# SPE20S60N-D

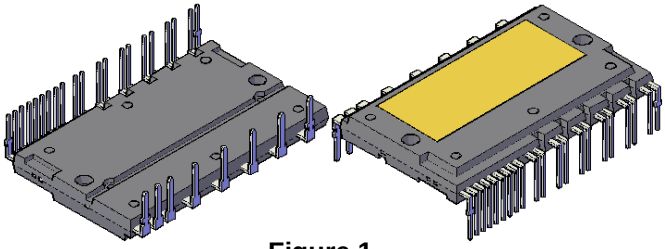


Figure 1

**INTEGRATED POWER FUNCTIONS**

600V/20A low-loss 6th generation IGBT inverter bridge for three phase DC-to-AC power conversion.

Open emitter type.

**INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS**

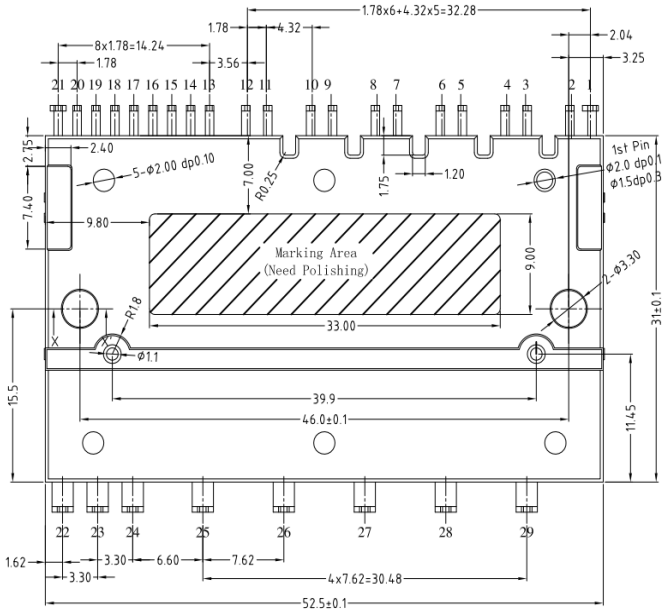
- For upper-leg IGBTS : Advanced input filter, Shoot through prevention, Drive circuit, High voltage high-speed level shifting, Control supply under-voltage (UV) protection, Short circuit protection (SC), Integrate bootstrap diodes.
- For lower-leg IGBTS : Advanced input filter, Shoot through prevention, Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC).
- Fault signaling : Corresponding to an SC fault, a UV fault (Lower-side supply).
- Input interface: 3V, 5V line(High Active).
- Analog temperature output.

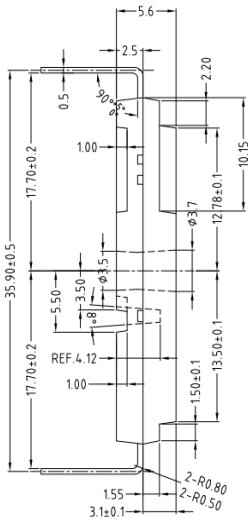
## APPLICATION

AC100V~220V inverter drive for small power motor control, such as: Refrigerators、 Inverter air-conditioner、Small Servo Motors Small Motor Control etc.

## Detailed Package Outline Drawings:

Dimensions in mm

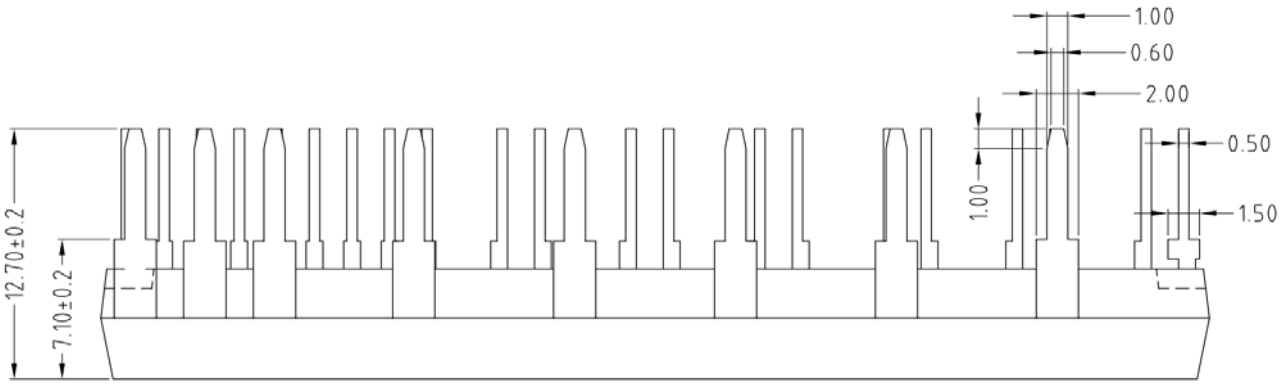


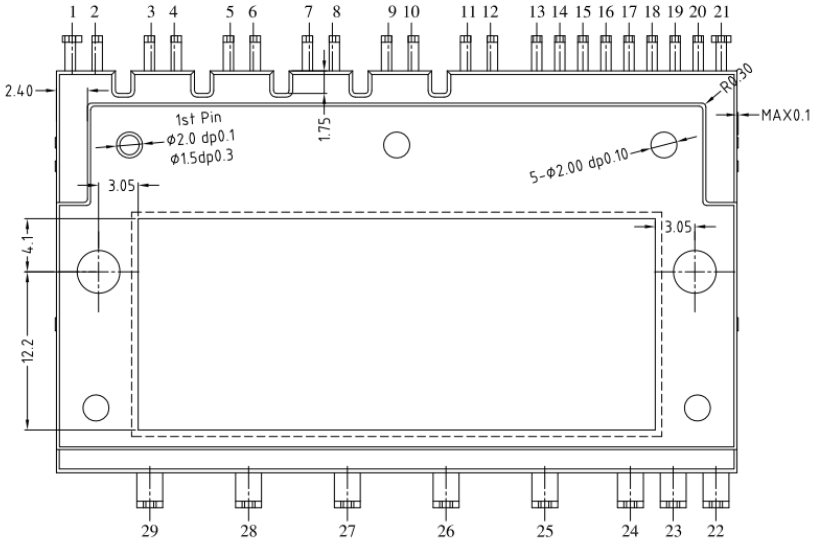



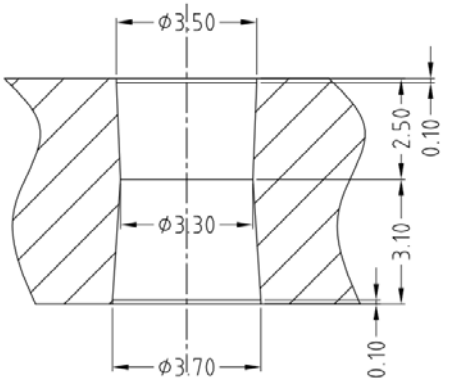

| | |
|---|---|
| 1 VUFS | 15VN |
| 2 VUFB | 16 WN |
| 3 VP1 | 17 FO |
| 4UP | 18 NC |
| 5 VVFS | 19CIN |
| 6VVFB | 20 VNC |
| 7 VP1 | 21 VN1 |
| 8 VP | 22 NW |
| 9 VWFS | 23 NV |
| 10 VWFB | 24 NU |
| 11 VP1 | 25 W |
| 12 WP | 26 V |
| 13 VNO | 27 U |
| 14 UN | 28 P |
| | 29 NC |

## Detailed Package Outline Drawings:

Dimensions in mm



## Pin Configuration

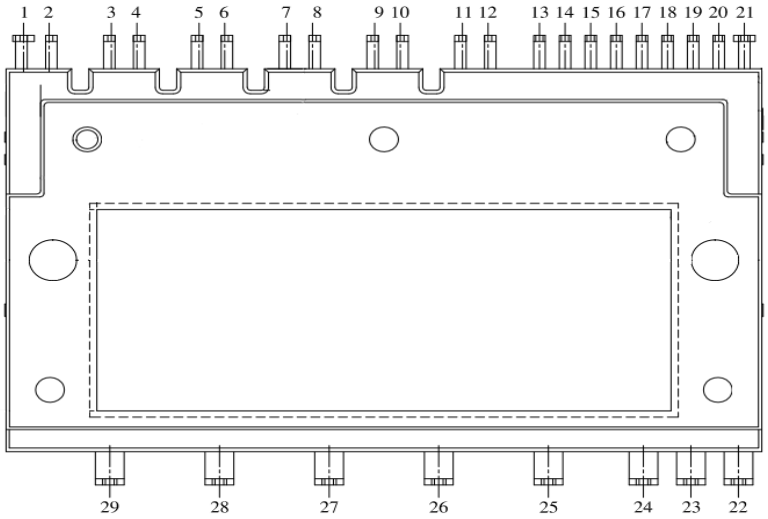



**Figure 2 .Pin Configuration**

## Pin Descriptions

| Pin number | Pin name | Pin Description |
|---|---|---|
| 1 | VUFS | U-phase high side floating IC supply offset voltage |
| 2 | VUFB | U-phase high side floating IC supply voltage |
| 3 | VP1 | IC supply voltage |
| 4 | UP | U-phase high side gate driver input |
| 5 | VVFS | V-phase high side floating IC supply offset voltage |
| 6 | VVFB | V-phase high side floating IC supply voltage |
| 7 | VP1 | IC supply voltage |
| 8 | VP | V-phase high side gate driver input |
| 9 | VWFS | W-phase high side floating IC supply offset voltage |
| 10 | VWFB | W-phase high side floating IC supply voltage |
| 11 | VP1 | IC supply voltage |
| 12 | WP | W-phase high side gate driver input |
| 13 | VNO | Supply Ground |
| 14 | UN | U-phase low side gate driver input |
| 15 | VN | V-phase low side gate driver input |
| 16 | WN | W-phase low side gate driver input |
| 17 | FO | Fault output |
| 18 | NC | No connection |
| 19 | CIN | Analog input for over current shutdown |
| 20 | VNC | Common Supply Ground |
| 21 | VN1 | IC supply voltage |
| 22 | NW | Negative DC-Link input for W-phase |
| 23 | NV | Negative DC-Link input for V-phase |
| 24 | NU | Negative DC-Link input for U-phase |
| 25 | W | Motor W-phase output |
| 26 | V | Motor V-phase output |
| 27 | U | Motor U-phase output |
| 28 | P | Positive bus input voltage |

| | | |
|---|---|---|
| 29 | NC | No connection |

## Internal Function Block Diagram

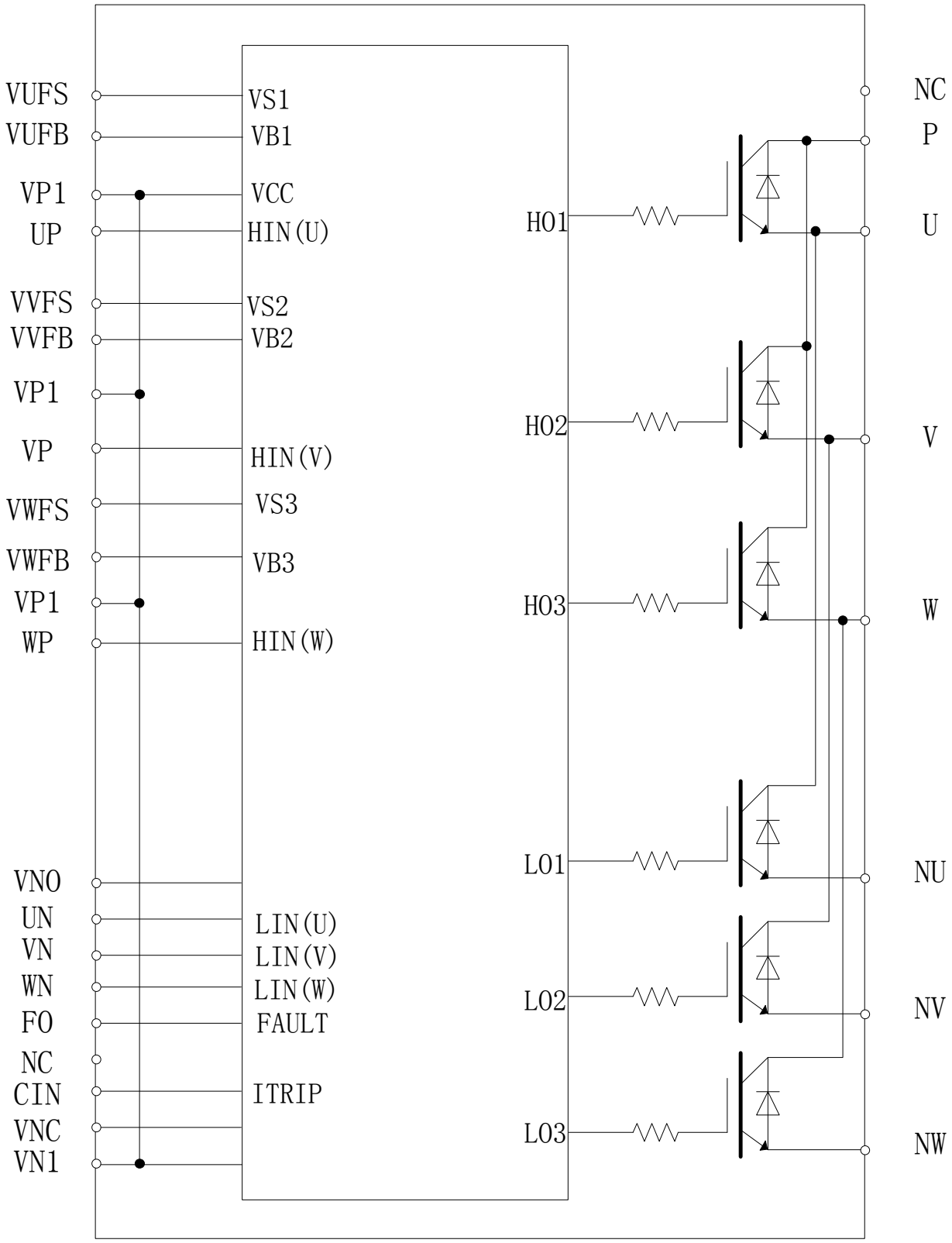



**Figure 3 . Function Block Diagram**

## Absolute Maximum Ratings (Tj= 25°C, Unless Otherwise Specified)

### Inverter Part

| Symbol | Parameter | Conditions | 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 |
| ± $I_C$ | Each IGBT Collector Current | $T_C$ = 25°C | 20 | A |
| ± $I_{CP}$ | Each IGBT Collector Current (Peak) | $T_C$ = 25°C, Less than 1ms | 40 | A |
| $P_C$ | Collector Dissipation | $T_C$ = 25°C Per One Chip | 78 | W |
| $T_j$ | Operating Junction Temperature | (Note 1) | -40 ~ +150 | °C |

**Note:**

1. The maximum junction temperature rating of the power chips integrated within the IPM is 175°C(@Tc ≤ 100°C). However, to insure safe operation of the IPM, the junction temperature should be limited to $T_j$(av) ≤ 150°C (@Tc ≤ 100°C).

### Control Part

| Symbol | Parameter | Conditions | Ratings | Unit |
|---|---|---|---|---|
| $V_{DB}$ | High side floating supply voltage | (Applied between VUFB-UUFS, VVFB-VVFS, VWFB-WWFS) | 17.5 | V |
| $V_D$ | Low side supply voltage | Applied between VP1-VNC, VN1-VNC | 17.5 | V |
| $V_{IN}$ | Input Signal Voltage | Applied between UP, VP, WP, UN ,VN ,WN - $V_{NC}$ | -1~10 | V |
| $V_{FO}$ | Fault Output Supply Voltage | Applied between FO-VNC | -0.3~VD+0.3 | V |
| $I_{FO}$ | Fault Output Current | Sink Current at $F_O$ Pin | 1.5 | mA |
| $V_{SC}$ | Current Sensing Input Voltage | Applied between CIN - $V_{NC}$ | -1~ 10 | V |

### Total System

| Symbol | Parameter | Conditions | Ratings | Unit |
|---|---|---|---|---|
| $V_{CC(PROT)}$ | Self Protection Supply Voltage Limit(Short Circuit Protection Capability) | $V_D$ = $V_{DB}$ = 13.5 ~ 16.5V<br>$T_j$= 150°C, Non-repetitive, less than 2us | 400 | V |
| $T_C$ | Module Case Operation Temperature | -20℃≤$T_j$ ≤150°C, | -20 ~ +100 | °C |
| $T_{STG}$ | Storage Temperature | | -40 ~ +150 | °C |
| $V_{ISO}$ | Isolation Voltage | 60Hz, Sinusoidal, AC 1 minute, between Pins and heat-sink plate | 2500 | $V_{rms}$ |

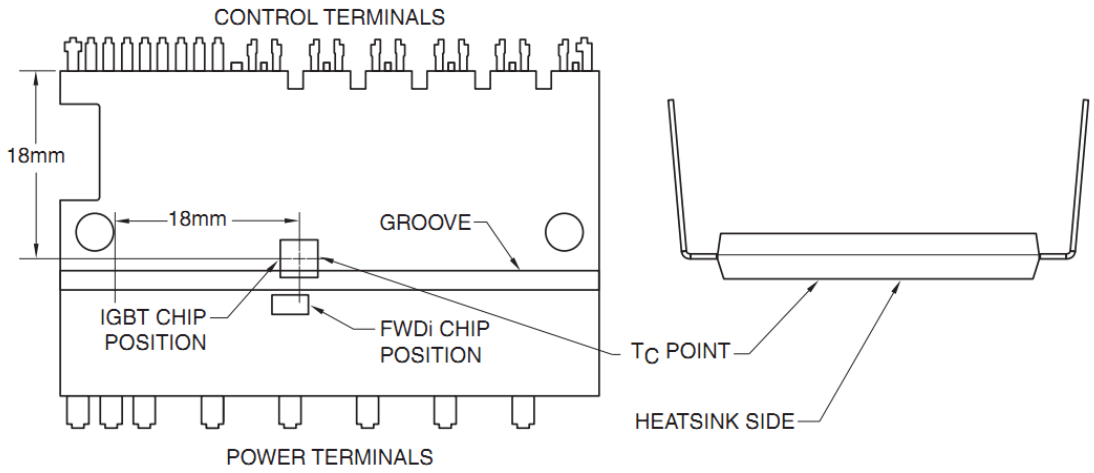



**Figure 4. Tc measurement point**

## Thermal Resistance

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $R_{th(j-c)Q}$ | Junction to Case Thermal Resistance | Inverter IGBT part (per 1/6 module) | - | - | 1.6 | °C/W |
| $R_{th(j-c)F}$ | | Inverter FWD part (per 1/6 module) | - | - | 2.8 | °C/W |

## Electrical Characteristics ($T_j$ = 25°C, Unless Otherwise Specified)

### Inverter Part

| Symbol | Parameter | Conditions | 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 | - | 1.65 | - | V |
| | | $V_D$ = $V_{DB}$ = 15V, $V_{IN}$ = 5V, $I_C$ =20A, $T_j$= 125°C | - | 2.05 | - | V |
| $V_F$ | FWD Forward Voltage | $V_{IN}$ = 0V， $I_C$ =-20A, $T_j$ = 25°C | | 1.5 | - | V |
| | | $V_{IN}$ = 0V， $I_C$ =-20A, $T_j$ = 125°C | - | 1.4 | - | V |
| $t_{ON}$ | Switching Times | $V_{PN}$ = 300V, $V_D$ = $V_{DB}$ = 15V, $I_C$ = 20A, $V_{IN}$ = 0V –5V, Inductive Load | | 0.78 | - | μs |
| $t_{C(ON)}$ | | | - | 0.3 | - | μs |
| $t_{OFF}$ | | | - | 0.8 | - | μs |
| $t_{C(OFF)}$ | | | - | 0.08 | | μs |
| $t_{rr}$ | | | - | 0.2 | - | μs |
| $I_{CES}$ | Collector-Emitter Leakage Current | $V_{CE}$= $V_{CES}$ $T_j$= 25°C | - | - | 75 | μA |
| | | $V_{CE}$= $V_{CES}$ $T_j$= 125°C | - | - | 1 | mA |

**Note:**

2. $t_{ON}$ and $t_{OFF}$ include the propagation delay time of the internal drive IC. $t_{C(ON)}$ and $t_{C(OFF)}$ are the switching time of IGBT itself under the given gate driving condition internally. For the detailed information, please see Figure 5.

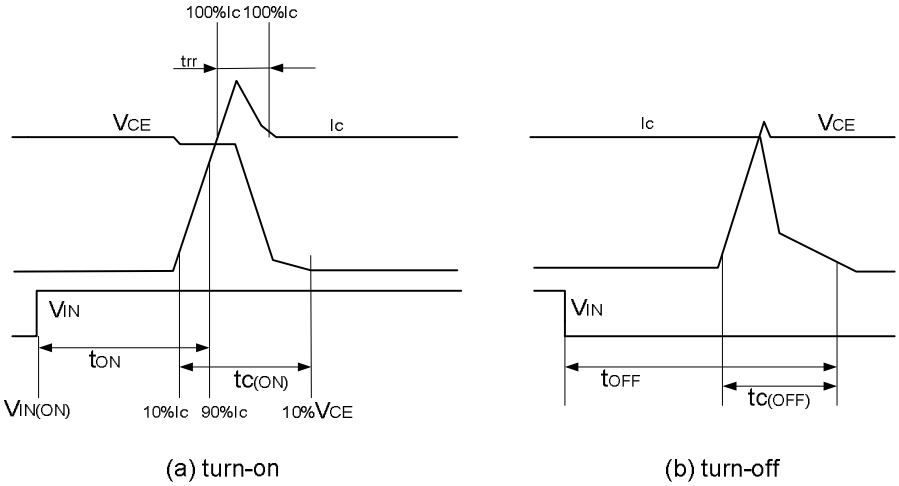



**Figure 5 . Switching Time Definition**

## Electrical Characteristics ($T_j$= 25°C, Unless Otherwise Specified)

### Control Part

| Symbol | Parameter | Condition | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|
| $I_D$ | Quiescent $V_D$ Supply Current | $V_D$ = 15V<br>$V_{IN}$ = 5V | VP1,VN1-VNC | - | 0.52 | 1 | mA |
| $I_{DB}$ | Quiescent $V_{DB}$ Supply Current | $V_{DB}$ = 15V<br>$V_{IN}$ = 5V | VUFB - U, VVFB - V, VWFB - W | - | 0.36 | 0.55 | μA |
| $V_{FOH}$ | Fault Output Voltage | $V_{sc}$ = 0V, $F_O$ Terminal pull up to 5V by 10kohm | | 4.9 | - | - | V |
| $V_{FOL}$ | | $V_{sc}$ =1V, $I_{FO}$=1.0mA | | - | - | 1.05 | V |
| $V_{sc,TH+}$ | Short circuit positive going threshold | $V_D$ = 15V (Note 3) | | 0.37 | 0.46 | 0.55 | V |
| $V_{sc,TH-}$ | Short circuit negative going threshold | VD= 15V | | - | 0.4 | - | V |
| $UV_{Dt}$ | Control supply under-voltage protection | Trip Level | | 9.5 | 10.4 | 11.0 | V |
| $UV_{Dr}$ | | Reset Level | | 11 | 12.1 | 12.8 | |
| $UV_{DBt}$ | | Trip Level | | 9.5 | 10.4 | 11.0 | |
| $UV_{DBr}$ | | Reset Level | | 11 | 12.1 | 12.8 | |
| $R_{on,FLT}$ | FLT low on resistance | I=1.5mA | | | 50 | 90 | ohm |
| $t_{FO}$ | Fault-out Pulse Width | CFO = 22nF | | 20 | - | - | μs |
| $t_{FIL,IN}$ | Input filter time (U/V/WP, U/V/WN, CIN) | VIN = 0 V & 5 V | | 140 | 290 | - | ns |
| $t_{BL}$ | CIN blanking time | VIN = 0 V or 5 V,VCIN = 5 V | | - | 400 | - | ns |
| $V_{IN(ON)}$ | ON Threshold Voltage | Applied between $U_P,V_P,W_P,U_N,V_N,W_N$- VNC | | 1.7 | 2.1 | 2.4 | V |
| $V_{IN(OFF)}$ | OFF Threshold Voltage | | | 0.7 | 0.85 | 1.1 | |
| BSD Forward voltage | $V_F$ | IF=10mA including voltage | | - | 1.0 | 1.3 | V |
| BSD current limiting resistor | R | | | 22 | 36 | 50 | ohm |

**Note:** 3. Short-circuit current protection is functioning at both low-side and high side.

## Recommended Operating Conditions

| Symbol | Parameter | Conditions | Values | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| $V_{CC}$ | Supply Voltage | Applied between P - NU, NV, NW | - | 300 | 400 | V |
| $V_D$ | Control Supply Voltage | Applied between VP1,VN1 - VNC | 13.5 | 15 | 16.5 | V |
| $V_{DB}$ | High-side Bias Voltage | Applied between VUFB-VUFS,VVFB-VVFS, VWFB-VWFS | 13 | 15 | 18.5 | V |
| $t_{dead}$ | Blanking Time for Preventing Arm-short | For Each Input Signal | 1.5 | - | - | us |
| $f_{PWM}$ | PWM Input Signal | -20°C≤Tc ≤+100°C, -20°C≤ Tj≤+150°C | - | - | 20 | kHz |
| $P_{WIN(ON)}$ | Minimum Input Pulse Width | | 1 | - | - | us |
| $P_{WIN(OFF)}$ | | | 1 | - | - | us |
| Tj | Junction temperature | | -20 | - | 125 | ° C |

## Internal NTC - Thermistor Characteristics

| symbol | parameter | conditions | Values | | | unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| $R_{NTC}$ | Resistance of Thermistor | $T_{NTC}$ = 25°C see Figure 15. | 98 | 100 | 102 | Kohm |
| | | $T_{NTC}$ = 125°C | 3.43 | 3.58 | 3.75 | Kohm |
| Temperature Range | | | -40 | - | +125 | °C |

## Mechanical Characteristics and Ratings

| Parameter | Conditions | Limits | | | Unit |
|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | |
| Mounting Torque | Mounting Screw: - M3 | - | 0.69 | - | N•m |
| Device Flatness | see Figure 6. | 0 | - | +120 | um |
| Weight | | - | 7 | - | g |

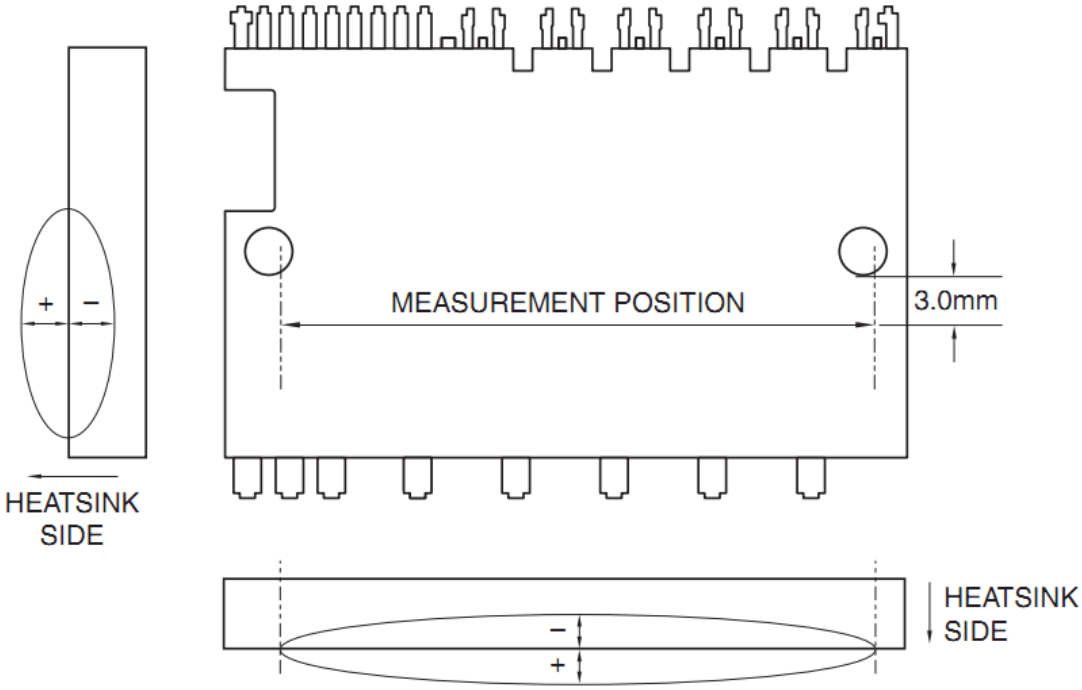



**Figure 6. Flatness Measurement Position**

## Advanced input filter

The advanced input filter allows an improvement in the input/output pulse symmetry of HVIC inside the module and helps to reject noise spikes and short pulses. The advantage of the new filter is shown in Figures 7 and 8.

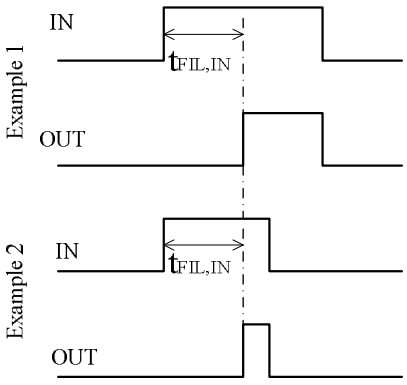



**Figure 7. Typical input filter**

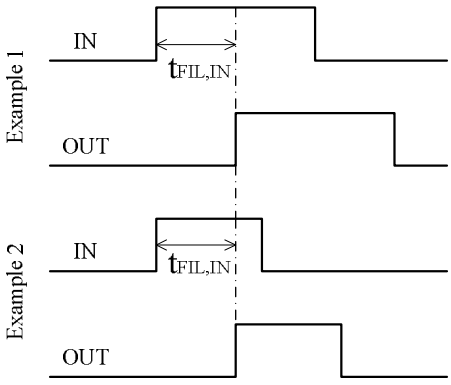
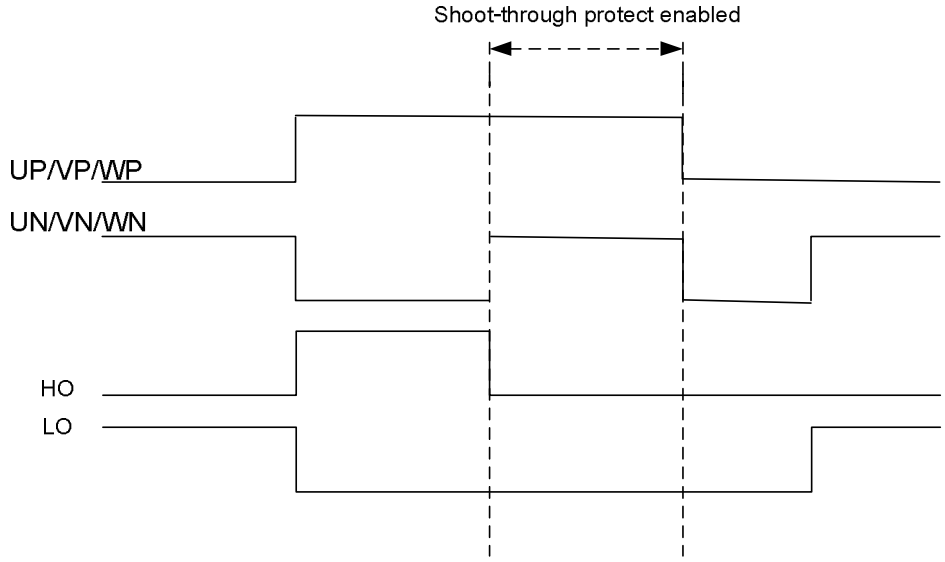



**Figure 8. Advanced input filter**

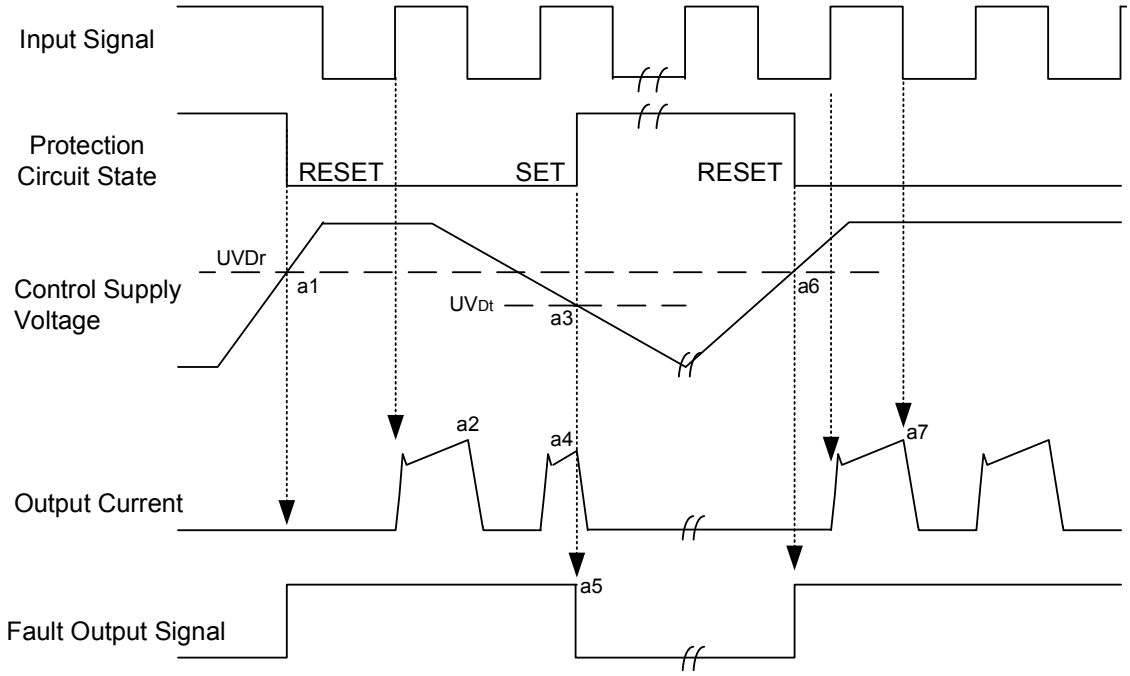
## Time Charts of Protective Function




**Note:**

5. The signal HO and LO are gate output of the internal HVIC.

**Figure 9 . Shoot-through（cross-conduction）protection**




a1 : Control supply voltage rises: After the voltage rises $UV_{Dr}$, the circuits start to operate when next input is applied.

a2 : Normal operation: IGBT ON and carrying current.

a3 : Under voltage detection ($UV_{Dt}$).

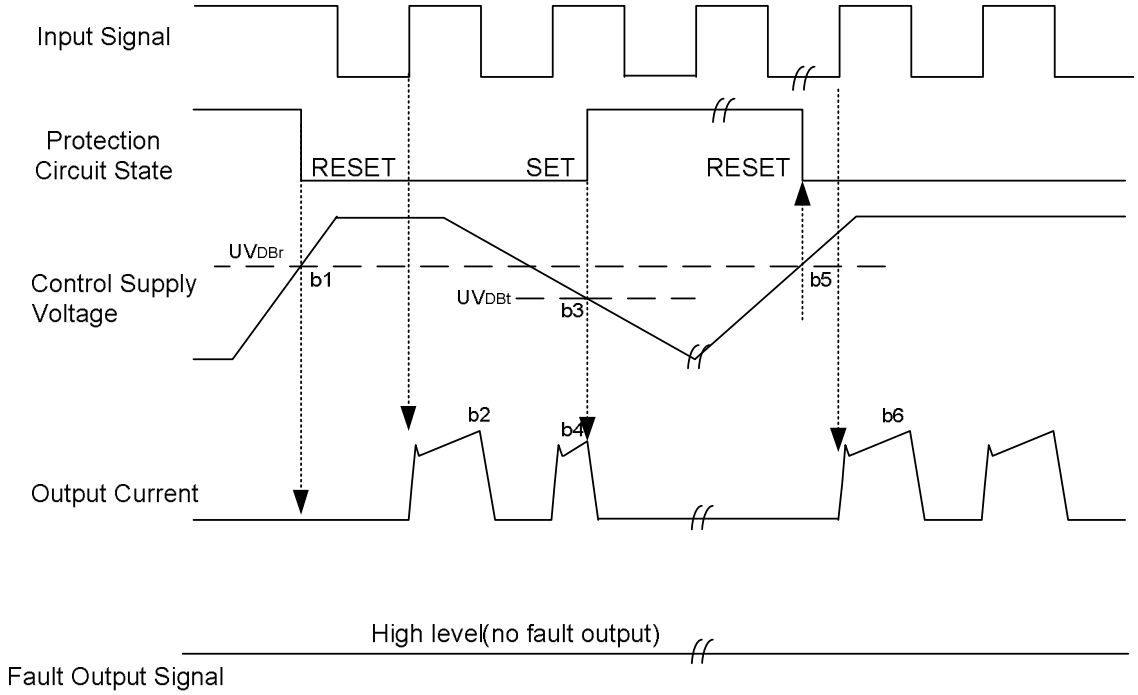
a4 : IGBT OFF in spite of control input condition.

a5 : Fault output operation starts.

a6 : Under voltage reset ($UV_{Dr}$).

a7 : Normal operation: IGBT ON and carrying current.

**Figure 10. Under-Voltage Protection (Low-side Operation)**




b1 : Control supply voltage rises: After the voltage reaches $UV_{DBr}$, the circuits start to operate when next input is applied.

b2 : Normal operation: IGBT ON and carrying current.

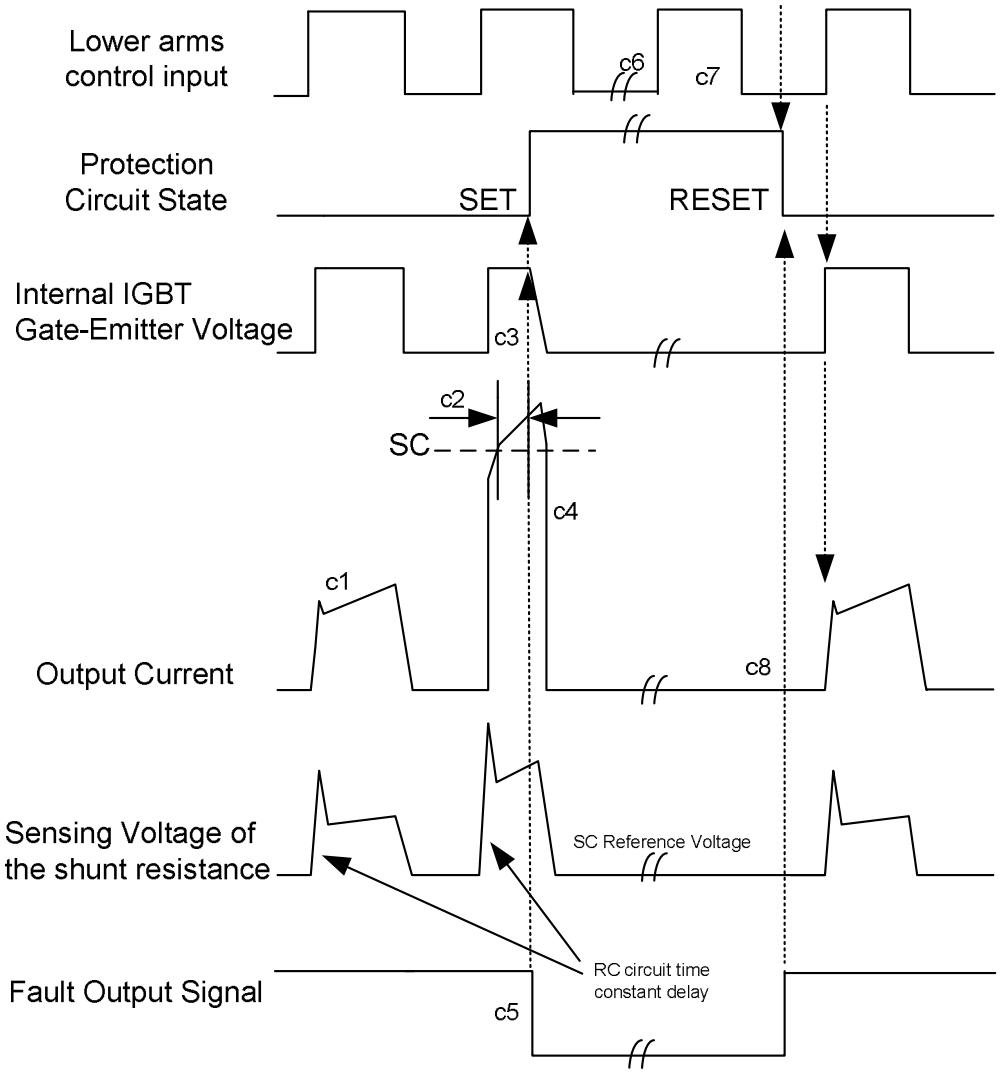
b3 : Under voltage detection ($UV_{DBt}$).

b4 : IGBT OFF in spite of control input condition, but there is no fault output signal.

b5 : Under voltage reset ($UV_{DBr}$).

b6 : Normal operation: IGBT ON and carrying current.

**Figure 11. Under-Voltage Protection (High-side Operation only)**




(with the external shunt resistance connection)

c1 : Normal operation: IGBT ON and carrying current.

c2 : Short circuit current detection (CIN trigger).

c3 : Hard IGBT gate interrupt.

c4 : IGBT turns OFF.

c5 : Fault output timer operation starts: The pulse width of the fault output signal is set by the internal capacitor.

c6 : Input “L” : IGBT OFF state.

c7 : Input “H”: IGBT ON state, but during the active period of fault output the IGBT doesn’t turn ON.

c8 : IGBT OFF state

**Figure 12. Short-Circuit Current Protection (Low-side And High-side Operation)**

## Input/Output Interface Circuit

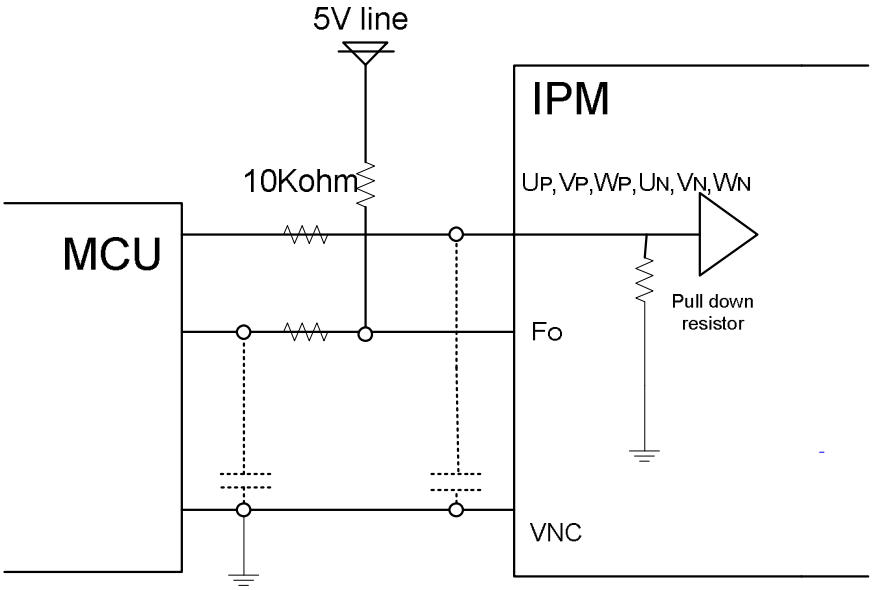



**Figure 13. Recommended CPU I/O Interface Circuit**

**Note:**

6. RC coupling at each input (parts shown dotted) might change depending on the PWM control scheme used in the application and the wiring impedance of the application's printed circuit board.
7. The logic input is compatible with standard CMOS or LSTTL outputs

## Wiring Around The Shunt Resistor

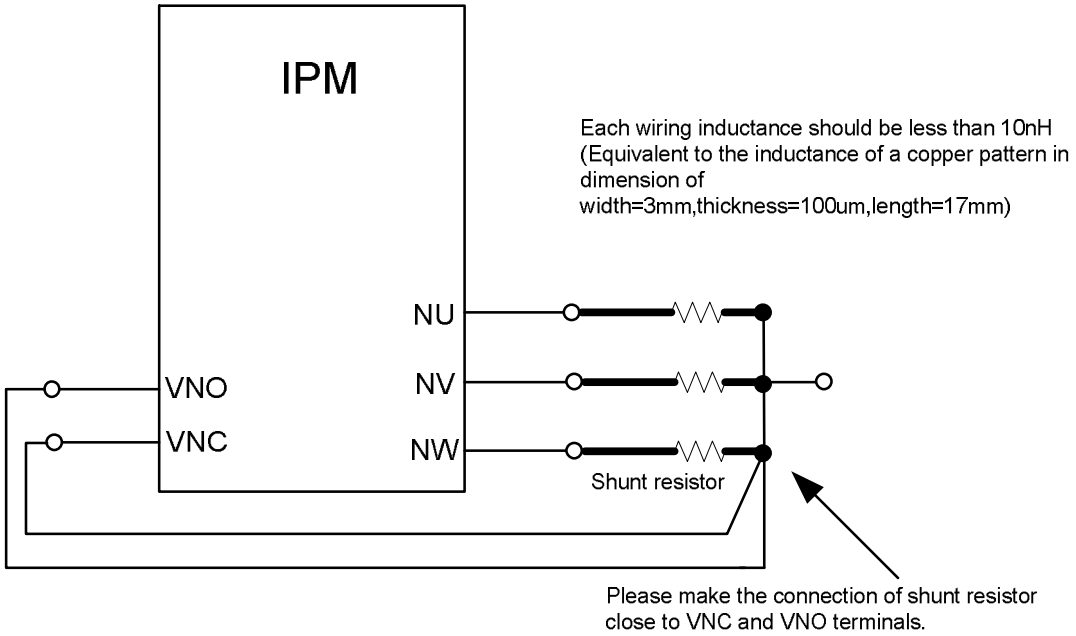
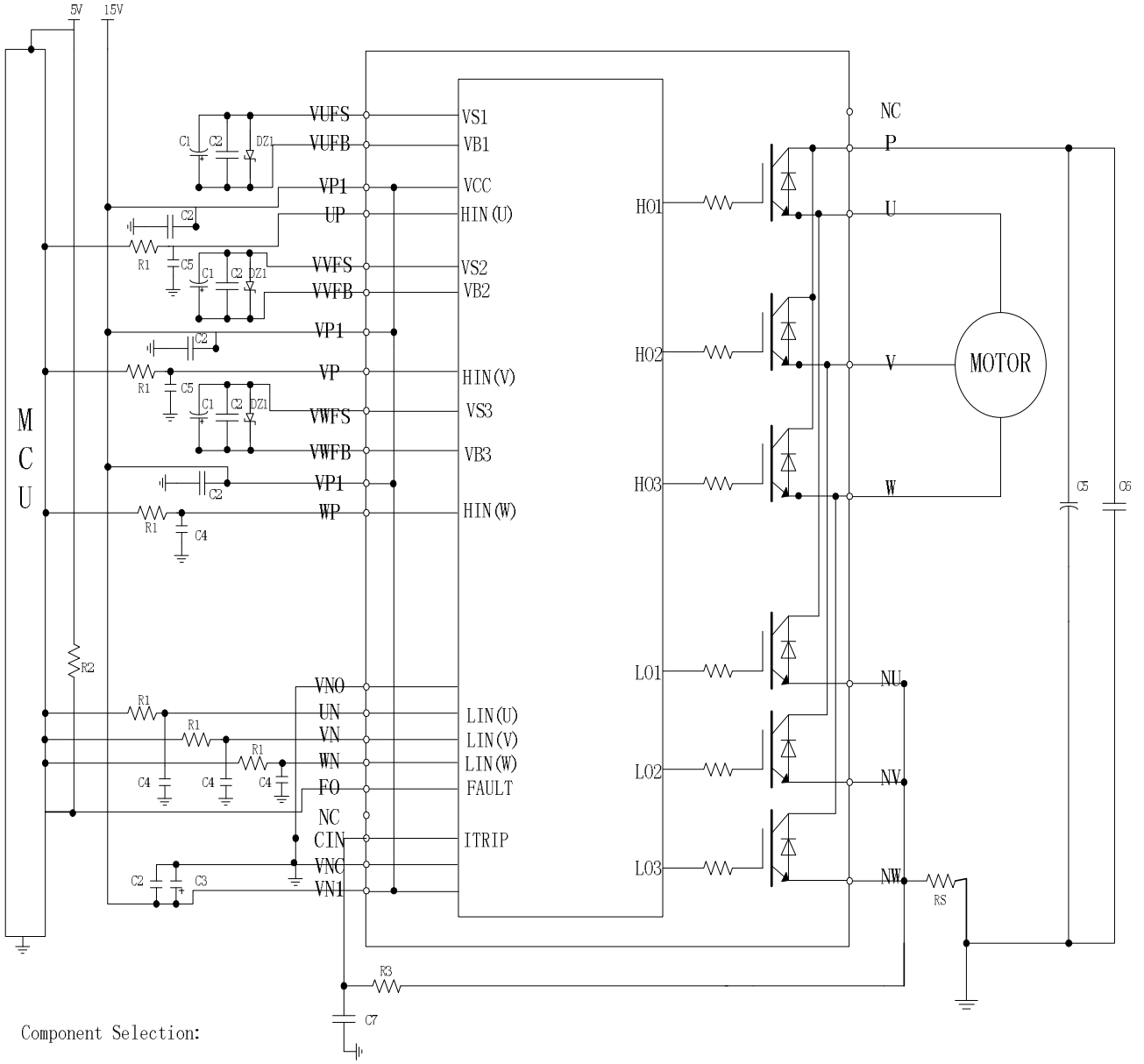



**Figure 14. Recommended Wiring Around The Shunt Resistor**




Component Selection:

| Dsgn. | Typ. Value | Description |
|---|---|---|
| DZ1 | 18V, 0.5W | Control and boot strap supply over voltage suppression |
| C1 | 10-47uF, 50V | Boot strap supply reservoir - Electrolytic, long life, low Impedance, 105° C (Note 5) |
| C2 | 0.1-1.0uF, 50V | Local decoupling/High frequency noise filters - Multilayer ceramic (Note 5) |
| C3 | 100-470uF, 50V | Control power supply filter - Electrolytic, long life, low Impedance, 105° C (Note 5) |
| C4 | 100-1000pF, 50V | Optional Input signal noise filter - Multilayer ceramic (Note 1) |
| C5 | 200-2000uF, | 450V Main DC bus filter capacitor - Electrolytic, long life, high ripple current, 105° C |
| C6 | 0.1-0.22uF, | 450V Surge voltage suppression capacitor - Polyester/Polypropylene film (Note 8) |
| R1 | 100-1000ohm | Optional control input noise filter (Note 1, Note 2) |
| R2 | 10k ohm | Fault output signal pull-up resistor (Note 3) |
| RS | >9 mohm | Current sensing resistor - Non-inductive, temperature stable, tight tolerance (Note 9) |
| R3, C7 | 1k, 1000pF | RC filtering for current sense |

**Figure 15. Typical Application Circuit**

**Note:**

1) Input drive is active-high type. There is a 2.5k7(min.) pull-down resistor integrated in the IC input circuit. 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 meets the turn-on and turn-off threshold voltage. See application notes for details.
2) Internal HVIC provides high voltage level shifting allowing direct connection of all six driving signals to the controller.
3) FO output is an open collector type. Pull up resistor (R3) should be adjusted to current sink capability of the controller.
4) To prevent input signal oscillations, minimize wire length to controller (~2cm). Additional RC filtering (C5 etc.) may be required. If filtering is added be careful to maintain proper dead time and voltage levels. See application notes for details.
5) All capacitors should be mounted as close to the terminals as possible. (C1: good temperature, frequency characteristic electrolytic type, and C2, C3: good temperature, frequency and DC bias characteristic ceramic type are recommended.)
6) Shows short circuit protection disabled. See application notes for use of short circuit protection.
7) Local decoupling frequency filter capacitors must be connected as close as possible to the module's pins.
8) The length of the DC link wiring between C4, C5, the DIP's P terminal and the shunt must be minimized to prevent excessive transient voltages. In particular C6 should be mounted as close to the DIP as possible.
9) Use high quality, tight tolerance current sensing resistor. Connect resistor as close as possible to the DIP's N terminal. Be careful to check for proper power rating. See application notes for calculation of resistance value.
10) Inserting a Zener diode (24V/1W) between each pair of control supply terminals to prevent surge destruction is recommended.