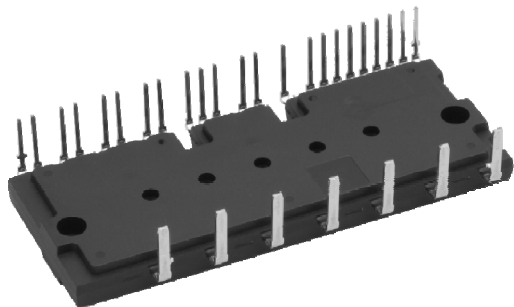


# PS21A7A

TRANSFER-MOLD TYPE  
INSULATED TYPE

## PS21A7A



### MAIN FUNCTION AND RATINGS

- 3 phase inverter with N-side open emitter structure
- 600V / 75A (CSTBT)

### APPLICATION

- AC100 ~ 200Vrms class, motor control

### INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS

- For P-side : Drive circuit, High voltage high-speed level shifting, Control supply under-voltage (UV) protection
- For N-side : Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC),
- Fault signaling : Corresponding to SC fault (N-side IGBT), UV fault (N-side supply)
- Temperature monitoring : Analog output of LVIC temperature
- Input interface : 3, 5V line, Schmitt trigger receiver circuit (High Active)
- UL Approved : Yellow Card No. E80276

### MAXIMUM RATINGS (T<sub>j</sub> = 25°C, unless otherwise noted)

#### INVERTER PART

| Symbol                 | Parameter                          | Condition                            | Ratings  | Unit |
|------------------------|------------------------------------|--------------------------------------|----------|------|
| V <sub>CC</sub>        | Supply voltage                     | Applied between P-NU, NV, NW         | 450      | V    |
| V <sub>CC(surge)</sub> | Supply voltage (surge)             | Applied between P-NU, NV, NW         | 500      | V    |
| V <sub>CES</sub>       | Collector-emitter voltage          |                                      | 600      | V    |
| ±I <sub>C</sub>        | Each IGBT collector current        | T <sub>C</sub> = 25°C                | 75       | A    |
| ±I <sub>CP</sub>       | Each IGBT collector current (peak) | T <sub>C</sub> = 25°C, less than 1ms | 150      | A    |
| P <sub>C</sub>         | Collector dissipation              | T <sub>C</sub> = 25°C, per 1 chip    | 162      | W    |
| T <sub>j</sub>         | Junction temperature               |                                      | -20~+150 | °C   |

#### CONTROL (PROTECTION) PART

| Symbol          | Parameter                     | Condition   | Ratings                  | Unit |
|-----------------|-------------------------------|---|--------------------------|------|
| V <sub>D</sub>  | Control supply voltage        | Applied between V <sub>P1</sub> -V <sub>PC</sub> , V <sub>N1</sub> -V <sub>NC</sub>   | 20                       | V    |
| V <sub>DB</sub> | Control supply voltage        | Applied between V <sub>UFB</sub> -V <sub>UFS</sub> , V <sub>VFB</sub> -V <sub>VFS</sub> , V <sub>WFB</sub> -V <sub>WFS</sub>                          | 20                       | V    |
| V <sub>IN</sub> | Input voltage                 | Applied between U <sub>P</sub> , V <sub>P</sub> , W <sub>P</sub> -V <sub>PC</sub> , U <sub>N</sub> , V <sub>N</sub> , W <sub>N</sub> -V <sub>NC</sub> | -0.5~V <sub>D</sub> +0.5 | V    |
| V <sub>FO</sub> | Fault output supply voltage   | Applied between F <sub>O</sub> -V <sub>NC</sub>   | -0.5~V <sub>D</sub> +0.5 | V    |
| I <sub>FO</sub> | Fault output current          | Sink current at F <sub>O</sub> terminal   | 1                        | mA   |
| V <sub>SC</sub> | Current sensing input voltage | Applied between C <sub>IN</sub> -V <sub>NC</sub>  | -0.5~V <sub>D</sub> +0.5 | V    |

#### TOTAL SYSTEM

| Symbol                | Parameter  | Condition   | Ratings  | Unit             |
|-----------------------|--|---|----------|------------------|
| V <sub>CC(PROT)</sub> | Self protection supply voltage limit (Short circuit protection capability) | V <sub>D</sub> = 13.5~16.5V, Inverter Part<br>T <sub>j</sub> = 125°C, non-repetitive, less than 2μs | 400      | V                |
| T <sub>C</sub>        | Module case operation temperature  | (Note 1)  | -20~+100 | °C               |
| T <sub>stg</sub>      | Storage temperature  |   | -40~+125 | °C               |
| V <sub>iso</sub>      | Isolation voltage  | 60Hz, Sinusoidal, AC 1minute, between connected all pins and heat-sink plate                        | 2500     | V <sub>rms</sub> |

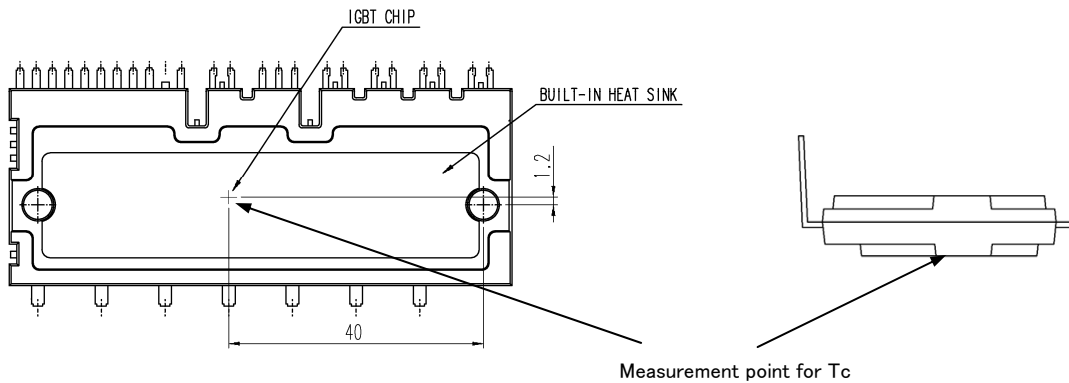
Note 1: T<sub>C</sub> measurement point is described in Fig.1.

#### THERMAL RESISTANCE

| Symbol                | Parameter                                    | Condition                           | Limits |      |      | Unit |
|-----------------------|--|-------------------------------------|--------|------|------|------|
|                       |  |                                     | Min.   | Typ. | Max. |      |
| R <sub>th(j-c)Q</sub> | Junction to case thermal resistance (Note 2) | Inverter IGBT part (per 1/6 module) | -      | -    | 0.77 | °C/W |
| R <sub>th(j-c)F</sub> |  | Inverter FWDi part (per 1/6 module) | -      | -    | 1.25 | °C/W |

Note 2: Grease with good thermal conductivity and long-term endurance should be applied evenly with about +100μm~+200μm on the contacting surface of DIPIPM and heat-sink. The contacting thermal resistance between DIPIPM case and heat sink R<sub>th(c-f)</sub> is determined by the thickness and the thermal conductivity of the applied grease. For reference, R<sub>th(c-f)</sub> is about 0.2°C/W (per 1/6 module, grease thickness: 20μm, thermal conductivity: 1.0W/m·k).

Fig. 1: T<sub>c</sub> MEASUREMENT POINT



**ELECTRICAL CHARACTERISTICS** (T<sub>j</sub> = 25°C, unless otherwise noted)  
**INVERTER PART**

| Symbol               | Parameter                            | Condition   | Limits  |        |              | Unit         |    |
|----------------------|--------------------------------------|---|---|--------|--------------|--------------|----|
|                      |                                      |   | Min.  | Typ.   | Max.         |              |    |
| V <sub>CE(sat)</sub> | Collector-emitter saturation voltage | V <sub>D</sub> =V <sub>DB</sub> = 15V<br>V <sub>IN</sub> = 5V, I <sub>C</sub> = 75A   | T <sub>j</sub> = 25°C<br>T <sub>j</sub> = 125°C | -<br>- | 1.55<br>1.65 | 2.05<br>2.10 | V  |
| V <sub>EC</sub>      | FWDi forward voltage                 | -I <sub>C</sub> = 75A, V <sub>IN</sub> = 0V   |   | -      | 1.70         | 2.20         | V  |
| t <sub>on</sub>      | Switching times                      | V <sub>CC</sub> = 300V, V <sub>D</sub> = V <sub>DB</sub> = 15V<br>I <sub>C</sub> = 75A, T <sub>j</sub> = 125°C, V <sub>IN</sub> = 0→5 V<br>Inductive Load (upper-lower arm) |   | 1.80   | 2.40         | 3.60         | μs |
| t <sub>C(on)</sub>   |                                      |   |   | -      | 0.40         | 0.60         | μs |
| t <sub>off</sub>     |                                      |   |   | -      | 3.40         | 4.80         | μs |
| t <sub>C(off)</sub>  |                                      |   |   | -      | 0.60         | 1.20         | μs |
| t <sub>rr</sub>      |                                      |   |   | -      | 0.30         | -            | μs |
| I <sub>CES</sub>     | Collector-emitter cut-off current    | V <sub>CE</sub> =V <sub>CES</sub>   | T <sub>j</sub> = 25°C<br>T <sub>j</sub> = 125°C | -<br>- | -<br>-       | 1<br>10      | mA |

**CONTROL (PROTECTION) PART**

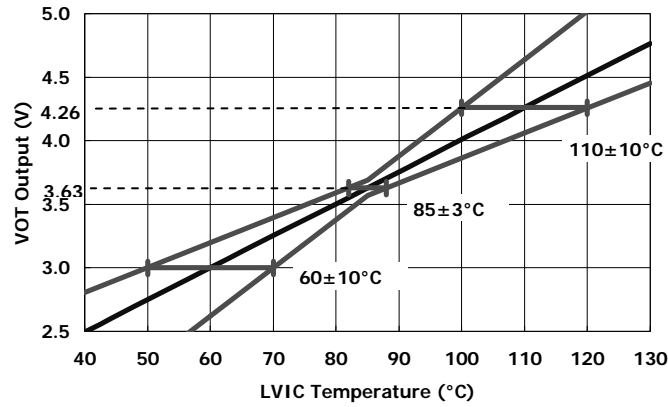
| Symbol               | Parameter                               | Condition   | Limits   |             |        | Unit         |      |   |
|----------------------|---|---|--|-------------|--------|--------------|------|---|
|                      |   |   | Min.   | Typ.        | Max.   |              |      |   |
| I <sub>D</sub>       | Circuit current                         | Total of V <sub>P1</sub> -V <sub>PC</sub> , V <sub>N1</sub> -V <sub>NC</sub>  | V <sub>D</sub> = 15V, V <sub>IN</sub> = 0V<br>V <sub>D</sub> = 15V, V <sub>IN</sub> = 5V                                     | -<br>-      | -<br>- | 5.50<br>5.50 | mA   |   |
| I <sub>DB</sub>      | Circuit current                         | V <sub>UFB</sub> -V <sub>UFS</sub> , V <sub>VFB</sub> -V <sub>VFS</sub> ,<br>V <sub>WFB</sub> -V <sub>WFS</sub>                                       | V <sub>D</sub> = V <sub>DB</sub> = 15V, V <sub>IN</sub> = 0V<br>V <sub>D</sub> = V <sub>DB</sub> = 15V, V <sub>IN</sub> = 5V | -<br>-      | -<br>- | 0.55<br>0.55 | mA   |   |
| I <sub>SC</sub>      | Short circuit trip level                | -20°C≤T <sub>j</sub> ≤125°C, R <sub>S</sub> = 23.2Ω (±1%),<br>Not connecting outer shunt resistors to<br>NU, NV, NW terminals (Note 3)                |  | 127         | -      | -            | V    |   |
| UV <sub>DBt</sub>    | Control supply under-voltage protection | T <sub>j</sub> ≤125°C   | P-side   | Trip level  | 10.0   | -            | 12.0 | V |
| UV <sub>DBr</sub>    |   |   |  | Reset level | 10.5   | -            | 12.5 | V |
| UV <sub>Dt</sub>     |   |   | N-side   | Trip level  | 10.3   | -            | 12.5 | V |
| UV <sub>Dr</sub>     |   |   |  | Reset level | 10.8   | -            | 13.0 | V |
| V <sub>FOH</sub>     | Fault output voltage                    | V <sub>SC</sub> = 0V, F <sub>O</sub> terminal pull-up to 5V by 10kΩ   |  | 4.9         | -      | -            | V    |   |
| V <sub>FOL</sub>     |   | V <sub>SC</sub> = 1V, I <sub>FO</sub> = 1mA   |  | -           | -      | 0.95         | V    |   |
| t <sub>FO</sub>      | Fault output pulse width                | C <sub>FO</sub> =22nF (Note 4)  |  | 1.6         | 2.4    | -            | ms   |   |
| I <sub>IN</sub>      | Input current                           | V <sub>IN</sub> = 5V  |  | 0.7         | 1.0    | 1.5          | mA   |   |
| V <sub>th(on)</sub>  | ON threshold voltage                    | Applied between U <sub>P</sub> , V <sub>P</sub> , W <sub>P</sub> -V <sub>PC</sub> , U <sub>N</sub> , V <sub>N</sub> , W <sub>N</sub> -V <sub>NC</sub> |  | 2.1         | 2.3    | 2.6          | V    |   |
| V <sub>th(off)</sub> | OFF threshold voltage                   |   |  | 0.8         | 1.4    | 2.1          | V    |   |
| V <sub>OT</sub>      | Temperature output                      | LVIC temperature = 85°C (Note 5)  |  | 3.57        | 3.63   | 3.69         | V    |   |

Note 3 : Short circuit protection can work for N-side IGBTs only. I<sub>sc</sub> level can change by sense resistance. For details, please refer the application note for this DIPIPM or contact us. And in that case, it should be for sense resistor to be larger resistance than the value mentioned above.

4 : Fault signal is output when short circuit or N-side control supply under-voltage protective functions operate. The fault output pulse-width t<sub>FO</sub> depends on the capacitance value of C<sub>FO</sub>. (C<sub>FO</sub> (typ.) = t<sub>FO</sub> x (9.1 x 10<sup>9</sup>) [F])

5 : DIPIPM don't shutdown IGBTs and output fault signal automatically when temperature rises excessively. When temperature exceeds the protective level that user defined, controller (MCU) should stop the DIPIPM. And this output might exceed 5V when temperature rises excessively, so it is recommended for protection of control part like MCU to insert a clamp Di between supply (e.g. 5V) for control part and this output. Temperature of LVIC vs. V<sub>OT</sub> output characteristics is described in Fig.2

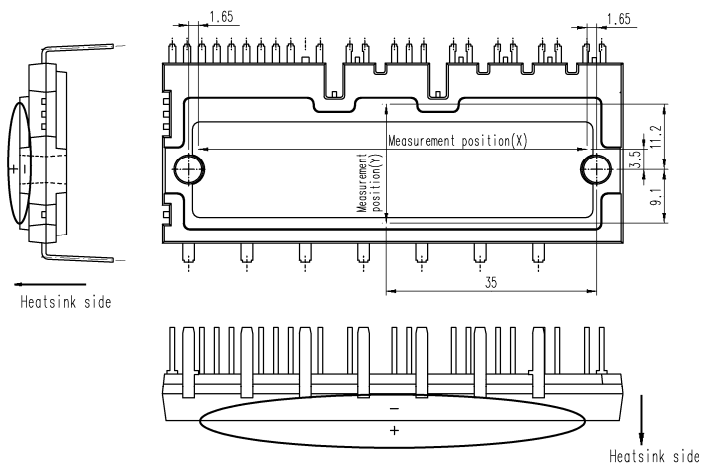
Fig.2 Temperature of LVIC - V<sub>OT</sub> output characteristics



**MECHANICAL CHARACTERISTICS AND RATINGS**

| Parameter                 | Condition              |             | Limits       |      |      | Unit |       |
|---------------------------|------------------------|-------------|--------------|------|------|------|-------|
|                           |                        |             | Min.         | Typ. | Max. |      |       |
| Mounting torque           | Mounting screw : M4    | Recommended | 1.18N·m      | 0.98 | 1.18 | 1.47 | N·m   |
| Terminal pulling strength | Load 19.6N             |             | EIAJ-ED-4701 | 10   | -    | -    | s     |
| Terminal bending strength | Load 9.8N, 90deg. bend |             | EIAJ-ED-4701 | 2    | -    | -    | times |
| Weight                    |                        |             |              | -    | 46   | -    | g     |
| Heat-sink flatness        |                        | (Note 6)    |              | -50  | -    | 100  | μm    |

Note 6: Measurement point of heat-sink flatness



RECOMMENDED OPERATION CONDITIONS

| Symbol                      | Parameter                       | Condition   | Limits                        |      |      | Unit             |         |
|-----------------------------|---------------------------------|---|-------------------------------|------|------|------------------|---------|
|                             |                                 |   | Min.                          | Typ. | Max. |                  |         |
| $V_{CC}$                    | Supply voltage                  | Applied between P-NU, NV, NW  | 0                             | 300  | 400  | V                |         |
| $V_D$                       | Control supply voltage          | Applied between $V_{P1}-V_{PC}$ , $V_{N1}-V_{NC}$   | 13.5                          | 15.0 | 16.5 | V                |         |
| $V_{DB}$                    | Control supply voltage          | Applied between $V_{UFB}-V_{UFS}$ , $V_{VFB}-V_{VFS}$ , $V_{WFB}-V_{WFS}$   | 13.0                          | 15.0 | 18.5 | V                |         |
| $\Delta V_D, \Delta V_{DB}$ | Control supply variation        |   | -1                            | -    | +1   | V/ $\mu$ s       |         |
| $t_{dead}$                  | Arm shoot-through blocking time | For each input signal, $T_C \leq 100^\circ\text{C}$   | 2.7                           | -    | -    | $\mu$ s          |         |
| $f_{PWM}$                   | PWM input frequency             | $T_C \leq 100^\circ\text{C}$ , $T_J \leq 125^\circ\text{C}$   | -                             | -    | 20   | kHz              |         |
| $I_o$                       | Allowable r.m.s. current        | $V_{CC} = 300\text{V}$ , $V_D = 15\text{V}$ , P.F = 0.8,<br>Sinusoidal PWM<br>$T_C \leq 100^\circ\text{C}$ , $T_J \leq 125^\circ\text{C}$ (Note 7)  | $f_{PWM} = 5\text{kHz}$       | -    | -    | 35.0             | Arms    |
|                             |                                 |   | $f_{PWM} = 15\text{kHz}$      | -    | -    | 17.0             |         |
| PWIN(on)                    | Minimum input pulse width       | $200 \leq V_{CC} \leq 350\text{V}$ , $13.5 \leq V_D \leq 16.5\text{V}$ ,<br>$13.0 \leq V_{DB} \leq 18.5\text{V}$ , $-20^\circ\text{C} \leq T_C \leq 100^\circ\text{C}$ ,<br>N line wiring inductance less than 10nH<br>(Note 9) | (Note 8)                      | 1.3  | -    | -                | $\mu$ s |
| PWIN(off)                   |                                 |   | $I_C \leq 75\text{A}$         | 3.0  | -    | -                |         |
|                             |                                 |   | $75 < I_C \leq 127.5\text{A}$ | 5.0  | -    | -                |         |
| $V_{NC}$                    | $V_{NC}$ variation              | Between $V_{NC}-\text{NU}$ , NV, NW (including surge)   | -5.0                          | -    | +5.0 | V                |         |
| $T_J$                       | Junction temperature            |   | -20                           | -    | +125 | $^\circ\text{C}$ |         |

Note 7: The allowable r.m.s. current value depends on the actual application conditions.

8: DIIPM might not make response to the input on signal with pulse width less than PWIN (on).

9: IPM might make no response or delayed response (at P-side IGBT only) for the input signal with off pulse width less than PWIN(off). Please refer Fig. 3 about delayed response.

Fig. 3 About Delayed Response Against Shorter Input Off Signal Than PWIN(off) (P-side only)

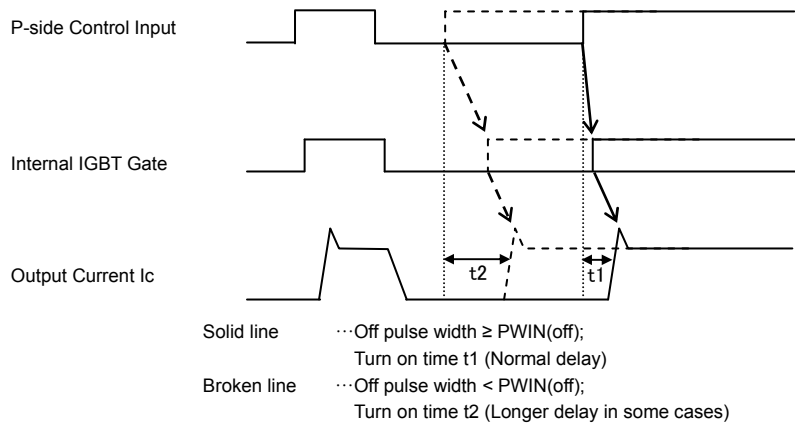


Fig. 4 INTERNAL CIRCUIT

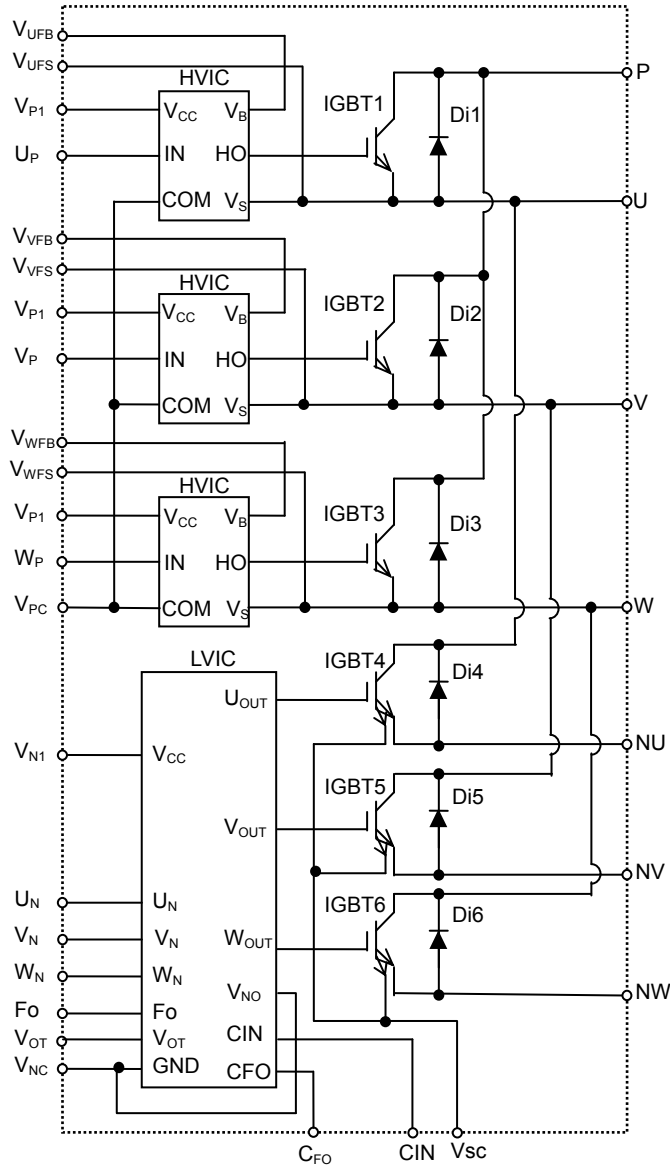
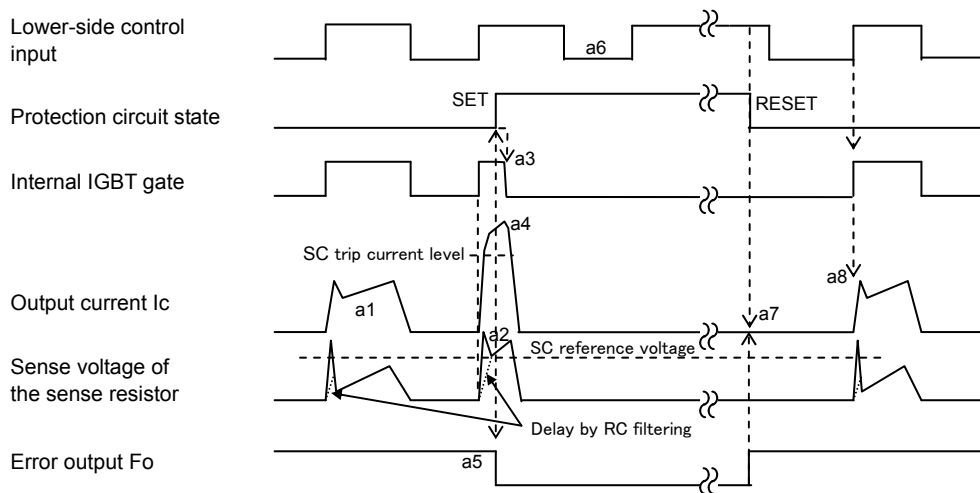


Fig. 5 TIMING CHARTS OF THE DIIPM PROTECTIVE FUNCTIONS

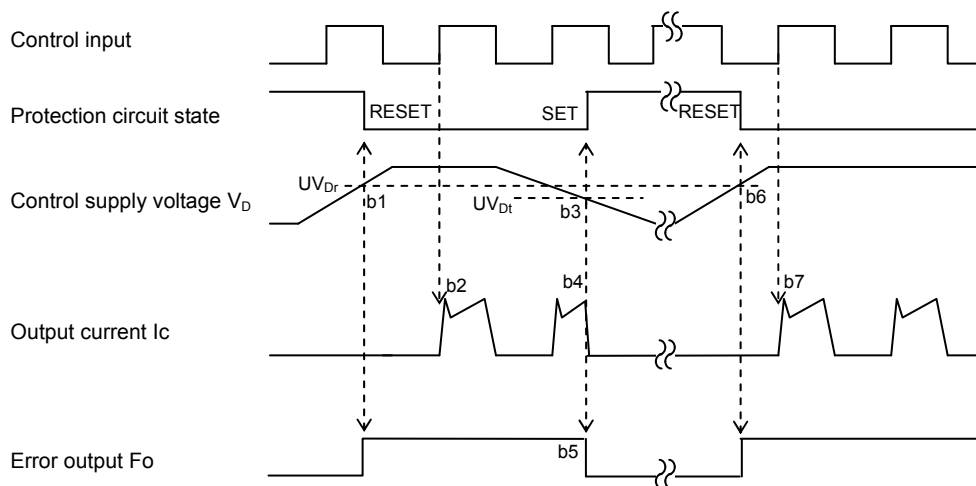
**[A] Short-Circuit Protection (N-side only with the external sense resistor and RC filter)**

- a1. Normal operation: IGBT ON and outputs current.
- a2. Short circuit current detection (SC trigger) (It is recommended to set RC time constant 1.5~2.0 $\mu$ s so that IGBT shut down within 2.0 $\mu$ s when SC.)
- a3. All N-side IGBT's gates are hard interrupted.
- a4. All N-side IGBTs turn OFF.
- a5.  $F_o$  outputs with a fixed pulse width determined by the external capacitor  $C_{FO}$ .
- a6. Input = "L": IGBT OFF
- a7.  $F_o$  finishes output, but IGBTs don't turn on until inputting next ON signal (L $\rightarrow$ H).
- (IGBT of each phase can return to normal state by inputting ON signal to each phase.)
- a8. Normal operation: IGBT ON and outputs current.



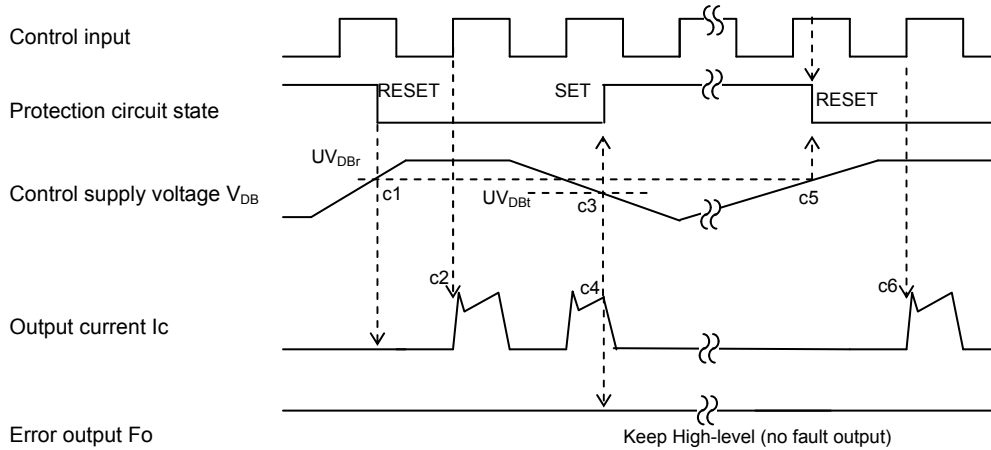
**[B] Under-Voltage Protection (N-side,  $UV_D$ )**

- b1. Control supply voltage  $V_D$  exceeds under voltage reset level ( $UV_{Dr}$ ), but IGBT turns ON when inputting next ON signal (L $\rightarrow$ H).
- (IGBT of each phase can return to normal state by inputting ON signal to each phase.)
- b2. Normal operation: IGBT ON and outputs current.
- b3.  $V_D$  level drops to under voltage trip level. ( $UV_{Dt}$ ).
- b4. All N-side IGBTs turn OFF in spite of control input condition.
- b5.  $F_o$  outputs for the period determined by the capacitance  $C_{FO}$ , but output is extended during  $V_D$  keeps below  $UV_{Dr}$ .
- b6.  $V_D$  level reaches  $UV_{Dr}$ .
- b7. Normal operation: IGBT ON and outputs current.

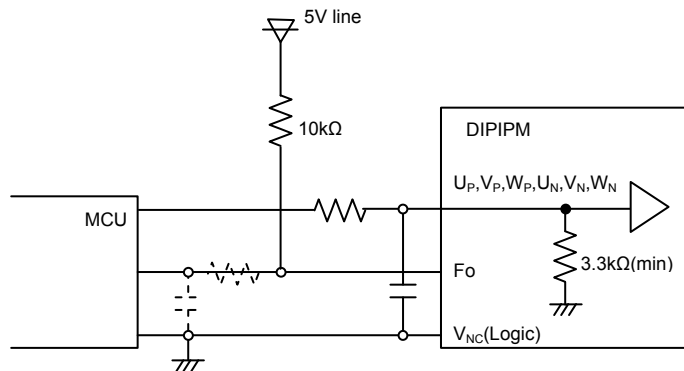


**[C] Under-Voltage Protection (P-side,  $UV_{DB}$ )**

- c1. Control supply voltage  $V_{DB}$  rises. After the voltage reaches under voltage reset level  $UV_{DBr}$ , IGBT can turn on when inputting next ON signal (L→H).
- c2. Normal operation: IGBT ON and outputs current.
- c3.  $V_{DB}$  level drops to under voltage trip level ( $UV_{DBt}$ ).
- c4. IGBT of correspond phase only turns OFF in spite of control input signal level, but there is no  $F_o$  signal output.
- c5.  $V_{DB}$  level reaches  $UV_{DBr}$ .
- c6. Normal operation: IGBT ON and outputs current.



**Fig. 6 MCU I/O INTERFACE CIRCUIT**

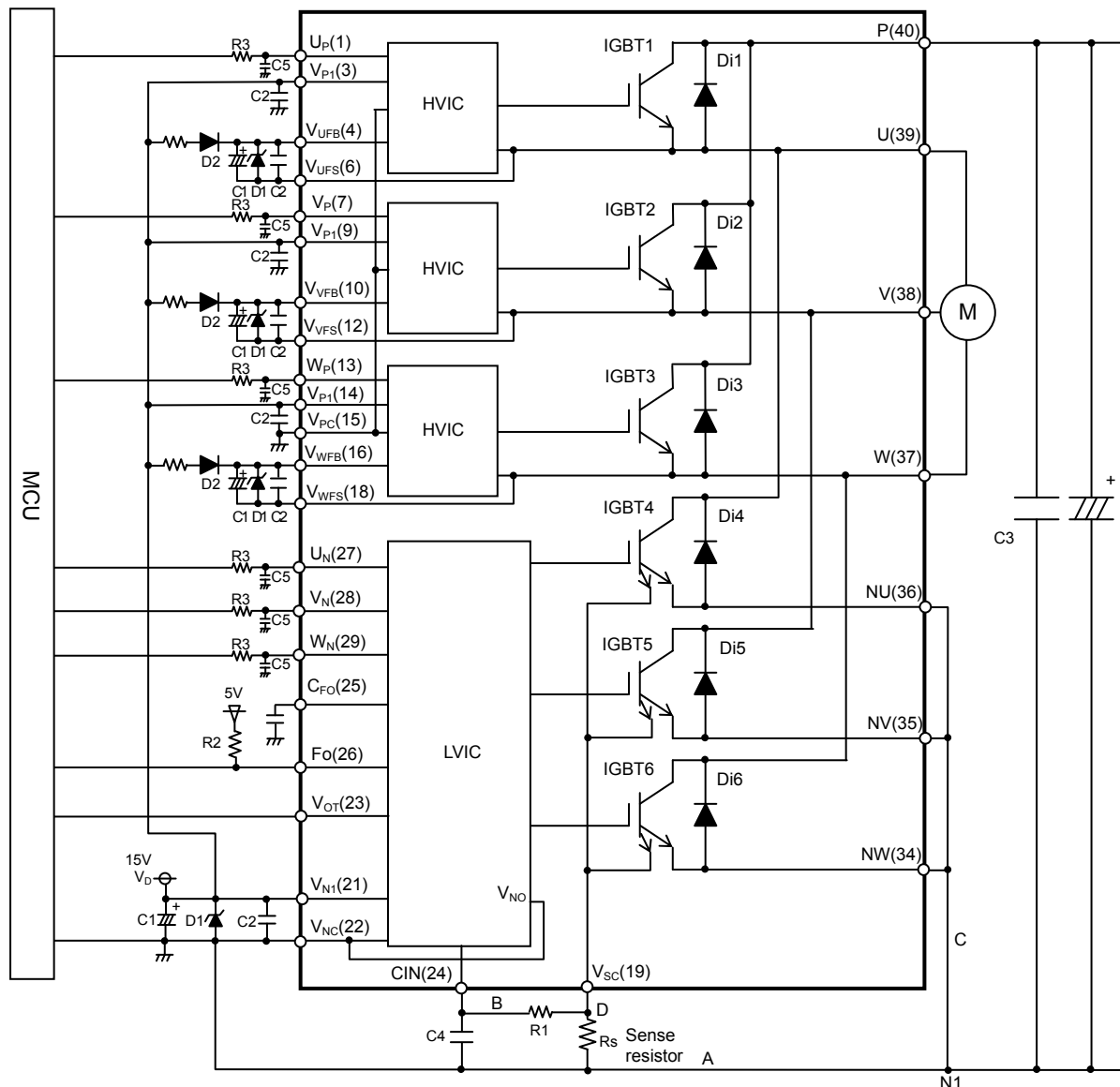


Note)

Design for input RC filter depends on the PWM control scheme used in the application and the wiring impedance of the printed circuit board. The DIPIPM input signal interface integrates a 3.3kΩ(min) pull-down resistor. Therefore, when using RC filter, be careful to satisfy the turn-on threshold voltage requirement.

$F_o$  output is open drain type. It should be pulled up to the positive side of 5V or 15V power supply with the resistor that limits  $F_o$  sink current  $I_{F_o}$  under 1mA. In the case of pulling up to 5V supply, over 5.1kΩ is needed. (10kΩ is recommended.)

Fig. 7 AN EXAMPLE OF APPLICATION CIRCUIT



Note

- 1 :If control GND is connected to power GND by broad pattern, it may cause malfunction by power GND fluctuation. It is recommended to connect control GND and power GND at only a point at which NU, NV, NW are connected to power GND line.
- 2 :To prevent surge destruction, the wiring between the smoothing capacitor and the P,N1 terminals should be as short as possible. Generally inserting a 0.1 $\mu$ ~0.22 $\mu$ F snubber capacitor C3 between the P-N1 terminals is recommended.
- 3 :The time constant R1C4 of RC filter for preventing protection circuit malfunction should be selected in the range of 1.5 $\mu$ s~2 $\mu$ s. SC interrupting time might vary with the wiring pattern. Tight tolerance, temp-compensated type is recommended for R1,C4. When R1 is too small, it will leads to delay of protection. So R1 should be min. 10 times larger resistance than Rs. (Over 100 times is recommended.)
- 4 :All capacitors should be mounted as close to the terminals of the DIPIM as possible. (C1: good temperature, frequency characteristic electrolytic type, and C2: 0.22 $\mu$ ~2.0 $\mu$ F, good temperature, frequency and DC bias characteristic ceramic type are recommended.)
- 5 :It is recommended to insert a Zener diode D1 (24V/1W) between each pair of control supply terminals to prevent surge destruction.
- 6 :To prevent erroneous SC protection, the wiring from V<sub>sc</sub> terminal to CIN filter should be divided at the point D that is close to the terminal of sense resistor. And the wiring should be patterned as short as possible.
- 7 :For sense resistor, the variation within 1%(including temperature characteristics), low inductance type is recommended. And the over 1/8W is recommended, but it is necessary to evaluate in your real system finally.
- 8 :To prevent erroneous operation, the wiring of A, B, C should be as short as possible.
- 9 :Fo output is open drain type. It should be pulled up to the positive side of 5V or 15V power supply with the resistor that limits Fo sink current I<sub>Fo</sub> under 1mA. In the case pull up to 5V supply, over R2=5.1k $\Omega$  is needed. (10k $\Omega$  is recommended.)
- 10 :Error signal output width (t<sub>Fo</sub>) can be set by the capacitor connected to C<sub>Fo</sub> terminal. C<sub>Fo</sub>(typ.) = t<sub>Fo</sub> × (9.1 × 10<sup>-6</sup>) (F)
- 11 :High voltage (V<sub>RRM</sub> =600V or more) and fast recovery type (trr=less than 100ns or less) diode D2 should be used in the bootstrap circuit.
- 12 :If high frequency noise superimposed to the control supply line, IC malfunction might happen and cause erroneous operation. To avoid such problem, voltage ripple of control supply line should meet dV/dt  $\leq$  +/-1V/ $\mu$ s, Vripples $\leq$ 2Vp-p.
- 13 :Input drive is High-Active type. There is a 3.3k $\Omega$ (min.) pull-down resistor integrated in the IC input circuit. To prevent malfunction, the wiring of each input should be patterned as short as possible. When using RC filter R3C5, it is necessary to confirm the input signal level to meet the turn-on and turn-off threshold voltage. Thanks to HVIC inside the module, direct coupling to MCU without any opto-coupler or transformer isolation is possible.

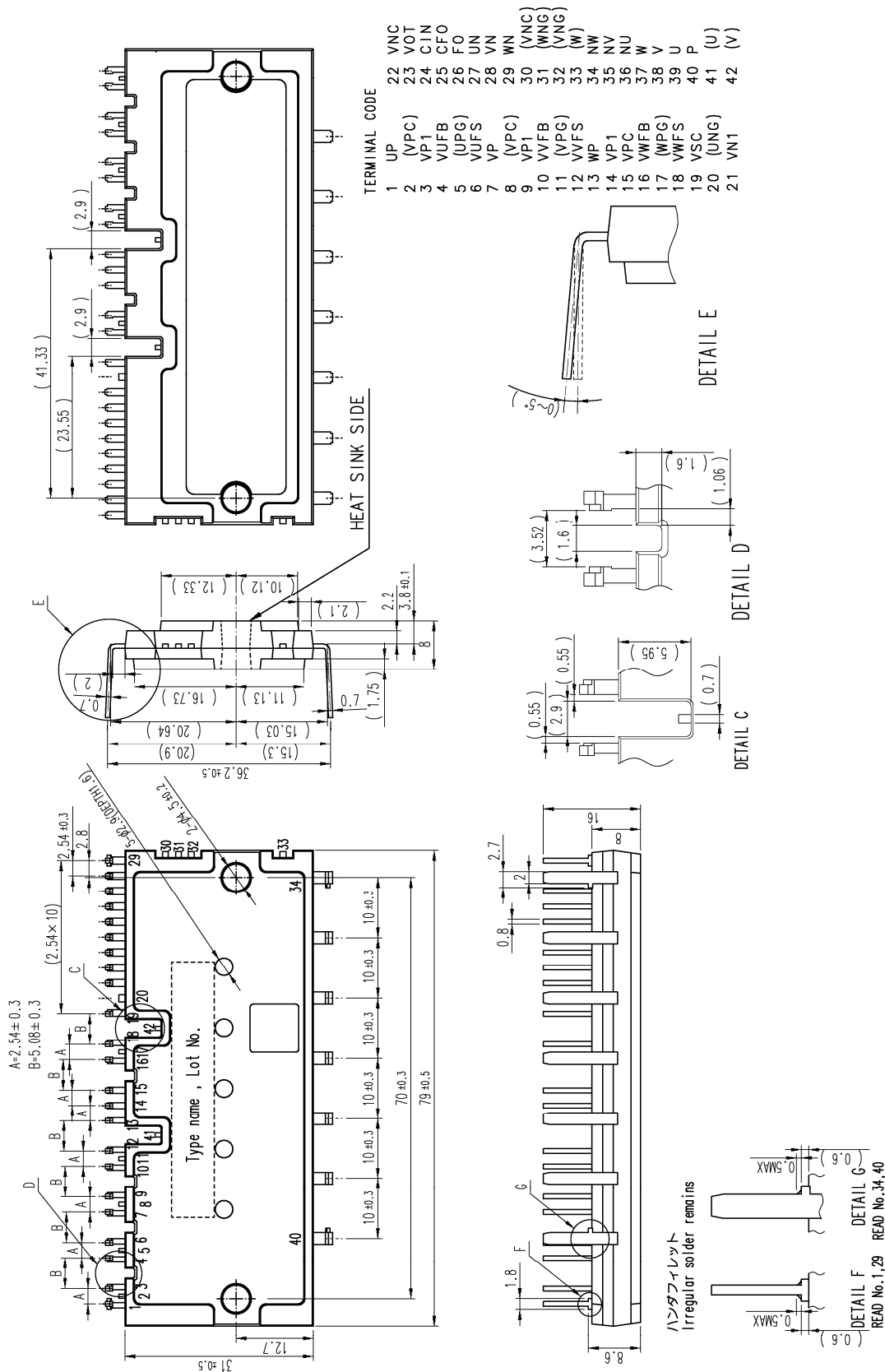


# PS21A7A

TRANSFER-MOLD TYPE  
INSULATED TYPE

Fig. 8 PACKAGE OUTLINES

Dimensions in mm



**Keep safety first in your circuit designs!**

Mitsubishi Electric Corporation puts the maximum effort into making semiconductor products better and more reliable, but these are always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage. Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (1) placement of substitutive, auxiliary circuits, (2) use of non-flammable material or (3) prevention against any malfunction or mishap.

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