INTEGRATED POWER FUNCTIONS
- 600V/3A low-loss 5th generation IGBT inverter bridge for 3 phase DC-to-AC power conversion.

INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS
- For upper-leg IGBTs: Drive circuit, High voltage isolated high-speed level shifting, Control circuit under-voltage protection (UV).
- For lower-leg IGBTs: Drive circuit, Control circuit under-voltage protection (UV), Short circuit protection (SC).
- Fault signaling: Corresponding to an SC fault (Lower-side IGBT) or a UV fault (Lower-side supply).
- Input interface: 5V line CMOS/TTL compatible Schmitt Trigger receiver circuit (Active high), Arm-short-through interlock protection.

APPLICATION
AC100V~200V, three-phase inverter drive for small power motor control.
### Maximum Ratings

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Condition</th>
<th>Parameter</th>
<th>Ratings</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vc</td>
<td>Supply voltage</td>
<td>Applied between P-N</td>
<td>450</td>
<td>V</td>
</tr>
<tr>
<td>Vc(surge)</td>
<td>Supply voltage (surge)</td>
<td>Applied between P-N</td>
<td>500</td>
<td>V</td>
</tr>
<tr>
<td>Vces</td>
<td>Collector-emitter voltage</td>
<td>Tr = 25°C</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>Ic</td>
<td>Collector current</td>
<td>Tr = 25°C, tw ≤ 1msec</td>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td>Icp</td>
<td>Collector current (peak)</td>
<td>Tr = 25°C, per 1 chip</td>
<td>13.8</td>
<td>W</td>
</tr>
<tr>
<td>Tj</td>
<td>Junction temperature</td>
<td>(Note 1)</td>
<td>–20–+150</td>
<td>°C</td>
</tr>
</tbody>
</table>

**Note 1:** The maximum junction temperature rating of the power chips integrated within the SIP-IPM is 150°C (Tf ≤ 100°C) however, to insure the safe operation of the SIP-IPM, the average junction temperature should be limited to Tj(avg) ≤ 125°C (Tf ≤ 100°C).

### Control (Protection) Part

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Condition</th>
<th>Parameter</th>
<th>Ratings</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vb</td>
<td>Control supply voltage</td>
<td>Applied between VN1-VNC</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>Vbs</td>
<td>Control supply voltage</td>
<td>Applied between VUFB-U (VUFS), VVFB-V (VVFS), VWFB-W (VWFS)</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>Vn</td>
<td>Input voltage</td>
<td>Applied between UP, VP, WP-VNC, UN, VN, WN-VNC</td>
<td>–0.5–Vb</td>
<td>V</td>
</tr>
<tr>
<td>Vfo</td>
<td>Fault output supply voltage</td>
<td>Applied between FG-VNC</td>
<td>–0.5–Vb</td>
<td>V</td>
</tr>
<tr>
<td>Ifo</td>
<td>Fault output current</td>
<td>Sink current at Fo terminal</td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td>Vsc</td>
<td>Current sensing input voltage</td>
<td>Applied between CIN-Vnc</td>
<td>–0.5–Vb</td>
<td>V</td>
</tr>
</tbody>
</table>

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**Fig. 2**: PS21661-FR Package Outlines

Dimensions in mm

1~99: pins numbers. The terminals array, please reference to the Fig.7.
### TOTAL SYSTEM

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Condition</th>
<th>Ratings</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC PROT</td>
<td>Self protection supply voltage limit</td>
<td>V0 = 13.5~16.5V, Inverter part</td>
<td>400</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>(short circuit protection capability)</td>
<td>Tj = 125°C start, non-repetitive, less than 2 µs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tt</td>
<td>Heat sink operation temperature</td>
<td>(Note 2)</td>
<td>-20~100</td>
<td>°C</td>
</tr>
<tr>
<td>Tstg</td>
<td>Storage temperature</td>
<td></td>
<td>-40~125</td>
<td>°C</td>
</tr>
<tr>
<td>Viso</td>
<td>Isolation voltage</td>
<td>60Hz, Sinusoidal, AC 1 minute, connection pins to heat sink plate</td>
<td>1500</td>
<td>Vrms</td>
</tr>
</tbody>
</table>

**Note 2:** Tf MEASUREMENT POINT

AI Board Specification: Dimensions 50 × 50 × 10 mm, finishing 12s, warp –50~+100 µm

### THERMAL RESISTANCE

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Condition</th>
<th>Limits</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rth(j-f)</td>
<td>Junction to fin thermal resistance</td>
<td>Inverter IGBT part (per 1/6 module) (Note 3)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Rth(f)</td>
<td>Inverter FWD part (per 1/6 module) (Note 3)</td>
<td></td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**Note 3:** Grease with good thermal conductivity should be applied evenly about +100µm ~ +200µm on the contact surface of SIP-IPM and a heat-sink.

### ELECTRICAL CHARACTERISTICS (**Tj** = 25°C, unless otherwise noted)

#### INVERTER PART

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Condition</th>
<th>Limits</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCE(sat)</td>
<td>Collector-emitter saturation voltage</td>
<td>V0 = 40V, V0B = 15V</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VIn = 5V</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>VCE</td>
<td>FWD forward voltage</td>
<td>Tj = 25°C, Tj = 125°C</td>
<td>0.35</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IC = 3A, Tj = 25°C</td>
<td>0.20</td>
<td>V</td>
</tr>
<tr>
<td>ttr</td>
<td>Switching times</td>
<td>VCC = 300V, V0 = 15V</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IC = 3A, Tj = 125°C</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>t(on)</td>
<td>Inductive load (upper-lower arm)</td>
<td>VIn = 0 ↔ 5V</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>t(off)</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ICES</td>
<td>Collector-emitter cut-off current</td>
<td>VCE = VCES</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tj = 25°C</td>
<td>1.06</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tj = 125°C</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

#### CONTROL (PROTECTION) PART

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Condition</th>
<th>Limits</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Circuit current</td>
<td>V0 = 15V, VIn = 0V</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V0 = 15V, VIn = 0V</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>IDB</td>
<td>Supply current under-voltage protection</td>
<td>V0B = 15V, VIn = 0V</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UVFB-U (VVFS), UVFB-V (VVFS),</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VWFB-W (VVWS)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>VFOH</td>
<td>Fault output voltage</td>
<td>VSC = 0V, FO circuit: 1kΩ to 5V pull-up</td>
<td>4.9</td>
<td>V</td>
</tr>
<tr>
<td>VFO</td>
<td></td>
<td>Vsc = 1V, IFO = 10mA</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>IN</td>
<td>Input current</td>
<td>VIn = 5V</td>
<td>0.70</td>
<td>mA</td>
</tr>
<tr>
<td>V(SC)</td>
<td>Short circuit trip level</td>
<td>Tj = 25°C, V0 = 15V</td>
<td>0.43</td>
<td>V</td>
</tr>
<tr>
<td>UV</td>
<td>Supply current under-voltage protection</td>
<td>Tj ≤ 125°C</td>
<td>10.0</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trip level</td>
<td>12.0</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reset level</td>
<td>10.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trip level</td>
<td>12.5</td>
<td>V</td>
</tr>
<tr>
<td>UVbr</td>
<td></td>
<td>Reset level</td>
<td>10.3</td>
<td>V</td>
</tr>
<tr>
<td>UVbr</td>
<td></td>
<td>Reset level</td>
<td>13.0</td>
<td>V</td>
</tr>
<tr>
<td>VFO</td>
<td>Fault output pulse width</td>
<td>(Note 4)</td>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>V(on)</td>
<td>ON threshold voltage</td>
<td>Applied between:</td>
<td>2.10</td>
<td>V</td>
</tr>
<tr>
<td>Voff</td>
<td>OFF threshold voltage</td>
<td>Up, Vp, Wp-Vnc, Un, Vn, Wn-Vnc</td>
<td>1.10</td>
<td>V</td>
</tr>
</tbody>
</table>

**Note 4:** Short circuit protection is functioning only at the low-arms. Please select the value of the external shunt resistor such that the SC trip-level is less than 5.1A.
PS21661-RZ/FR
TRANSFER-MOLD TYPE
INSULATED TYPE

MECHANICAL CHARACTERISTICS AND RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Limits</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting torque</td>
<td>Mounting screw : (M3)</td>
<td>0.59</td>
<td>0.69</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td>—</td>
<td>10</td>
</tr>
<tr>
<td>Heat-sink flatness</td>
<td>(Note 5)</td>
<td>−50</td>
<td>—</td>
</tr>
</tbody>
</table>

Note 5: Measurement point of heat-sink flatness

RECOMMENDED OPERATION CONDITIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Condition</th>
<th>Limits</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vcc</td>
<td>Supply voltage</td>
<td>Applied between P-N</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>Vd</td>
<td>Control supply voltage</td>
<td>Applied between VN1-VNC</td>
<td>13.5</td>
<td>15.0</td>
</tr>
<tr>
<td>VDB</td>
<td>Control supply voltage</td>
<td>Applied between VUFB-U (VUFS), VVFB-V (VVFS), VWFB-W (WVFS)</td>
<td>13.0</td>
<td>15.0</td>
</tr>
<tr>
<td>∆VD, ∆VDB</td>
<td>Control supply variation</td>
<td></td>
<td>−1</td>
<td>—</td>
</tr>
<tr>
<td>tdead</td>
<td>Arm shoot-through blocking time</td>
<td>Relates to corresponding input signal for blocking arm shoot-through</td>
<td>1.5</td>
<td>—</td>
</tr>
<tr>
<td>fPWM</td>
<td>PWM input frequency</td>
<td></td>
<td>—</td>
<td>15</td>
</tr>
<tr>
<td>Io</td>
<td>Allowable r.m.s current</td>
<td>Vcc = 300V, Vd = 15V, fc = 15kHz, P.F = 0.8, sinusoidal</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Vnc</td>
<td>Vnc terminal voltage</td>
<td>Applied between VNC-N (include surge voltage)</td>
<td>−5</td>
<td>—</td>
</tr>
<tr>
<td>txx</td>
<td>minimum on pulse width</td>
<td>UP, VP, WP, UN, VN, WN terminal</td>
<td>0.7</td>
<td>—</td>
</tr>
</tbody>
</table>
Fig. 3 THE SIP-IPM INTERNAL CIRCUIT
Fig. 4 PS21661-RZ PACKAGE OUTLINES

- Terminal No: Symbol: Description
  - 1: N: Inverter DC-link negative (GND) terminal
  - 2: P: Inverter DC-link positive terminal
  - 3: Fo: Fault output terminal
  - 5: VNC: Control GND terminal
  - 6: CIN: Short-circuit trip voltage sensing terminal
  - 7: VN1: Control supply terminal
  - 9: WN: W-phase N-side control input terminal
  - 10: VWFB: W-phase P-side drive supply terminal
  - 11: WP: W-phase P-side control input terminal
  - 12: W(VWFS): W-phase inverter output terminal (W-phase P-side drive supply GND terminal)
  - 15: VN1: Control supply terminal
  - 17: VN: V-phase N-side control input terminal
  - 18: VVF: V-phase P-side drive supply terminal
  - 19: VP: V-phase P-side control input terminal
  - 20: V(VVFS): V-phase inverter output terminal (V-phase P-side drive supply GND terminal)
  - 23: VN1: Control supply terminal
  - 25: UN: U-phase N-side control input terminal
  - 26: VFU: U-phase P-side drive supply terminal
  - 27: UP: U-phase P-side control input terminal
  - 28: U(VVFS): U-phase inverter output terminal (U-phase P-side drive supply GND terminal)

The following pins are dummy pins and therefore should not be connected. 4, 8, 13, 14, 16, 21, 22, 24, 29, 30–35 (30–35 are the high voltage side pins.)

Fig. 5
Fig. 6 PS21661-FR PACKAGE OUTLINES

<table>
<thead>
<tr>
<th>Terminal No</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N</td>
<td>Inverter DC-link negative (GND) terminal</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>Inverter DC-link positive terminal</td>
</tr>
<tr>
<td>3</td>
<td>Fo</td>
<td>Fault output terminal</td>
</tr>
<tr>
<td>4</td>
<td>VNC</td>
<td>Control GND terminal</td>
</tr>
<tr>
<td>5</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>6</td>
<td>CN1</td>
<td>Short-circuit tripping voltage sensing terminal</td>
</tr>
<tr>
<td>7</td>
<td>VN2</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>8</td>
<td>WN</td>
<td>W-phase N-side control input terminal</td>
</tr>
<tr>
<td>9</td>
<td>VWFN</td>
<td>W-phase P-side drive supply terminal</td>
</tr>
<tr>
<td>10</td>
<td>Wp</td>
<td>W-phase P-side control input terminal</td>
</tr>
<tr>
<td>11</td>
<td>W(VWFN)</td>
<td>W-phase inverter output terminal (W-phase P-side drive supply GND terminal)</td>
</tr>
<tr>
<td>12</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>13</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>14</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>15</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>16</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>17</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>18</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>19</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>20</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>21</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>22</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>23</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>24</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>25</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>26</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>27</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
<tr>
<td>28</td>
<td>VN1</td>
<td>Control supply terminal</td>
</tr>
</tbody>
</table>

The following pins are dummy pins and therefore should not be connected: 4,8,15,14,16,21,22,24,29,30~35 (30~35 are the high voltage side pins.)

Fig. 7
Fig. 8 TIMING CHARTS OF THE SIP-IPM PROTECTIVE FUNCTIONS

[A] Short-Circuit Protection (Lower-arms only)
- a1. Normal operation: IGBT ON and carrying current.
- a2. Short circuit current detection (SC trigger).
- a3. Hard IGBT gate interrupt.
- a4. IGBT turns OFF.
- a5. Fo output (20~80μs).
- a7. Input “H”: IGBT ON state, but during the Fo active signal the IGBT doesn't turn ON.
- a8. IGBT OFF state.

[B] Under-Voltage Protection (Lower-arms, UV0)
- a1. Control supply voltage rises: After the voltage level reaches UV0r, the circuits start to operate when the next input is applied.
- a3. Under voltage trip (UV0).
- a4. IGBT OFF in spite of control input condition.
- a5. Fo output (20~80μs).
- a6. Under voltage reset (UV0).

Note: The CR time constant safe guards against erroneous SC signal resulting from di/dt generated voltages when IGBT turns ON. The optimum setting for the CR circuit time constant is 1.5~2.0μs.
[C] Under-Voltage Protection (Upper-arms, V_{Oe})

a1. Control supply voltage rises: After the voltage level reaches V_{Oer}, the circuits start to operate when the next input is applied.

a2. Normal operation: IGBT ON and carrying current.

a3. Under voltage trip (UV_{Oer}).

a4. IGBT OFF in spite of control input condition, but there is no Fo signal output.

a5. Under voltage reset (UV_{Oer}).


[D] Simultaneous input signal prevention function

a1 a3. Normal operation: IGBT ON and outputing IGBT gate voltage.

a2 a4. Normal operation: IGBT ON and outputing IGBT gate voltage.

a5. Abnormal pulse input.

a6. IGBT OFF state.

a7. No fault output.
Note 1: Input signal lines are pulled-down with 4.7kΩ (min.) internal resistor. If these input lines are susceptible to noise, an RC coupling at each input is recommended. Input signal voltage is determined by the values of internal pull-down resistor and the external connected resistor. Set the external resistance value so that input signal voltage exceeds the on-threshold voltage. To prevent the input signals oscillation, the wiring of each input should be as short as possible.

2: By virtue of integrating the specific type HVIC inside the module, direct coupling to CPU terminals without any opto-coupler or transformer isolation is possible.

3: FO output is open collector type. This signal line should be pulled up to the positive side of the 5V power supply with approximately 1kΩ resistance.

4: Approximately a 0.1~2µF by-pass capacitor should be used across each power supply connection terminals.

5: To prevent errors of the protection function, the wiring of A should be as short as possible.

6: Each capacitor should be located as close to the pins of the SIP-IPM as possible.

7: In the recommended protection circuit, please select the R1C4 time constant in the range of 1.5~2µs.

8: To prevent surge destruction, the wiring between the smoothing capacitor and the P&N1 pins should be as short as possible. Approximately a 0.1~0.22µF snubber capacitor between the P&N1 pins is recommended.