CATAPULT
Compound Semiconductor Applications

Double Pulse Testing

Technical capability brief

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Double Pulse Testing (DPT)

Double Pulse Testing (DPT) is a crucial method for dynamic characterisation of advanced power electronic devices. It uses two controlled pulses to characterise the turn-on and turn-off behaviour of a device.

This test can be used to characterize discrete components like MOSFETs or IGBT, as well as modules made up of several devices. Since static measurements and datasheet values alone don't fully reveal how a device performs in real-world scenarios. DPT enables engineers to precisely characterise switching performance during transitions under realistic operating conditions.

Most energy losses in modern power electronics happen during these switching periods, so it's essential to thoroughly understand device behaviour throughout this process. Reducing power losses remains a significant reason for adopting compound semiconductor-based power electronics. DPT can help compare technologies such as silicon (Si) and silicon carbide (SiC), as well as validate new device designs.

DPT at Compound Semiconductor Applications Catapult

Carrying out DPT demands high-accuracy measurement capability, combining wide bandwidth, high resolution instrumentation, and the expertise to apply it effectively.

At Compound Semiconductor Applications Catapult (CSA Catapult), our Power Electronics team has extensive experience across all aspects of DPT, from test design through to data analysis, fully compliant with BS IEC 60747-8-4. We also have access to cutting edge measurement equipment including high resolution oscilloscopes and high bandwidth (1Ghz) high voltage probes.

We select and configure measurement equipment appropriate to the specific device and operating conditions, ensuring optimal signal integrity and repeatability. Our team designs dedicated test PCBs, gate driver circuitry, and carefully specifies peripheral components to minimise parasitic inductance and capacitance, thereby preserving the accuracy of the characterisation results.

This is particularly important when measuring compound semiconductor-based devices, as they can switch faster, exacerbating challenges such as EMI and ringing. We implement robust safety procedures and high-voltage test infrastructure to protect both personnel and devices under test (DUTs).

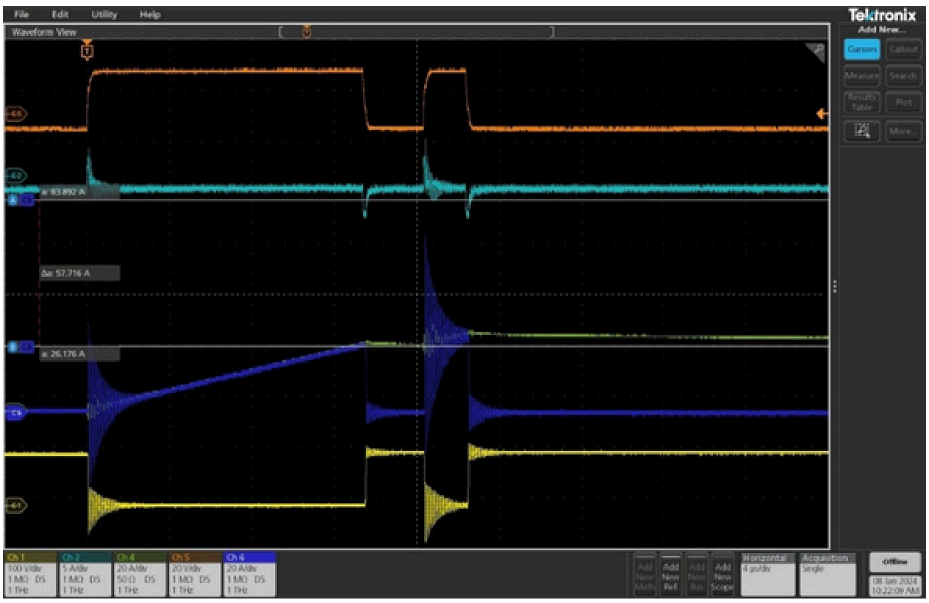
CSA Catapult has developed in-house automation capabilities for DPT, enabling efficient execution of large test matrices across a range of voltages, currents, and temperatures. Table 1 shows the current maximum ratings available at CSA Catapult. Automation improves throughput, repeatability, and consistency while reducing manual intervention. To ensure measurement accuracy, we minimise parasitic losses within the test setup and employ high-performance instrumentation, including high-bandwidth oscilloscopes, Rogowski coils for non-intrusive current measurement, and differential voltage probes. As this capability was designed and developed in house, CSA Catapult also retains a high degree of control and testing flexibility when required.

Table 1

Parameter	Current maximum at CSA Catapult
Voltage	1.5kV
Current	1kA
Temperature	25 °C to 175 °C

In addition, we have automated the extraction of key switching parameters directly from captured DPT waveforms, enabling rapid and consistent analysis. An example waveform of switching transitions can be found in figure 1.

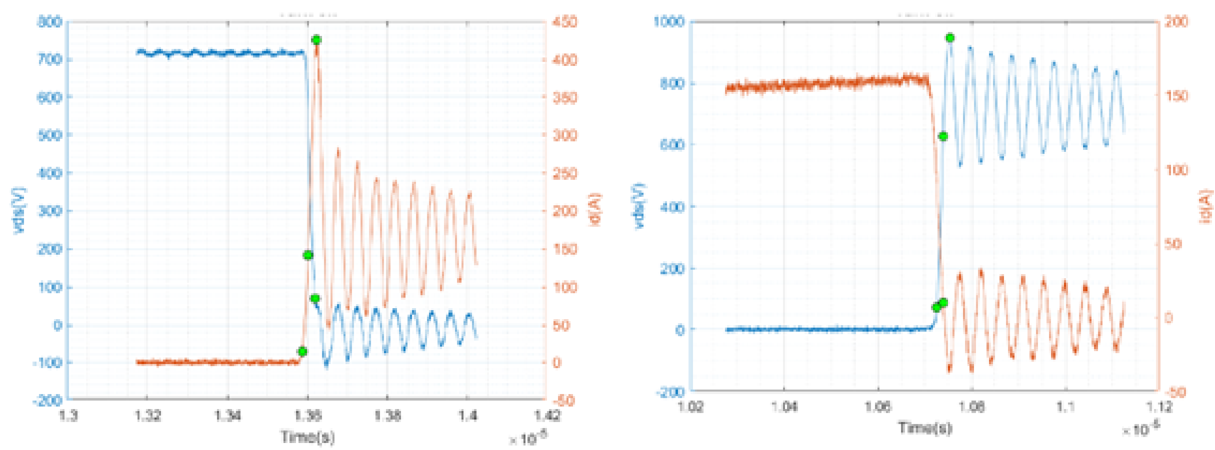
Figure 1



What can DPT tell us about device performance?

The transitions characterise the dynamic behaviour of a device during turn-off and turn-on, respectively. Analysis of these switching waveforms enables extraction of the key parameters that define switching performance and efficiency. Examples of switching transitions after post-processing can be found in figure 2.

Figure 2



E_{total}, E_{on}, E_{off}, these represent the switching energy losses.

- E_{on}: Energy dissipated during the turn-on transition.
- E_{off}: Energy dissipated during the turn-off transition.
- E_{total}: The total switching energy per cycle (E_{on} + E_{off}).

These values are obtained by integrating the instantaneous power over the respective transition period. Switching losses directly impact device efficiency, thermal performance, and power density.

I_{rr}, t_{rr}, Q_{rr}, these parameters describe reverse-recovery behaviour, typically associated with the intrinsic or external diode in the switching path.

- I_{rr}: Peak reverse recovery current.
- t_{rr}: Reverse recovery time.
- Q_{rr}: Total reverse recovery charge.

Reverse recovery performance is critical because high I_{rr} and Q_{rr} increase switching losses, current overshoot, electromagnetic interference (EMI). Faster recovery generally improves efficiency and reduces switching stress.

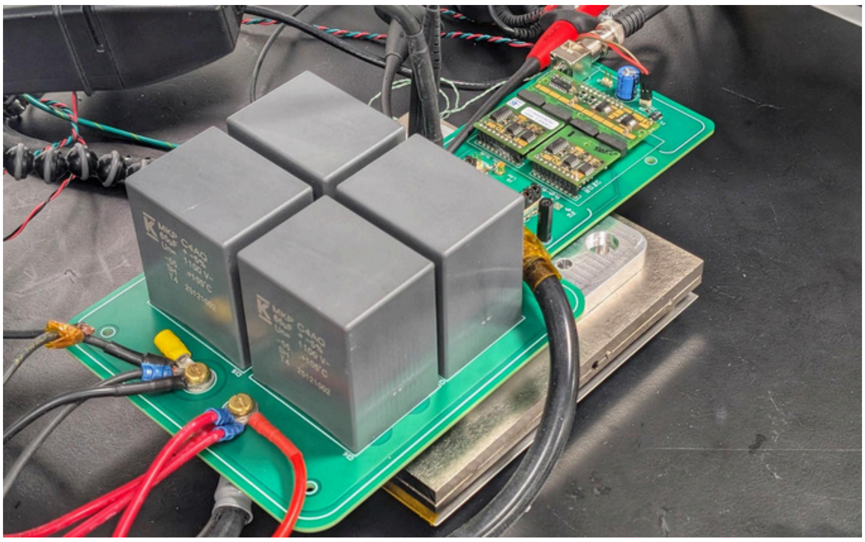
di/dt, dv/dt, these quantify the rate of change (or slew rates) of current and voltage during switching transitions.

- di/dt: Rate of change of current.
- dv/dt: Rate of change of voltage.

Higher slew rates typically enable faster switching and reduced energy losses during switching; however, they can also increase EMI and induce ringing due to parasitic inductance and capacitance.

- t_{rise}, t_{fall}, these define the duration of the switching transitions.
- t_{rise}: Time for current (or voltage) to rise between specified percentages (usually 10–90%).
- t_{fall}: Time for current (or voltage) to fall between specified percentages.

Shorter transition times generally correspond to faster device operation and reduced switching losses, but may increase overshoot, ringing, and EMI.



Together, these parameters provide a comprehensive assessment of switching performance, efficiency, and suitability of the device for power electronic applications.

The transitions can also be inspected under a number of different operating points and conditions such as at elevated temperatures and using different external gate resistances. This gives an in depth look at how the devices will operate under different realistic conditions.

Transitions can also reveal other important characteristics of device performance such as voltage overshoots and ringing, as well as monitoring switches in modules which are “off” during testing for miller turn on during transitions – this is important as it can monitor for a phenomenon known as “shoot through”, which can lead to catastrophic failure.

CSA Catapult has achieved full automation of extracting these key parameters from transitions, allowing engineers to rapidly assess the performance of devices at a high number of operating points and conditions. This also allows engineers to efficiently plot and characterise a multitude of parameters– allowing an overview of the performance under vast numbers of differing realistic conditions.

Additionally, CSA Catapult has the capability to create advanced simulation models using the output of DPT.

Future developments

On top of CSA Catapults’ existing capabilities, we plan to develop our testing setup to allow testing at increased voltages and currents, as well as a wider range of temperatures. We also aim to further improve the accuracy of gate current measurement by implementing differential gate current measurements, as well as other continual improvements to the measurement system by acquiring the latest offerings in high bandwidth high-voltage probes. We are also currently developing optimised PCBs for measuring standard device packaging types such as TO-247.

Summary

Double Pulse Testing (DPT) is a vital technique for dynamic characterization of power electronic devices. It helps in understanding switching losses, comparing technologies, and validating device designs. DPT characterizes both discrete components and modules, revealing device performance during switching transitions, which are critical for energy loss reduction in power electronics. It provides insights beyond static datasheet values.

CSA Catapult offers high-accuracy DPT with tailored measurement equipment, custom test PCBs, gate driver circuits, and safety infrastructure for high-voltage testing. Our in-house automation enhances throughput, repeatability, and flexibility, using advanced instrumentation. Automated extraction of key switching parameters such as energy losses (E_{total}, E_{on}, E_{off}), recovery metrics (I_{rr}, t_{rr}, Q_{rr}), rates of change (di/dt, dv/dt), and transition times (t_{rise}, t_{fall}) enables rapid and consistent device assessment under various conditions including temperature and gate resistance variations.

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