TRANSFORMING THE WORLD
WITH SMALLER, LOWER COST, MORE EFFICIENT POWER ELECTRONICS

Power Systems Design
Get Going with GaN
Market leader for GaN power transistors
- GaN-on-Silicon transistors for the power conversion market
- Industry’s most extensive & highest-performance products
  - Enhancement mode devices
  - 100V & 650V devices; industry-best performance

Global company with decades of experience in GaN
- Parts shipping overnight from Mouser since 2014
- World-class fabless manufacturing and advanced packaging
- HQ and R&D in Ottawa, Canada
- Sales & App. Eng. in Germany, Japan, China, Taiwan, Korea, USA
Why GaN?

- Smaller size 2x to 10x
- Lighter weight 2x to 8x
- Lower power loss 2x to 6x
- BoM cost reduction 10% to 20%
- System cost reduction 10% to 30%

You know the benefits. Is it difficult? How is it done?
Designing with GaN is straight-forward

• GaN is a super-fast FET
  - It’s not difficult
  - It’s not new

• Similarities to a Silicon MOSFET
  - True enhancement-mode, normally off
  - Voltage driven: driver charges/discharges $C_{ISS}$
  - Supply Gate leakage $I_{GSS}$ only
  - Easy slew rate control by $R_G$
  - Easily driven by Si gate driver chip

• Differences
  - Much Lower $Q_G$: lower drive loss; faster switching
  - Higher gain and lower $V_{GS}$: +5 or +6V gate bias to turn on
  - Lower $V_{G(th)}$: +1.5V

\[ (C_{ISS} = C_{GD} + C_{GS}) \]
How to get the most advantage for your system

**Higher frequency**
- Magnetics get smaller ... capacitors too
- 100 kHz
- 7 W/in³
- 500 kHz
- 30 W/in³
- 4x smaller
- EMI filtering reduced

**Best topologies**
- Bridgeless Totem Pole
- More efficient, Lower cost
- Simpler, part count reduced 33%
- T-type traction inverter

**Best components**
- Gate Driver
  - Maximize performance with gate driver that has high CMTI, high dV/dt immunity
- Magnetics
  - Select magnetics with low AC core-loss to minimize power loss

**Resulting in power systems that are ...**

- **Smaller size**
- **Better performance**
- **Even better performance**
How to get the info?

- Layout
- Gate Driver
- Paralleling
- Thermals
- EMI
- Dynamic Rdson
• Circuit design
  - Control noise coupling from power to gate drive loop
  - Mitigate gate ringing/oscillations

• Minimizing parasitics
  - 5 step list including guidance on loop inductance and loop capacitance

• Layout best practice
  - 5 key areas to maximize performance
Drivers and Controllers

- Validated list of drivers and controllers
- Half bridge and Full Bridge
- Design examples included
EZDrive™ circuit

• Use standard MOSFET controller with integrated driver to drive GaN Systems’ transistors

• Low cost, easy way to implement a GaN driving circuit

• Adaptable to wide range of power levels, frequency, and LLC and PFC controllers

• The EZDrive circuit also provides design control for the optimization of efficiency and EMI
Modeling GaN devices and circuits

• Device-level simulation
  - LTspice and Pspice
  - Device characteristics (Qg, Coss/Ciss, IV/CV curve, Eon/Eoff)
  - Simple system simulation
  - Capability to observe parasitic effect on switching performance

• System-level simulation
  - PLECS
  - Simplify the switching transient
  - Observe converter operating waveforms
  - Accommodate complicated device-based, system-level simulation and analysis
Dynamic Rds(on)

• Clear analysis presented at PCIM
  - Define what it is
  - How to test
  - Measure the loss
  - Quantify the impact

• Conclusion
  - Power loss due to dynamic Rds is insignificant in total system power loss
  - Total system power loss: GaN outperforms silicon by a wide margin
Evaluation Kits and Reference Designs

1.5-2.5kW Half bridge power stage and universal motherboard

2-7 kW Insulated Metal Substrate Configurable Full/Half Bridge

14 kW Insulated Metal Substrate Reference Design

EZDrive™ Eval Kit

3 kW bridgeless totem pole PFC

50W, 100W to 300W+ Wireless Power Transfer Power Amplifiers

170W AC/DC PFC/LLC

Buck Converter with 5MHz GaN Driver

Full Bridge optimized for Class D Amplifier

14 kW Insulated Metal Substrate Reference Design
• GaN is not difficult
  - Many similarities to MOSFET
  - Differences require attention to detail but no new concepts

• Many resources available
  - Easy to find
  - Easy to use
  - GaN Systems applications engineering team to help
Join the wave - revolutionize your power electronics

**Broodest line of Products**

<table>
<thead>
<tr>
<th>650 V GaN</th>
<th>100 V GaN</th>
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<tbody>
<tr>
<td>GS66502B</td>
<td>GS61004B</td>
</tr>
<tr>
<td>7.5 A, 200 mΩ</td>
<td>45 A, 15 mΩ</td>
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<td>6.6 x 5.0 mm</td>
<td>4.6 x 4.4 mm</td>
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<td>GS61008P</td>
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<td>15 A, 100 mΩ</td>
<td>90 A, 7 mΩ</td>
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<td>7.6 x 4.6 mm</td>
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<tr>
<td>GS66506T</td>
<td>GS61008T</td>
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<td>22 A, 67 mΩ</td>
<td>90 A, 7 mΩ</td>
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<td>5.6 x 4.5 mm</td>
<td>7.0 x 4.0 mm</td>
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<tr>
<td>GS66508T</td>
<td>GS-O10-120-1P</td>
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<tr>
<td>30 A, 50 mΩ</td>
<td>120 A, 5 mΩ</td>
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<td>7.0 x 4.5 mm</td>
<td>7.6 x 4.6 mm</td>
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<tr>
<td>GS66508B</td>
<td>GS66516T</td>
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<td>30 A, 50 mΩ</td>
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<td>GS66516B</td>
<td>GS-O65-011-1-L</td>
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<td>60 A, 25 mΩ</td>
<td>11 A, 150 mΩ</td>
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<td>9.0 x 7.6 mm</td>
<td>5.0 x 6.0 mm</td>
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<td>GS-O65-008-1-L</td>
<td>GS-O65-004-1-L</td>
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<td>8 A, 225 mΩ</td>
<td>3.5 A, 500 mΩ</td>
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<td>5.0 x 6.0 mm</td>
</tr>
</tbody>
</table>

**Many Eval Kits & Reference Designs**

- Half bridge power stage
- High power Paralleling
- High density PFC/LLC
- 650 V test kit
- 3 kW bridgeless totem pole PFC
- 300 W wireless power transfer

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