EVAL-COOLSIC-2kVHCC

Evaluation Board for CoolSiC™ MOSFET 2000 V

About this document

Scope and purpose

This document describes an evaluation board having 2000 V CoolSiC™ MOSFETs in a TO-247PLUS-4-HCC package with high creepage and clearance distance as well as EiceDRIVER™ 1EDX3 compact gate driver ICs. This board can also work with an external XMC4400 control board to provide a double-pulse signal with different dead times or constant pulse width modulation signals. This guide explains the board's hardware, GUI, and provides detailed instructions on how to use it for addressing various measurement tasks. Finally, practical examples have been given to demonstrate the performance of the MOSFET.

Intended audience

This document is intended for engineers who want to use 2000 V CoolSiC™ devices with EiceDRIVER™ 1EDX3 compact gate driver ICs for half-bridge topology applications such as solar and energy storage systems.

Reference board/kit

Product(s) on a PCB, with a focus on specific applications and defined use cases, can include software, PCB, and auxiliary circuits that are optimized for the requirements of the target application.

Boards do not necessarily meet safety, Electromagnetic interference, or quality standards (for example UL, CE) requirements.

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Safety precautions

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

Table 1 Safety precautions

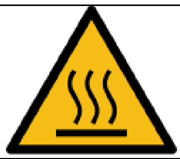
	**Warning:** *The DC link potential of this board is up to 1000 V_{DC}. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death.*
	**Warning**: *The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait few minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *The evaluation or reference board is connected to the grid input during testing. Hence, high-voltage differential probes must be used when measuring voltage waveforms by oscilloscope. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	**Caution:** *The 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 The board at a glance

The evaluation board EVAL-COOLSIC-2kVHCC was designed to be used as a testing platform for **2000 V** CoolSiC™ MOSFETs in TO-247PLUS-4-HCC packages. The board is also compatible with CoolSiC™ diodes in the same or other similar packages, such as the TO-247 2pin package.

This chapter outlines the possible applications of the evaluation board and describes the essential parts shipped together.

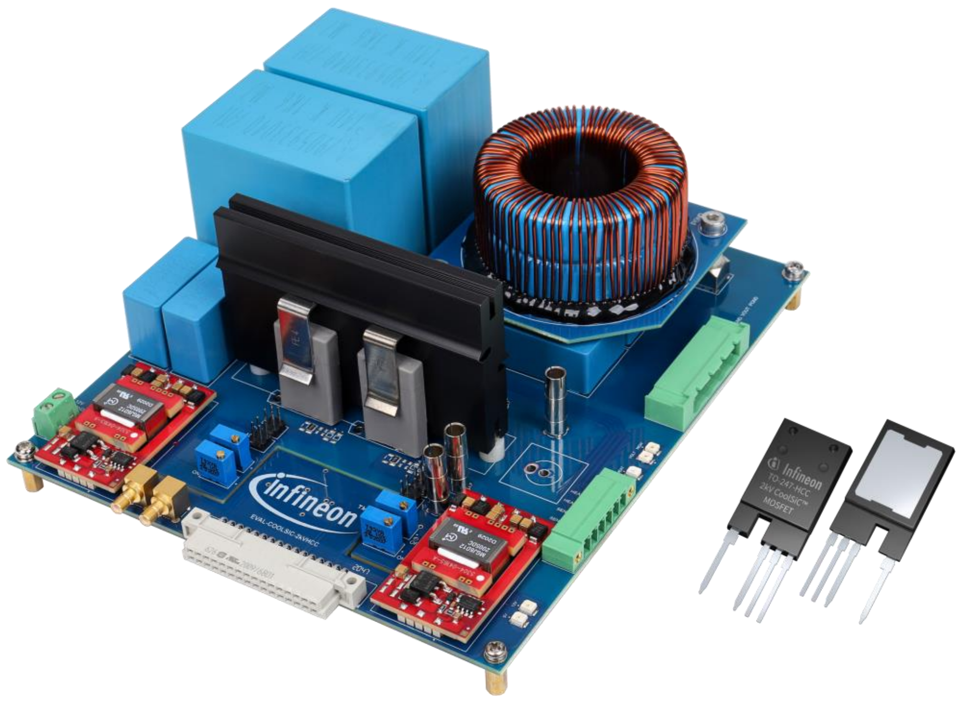


Figure 1 The evaluation board and the device under test

1.1 Purpose of the board

The evaluation board illustrated in Figure 1 was created primarily to serve as a single, global test platform for **2000 V** silicon carbide MOSFETs packaged in TO-247 4pin and TO-247 2pin packages. It helps compare the benefits of the CoolSiC™ MOSFETs technology with the performance provided by CoolSiC™ diodes. This board was improved for 2000 V devices based on the evaluation board EVAL-IGBT-1200V-TO247PLUS. Please see the application notes [1] for further information on board settings.

Similar to EVAL-IGBT-1200V-TO247PLUS, this board also supports two distinct operating modes. It may be utilized to examine the switching behavior and estimating the switching losses for CoolSiC™ MOSFETs and CoolSiC™ diodes under various circumstances. It is simple to alter variables such as the gate voltages and resistors, load current, device temperature, and the DC link voltage. Snubbers could also be put together if desired. The board can also be used as a step-up or step-down DC/DC converter. As a result, the same configuration can be used to characterize and operate devices in continuous mode.

Compared to EVAL-IGBT-1200V-TO247PLUS, there have been some additional features.

- Compatible with TO-247 2pin package
- Turn-off voltage can be adjusted by resistor from 0 V to -5 V
- Turn-on voltage can also be adjusted
- Supports an external XMC4400 controller board to provide double-pulse or constant PWM signal
- The bus capacitor can withstand 1500 V bus voltage

1.2 Scope of supply

The evaluation board is shipped with a plastic enclosure for high voltage measurements as shown in Figure 2, in a carton box:

- The EVAL-COOLSIC-2kVHCC evaluation board
- 2000 V CoolSiC™ MOSFETs — IMYH200R024M1H
- 1EDX3 compact isolated gate driver ICs —1ED3124MUH12 — in a 300mil wide body package

Figure 2 Scope of delivery: evaluation board with protection case

2 System and functional description

A brief overview of the board's hardware is provided in this chapter of the user guide (UG-2023-06). First, the power circuitry, key components, and connectors are outlined. Then, suggested accessories use for applications is given.

2.1 Circuit and main components

The evaluation board is essentially a half-bridge converter made of two MOSFETs —S1 and S2— as shown in Figure 3 (a). It is feasible to create a TO-247PLUS High Creepage package with four leads and a typical TO-247 2pin package thanks to the clip-based heat sink installation and the universal socket on the PCB.

The switches are driven using EiceDriver™ 1EDX3 compact driver ICs. These drivers are well suited for applications that call for high voltages, and switching speeds because of the robust nature of the coreless transformer technology paired with the 300mil wide-body packaging. The two drivers are independently controlled by PWM signals on the connectors SIG-HS and SIG-LS. Additionally, the 2000 V CoolSiC™ evaluation board supports an external XMC4400 controller board to supply double pulse or constant PWM signals. Two independent DC/DC converters with a 12 V auxiliary supply is used power the MOSFETs.

For versatility reasons, the evaluation board was equipped with input and output capacitors C_{in} and C_{out} as well as a load inductor L. While the input capacitor and the load inductor were designed having mainly switching loss measurements in mind, the output capacitor is required for continuous operation, for instance as a buck converter. The filter inductor provided might not meet the requirements for the latter case but it can be easily replaced by a custom solution.
The heat sink follows the same feedback, whose dimensions and design suggest that it is unable to provide the degree of cooling required for continuous operation. As opposed to that, it is intended to serve as a heating element for studies of switching loss at high temperatures. The power resistor R_{POW} and the thermistor R_{NTC} can be used to adjust and monitor the heat sink temperature. Again, it is simple to replace the provided heatsink with a more effective one.

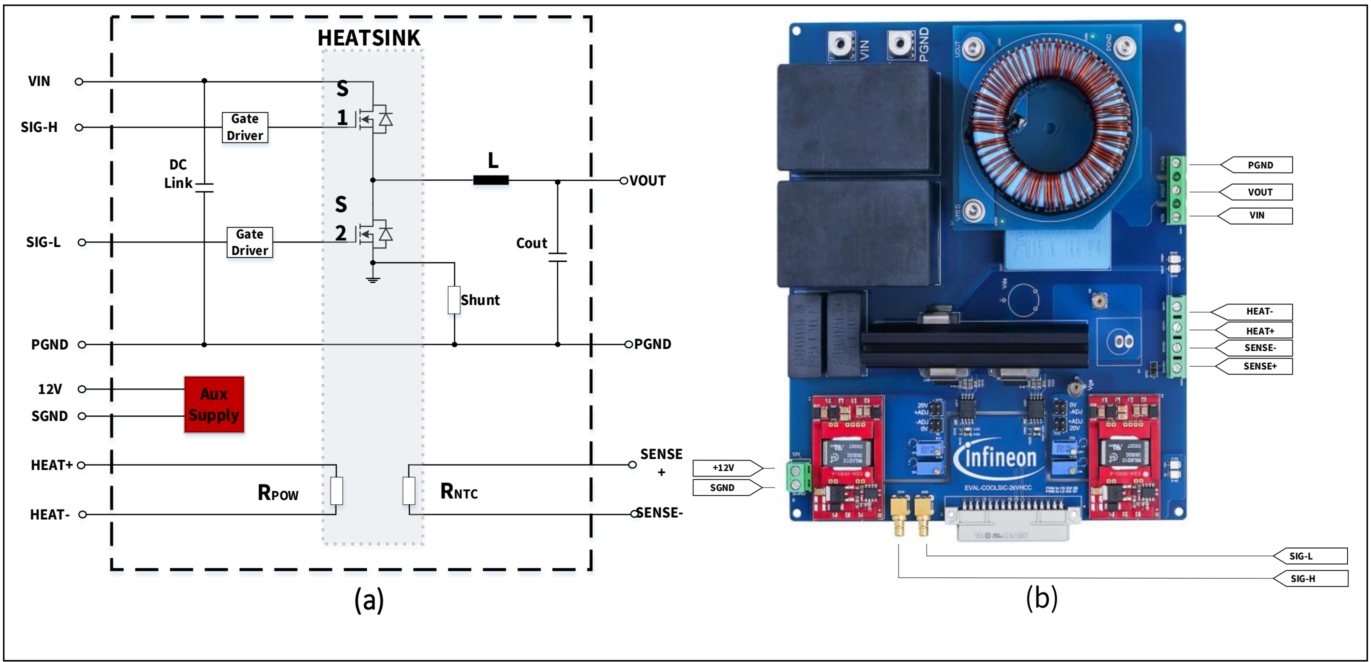


Figure 3 Overview of (a) the board schematics and (b) the components

The gate voltage, the drain-source voltage, and the drain current must be measured using an oscilloscope to experimentally investigate the device's switching behavior. While measuring the voltage is simple, measuring current is more challenging, especially when there are high current slopes. A straightforward Surface Mounted Device shunt resistor solution is provided on this evaluation board. Although it gives a sense of the drain current waveform, there are better options to get accurate readings. However, utilizing the Rogowski coil to measure the pin current directly is recommended from the standpoint of straightforward testing.

2.2 Getting started

The evaluation board is adaptable enough to deal with various measuring issues. This chapter offers comprehensive instructions on setting up and using the board. The preceding sections cover its fundamental function and hardware. The modification of specific board settings is covered in Section 2.3 and planning of the various experiments is covered in Section 2.4.

2.3 Modes of operation

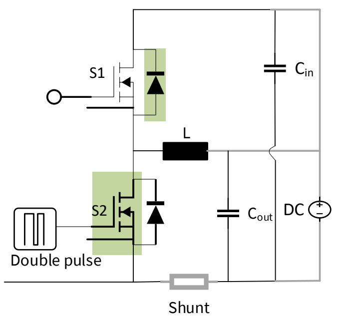
The evaluation board implements a half-bridge circuit with independent driver stages for the high side and low side semiconductor devices, as mentioned in Section 2.1. The board can be used in various operational modes thanks to the ubiquitous nature of this architecture. The potential measurement configurations and methods are described in the next section.

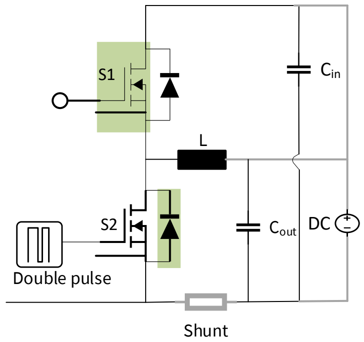
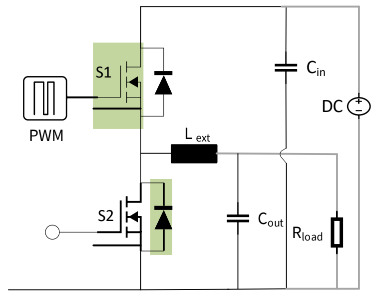
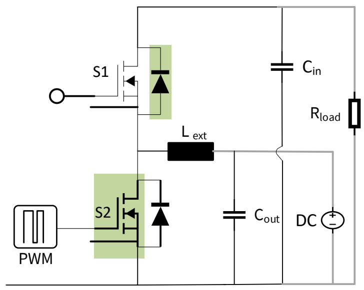
Attention: Before measuring ensure that the board settings are correct. Make sure no physical short circuits or floating gates are present. Increase the input voltage slowly and check if the circuit behaves as excepted.

The configurations of the primary board are summarized in Table 2. The first two lines shows how to evaluate the switching behavior for CoolSiC™ MOSFET and diode combinations. It is feasible to produce an event with a specific voltage and current by switching the MOSFET in response to a double-pulse signal. Switching losses of the devices can be estimated by measuring the current and voltage waveforms on the oscilloscope. Configuration (1) can be used to analyze the MOSFET and configuration (2) to analyze the diode. Using the low side device, S_2, for oscilloscope measurements is recommended for maximize accuracy.

For buck and boost converters, use configuration (3) and configuration (4). As these converters process power continuously, the heat sink and the inductor must each fulfill specific voltage, power, and switching frequency specifications. It is simple to swap out those components with suitable custom solutions.

Table 2 Modes of operation

Configuration	Device Under Test	Parameters and limits		Simplified topology
(1) Switching (Switch characterization)	Switch S_2 Diode S_1	V_{DS} I_D T_C V_{GS} Package	< 1600 V[1] < 150 A[2] < 150°C[3] -5 V to 24 V TO-247-x[4]	

(2) Switching (Switch characterization)	Diode S_2 Switch S_1	V_{DS} I_D T_C V_{GS} Package	< 1600 V[1] < 150 A[2] < 150°C[3] -5 V to 24 V TO-247-x[4]	
(3) Converter (Buck)	Switch S_1 Diode S_2	V_{DS} F_{sw} P_{out} V_{GS} Package	< 1600 V[1] - -[5] -5 V to 24 V TO-247-x[4]	
(4) Converter (Boost)	Switch S_2 Diode S_1	V_{DS}/ (1-d) F_{sw} P_{out} V_{GS} Package	< 1600 V[1] - -[5] -5 V to 24 V TO-247-x[4]	

Note:

[1]Limited by ceramic DC link capacitors, C201 and C202, on the bottom side of the PCB.

[2]Not a hard limit due to the soft saturation behavior of the inductor core.

[3]Limited by the maximum temperature of the power resistor.

[4]TO-247-x refers to TO-247 and TO-247PLUS as well as TO-247 4pin/2pin and TO-247PLUS 4pin packages.

[5] Limit is determined by the device chosen and the board's cooling capabilities.

2.4 Settings

The evaluation board can help perform numerous tests on the TO-247 2pin and TO-247PLUS packages with four leads. This section offers detailed instructions for assembling several package types and performing the most crucial modifications, particularly to the driving circuits.

Attention: To prevent potential exposure to hazardous voltages, turn off all power supplies and discharge the DC link capacitors before undertaking any of the modifications described in this section.

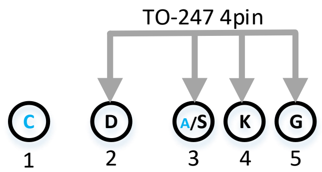
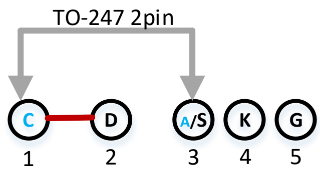
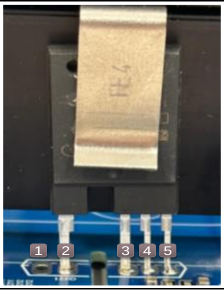
2.4.1 Changing between 4pin and 2pin packages

The evaluation board features specific five pin sockets that can fit different package variations because it must function as a universal test platform for TO-247 and similar packages with two and four leads.

The connection schemes for switches and drivers are listed in Table 3 with the possible sequence of steps.

1. Connect the discrete semiconductor package with solder to the appropriate socket pins: pins 1-2 for two lead packages and pins 2-5 for four lead packages.
2. Make sure the appropriate source lead is linked to the driver output's reference using a 0 Ω resistor: Build R212/R222 for a four-pin setup.

Table 3 Assembly of TO-247 and similar packages with two and four pins

Package	TO-247PLUS 4pin	TO-247 2pin
Connected press fit pins	Pins 2, 3, 4, 5	Pins 1, 3
Connection Scheme		
Picture		**Applicable for all TO247 2pin packages**
Comment	Intended operation of the 4pin package	Intended operation of the 2pin package (pin 1 and pin 2 to be shorted)

2.4.2 Tuning gate voltages and resistors

The drive circuitry used to operate both the high side and low side switches is schematically shown in Figure 4. Along with highlighting the most crucial part labels, it also shows the relevant circuitry components.
SiC MOSFETs are driven by a galvanically isolated EiceDriver™ 1EDX3 compact IC, 1ED3124MU12H, with separate sink and source outputs in a DSO-8 wide body package with a nominal current rating of 14 A. The primary or input side of the driver is powered by a voltage of 5 V, referring to Signal Ground, which is produced based on the 12 V auxiliary input using a linear regulator, TLE4264-2G, and controlled by a PWM signal on the input Sig-X. Please note that there is no need to use an extra RC low-pass filter on the signal path because the driver already includes high-precision input filters. RC low-pass filter is not advised because it would need extra parts and would have a larger propagation delay tolerance.

The jumpers, X121 and X5, and the potentiometers R110, R17, R19, and R120 that are used to control the driving voltages on the output or secondary side of the driver, are supplied by an isolated DC/DC converter. As shown in Figure 4(b), these parts are assembled on the board's top side.

To modify the low side gate voltage levels, follow these steps:

1. Set the jumper X121 to +ADJ and tune the potentiometer R120 with a flat screwdriver until the recommended value of 18 V is reached.
2. Using the jumper X6, choose a turn-off voltage of either -5 V or 0 V. The turn-off voltage can be changed from 0 V to -5 V by tuning the potentiometer R19.
3. Using an oscilloscope or multimeter, track the gate voltage values.

The top side of the board has turn-on and turn-off resistors, R221 and R222, that are constructed separately and have the labels — ON and OFF, as shown in Figure 4(c). A soldering iron can be used to modify the gate resistors values. In Figure 5, you can see the schematics of the driver IC.

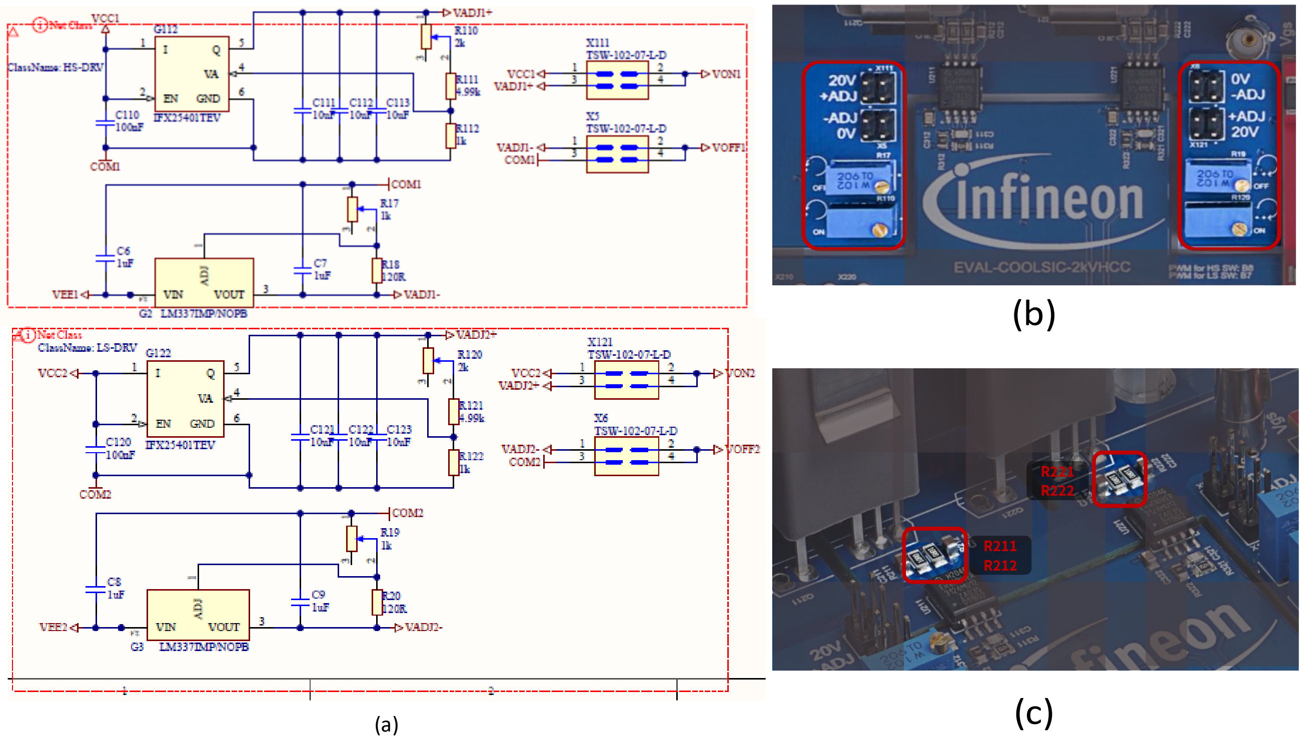


Figure 4 Gate driver settings: (a) Schematics of the gate driver circuitry (b) Gate voltage settings (c) Gate resistors

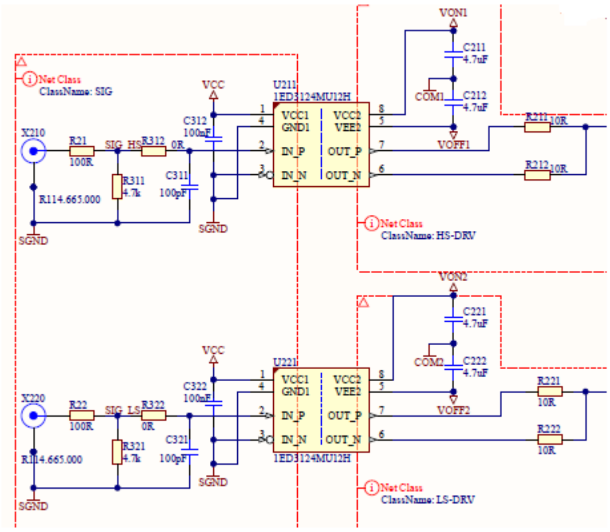


Figure 5 Circuit schematics of the driver IC

2.4.3 Adjusting and monitoring the heat sink temperature

Apart from room temperature, switching losses can also be measured at 100°C and beyond. Therefore, the measuring setup needs to allow users to control and keep track of the case temperature of the test device.

A small heat sink that functions as a tiny heating element is included on this test board. The temperature of this heat sink can be controlled and monitored using the power resistor E200 and the negative temperature coefficient (NTC) thermistor B200, respectively. E200 is assembled on the rear side of this heat sink.

To adjust the heat sink temperature:

1. Connect the laboratory's power supply to the HEAT+/HEAT- terminals of the power resistor.
2. Connect an ohmmeter to the SENSE+/SENSE- terminals of the NTC thermistor.
3. Use the power supply to adjust the heat sink temperature.
4. Monitor the actual temperature value using the ohmmeter and the NTC characteristic.

With a thermal resistance to the ambient of around 6 K/W and a thermal time constant of roughly 7 minutes, the behavior of the heat sink can be roughly predicted. If the heat sink facing upwards and is not subject to forced air cooling, the behavior of heat sink description is valid.

2.4.4 Configuring the double-pulse test

Double-pulse testing is a method for calculating switching losses. Applying two successive pulses to a switch's gate creates both a turn-off and a turn-on event, hence the term "double-pulse". This section explains how to conduct a double-pulse test using configuration (1). Configuration (2), however, is controlled as described in Section 2.3.

To perform a double-pulse test on the evaluation board:

1. Assemble the devices under tests S_1 and S_2 as described in Section 2.4.1.
2. Connect the driver to the proper emitter pin as explained in Section 2.4.1.

3. Adjust the driving circuitry for S_2, and if necessary also for S_1, according to Section 2.4.2:
   a. Set the jumper X111/X121 to +ADJ.
   b. Use the jumper X5/X6 to set the turn-off voltage to 0 V or -5 V.
   c. Adjust the turn-on and turn-off gate resistors, R211/R221 and R212/R222, respectively.
4. Connect oscilloscope probes to measure V_{DS}, V_{GS}, and I_D of S_2:
   a. Use the probe adapters to measure V_{DS} and V_{GS} with ordinary voltage probes.
   b. Measure I_D using shunt. If possible, use a Rogowski coil as recommended in Section 2.1.
5. Connect an auxiliary supply to the 12 V/S_{GND} terminal of the board to provide a voltage of 12 V.
6. Connect a signal generator to X220/X210 and provide a double-pulse pattern with 5 V amplitude. The double-pulse pattern can also be provided with XMC4400, as explained in Chapter 3.
7. If required, connect a power supply to the HEAT+/HEAT- terminals and set the voltage level. Monitor the temperature using the ohmmeter connected to SENSE+/SENSE- as explained in Section 2.4.3.
8. Connect a high voltage source to V_{IN} and P_{GND} and short V_{IN} and V_{OUT}.
9. Slowly increase the voltage and monitor the current and voltage waveforms on the oscilloscope.

2.4.5 Configuring the efficiency measurement

To fully comprehend the switching behavior of a semiconductor device, it must be tested inside a switching cell. Converting the received switching loss data into values that are more useful for an application, such as the efficiency of the converter, the temperature of the devices, or the required cooling effort, however, requires some analysis. This section outlines the steps necessary to set up and operate the board as a buck converter under configuration (3) as listed in Table 2.

The following steps must be taken before the evaluation board can be used as a buck converter:

1. Short circuit the shunt resistors R15 and R16 to avoid unnecessary power dissipation.
2. Replace the heat sink:
   a. Remove the M3 screws holding the heat sink to the board from the bottom.
   b. Pull the heat sink away from the board so that the spring clips fall off.
   c. Unsolder the power resistor E200.
   d. If necessary, solder the film capacitors C203 and C204 to the other side of the board.
   e. Install a suitable heat sink. If possible, put an insulation layer between the heat sink and the board.
3. Replace the inductor
   a. Disconnect the daughter card containing the inductor by unfastening the M4 screws.
   b. Connect a custom inductor between the V_{MID} and the V_{OUT} potential.

Preparing the test setup for measuring efficiency:

1. Assemble the devices under tests S_1 and S_2 as described in Section 2.4.1.
2. Connect the driver to the proper emitter pin as explained in Section 2.4.1.
3. Adjust the driving circuitry for S_2, and if necessary also for S_1, according to Section 2.4.2.
    a. Set the jumper X111/X121 to +ADJ.
    b. Use the jumper X5/X6 to set the turn-off voltage to 0 V or -5 V.
    c. Adjust the turn-on and turn-off gate resistors, R211/R221 and R212/R222, respectively.
4. Connect the oscilloscope probes to measure V_{DS}, V_{GS}, and I_D of S_2.
    a. Use the probe adapters to measure V_{DS} and V_{GS} with ordinary voltage probes.
    b. Measure I_D using a shunt. If possible, use a Rogowski coil as recommended in Section 2.1.
5. Connect an auxiliary supply to the 12 V/S_{GND} terminal of the board and provide a voltage of 12 V.
6. Connect a signal generator to X220/X210 and provide a double-pulse pattern with 5 V amplitude. The double-pulse pattern can also be provided with XMC4400, as explained in Chapter 3.
7. Connect a high voltage source to V_{IN} and P_{GND}.
8. Connect an Ohmic load to V_{OUT} and P_{GND}.
9. Measure the input and output power using a power meter and the device's temperatures using an infrared camera.
10. Slowly increase the input voltage while monitoring the waveforms and device temperatures

3 XMC4400 graphic user interface (GUI) for Evaluation Board for CoolSiC™ MOSFET 2000 V

This chapter introduces how to run the double-pulse test with XMC4400 on the evaluation board for CoolSiC™ 2000 V MOSFET, including HEX software installation and functional testing setup. Visit 32-bit XMC4000 Industrial Microcontroller ARM® Cortex®-M4 on Infineon's website to read about XMC4400 products/devices. The user guide [1] explains detailed description of the XMC4400 drive card.

3.1 Preparing the XMC™ Flasher

In order to ensure the safe programming of the flash, managing the integrity of the microcontroller flash is essential at the time of production, throughout each firmware update, or even during each startup. To manage flash integrity, there are standard procedures in place, including redundancy checks, checksums, fallback boot modes, and so forth.

3.1.1 Installing Infineon Developer Center

Infineon Developer Center (former Infineon Toolbox) is the one stop shop for engineers for downloading and design-in of all Infineon development tools, embedded software, services, and solutions.

The following steps must be taken to access the Infineon development tools or software

Download the Infineon Developer Center Launcher utility on your system (based on the operating system). Login credentials are required for this.

- → Register first
- → Login and download launcher utility
- → Search for tools or software
- → Download and install
- → Manage tools in laucher utility

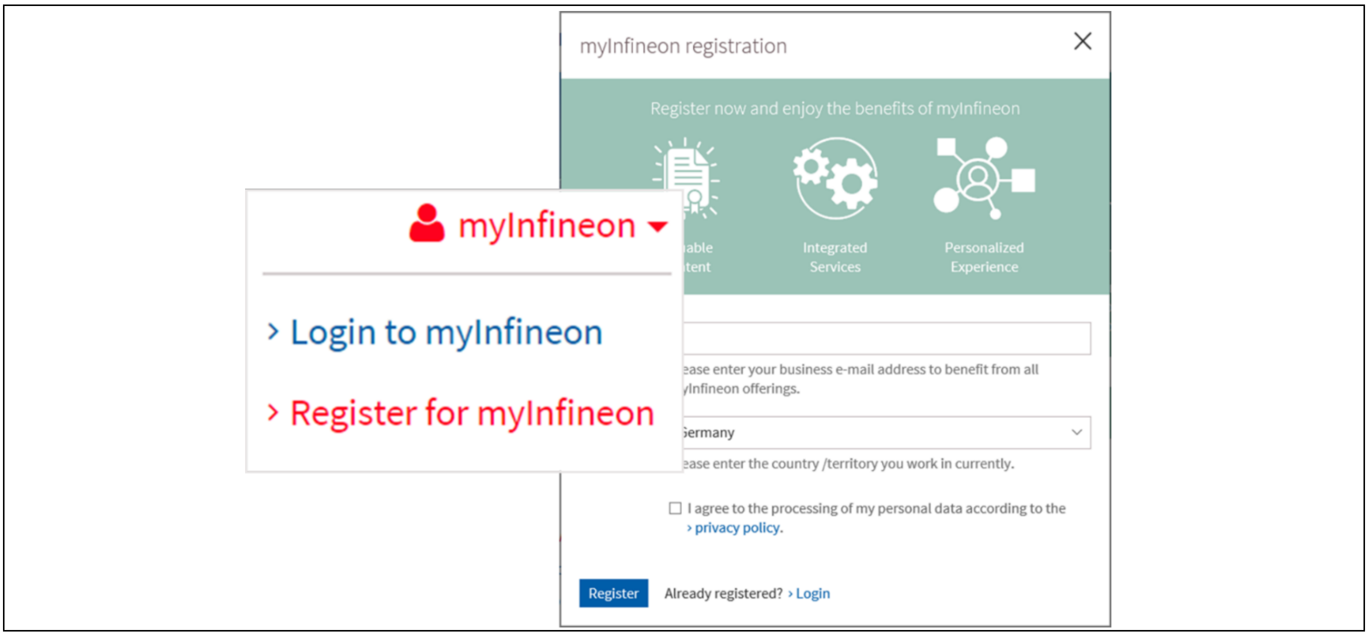


Figure 6 myinfineon registration for exclusive information

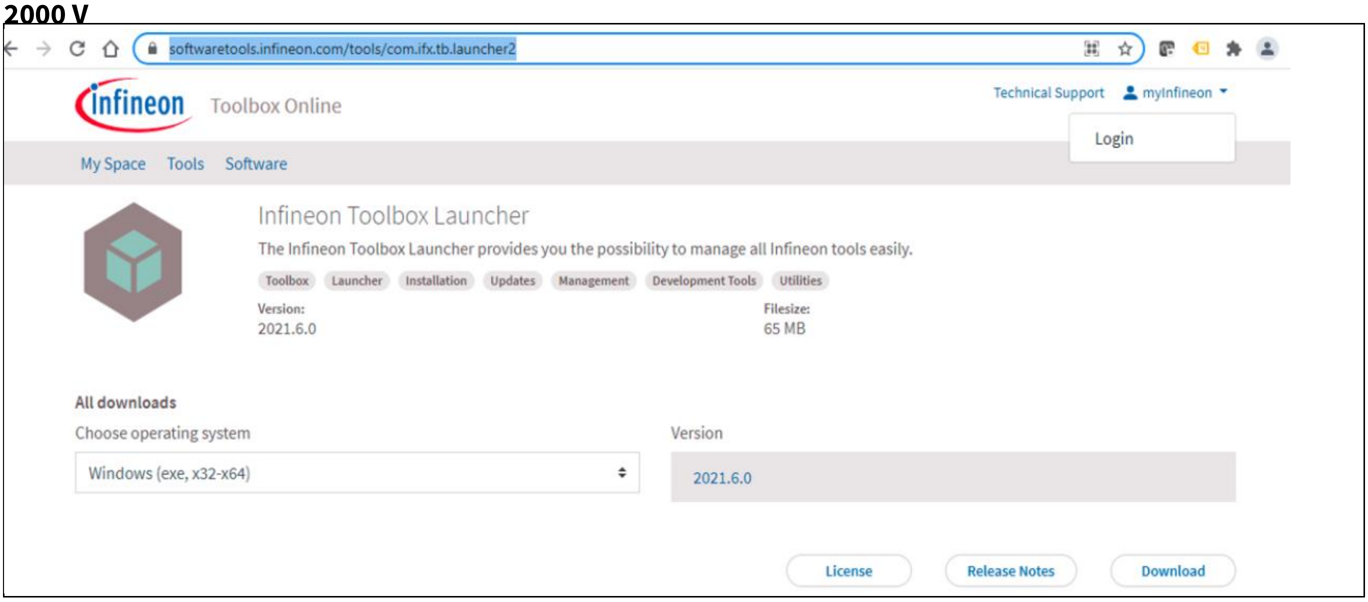


Figure 7 Download the launcher utility

3.1.2 Installing the XMC^{TM} Flasher software

In the Infineon Developer Center, search for XMC^{TM} Flasher, as shown in Figure 8.

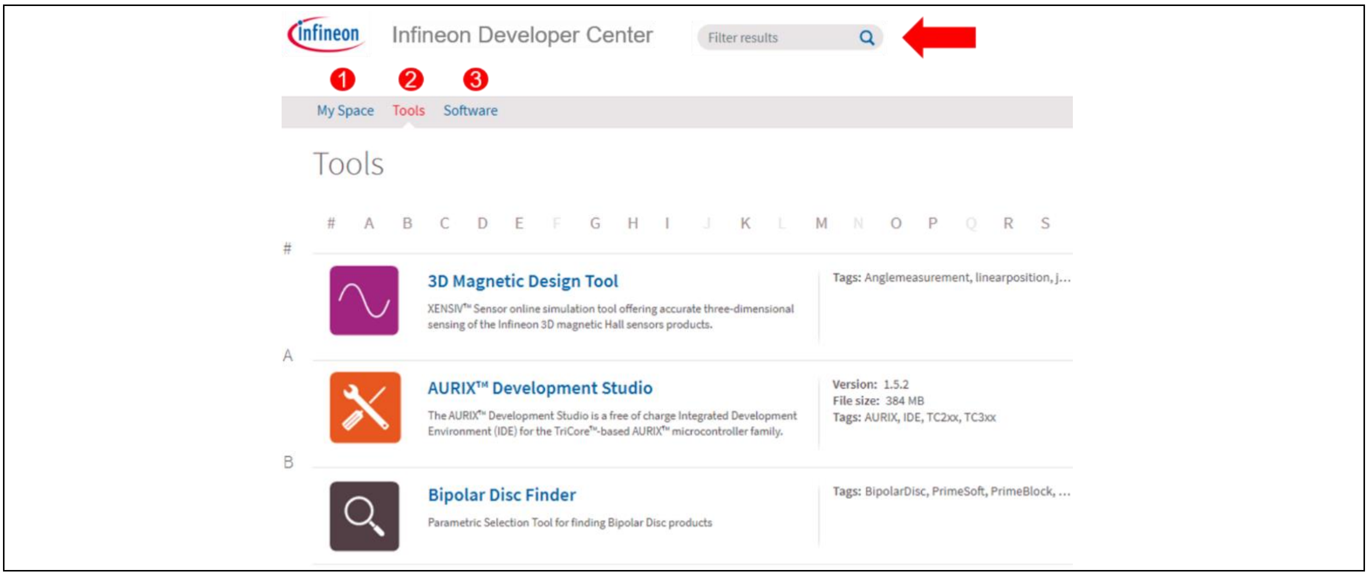


Figure 8 Search for XMC Flasher in Infineon Developer Center

Click **Download** to download the tool and install the tool, as shown in Figure 9.

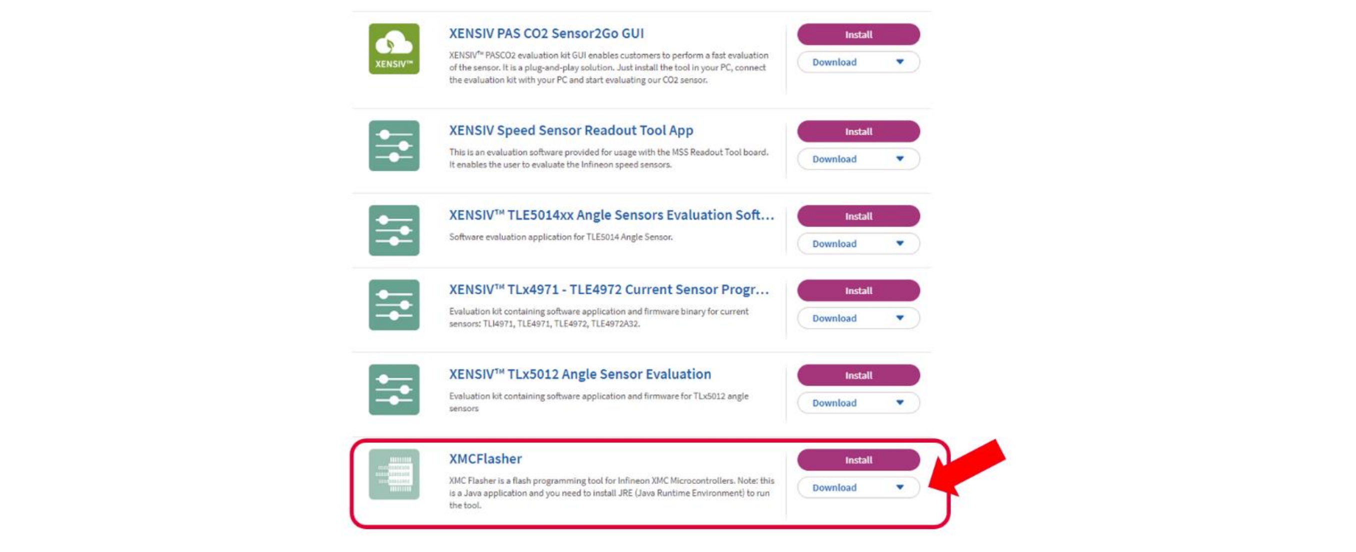


Figure 9 Download XMC Flasher

3.1.3 Setting up hardware for HEX flashing

A hexadecimal source file used by programmed logic devices such as microcontrollers in remote controls is known as a HEX file. It stores settings, configuration data, or other data in hexadecimal format. The hardware connection set up is shown in Figure 10.

An external +5 V DC source is connected to the GND and VDD5 pins in the XMC4400 and a computer is connected to the XMC4400 with a USB cable.

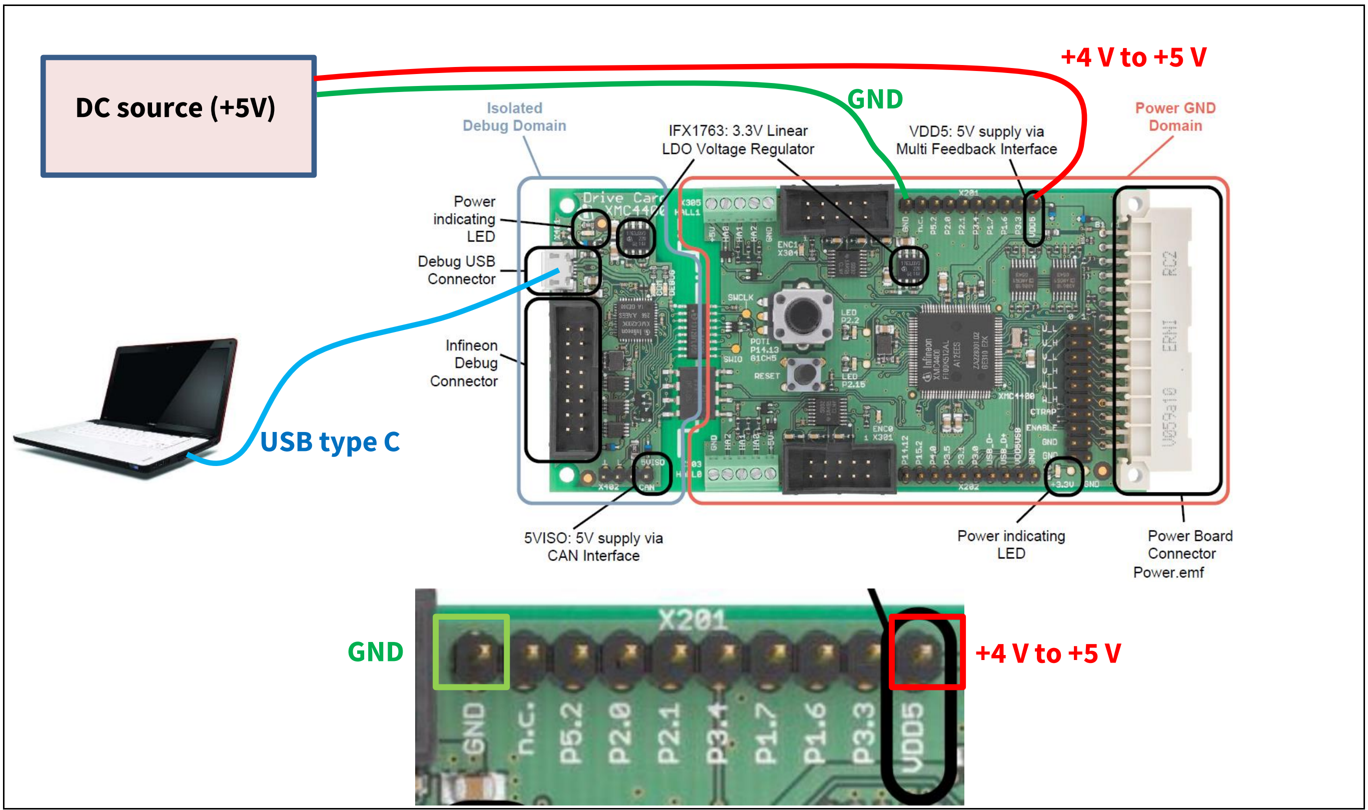


Figure 10 Hardware setup for HEX flashing

3.1.4 Run the XMC™ Flasher

Run the **XMC Flasher**, and configure the Microcontroller as “XMC 4400 512”, as shown in Figure 11 and Figure 12

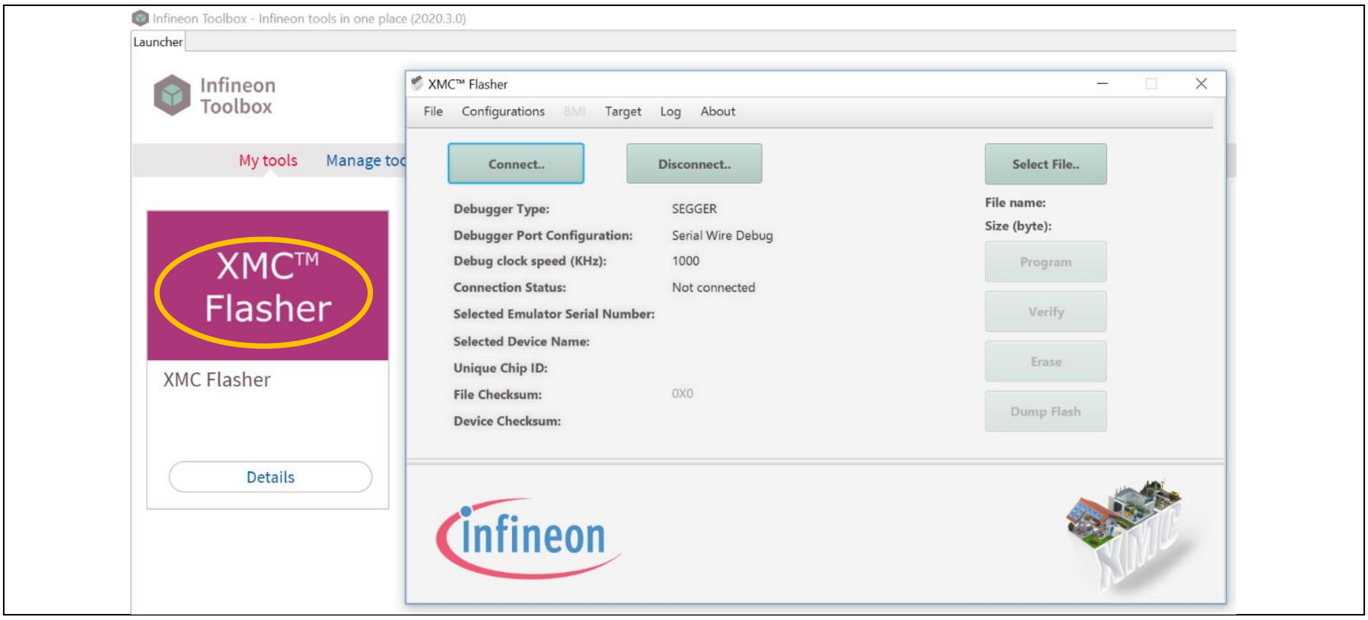


Figure 11 Running XMC Flasher in Infineon toolbox

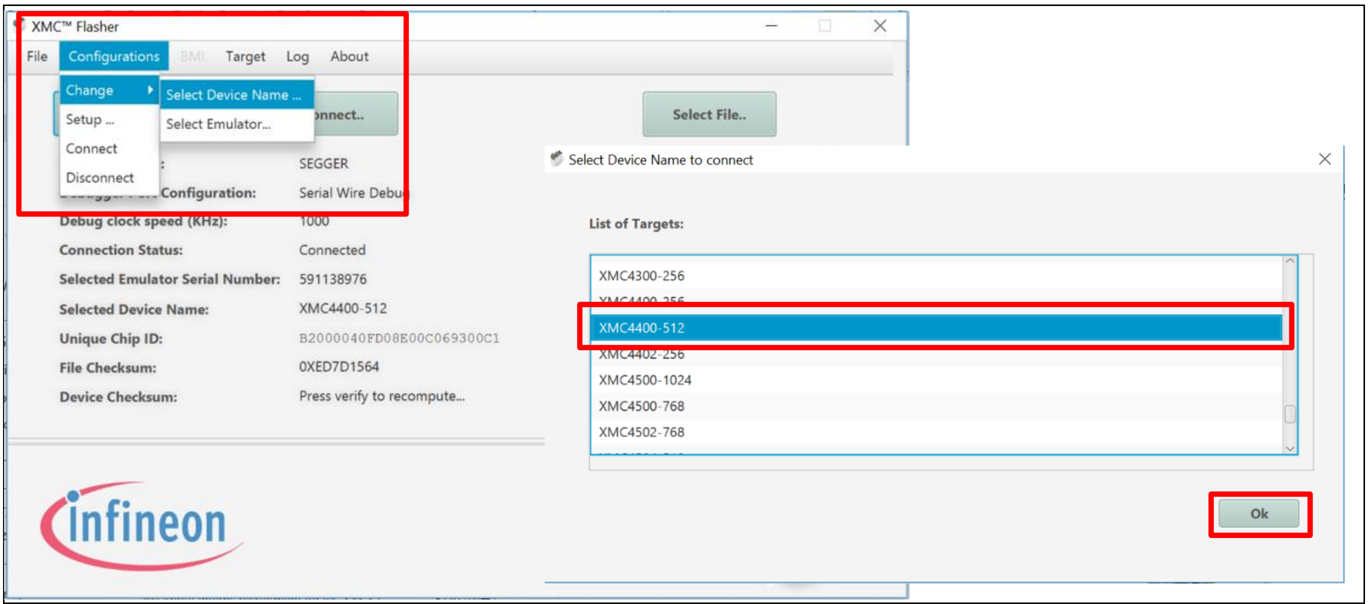


Figure 12 Select the MCU XMC4400-512

In the new window, as shown in Figure 13, upload the executable file by clicking **Select File** → Open the executable file on the computer → Click **Program**.

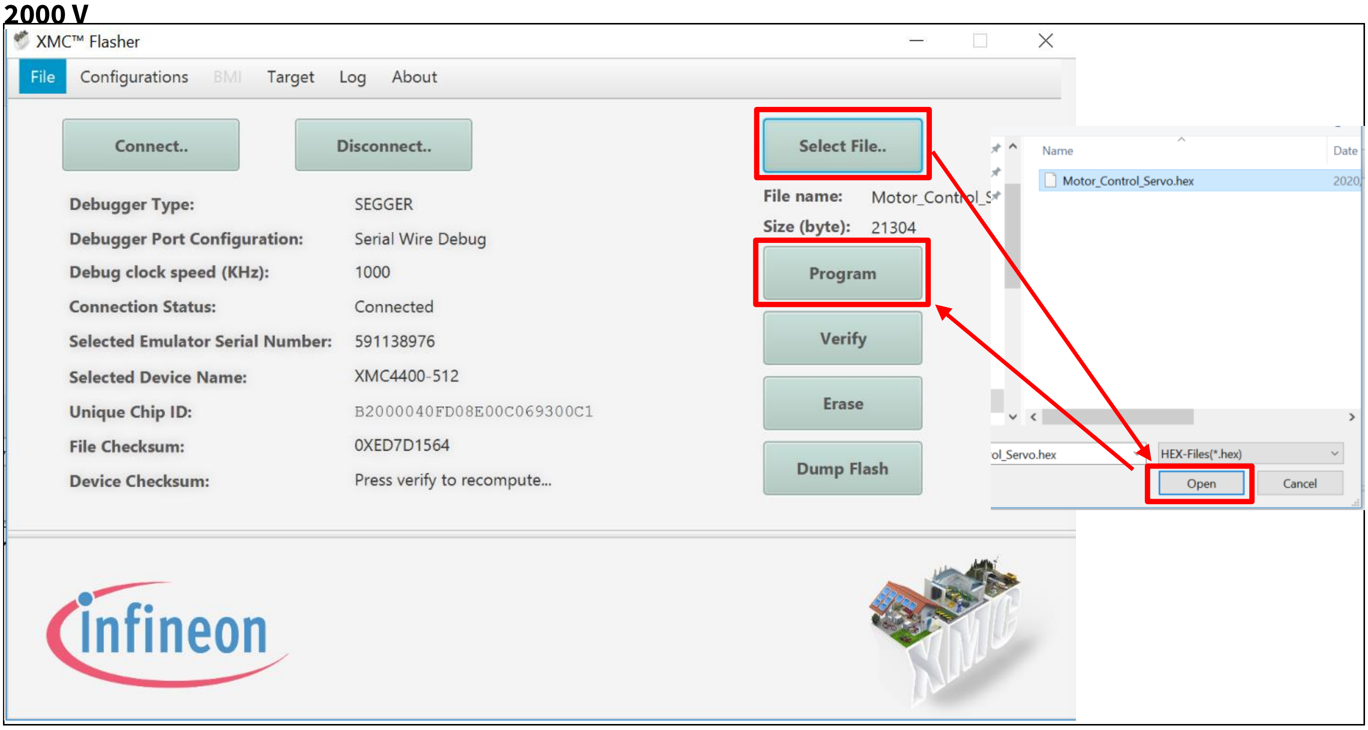


Figure 13 Upload the HEX file and program it

3.2 GUI preparation

3.2.1 Installing the GUI

The GUI package can be found in the webpage of the Evaluation Board for CoolSiC™ MOSFET 2000 V, after unzipping the provided package, users need to install the **IFX Inverter Control_Setup** software package. To use the software, users must follow the guidelines provided in Figure 13, 14, and 15.

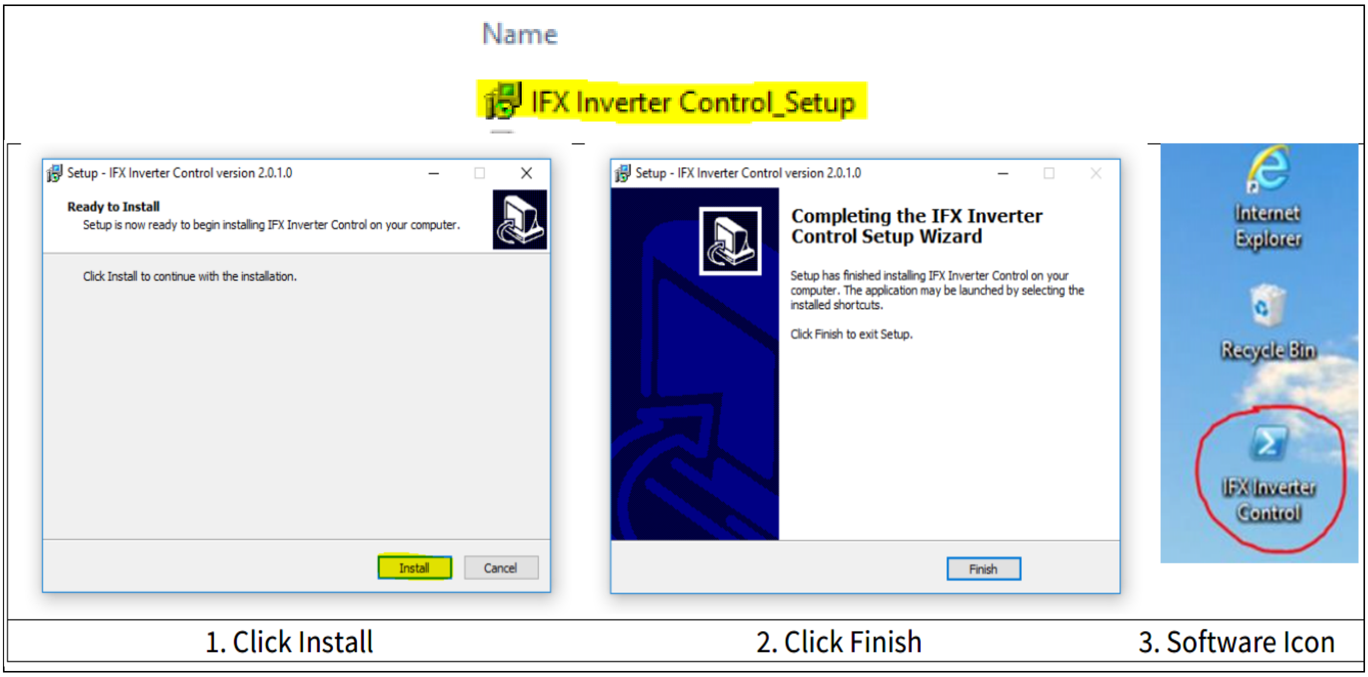
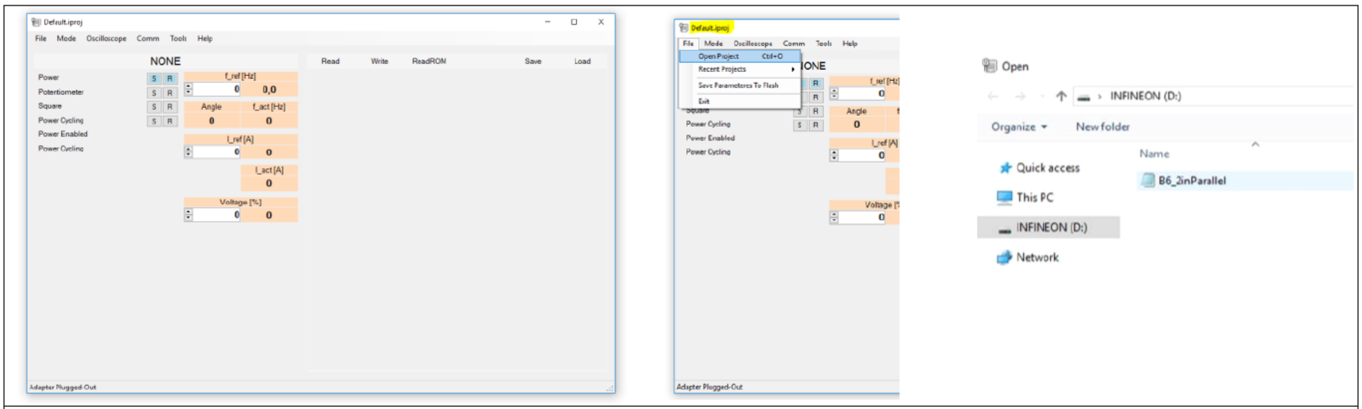


Figure 14 Installing the IFX Inverter Control_Setup software

3 XMC4400 graphic user interface (GUI) for Evaluation Board for CoolSiCTM MOSFET 2000 V

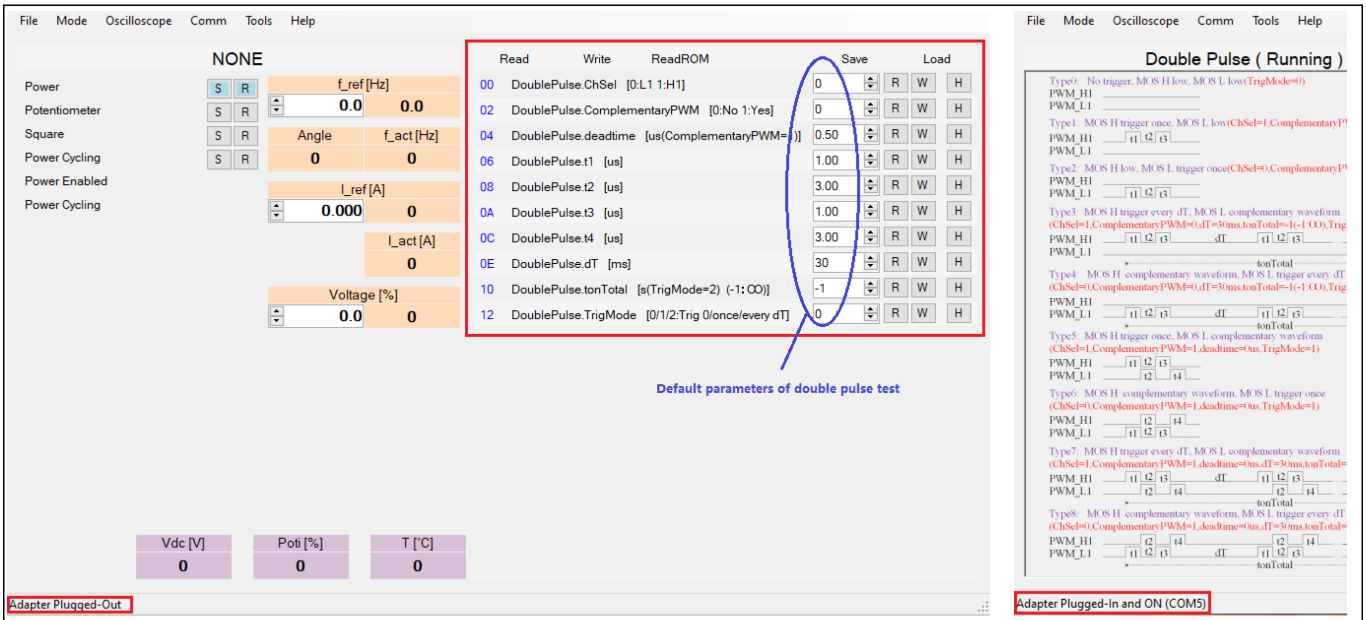
After the IFX Inverter Control software is installed, double-click the icon to open it. The default GUI is empty with no parameters. To open the GUI configuration provided, follow the steps shown in Figure 15



4. Empty GUI – default configuration | 5. Click **File>Open Project** | 6. Choose B6-2inParallel

Figure 15 Configuring the demo GUI

The software GUI displays the current status, whether or not a device is connected to the computer. For example, Figure 16 shows NONE i.e., no board is connected. The same message is provided at the bottom of the window as well —Adapter Plugged-Out.



7. Adapter Plugged-Out - No connection to XMC card | 8.GUI is ready to use

Figure 16 Inactive software — No board is connected to the computer

Note of the double pulse test parameters:

00: DoublePulse.ChannelSelect: 1 - L MOS double pulse test; 0 - H MOS double pulse test
02: DoublePulse.ComplementaryPWM: 0 – single MOS PWM (L MOS PWM or H MOS PWM, depending on the value of the DoublePulse.ChannelSelect) double pulse test; 1 – Both L MOS and H MOS double pulse test with complementary PWM
04: DoublePulse.deadtime: The unit is 1us. DoublePulse.deadtime is only enabled under the condition that DoublePulse.ComplementaryPWM is set to 1
06: DoublePulse.t1: The unit is 1us. DoublePulse.t1 ranges from 0us to 500us
08: DoublePulse.t2: The unit is 1us. DoublePulse.t2 ranges from 0us to 500us
0A: DoublePulse.t3: The unit is 1us. DoublePulse.t3 ranges from 0us to 500us
0C: DoublePulse.t4: The unit is 1us. DoublePulse.t4 ranges from 0us to 500us
0E: DoublePulse.dT: The unit is 1ms. DoublePulse.dT ranges from 0ms to 50000ms, DoublePulse.dT is only used under continuously trigger condition
10: DoublePulse.tonTotal: The unit is 1s. DoublePulse.tonTotal ranges from 0s to 30000s, and the time will no limit if the value is -1, while
11: DoublePulse.tonTotal is only enabled under the condition that DoublePulse.TrigMode is set to 2
12: DoublePulse.TrigMode: 0 - no trigger; 1 - trigger once mode; 2 – continuously trigger every DoublePulse.dT time mode

DoublePulse.ChannelSelect / LED status / DoublePulse.TrigMode	0 (L MOS)	1 (H MOS)
0 (no trigger)	LED P2.2 OFF LED P2.15 OFF	LED P2.2 OFF LED P2.15 OFF
1 (trigger once mode)	LED P2.2 OFF LED P2.15 ON	LED P2.2 ON LED P2.15 OFF
2 (continuously trigger every dT time mode)	LED P2.2 OFF LED P2.15 BLINKING	LED P2.2 BLINKING LED P2.15 OFF

When the XMC driver card is connected to the computer, the software automatically recognizes the controller. The software will then show the status Adapter Plugged-in and ON (COMX). If the controller is connected when the software is already running, the software needs to be restarted.

4 System performance

This chapter provides real world examples of GUI functional tests and switching losses.

4.1 GUI functional test

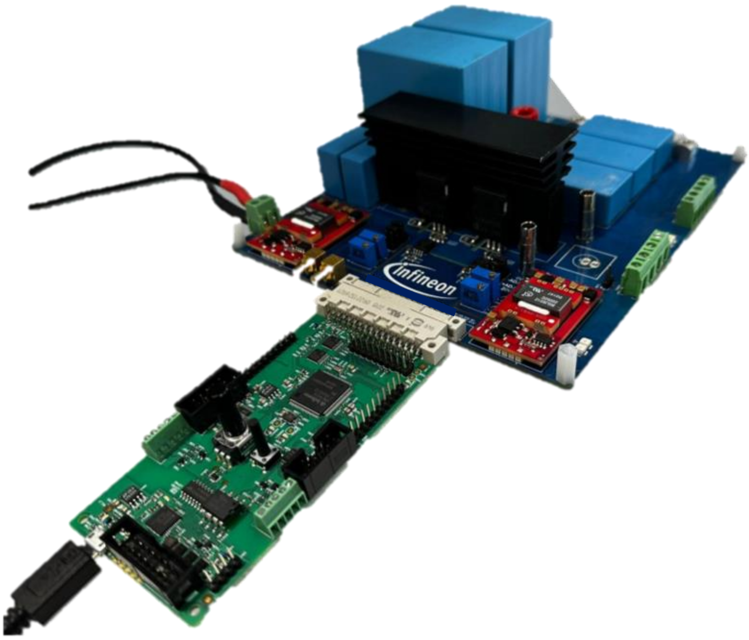


Figure 17 GUI test setup

The functional double-pulse test procedure is as follows:

1. Install the GUI as described in Section 3.2.1.
2. Flash the XMC drive card with the provided hex file.
3. Don't plug-in the XMC drive card yet and apply 480—500 V_{DC} on the DC input.
4. Confirm that AUX is running—the relay switching can be heard and the LEDs are on.
5. Switch off the DC and plug-in the drive card.
6. Plug-in an inductor.
7. Switch on the DC again
8. Check each phase current via a current probe
9. Switch the DC off to end the test.

Using the demo GUI for CoolSiC™ MOSFET

By following the instructions in previous sections, users can start operating the CoolSiC™ MOSFET motor drives evaluation board with the demo software provided.

This section shows through an example how to use Infineon's demo GUI for controlling the evaluation board and testing the performance of SiC MOSFETs in a motor drive application.

To perform the double-pulse test for the low side MOSFET in the trigger once mode, use the configuration values shown in Figure 18.

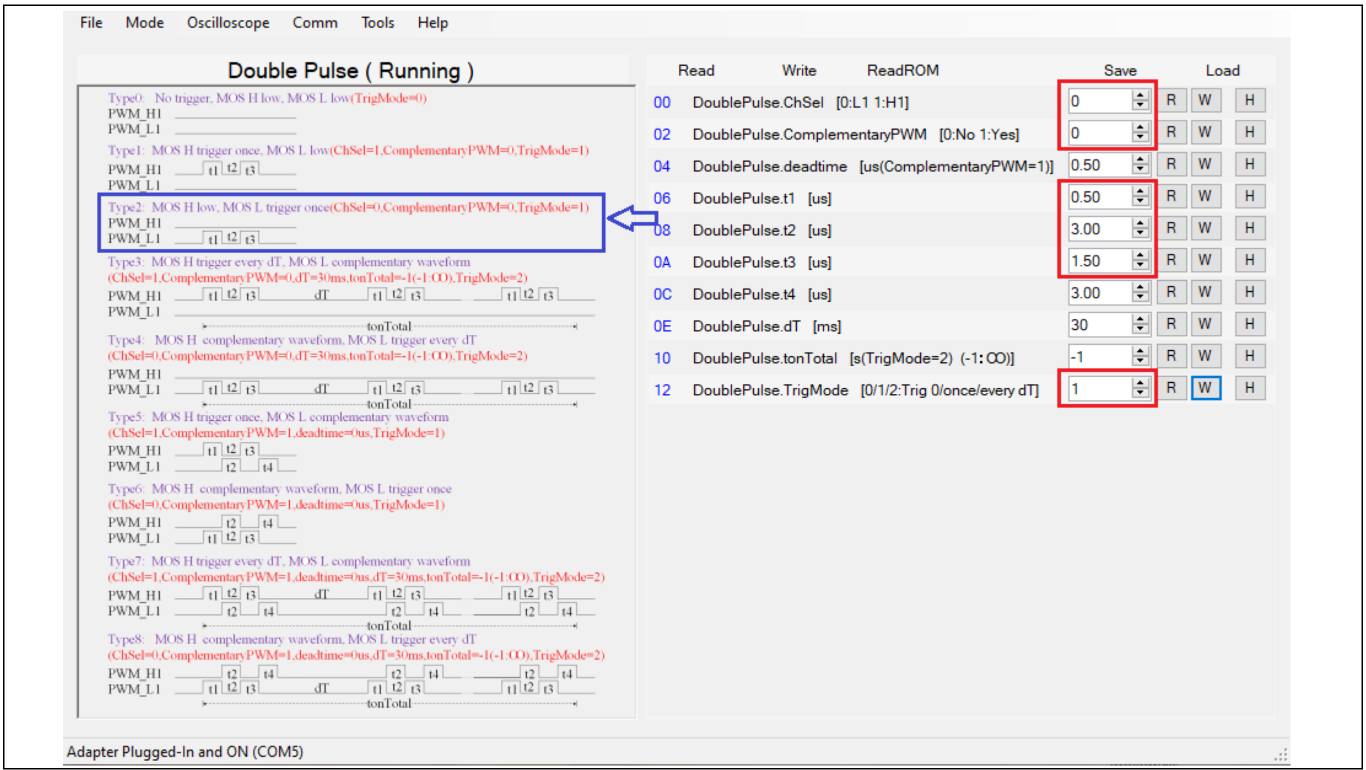
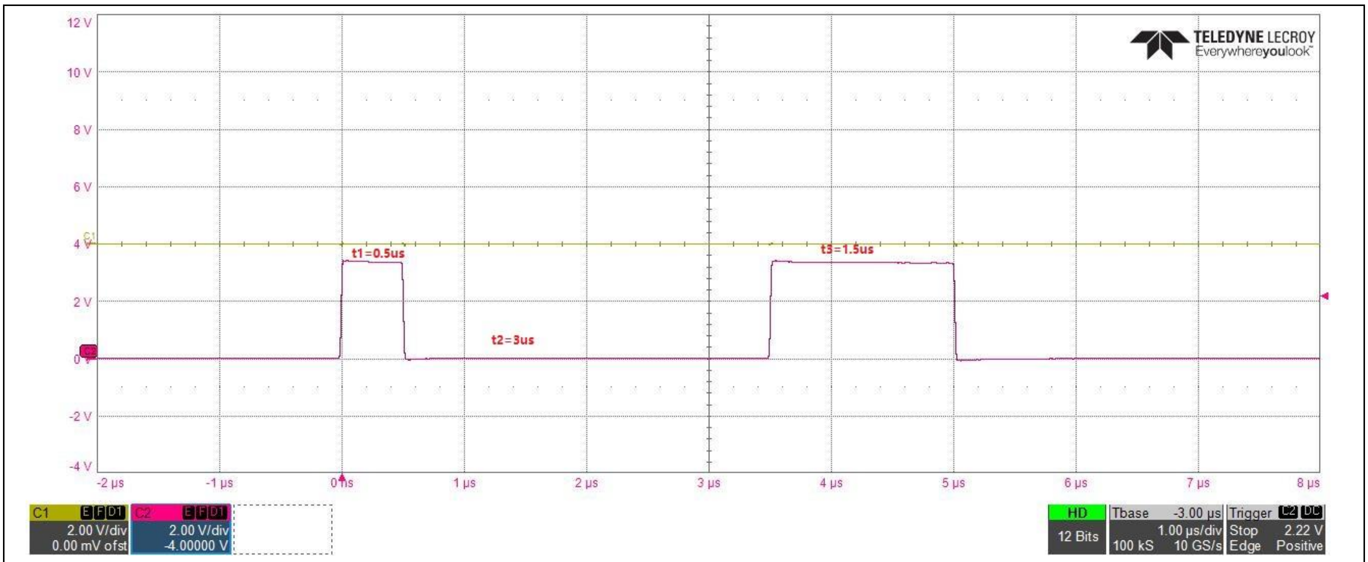


Figure 18 Trigger once mode configuration for the low side MOSFET

The double-pulse test waveform for the low side MOSFET, in the trigger once mode, is shown in the Figure 19. The status of LED P2.2 is OFF and LED P2.15 is ON.



Trigger once: L MOS double-pulse test (waveform CH1:H MOS CH2 L MOS)

Figure 19 Double-pulse test waveform for low side MOSFET in trigger once mode

To perform the double-pulse test for the high side MOSFET in the trigger once mode, use the configuration values shown in Figure 20. The resulting double-pulse waveform is shown in Figure 21, where the status of LED P2.2 is ON and of LED P2.15 is OFF.

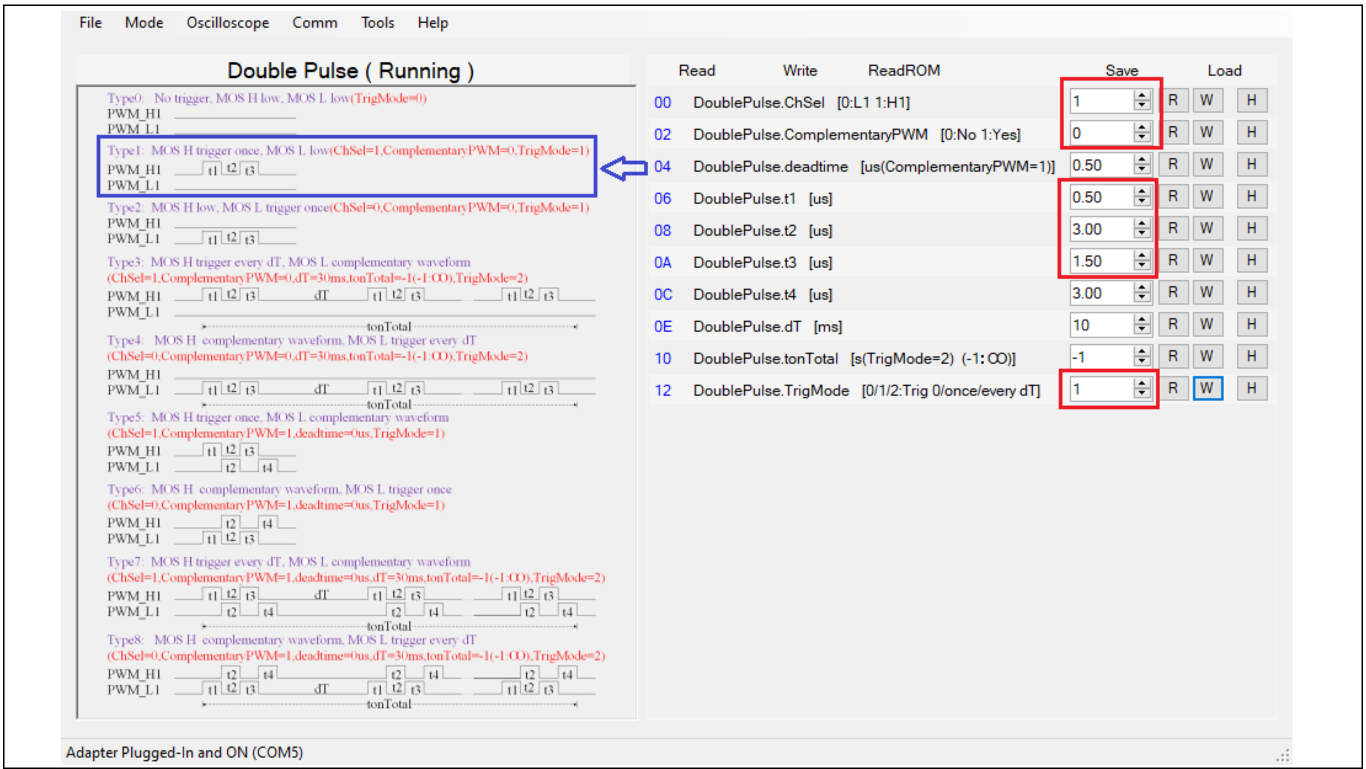


Figure 20 Trigger once mode configuration for the high side MOSFET

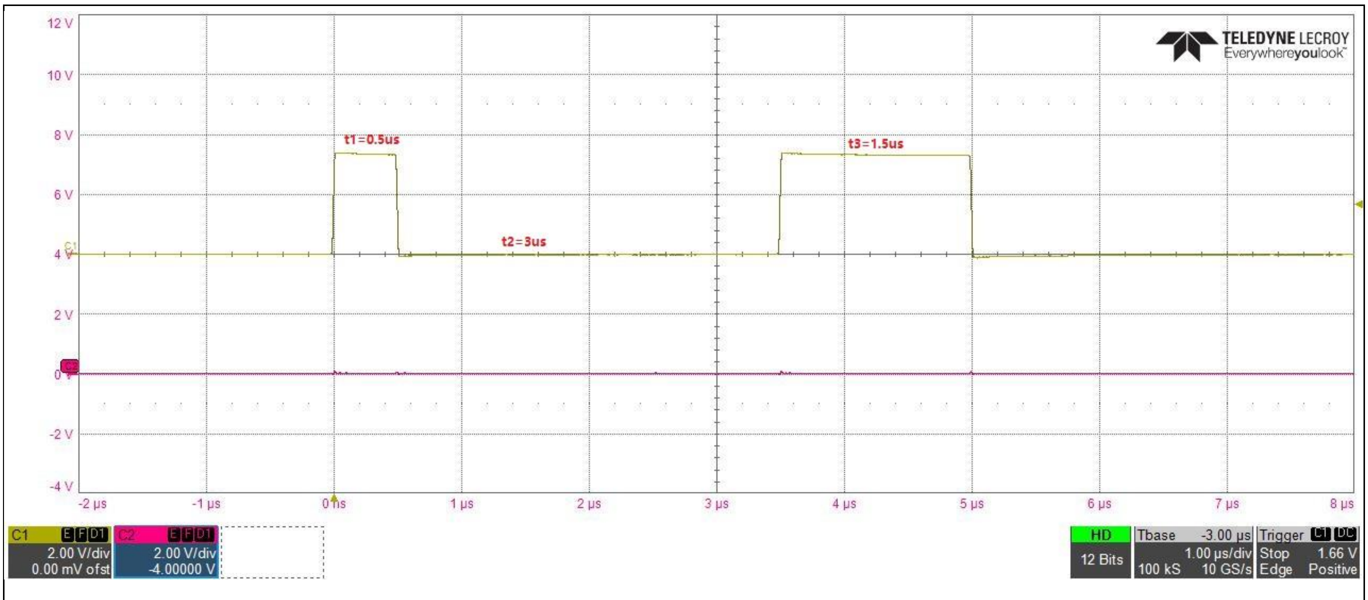


Figure 21 Double-pulse test waveform for high side MOSFET in trigger once mode

To perform the double-pulse test for the low side MOSFET in the trigger every mode, use the configuration values shown in Figure 22.

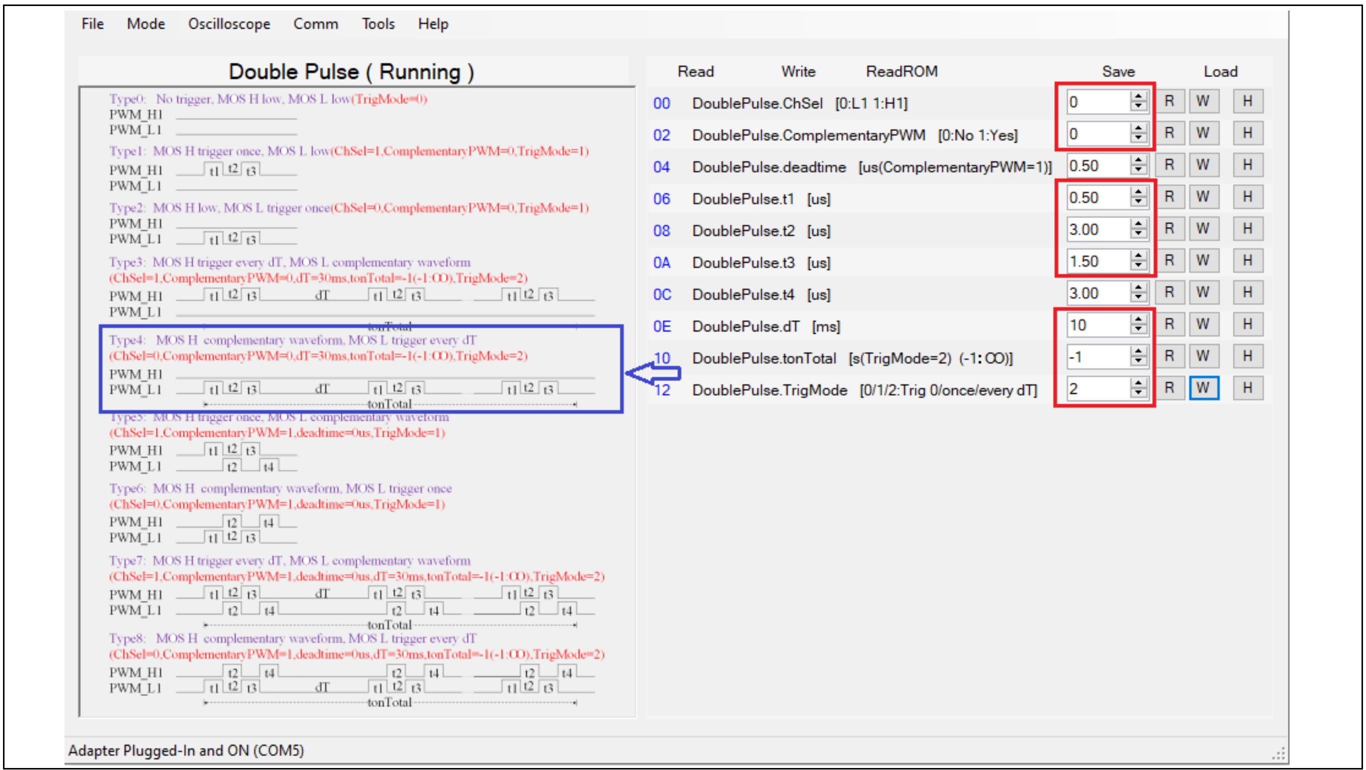


Figure 22 Trigger every mode configuration for the low side MOSFET

The double-pulse test waveform for the low side MOSFET, in the trigger every mode, is shown in the Figure 23. The status of LED P2.2 is OFF and of LED P2.15 is BLINKING at 1 Hz frequency.

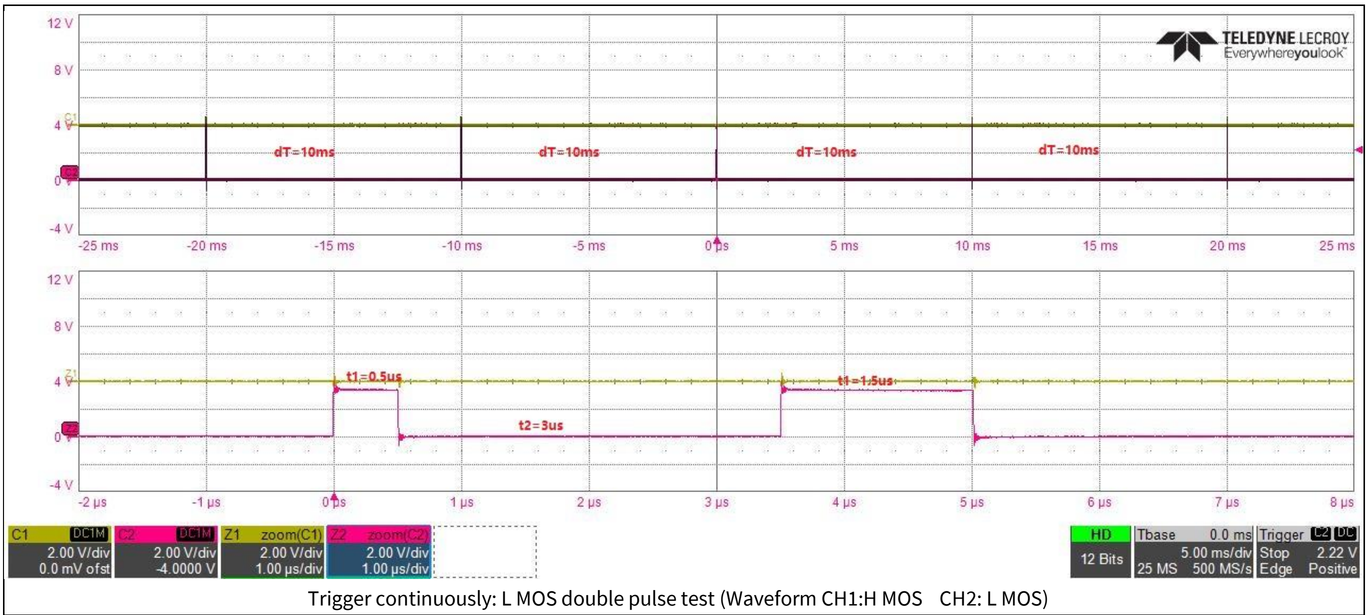


Figure 23 Double-pulse test waveform for low side MOSFET in trigger every mode

To perform a double-pulse test in the trigger every mode for the high side MOSFET and the low side MOSFET with complementary PWM, use the configuration values shown in Figure 24. The resulting double-pulse waveform is shown in Figure 25, where the status of LED P2.2 is BLINKING at 1 Hz frequency and of LED P2.15 is OFF.

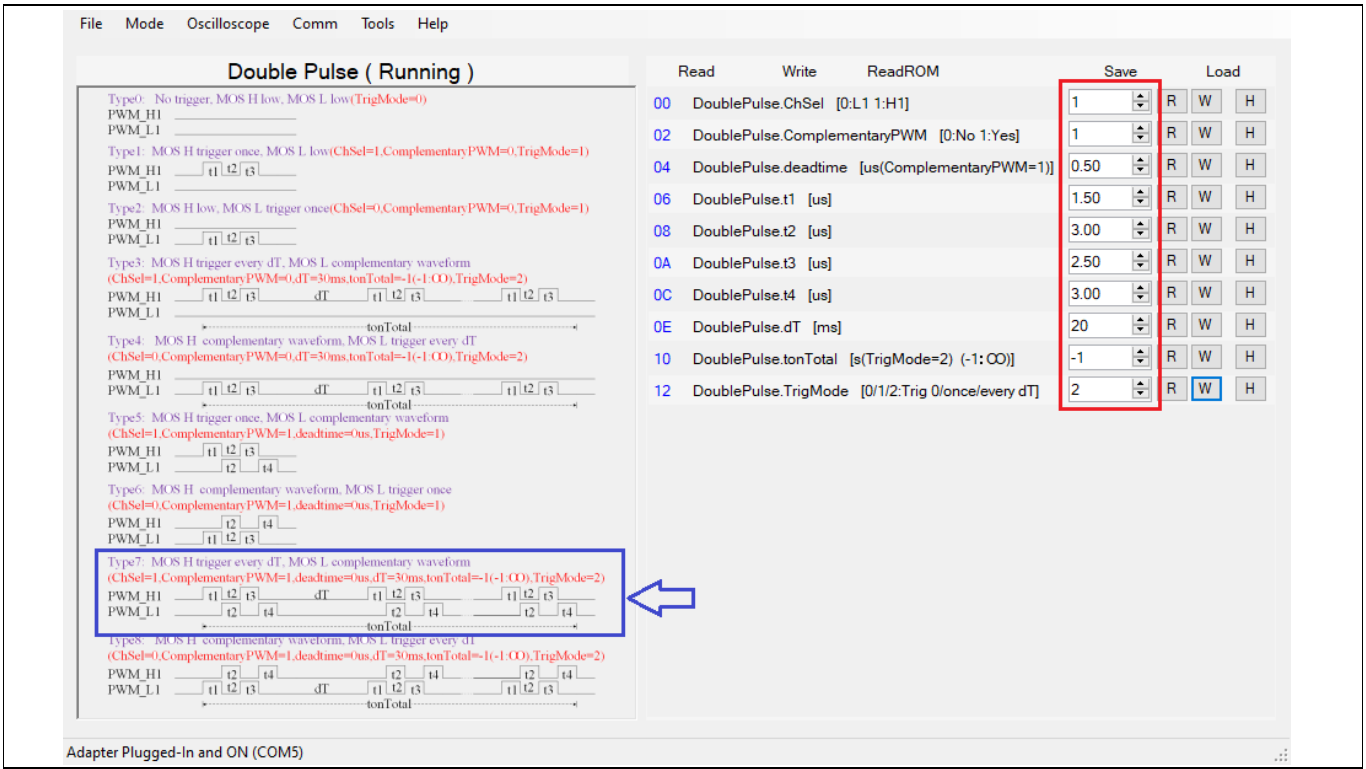


Figure 24 Trigger every mode configuration for the high side MOSFET

Trigger continuously: H MOS double pulse test (Waveform CH1:H MOS CH3: L MOS)

Figure 25 Double-pulse test waveform for high side MOSFET in "trigger every" mode

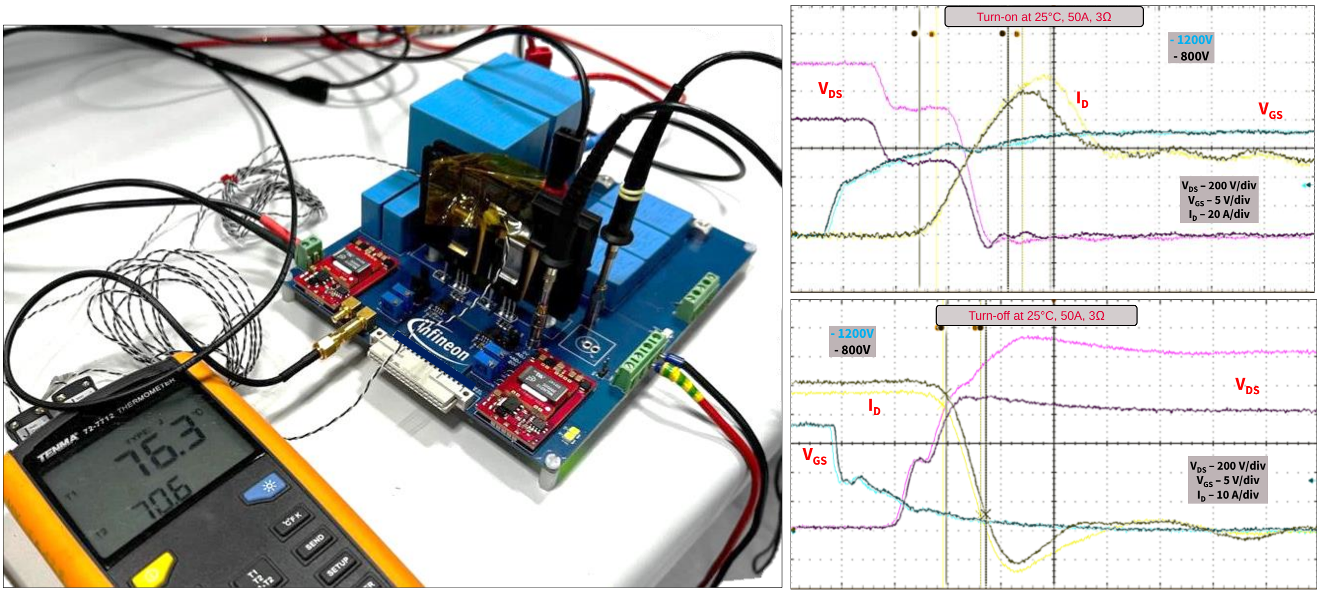
4.2 Switching losses

To compare switching losses under different conditions, the evaluation board was set up as explained in Section 2.4.2. Following the recommendations given in Section 2.1, the current was measured using a Rogowski coil. The voltage probes are connected via PCB adapters. Figure 26(a) shows the evaluation board and the measurement hardware as the main part of the setup. Power supplies and the signal generator are not included in the picture.

Table 4 Test conditions for loss comparison

	Condition 1	Condition 2	Condition 3	Condition 4
Part number (S_1 and S_2)	IMYH200R075M1H	IMYH200R075M1H	IMYH200R075M1H	IMYH200R075M1H
Package	TO-247PLUS	TO-247PLUS	TO-247PLUS	TO-247PLUS
Junction temperature Tj=Tc	25°C	25°C	25°C	25°C
Switched voltage (V_{DS})	800 V	800 V	1200 V	1200 V
Switched current (I_D)	50 A	50 A	50 A	50 A
Gate voltages (V_{GS})	0/18 V	0/18 V	0/18 V	0/18 V
Gate resistors (R_G)	1 Ω	2.7 Ω	1 Ω	2.7 Ω

On the oscilloscope, the waveform of the momentary power dissipation was computed by multiplying V_{DS} and I_D. The energy values E_{on} and E_{off} obtained from integrating this power waveform for various R_g values and voltage levels.



(a) (b)

Figure 26 (a) test setup, (b) measured losses

4.3 System design

4.4 Schematics

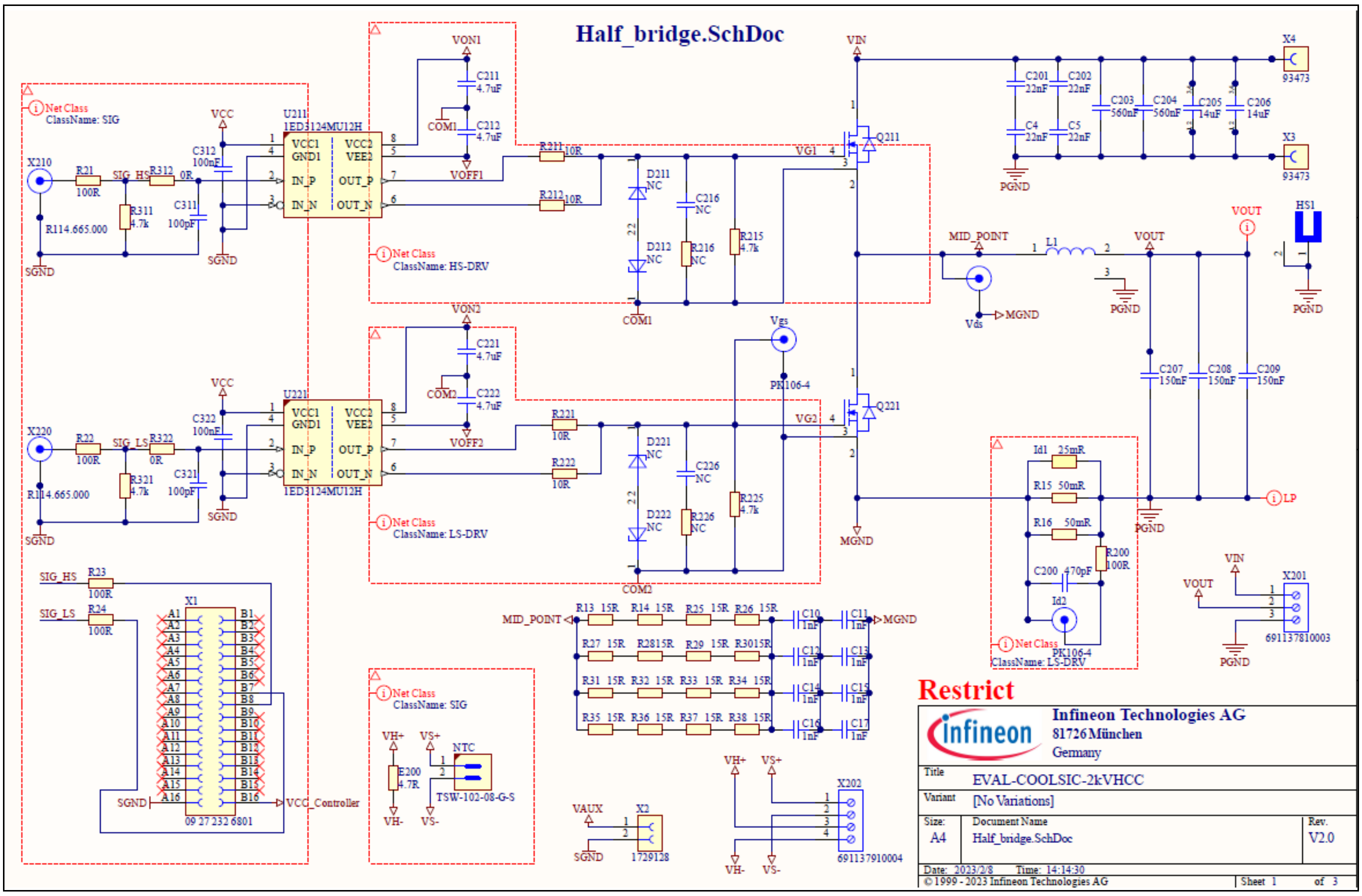


Figure 27 Half-bridge circuitry

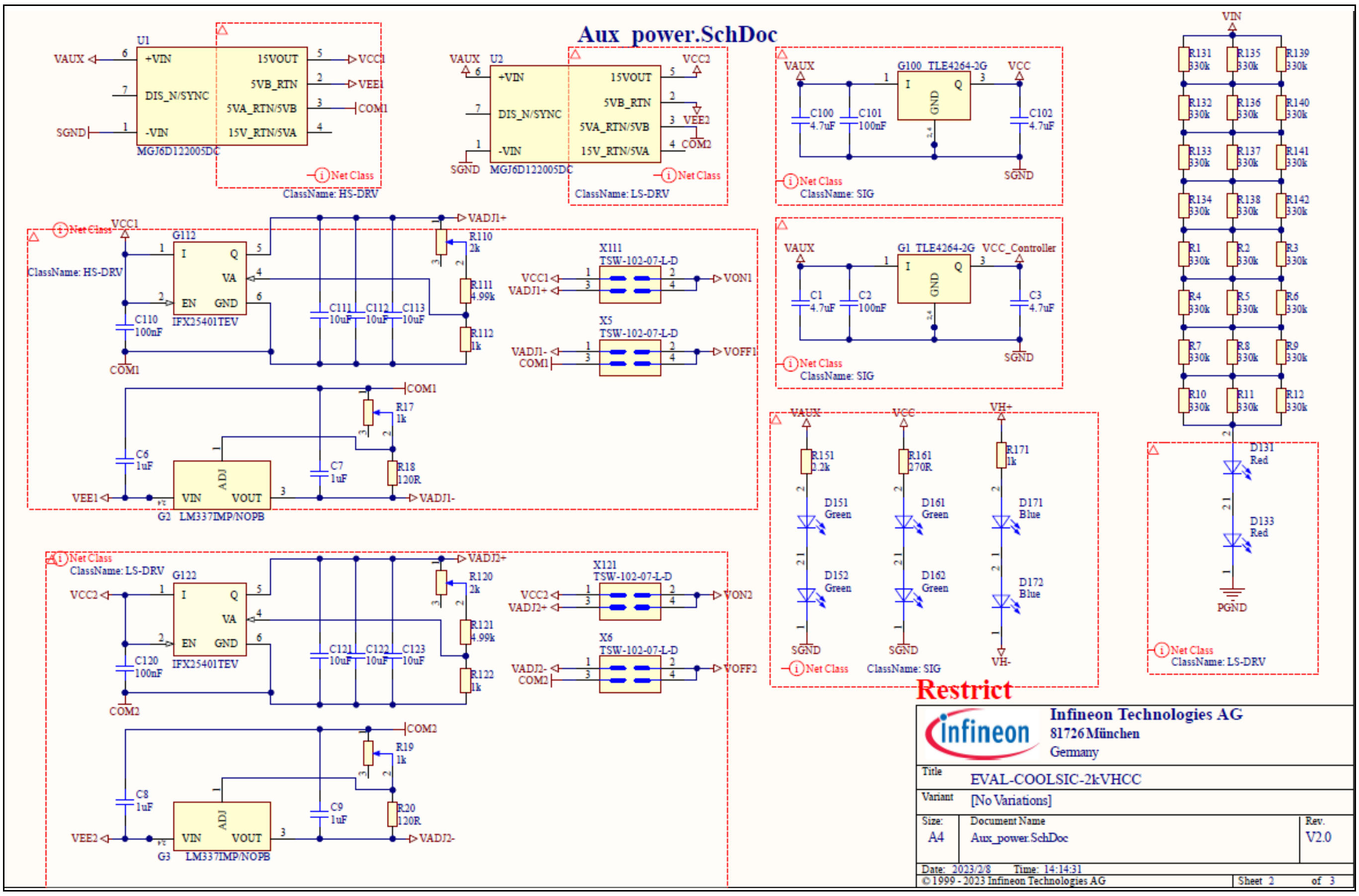


Figure 28 Auxiliary supply

4.5 Layout

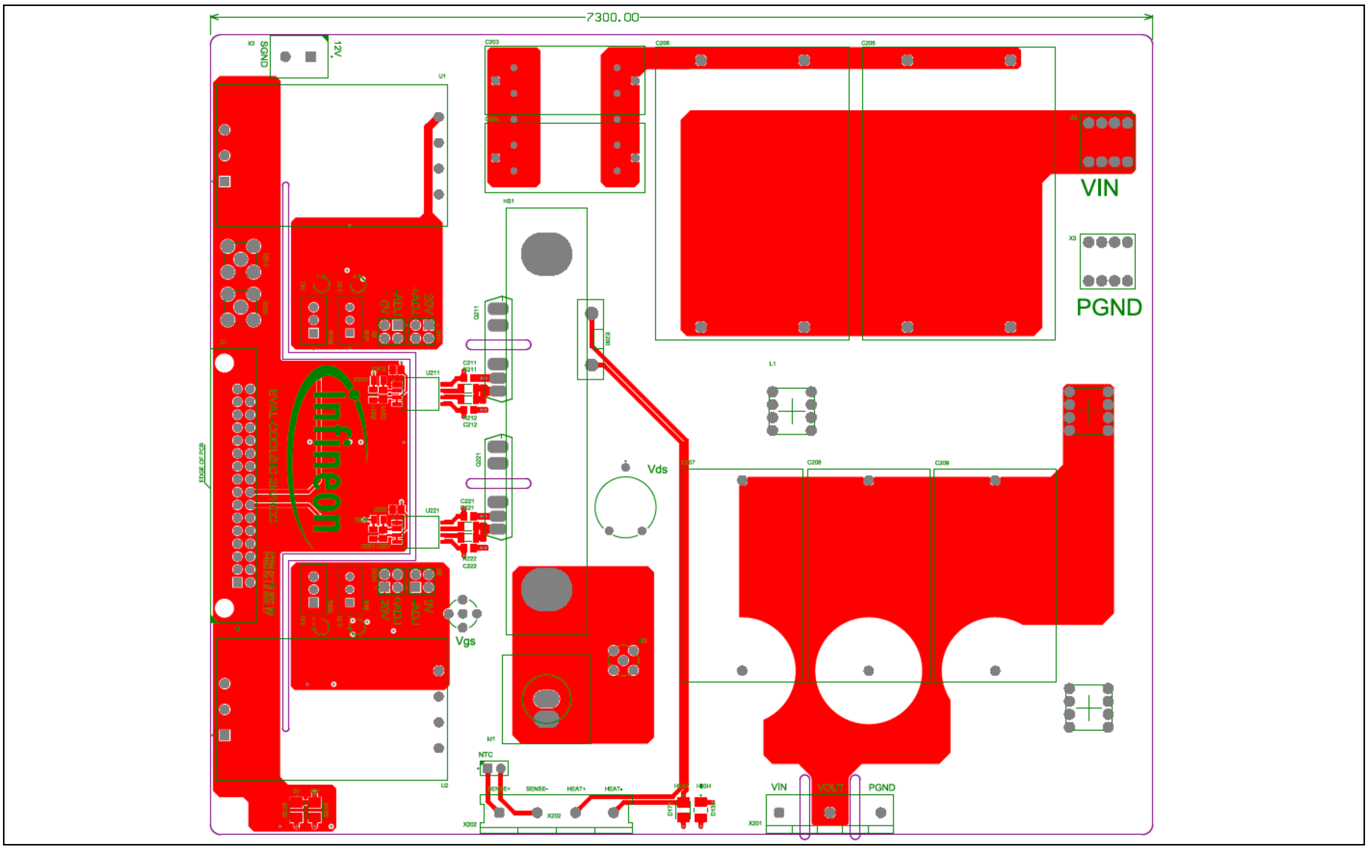


Figure 29 Layer 1 (top)

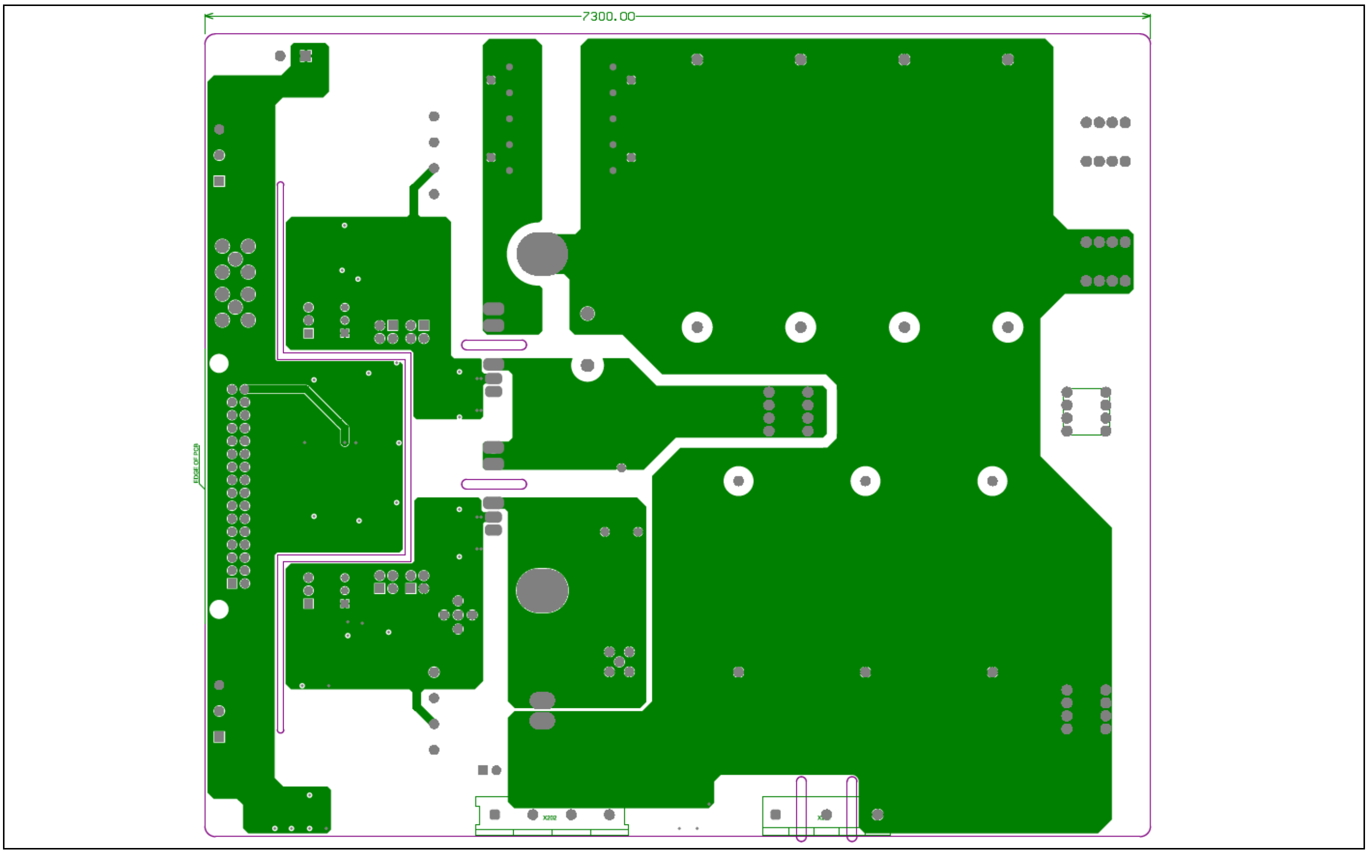


Figure 30 Layer 2

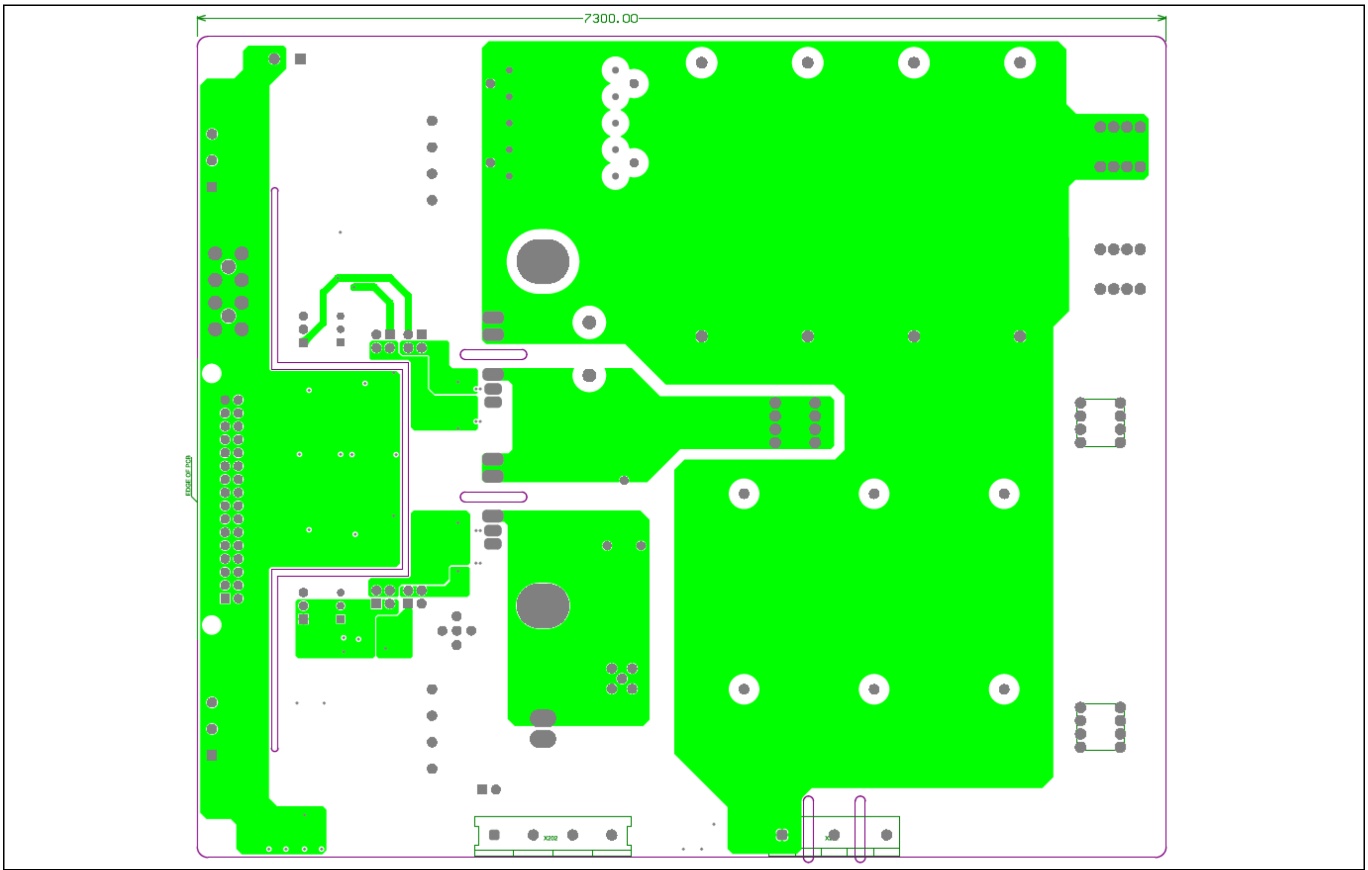


Figure 31 Layer 3

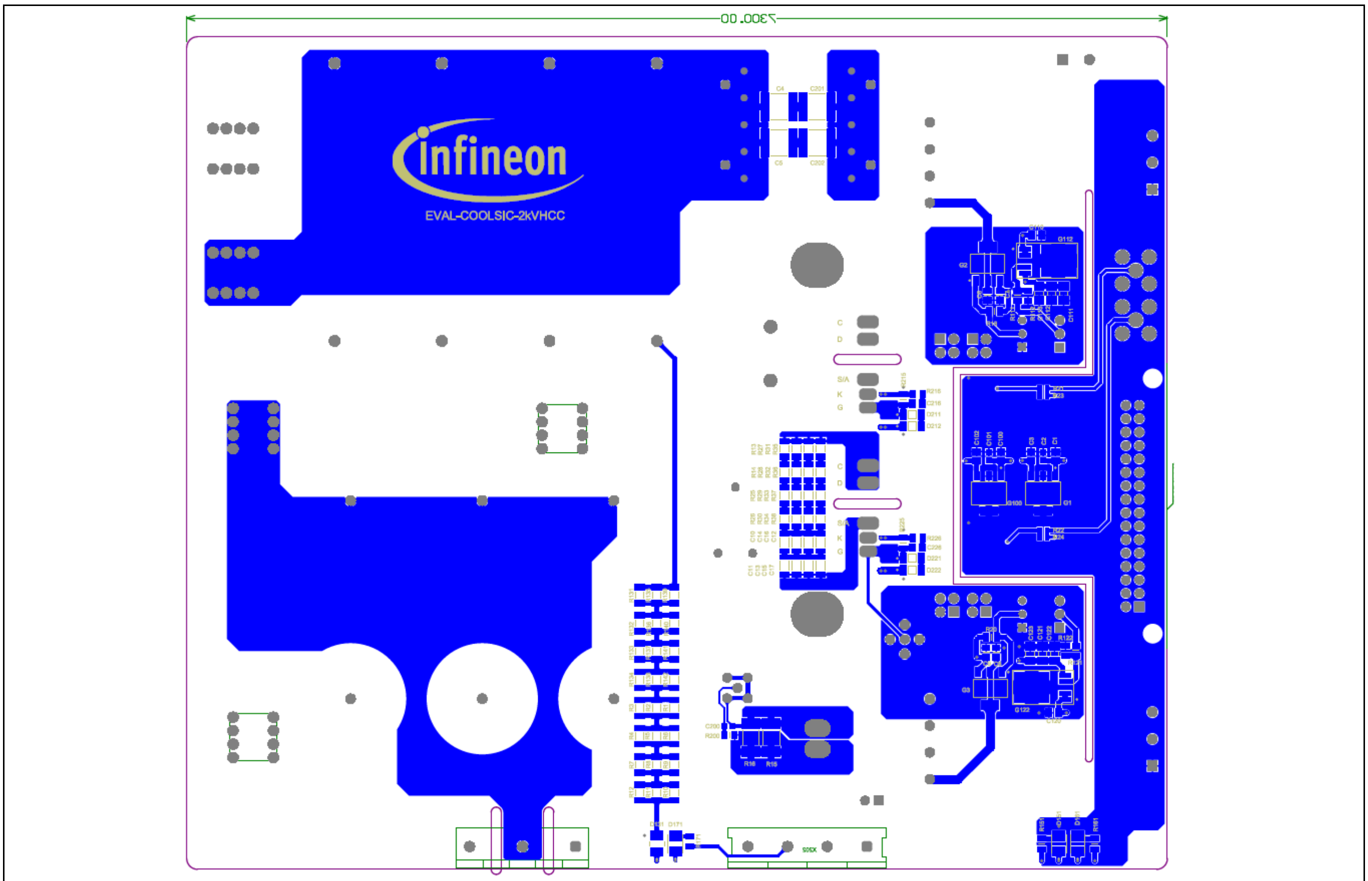


Figure 32 Layer 4 (bottom)

4.6 Bill of material

S. No	Designator	Value	Description	Manufacturer	Manufacturer Order Number
01	G1, G100	TLE4264-2G	5-V Low Drop Fixed Voltage Regulator	Infineon Technologies	TLE4264-2G
02	G112, G122	IF25401TEV	Low Dropout Linear Voltage Regulator	Infineon Technologies	IFX25401TEV
03	Q211, Q221	IMYH200R024M1H	MOSFET with Kelvin Emitter TO-247 PLUS HCC package	Infineon Technologies	IMYH200R024M1H
04	U211, U221	1ED3124MU12H	EiceDRIVER 1ED312xMU Compact Single channel isolated IGBT gate driver IC	Infineon Technologies	1ED3124MU12H

5 References

[1] AN2017-44 1200V HighSpeed 3 IGBT in TO-247PLUS Evaluation Board

[2] KIT_XMC4400_DC_V1 XMC4400 Drive Card V1.0

Revision history

Document version	Date of release	Description of changes
1.0	1 April 2023	First version

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