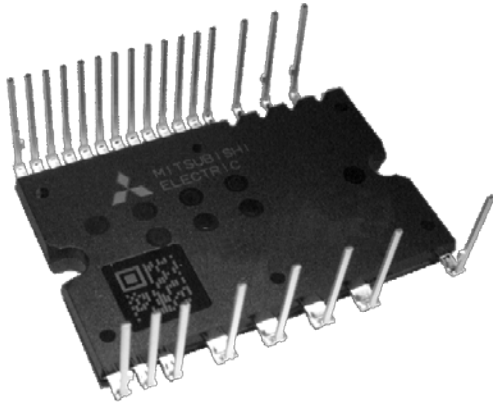


< Dual-In-Line Package Intelligent Power Module >

# PSM03S93E5-A

TRANSFER MOLDING TYPE  
INSULATED TYPE

## OUTLINE



## MAIN FUNCTION AND RATINGS

- 3 phase DC/AC inverter
- 500V / 3A (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

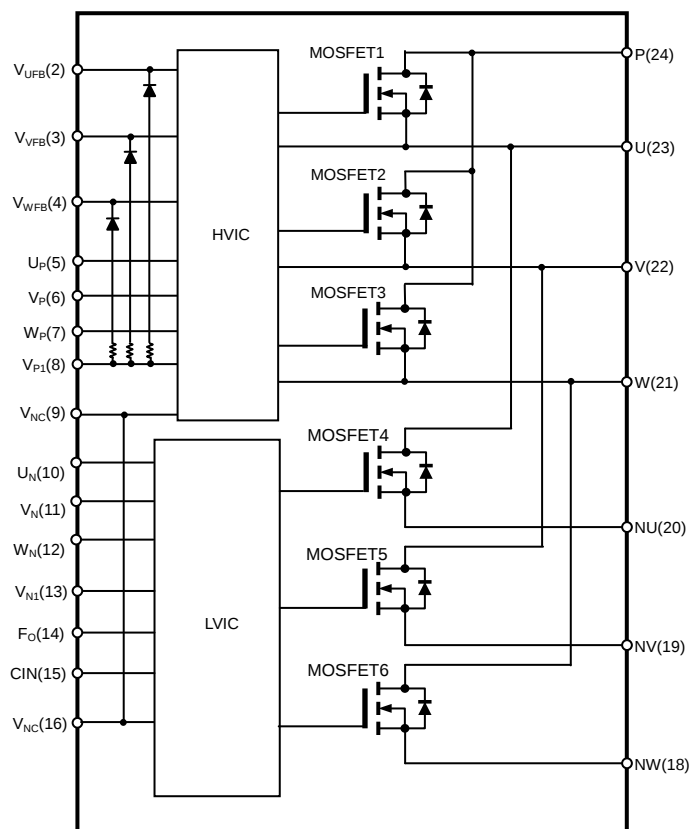
## TYPE NAME

|              |                                  |
|--------------|----------------------------------|
| PSM03S93E5-A | With over temperature protection |
|--------------|----------------------------------|

## 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), Over temperature protection (OT)
- Fault signaling : Corresponding to SC fault (N-side MOSFET), UV fault (N-side supply) and OT fault
- Input interface : 3, 5V line, Schmitt trigger receiver circuit (High Active)
- UL Recognized : UL1557 File E323585

## INTERNAL CIRCUIT



**PSM03S93E5-A**

TRANSFER MOLDING TYPE

INSULATED TYPE

**MAXIMUM RATINGS** ( $T_{ch} = 25^{\circ}\text{C}$ , unless otherwise noted)**INVERTER PART**

| Symbol          | Parameter                        | Condition                                  | Ratings  | Unit               |
|-----------------|----------------------------------|--------------------------------------------|----------|--------------------|
| $V_{DD}$        | Supply voltage                   | Applied between P-NU, NV, NW               | 400      | V                  |
| $V_{DD(surge)}$ | Supply voltage (surge)           | Applied between P-NU, NV, NW               | 450      | V                  |
| $V_{DSS}$       | Drain-source voltage             |                                            | 500      | V                  |
| $\pm I_D$       | Each MOSFET drain current        | $T_C = 25^{\circ}\text{C}$                 | 3        | A                  |
| $\pm I_{DP}$    | Each MOSFET drain current (peak) | $T_C = 25^{\circ}\text{C}$ , less than 1ms | 6        | A                  |
| $P_D$           | Drain dissipation                | $T_C = 25^{\circ}\text{C}$ , per 1 chip    | 29.4     | W                  |
| $T_{ch}$        | Channel temperature              | (Note 1)                                   | -20~+150 | $^{\circ}\text{C}$ |

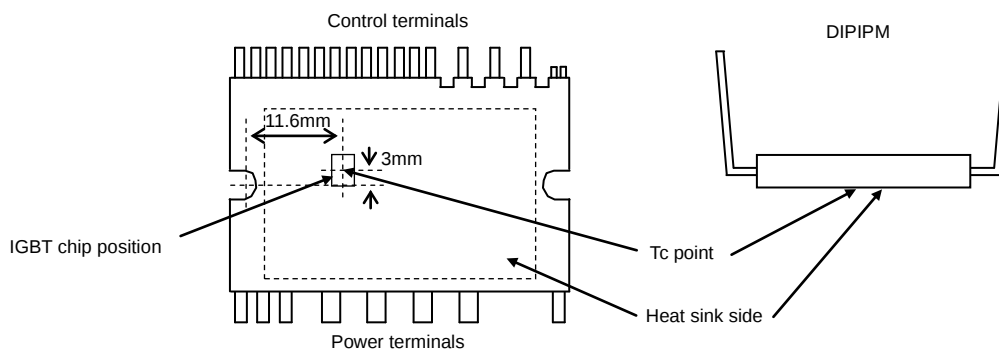
Note1: The maximum junction temperature rating of built-in power chips is  $150^{\circ}\text{C}$  ( $@T_C \leq 100^{\circ}\text{C}$ ). However, to ensure safe operation of DIPIPM, the average channel temperature should be limited to  $T_{ch(Ave)} \leq 125^{\circ}\text{C}$  ( $@T_C \leq 100^{\circ}\text{C}$ ).

**CONTROL (PROTECTION) PART**

| Symbol   | Parameter                     | Condition                                                                   | Ratings         | Unit |
|----------|-------------------------------|-----------------------------------------------------------------------------|-----------------|------|
| $V_D$    | Control supply voltage        | Applied between $V_{PI}-V_{NC}$ , $V_{NI}-V_{NC}$                           | 20              | V    |
| $V_{DB}$ | Control supply voltage        | Applied between $V_{UFB}-U$ , $V_{VFB}-V$ , $V_{WFB}-W$                     | 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 $F_O-V_{NC}$                                                | -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               |
|----------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|----------|--------------------|
| $V_{DD(prot)}$ | Self protection supply voltage limit (Short circuit protection capability) | $V_D = 13.5\sim 16.5\text{V}$ , Inverter Part<br>$T_{ch} = 125^{\circ}\text{C}$ , non-repetitive, less than $2\mu\text{s}$ | 400      | V                  |
| $T_C$          | Module case operation temperature                                          | Measurement point of $T_C$ is provided in Fig.1                                                                            | -20~+100 | $^{\circ}\text{C}$ |
| $T_{stg}$      | Storage temperature                                                        |                                                                                                                            | -40~+125 | $^{\circ}\text{C}$ |
| $V_{iso}$      | Isolation voltage                                                          | 60Hz, Sinusoidal, AC 1min, between connected all pins and heat sink plate                                                  | 1500     | $V_{rms}$          |

Fig. 1:  $T_C$  MEASUREMENT POINT**THERMAL RESISTANCE**

| Symbol          | Parameter                                   | Condition  | Limits |      |      | Unit |
|-----------------|---------------------------------------------|------------|--------|------|------|------|
|                 |                                             |            | Min.   | Typ. | Max. |      |
| $R_{th(ch-c)Q}$ | Junction to case thermal resistance (Note2) | 1/6 module | -      | -    | 3.4  | K/W  |

Note 2: Grease with good thermal conductivity and long-term endurance should be applied evenly with about  $+100\mu\text{m}\sim +200\mu\text{m}$  on the contacting surface of DIPIPM and heat sink. The contacting thermal resistance between DIPIPM 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  $0.3\text{K/W}$  (per 1/6 module, grease thickness:  $20\mu\text{m}$ , thermal conductivity:  $1.0\text{W/m}\cdot\text{k}$ ).

**ELECTRICAL CHARACTERISTICS** ( $T_{ch} = 25^{\circ}\text{C}$ , unless otherwise noted)**INVERTER PART**

| Symbol       | Parameter                        | Condition                                                                                                                                                                        | Limits                        |      |      | Unit          |
|--------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|------|------|---------------|
|              |                                  |                                                                                                                                                                                  | Min.                          | Typ. | Max. |               |
| $V_{DS(on)}$ | Drain-source on-state resistance | $V_D=V_{DB} = 15\text{V}$ , $V_{IN}= 5\text{V}$ , $I_D= 3\text{A}$                                                                                                               | $T_{ch}= 25^{\circ}\text{C}$  |      | 2.00 | $\Omega$      |
|              |                                  |                                                                                                                                                                                  | $T_{ch}= 125^{\circ}\text{C}$ |      | 4.50 |               |
| $V_{SD}$     | Source-drain voltage drop        | $V_{IN}= 0\text{V}$ , $-I_D= 3\text{A}$                                                                                                                                          | -                             | 0.90 | 1.30 | V             |
| $t_{on}$     | Switching times                  | $V_{DD}= 300\text{V}$ , $V_D= V_{DB}= 15\text{V}$<br>$I_D= 3\text{A}$ , $T_{ch}= 125^{\circ}\text{C}$ , $V_{IN}= 0\leftrightarrow 5\text{V}$<br>Inductive Load (upper-lower arm) | 0.65                          | 1.15 | 1.65 | $\mu\text{s}$ |
| $t_{C(on)}$  |                                  |                                                                                                                                                                                  | -                             | 0.35 | 0.55 | $\mu\text{s}$ |
| $t_{off}$    |                                  |                                                                                                                                                                                  | -                             | 1.00 | 1.50 | $\mu\text{s}$ |
| $t_{C(off)}$ |                                  |                                                                                                                                                                                  | -                             | 0.10 | 0.20 | $\mu\text{s}$ |
| $t_{rr}$     |                                  |                                                                                                                                                                                  | -                             | 0.25 | -    | $\mu\text{s}$ |
| $I_{DSS}$    | Drain-source cut-off current     | $V_{DS}=V_{DSS}$                                                                                                                                                                 | $T_{ch}= 25^{\circ}\text{C}$  |      | 1    | mA            |
|              |                                  |                                                                                                                                                                                  | $T_{ch}= 125^{\circ}\text{C}$ |      | 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> =15V, V <sub>IN</sub> =0V                  | -      | -    | 2.80 | mA   |
|                      |                                                    |                                                                                                                                      | V <sub>D</sub> =15V, V <sub>IN</sub> =5V                  | -      | -    | 2.80 |      |
| I <sub>DB</sub>      |                                                    | 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> =15V, V <sub>IN</sub> =0V | -      | -    | 0.10 |      |
|                      |                                                    |                                                                                                                                      | V <sub>D</sub> =V <sub>DB</sub> =15V, V <sub>IN</sub> =5V | -      | -    | 0.10 |      |
| V <sub>SC(ref)</sub> | Short circuit trip level                           | V <sub>D</sub> = 15V (Note 3)                                                                                                        |                                                           | 0.43   | 0.48 | 0.53 | V    |
| UV <sub>DBt</sub>    | P-side Control supply under-voltage protection(UV) | Tch ≤125°C                                                                                                                           | Trip level                                                | 7.0    | 10.0 | 12.0 | V    |
| UV <sub>DBr</sub>    |                                                    |                                                                                                                                      | Reset level                                               | 7.0    | 10.0 | 12.0 | V    |
| UV <sub>Dt</sub>     | N-side Control supply under-voltage protection(UV) |                                                                                                                                      | Trip level                                                | 10.3   | -    | 12.5 | V    |
| UV <sub>Dr</sub>     |                                                    |                                                                                                                                      | Reset level                                               | 10.8   | -    | 13.0 | V    |
| OT <sub>t</sub>      | Over temperature protection (OT)<br>(Note4)        | V <sub>D</sub> = 15V                                                                                                                 | Trip level                                                | 100    | 120  | 140  | °C   |
| OT <sub>rh</sub>     |                                                    | Detect LVIC temperature                                                                                                              | Hysteresis of trip-reset                                  | -      | 10   | -    | °C   |
| 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>FO</sub> = 1mA                                                                                          |                                                           | -      | -    | 0.95 | V    |
| t <sub>FO</sub>      | Fault output pulse width                           | (Note 5)                                                                                                                             |                                                           | 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   | 1.30 | -    |      |
| 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 6)                                                            |                                                           | 1.1    | 1.7  | 2.3  | V    |
| R                    | Built-in limiting resistance                       | Included in bootstrap Di                                                                                                             |                                                           | 80     | 100  | 120  | Ω    |

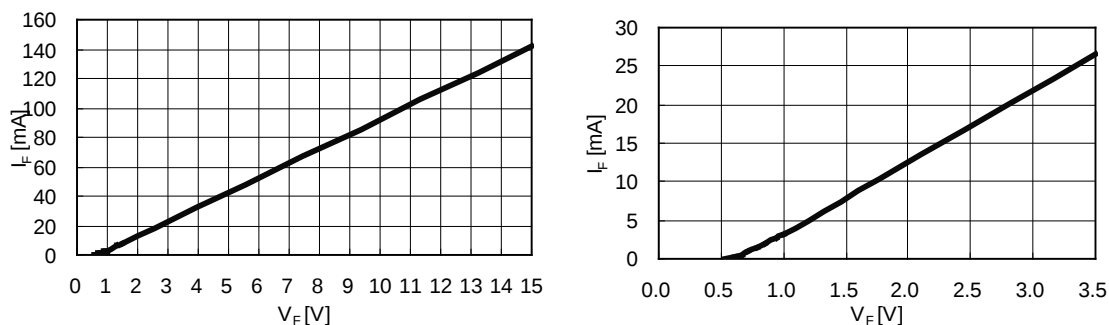
Note 3 : SC protection works for N-side only. Please select the external shunt resistance such that the SC trip-level is less than 1.7 times of the current rating.

4 : When the LVIC temperature exceeds OT trip temperature level( $OT_t$ ), OT protection works and  $F_O$  outputs. In that case if the heat sink dropped off or fixed loosely, don't reuse that DIPIPM. (There is a possibility that channel temperature of power chips exceeded maximum  $T_{ch}(150^{\circ}\text{C})$ ).

5 : Fault signal  $F_O$  outputs when SC, UV or OT protection works.  $F_O$  pulse width is different for each protection modes. At SC failure,  $F_O$  pulse width is a fixed width (=minimum 20 $\mu\text{s}$ ), but at UV or OT failure,  $F_O$  outputs continuously until recovering from UV or OT state. (But minimum  $F_O$  pulse width is 20 $\mu\text{s}$ .)

6 : 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.)



**PSM03S93E5-A**

TRANSFER MOLDING TYPE

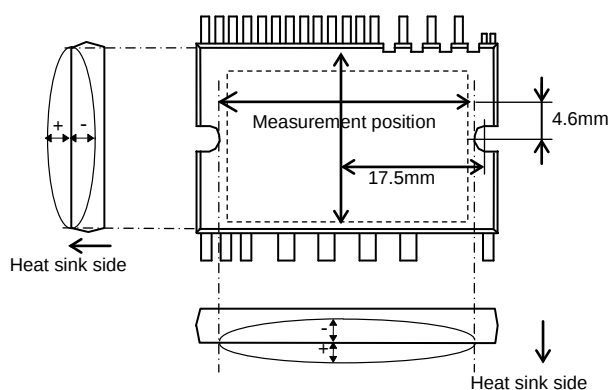
INSULATED TYPE

**MECHANICAL CHARACTERISTICS AND RATINGS**

| Parameter                 | Condition                                                                |                     | Limits |      |      | Unit  |
|---------------------------|--------------------------------------------------------------------------|---------------------|--------|------|------|-------|
|                           |                                                                          |                     | Min.   | Typ. | Max. |       |
| Mounting torque           | Mounting screw : M3 (Note 8)                                             | Recommended 0.69N·m | 0.59   | 0.69 | 0.78 | N·m   |
| Terminal pulling strength | Control terminal: Load 4.9N<br>Power terminal: Load 9.8N                 | EIAJ-ED-4701        | 10     | -    | -    | s     |
| Terminal bending strength | Control terminal: Load 2.45N<br>Power terminal: Load 4.9N<br>90deg. bend | EIAJ-ED-4701        | 2      | -    | -    | times |
| Weight                    |                                                                          |                     | -      | 8.5  | -    | 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 $V_{UFB}$ -U, $V_{VFB}$ -V, $V_{WFB}$ -W                                                                                              | 13.0                     | 15.0 | 18.5 | 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                                                                                                                                 | 1.0                      | -    | -    | μs   |
| $f_{PWM}$                   | PWM input frequency             | $T_C \leq 100^\circ\text{C}$ , $T_{ch} \leq 125^\circ\text{C}$                                                                                        | -                        | -    | 20   | kHz  |
| $I_o$                       | Allowable r.m.s. current        | $V_{DD} = 300\text{V}$ , $V_D = 15\text{V}$ , P.F = 0.8,<br>Sinusoidal PWM<br>$T_C \leq 100^\circ\text{C}$ , $T_{ch} \leq 125^\circ\text{C}$ (Note10) | $f_{PWM} = 5\text{kHz}$  | -    | -    | 1.5  |
|                             |                                 |                                                                                                                                                       | $f_{PWM} = 15\text{kHz}$ | -    | -    | 1.2  |
| PWIN(on)                    | Minimum input pulse width       | (Note 11)                                                                                                                                             | 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    |
| $T_{ch}$                    | Channel temperature             |                                                                                                                                                       | -20                      | -    | +125 | °C   |

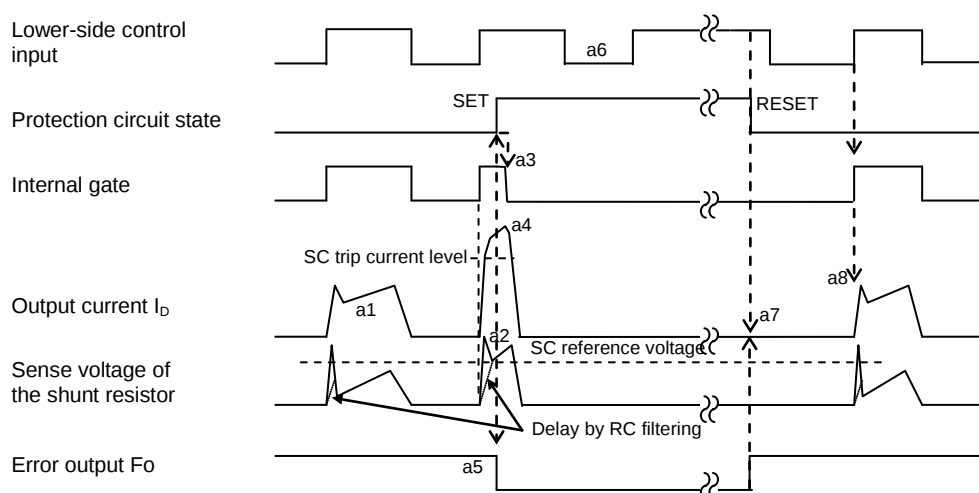
Note 10: Allowable r.m.s. current depends on the actual application conditions.

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

Fig. 3 Timing Charts of The DIPIPM Protective Functions

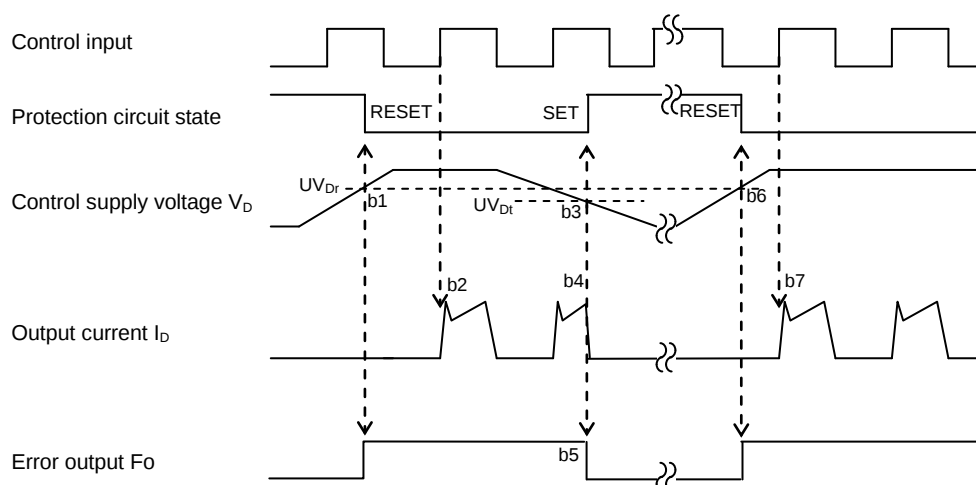
[A] Short-Circuit Protection (N-side only with the external shunt resistor and RC filter)

- a1. Normal operation: 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,  $UV_D$ )

- 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.



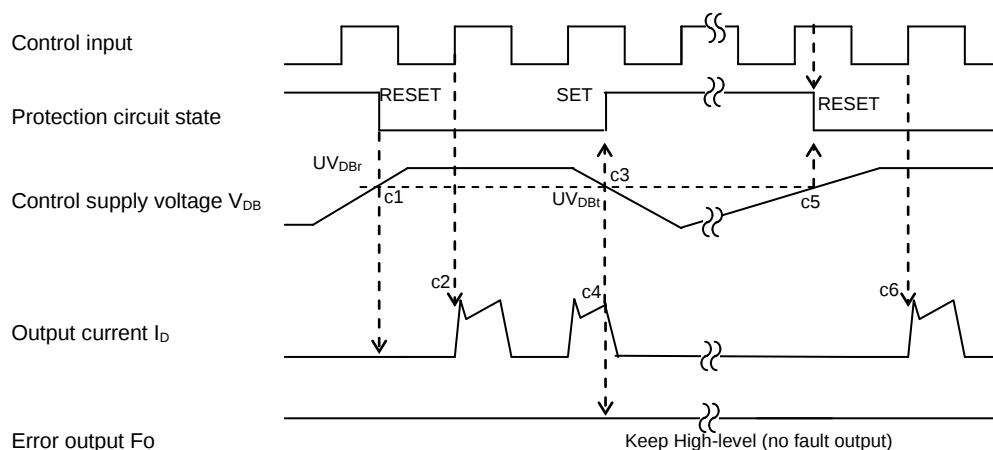
# PSM03S93E5-A

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  $UV_{DBr}$ , 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 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: MOSFET ON and outputs current.



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

- d1. Normal operation: MOSFET ON and outputs current.
- d2. LVIC temperature exceeds over temperature trip level ( $OT_t$ ).
- d3. All N-side MOSFETs turn OFF in spite of control input condition.
- d4.  $F_o$  outputs for  $t_{Fo}$ =minimum 20 $\mu$ s, but output is extended during LVIC temperature keeps over  $OT_t$ .
- d5. LVIC temperature drops to over temperature reset level.
- d6. Normal operation: MOSFET turns on by next ON signal (L→H).

(MOSFET of each phase can return to normal state by inputting ON signal to each phase.)

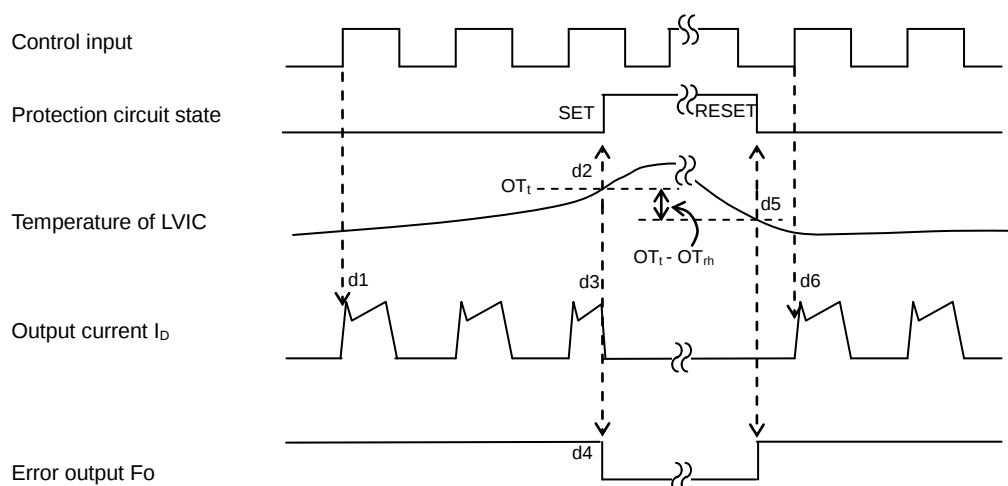
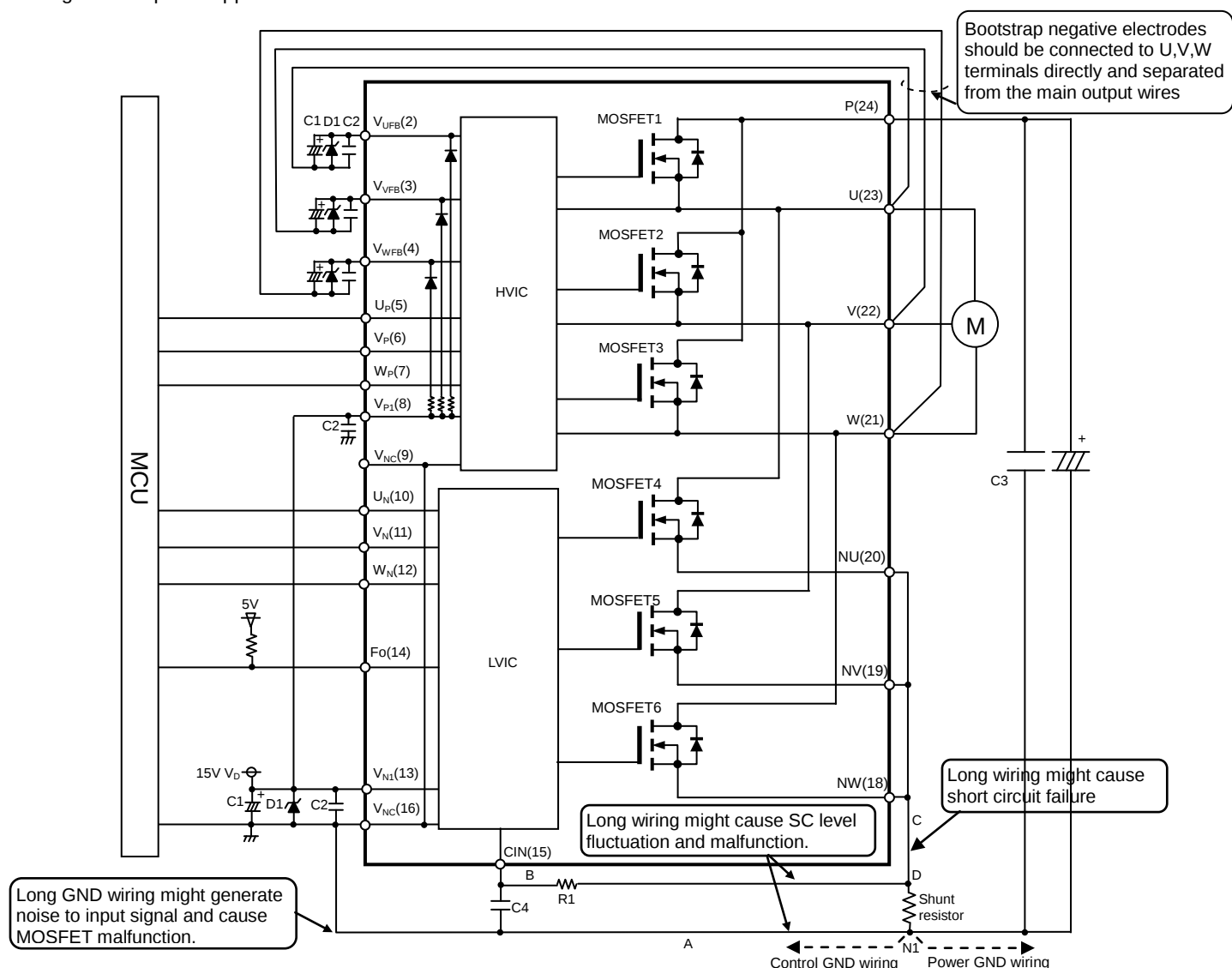
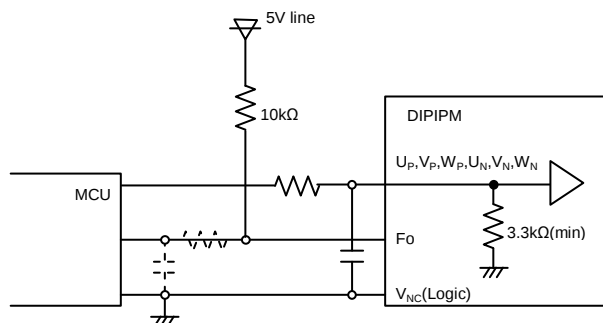


Fig. 4 Example of Application Circuit



- (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,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, 10k $\Omega$  (5k $\Omega$  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  $V_{NC}$  terminals (9 & 16 pin) are connected inside DIPIM, 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 DIPIM erroneous operation. To avoid such problem, line ripple voltage should meet  $dV/dt \leq \pm 1V/\mu s$ ,  $V_{ripple} \leq 2Vp-p$ .
- (13) For DIPIM, it isn't recommended to drive same load by parallel connection with other phase MOSFET or other DIPIM.

Fig. 5 MCU I/O Interface Circuit

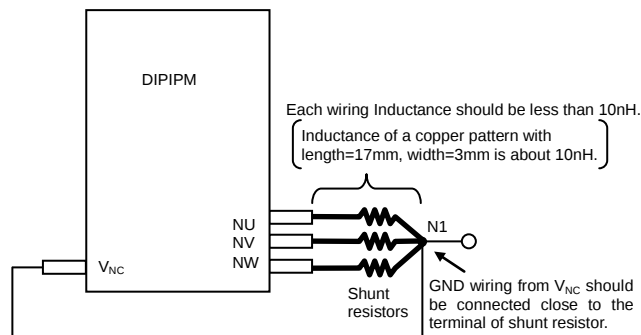
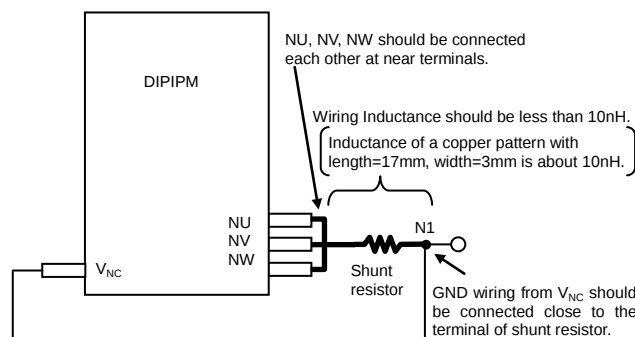


Note)

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  $I_{F0}$  1mA or less. In the case of pulled up to 5V supply, 10kΩ (5kΩ or more) is recommended.

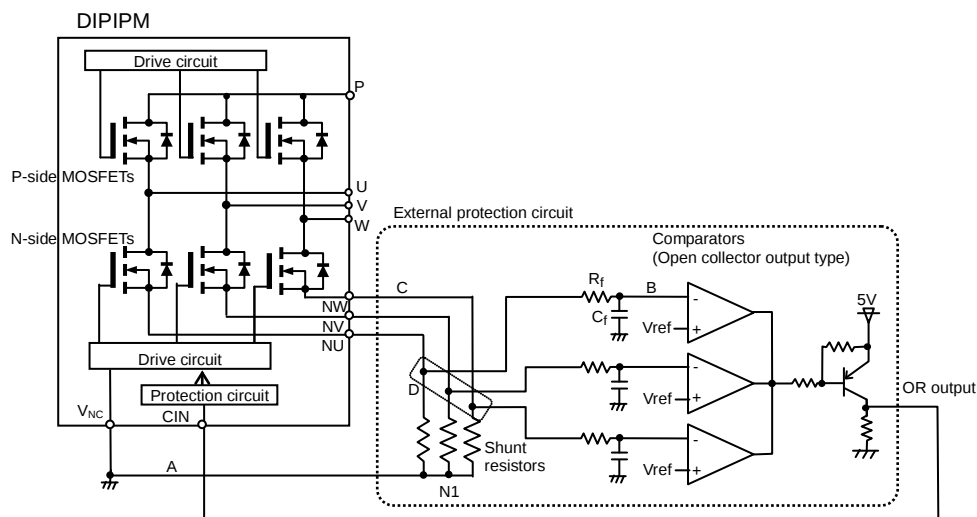
Fig. 6 Pattern Wiring Around the Shunt Resistor



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

Fig. 7 Pattern Wiring Around the Shunt Resistor (for the case of open source)

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.



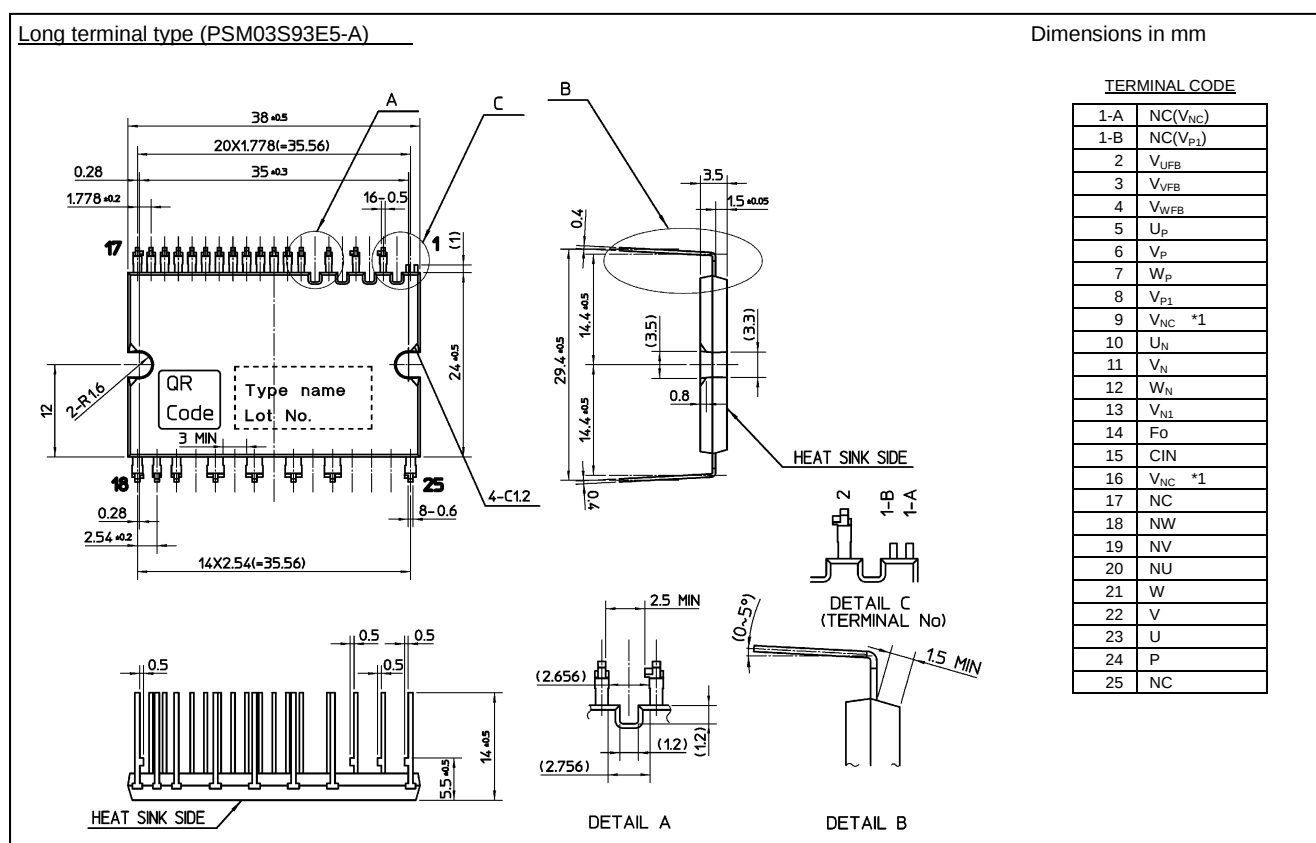
- (1) It is necessary to set the time constant  $R_f C_f$  of external comparator input so that MOSFET stops within 2μs when short circuit occurs. SC interrupting time might vary with the wiring pattern, comparator speed and so on.
- (2) It is recommended for the threshold voltage  $V_{ref}$  to set 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 ( $\approx 1.7$  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 0.53V ( $\approx$  maximum  $V_{sc(ref)}$  rating).

# PSM03S93E5-A

TRANSFER MOLDING TYPE

INSULATED TYPE

Fig. 8 Package Outlines



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

QR Code is registered trademark of DENSO WAVE INCORPORATED in JAPAN and other countries.

< Dual-In-Line Package Intelligent Power Module >

## PSM03S93E5-A

TRANSFER MOLDING TYPE

INSULATED TYPE

---

### Revision Record

| Rev. | Date       | Page | Revised contents |
|------|------------|------|------------------|
| 1    | 10/15/2013 | -    | New              |

### **Keep safety first in your circuit designs!**

Mitsubishi Electric Corporation puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage. Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of non-flammable material or (iii) prevention against any malfunction or mishap.

### **Notes regarding these materials**

- These materials are intended as a reference to assist our customers in the selection of the Mitsubishi semiconductor product best suited to the customer's application; they do not convey any license under any intellectual property rights, or any other rights, belonging to Mitsubishi Electric Corporation or a third party.
- Mitsubishi Electric Corporation assumes no responsibility for any damage, or infringement of any third-party's rights, originating in the use of any product data, diagrams, charts, programs, algorithms, or circuit application examples contained in these materials.
- All information contained in these materials, including product data, diagrams, charts, programs and algorithms represents information on products at the time of publication of these materials, and are subject to change by Mitsubishi Electric Corporation without notice due to product improvements or other reasons. It is therefore recommended that customers contact Mitsubishi Electric Corporation or an authorized Mitsubishi Semiconductor product distributor for the latest product information before purchasing a product listed herein.

The information described here may contain technical inaccuracies or typographical errors. Mitsubishi Electric Corporation assumes no responsibility for any damage, liability, or other loss rising from these inaccuracies or errors.

Please also pay attention to information published by Mitsubishi Electric Corporation by various means, including the Mitsubishi Semiconductor home page (<http://www.MitsubishiElectric.com/>).

- When using any or all of the information contained in these materials, including product data, diagrams, charts, programs, and algorithms, please be sure to evaluate all information as a total system before making a final decision on the applicability of the information and products. Mitsubishi Electric Corporation assumes no responsibility for any damage, liability or other loss resulting from the information contained herein.
- Mitsubishi Electric Corporation semiconductors are not designed or manufactured for use in a device or system that is used under circumstances in which human life is potentially at stake. Please contact Mitsubishi Electric Corporation or an authorized Mitsubishi Semiconductor product distributor when considering the use of a product contained herein for any specific purposes, such as apparatus or systems for transportation, vehicular, medical, aerospace, nuclear, or undersea repeater use.
- The prior written approval of Mitsubishi Electric Corporation is necessary to reprint or reproduce in whole or in part these materials.
- If these products or technologies are subject to the Japanese export control restrictions, they must be exported under a license from the Japanese government and cannot be imported into a country other than the approved destination.  
Any diversion or re-export contrary to the export control laws and regulations of Japan and/or the country of destination is prohibited.
- Please contact Mitsubishi Electric Corporation or an authorized Mitsubishi Semiconductor product distributor for further details on these materials or the products contained therein.