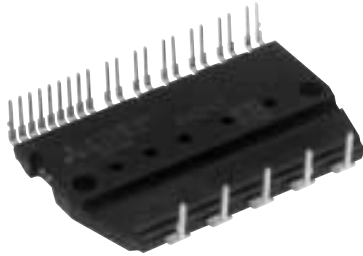


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INTEGRATED POWER FUNCTIONS

600V/5A low-loss 5th generation inverter bridge for three phase DC-to-AC power conversion

INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS

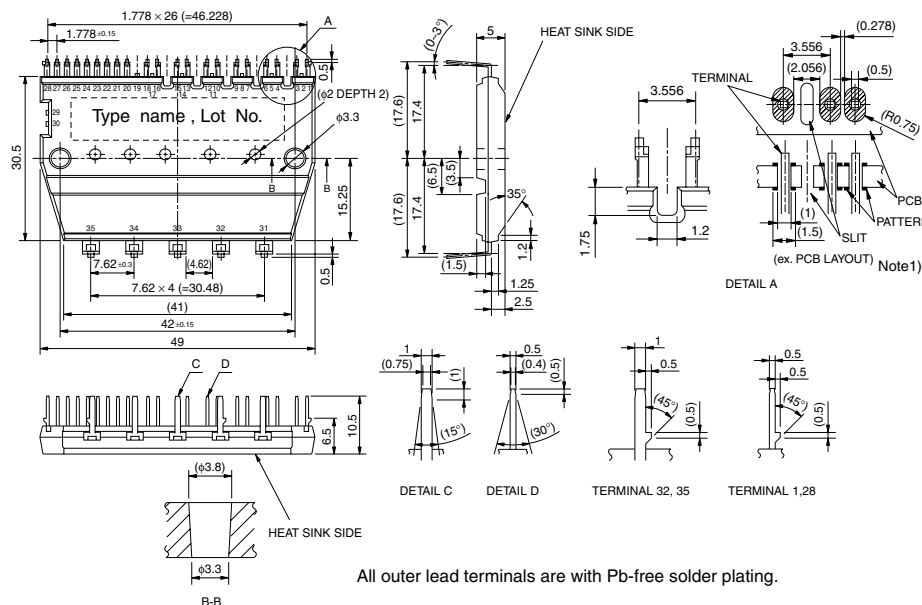
- For upper-leg IGBTs : Drive circuit, High voltage isolated high-speed level shifting, Control supply under-voltage (UV) protection.
- For lower-leg IGBTs : Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC).
- Fault signaling : Corresponding to an SC fault (Lower-leg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

APPLICATION

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

Fig. 1 PACKAGE OUTLINES

Dimensions in mm



TERMINAL CODE

1	VUFS
2	(UPG)
3	VUFB
4	VP1
5	(COM)
6	UP
7	VVFS
8	(VPG)
9	VVFB
10	VP1
11	(COM)
12	VP
13	VWFS
14	(WPG)
15	VWFB
16	VP1
17	(COM)
18	WP
19	(UNG)
20	VNO Note2)
21	UN
22	VN
23	WN
24	FO
25	CFO
26	CIN
27	VNC
28	VN1
29	(VNG)
30	(VNG)
31	P
32	U
33	V
34	W
35	N

Note 1 : In order to get enough creepage distance between the terminals, please take some countermeasure such as a slit on PCB.
2 : The 20th terminal VNO is treated as a NC in DIP-IPM ver.2, it should be connected with the terminal N outside in PS21562-P.

Fig. 2 INTERNAL FUNCTIONS BLOCK DIAGRAM (TYPICAL APPLICATION EXAMPLE)

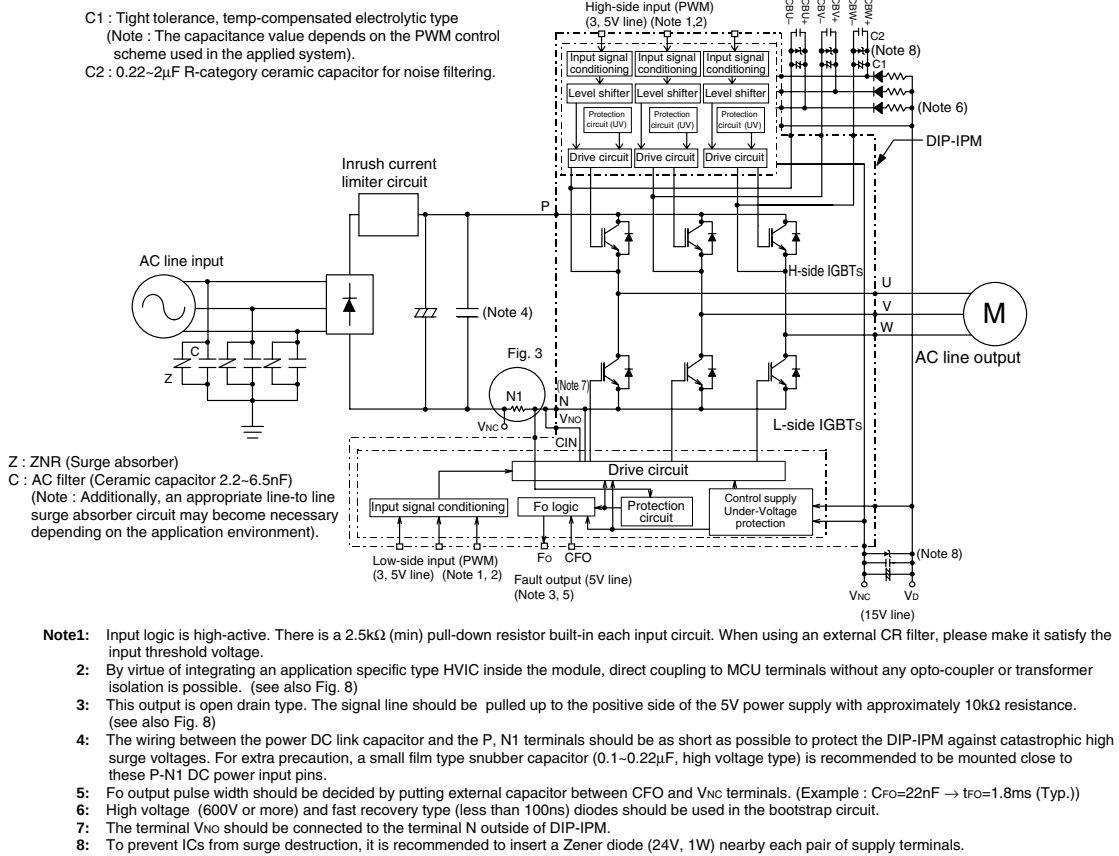
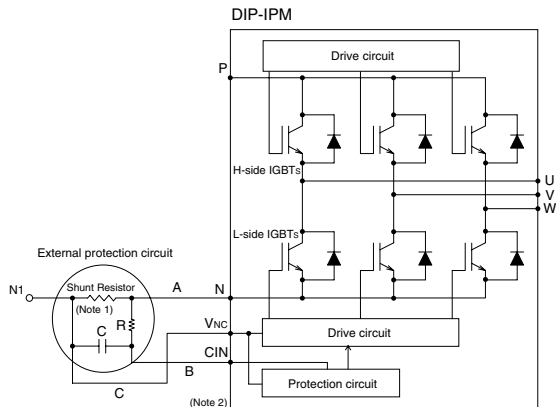


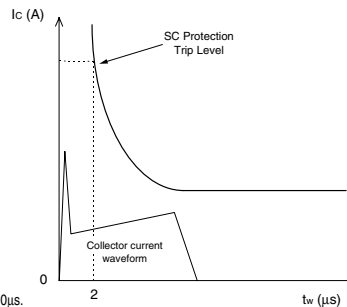
Fig. 3 EXTERNAL PART OF THE DIP-IPM PROTECTION CIRCUIT



- 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.



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MAXIMUM RATINGS ($T_j = 25^\circ\text{C}$, 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
$\pm I_C$	Each IGBT collector current	$T_f = 25^\circ\text{C}$	5	A
$\pm I_{CP}$	Each IGBT collector current (peak)	$T_f = 25^\circ\text{C}$, less than 1ms	10	A
P _C	Collector dissipation	$T_f = 25^\circ\text{C}$, per 1 chip	16.7	W
T _j	Junction temperature	(Note 1)	-20~+125	$^\circ\text{C}$

Note 1 : The maximum junction temperature rating of the power chips integrated within the DIP-IPM is 150°C (@ $T_f \leq 100^\circ\text{C}$) however, to ensure safe operation of the DIP-IPM, the average junction temperature should be limited to $T_{j(\text{ave})} \leq 125^\circ\text{C}$ (@ $T_f \leq 100^\circ\text{C}$).

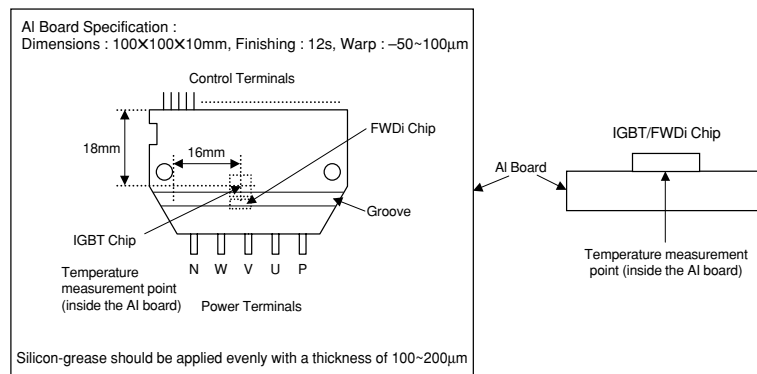
CONTROL (PROTECTION) PART

Symbol	Parameter	Condition	Ratings	Unit
V _D	Control supply voltage	Applied between VP1-VNC, VN1-VNC	20	V
V _{DB}	Control supply voltage	Applied between VUFB-VUFS, VVFB-VVFS, VWFB-VWFS	20	V
V _{IN}	Input voltage	Applied between UP, VP, WP, UN, VN, WN-VNC	-0.5~V _D +0.5	V
V _{FO}	Fault output supply voltage	Applied between FO-VNC	-0.5~V _D +0.5	V
I _{FO}	Fault output current	Sink current at FO terminal	1	mA
V _{SC}	Current sensing input voltage	Applied between CIN-VNC	-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 $T_j = 125^\circ\text{C}$, non-repetitive, less than 2 μs	400	V
T _f	Module case operation temperature	(Note 2)	-20~+100	$^\circ\text{C}$
T _{stg}	Storage temperature		-40~+125	$^\circ\text{C}$
V _{iso}	Isolation voltage	60Hz, Sinusoidal, 1 minute, All connected pins to heat-sink plate	2500	V _{rms}

Note 2 : T_f measurement point



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THERMAL RESISTANCE

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
$R_{th(j-f)Q}$	Junction to case thermal resistance (Note 3)	Inverter IGBT part (per 1/6 module)	—	—	6.0	°C/W
$R_{th(j-f)F}$		Inverter FWD part (per 1/6 module)	—	—	6.5	°C/W

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

ELECTRICAL CHARACTERISTICS ($T_j = 25^\circ\text{C}$, unless otherwise noted)**INVERTER PART**

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_D = V_{DB} = 15\text{V}$ $V_{IN} = 5\text{V}$	—	1.60	2.10	V
		$I_C = 5\text{A}, T_j = 25^\circ\text{C}$ $I_C = 5\text{A}, T_j = 125^\circ\text{C}$	—	1.70	2.20	
V_{EC}	FWD forward voltage	$T_j = 25^\circ\text{C}, -I_C = 5\text{A}, V_{IN} = 0\text{V}$	—	1.50	2.00	V
t_{on}	Switching times	$V_{CC} = 300\text{V}, V_D = V_{DB} = 15\text{V}$ $I_C = 5\text{A}, T_j = 125^\circ\text{C}, V_{IN} = 0 \leftrightarrow 5\text{V}$ Inductive load (upper-lower arm)	0.60	1.20	1.80	μs
t_{rr}			—	0.30	—	μs
$t_{c(on)}$			—	0.40	0.60	μs
t_{off}			—	1.30	2.00	μs
$t_{c(off)}$			—	0.50	0.80	μs
I_{CES}	Collector-emitter cut-off current	$V_{CE} = V_{CES}$ $T_j = 25^\circ\text{C}$	—	—	1	mA
		$T_j = 125^\circ\text{C}$	—	—	10	

CONTROL (PROTECTION) PART

Symbol	Parameter	Condition		Limits			Unit
				Min.	Typ.	Max.	
Id	Circuit current	VD = VDB = 15V VIN = 5V	Total of VP1-VNC, VN1-VNC	—	—	5.00	mA
			VUFB-VUFS, VVFB-VVFS, VWFB-VWFS	—	—	0.40	
		VD = VDB = 15V VIN = 0V	Total of VP1-VNC, VN1-VNC	—	—	7.00	
			VUFB-VUFS, VVFB-VVFS, VWFB-VWFS	—	—	0.55	
VFOH	Fault output voltage	VSC = 0V, FO circuit pull-up to 5V with 10kΩ		4.9	—	—	V
VFOL		VSC = 1V, IFO = 1mA		—	—	0.95	V
VSC(ref)	Short circuit trip level	Tf = -20~100°C, Vd = 15V (Note 4)		0.45	—	0.52	V
IIN	Input current	VIN = 5V		1.0	1.5	2.0	mA
UVDBt	Control supply under-voltage protection	Tj ≤ 125°C	Trip level	10.0	—	12.0	V
UVDBr			Reset level	10.5	—	12.5	V
UVDt			Trip level	10.3	—	12.5	V
UVDr			Reset level	10.8	—	13.0	V
tFO	Fault output pulse width	CFO = 22nF (Note 5)		1.0	1.8	—	ms
Vth(on)	ON threshold voltage	Applied between UP, VP, WP-VNC, UN, VN, WN-VNC		2.1	2.3	2.6	V
Vth(off)	OFF threshold voltage			0.8	1.4	2.1	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 2.0 times of the current rating.

5: Fault signal is asserted corresponding to a short circuit or lower side control supply under-voltage failure. The fault output pulse width t_{FO} depends on the capacitance value of C_{FO} according to the following approximate equation : $C_{FO} = 12.2 \times 10^{-6} \times t_{FO} [\text{F}]$.

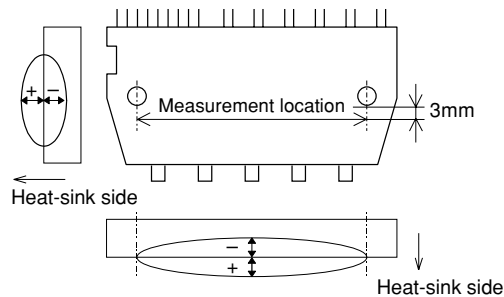
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MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition		Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M3	Recommended : 0.78 N·m	0.59	—	0.98	N·m
Weight			—	20	—	g
Heat-sink flatness	(Note 6)		-50	—	100	μm

Note 6: Measurement point of heat-sink flatness



RECOMMENDED OPERATION CONDITIONS

Symbol	Parameter	Condition	Recommended value			Unit
			Min.	Typ.	Max.	
V _{CC}	Supply voltage	Applied between P-N	0	300	400	V
V _D	Control supply voltage	Applied between VP1-V _{NC} , VN1-V _{NC}	13.5	15.0	16.5	V
V _{DB}	Control supply voltage	Applied between VUFB-VUFS, VVFB-VVFS, VWFB-VWFS	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 _f ≤ 100°C	1.5	—	—	μs
f _{PWM}	PWM input frequency	T _f ≤ 100°C, T _j ≤ 125°C	—	—	20	kHz
I _O	Allowable r.m.s. current	V _{CC} = 300V, V _D = V _{DB} = 15V, P.F = 0.8, sinusoidal output T _f ≤ 100°C, T _j ≤ 125°C (Note 7)	f _{PWM} = 5kHz		3.5	Arms
			f _{PWM} = 15kHz		3.2	
PWIN(on)	Allowable minimum input pulse width	(Note 8)	0.3	—	—	μs
		200 ≤ V _{CC} ≤ 350V, 13.5 ≤ V _D ≤ 16.5V, 13.0 ≤ V _{DB} ≤ 18.5V, -20°C ≤ T _f ≤ 100°C, N-line wiring inductance less than 10nH (Note 9)	Below rated current	0.5	—	
			Between rated current and 1.7 times of rated current	0.5	—	
			Between 1.7 times and 2.0 times of rated current	0.5	—	
V _{NC}	V _{NC} variation	Between V _{NC} -N (including surge)	-5.0	—	5.0	V

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

8: The input pulse width less than PWIN(on) might make no response.

9: IPM might not work properly or make response for the input signal with OFF pulse width less than PWIN(off).

Please refer to Fig.7.

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Fig. 4 THE DIP-IPM INTERNAL CIRCUIT

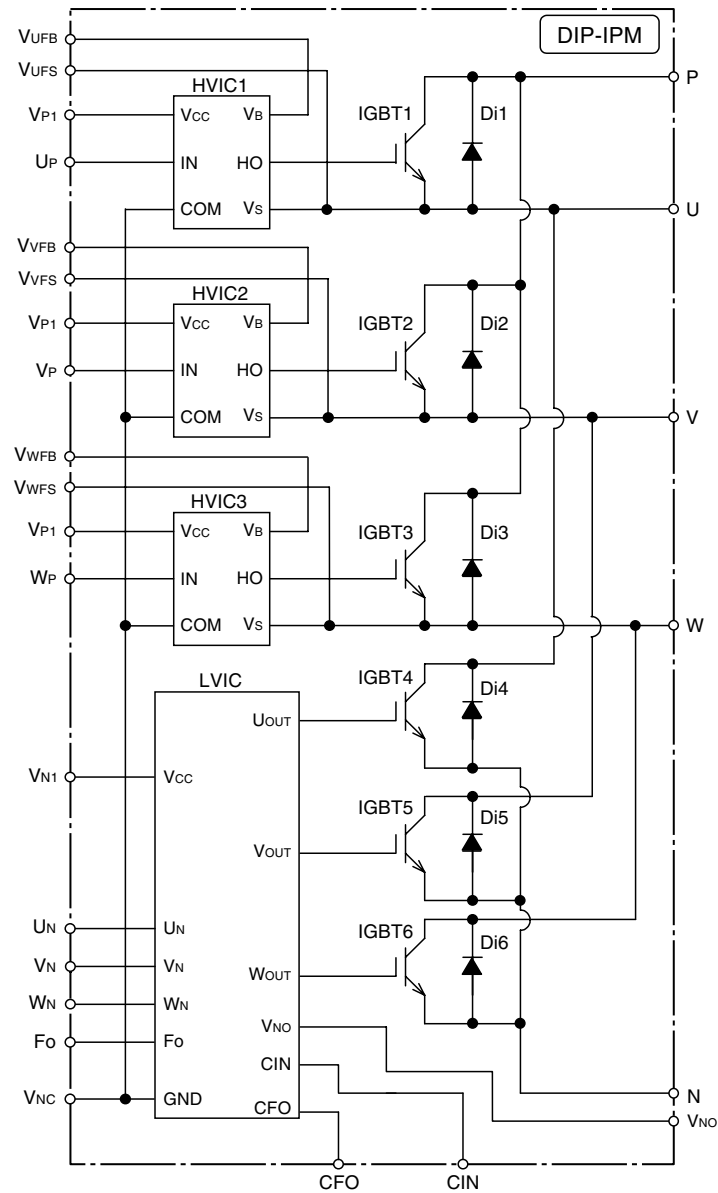
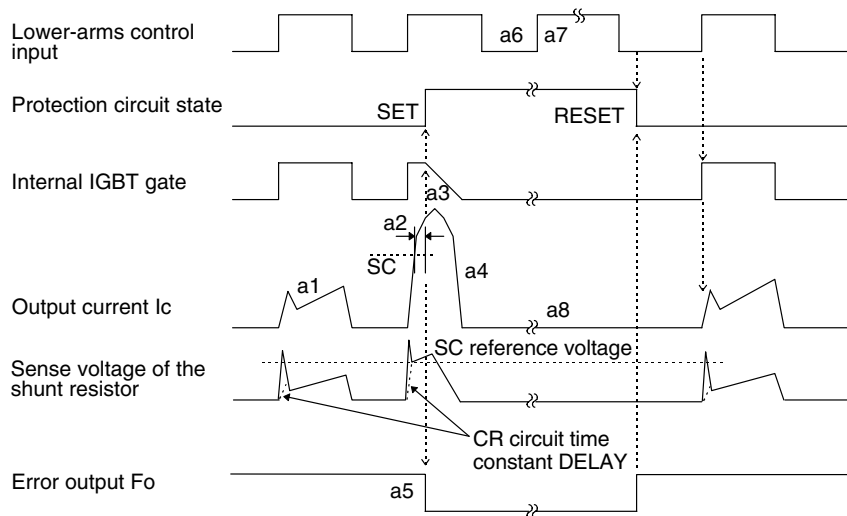


Fig. 5 TIMING CHART OF THE DIP-IPM PROTECTIVE FUNCTIONS

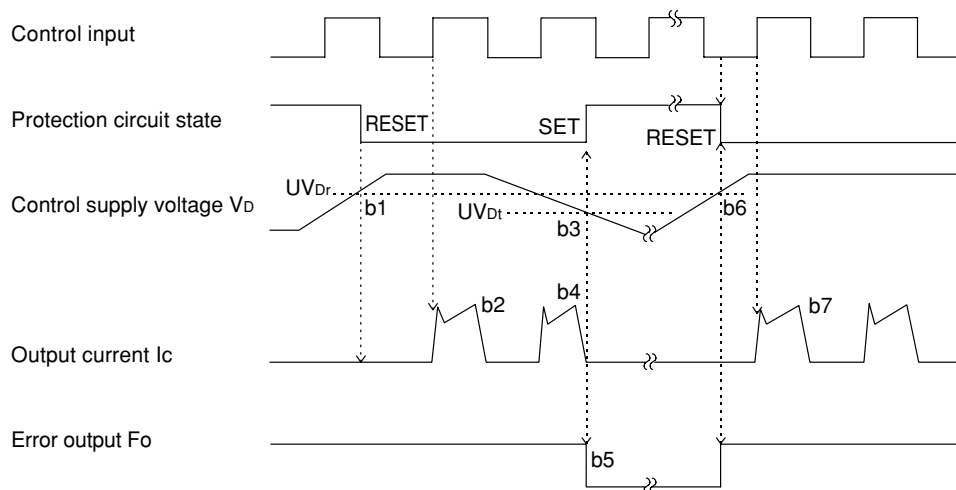
[A] Short-Circuit Protection (Lower-arms only with the external shunt resistor and CR filter)

- a1. Normal operation : IGBT ON and carrying current.
- a2. Short circuit current detection (SC trigger).
- a3. IGBT gate hard interruption.
- a4. IGBT turns OFF.
- a5. FO timer operation starts : The pulse width of the Fo signal is set by the external capacitor C_{FO}.
- a6. Input "L" : IGBT OFF.
- a7. Input "H" : IGBT ON.
- a8. IGBT OFF in spite of input "H".



[B] Under-Voltage Protection (Lower-arm, UVd)

- b1. Control supply voltage rises : After the voltage level reaches UV_{Dr}, the circuits start to operate when next input is applied.
- b2. Normal operation : IGBT ON and carrying current.
- b3. Under voltage trip (UV_{Dt}).
- b4. IGBT OFF in spite of control input condition.
- b5. FO operation starts.
- b6. Under voltage reset (UV_{Dr}).
- b7. Normal operation : IGBT ON and carrying current.



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[C] Under-Voltage Protection (Upper-arm, UVDB)

- c1. Control supply voltage rises : After the voltage reaches UVDBr, the circuits start to operate when next input is applied.
- c2. Normal operation : IGBT ON and carrying current.
- c3. Under voltage trip (UVDBt).
- c4. IGBT OFF in spite of control input condition, but there is no Fo signal output.
- c5. Under voltage reset (UVDBr).
- c6. Normal operation : IGBT ON and carrying current.

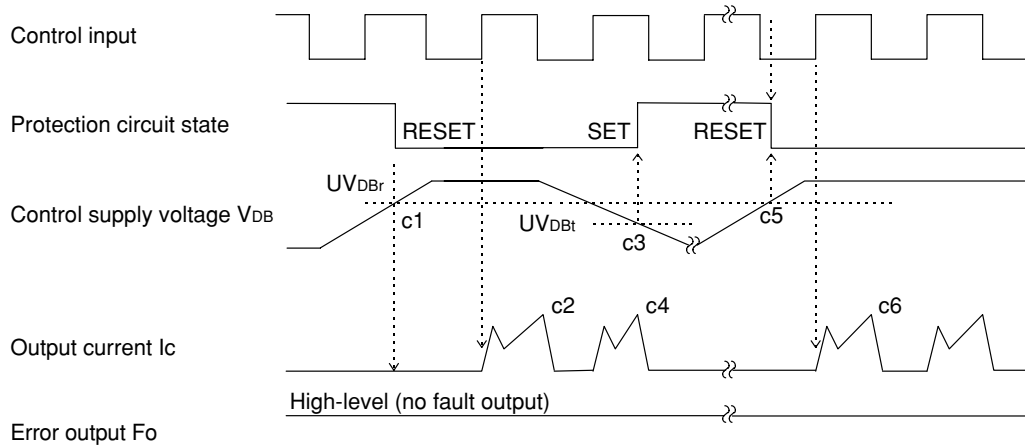
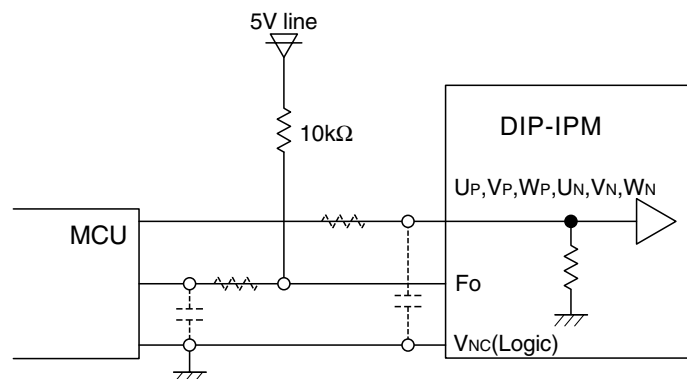


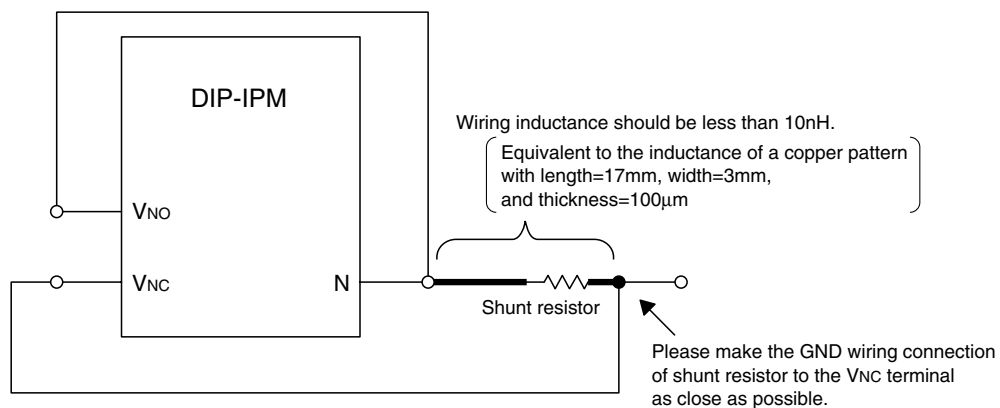
Fig. 6 RECOMMENDED CPU I/O INTERFACE CIRCUIT



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 2.5kΩ (min) pull-down resistor. Therefore, when using an external filtering resistor, pay attention to the turn-on threshold voltage.

Fig. 7 WIRING CONNECTION OF SHUNT RESISTOR

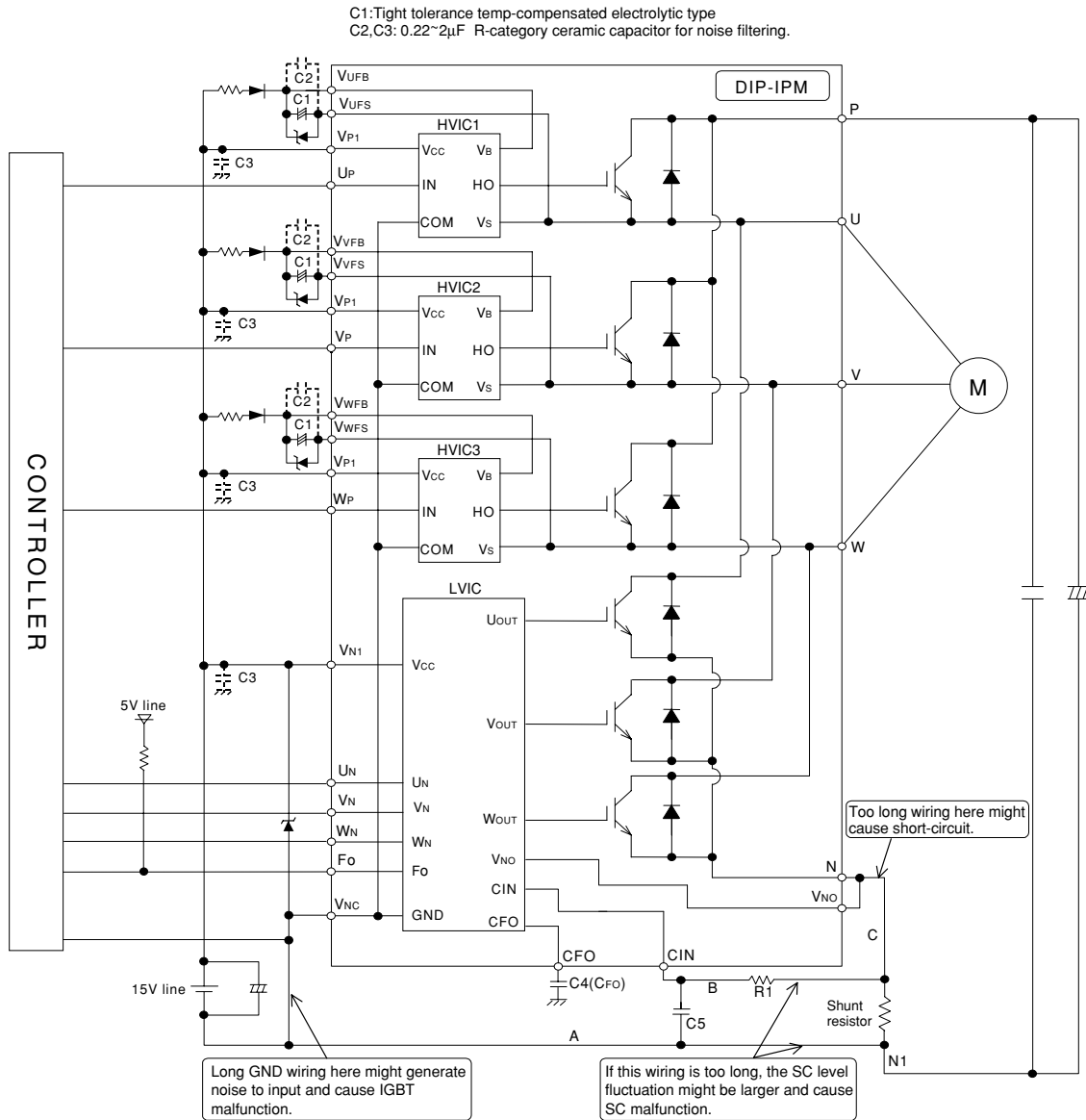


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Fig. 8 TYPICAL DIP-IPM APPLICATION CIRCUIT EXAMPLE



Note 1: To prevent the input signals oscillation, the wiring of each input should be as short as possible. (Less than 2cm)

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

3: Fo output is open drain type. This signal line should be pulled up to the positive side of the 5V power supply with approximately 10kΩ resistor.

4: Fo output pulse width is determined by the external capacitor between Cfo and Vnc terminals (Cfo). (Example : Cfo = 22 nF → tFo = 1.8 ms (typ.))

5: The logic of input signal is high-active. The DIP-IPM input signal section integrates a 2.5kΩ (min) pull-down resistor. Therefore, when using external filtering resistor, care must be taken to satisfy the turn-on threshold voltage requirement.

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

7: Please set the C5R1 time constant in the range 1.5~2μs.

8: Each capacitor should be located as nearby the pins of the DIP-IPM as possible.

9: 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.

10: The terminal Vno should be connected with the terminal N outside.

11: To prevent ICs from surge destruction, it is recommended to insert a Zener diode (24V, 1W) nearby each pair of supply terminals.