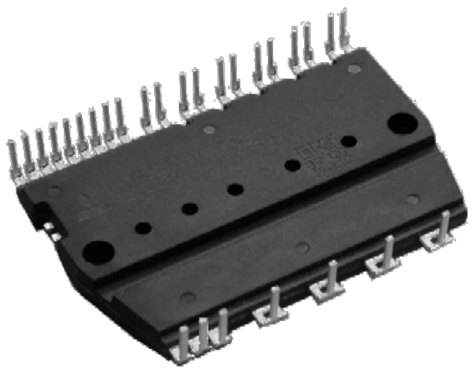
MITSUBISHI ELECTRIC

< DIPIPM >

PSS20S51F6 / PSS20S51F6-C

TRANSFER MOLDING TYPE
INSULATED TYPE

OUTLINE



PSSxxS51F6 (Short terminal type)

MAIN FUNCTION AND RATINGS

- 3 phase DC/AC inverter
- 600V / 20A (CSTBT)
- N-side IGBT open emitter
- Built-in bootstrap diodes with current limiting resistor

APPLICATION

- AC 100~240Vrms(DC voltage:400V or below) class low power motor control

TYPE NAME

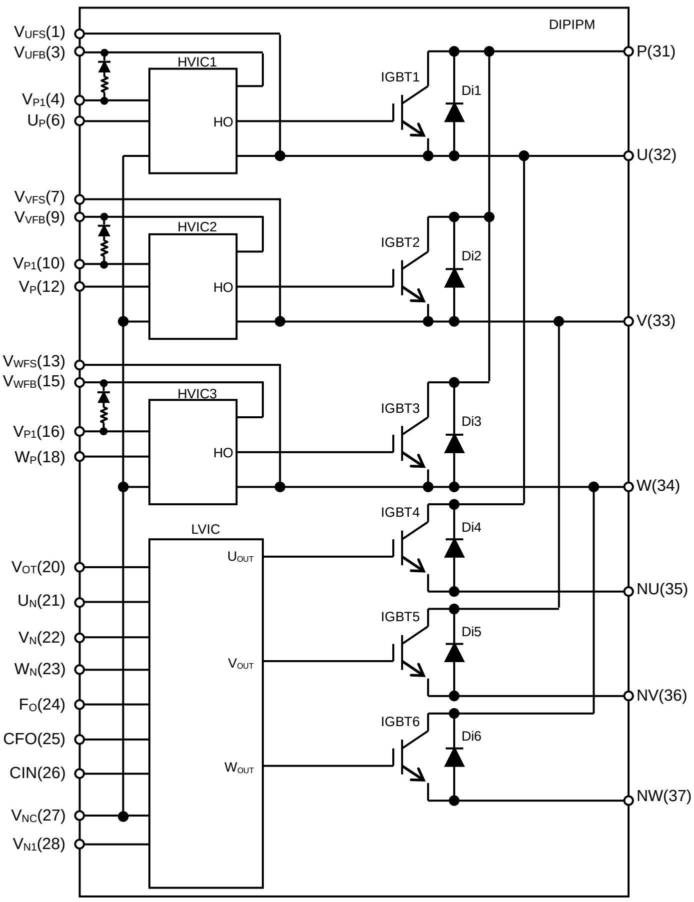
PSS20S51F6 /-C	With temperature output function

-C : Control side zigzag terminal (none) : Short terminal

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



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_f = 25°C (Note1)	20	A
$\pm I_{CP}$	Each IGBT collector current (peak)	T_f = 25°C, less than 1ms	40	A
P_C	Collector dissipation	T_f = 25°C, per 1 chip	25.0	W
T_j	Junction temperature	(Note2)	-20~+125	°C

(Note1) Pulse width and period are limited due to junction temperature.
(Note2) The maximum junction temperature rating of the power chips integrated within the DIPIPM is 150°C (@Tf≤100°C).However, to ensure safe operation of the DIPIPM, the average junction temperature should be limited to Tj(ave)≤125°C (@Tf≤100°C).

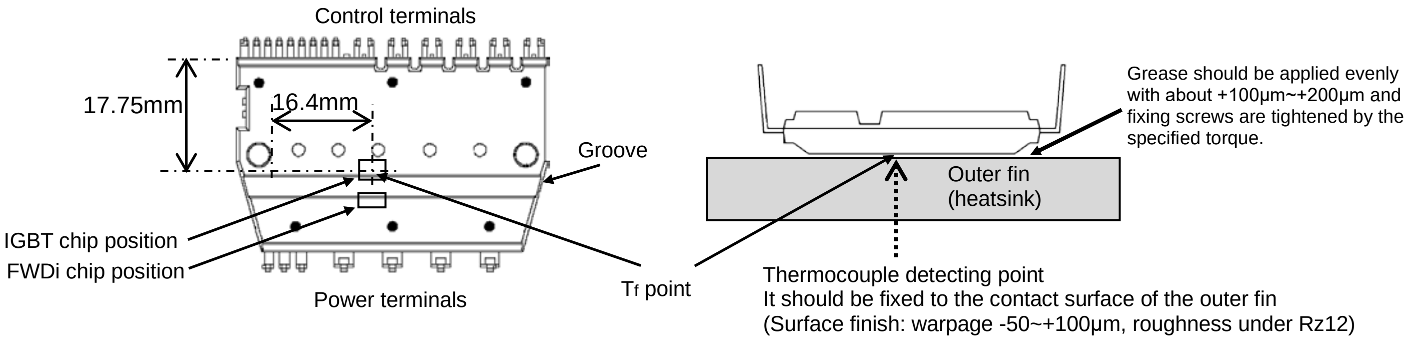
CONTROL (PROTECTION) PART

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 = 125°C, non-repetitive, less than 2μs	400	V
T_f	Module operation temperature	Measurement point of T_f is provided in Fig.1	-20~+100	°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: Tf MEASUREMENT POINT



THERMAL RESISTANCE

Symbol	Parameter	Condition	Limits Min.	Limits Typ.	Limits Max.	Unit
$R_{th(j-f)Q}$	Junction to fin thermal resistance (Note 3)	Inverter IGBT part (per 1/6 module)	-	-	4.0	K/W
$R_{th(j-f)F}$		Inverter FWDi part (per 1/6 module)	-	-	6.5	K/W

Note 3: Grease with good thermal conductivity and long-term endurance should be applied evenly with about +100μm~+200μm thickness on the contacting surface of heat sink. Fixing screws are tightened by the specified torque.

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= 20A, T_j= 25°C	-	1.50	2.00	V
			I_C= 20A, T_j= 125°C	-	1.60	2.10	
V_{EC}	FWDi forward voltage	V_{IN}= 0V, -I_C= 20A		-	1.60	2.10	V
t_{on}	Switching times	V_{CC}= 300V, V_D= V_{DB}= 15V I_C= 20A, T_j= 125°C, V_{IN}= 0↔5V Inductive Load (upper-lower arm)		0.60	1.20	1.80	μs
$t_{C(on)}$				-	0.30	0.60	μs
t_{off}				-	1.60	2.60	μs
$t_{C(off)}$				-	0.35	0.80	μs
t_{rr}				-	0.30	-	μs
I_{CES}	Collector-emitter cut-off current	V_{CE}=V_{CES}	T_j= 25°C	-	-	1	mA
			T_j= 125°C	-	-	10	

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	-	-	6.00	mA
			V_D=15V, V_{IN}=5V	-	-	6.00	
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	-	-	0.55	
			V_D=V_{DB}=15V, V_{IN}=5V	-	-	0.55	
$V_{SC(ref)}$	Short circuit trip level	V_D = 15V (Note 4)		0.45	0.48	0.51	V
UV_{DBt}	P-side Control supply under-voltage protection(UV)	T_j ≤125°C	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_{OT}	Temperature Output	Pull down R=5kΩ (Note 5)	LVIC Temperature=100°C	2.90	3.02	3.15	V
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	C_{FO}=22nF (Note 6)		1.6	2.4	-	ms
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}		-	2.10	2.60	V
$V_{th(off)}$	OFF threshold voltage			0.80	1.30	-	
$V_{th(hys)}$	ON/OFF threshold hysteresis voltage			0.35	0.80	-	
V_F	Bootstrap Di forward voltage	I_F=10mA including voltage drop by limiting resistor (Note 7)		0.5	0.9	1.3	V
R	Built-in limiting resistance	Included in bootstrap Di		16	20	24	Ω

Note 4 : SC protection works only for N-side IGBT. Please select the external shunt resistance such that the SC trip-level is less than 2.0 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. VOT output characteristics is described in Fig. 3.
6 : Fault signal Fo outputs when SC or UV protection works. Fo pulse width is different for each protection modes. At SC failure, Fo pulse width is a fixed width which is specified by the capacitor connected to C_{FO} terminal. (C_{FO}=9.1 x 10^{-6} x t_{FO} [F]), but at UV failure, Fo outputs continuously until recovering from UV state. (But minimum Fo pulse width is the specified time by C_{FO}.)
7 : The characteristics of bootstrap Di is described in Fig.2.

Fig. 2 Characteristics of bootstrap Di V_F-I_F curve including voltage drop by limiting resistor (Right chart is enlarged chart.)

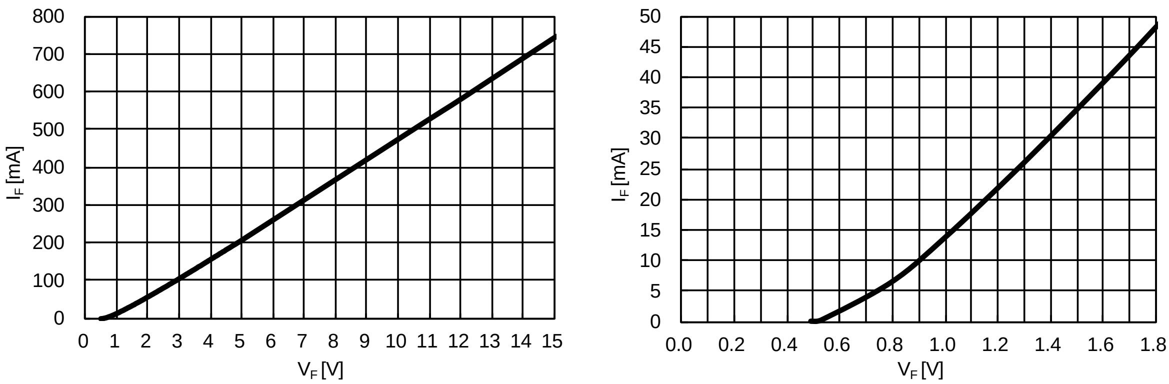


Fig. 3 Temperature of LVIC vs. V_{OT} output characteristics

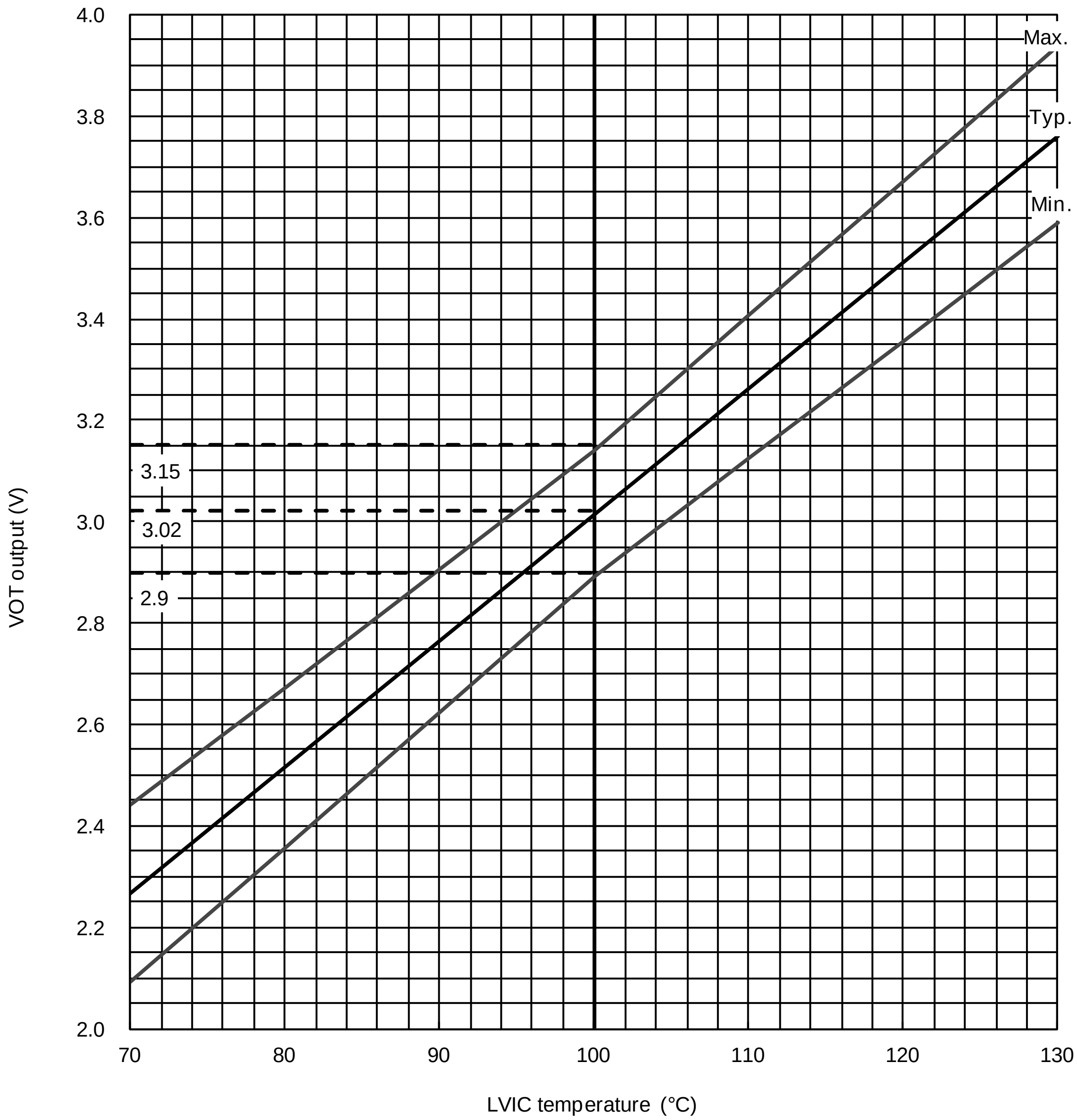
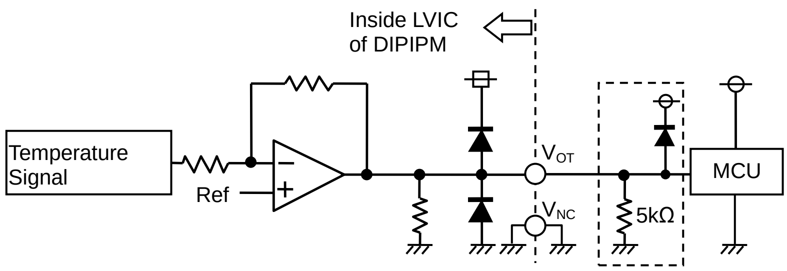


Fig. 4 V_{OT} output circuit



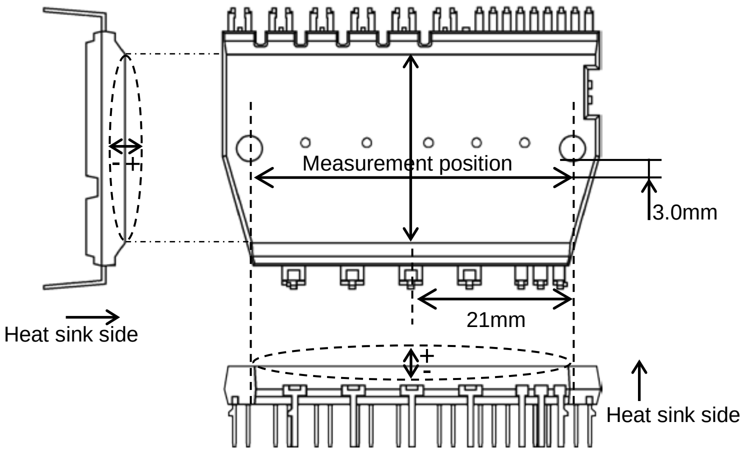
(1) It is recommended to insert 5kΩ (5.1kΩ is recommended) pull down resistor for getting linear output characteristics at low temperature below room temperature. When the pull down resistor is inserted between V_{OT} and V_{NC}(control GND), the extra circuit current, which is calculated approximately 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.
(2) 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.
(3) 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}.

MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition		Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M3 (Note 8)	Recommended 0.78N·m	0.59	-	0.98	N·m
Terminal pulling strength	Load 9.8N	JEITA-ED-4701	10	-	-	s
Terminal bending strength	Load 4.9N, 90deg. bend	JEITA-ED-4701	2	-	-	times
Weight			-	20	-	g
Heat-sink flatness	(Note 9)		-50	-	100	μm

Note 8: Plain washers (ISO 7089~7094) are recommended.
Note 9: Measurement point of heat sink flatness



RECOMMENDED OPERATION CONDITIONS

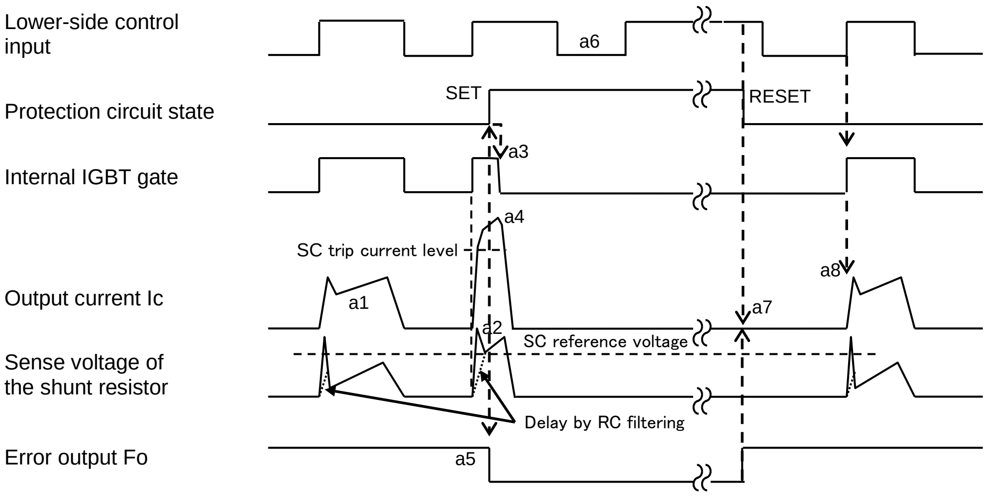
Symbol	Parameter	Condition		Limits			Unit
				Min.	Typ.	Max.	
V_{CC}	Supply voltage	Applied between P-NU, NV, NW		0	300	400	V
V_D	Control supply voltage	Applied between V_{P1}-V_{NC}, V_{N1}-V_{NC}		13.5	15.0	16.5	V
V_{DB}	Control supply voltage	Applied between V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS}, V_{WFB}-V_{WFS}		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		1.5	-	-	μs
f_{PWM}	PWM input frequency	Tf ≤ 100°C, T_j ≤ 125°C		-	-	20	kHz
I_O	Allowable r.m.s. current	V_{CC} = 300V, V_D = 15V, P.F = 0.8, Sinusoidal PWM Tf ≤ 100°C, T_j ≤ 125°C (Note10)	f_{PWM}= 5kHz	-	-	10.0	Arms
			f_{PWM}= 15kHz	-	-	6.4	
PWIN(on)	Minimum input pulse width	(Note 11)		1.0	-	-	μs
PWIN(off)				1.0		-	
V_{NC}	V_{NC} variation	Between V_{NC}-NU, NV, NW (including surge)		-5.0	-	+5.0	V
T_j	Junction temperature			-20	-	+125	°C

Note 10: Allowable r.m.s. current depends on the actual application conditions.
11: DIPIPM might not make response if the input signal pulse width is less than PWIN(on), PWIN(off)

Fig. 5 Timing Charts of The DIPIPM Protective Functions

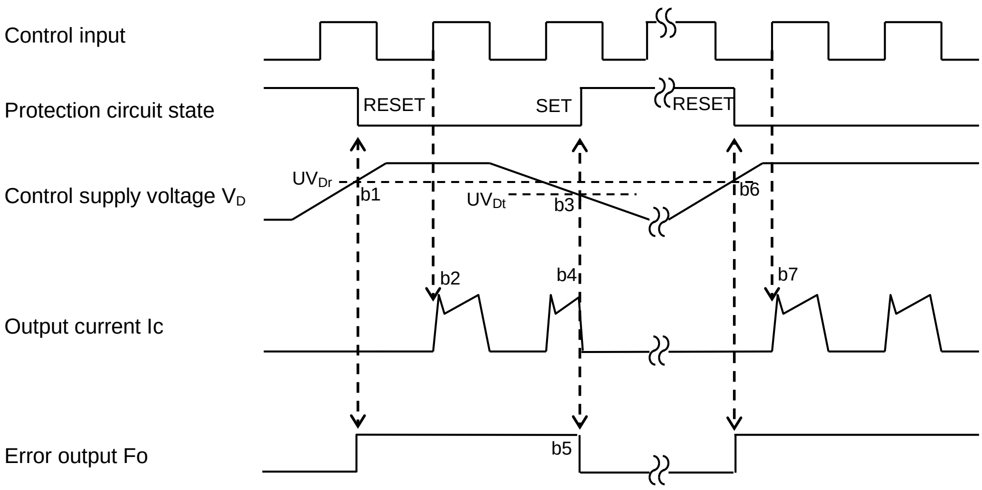
[A] Short-Circuit Protection (N-side only with the external shunt resistor and RC filter)

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. The pulse width of the Fo signal is set by the 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→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 the period set by the capacitance $C_{FO,}$ 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.

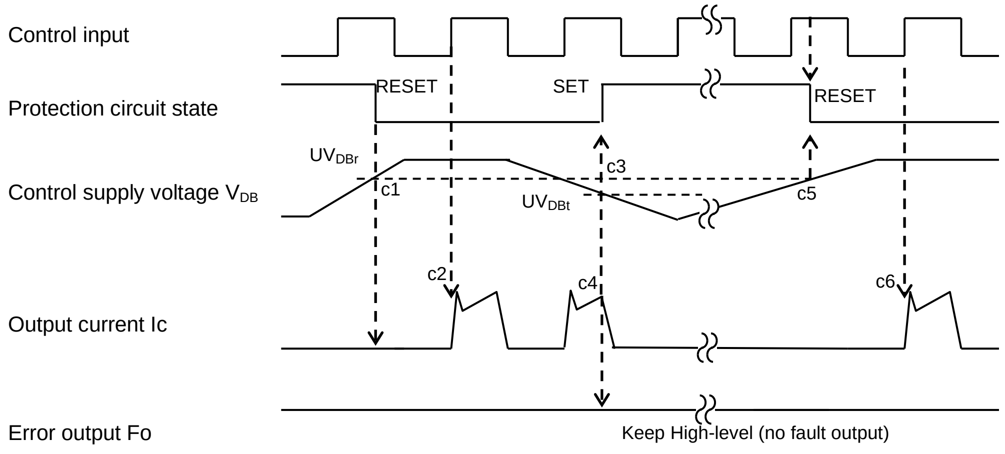
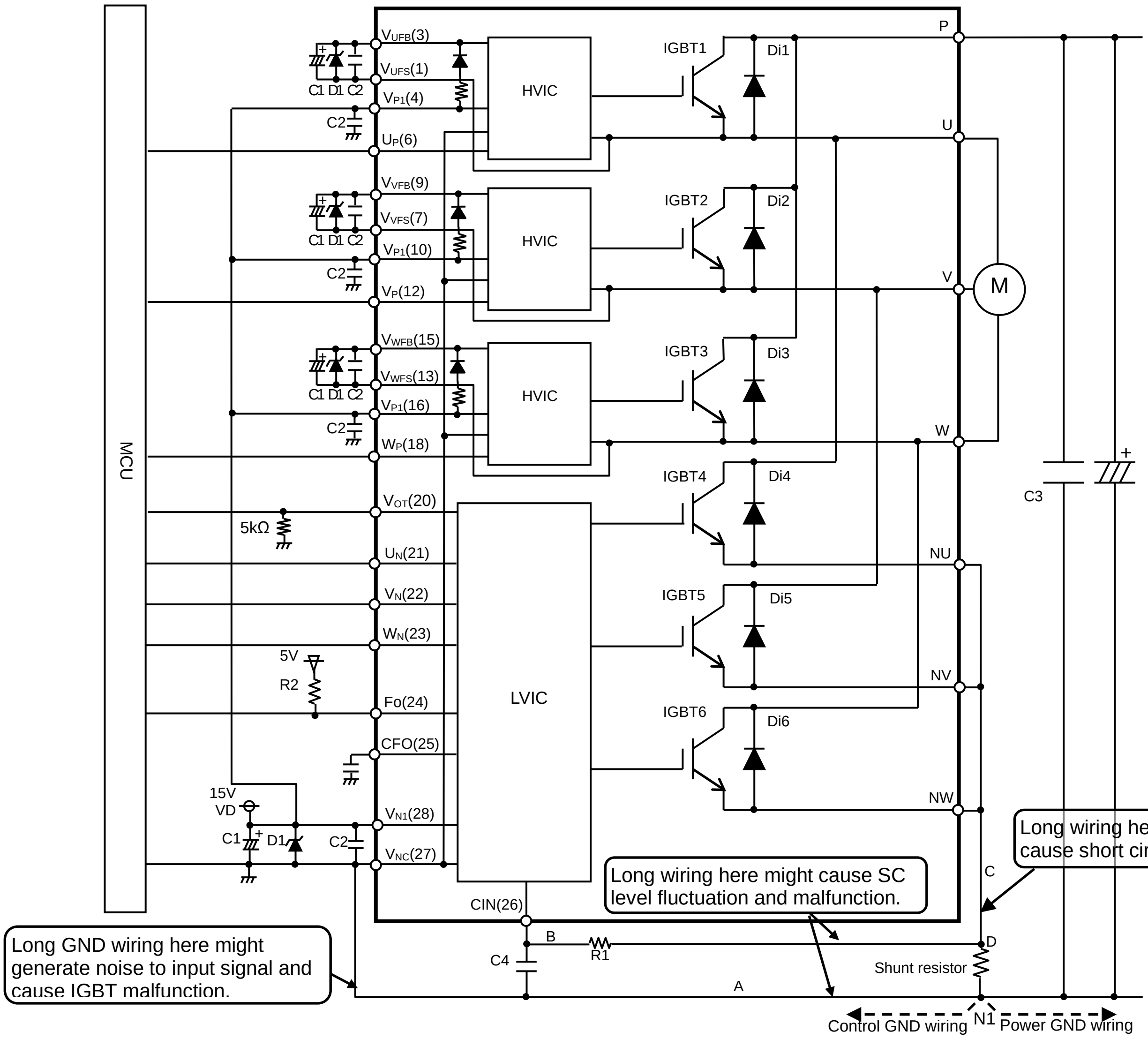
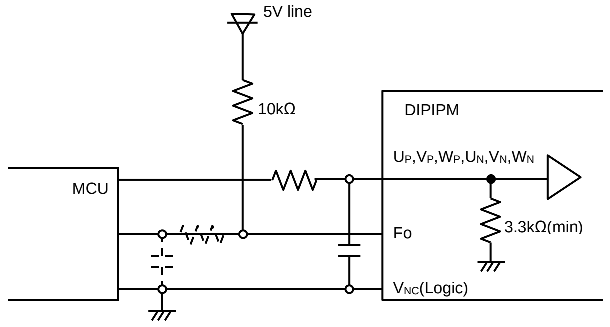


Fig. 6 Example of Application Circuit



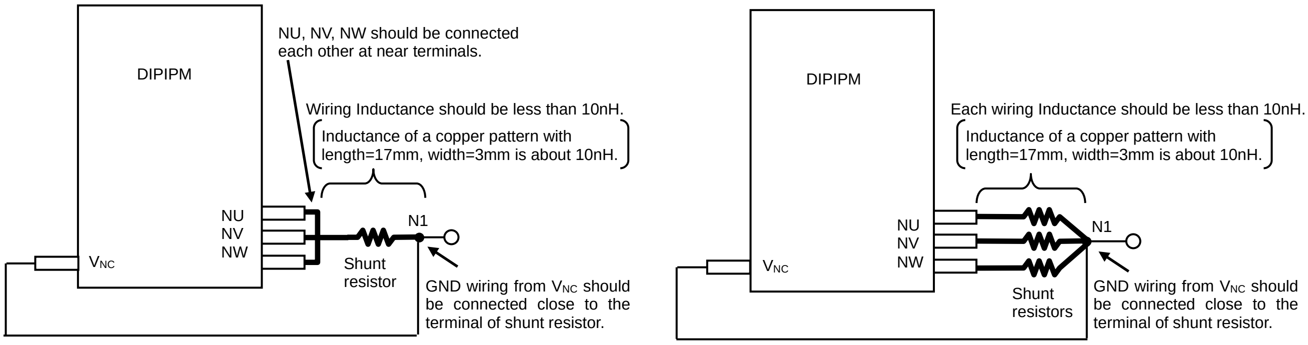
(1) If control GND is connected with power GND by common broad pattern, it may cause malfunction by power GND fluctuation. It is recommended to connect control GND and power GND at only a point N1 (near the terminal of shunt resistor).
(2) It is recommended to insert a Zener diode D1(24V/1W) between 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 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 at near NU, NV, NW 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 C2:0.22μ-2μF, good temperature, frequency and DC bias characteristic ceramic type are recommended.)
(8) Input logic is High-active. There is a 3.3kΩ(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. It should be pulled up to power supply of MCU (e.g. 5V,3.3V) 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.) When using opto coupler, Fo also can be pulled up to 15V (control supply of DIPIPM) by the resistor.
(10) Fo pulse width can be set by the capacitor connected to CFO terminal. $C_{FO}(F) = 9.1 \times 10^{-6} \times t_{FO}$ (Required Fo pulse width).
(11) 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.
(12) For DIPIPM, it isn't recommended to drive same load by parallel connection with other phase IGBT or other DIPIPM.

Fig. 7 MCU I/O Interface Circuit



Note)
Design for input RC filter depends on PWM control scheme used in the application and wiring impedance of the printed circuit board.
DIPIPM input signal interface integrates a minimum 3.3kΩ pull-down resistor. Therefore, when inserting RC filter, it is necessary to satisfy turn-on threshold voltage requirement.
Fo output is open drain type. It should be pulled up to control power supply (e.g. 5V, 15V) with a resistor that makes Fo sink current I_{Fo} 1mA or less. In the case of pulled up to 5V supply, 10kΩ (5kΩ or more) is recommended.

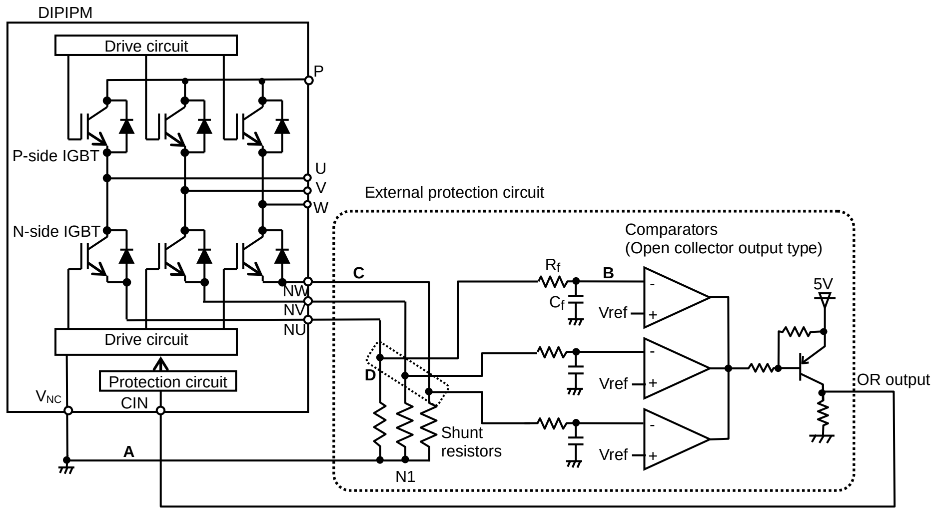
Fig. 8 Pattern Wiring Around the Shunt Resistor



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

Fig. 9 Pattern Wiring Around the Shunt Resistor (for the case of open emitter)

When DIPIPM is operated with three shunt resistors, voltage of each shunt resistor cannot be input to CIN terminal directly. In that case, it is necessary to use the external protection circuit as below.



(1) It is necessary to set the time constant R_fC_f of external comparator input so that IGBT stops within 2μs when short circuit occurs. SC interrupting time might vary with the wiring pattern, comparator speed and so on.
(2) It is recommended for the threshold voltage Vref to set to 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 value (=2.0 times of rating current).
(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 close to the terminal of shunt resistor.
(6) OR output high level when protection works should be over 0.51V (=maximum Vsc(ref) rating).
(7) GND of Comparator, GND of Vref circuit and Cf should be not connected to power GND but to control GND wiring.

Fig. 10 Package Outlines PSSxxS51F6 (Short terminal type)

Dimensions in mm

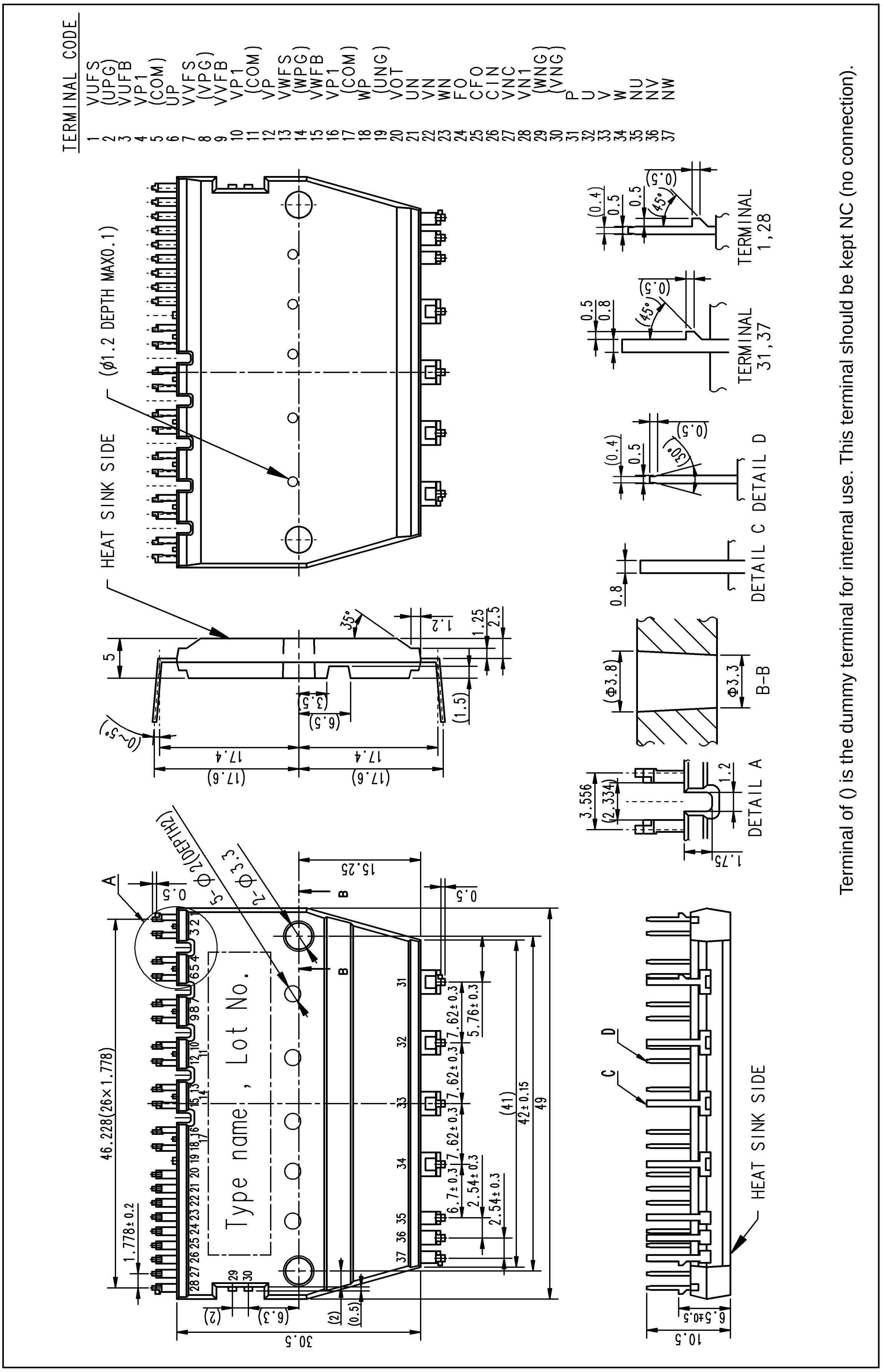
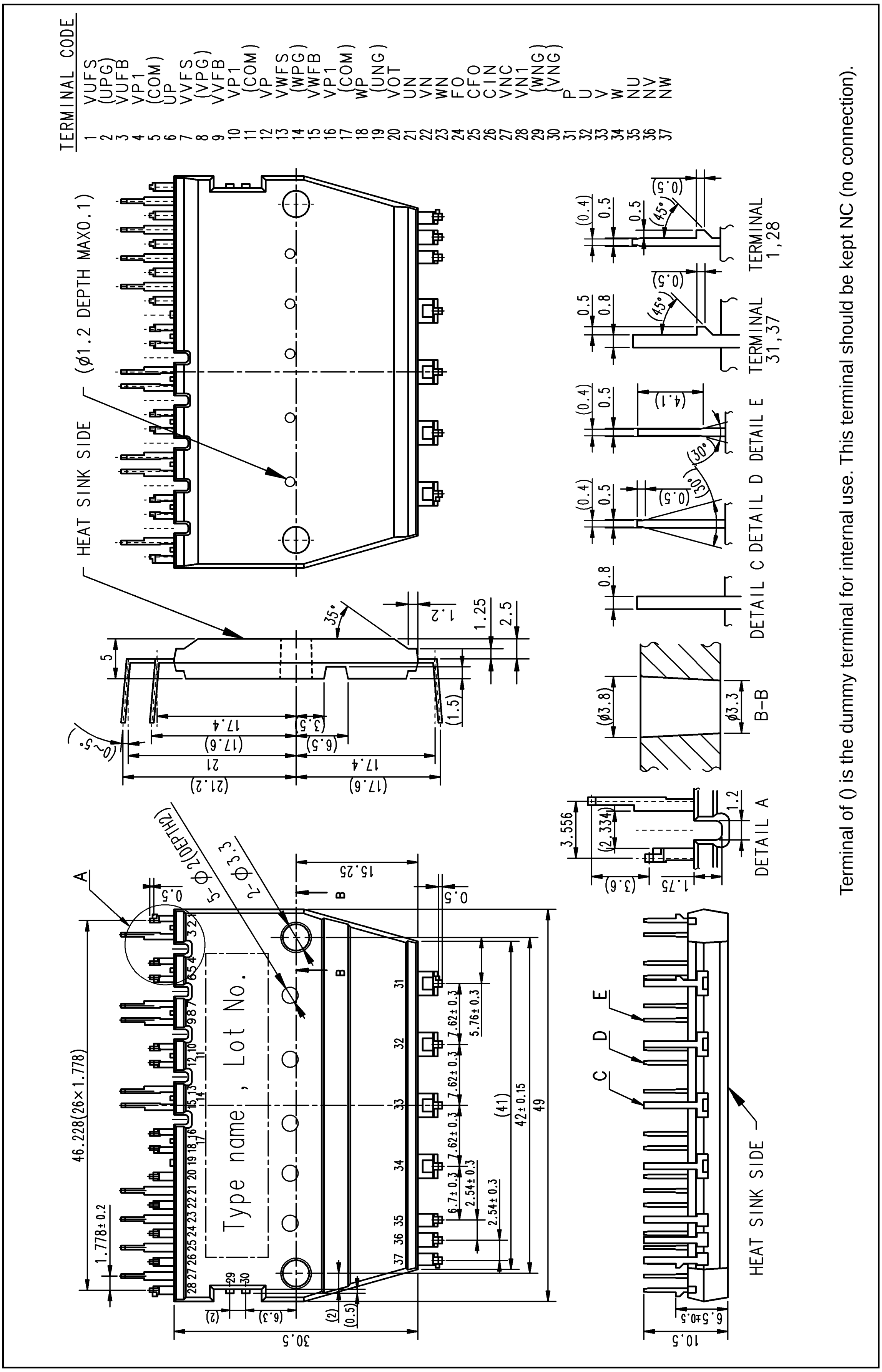


Fig. 11 Package Outlines PSSxxS51F6-C (Control side zigzag terminal type)

Dimensions in mm



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