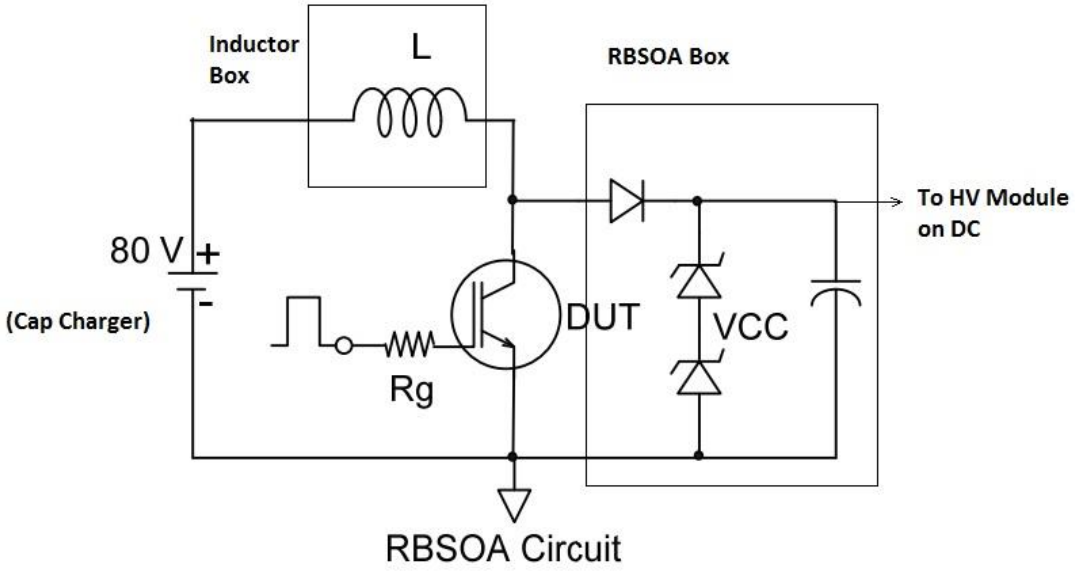
Hard-Switching Inductive Load Tests with FTI 1000

The Hard-Switching Inductive Load Test Option with FTI 1000 provides a double-pulse test for GaN power discrete devices. Parameters that can be measured include Dynamic Rdson, Eon/Eoff Energy Loss and RBSOA. The basic test circuit is shown below.



The RBSOA test is a double pulse inductive switching test used to stress a device. The test uses a capacitor as a power source charged to a VDD voltage. The device is first turned on for a time T1 to charge the inductor up to just below the programmed ID. It is then driven off for time T2, then pulses on again for time T3. The VDS voltage and ID current at the mid point of T3 are datalogged.
A typical waveform for the test is shown below:

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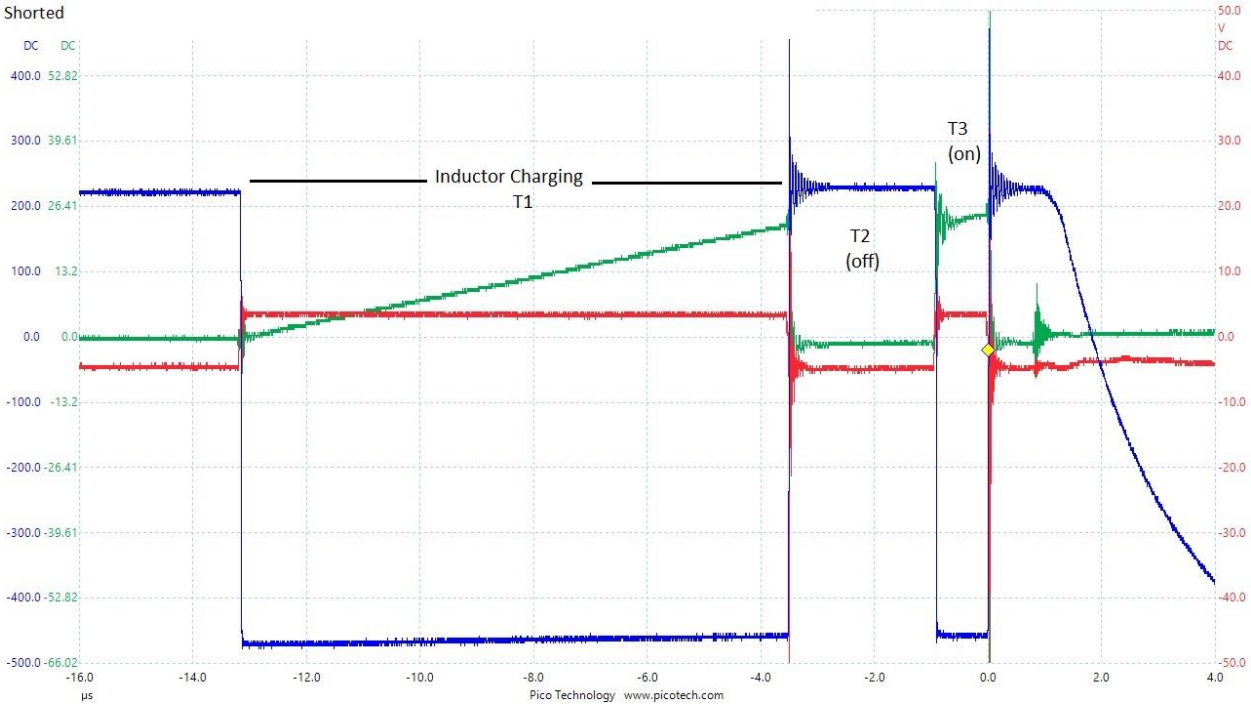

The blue trace is the VDS voltage. It is offset by 470V to use the full range of the oscilloscope, so where it is shown starting at 230V, this is really 700V of VDS.
The green trace is the ID current. This is measured using a current sense resistor of nominally 0.3 ohms, so at 24A, this takes a voltage drop of 8V. The current sense resistor can be configured as required to give the best current range.
The red trace is the VGS voltage. The device shown has a clamp on the high side at about 4V, so even though the tester is programmed to +12V for VGS high, the waveform only goes to about +4V.

The RBSOA setup screen on the FTI-1000 is configured as follows:

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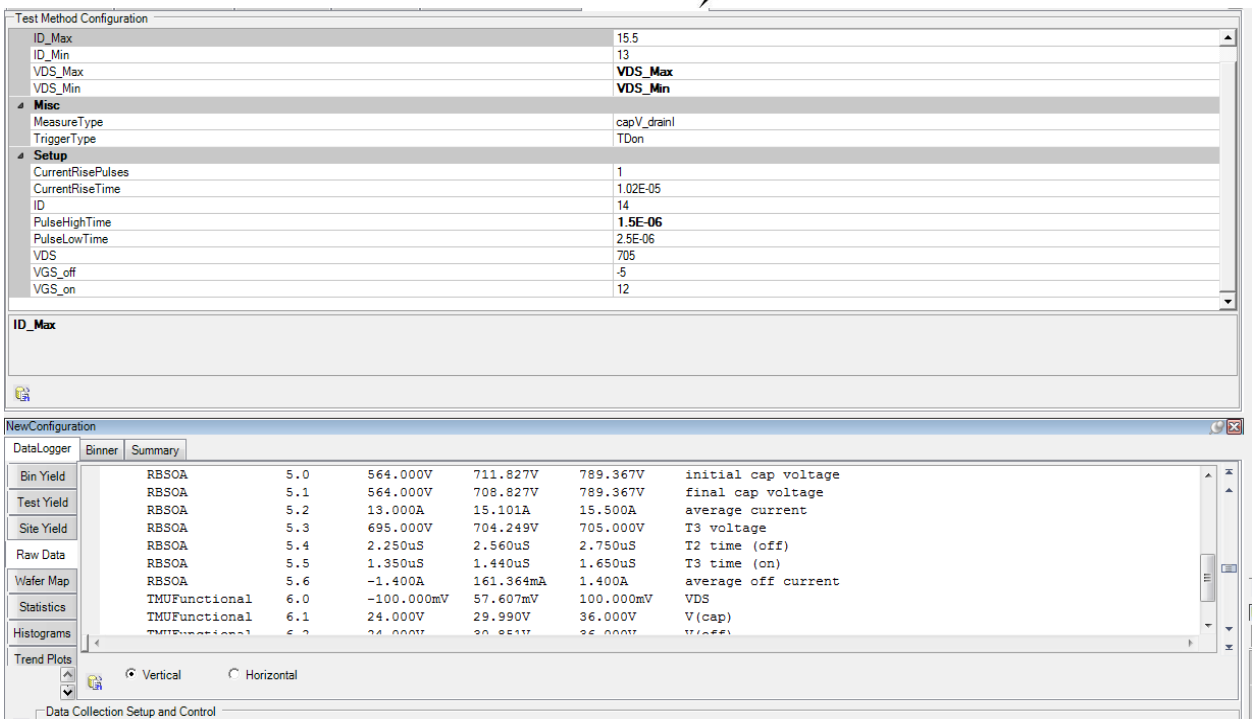

Limits can be set for the VDS Voltage and ID current. These must match the configured VDS and ID. All other limits are calculated automatically from the other settings.

The ID is limited in software to 40A maximum for safety. If a lower sense resistor was used for higher currents, then this would be adjusted appropriately. This setup is configured for 15A – 30A operation and can work well from 5A to 65A. Changing the current sense resistor is required for different ranges.

The PulseHighTime is the time set for T3 (the second on pulse). This can be programmed from 0 to 10 usec. The shortest useful time is about 800 ns. The upper limit is for safety, as the current will continue to ramp up during this entire time.

The PulseLowTime is the time set for T2 (the off period between current pulses). This has no limits, but the lowest possible time is 240 ns.

CurrentRisePulses and CurrentRiseTime are no longer used and are ignored, but they could be used to control the test by timing rather than by current.

VGS_Off and VGS_On are the low and high levels for the gate drive. These must have a minimum swing of at least 8V, and a maximum of 18V. Different driver options are available that can work with smaller or higher swings.

MeasureType: best operation is set by using capV_drainI. Other possible values are:

- None: No data is captured
- drainV: Disabled – directly monitor the switching voltage. This can be used at lower currents, and up to about 400V, but creates problems at higher voltages.
- capV: Just monitor the capacitor VDD voltage
- drainV_drainI: Same as drainV, but also monitor the drain current.

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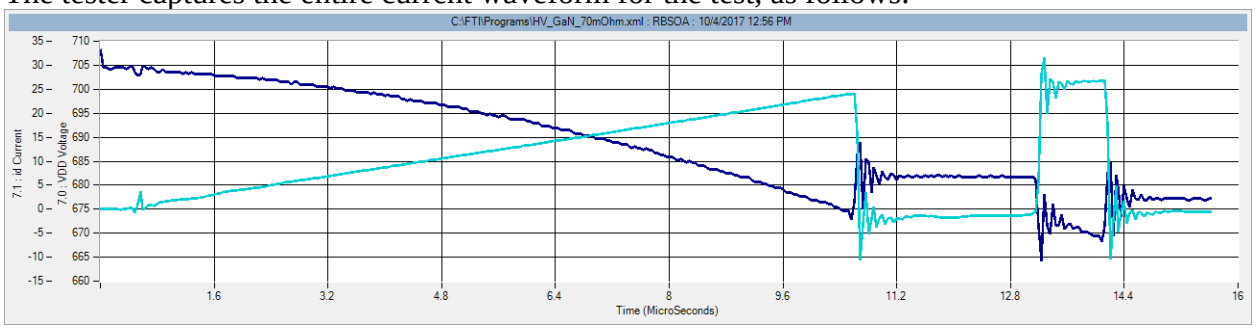
- drainV_gateV: Monitor VDS and VGS..
- capV_gateV: Monitors the capacitor VDD and gate voltage.
- capV_drainI: Recommended setting

TriggerType is for debug purposes. It sends a synchronous trigger pulse at different points during the test.
The tester captures the entire current waveform for the test, as follows:



The light blue is the current, and the dark blue is the VDD voltage on the cap. This can be displayed with the FTI Studio Scope Tool.
From the captured waveform, the following items are datalogged:

0. Initial Cap voltage. This will be higher than the programmed VDD as it is adjusted to allow for the drop during the test, as well as the drop in the ID sense resistor.
1. Final Cap voltage. After the test is completed.
2. ID Current. The current through the entire T3 time is averaged and reported
3. T3 Voltage. The VDS voltage at the center of the T3 time.
4. T2 (off) time. The pulse width of the off time between pulses (using 50% of the peak current during the T1 time)
5. T3 (on) time. The pulse width of the second on time , using the same thresholds as the T2 time.
6. Off Current. The average current during the T2 time is reported.

For safety, the VDD capacitor is charged up and discharged for each test. In the case of a shorted DUT, the capacitor will not charge, and the datalog will just be test 10 and 11 indicating the max voltage achieved before the test shut down.
As the RBSOA test is likely to damage devices, it must be run in conjunction with a DUT Functional test. This does a similar test at low voltage to ensure that the hardware if functioning properly, and to detect shorted devices.
Every time a device fails the RBSOA, a flag is set that will not allow another RBSOA test until the functional test has run correctly. If the functional test detects a serious problem, it will report it and not allow the test to be run again. Possible serious failures are:

- Shorted flywheel diode. The system will display “Inductor is shorted. Replace Diode D2 on RBSOA board”

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- Current Limit switch. The system will display “Current Limit Switch failed. Replace Q6 on RBSOA board”

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