Fuji IGBT modules for wind power system

Device Application Technology Dept.
Semiconductor Sales Div.
Global Sales Group
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- Fuji IGBT modules for wind power system
- Fuji solution in Gate Driver Unit (GDU)
- Fuji solution
# Topology in wind power system

<table>
<thead>
<tr>
<th>Topology</th>
<th>Double</th>
<th>Direct</th>
<th>Direct + Multi level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gear</td>
<td>![Gear Diagram]</td>
<td>![Gear Diagram]</td>
<td>![Gear Diagram]</td>
</tr>
<tr>
<td>I-G</td>
<td>![I-G Diagram]</td>
<td>![I-G Diagram]</td>
<td>![I-G Diagram]</td>
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<tr>
<td>Transformer</td>
<td>![Transformer Diagram]</td>
<td>![Transformer Diagram]</td>
<td>![Transformer Diagram]</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Efficiency</th>
<th>Cost</th>
<th>Quality</th>
<th>Gear box</th>
<th>Step up Transformer</th>
<th>Generator</th>
<th>Converter capacity</th>
<th>IGBT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>89%</td>
<td>100%</td>
<td>Low</td>
<td>Need</td>
<td>Need</td>
<td>Induction</td>
<td>15～30%</td>
<td>1700V/450A～1000A</td>
</tr>
<tr>
<td></td>
<td>90%</td>
<td>98～100%</td>
<td>High</td>
<td>Not need</td>
<td>Not need</td>
<td>Synchronous</td>
<td>100%</td>
<td>1700V/1000A～3600A</td>
</tr>
<tr>
<td></td>
<td>93%</td>
<td>90～95%</td>
<td>High</td>
<td>Not need</td>
<td>Not need</td>
<td>Synchronous + Multi winding</td>
<td>100%</td>
<td>3300V/150A～400A</td>
</tr>
</tbody>
</table>

**Wind turbine systems will be changed to direct drive system from double fet drive system depend on the high efficiency and without gear box.**

Jan. 2015

MT5F27336

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Outline view of double fed wind turbine

Double fed systems have large gear box and large generator.
Comparison of double fed system and direct drive system

**Double fed system**
- Large gear box
- Low reliability for mechanical stress.

**Direct drive system**
- Without Gear Box

**System efficiency**
- 89% ⇒ 90%

---

**Advantages**
- Not necessary
- High Power

**Disadvantages**
- High Power IGBT is necessary.
- 3times rating current

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Comparison of direct drive system and multi level system

Direct drive system
- SG
- PWM Converter
- PWM Inverter
- Need Transformer
- Large filter
- System efficiency 90% ⇒ 93%

Multi level system
- Need Multi winding generator
- Small filter
- Not need Transformer
- To decrease steps of serial, 1.7kV ⇒ 3.3kV
- IGBT will be applied
- 7 series Inverter × 3 phase
- System efficiency 90% ⇒ 93%
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Fuji IGBT modules for wind power system

IGBT modules proposal for Double fed system

<table>
<thead>
<tr>
<th>Wind Power Converter</th>
<th>Package</th>
<th>Rotor side</th>
<th>Grid side</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IGBT P/N</td>
<td>Number of Parallel</td>
</tr>
<tr>
<td>1.5MW</td>
<td>Dual XT</td>
<td>2MBI450VN-170-50</td>
<td>3</td>
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<tr>
<td></td>
<td>EconoPACK™+</td>
<td>6MBI450V-170-50</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>PrimePACK™</td>
<td>2MBI1000VXB-170E-50</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2MBI1400VXB-170P-50</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>HPM</td>
<td>1MBI1600VC-170E</td>
<td>1</td>
</tr>
<tr>
<td>2.0MW</td>
<td>Dual XT</td>
<td>2MBI450VN-170-50</td>
<td>4</td>
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<tr>
<td></td>
<td>PrimePACK™</td>
<td>2MBI1000VXB-170E-50</td>
<td>3</td>
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<tr>
<td></td>
<td></td>
<td>2MBI1400VXB-170P-50</td>
<td>2</td>
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<tr>
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<td>HPM</td>
<td>1MBI2400VC-170E</td>
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<tr>
<td></td>
<td></td>
<td>1MBI2400VD-170E</td>
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</tbody>
</table>

Note: EconoPACK™+ and PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.
## Fuji IGBT modules for wind power system

### IGBT modules proposal for Direct drive system

<table>
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<tr>
<th>Wind Power Converter</th>
<th>Package</th>
<th>Rotor side</th>
<th>Grid side</th>
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<tbody>
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<td></td>
<td>IGBT P/N</td>
<td>Number of Parallel</td>
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<td>PrimePACK™</td>
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<td>3</td>
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<tr>
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<td>2MBI1400VXB-170E-50</td>
<td>2</td>
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<tr>
<td></td>
<td>HPM</td>
<td>1MBI1200VC-170E</td>
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<td>1MBI2400VC-170E</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1MBI2400VD-170E</td>
<td>1</td>
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<tr>
<td>2.0MW</td>
<td>PrimePACK™</td>
<td>2MBI1000VXB-170E-50</td>
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<td>2MBI1400VXB-170E-50</td>
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<td>HPM</td>
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<tr>
<td></td>
<td></td>
<td>1MBI2400VD-170E</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.
**LVRT: Low Voltage Ride Through Circuit**

Conventional system had used the clover circuit. It can not be possible to supply to output power for grid line, because DC bus voltage is zero voltage at clover circuit operating.

It can be possible to supply to output power for grid line, because DC bus voltage is kept at LVRT circuit operating. Therefore this system is more higher reliability system.

---

**IGBT modules proposal for LVRT**

<table>
<thead>
<tr>
<th>Type Name</th>
<th>Current</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
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<td>1700V</td>
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<tr>
<td>1MB1600VC-170E</td>
<td>1600A</td>
<td>1700V</td>
</tr>
<tr>
<td>1MB2400VC-170E</td>
<td>1200A</td>
<td>1700V</td>
</tr>
<tr>
<td>1MB2400VD-170E</td>
<td>2400A</td>
<td>1700V</td>
</tr>
<tr>
<td>1MB3600VD-170E</td>
<td>3600A</td>
<td>1700V</td>
</tr>
<tr>
<td>2MB1600VG-170E</td>
<td>600A</td>
<td>1700V</td>
</tr>
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<td>2MB800VG-170E</td>
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<td>1700V</td>
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<td>2MB1200VG-170E</td>
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<td>1700V</td>
</tr>
<tr>
<td>1MB1200VR-170E</td>
<td>1200A</td>
<td>1700V</td>
</tr>
<tr>
<td>1MB1600VR-170E</td>
<td>1600A</td>
<td>1700V</td>
</tr>
<tr>
<td>1MB2400VR-170E</td>
<td>1200A</td>
<td>1700V</td>
</tr>
<tr>
<td>1MB2400VS-170E</td>
<td>2400A</td>
<td>1700V</td>
</tr>
<tr>
<td>1MB3600VS-170E</td>
<td>3600A</td>
<td>1700V</td>
</tr>
<tr>
<td>2MB1600VT-170E</td>
<td>600A</td>
<td>1700V</td>
</tr>
<tr>
<td>2MB800VT-170E</td>
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<td>1700V</td>
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<tr>
<td>2MB1200VT-170E</td>
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<td>1700V</td>
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</tbody>
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Fuji IGBT modules for wind power system

PrimePACK™
1200V 600-1400A
1700V 650-1400A (plan)

Dual XT, EP+
Standard module

EP-PIM, PC-6pack

HPM
1200V 600-3600A
1700V 600-3600A

3300V
800-1500A (plan)

Note: PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.
Fuji IGBT modules for wind power system

Dual XT

EconoPACK™+ 6in1

PrimePACK™

HPM 1in1 (1200～2400A)

HPM 1in1 (2400～3600A)

3.3kV

Note: EconoPACK™+ and PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.
## Fuji IGBT module for wind power - EconoPACK™+, Dual XT

### Feature

- Low power dissipation with V-silicon chipset
- Extra thermal design ($T_{jmax} = 175^\circ C$ repetitive guarantee)
- 2 kinds of pin connection for Dual XT (Solder/Spring)

<table>
<thead>
<tr>
<th>IGBT P/N</th>
<th>Current</th>
<th>Voltage</th>
<th>Package</th>
<th>Equivalent circuit</th>
<th>Base plate</th>
<th>Isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>EconoPACK™+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6MBI300V-170-50</td>
<td>300A</td>
<td>1700V</td>
<td>M629:150 x 162 x 17mm</td>
<td>Copper (Cu)</td>
<td></td>
<td>$Al_2O_3$ Viso=4.0kV/60s</td>
</tr>
<tr>
<td>6MBI450V-170-50</td>
<td>450A</td>
<td>1700V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual XT</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2MBI300VN-170-50</td>
<td>300A</td>
<td>1700V</td>
<td>M254:150 x 62 x 17mm</td>
<td>Copper (Cu)</td>
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<td>$Al_2O_3$ Viso=4.0kV/60s</td>
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<tr>
<td>2MBI450VN-170-50</td>
<td>450A</td>
<td>1700V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2MBI550VN-170-50</td>
<td>550A</td>
<td>1700V</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>2MBI550VJ-170-50</td>
<td>550A</td>
<td>1700V</td>
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</tbody>
</table>

Note: EconoPACK™+ are registered trademarks of Infineon Technology AG, Germany.

*Feature*:

- Low power dissipation with V-silicon chipset
- Extra thermal design ($T_{jmax} = 175^\circ C$ repetitive guarantee)
- 2 kinds of pin connection for Dual XT (Solder/Spring)

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Fuji IGBT module for wind power system - PrimePACK™

Feature

- Low power dissipation with V-silicon chipset
- Extra thermal design (Tjmax=175°C repetitive guarantee)
- Low inductance and good current balance package
- Long-term reliability (CTI > 600, High Tc capability)

<table>
<thead>
<tr>
<th>PrimePACK™</th>
<th>IGBT part No.</th>
<th>Current</th>
<th>Voltage</th>
<th>Package</th>
<th>Equivalent circuit</th>
<th>Base plate</th>
<th>Isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2MBI650VXA-170E-50</td>
<td>650A</td>
<td>1700V</td>
<td>M271:172 x 89 x 38mm</td>
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<td>Copper</td>
<td>Al₂O₃ Viso=4.0kV/60s</td>
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<tr>
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<td>2MBI1000VXB-170E-50</td>
<td>1000A</td>
<td>1700V</td>
<td>M272:250 x 89 x 38mm</td>
<td></td>
<td>Copper</td>
<td>Al₂O₃ Viso=4.0kV/60s</td>
</tr>
<tr>
<td></td>
<td>2MBI1400VXB-170E-50</td>
<td>1400A</td>
<td>1700V</td>
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<td></td>
<td>Copper</td>
<td>Al₂O₃ Viso=4.0kV/60s</td>
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<td></td>
<td>2MBI1400VXB-170P-50</td>
<td>1400A</td>
<td>1700V</td>
<td></td>
<td></td>
<td>Copper</td>
<td>Al₂O₃ Viso=4.0kV/60s</td>
</tr>
</tbody>
</table>

Note: PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.
Fuji  IGBT module for wind power system - HPM(1in1)

**Feature**

- ✓ Low power dissipation with V-silicon chipset
- ✓ Extra thermal design (Tjmax=175°C), SiN-DCB
- ✓ Low inductance and good current balance package
- ✓ Long-term reliability ( CTI > 600, High Tc capability)
- ✓ 1700V-3600A max rating

<table>
<thead>
<tr>
<th>IGBT part No.</th>
<th>Current</th>
<th>Voltage</th>
<th>Package</th>
<th>Equivalent circuit</th>
<th>Base plate</th>
<th>Isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1MBI1200VC-170E</td>
<td>1200A</td>
<td>1700V</td>
<td>M151:130 x 140 x 38mm</td>
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<td>Si₃N₄ Viso=4.0kV/60s</td>
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<tr>
<td>1MBI1600VC-170E</td>
<td>1600A</td>
<td>1700V</td>
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<td></td>
</tr>
<tr>
<td>1MBI2400VC-170E</td>
<td>2400A</td>
<td>1700V</td>
<td></td>
<td></td>
<td>Copper (Cu)</td>
<td></td>
</tr>
<tr>
<td>1MBI2400VD-170E</td>
<td>2400A</td>
<td>1700V</td>
<td>M152:190 x 140 x 38mm</td>
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<td>Si₃N₄ Viso=4.0kV/60s</td>
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<tr>
<td>1MBI3600VD-170E</td>
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<td>1700V</td>
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</table>
**Feature**

- Low power dissipation with V-silicon chipset
- Extra thermal design (Tjmax=175°C), AlSiC base plate
- Low inductance and good current balance package
- Long-term reliability (CTI > 600, High Tc capability)
- 1700V-3600A max rating

<table>
<thead>
<tr>
<th>IGBT part No.</th>
<th>Current</th>
<th>Voltage</th>
<th>Package</th>
<th>Equivalent circuit</th>
<th>Base plate</th>
<th>Isolation</th>
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<tbody>
<tr>
<td>1MBI1200VR-170E</td>
<td>1200A</td>
<td>1700V</td>
<td>M155:130 x 140 x 38mm</td>
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<td>AlSiC</td>
<td>AIN Viso=4.0kV/60s</td>
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<tr>
<td>1MBI1600VR-170E</td>
<td>1600A</td>
<td>1700V</td>
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<td>AlSiC</td>
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<td>1MBI2400VR-170E</td>
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<td>1700V</td>
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<td>AlSiC</td>
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</tr>
<tr>
<td>1MBI2400VS-170E</td>
<td>2400A</td>
<td>1700V</td>
<td>M156:190 x 140 x 38mm</td>
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<td>AlSiC</td>
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</tr>
<tr>
<td>1MBI3600VS-170E</td>
<td>3600A</td>
<td>1700V</td>
<td></td>
<td></td>
<td>AlSiC</td>
<td></td>
</tr>
</tbody>
</table>
Fuji IGBT module for wind power system - 3.3kV module

Feature

- Trench gate structure for reducing Vce(sat)
- FS (field-stop) structure for fast switching and low Vce(sat)
- High ruggedness even at Tj = 150°C operation
- High tracking (CTI > 600) special resin for high Viso guarantee
- High thermal cycling life time with AlSiC base plate

<table>
<thead>
<tr>
<th>IGBT part No.</th>
<th>Current</th>
<th>Voltage</th>
<th>Package</th>
<th>Equivalent circuit</th>
<th>Base plate</th>
<th>Isolation</th>
</tr>
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<tbody>
<tr>
<td>1MBI800UG-330</td>
<td>800A</td>
<td>3300V</td>
<td>M155:130 x 140 x 38mm</td>
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<td>AlSiC</td>
<td>AlN Viso=6.0kV/60s</td>
</tr>
<tr>
<td>1MBI1000UG-330</td>
<td>1000A</td>
<td>3300V</td>
<td>M156:190 x 140 x 38mm</td>
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<td>AlSiC</td>
<td>AlN Viso=6.0kV/60s</td>
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<tr>
<td>1MBI1200UE-330</td>
<td>1200A</td>
<td>3300V</td>
<td></td>
<td></td>
<td>AlSiC</td>
<td>AlN Viso=6.0kV/60s</td>
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<td>1MBI1500UE-330</td>
<td>1500A</td>
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<td>AlN Viso=6.0kV/60s</td>
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</table>
Table of contents

- Topology in wind power system
- Fuji IGBT modules for wind power system
- Fuji solution in Gate Driver Unit (GDU)
- Fuji solution
<table>
<thead>
<tr>
<th>IC rating</th>
<th>IGBT P/N (example)</th>
<th>Driver type (example)</th>
<th>Driver type (example)</th>
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<td>2MBI300VN-170-50</td>
<td>2SP0115T2Ax-17</td>
<td>VLA546**</td>
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<td>2MBI550VN-170-50</td>
<td>2SP0115T2Ax-17</td>
<td>VLA500K</td>
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<td>EP+</td>
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</tr>
<tr>
<td>450A</td>
<td>6MBI450V-170-50</td>
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<tr>
<td>PrimePACK™</td>
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<td>650A</td>
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<td>2SP0320x2Ax-2MBI650VXA-170E-50</td>
<td>VLA500K</td>
</tr>
<tr>
<td>1000A</td>
<td>2MBI1000VXB-170E-50</td>
<td>2SP0320x2Ax-2MBI1000VXB-170E-50</td>
<td>VLA539</td>
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<td>VLA539</td>
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<td>2SP0320x2Ax-2MBI1400VXB-170P-50</td>
<td>VLA539</td>
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<tr>
<td>HPM</td>
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<td>VLA539</td>
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Note: PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.
Table of contents

- Topology in wind power system
- Fuji IGBT modules for wind power system
- Fuji solution in Gate Driver Unit (GDU)
- Fuji solution
Fuji solution – PrimePACK™ 2 parallel

Side view


Gate Drive Unit  Cooling fin

Snubber C : 2～3 uF

Top view

PrimePACK™ can easily construct inverter circuit. This figure shows the example.

Laminate bus bar to realize low leakage inductance.

Note: PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.
Fuji solution – Dual XT 4 parallel

2MBI450VN-170-50 4P
Snubber capacitors

\[ C_S = \frac{L \cdot I_o^2}{(V_{CEP} - Ed)^2} \]

L: Main circuit wiring parasitic inductance
Io: Collector current at IGBT turn-off
V_{CEP}: Snubber capacitor peak voltage
Ed: DC supply voltage

<table>
<thead>
<tr>
<th>Module rating</th>
<th>DC line inductance</th>
<th>snubber capacitance</th>
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<td>0.046 ( \mu \text{H} )</td>
<td>47 ( \mu \text{F} )</td>
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