PS21993-4E/-4AE/-4CE/-4EW

TRANSFER-MOLD TYPE
INSULATED TYPE

PS21993-4E

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

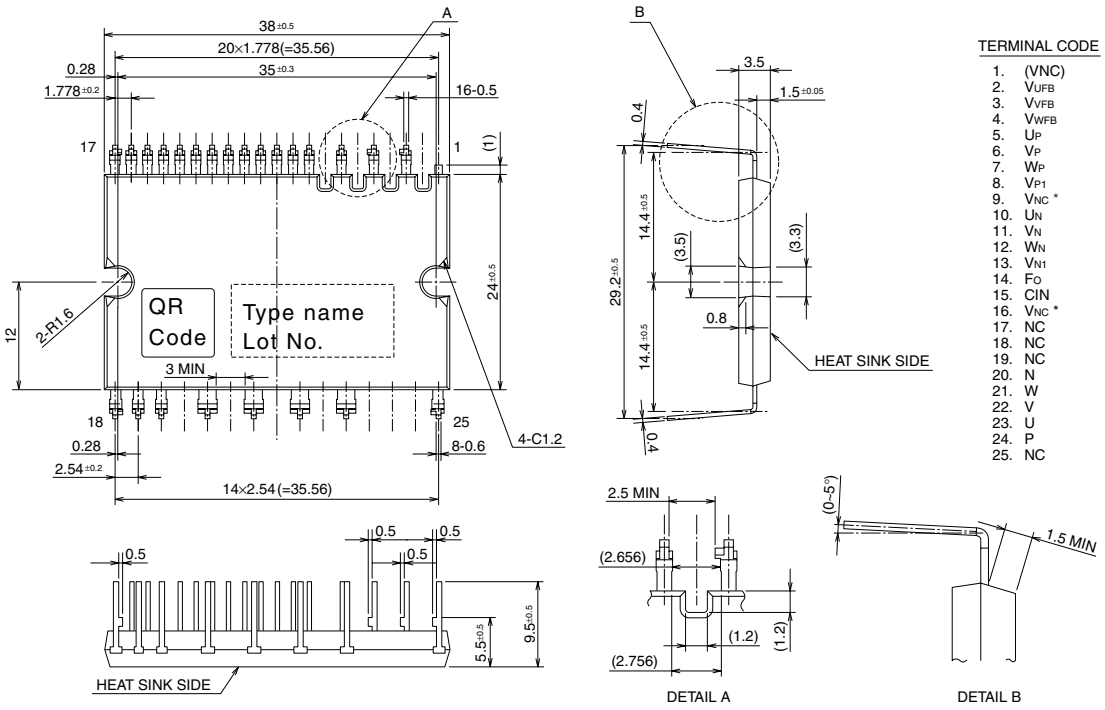
- For P-side : Drive circuit, High voltage high-speed level shifting, Control supply under-voltage (UV) protection.
- For N-side : Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC).
- Fault signaling : Corresponding to a SC fault (N-side IGBT), a UV fault (N-side supply).
- Input interface : 3~5V line (High Active).
- UL Recognized : Yellow Card No. E80276

APPLICATION

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

Fig. 1 PACKAGE OUTLINES (PS21993-4E)

Dimensions in mm



TERMINAL CODE

1. (VNC)
2. V_{UFB}
3. V_{VFB}
4. V_{WFB}
5. U_P
6. V_P
7. W_P
8. V_{P1}
9. V_{NC} *
10. U_N
11. V_N
12. W_N
13. V_{N1}
14. F_O
15. CIN
16. V_{NC} *
17. NC
18. NC
19. NC
20. N
21. W
22. V
23. U
24. P
25. NC

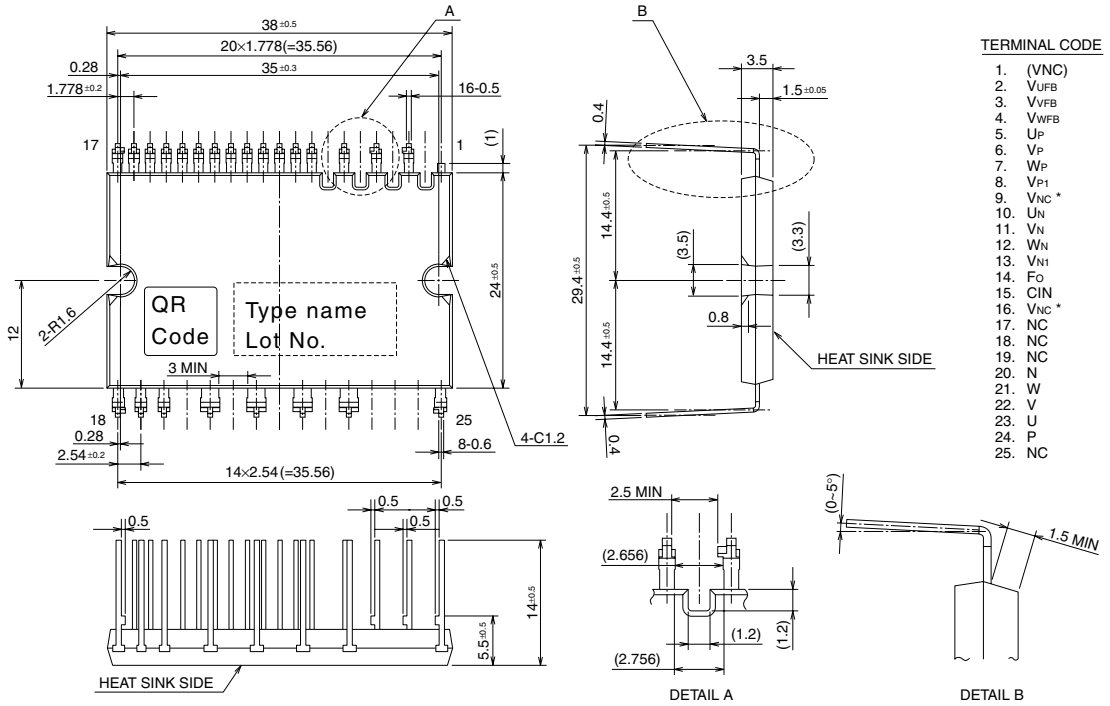
*) Two V_{NC} terminals (9 & 16 pin) are connected inside DIPIPM, please connect either one to the 15V power supply GND outside and leave another one open.

Note : CSTBT is registered trademark of MITSUBISHI ELECTRIC CORPORATION in Japan.

MITSUBISHI ELECTRIC

Fig. 2 LONG TERMINAL TYPE PACKAGE OUTLINES (PS21993-4AE)

Dimensions in mm



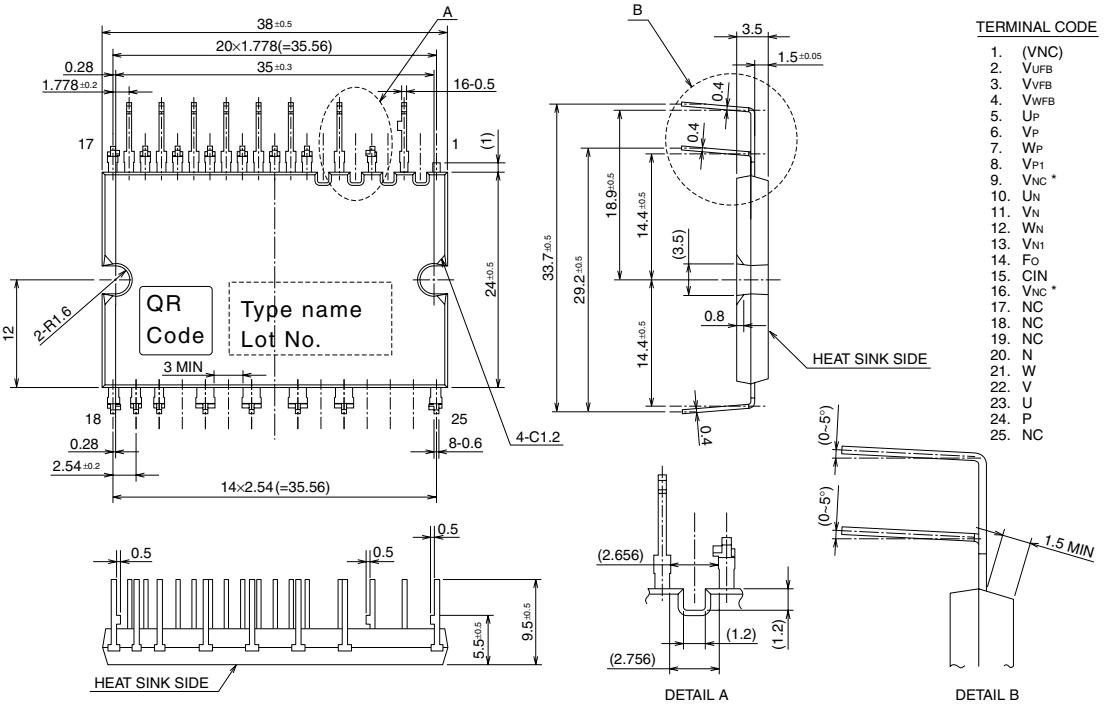
TERMINAL CODE

1. (VNC)
2. V_{UFB}
3. V_{VFB}
4. V_{WFB}
5. U_P
6. V_P
7. W_P
8. V_{P1}
9. V_{NC} *
10. U_N
11. V_N
12. W_N
13. V_{N1}
14. F_O
15. CIN
16. V_{NC} *
17. NC
18. NC
19. NC
20. N
21. W
22. V
23. U
24. P
25. NC

*) Two V_{NC} terminals (9 & 16 pin) are connected inside DIPIPM, please connect either one to the 15V power supply GND outside and leave another one open.

Fig. 3 ZIGZAG TERMINAL TYPE PACKAGE OUTLINES (PS21993-4CE)

Dimensions in mm



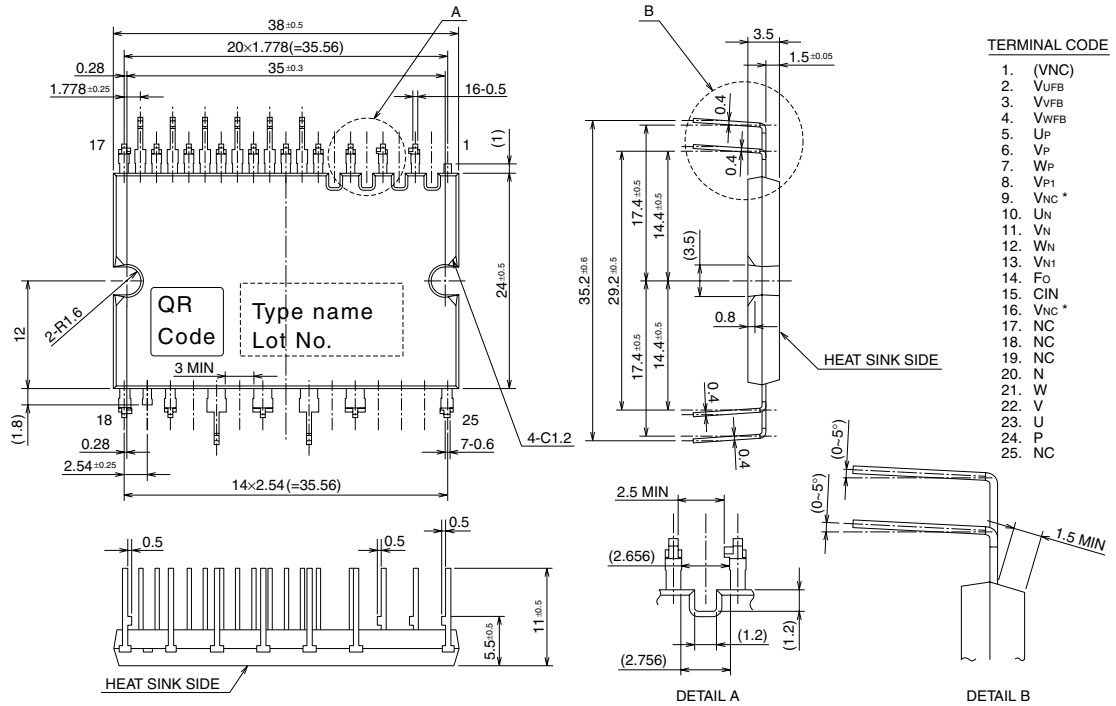
TERMINAL CODE

1. (VNC)
2. V_{UFB}
3. V_{VFB}
4. V_{WFB}
5. U_P
6. V_P
7. W_P
8. V_{P1}
9. V_{NC} *
10. U_N
11. V_N
12. W_N
13. V_{N1}
14. F_O
15. CIN
16. V_{NC} *
17. NC
18. NC
19. NC
20. N
21. W
22. V
23. U
24. P
25. NC

*) Two V_{NC} terminals (9 & 16 pin) are connected inside DIPIPM, please connect either one to the 15V power supply GND outside and leave another one open.

Fig. 4 BOTH SIDES ZIGZAG TERMINAL TYPE PACKAGE OUTLINES (PS21993-4EW)

Dimensions in mm



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

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

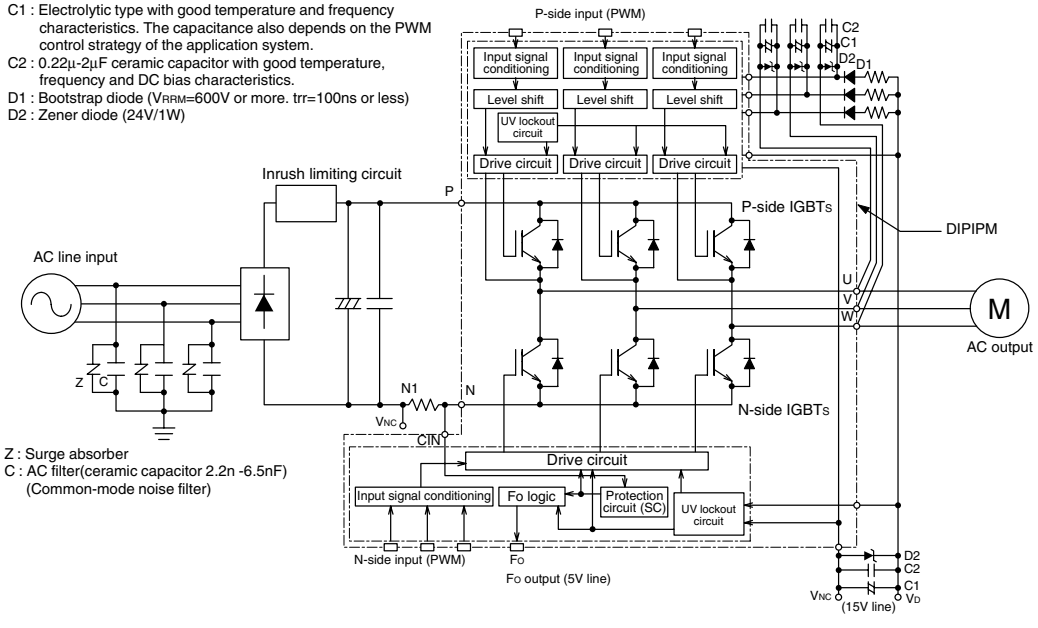
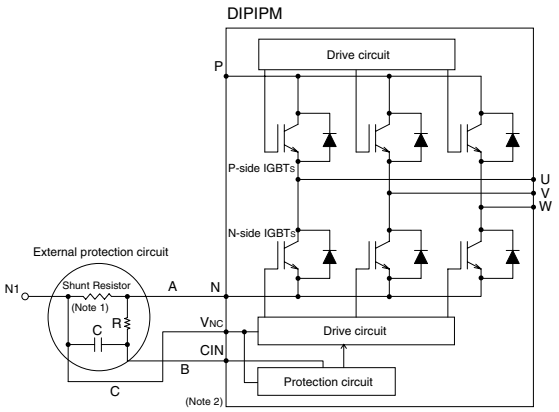
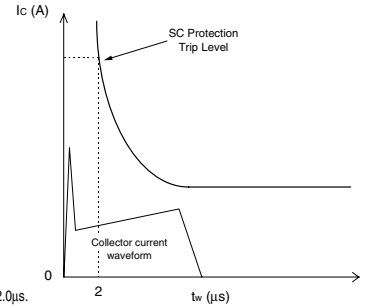


Fig. 6 EXTERNAL PART OF THE DIPIPM PROTECTION CIRCUIT



Short Circuit Protective Function (SC) :
SC protection is achieved by sensing the N-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 N-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.



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.

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

INVERTER PART

Symbol	Parameter	Condition	Ratings	Unit
V_{CC}	Supply voltage	Applied between P-N	450	V
$V_{CC(surge)}$	Supply voltage (surge)	Applied between P-N	500	V
V_{CES}	Collector-emitter voltage		600	V
±I_C	Each IGBT collector current	T_C = 25°C	8	A
±I_{CP}	Each IGBT collector current (peak)	T_C = 25°C, less than 1ms	16	A
P_C	Collector dissipation	T_C = 25°C, per 1 chip	24.3	W
T_j	Junction temperature	(Note 1)	–20~+125	°C

Note 1 : The maximum junction temperature rating of the power chips integrated within the DIPIPM is 150°C (@ $T_C \leq$ 100°C). However, to ensure safe operation of the DIPIPM, the average junction temperature should be limited to $T_{j(ave)} \leq$ 125°C (@ $T_C \leq$ 100°C).

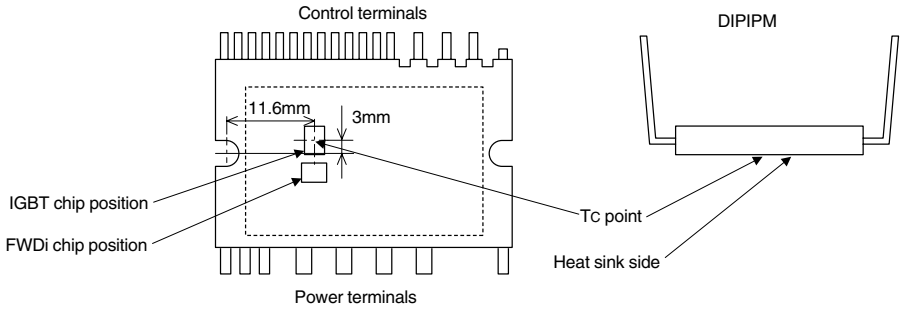
CONTROL (PROTECTION) PART

Symbol	Parameter	Condition	Ratings	Unit
V_D	Control supply voltage	Applied between V_{P1}-V_{NC}, V_{N1}-V_{NC}	20	V
V_{DB}	Control supply voltage	Applied between V_{UFB}-U, V_{VFB}-V, V_{WFB}-W	20	V
V_{IN}	Input voltage	Applied between U_P, V_P, W_P, U_N, V_N, W_N-V_{NC}	–0.5~V_D+0.5	V
V_{FO}	Fault output supply voltage	Applied between F_O-V_{NC}	–0.5~V_D+0.5	V
I_{FO}	Fault output current	Sink current at F_O terminal	1	mA
V_{SC}	Current sensing input voltage	Applied between CIN-V_{NC}	–0.5~V_D+0.5	V

TOTAL SYSTEM

Symbol	Parameter	Condition	Ratings	Unit
$V_{CC(PROT)}$	Self protection supply voltage limit (short circuit protection capability)	V_D = 13.5~16.5V, Inverter part T_j = 125°C, non-repetitive, less than 2μs	400	V
T_C	Module case operation temperature	(Note 2)	–20~+100	°C
T_{stg}	Storage temperature		–40~+125	°C
V_{iso}	Isolation voltage	60Hz, Sinusoidal, 1 minute, Between pins and heat sink plate	1500	V_{rms}

Note 2: T_C measurement point



THERMAL RESISTANCE

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
$R_{th(j-c)Q}$	Junction to case thermal resistance (Note 3)	Inverter IGBT part (per 1/6 module)	—	—	4.1	°C/W
$R_{th(j-c)F}$		Inverter FWDi part (per 1/6 module)	—	—	5.4	°C/W

Note 3: Grease with good thermal conductivity and long-term quality should be applied evenly with +100μm~+200μm on the contacting surface of DIPIPM and heat sink.
The contacting thermal resistance between case and heat sink ($R_{th(c-f)}$) is determined by the thickness and the thermal conductivity of the applied grease.
For reference, $R_{th(c-f)}$ (per 1/6 module) is about 0.3°C/W when the grease thickness is 20μm and the thermal conductivity is 1.0W/mK.

ELECTRICAL CHARACTERISTICS (T_j = 25°C, unless otherwise noted)

INVERTER PART

Symbol	Parameter	Condition		Limits			Unit
				Min.	Typ.	Max.	
$V_{CE(sat)}$	Collector-emitter saturation voltage	V_D = V_{DB} = 15V, V_{IN} = 5V	I_C = 8A, T_j = 25°C	—	1.60	2.10	V
			I_C = 8A, T_j = 125°C	—	1.70	2.20	
V_{EC}	FWDi forward voltage	T_j = 25°C, –I_C = 8A, V_{IN} = 0V		—	1.90	2.35	V
t_{on}	Switching times	V_{CC} = 300V, V_D = V_{DB} = 15V I_C = 8A, T_j = 125°C, V_{IN} = 0 ↔ 5V Inductive load (upper-lower arm)		0.60	1.10	1.70	μs
t_{rr}				—	0.30	—	μs
$t_{c(on)}$				—	0.40	0.60	μs
t_{off}				—	1.50	2.35	μs
$t_{c(off)}$				—	0.40	1.00	μs
I_{CES}	Collector-emitter cut-off current	V_{CE} = V_{CES}	T_j = 25°C	—	—	1	mA
			T_j = 125°C	—	—	10	

CONTROL (PROTECTION) PART

Symbol	Parameter	Condition		Limits			Unit
				Min.	Typ.	Max.	
I_D	Circuit current	$V_D = V_{DB} = 15V$, $V_{IN} = 5V$	Total of V_{P1}-V_{NC}, V_{N1}-V_{NC}	—	—	2.80	mA
			V_{UFB}-U, V_{VFB}-V, V_{WFB}-W	—	—	0.55	mA
		$V_D = V_{DB} = 15V$, $V_{IN} = 0V$	Total of V_{P1}-V_{NC}, V_{N1}-V_{NC}	—	—	2.80	mA
			V_{UFB}-U, V_{VFB}-V, V_{WFB}-W	—	—	0.55	mA
V_{FOH}	Fault output voltage	V_{SC} = 0V, F_O terminal pull-up to 5V by 10kΩ		4.9	—	—	V
V_{FOL}		V_{SC} = 1V, I_{FO} = 1mA		—	—	0.95	V
$V_{SC(ref)}$	Short circuit trip level	V_D = 15V (Note 4)		0.43	0.48	0.53	V
I_{IN}	Input current	V_{IN} = 5V		0.70	1.00	1.50	mA
UV_{DBt}	Control supply under-voltage protection	$T_j \leq 125°C$	Trip level	10.0	—	12.0	V
UV_{DBr}			Reset level	10.5	—	12.5	V
UV_{Dt}			Trip level	10.3	—	12.5	V
UV_{Dr}			Reset level	10.8	—	13.0	V
t_{FO}	Fault output pulse width	(Note 5)		20	—	—	µs
$V_{th(on)}$	ON threshold voltage	Applied between U_P, V_P, W_P, U_N, V_N, W_N-V_{NC}		—	2.1	2.6	V
$V_{th(off)}$	OFF threshold voltage			0.8	1.3	—	V
$V_{th(hys)}$	ON/OFF threshold hysteresis voltage			0.35	0.65	—	V

Note 4 : Short circuit protection works only for the N-side. Please select the external shunt resistance such that the SC trip-level is up to 1.7 times of the current rating.

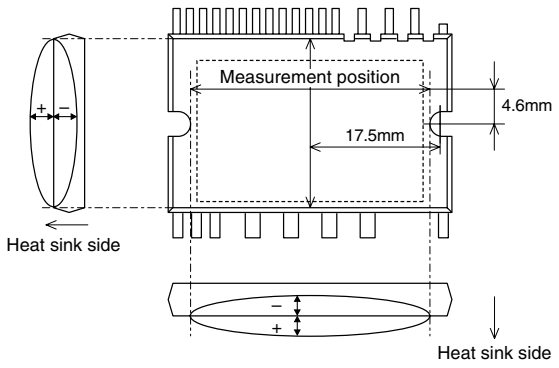
5 : Fault signal is asserted only corresponding to a SC or a UV failure at N-side, and the Fo pulse width is different for each failure modes. For SC failure, Fo output is with a fixed width of 20µs(min), but for UV failure, Fo outputs continuously during the whole UV period, however, the minimum Fo pulse width is 20µs(min) for very short UV period less than 20µs.

MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition		Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M3 (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



RECOMMENDED OPERATION CONDITIONS

Symbol	Parameter	Condition		Limits			Unit
				Min.	Typ.	Max.	
V_{CC}	Supply voltage	Applied between P-N		0	300	400	V
V_D	Control supply voltage	Applied between V_{P1}-V_{NC}, V_{N1}-V_{NC}		13.5	15.0	16.5	V
V_{DB}	Control supply voltage	Applied between V_{UFB}-U, V_{VFB}-V, V_{WFB}-W		13.0	15.0	18.5	V
ΔV_D, ΔV_{DB}	Control supply variation			–1	—	1	V/μs
t_{dead}	Arm shoot-through blocking time	For each input signal, $T_C \leq 100°C$		1.5	—	—	μs
f_{PWM}	PWM input frequency	$T_C \leq 100°C$, $T_j \leq 125°C$		—	—	20	kHz
I_O	Allowable rms current	V_{CC} = 300V, V_D = V_{DB} = 15V, P.F = 0.8, sinusoidal PWM, $T_j \leq 125°C$, $T_C \leq 100°C$ (Note 8)	f_{PWM} = 5kHz	—	—	4.5	Arms
			f_{PWM} = 15kHz	—	—	3.0	
PWIN(on)	Allowable minimum input pulse width	(Note 9)		0.5	—	—	μs
PWIN(off)				0.5	—	—	
V_{NC}	V_{NC} variation	Between V_{NC}-N (including surge)		–5.0	—	5.0	V

Note 8 : The allowable rms 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 DIPIPM INTERNAL CIRCUIT

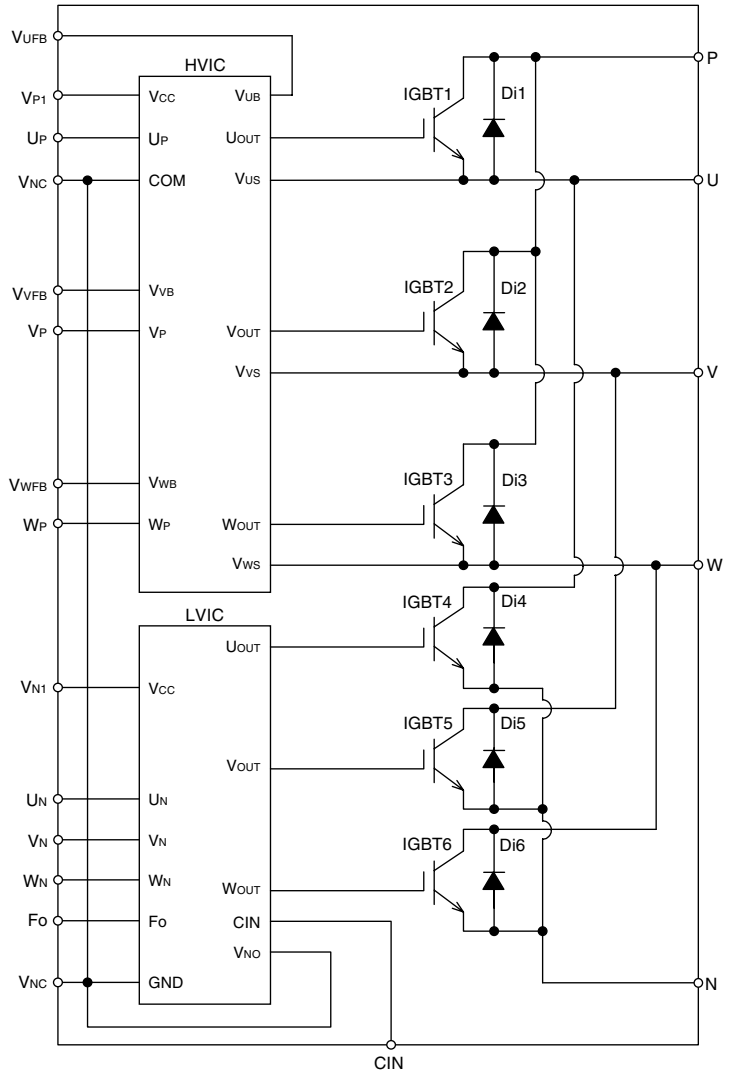
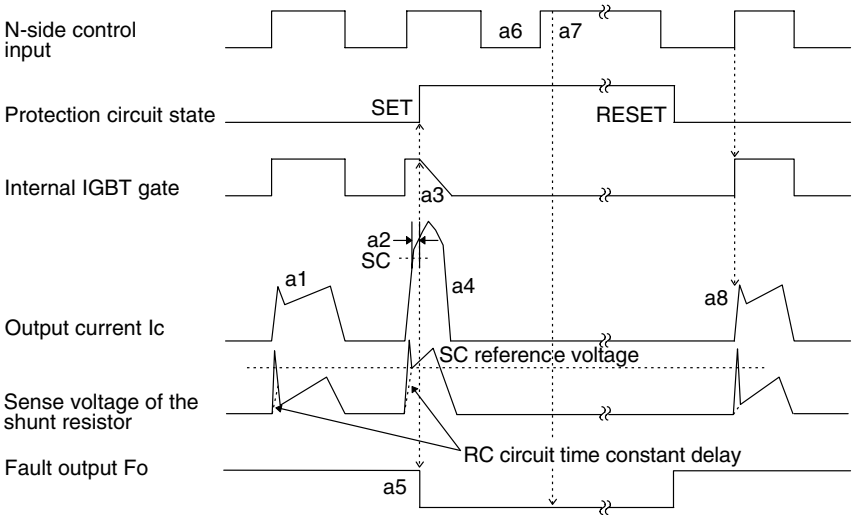


Fig. 8 TIMING CHART OF THE PROTECTIVE FUNCTIONS

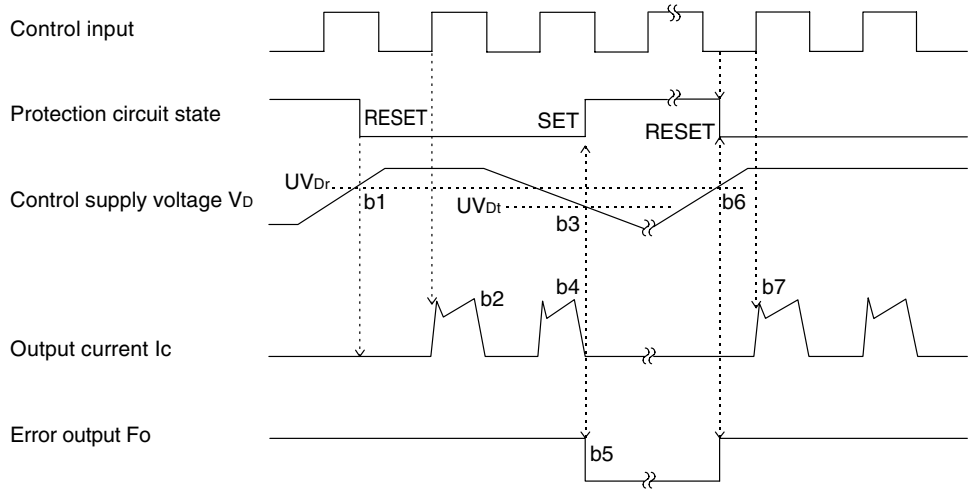
[A] Short-Circuit Protection (N-side only with the external shunt resistor and RC filter)

a1. Normal operation : IGBT ON and carrying current.
a2. Short circuit is detected (SC trigger).
a3. All N-side IGBTs' gates are hard interrupted.
a4. All N-side IGBTs turn OFF.
a5. FO is output ($t_{FO(min)}$ = 20µs).
a6. Input "L".
a7. Input "H". But IGBT is still OFF state during outputting FO.
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 rises over under voltage reset level (UV_{Dr}), the circuits start to operate when next input is applied.
b2. Normal operation : IGBT ON and carrying 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. ($t_{FO} \geq 20\mu s$ and FO outputs continuously during UV period).
b6. V_D level rises over UV_{Dr}.
b7. Normal operation : IGBT ON and carrying current.



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

c1. Control supply voltage V_{DB} rises : After V_{DB} level rises over under voltage reset level (UV_{DBr}), the circuits start to operate when next input is applied.
c2. Normal operation : IGBT ON and carrying 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 F_O signal output.
c5. V_{DB} level rises over UV_{DBr}.
c6. Normal operation : IGBT ON and carrying current.

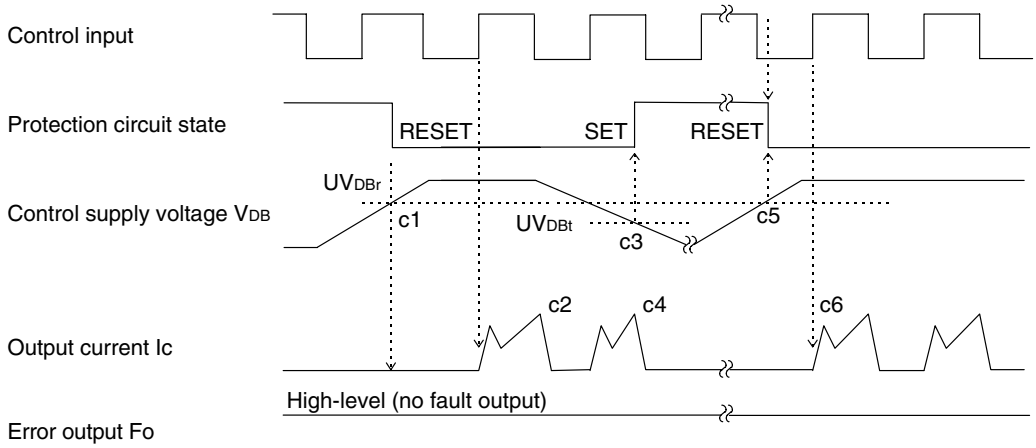
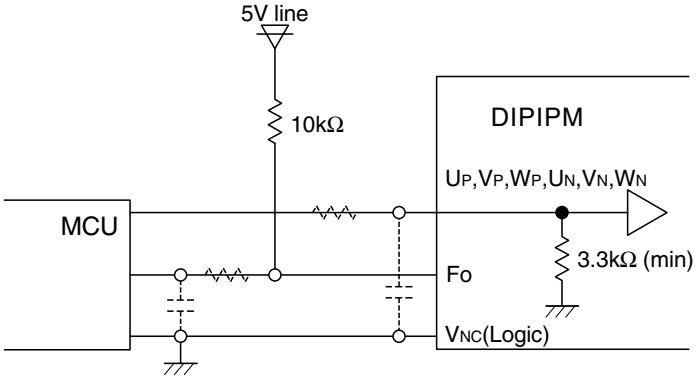


Fig. 9 AN INSTANCE OF INTERFACE CIRCUIT



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.
Input circuit 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

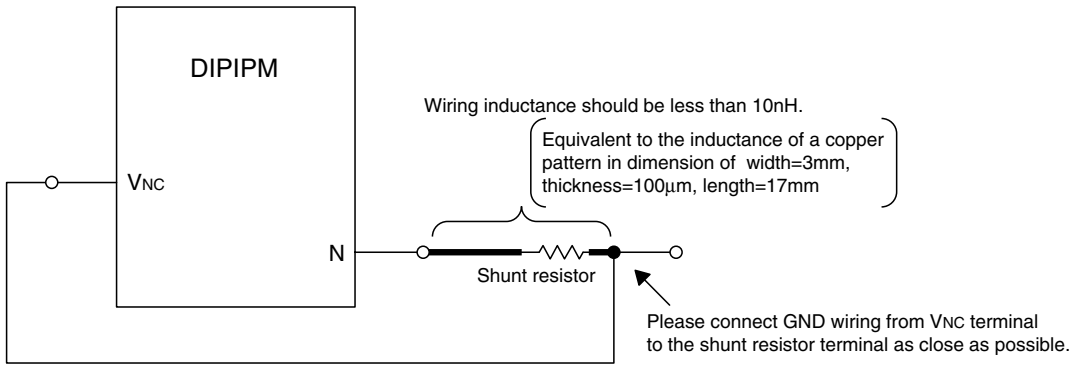
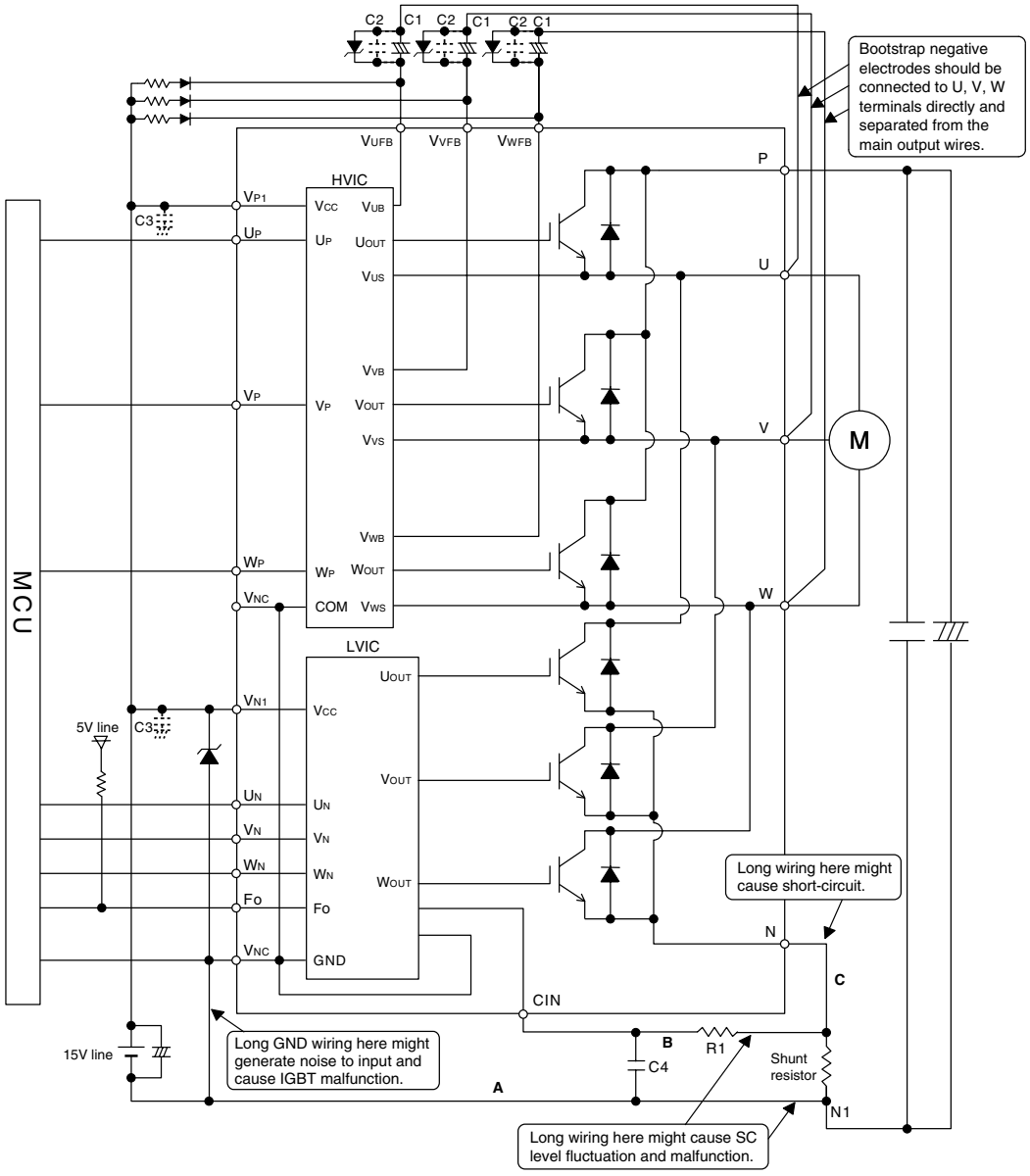


Fig. 11 AN EXAMPLE OF TYPICAL DIPIPM APPLICATION CIRCUIT



Note 1 : Input drive is High-active type. There is a 3.3kΩ (Min.) pull-down resistor in the input circuit of IC. To prevent malfunction, the wiring of each input should be as short as possible. When using RC coupling circuit, make sure the input signal level meet the turn-on and turn-off threshold voltage.

2 : Thanks to HVIC inside the module, direct coupling to MCU without any opto-coupler or transformer isolation is possible.

3 : Fo output is open drain type. It should be pulled up to the MCU or control power supply (e.g. 5V, 15V) by a resistor that makes I_{Fo} up to 1mA.

4 : To prevent erroneous protection, the wiring of A, B, C should be as short as possible.

5 : The time constant R1C4 of the protection circuit should be selected in the range of 1.5-2μs. SC interrupting time might vary with the wiring pattern. Tight tolerance, temp-compensated type is recommended for R1, C4

6 : All capacitors should be mounted as close to the terminals of DIPIPM as possible. (C1: good temperature, frequency characteristic electrolytic type, and C2, C3 (0.22~2μF) : good temperature, frequency and DC bias characteristic ceramic type are recommended.)

7 : To prevent surge destruction, the wiring between the smoothing capacitor and the P, N1 terminals should be as short as possible. Generally a 0.1-0.22μF snubber between the P-N1 terminals is recommended.

8 : Two V_{NC} terminals (9 & 16 pin) are connected inside DIPIPM, please connect either one to the 15V power supply GND and leave the other open.

9 : It is recommended to insert a Zener diode (24V/1W) between each pair of control supply terminals to prevent surge destruction.

10 : If control GND is connected with power GND by common broad pattern, it may cause malfunction by power GND fluctuation. It is recommended to connect control GND and power GND at only a point N1.

11 : High voltage (V_{RRM} =600V or more) and fast recovery type (t_{rr}=100ns or less) diodes should be used in the bootstrap circuit.