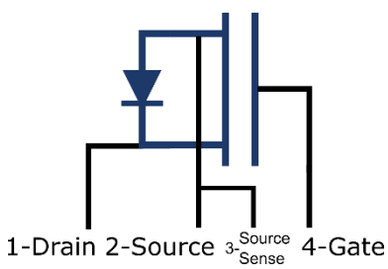
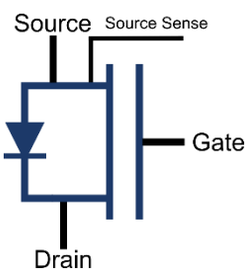
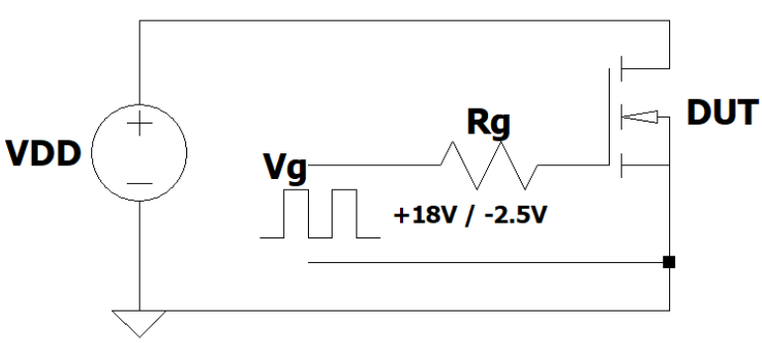
1.7kV SiC MOSFET Short Circuit Testing Report





Evaluation board with enclosure



Circuit diagram

Part Number	Package	Marking
CC1740744L	TO-247-4L	CoolCADElectronics

Overview:

Short-circuit testing was performed on a 1.7kV SiC power MOSFET in a TO-247-4 lead package manufactured by CoolCAD Electronics. The purpose of this test is to determine the device's short-circuit withstand time (SCWT), which is the maximum duration the MOSFET can safely endure a short-circuit condition before sustaining permanent damage.

Understanding the SCWT is critical for designing reliable protection systems in power electronic applications. By identifying this time limit, engineers can ensure that fault detection and protection circuits respond quickly enough to interrupt the current and safely turn off the device before its thermal and electrical limits are exceeded. Short-circuit testing typically involves intentionally subjecting the device to a controlled fault condition such as a hard short across the output while monitoring key parameters like current and voltage. This helps prevent device degradation, improves system robustness, and enhances overall operational safety.

Figure 1 shows a top side view of the board with key components labeled.
Figure 2 shows a down-side view of the board with components labeled.
Figure 3 shows the daughter car with provision to solder a power device with TO247-4L package.
Figure 4 shows the evaluation board with daughter card mounted.
Figure 5 shows the evaluation board mounted with a safety enclosure for the daughter card.
Figure 6 shows a block diagram of the board circuitry.

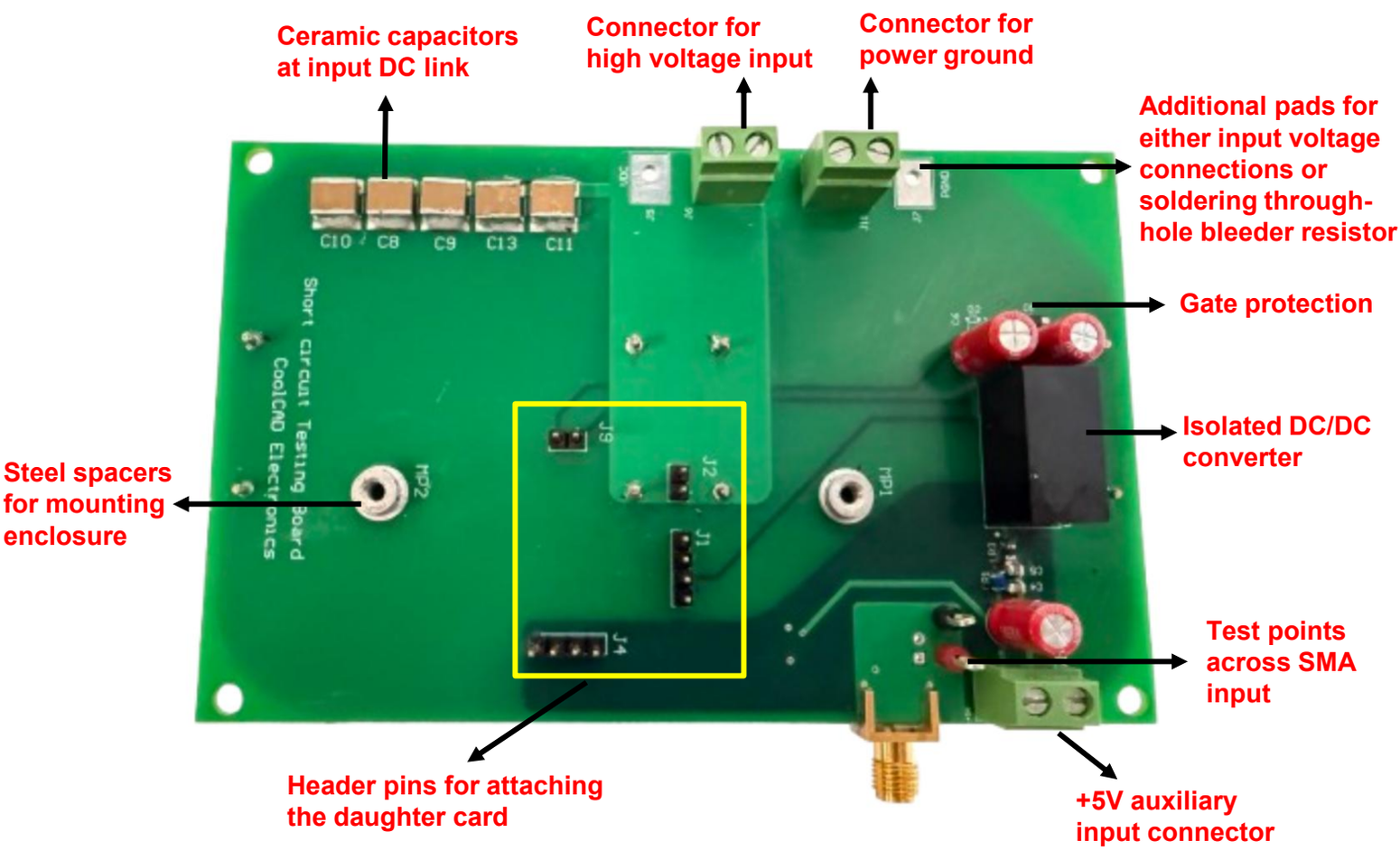


Figure 1 : SCT evaluation board: Top side view with components and test points.

Figure 2 : SCT evaluation board: Down-side view with components.

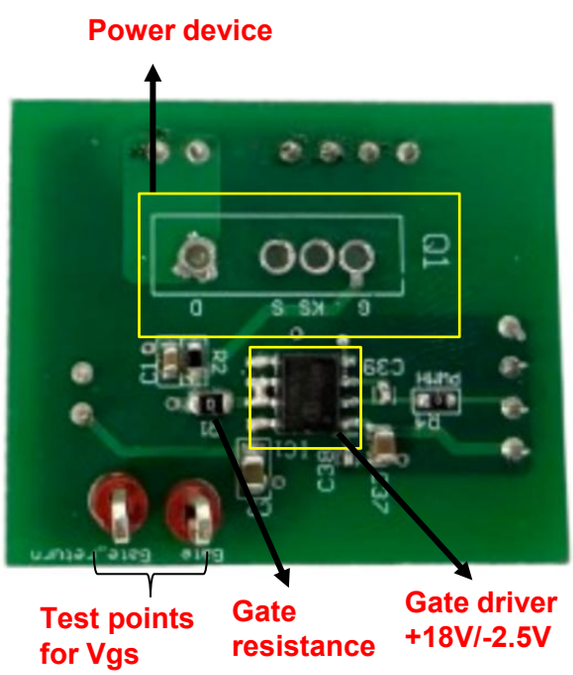


Figure 3 : SCT evaluation board: Daughter card with TO-247-4L footprint and a gate driver.

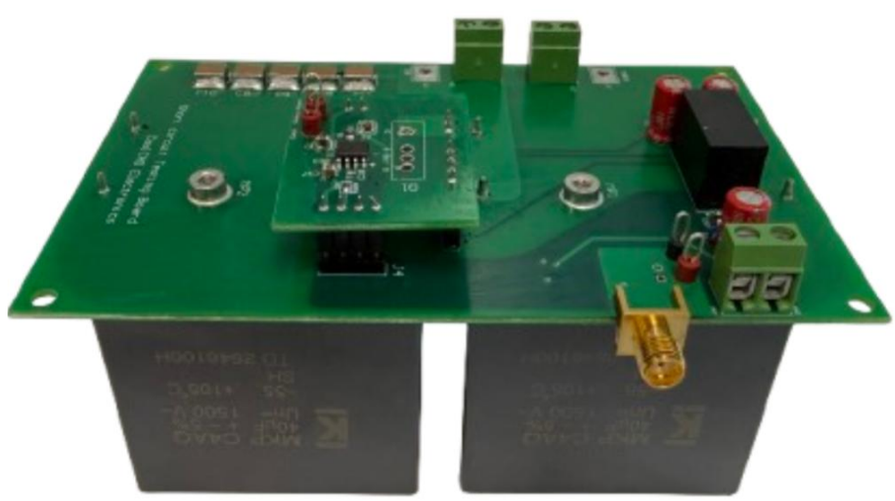


Figure 4 : SCT evaluation board: Up-side view of the board with daughter car mounted.

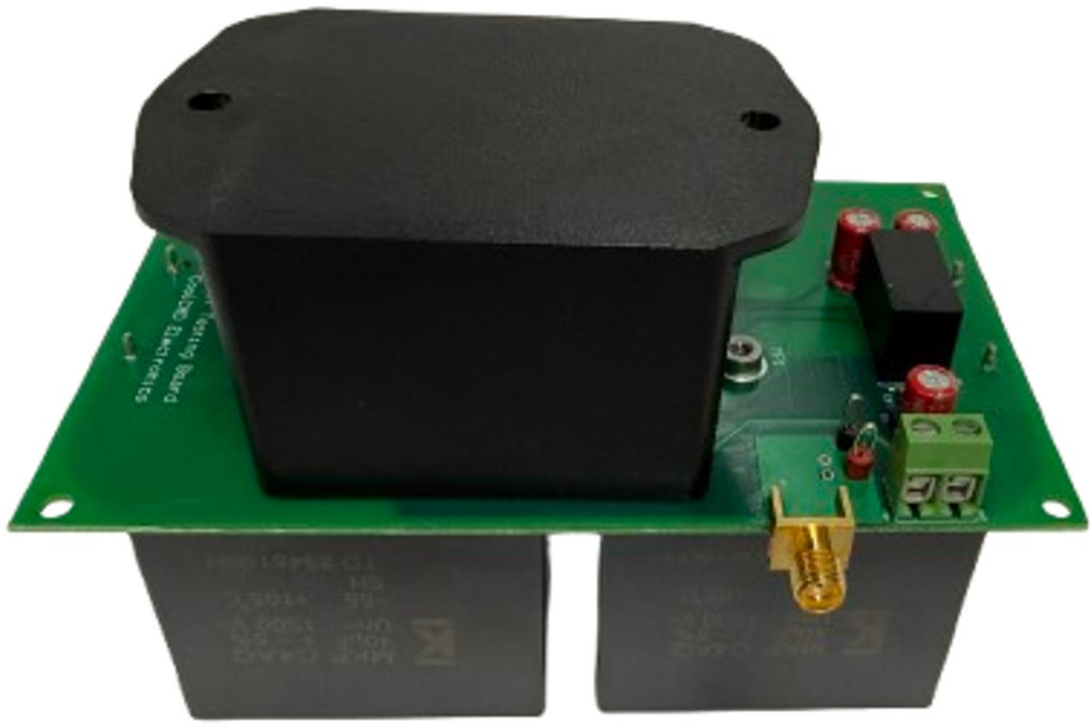


Figure 5 : SCT evaluation board: Up-side view of the board with safety enclosure.

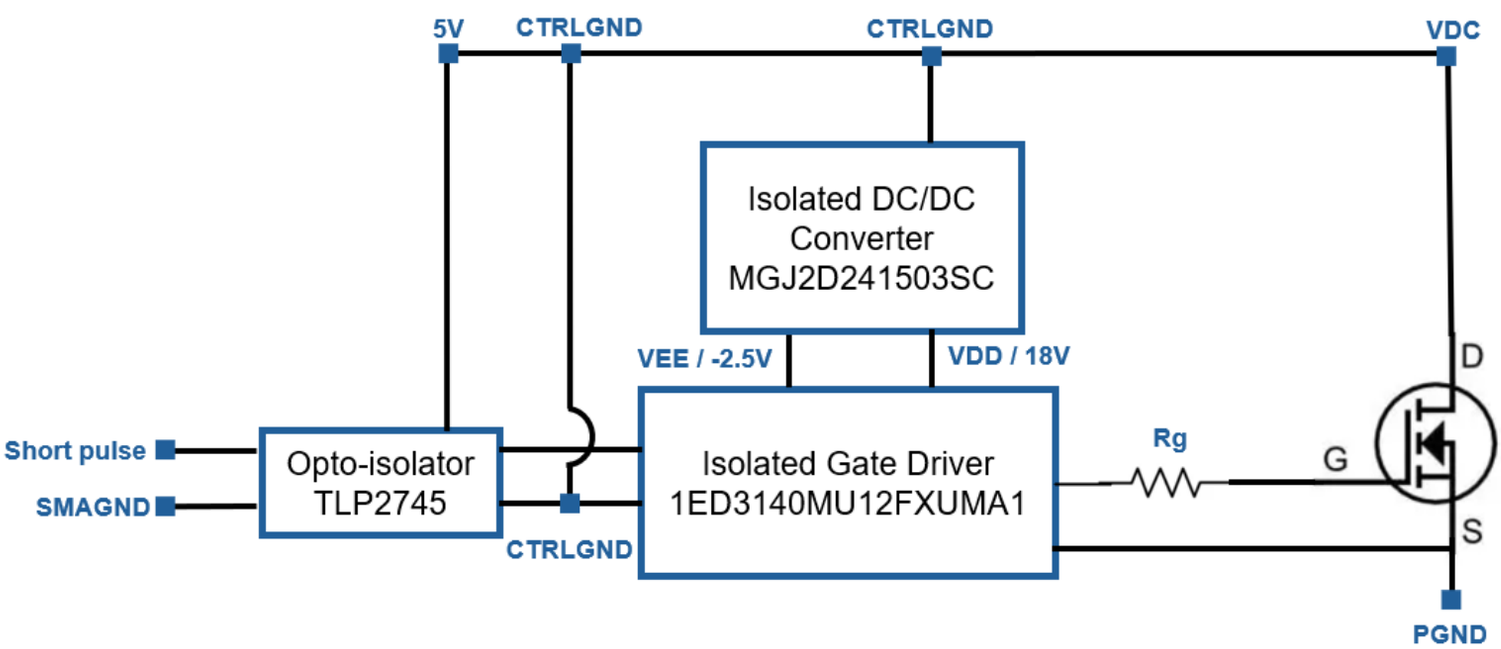


Figure 6: SCT evaluation board block diagram.

Table 2: List of important board components that are labeled in **Figures 1-3** with a detailed description of their functionality.

Component/Subcircuit	Description
Isolated DC/DC Converter	Dual Channel Output Supply for Each Gate Driver Chip (MGJ2D051802SC)
Gate Protection/Regulation	Zener diodes used to stabilize the MOSFET on and off signals and prevent over and under shoot
Gate Driver	Converts a low current input signal to a high current signal that drives the MOSFET gates (1ED3140MU12FXUMA1)
DC Link Capacitors	Stores energy to provide the short circuit with enough energy for the test
Gate Resistors	Swapable resistors for observing effect of gate resistance on switching behavior
SMA Connector	Connectors for providing an input pulse signal for both the power device
Terminal Blocks	Screwable terminals for making external connections to +5/GND for auxiliary supply and VDC/PGND for the high voltage bus
TO-247-4L Footprint	Through holes for soldering both 4 lead variant of a TO-247 power device
Opto-isolator	Additional protection for the low voltage pulsed input coupled via optical isolation

Table 3: Recommended operating conditions and absolute maximum ratings

Parameter	Symbol	Min	Typ	Max	Unit	Note
High Voltage DC Input	VDC	-	-	**1500**	V	VDC-PGND
Short circuit Current	I_{DUT}	-	-	**1200**	A	-
Auxiliary Supply	+5V	-	**5**	**6**	V	+5V-CTRLGND
Pulsed input	Short pulse	**-0.3**	**5**	**6.5**	V	Pulse-SMAGND
Gate Driver Positive Supply Voltage	VDDH, VDDL		**18**		V	
Gate Driver Negative Supply Voltage	VEEH, VEEL	-	**-2.5**	-	V	-
Ambient Temperature	T_A	**-40**	**27**	**105**	°C	-

Test setup:

The setup consists of a main board with a pulsed input, a DC-DC converter that generates +18V and −2.5V for the gate driver, a DC-link capacitor to supply current during short-circuit conditions, and a daughter card that includes the gate driver and power device. Since the components on the daughter card are most likely to be damaged during short-circuit testing, they are placed on a separate board to isolate them from the rest of the circuitry. **Figure 7** shows the test setup used to determine short circuit withstand time of a SiC device at 800V DC link voltage.

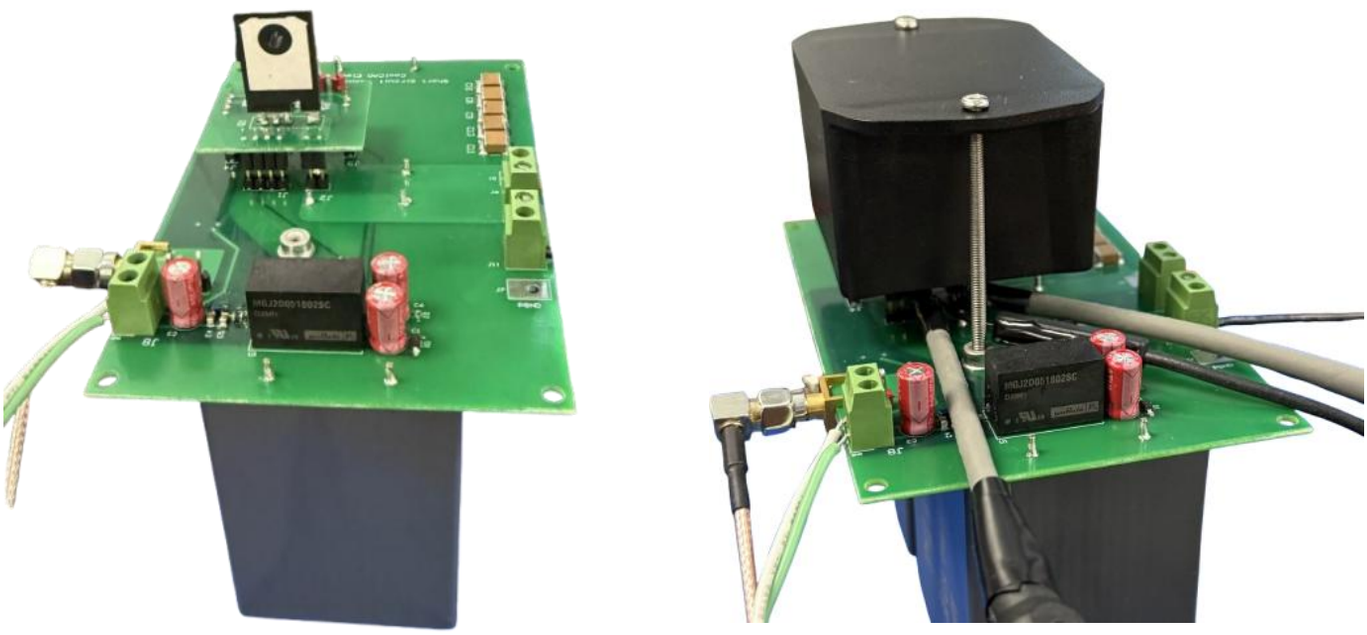


Figure 7 : SCT evaluation board: Test setup without enclosure (left) and with enclosure (right).

We are using the MGJ2D051802SC isolated DC-DC converter from Murata to supply the high-side voltage to the gate driver. The TLP2745 optical isolator provides additional isolation at the PWM input. The gate driver employed is Infineon's 1ED3140MU12FXUMA1. Two 40 µF capacitors (C4AQSEW5400A3BJ) are connected in parallel to supply the required charge during short-circuit events.

The short-circuit withstand time of the devices is measured with an 800V DC link supplied by a high-voltage source. A single pulse from a function generator is used for testing, with pulse durations starting from 1µs and increasing until device failure occurs.

Table 1: DUT information

	Description
Package	TO247-4L
Part number	CC1740744L

Waveforms:

Measurements are taken using an oscilloscope from a short-circuit test performed on 1.7kV device mentioned in **Table 1** using the evaluation board (*CC1500VSCTV1)*, with the test conducted at 800V across the DUT and approximately 500A peak current using an 80µF external DC link capacitor and 0Ω gate resistance.

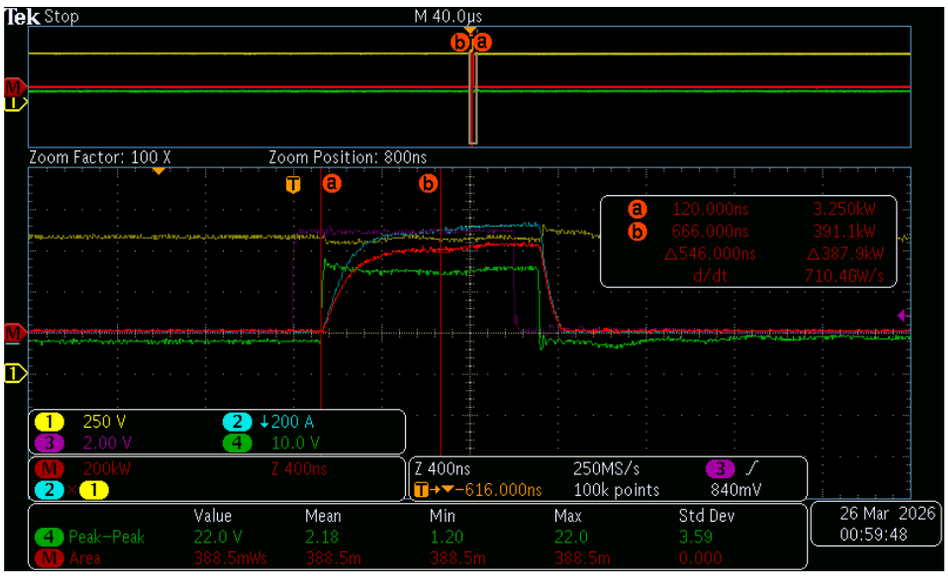


Figure 8: Oscilloscope waveform obtained during an 800V SCT with a 1µs pulse

In **Figure 8**, Channel 1 (yellow) shows the DC-link voltage applied across the DUT; Channel 2 (blue) represents the short-circuit current; Channel 3 (pink) displays the single-pulse input; and Channel 4 (green) shows the gate-to-source voltage. Orange waveform represents the power dissipated across the device in short duration. Ignore the cursors in the waveform, as the short-circuit energy is measured over the entire capture window. **The short-circuit energy recorded at this moment is 0.385J.**

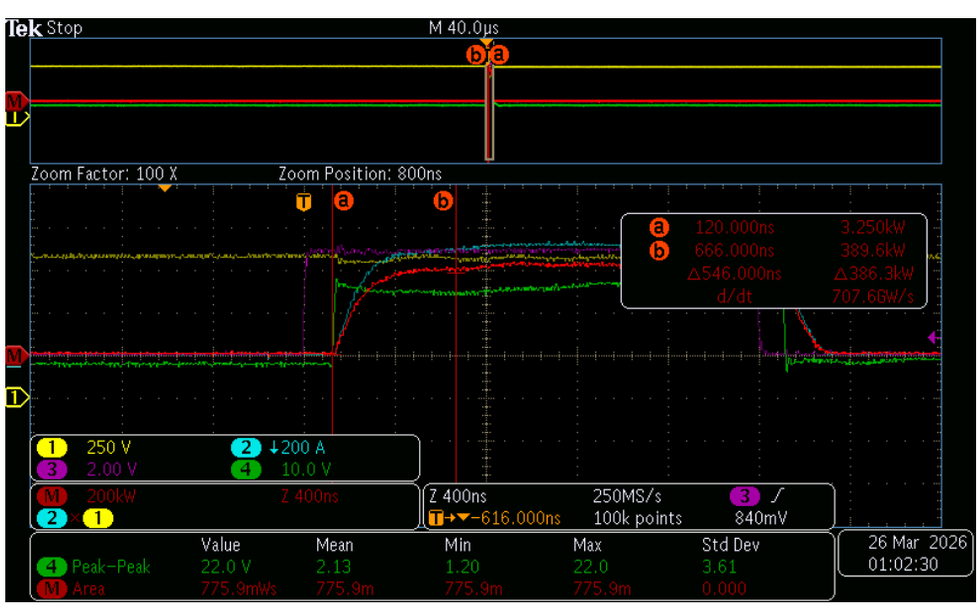


Figure 9: Oscilloscope waveform obtained during an 800V SCT with a 2µs pulse

In **Figure 9**, Channel 1 (yellow) shows the DC-link voltage applied across the DUT; Channel 2 (blue) represents the short-circuit current; Channel 3 (pink) displays the single-pulse input; and Channel 4 (green) shows the gate-to-source voltage. Orange waveform represents the power dissipated across the device in short duration. Ignore the cursors in the waveform, as the short-circuit energy is measured over the entire capture window. **The short-circuit energy recorded at this moment is 0.776J.**

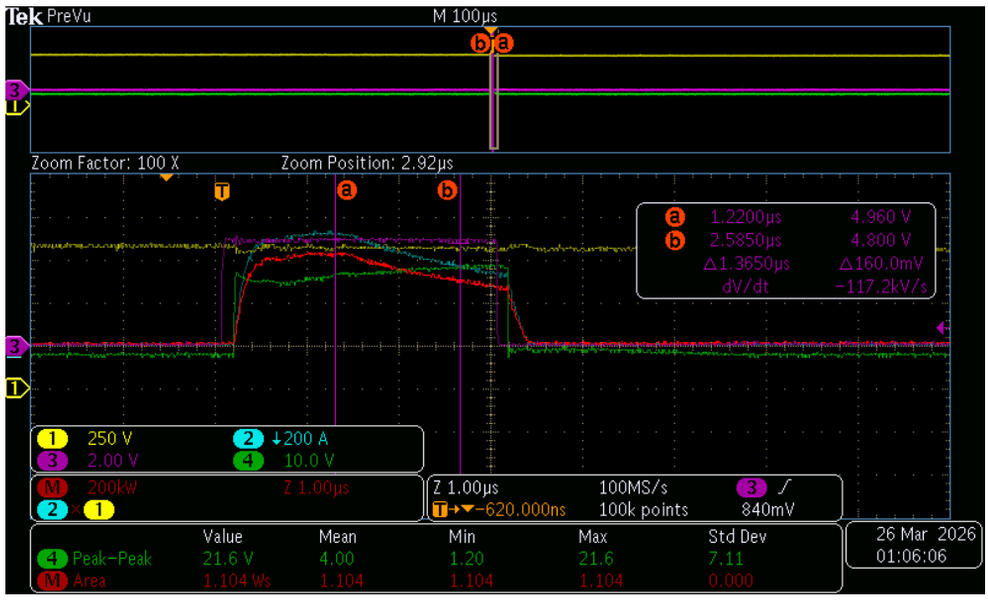


Figure 10: Oscilloscope waveform obtained during an 800V SCT with a 3µs pulse

In **Figure 10**, Channel 1 (yellow) shows the DC-link voltage applied across the DUT; Channel 2 (blue) represents the short-circuit current; Channel 3 (pink) displays the single-pulse input; and Channel 4 (green) shows the gate-to-source voltage. Orange waveform represents the power dissipated across the device in short duration. Ignore the cursors in the waveform, as the short-circuit energy is measured over the entire capture window. **The short-circuit energy recorded at this moment is 1.1J.**

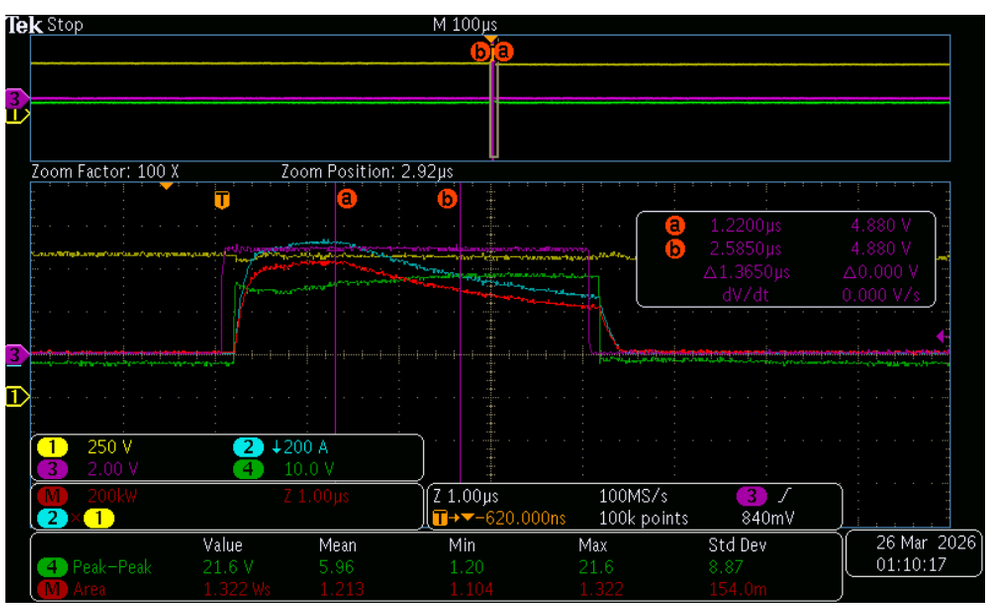


Figure 11: Oscilloscope waveform obtained during an 800V SCT with a 4µs pulse

In **Figure 11**, Channel 1 (yellow) shows the DC-link voltage applied across the DUT; Channel 2 (blue) represents the short-circuit current; Channel 3 (pink) displays the single-pulse input; and Channel 4 (green) shows the gate-to-source voltage. Orange waveform represents the power dissipated across the device in short duration. Ignore the cursors in the waveform, as the short-circuit energy is measured over the entire capture window. **The short-circuit energy recorded at this moment is 1.322J.**

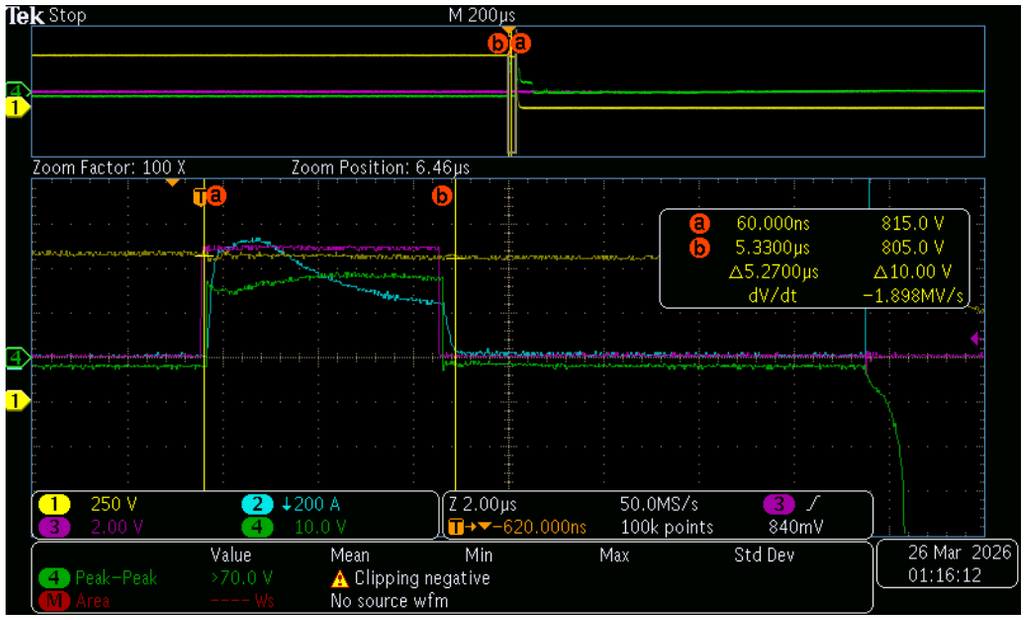


Figure 12: Oscilloscope waveform obtained during an 800V SCT with a 5µs pulse

In **Figure 12**, Channel 1 (yellow) shows the DC-link voltage applied across the DUT; Channel 2 (blue) represents the short-circuit current; Channel 3 (pink) displays the single-pulse input; and Channel 4 (green) shows the gate-to-source voltage. Orange waveform represents the power dissipated across the device in short duration. **The short-circuit energy recorded at this moment is 1.6J, after which the device fails permanently 6–8µs following the end of the pulse.**

Summary:

A 5µs pulse under short-circuit conditions is sufficient for the device to accumulate enough heat to cause catastrophic failure. Based on this testing data, it is recommended to define the short-circuit withstand capability of the device for a duration less than 5µs.