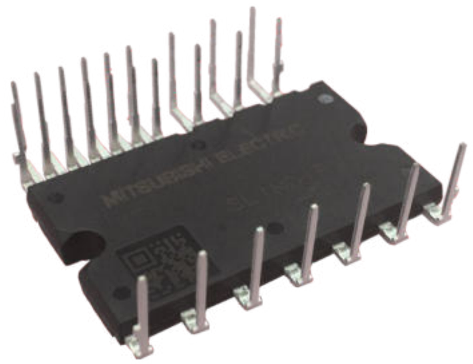
MITSUBISHI ELECTRIC

< DIPIPM >

SLIMDIP-M

TRANSFER MOLDING TYPE
INSULATED TYPE

OUTLINE



Normal terminal type

MAIN FUNCTION AND RATINGS

- RC-IGBT inverter bridge for three phase DC-to-AC power conversion
- Built-in bootstrap diodes with current limiting resistor
- Open emitter type

APPLICATION

- AC 100~240V (DC voltage:400V or below) three phase low power motor inverter drive

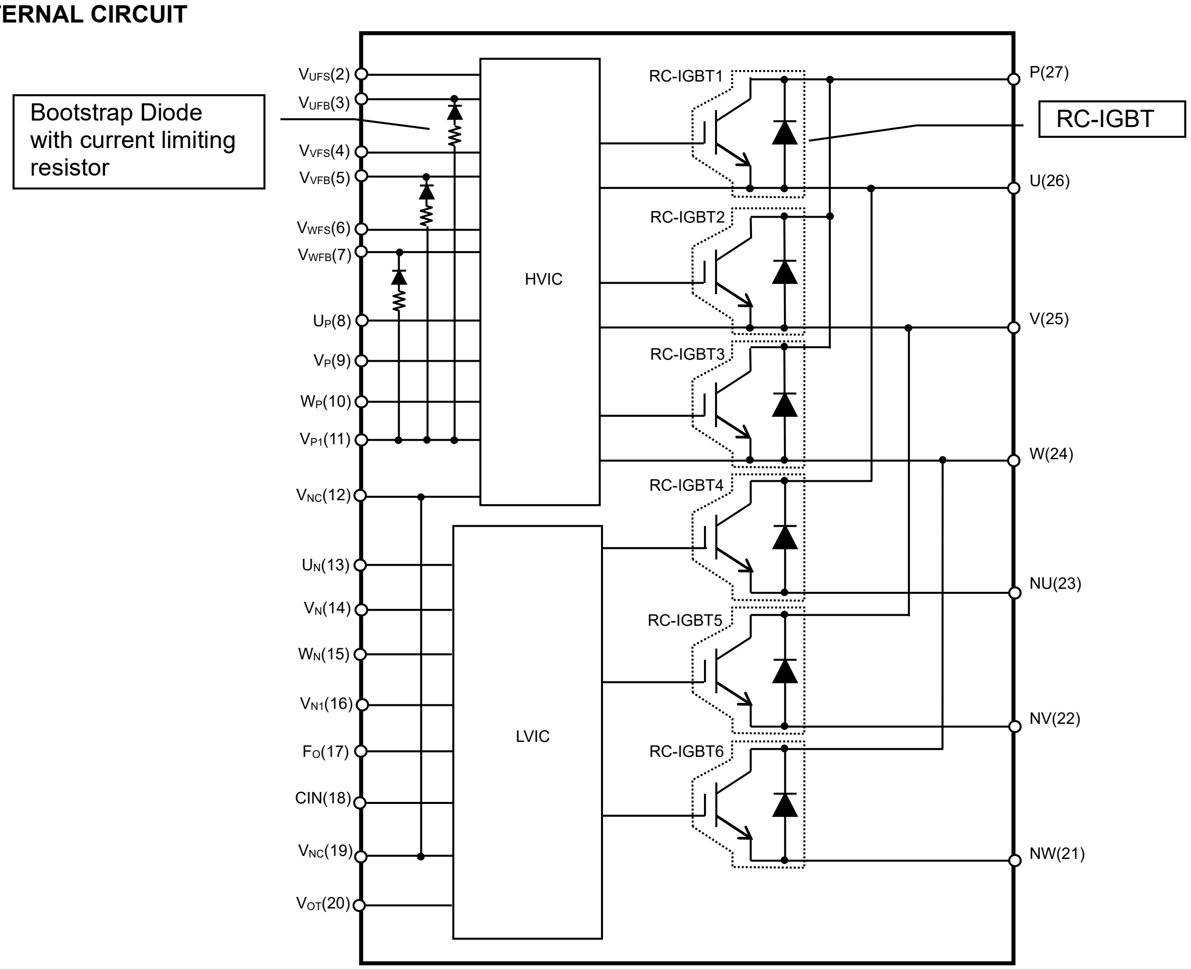
TERMINAL LINE UP

Terminal	Part number	Suffix
Normal terminal	SLIMDIP-M	500
Short terminal	SLIMDIP-M	505

INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS

- For P-side : Drive circuit, High voltage high-speed level shifting, Control supply under-voltage protection (UV)
- For N-side : Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC), Over temperature protection (OT)
- Fault signaling : Corresponding to SC fault (N-side IGBT), UV fault (N-side supply) and OT fault
- Temperature monitoring : Outputting LVIC temperature by analog signal
- Input interface : Schmitt-triggered 3V, 5V input compatible, high active logic.
- UL Recognized : UL1557 File E323585

INTERNAL CIRCUIT



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
$\pm I_C$	Each IGBT collector current	T_C= 25°C (Note 1)	10	A
$\pm I_{CP}$	Each IGBT collector current (peak)	T_C= 25°C, less than 1ms V_D,V_{DB}=15V	20	A
T_j	Junction temperature	(Note 2)	-30~+150	°C

Note1: Pulse width and period are limited due to junction temperature.
Note2: The maximum junction temperature rating of built-in chips is 150°C (@Tc≦115°C). However, to ensure safe operation of DIPIPM, the average junction temperature should be limited to Tj(Ave)≦125°C (@Tc≦115°C).

CONTROL (PROTECTION) PART

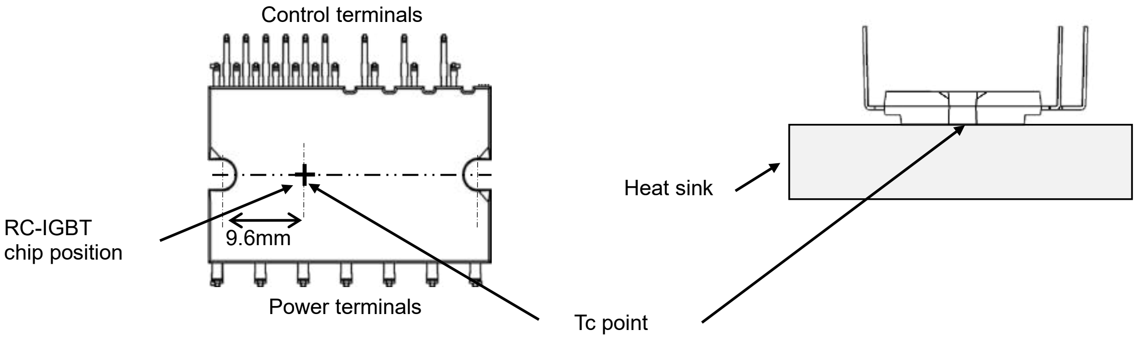
Symbol	Parameter	Condition	Ratings	Unit
V_D	Control supply voltage	Applied between V_{P1}-V_{NC}, V_{N1}-V_{NC}	20	V
V_{DB}	Control supply voltage	Applied between V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS},V_{WFB}-V_{WFS}	20	V
V_{IN}	Input voltage	Applied between U_P, V_P, W_P, U_N, V_N, W_N-V_{NC}	-0.5~V_D+0.5	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	1	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, less than 2μs	400	V
T_C	Module case operation temperature	Measurement point of Tc is described in Fig.1 (Note3)	-30~+115	°C
T_{stg}	Storage temperature		-40~+125	°C
V_{iso}	Isolation voltage	60Hz, Sinusoidal, AC 1min, between connected all pins and heat sink plate	2000	V_{rms}

Note3 T_C MEASUREMENT POINT

Fig. 1



THERMAL RESISTANCE

Symbol	Parameter	Condition	Limits Min.	Limits Typ.	Limits Max.	Unit
$R_{th(j-c)Q}$	Junction to case thermal resistance (Note 4)	Inverter RC-IGBT part (per 1/6 module)	-	-	5.2	K/W

Note 4: Grease with good thermal conductivity and long-term endurance should be applied evenly with about +100μm~+200μm on the contacting surface of DIPIPM and heat sink. The contacting thermal resistance between DIPIPM case and heat sink Rth(c-f) is determined by the thickness and the thermal conductivity of the applied grease. For reference, Rth(c-f) is about 0.4K/W (per 1/6 module, grease thickness: 20μm, thermal conductivity: 1.0W/m•K).

ELECTRICAL CHARACTERISTICS (T_j = 25°C, unless otherwise noted)

INVERTER PART

Symbol	Parameter	Condition		Limits Min.	Typ.	Max.	Unit
$V_{CE(sat)}$	Collector-emitter saturation voltage	V_D=V_{DB} = 15V, V_{IN}= 5V	I_C= 10A, T_j= 25°C	-	2.25	2.85	V
V_{EC}	FWDi forward voltage	V_{IN}= 0V, -I_C= 10A		-	1.90	2.40	V
t_{on}	Switching times	V_{CC}= 300V, V_D= V_{DB}= 15V I_C= 10A, T_j= 25°C, V_{IN}= 0↔5V Inductive Load (upper-lower arm)		0.50	0.85	1.20	μs
$t_{C(on)}$				-	0.30	0.50	μs
t_{off}				-	0.85	1.20	μs
$t_{C(off)}$				-	0.10	0.30	μs
t_{rr}				-	0.10	-	μs
I_{CES}	Collector-emitter cut-off current	V_{CE}=V_{CES}	T_j= 25°C	-	-	1	mA

CONTROL (PROTECTION) PART

Symbol	Parameter	Condition		Limits Min.	Typ.	Max.	Unit
I_D	Circuit current	Total of V_{P1}-V_{NC}, V_{N1}-V_{NC}	V_D=15V, V_{IN}=0V	-	-	3.10	mA
			V_D=15V, V_{IN}=5V	-	-	4.20	
I_{DB}		Each part of V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS}, V_{WFB}-V_{WFS}	V_D=V_{DB}=15V, V_{IN}=0V	-	-	0.10	
			V_D=V_{DB}=15V, V_{IN}=5V	-	-	0.10	
$V_{SC(ref)}$	Short circuit trip level	V_D = 15V (Note 5)		0.455	0.480	0.505	V
UV_{DBt}	P-side Control supply under-voltage protection(UV)	Trip level		9.0	10.0	12.0	V
UV_{DBr}		Reset level		9.0	10.0	12.0	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_{OT}	Temperature Output	Pull down R=5.1kΩ (Note 6)	LVIC Temperature=95°C	2.76	2.89	3.03	V
OT_t	Over temperature protection (Note 7)	V_D = 15V, Detect LVIC temperature	Trip level	115	130	145	°C
OT_{rh}			Hysteresis of trip-reset	-	10	-	°C
V_{FOH}	Fault output voltage	V_{SC} = 0V, F_O terminal pulled up to 5V by 10kΩ		4.9	-	-	V
V_{FOL}		V_{SC} = 1V, I_{FO} = 1mA		-	-	0.95	V
t_{FO}	Fault output pulse width	(Note 8)		20	-	-	μs
I_{IN}	Input current	V_{IN} = 5V		0.70	1.00	1.50	mA
$V_{th(on)}$	ON threshold voltage	Applied between U_P, V_P, W_P, U_N, V_N, W_N-V_{NC}		-	1.70	2.35	V
$V_{th(off)}$	OFF threshold voltage			0.70	1.30	-	
$V_{th(hys)}$	ON/OFF threshold hysteresis voltage			0.25	0.40	-	
V_F	Bootstrap Di forward voltage	I_F=10mA including voltage drop by limiting resistor (Note 9)		1.1	1.7	2.3	V
R	Built-in limiting resistance	Included in bootstrap Di		80	100	120	Ω

Note 5 : SC protection works only for N-side IGBT. Please select the external shunt resistance such that the SC trip-level is less than 1.5 times of the current rating in case of V_D<15V and less than 1.7 times of the current rating in case of V_D≥15V.
6 : 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=95°C limits.
7 : When the LVIC temperature exceeds OT trip temperature level(OT_t), OT protection works and Fo outputs. In that case if the heatsink dropped off or fixed loosely, don't reuse that DIPIPM. (There is a possibility that junction temperature of power chips exceeded maximum T_j(150°C).
8 : Fault signal Fo outputs when SC, UV or OT protection works. Fo pulse width is different for each protection modes. At SC failure, Fo pulse width is a fixed width (=minimum 20μs), but at UV or OT failure, Fo outputs continuously until recovering from UV or OT state. (But minimum Fo pulse width is 20μs.)
9 : The characteristics of bootstrap Di is described in Fig.2.

Fig. 2 Characteristics of Bootstrap Di V_F-I_F curve (@Ta=25°C) Including Voltage Drop by Limiting Resistor (Right chart is enlarged chart.)

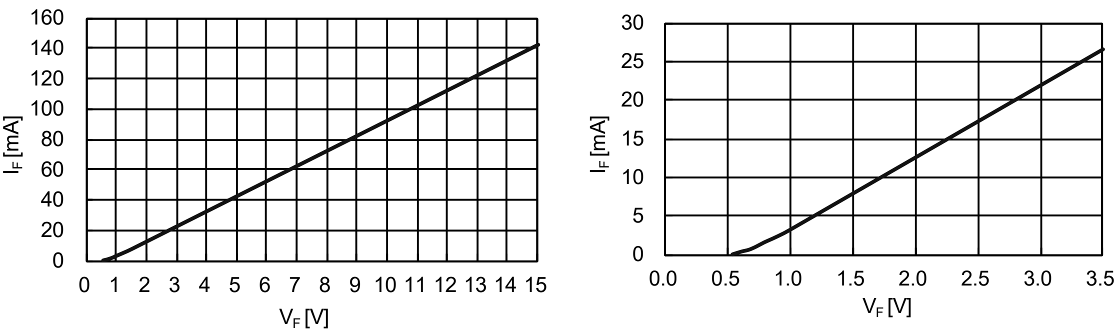


Fig. 3 Temperature of LVIC vs. V_{OT} Output Characteristics

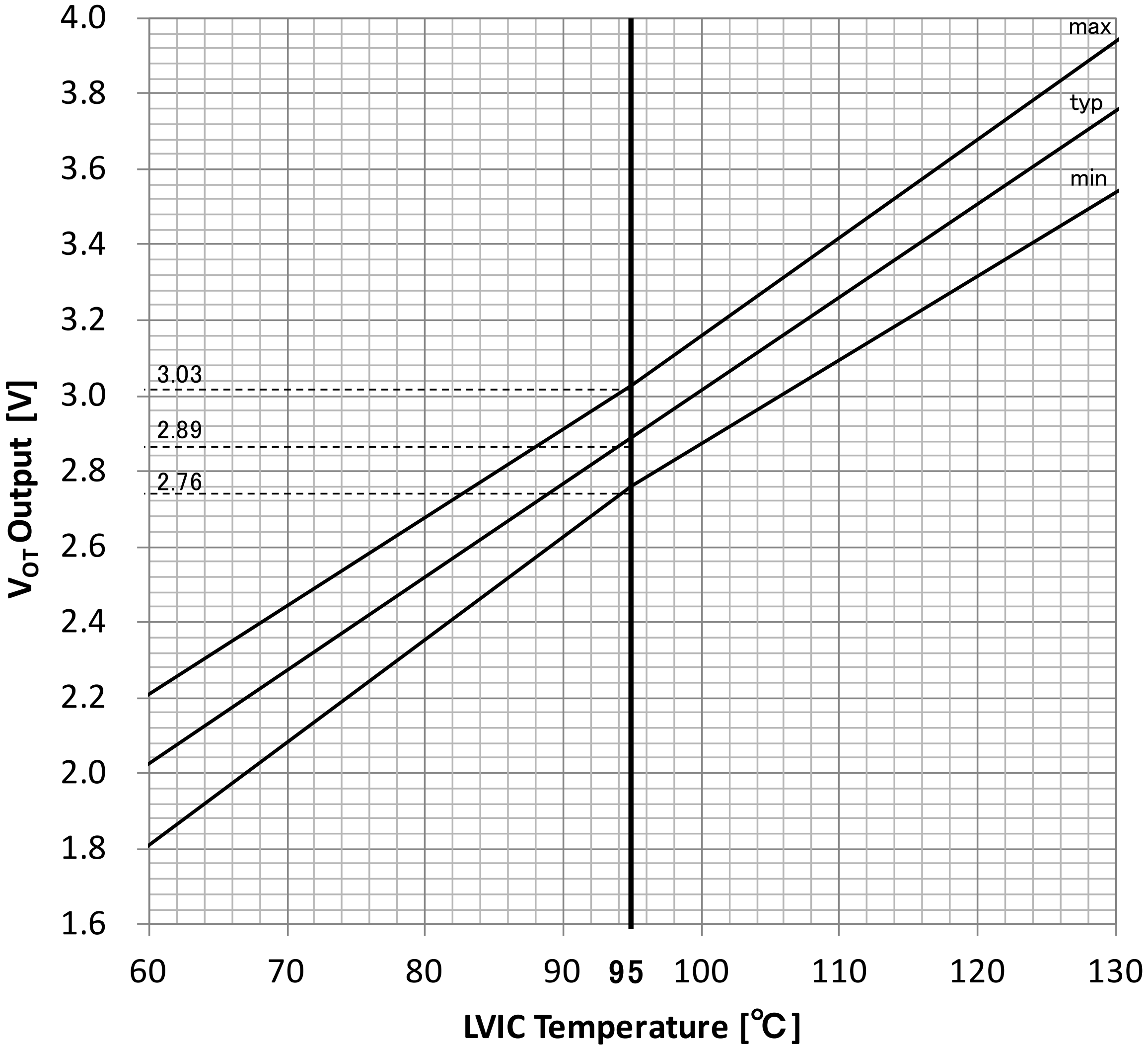
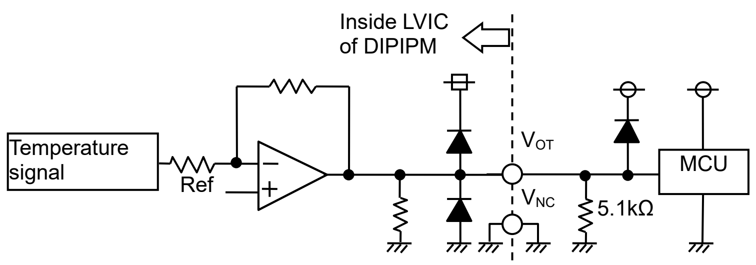


Fig. 4 Pattern Wiring Around the Analog Voltage Output Circuit [V_{OT} terminal]



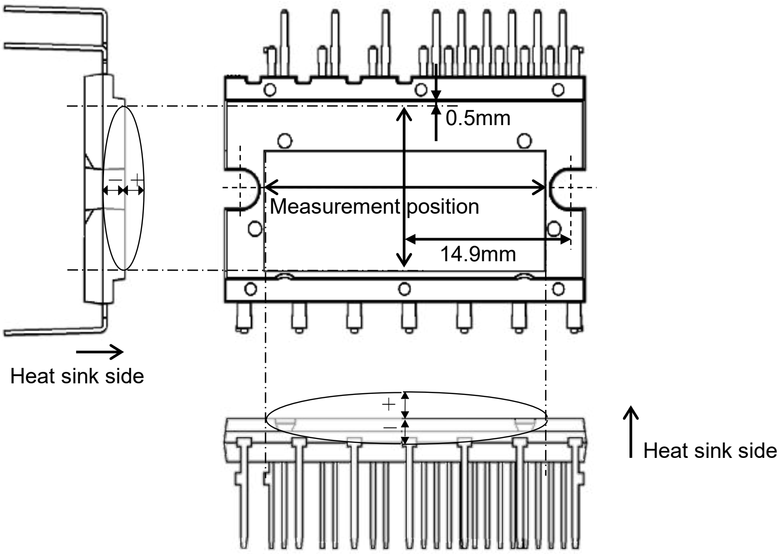
(1) V_{OT} outputs the analog signal that is amplified signal of temperature detecting element on LVIC by inverting amplifier.
(2) It is recommended to insert 5kΩ (5.1kΩ is recommended) pull down resistor for getting linear output characteristics at low temperature below room temperature. When the pull 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.
(3) In the case of using V_{OT} with low voltage controller like 3.3V MCU, V_{OT} output might exceed control supply voltage 3.3V when temperature rises excessively. If system uses low voltage controller, it is recommended to insert a clamp Di between control supply of the controller and V_{OT} output for preventing over voltage destruction.
(4) In the case of not using V_{OT}, leave V_{OT} output NC (No Connection).

Refer the application note for SLIMDIP series about the usage of V_{OT}.

MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition	Reference	Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M3 (Note 10)	JEITA-ED-4701 402 method Ⅱ	0.59	0.69	0.78	N·m
Terminal strength pull	Control terminal: Load 5N Power terminal: Load 10N	JEITA-ED-4701 401 method Ⅰ	10	-	-	s
Terminal strength bending	Control terminal: Load 2.5N Power terminal: Load 5N 90deg. bend	JEITA-ED-4701 401 method Ⅲ	2	-	-	times
Weight		-	-	5.5	-	g
Heat radiation part flatness	(Note 11)	-	-30	-	80	μm

Note 10: Plain washers (ISO 7089~7094) are recommended.
Note 11: Measurement positions of heat radiation part flatness are as below



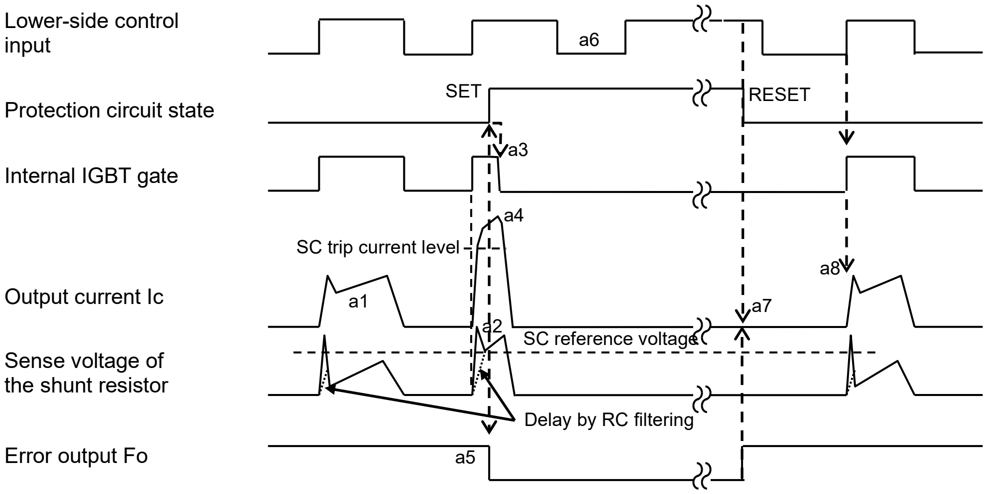
RECOMMENDED OPERATION CONDITIONS

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_{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}	13.0	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	1.0	-	-	μs
f_{PWM}	PWM input frequency	$T_C \leq 115°C$, $T_j \leq 125°C$	-	-	20	kHz
PWIN(on)	Minimum input pulse width		0.7	-	-	μs
PWIN(off)			0.7	-	-	
V_{NC}	V_{NC} variation	Between V_{NC}-NU, NV, NW (including surge)	-5.0	-	+5.0	V
Tj	Junction temperature		-20	-	125	°C

Fig. 5 Timing Charts of The DIPIPM Protective Functions

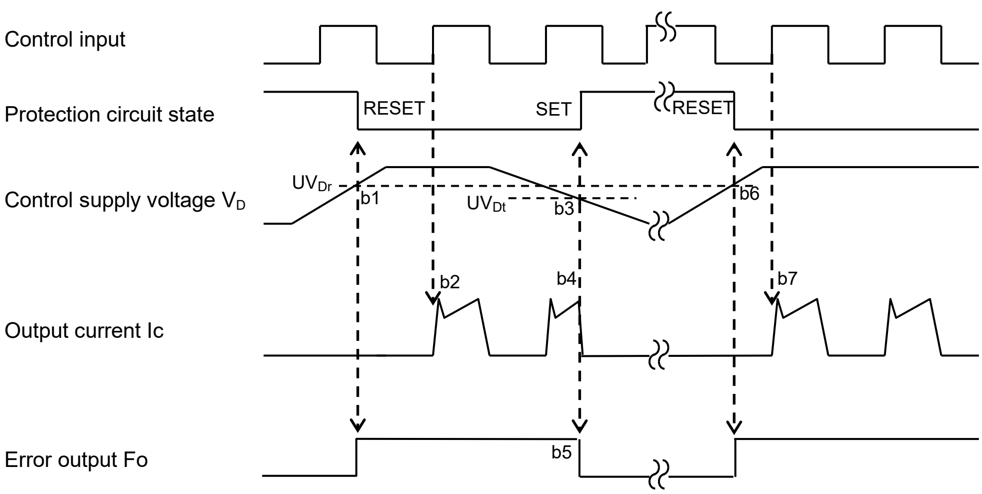
[A] Short-Circuit Protection (N-side only with the external shunt resistor and RC filter)

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.)
a3. All N-side IGBT's gates are hard interrupted.
a4. All N-side IGBTs turn OFF.
a5. F_O outputs for t_{Fo}=minimum 20μs.
a6. Input = “L”: IGBT OFF
a7. Fo 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.



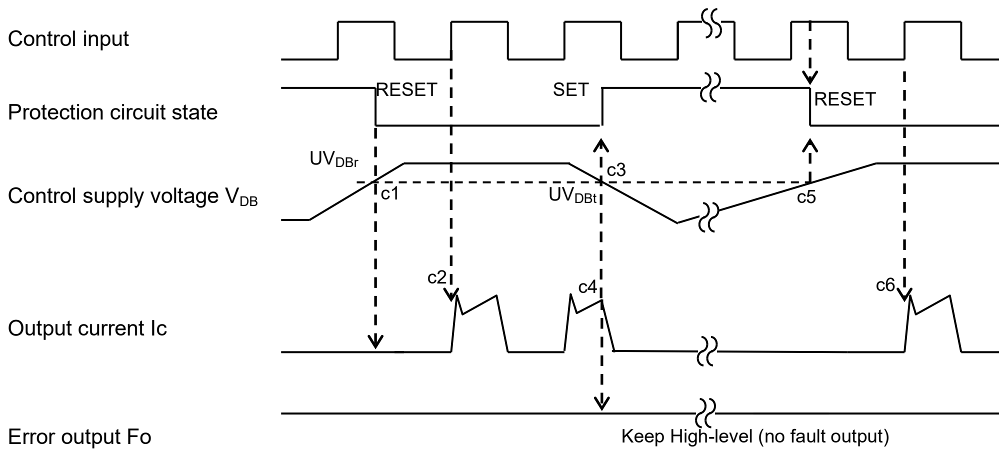
[B] Under-Voltage Protection (N-side, UV_D)

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. Fo outputs for t_{Fo}=minimum 20μs, 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.



[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 the 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.



[D] Over Temperature Protection (N-side, Detecting LVIC temperature)

d1. Normal operation: IGBT ON and outputs current.
d2. LVIC temperature exceeds over temperature trip level(OT_t).
d3. All N-side IGBTs turn OFF in spite of control input condition.
d4. Fo outputs for t_{Fo}=minimum 20μs, but output is extended during LVIC temperature keeps over OT_t.
d5. LVIC temperature drops to over temperature reset level.
d6. Normal operation: 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.)

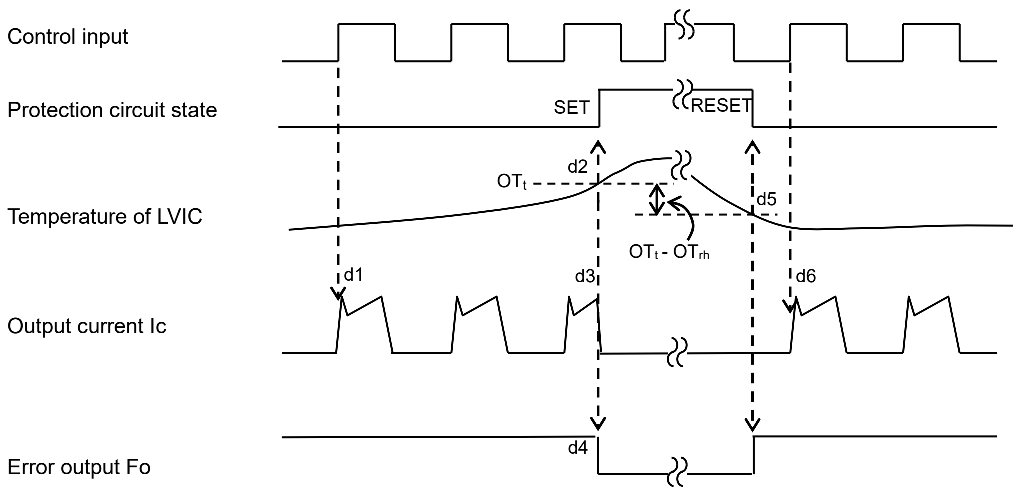
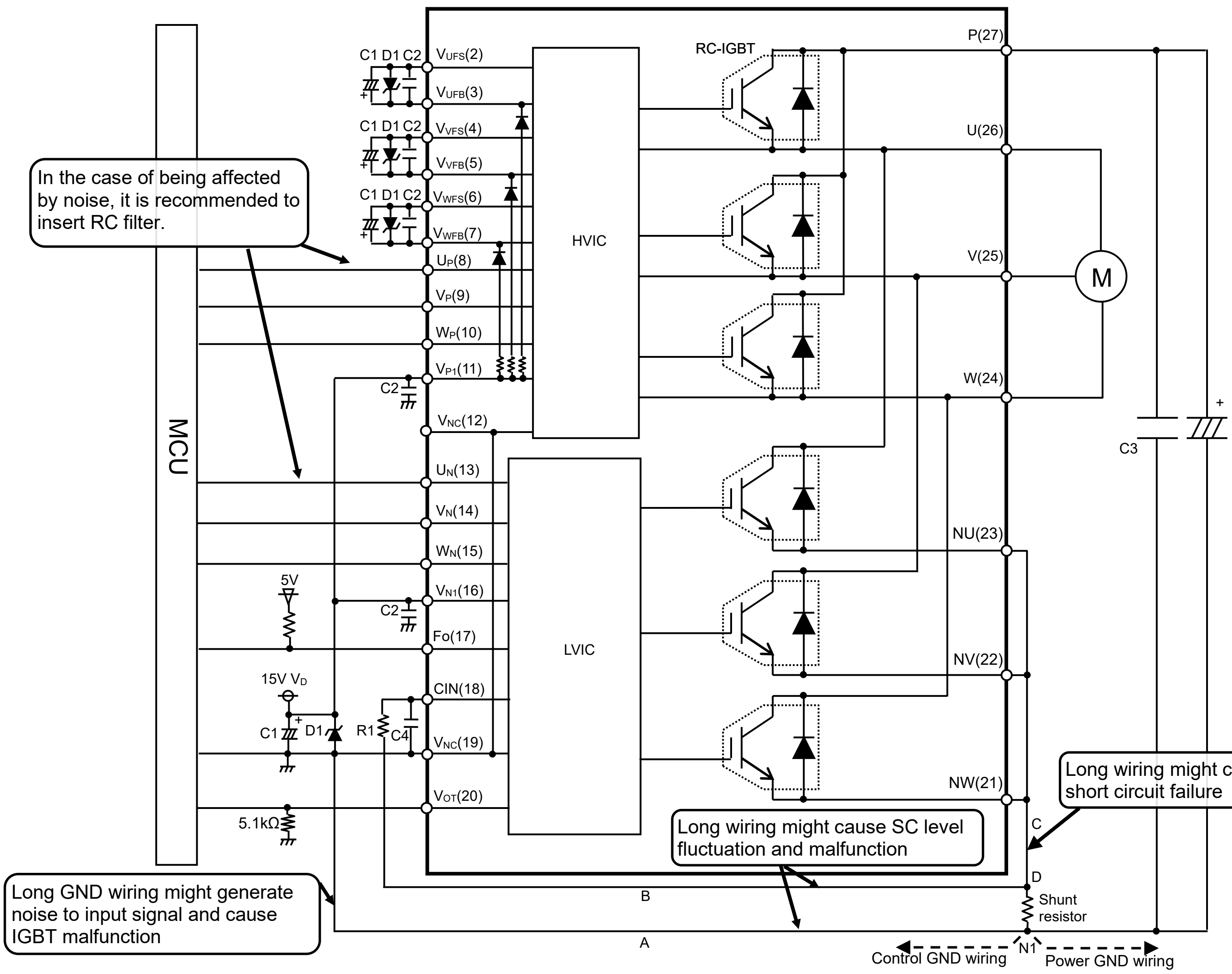
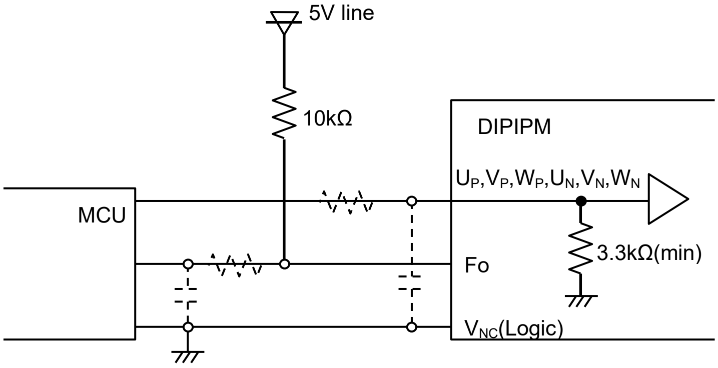


Fig. 6 Example of Application Circuit



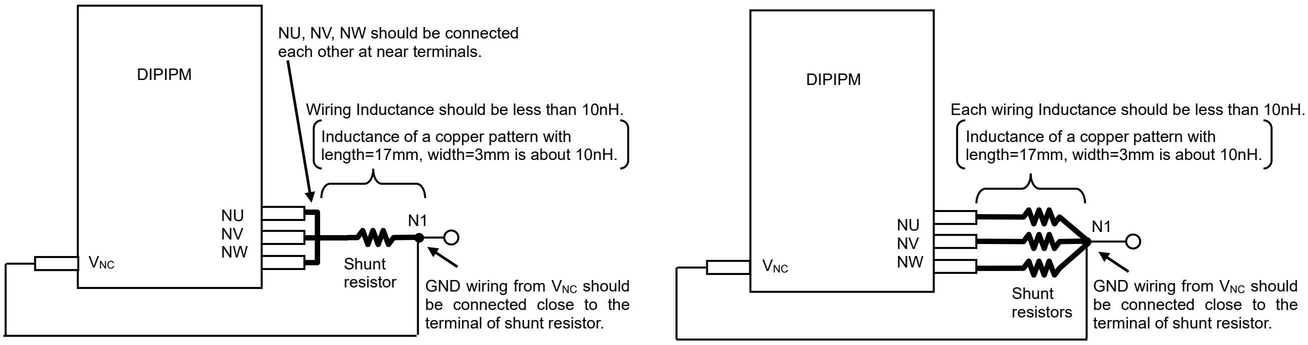
(1) If control GND is connected with power GND by common broad pattern, it may cause malfunction by power GND fluctuation. It is recommended to connect control GND and power GND at only a point N1 (near the terminal of shunt resistor).
(2) It is recommended to insert a Zener diode D1(24V/1W) between 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 a 0.1-0.22μF 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 2μs. (1.5μs~2μs is general value.) SC interrupting time might vary with the wiring pattern, so the enough evaluation on the real system is necessary.
(5) To prevent malfunction, the wiring of A, B, C should be as short as possible.
(6) The point D at which the wiring to CIN filter is divided should be near the terminal of shunt resistor. NU, NV, NW terminals should be connected at near NU, NV, NW terminals.
(7) All capacitors should be mounted as close to the terminals as possible. (C1: good temperature, frequency characteristic electrolytic type and C2:0.01μ-2μF, good temperature, frequency and DC bias characteristic ceramic type are recommended.)
(8) Input drive is High-active type. There is a minimum 3.3kΩ pull-down resistor in the input circuit of IC. To prevent malfunction, the wiring of each input should be as short as possible. When using RC coupling circuit, make sure the input signal level meet the turn-on and turn-off threshold voltage.
(9) Thanks to built-in HVIC, direct coupling to MCU without any optocoupler or transformer isolation is possible.
(10) Fo output is open drain type. 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. (I_{FO} is estimated roughly by the formula of control power supply voltage divided by pull-up resistance. In the case of pulled up to 5V, 10kΩ (5kΩ or more) is recommended.)
(11) Two V_{NC} terminals are connected inside DIPIPM, please connect either one to the 15V power supply GND outside and leave another one open.
(12) If high frequency noise superimposed to the control supply line, IC malfunction might happen and cause DIPIPM erroneous operation. To avoid such problem, line ripple voltage should meet dV/dt ≤+/-1V/μs, Vripple≤2Vp-p.

Fig. 7 MCU I/O Interface Circuit



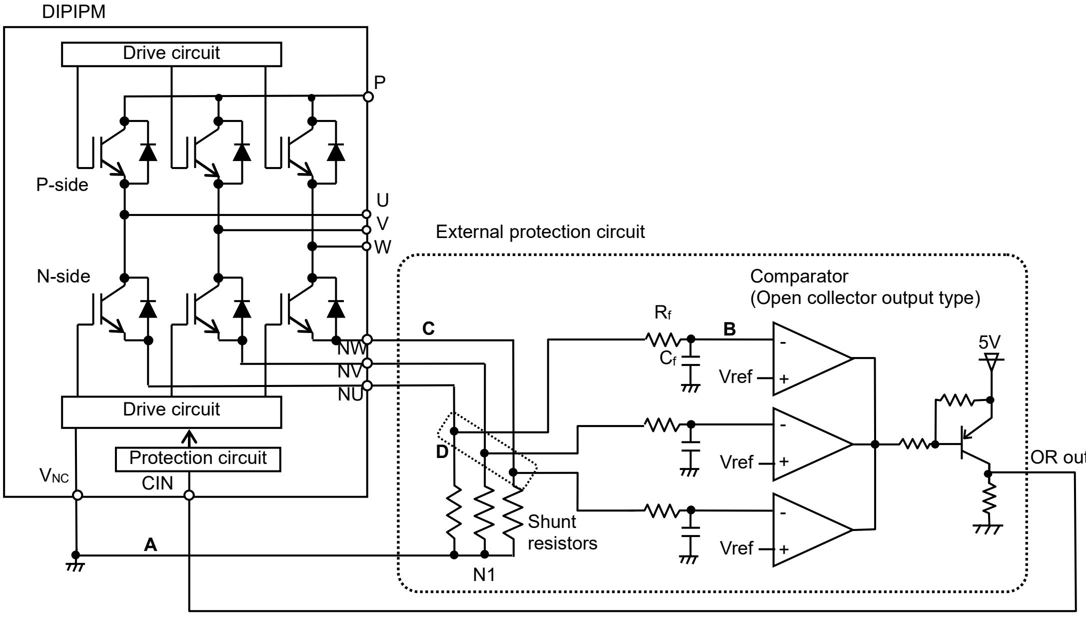
Note: The RC coupling (parts shown in the dotted line) at each input depends on user's PWM control strategy and the wiring impedance of the printed circuit board. The DIPIPM signal input section integrates a 3.3kΩ(min) pull-down resistor. Therefore, when using an external filtering resistor, please pay attention to the signal voltage drop at input terminal.

Fig. 8 Pattern Wiring Around the Shunt Resistor



Low inductance shunt resistor like surface mounted (SMD) type is recommended.

Fig. 9 External SC Protection Circuit with Using Three Shunt Resistors



(1) It is necessary to set the time constant R_fC_f of external comparator input so that IGBT stop within 2μs when short circuit occurs. SC interrupting time might vary with the wiring pattern, comparator speed and so on.
(2) The threshold voltage Vref should be set up the same rating of short circuit trip level (Vsc(ref) typ. 0.48V).
(3) Select the external shunt resistance so that SC trip-level is less than specified maximum value.
(4) To avoid malfunction, the wiring A, B, C should be as short as possible.
(5) The point D at which the wiring to comparator is divided should be near the terminal of shunt resistor.
(6) OR output high level should be over 0.505V (=maximum Vsc(ref)).
(7) GND of Comparator, Vref circuit and Cf should be not connected to noisy power GND but to control GND wiring.

Fig. 10 (Reference Figure) PCB Through-hole Pattern
Recommended through-hole locations and diameter layout for SLIMDIP [Dimension: mm]

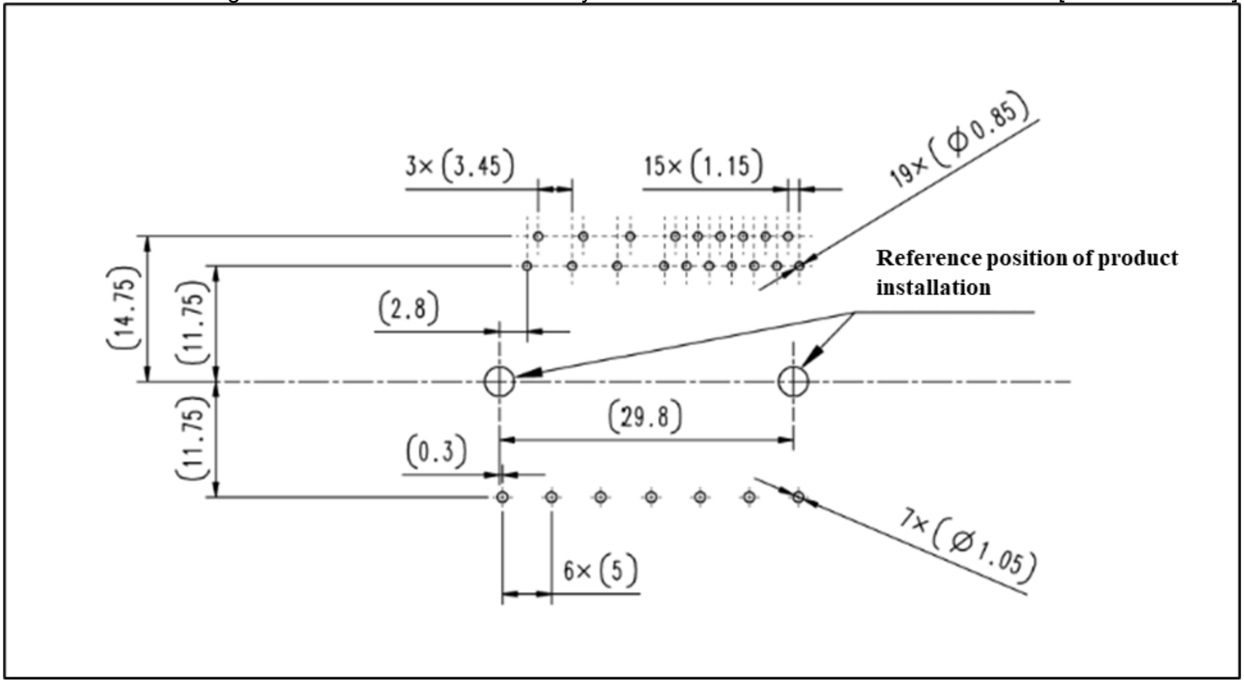
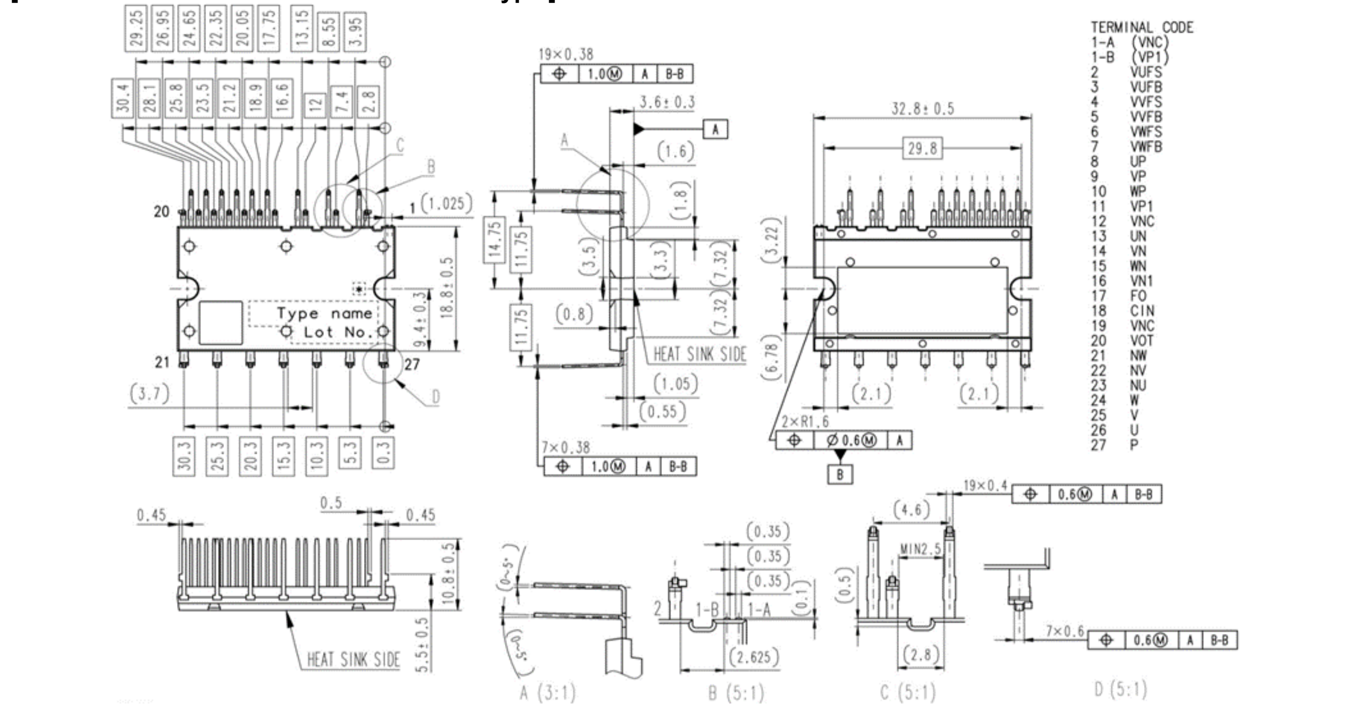
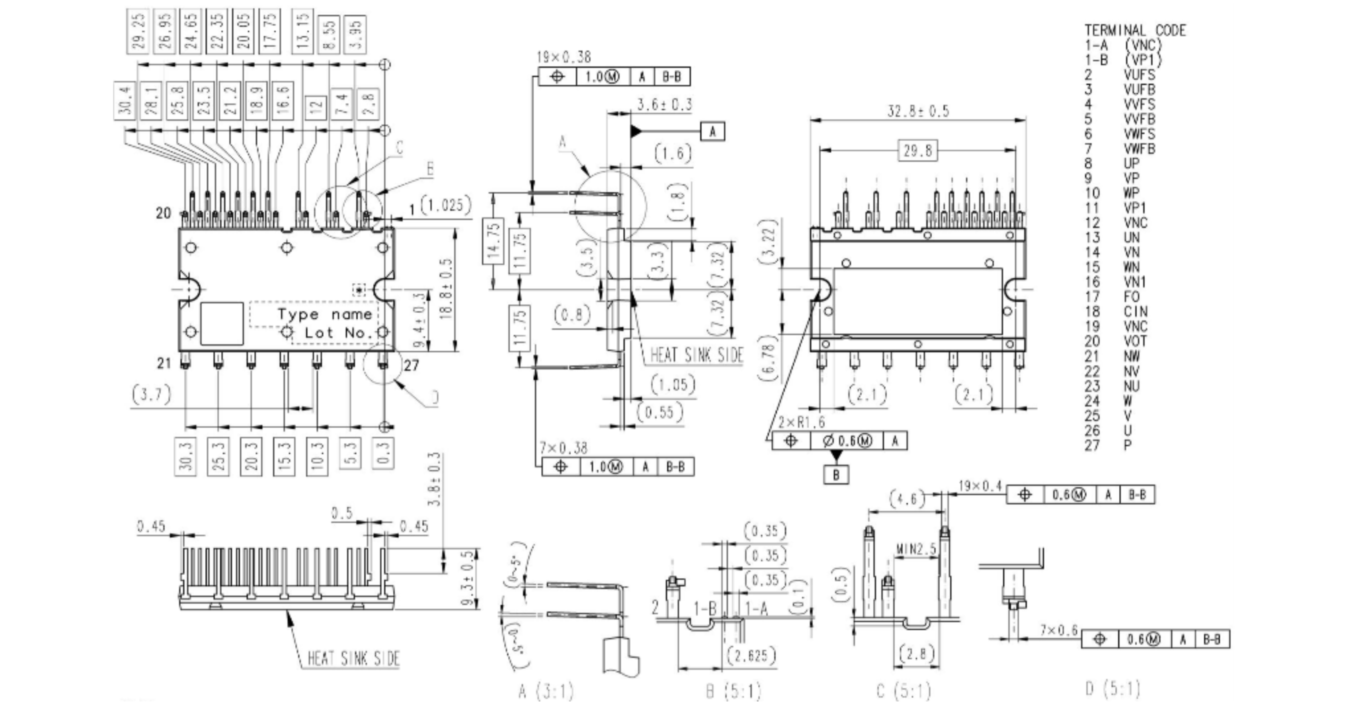


Fig. 11 Package Outlines [Dimension: mm]

[SLIMDIP-M Suffix:500 : Normal Terminal Type]



[SLIMDIP-M Suffix:505 : Short Terminal Type]



Note: Connect only one V_{NC} terminal (No.12 or 19) to the system GND and leave another one open.

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