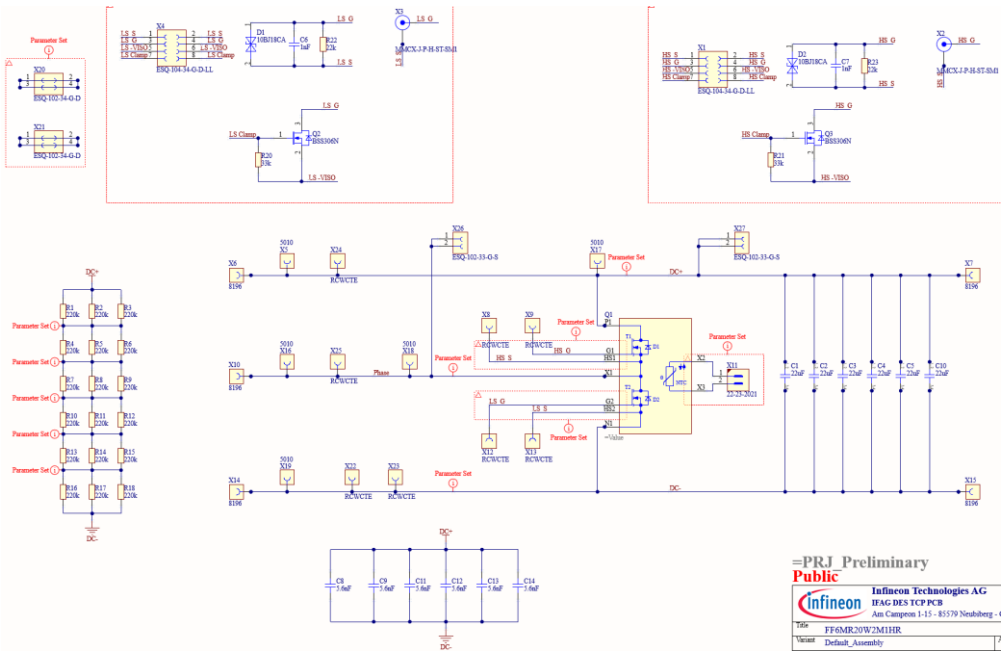

Figure 6 EVAL-FFXMR20W2M1HR schematics

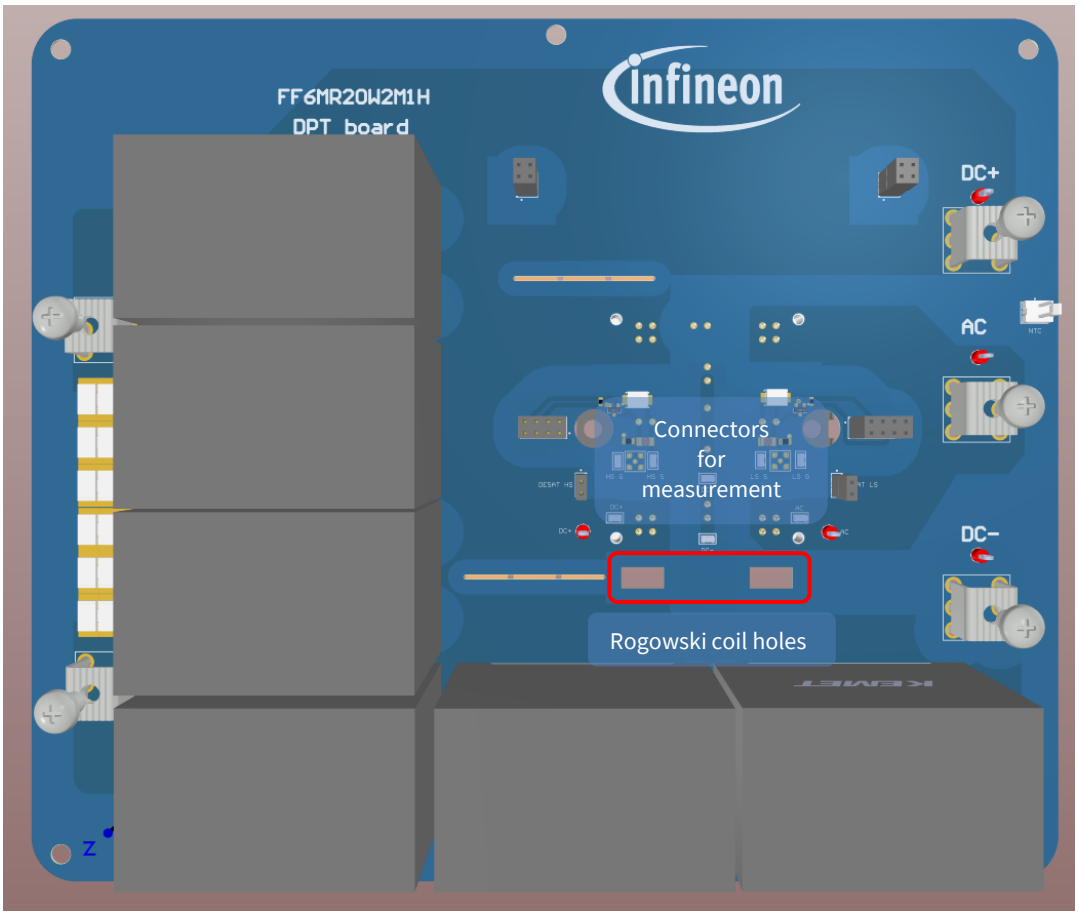

Figure 7 EVAL-FFXMR20W2M1HR power board

For both board variants a pin header connection to the NTC inside the module is provided. To further use the NTC please refer to AN2009-10 [1].

For information regarding pressing the power module please refer to AN2023-07 [2].

3 Gate driver board

The following figure shows the functional blocks of the gate driver board. Proper gate resistors need to be soldered onto the board, based on the application's switching conditions.

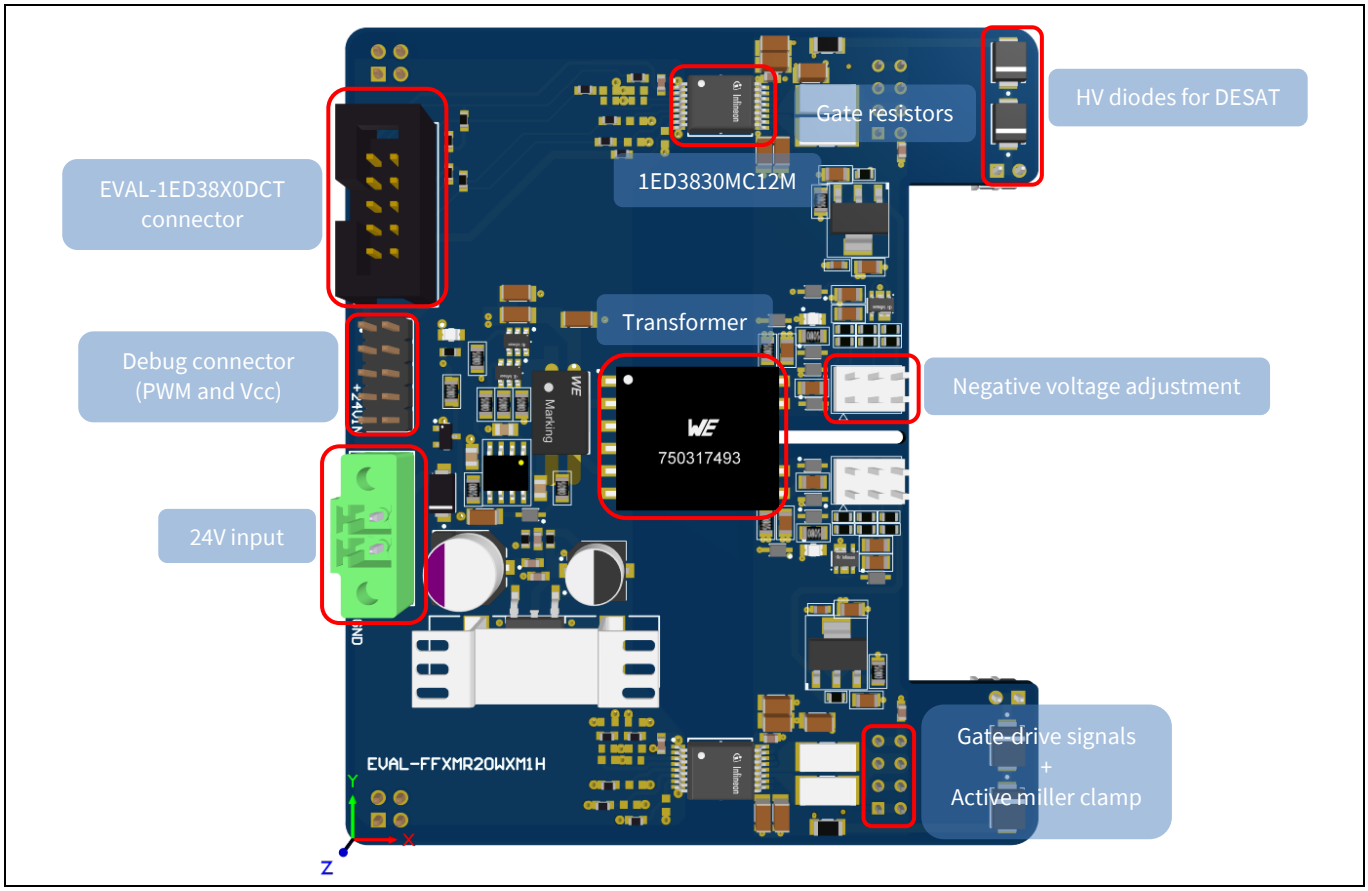

Figure 8 Overview of the functional blocks of the EVAL-FFXMR20KM1HDR

The main features of the board and gate driver include:

- Driver IC 1ED3890MC12M or 1ED3890MU12M (X3 digital) with I^2C bus for parameter adjustment
- The X3 digital gate driver can also be changed to the X3 analog gate driver through adding and removing some 0-ohm resistors specifically R4, R13, R14, R51, R23 and R43. The testing has been performed only on the X3D version
- Negative voltage adjustment from -5 V to 0 V through jumpers
- Separate source and sink output for optimized gate driving
- Adjustable clamp/clamp driver/ADC pin
- I^2C bus for parameter adjustment, state and fault feedback, ADC measurements, and condition monitoring

3.1 Board parameters and technical data

Table 6 Gate driver board parameters

Parameter	Symbol	Conditions	Value	Unit
Power supply input voltage	Vin	Referenced to SGND	+24	V
Primary side supply voltage	VCC1	Referenced to SGND. Not to be used with EiceDRIVER™ Eval-1ED38x0DCT	-0.3 … 6.5	V
I^2C Serial Clock Line	SCL	Referenced to SGND	-0.3 … 6.5	V
I^2C Serial Data Line	SDA	Referenced to SGND	-0.3 … 6.5	V
Ready state output/ fault-clear input and fault-off input	RDYC	Input/Output digital signal. Referenced to SGND	-0.3 … 6.5	V
Fault output/ fault-off input	FLT#	Input/Output Digital signal. Referenced to SGND	-0.3 … 6.5	V
PWM input for the high-side gate driver	IN_HS	Referenced to SGND	-0.3 … 6.5	V
PWM input for the low-side gate driver	IN_LS	Referenced to SGND	-0.3 … 6.5	V
Secondary side positive supply voltages	VCC2H/ VCC2L	Referenced to VEE2H/VEE2L. Not to be used with power supply circuit enabled	-0.3 … 40	V
Secondary side negative supply voltages	VEE2H/ VEE2L	Referenced to GND2H/GND2L. Not to be used with power supply circuit enabled	-40 … 0.3	V

3.2 Schematics

3.2.1 Power supply

An external 24 V is needed to power up the board. The 24 V is then fed to an adjustable voltage regulator to generate a voltage of up to 18 V depending on load conditions. This voltage is used to generate the positive voltage rail for the gate-driver circuit. The positive voltage can also be adjusted by the user through changing the resistor R38.

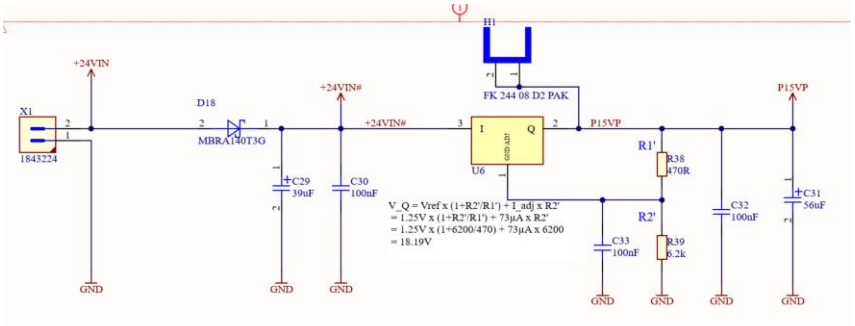

Figure 9 Power supply

Afterwards the output is fed to a half-bridge isolated DC-DC converter where the secondary side has two windings. Each winding is used for one gate driver.

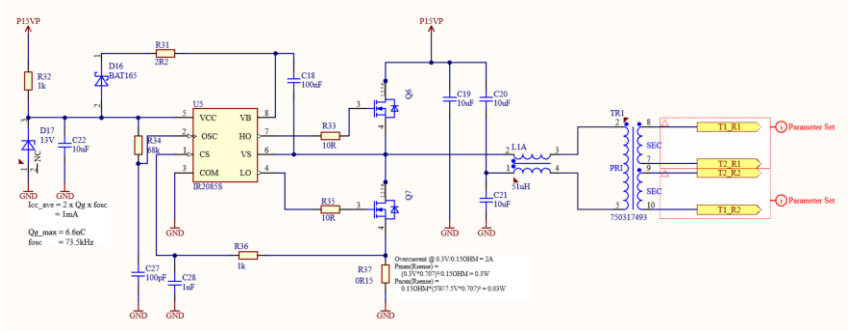

Figure 10 Half-bridge circuit

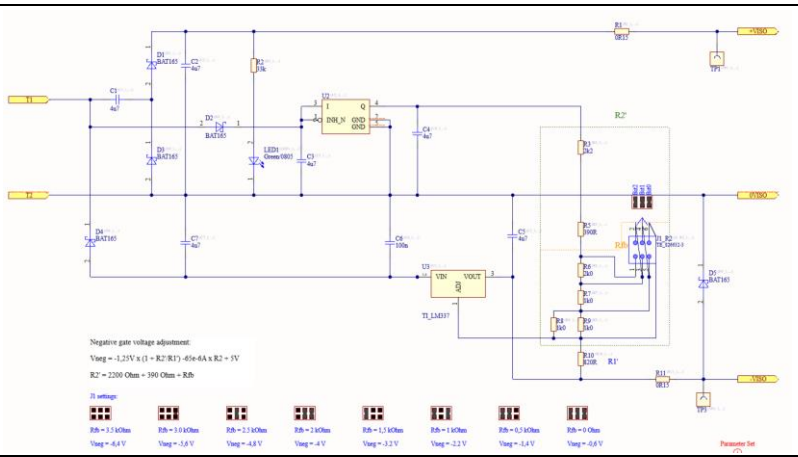

Figure 11 Rectifier

The on-board isolated DC/DC converter generates an output voltage of up to 18 V depending on the load conditions. The positive voltage is fed to the secondary side of the driver circuit directly, whereas the negative voltage is adjustable using the jumper settings shown in the figure below.

Figure 12 Jumper settings for the negative voltage adjustment V_{neg}

The adjustable output voltage (Vneg) can be calculated by the equation given below.

$$Vneg = -1.25\text{V} * \left(1 + \frac{\text{R2}'}{\text{R1}'}\right) - 65 * 10^{-6} A * R2 + 5V, where\ R2' = 2.2k\Omega + 390\Omega + Rfb$$

Equation 1 Equation to calculate *Vneg* for the negative gate voltage adjustment

3.2.2 Gate driver

3.2.2.1 Interfaces

The connector X2 can be used to interface the gate driver board with EVAL-1ED38X0DCT which can be used to control the board. The connector X3 is there for the user to check important signals like 5V rail and PWM signals.

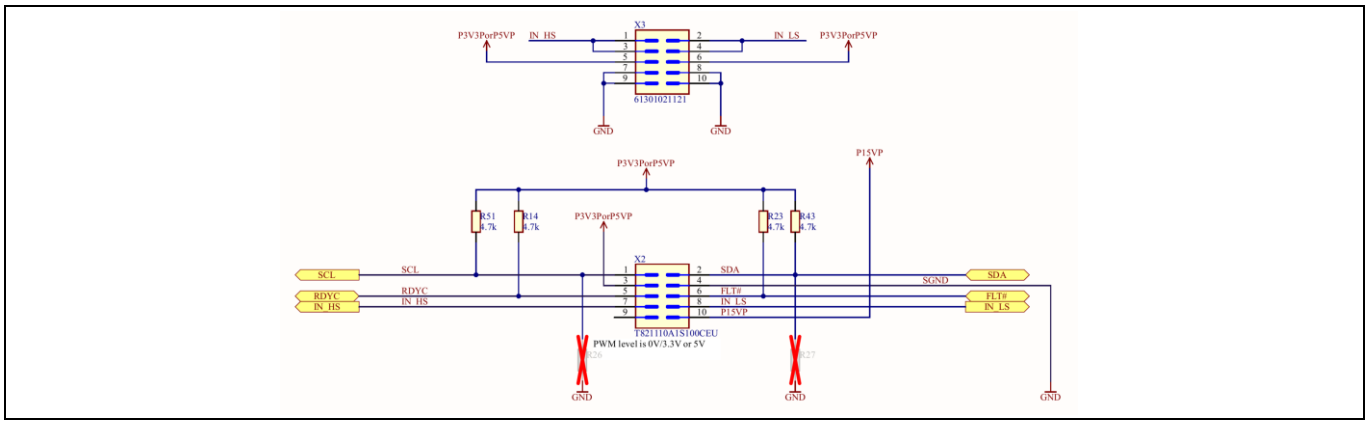

Figure 13 Gate driver board interfaces

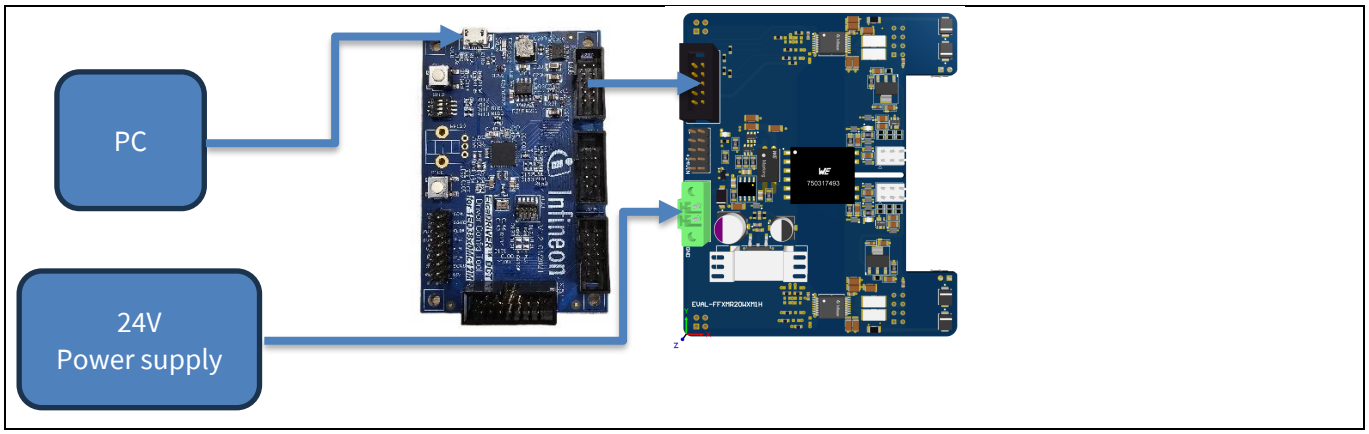

Figure 14 Interfacing EVAL-1ED38X0DCT with EVAL-FFXMR20WXM1H

Disclaimer: The microcontroller board provides no isolation. The combination of the microcontroller board and the power board only provide **functional** isolation.

3.2.2.2 Gate drive circuit

The gate driver schematic can be seen in the following figure. The gate driver board comes with a 9.1 Ω turn-on resistor and a 2.2 Ω turn-off resistors. These are the resistors Infineon used to characterize this module. The user can desolder and resolder other resistors to evaluate the module at other operating points. Two high voltage diodes are placed in series to be connected to the drain of the MOSFETs for DESAT detection.

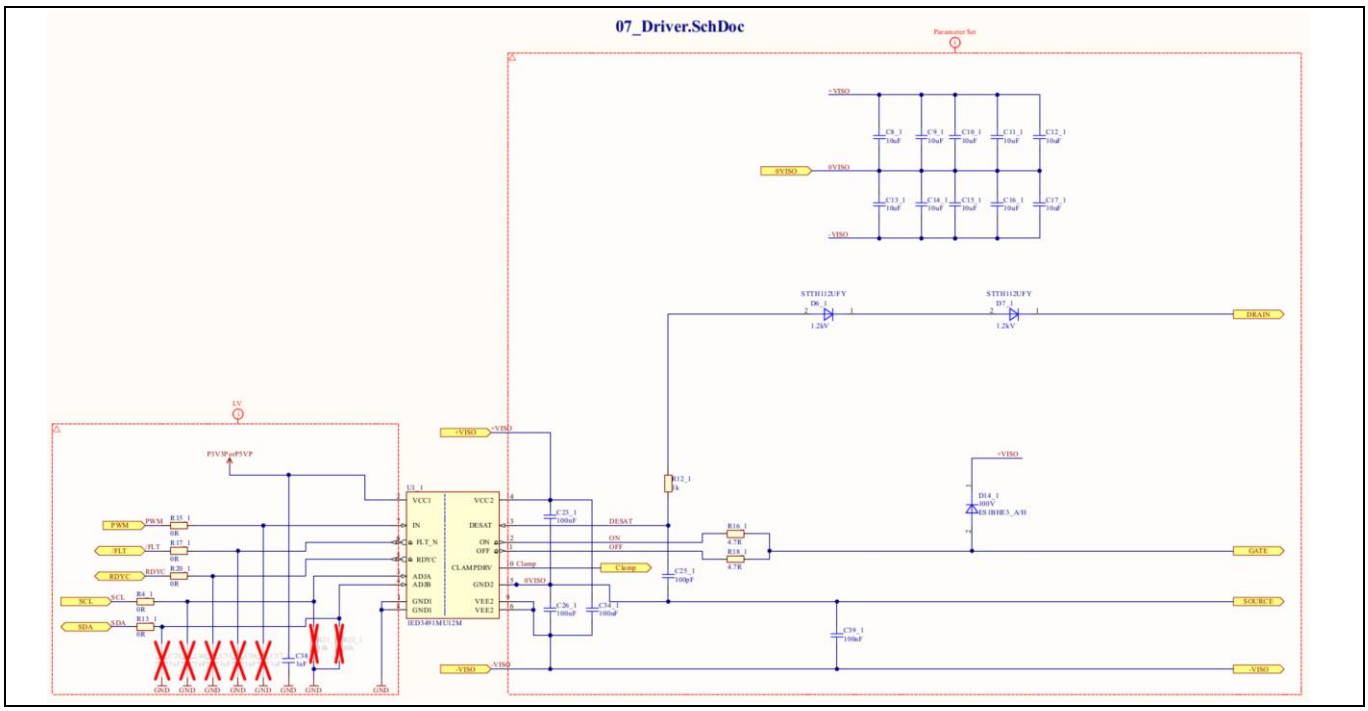

Figure 15 Gate driver

4 Testing

4.1 Prerequisites

- PC with Windows 7 or higher with Infineon XMC USB driver installed
- EiceDRIVER™ 1ED38x0 DCT software installed
- USB A to micro-USB cable
- EiceDRIVER™ Eval-1ED38x0DCT microcontroller board
- EVAL-FFXMR20WXM1H
- Low-voltage power supply for supplying primary-side power supply circuit, capable of supplying 24 V
- High-voltage power supply for supplying the power stage
- A suitable inductive load for double-pulse testing

Note:

- The µC board EiceDRIVER™ Eval-1ED38x0DCT has to be purchased separately
- EiceDRIVER™ Eval-1ED38x0DCT is only used in the context of double pulse testing in this user guide
- EiceDRIVER™ Eval-1ED38x0DCT has many other features that are not addressed in this user guide, a detailed explanation can be found here.

4.2 EiceDRIVER™ 1ED38x0 DCT software installation process

The following steps are required to install the EiceDRIVER™ 1ED38x0 DCT software. The same process should be used for downloading future software updates.

If the Infineon toolbox is already installed, please jump to step 3.

1. Visit www.infineon.com/toolbox and download the latest version
2. Start the toolbox
3. Search for “EiceDRIVER 1ED38x0 DCT”
4. Install the software
5. Locate the installation directory and find the USB device drivers
6. Install the XMC USB drivers

4.3 Evaluation of the EVAL-FFXMR20WXM1H with another microcontroller

While not recommended to new users or for fast evaluation, the EVAL-FFXMR20WXM1H can be used with any microcontroller capable of communicating over I^2C and generating PWM signals. For this, it is important to read the documentation, especially the reference manual, of the gate drivers. Special care should be taken when reviewing the I^2C section, where the byte format, read/write operation and initial addressing are described. The EiceDRIVER™ 1ED38x0 DCT can be used to configure the registers and export them.

4.4 Power-up sequence

Attention: Be very carerful when connecting and disconnecting the Eval-1ED38x0DCT board and the EVAL-FFXMR20WXM1H. This should be done without power being supplied to any of the boards.

1. Connect the EiceDRIVER™ 1ED38x0 DCT (connector X150) to the connector X2 of the EVAL-FFXMR20WXM1H via the ribbon cable.
2. Connect the EiceDRIVER™ 1ED38x0 DCT via the USB cable to the computer used for configuration.
3. Make sure that your test setup, e.g. DC-Link, or inductive load is connected properly.
4. Supply the input side power supply according to table 4.

5. The green LEDs will turn on to signal that the voltages are present.
   Note: One problem you might face is that your PC might not recognize the hardware. To fix this issue go to the device manager on your PC and update the USB driver using the directory where the GUI app is located on your PC. Alternatively, you can double click on the setup-information to update the driver. This setup-information is stored in the driver-folder of the Eice-Driver installation.
6. Start the GUI-software for the EiceDRIVER™ 1ED38x0 DCT.exe.
7. Press the “Quick-Start” button (Comes up if every thing works correctly – see Figures 16 and 17)
8. If the GUI is connected correctly with the EiceDRIVER™ Eval-1ED38x0DCT microcontroller board and the EVAL-FFXMR20WXM1H, the landing page will change as shown in Figure 17.
9. Use the GUI to configure the gate drivers corresponding to your requirements.

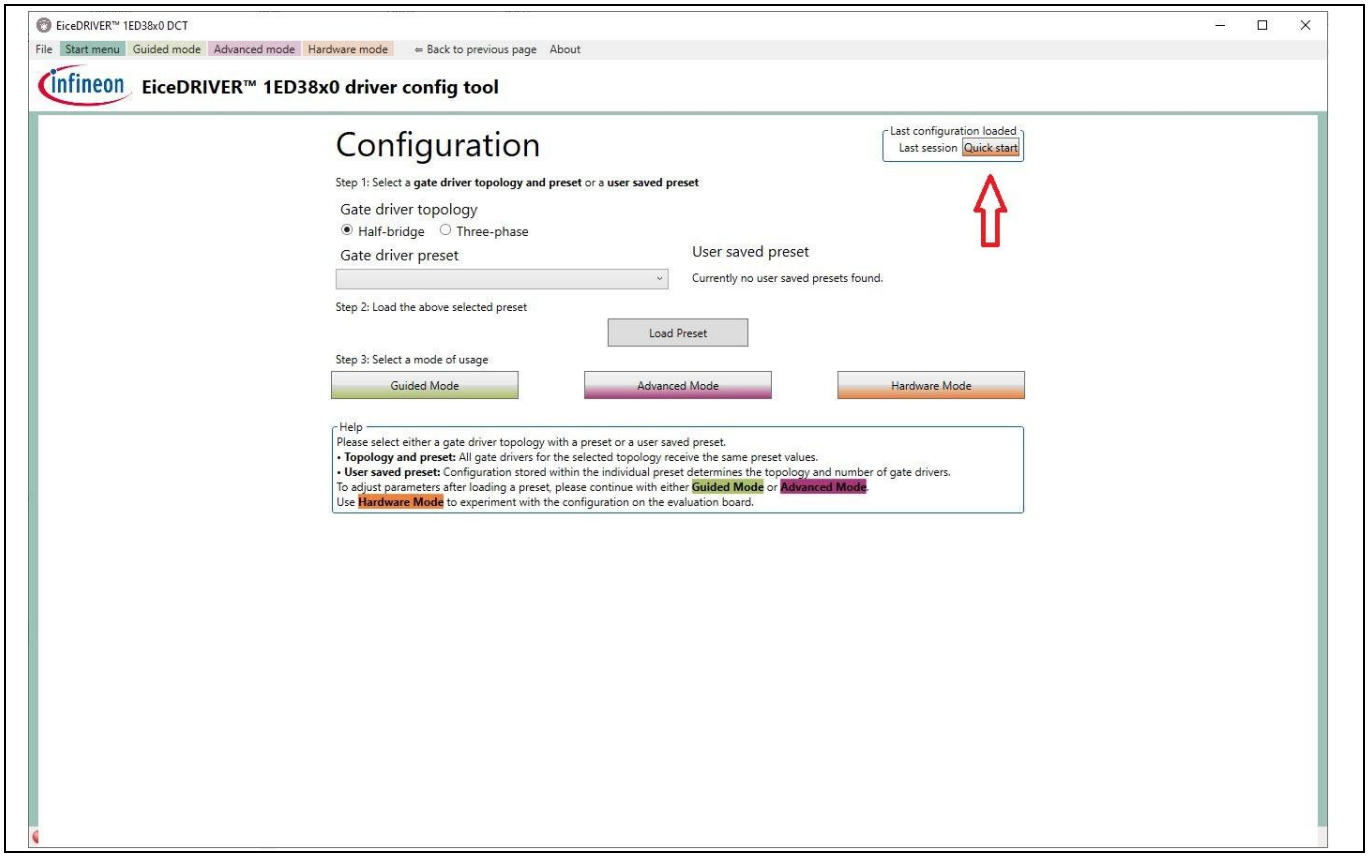

Figure 16 Landing page after starting the GUI 1ED38x0_DCT.exe

Figure 18 shows the landing page that is available once the communication between the computer, the EiceDRIVER™ Eval-1ED38x0DCT and the EVAL-FFXMR20KM1HDR is working.

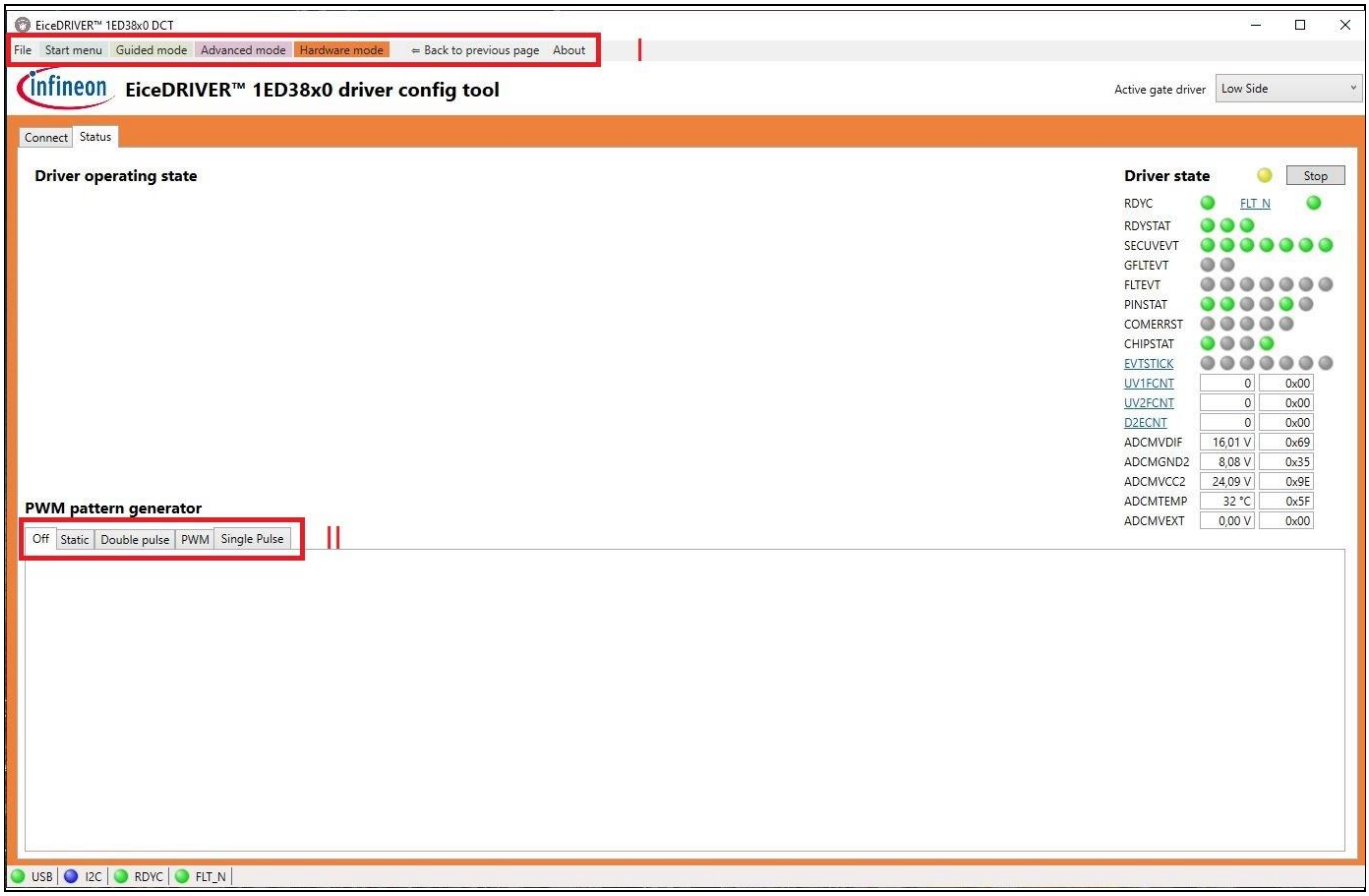

Figure 17 Landing page if GUI is connected with the DCT-board and the EVAL-FFXMR20KM1HDR

The landing page as shown in Figure 1717 can be separated into two sections. The top bar that is used to set up the registers of the gate driver via the I^2C bus.

The display on the right shows status signals and registers contents. If you move the PC mouse over the names of the corresponding registers, the contents are briefly explained.

The bottom section of the page offers the user various control functions. Either the static switching, double pulse or the PWM signals can be used, whereby the frequencies and the duty cycle can be freely selected within certain limits. **For this board only the double pulse tab should be used.** The following figure shows the double pulse tab. It allows the user to set the pulse width of the first and the second pulse and also to choose the high side (HS) or the low side (LS) switch.

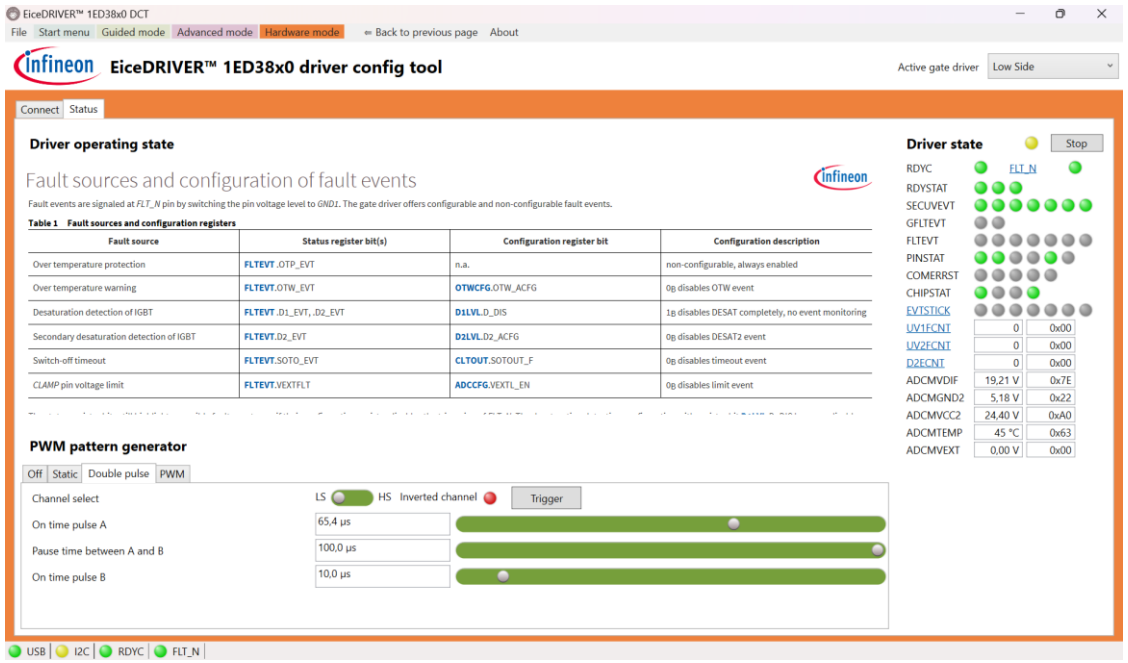

Figure 18 DPT settings

4.5 Introduction to EiceDRIVER™ 1ED38x0 DCT

The user guide focuses mainly on the power board and the DPT function of the control board GUI. This chapter will provide a short overview of the EiceDRIVER™ 1ED38x0 DCT, for a detailed explanation of the software please read the EiceDRIVER™ 1ED38x0 DCT user guide.

The EiceDRIVER™ 1ED38x0 DCTdriver IC is highly configurable via I^2C. In order to familiarize yourself with it, and to easily evaluate its performance, the EiceDRIVER™ 1ED38x0 DCT microcontroller board can be used with the EVAL-FFXMR20KM1HDR. It is recommended that first-time users select the guided mode, as this also provides a detailed explanation for each configurable parameter as shown in Figure 19.

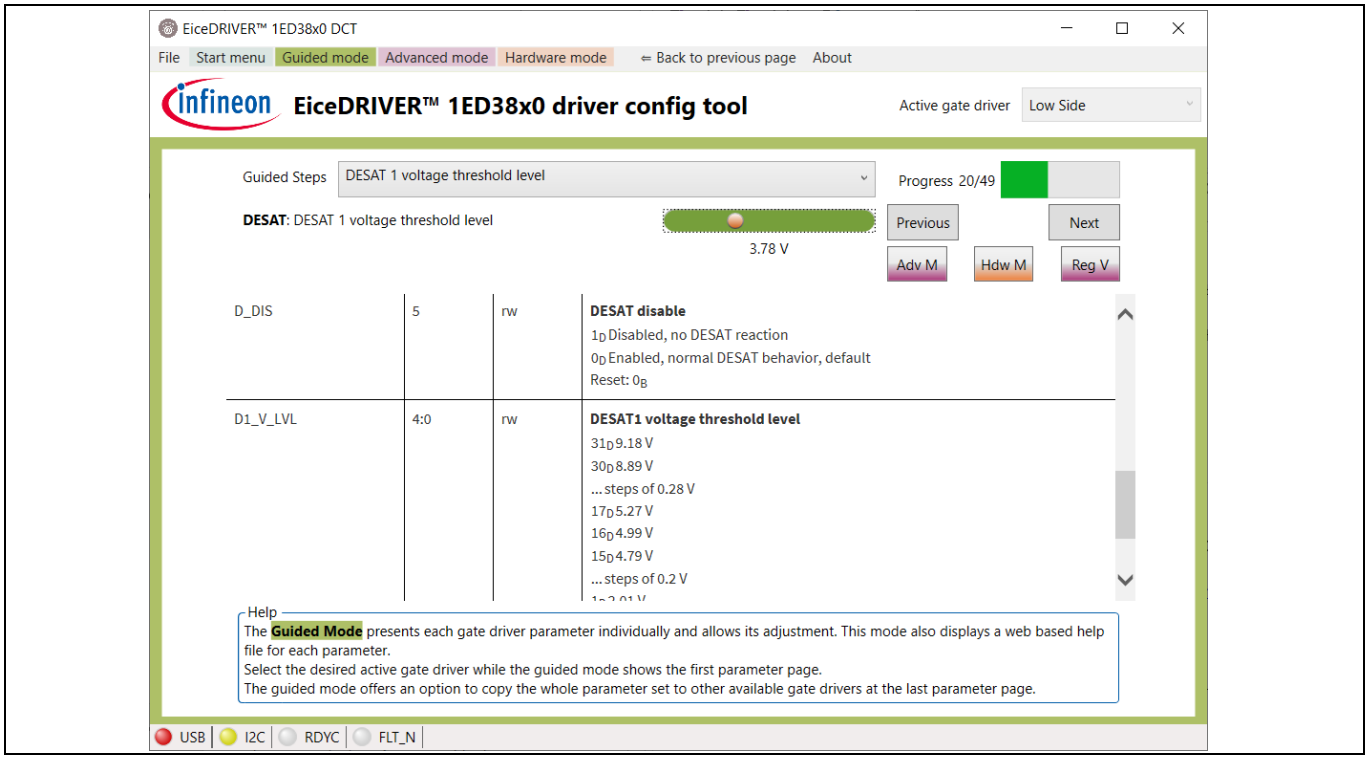

Figure 19 Example: DESAT 1 voltage threshold level of the guided mode

Figure 19 shows the guided mode with more details on how to configure the threshold level of the DESAT 1 function for example. Besides that, the advanced mode can be used as shown in Figure 20.

Please read the reference manual of the EiceDRIVER™ 1ED38x0Mc12M to get detailed information on the various functions of the X3 digital gate driver.

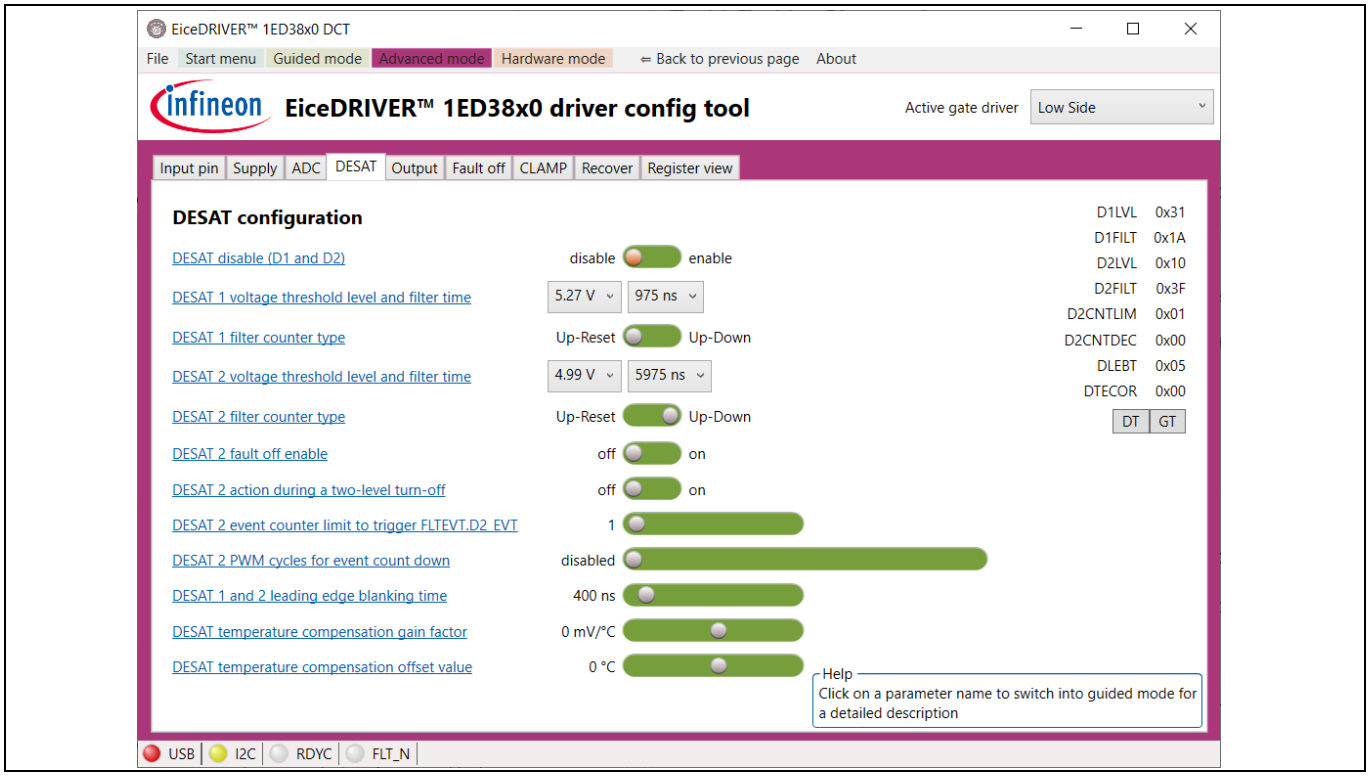

Figure 20 Example: DESAT configuration table of the advanced mode

4.6 Double pulse test results

In this section several waveforms are captured under different conditions highlighting the excellent switching performance with low oscillations of the FF6MR20W2M1H module.

The following measurements are done on the low-side switch.

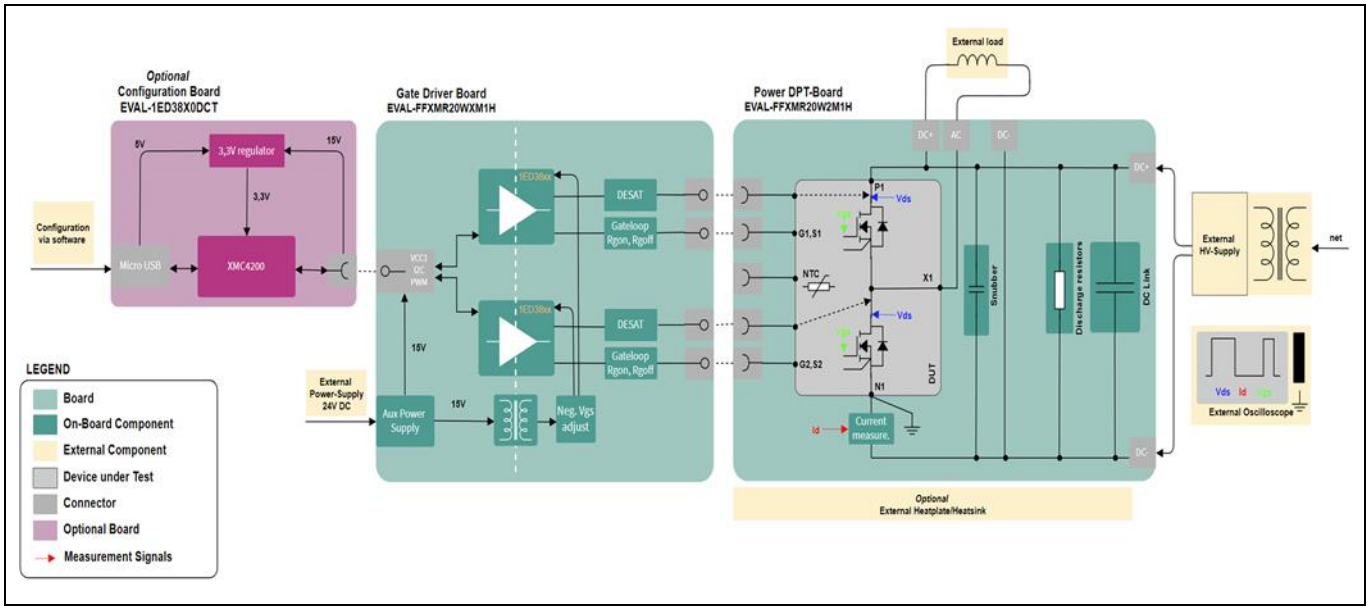

Figure 21 DPT setup block diagram

Test setup:

For information on how to do a double pulse test, please refer to the following document [1].

1. High voltage source up to 1500 V
2. Variable inductance between 800 µH and 20 µH
3. Heating plate up to 175 °C
4. PC and a USB cable

For information on how to perform double pulse testing, please refer to [3].

Note: The DC-link is equipped with a discharge resistor with a total value of 440 kΩ. The user must wait and ensure that the voltage of the DC-link is at a safe level before touching the board after use. The user can also change the values of the discharge resistors to have a smaller discharge time.

Note: Oscillations on the gate-source voltage waveforms can be reduced by making the measurement loop smaller as some of these oscillations are mainly measurement errors.

4.6.1 EVAL-FFXMR20W2M1HR

5. Oscilloscope probes:
   - Channel 1 (V_{ds}): PMK PHV 642-L

     Remark: The DUT had no direct connection to the mains: No measurement category according to IEC 61010-031. In other cases, the maximum rated voltage needs to be reduced, please refer to the probe supplier instructions

- Channel 2 (I_d): Rogowski CWTUM/3/B **(Additional silicon tube isolation is needed)**
- Channel 3 (V_{gs}): Tek P6139B

4.6.1.1 Turn-on waveforms

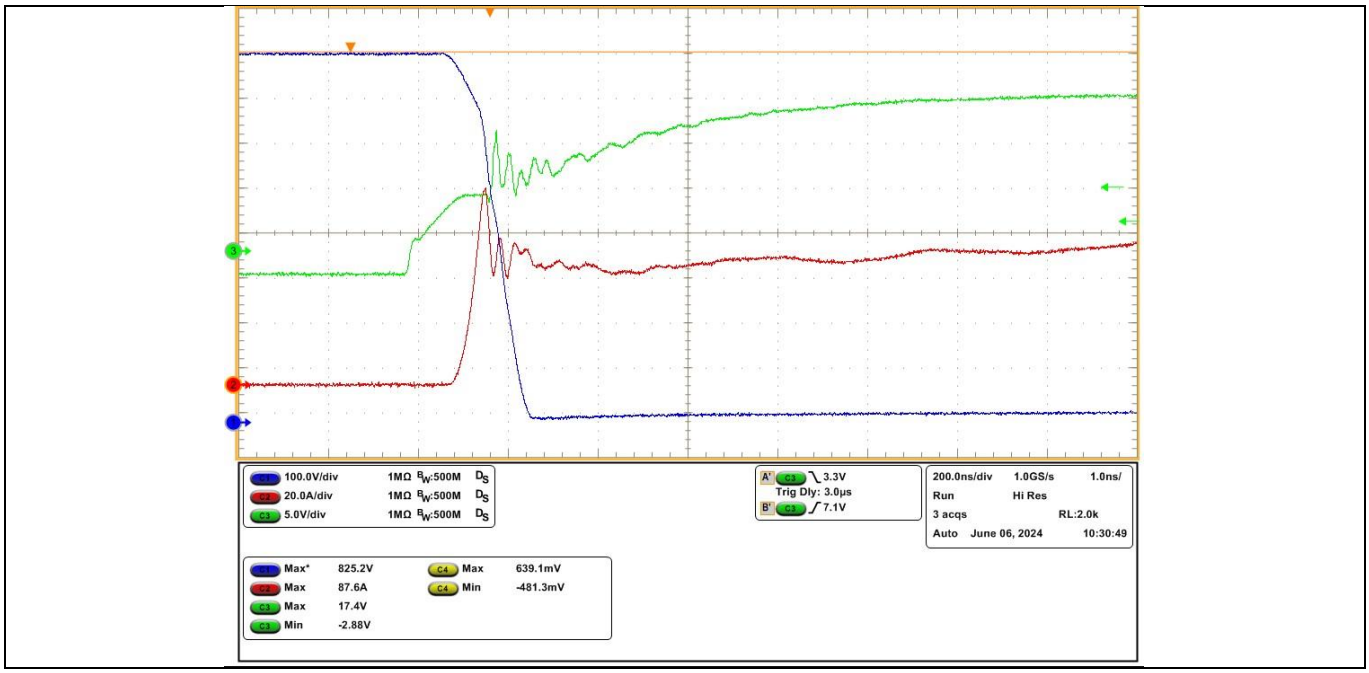

Figure 22 U_{dc} = 800V, I_d = 50 A, T = 25°C, V_{gs} = 18V and -3V

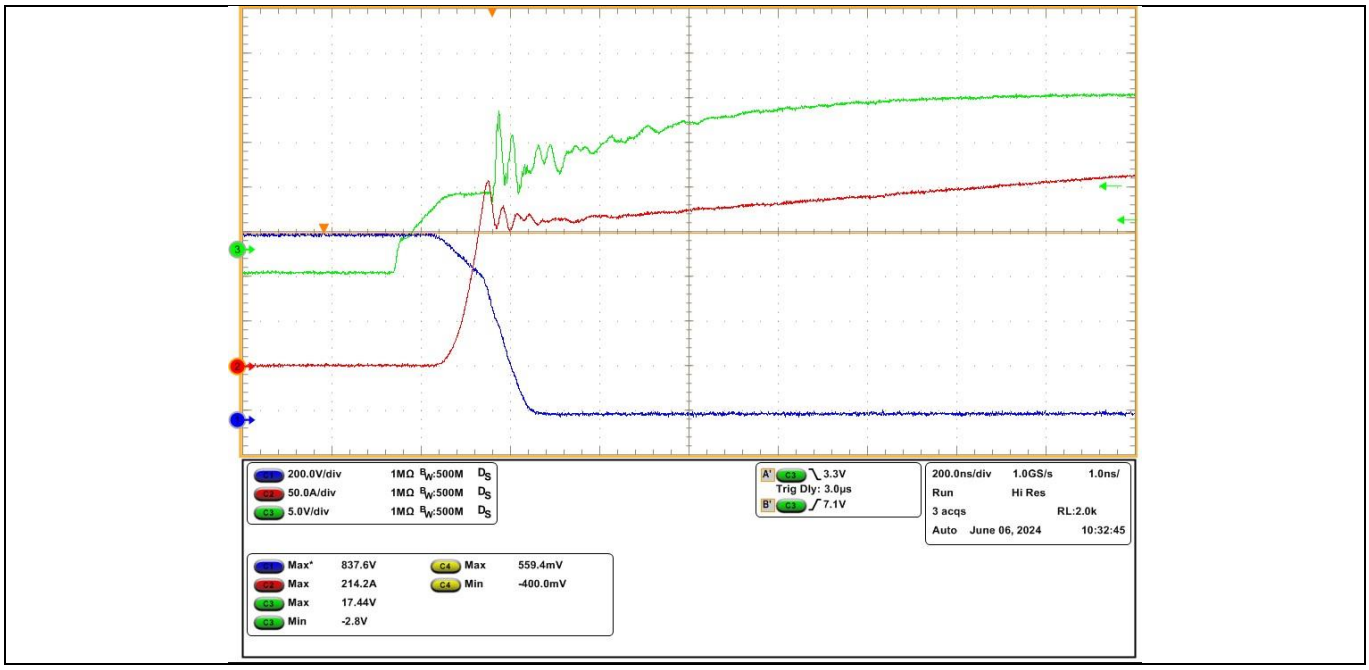

Figure 23 U_{dc} = 800V, I_d = 160A, T = 25°C, V_{gs} = 18V and -3V

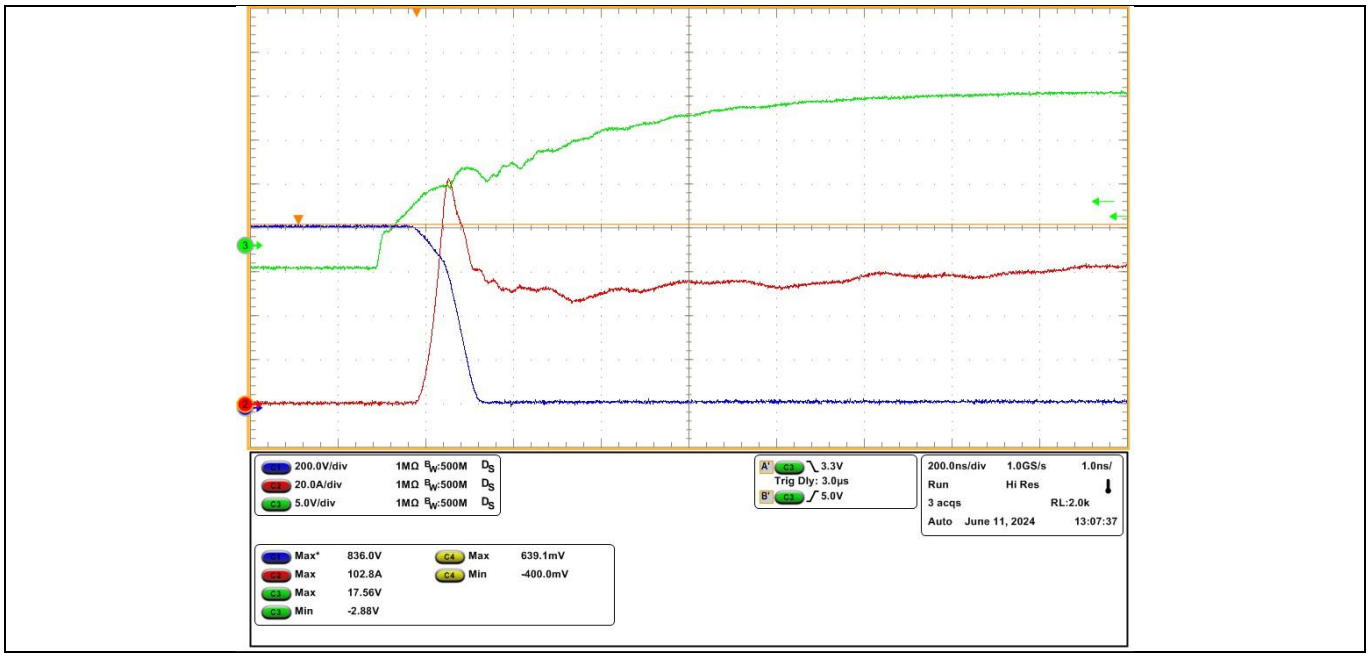

Figure 24 U_{dc} = 800V, I_d = 50 A, T = 175°C, V_{gs} = 18V and -3V

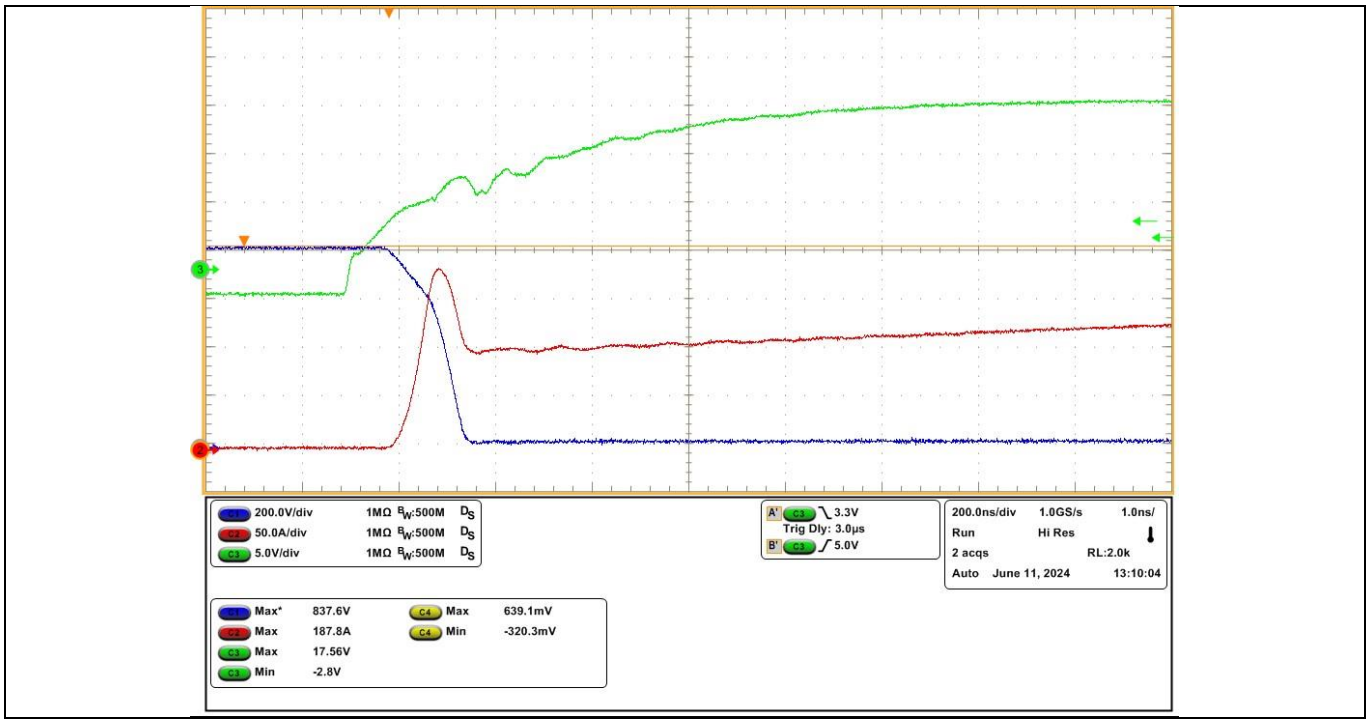

Figure 25 U_{dc} = 800V, I_d = 100 A, T = 175°C, V_{gs} = 18V and -3V

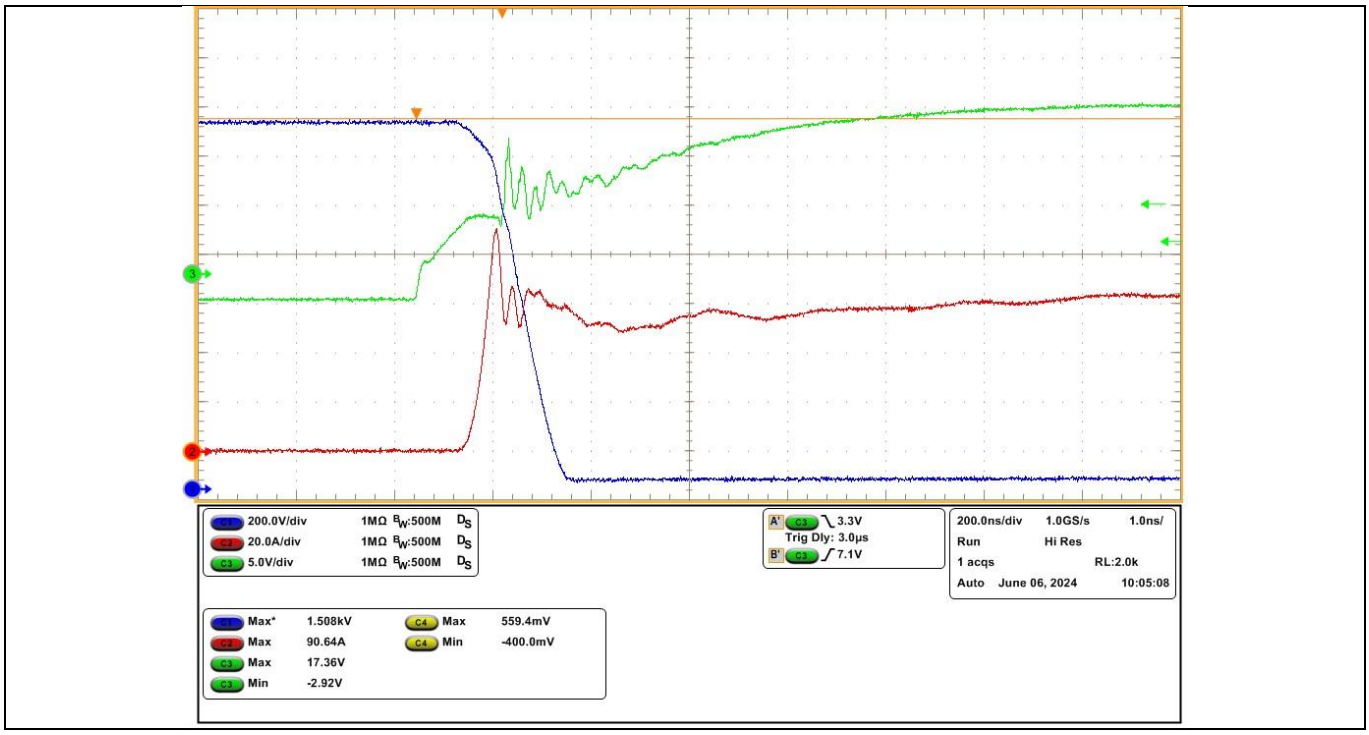

Figure 26 U_{dc} = 1450V, I_d = 50 A, T = 25°C, V_{gs} = 18V and -3V

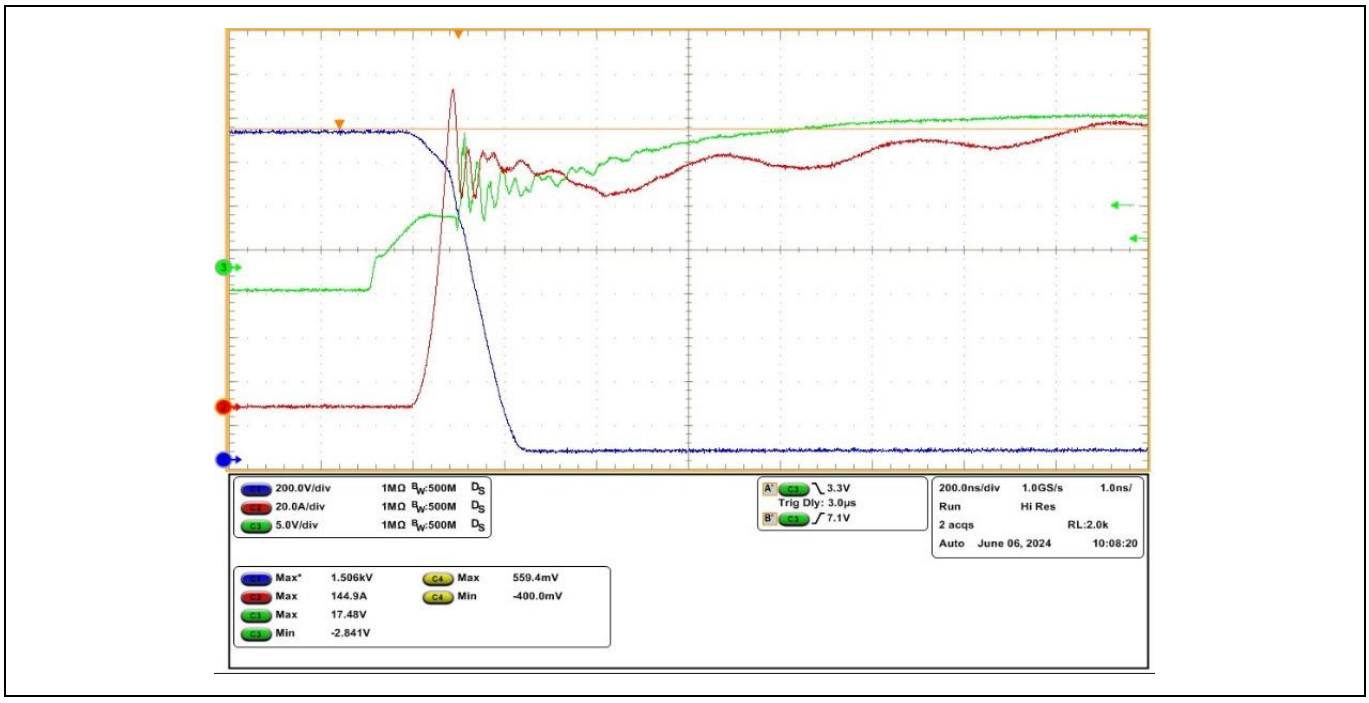

Figure 27 U_{dc} = 1450V, I_d = 100A, T = 25°C, V_{gs} = 18V and -3V

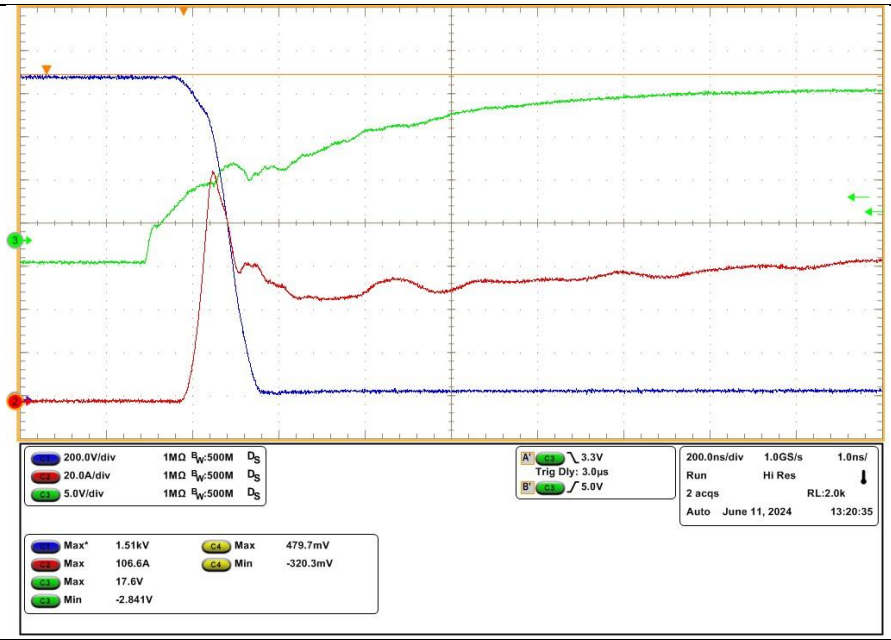

Figure 28 U_{dc} = 1450V, I_d = 50 A, T = 175°C, V_{gs} = 18V and -3V

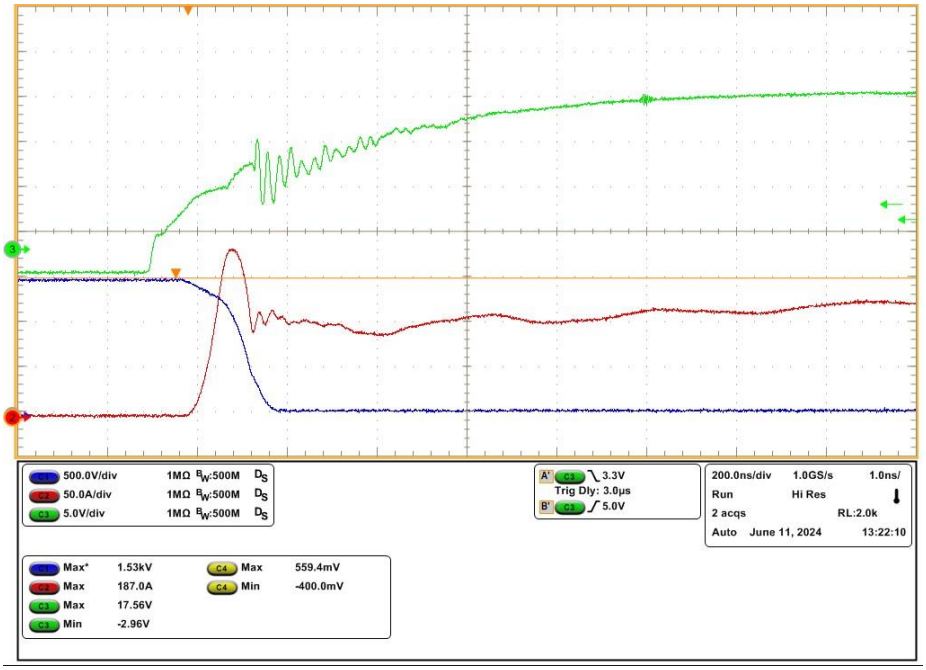

Figure 29 U_{dc} = 1450V, I_d = 100 A, T = 175°C, V_{gs} = 18V and -3V

4.6.1.2 Turn-off waveforms

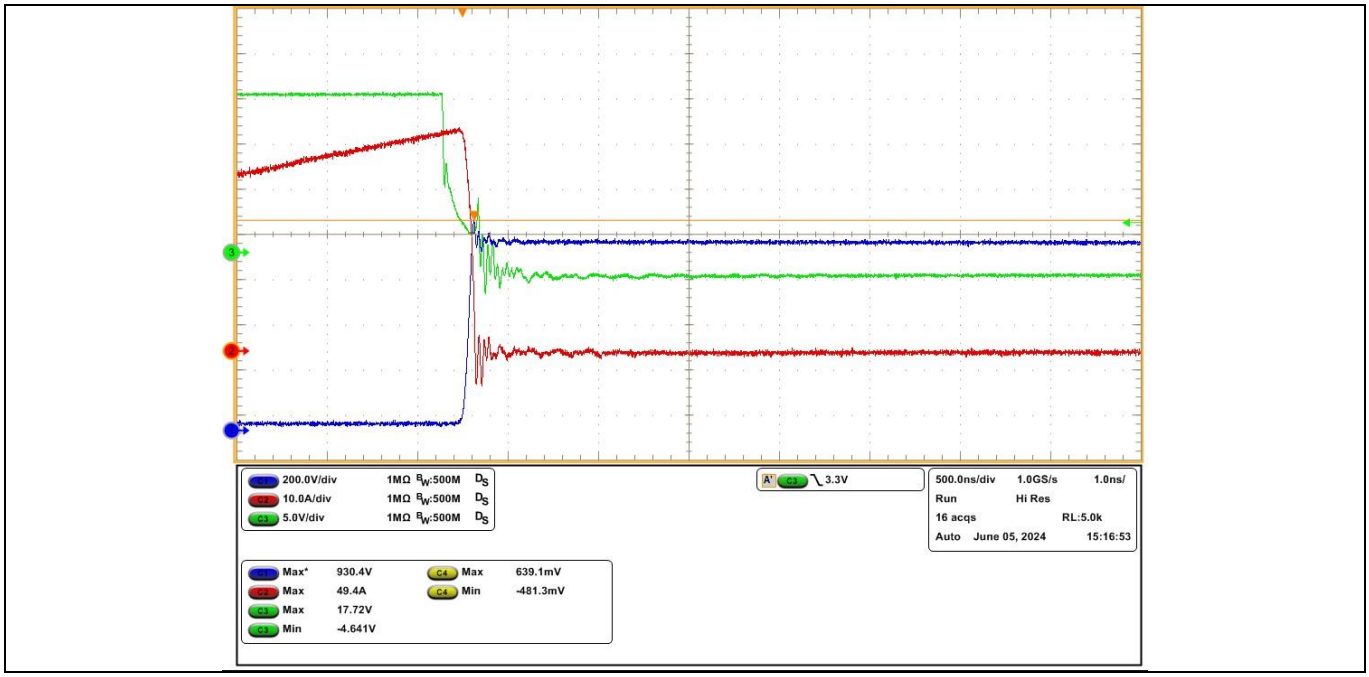

Figure 30 U_{dc} = 800V, I_d = 50 A, T = 25°C, V_{gs} = 18V and -3V

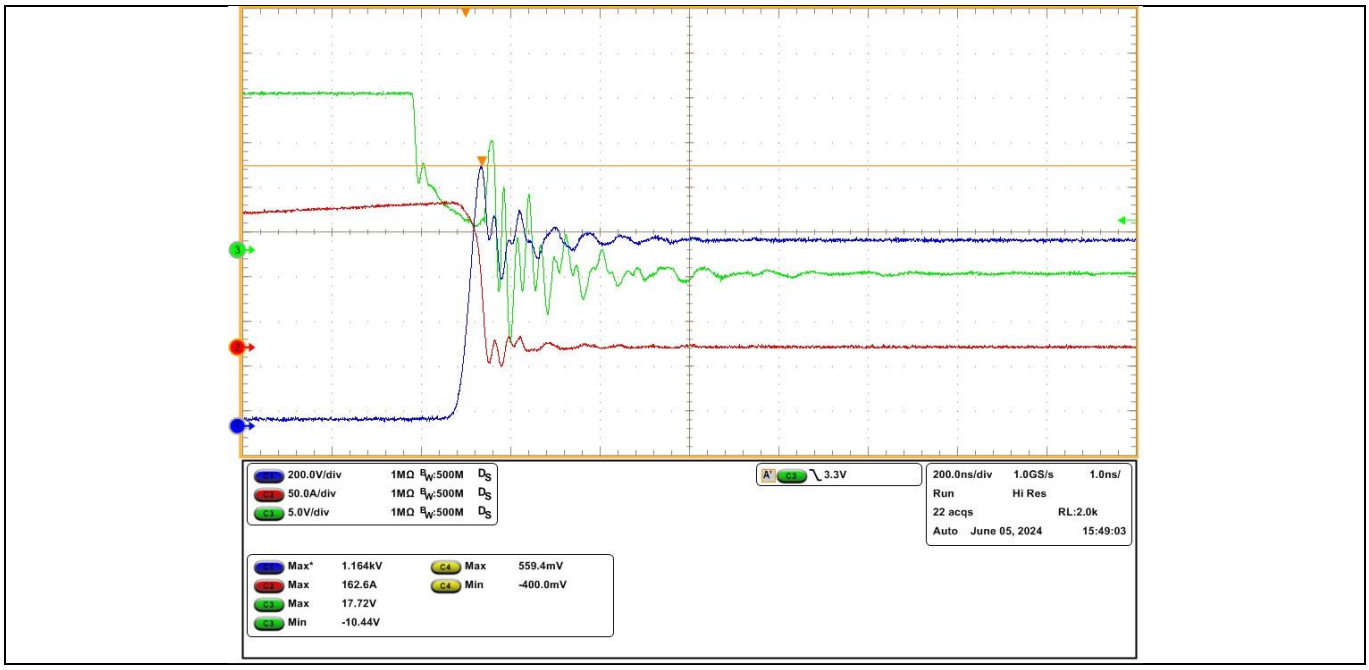

Figure 31 U_{dc} = 800V, I_d = 160A, T = 25°C, V_{gs} = 18V and -3V

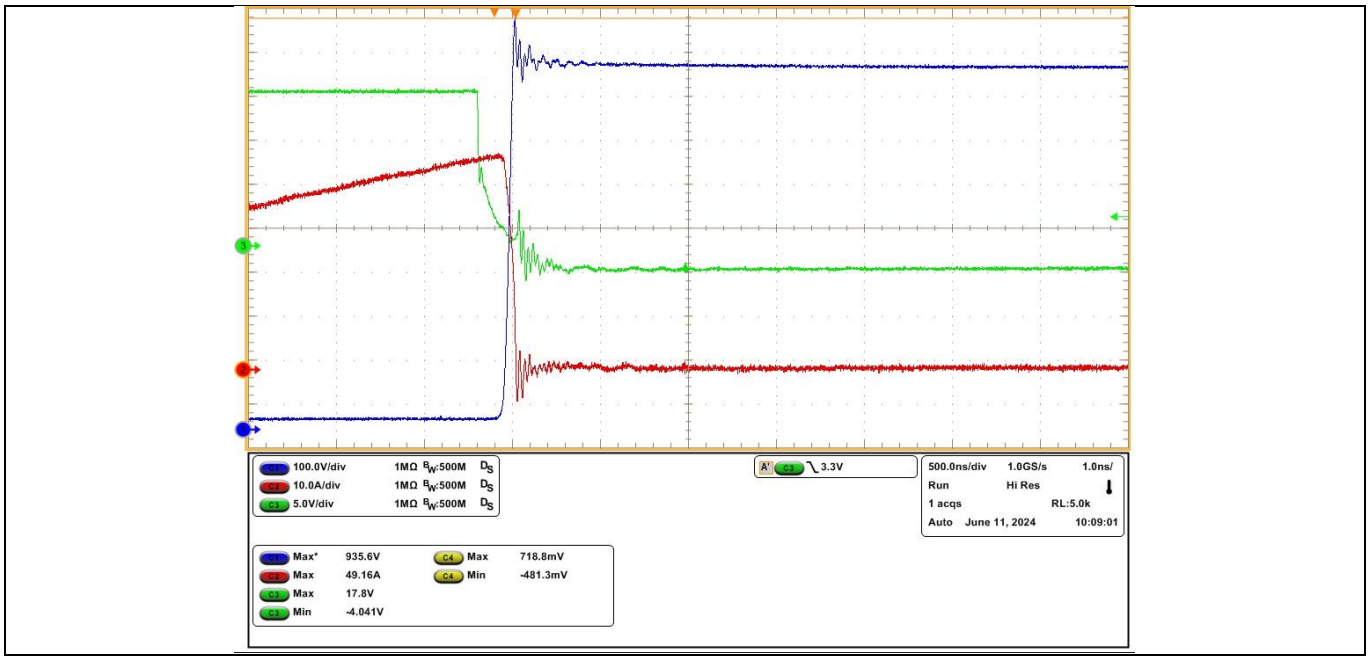

Figure 32 U_{dc} = 800V, I_d = 50 A, T = 175°C, V_{gs} = 18V and -3V

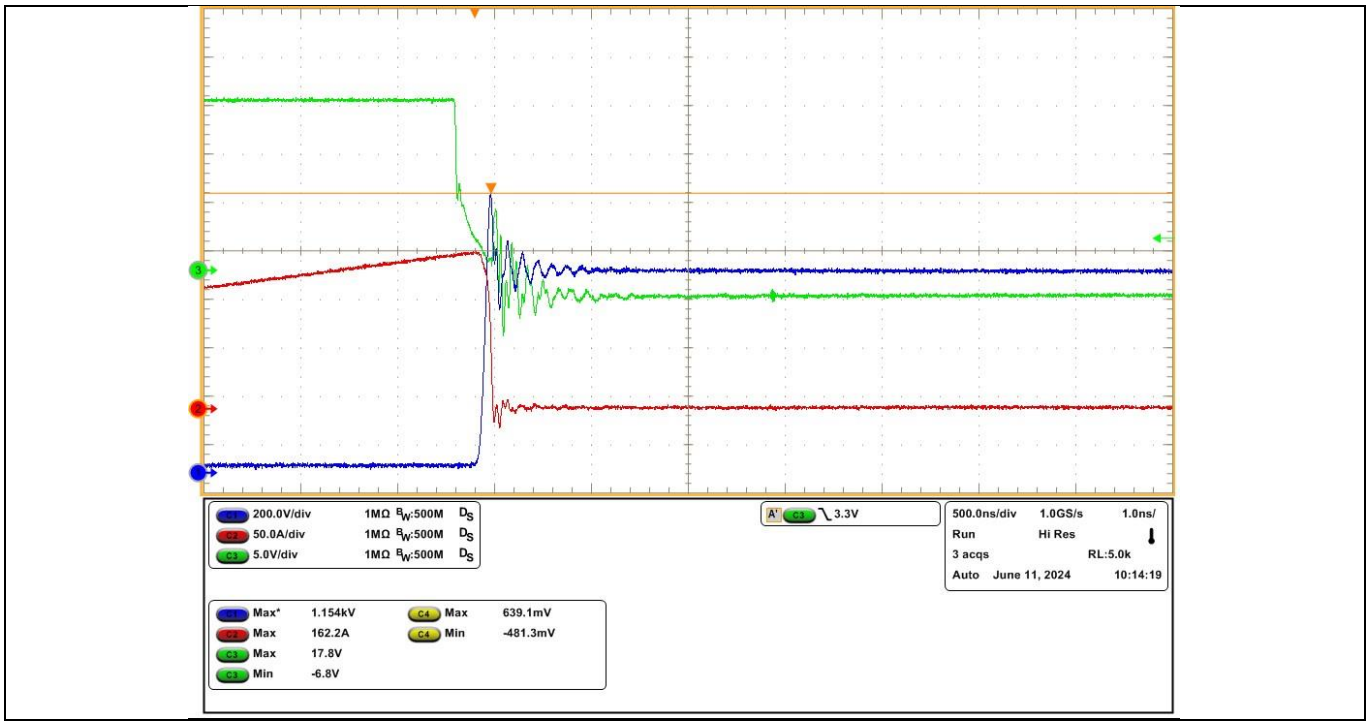

Figure 33 U_{dc} = 800V, I_d = 100 A, T = 175°C, V_{gs} = 18V and -3V

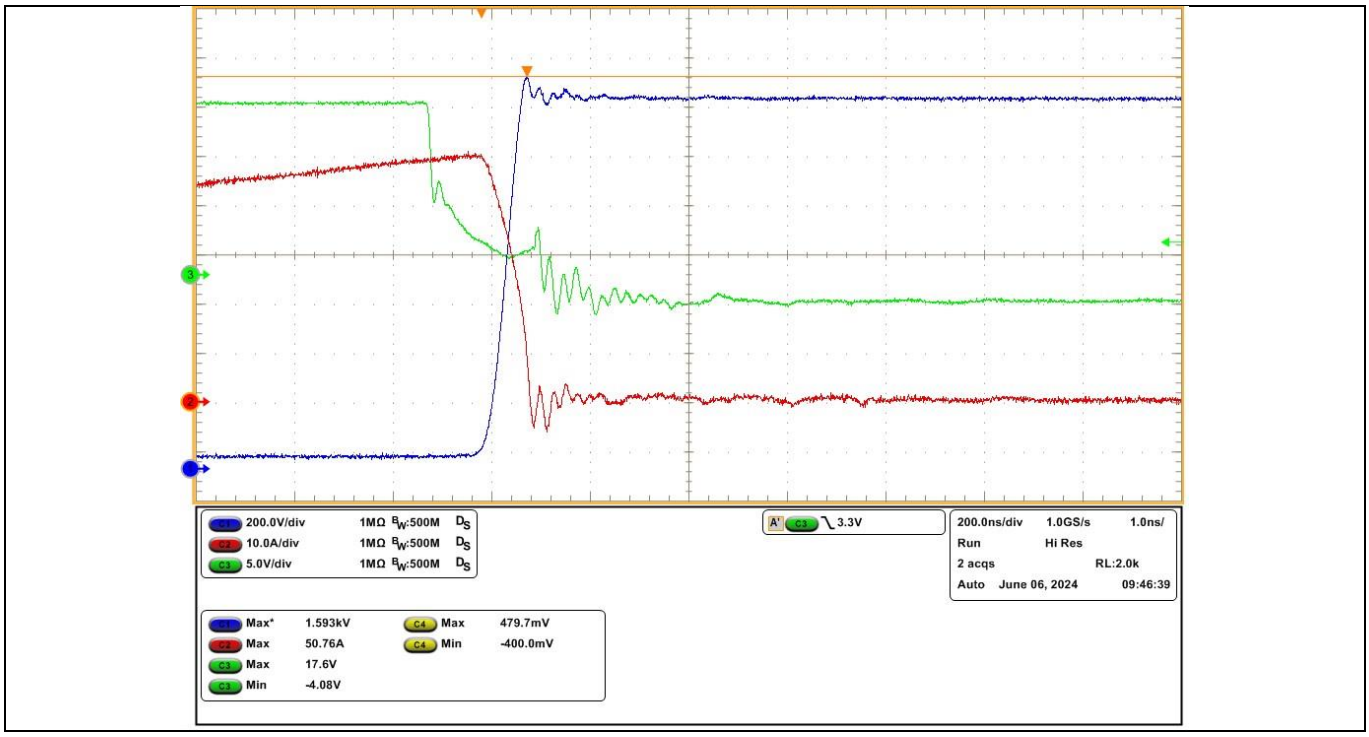

Figure 34 U_{dc} = 1450V, I_d = 50 A, T = 25°C, V_{gs} = 18V and -3V

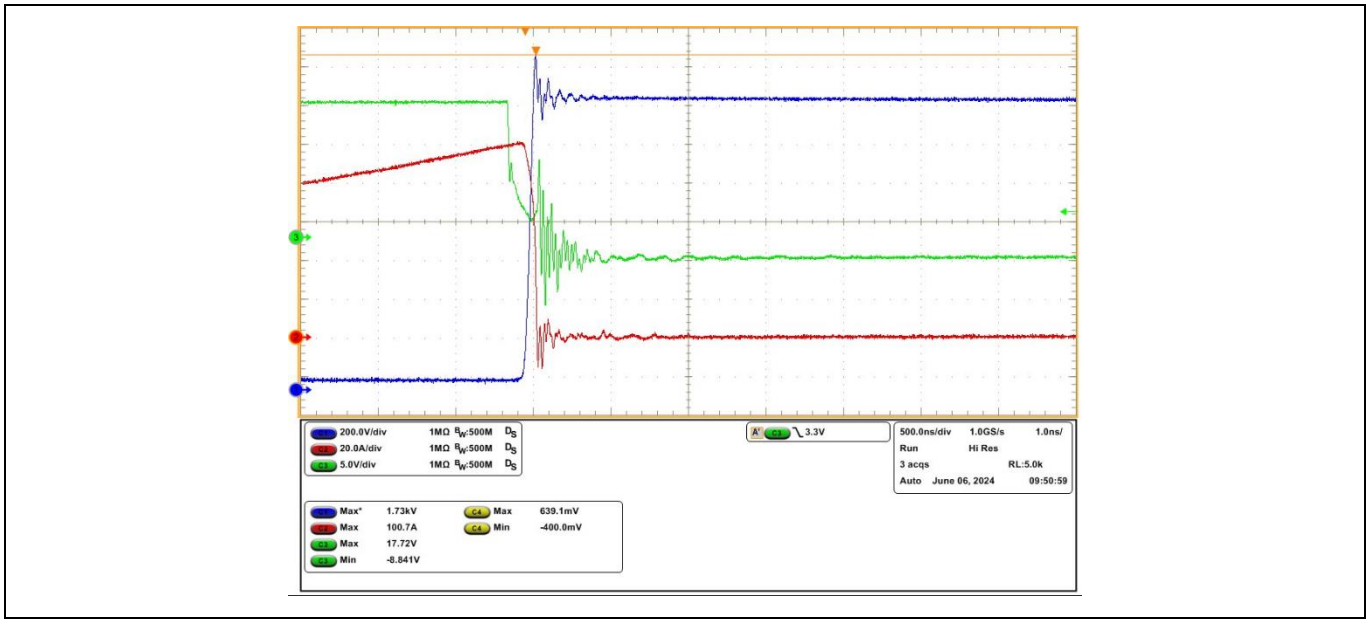

Figure 35 U_{dc} = 1450V, I_d = 100A, T = 25°C, V_{gs} = 18V and -3V

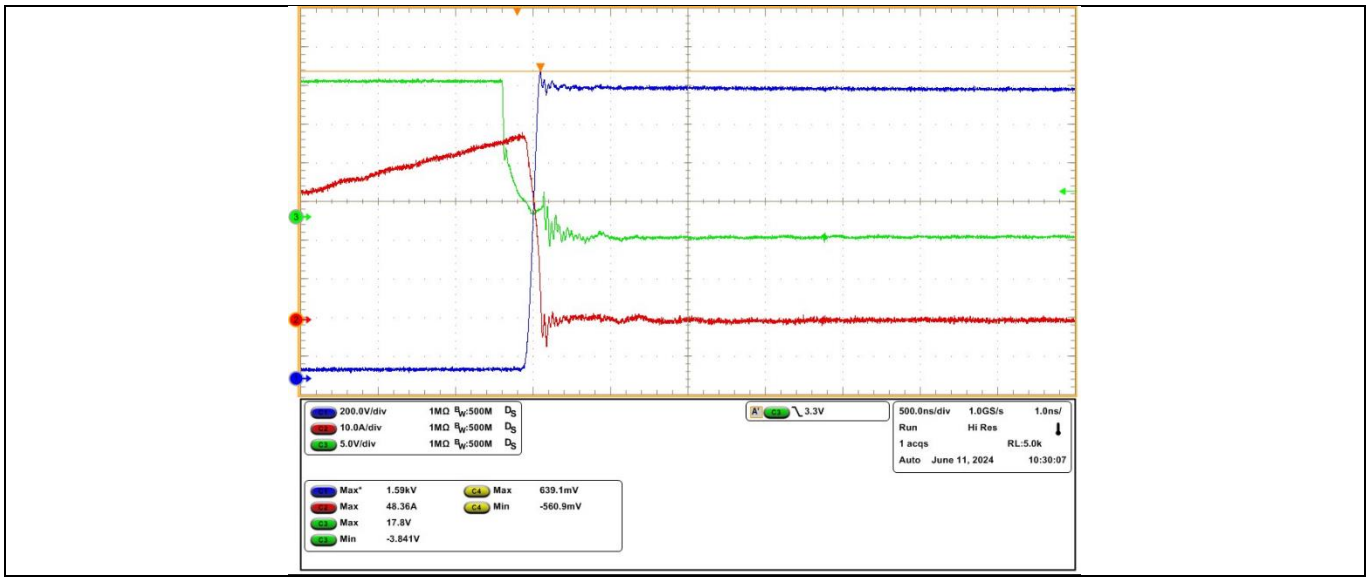

Figure 36 U_{dc} = 1450V, I_d = 50 A, T = 175°C, V_{gs} = 18V and -3V

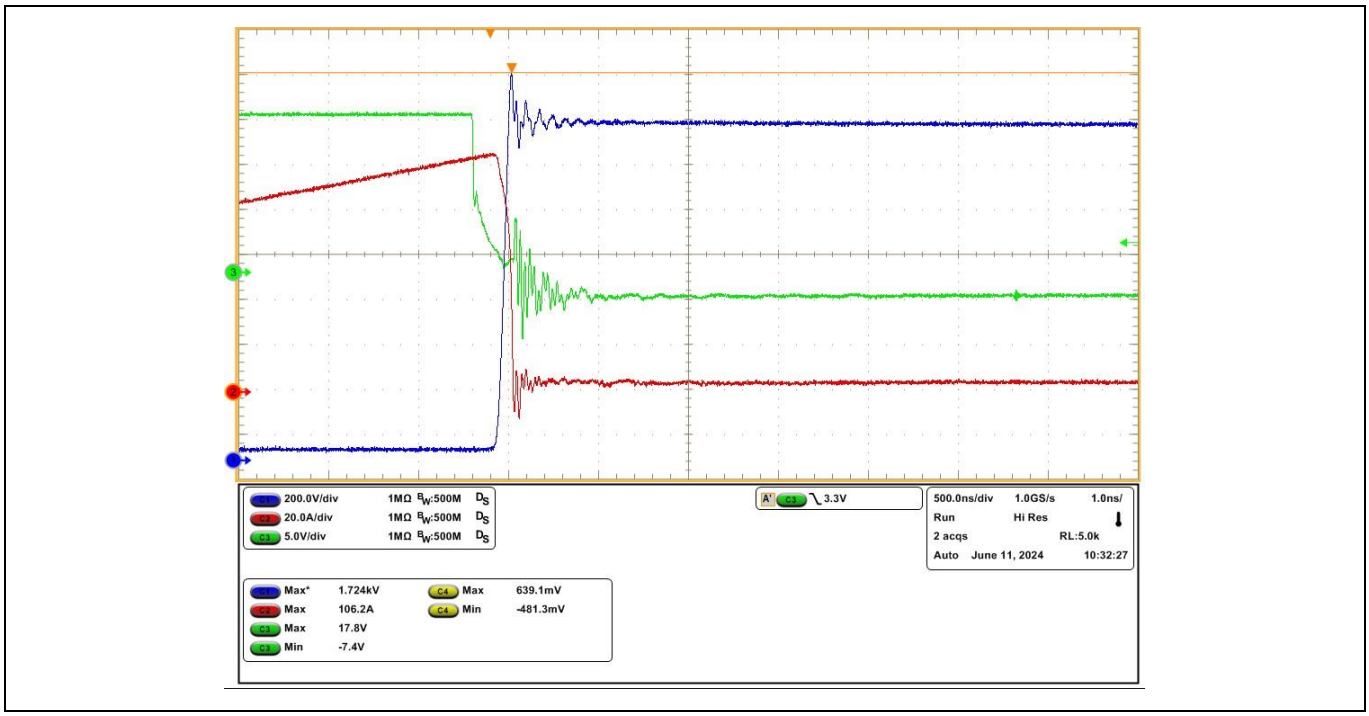

Figure 37 U_{dc} = 1450V, I_d = 100 A, T = 175°C, V_{gs} = 18V and -3V

Note: Switching noise can be observed on the Rogowski current measurement signal for low currents, but the effect is negligible for higher currents

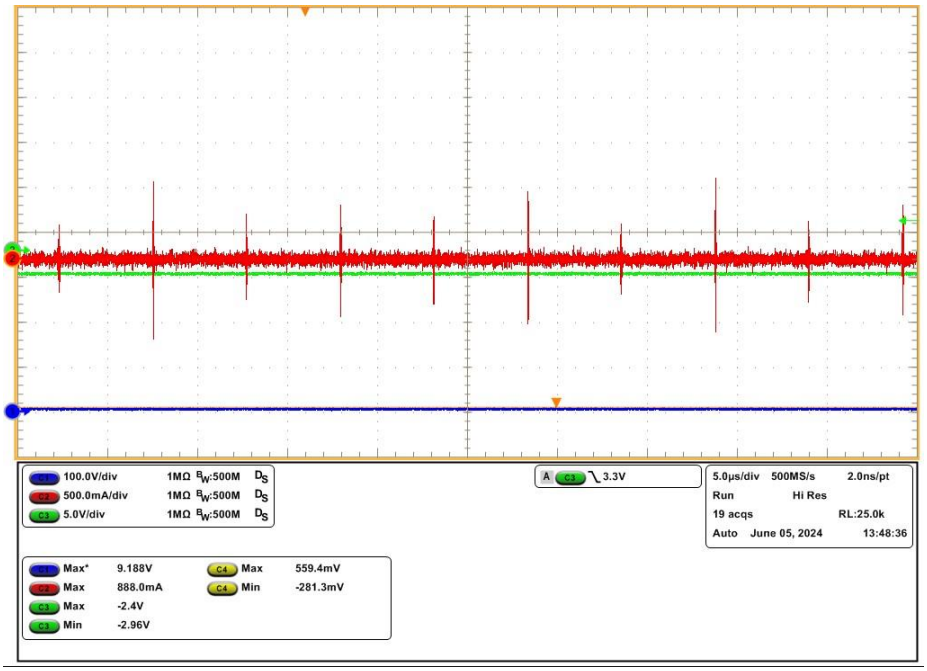

Figure 38 Switching noise at low currents

4.6.2 EVAL-FFXMR20W2M1HS

The probes used are:

- Channel 1 (V_{ds}): PMK PHV 642-L

  Remark: The DUT had no direct connection to the mains: No measurement category according to IEC 61010-031. In other cases, the maximum rated voltage needs to be reduced, please refer to the probe supplier instructions

- Channel 2 (I_d): BNC cable connected to the coaxial shunt
- Channel 3 (V_{gs}): Not connected (**The user must use a differential probe to measure Vgs for this board**)

4.6.2.1 Turn-on waveforms

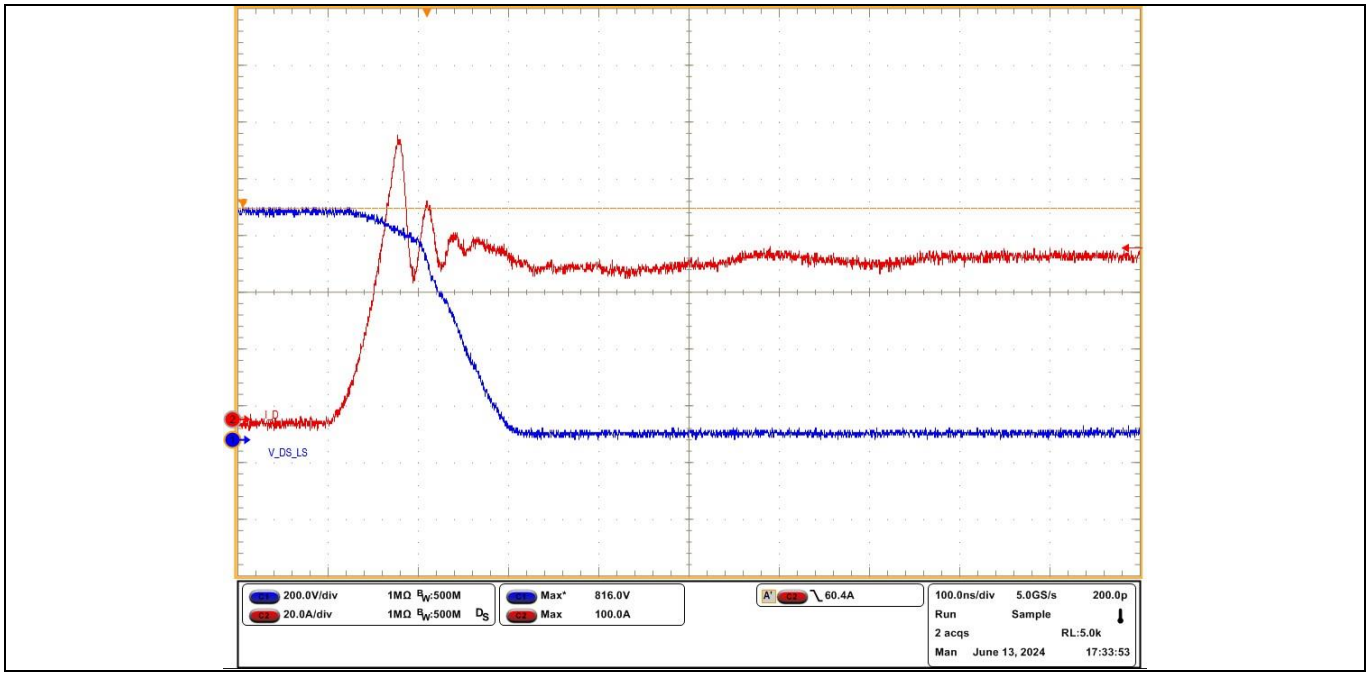

Figure 39 U_{dc} = 800V, I_d = 50 A, T = 25°C, V_{gs} = 18V and -3V

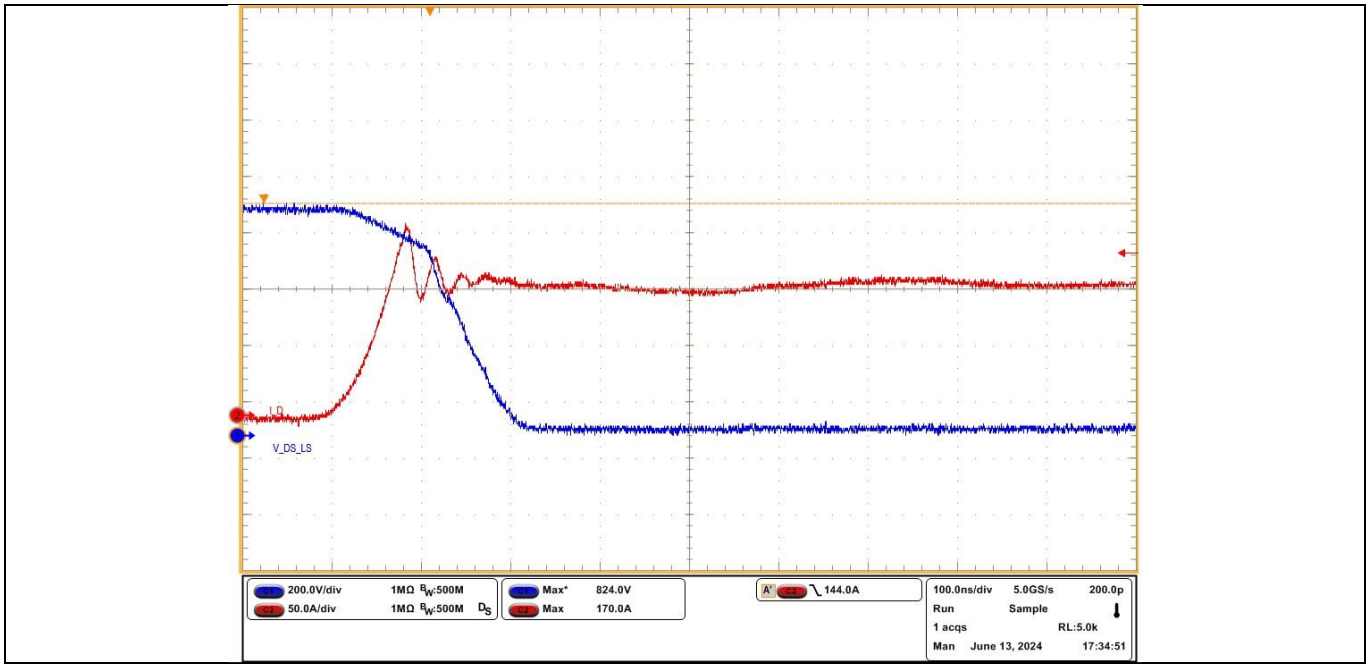

Figure 40 U_{dc} = 800V, I_d = 100A, T = 25°C, V_{gs} = 18V and -3V

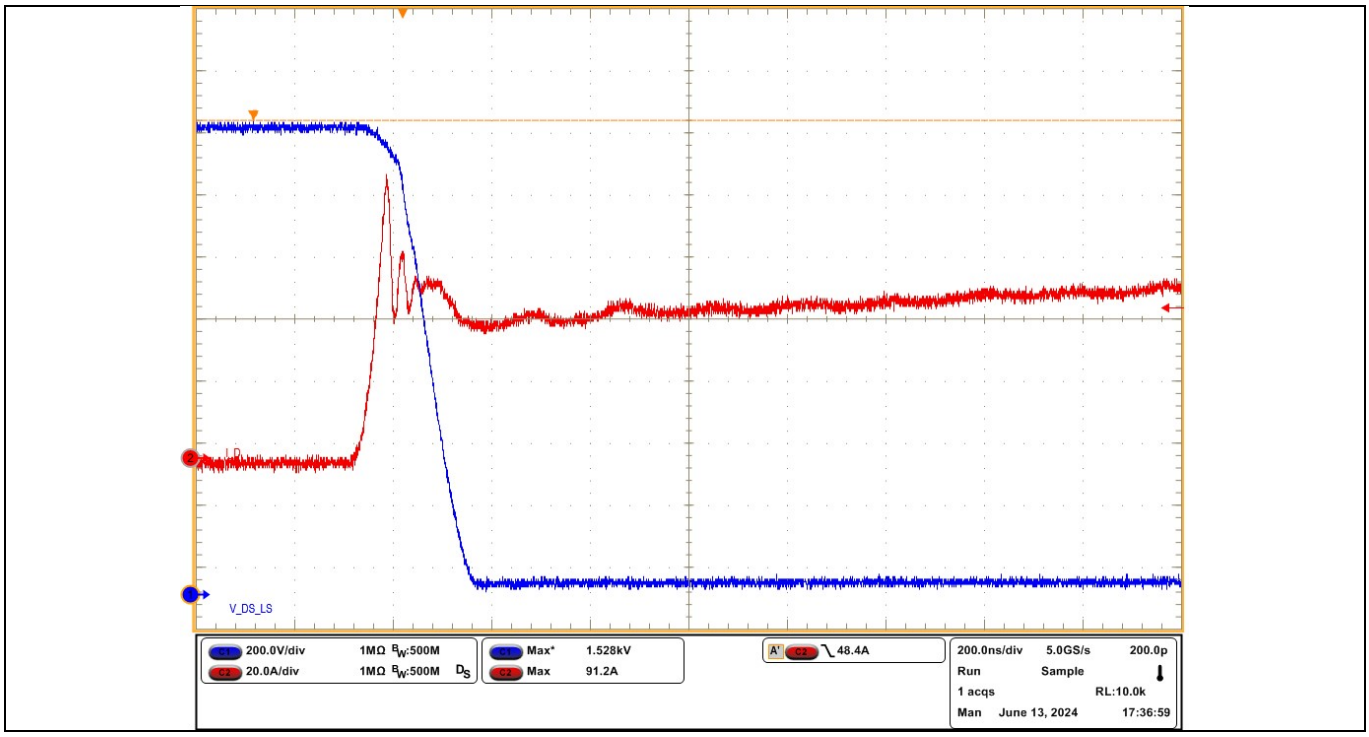

Figure 41 U_{dc} = 1450V, I_d = 50 A, T = 25°C, V_{gs} = 18V and -3V

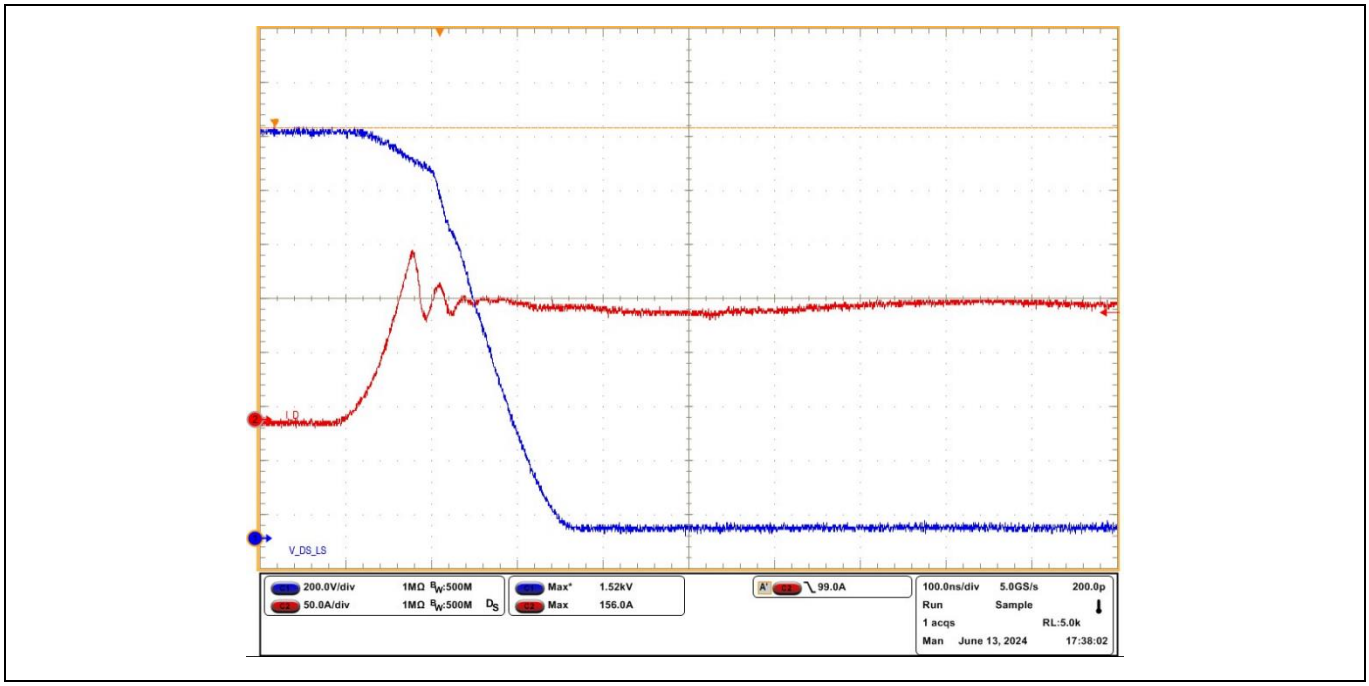

Figure 42 U_{dc} = 1450V, I_d = 100A, T = 25°C, V_{gs} = 18V and -3V

4.6.2.2 Turn-off waveforms

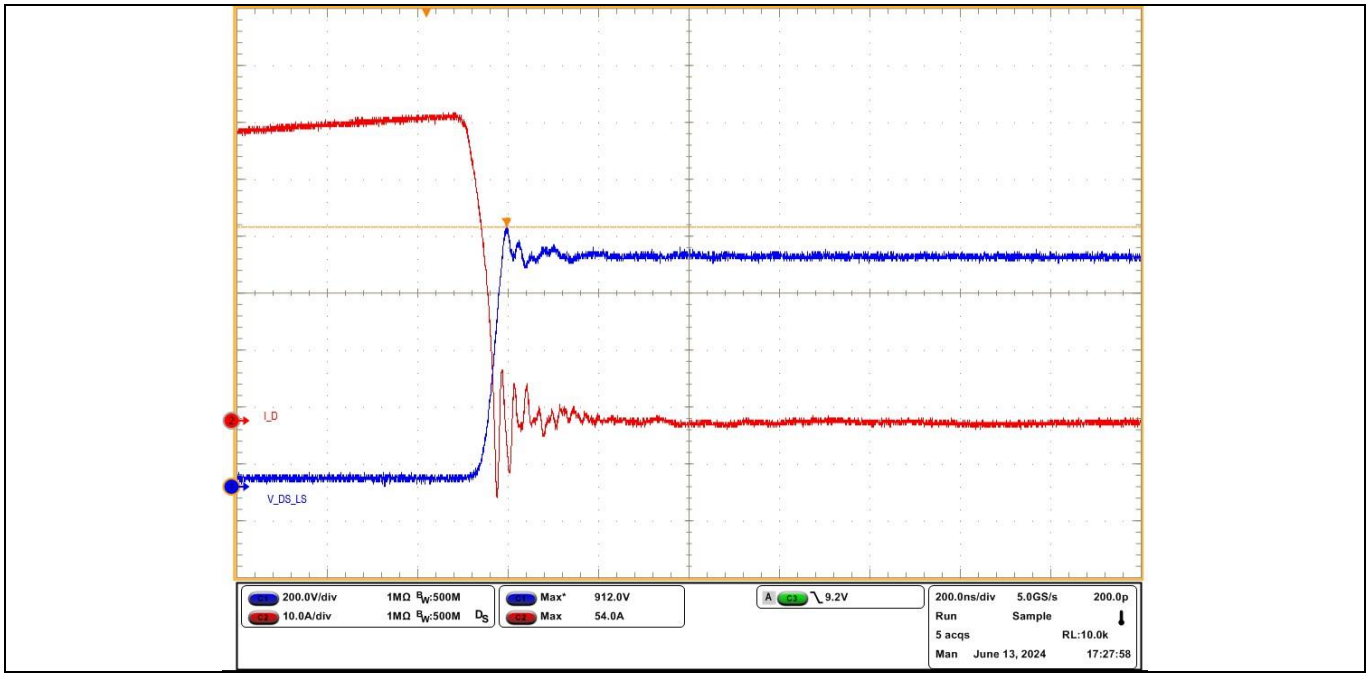

Figure 43 U_{dc} = 800V, I_d = 50 A, T = 25°C, V_{gs} = 18V and -3V

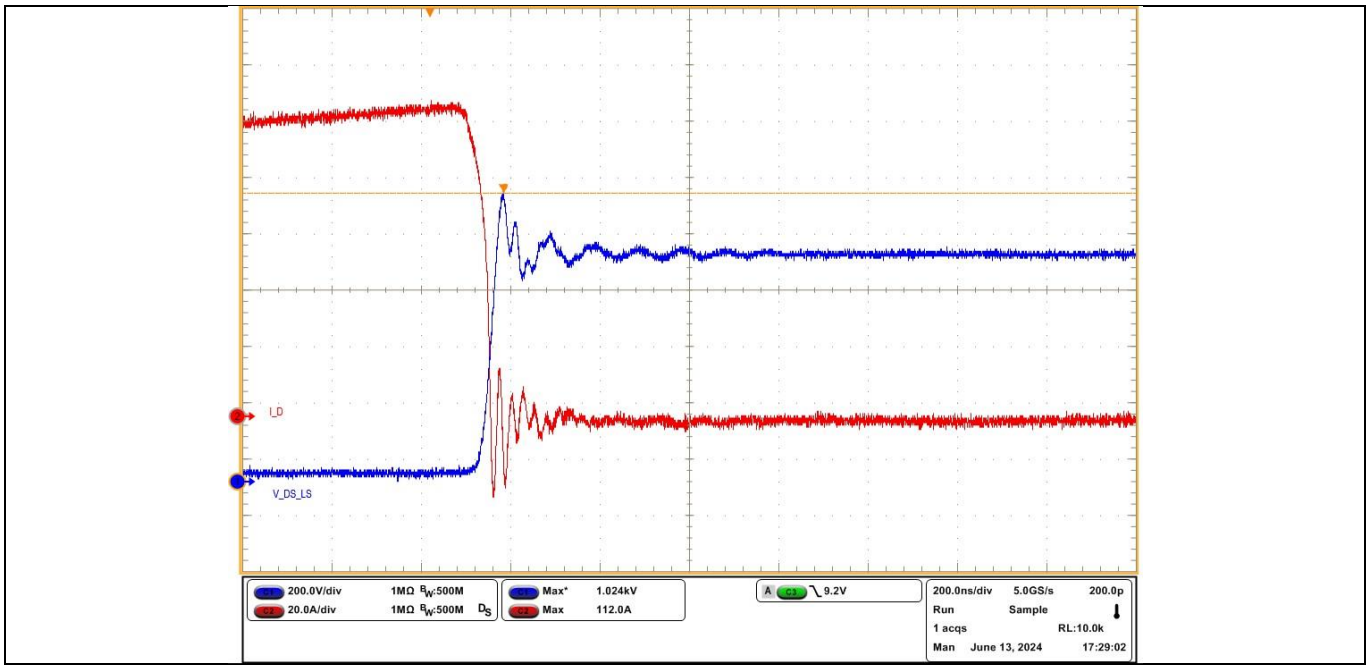

Figure 44 U_{dc} = 800V, I_d = 100A, T = 25°C, V_{gs} = 18V and -3V

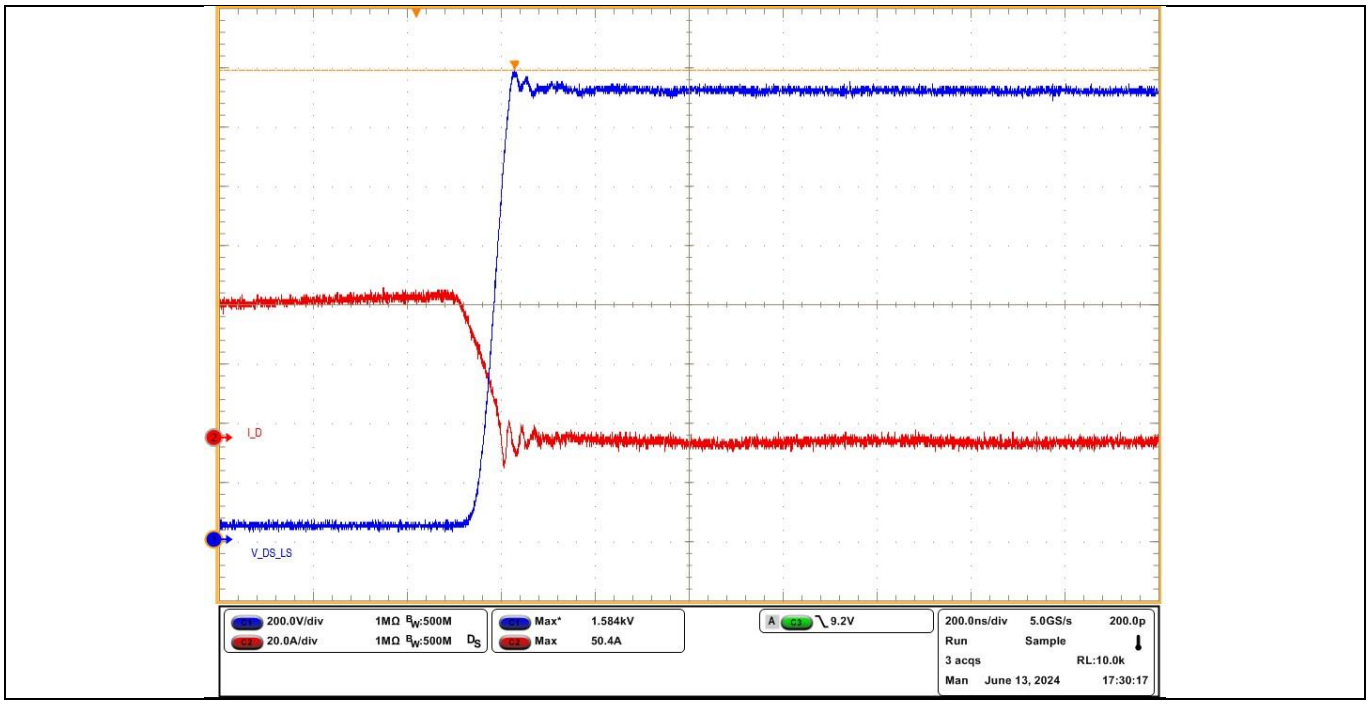

Figure 45 U_{dc} = 1450V, I_d = 50 A, T = 25°C, V_{gs} = 18V and -3V

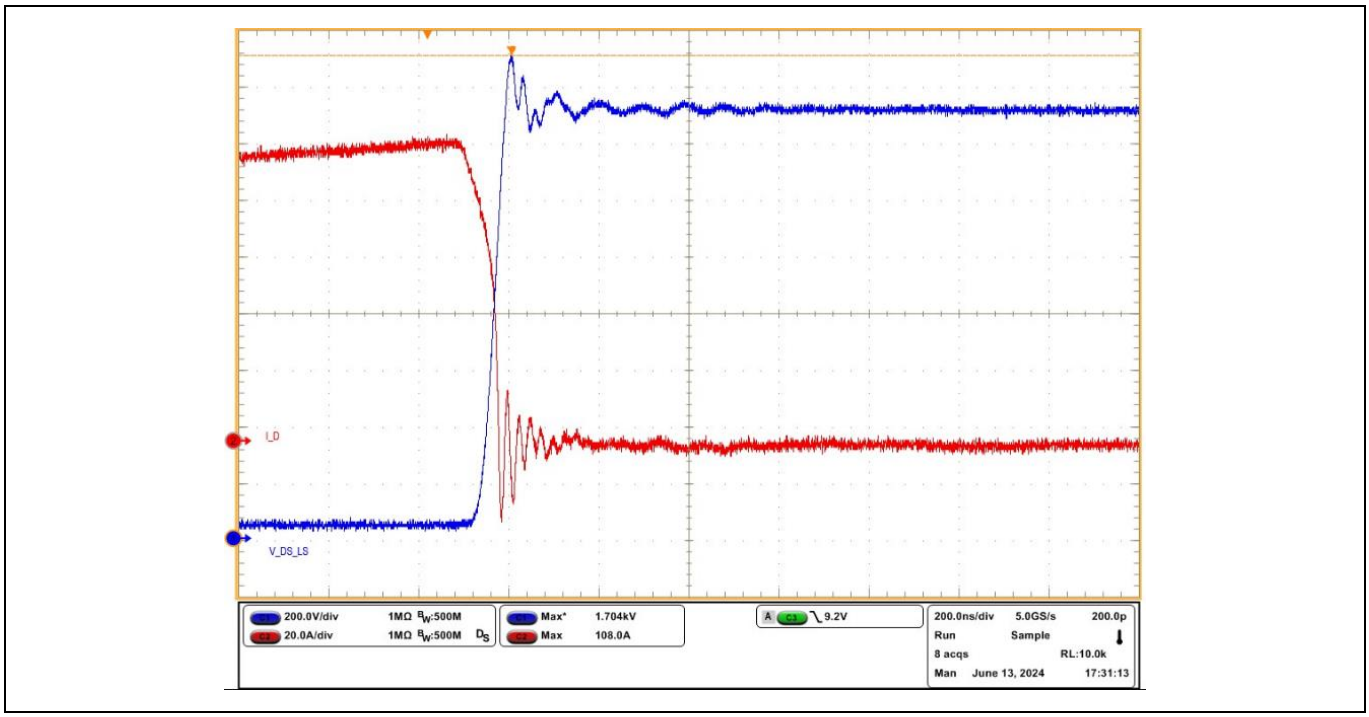

Figure 46 U_{dc} = 1450V, I_d = 100A, T = 25°C, V_{gs} = 18V and -3V

5 Layout

The layout has been designed to reduce the parasitic inductance in the commutation and gate drive loops. The original Altium files can be found on the board website.

5.1 Gate driver board

Table 7 Mechanical data

Dimensions	93mm x 79mm
No. of layers	4
Copper thickness	35 µm

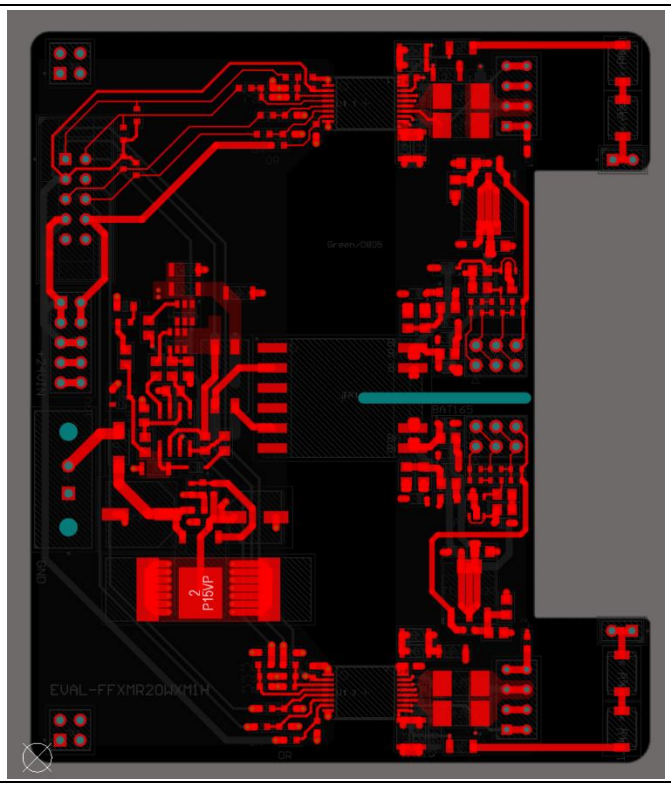

Figure 47 Top layer

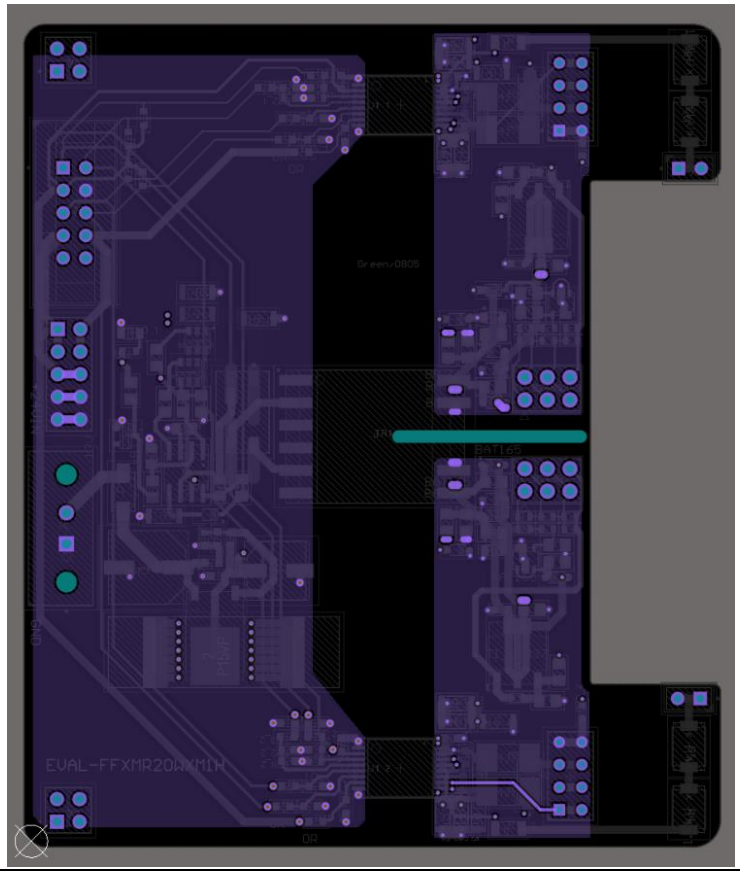

Figure 48 Layer 2

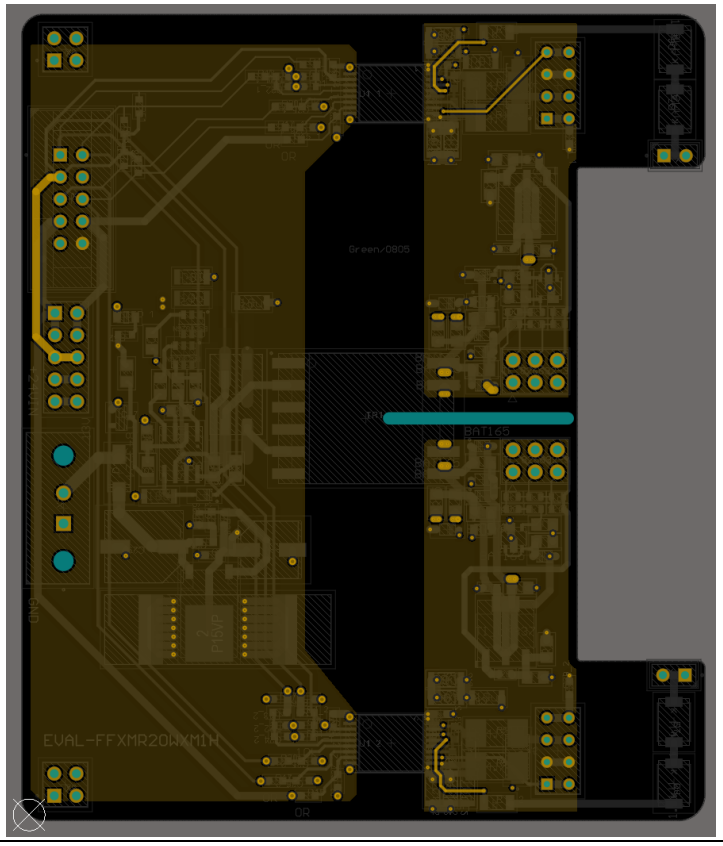

Figure 49 Layer 3

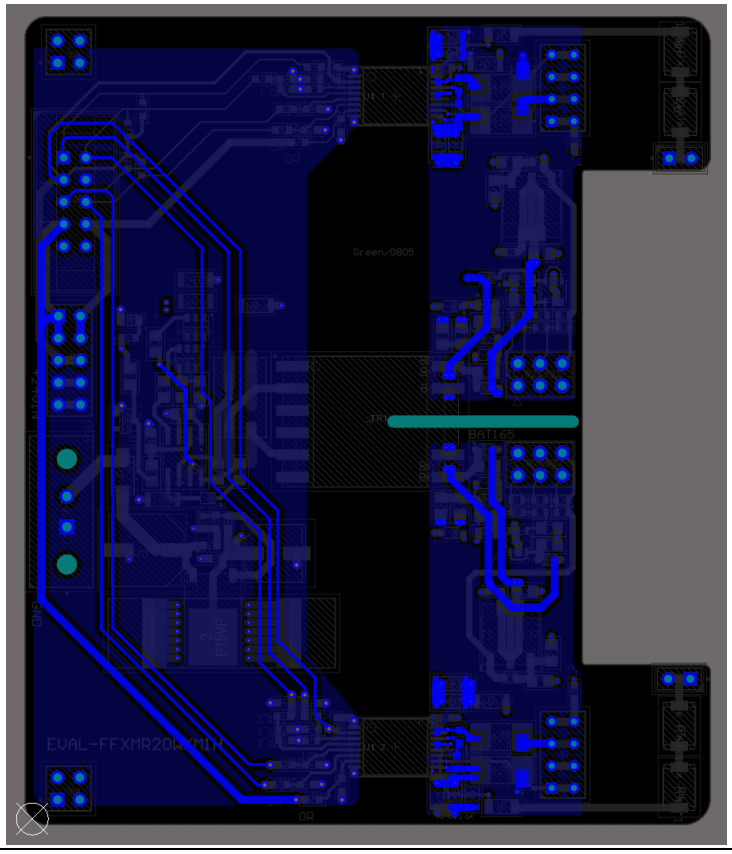

Figure 50 Bottom layer

5.2 EVAL-FFXMR20W2M1HS power board

Table 8 Mechanical data

Dimensions	223mm x 201mm
No. of layers	4
Copper thickness	70 µm

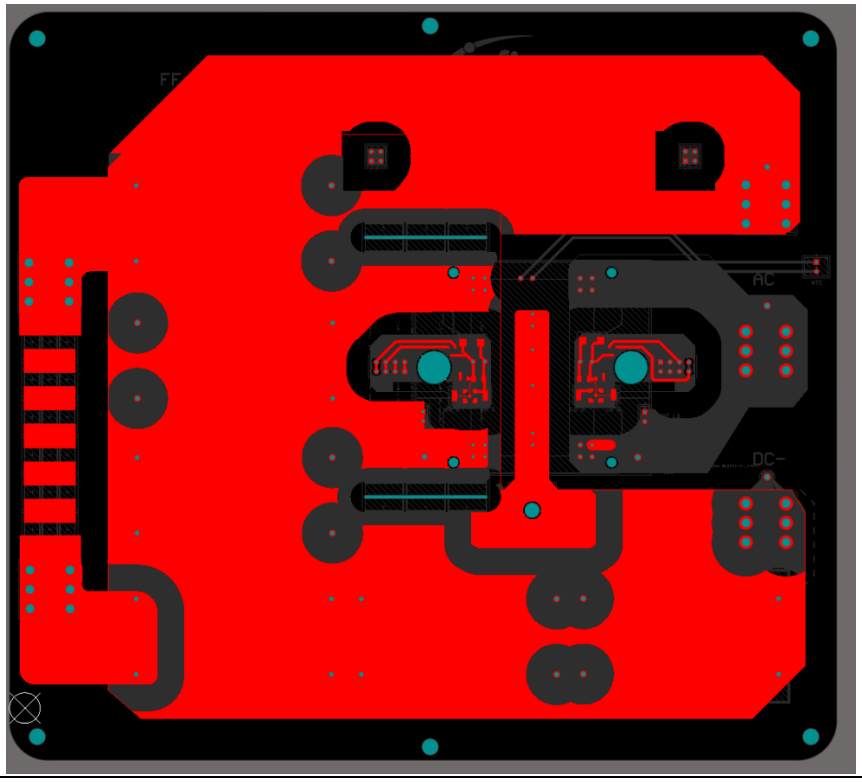

Figure 51 Top layer

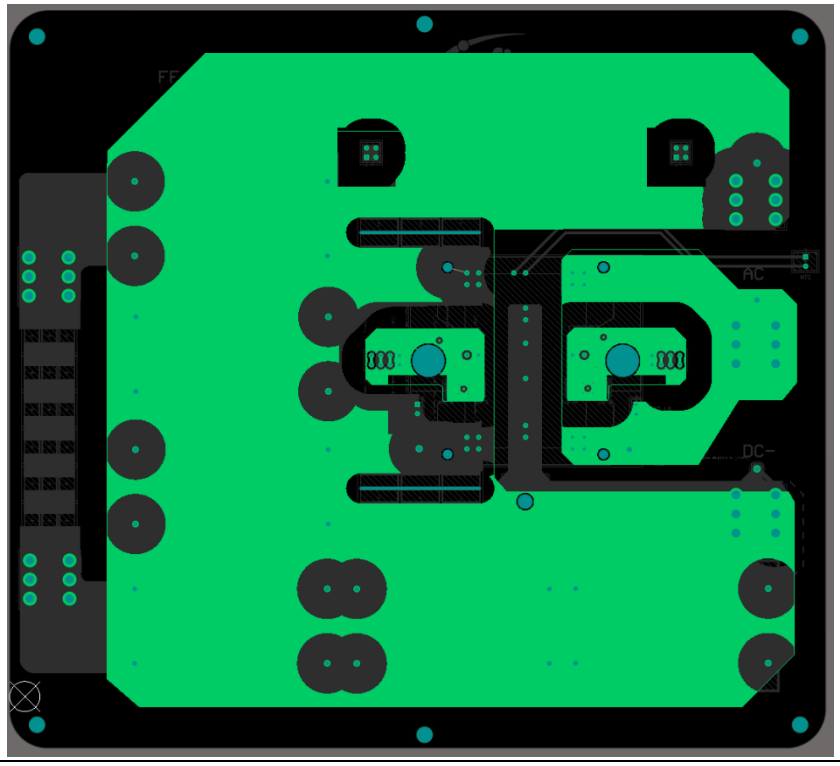

Figure 52 Layer 2

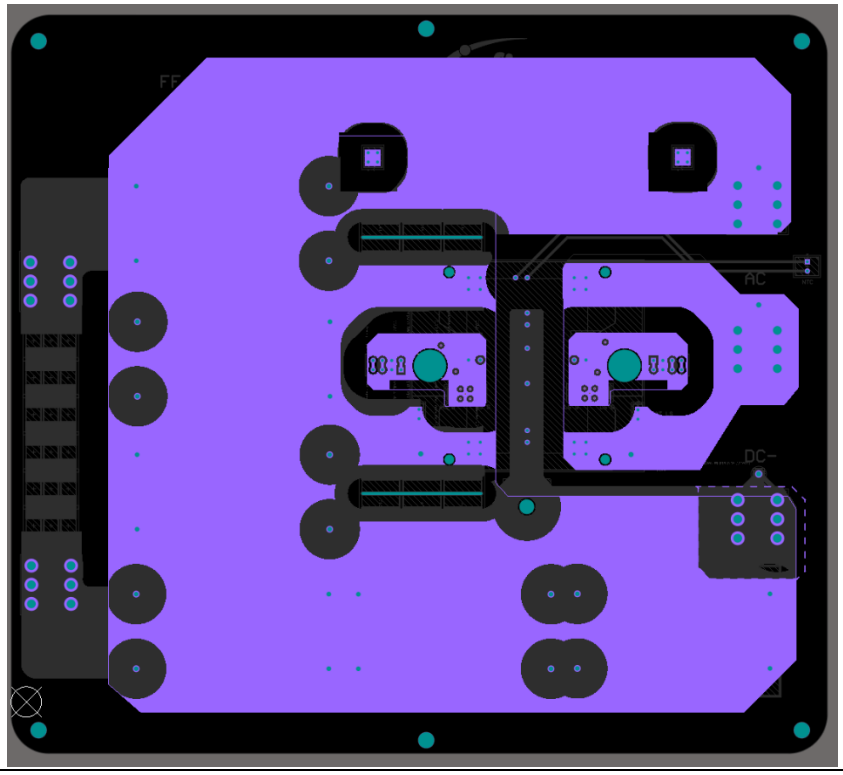

Figure 53 Layer 3

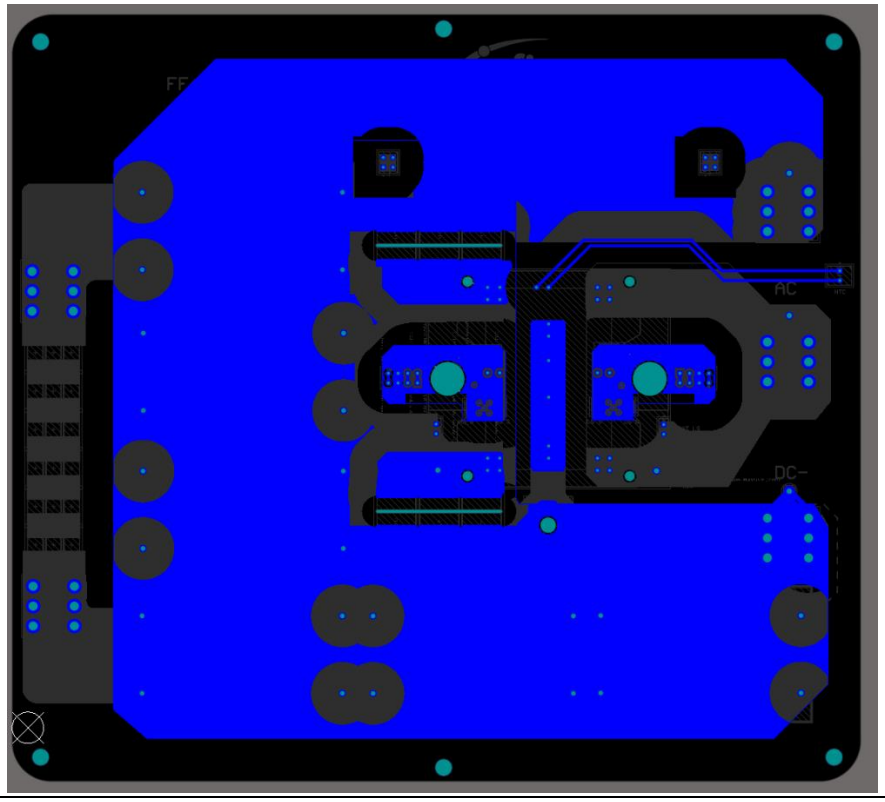

Figure 54 Bottom layer

5.3 EVAL-FFXMR20W2M1HR power board

Table 9 Mechanical data

Dimensions	240mm x 201mm
No. of layers	4
Copper thickness	70 µm

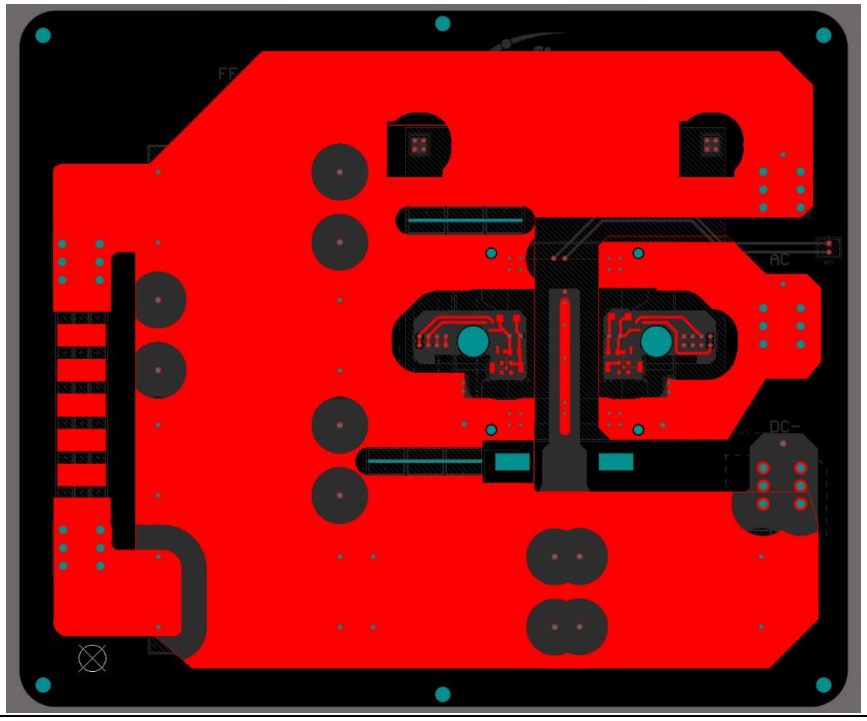

Figure 55 Top layer

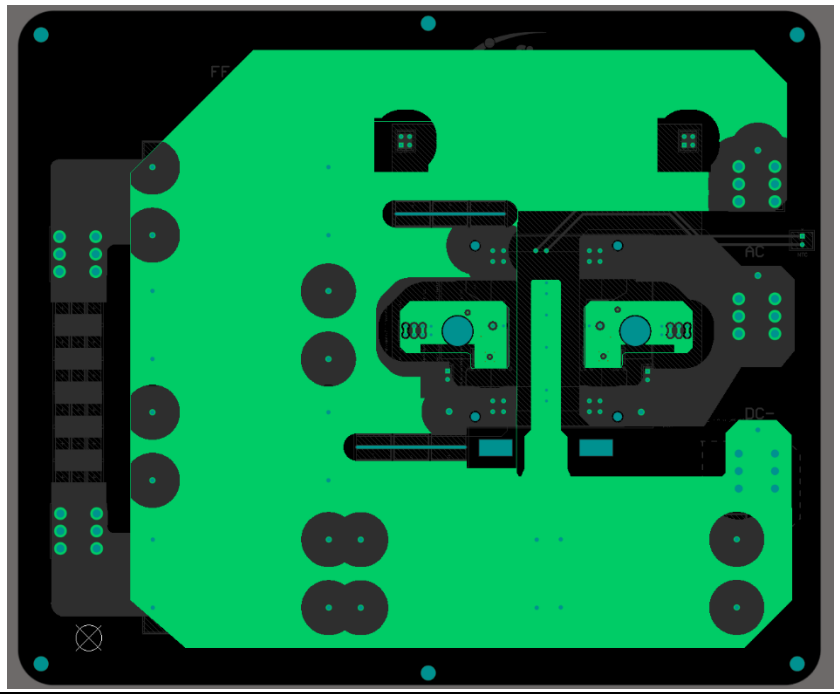

Figure 56 Layer 2

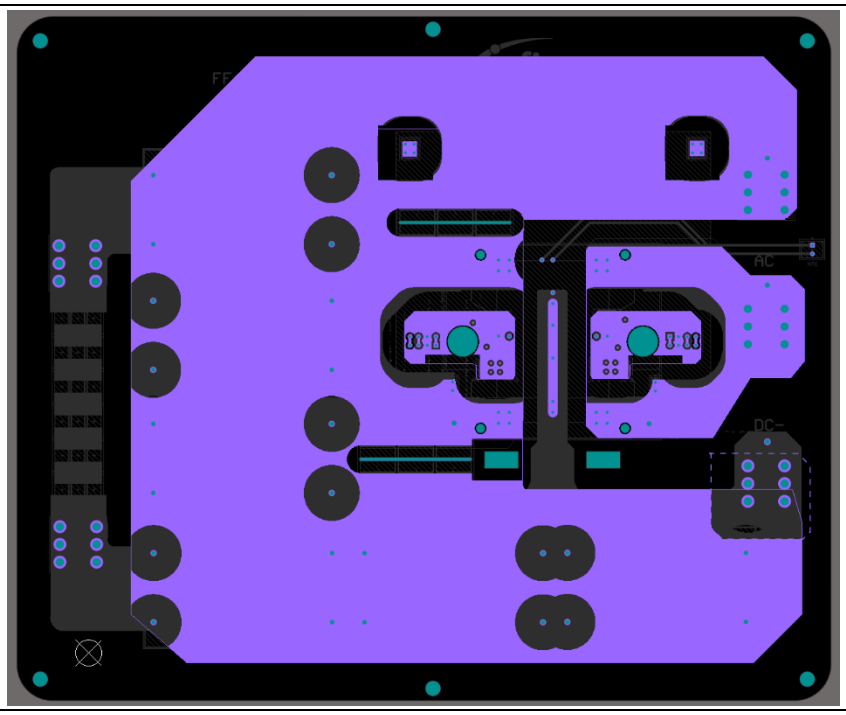

Figure 57 Layer 3

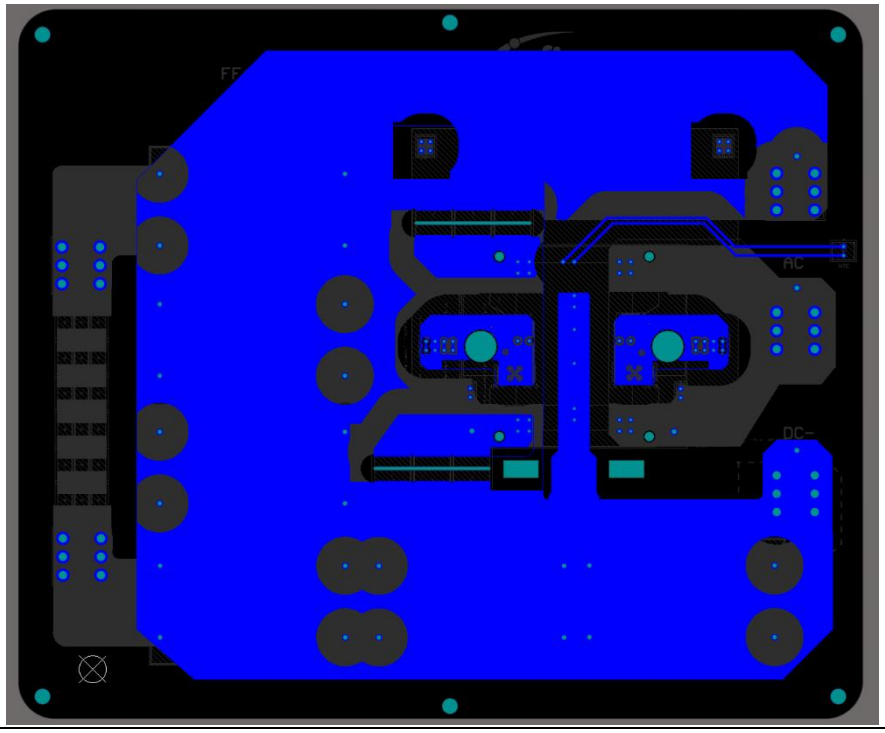

Figure 58 Bottom layer

6 Bill of materials (BoM)

Table 10 BoM

Part	Description
FF6MR20W2M1H	2 kV CoolSiC™ MOSFET half-bridge module
1ED3830MC12M	Single-channel isolated gate driver
IR2085S	30V Single N-Channel StrongIRFET™ MOSFET
IRFTS8342	High precision coreless current sensor for industrial applications
TLE4284DV	Linear voltage regulator
TLE4296	Linear voltage regulator

1 References

[1] https://www.infineon.com/dgdl/Infineon-AN2009_10_Using_the_NTC-ApplicationNotes-v01_00-EN.pdf?fileId=db3a304325afd6e0012628b593e62233

[2]https://www.infineon.com/export/sites/default/jp/product/promopages/event/power_device_module_expo_2024/dl/Power_PDF/Infineon-AN2023-07_Assembly_Instructions_for_the_Easy_Modules-ApplicationNotes-v01_25-EN.pdf

[3] https://www.infineon.com/dgdl/Infineon-Double_pulse_testing-Bodos_power_systems-Article-v01_00-EN.pdf?fileId=5546d46271bf4f920171ee81ad6c4a1f

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