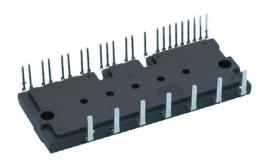


< Dual-In-Line Package Intelligent Power Module >

PS22A78-E

TRANSFER MOLDING TYPE **INSULATED TYPE**

OUTLINE



MAIN FEATURES AND RATINGS

- 3 phase DC/AC inverter
- 1200V / 35A
- Built-in LPT-CSTBT (5th generation IGBT)
- Insulated transfer molding package
- N-side IGBT open emitter

APPLICATION

• AC 400V class motor control

INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS

: Drive circuit, High voltage high-speed level shifting, Control supply under-voltage (UV) protection • For P-side

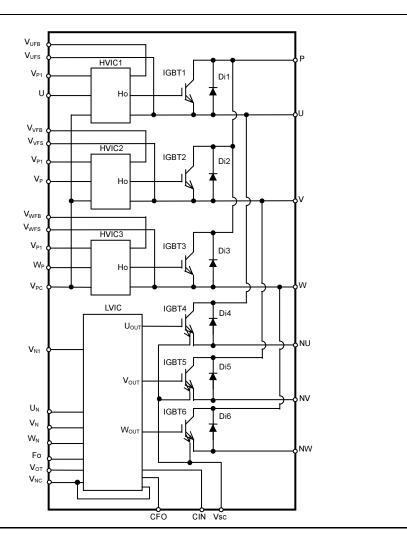
: Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC) • For N-side

• Fault signaling : Corresponding to SC fault (N-side IGBT), UV fault (N-side supply)

• Temperature output : Outputting LVIC temperature by analog signal

Input interface : 5V line, Schmitt trigger receiver circuit (High Active)
UL Recognized : UL1557 File E80276

INTERNAL CIRCUIT



INSULATED TYPE

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

INVERTER PART

Symbol	Parameter	Condition	Ratings	Unit
Vcc	Supply voltage	Applied between P-NU,NV,NW	900	V
$V_{CC(surge)}$	Supply voltage (surge)	Applied between P-NU,NV,NW	1000	V
V _{CES}	Collector-emitter voltage		1200	V
±lc	Each IGBT collector current	T _C = 25°C	35	Α
±I _{CP}	Each IGBT collector current (peak)	T _C = 25°C, up to 1ms	70	Α
Pc	Collector dissipation	T _C = 25°C, per 1 chip	129.9	W
Tj	Junction temperature		-20~+150	°C

CONTROL (PROTECTION) PART

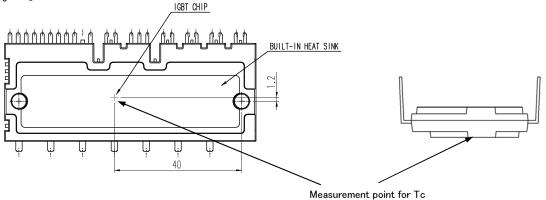
Symbol	Parameter	Condition	Ratings	Unit
V _D	Control supply voltage	Applied between V _{P1} -V _{PC} , V _{N1} -V _{NC}	20	V
V_{DB}	Control supply voltage	Applied between V _{UFB} -V _{UFS} , V _{VFB} -V _{VFS} , V _{WFB} -V _{WFS}	20	V
V _{IN}	Input voltage	Applied between U _P , V _P , W _P -V _{PC} , U _N , V _N , W _N -V _{NC}	-0.5~V _D +0.5	V
V_{FO}	Fault output supply voltage	Applied between Fo-V _{NC}	-0.5~V _D +0.5	V
I _{FO}	Fault output current	Sink current at Fo 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 _i = 125°C, non-repetitive, up to 2μs	800	V
T _C	Module case operation temperature	(Note 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 _{ms}

Note 1: To measurement point is described in Fig.1.





THERMAL RESISTANCE

Symbol Parameter		Condition		Limits		
Symbol	i arameter	Condition	Min.	Тур.	Max.	Unit
R _{th(j-c)Q}	Junction to case thermal	Inverter IGBT part (per 1/6 module)	-	-	0.77	K/W
R _{th(j-c)F}	resistance (Note 2)	Inverter FWDi part (per 1/6 module)	-	-	1.25	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 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 0.2K/W (per 1/6 module, grease thickness: 20µm, thermal conductivity: 1.0W/m•k).

TRANSFER MOLDING TYPE **INSULATED TYPE**

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

Symbol	Parameter	Condit	Condition		Limits		
Syllibol	Parameter	Condit			Тур.	Max.	Unit
V	Collector-emitter saturation	$V_D = V_{DB} = 15V, V_{IN} = 5V, I_C = 35A$	T _j = 25°C	-	1.90	2.60	V
V _{CE(sat)}	voltage	V _D -V _{DB} - 13V, V _{IN} - 3V, I _C - 33A	T _j = 125°C	-	2.00	2.70	·
V _{EC}	FWDi forward voltage	V _{IN} = 0V, -I _C = 35A		-	2.20	2.80	V
t _{on}				0.50	1.20	1.90	μs
t _{C(on)}		V _{CC} = 600V, V _D = V _{DB} = 15V		-	0.60	0.90	μs
t _{off}	Switching times	I _C = 35A, T _j = 125°C, V _{IN} = 0↔5V		-	2.40	3.50	μs
$t_{C(off)}$		Inductive Load (upper-lower arm)		-	0.60	0.90	μs
t _{rr}				-	0.50	-	μs
1	Collector-emitter cut-off	V _{CE} =V _{CES}	T _j = 25°C	-	-	1	mA
I _{CES}	current	V _{CE} =V _{CES}	T _j = 125°C	-	-	10	111/

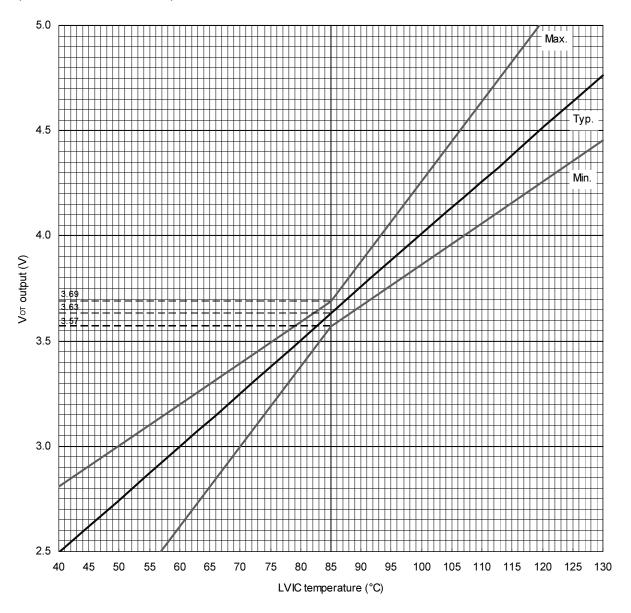
CONTROL (PROTECTION) PART

Symbol	Parameter		Condition			Limits		Unit
Syllibol	Parameter		Condition	Solidition		Тур.	Max.	Offic
_		Total of V _{P1} -V _{PC} , V _{N1} -V _{NC}	V _D =15V, V _{IN} =0V		-	-	5.60	
I _D	Circuit current	Total of VP1-VPC, VN1-VNC	V _D =15V, V _{IN} =5V		-	-	5.60	mA
L	Circuit current	Each part of V _{UFB} -V _{UFS} ,	$V_D=V_{DB}=15V$, $V_{IN}=0V$		-	-	1.10	III/A
I _{DB}		V_{VFB} - V_{VFS} , V_{WFB} - V_{WFS}	$V_D=V_{DB}=15V$, $V_{IN}=5V$		-	-	1.10	
I _{sc}	Short circuit trip level		-20°C≤Tj≤125°C, Rs= 48.7Ω (±1%), Not connecting outer shunt resistors to NU.NV.NW terminals (Note 3)		59.5	-	-	Α
UV_DBt	P-side Control supply	T <405°C	Trip level		10.0	-	12.0	V
UV_DBr	under-voltage protection(UV)	T _j ≤125°C	Reset level		10.5	-	12.5	V
UV_Dt	N-side Control supply under-voltage	T _i ≤125°C	Trip level		10.3	-	12.5	V
UV_Dr	protection(UV)	1 _j = 125 C	Reset level		10.8	-	13.0	٧
V_{FOH}	Fault output voltage	V _{SC} = 0V, F _O terminal pulled	d up to 5V by 10kΩ		4.9	-	-	V
V_{FOL}	Fault output voltage	V _{SC} = 1V, I _{FO} = 1mA			-	-	0.95	V
t _{FO}	Fault output pulse width	C _{FO} =22nF (Note 4)		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}		-	-	3.5	V	
$V_{th(off)}$	OFF threshold voltage	Applied between op, vp, vv	P, ON, VN, VVN-VNC		8.0	-	-	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \
V_{OT}	Temperature output	LVIC temperature = 85°C		(Note 5)	3.57	3.63	3.69	V

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. For details, please refer the application note for this DIPIPM.

 ^{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} (typ.) = t_{FO} x (9.1 x 10⁻⁶) [F])
 5: DIPIPM 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 the DIPIPM immediately. This output might exceed 5V when temperature rises excessively, so it is recommended to insert a clamp Di between controller supply (e.g. 5V) and V_{OT} output for overvoltage protection. Temperature of LVIC vs. V_{OT} output characteristics is described in Fig.2

Fig. 2 Temperature of LVIC vs. V_{OT} Output Characteristics



Please refer the application note about the usage of V_{OT} too.

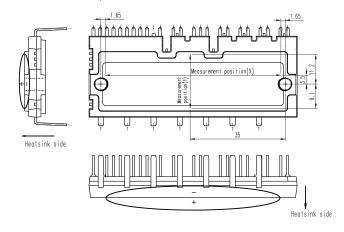
TRANSFER MOLDING TYPE

INSULATED TYPE

MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition		Limits			Unit
Farameter	Condition			Тур.	Max.	Offic
Mounting torque	Mounting screw : M4	Recommended 1.18N·m	0.98	1.18	1.47	N·m
Terminal pulling strength	Load 19.6N	EIAJ-ED-4701	10	-	-	s
Terminal bending strength	Load 9.8N, 90deg. bend	EIAJ-ED-4701	2	-	-	times
Weight			1	46	-	g
Heat-sink flatness	(Note 6)			-	100	μm

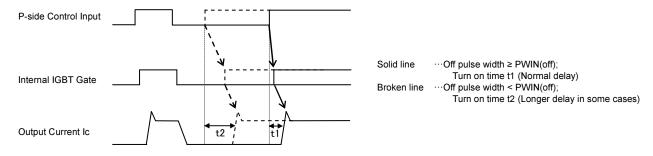
Note 6: Measurement point of heat-sink flatness



RECOMMENDED OPERATION CONDITIONS

Symbol	Parameter	Condition			Unit		
Symbol Farameter		Condition	Min.	Тур.	Max.	Offic	
Vcc	Supply voltage	Applied between P-NU, NV, NW		350	600	800	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 _V	_{VFB} -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		3.0	-	-	μs
f _{PWM}	PWM input frequency	$T_{\rm C} \le 100^{\circ}{\rm C}, T_{\rm j} \le 125^{\circ}{\rm C}$			-	20	kHz
٥_	Allowable r.m.s. current	V_{CC} = 600V, V_D = 15V, P.F = 0.8, Sinusoidal PWM	f _{PWM} = 5kHz		-	19.1	Arms
10	Allowable I.III.S. Cullent	$T_C \le 100^{\circ}C$, $T_j \le 125^{\circ}C$ (Note 7) $f_{PWM} = 15kHz$	f _{PWM} = 15kHz	-	-	12.8	Aiiiis
PWIN(on)			(Note 8)	1.5	-	-	
PWIN(off)	Minimum input pulse width	$350 \le V_{CC} \le 800V$, $13.5 \le V_D \le 16.5V$, $13.0 \le V_{DB} \le 18.5V$, $-20^{\circ}C \le T_C \le 100^{\circ}C$,	I _C ≤35A	2.3	-	-	μs
FVVIIV(OII)	N line wiring inductance less than 10nH (Note 9)	35A <i<sub>c≤59.5A</i<sub>	2.9	-	-		
V_{NC}	V _{NC} variation	Between V _{NC} -NU, NV, NW (including surge)		-5.0	-	+5.0	٧
Tj	Junction temperature			-20	-	+125	°C

Fig. 3 About Delayed Response Against Shorter Input Off Signal Than PWIN(off) (P-side only)



^{7:} The allowable r.m.s. current value depends on the actual application conditions.

8: DIPIPM might not make response to the input on signal with pulse width less than PWIN (on).

9: IPM 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 Fig. 3 about delayed response.

TRANSFER MOLDING TYPE

INSULATED TYPE

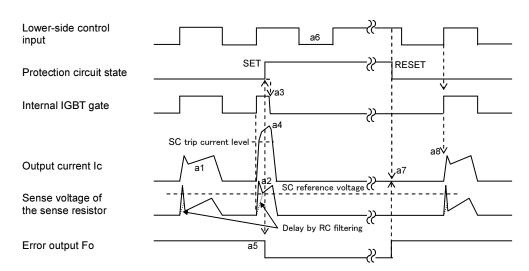
Fig. 4 Timing Charts of DIPIPM Protective Functions

[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)

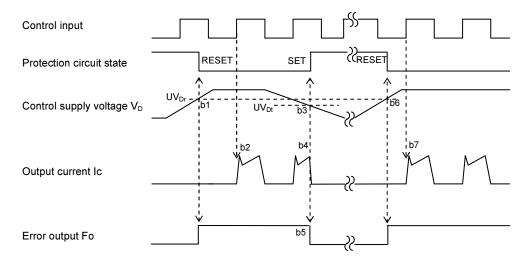
(It is recommended to set RC time constant 1.5~2.0µs so that IGBT shut down within 2.0µs when SC occurs.)

- a3. All N-side IGBT's gates are hard interrupted.
- a4. All N-side IGBTs turn OFF.
- a5. Fo outputs with a fixed pulse width determined by the external capacitor CFO.
- 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 ($L\rightarrow H$). (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 determined 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 by next ON signal ($L\rightarrow H$).



TRANSFER MOLDING TYPE

INSULATED TYPE

- [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 \rightarrow 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 Fo signal output.
- c5. V_{DB} level reaches UV_{DBr} .
- c6. Normal operation: IGBT ON and outputs current by next ON signal (L→H).

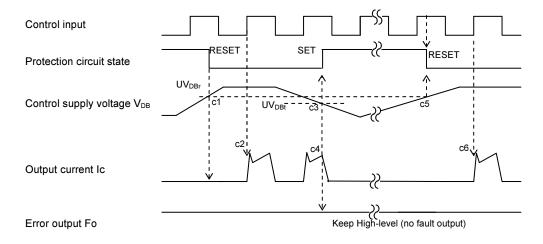
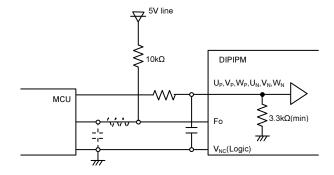


Fig. 5 MCU I/O Interface Circuit



Note)

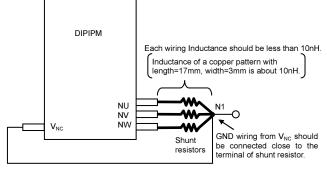
Design for input RC filter depends on the PWM control scheme used in the application and the wiring impedance of the printed circuit board.

But because noisier in the application for 1200V, it is strongly recommended to insert RC filter. (Time constant: over 100ns. e.g. 100Ω , 1000pF)

The DIPIPM 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_{F0} under 1mA. In the case of pulling up to 5V supply, over $5.1k\Omega$ is needed. (10k Ω is recommended.)

Fig. 6 Wiring Pattern around the Shunt Resistor in the Case of Inserting into Main Current Path

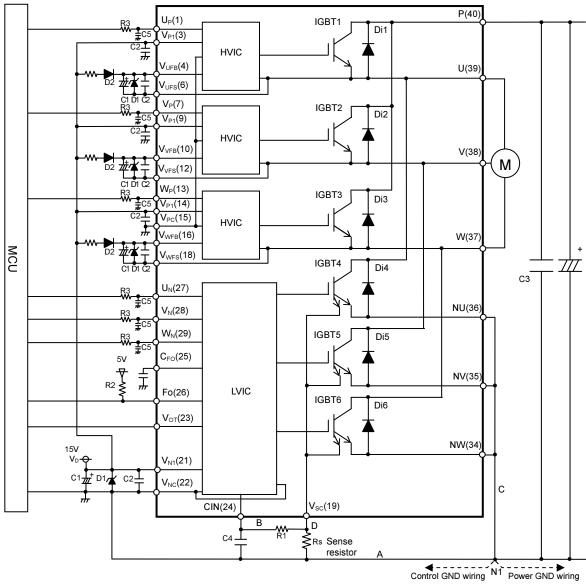


Low inductance shunt resistor like surface mounted (SMD) type is recommended. Protection current level I_{SC} changes by inserting shunt resistor.

TRANSFER MOLDING TYPE

INSULATED TYPE

Fig. 7 Example of Application Circuit

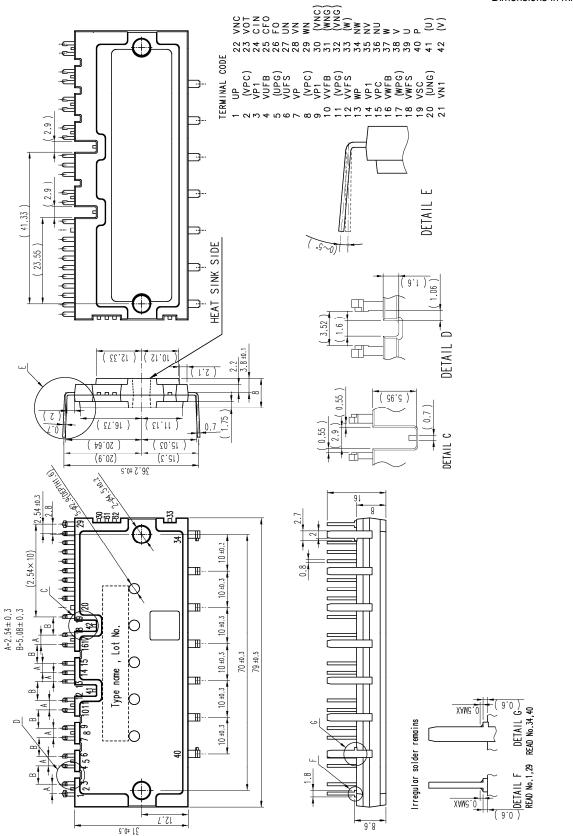


Note

- 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 0.1μ~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 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 1/8W 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 DIPIPM as possible. (C1: good temperature, frequency characteristic electrolytic type, and C2: 0.22µ~2.0µF, good temperature, frequency and DC bias characteristic ceramic type are recommended.)
- 9 :Input drive is High-active type. There is a min. 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. And it is strongly recommended to insert RC filter (e.g. R3=100Ω 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. It should be pulled up to MCU or control power supply (e.g. 5V,15V) by a resistor that makes IFo up to 1mA. (IFO is estimated roughly by the formula of control power supply voltage divided by pull-up resistance. In the case of pulled up to 5V, $10k\Omega$ ($5k\Omega$ or more) is recommended.)
- 11 :Error signal output width (t_{F_0}) can be set by the capacitor connected to C_{F_0} terminal. $C_{F_0}(typ.) = t_{F_0} \times (9.1 \times 10^{-6})$ (F)
- 12: High voltage (V_{RRM} =1200V or more) and fast recovery diode (trr=less than 100ns or less) should be used for D2 in the bootstrap circuit.
- 13 :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/μs, Vripple≤2Vp-p.
- 14 :For DIPIPM, it isn't recommended to drive same load by parallel connection with other phase IGBT or other DIPIPM.

Fig. 8 Package Outlines

Dimensions in mm



< Dual-In-Line Package Intelligent Power Module >

PS22A78-E

TRANSFER MOLDING TYPE

INSULATED TYPE

Revision Record

Rev.	Date	Page	Revised contents
1	3/15/2011	-	New
2	1/31/2012	-	Change document format
		7	Add Fig.6.
		8	Revise notes.

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