Tektronix Advanced Semiconductor Laboratory: Breakthrough testing of 1200V GaN devices from GaNPower

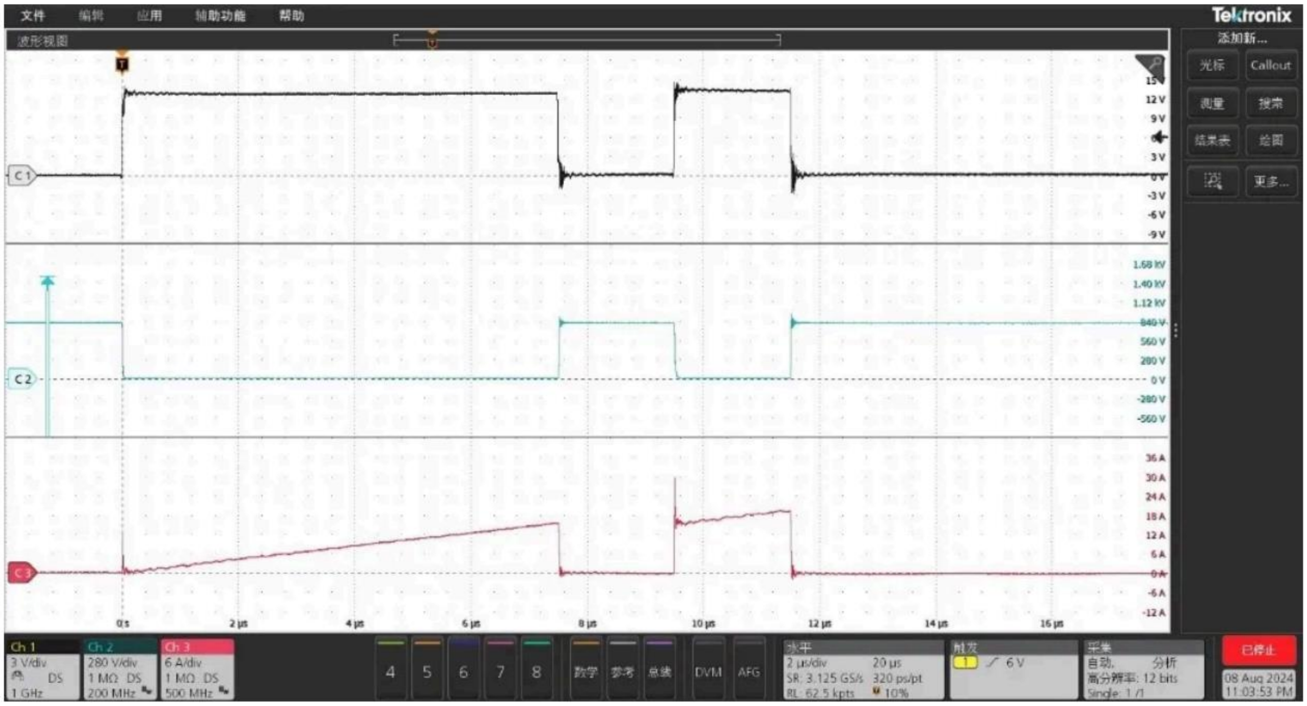
(Translated from) Tektronix Tektronix Sep 2, 2024

In August 2024, at **the Tektronix Advanced Semiconductor Open Lab**, we had the privilege of witnessing dynamic parameter testing of **GaNPower's** next-generation **1200V GaN power devices**. As the world's first manufacturer to successfully tape out and mass-produce 1200V GaN power devices, GaNPower has achieved significant performance improvements with its latest products. This advancement not only highlights remarkable technological progress but also offers innovative solutions for our customers.

Test Overview

In August this year, GaNPower introduced a new generation of high-voltage GaN devices with rated operating conditions of 1200V/20A (70mΩ) and an output current exceeding 20A at a gate voltage of 12V. This performance improvement makes GaNPower's GaN devices comparable to silicon carbide (SiC) devices of the same specifications in terms of operating performance.

The figure below illustrates the switch test waveform of the TO-247 packaged GaN HEMT device provided by GaNPower under 1200V/15A conditions. The gate voltage ranges from 0 to 12V, and a 1200V SiC diode is used as a flyback diode. (Test conditions: SiC flyback diode, R_{on} = R_{off} = 10Ω, load inductance 400uH, V_{ds}: 800V, V_{gs}: 0~12V, I_d: 15A)



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15 V
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0 V
-3 V
-6 V
-9 V
1.68 kV
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840 V
560 V
280 V
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-560 V
36 A
30 A
24 A
18 A
12 A
6 A
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Ch 1
3 V/div
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Ch 2
280 V/div
1 MΩ DS
200 MHz
Ch 3
6 A/div
1 MΩ DS
500 MHz
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数学
参考
总线
DVM
AFG
水平
2 µs/div 20 µs
SR: 3.125 GS/s 320 ps/pt
RL: 62.5 kpts 10%
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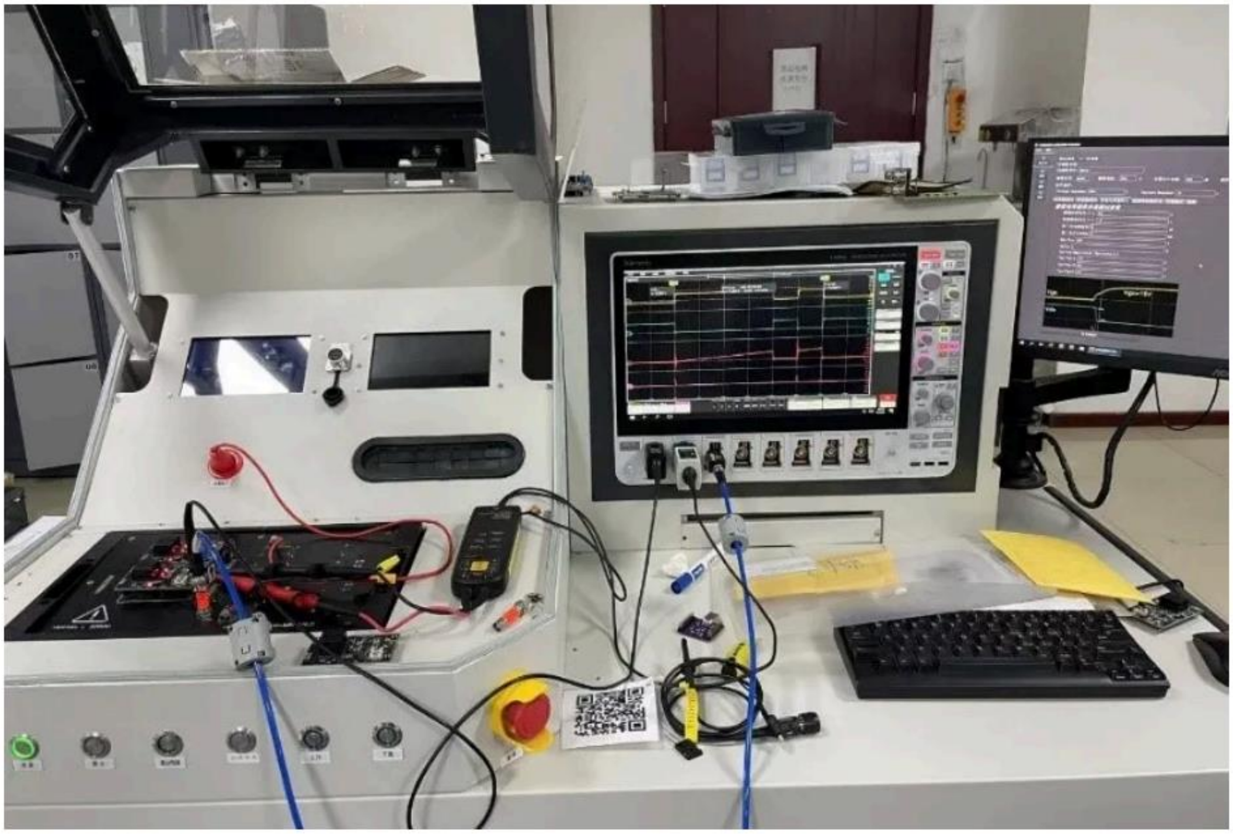
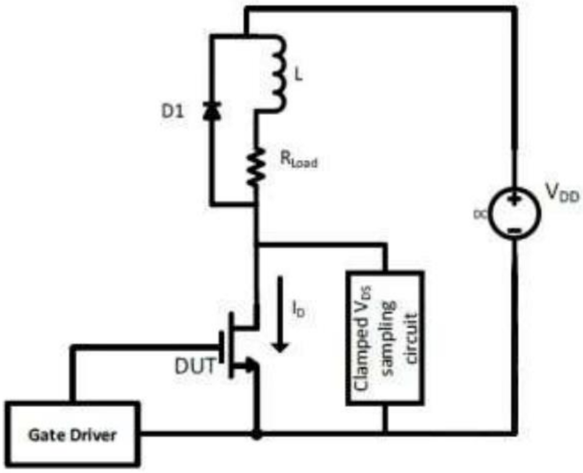
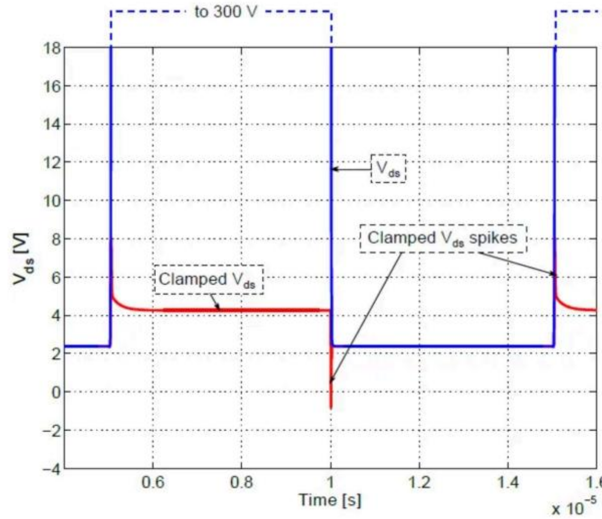
Testing Challenges and Solutions



The main challenge in achieving high-voltage switching with lateral-structured GaN power devices is to addressing the current collapse issue. The on-resistance $R_{ds(on)}$ of GaN power devices during the conduction phase is referred to as dynamic on-resistance. For a detailed definition and test method, please refer to JEP173. Common GaN devices experience current collapse when the operating voltage exceeds 700V, causing a sudden rise in dynamic on-resistance. This issue is particularly severe at high current and high frequency, leading to device heating, increased conduction loss, and restricted current rise. The new generation of 1200V power devices from GaNPower are the world's first GaN products to achieve stable dynamic on-resistance under high-frequency and high-voltage switching.

DPT1000A test machine





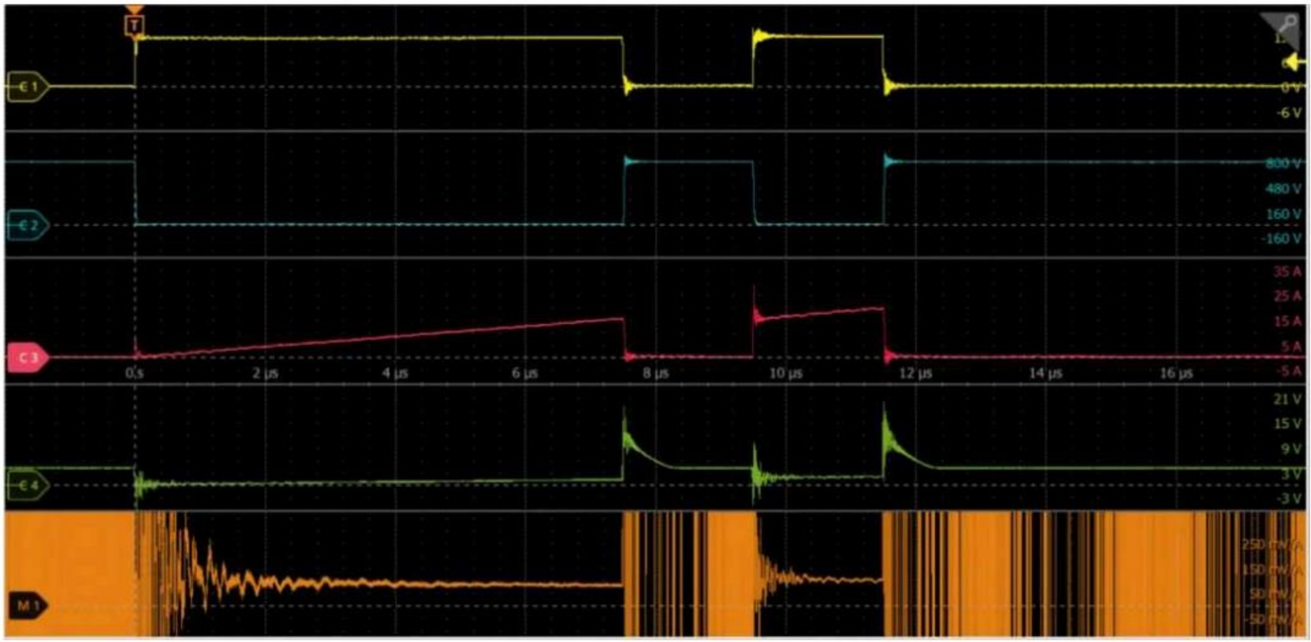
The double pulse test was conducted using the DPT1000A test machine from Tektronix Advanced Semiconductor Laboratory. The test platform included a high-voltage test board, Tektronix's high-resolution oscilloscope MSO58B, 1GHz bandwidth 8-channel oscilloscope, AFG31000 dual-channel signal source, and Magnapower 2000V high-voltage system power supply. Tektronix's TPP1000A single-ended probe was used to test the gate voltage and THDP0200 high-voltage differential probe was used to test the source-drain voltage. The current probe uses T&M's 400MHz bandwidth current sensor.

To verify the performance of dynamic on-resistance, we employed a voltage probe with a clamping function for clamping voltage test. Due to the limited vertical resolution of the oscilloscope, even a high-resolution oscilloscope cannot accurately test the on-voltage of several volts under the high-voltage conditions. According to the JEP173 test guide from JEDEC, it is recommended to test the low-voltage V_{ds} in the on state through a clamping circuit (see the figure below). Previously, 500V withstand voltage condition was sufficient for testing GaN devices. However, the clamping circuit introduced large oscillations during the switching process, affecting the dynamic on-resistance judgment. This time, we used a 1200V withstand voltage clamping probe for V_{ds} testing to obtain clamping test results under higher voltage conditions.

Test Results

After obtaining the V_{ds}-clamp voltage and on-current I_d waveform, the dynamic on-resistance curve of the device can be calculated. During the double pulse test, we connected the clamp probe simultaneously, and the test circuit is shown in the figure below:

The figure below shows the waveform results with the clamping voltage, where CH1 represents the gate voltage V_{gs}, CH2 is the source-drain voltage V_{ds}, C3 is the drain current I_d, C4 is the source-drain voltage V_{ds}-clamp after clamping, and M1 is the calculated dynamic on-resistance $R_{ds(on)}$, given by M1 = C4 / C3. Zooming in on the test waveform of M1 reveals the dynamic on-resistance waveform curve during the conduction phase. The clamping voltage waveform is relatively stable, and the waveform oscillation time is short, allowing for a stable dynamic on-resistance reading within a few hundred nanoseconds.



Conclusion

According to calculations, when V_{bus} is 400V, the dynamic on-resistance is approximately 93mΩ; at 600V, it is about 95mΩ; at 800V, it is about 101mΩ. Compared to the on-resistance of 74mΩ tested under static conditions, the dynamic on-resistance degradation of the device is minimal as the V_{bus} voltage increases under switching conditions, and the resistance value is very close to the static on-resistance test result.

测试条件 (test condition)	Vbus(v)	Rdsin(ohm)
	400V	0.093
Vgs=0~12V	600V	0.095
Rgon=Rgoff=10Ω	700V	0.095
Id=20A	800V	0.101

In recent years, there has been skepticism about whether GaN power devices can break through niche application scenarios. The application market above 1000V has traditionally been dominated by silicon-based IGBT and SiC power devices. For GaN to achieve large-scale application, it must support a wider voltage and current range, more application scenarios, and better cost performance. Through persistent efforts, GaNPower has enabled lateral structure GaN devices to achieve 1200V high-voltage operation, making their high-voltage GaN comparable to SiC devices of the same specifications in switching and static characteristics. This breakthrough opens up new possibilities for expanding the application scenarios of GaN power devices in new energy, electric vehicles, power electronics and other industries.

NOTE: This is a translated version of the original article, which can be accessed in Chinese at the following link: https://mp.weixin.qq.com/s/oJblYKO8RQ54C0cs1mMz1w