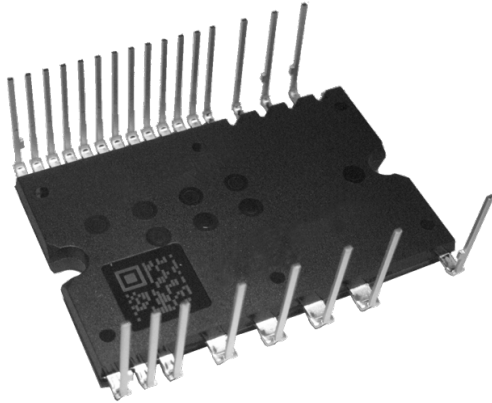


< DIIPM >

# PSF15S92F6-A6

TRANSFER MOLDING TYPE  
INSULATED TYPE

## OUTLINE



## MAIN FUNCTION AND RATINGS

- 3 phase DC/AC inverter
- 600V / 15A (MOSFET)
- N-side MOSFET open source
- Built-in bootstrap diodes with current limiting resistor

## APPLICATION

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

## TYPE NAME

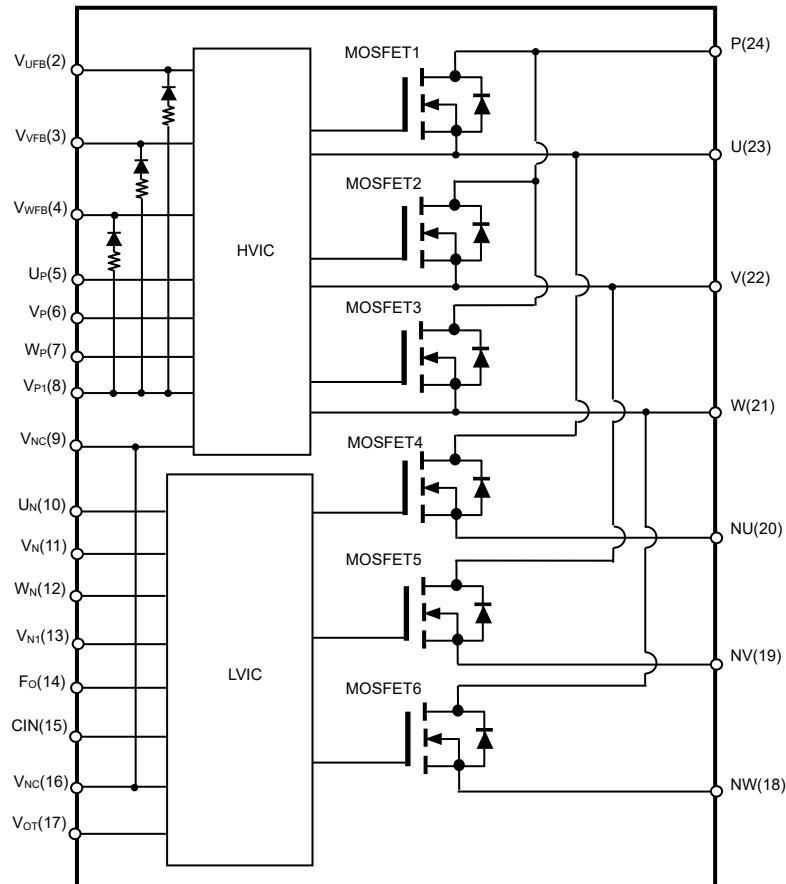
PSF15S92F6-A6

With temperature output function

## 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 MOSFET), 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 E323585

## INTERNAL CIRCUIT



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## MAXIMUM RATINGS (T<sub>ch</sub> = 25°C, unless otherwise noted)

### INVERTER PART

Symbol	Parameter	Condition	Ratings	Unit
V <sub>DD</sub>	Supply voltage	Applied between P-NU,NV,NW	450	V
V <sub>DD(surge)</sub>	Supply voltage (surge)	Applied between P-NU,NV,NW	500	V
V <sub>DSS</sub>	Drain-source voltage		600	V
±I <sub>D</sub>	Each MOSFET drain current	T <sub>C</sub> = 25°C (Note 1)	15	A
±I <sub>DP</sub>	Each MOSFET drain current (peak)	T <sub>C</sub> = 25°C, less than 1ms	30	A
T <sub>ch</sub>	Channel temperature	(Note 2)	-30~+150	°C

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

Note2: The maximum channel temperature rating of built-in power chips is 150°C(@T<sub>c</sub>≤100°C).However, to ensure safe operation of DIIPM, the average channel temperature should be limited to T<sub>ch(Ave)</sub>≤125°C (@T<sub>c</sub>≤100°C).

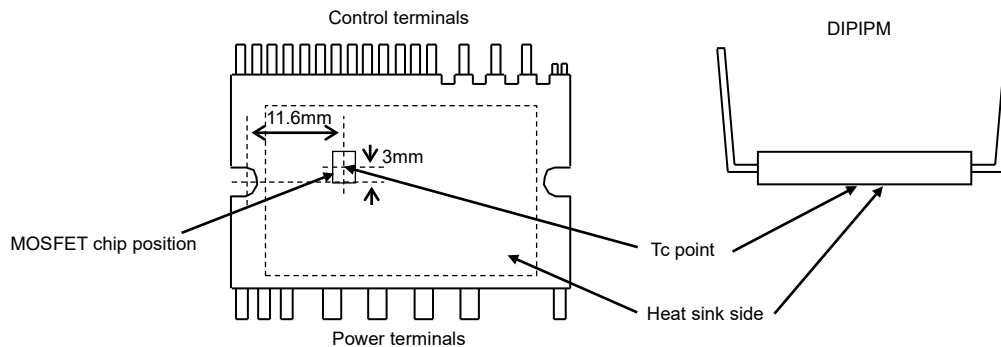
### CONTROL (PROTECTION) PART

Symbol	Parameter	Condition	Ratings	Unit
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>	24	V
V <sub>DB</sub>	Control supply voltage	Applied between V <sub>UFB</sub> -U, V <sub>VFB</sub> -V, V <sub>WFB</sub> -W	24	V
V <sub>IN</sub>	Input voltage	Applied between U <sub>P</sub> , V <sub>P</sub> , W <sub>P</sub> , U <sub>N</sub> , V <sub>N</sub> , W <sub>N</sub> -V <sub>NC</sub>	-0.5~V <sub>D</sub> +0.5	V
V <sub>FO</sub>	Fault output supply voltage	Applied between F <sub>O</sub> -V <sub>NC</sub>	-0.5~V <sub>D</sub> +0.5	V
I <sub>FO</sub>	Fault output current	Sink current at F <sub>O</sub> terminal	1	mA
V <sub>SC</sub>	Current sensing input voltage	Applied between CIN-V <sub>NC</sub>	-0.5~V <sub>D</sub> +0.5	V

### TOTAL SYSTEM

Symbol	Parameter	Condition	Ratings	Unit
V <sub>DD(PROT)</sub>	Self protection supply voltage limit (Short circuit protection capability)	V <sub>D</sub> = 17~19V, Inverter Part T <sub>ch</sub> = 125°C, non-repetitive, less than 2μs	400	V
T <sub>C</sub>	Module case operation temperature	Measurement point of T <sub>C</sub> is provided in Fig.1	-30~+100	°C
T <sub>stg</sub>	Storage temperature		-40~+125	°C
V <sub>iso</sub>	Isolation voltage	60Hz, Sinusoidal, AC 1min, between connected all pins and heat sink plate	1500	V <sub>rms</sub>

Fig. 1: T<sub>C</sub> MEASUREMENT POINT



### THERMAL RESISTANCE

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
R <sub>th(ch-c)Q</sub>	Channel to case thermal resistance	Inverter MOSFET part (per 1/6 module)	-	-	3.7	K/W

Note 3: 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<sub>th(c-f)</sub> is determined by the thickness and the thermal conductivity of the applied grease. For reference, R<sub>th(c-f)</sub> is about 0.3K/W (per 1/6 module, grease thickness: 20μm, thermal conductivity: 1.0W/m·K).

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## ELECTRICAL CHARACTERISTICS (T<sub>ch</sub> = 25°C, unless otherwise noted)

### INVERTER PART

Symbol	Parameter	Condition	Limits			Unit	
			Min.	Typ.	Max.		
V <sub>DS(on)</sub>	Drain-source on-state voltage	V <sub>D</sub> =V <sub>DB</sub> = 18V, V <sub>IN</sub> = 5V	I <sub>D</sub> = 15A, T <sub>ch</sub> = 25°C	-	1.10	1.80	V
			I <sub>D</sub> = 15A, T <sub>ch</sub> = 125°C	-	1.00	1.65	
V <sub>SD(off)</sub>	Source- drain voltage	V <sub>D</sub> =V <sub>DB</sub> = 18V, V <sub>IN</sub> = 0V, -I <sub>D</sub> = 15A	-	4.00	5.00	V	
t <sub>on</sub>	Switching times	V <sub>DD</sub> = 300V, V <sub>D</sub> = V <sub>DB</sub> = 18V I <sub>D</sub> = 15A, T <sub>ch</sub> = 125°C, V <sub>IN</sub> = 0↔5V Inductive Load (upper-lower arm)	-	0.70	1.30	1.85	μs
t <sub>c(on)</sub>			-	0.10	0.36	μs	
t <sub>off</sub>			-	1.50	2.10	μs	
t <sub>c(off)</sub>			-	0.10	0.18	μs	
t <sub>rr</sub>			-	0.10	-	μs	
I <sub>DSS</sub>	Drain-Source cut-off current	V <sub>DS</sub> =V <sub>DSS</sub>	T <sub>ch</sub> = 25°C	-	-	1	mA
			T <sub>ch</sub> =125°C	-	-	10	

### CONTROL (PROTECTION) PART

Symbol	Parameter	Condition	Limits			Unit	
			Min.	Typ.	Max.		
I <sub>D</sub>	Circuit current	Total of V <sub>P1</sub> -V <sub>NC</sub> , V <sub>N1</sub> -V <sub>NC</sub>	V <sub>D</sub> =18V, V <sub>IN</sub> =0V	-	-	3.50	mA
			V <sub>D</sub> =18V, V <sub>IN</sub> =5V	-	-	3.50	
I <sub>DB</sub>	Circuit current	Each part of V <sub>UFB</sub> -U, V <sub>VFB</sub> -V, V <sub>WFB</sub> -W	V <sub>D</sub> =V <sub>DB</sub> =18V, V <sub>IN</sub> =0V	-	-	0.38	mA
			V <sub>D</sub> =V <sub>DB</sub> =18V, V <sub>IN</sub> =5V	-	-	0.38	
V <sub>SC(ref)</sub>	Short circuit trip level	V <sub>D</sub> = 18V (Note 4)	0.455	0.480	0.505	V	
UV <sub>DBt</sub>	P-side Control supply under-voltage protection(UV)	T <sub>ch</sub> ≤125°C	Trip level	10.0	-	12.0	V
UV <sub>DBr</sub>			Reset level	10.5	-	12.5	V
UV <sub>Dt</sub>	N-side Control supply under-voltage protection(UV)	T <sub>ch</sub> ≤125°C	Trip level	10.3	-	12.5	V
UV <sub>Dr</sub>			Reset level	10.8	-	13.0	V
V <sub>OT</sub>	Temperature Output	Pull down R=5.1kΩ (Note 5)	LVIC Temperature=90°C	2.63	2.77	2.91	V
			LVIC Temperature=25°C	0.88	1.13	1.39	V
V <sub>FOH</sub>	Fault output voltage	V <sub>SC</sub> = 0V, F <sub>O</sub> terminal pulled up to 5V by 10kΩ	4.9	-	-	V	
V <sub>FOL</sub>		V <sub>SC</sub> = 1V, I <sub>F0</sub> = 1mA	-	-	0.95	V	
t <sub>FO</sub>	Fault output pulse width	(Note 6)	20	-	-	μs	
I <sub>IN</sub>	Input current	V <sub>IN</sub> = 5V	0.70	1.00	1.50	mA	
V <sub>th(on)</sub>	ON threshold voltage	Applied between U <sub>P</sub> , V <sub>P</sub> , W <sub>P</sub> , U <sub>N</sub> , V <sub>N</sub> , W <sub>N</sub> -V <sub>NC</sub>	-	2.10	2.60	V	
V <sub>th(off)</sub>	OFF threshold voltage		0.80	1.50	-		
V <sub>th(hys)</sub>	ON/OFF threshold hysteresis voltage		0.35	0.65	-		
V <sub>F</sub>	Bootstrap Di forward voltage	I <sub>F</sub> =10mA including voltage drop by limiting resistor (Note 7)	0.9	1.3	1.7	V	
R	Built-in limiting resistance	Included in bootstrap Di	48	60	72	Ω	

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

5 : For temperature output type, DIIPM don't shutdown MOSFETs and output fault signal automatically when temperature rises excessively. When temperature exceeds the protective level that user defined, controller (MCU) should stop the DIIPM. 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 (=minimum 20μs), but at UV failure, Fo outputs continuously until recovering from UV state. (But minimum Fo pulse width is 20μs.)

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

Fig. 2 Characteristics of bootstrap Di V<sub>F</sub>-I<sub>F</sub> curve (@Ta=25°C) including voltage drop by limiting resistor (Right chart is enlarged chart.)

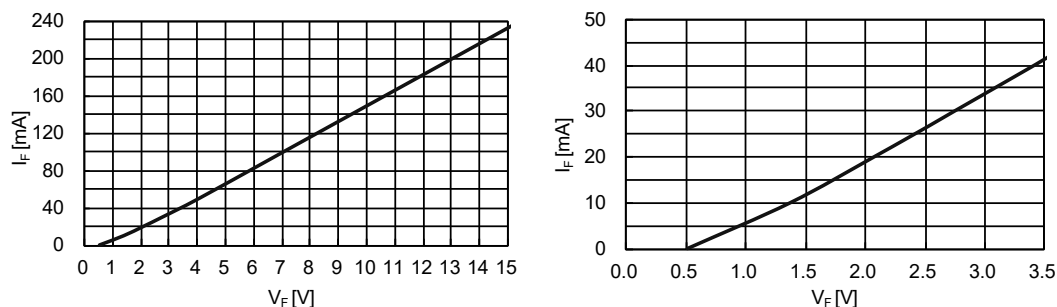


Fig. 3 Temperature of LVIC vs.  $V_{OT}$  output characteristics

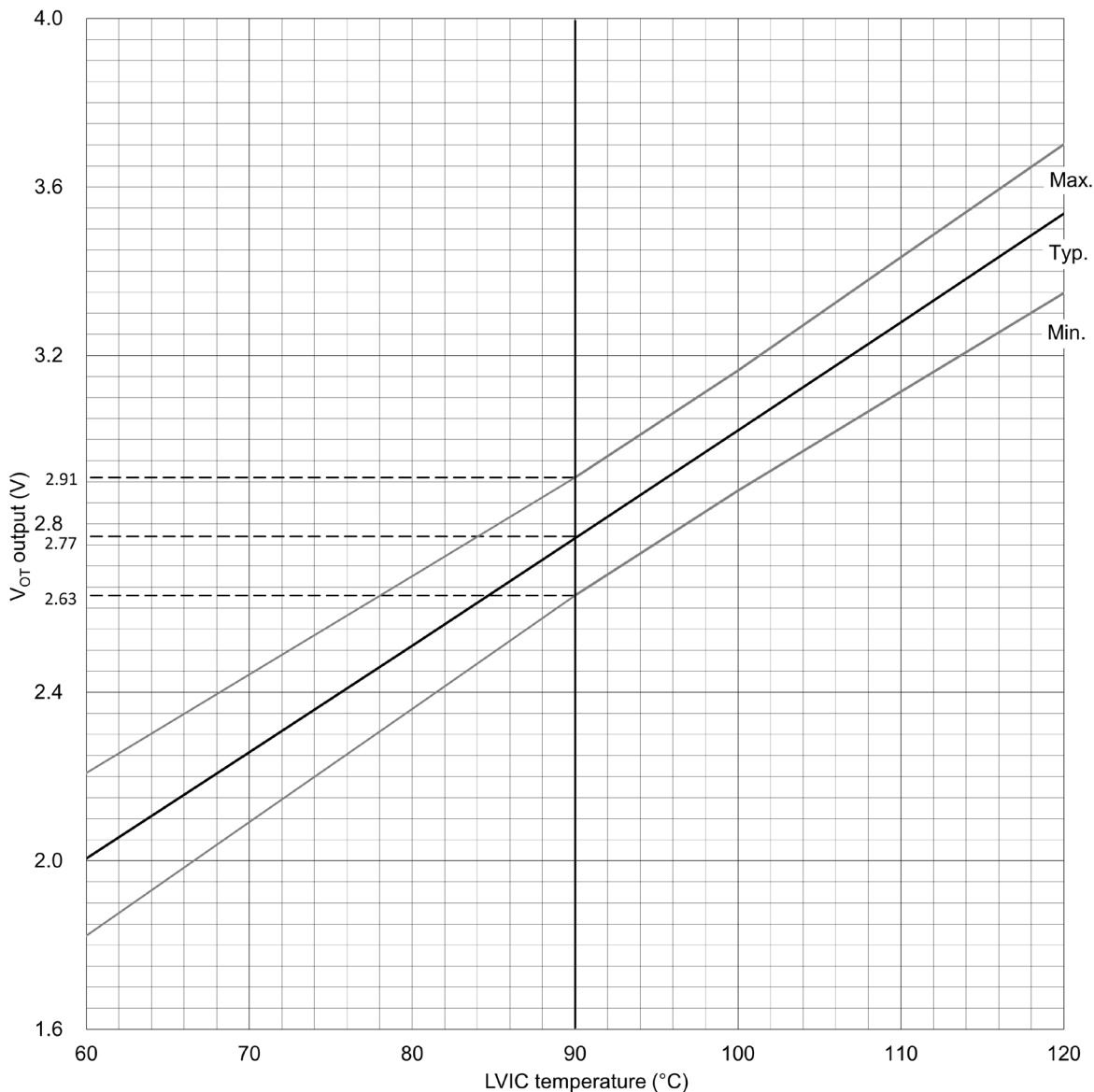
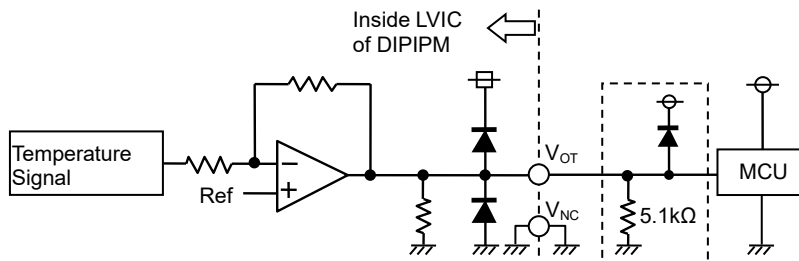


Fig. 4  $V_{OT}$  output circuit



- (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 about the usage of  $V_{OT}$ .

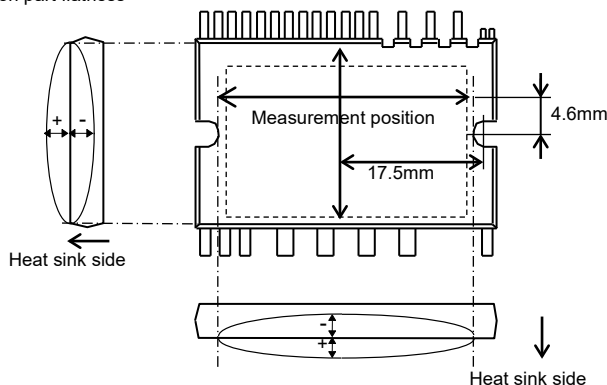
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TRANSFER MOLDING TYPE  
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## MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition	Reference	Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M3 (Note 8)	JEITA-ED-4701 402 method II	0.59	0.69	0.78	N·m
Terminal pulling strength	Control terminal: Load 5N Power terminal: Load 10N	JEITA-ED-4701 401 method I	10	-	-	s
Terminal bending strength	Control terminal: Load 2.5N Power terminal: Load 5N 90deg. bend	JEITA-ED-4701 401 method III	2	-	-	times
Weight			-	8.5	-	g
Heat radiation part flatness	(Note 9)		-50	-	100	μm

Note 8: Plain washers (ISO 7089-7094) are recommended.  
Note 9: Measurement point of heat radiation part flatness

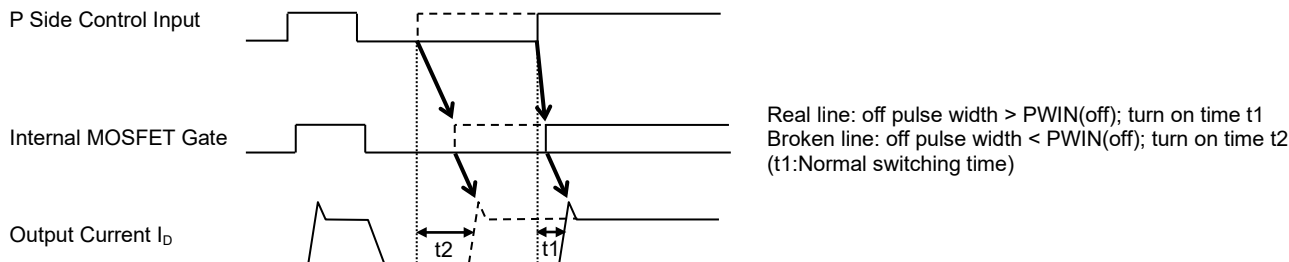


## RECOMMENDED OPERATION CONDITIONS

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
$V_{DD}$	Supply voltage	Applied between P-NU, NV, NW	0	300	400	V
$V_D$	Control supply voltage	Applied between $V_{P1}$ - $V_{NC}$ , $V_{N1}$ - $V_{NC}$	17.0	18.0	19.0	V
$V_{DB}$	Control supply voltage	Applied between $V_{UFB-U}$ , $V_{VFB-V}$ , $V_{WFB-W}$	15.0	18.0	22.0	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	1.5	-	-	μs
$f_{PWM}$	PWM input frequency	$T_C \leq 100^\circ C, T_{ch} \leq 125^\circ C$	-	5	20	kHz
PWIN(on)		(Note 10)	0.7	-	-	
PWIN(off)	Minimum input pulse width	$200V \leq V_{DD} \leq 350V,$ $17V \leq V_D \leq 19V,$ $15V \leq V_{DB} \leq 22V,$ $-30^\circ C \leq T_C \leq 100^\circ C,$ N-line wiring inductance less than 10nH (Note 11)	1.5	-	-	μs
$V_{NC}$	$V_{NC}$ variation	Between $V_{NC}$ -NU, NV, NW (including surge)	-5	-	+5	V
$T_{ch}$	Channel temperature		-30	-	+125	°C

Note 10: DIIPM might not make response if the input signal pulse width is less than PWIN(on).  
Note 11: IPM might make delayed response or no response for the input signal with off pulse width less than PWIN(off). Please refer below about delayed response.

### Delayed Response against Shorter Input Off Signal than PWIN(off) (P-side only)



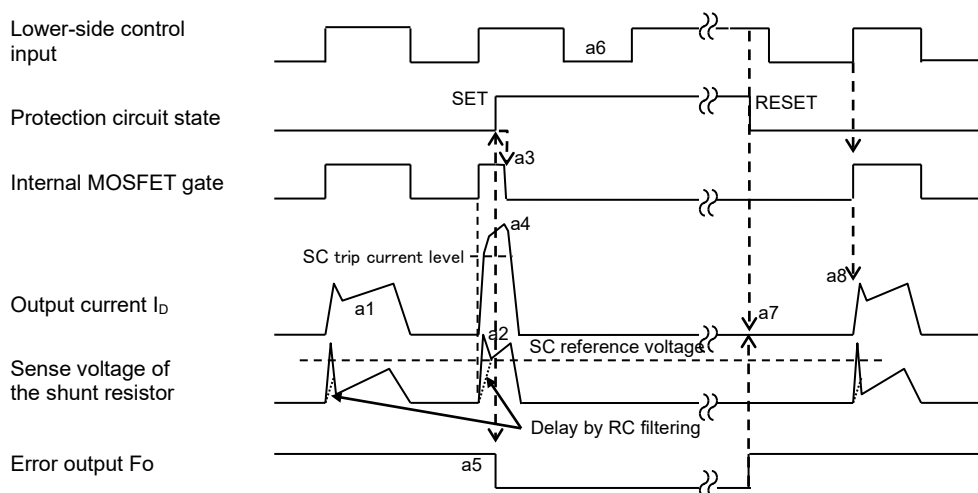
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Fig. 5 Timing Charts of The DIIPM Protective Functions

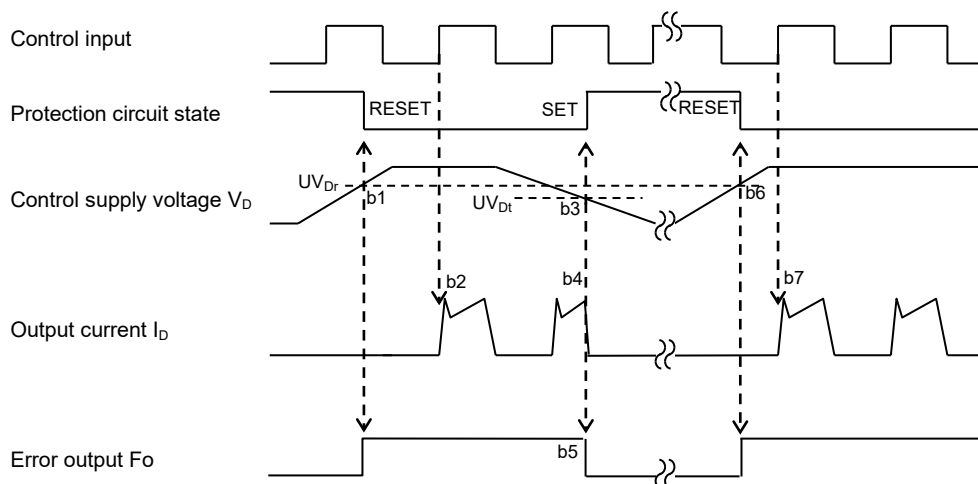
[A] Short-Circuit Protection (N-side only with the external shunt resistor and RC filter)

- a1. Normal operation: MOSFET 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 MOSFET shut down within 2.0 $\mu$ s when SC.)
- a3. All N-side MOSFET's gates are hard interrupted.
- a4. All N-side MOSFETs turn OFF.
- a5.  $F_o$  outputs for  $t_{Fo}$ =minimum 20 $\mu$ s.
- a6. Input = "L": MOSFET OFF
- a7.  $F_o$  finishes output, but MOSFETs don't turn on until inputting next ON signal (L $\rightarrow$ H).
- (MOSFET of each phase can return to normal state by inputting ON signal to each phase.)
- a8. Normal operation: MOSFET 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 MOSFET turns ON by next ON signal (L $\rightarrow$ H).  
(MOSFET of each phase can return to normal state by inputting ON signal to each phase.)
- b2. Normal operation: MOSFET ON and outputs current.
- b3.  $V_D$  level drops to under voltage trip level. ( $UV_{Dt}$ ).
- b4. All N-side MOSFETs turn OFF in spite of control input condition.
- b5.  $F_o$  outputs for  $t_{Fo}$ =minimum 20 $\mu$ s, but output is extended during  $V_D$  keeps below  $UV_{Dr}$ .
- b6.  $V_D$  level reaches  $UV_{Dr}$ .
- b7. Normal operation: MOSFET ON and outputs current.

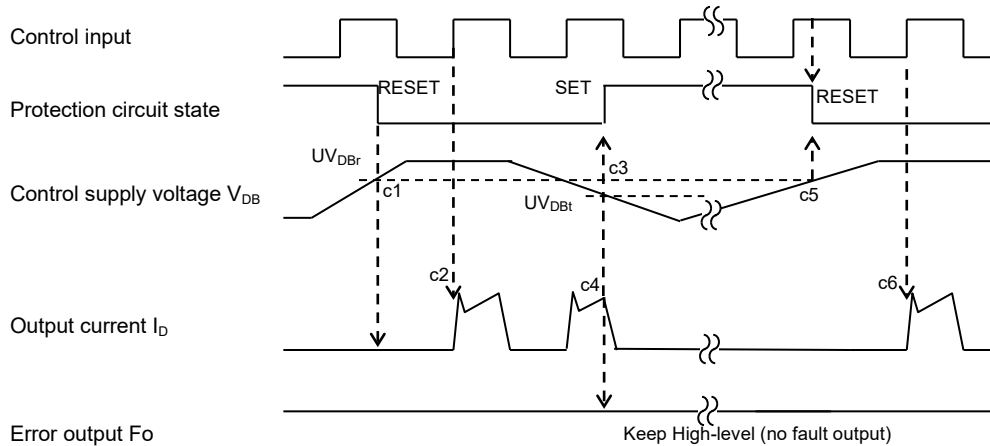


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## [C] Under-Voltage Protection (P-side, $UV_{DB}$ )

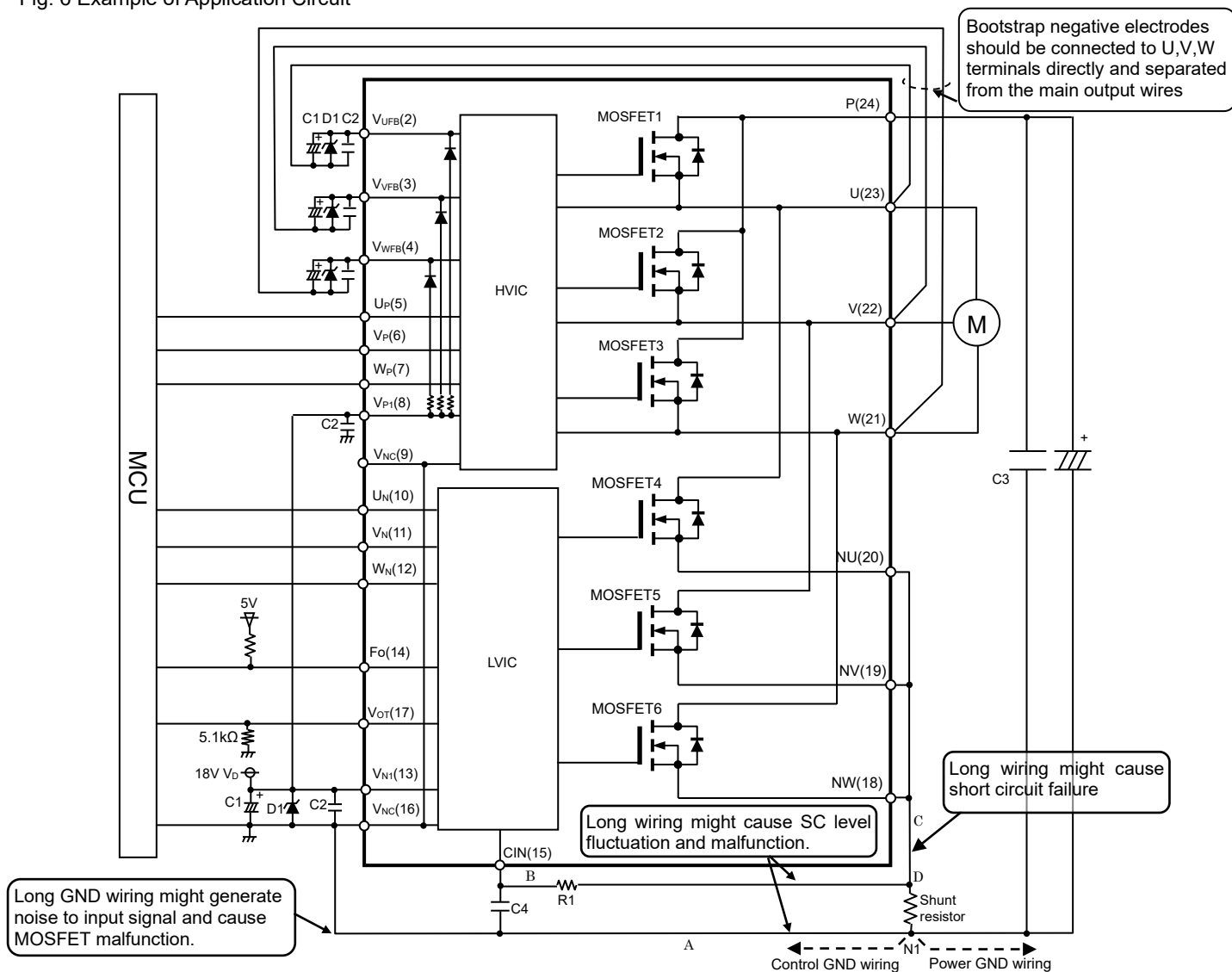
- c1. Control supply voltage  $V_{DB}$  rises. After the voltage reaches under voltage reset level  $UV_{DBr}$ , MOSFET turns on by next ON signal (L→H).
- c2. Normal operation: MOSFET ON and outputs current.
- c3.  $V_{DB}$  level drops to under voltage trip level ( $UV_{DBt}$ ).
- c4. MOSFET of the 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: MOSFET ON and outputs current.



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Fig. 6 Example of Application Circuit



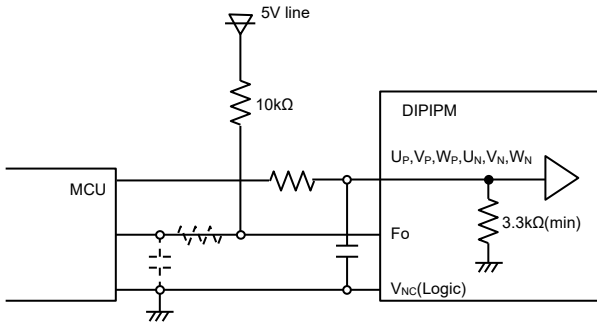
- (1) If control GND is connected with power GND by common broad pattern, it may cause malfunction by power GND fluctuation. It is recommended to connect control GND and power GND at only a point N1 (near the terminal of shunt resistor).
- (2) It is recommended to insert a Zener diode D1(24V/1W) between 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 0.1-0.22 $\mu$ 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 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 C2:0.22 $\mu$ -2 $\mu$ F, good temperature, frequency and DC bias characteristic ceramic type are recommended.)
- (8) Input drive is High-active type. There is a minimum 3.3k $\Omega$  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) Fo output is open drain type. It should be pulled up to MCU or control power supply (e.g. 5V,18V) by a resistor that makes I<sub>FO</sub> up to 1mA. (I<sub>FO</sub> 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 $\Omega$  (5.1k $\Omega$  or more) is recommended.)
- (10) Thanks to built-in HVIC, direct coupling to MCU without any opto-coupler or transformer isolation is possible.
- (11) Two V<sub>NC</sub> terminals (9 & 16 pin) are connected inside DIIPIM, please connect either one to the 18V 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 DIIPIM erroneous operation. To avoid such problem, line ripple voltage should meet dV/dt  $\leq$  +/-1V/ $\mu$ s, Vripples $\leq$ 2Vp-p.
- (13) For DIIPIM, it isn't recommended to drive same load by parallel connection with other phase MOSFET or other DIIPIM.



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Fig. 7 MCU I/O Interface Circuit

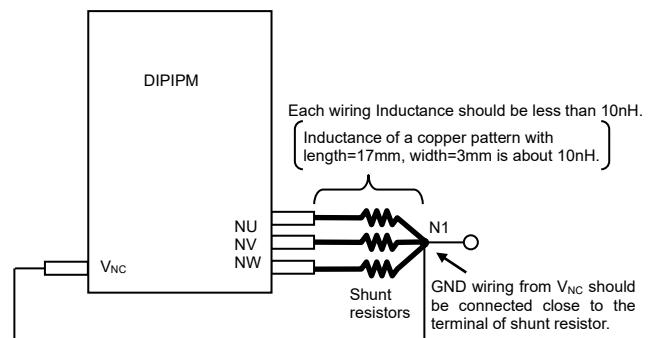
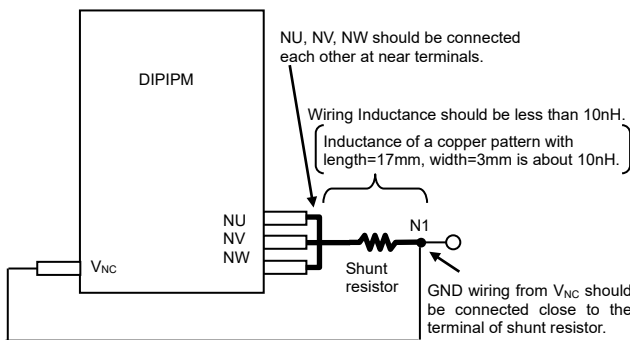


Note)

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

F<sub>o</sub> output is open drain type. It should be pulled up to the positive side of 5V or 18V power supply with the resistor that limits F<sub>o</sub> sink current I<sub>Fo</sub> under 1mA. In the case of pulling up to 5V supply, over 5.1kΩ is needed. (10kΩ is recommended.)

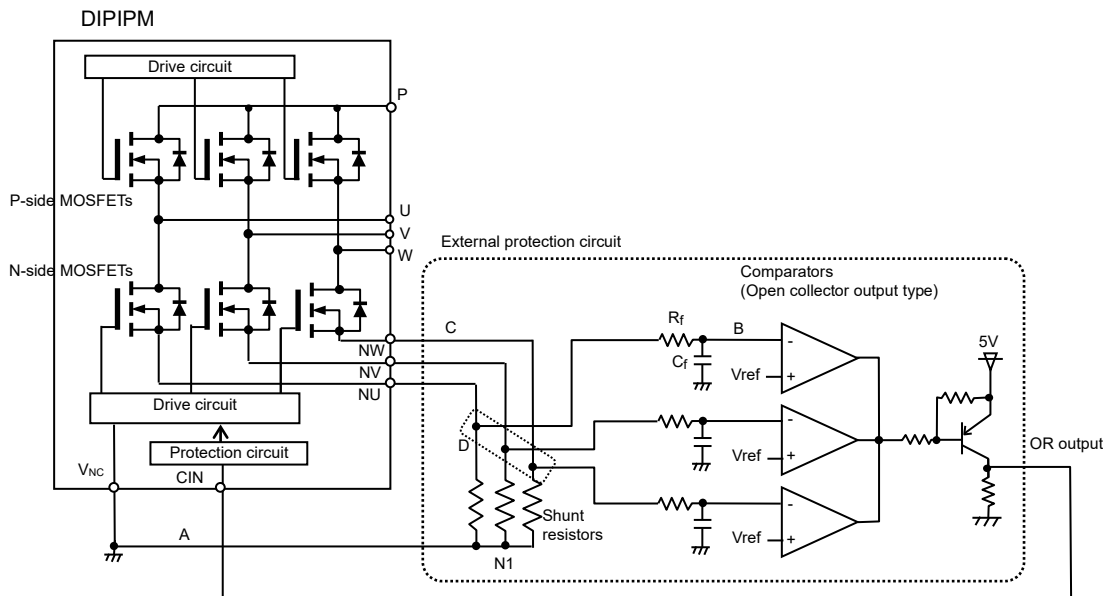
Fig. 8 Pattern Wiring Around the Shunt Resistor



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 DIIPM 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.



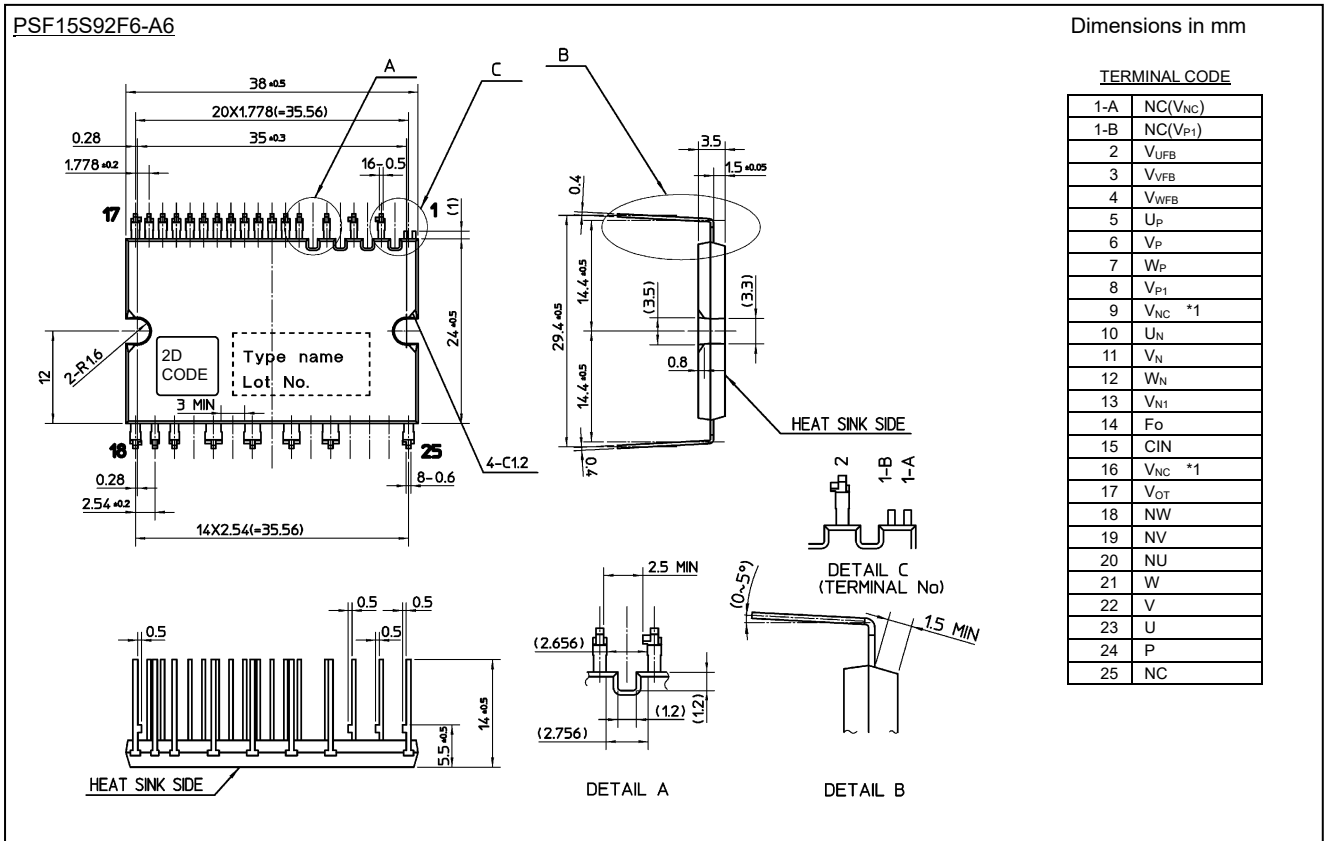
- (1) It is necessary to set the time constant  $R_f C_f$  of external comparator input so that MOSFET stops within 2μs when short circuit occurs. SC interrupting time might vary with the wiring pattern, comparator speed and so on.
- (2) It is recommended for the threshold voltage  $V_{ref}$  to set to 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 (=1.7 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 0.505V (=maximum  $V_{sc(ref)}$  rating).

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Fig. 10 Package Outlines



1) 9 & 16 pins (V<sub>NC</sub>) are connected inside DIIPM, please connect either one to the control power supply GND outside and leave another one open.

### Important Notice

The information contained in this datasheet shall in no event be regarded as a guarantee of conditions or characteristics. This product has to be used within its specified maximum ratings, and is subject to customer's compliance with any applicable legal requirement, norms and standards.

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