650V GaN Technology for a New Generation of OBCs, DC/DCs and Inverters in EVs

The Highest Efficiency with GaN

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Agenda

• Vision for the xEV market

• VisIC GaN advantages

• xEV power systems using VisIC GaN

• Summary
VisIC’s Vision →
xEV Market Needs

- Lightweight and high density designs
- Cool and efficient power conversion
- High quality and reliability
- Fast charging and long range

VisIC Technologies is able to provide the highest performance and most reliable solution to the EV market, based on GaN power devices.
Where does VisIC fit in xEVs

The power switch defines the performance and efficiency of all HV power systems in the car
VisIC GaN Advantages
Innovation ➔ Performance excellence

Package
- High frequency
- Low thermal resistance

GaN die
- High yield
- Stable,
- Reliable,
- Scalable

Electronics
- Robust, Safe, Easy to Use

VisIC: A small step in design, a GiaNt leap in efficiency
Our Products ➔ System Value

3 Main Advantages

1. Extremely low switching energy
   - Low switching losses: Higher frequency ➔ Efficiency/Density!

2. High thermal conductive packaging
   - 2.5kV isolated package: More power ➔ Cool operation/Density!

3. Robust and easy to use
   - Direct Drive D-mode approach ➔ Reliable!
   - Standard drivers: 0-15V ➔ Cost Efficient!
   - High noise immunity: 5V threshold ➔ Robust!
Advantage 1: Lowest Switching Energy

Direct product measurements, package and add-on electronics included

Automotive devices used for the comparison

400V Buck Converter Efficiency Comparison at 100kHz

VisIC: A small step in design, a giant leap in efficiency
Advantage 2: Highest Thermal Conductivity

GAN Die
FR5 Frame
AIN ceramic

No thermal pad is needed
Thin layer of thermal grease ≈0.1°C/W

2.5 kV isolated package!

Embedded AIN Under GaN

Best $\theta$ _ junction to heatsink
GaN solution on the market
Advantage 3
Easy to Use and Robust

- **D-Mode Direct Drive circuit**
  - Not Cascode
  - With driver protection
- $V_{TH}$ is +5V
  - Use with standard drivers with gate voltage 0V to +15V
  - No negative drive voltage needed
- Controllable slew rate – gate resistor
  - Easy paralleling
xEV Power Systems Using GaN
On Board Chargers and DC/DCs

Replacement of Si MOSFETs by VisIC’s GaN in both PFC and DC/DC stages enables essential system advantage

- 2x Power
- 50% reduction in power loss
- ½ the weight

VisIC’s GaN: double power, smaller size, lower cost

VisIC: A small step in design, a Giant leap in efficiency
**GaN Unidirectional OBC, 6.7 kW**

<table>
<thead>
<tr>
<th></th>
<th>VisIC GaN V22</th>
<th>Si MOSFET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions, mm</td>
<td>230D x 170W x 60H</td>
<td>450D x 200W x 70H</td>
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<tr>
<td>Weight, kg</td>
<td>4.5</td>
<td>10</td>
</tr>
<tr>
<td>Power, kW</td>
<td>6.7</td>
<td>6.6</td>
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<tr>
<td>Efficiency, %</td>
<td>&gt; 96%</td>
<td>93% - 94%</td>
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<tr>
<td>Power density, kW/L</td>
<td>2.8</td>
<td>1.04</td>
</tr>
<tr>
<td>HV transistors count</td>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

Smallest 6.7kW / 2.3L OBC available
2.8 kW/L → highest power density

V22N65A enables next generation 6.7kW OBC
→ higher efficiency, smaller size and comparable cost
Design Flexibility

Universal AC Input
DC output
Coolant Inlet & Output
Universal AC Input
Coolant path
Input Filter
Output Filter
CAN comm.

GaN devices are cooled through the case
Resonant Choke
LLC Transformer
PFC Chokes
Dual Boost PFC GaN
Full Bridge LLC

Design Package Available

VisIC: A small step in design, a Giant leap in performance
OBC + DC/DC Integration

Smallest 7.2kW / 5L Bi-directional OBC + DC/DC

- Efficiency: > 96%
- # of devices: total 14 of V22N65ACA
- $V_{\text{OUT}}$:
  - 200...430V Charger
  - 85 ... 265 V inverter
  - 14 V LVDC
High Power Inverters - Drive

Now also with GaN

- $I_{\text{peak}} = 600\text{A}$
- 6x V22 devices parallel per leg
- Bus voltage = 400V
- Equal current distribution with trace compensation
- Liquid cooling
- 98% efficiency @ 100kHz, 300A, hard switching
DC Fast Charging

Modular design for 100kW+ charging power

**State of the Art**
- 10-15kW modules
- 95% Efficiency
- 1kW/L power density
- Can reach 1 Ton

**With VisIC GaN**
- 20-30kW modules
- 97% Efficiency
- 4kW/L power density
- Below 250kg

**Robust 500 V operation**

½ Footprint  ¼ Weight  ~50% reduction in Power Loss

VisIC: A small step in design, a giant leap in efficiency
Summary

- Innovation in GaN semi, packaging & system for power electronics
  - State-of-the-art power devices and modules

- Direct Drive D-Mode Technology - Robust
  - Easy to use with standard drivers, 5V threshold voltage

- Automotive supply chain
  - Design for 650V automotive qualification
Thank you for your attention