

# PS21963-4E/-4AE/-4CE/-4EW

TRANSFER-MOLD TYPE  
INSULATED TYPE

## PS21963-4E



### INTEGRATED POWER FUNCTIONS

600V/8A low-loss CSTBT™ inverter bridge for three phase DC-to-AC power conversion

### INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS

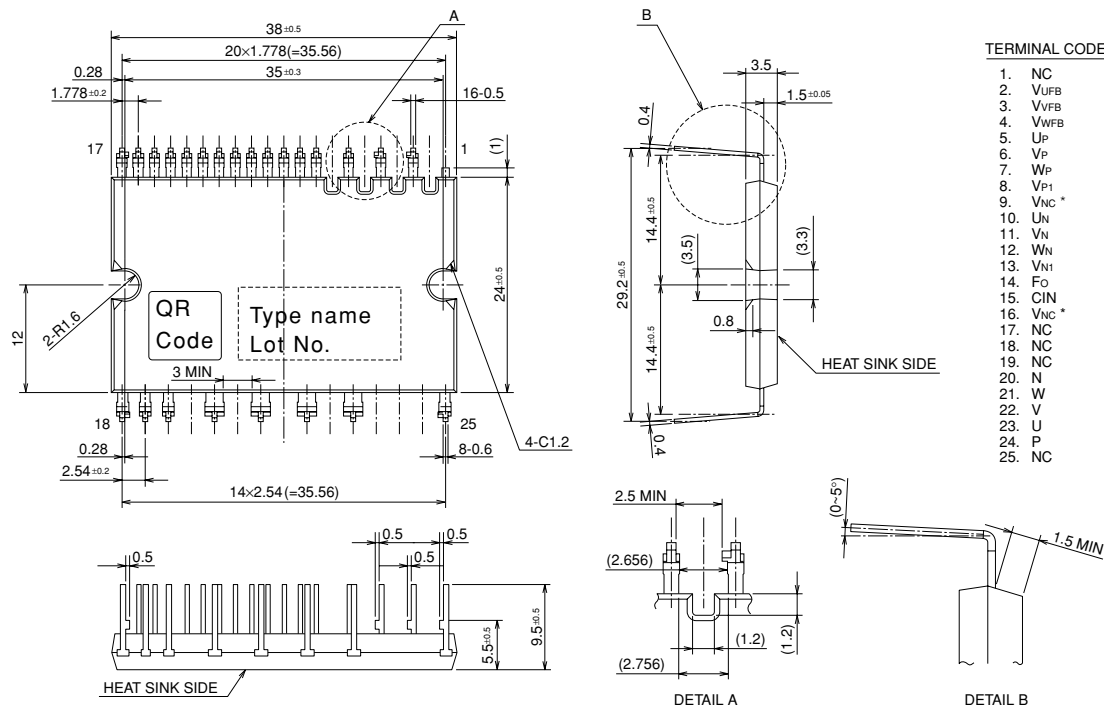
- For upper-leg IGBTs : Drive circuit, High voltage high-speed level shifting, Control supply under-voltage (UV) protection.
- For lower-leg IGBTs : Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC).
- Fault signaling : Corresponding to an SC fault (Lower-leg IGBT) or a UV fault (Lower-side supply).
- Input interface : 3V, 5V line (High Active).
- UL Approved : Yellow Card No. E80276

## APPLICATION

AC100V~200V three-phase inverter drive for small power motor control.

Fig. 1 PACKAGE OUTLINES (PS21963-4E)

Dimensions in mm



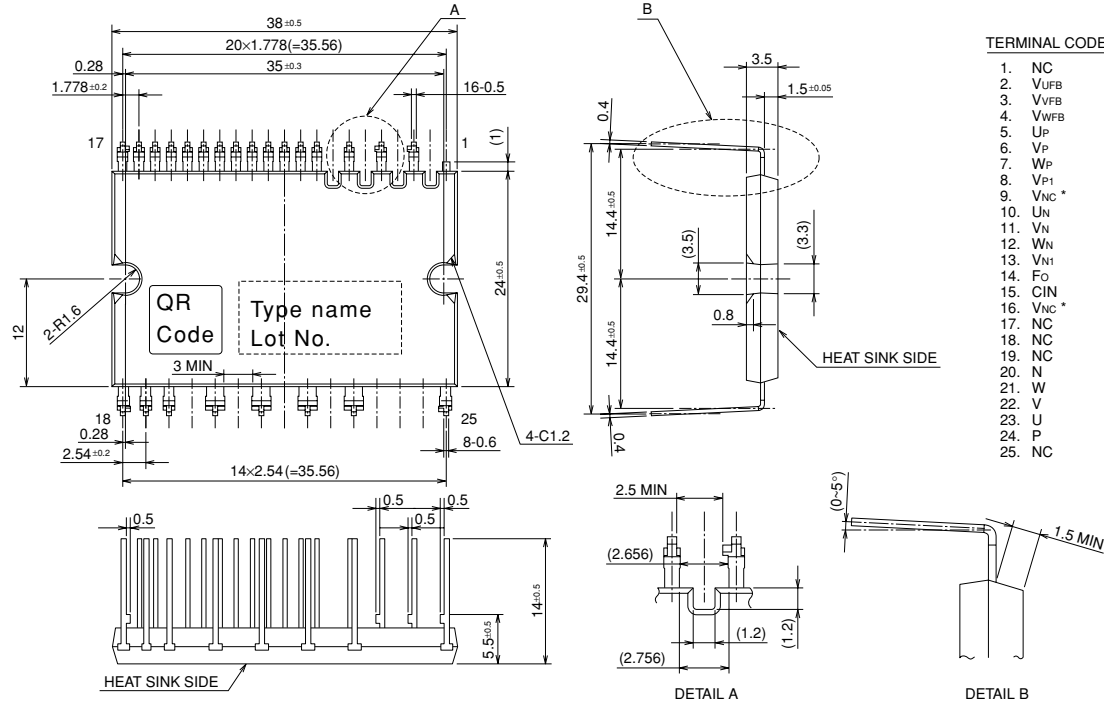
\*) Two V<sub>NC</sub> terminals (9 & 16 pin) are connected inside DIP-IPM, please connect either one to the 15V power supply GND outside and leave another one open.

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Fig. 2 LONG TERMINAL TYPE PACKAGE OUTLINES (PS21963-4AE)

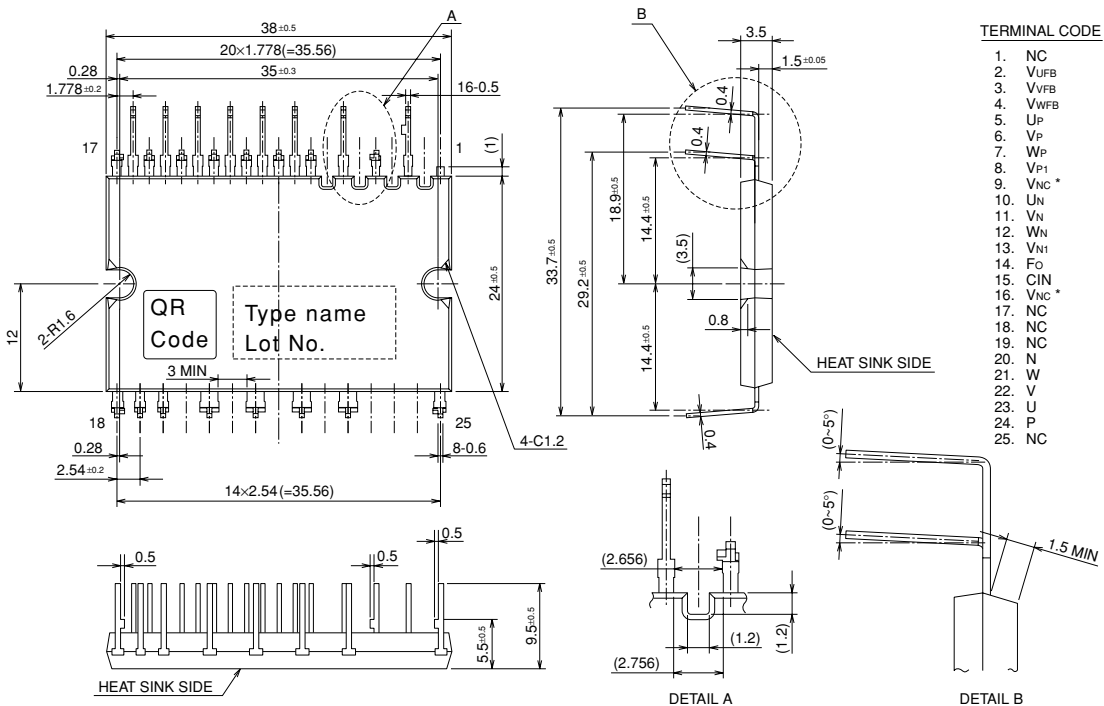
Dimensions in mm



\*) Two VNC terminals (9 & 16 pin) are connected inside DIP-IPM, please connect either one to the 15V power supply GND outside and leave another one open.

Fig. 3 ZIGZAG TERMINAL TYPE PACKAGE OUTLINES (PS21963-4CE)

Dimensions in mm



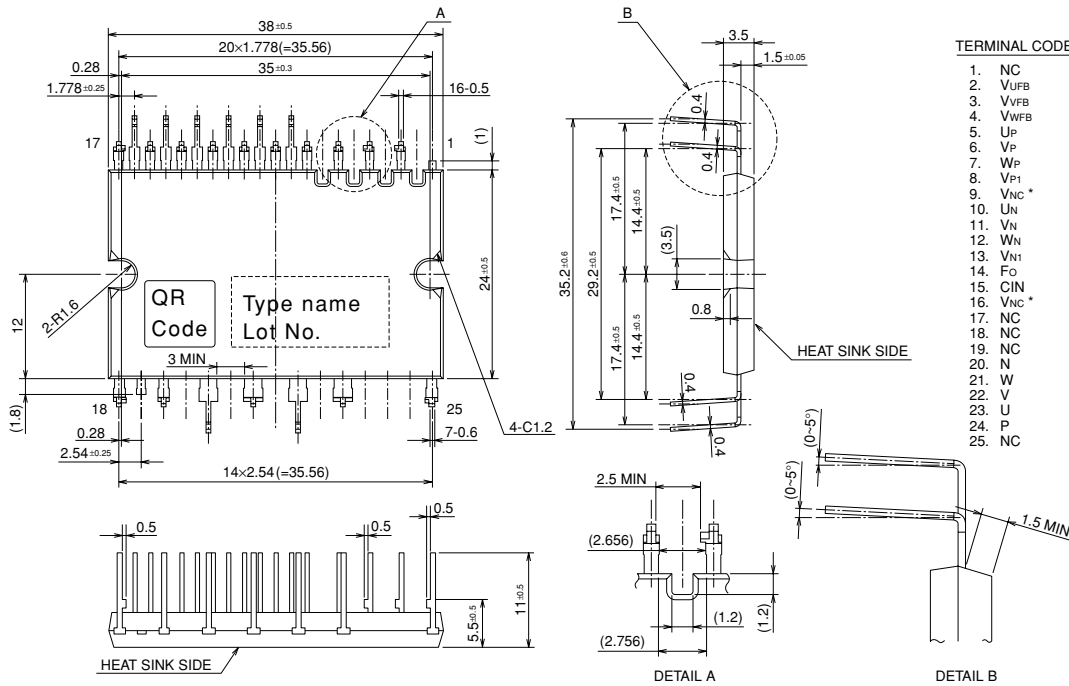
\*) Two VNC terminals (9 & 16 pin) are connected inside DIP-IPM, please connect either one to the 15V power supply GND outside and leave another one open.

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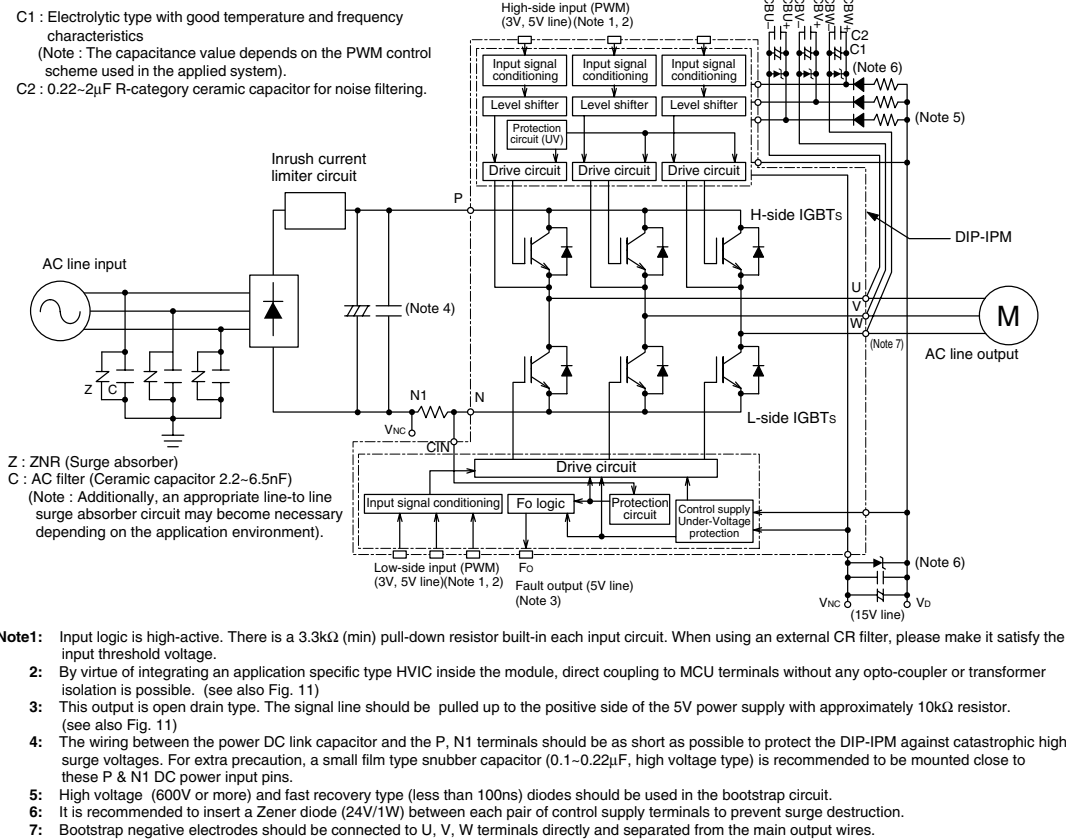
Fig. 4 BOTH SIDES ZIGZAG TERMINAL TYPE PACKAGE OUTLINES (PS21963-4EW)

Dimensions in mm



\*) Two V<sub>NC</sub> terminals (9 & 16 pin) are connected inside DIP-IPM, please connect either one to the 15V power supply GND outside and leave another one open.

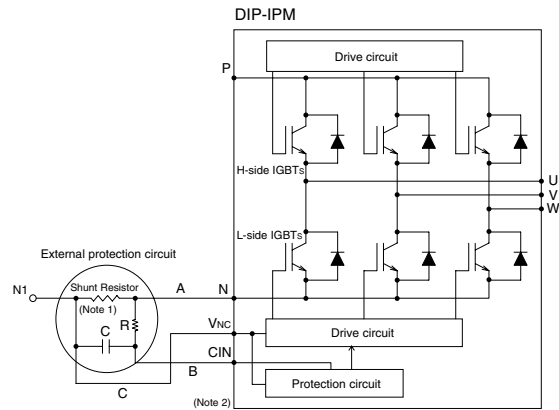
Fig. 5 INTERNAL FUNCTIONS BLOCK DIAGRAM (TYPICAL APPLICATION EXAMPLE)



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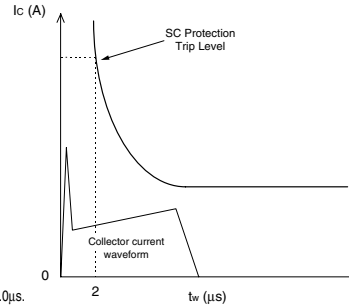
**Fig. 6 EXTERNAL PART OF THE DIP-IPM PROTECTION CIRCUIT**



**Note1:** In the recommended external protection circuit, please select the RC time constant in the range 1.5~2.0μs.  
**2:** To prevent erroneous protection operation, the wiring of A, B, C should be as short as possible.

## Short Circuit Protective Function (SC) :

SC protection is achieved by sensing the L-side DC-Bus current (through the external shunt resistor) after allowing a suitable filtering time (defined by the RC circuit). When the sensed shunt voltage exceeds the SC trip-level, all the L-side IGBTs are turned OFF and a fault signal (Fo) is output. Since the SC fault may be repetitive, it is recommended to stop the system when the Fo signal is received and check the fault.



## MAXIMUM RATINGS (Tj = 25°C, unless otherwise noted)

### INVERTER PART

| Symbol     | Parameter                          | Condition                | Ratings  | Unit |
|------------|------------------------------------|--------------------------|----------|------|
| VCC        | Supply voltage                     | Applied between P-N      | 450      | V    |
| VCC(surge) | Supply voltage (surge)             | Applied between P-N      | 500      | V    |
| VCEs       | Collector-emitter voltage          |                          | 600      | V    |
| ±Ic        | Each IGBT collector current        | Tc = 25°C                | 8        | A    |
| ±ICP       | Each IGBT collector current (peak) | Tc = 25°C, less than 1ms | 16       | A    |
| Pc         | Collector dissipation              | Tc = 25°C, per 1 chip    | 24.3     | W    |
| Tj         | Junction temperature               | (Note 1)                 | -20~+125 | °C   |

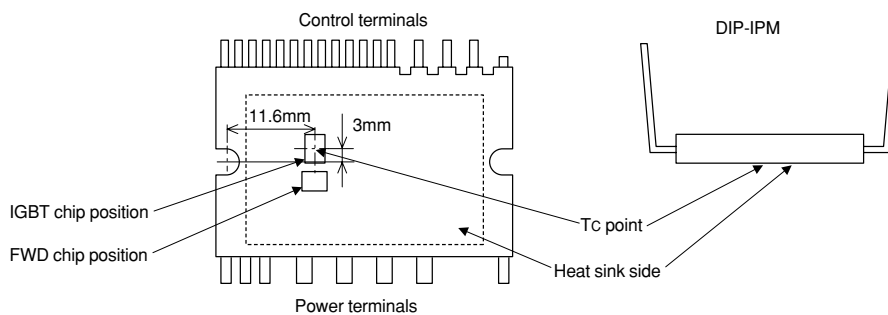
**Note 1 :** The maximum junction temperature rating of the power chips integrated within the DIP-IPM is 150°C (@ Tc ≤ 100°C). However, to ensure safe operation of the DIP-IPM, the average junction temperature should be limited to Tj(ave) ≤ 125°C (@ Tc ≤ 100°C).

### CONTROL (PROTECTION) PART

| Symbol | Parameter                     | Condition                                  | Ratings     | Unit |
|--------|-------------------------------|--------------------------------------------|-------------|------|
| VD     | Control supply voltage        | Applied between VP1-VNC, VN1-VNC           | 20          | V    |
| VDB    | Control supply voltage        | Applied between VUFB-U, VVFB-V, VWFB-W     | 20          | V    |
| VIN    | Input voltage                 | Applied between UP, VP, WP, UN, VN, WN-VNC | -0.5~VD+0.5 | V    |
| VFO    | Fault output supply voltage   | Applied between Fo-VNC                     | -0.5~VD+0.5 | V    |
| Ifo    | Fault output current          | Sink current at Fo terminal                | 1           | mA   |
| Vsc    | Current sensing input voltage | Applied between CIN-VNC                    | -0.5~VD+0.5 | V    |

**PS21963-4E/-4AE/-4CE/-4EW****TRANSFER-MOLD TYPE  
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| 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 2)                                                                                            | -20~+100 | °C               |
| T <sub>stg</sub>      | Storage temperature                                                        |                                                                                                     | -40~+125 | °C               |
| V <sub>iso</sub>      | Isolation voltage                                                          | 60Hz, Sinusoidal, 1 minute,<br>Between pins and heat-sink plate                                     | 1500     | V <sub>rms</sub> |

**Note 2:** T<sub>C</sub> measurement point**THERMAL RESISTANCE**

| Symbol                | Parameter                                    | Condition                           | Limits |      |      | Unit |
|-----------------------|----------------------------------------------|-------------------------------------|--------|------|------|------|
|                       |                                              |                                     | Min.   | Typ. | Max. |      |
| R <sub>th(j-c)Q</sub> | Junction to case thermal resistance (Note 3) | Inverter IGBT part (per 1/6 module) | —      | —    | 4.1  | °C/W |
| R <sub>th(j-c)F</sub> |                                              | Inverter FWD part (per 1/6 module)  | —      | —    | 5.4  | °C/W |

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

The contacting thermal resistance between DIP-IPM 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> (per 1/6 module) is about 0.3°C/W when the grease thickness is 20μm and the thermal conductivity is 1.0W/m·K.

**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                                | I <sub>C</sub> = 8A, T <sub>j</sub> = 25°C  | —      | 1.70 | 2.20 | V    |
|                      |                                      | V <sub>IN</sub> = 5V                                                  | I <sub>C</sub> = 8A, T <sub>j</sub> = 125°C | —      | 1.80 | 2.30 |      |
| V <sub>EC</sub>      | FWD forward voltage                  | T <sub>j</sub> = 25°C, -I <sub>C</sub> = 8A, V <sub>IN</sub> = 0V     |                                             | —      | 1.90 | 2.35 | V    |
| t <sub>on</sub>      | Switching times                      | V <sub>CC</sub> = 300V, V <sub>D</sub> = V <sub>DB</sub> = 15V        |                                             | 0.60   | 1.10 | 1.70 | μs   |
| t <sub>rr</sub>      |                                      | I <sub>C</sub> = 8A, T <sub>j</sub> = 125°C, V <sub>IN</sub> = 0 ↔ 5V |                                             | —      | 0.30 | —    | μs   |
| t <sub>c(on)</sub>   |                                      | Inductive load (upper-lower arm)                                      |                                             | —      | 0.40 | 0.60 | μs   |
| t <sub>off</sub>     |                                      |                                                                       |                                             | —      | 1.40 | 2.00 | μs   |
| t <sub>c(off)</sub>  |                                      |                                                                       |                                             | —      | 0.40 | 0.75 | μs   |
| I <sub>CES</sub>     | Collector-emitter cut-off current    | V <sub>CE</sub> = V <sub>CES</sub>                                    | T <sub>j</sub> = 25°C                       | —      | —    | 1    | mA   |
|                      |                                      |                                                                       | T <sub>j</sub> = 125°C                      | —      | —    | 10   |      |

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## CONTROL (PROTECTION) PART

| Symbol               | Parameter                               | Condition                                                                                                                            | Limits                                                                       |      |      | Unit |
|----------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|------|------|------|
|                      |                                         |                                                                                                                                      | Min.                                                                         | Typ. | Max. |      |
| I <sub>D</sub>       | Circuit current                         | V <sub>D</sub> = V <sub>DB</sub> = 15V<br>V <sub>IN</sub> = 5V                                                                       | Total of V <sub>P1</sub> -V <sub>N1</sub> , V <sub>N1</sub> -V <sub>N2</sub> |      | 2.80 | mA   |
|                      |                                         |                                                                                                                                      | V <sub>UFB</sub> -U, V <sub>VFB</sub> -V, V <sub>WFB</sub> -W                |      | 0.55 | mA   |
|                      |                                         | V <sub>D</sub> = V <sub>DB</sub> = 15V<br>V <sub>IN</sub> = 0V                                                                       | Total of V <sub>P1</sub> -V <sub>N1</sub> , V <sub>N1</sub> -V <sub>N2</sub> |      | 2.80 | mA   |
|                      |                                         |                                                                                                                                      | V <sub>UFB</sub> -U, V <sub>VFB</sub> -V, V <sub>WFB</sub> -W                |      | 0.55 | mA   |
| 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    |
| V <sub>SC(ref)</sub> | Short circuit trip level                | T <sub>j</sub> = 25°C, V <sub>D</sub> = 15V (Note 4)                                                                                 | 0.43                                                                         | 0.48 | 0.53 | V    |
| I <sub>IN</sub>      | Input current                           | V <sub>IN</sub> = 5V                                                                                                                 | 0.70                                                                         | 1.00 | 1.50 | mA   |
| UV <sub>DBt</sub>    | Control supply under-voltage protection | T <sub>j</sub> ≤ 125°C                                                                                                               | Trip level                                                                   |      | 10.0 | V    |
| UV <sub>DBr</sub>    |                                         |                                                                                                                                      | Reset level                                                                  |      | 10.5 | V    |
| UV <sub>Dt</sub>     |                                         |                                                                                                                                      | Trip level                                                                   |      | 10.3 | V    |
| UV <sub>Dr</sub>     |                                         |                                                                                                                                      | Reset level                                                                  |      | 10.8 | V    |
| t <sub>FO</sub>      | Fault output pulse width                | (Note 5)                                                                                                                             | 20                                                                           | —    | —    | μs   |
| V <sub>th(on)</sub>  | ON threshold voltage                    | Applied between U <sub>P</sub> , V <sub>P</sub> , W <sub>P</sub> , U <sub>N</sub> , V <sub>N</sub> , W <sub>N</sub> -V <sub>N2</sub> | —                                                                            | 2.1  | 2.6  | V    |
| V <sub>th(off)</sub> | OFF threshold voltage                   |                                                                                                                                      | 0.8                                                                          | 1.3  | —    | V    |
| V <sub>th(hys)</sub> | ON/OFF threshold hysteresis voltage     |                                                                                                                                      | 0.35                                                                         | 0.65 | —    | V    |

**Note 4 :** Short circuit protection is functioning only for the lower-arms. Please select the external shunt resistance such that the SC trip-level is less than 1.7 times of the current rating.

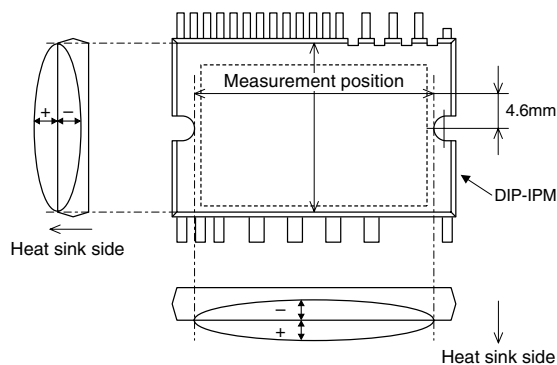
**5 :** Fault signal is asserted corresponding to a short circuit or lower side control supply under-voltage failure.

## MECHANICAL CHARACTERISTICS AND RATINGS

| Parameter          | Condition                                              | Limits |      |      | Unit |
|--------------------|--------------------------------------------------------|--------|------|------|------|
|                    |                                                        | Min.   | Typ. | Max. |      |
| Mounting torque    | Mounting screw : M3<br>(Note 6) Recommended : 0.69 N·m | 0.59   | —    | 0.78 | N·m  |
| Weight             |                                                        | —      | 10   | —    | g    |
| Heat-sink flatness | (Note 7)                                               | -50    | —    | 100  | μm   |

**Note 6 :** Plain washers (ISO 7089~7094) are recommended.

**Note 7 :** Flatness measurement position



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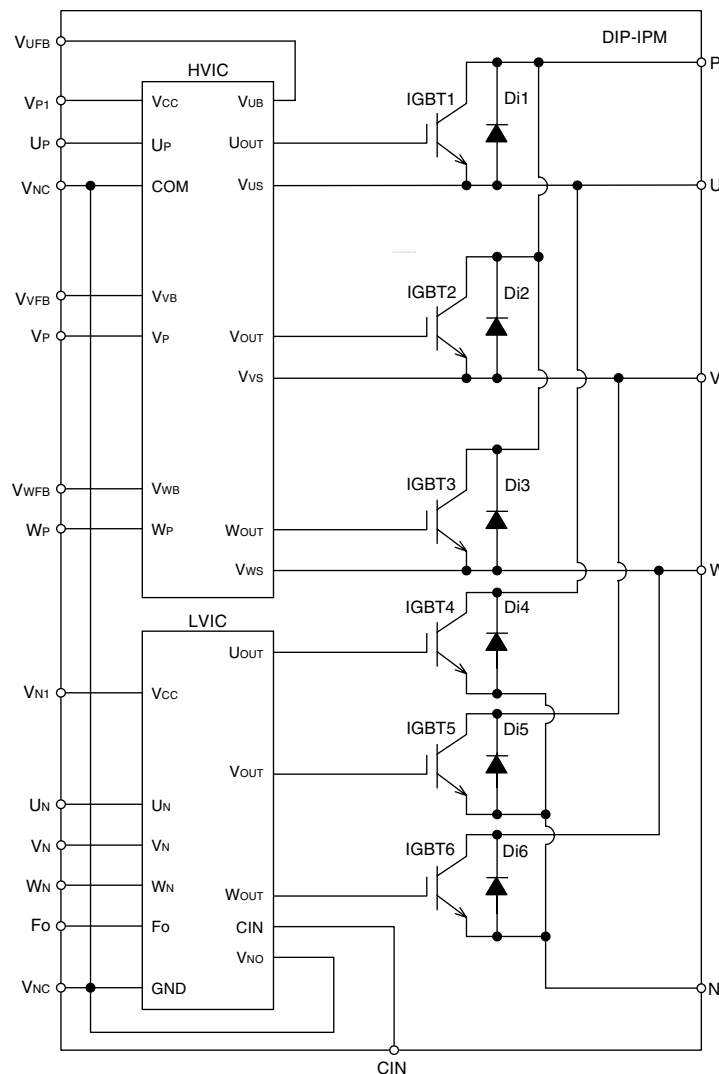
## RECOMMENDED OPERATION CONDITIONS

| Symbol                             | Parameter                           | Condition                                                                                                                                                | Limits                   |      |      | Unit |
|------------------------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------|------|------|
|                                    |                                     |                                                                                                                                                          | Min.                     | Typ. | Max. |      |
| V <sub>CC</sub>                    | Supply voltage                      | Applied between P-N                                                                                                                                      | 0                        | 300  | 400  | V    |
| V <sub>D</sub>                     | Control supply voltage              | Applied between V <sub>P1</sub> -V <sub>NC</sub> , V <sub>N1</sub> -V <sub>NC</sub>                                                                      | 13.5                     | 15.0 | 16.5 | V    |
| V <sub>DB</sub>                    | Control supply voltage              | Applied between V <sub>UFB</sub> -U, V <sub>VFB</sub> -V, V <sub>WFB</sub> -W                                                                            | 13.0                     | 15.0 | 18.5 | V    |
| ΔV <sub>D</sub> , ΔV <sub>DB</sub> | Control supply variation            |                                                                                                                                                          | -1                       | —    | 1    | V/μs |
| t <sub>dead</sub>                  | Arm shoot-through blocking time     | For each input signal, T <sub>c</sub> ≤ 100°C                                                                                                            | 1.5                      | —    | —    | μs   |
| f <sub>PWM</sub>                   | PWM input frequency                 | T <sub>c</sub> ≤ 100°C, T <sub>j</sub> ≤ 125°C                                                                                                           | —                        | —    | 20   | kHz  |
| I <sub>O</sub>                     | Allowable r.m.s. current            | V <sub>CC</sub> = 300V, V <sub>D</sub> = V <sub>DB</sub> = 15V,<br>P.F = 0.8, sinusoidal PWM,<br>T <sub>j</sub> ≤ 125°C, T <sub>c</sub> ≤ 100°C (Note 8) | f <sub>PWM</sub> = 5kHz  | —    | 4.0  | Arms |
|                                    |                                     |                                                                                                                                                          | f <sub>PWM</sub> = 15kHz | —    | 2.5  |      |
| P <sub>WIN(on)</sub>               | Allowable minimum input pulse width | (Note 9)                                                                                                                                                 | 0.5                      | —    | —    | μs   |
| P <sub>WIN(off)</sub>              |                                     |                                                                                                                                                          | 0.5                      | —    | —    |      |
| V <sub>NC</sub>                    | V <sub>NC</sub> variation           | Between V <sub>NC</sub> -N (including surge)                                                                                                             | -5.0                     | —    | 5.0  | V    |

**Note 8 :** The allowable r.m.s. current value depends on the actual application conditions.

**9 :** IPM might not make response if the input signal pulse width is less than the recommended minimum value.

Fig. 7 THE DIP-IPM INTERNAL CIRCUIT



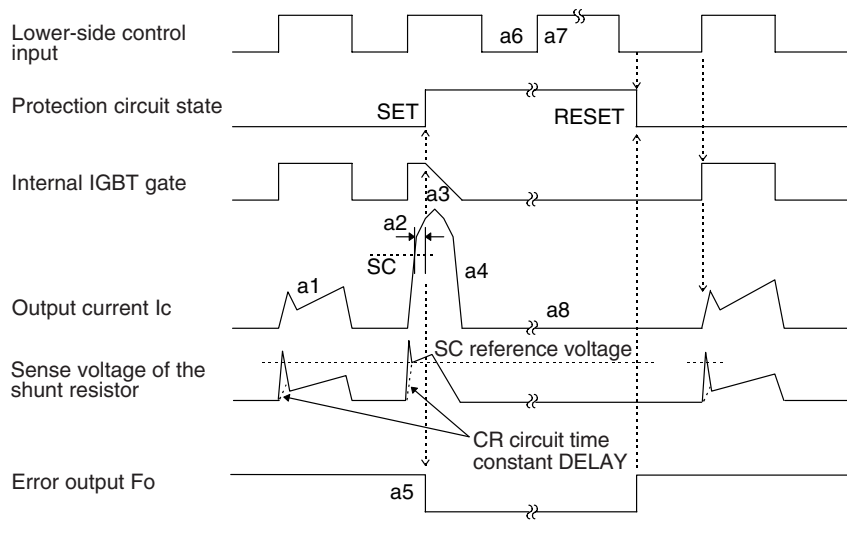
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**Fig. 8 TIMING CHART OF THE DIP-IPM PROTECTIVE FUNCTIONS**

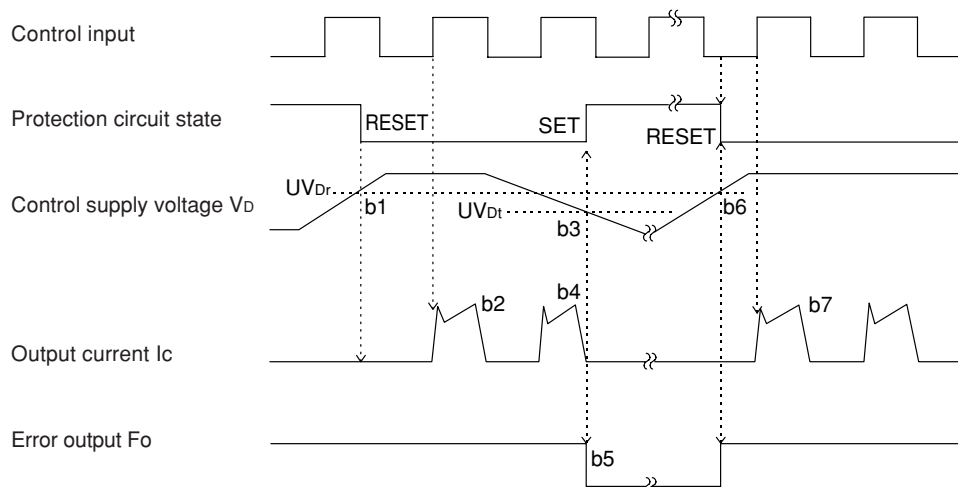
**[A] Short-Circuit Protection (Lower-side only with the external shunt resistor and CR filter)**

- a1. Normal operation : IGBT ON and carrying current.
- a2. Short circuit detection (SC trigger).
- a3. IGBT gate hard interruption.
- a4. IGBT turns OFF.
- a5. Fo outputs ( $t_{FO(min)} = 20\mu s$ ).
- a6. Input "L" : IGBT OFF.
- a7. Input "H" : IGBT ON.
- a8. IGBT OFF in spite of input "H".



**[B] Under-Voltage Protection (Lower-side, UV<sub>D</sub>)**

- b1. Control supply voltage rising : After the voltage level reaches UV<sub>Dr</sub>, the circuits start to operate when next input is applied.
- b2. Normal operation : IGBT ON and carrying current.
- b3. Under voltage trip (UV<sub>Dt</sub>).
- b4. IGBT OFF in spite of control input condition.
- b5. Fo outputs ( $t_{FO} \geq 20\mu s$  and Fo outputs continuously during UV period).
- b6. Under voltage reset (UV<sub>Dr</sub>).
- b7. Normal operation : IGBT ON and carrying current.



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## [C] Under-Voltage Protection (Upper-side, UV<sub>DB</sub>)

- c1. Control supply voltage rising : After the voltage level reaches UV<sub>DBr</sub>, the circuits start to operate when next input is applied.
- c2. Normal operation : IGBT ON and carrying current.
- c3. Under voltage trip (UV<sub>DBt</sub>).
- c4. IGBT OFF in spite of control input signal level, but there is no Fo signal outputs.
- c5. Under voltage reset (UV<sub>DBr</sub>).
- c6. Normal operation : IGBT ON and carrying current.

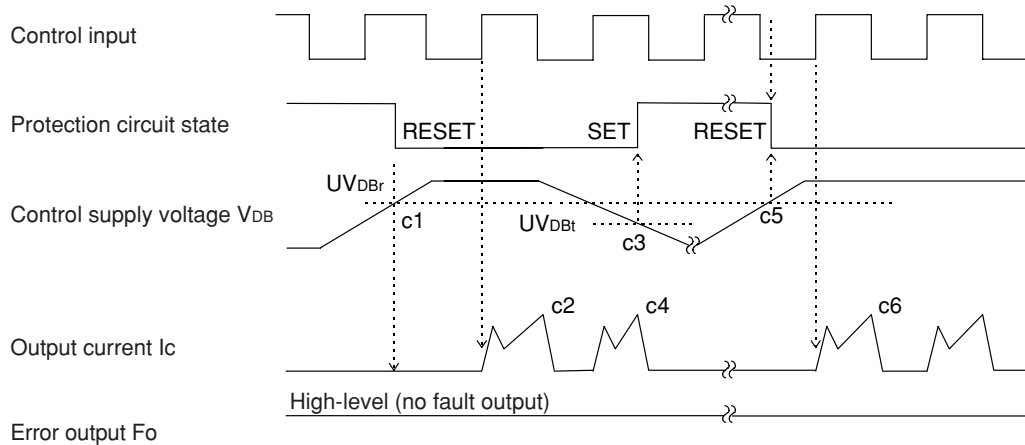
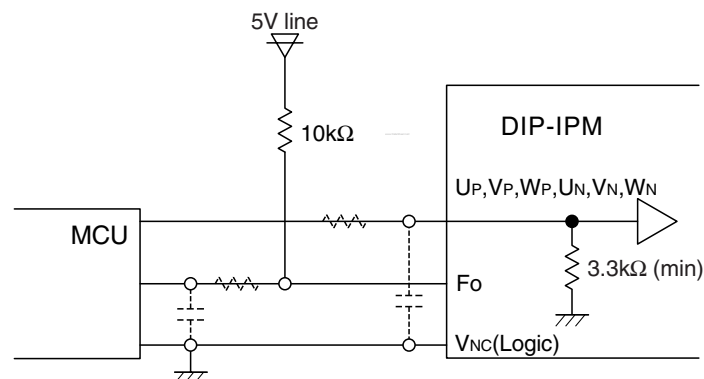


Fig. 9 RECOMMENDED MCU I/O INTERFACE CIRCUIT



**Note :** The setting of RC coupling at each input (parts shown dotted) depends on the PWM control scheme and the wiring impedance of the printed circuit board.  
The DIP-IPM input section integrates a 3.3kΩ (min) pull-down resistor. Therefore, when using an external filtering resistor, pay attention to the turn-on threshold voltage.

Fig. 10 WIRING CONNECTION OF SHUNT RESISTOR

