New Transfer Molded Power Integrated Module (TMPIM) Packaging for Industrial Drive

May 18, 2021
Agenda

• TMPIM Introduction
• Construction and application
• TMPIM Performance
  • Electrical, Thermal & Mechanical
  • Reliability
• Summary
What is “TMPIM”?

TMPIM stands for Transfer Molded Power Integrated Module. Transfer mold is its manufacturing process.
### Construction: TMPIM vs. Current PIM (gel filled)

**TMPIM**

**Cross-section:**
- Leadframe (x1)
- Epoxy
- Bond wire
- DBC
- Chip
- Solder
- 6.0mm

**Gel filled Module (Comp-A)**

**Cross-section:**
- Plastic housing
- Terminals (30+)
- Silicone gel
- Bond wire
- DBC
- Chip
- Solder

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<table>
<thead>
<tr>
<th>ITEM</th>
<th>TMPIM</th>
<th>Gel-filled Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Leadframe x 1</td>
<td>DBC</td>
</tr>
<tr>
<td>2</td>
<td>DBC</td>
<td>DBC</td>
</tr>
<tr>
<td>3~6</td>
<td>IGBT /Diode x 20</td>
<td>IGBT /Diode</td>
</tr>
<tr>
<td>7~8</td>
<td>Al Wire</td>
<td>Al Wire</td>
</tr>
<tr>
<td>9</td>
<td>Solder</td>
<td>Solder Paste</td>
</tr>
<tr>
<td>11</td>
<td>Thermistor</td>
<td>Thermistor</td>
</tr>
<tr>
<td>12</td>
<td>Epoxy</td>
<td>Epoxy</td>
</tr>
<tr>
<td>14a</td>
<td>pin holder</td>
<td>pin holder</td>
</tr>
<tr>
<td>14b</td>
<td>Pin</td>
<td>Pin</td>
</tr>
<tr>
<td>15</td>
<td>Glue</td>
<td>Glue</td>
</tr>
<tr>
<td>16</td>
<td>Silicone gel</td>
<td>Silicone gel</td>
</tr>
<tr>
<td>17</td>
<td>Housing</td>
<td>Housing</td>
</tr>
<tr>
<td>18</td>
<td>Baseplate (comp-B &amp;C)</td>
<td>Baseplate (comp-B &amp;C)</td>
</tr>
</tbody>
</table>

**Public Information**

- 28 components
  - e.g., 1200V 35A CIB
- 97 components
  - e.g., 1200V 35A CIB
Application Scheme of TMPIM CIB Power Modules

Converter R/S/T Input:
- 3-phase ~ 240V: 650V CIB TMPIM
- 3-phase ~ 400V: 1200V CIB TMPIM

Brake Resistor:
Control the bus voltage when motor slow/stopping

Inverter U/V/W Output:
- 5kW: 1200V 25A CIB TMPIM
- 7.5kW: 1200V 35A CIB TMPIM
- 10kW: 1200V 50A CIB TMPIM
- 15kW: 1200V 75A CIB QLP
- 20kW: 1200V 100A CIB QLP
Transfer Molded PIMs (TMPIMs)

Gel-filled Platforms
- Comp-A
- Comp-B
- Comp-C

Gel fill Modules
- Parameters
  - Norm
  - 1x
- ON TMPIM
  - Power Density: High
  - Temp Cycling Life: 10x
  - Corrosion Resist: Good

Features
- Transfer molded
  - Long lifetime
  - Robust
  - Corrosion resistant
- Advanced substrate
  - Eliminating baseplate
  - Light weight and compact
- Concise process
  - Cost effective
  - Flexible in customer design
- Full power portfolio
  - Wide power spectrum selection

High Reliability, High Power
- 600V ~1200V
- 10 A ~ 150A C-I-B
- Year 2020, 2021, 2022
- DIP-26 QLP-74
- Compact
# Released Products

<table>
<thead>
<tr>
<th>Part #</th>
<th>Rating</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>NXH25C120L2C2SG</td>
<td>1200V 25A</td>
<td>Converter - Inverter -Brake</td>
</tr>
<tr>
<td>NXH35C120L2C2SG</td>
<td>1200V 35A</td>
<td>Converter - Inverter -Brake</td>
</tr>
<tr>
<td>NXH35C120L2C2S1G</td>
<td></td>
<td>Converter - Inverter</td>
</tr>
<tr>
<td>NXH35C120L2C2ESG</td>
<td></td>
<td>Converter - Inverter -Brake</td>
</tr>
<tr>
<td>NXH50C120L2C2ESG</td>
<td>1200V 50A</td>
<td>Converter - Inverter -Brake</td>
</tr>
<tr>
<td>NXH50C120L2C2ES1G</td>
<td></td>
<td>Converter - Inverter</td>
</tr>
<tr>
<td>NXH50M65L4C2ESG</td>
<td>650V 50A</td>
<td>Converter - Inverter -PFC</td>
</tr>
<tr>
<td>NXH50M65L4C2SG</td>
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<td></td>
</tr>
</tbody>
</table>

More information available in [www.onsemi.com](http://www.onsemi.com)
TMPIM Structures: Standard and Enhanced

**Standard TMPIM**
1. Manufactured thru transfer molded process
2. Standard Al₂O₃ DBC substrate

**Enhanced TMPIM**
Advanced substrate with thick copper
1. High reliability
2. Low thermal resistance

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**VS**

Gel filled Module: non-baseplated
e.g., Comp-A

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**VS**

Gel filled Module: non-baseplated
e.g., Comp-B & Comp-C

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Identical Pinout process Size Outlook
# Low Thermal Resistance

<table>
<thead>
<tr>
<th></th>
<th>Comp-B (1200V 50A CIB)</th>
<th>NXH50C120L2C2SG (1200V 50A CIB)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rth (K/W)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IGBT INVERTER</strong></td>
<td>Rth-jc : 0.43 Rth-js : 0.65</td>
<td>Rth-jc : 0.27 Rth-js : 0.52</td>
</tr>
<tr>
<td><strong>DIODE INVERTER</strong></td>
<td>Rth-jc : 0.735 Rth-js : 0.9</td>
<td>Rth-jc : 0.54 Rth-js : 0.78</td>
</tr>
<tr>
<td><strong>RECTIFIER</strong></td>
<td>Rth-jc : 0.825 Rth-js : 1.05</td>
<td>Rth-jc : 0.62 Rth-js : 0.98</td>
</tr>
</tbody>
</table>

** Thermal characterization test acc. to JEDEC51-14 IGBT
High Power Density

**High power density**

1. Low thermal resistance & good efficiency
2. Level up maximum power a module can handle
3. Compact outline

**Competition B** 1200V 50A CIB Module Volume: 82 cm³

**TMPIM** 1200V 50A CIB Module Volume: 35 cm³

Motor test in HVAC compressor / customer feedback

**1200V 50A CIB: NXH50C120L2C2ESG**

- **1200V 50A Comp-A**
- **1200V 50A Comp-B**
- **1200V 50A TMPIM**

Notes:
- Modules are tested on the same motor, control/sensing system, 400Vac; the same heatsink/thermal grease.

**1200V 50A TMPIM** delivers the output power as Infineon 1200V 50A Comp-B; 30% more power than 50A module.
**Long lifetime**

- Side by side comparison: Temperature cycling to 1000 cycles.
- Testing condition: -40 °C ~ 125 °C

<table>
<thead>
<tr>
<th>Package</th>
<th>Part #</th>
<th>TC @ 0 cycle</th>
<th>TC @ 100 cycle</th>
<th>TC @ 500 cycle</th>
<th>TC @ 1000 cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMPIM</td>
<td>NXH35C120L2C2SG</td>
<td></td>
<td><strong>pass</strong></td>
<td><strong>pass</strong></td>
<td><strong>pass</strong></td>
</tr>
<tr>
<td>Gel filled module</td>
<td>Comp-A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gel filled module with baseplate</td>
<td>Comp-B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Slightly DBC delam
- DBC delam failure
- Failure Gross Delam
- Solder delam
- Delam btw DBC and base
- Failure across module width
### TMPIM DIP Series CIB Summary

<table>
<thead>
<tr>
<th>Description</th>
<th>Gel filled Module</th>
<th>Transfer Mold PIM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Converter–Inverter-Brake Module</strong></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>Components to assemble</strong></td>
<td>97 components</td>
<td>28 components</td>
</tr>
<tr>
<td><strong>Electrical Performance</strong></td>
<td>Overall Efficiency</td>
<td>Good, or better</td>
</tr>
<tr>
<td></td>
<td>Vcesat</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Short circuit (µs)</td>
<td>2.15 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td><strong>Thermal Performance</strong></td>
<td>Thermal Resistance</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good, or better</td>
</tr>
<tr>
<td><strong>Mechanical</strong></td>
<td>Robustness</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Mounting Height</td>
<td>Good, or better</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.0 mm</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>Temp Cycling (Cyc)</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Safety Standard</strong></td>
<td>Clearance distance</td>
<td>6.0mm</td>
</tr>
<tr>
<td></td>
<td>Creepage Distance</td>
<td>6.0mm</td>
</tr>
<tr>
<td></td>
<td>Isolation Voltage</td>
<td>3,000 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,000 V</td>
</tr>
</tbody>
</table>

**Platform Technology**
- **Outline Dimension**
  - Gel filled: 62.8mm x 56.7mm x 12.0mm
  - Transfer mold: 73mm x 47mm x 8.0mm
- **Substrate area**: 2,117 mm²

**Electrical Performance**
- **Overall Efficiency**
  - Gel filled: Good
  - Transfer mold: Good, or better
- **Vcesat**
  - Gel filled: 2.15 V
  - Transfer mold: 2.1 V
- **Short circuit (µs)**
  - Gel filled: 10
  - Transfer mold: 10

**Thermal Performance**
- **Thermal Resistance**
  - Gel filled: Good
  - Transfer mold: Good, or better

**Mechanical**
- **Robustness**
  - Gel filled: Good
  - Transfer mold: Good, or better
- **Mounting Height**
  - Gel filled: 12.0 mm
  - Transfer mold: 12.0 mm

**Reliability**
- **Temp Cycling (Cyc)**
  - Gel filled: 100
  - Transfer mold: 1,000

**Safety Standard (IEC61800-5-1)**
- **Clearance distance**
  - Gel filled: 5.0mm
  - Transfer mold: 6.0mm
- **Creepage Distance**
  - Gel filled: 6.3mm
  - Transfer mold: 6.0mm
- **Isolation Voltage**
  - Gel filled: 3,000 V
  - Transfer mold: 3,000 V
## TMPIM QLP Series CIB Summary

<table>
<thead>
<tr>
<th>Description</th>
<th>Gel filled Module</th>
<th>NXH75C120L2QLSG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Converter–Inverter-Brake Module</strong></td>
<td><img src="image.png" alt="Diagram" /></td>
<td><img src="image.png" alt="Image" /></td>
</tr>
<tr>
<td>Platform Technology</td>
<td>Gel filled 122mm x 62.5mm x 20.5mm Copper Base Plate</td>
<td>Transfer mold 115.7mm x 59.4mm x 20.5mm Advanced DBC Substrate</td>
</tr>
<tr>
<td>Outline Dimension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat Dissipation</td>
<td></td>
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</tr>
<tr>
<td><strong>Electrical Performance</strong></td>
<td>Good, or better 2.1 V 10</td>
<td>Good, or better 2.1 V 10</td>
</tr>
<tr>
<td>Overall Efficiency</td>
<td>Good</td>
<td>Good, or better</td>
</tr>
<tr>
<td>Vcesat</td>
<td>2.15 V</td>
<td></td>
</tr>
<tr>
<td>Short circuit (µs)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td><strong>Thermal Performance</strong></td>
<td>Good</td>
<td>Good, or better</td>
</tr>
<tr>
<td>Thermal Resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical</strong></td>
<td>Good</td>
<td>Good, or better</td>
</tr>
<tr>
<td>Robustness</td>
<td>Good</td>
<td>Good, or better</td>
</tr>
<tr>
<td>Mounting Height</td>
<td>20.5 mm</td>
<td>20.5 mm</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>Temp Cycling (Cyc) 100</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Safety Standard (IEC61800-5-1 )</strong></td>
<td>Clearance distance 7.5 mm 10 mm &gt;200 3,000 V</td>
<td>Material CTI 6.0mm 9.0 mm 600 3,000 V</td>
</tr>
<tr>
<td></td>
<td>Creepage Distance 10 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material CTI 600</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isolation Voltage 3,000 V</td>
<td></td>
</tr>
</tbody>
</table>

**Public Information**
Key Takeaways

- An innovative TMPIM packaging have been released for solid state power switching module.
- TMPIM which adopts novel design, reliable substrate and epoxy transfer molded technology, simplifies the assembly, improves the thermal cycling lifetime by 10x than normal gel filled power module as well as active power cycling lifetime. It will benefit end customer system with long lifetime & high reliability.
- The module using thick copper advanced substrate eliminates the baseplate, half-sized while able to output the same power. Greatly increase the power density.
- The module was hermetic and encapsulated by epoxy mold compound, and backside metal nickel plated, which can prevent dendrite formation between copper pad and suitable to work under certain corrosion gas working environment.
- The module which designed according to IEC61800-5-1 standard with 6mm pin to heatsink clearance distance, and UL1557 standard certified.
- More TMPIM products coming!