Power Electronics Device Modeling

Power Electronics (PE) design engineers are under strong schedule pressure to address the growing needs of power conversion, motor drivers, etc. Meanwhile, to enable smaller designs, the switching frequencies are going up into the 100s of kHz and even low MHz. While these might be modest frequencies, the voltages, and in particular, the changes in voltages versus time (dV/dt) are very large. GaN devices today are switching within 250 ps, generating harmonic content into the GHz range. Inductances as small as 0.1 nH can reshape the waveforms driving the gate, causing ringing and transient induced noise. Stray inductance in the high current path is very common, leading to large L*di/dt.

These surges in voltage and current, along with the ringing that follows can cause circuit malfunction, and in some cases, circuit explosion. The high switching frequencies and associated harmonics lead to undesirable electromagnetic interference.

These are big problems that need to be simulated and resolved. On the one hand, designers may improve reliability by using larger power modules, but this leads to increased cost and size. On the other hand, smaller nimbler devices must be simulated to predict voltage and current surge issues. Modern power converters are now increasingly digitally controlled, with arrays of discrete power devices placed side-by-side. To capture a transient over-voltage of a device, the question arises: “How can we model this?”

Many PE designers simply give up, relying instead on their decades of experience making circuits work on the lab bench. Designs are therefore iterative, with managers planning small changes between hardware releases. R&D budgets can swell due to longer than expected design cycles. Even worse, the design team loses its edge on the competition.
But there is a better way. What if we could accurately model both the device and the board?

What if a design team could quickly transition from a 400 V, 1 A converter to a 10 V, 100 A converter in a significantly smaller form factor? To do this, one would need accurate models, models based on measured data and extracted quickly and efficiently using state-of-the-art modeling tools. Fortunately, we have a solution.

What data do we need for accurate modeling?

1. DC IV data, collected by both a curve tracer using double pulse test (or clamped inductive load).

2. Off-state capacitances may be derived from AC measurements built into the curve tracer.

3. Zero bias S-parameters may be used to estimate device gate resistance (Rg) and series inductances. "Ls" is especially important for ringing and oscillations.

4. S-parameters may be measured under DC bias with an SMU and bias tee to give on-state capacitance vs. frequency.

The PD1000A Power Device Measurement System for Advanced Modeling control software is used to orchestrate these measurements and organize the data into directories. To create a device model, the data is then read in using Keysight’s Power Electronics Model Generator software (W8598BP). This software currently supports 3 different power electronics device models, although more are expected to be added soon.

All 3 of these models have been implemented in Verilog-A, and are available for simulation in ADS 2017. The Si/SiC and IGBT models have been specially formulated for customers who do not have access to device process parameters, a situation that is common in power electronics design labs.

1. Image used by permission.
The user interface reflects the major steps that any modeling engineer must undergo.

- Set project parameters, model flags and device constants.
- Load data from a highly structured directory.
- Extract model parameters.
- Verify model accuracy.
- Export device model parameters.

With the latest, most accurate models, one may rest assured that the device behavior has been captured with excellent accuracy.

Various modeling steps are shown on the left. On the right, parameters may be manually tuned using sliders.

We invite you to stay ahead of the curve, and get your designs to production sooner and with greater confidence. The PEMG provides a comprehensive modeling solution for discrete power electronics devices, with an intuitive UI and the latest, most powerful models.
Ordering Information

IC-CAP users who require the maximum flexibility may customize the extraction flow using the following add-on packages.

- W8536EP/ET SiC PowerMOS Power Electronic Modeling
- W8537EP/ET IGBT Power Electronic Modeling
- W8538EP/ET GaN Power Electronic Modeling

These packages require the W8501E IC-CAP Core Environment and W8502E IC-CAP Analysis, both of which are included in the W8500B Modeling Bundle.

All three models are also offered in a stand-alone software that is part of a larger PD1000A solution called “Power Device Measurement System for Advanced Modeling.”

- W8598BP/BT Power Electronics Model Generator (PEMG) Software
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