# PS22A78-E

**Transfer-Mold Type**
**Insulated Type**

TENTATIVE

| Pre. | K.Kuriaki,T.Iwagami,T.Nagahara | Rev. | D | T.Nagahara,M.Sakai,Shang,T.Nakano |
|---|---|---|---|---|
| Apr. | Y.Nagashima 29-Jan-'07 | | | T.Iwagami 4-Jul.-'08 |



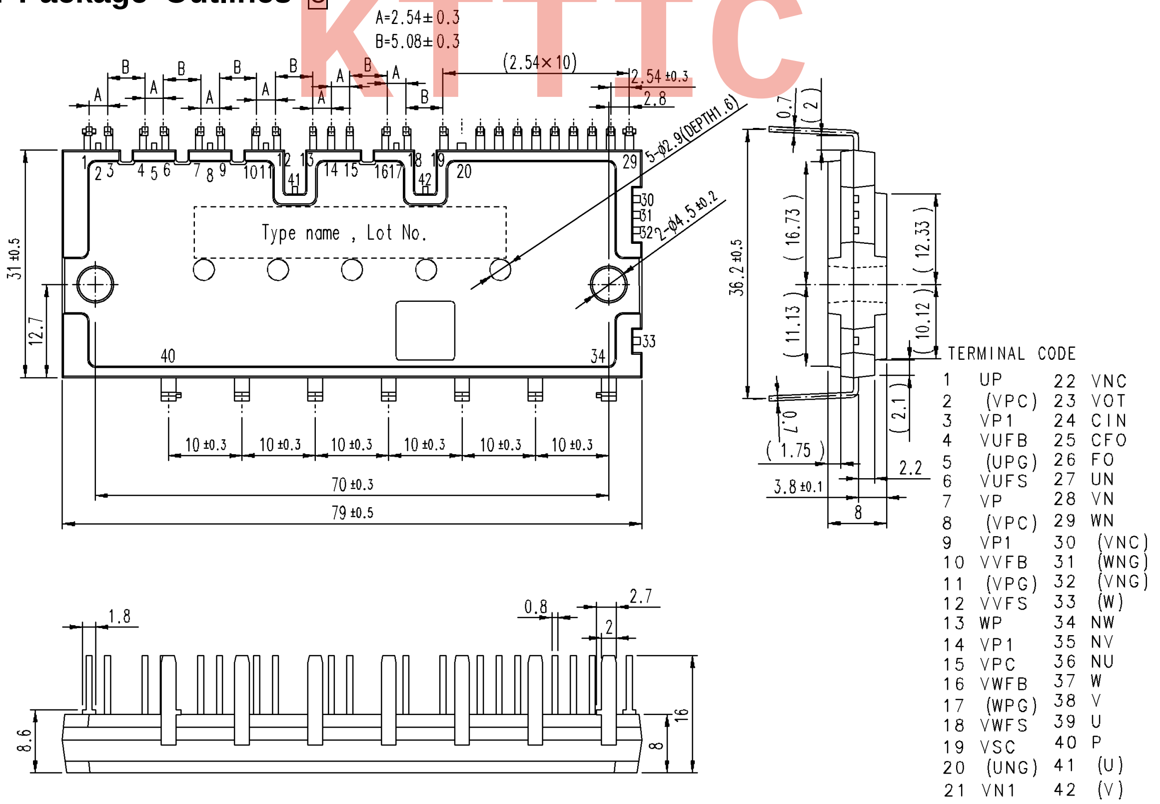
**Applications :** 0.2~5.5kW/AC400Vrms three-phase motor variable speed inverter drive.

**Integrated Power Functions :**
1200V/35A low-loss CSTBT inverter bridge with N-side open emitter structure for DC-to-AC power conversion

**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 a SC fault (N-side IGBT), a UV fault (N-side supply)
- -Input interface : 5V line, Schmitt Trigger receiver circuit (High Active).

**Fig. 1 Package Outlines** C






**Note:**
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Maximum Ratings (Tj=25°C, unless otherwise noted):
Inverter Part:

| Item | Symbol | Condition | Rating | Unit |
|---|---|---|---|---|
| Supply voltage | $V_{CC}$ | Applied between P-NU,NV,NW | 900 | V |
| Supply voltage (surge) | $V_{CC(surge)}$ | Applied between P-NU,NV,NW | 1000 | V |
| Collector-emitter voltage | $V_{CES}$ | | 1200 | V |
| Each IGBT collector current | $\pm I_C$ | Tc=25°C | 35 | A |
| Each IGBT collector current (peak) | $\pm I_{CP}$ | Tc=25°C, less than 1ms | 70 | A |
| Collector dissipation | $P_C$ | Tc=25°C, per 1 chip | (129.9) | W |
| Junction temperature | $T_j$ | | -20~+150 | °C |

Control (Protection) Part

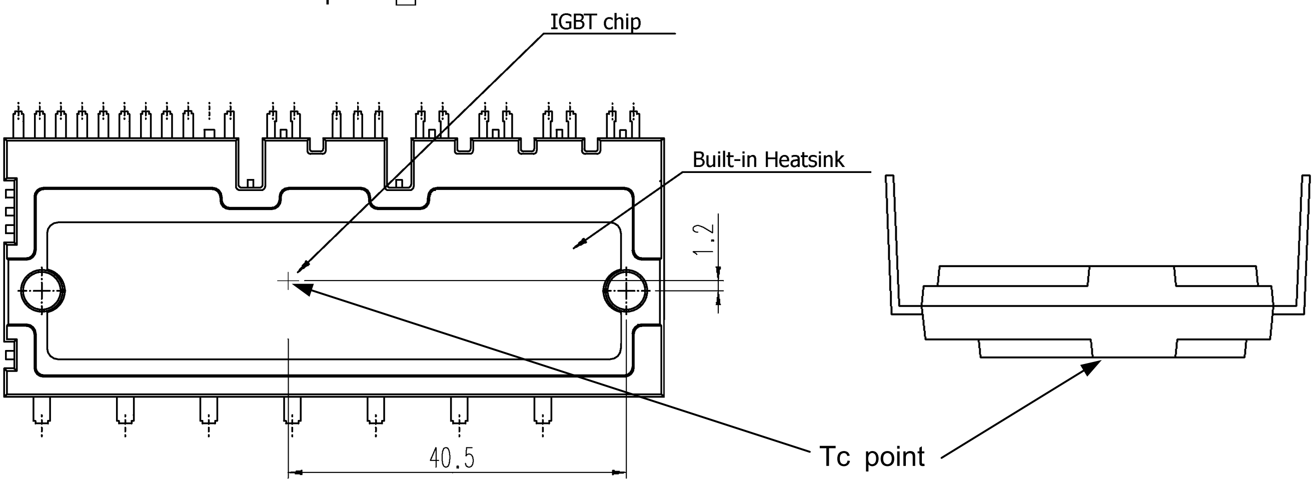
| Item | Symbol | Condition | Rating | Unit |
|---|---|---|---|---|
| Control supply voltage | $V_D$ | Applied between $V_{P1}$-$V_{PC}$,$V_{N1}$-$V_{NC}$ | 20 | V |
| Control supply voltage | $V_{DB}$ | Applied between $V_{UFB}$-$V_{UFS}$, $V_{VFB}$-$V_{VFS}$ ,$V_{WFB}$-$V_{WFS}$ | 20 | V |
| Input voltage | $V_{IN}$ | Applied between $U_P$,$V_P$,$W_P$-$V_{PC}$, $U_N$,$V_N$,$W_N$-$V_{NC}$ | -0.5~$V_D$+0.5 | V |
| Fault output supply voltage | $V_{FO}$ | Applied between Fo-$V_{NC}$ | -0.5~$V_D$+0.5 | V |
| Fault output current | $I_{FO}$ | Sink current at Fo terminal | 1 | mA |
| Current sensing input voltage | $V_{SC}$ | Applied between CIN-$V_{NC}$ | -0.5~$V_D$+0.5 | V |



Total System

| Item | Symbol | Condition | Rating | Unit |
|---|---|---|---|---|
| Self protection supply voltage limit (short circuit protection capability) | $V_{CC(PROT)}$ | $V_D$=13.5~16.5V, Inverter part Tj=125°C, non-repetitive less than 2μs | 800 | V |
| Module case operation temperature | Tc | (Note 1) | -20~+100 | °C |
| Storage temperature | Tstg | | -40~+125 | °C |
| Isolation voltage | Viso | 60Hz, Sinusoidal, AC 1 minute, connection pins to heat sink plate | 2500 | Vrms |

Note 1: Tc measurement point



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Thermal Resistance :

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Junction to case thermal resistance | $R_{th(j-c)Q}$ | Inverter IGBT part (per 1/6 module) | - | - | (0.77) | °C / W |
| | $R_{th(j-c)F}$ | Inverter FWDi part (per 1/6 module) | - | - | (1.25) | |

(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.

Electrical Characteristics (Tj=25°C, unless otherwise noted ) :
Inverter Part

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | $V_D$=$V_{DB}$=15V $V_{IN}$=5V, $I_C$=35A, | Tj=25°C | - | (1.9) | (2.6) | V |
| | | | Tj=125°C | - | (2.0) | (2.7) | |
| FWDi forward voltage B | $V_{EC}$ | $V_{IN}$=0V, -$I_C$=35A | | - | (2.8) | (3.3) | V |
| Switching time A | $t_{on}$ | $V_{CC}$=600V, $V_D$=$V_{DB}$=15V $I_C$=35A, $V_{IN}$=0-5V Tj=125°C Inductive load | | (0.8) | (1.5) | (2.2) | μs |
| | $t_{rr}$ | | | - | (0.3) | - | |
| | $t_{c(on)}$ | | | - | (0.6) | (0.9) | |
| | $t_{off}$ | | | - | (2.8) | (3.8) | |
| | $t_{c(off)}$ | | | - | (0.7) | (1.0) | |
| Collector-emitter cut-off current | $I_{CES}$ | $V_{CE}$=$V_{CES}$ | Tj=25°C | - | - | 1 | mA |
| | | | Tj=125°C | - | - | 10 | |

Control (Protection) Part :

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Circuit current | $I_D$ | $V_D$=$V_{DB}$=15V $V_{IN}$=5V | Total of $V_{P1}$-$V_{PC}$,$V_{N1}$-$V_{NC}$ | - | - | (3.70) | mA |
| | | | $V_{UFB}$-$V_{UFS}$,$V_{VFB}$-$V_{VFS}$,$V_{WFB}$-$V_{WFS}$ | - | - | (1.30) | |
| | | $V_D$=$V_{DB}$=15V $V_{IN}$=0V | Total of $V_{P1}$-$V_{PC}$,$V_{N1}$-$V_{NC}$ | - | - | (3.50) | |
| | | | $V_{UFB}$-$V_{UFS}$,$V_{VFB}$-$V_{VFS}$,$V_{WFB}$-$V_{WFS}$ | - | - | (1.30) | |
| Fo output voltage | $V_{FOH}$ | Vsc=0V, Fo terminal pull-up to 5V by 10kΩ | | 4.9 | - | - | V |
| | $V_{FOL}$ | Vsc=1V, $I_{FO}$=1mA | | - | - | 1.10 | |
| Input current | $I_{IN}$ | $V_{IN}$=5V | | 0.7 | 1.5 | 2.0 | mA |
| Short circuit trip level C | $I_{SC}$ | −20°C≤Tj≤125°C, $V_D$=15V (Note 3) | | (59.5) | - | ( - ) | A |
| Control supply under-voltage protection | $UV_{DBt}$ | Tj≤125°C | Trip level | 10.0 | - | 12.0 | V |
| | $UV_{DBr}$ | | Reset level | 10.5 | - | 12.5 | |
| | $UV_{Dt}$ | | Trip level | 10.3 | - | 12.5 | |
| | $UV_{Dr}$ | | Reset level | 10.8 | - | 13.0 | |
| Fault output pulse width | $t_{FO}$ | $C_{FO}$=22nF (Note 4) | | (1.6) | (2.4) | - | ms |
| ON threshold voltage A | Vth(on) | Applied between $U_P$,$V_P$,$W_P$-$V_{PC}$, $U_N$,$V_N$,$W_N$-$V_{NC}$ | | - | - | (3.5) | V |
| OFF threshold voltage | Vth(off) | | | (0.8) | - | - | |
| Temperature output C | $V_{OT}$ | LVIC temperature = 85°C (Note 5) | | (3.50) | (3.63) | (3.76) | V |

(Note 3) Short circuit protection is functioning only for N-side IGBTs.
About rating and external resistance Rs for detecting short circuit are under consideration. C
(Note 4) Fault signal is output when short circuit or control supply under-voltage protective functions operate at N-side.
The fault output pulse-width $t_{FO}$ depends on the capacitance value of $C_{FO}$ ($C_{FO}$= 9.3 × $10^{-6}$ × $t_{FO}$ [F])
(Note 5) DIPIPM don't shutdown IGBTs and output fault signal automatically when temperature rises excessively.
When temperature exceeds the protect level that customer defined, controller (MCU) should stop the DIPIPM. C

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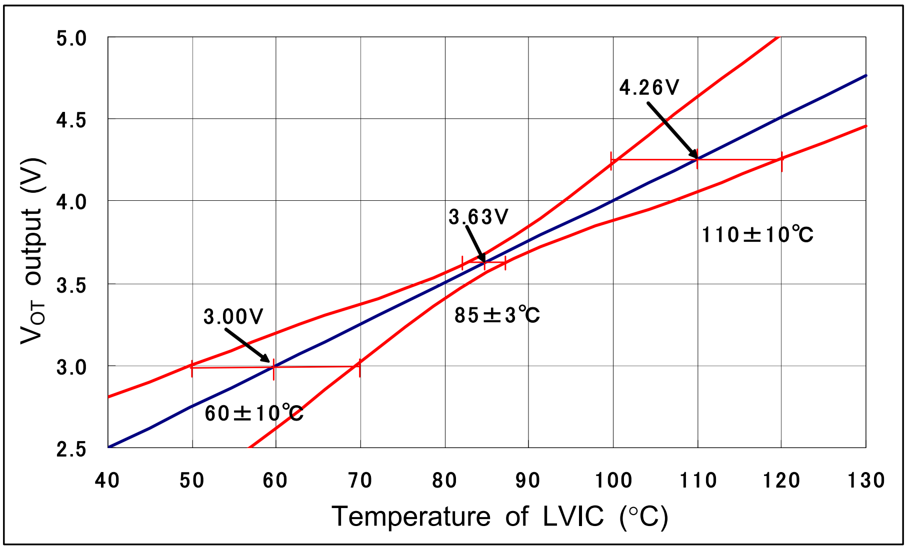
Fig.2 Temperature of LVIC - $V_{OT}$ output characteristics C

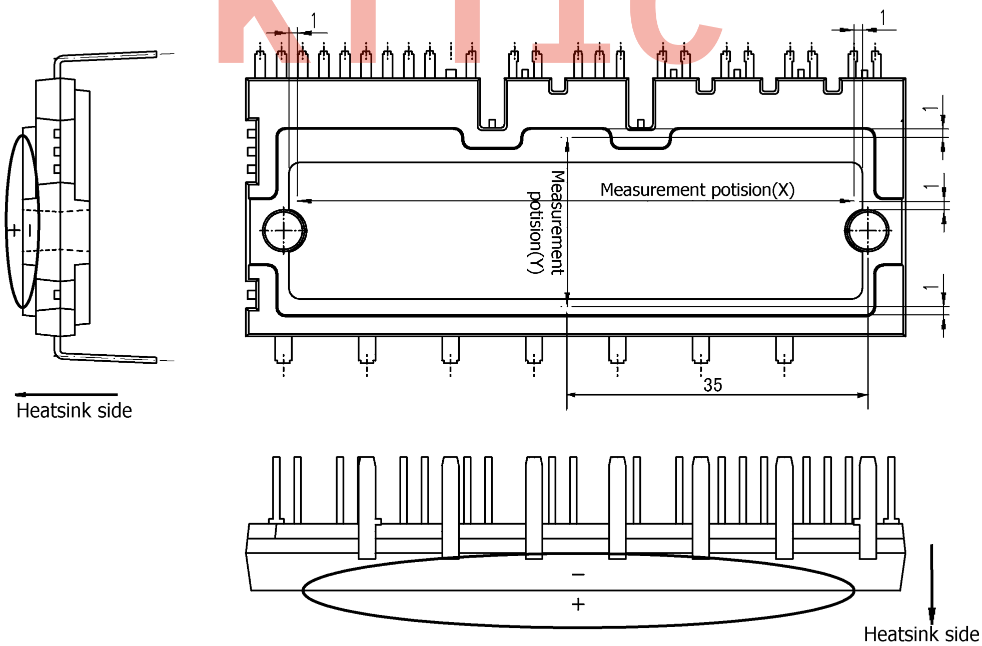



Mechanical Characteristics and Ratings:

| Item | Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Mounting torque | Mounting screw: (M4) | Recommended: 1.18N·m | (0.98) | – | (1.47) | N·m |
| Weight | | | – | (65) | – | g |
| Heat sink flatness | | (Note 6) | (–50) | – | (100) | μm |

Note 6: Flatness measurement position D





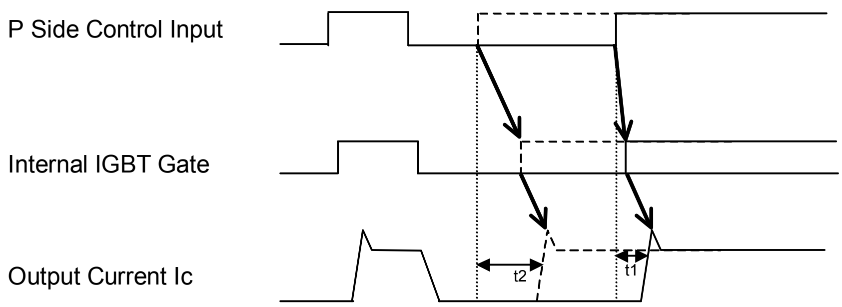
Recommended Operation Conditions :

| Item | Symbol | Condition | Recommended Min. | Recommended Typ. | Recommended Max. | Unit |
|---|---|---|---|---|---|---|
| Supply voltage | $V_{CC}$ | Applied between P-NU,NV,NW | 350 | 600 | 800 | V |
| Control supply voltage | $V_D$ | Applied between $V_{P1}$-$V_{PC}$,$V_{N1}$-$V_{NC}$ | 13.5 | 15.0 | 16.5 | V |
| Control supply voltage D | $V_{DB}$ | Applied between $V_{UFB}$-$V_{UFS}$,$V_{VFB}$-$V_{VFS}$,$V_{WFB}$-$V_{WFS}$ | 13.0 | 15.0 | 18.5 | V |
| Control supply variation | $\Delta V_D$,$\Delta V_{DB}$ | | -1 | - | +1 | V/μs |
| Arm-shoot-through blocking time | $t_{dead}$ | For each input signal, $T_C \le 100°C$ | (3.3) | - | - | μs |
| PWM input frequency | $f_{PWM}$ | $T_C \le 100°C$, $T_j \le 125°C$ | - | - | (15) | kHz |
| Allowable rms current | $I_O$ | $V_{CC}$=600V, $V_D$=15V, $f_C$=15kHz, P.F=0.8, Sinusoidal PWM, $T_C \le 100°C$, $T_j \le 125°C$ (Note 7) | - | - | (12.8) | $A_{rms}$ |
| Minimum input pulse width D | PWIN(on) | (Note 8) | (-) | - | - | μs |
| | PWIN(off) | $350 \le V_{CC} \le 800V$, $13.5 \le V_D \le 16.5V$, $13.5 \le V_{DB} \le 16.5V$, $-20 \le T_C \le 100°C$, N line wiring inductance less than 10nH (Note 9); $I_C \le 35A$ | (-) | - | - | μs |
| | PWIN(off) | $350 \le V_{CC} \le 800V$, $13.5 \le V_D \le 16.5V$, $13.5 \le V_{DB} \le 16.5V$, $-20 \le T_C \le 100°C$, N line wiring inductance less than 10nH (Note 9); $35 < I_C \le 59.5A$ | (-) | - | - | μs |
| $V_{NC}$ variation | $V_{NC}$ | Potential difference between $V_{NC}$-NU,NV,NW including surge voltage | -5.0 | - | +5.0 | V |
| Junction temperature | Tj | | -20 | - | 125 | °C |

(Note 7) The allowable output rms current also depends on user application conditions.
(Note 8) DIPIPM might make no response to the input on signal with pulse width less than PWIN(on).
(Note 9) IPM might make delayed response (less than about 2μs) or no response for the input signal with off pulse width less than PWIN(off). Please refer Fig. 3 about delayed response. C

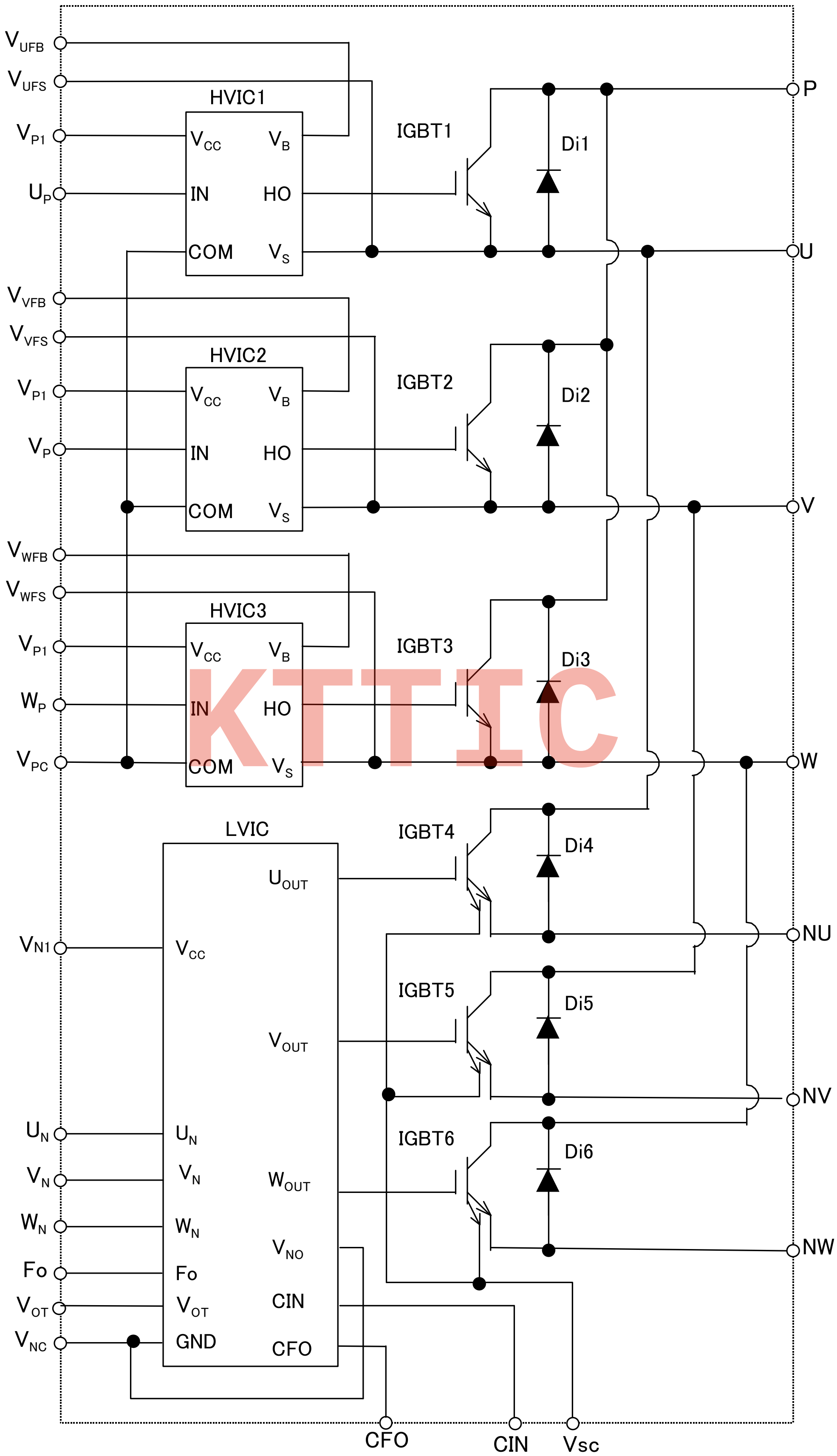


**Fig.3 About Delayed Response Against Shorter Input Off Signal Than PWIN(off)** **(P side only)** C



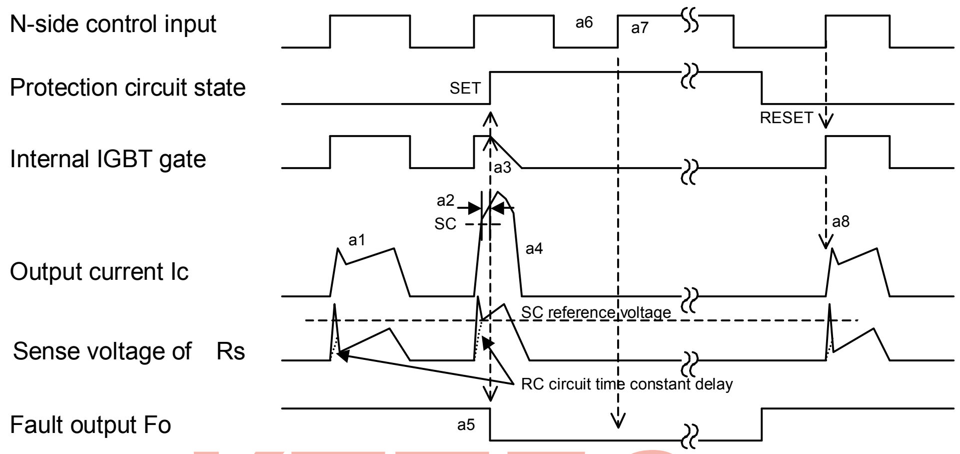

Real line···off pulse width>PWIN(off); turn on time t1
Broken line···off pulse width<PWIN(off); turn on time t2

**Fig.4 DIPIPM Internal Circuit**



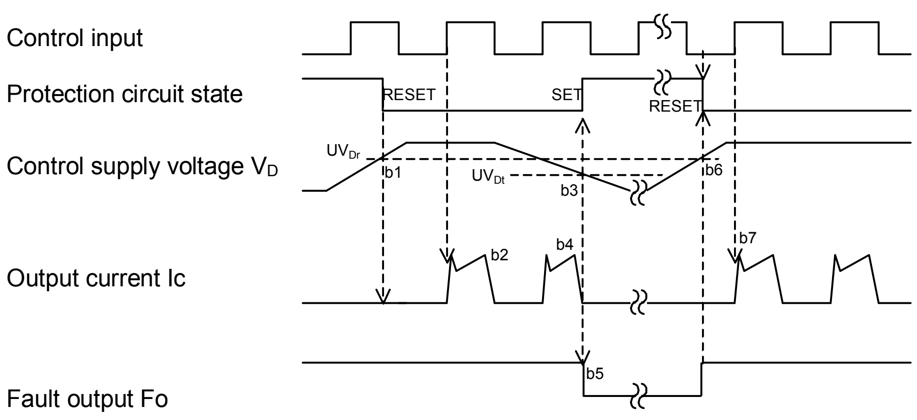
## Fig.5 Timing Charts of the Protective Functions

[A] Short-Circuit Protection ( N-side only, with external resistor and RC filter )
a1. Normal operation: IGBT turn on and carry current.
a2. Short circuit current detected (SC trigger).
a3. All N-side IGBTs' gates are hard interrupted.
a4. All N-side IGBTs turn OFF.
a5. Fo output with a fixed pulse width (determined by the external capacitance $C_{FO}$).
a6. Input “L”: IGBT off.
a7. Input “H”: IGBT on, but during the Fo output period the IGBT will not turn on.
a8. IGBT turns ON when L→H signal is input after Fo is reset.



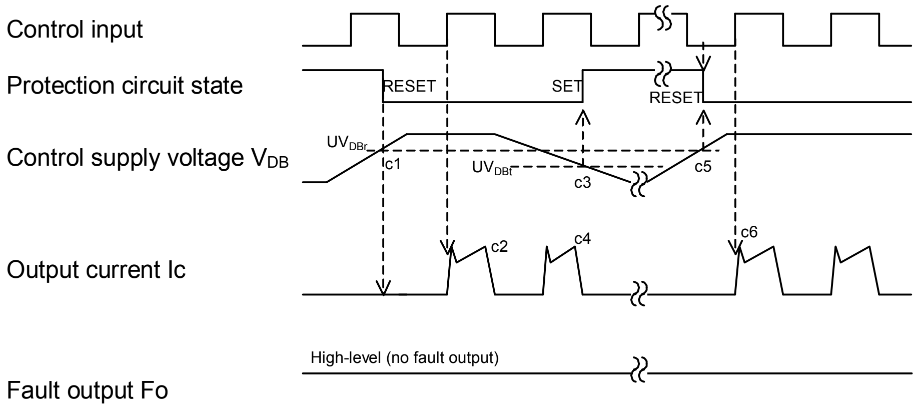



[B] Under- Voltage Protection (N-side, $UV_D$)
b1. Control supply voltage $V_D$ rises: After $V_D$ level reaches under voltage reset level ($UV_{Dr}$), the circuits start to operate when next input is applied.
b2. Normal operation: IGBT turn on and carry current.
b3. $V_D$ level dips to under voltage trip level. ($UV_{Dt}$).
b4. All N-side IGBTs turn OFF in spite of control input condition.
b5. Fo is output for the period determined by the capacitance $C_{FO}$ but continuously during UV period.
b6. $V_D$ level reaches $UV_{Dr}$.
b7. Normal operation: IGBT turn on and carry current.

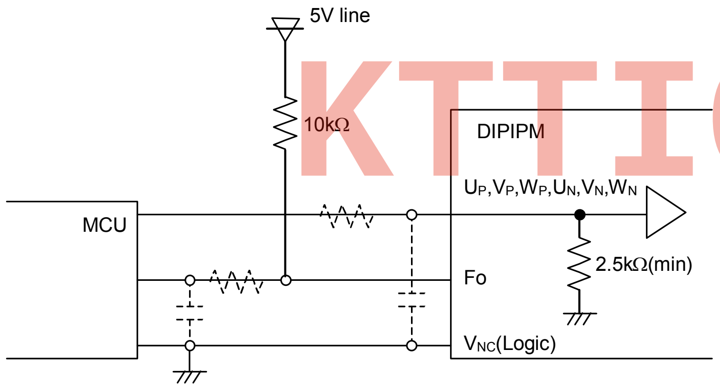


[C] Under- Voltage Protection (P-side, $UV_{DB}$ )

c1. Control supply voltage $V_{DB}$ rises : After $V_{DB}$ level reaches under voltage reset level ($UV_{DBr}$), the circuits start to operate when next input is applied.
c2. Normal operation: IGBT turn on and carry current.
c3. $V_{DB}$ level dips to under voltage trip level ($UV_{DBt}$).
c4. P-side IGBT turns OFF in spite of control input signal level, but there is no Fo signal output.
c5. $V_{DB}$ level reaches $UV_{DBr}$.
c6. Normal operation: IGBT turn on and carry current.



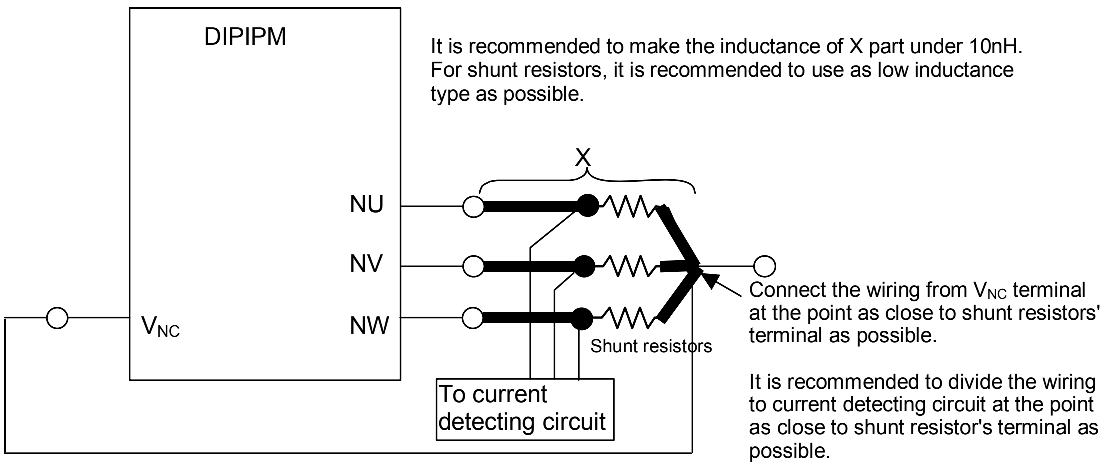

## Fig.6 An Instance of Interface Circuit




Note) RC coupling at each input (parts shown dotted) may change depending on the PWM control scheme used in the application and the wiring impedance of the application's printed circuit board. The DIPIPM input signal section integrates a 2.5kΩ(min) pull-down resistor. Therefore, when using a external filtering resistor, care must be taken to satisfy the turn-on threshold voltage requirement.



## Fig.7 An Instance of Current Detecting Part C

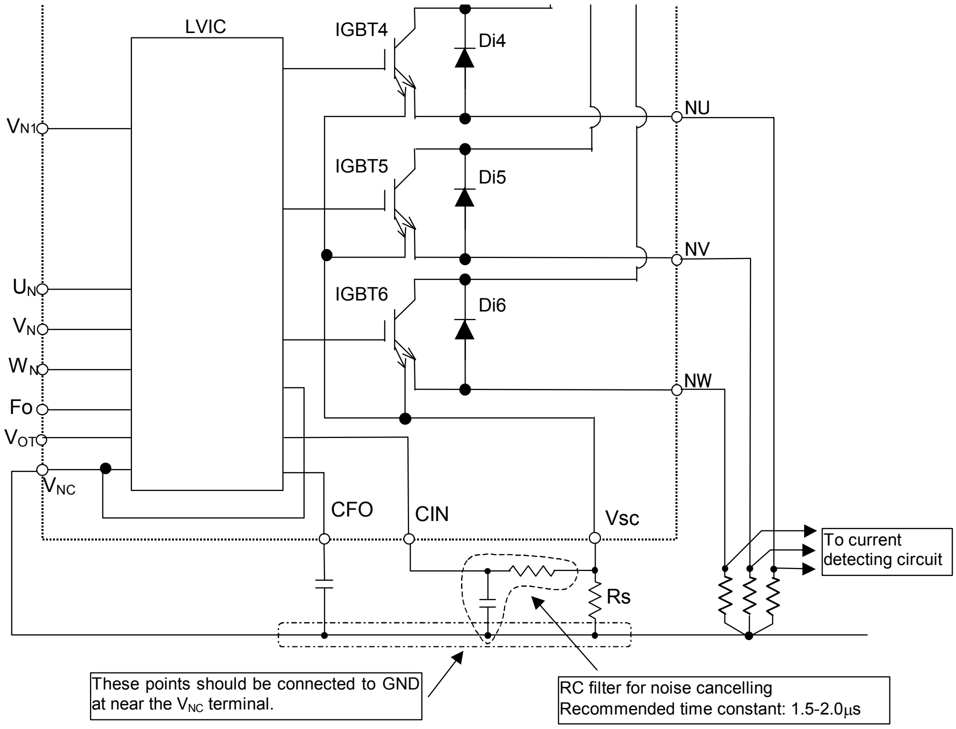



It is recommended to make the inductance of X part under 10nH. For shunt resistors, it is recommended to use as low inductance type as possible.

Connect the wiring from $V_{NC}$ terminal at the point as close to shunt resistors' terminal as possible.

It is recommended to divide the wiring to current detecting circuit at the point as close to shunt resistor's terminal as possible.

## Fig.8 An Instance of SC Protection Circuit



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