Tackling the Challenges of Solar Inverters with SiC

Matthias Tauer
Technical Marketing Manager
AGENDA

- Benefits of WBG SiC components
  Potential for higher efficiency and greater switching frequency

- Why are SiC MOSFETs seeing wider use in solar inverters?
  The need for a higher frequency and greater efficiency

- Integrated ceramic capacitor
  Smaller commutation loop and less voltage overshoot

- Creation of New Power Module Concepts
  Cost and performance benchmark of multiple components and topologies
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Motion Control

**MOTION CONTROL**

Higher Output Power Rating for Motor Inverters
Step your motor inverter portfolio up to a higher power level

**SiC MOSFETs vs. IGBTs:**
Lower static losses
/ Same power dissipation, but higher output power with SiC MOSFETs
/ Higher maximum power in the same frame size

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[Diagram showing output power comparison at the same power dissipation]

- **IGBT 75 A**
- **IGBT 100 A**
- **SiCMOS 20 mR**

Output Power Comparison at Same Power Dissipation

+ 20 %
Benefits of WBG SiC Components
EV Charger

**CHARGER**

Greater Efficiency and Deeper Integration for EV Chargers
SiC diodes enable higher PFC switching frequency and efficiency

SiC MOSFETs boost efficiency in resonant dc/dc converter (LLC)
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**Solar inverter applications in clusters**

<table>
<thead>
<tr>
<th>Inverter Type</th>
<th>Single-phase</th>
<th>Three-phase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residential inverter</strong></td>
<td>&lt; 6 kW</td>
<td>&lt; 20 kW</td>
</tr>
<tr>
<td><strong>Commercial inverter</strong></td>
<td></td>
<td>&lt; 60 kW</td>
</tr>
<tr>
<td><strong>Utility multi-string inverter</strong></td>
<td></td>
<td>up to 120 kW</td>
</tr>
<tr>
<td><strong>Utility central inverter</strong></td>
<td></td>
<td>up to several MW</td>
</tr>
</tbody>
</table>

- **Utility multi-string inverter**: Three-phase up to 120 kW, 1500 V system voltage.
Why are SiC MOSFETs seeing wider use in solar inverters?

Global trend in solar inverters calls for:
- Increased efficiency
- Optimized total cost
- Greater power density

Limiting factors:
- Maximum unit weight for two-person installation
- Challenging efficiency targets

SiC MOSFET benefits
- Higher switching frequency → smaller, lighter inductors
- Reduced static and dynamic losses → greater efficiency
Solutions for 1500 V string inverters

- Full silicon solution
- Hybrid solution
- Full SiC solution

- HS IGBT
- Tandem diode
- SiC diode
- SiC MOSFET

Switching frequency
Solutions for 1500 V string inverters

**ANPC**

- Three-level inverter topology for high switching frequency
- Active switch in the neutral path
- Only the inner switches are chopped (even at reactive power)
- Four slow line-frequency synchronized switches
- Two fast switches

Relative power module cost

- f_{sw} up to 64 kHz
- ANPC: 40% lower cost
- Same functionality
Solutions for 1500 V string inverters

Make the most of fast-switching SiC MOSFET’s performance with the Vincotech flowANPC 1 split power module:

Benefits:

- High-speed SiC MOSFET technology
- Multiple source SiC components
- Convex 0.38 mm ceramic substrate for superior thermal performance
- Split output for improved switching performance
- Press-fit pins for easy assembly
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Module integrated capacitor
Features & Benefits

/ Smallest possible commutation loop
/ Mitigation of pin-inductance and inductance to dc-link capacitor
/ Reduction of voltage overshoot

Commutation loop including parasitic inductance of module pin and PCB.

Snubber capacitor closes HF commutation loop.
→ Reduced voltage overshoot
Module integrated capacitor

/ Many products (standard and custom) with integrated capacitors
/ Part of our standard process
/ Qualification includes:
  / Thermal shock
  / HTRB
  / H3TRB

<table>
<thead>
<tr>
<th>PART-NO</th>
<th>TOPOLOGY</th>
<th>SUB-TOPOLOGY</th>
<th>PRODUCT LINE</th>
<th>VOLTAGE IN V</th>
<th>CURRENT IN A</th>
<th>MAIN CHIP TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-FY8704PA0800CR-L381F7F8</td>
<td>H-Bridge</td>
<td>H-Bridge-DE-KE-Cap-NTC</td>
<td>fastPACK 1 M03</td>
<td>650</td>
<td>40</td>
<td>Infineon CoolMOS™ CFD2</td>
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<tr>
<td>10-FY874PA100SM-L583F80</td>
<td>H-Bridge</td>
<td>H-Bridge-KE-DE-Cap-NTC</td>
<td>fastPACK 1 H C</td>
<td>650</td>
<td>100</td>
<td>IGBT-H5</td>
</tr>
<tr>
<td>10-FY874PA100SM01-L583F18</td>
<td>H-Bridge</td>
<td>H-Bridge-KE-DE-Cap-NTC</td>
<td>fastPACK 1 H C</td>
<td>650</td>
<td>100</td>
<td>IGBT-H5</td>
</tr>
<tr>
<td>10-FY8704PA801MC-MS20E50</td>
<td>Single-phase Inverter</td>
<td>Dual Booster + H-Bridge-KE-Cap-NTC</td>
<td>fastPACK 1 SI [TL]</td>
<td>650</td>
<td>33</td>
<td>Infineon CoolMOS™ CFD2</td>
</tr>
</tbody>
</table>

Webpage: ‘Cap’ in sub-topology column indicates integrated capacitor
Comparative Measurement

Comparison of SiC MOSFET booster with following options:

<table>
<thead>
<tr>
<th>option</th>
<th>value</th>
<th>over shoot (absolute value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>no capacitor</td>
<td>-</td>
<td>205 V (805 V)</td>
</tr>
<tr>
<td>X7R</td>
<td>100 nF</td>
<td>150 V (750 V)</td>
</tr>
<tr>
<td>C0G</td>
<td>22 nF</td>
<td>121 V (721 V)</td>
</tr>
</tbody>
</table>

Benefits:
- Lower voltage overshoot
- Lower amplitude of ringing
- Higher damping of ringing

conditions: $U_{dc}=600$ V, $I_d=32$ A, $R_g=4$, $T_j=125^\circ$C
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We Empower Your Ideas

Customer application input  Chip and housing selection  Simulation  Concept

All power loss and temperature calculations are based on real measurements taken from each switching pair.
How We Empower Your Ideas

Customer application input
- Application parameters
- Topology selection

Chip and housing selection
- Housing selection
- Chipset selection

Simulation
- Feasibility check
- Power loss
- Chip temperature
- Efficiency

Concept
- Circuit description
- Target datasheet

Multiple SiC suppliers for MOSFET and diode
→ Multiple combinations of switching pair possible
How We Empower Your Ideas

Customer application input → Chip and housing selection → Simulation → Concept #1

Customer application input → Chip and housing selection → Simulation → Concept #2

... 

Customer application input → Chip and housing selection → Simulation → Concept #n

Comparison of
Power losses
Chip temperature
Efficiency
Cost
Concept comparison result
Visit us at the exhibition...

... and experience our Product Creator Live Demonstration
EMPOWERING YOUR IDEAS

Further information:

www.vincotech.com/SiC

THANK YOU.