CC100A1KDPTV2

Double Pulse Test Circuit

A highly versatile and easy to use evaluation board to perform double pulse tests (DPTs) on TO-247 (3 lead and 4 lead) packaged Silicon Carbide and Silicon power devices.

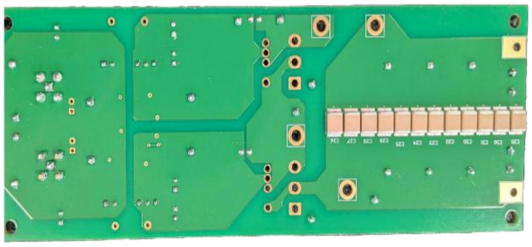
BENEFITS

- Easy to use
- Versatile
- Adjustable
- Intuitive

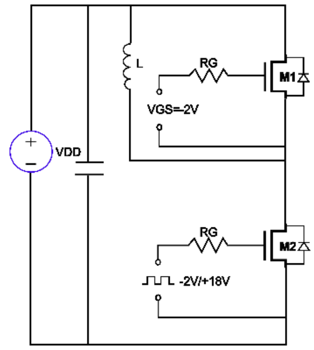
APPLICATIONS INCLUDE

DPT is commonly used to determine transient characteristics of power MOSFETs, IGBTs, and JFETs, including switching energy, switching times, gate charge, and reverse recovery for the body diode.

Top view



Bottom view



Simplified DPT circuit schematic.

Part Number	Package	Marking
CC100A1KDPTV2	PCB	CoolCAD Electronics

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Features and Board Functionality:

This evaluation board is designed to perform double pulse testing (DPT) for characterizing power devices in the TO-247 package (3 and 4 lead).

The DPT evaluation board includes:

- Slots for soldering a TO-247 power device in both the top and bottom position of the half bridge
- Through holes for soldering an inductor of desired value. (Inductor not included.)
- Various tests points for probing voltages such as VDD, switch node, ground, and both gates.
- Swappable gate resistor. (0Ω resistor included.)
- Pins for switching between 3 lead and 4 lead testing.
- SMA connectors for gate input pulses.
- Screw terminals for +5V auxiliary input, control ground, VDC, and power ground.

Table 1 lists the physical dimensions of the board.

Figure 1 shows a top side view of the board with key test points labeled
Figure 2 shows a bottom side view of the board.
Figure 3 shows a block diagram of the board circuitry.
Figure 4 indicates key components and features of the board.

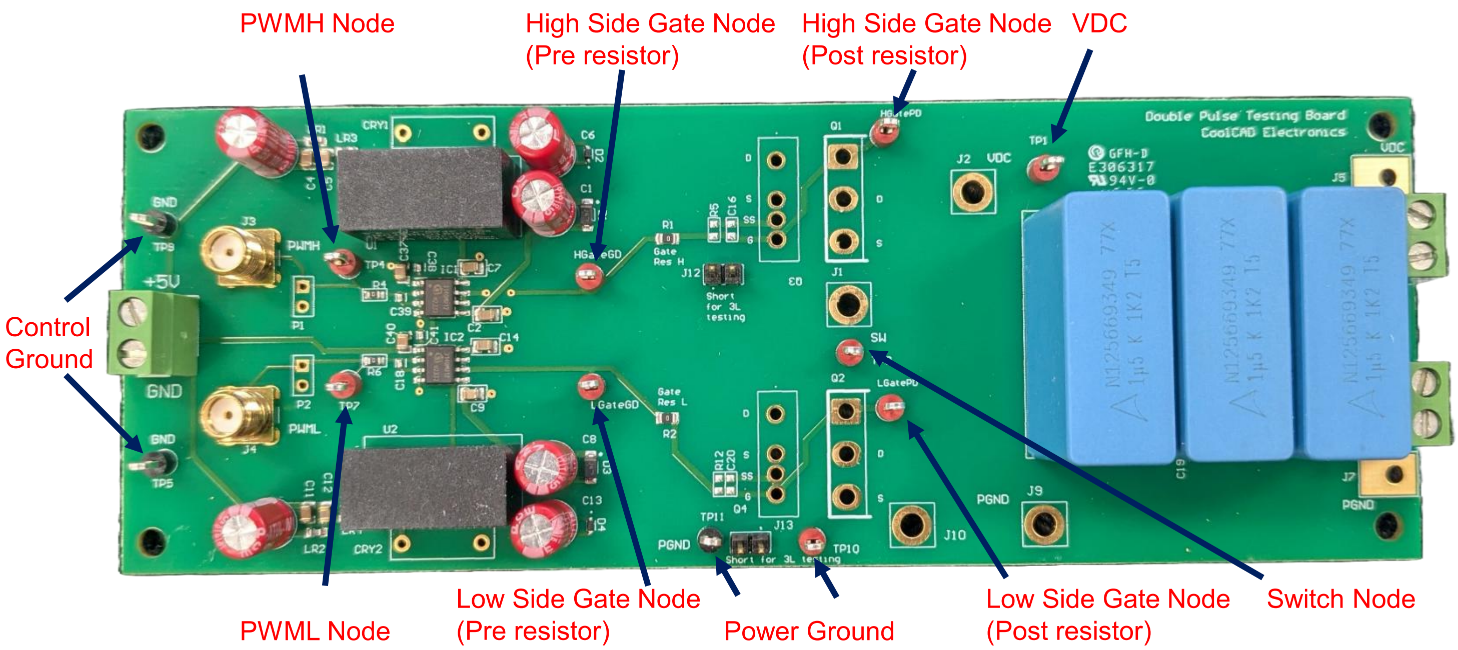

Figure 1 : DPT evaluation board: Top side view of test points.

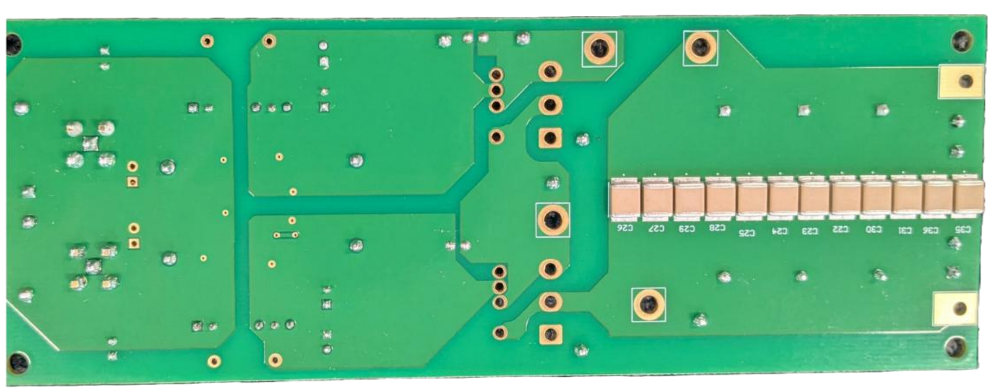

Figure 2: DPT evaluation board: Bottom side view.

Table 1: DPT board dimensions.

	Dimension
Length	165.1mm
Width	59.3mm

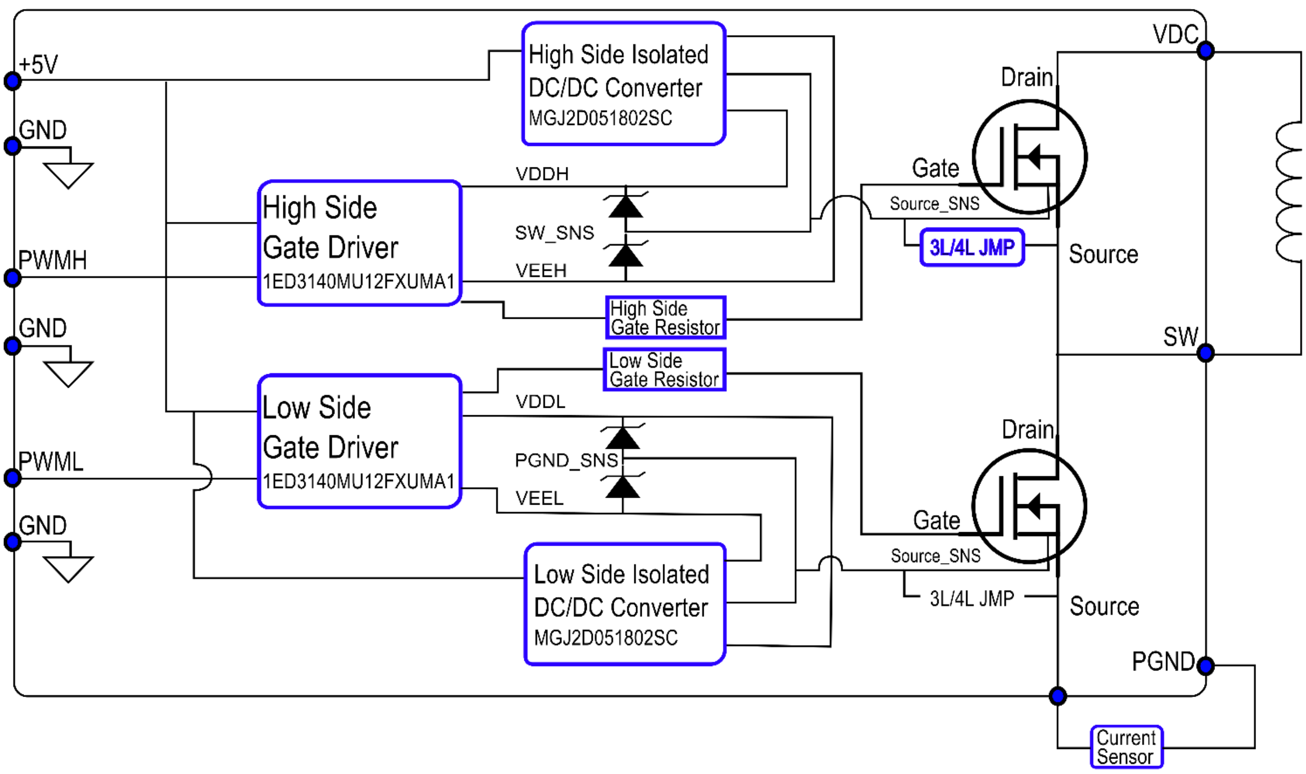

Figure 3: DPT evaluation board block diagram. Inductor and current sensor are external (not included).

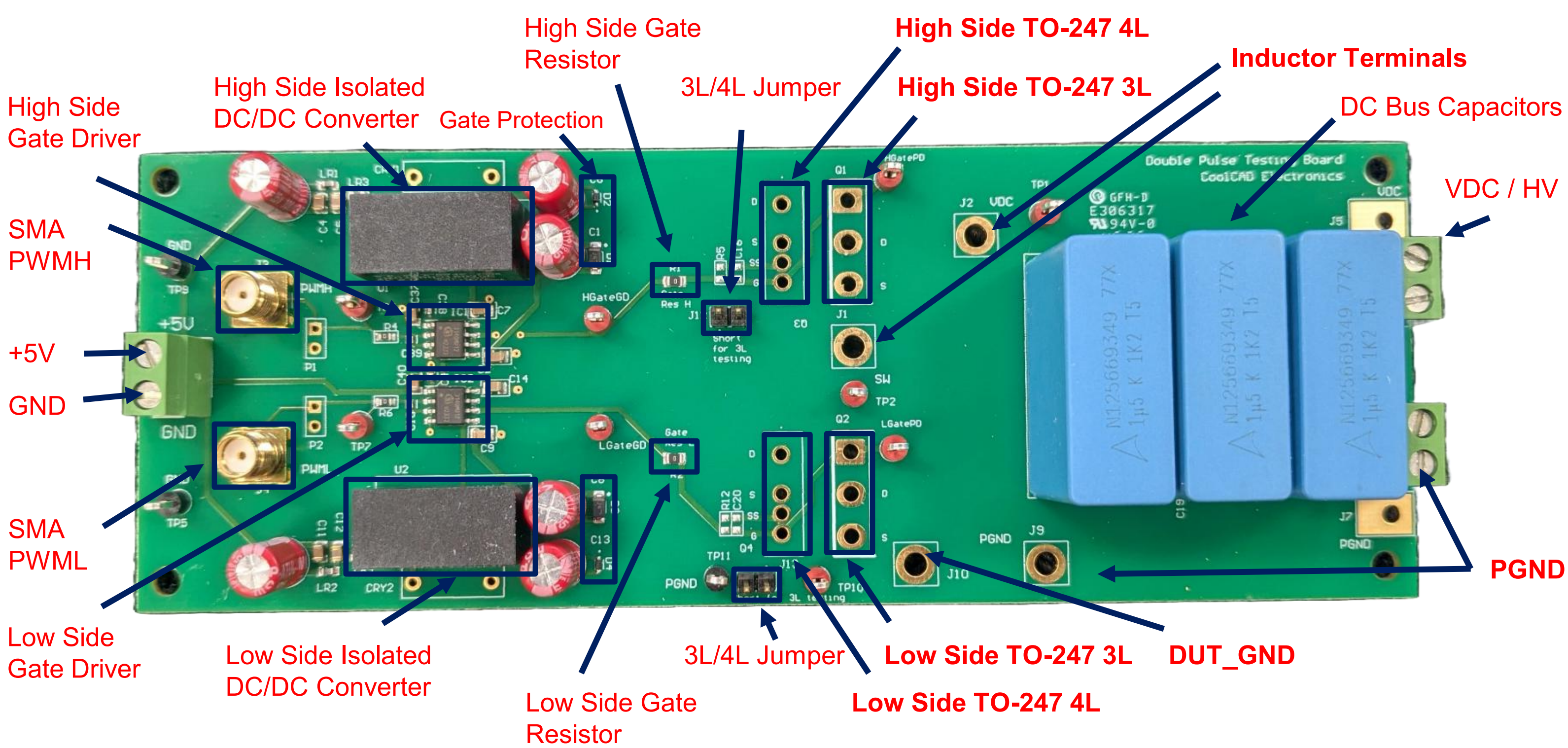

Figure 4: DPT evaluation board: Top side view of components.

Table 2: List of important board components that are labeled in **Figures 3** and **4** 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 digital input signal to a high current signal that drives the MOSFET gates (1ED3140MU12FXUMA1)
DC Bus Capacitors	Stores energy to provide the double pulse circuit with enough current for the test
Gate Resistors	Swapable resistors for observing effect of gate resistance on switching behavior
SMA Connectors	Connectors for providing an input pulse signal for both the top and bottom side 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 Footprints	Through holes for soldering both 3 lead and 4 lead variants of a TO-247 power devices on high and low side of the half bridge
3L/4L Jumper	Jumper used when testing 3 lead packaged devices. Shorts the sense source plane to the power source plane
External Inductor	Inductor that is soldered to the indicated inductor terminal through holes. The value can be determined based off the desired pulse length and current magnitude needed for the test.
Current Sensor	Connected between DUT_GND and PGND and is used to sense the current flowing through the device under test

Table 3: Recommended operating conditions and absolute maximum ratings

Parameter	Symbol	Min	Typ	Max	Unit	Note
High Voltage DC Input	VDC	-	-	**1000**	V	VDC-PGND
Double Pulse Current	I_{DUT}	-	-	**100**	A	-
Auxiliary Supply	+5V	-	**5**	**6**	V	+5V-GND
High Side Logic Input	PWMH	**-0.3**	**5**	**6.5**	V	PWMH-GND
Low Side Logic Input	PWML	**-0.3**	**5**	**6.5**	V	PWML-GND
Gate Driver Positive Supply Voltage	VDDH, VDDL	-	**18**	-	V	-
Gate Driver Negative Supply Voltage	VEEH, VEEL	-	**-2**	-	V	-
Ambient Temperature	T_A	**-40**	**27**	**105**	°C	-

Quick Start Instruction:

1. Solder the DUT to the low side TO-247 footprint. For the top side, the same device as the DUT can be used if it has a body diode. If not, solder a power diode to the top side.
   - *Note: if you are using a 3 Lead TO-247 device, short the 3L/4L Jumper pins located at the bottom left of the TO-247 footprint.)*

2. Apply 5V across the +5V and GND input supply nodes using the screw terminals located on the left side of the board when viewing from the top. The inductor (L) needs to be formed and kept off the board externally *(This inductor is not included)*. The inductance value can be determined using $V = L \times \frac{dI}{dt}$ where V is the bus voltage, dI is the current rise during the first pulse (i.e. the current level during the switching test), and dt is the duration of the first pulse. Ensure that the current during the switching test does not exceed the saturation current of the selected inductor.

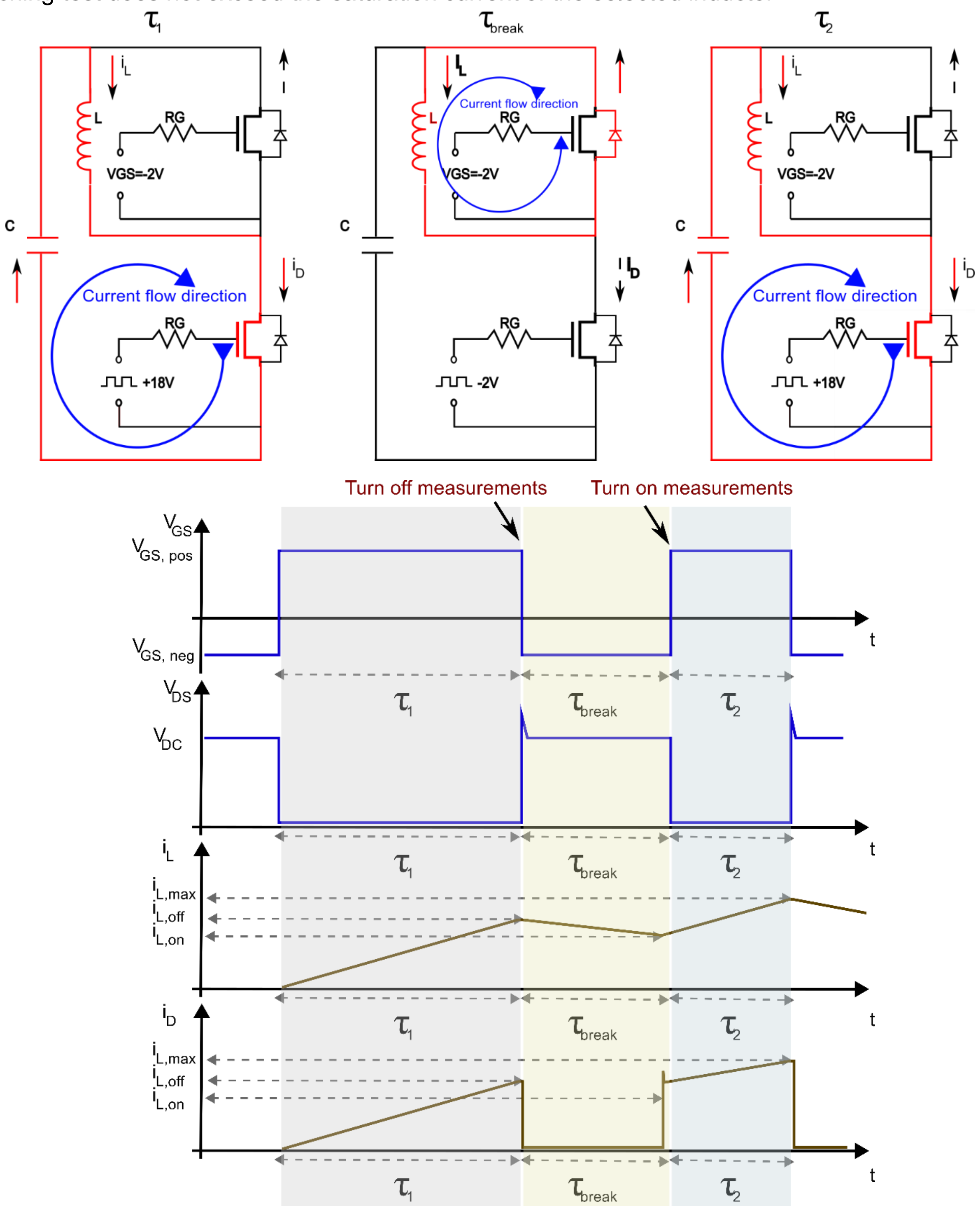

Figure 5: DPT waveforms.

Quick Start Instruction (cont.):

3. Connect a high voltage supply across the VDC and PGND nodes using the two screw terminals on the right side of the board.

4. Using an external wire, short the DUT_GND node to the PGND node. This provides a loop which allow for a current sensor clamp to be used to measure the current through the DUT.

5. Connect a signal generator to the PWML SMA terminal. If using a MOSFET for the high side device, short the signal connection of the PWMH SMA terminal to its shield. Program the signal generator to the desired pulse duration.

- *Note: ensure the signal generator output is set to high impedance mode (for example, 1MΩ).*
- *Warning: ensure the pulse trigger is set to manual mode and that only two pulses are generated at a time. Sending constant pulses may damage the board and DUT due to the high current.*

6. To carry out the test, initially, the DC link capacitor bank is charged to the desired test voltage via the power supply. The actual voltage must be slightly higher than the test voltage since the energy required to magnetize the inductive load must also be stored in the capacitor bank, resulting in some voltage drop during the first pulse. The initial voltage drop can be calculated using $I = C \times \frac{dV}{dt}$ where I is half the current through the device under test (DUT) during the test, C is the DC bus capacitance of 6.04µF, dV is the DC bus voltage drop, and dt is the duration of the pulse. For the double pulse test, the necessary pulse sequence is calculated beforehand and is determine by the signal generator. The test consists of three phases, which can be seen in **Figure 6**. The phases are as follows:

I. First pulse with duration τ_1 *(It is recommended to limit this to 2µs or 3µs to reduce the voltage drop on the capacitor bank).*
II. The pulse break with duration τ_{break}.
III. Second pulse with duration τ_2 *(It is recommended to keep this low to prevent excessive current increase).*

7. Trigger the pulses with the manual trigger in the signal generator. For the first pulse with duration τ_1: the top side body diode is turned off, the DUT is ON, and the current rises linearly. At the end of $\tau_1$duration, the current reaches rated value at which switching will be performed.

8. During the pulse break τ_{break}, the DUT is turned off and the current flows through the freewheeling diode.

9. With the second pulse τ_2, the DUT is turned on again, and energy is transferred from the capacitor bank to the load inductor. As a result, the voltage drops and the current continues to rise. The duration of the second pulse should be chosen so that the current through the DUT does not reach an impermissibly high value.

The peak overshoot in the current observed in **Figure 6** (top) is caused by the reverse recovery of the freewheeling diode. Here, the stored charge of the diode adds an additional current component which must be taken by the switch. We note that both turn-on and turn-off waveforms of the device under test can be measured over the complete test period.

Example waveforms:

Figure 6 shows an oscilloscope screenshot from a double pulse test that we performed on one of our devices using this evaluation board. The green waveform is the voltage across the DUT, the purple is the current through the DUT, the yellow is the pulse from the signal generator, the blue is the DUT gate voltage, and the red is the switching loss. This test was performed with 800V across the DUT and 30A through the DUT. An 80µH external inductor was used along with 0Ω of gate resistance.

Figure 7 shows a plot with information from multiple double pulse tests that we performed on our own devices with the evaluation board. The turn on/off and total switching energy are plotted with respect to DUT currents ranging from 10A to 50A.

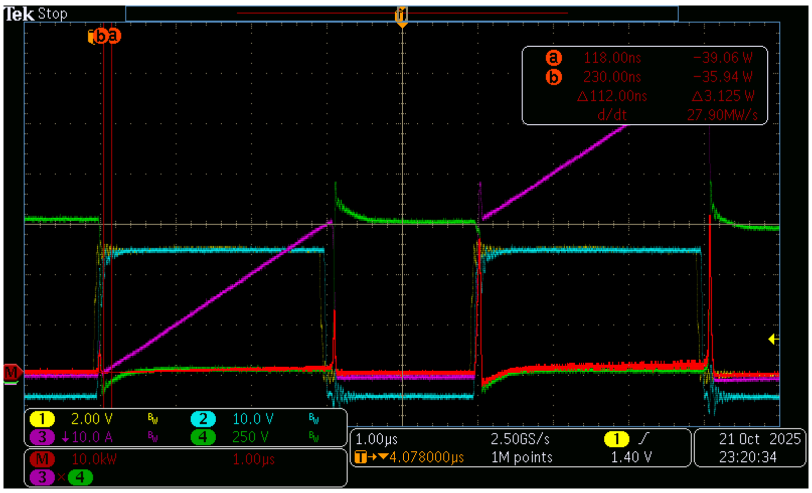

Figure 6: Oscilloscope waveform obtained during an 800V, 30A DPT of CC-33-80-354L using this evaluation board

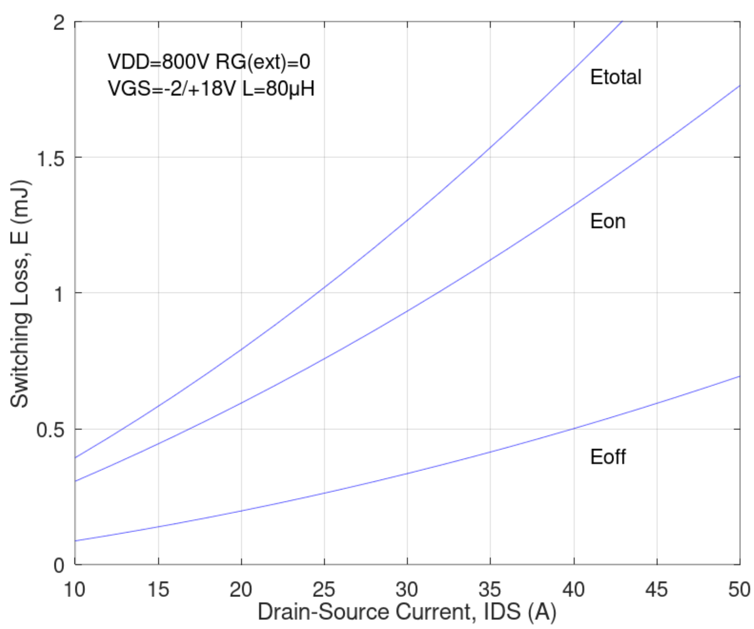

Figure 7: Calculated switching energies for CC-33-80-354L. The empirical data were obtained using this evaluation board

Warnings

1. The DPT evaluation board should only be used by experts, knowing and understanding of its configuration.

2. The choices of external components and timing specifications require understanding of the circuit operation.

3. The user is responsible for the electrical safety and the proper handling and use of the evaluation board. It is your responsibility to use this board correctly and safely.

4. When using this board at high voltage, use it in an environment where sufficient safety measures have been taken.

5. CoolCAD Electronics is not responsible for accidents or injuries caused when using this board.

6. CoolCAD Electronics is not responsible for any consequences arising from the use of this board.

7. The evaluation board is provided as is without any warranties, except for in the case of shipping damage or existing manufacturing issue. The customer should alert CoolCAD Electronics within 30 days of purchase of this board for warranty.

8. If this board is modified or damaged by the customer, it cannot be replaced.

9. This datasheet is provided for reference only.

10. The data collected using this evaluation board may not be considered as a guarantee of components characteristics. Components must be tested thoroughly depending on intended application as adjustments may be necessary.

11. This board cannot be commercialized or sold by incorporating it into another product or equipment.

12. CoolCAD Electronics reserves the right to make any or all changes to the board's documentation, reference manuals, designs and specifications at any time without notice.

13. Diagrams and photos may differ from the actual board you have.

14. Please contact the distributor you purchased from for any inquiries.

CAUTION: These devices and circuits are ESD sensitive. Use proper handling procedures.