

Using Pulsed IV Measurements to Improve GaN Device Modeling and Validation

Application Note / 202610-1A



Abstract

Accurate IV measurements are essential for understanding semiconductor device behavior and extracting parameters for compact and behavioral models. However, the measurement conditions themselves can influence the observed response. Pulsed IV uses short-duration bias pulses to help minimize these effects and support measurements under quasi-isothermal, or approximately constant-temperature, conditions.

This application note examines the importance of pulsed IV characterization, key measurement considerations, and the capabilities of the Maury PIV Series and InsightPro™, followed by a practical GaN device measurement example.

Pulsed IV Measurement Challenges

During conventional DC IV characterization, steady voltage and current conditions are applied to the device. Continuously applying these conditions can make it more difficult to isolate the device's intrinsic behavior due to effects such as self-heating and charge trapping.

Self-heating: As the device continuously conducts current during the measurement, heat builds within the semiconductor. The resulting temperature increase can alter the electrical response, causing the measured IV characteristics to reflect both the applied electrical conditions and thermal effects.

Charge trapping: III-V devices such as GaN are also susceptible to charge-trapping effects. Defects and imperfections within the semiconductor can temporarily trap electrical charge, altering the device response and potentially affecting performance and long-term reliability. Characterizing these dynamic effects is important for developing more predictive and robust device models.

Pulsed IV characterization instead applies short-duration gate and drain voltage pulses while measuring the corresponding voltage and current response. The brief pulse duration minimizes self-heating, enabling characterization under quasi-isothermal conditions.

Controlling pulse and bias conditions also allows engineers to evaluate dynamic device behavior and model charge-trapping effects. Comparing the device response under different conditions can provide a clearer view of intrinsic behavior and support parameter extraction for compact and behavioral models.

Pulsed IV Measurement Setup and System Architecture

A typical pulsed IV measurement setup uses separate gate and drain paths to apply the required bias conditions to the DUT and measure its response. For measurements that also include RF characterization, a VNA can be incorporated into the setup for pulsed S-parameter measurements.

Figure 1 illustrates this basic measurement architecture, with separate gate and drain paths connected to the DUT and a VNA included for RF measurements. The gate and drain paths provide the required bias conditions while the corresponding voltage and current response of the device is measured.

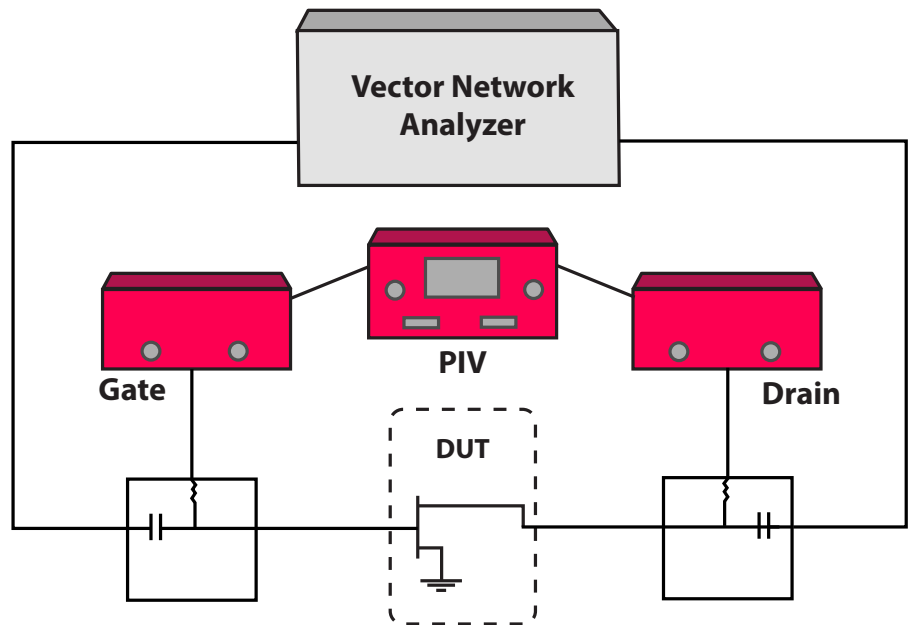


Figure 1. Typical setup for pulsed IV device characterization.

The Maury PIV measurement system (Figure 2) provides an integrated implementation of this measurement architecture. It combines the sourcing, pulsing, and measurement functions required for DC and pulsed IV characterization under quasi-isothermal conditions. The system also supports measurement and pulsed triggering for S-parameter and fast power measurements.

The PIV Series consists of three integrated modules:

- > **PIV-MAIN:** High-voltage AC/DC power supply module
- > **PIV-30V-BP:** Bipolar ± 30 V gate pulsed IV module
- > **PIV-280V:** 280 V drain pulsed IV module



Figure 2. Maury PIV Series pulsed IV measurement system.

Key Pulsed IV Measurement Capabilities

Pulsed IV characterization places demanding requirements on the measurement system, particularly when short-duration pulses, fast transitions, and changing device conditions must be captured accurately. The system must maintain signal integrity, allow voltage and current waveforms to settle without distortion, and precisely capture the DUT response during the brief pulse. Capabilities such as timing resolution, voltage and current range, and pulse performance directly influence how effectively the system can characterize the DUT across different operating conditions.

High-Resolution Measurements

During a pulsed IV measurement, voltage and current are captured within a short-duration pulse, and the measured current can change as a function of time. The timing resolution of the measurement system therefore determines how closely the pulse can be examined and how precisely the measurement window can be positioned.

Finer timing resolution provides greater visibility into pulse-shape behavior, including effects such as overshoot, and allows narrower measurement windows to be defined within the pulse. This helps capture the desired current response at the appropriate point in time.

The Maury PIV Series provides 10 ns timing resolution for precise DC and pulsed IV measurements. Figure 3 illustrates the benefit of finer timing resolution across a 200 ns pulse. With 10 ns resolution, pulse-shape details can be evaluated that may be missed at 20 ns resolution. Since current can change as a function of time, the finer resolution allows narrower windows to be positioned within the pulse to capture the desired current response.

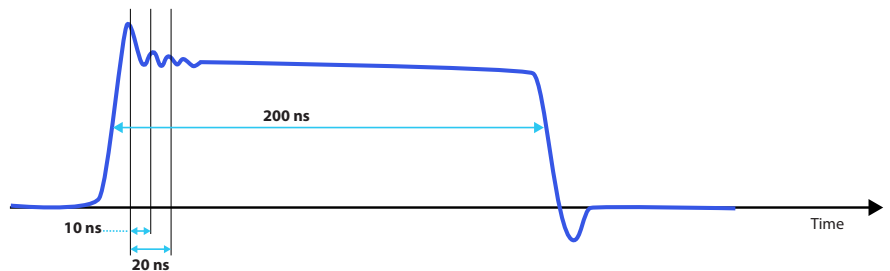


Figure 3. Illustration of 10 ns and 20 ns timing resolution across a 200 ns pulse.

Wide Voltage and Current Coverage

Voltage and current range are key parameters during pulsed IV measurements, determining the gate and drain bias conditions that can be applied to the DUT and the operating range over which the device can be evaluated. Measurement solutions with higher voltage and current capability can accommodate elevated voltage, current, or overshoot conditions without interrupting the measurement.

The Maury PIV Series provides wide voltage and current coverage, with the gate module supporting ± 30 V and ± 1.5 A pulsed current and the drain module supporting up to 280 V and 40 A pulsed current.

Fast Pulse Performance

Fast pulse performance allows the applied gate and drain pulses to reach the intended operating condition quickly enough for the DUT response to be measured within the available pulse duration. The measurement system must generate fast rise and fall times while maintaining signal integrity and allowing the voltage and current waveforms to settle without distortion.

The Maury PIV Series supports pulse widths down to 200 ns. In Fast mode, typical rise and fall times are as low as 25 ns at the gate and 30 ns at the drain, supporting rapid transitions within short pulse durations. Figure 4 shows measured gate and drain pulse examples at 1 μ s and 500 ns.

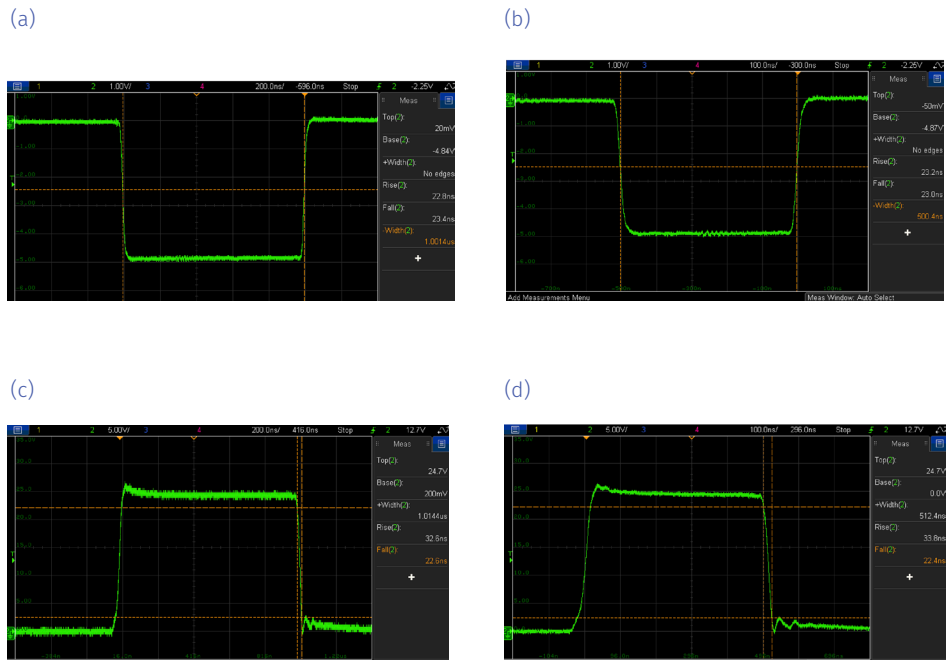


Figure 4. Measured gate and drain pulse examples at 1 μ s and 500 ns: (a) -5 V gate pulse at 1 μ s, (b) -5 V gate pulse at 500 ns, (c) +25 V drain pulse at 1 μ s, and (d) +25 V drain pulse at 500 ns.

Measurement Configuration with InsightPro

InsightPro serves as the software interface for configuring, controlling, visualizing, and analyzing device characterization measurements with the PIV Series. For pulsed IV applications, it supports pulsed IV measurements, pulsed S-parameter measurements, and data visualization within a unified environment.

For pulsed IV measurements, InsightPro provides a bench setup editor and pulse timing configuration tools that allow users to define the measurement setup and control the timing relationship between the applied bias pulses and the measurement window. Additional capabilities include pulse-window setup, real-time setup changes, sweep plans, real-time data viewing, and integrated time-domain capabilities.

Figure 5 shows the InsightPro pulsed measurement chronogram used to visualize and configure the timing relationship between the source pulses and the measurement window. The source pulse timing is displayed together with the defined measurement region, allowing the user to position the measurement window within the pulse and control when the DUT voltage and current response are captured.

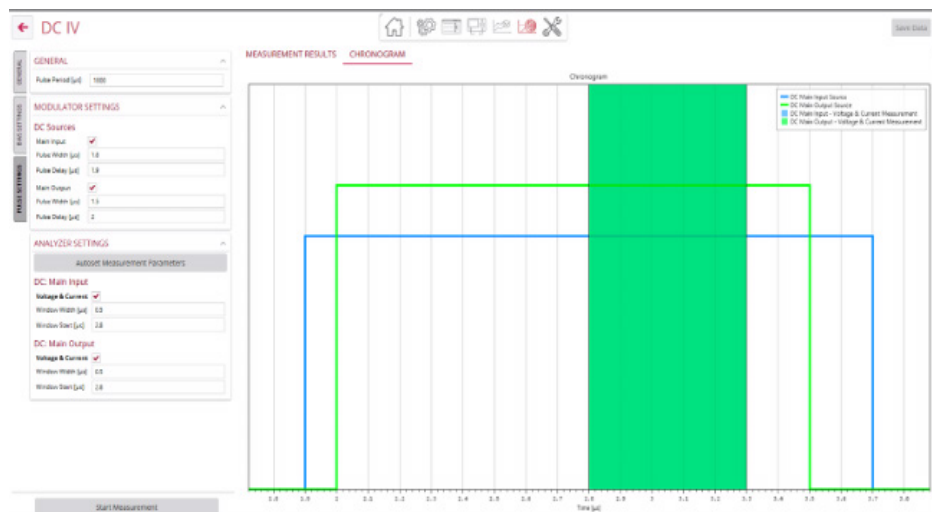


Figure 5. InsightPro chronogram showing source and measurement timing configuration for IV characterization.

Example Pulsed IV Measurement of a GaN Device

A fixture GaN DUT was characterized using the Maury PIV Series and InsightPro. A bias tee was included in the setup to improve stability. For each IV curve, the device was held at a particular gate condition while the drain voltage was varied and the resulting drain current was measured. Repeating the measurement at different gate conditions produced the family of IV curves shown in Figure 6.

The measurement was repeated using two pulse widths: 5 μs and 1 μs , both at a 1% duty cycle. The black curves represent the 5 μs measurements, while the red curves represent the 1 μs measurements. Comparing the paired curves shows that the measured IV response changes with pulse width.

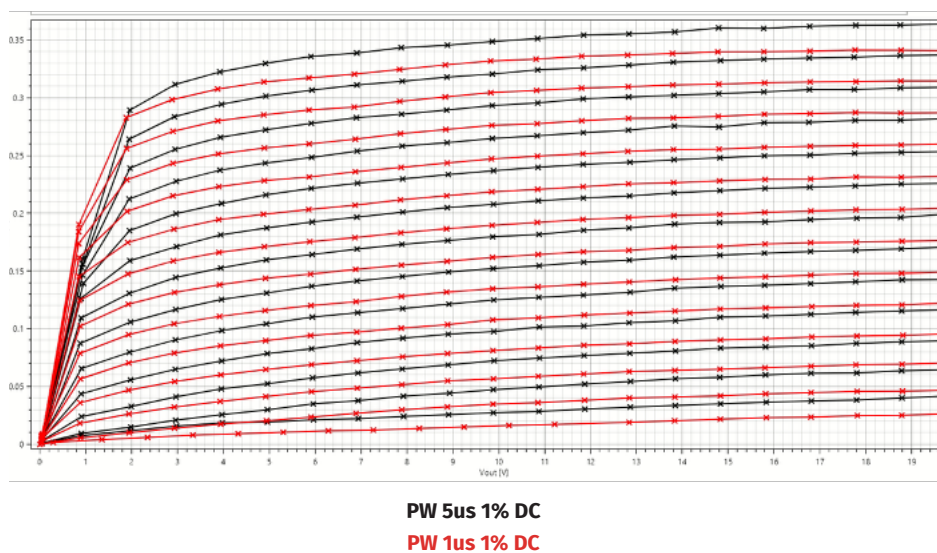


Figure 6. Pulsed IV measurements of a fixture GaN DUT with a bias tee to improve stability, performed with the Maury PIV Series and InsightPro using 5 μs and 1 μs pulse widths at a 1% duty cycle.

Improving Model Accuracy with Pulsed IV Measurements

Pulsed IV characterization provides a way to evaluate semiconductor devices under quasi-isothermal conditions while reducing the influence of self-heating and enabling investigation of dynamic effects such as charge trapping. The Maury PIV Series combines 10 ns timing resolution, wide gate and drain voltage/current coverage, fast pulse performance, and integration with InsightPro for DC IV, pulsed IV, pulsed S-parameter measurements, and waveform analysis. By controlling pulse and bias conditions, engineers can more accurately assess intrinsic device behavior and extract parameters for compact and behavioral models.



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