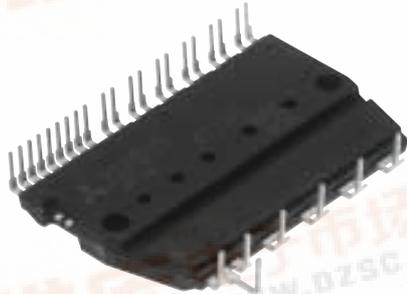


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INTEGRATED POWER FUNCTIONS

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

INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS

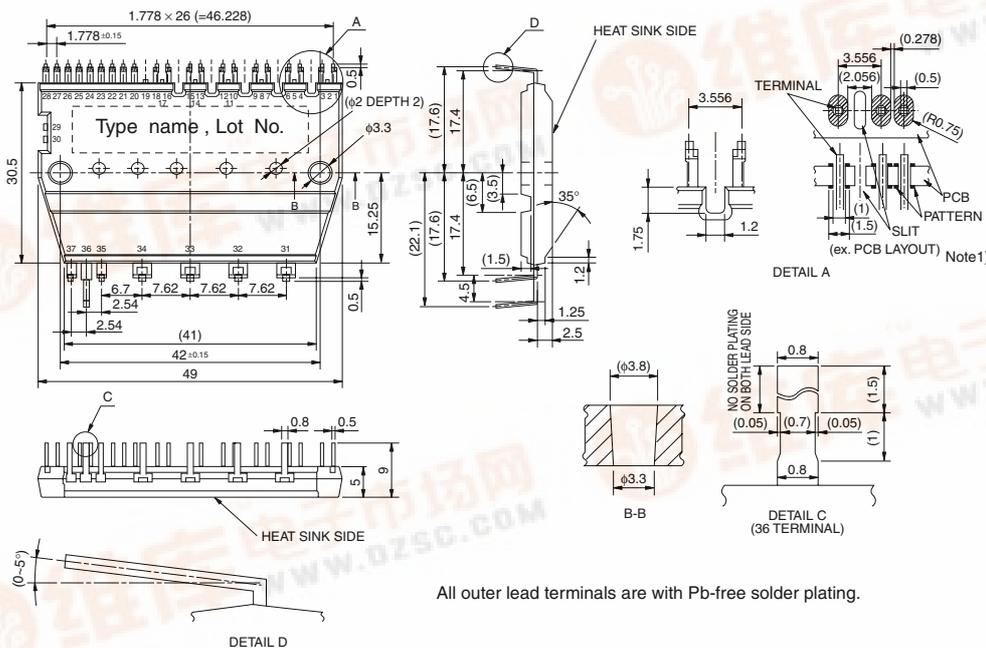
- For upper-leg IGBTs : Drive circuit, High voltage isolated high-speed level shifting, Control supply under-voltage (UV) protection.
- For lower-leg IGBTs : Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC).
- Fault signaling : Corresponding to an SC fault (Lower-leg 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 | VVFS |
| 14 | (WPG) |
| 15 | VVFB |
| 16 | VP1 |
| 17 | (COM) |
| 18 | WP |
| 19 | (UNG) |
| 20 | VNO |
| 21 | UN |
| 22 | VN |
| 23 | WN |
| 24 | FO |
| 25 | CFO |
| 26 | CIN |
| 27 | VNC |
| 28 | VN1 |
| 29 | (WNG) |
| 30 | (VNG) |
| 31 | P |
| 32 | U |
| 33 | V |
| 34 | W |
| 35 | NU |
| 36 | NV |
| 37 | NW |

Note 1 : In order to get enough creepage distance between the terminals, please take some countermeasure such as a slit on PCB.

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MAXIMUM RATINGS ($T_j = 25^\circ\text{C}$, unless otherwise noted)

INVERTER PART

Symbol	Parameter	Condition	Ratings	Unit
VCC	Supply voltage	Applied between P-NU, NV, NW	450	V
VCC(surge)	Supply voltage (surge)	Applied between P-NU, NV, NW	500	V
VCEs	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
PC	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 $T_{j(\text{ave})} \leq 125^\circ\text{C}$ ($@ T_f \leq 100^\circ\text{C}$).

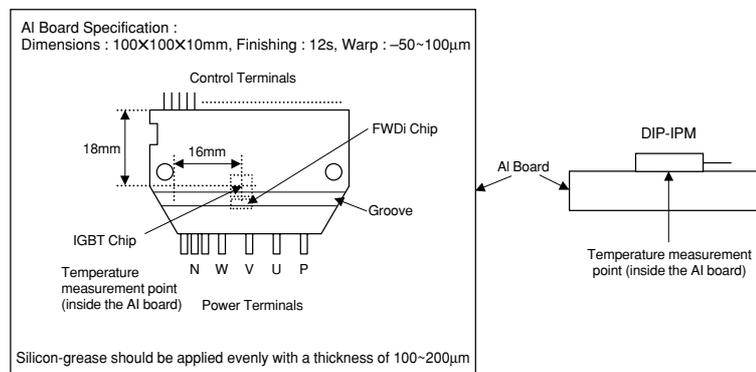
CONTROL (PROTECTION) PART

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
VCC(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	Inverter IGBT part (per 1/6 module)	—	—	6.0	°C/W
R _{th(j-f)F}	(Note 3)	Inverter FWD part (per 1/6 module)	—	—	6.5	°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.

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 I _C = 5A, T _j = 25°C	—	1.60	2.10	V
		V _{IN} = 5V I _C = 5A, T _j = 125°C	—	1.70	2.20	
V _{EC}	FWD forward voltage	T _j = 25°C, -I _C = 5A, V _{IN} = 0V	—	1.50	2.00	V
t _{on}	Switching times	V _{CC} = 300V, V _D = V _{DB} = 15V I _C = 5A, T _j = 125°C, V _{IN} = 0 ↔ 5V Inductive load (upper-lower arm)	0.60	1.20	1.80	μs
t _{tr}			—	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°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-VNC} , V _{N1-VNC}	—	—	5.00	mA
			V _{UFB-VUFS} , V _{VFB-VVFS} , V _{WFB-VWFS}	—	—	0.40	
		V _D = V _{DB} = 15V V _{IN} = 0V	Total of V _{P1-VNC} , V _{N1-VNC}	—	—	7.00	
			V _{UFB-VUFS} , V _{VFB-VVFS} , V _{WFB-VWFS}	—	—	0.55	
V _{FOH}	Fault output voltage	V _{SC} = 0V, F _O circuit pull-up to 5V with 10kΩ	4.9	—	—	V	
V _{FOL}		V _{SC} = 1V, I _{FO} = 1mA	—	—	0.95	V	
V _{SC(ref)}	Short circuit trip level	T _f = -20~100°C, V _D = 15V (Note 4)	0.45	—	0.52	V	
I _{IN}	Input current	V _{IN} = 5V	1.0	1.5	2.0	mA	
UV _{DBt}	Control supply under-voltage protection	T _j ≤ 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	C _{FO} = 22nF (Note 5)	1.0	1.8	—	ms	
V _{th(on)}	ON threshold voltage	Applied between U _P , V _P , W _{P-VNC} , U _N , V _N , W _{N-VNC}	2.1	2.3	2.6	V	
V _{th(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 × 10⁻⁶ × t_{FO} [F].

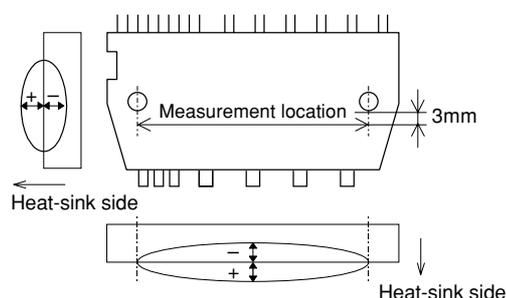
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MECHANICAL CHARACTERISTICS AND RATINGS

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-NU, NV, NW	0	300	400	V	
V _D	Control supply voltage	Applied between VP1-VNC, VN1-VNC	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	
P _{WIN(on)}	Allowable minimum input pulse width	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)	(Note 8)	0.3	—	—	μs
P _{WIN(off)}			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} -NU, NV, NW (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 P_{WIN(on)} might make no response.

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

Please refer to Fig.5.

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Fig. 2 THE DIP-IPM INTERNAL CIRCUIT

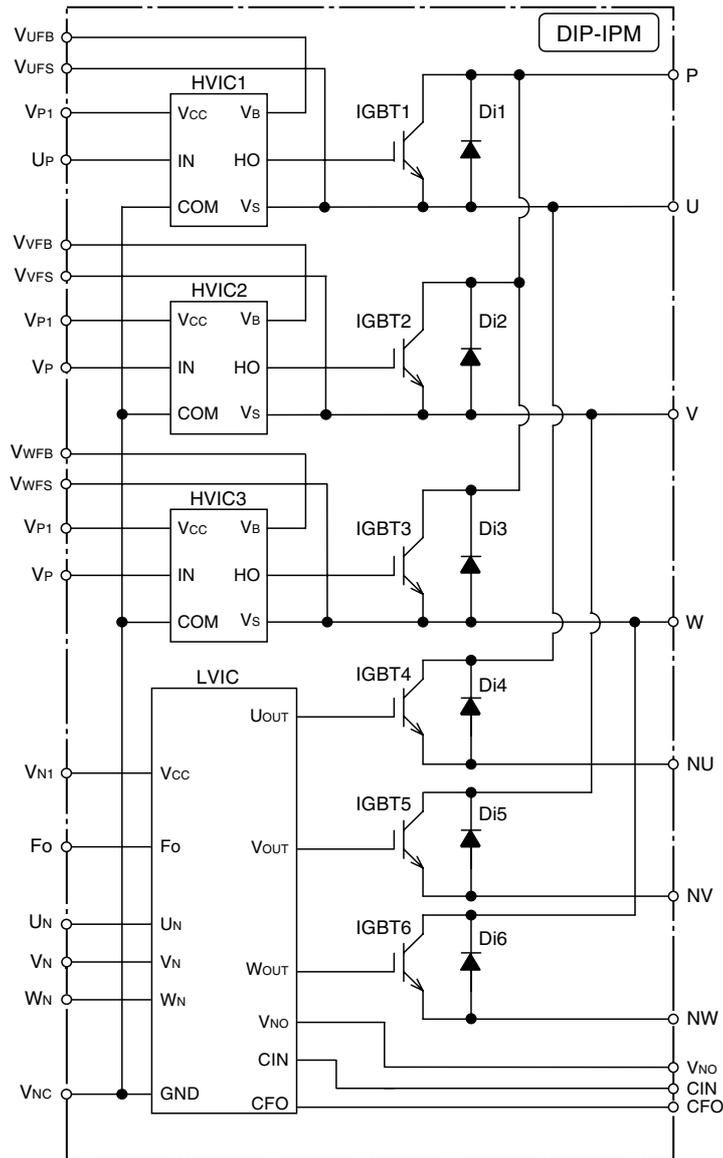
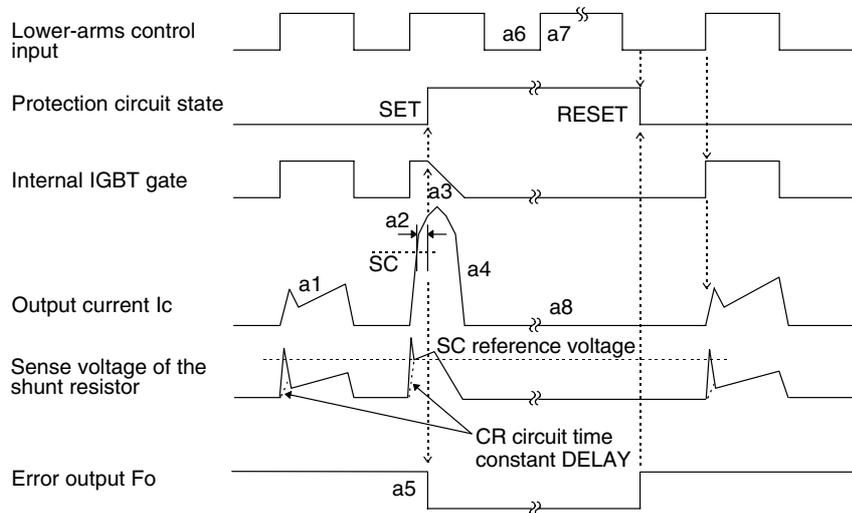


Fig. 3 TIMING CHART OF THE DIP-IPM PROTECTIVE FUNCTIONS

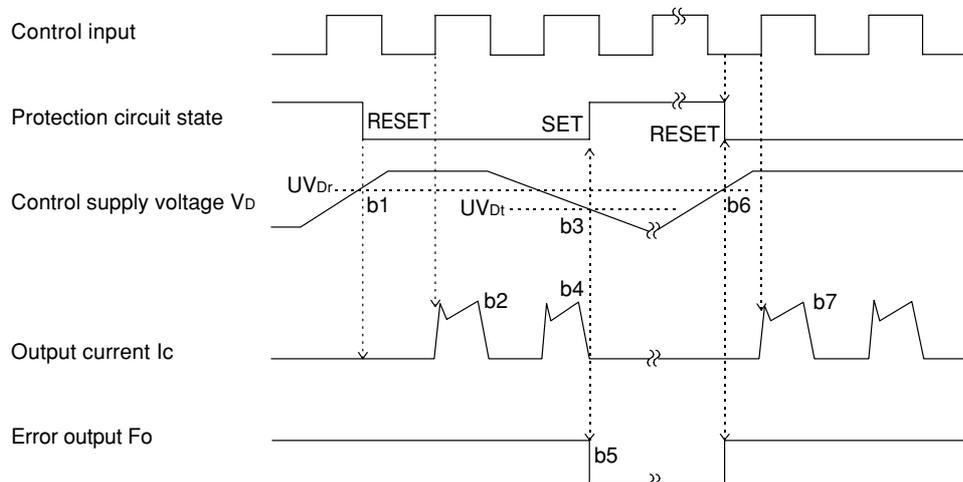
[A] Short-Circuit Protection (Lower-arms only with the external shunt resistor and CR filter)

- 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, UV_D)

- 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 UV_{DBr} , the circuits start to operate when next input is applied.
- c2. Normal operation : IGBT ON and carrying current.
- c3. Under voltage trip (UV_{DBt}).
- c4. IGBT OFF in spite of control input condition, but there is no Fo signal output.
- c5. Under voltage reset (UV_{DBr}).
- c6. Normal operation : IGBT ON and carrying current.

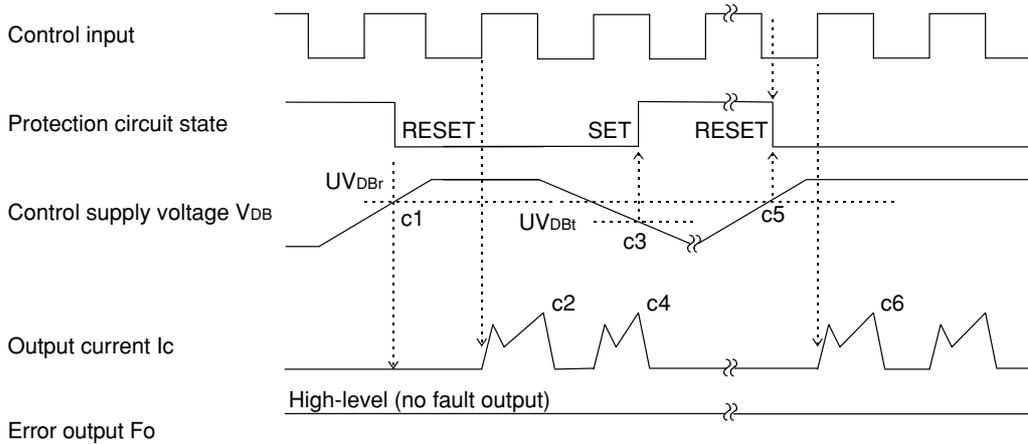
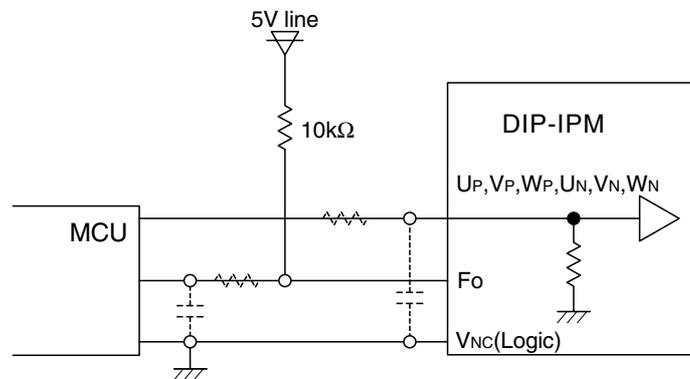
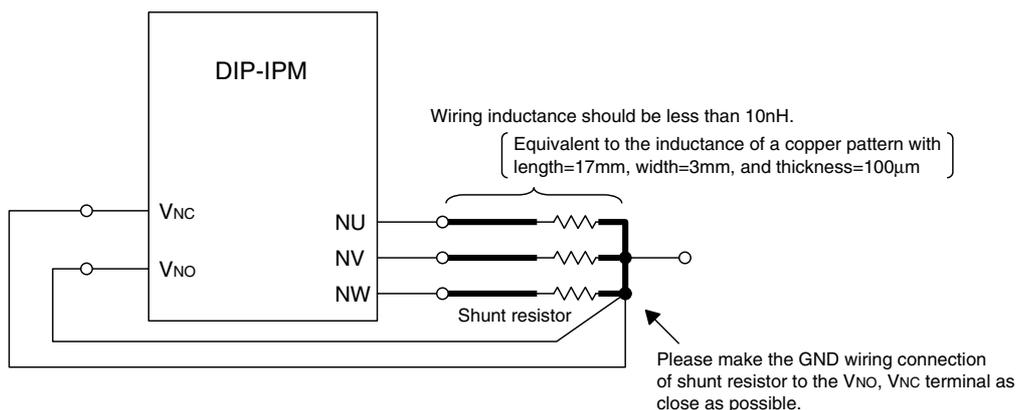


Fig. 4 RECOMMENDED CPU I/O INTERFACE CIRCUIT



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. 5 WIRING CONNECTION OF SHUNT RESISTOR

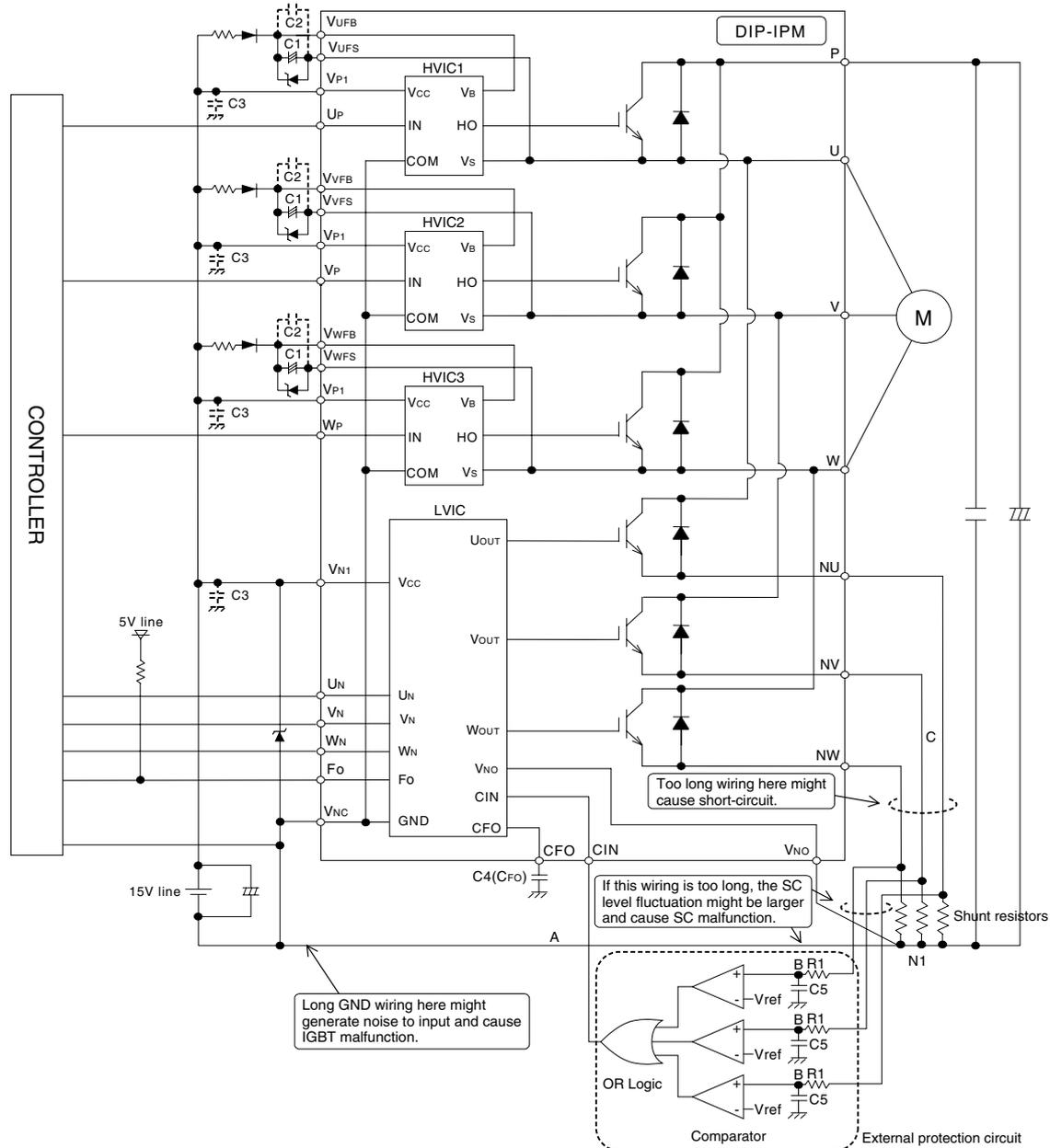


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Fig. 6 TYPICAL DIP-IPM APPLICATION CIRCUIT EXAMPLE

C1:Tight tolerance temp-compensated electrolytic type C2,C3: 0.22~2μF R-category ceramic capacitor for noise filtering



- 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:** To prevent ICs from surge destruction, it is recommended to insert a Zener diode (24V, 1W) between each control supply terminals.
- 11:** The reference voltage Vref of comparator should be set up the same rating of short circuit trip level (Vsc(ref): min.0.45V to max.0.52V).
- 12:** OR logic output level should be set up the same rating of short circuit trip level (Vsc(ref): min.0.45V to max.0.52V).