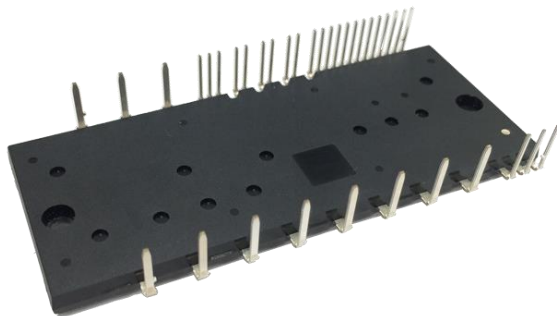


< DIIPM >

# PSS35NC1FT

TRANSFER MOLDING TYPE  
INSULATED TYPE

## OUTLINE



## MAIN FUNCTION

CI(Converter + Inverter) type IPM

- 3-phase Inverter
- 3-phase Converter

## RATING

- Inverter part : 35A/1200V (CSTBT)

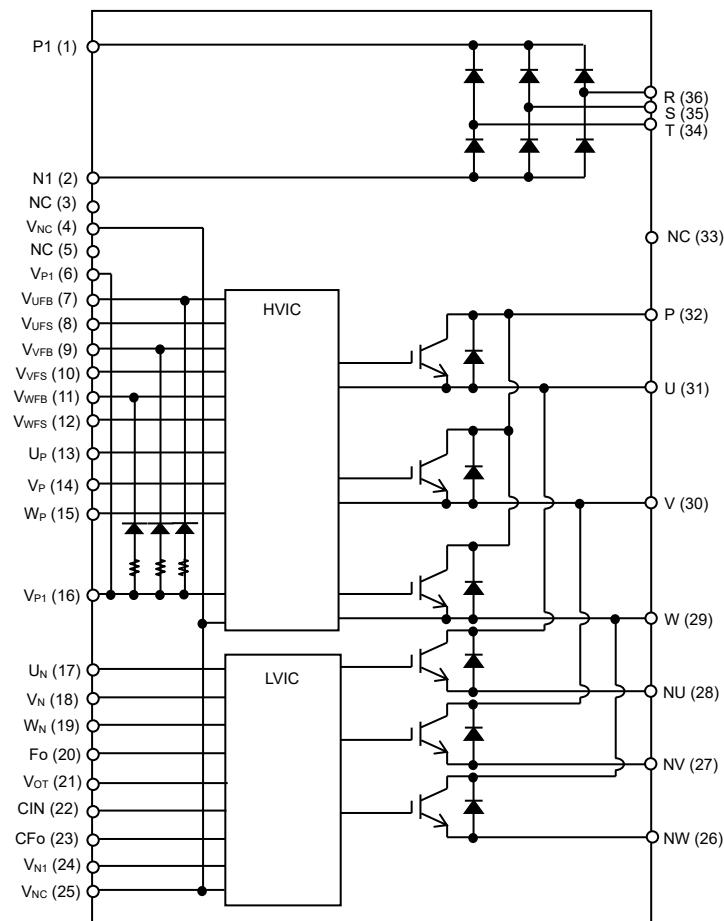
## APPLICATION

- AC400V three phase motor inverter drive

## INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS

- For P-side : Drive circuit, High voltage high-speed level shifting, Control supply under-voltage protection (UV) without fault signal output Built-in discrete bootstrap diode chips with current limiting resistor
- For N-side : Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC) by detecting voltage of external shunt resistor
- Fault signaling : Corresponding to SC fault (N-side IGBT) and UV fault (N-side supply)
- Temperature monitoring : Outputting LVIC temperature by analog signal (No self over temperature protection)
- Input interface : 5V high active logic
- UL Recognized : UL1557 File E323585

## INTERNAL CIRCUIT



**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-NU,NV,NW	900	V
$V_{CC(\text{surge})}$	Supply voltage (surge)	Applied between P-NU,NV,NW	1000	V
$V_{CES}$	Collector-emitter voltage		1200	V
$\pm I_C$	Each IGBT collector current	$T_C = 25^\circ\text{C}$ (Note 1)	35	A
$\pm I_{CP}$	Each IGBT collector current (peak)	$T_C = 25^\circ\text{C}$ , less than 1ms	70	A
$T_j$	Junction temperature		-30~+150	$^\circ\text{C}$

Note1: Pulse width and period are limited due to junction temperature.

**CONVERTER PART**

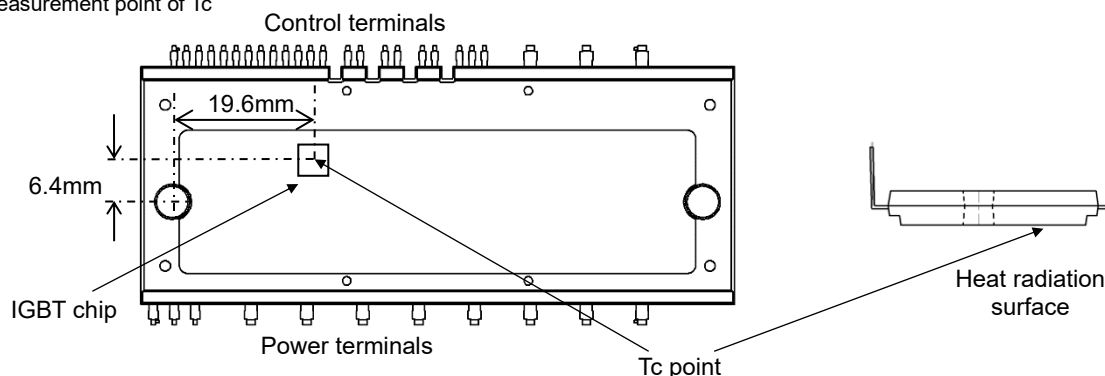
Symbol	Parameter	Condition	Ratings	Unit
$V_{RRM}$	Repetitive peak reverse voltage		1600	V
$I_O$	DC output current	3-phase full wave rectification	35	A
$I_{FSM}$	Surge forward current	Peak value of half cycle at 60Hz, Non-repetitive	350	A
$I^2t$	$I^2t$ capability	Value for 1 cycle of surge current	510	$\text{A}^2\text{s}$
$T_j$	Junction temperature		-30~+150	$^\circ\text{C}$

**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	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
$V_{CC(\text{PROT})}$	Self protection supply voltage limit (Short circuit protection capability)	$V_D = 13.5\sim 16.5\text{V}$ , Inverter Part $T_j = 125^\circ\text{C}$ , non-repetitive, less than 2 $\mu\text{s}$	800	V
$T_C$	Module case operation temperature	(Note 2)	-30~+110	$^\circ\text{C}$
$T_{stg}$	Storage temperature		-40~+125	$^\circ\text{C}$
$V_{iso}$	Isolation voltage	60Hz, Sinusoidal, AC 1min, between connected all pins and heat sink plate	2500	$V_{rms}$

Note2: Measurement point of  $T_C$  is described in Fig.1.Fig. 1 Measurement point of  $T_C$ **THERMAL RESISTANCE**

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
$R_{th(j-c)Q}$	Junction to case thermal resistance (Note 3)	Inverter IGBT part (per 1/6 module)	-	-	0.95	K/W
$R_{th(j-c)F}$		Inverter FWD part (per 1/6 module)	-	-	1.30	
$R_{th(j-c)R}$		Converter part (per 1/6 module)	-	-	1.10	

Note 3: Grease with good thermal conductivity and long-term endurance should be applied evenly with about +100 $\mu\text{m}$ ~+200 $\mu\text{m}$  on the contacting surface of DIIPIM and heat sink. The contacting thermal resistance between DIIPIM 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 0.25K/W (per 1chip, grease thickness: 20 $\mu\text{m}$ , thermal conductivity: 1.0W/m $\cdot$ 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	$V_D=V_{DB} = 15\text{V}$ , $V_{IN}= 5\text{V}$	-	1.50	2.20	V
		$I_C= 35\text{A}$ , $T_j= 25^\circ\text{C}$		1.80	2.45	
$V_{EC}$	FWDi forward voltage	$V_{IN}= 0\text{V}$ , $-I_C= 35\text{A}$	-	2.40	3.10	V
$t_{on}$	Switching times	$V_{CC}= 600\text{V}$ , $V_D= V_{DB}= 15\text{V}$ $I_C= 35\text{A}$ , $T_j= 125^\circ\text{C}$ , $V_{IN}= 0\sim 5\text{V}$ Inductive Load (upper-lower arm)	1.10	1.90	2.60	$\mu\text{s}$
$t_{C(on)}$			-	0.60	0.95	$\mu\text{s}$
$t_{off}$			-	2.70	3.80	$\mu\text{s}$
$t_{C(off)}$			-	0.40	0.90	$\mu\text{s}$
$t_{rr}$			-	0.60	-	$\mu\text{s}$
$I_{CES}$	Collector-emitter cut-off current	$V_{CE}=V_{CES}$	-	-	1	mA
		$T_j= 125^\circ\text{C}$	-	-	10	

**CONVERTER PART**

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
$I_{RRM}$	Repetitive reverse current	$V_R=V_{RRM}$ , $T_j=125^\circ\text{C}$	-	-	7.0	mA
$V_F$	Forward voltage drop	$I_F=35\text{A}$	-	1.1	1.4	V

**CONTROL (PROTECTION) PART**

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
$I_D$	Circuit current	Total of $V_{P1}-V_{NC}$ , $V_{N1}-V_{NC}$	-	-	4.70	mA
		$V_D=15\text{V}$ , $V_{IN}=0\text{V}$			4.70	
		Each part of $V_{UFB}-V_{UFS}$ , $V_{VFB}-V_{VFS}$ , $V_{WFB}-V_{WFS}$	-	-	0.55	
$I_{DB}$		$V_D=V_{DB}=15\text{V}$ , $V_{IN}=5\text{V}$	-	-	0.55	
$V_{SC(ref)}$	Short circuit trip level	$V_D = 15\text{V}$ (Note 4)	0.455	0.480	0.505	V
$UV_{DBt}$	Control supply under-voltage protection(UV) for P-side of inverter part	Trip level	10.0	-	12.0	V
$UV_{DBr}$		Reset level	10.5	-	12.5	V
$UV_{Dt}$	Control supply under-voltage protection(UV) for N-side of inverter part	Trip level	10.3	-	12.5	V
$UV_{Dr}$		Reset level	10.8	-	13.0	V
$V_{OT}$	Temperature Output	Pull down $R=5.1\text{k}\Omega$ , LVIC Temperature= $100^\circ\text{C}$ (Note 5)	2.89	3.02	3.14	V
$V_{FOH}$	Fault output voltage	$V_{SC} = 0\text{V}$ , $F_O$ terminal pulled up to 5V by 10k $\Omega$	4.9	-	-	V
$V_{FOL}$		$V_{SC} = 1\text{V}$ , $I_{FO} = 1\text{mA}$	-	-	0.95	V
$t_{FO}$	Fault output pulse width	In case of $C_{FO}=22\text{nF}$ (Note 6,7)	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 $U_P, V_P, W_P, U_N, V_N, W_N - V_{NC}$	-	-	3.5	V
$V_{th(off)}$	OFF threshold voltage		0.8	-	-	
$V_F$	Bootstrap Di forward voltage	$I_F=10\text{mA}$ including voltage drop by limiting resistor (Note 8)	-	0.9	1.3	V
$R$	Built-in limiting resistance	Included in bootstrap Di	16	20	24	$\Omega$

Note 4 : SC protection works only for N-side IGBT in inverter part. Please select the external shunt resistance such that the SC trip-level is less than 1.7 times of the current rating.

5 : DIPIPM don't shutdown IGBTs and output fault signal automatically when temperature rises excessively. When temperature exceeds the protective level that user defined, controller (MCU) should stop the DIPIPM. Temperature of LVIC vs.  $V_{OT}$  output characteristics is described in Fig. 3.

6 : Fault signal  $F_O$  outputs when SC or UV protection works for N-side IGBT in inverter part. The fault output pulse-width  $t_{FO}$  is depended on the capacitance value of  $C_{FO}$  ( $C_{FO} = t_{FO} \times 9.1 \times 10^{-6}$  [F]).

7 : UV protection also works for P-side IGBT in inverter part without fault signal  $F_O$ .

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

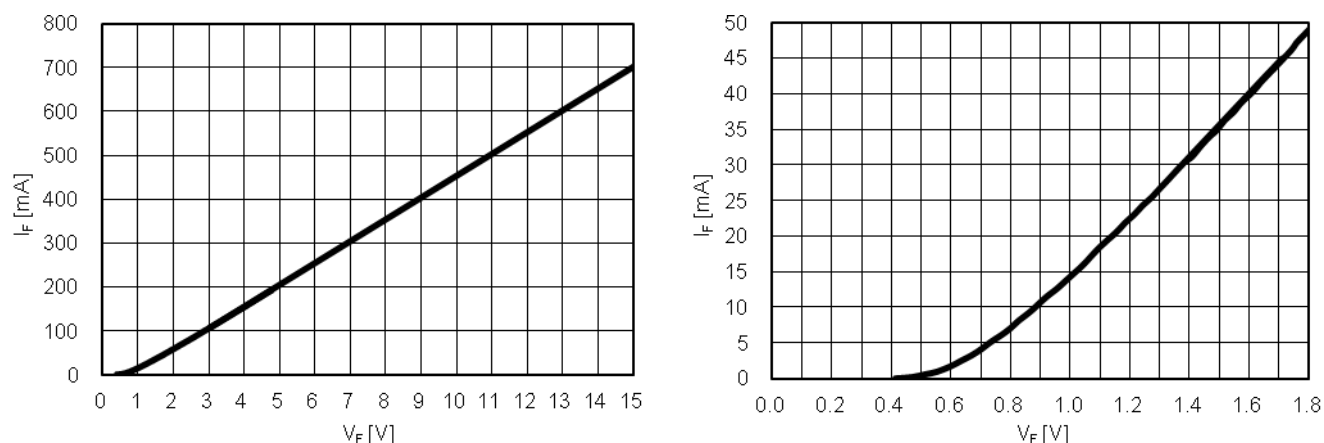
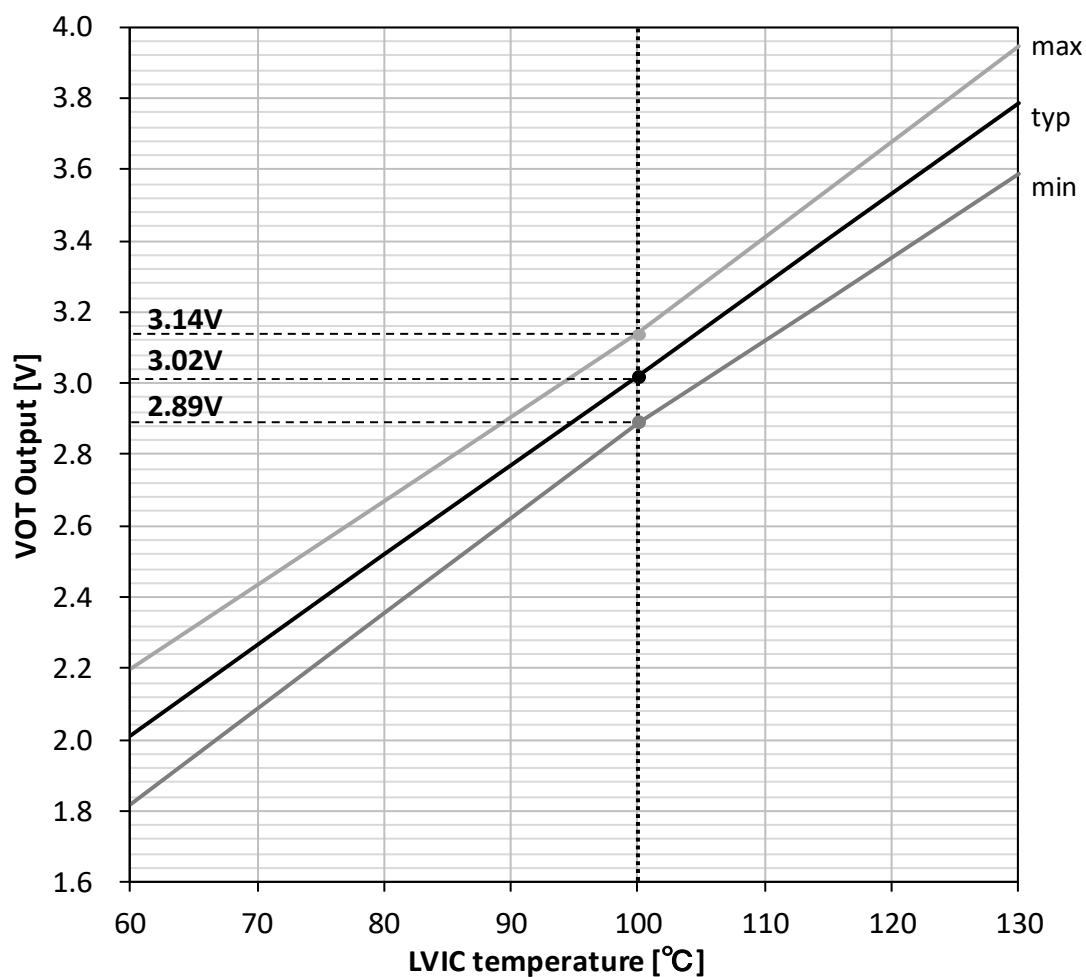
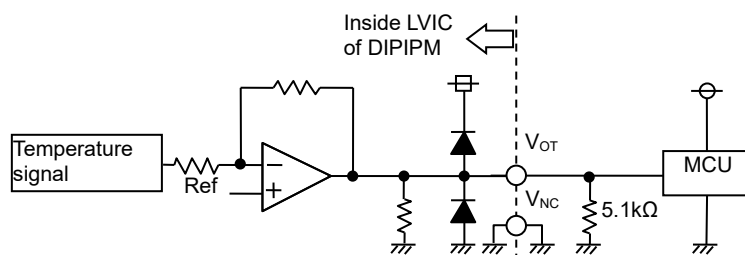
Fig. 2 Characteristics of Bootstrap Di  $V_F$ - $I_F$  curve (@ $T_a=25^\circ\text{C}$ ) Including Voltage Drop by Limiting Resistor (Right chart is enlarged chart.)Fig. 3 Temperature of LVIC vs.  $V_{OT}$  Output Characteristics

Fig. 4 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 not using  $V_{OT}$ , leave  $V_{OT}$  output NC (No Connection).

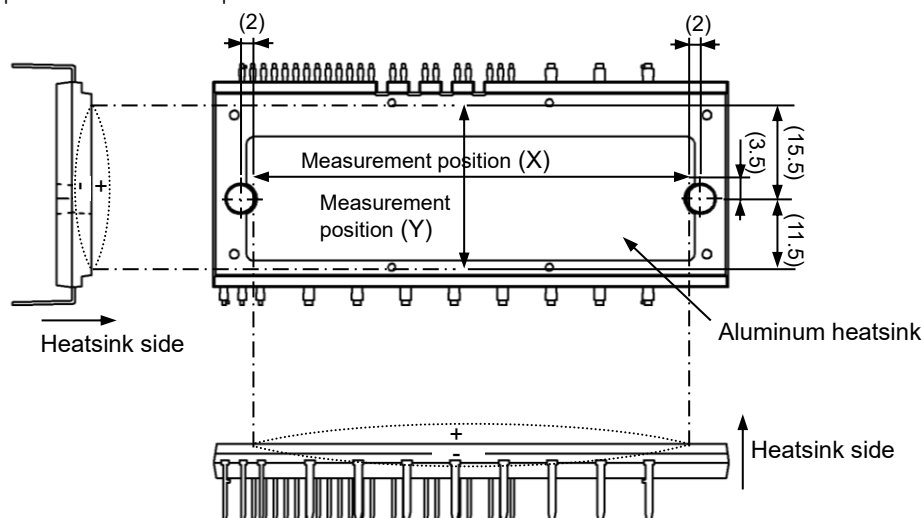
Refer the application note for DIIPM+ series about the usage of  $V_{OT}$ .

**MECHANICAL CHARACTERISTICS AND RATINGS**

Parameter	Condition		Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M4 (Note 9)	Recommended 1.18N·m	0.98	1.18	1.47	N·m
Terminal pulling strength	20N load	JEITA-ED-4701	10	-	-	s
Terminal bending strength	90deg bending with 10N load	JEITA-ED-4701	2	-	-	times
Weight			-	40	-	g
Heat radiation part flatness		(Note 10)	-50	-	+100	μm

Note 9: Plain washers (ISO 7089-7094) are recommended.

Note 10: Measurement positions of heat radiation part flatness are as below.



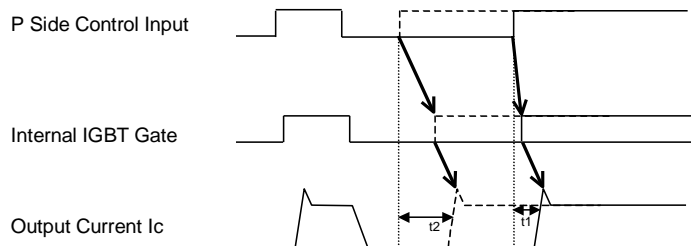
**RECOMMENDED OPERATION CONDITIONS**

Symbol	Parameter	Condition		Limits			Unit
				Min.	Typ.	Max.	
V <sub>CC</sub>	Supply voltage	Applied between P-NU,NV,NW		0	600	800	V
V <sub>D</sub>	Control supply voltage	Applied between V <sub>P1</sub> -V <sub>NC</sub> , V <sub>N1</sub> -V <sub>NC</sub>		13.5	15.0	16.5	V
V <sub>DB</sub>	Control supply voltage	Applied between V <sub>UFB</sub> -V <sub>UFS</sub> , V <sub>VFB</sub> -V <sub>VFS</sub> , V <sub>WFB</sub> -V <sub>WFS</sub>		13.0	15.0	18.5	V
ΔV <sub>D</sub> , ΔV <sub>DB</sub>	Control supply variation			-1	-	1	V/μs
t <sub>dead</sub>	Arm shoot-through blocking time	For each input signal		3.0	-	-	μs
f <sub>PWM</sub>	PWM input frequency	T <sub>C</sub> ≤100°C, T <sub>J</sub> ≤125°C		-	-	20	kHz
PWIN(on)	Minimum input pulse width	I <sub>C</sub> ≤1.7 times of rated current (Note 11)		1.5	-	-	μs
PWIN(off)		0≤V <sub>CC</sub> ≤800V, 13.5≤V <sub>D</sub> ≤16.5V, 13.0≤V <sub>DB</sub> ≤18.5V, -20≤T <sub>C</sub> ≤100°C, N line wiring inductance less than 10nH (Note 12)	Less than rated current	3.0	-	-	
			From rated current to 1.7 times of rated current	3.5	-	-	
V <sub>NC</sub>	V <sub>NC</sub> variation	Between V <sub>NC</sub> - NU, NV, NW (including surge)		-5.0	-	+5.0	V
T <sub>i</sub>	Junction temperature			-20	-	125	°C

Note 11: DIIPM might not make response if the input signal pulse width is less than PWIN(on).

Note 12: DIIPM might make no response or delayed response (P-side IGBT only) for the input signal with off pulse width less than PWIN(off). Please refer below figure about delayed response.

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



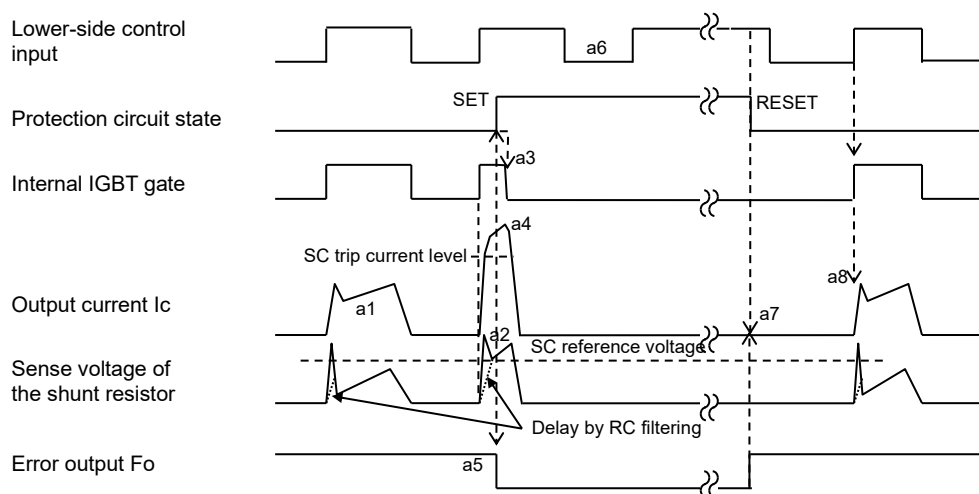
Real line···off pulse width>PWIN(off); turn on time t1

Broken line···off pulse width<PWIN(off); turn on time t2

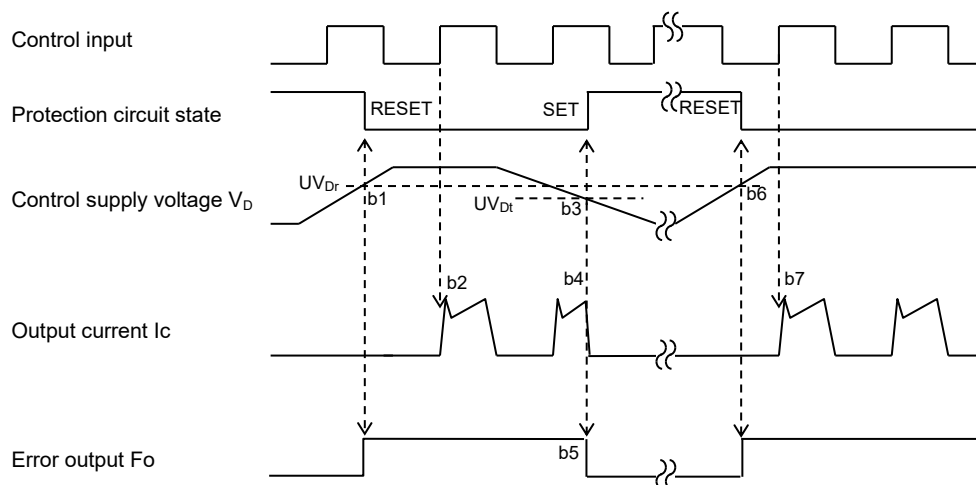
Fig. 5 Timing Charts of The DIIPM Protective Functions

**[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 1.5~2.0 $\mu$ s so that IGBT shut down within 2.0 $\mu$ s when SC.)
- a3. All N-side IGBT's gates are hard interrupted.
- a4. All N-side IGBTs turn OFF.
- a5. LVIC starts outputting fault signal (fault signal output time is controlled by external capacitor  $C_{FO}$ )
- a6. Input = "L": IGBT OFF
- a7. Fo finishes output, but IGBTs don't turn on until inputting next ON signal (L $\rightarrow$ 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.

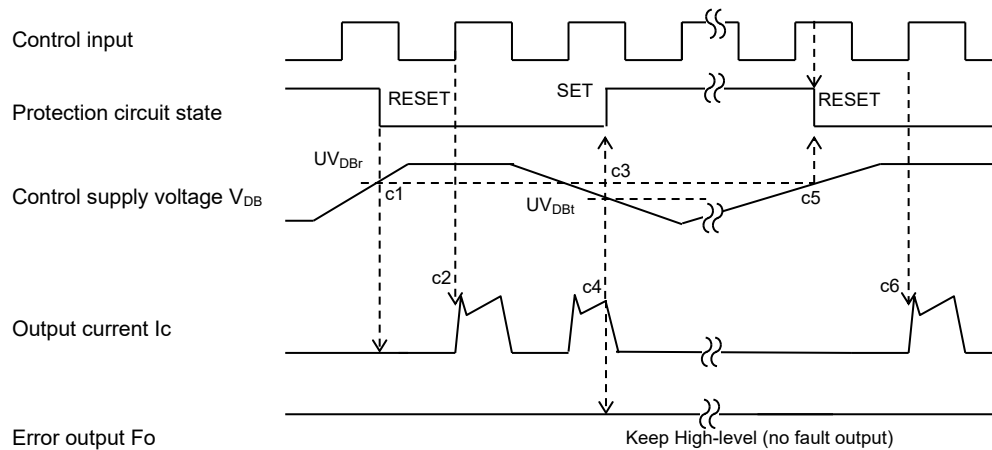
**[B] Under-Voltage Protection (N-side, UV<sub>D</sub>)**

- b1. Control supply voltage  $V_D$  exceeds under voltage reset level ( $UV_{Dr}$ ), but IGBT turns ON by next ON signal (L $\rightarrow$ 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 the period set by external capacitor  $C_{FO}$ , 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 correspond 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.



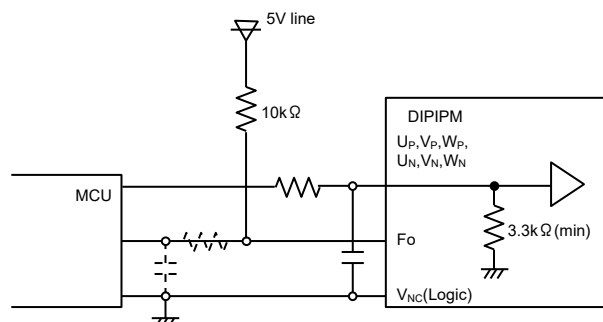


The schematic diagram illustrates a power MOSFET driver circuit. Key components include an MCU, HVIC (High Voltage IGBT Driver), and LVIC (Low Voltage IGBT Driver). The circuit is powered by an AC input through a bridge rectifier and a filter capacitor. The MCU controls the driver via a 5V supply and various resistors (R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R48, R49, R50, R51, R52, R53, R54, R55, R56, R57, R58, R59, R60, R61, R62, R63, R64, R65, R66, R67, R68, R69, R70, R71, R72, R73, R74, R75, R76, R77, R78, R79, R80, R81, R82, R83, R84, R85, R86, R87, R88, R89, R90, R91, R92, R93, R94, R95, R96, R97, R98, R99, R100). The driver controls a motor (M) through a shunt resistor (R1) and a current sense resistor (R2). The circuit also includes a prevention circuit for inrush current (X) and a long GND wiring warning (Y). Annotations highlight potential issues: 'Long wiring might cause short circuit failure', 'Long wiring might cause SC level fluctuation and malfunction', and 'Long GND wiring might generate noise to input signal and cause IGBT malfunction'.

## Note for the previous 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 0.1-0.22 $\mu$ 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 $\mu$ s. (1.5 $\mu$ s~2 $\mu$ s is recommended generally.) 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 each other at near those three terminals when it is used by one shunt operation. Low inductance SMD type with tight tolerance, temp-compensated type is recommended for shunt resistor.
- (7) All capacitors should be mounted as close to the terminals as possible. (C1: good temperature, frequency characteristic electrolytic type and C2:0.01 $\mu$ -2 $\mu$ F, good temperature, frequency and DC bias characteristic ceramic type are recommended.)
- (8) Input logic is High-active. There is a 3.3k $\Omega$ (min.) pull-down resistor in the input circuit of IC. To prevent malfunction, the input wiring should be as short as possible. When using RC coupling, make the input signal level meet the turn-on and turn-off threshold voltage.
- (9) Fo output is open drain type. Fo output will be max 0.95V(@I<sub>FO</sub>=1mA,25°C), so it should be pulled up to MCU or control power supply (e.g. 5V,15V) by a resistor that makes I<sub>FOup</sub> to 1mA. (In the case of pulled up to 5V, 10k $\Omega$  is recommended.) About driving opto coupler by Fo output, please refer the application note of this series.
- (10) Fo pulse width can be set by the capacitor connected to CFO terminal. C<sub>FO</sub>(F) = 9.1 x 10<sup>-6</sup> x t<sub>FO</sub> (Required Fo pulse width).
- (11) If high frequency noise superimposed to the control supply line, IC malfunction might happen and cause DIIPM erroneous operation. To avoid such problem, line ripple voltage should meet dV/dt  $\leq$  +/-1V/ $\mu$ s, V<sub>ripple</sub> $\leq$ 2Vp-p.
- (12) For DIIPM, it isn't recommended to drive same load by parallel connection with other phase IGBT or other DIIPM.
- (13) No.4 and No.25 V<sub>NC</sub> terminals (GND terminal for control supply) are connected mutually inside of DIIPM+ and also No.6 and No.16 V<sub>P1</sub> terminals are connected mutually inside, please connect either No.4 or No.25 terminal to GND and also connect either No.6 or No.16 terminal to supply and make the unused terminal leave no connection.

Fig. 7 MCU I/O Interface Circuit



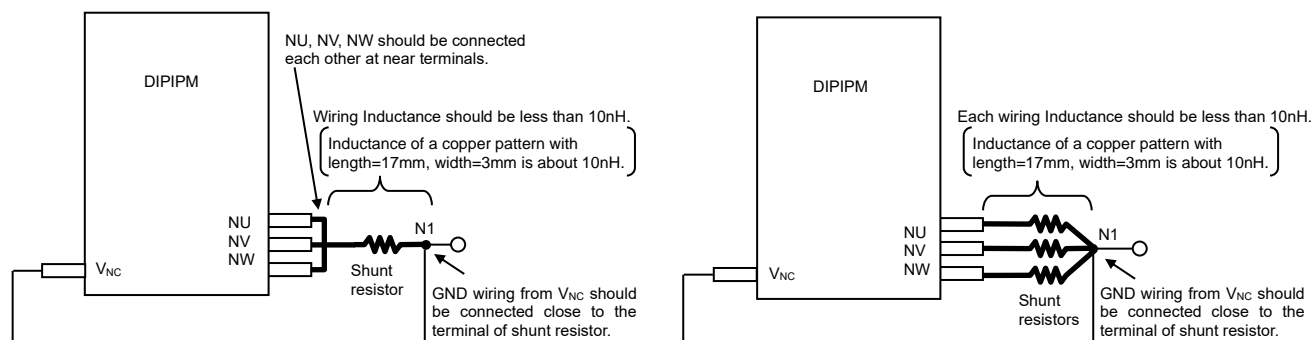
## Note)

Design for input RC filter depends on the PWM control scheme used in the application and the wiring impedance of the printed circuit board. But because noisier in the application for 1200V rating, it is strongly recommended to insert RC filter. (Time constant: over 100ns. e.g. 100 $\Omega$ , 1000pF)

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

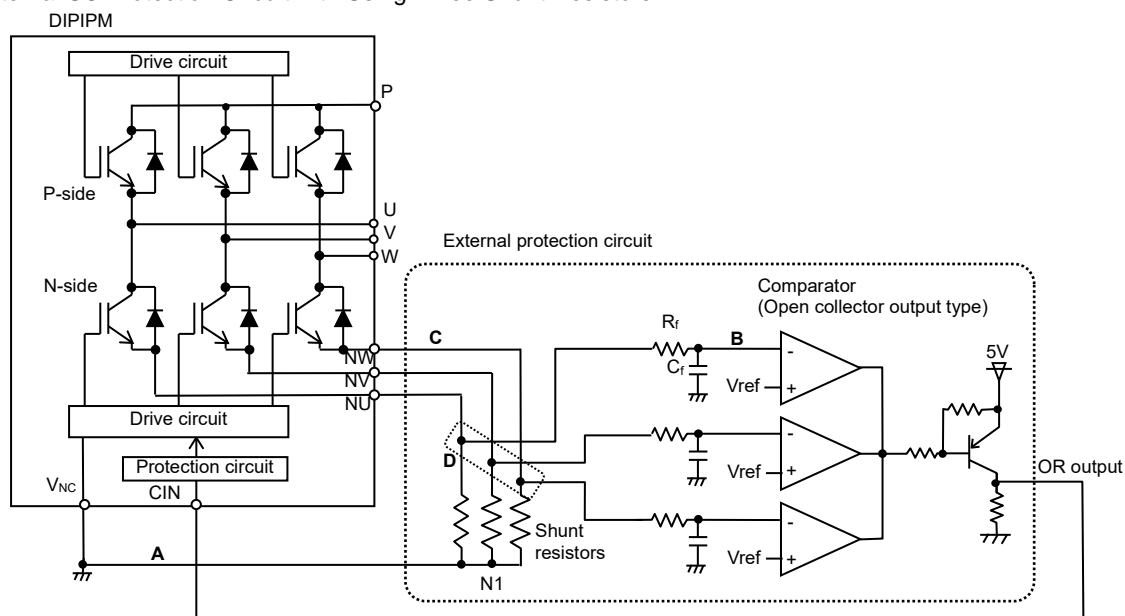
Fo output is open drain type. It should be pulled up to the positive side of 5V or 15V power supply with the resistor that limits Fo sink current I<sub>FO</sub> under 1mA. In the case of pulling up to 5V supply, over 5.1k $\Omega$  is needed. (10k $\Omega$  is recommended.)

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

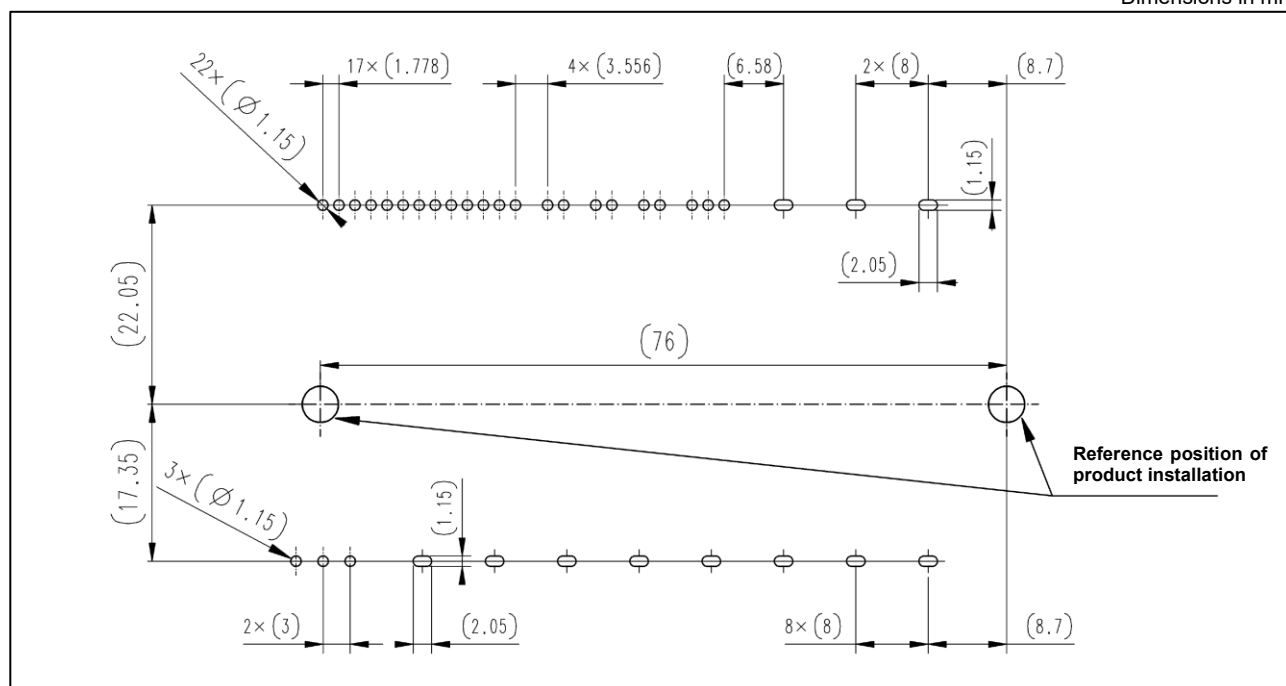


- (1) It is necessary to set the time constant  $R_r C_f$  of external comparator input so that IGBT stop within  $2\mu\text{s}$  when short circuit occurs. SC interrupting time might vary with the wiring pattern, comparator speed and so on.
- (2) The threshold voltage  $V_{ref}$  should be set up the same rating of short circuit trip level ( $V_{sc(ref)}$  typ. 0.48V).
- (3) Select the external shunt resistance so that SC trip-level is less than specified 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  $V_{sc(ref)}$ ).
- (7) GND of Comparator,  $V_{ref}$  circuit and  $C_f$  should be not connected to noisy power GND but to control GND wiring.

Fig. 10 PCB through-hole pattern

The recommended through-hole positions and diameters layout are shown.

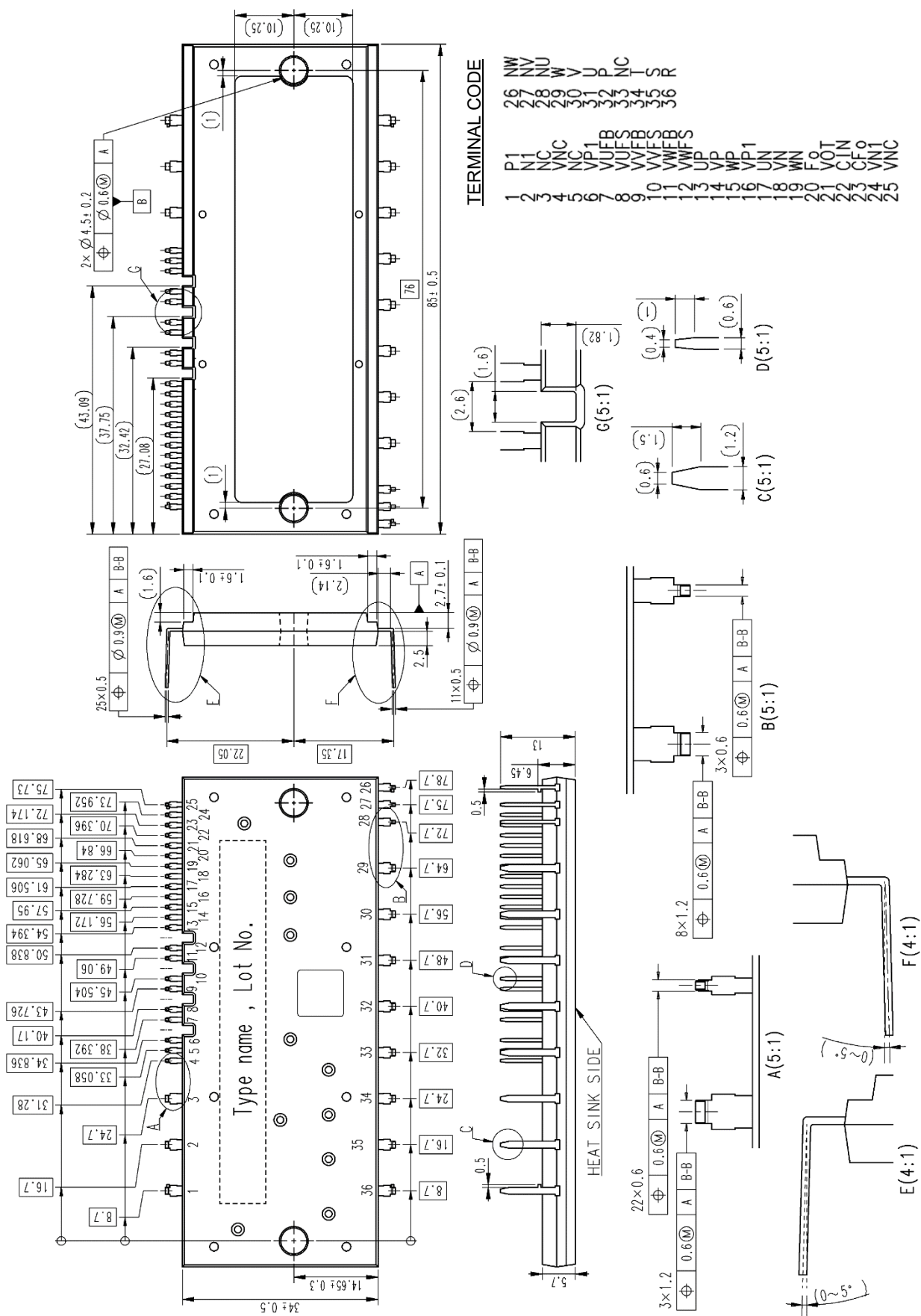
Dimensions in mm



## TRANSFER MOLDING TYPE INSULATED TYPE

Fig. 11 Package Outlines

Dimensions in mm



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