Advances Through Innovation:
Transphorm Changes the Game with Gen-IV SuperGaN™ 650V GaN Platform

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Outline

1. Overview—History and status of 600 V+ GaN products
2. Device configuration and Generation 4 SuperGaN™ design
3. Device characteristics
4. Application performance
5. Summary
### Transphorm—A Leader in 600 V+ GaN Power Electronics

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Transphorm Has Shipped 500,000 GaN Parts To The Market:

*Enabled total conversion capacity in field: 200 MW*

Markets

High-voltage GaN technology benefits numerous markets that require reliable higher efficiency, higher performance power conversion. The highest adoption rates are projected for the following application areas:

**Infrastructure and IT Power Supplies**

Increases clean power output in standardized server and telecom form factors.

**Consumer and Computing Adapters, Gaming Power Supplies**

Improved efficiencies result in lower thermals, improved power density and lower system cost.

**Broad Industrial Battery Chargers, UPS**

Reduces size and weight of systems that run industrial factories, charge battery powered forklifts, electric vehicles and keep critical data accessible.

**Automotive EV and Charging**

Generates longer distance per charge with a lower overall system cost.
Field PPM Rates Showing Excellent Reliability

To Date: 4ppm Field Failure Rate

Transphorm GaN Field Data

Field Reliability Data  Field Hours  Field Reliability Data

< 2.0  5B  < 19.8

Failures per Billion Hours (FIT)  Parts per Million per Year (PPM)
GaN 2-chip Normally Off Implementation

*Packs High Performance With High Reliability*

**Standard Gate Driver Examples:**
- Silicon Labs
- ON Semiconductor
- Texas Instruments

**Simple to Drive GaN FET**

**HV GaN FET**

- Low R_{ON}
- Minimal miller plateau
- Fast switching
- Diode free bridge

**Transphorm**

**Standard Gate Drivers**

**High Noise Immunity**

**Robust Gate**

**High Gate Drive Margin**

**Normally off Packaged Part**
Innovative Design Enables Simplest 2-chip Normally-off GaN

- Patented innovation transforms a complex 2-chip design into a simplistic “1-chip-like” package
- Multiple components/wires were removed from previous product
- Targeting remarkable cost reduction and significant performance improvement
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TPH Gen IV GaN Vs. Other GaN: $I_{DSS}$ Comparison

- TPH Gen IV: 1200 V at 25°C
- 300 V higher than competition
Gen IV $I_{\text{DSS}}$ At High Temperatures

1000 V breakdown even at higher 175°C temperature
- Breakdown at 150°C: 1050 V
- Breakdown at 175°C: 1000 V
In Circuit Test - DyRon vs. Vd Very Stable at RT & 150°C

Switching to 700 V

- Max/typical/low Ron devices tested
- Flat Dynamic $R_{DS(on)}$ to 700 V at 25°C & 150°C
Dynamic Parameters - $C_{oss}$ & $Q_{oss}$ vs. $V_d$

- **Gen III vs Gen IV (Coss)**
  - Gen III
  - Gen IV

- **Gen III vs Gen IV (Qoss)**
  - Gen III
  - Gen IV

- Reduced $C_{oss}$ & $Q_{oss}$
Verified Switching Performance: Gen IV

- Gen IV: Higher speed but much lower turn-off ringing
  => Improved stability
- Turn-on spike can be controlled (next slide)
Switching Performance: Speed Controllability

- Switching speed controllable with Vg (or Rg)
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Performance Benefit, Gen IV vs. Gen III

Synchronous Boost Converter: 240 V:400 V @ 100 kHz

• Gen IV further improves efficiency:
  ✓ 0.2-0.4% improvement at low load & >0.1% at mid to high load.
Performance Benefit at 200 and 300 kHz

Synchronous Boost Converter: 240 V:400 V

- All test were in hard-switching (Expect higher Eff. in soft switching)
  - [200kHz] Peak efficiency: Gen IV 98.70% => Best-in-class
  - [300kHz] Peak efficiency: Gen IV 98.21% => Best-in-class
Performance Compared to SiC MOSFET (30mΩ)

_Synchronous Boost Converter: 240 V:400 V @ 100 kHz_

Half-bridge Boost Converter

[Gate drive] GaN: 0-12V, $R_G=30$

SiC: 0-18V, $R_G=0$

GaN: Efficiency improvement >0.2% from 3 kW-7.2 kW
✓ The only GaN product to deliver 7.3 kW (100kHz)
Best-in-Class Totem-pole PFC Performance

Highest Efficiency and Power Level By Discrete GaN: 230 Vrms:390 Vdc @ 65 kHz

- Same operation voltages & frequency in the same test setup.
- All auxiliary power & fan consumption included
- Peak efficiency: >99.0% vs. <98.9% (0.17% higher)
- Max power: 4.13kW vs. 2.50kW (65% higher)
Transphorm – Technology Price Reduction Y-O-Y

Percentage Reduction

Year

Gen I
Gen II
Gen III
Gen IV
Summary

1. Transphorm has a proven success track record with 2-chip normally-off 600V+ GaN products based on a robust technology.

2. Continued innovation leads to Generation-4 devices transforming the 2-chip design into a 1-chip-like simplicity.

3. While Gen II/Gen III are matured and qualified as automotive grade (AEC Q101), Gen IV design is being introduced for commercial / industrial applications.

4. The simplicity and high-performance Gen IV product will accelerate GaN adoption in the power electronics market.
Thank you!