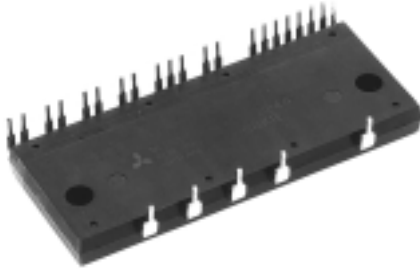


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INTEGRATED POWER FUNCTIONS

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 supply).
- Input interface : 5V line CMOS/TTL compatible, Schmitt Trigger receiver circuit.

APPLICATION

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

Fig. 1 PACKAGE OUTLINES

Dimensions in mm

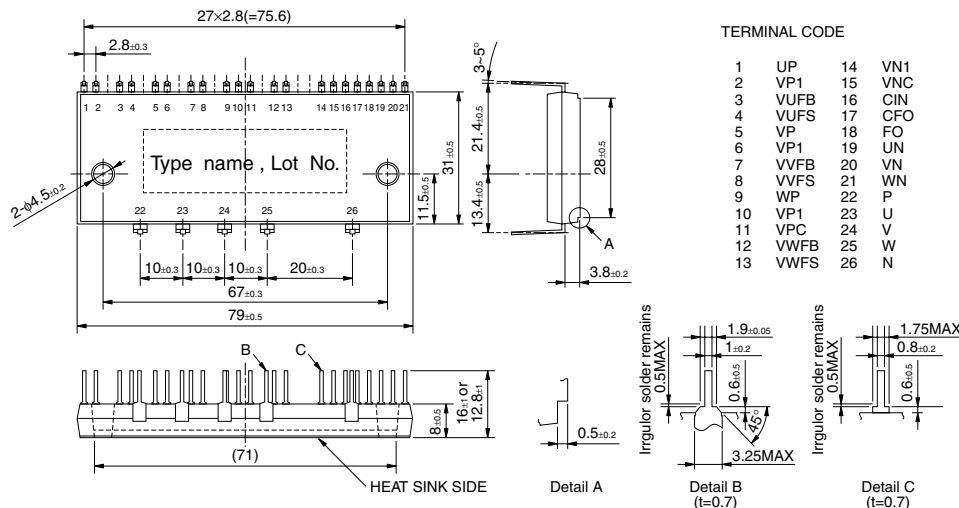


Fig. 2 INTERNAL FUNCTIONS BLOCK DIAGRAM (TYPICAL APPLICATION EXAMPLE)

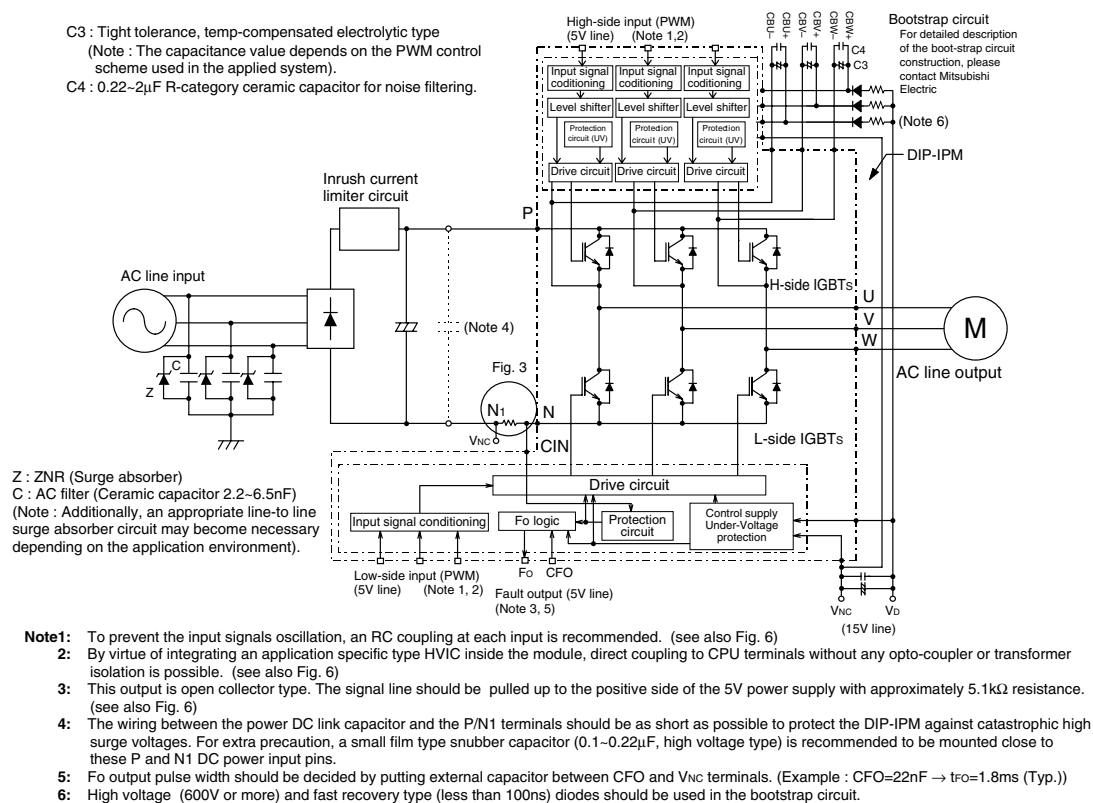
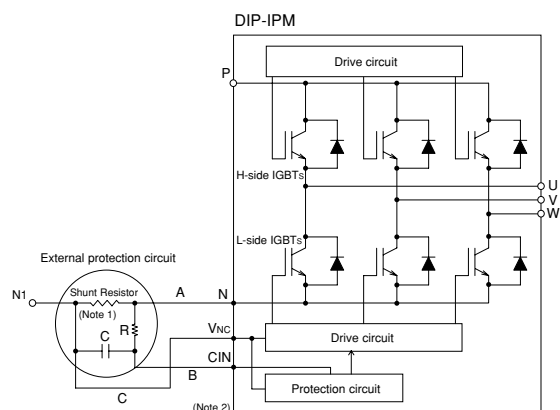
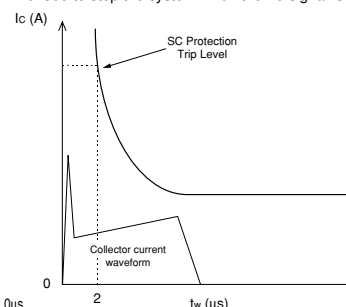


Fig. 3 EXTERNAL PART OF THE DIP-IPM PROTECTION CIRCUIT



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.



Note1: In the recommended external protection circuit, please select the RC time constant in the range 1.5~2.0μs.
Note2: To prevent erroneous protection operation, the wiring of A, B, C should be as short as possible.

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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	$T_c = 25^\circ\text{C}$	25	A
$\pm I_{CP}$	Each IGBT collector current (peak)	$T_c = 25^\circ\text{C}$, instantaneous value (pulse)	50	A
P _C	Collector dissipation	$T_c = 25^\circ\text{C}$, per 1 chip	59.5	W
T _j	Junction temperature	(Note 1)	-20~+150	°C

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

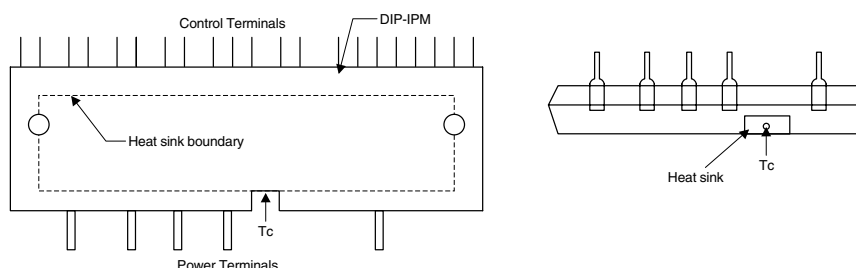
CONTROL (PROTECTION) PART

Symbol	Parameter	Condition	Ratings	Unit
V _D	Control supply voltage	Applied between VP1-VPC, VN1-VNC	20	V
V _{DB}	Control supply voltage	Applied between VUFB-VUFS, VVFB-VVFS, VWFB-VWFS	20	V
V _{CIN}	Input voltage	Applied between UP, VP, WP-VPC, UN, VN, WN-VNC	-0.5~+5.5	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	15	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 _C	Module case operation temperature	(Note 2)	-20~+100	°C
T _{stg}	Storage temperature		-40~+125	°C
V _{iso}	Isolation voltage	60Hz, Sinusoidal, AC 1 minute, connection pins to heat-sink plate	1500	V _{rms}

Note 2 : T_C MEASUREMENT POINT



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THERMAL RESISTANCE

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
R _{th(j-c)Q}	Junction to case thermal resistance	Inverter IGBT part (per 1/6 module)	—	—	2.1	°C/W
R _{th(j-c)F}		Inverter FWD part (per 1/6 module)	—	—	3.0	°C/W
R _{th(c-f)}	Contact thermal resistance	Case to fin, (per 1 module) thermal grease applied	—	—	0.067	°C/W

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 _{CIN} = 0V	—	1.55	2.15	V
V _{EC}	FWD forward voltage	T _j = 25°C, -I _C = 25A, V _{CIN} = 5V	—	2.50	3.40	V
t _{on}	Switching times	V _{CC} = 300V, V _D = V _{DB} = 15V I _C = 25A, T _j = 125°C, V _{CIN} = 5V ↔ 0V Inductive load (upper-lower arm)	0.10	0.80	1.30	μs
t _{rr}			—	0.10	—	μs
t _{c(on)}			—	0.30	0.70	μs
t _{off}			—	1.50	2.60	μs
t _{c(off)}			—	0.80	1.70	μs
I _{CES}	Collector-emitter cut-off current	V _{CE} = V _{CES}	—	—	1	mA
		T _j = 25°C	—	—	10	
		T _j = 125°C	—	—	10	

CONTROL (PROTECTION) PART

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
V _D	Control supply voltage	Applied between V _{P1} -V _{PC} , 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
I _D	Circuit current	V _D = V _{DB} = 15V V _{CIN} = 5V	—	—	8.50	mA
		Total of V _{P1} -V _{PC} , V _{N1} -V _{NC} V _{UFB} -V _{UFS} , V _{VFB} -V _{VFS} , V _{WFB} -V _{WFS}	—	—	1.00	
V _{FOH}	Fault output voltage	V _{SC} = 0V, F _O = 10kΩ 5V pull-up	4.9	—	—	V
V _{FOL}		V _{SC} = 1V, F _O = 10kΩ 5V pull-up	—	0.8	1.2	V
V _{FOsat}		V _{SC} = 1V, I _{FO} = 15mA	0.8	1.2	1.8	V
t _{dead}	Arm shoot-through blocking time	Relates to corresponding input signal for blocking arm shoot-through. -20°C ≤ T _C ≤ 100°C	2.5	—	—	μs
V _{SC(ref)}	Short circuit trip level	T _j = 25°C, V _D = 15V (Note 3)	0.45	0.5	0.55	V
UV _{DBt}	Supply circuit under-voltage protection	T _j ≤ 125°C	Trip level		10.0	V
UV _{DBr}			Reset level		10.5	V
UV _{Dt}			Trip level		10.3	V
UV _{Dr}			Reset level		10.8	V
t _{FO}	Fault output pulse width	C _{FO} = 22nF (Note 4)	1.0	1.8	—	ms
V _{th(on)}	ON threshold voltage	Applied between : UP, VP, WP-V _{PC} , UN, VN, WN-V _{NC}	0.8	1.4	2.0	V
V _{th(off)}	OFF threshold voltage		2.5	3.0	4.0	V

Note 3 : Short circuit protection is functioning only at the low-arms. Please select the value of the external shunt resistor such that the SC trip-level is less than 42.5 A.

4 : Fault signal is output when the low-arms 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 × 10⁻⁶ × t_{FO} [F].

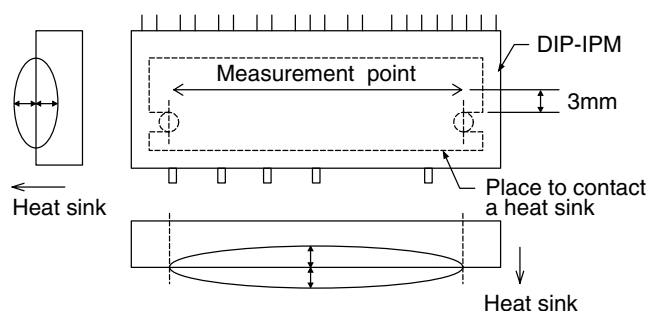
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MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition		Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M4	—	0.98	1.18	1.47	N·m
Terminal pulling strength	Weight 19.6N	EIAJ-ED-4701	10	—	—	s
Bending strength	Weight 9.8N. 90deg bend	EIAJ-ED-4701	2	—	—	times
Weight		—	—	54	—	g
Heat-sink flatness	(Note 5)	—	-50	—	100	μm

Note 5: 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 VP1-VPC, VN1-VNC	13.5	15.0	16.5	V
V _{DB}	Control supply voltage	Applied between VUFB-VUFS, VVFB-VVFS, VWFB-VWFS	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	Relates to corresponding input signal for blocking arm shoot-through	2.5	—	—	μs
f _{PWM}	PWM input frequency	T _c ≤ 100°C, T _j ≤ 125°C	—	5	—	kHz
V _{CIN(ON)}	Input ON threshold voltage	Applied between UP, VP, WP-VPC	0~0.65			V
V _{CIN(OFF)}	Input OFF threshold voltage	Applied between UN, VN, WN-VNC	4.0~5.5			V

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Fig. 4 THE DIP-IPM INTERNAL CIRCUIT

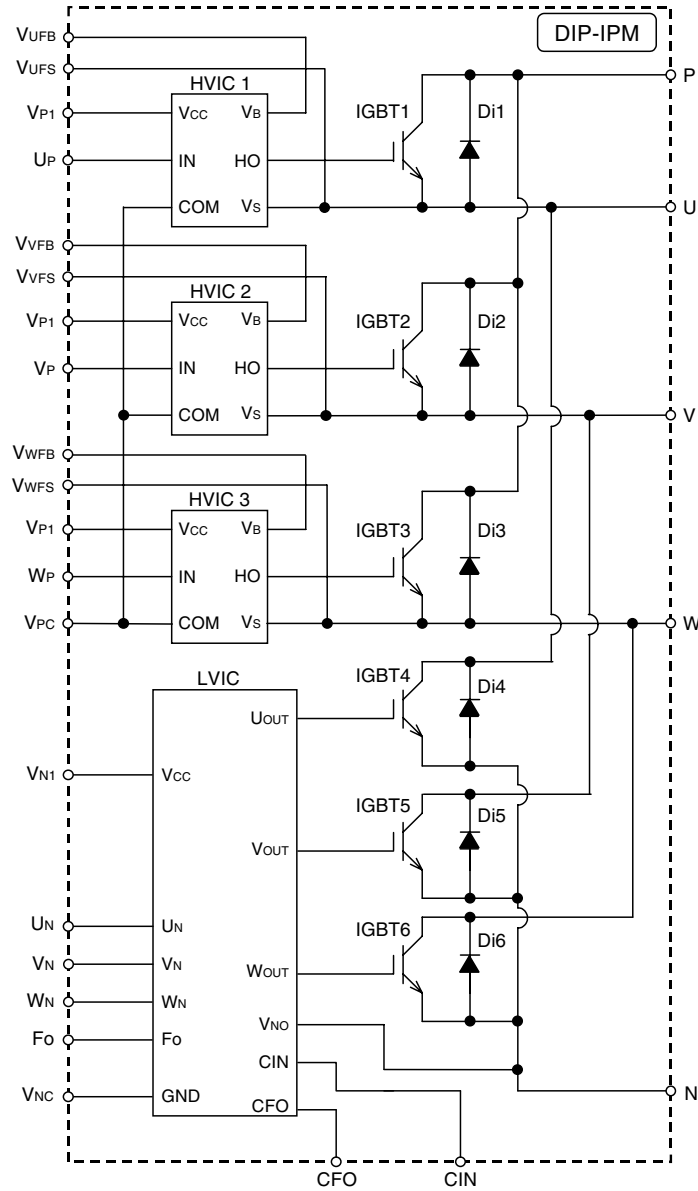
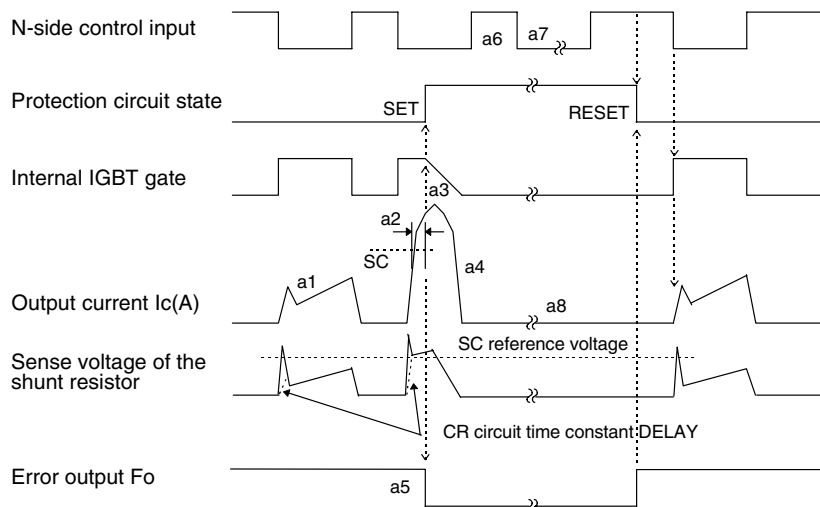


Fig. 5 TIMING CHARTS OF THE DIP-IPM PROTECTIVE FUNCTIONS

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

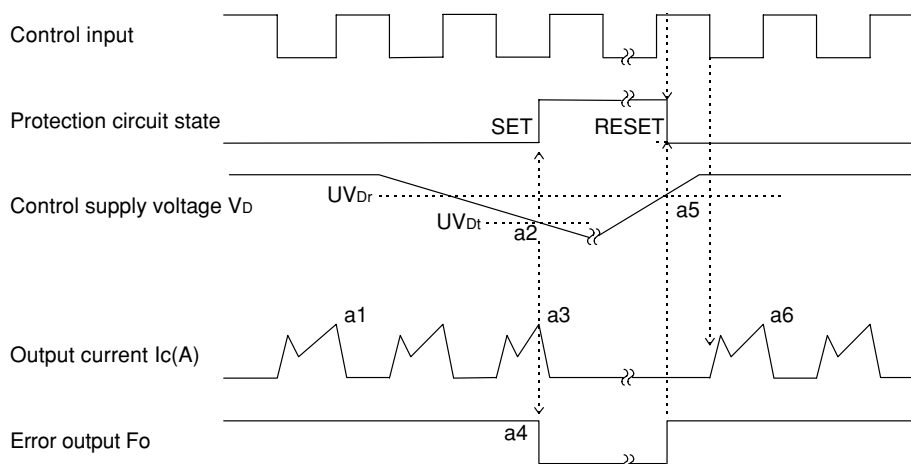
(For the external shunt resistor and CR connection.)

- a1. Normal operation : IGBT ON and carrying current.
- a2. Short circuit current detection (SC trigger).
- a3. Hard 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, UV_D)

- a1. Normal operation : IGBT ON and carrying current.
- a2. Under voltage trip (UV_{Dt}).
- a3. IGBT OFF in spite of control input condition.
- a4. Fo timer operation starts.
- a5. Under voltage reset (UV_{Dr}).
- a6. Normal operation : IGBT ON and carrying current.



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

- a1. Control supply voltage rises : After the voltage level reaches UVDBr, the circuits start to operate when the next input is applied.
- a2. Normal operation : IGBT ON and carrying current.
- a3. Under voltage trip (UVDBt).
- a4. IGBT OFF in spite of control input condition, but there is no Fo signal output.
- a5. Under-voltage reset (UVDBr).
- a6. Normal operation : IGBT ON and carrying current.

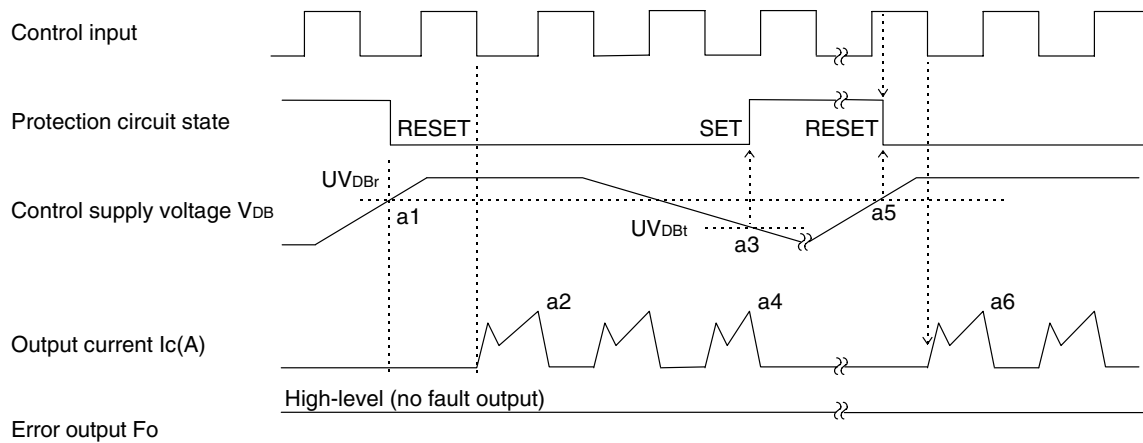
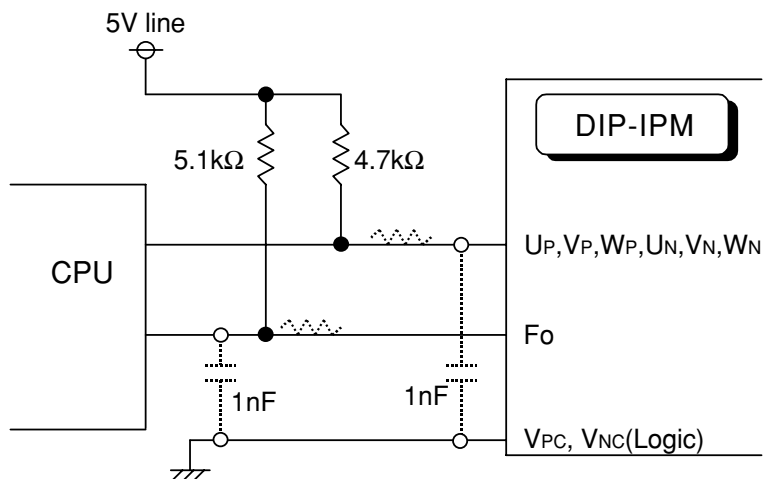


Fig. 6 RECOMMENDED CPU I/O INTERFACE CIRCUIT

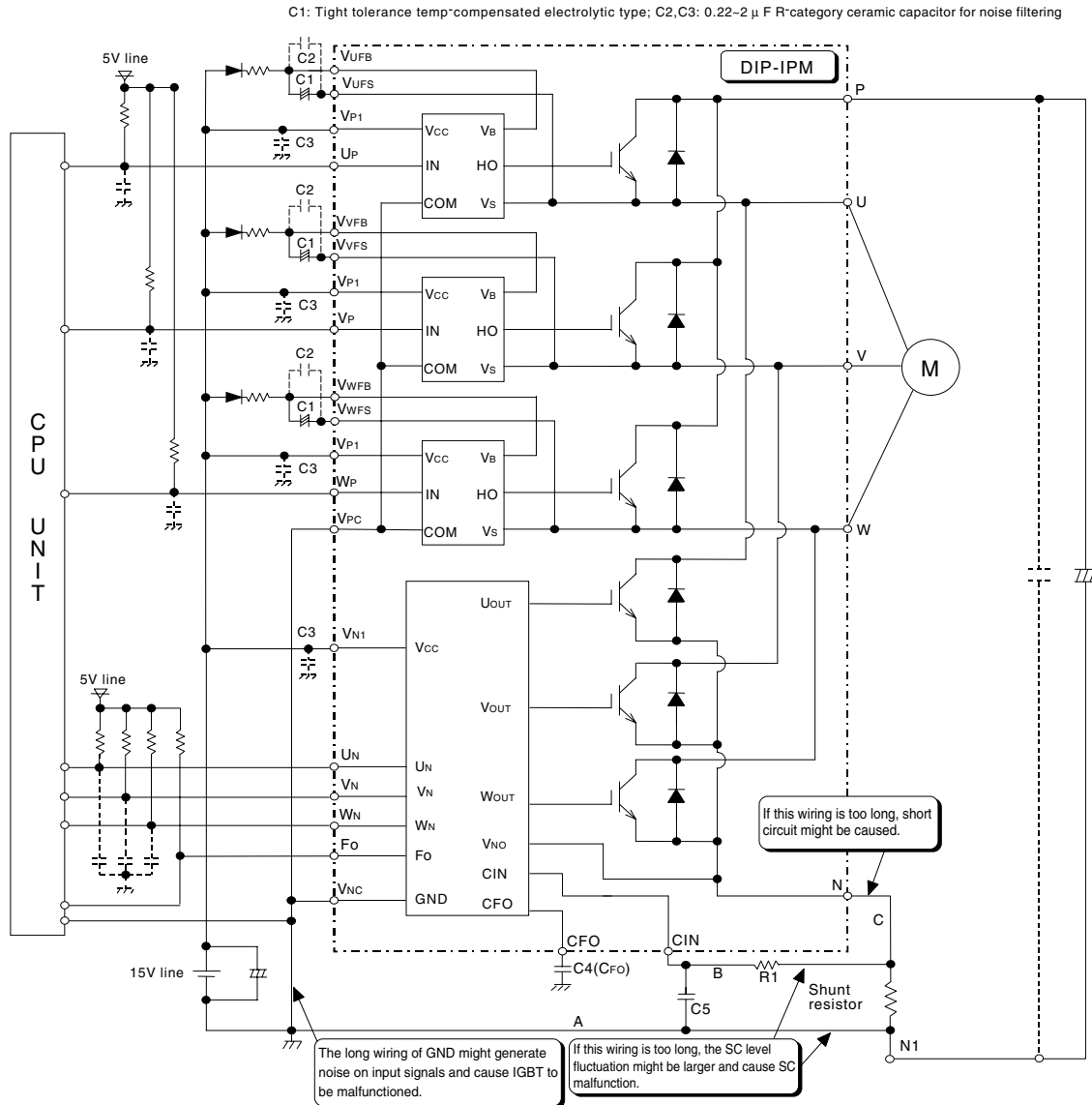


Note : RC coupling at each input (parts shown dotted) may change depending on the PWM control scheme used in the application and on the wiring impedances of the application's printed circuit board.

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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 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 1.5~2 μ s.
- 8:** Each capacitor should be put 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 0.1~0.22 μ F snubber capacitor between the P&N1 pins is recommended.