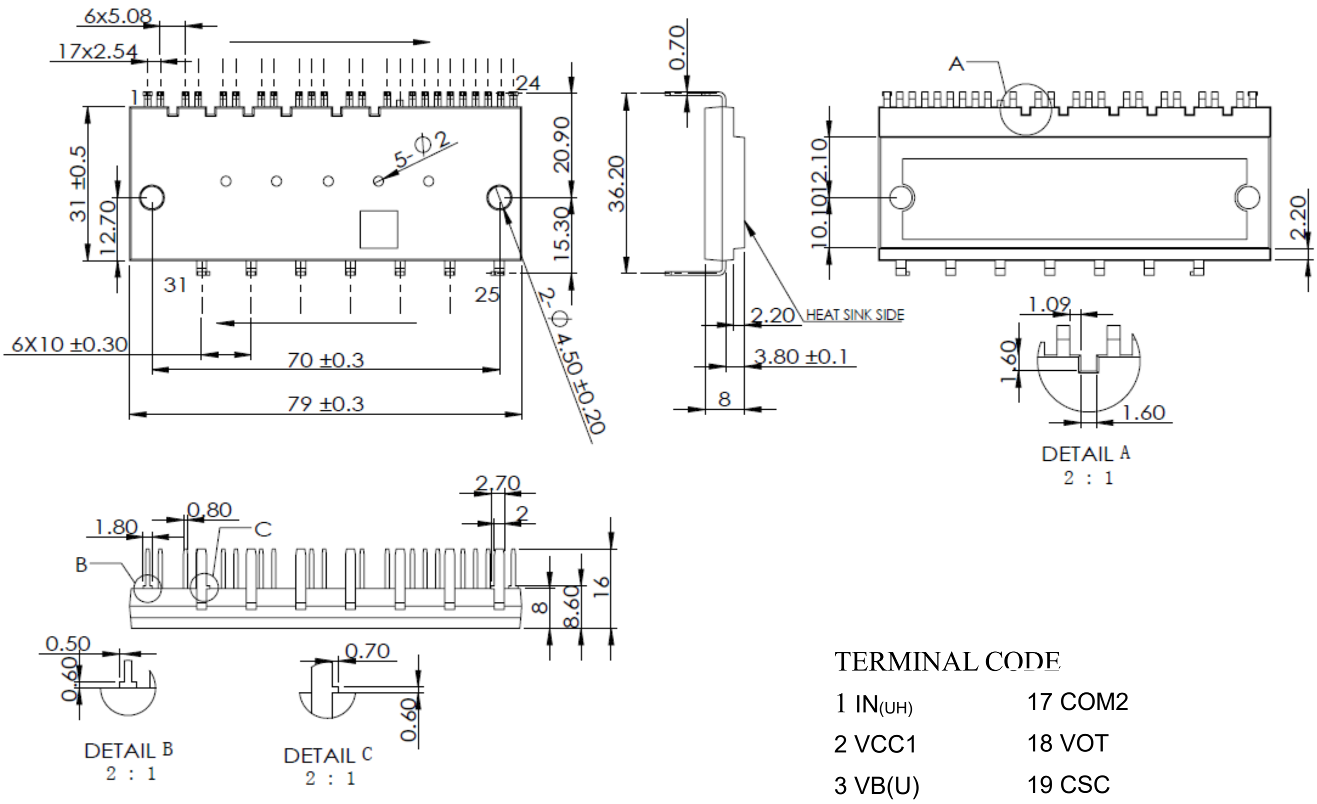
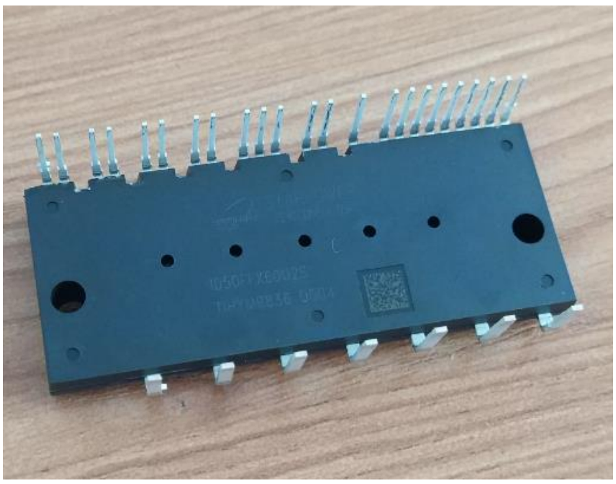
# *Compact - IPM ID50FFX60U2S*

## Features

- Adopt the latest trench IGBT technology to get a good overall loss trade-off.
- Open Emitter on N terminal for low cost current sensing application.
- Matched propagation delay and arm shooting through prevention.
- Provided a fault signal (FO pin) and shut-off internal IGBT when suffer S.C. and under-voltage faulty event.
- Provided a temperature output function by integarted NTC inside



TERMINAL CODE

| | |
|---|---|
| 1 IN$_{(UH)}$ | 17 COM2 |
| 2 VCC1 | 18 VOT |
| 3 VB(U) | 19 CSC |
| 4 VS(U) | 20 CFOD |
| 5 IN$_{(VH)}$ | 21 VFO |
| 6 VCC1 | 22 IN$_{(UL)}$ |
| 7 VB(V)) | 23 IN$_{(VL)}$ |
| 8 VS(V) | 24 IN$_{(WL)}$ |
| 9 IN$_{(WH)}$ | 25 NW |
| 10 VCC1 | 26 NV |
| 11 COM1 | 27 NU |
| 12 VB(W)) | 28 W |
| 13 VS(W)) | 29 V |
| 14 VSC | 30 U |
| 15 NC | 31 P |
| 16 VCC2 | |

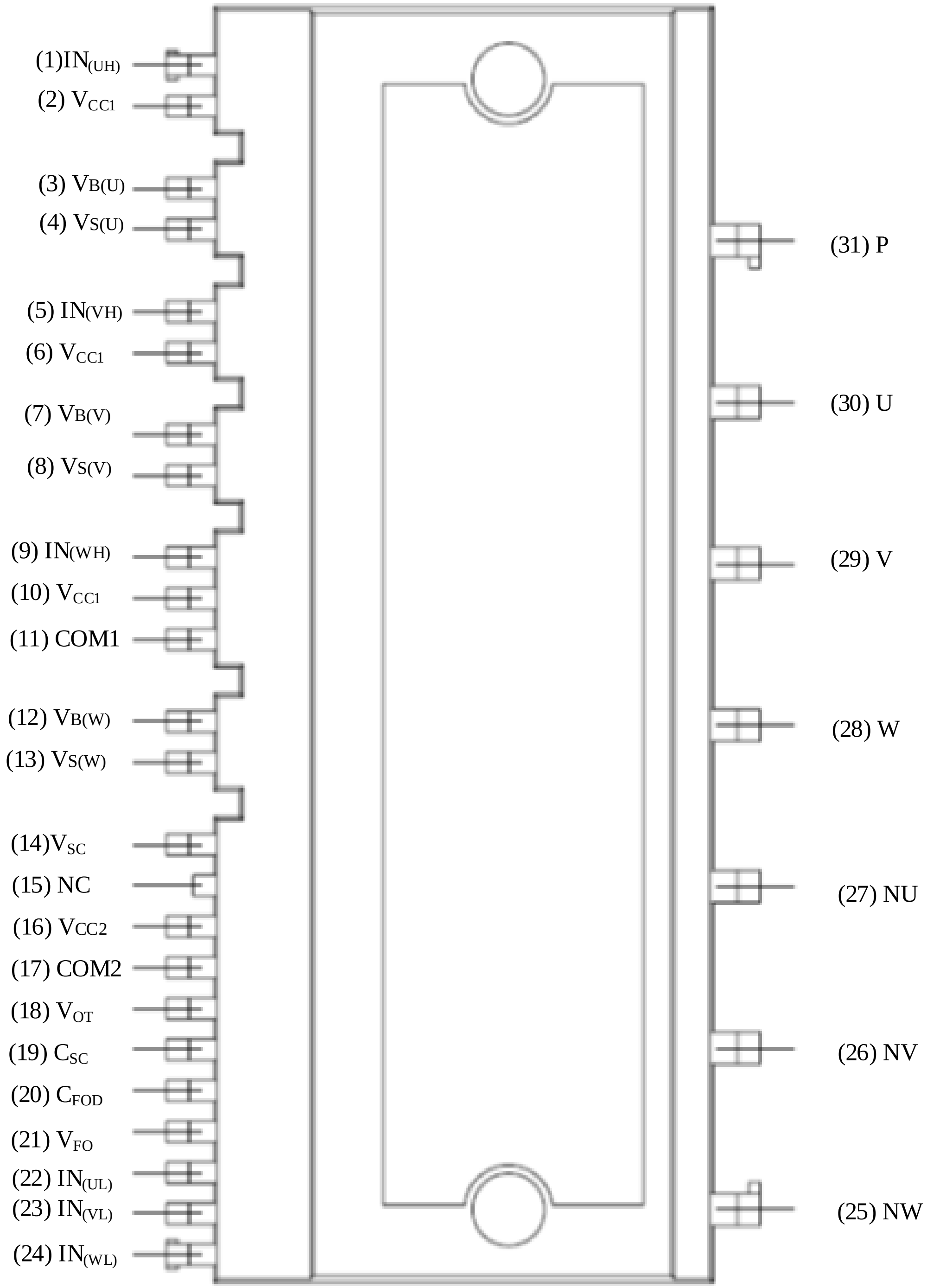
## Table1: Pin Descriptions

| No. | Symbol | Pin Description |
|---|---|---|
| 1 | $IN_{(UH)}$ | Signal Input Terminal for High-side U Phase |
| 2 | $V_{CC1}$ | Supply Voltage Terminal for Driver IC |
| 3 | $V_{B(U)}$ | High - side Bias Voltage for U Phase IGBT Driving |
| 4 | $V_{S(U)}$ | High - side Bias Voltage Ground for U Phase IGBT Driving |
| 5 | $IN_{(VH)}$ | Signal Input Terminal for High-side V Phase |
| 6 | $V_{CC1}$ | Supply Voltage Terminal for Driver IC |
| 7 | $V_{B(V)}$ | High - side Bias Voltage for V Phase IGBT Driving |
| 8 | $V_{S(V)}$ | High - side Bias Voltage Ground for V Phase IGBT Driving |
| 9 | $IN_{(WH)}$ | Signal Input Terminal for High-side W Phase |
| 10 | $V_{CC1}$ | Supply Voltage Terminal for Driver IC |
| 11 | COM1 | Reference Voltage Terminal for Driver IC |
| 12 | $V_{B(W)}$ | High - side Bias Voltage for W Phase IGBT Driving |
| 13 | $V_{S(W)}$ | High - side Bias Voltage Ground for W Phase IGBT Driving |
| 14 | $V_{SC}$ | Current sensing input voltage |
| 15 | NC | No connection |
| 16 | $V_{CC2}$ | Supply Voltage Terminal for Driver IC |
| 17 | COM2 | Reference Voltage Terminal for Driver IC |
| 18 | $V_{OT}$ | Temperature Output Terminal |
| 19 | $C_{SC}$ | Capacitor (Low-pass Filter) for Short-Current Detection Input |
| 20 | $C_{FOD}$ | Capacitor for Fault Output Duration Time Selection |
| 21 | $V_{FO}$ | Fault Output Terminal |
| 22 | $IN_{(UL)}$ | Signal Input Terminal for Low-side U Phase |
| 23 | $IN_{(VL)}$ | Signal Input Terminal for Low-side V Phase |
| 24 | $IN_{(WL)}$ | Signal Input Terminal for Low-side W Phase |
| 25 | $N_W$ | Negative DC-Link Input Terminal for W Phase |
| 26 | $N_V$ | Negative DC-Link Input Terminal for V Phase |
| 27 | $N_U$ | Negative DC-Link Input Terminal for U Phase |
| 28 | W | Output Terminal for W Phase |
| 29 | V | Output Terminal for V Phase |
| 30 | U | Output Terminal for U Phase |
| 31 | P | Positive DC – Link Input |

(see figure 2, next page)

**Pin Configuration**

## Bottom View



## The IPM Internal Block Diagram

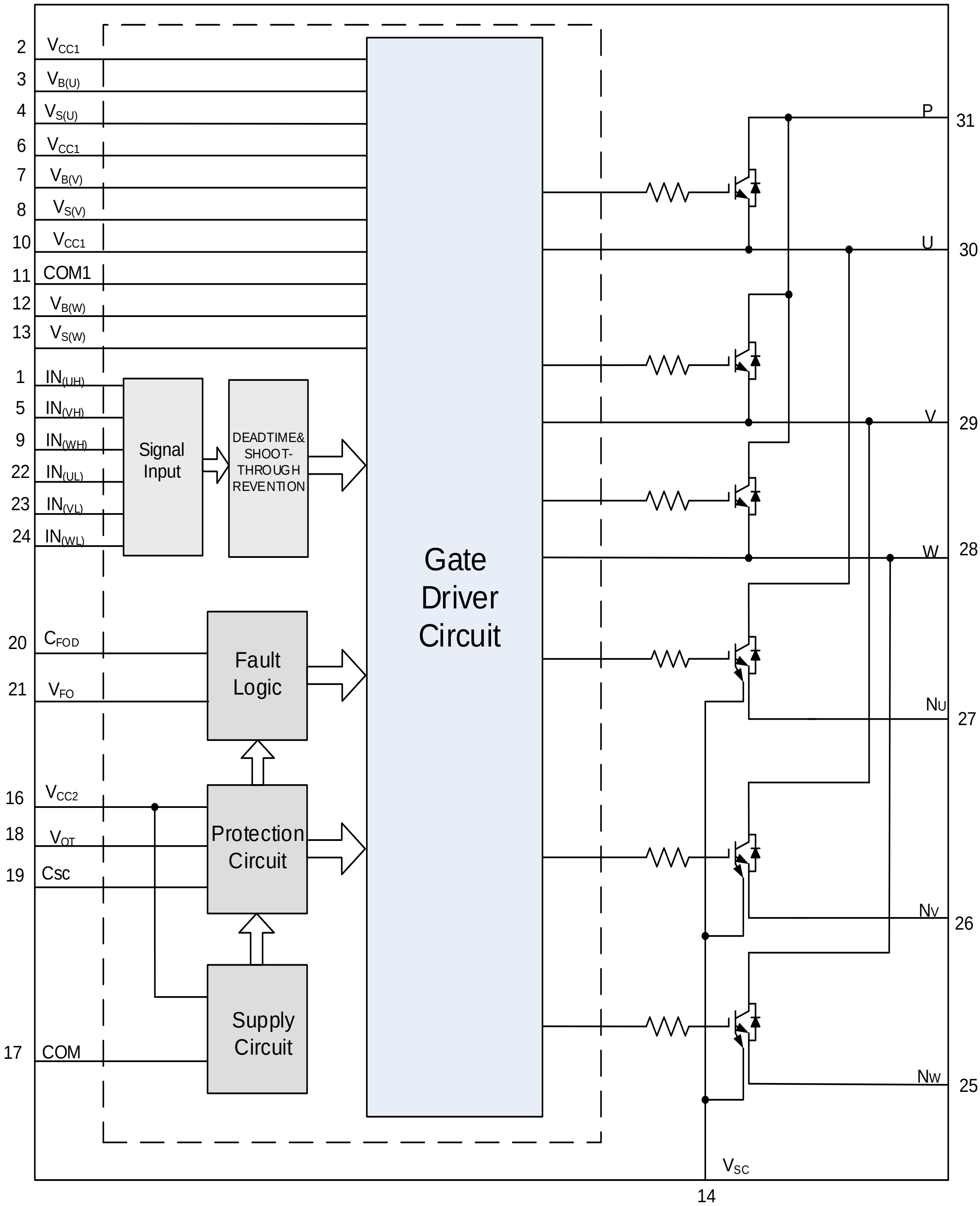



Figure 3. IPM Internal Block Diagram

Application:

- Short-circuit current protection AC 100~240Vrms class 3 phase output for low power motor control.
- Household electric appliances such as air conditioners, washing machines, refrigerators, etc..,
- Low power industrial servo drives applications such as sewing machine, treadmill, etc…

## MAXIMUM RATINGS ($T_j$ = 25℃)

### INVERTER PART

| Item | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|
| Between collector to emitter voltage | $V_{CES}$ (IGBT) | - | 600 | V |
| Supply voltage P-N | $V_{PN}$ | - | 450 | V |
| Supply voltage (surge) P-N | $V_{PN\ (surge)}$ | - | 500 | V |
| Each IGBT collector current | ± $I_C$ ( Tc = 25℃ ) | - | 50 | A |
| Each IGBT collector current (peak) | ± $I_{CP}$ ( Tc = 25℃, pulse ) | - | 150 | A |
| Collector dissipation | $P_C$ (Tc = 25℃, per one chip) | - | 211 | W |
| Junction temperature | $T_j$ **(Note 1)** | -40 | +150 | ℃ |

**Note 1**：Power chip in IPM is qualified for 150°C operation. But overall junction temperature should be limited by $T_j$ ≦ 125°C (@ Tc ≦ 100°C) to fit long term reliability requirement.

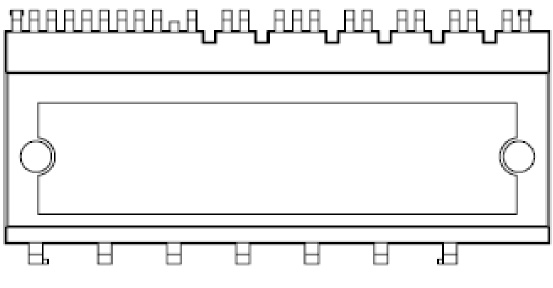
### CONTROL PART

| Item | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|
| Driver IC supply voltage | $V_{CC}$ | -0.3 | 20 | V |
| P - side floating supply voltage | $V_{B(u)S(u),\ B(V)S(V),\ B(W)S(W)}$ | -0.3 | 20 | V |
| Current sensing input voltage | $V_{SC}$ | -0.3 | Vcc+0.3 | V |
| Logic input voltage | $IN_{(UH)}$,$IN_{(VH)}$,$IN_{(WH)}$,<br>$IN_{(UL)}$,$IN_{(VL)}$,$IN_{(WL)}$ | -0.3 | Vcc+0.3 | V |
| Fault output voltage | $V_{FO}$ | -0.3 | Vcc+0.3 | V |
| Fault output current | $I_{FO}$ | - | 10 | mA |

### TOTAL SYSTEM

| Item | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|
| Module case operating temperature | $T_C$ **(Note 2)** | -20 | +100 | ℃ |
| Storage temperature | $T_{stg}$ | -40 | +125 | ℃ |
| Isolation voltage (60Hz Sinusoidal, AC 1 minute, pins to heat-sink plate) | $V_{iso}$ | - | 2500 | Vrms |

Control terminal



Power terminal

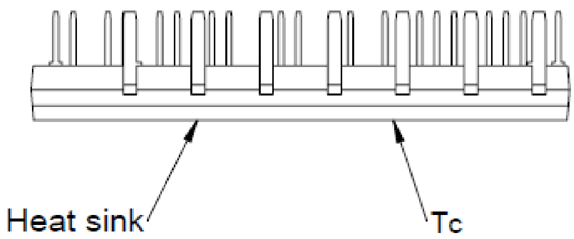



Figure 4. Tc Measurement Point

## THERMAL RESISTANCE

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Junction to case thermal resistance | $R_{th(j-c)Q}$ | IGBT part (1/6) | - | 0.71 | | ℃/W |
| | $R_{th(j-c)F}$ | FWD part (1/6) | - | 1.16 | | ℃/W |

## ELECTRICAL CHARACTERISTICS ($T_j$ = 25℃)

## INVERTER PART

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Collector-emitter saturation voltage | $V_{CE\ (sat)}$ | $V_{CC}$ = $V_{B(U)S(U),\ B(V)S(V),\ B(W)S(W)}$ = 15V, $I_C$ = 50, $V_{SC}$ = 0V; $T_j$=25℃ | | 1.64 | | V |
| FWD forward voltage drop | $V_F$ | $T_j$ =25℃, - $I_C$ = 50A | | 2.42 | | V |
| Switching times **(Fig. 5)** | $T_{on}$ | $V_D$ = 300V, $V_{CC}$ = $V_{B(U)S(U),\ B(V)S(V),\ B(W)S(W)}$ = 15V, $I_C$ = 50A, $T_j$ =25℃, $V_{IN}$ = 5V <—> 0V, $V_{SC}$ = 0V, Inductive Load | | 1.5 | | μs |
| | $T_r$ | | | 0.3 | | μs |
| | $T_{c(on)}$ | | | 0.4 | | μs |
| | $T_{off}$ | | | 3 | | μs |
| | $T_f$ | | | 0.15 | | μs |
| | $T_{c(off)}$ | | | 0.4 | | μs |
| | $T_{rr}$ | | | 0.25 | | μs |
| Collector-emitter cut-off current | $I_{CES}$ | $V_{CE}$ =$V_{CES}$ | | | 500 | μA |

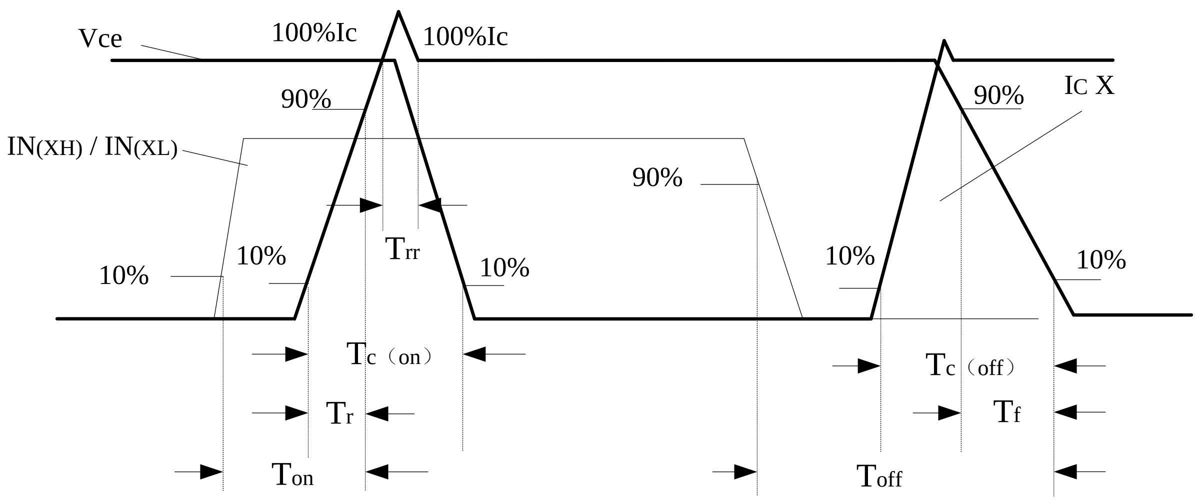



Figure 5. Switching Time Definition

**CONTROL PART** ($T_j$ = 25℃)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| IN(UH、VH、WH), IN(UL、VL、WL) ON threshold voltage | $V_{th(on)}$ | | - | 2.0 | 2.4 | V |
| IN(UH、VH、WH),IN(UL、VL、WL) OFF threshold voltage | $V_{th(off)}$ | | 0.8 | 1.1 | - | V |
| IN(UH、VH、WH) input bias current | $I_{IN(UH、VH、WH)(HI)}$ | $V_{IN(UH、VH、WH)}$ = 5V | - | - | 220 | μA |
| | $I_{IN(UH、VH、WH)(LO)}$ | $V_{IN(UH、VH、WH)}$ = 0V | - | - | 300 | |
| IN(UL、VL、WL) input bias current | $I_{IN(UL、VL、WL)(HI)}$ | $V_{IN(UL、VL、WL)}$ = 5V | - | - | 220 | μA |
| | $I_{IN(UL、VL、WL)(LO)}$ | $V_{IN(UL、VL、WL)}$ = 0V | - | - | 300 | |
| Short circuit trip level | Isc | Rs=40.2, not connecting external shut resistor | | 90 | | A |
| Driver IC supply voltage | $V_{CC}$ | | 13.5 | 15.0 | 16.5 | V |
| P - side floating supply voltage | $V_{B(U)S(U), B(V)S(V), B(W)S(W)}$ | | 13.5 | 15.0 | 16.5 | V |
| $V_{CC}$ terminal input current | $I_C$ | | - | - | 2.3 | mA |
| Fault output voltage | $V_{FOH}$ | $V_{SC}$ =0V **(Note 2)** | 4.9 | - | - | V |
| | $V_{FOL}$ | $V_{SC}$=1V | - | - | 200 | mV |
| Short circuit trip level | $V_{SC(ref)}$ | $V_{CC}$ =15V, $T_j$ = 25℃ | 0.41 | 0.46 | 0.51 | V |
| Fault output pulse width | Cfo=33nF | **(Note 3)** | 1 | | - | mS |
| Supply circuit under voltage protection | $UVT_{VCC}$ | Trip level | 8.6 | 9.4 | 10.2 | V |
| | $UVR_{VCC}$ | Reset level | 9.6 | 10.4 | 11.2 | V |
| | UVH | Hysteresis | - | 1.0 | - | V |
| IN(UL、VL、WL) Input filter time | $t_{IN,FIL}$ | VIN = 0 & 5V **(Note 4)** | 100 | 200 | - | ns |
| Temperature Output | $V_{OT}$ | $T_C$=85℃ | | 3.88 | | V |

**Note 2：** $V_{FO}$ output is open collector type, so this signal line should be pulled up to the +5V power supply with approximately 4.7KΩ

**Note 3：** Fault output pulse width is filter capacitor of S.C. depended.

**Note 4：** For high side PWM, IN(UH、VH、WH) pulse width must be ≧ 1 us.

## Input Filter Function

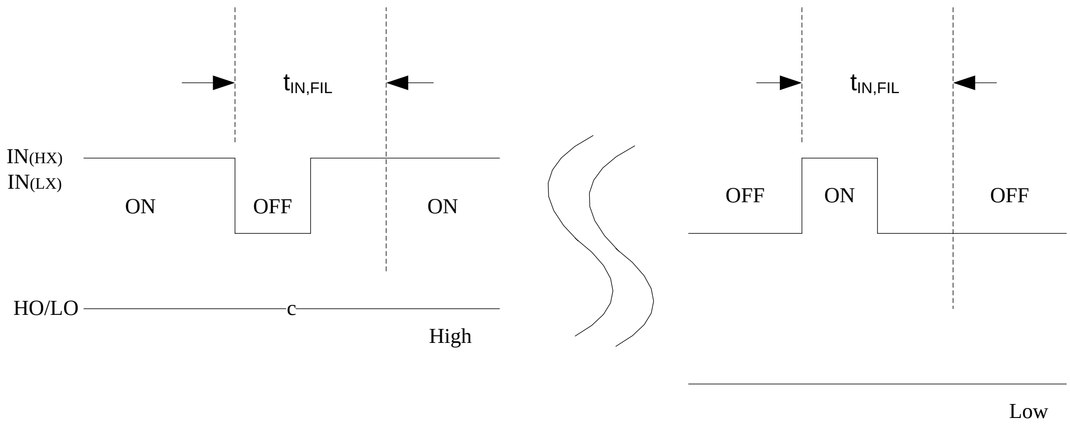



Figure 6. Input Filter Function

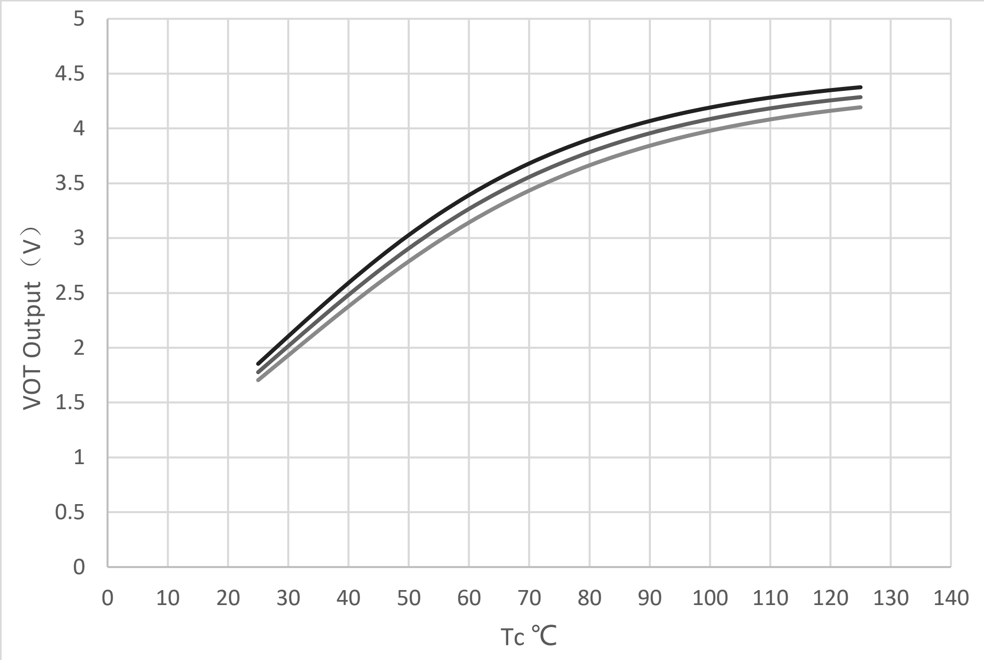



Figure 7. $V_{OT}$ output characteristics

## RECOMMENDED OPERATION CONDITIONS

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| DC – Link Supply voltage | $V_D$ | Applied between P-N | 0 | 400 | 450 | V |
| Driver IC supply voltage | $V_{CC}$ | Applied between $V_{CC}$ - COM | 13.5 | 15.0 | 16.5 | V |
| P - side floating supply voltage | $V_{BS}$ | Applied between $V_{B(u、v、w)}$ – $V_{S(u、v、w)}$ | 13.5 | 15.0 | 16.5 | V |
| Input ON threshold voltage | $V_{sc(ON)}$ | Applied between $IN_{(UH、VH、WH)}$ - COM and $IN_{(UL、VL、WL)}$ - COM | 0 ~ 0.65 | | | |
| Input OFF threshold voltage | $V_{sc(OFF)}$ | | 4.0 ~ 5.5 | | | |
| Supply voltage ripple | $\Delta V_D$ , $\Delta V_{DB}$ | | -1 | - | 1 | V/μs |
| Arm shoot-through blocking time | $t_{dead}$ | | 2 | - | - | μs |
| PWM input frequency | $f_{PWM}$ | $T_C$≦100℃, $T_j$≦125℃ | - | 15 | - | kHz |

## MECHANICAL CHARACTERISTICS AND RATINGS

| Item | Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Mounting torque | Mounting screw：M4 | Recommended 0.65N•m(修改) | 0.98 | 1.18 | 1.47 | N•m |
| Weight | | -- | - | 69 | - | g |
| Heat-sink flatness | | -- | -50 | - | 100 | μm |

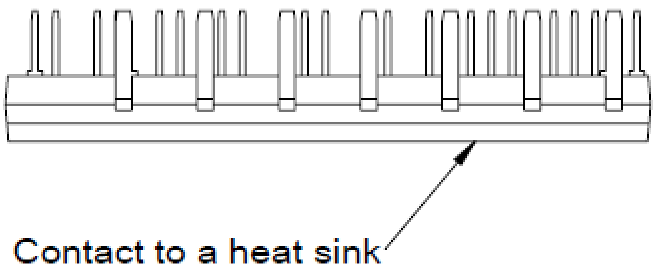



Figure 8. Measurement Location of Heat-sink Flatness

## Input/Output Timing Diagram

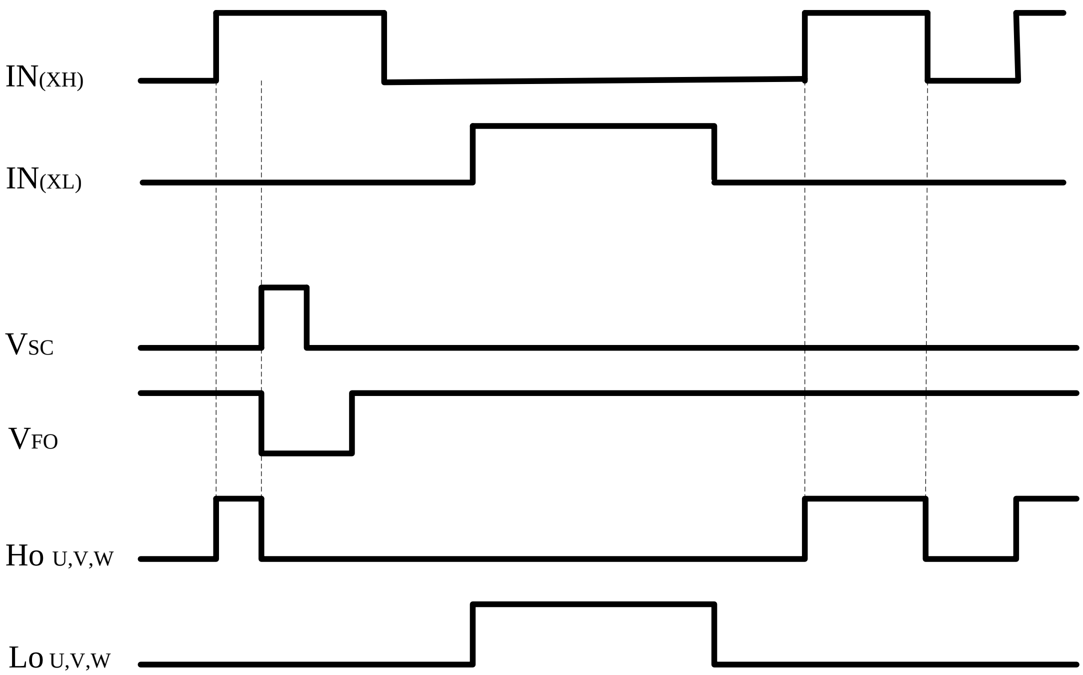
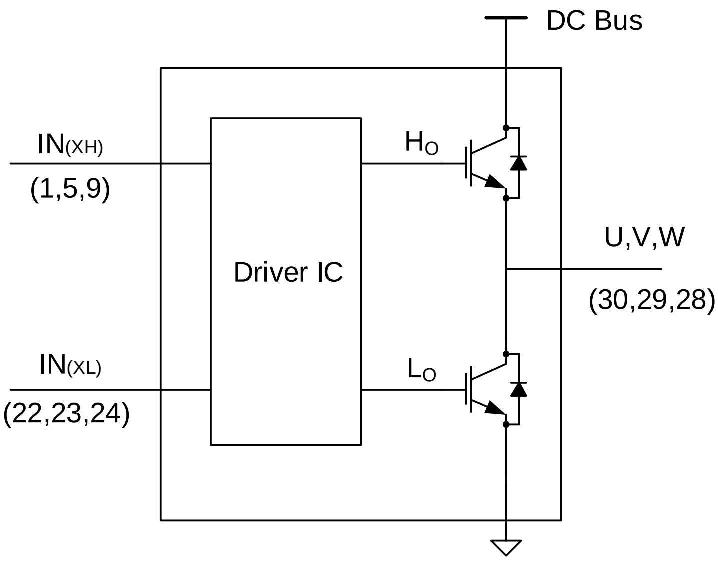



Figure 9. Input/Output Timing Diagram




| Vsc | IN(XH) | IN(XL) | U,V,W |
|---|---|---|---|
| 0 | 1 | 0 | DC Bus |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 0 | 1 | 0 |

(X=U,V,W)

Figure 10. Input/Output Signal Circuit

## IPM Short-Circuit Protection Function

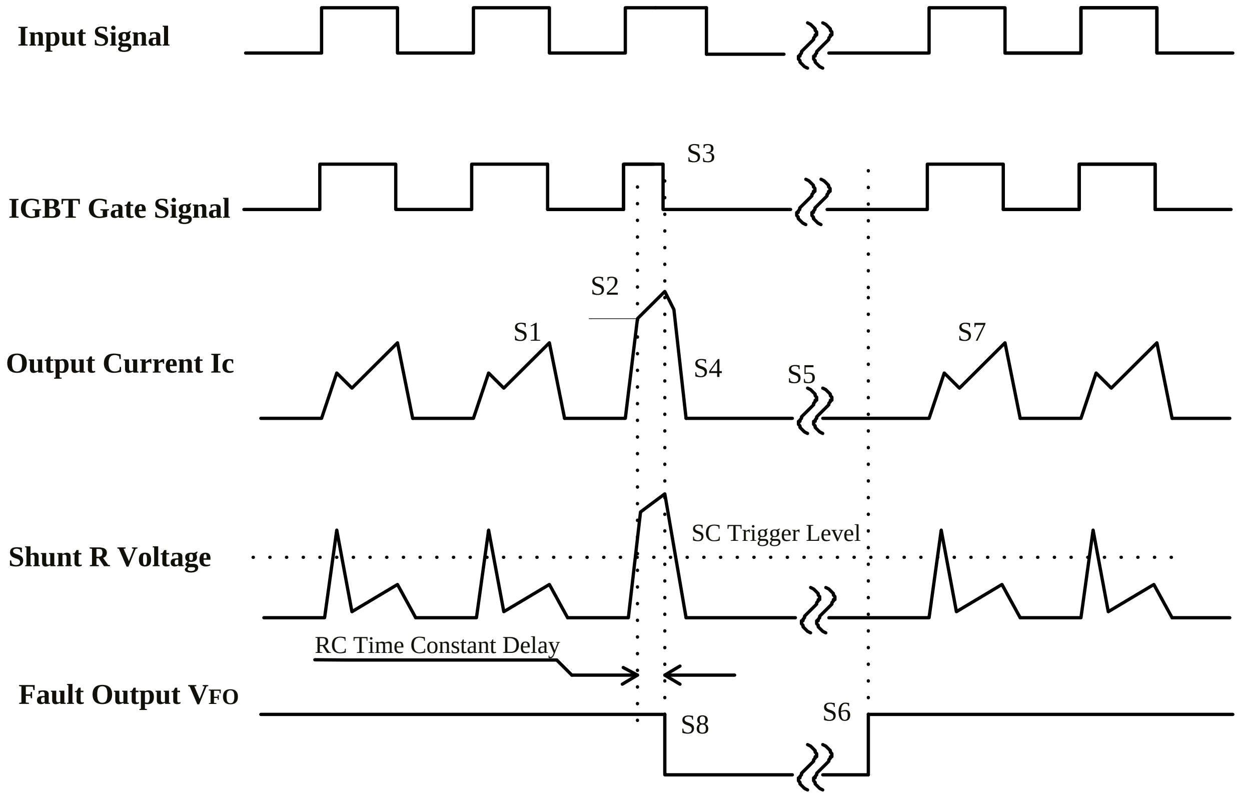



Figure 11. Timing Chart of SC Operation

S1. The IGBT's are controlled by input PWM signal.(Normal operation)
S2. Short circuit event occur and reach the limited level. (SC protection is trigger).
S3. IGBT gate driving signal is disabled.
S4. Current is cut off caused by IGBT turns OFF.
S5. Disabled state
S6. Fault level is kept on low level during the fault output activation
S7. IGBT returns for normal operation when fault state is reset
S8. Fault output starting once SC protection is trigger.

## IPM Under-Voltage Protection Function

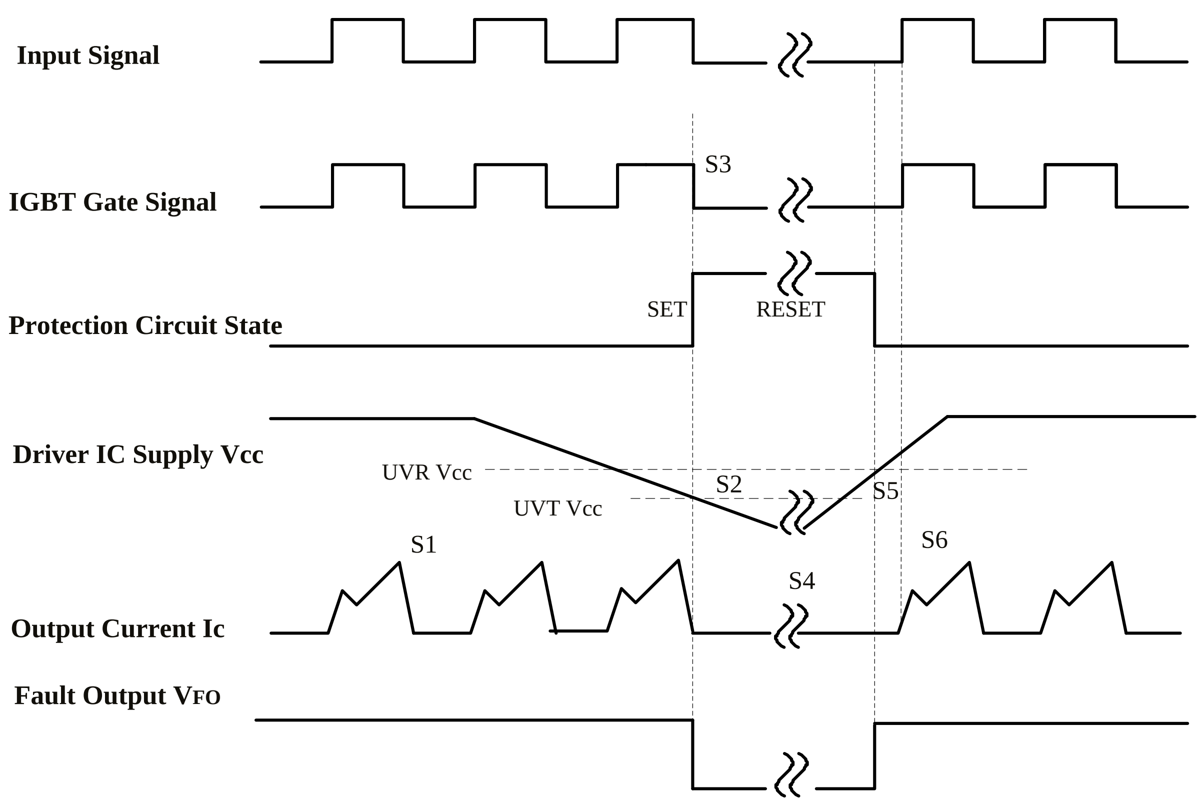



Figure 12. Timing Chart of Under-Voltage Operation

S1. The IGBT's are controlled by input PWM signal.(Normal operation)
S2. Under-voltage protection is trigger
S3. IGBT driving signals are disabled when fault condition occur
S4. Fault state and the period will be able to control by external capacitor value.
S5. Under-voltage event is recovered
S6. IGBT returns for normal operation when fault state is reset

## Direct Input (without Photo Coupler) Interface Example

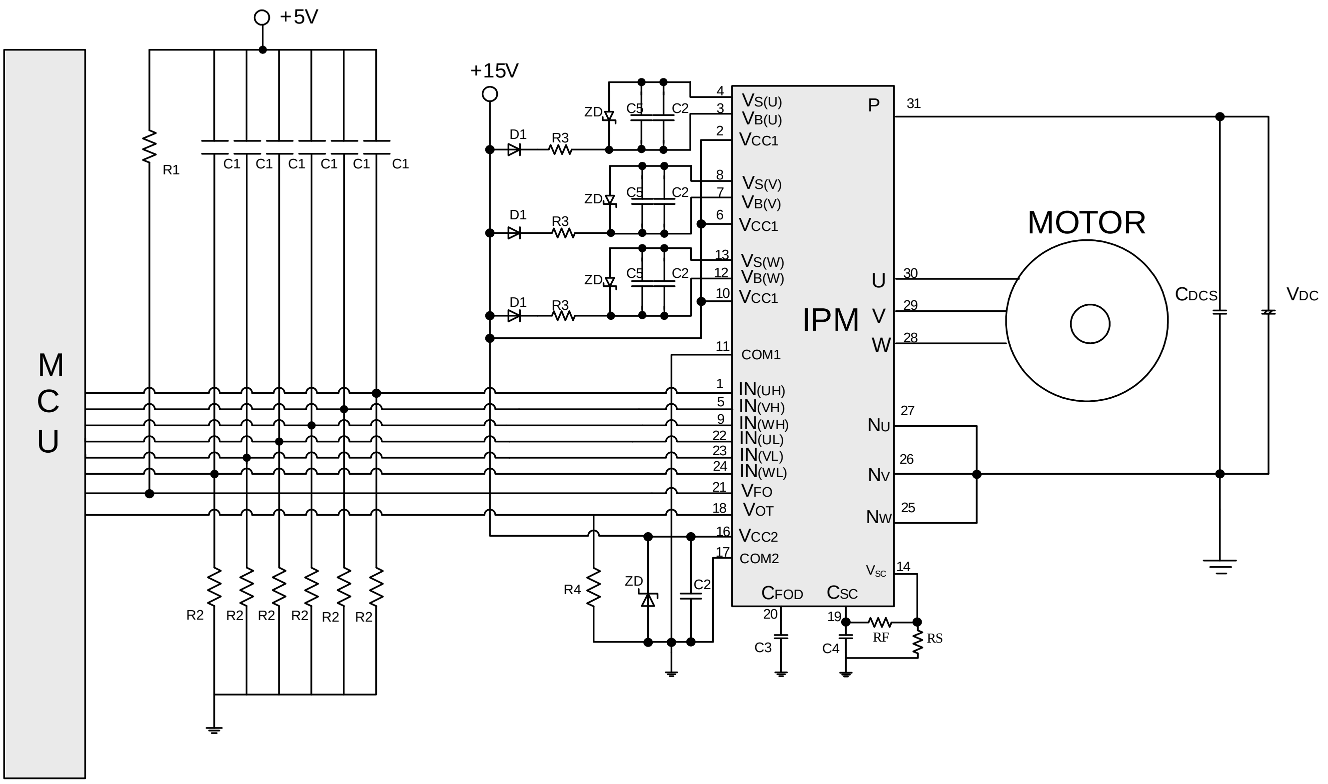



Figure 13. Typical Application Circuit Interface Example without Photo-Coupler

***Design reference:***

1. R1 : 4.7k
2. R2 : 680~4.7KΩ
3. R3: 2.4~22Ω ( It could be adjusted depending on the PWM frequency and negative voltage level on phase node. )
4. C1 : 100 ~ 1000pF ( Ceramic ) ( The capacitor could filter the noise, but should be careful to the dead time)
5. C2 : 0.22 ~ 2μF ( Ceramic )
6. C3 : 22~33nF ( Ceramic )
7. C4 : 22~33nF ( Ceramic )
8. C5 : 10 ~ 100μF ( Electrolytic, low impendence )
9. D1 : D1 : 600V/1A ( Ultra-Fast recovery diode )
10. ZD : 24V/1W Zener diode ( It is recommended to insert a Zener diode to prevent surge destruction)
11. It is recommended to connect control GND and power GND at only a point at which NU,NV,NM are connected to power GND line.

## Current Sense Shceme

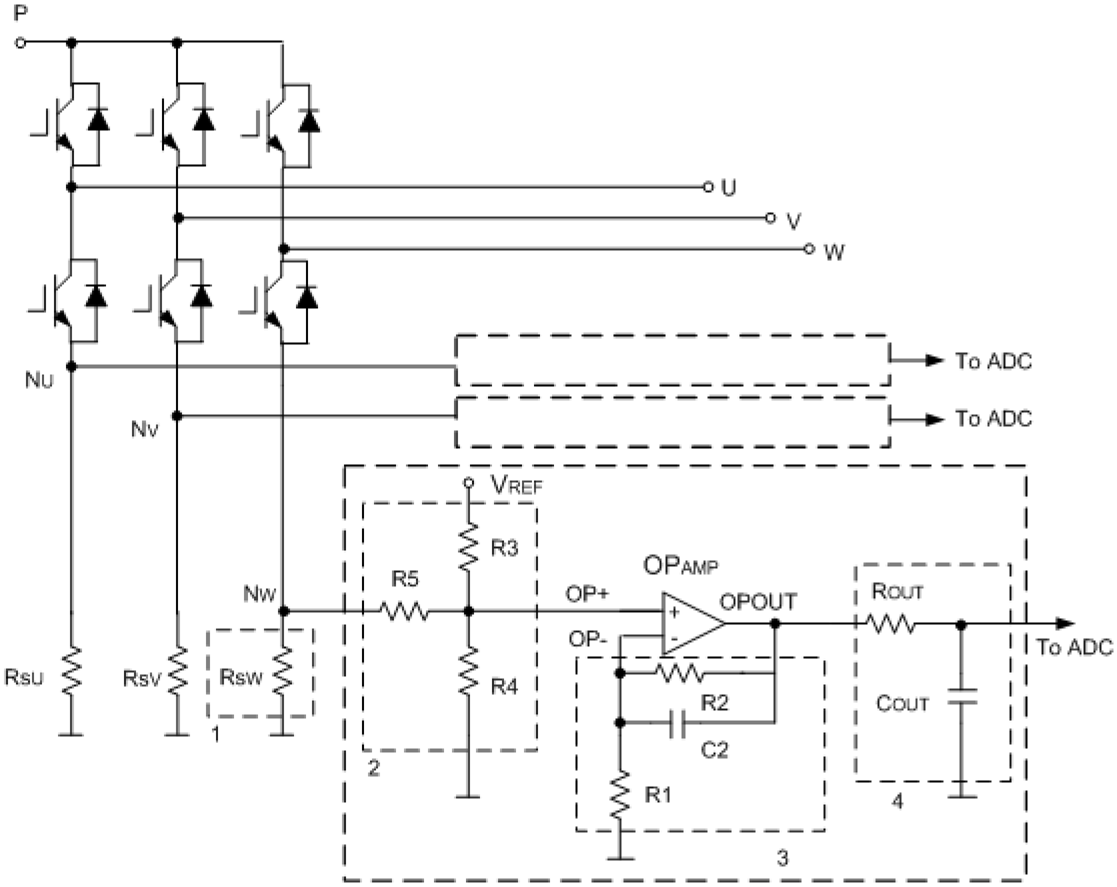



Figure 14. Current Sense Scheme

***Description :***

1、Half-bridge current sensing
2、Voltage shifting of the $V_{sense}$
3、Voltage gain and filtering
4、Capacitor required by the ADC for sampling purpose

$R_{OUT}$ resistor is usually required in order to make the $OP_{AMP}$ stable when the $C_{OUT}$ capacitance increases

***Design Reference :***

1. R1 : 1.0 KΩ
2. R2 : 5.6 KΩ
3. R3 : 4.7 KΩ
4. R4: 910 Ω
5. R5 : 910 Ω
6.ROUT : 1.0 KΩ
7. C2 :10pF ( Ceramic )

## Precautions on Electrostatic Electricity

(1) Operators must wear anti-static clothing and conductive shoes (or a leg or heel strap).

(2) Operators must wear a wrist strap grounded to earth via a resistor of about 1 MΩ.

(3) Soldering irons must be grounded from iron tip to earth, and must be used only at low voltages.

(4) If the tweezers you use are likely to touch the device terminals, use anti-static tweezers and in particular avoid metallic tweezers. If a charged device touches a low-resistance tool, rapid discharge can occur. When using vacuum tweezers, attach a conductive chucking pat to the tip, and connect it to a dedicated ground used especially for anti-static purposes (suggested resistance value: $10^4$ to $10^8$Ω).

(5) Do not place devices or their containers near sources of strong electrical fields (such as above a CRT).

(6) When storing printed circuit boards which have devices mounted on them, use a board container or bag that's protected against static charge. To avoid the occurrence of static charge or discharge due to friction, keep the boards separate from one other and do not stack them directly on top of one another.

(7) Ensure, if possible, that any articles (such as clipboards) which are brought to any location where the level of static electricity must be closely controlled are constructed of anti-static materials.

(8) In cases where the human body comes into direct contact with a device, be sure to wear anti-static finger covers or gloves (suggested resistance value: $10^8$Ω or less).

(9) Equipment safety covers installed near devices should have resistance ratings of $10^9$Ω or less.

(10) If a wrist strap cannot be used for some reason, and there is a possibility of imparting friction to devices, use an ionizer.

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