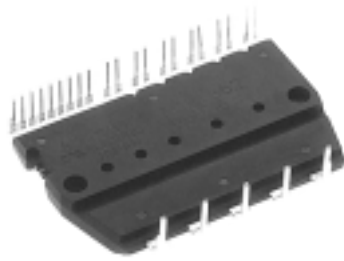


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INTEGRATED POWER FUNCTIONS

600V/5A low-loss 4th generation (planar) IGBT inverter bridge for 3 phase DC-to-AC power conversion.

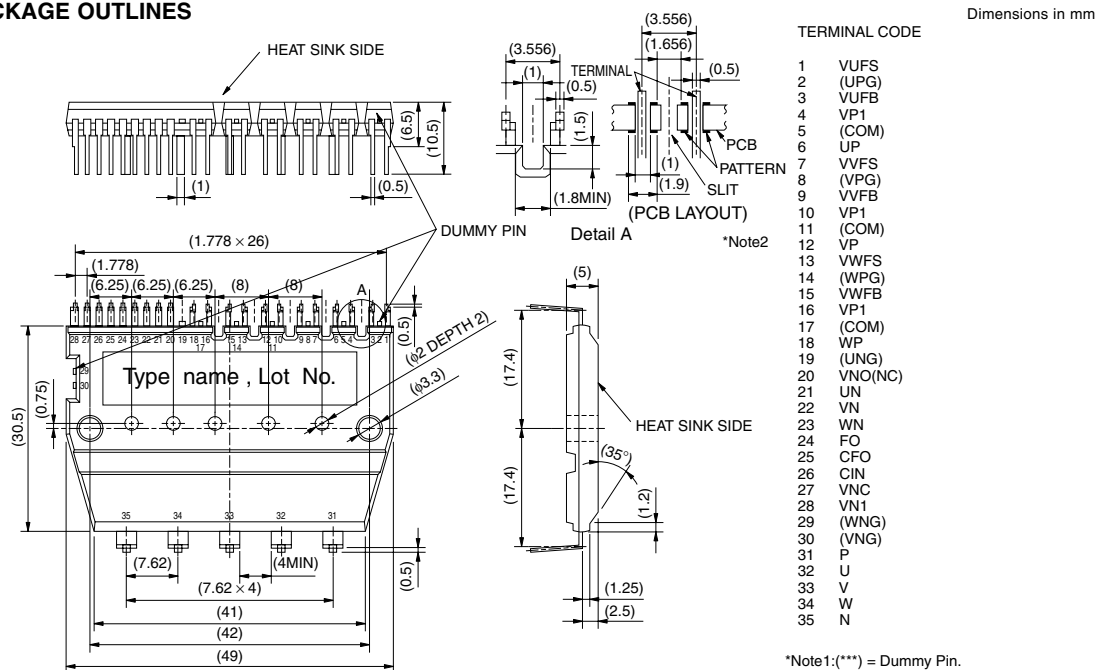
INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS

- For upper-leg IGBTs : Drive circuit, High voltage isolated high-speed level shifting, Control circuit under-voltage (UV) protection.
Note : Bootstrap supply scheme can be applied.
- For lower-leg IGBTs : Drive circuit, Control circuit under-voltage protection (UV), Short-circuit protection (SC).
- Fault signaling : Corresponding to a SC fault (Low-side IGBT) or a UV fault (Low-side IGBT).
- Input interface : 5V line CMOS/TTL compatible, Schmitt Trigger receiver circuit.

APPLICATION

AC100V~200V inverter drive for motor control.

Fig. 1 PACKAGE OUTLINES



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

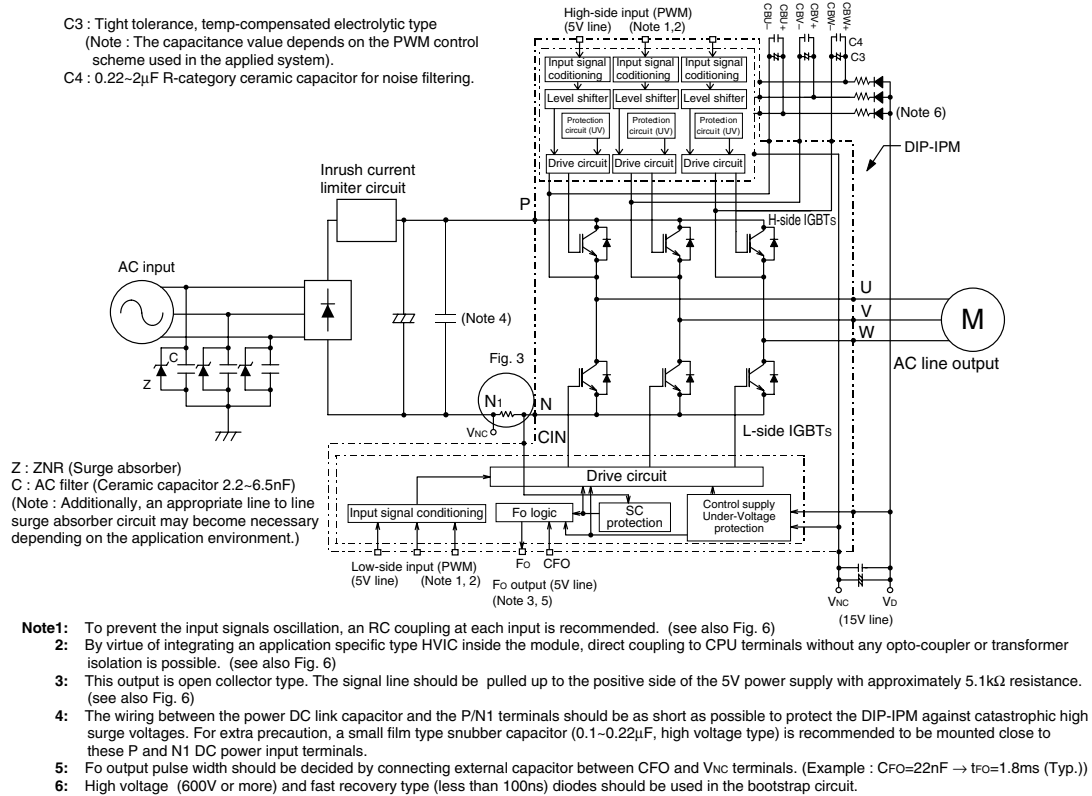
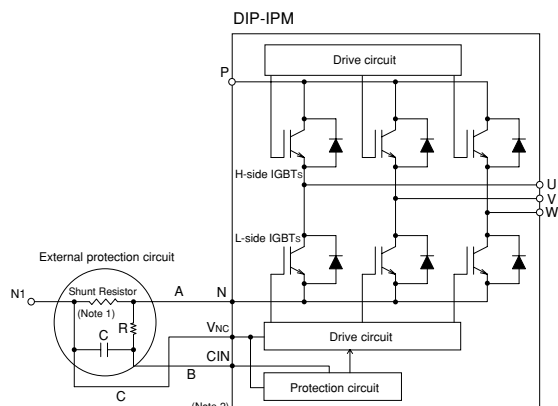
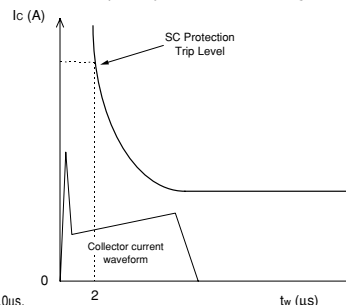


Fig. 3 EXTERNAL PART OF THE DIP-IPM PROTECTION CIRCUIT



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
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
$\pm I_C$	Each IGBT collector current	$T_f = 25^\circ\text{C}$	5	A
$\pm I_{CP}$	Each IGBT collector current (peak)	$T_f = 25^\circ\text{C}$, instantaneous value (pulse)	10	A
Pc	Collector dissipation	$T_f = 25^\circ\text{C}$, per 1 chip	20	W
Tj	Junction temperature	(Note 1)	-20~+150	$^\circ\text{C}$

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 $T_{j(\text{ave})} \leq 125^\circ\text{C}$ (@ $T_f \leq 100^\circ\text{C}$).

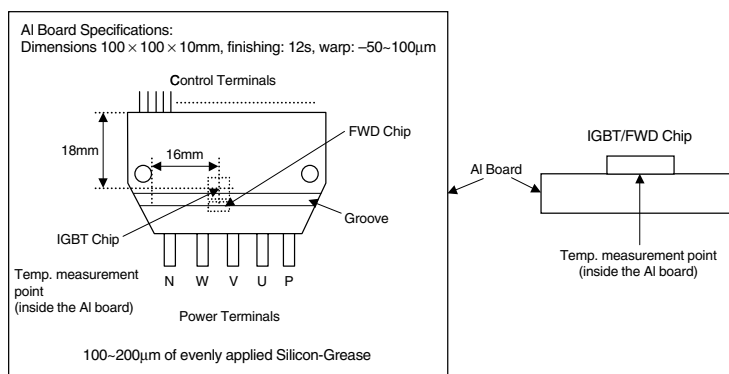
CONTROL (PROTECTION) PART

Symbol	Parameter	Condition	Ratings	Unit
VD	Control supply voltage	Applied between VP1-VNC, VN1-VNC	20	V
VDB	Control supply voltage	Applied between VUFB-VUFS, VVFB-VVFS, VWFB-VWFS	20	V
VCIN	Input voltage	Applied between UP, VP, WP-VNC, 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	15	mA
VSC	Current sensing input voltage	Applied between CIN-VNC	-0.5~VD+0.5	V

TOTAL SYSTEM

Symbol	Parameter	Condition	Ratings	Unit
VCC(Prot)	Self protection supply voltage limit (short-circuit protection capability)	VD = VDB = 13.5~16.5V, Inverter part $T_j = 125^\circ\text{C}$, non-repetitive, less than 2 μs	400	V
Tf	Heat-fin operation temperature	(Note 2)	-20~+100	$^\circ\text{C}$
Tstg	Storage temperature		-40~+125	$^\circ\text{C}$
Viso	Isolation voltage	60Hz, Sinusoidal, 1 minute, connection pins to heat-sink plate	1500	Vrms

Note 2 : Tf MEASUREMENT POINT



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THERMAL RESISTANCE

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

Note 3 : Grease with good thermal conductivity should be applied evenly about +100 μ m~+200 μ m on the contact surface of a DIP-IPM and a 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	$V_D = V_{DB} = 15\text{V}$ $V_{CIN} = 0\text{V}$	—	1.80	2.45	V
		$I_C = 5\text{A}$, $T_j = 25^\circ\text{C}$ $I_C = 5\text{A}$, $T_j = 125^\circ\text{C}$	—	1.90	2.60	
V_{EC}	FWD forward voltage	$T_j = 25^\circ\text{C}$, $-I_C = 5\text{A}$, $V_{CIN} = 5\text{V}$	—	2.20	3.00	V
t_{on}	Switching times	$V_{CC} = 300\text{V}$, $V_D = V_{DB} = 15\text{V}$ $I_C = 5\text{A}$, $T_j = 125^\circ\text{C}$ Inductive load (upper-lower arm) $V_{CIN} = 5 \leftrightarrow 0\text{V}$	0.40	0.90	1.35	μs
t_{rr}			—	0.20	—	μs
$t_{c(on)}$			—	0.40	0.65	μs
t_{off}			—	0.95	1.40	μs
$t_{c(off)}$			—	0.35	0.85	μs
I_{CES}	Collector-emitter cut-off current	$V_{CE} = V_{CES}$	—	—	1	mA
		$T_j = 25^\circ\text{C}$ $T_j = 125^\circ\text{C}$	—	—	10	

CONTROL (PROTECTION) PART

Symbol	Parameter	Condition		Limits			Unit
				Min.	Typ.	Max.	
ID	Circuit current	V _D = V _{DB} = 15V	Total of V _{P1} -V _{N1} , V _{N1} -V _{N1}	—	—	8.5	mA
		V _{CIN} = 5V	V _{UFB} -V _{UFS} , V _{VFB} -V _{VFS} , V _{WFB} -V _{WFS}	—	—	1.0	
		V _D = V _{DB} = 15V	Total of V _{P1} -V _{N1} , V _{N1} -V _{N1}	—	—	9.7	mA
		V _{CIN} = 0V	V _{UFB} -V _{UFS} , V _{VFB} -V _{VFS} , V _{WFB} -V _{WFS}	—	—	1.0	
V _{FOH}	Fault output voltage	V _{SC} = 0V, F _O = 10kΩ 5V pull-up		4.9	—	—	V
V _{FOL}		V _{SC} = 0V, I _{FO} = 1.5mA		—	0.6	0.9	V
V _{FOsat}		V _{SC} = 1V, I _{FO} = 15mA		0.8	1.2	1.8	V
V _{SC(ref)}	Short-circuit trip level	T _J = 25°C, V _D = 15V (Note 4)		0.43	0.48	0.53	V
UV _{DBt}	Supply circuit 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:		0.8	1.4	2.0	V
V _{th(off)}	OFF threshold voltage	U _P , V _P , W _P -V _{N1} , U _N , V _N , W _N -V _{N1}		2.5	3.0	4.0	V

Note 4 : Short-circuit protection operates only at the low-arms. Please select the value of the external shunt resistor such that the SC trip level is less than 8.5A

5 : Fault signal is outputted when the low-arm short-circuit or control supply under-voltage protective functions operate. The fault output pulse-width t_{FO} depends on the capacitance value of C_{FO} according to the following approximate equation. : $C_{FO} = (12.2 \times 10^{-6}) \times t_{FO} [\text{F}]$

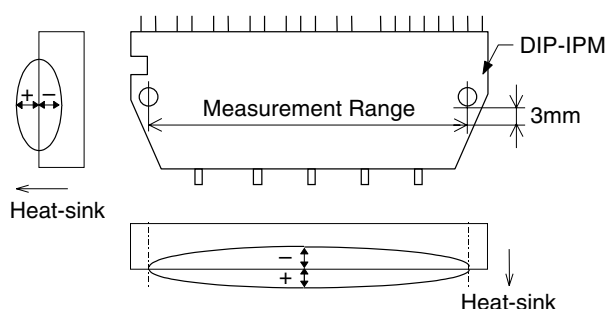
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MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition		Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M3	—	0.59	0.78	0.98	N·m
Terminal pulling strength	Weight 9.8N	EIAJ-ED-4701	10	—	—	s
Bending strength	Weight 4.9N. 90deg bend	EIAJ-ED-4701	2	—	—	times
Weight		—	—	20	—	g
Heat-sink flatness	(Note 6)	—	-50	—	100	μm

Note 6: Measurement point of heat-sink flatness



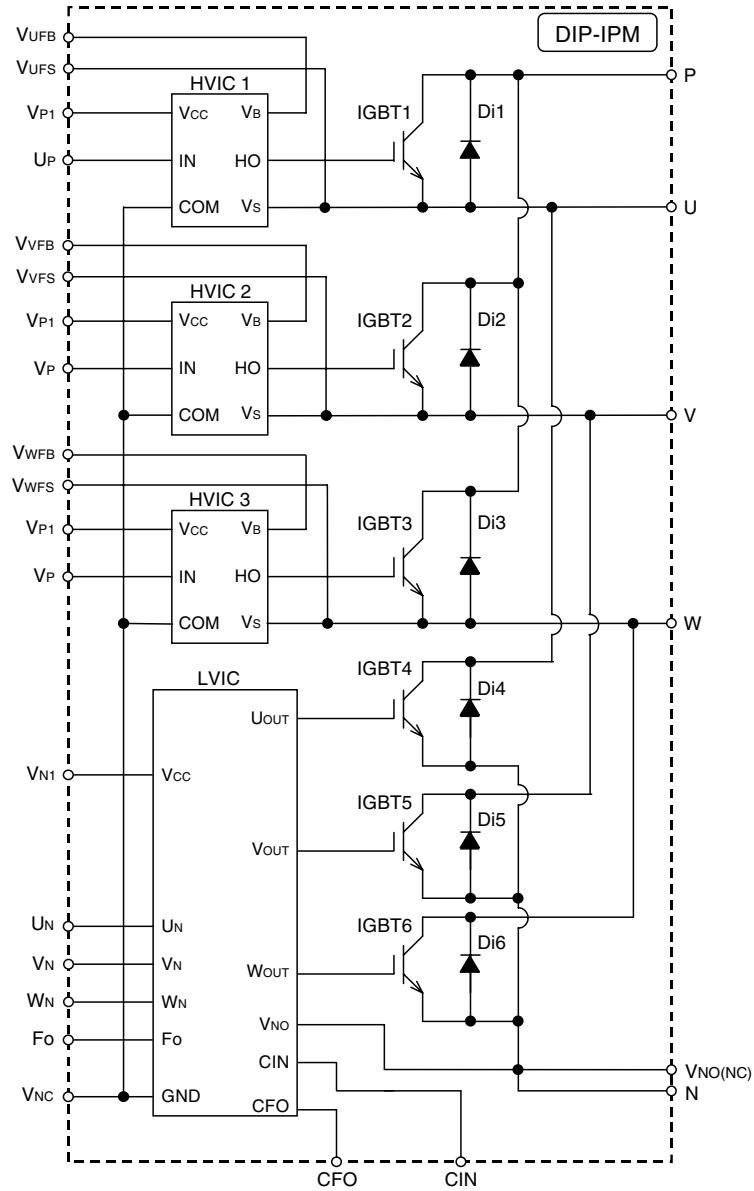
RECOMMENDED OPERATION CONDITIONS

Symbol	Parameter	Condition	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} -V _{UFS} , V _{VFB} -V _{VFS} , V _{WFB} -V _{WFS}	13.5	15.0	16.5	V
ΔV _D , ΔV _{DB}	Control supply variation		-1	—	1	V/μs
t _{dead}	Arm shoot-through blocking time	For each input signal	1.5	—	—	μs
f _{PWM}	PWM input frequency	T _J ≤ 125°C, T _r ≤ 100°C	—	15	—	kHz
V _{CIN(ON)}	Input ON voltage	Applied between U _P , V _P , W _P -V _{NC} , U _N , V _N , W _N -V _{NC}	0~0.65			V
V _{CIN(OFF)}	Input OFF voltage		4.0~5.5			V

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Fig. 4 THE DIP-IPM INTERNAL CIRCUIT



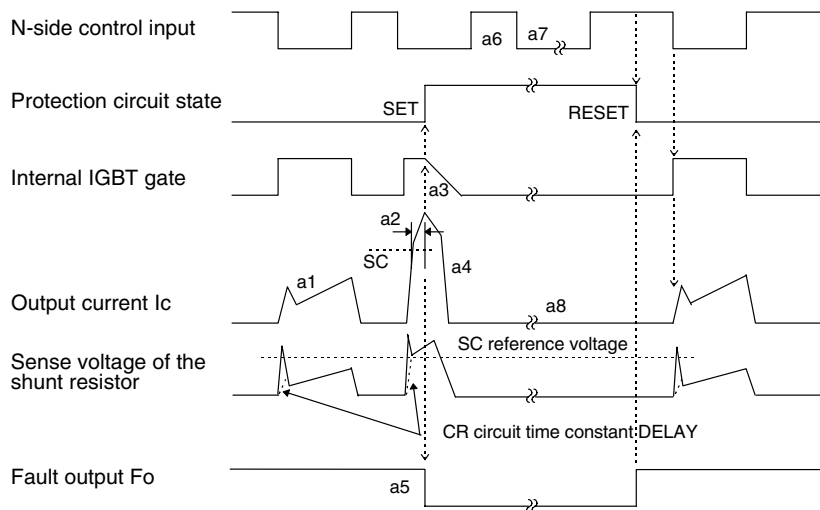
Note: The IGBTs gates and the HVICs COM terminals are connected to the dummy pins.

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

[A] Short-Circuit Protection (N-side only)

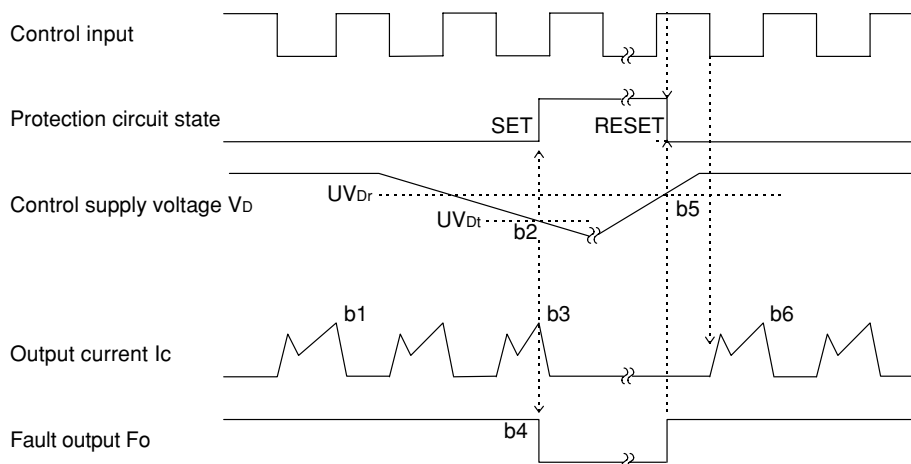
(For the external shunt resistor and CR connection, please refer to Fig. 3.)

- a1. Normal operation : IGBT ON and carrying current.
- a2. Short-circuit current detection (SC trigger).
- a3. IGBT gate interrupt.
- 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 "H" : IGBT OFF state.
- a7. Input "L" : IGBT ON state.
- a8. IGBT OFF state.



[B] Under-Voltage Protection (N-side, UVd)

- b1. Normal operation : IGBT ON and carrying current.
- b2. Under-voltage trip (UV_{Dt}).
- b3. IGBT OFF in spite of control input condition.
- b4. FO timer operation starts.
- b5. Under-voltage reset (UV_{Dr}).
- b6. Normal operation : IGBT ON and carrying current.



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[C] Under-Voltage Protection (P-side, UVDB)

- c1. Control supply voltage rises : After the voltage level reaches UV_{DBr} , the circuits start to operate when the 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 (there is no Fo signal output).
- c5. Under-voltage reset (UV_{DBr}).
- c6. Normal operation : IGBT ON and carrying current.

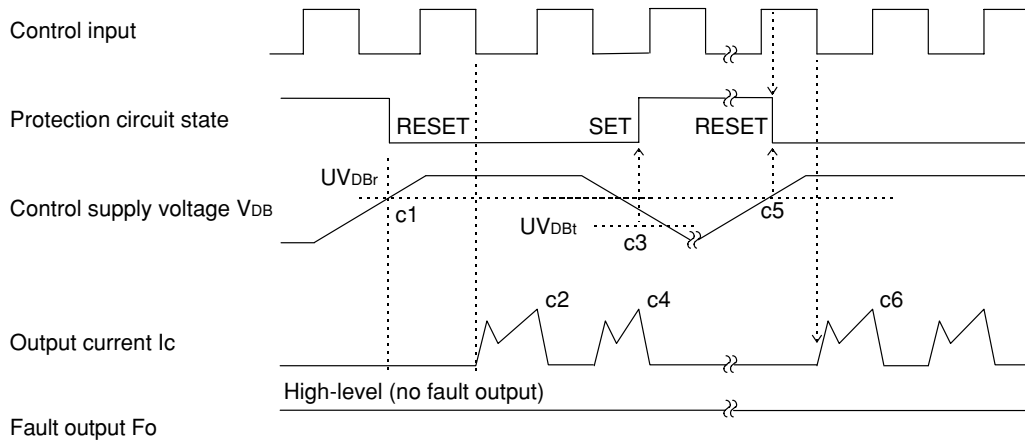
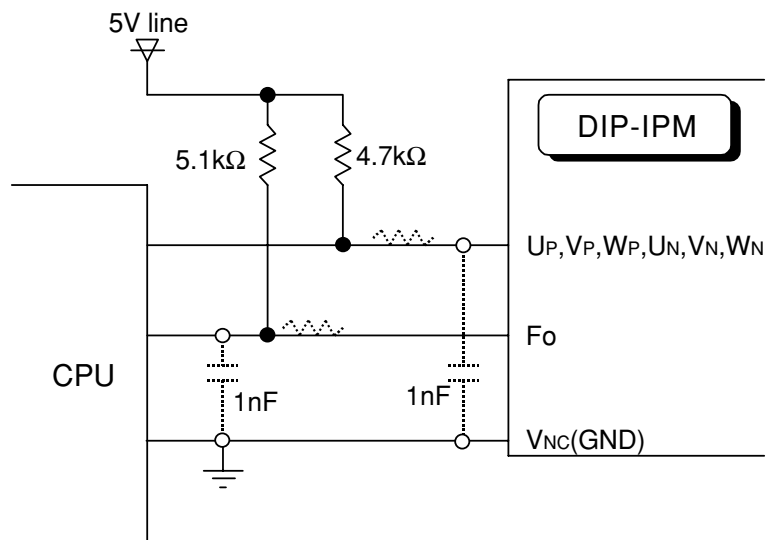


Fig. 6 RECOMMENDED CPU I/O INTERFACE CIRCUIT

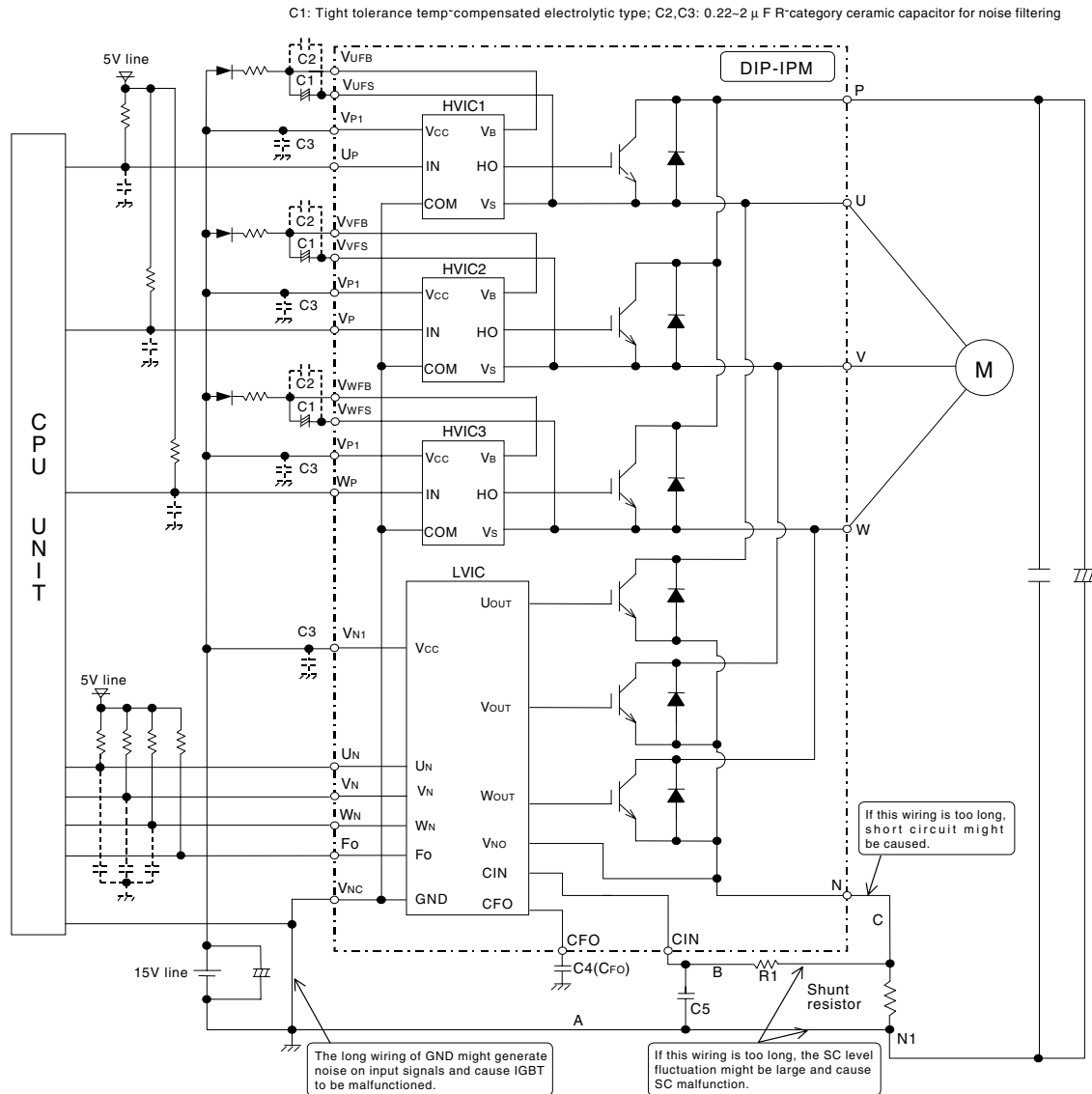


Note : RC coupling at each input (parts shown dotted) may change depending on the PWM control scheme used in the application and on the wiring impedance of the application's printed circuit board.

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Fig. 7 TYPICAL DIP-IPM APPLICATION CIRCUIT EXAMPLE



Note 1 : To prevent the input signals oscillation, an RC coupling at each input is recommended, and 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 CPU terminals without any opto-coupler or transformer isolation is possible.

3 : Fo output is open collector type. This signal line should be pulled up to the positive side of the 5V power supply with approximately 5.1k Ω resistance.

4 : Fo output pulse width should be decided by connecting an external capacitor between CFO and VNC terminals (CFO). (Example : CFO = 22 nF $\rightarrow$ tFO = 1.8 ms (typ.))

5 : Each input signal line should be pulled up to the positive side of the 5V power supply with approximately 4.7k Ω resistance (other RC coupling circuits at each input may be needed depending on the PWM control scheme used and on the wiring impedances of the system's printed circuit board). Approximately a 0.22~2 μ F by-pass capacitor should be used across each power supply connection terminals.

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

7 : In the recommended protection circuit, please select the R1C5 time constant in the range of 1.5~2 μ s.

8 : Each capacitor should be put as nearby the terminals of the DIP-IPM as possible.

9 : To prevent surge destruction, the wiring between the smoothing capacitor and the P&N1 terminals should be as short as possible. Approximately a 0.1~0.22 μ F snubber capacitor between the P&N1 terminals is recommended.