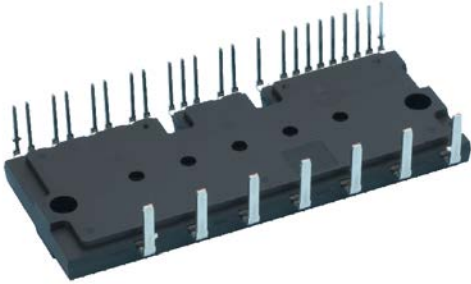


< DIIPM >

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TRANSFER MOLDING TYPE
INSULATED TYPE

OUTLINE



MAIN FEATURES AND RATINGS

- 3 phase DC/AC inverter
- 600V / 50A
- Built-in LPT-CSTBT (7th generation IGBT)
- Built-in bootstrap diodes with current limiting resistor
- Insulated transfer molding package
- N-side IGBT open emitter

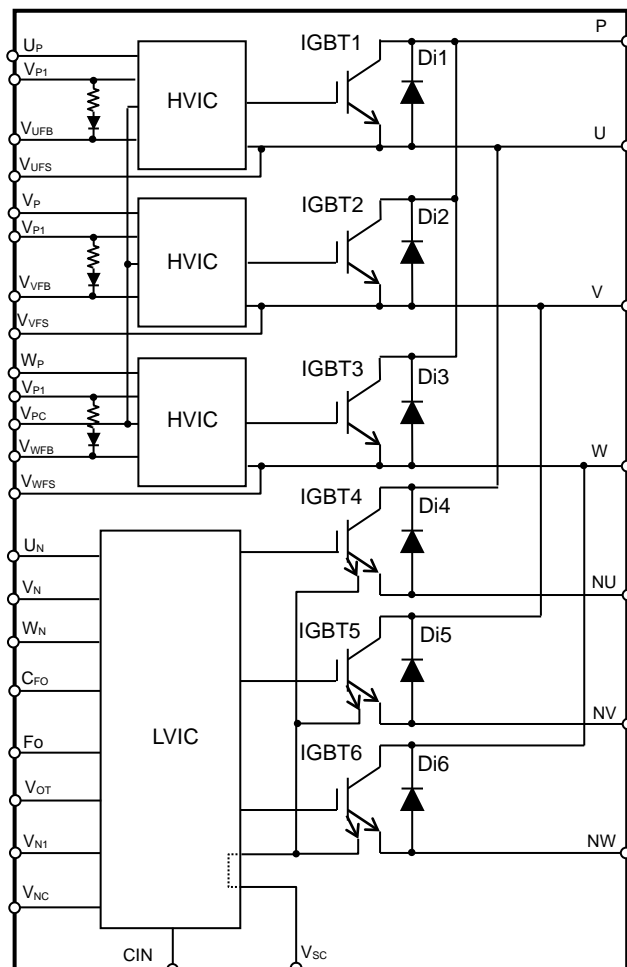
APPLICATION

- AC 400V class motor control

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 SC fault (N-side IGBT), UV fault (N-side supply)
- Temperature output : Outputting LVIC temperature by analog signal
- Input interface : 3, 5V line, Schmitt trigger receiver circuit (High Active)
- UL Recognized : UL1557 File E80276

INTERNAL CIRCUIT



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

INVERTER PART

Symbol	Parameter	Condition	Ratings	Unit
V _{CC}	Supply voltage	Applied between P-NU,NV,NW	450	V
V _{CC(surge)}	Supply voltage (surge)	Applied between P-NU,NV,NW	500	V
V _{CEs}	Collector-emitter voltage		600	V
±I _C	Each IGBT collector current	T _C = 25°C (Note 1)	50	A
±I _{CP}	Each IGBT collector current (peak)	T _C = 25°C, up to 1ms	100	A
T _j	Junction temperature		-30~+150	°C

Note 1: Pulse width and period are limited due to junction temperature.

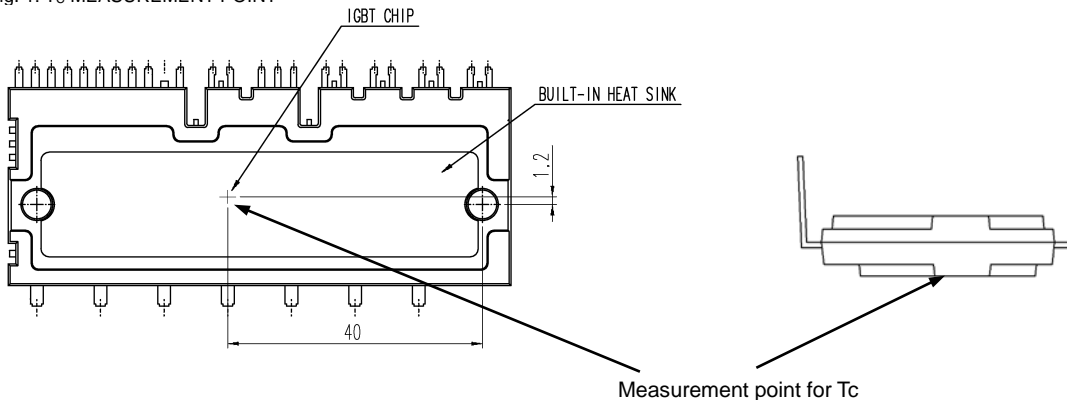
CONTROL (PROTECTION) PART

Symbol	Parameter	Condition	Ratings	Unit
V _D	Control supply voltage	Applied between V _{P1} -V _{PC} , V _{N1} -V _{NC}	20	V
V _{DB}	Control supply voltage	Applied between V _{UFB} -V _{UFS} , V _{VFB} -V _{VFS} , V _{WFB} -V _{WFS}	20	V
V _{IN}	Input voltage	Applied between U _P , V _P , W _P -V _{PC} , 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	5	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 = 150°C, non-repetitive, up to 2μs	400	V
T _C	Module case operation temperature	T _c measurement point is defined in Fig.1.	-30~+125	°C
T _{stg}	Storage temperature		-40~+125	°C
V _{ISO}	Isolation voltage	60Hz, Sinusoidal, AC 1min, between connected all pins and heat sink plate	2500	V _{rms}

Fig. 1: 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 2)	Inverter IGBT part (per 1/6 module)	-	-	0.88	K/W
R _{th(j-c)F}		Inverter FWDi part (per 1/6 module)	-	-	1.78	K/W

Note 2: Grease with good thermal conductivity and long-term endurance should be applied evenly with about +100μm~+200μm on the contacting surface of DIIPM and heat sink. The contacting thermal resistance between DIIPM 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)} is about 0.2K/W (per 1/6 module, grease thickness: 20μm, thermal conductivity: 1.0W/m·k).

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	$V_D=V_{DB}=15\text{V}$, $V_{IN}=5\text{V}$, $I_C=50\text{A}$	$T_j=25^\circ\text{C}$	-	1.30	1.60	V
			$T_j=125^\circ\text{C}$	-	1.40	1.70	
V_{EC}	FWDi forward voltage	$V_{IN}=0\text{V}$, $-I_C=50\text{A}$	-	1.70	2.20	V	
t_{on}	Switching times	$V_{CC}=300\text{V}$, $V_D=V_{DB}=15\text{V}$ $I_C=50\text{A}$, $T_j=125^\circ\text{C}$, $V_{IN}=0\leftrightarrow 5\text{V}$ Inductive Load (upper-lower arm)		1.20	1.80	2.40	μs
$t_{C(on)}$				-	0.40	0.65	μs
t_{off}				-	2.80	3.60	μs
$t_{C(off)}$				-	0.30	0.60	μs
t_{rr}				-	0.30	-	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.		
I_D	Circuit current	Total of $V_{P1}-V_{PC}$, $V_{N1}-V_{NC}$	$V_D=15\text{V}$, $V_{IN}=0\text{V}$	-	-	5.50	mA
			$V_D=15\text{V}$, $V_{IN}=5\text{V}$	-	-	5.50	
I_{DB}	Each part of $V_{UFB}-V_{UFS}$, $V_{VFB}-V_{VFS}$, $V_{WFB}-V_{WFS}$	$V_{DB}=15\text{V}$, $V_{IN}=0\text{V}$	-	-	0.55		
		$V_{DB}=15\text{V}$, $V_{IN}=5\text{V}$	-	-	0.55		
I_{SC}	Short circuit trip level	$R_s=31.6\Omega$ ($\pm 1\%$), Not connecting outer shunt resistors to NU, NV, NW terminals (Note 3)	85	-	-	A	
UV_{DBt}	P-side Control supply under-voltage protection(UV)	Trip level		10.0	-	12.0	V
UV_{DBr}			Reset level	10.5	-	12.5	V
UV_{Dt}	N-side Control supply under-voltage protection(UV)	Trip level		10.3	-	12.5	V
UV_{Dr}			Reset level	10.8	-	13.0	V
V_{FOH}	Fault output voltage	$V_{SC}=0\text{V}$, F_O terminal pulled up to 5V by 10k Ω	4.9	-	-	V	
V_{FOL}		$V_{SC}=1\text{V}$, $I_{FO}=1\text{mA}$	-	-	0.95	V	
t_{FO}	Fault output pulse width	$C_{FO}=22\text{nF}$ (Note 4)	1.6	2.4	-	ms	
I_{IN}	Input current	$V_{IN}=5\text{V}$	0.70	1.00	1.50	mA	
$V_{th(on)}$	ON threshold voltage	Applied between U_P , V_P , W_P-V_{PC} , U_N , V_N , W_N-V_{NC}		2.1	2.6	V	
$V_{th(off)}$	OFF threshold voltage			0.8	-		
V_{OT}	Temperature output	LVIC temperature= 75°C , pull-down resistor= $5.1\text{k}\Omega$ (Note 5)	2.26	2.38	2.51	V	
V_F	Bootstrap Di forward voltage	$I_F=10\text{mA}$ including voltage drop by limiting resistor (Note 6)	0.5	0.9	1.3	V	
R	Built-in limiting resistance	Included in bootstrap Di	16	20	24	Ω	

Note 3: Short circuit protection detects sense current divided from main current at N-side IGBT and works for N-side IGBT only. In the case that outer shunt resistor is inserted into main current path, protection current level I_{SC} changes.

4: Fault signal is output when short circuit or N-side control supply under-voltage protection works. The fault output pulse-width t_{FO} depends on the capacitance of C_{FO} . ($C_{FO}(\text{typ.}) = t_{FO} \times 9.1 \times 10^{-9}$) [F]

5: DIIPM doesn't shut down IGBTs and output fault signal automatically when temperature rises excessively. When temperature exceeds the protective level that user defined, controller (MCU) should stop immediately. Temperature of LVIC vs. V_{OT} output characteristics is described in Fig.3. These minimum and maximum curves are based on theoretical designed value excluding LVIC temperature= 75°C limits.

6: The characteristics of bootstrap Di is described in Fig.2.

Fig. 2 Characteristics of bootstrap Di V_F - I_F curve (@ $T_a=25^\circ\text{C}$) including voltage drop by limiting resistor (Right chart is enlarged chart.)

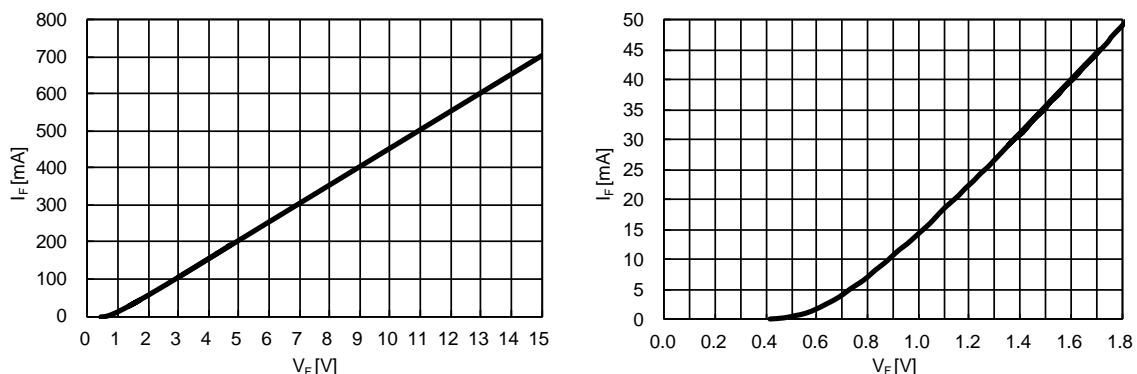


Fig. 3 Temperature of LVIC vs. V_{OT} Output Characteristics

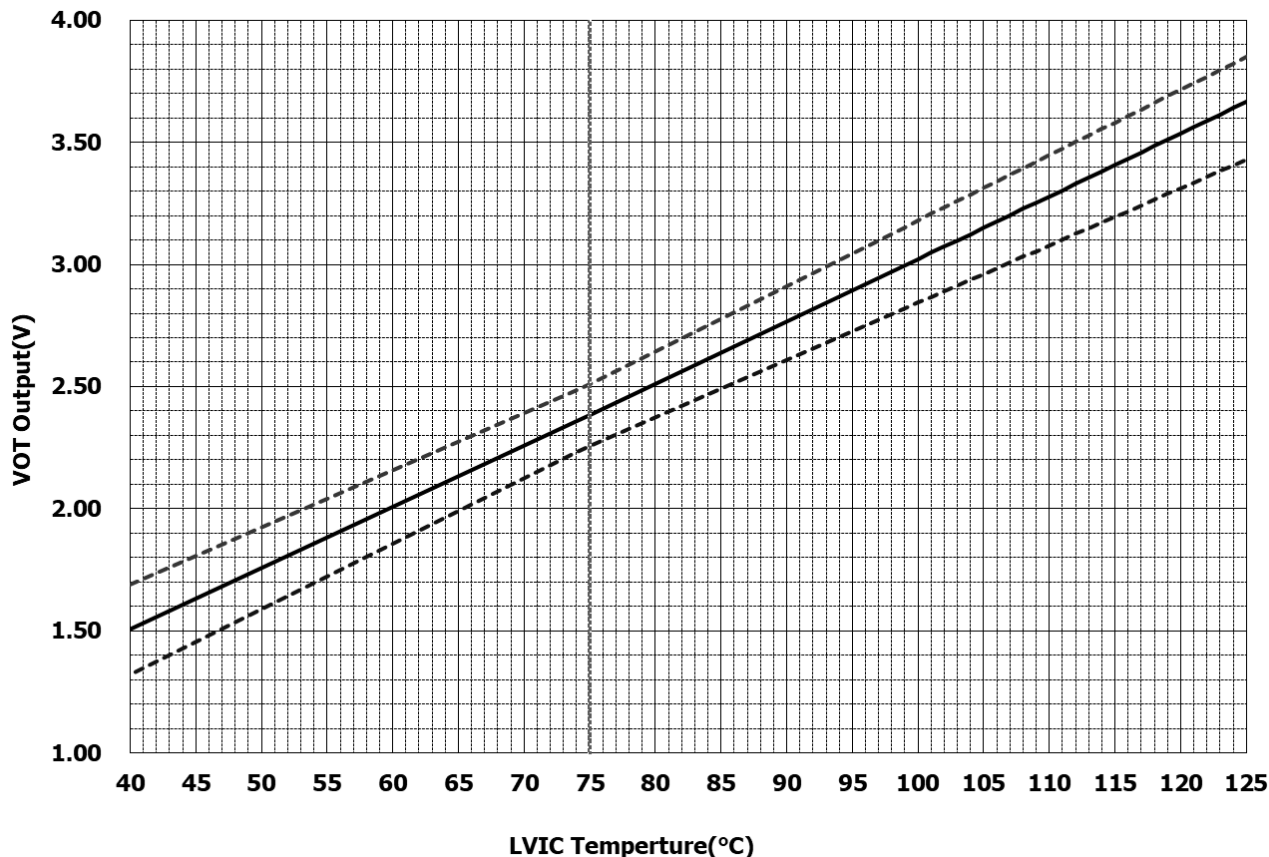
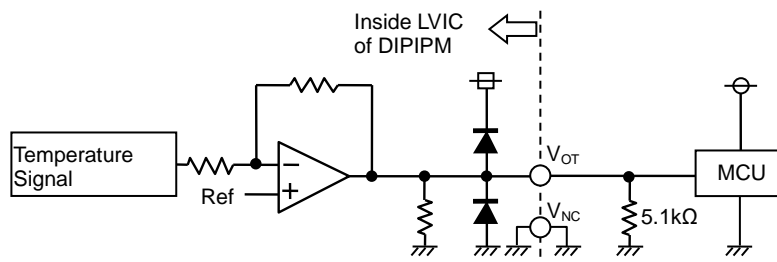


Fig. 4 V_{OT} output circuit



- (1) It is recommended to insert 5.1kΩ pull down resistor for getting linear output characteristics at low temperature below room temperature. When the pull down resistor is inserted between V_{OT} and V_{NC} (control GND), the extra circuit current, which is calculated approximately by V_{OT} output voltage divided by pull down resistance, flows as LVIC circuit current continuously. In the case of using V_{OT} for detecting high temperature over room temperature only, it is unnecessary to insert the pull down resistor.
- (2) In the case of not using V_{OT} , leave V_{OT} output NC (No Connection).

Refer the application note for this product about the usage of V_{OT} .

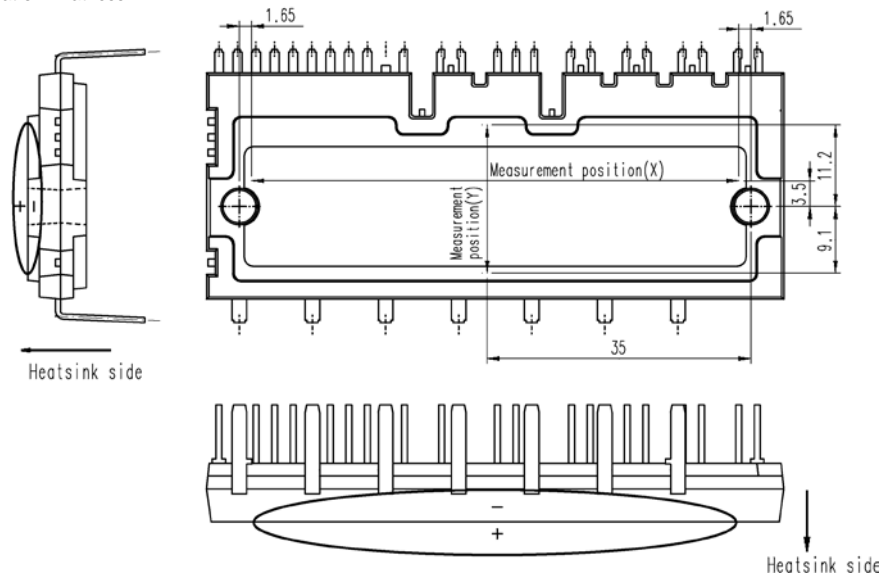
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MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition	Reference	Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M4 (Note 7)	JEITA-ED-4701 402 method II	0.98	1.18	1.47	N·m
Terminal strength pulling	Load 20N	JEITA-ED-4701 401 method I	10	-	-	s
Terminal strength bending	Load 10N, 90deg. bend	JEITA-ED-4701 401 method III	2	-	-	times
Weight			-	46	-	g
Heat radiation part flatness	(Note 8)		-50	-	100	μm

Note 7: Plain washers (ISO 7089-7094) are recommended.
Note 8: Measurement point of heat-sink flatness

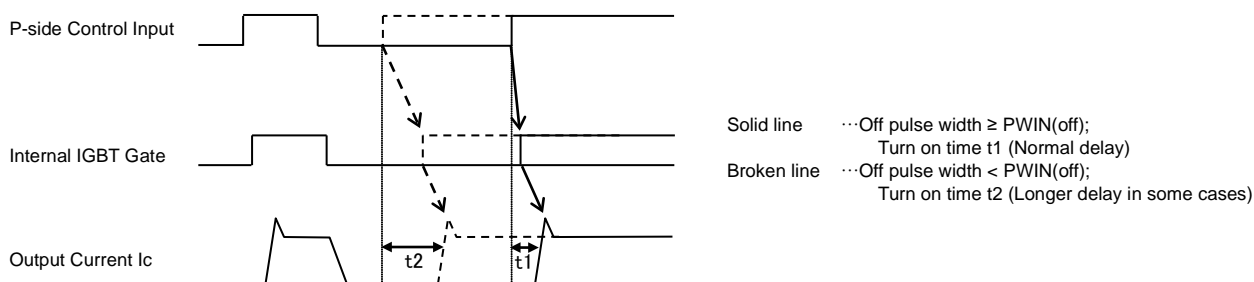


RECOMMENDED OPERATION CONDITIONS

Symbol	Parameter	Condition	Limits			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 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}	13.0	15.0	18.5	V
$\Delta V_D, \Delta V_{DB}$	Control supply variation		-1	-	+1	V/μs
t_{dead}	Arm shoot-through blocking time	For each input signal	2.2	-	-	μs
f_{PWM}	PWM input frequency	$T_C \leq 100^\circ\text{C}$, $T_I \leq 125^\circ\text{C}$	-	-	20	kHz
PWIN(on)	Minimum input pulse width	(Note 9) (Note 10)	1.5	-	-	μs
PWIN(off)			3.0	-	-	
V_{NC}	V_{NC} variation	Between V_{NC} -NU, NV, NW (including surge)	-5.0	-	+5.0	V

Note 9 : DIIPM might not make response if the input signal pulse width is less than PWIN(on).
Note 10: DIIPM might make no response or delayed response (P-side IGBT only) for input pulse width less than PWIN(off). Over rated collector current (I_c) operation, DIIPM might make delayed response even if the input signal pulse width is more than PWIN(off).

About Delayed Response Against Shorter Input Off Signal Than PWIN(off) (P-side only)



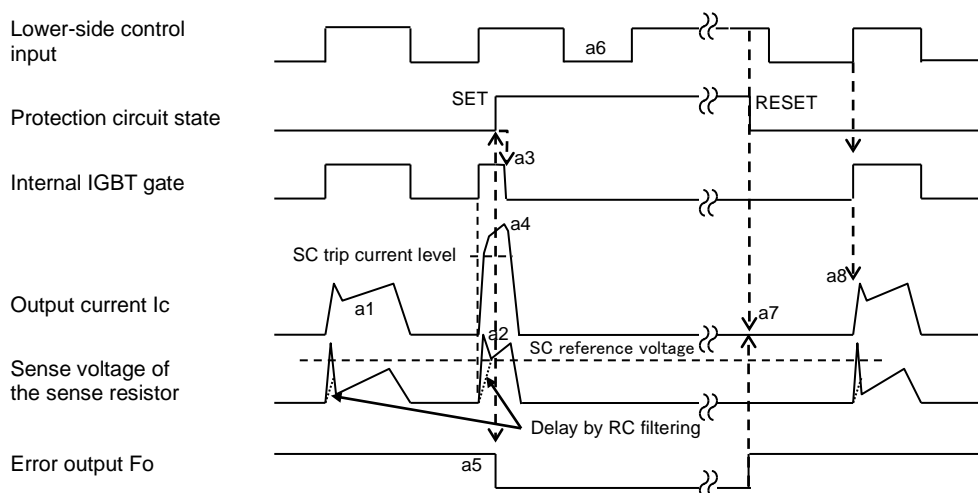
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TRANSFER MOLDING TYPE
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Fig. 5 Timing Charts of DIIPM Protective Functions

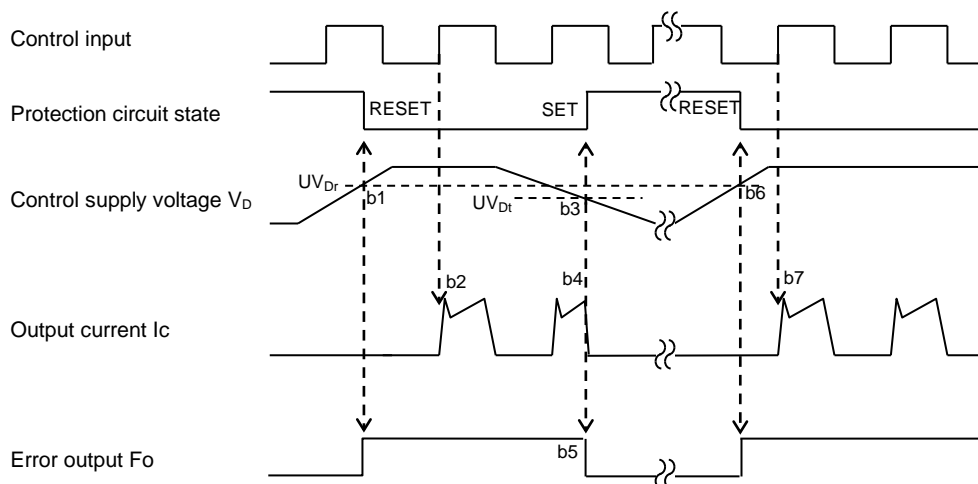
[A] Short-Circuit Protection (N-side only with the external sense resistor and RC filter)

- a1. Normal operation: IGBT ON and outputs current.
- a2. Short circuit current detection (SC trigger)
(It is recommended to set RC time constant 1.5~2.0μs so that IGBT shut down within 2.0μs when SC occurs.)
- a3. All N-side IGBT's gates are hard interrupted.
- a4. All N-side IGBTs turn OFF.
- a5. F_O outputs with a fixed pulse width determined by the external capacitor C_{F0}.
- a6. Input = "L": IGBT OFF
- a7. F_o finishes output, but IGBTs don't turn on until inputting next ON signal (L→H).
- (IGBT of each phase can return to normal state by inputting ON signal to each phase.)
- a8. Normal operation: IGBT ON and outputs current.



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

- b1. Control supply voltage V_D exceeds under voltage reset level (UV_{Dr}), but IGBT turns ON by next ON signal (L→H).
(IGBT of each phase can return to normal state by inputting ON signal to each phase.)
- b2. Normal operation: IGBT ON and outputs current.
- b3. V_D level drops to under voltage trip level. (UV_{Dt}).
- b4. All N-side IGBTs turn OFF in spite of control input condition.
- b5. F_o outputs for the period determined by the capacitance C_{F0}, but output is extended during V_D keeps below UV_{Dr}.
- b6. V_D level reaches UV_{Dr}.
- b7. Normal operation: IGBT ON and outputs current by next ON signal (L→H).



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

- c1. Control supply voltage V_{DB} rises. After the voltage reaches under voltage reset level UV_{DBr} , IGBT turns on by next ON signal (L→H).
- c2. Normal operation: IGBT ON and outputs current.
- c3. V_{DB} level drops to under voltage trip level (UV_{DBt}).
- c4. IGBT of corresponding phase only turns OFF in spite of control input signal level, but there is no F_o signal output.
- c5. V_{DB} level reaches UV_{DBr} .
- c6. Normal operation: IGBT ON and outputs current by next ON signal (L→H).

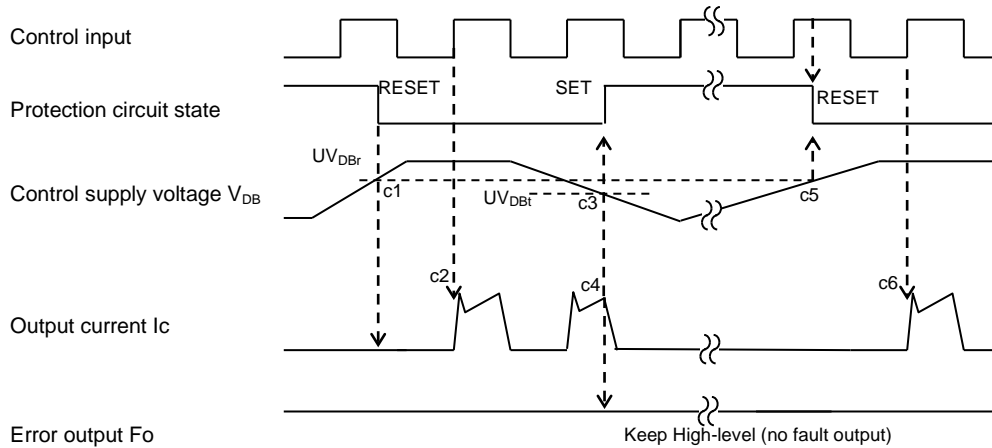
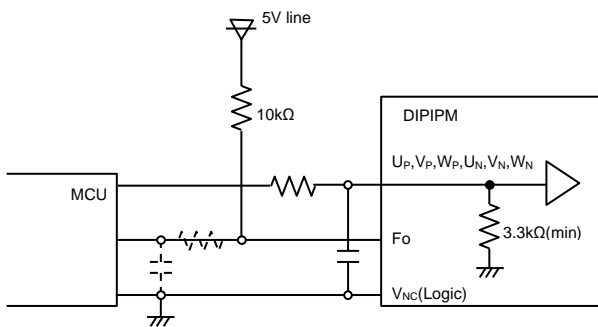


Fig. 6 MCU I/O Interface Circuit



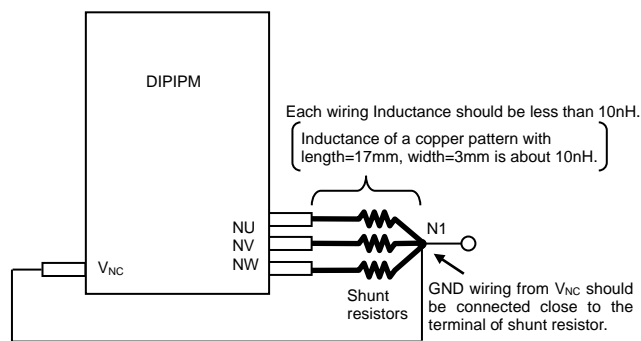
Note)

Design for input RC filter depends on the PWM control scheme used in the application and the wiring impedance of the printed circuit board.

The DIIPM input signal interface integrates a min. 3.3kΩ pull-down resistor. Therefore, when using RC filter, be careful to satisfy turn-on threshold voltage requirement.

F_o output is open drain type. It should be pulled up to the positive side of 5V or 15V power supply with the resistor that limits F_o sink current I_{F_o} under 1mA. In the case of pulling up to 5V supply, over 5.1kΩ is needed. (10kΩ is recommended.)

Fig. 7 Wiring Pattern around the Shunt Resistor in the Case of Inserting into Main Current Path

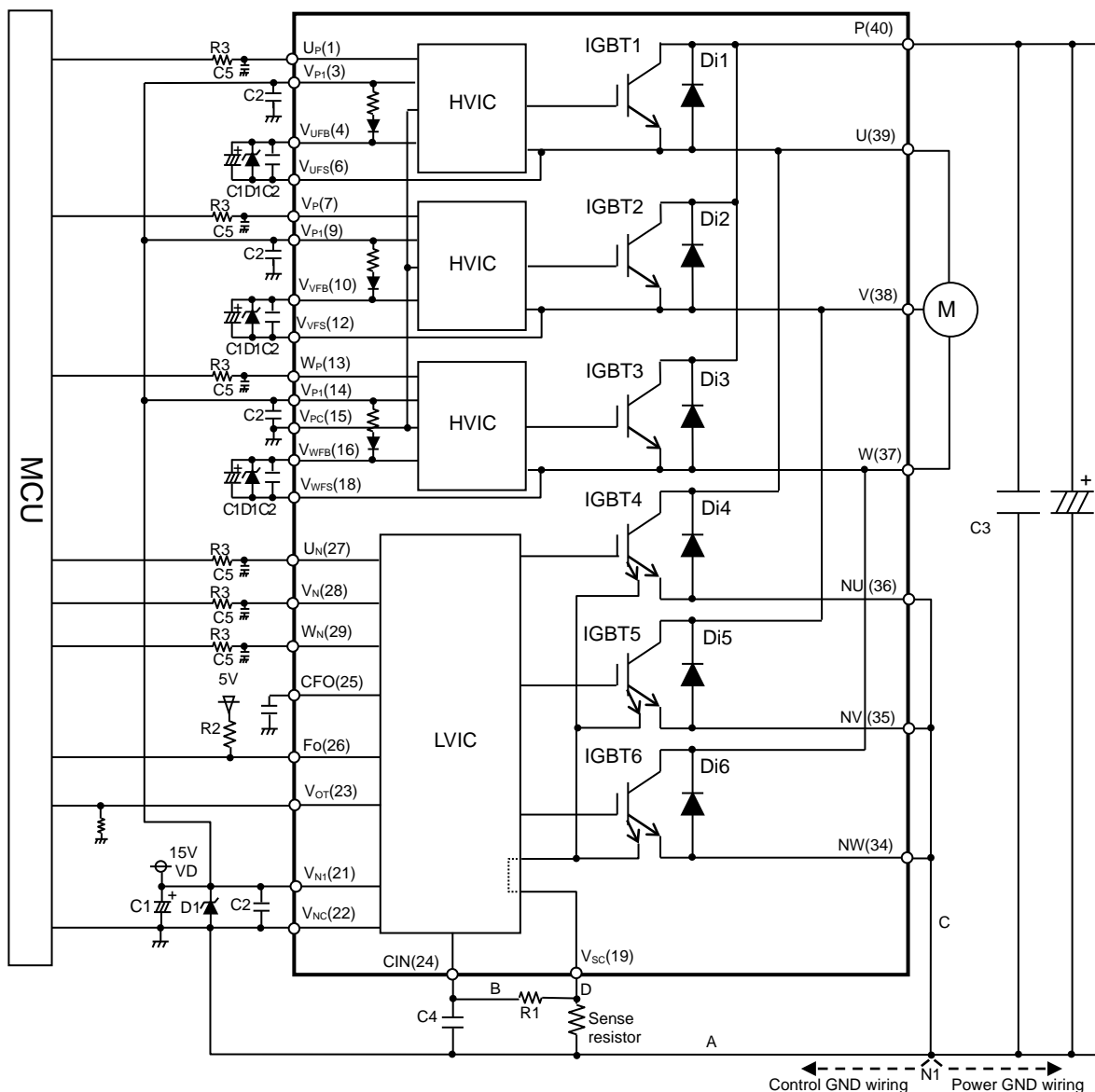


Low inductance shunt resistor like surface mounted (SMD) type is recommended.
Protection current level I_{sc} changes by inserting shunt resistor.

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Fig. 8 Example of Application Circuit



Note

- 1 :If control GND and power GND are patterned by common wiring, it may cause malfunction by fluctuation of power GND level. It is recommended to connect control GND and power GND at only a N1 point at which NU, NV, NW are connected to power GND line.
- 2 :It is recommended to insert a Zener diode D1 (24V/1W) between each pair of control supply terminals to prevent surge destruction.
- 3 :To prevent surge destruction, the wiring between the smoothing capacitor and the P, N1 terminals should be as short as possible. Generally inserting a 0.1 μ ~0.22 μ F snubber capacitor C3 between the P-N1 terminals is recommended.
- 4 :R1, C4 of RC filter for preventing protection circuit malfunction is recommended to select tight tolerance, temp-compensated type. The time constant R1C4 should be set so that SC current is shut down within 2 μ s. (1.5 μ s~2 μ s is general value.) SC interrupting time might vary with the wiring pattern, so the enough evaluation on the real system is recommended. If R1 is too small, it may leads to delay of protection. So R1 should be min. 10 times larger resistance than Rs. (100 times is recommended.)
- 5 :To prevent erroneous operation, the wiring of A, B, C should be as short as possible.
- 6 :For sense resistor, the variation within 1%(including temperature characteristics), low inductance type is recommended. And the over 0.03W is recommended, but it is necessary to evaluate in your real system finally.
- 7 :To prevent erroneous SC protection, the wiring from V_{sc} terminal to CIN filter should be divided at the point D that is close to the terminal of sense resistor. And the wiring should be patterned as short as possible.
- 8 :All capacitors should be mounted as close to the terminals of the DIIPM as possible. (C1: good temperature, frequency characteristic electrolytic type, and C2: 0.01 μ ~2.0 μ F, good temperature, frequency and DC bias characteristic ceramic type are recommended.)
- 9 :Input drive is High-active type. There is a min. 3.3k Ω pull-down resistor in the input circuit of IC. To prevent malfunction, the wiring of each input should be as short as possible. And it is recommended to insert RC filter (e.g. R3=100 Ω and C5=1000pF) and confirm the input signal level to meet the turn-on and turn-off threshold voltage. Thanks to HVIC inside the module, direct coupling to MCU without any opto-coupler or transformer isolation is possible.
- 10 :Fo output is open drain type. Fo output will be max 0.95V (@I_{FO}=1mA, 25 $^{\circ}$ C), so it should be pulled up to MCU or control power supply (e.g. 5V, 15V) by a resistor that makes I_{FO} up to 1mA. (In the case of pulled up to 5V, 10k Ω is recommended.)
- 11 :Error signal output width (t_{FO}) can be set by the capacitor connected to C_{FO} terminal. C_{FO}(typ.) = t_{FO} × 9.1 × 10⁻⁶ (F)
- 12 :If high frequency noise superimposed to the control supply line, IC malfunction might happen and cause erroneous operation. To avoid such problem, voltage ripple of control supply line should meet dV/dt ≤ ±1V/ μ s, Vripple ≤ 2Vp-p.
- 13 :For DIIPM, it isn't recommended to drive same load by parallel connection with other phase IGBT or other DIIPM.

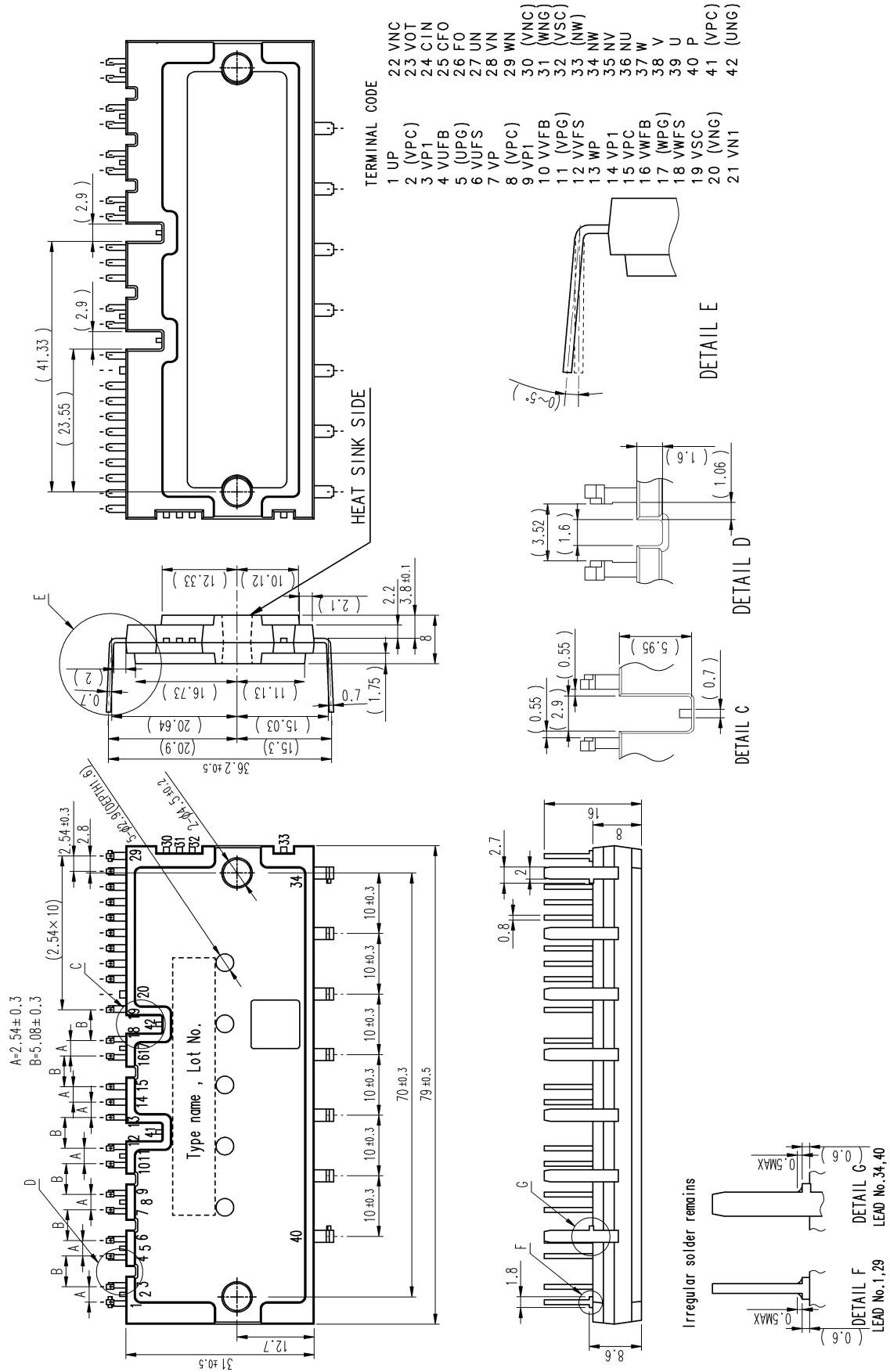
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Fig. 8 Package Outlines

Dimensions in mm



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