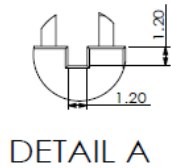
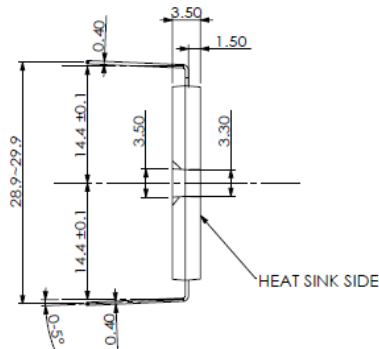
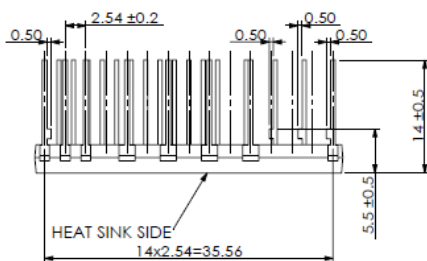
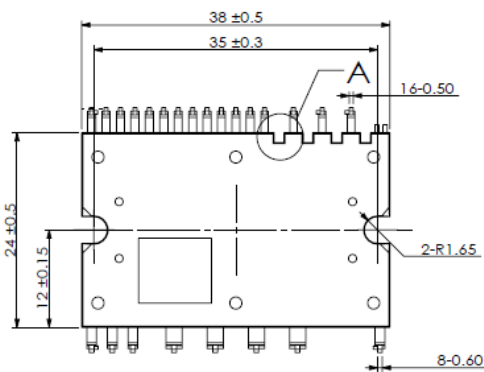
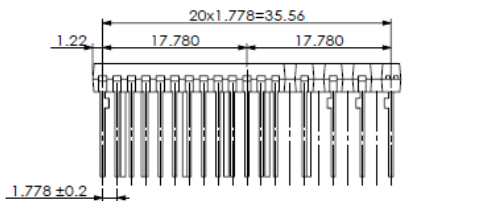


# Compact - IPM ID15FFX60U1S\_B

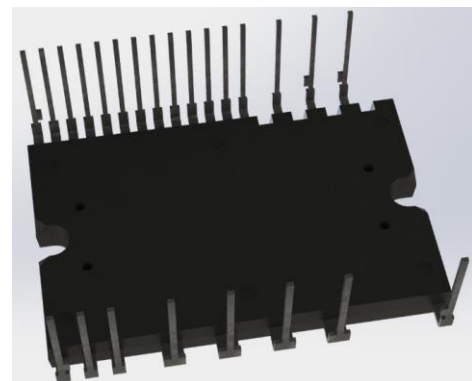
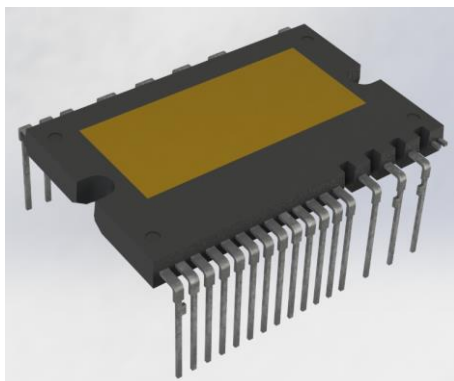
## Features

- UL 1557 Certified.
- 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.
- Match propagation delay and arm shooting through prevention.
- Built-in bootstrap diodes with current limiting resistor.
- Provide a fault signal (FO pin) and shut-off internal IGBT when suffer S.C. and under-voltage faulty event.
- Provide Temperature output by analog signal.
- Provided Over temperature protection.
- RoHS compatible.



### TERMINAL CODE

1 NC	16 COM
2 V <sub>B(U)</sub>	17 V <sub>OT</sub>
3 V <sub>B(V)</sub>	18 N <sub>w</sub>
4 V <sub>B(W)</sub>	19 N <sub>v</sub>
5 IN <sub>(UH)</sub>	20 N <sub>u</sub>
6 IN <sub>(VH)</sub>	21 W
7 IN <sub>(WH)</sub>	22 V
8 V <sub>CC</sub>	23 U
9 COM	24 P
10 IN <sub>(UL)</sub>	25 NC
11 IN <sub>(VL)</sub>	
12 IN <sub>(WL)</sub>	
13 V <sub>CC</sub>	
14 V <sub>FO</sub>	
15 C <sub>SC</sub>	



**Table1: Pin Descriptions**

No.	Symbol	Pin Description
1	NC	No Connection
2	$V_{B(U)}$	High - side Bias Voltage for U Phase IGBT Driving
3	$V_{B(V)}$	High - side Bias Voltage for V Phase IGBT Driving
4	$V_{B(W)}$	High - side Bias Voltage for W Phase IGBT Driving
5	$IN_{(UH)}$	Signal Input Terminal for High-side U Phase
6	$IN_{(VH)}$	Signal Input Terminal for High-side V Phase
7	$IN_{(WH)}$	Signal Input Terminal for High-side W Phase
8	$V_{CC}$	Supply Voltage Terminal for Driver IC
9	COM	Reference Voltage Terminal for Driver IC
10	$IN_{(UL)}$	Signal Input Terminal for Low-side U Phase
11	$IN_{(VL)}$	Signal Input Terminal for Low-side V Phase
12	$IN_{(WL)}$	Signal Input Terminal for Low-side W Phase
13	$V_{CC}$	Supply Voltage Terminal for Driver IC
14	$V_{FO}$	Fault Output Terminal
15	Csc	Short-Current Detection Input
16	COM	Reference Voltage Terminal for Driver IC
17	$V_{OT}$	Temperature output
18	$N_W$	Negative DC-Link Input Terminal for W Phase
19	$N_V$	Negative DC-Link Input Terminal for V Phase
20	$N_U$	Negative DC-Link Input Terminal for U Phase
21	W	Output Terminal for W Phase
22	V	Output Terminal for V Phase
23	U	Output Terminal for U Phase
24	P	Positive DC – Link Input
25	NC	No Connection

(see figure 2, next page)

### Pin Configuration

#### Bottom View

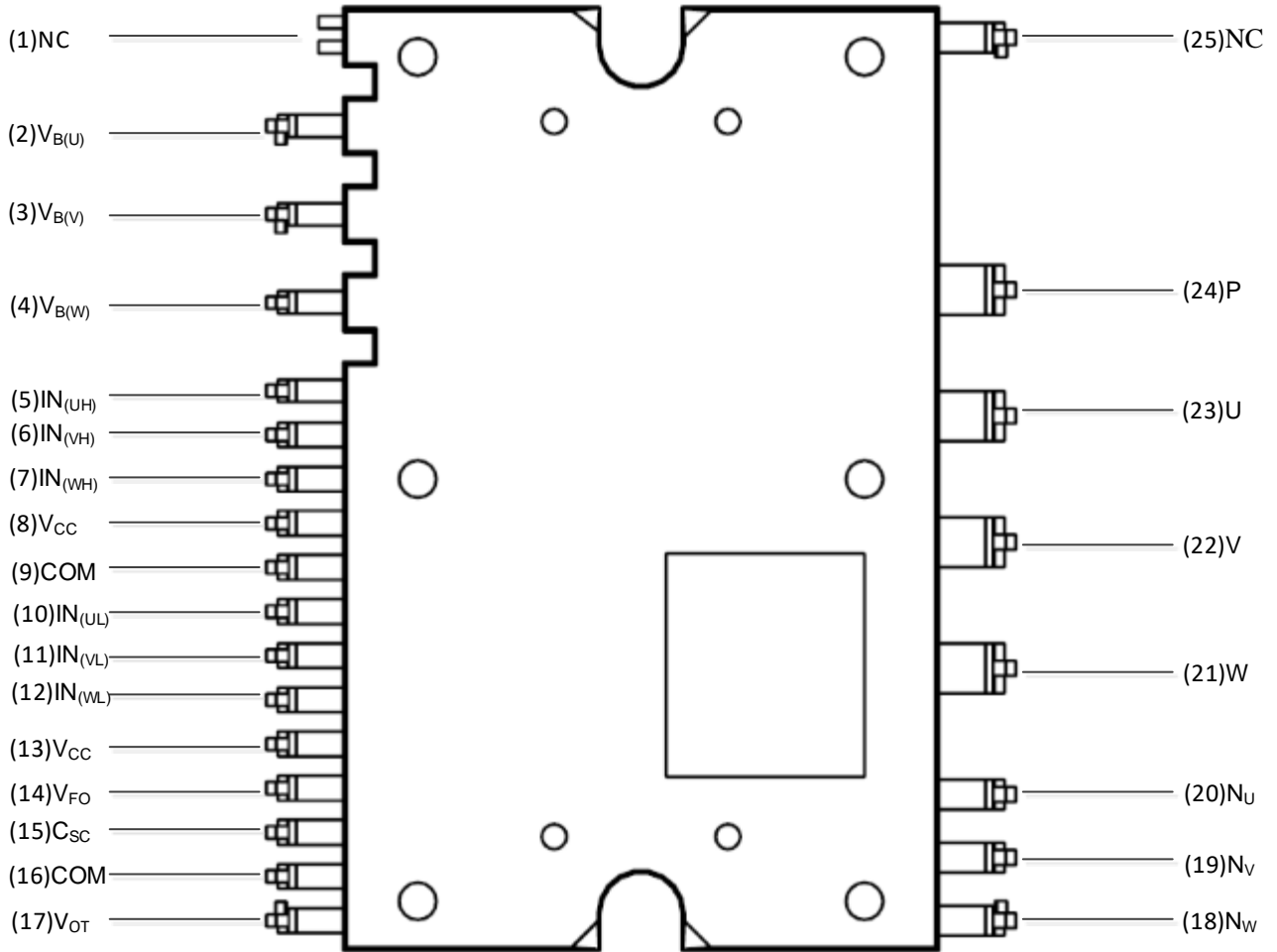


Figure 2. Pin Configuration

The IPM Internal Block Diagram

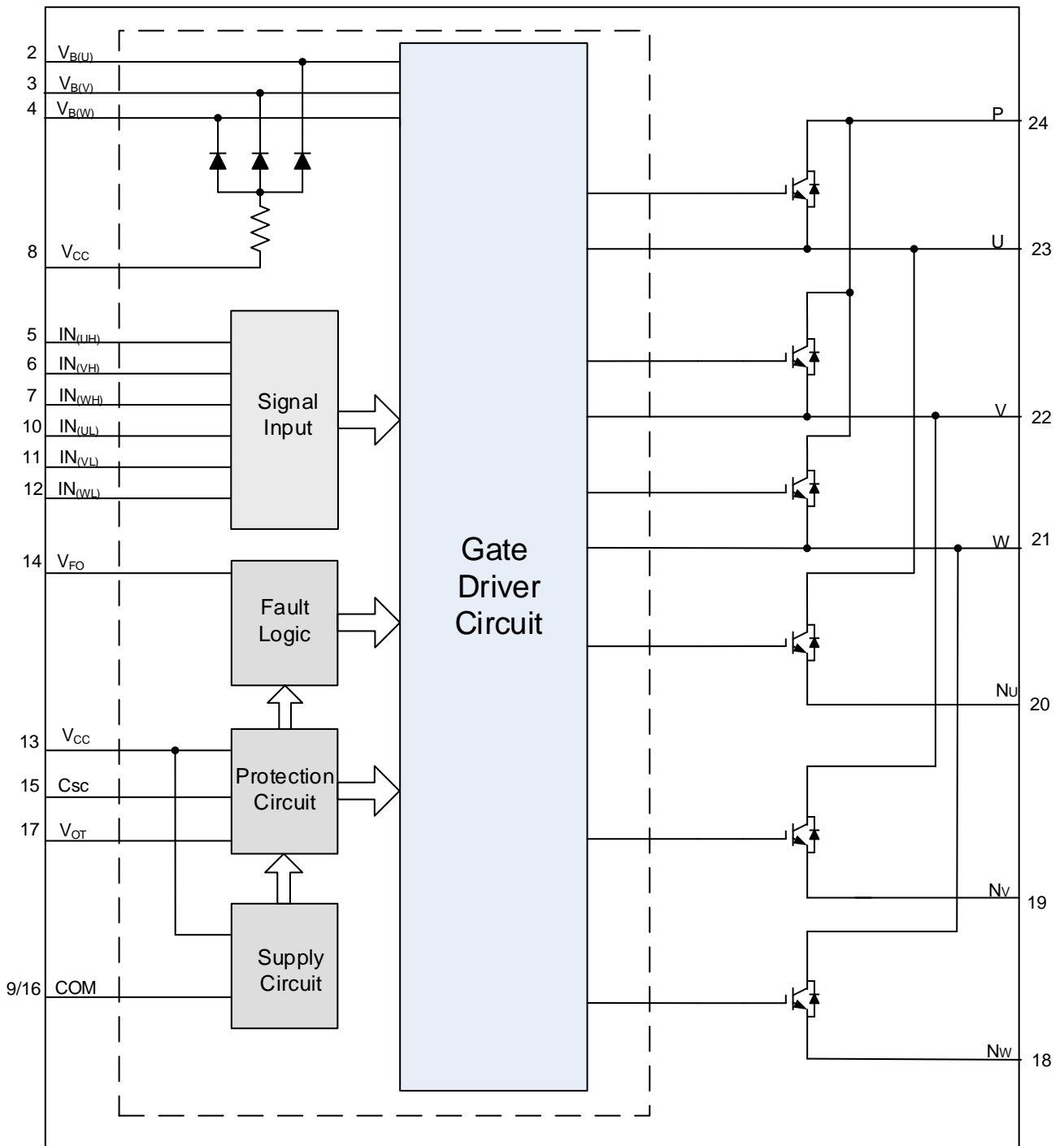


Figure 3. IPM Internal Block Diagram

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** ( $T_j = 25^\circ\text{C}$ )**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	$\pm I_C$ ( $T_C = 25^\circ\text{C}$ )	-	15	A
Each IGBT collector current	$\pm I_C$ ( $T_C = 90^\circ\text{C}$ )	-	11	A
Each IGBT collector current (peak)	$\pm I_{CP}$ ( $T_C = 25^\circ\text{C}$ , $T_j < 150^\circ\text{C}$ , Under 1ms Pulse Width)	-	30	A
Collector dissipation	$P_C$ ( $T_C = 25^\circ\text{C}$ , per one chip)	-	60	W
Junction temperature	$T_j$ <b>(Note 1)</b>	-	+150	$^\circ\text{C}$

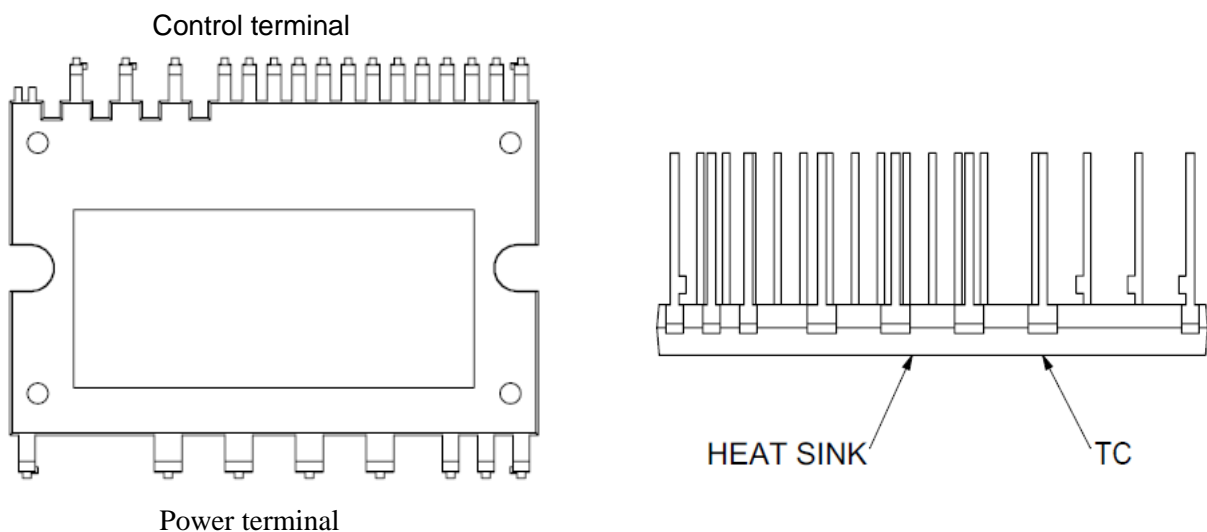
**Note 1:** Power chip in IPM is qualified for  $175^\circ\text{C}$  operation. But overall junction temperature should be limited by  $T_j \leq 125^\circ\text{C}$  (@  $T_C \leq 100^\circ\text{C}$ ) to fit long term reliability requirement.

**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	$V_{CC}+0.3$	V
Logic input voltage	$IN_{(UH)}, IN_{(VH)}, IN_{(WH)},$ $IN_{(UL)}, IN_{(VL)}, IN_{(WL)}$	-0.3	$V_{CC}+0.3$	V
Fault output voltage	$V_{FO}$	-0.3	$V_{CC}+0.3$	V
Fault output current	$I_{FO}$	-	1	mA

**TOTAL SYSTEM**

Item	Symbol	Min.	Max.	Unit
Module case operating temperature	$T_C$	-20	+100	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-40	+125	$^\circ\text{C}$
Isolation voltage (60Hz Sinusoidal, AC 1 minute, pins to heat-sink plate)	$V_{iso}$	-	1500	Vrms

Figure 4.  $T_C$  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)	-	2.1	-	°C/W
	$R_{th(j-c)F}$	FWD part (1/6)	-	3.1	-	

**ELECTRICAL CHARACTERISTICS (T<sub>j</sub> = 25°C)**

**INVERTER PART**

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Collector-emitter saturation voltage	$V_{CE(sat)}$	$V_{CC} = V_{B(U)S(U)}, B(V)S(V), B(W)S(W) = 15V, I_C = 15A, V_{SC} = 0V$ $T_j = 25°C$	-	1.50	-	V
FWD forward voltage drop	$V_F$	$T_j = 25°C, - I_C = 15A$	-	1.60	-	V
Switching times (Fig. 5)	$T_{on}$	$V_D = 300V,$ $V_{CC} = V_{B(U)}, B(V), B(W) = 15V,$ $I_C = 15A, T_j = 25°C,$ $V_{IN} = 5V \leftrightarrow 0V,$ $V_{SC} = 0V, \text{ Inductive Load}$	-	0.66	-	μs
	$T_{c(on)}$		-	0.09	-	
	$T_{off}$		-	0.74	-	
	$T_{c(off)}$		-	0.09	-	
	$T_{rr}$		-	0.09	-	
Collector-emitter cut-off current	$I_{CES}$	$V_{CE} = V_{CES}$	-	-	500	μA

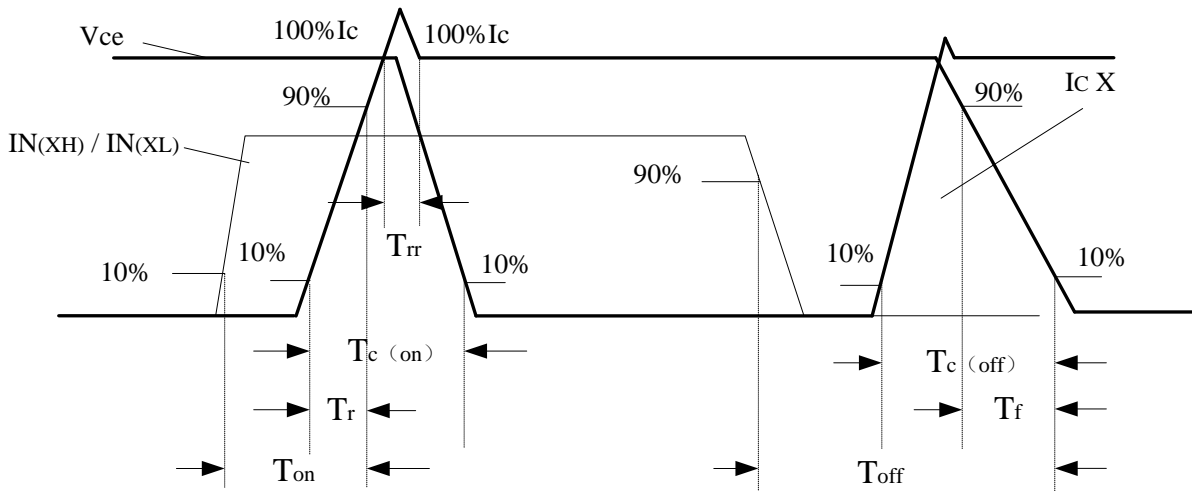


Figure 5. Switching Time Definition

**CONTROL PART** ( $T_j = 25^\circ\text{C}$ )

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
$\text{IN}_{(\text{UH}, \text{VH}, \text{WH}), \text{IN}_{(\text{UL}, \text{VL}, \text{WL})}}$ ON threshold voltage	$V_{\text{th(on)}}$		-	2.0	2.4	V
$\text{IN}_{(\text{UH}, \text{VH}, \text{WH}), \text{IN}_{(\text{UL}, \text{VL}, \text{WL})}}$ OFF threshold voltage	$V_{\text{th(off)}}$		0.8	1.1	-	V
$\text{IN}_{(\text{UH}, \text{VH}, \text{WH})}$ input bias current	$I_{\text{IN}(\text{UH}, \text{VH}, \text{WH})(\text{HI})}$	$V_{\text{IN}(\text{UH}, \text{VH}, \text{WH})} = 5\text{V}$	0.7	1.0	1.5	mA
	$I_{\text{IN}(\text{UH}, \text{VH}, \text{WH})(\text{LO})}$	$V_{\text{IN}(\text{UH}, \text{VH}, \text{WH})} = 0\text{V}$	-	0	-	
$\text{IN}_{(\text{UL}, \text{VL}, \text{WL})}$ input bias current	$I_{\text{IN}(\text{UL}, \text{VL}, \text{WL})(\text{HI})}$	$V_{\text{IN}(\text{UL}, \text{VL}, \text{WL})} = 5\text{V}$	0.7	1.0	1.3	mA
	$I_{\text{IN}(\text{UL}, \text{VL}, \text{WL})(\text{LO})}$	$V_{\text{IN}(\text{UL}, \text{VL}, \text{WL})} = 0\text{V}$	-	0	-	
Driver IC supply voltage	$V_{\text{CC}}$		13.5	15.0	16.5	V
P - side floating supply voltage	$V_{\text{B(U), B(V), B(W)}}$		13.5	15.0	16.5	V
$V_{\text{CC}}$ terminal input current	$I_{\text{C}}$		-	-	2.3	mA
Fault output voltage	$V_{\text{FOH}}$	$V_{\text{SC}} = 0\text{V}$ (Note 2)	4.9	-	-	V
	$V_{\text{FOL}}$	$V_{\text{SC}} = 1\text{V}$	-	-	950	mV
Short circuit trip level	$V_{\text{SC(ref)}}$	$V_{\text{CC}} = 15\text{V}, T_j = 25^\circ\text{C}$	0.455	0.480	0.505	V
Fault output pulse width	$t_{\text{FOD}}$		20	65	-	us
N-side supply circuit under voltage protection	$\text{UVT}_{\text{VCC}}$	Trip level	9.5	10.4	11.0	V
	$\text{UVR}_{\text{VCC}}$	Reset level	11.0	12.0	12.8	V
	$\text{UVH}$	Hysteresis	-	1.6	-	V
P-side supply circuit under voltage protection	$\text{UVT}_{\text{Vb}}$	Trip level	9.5	10.4	11.0	V
	$\text{UVR}_{\text{Vb}}$	Reset level	11.0	12.0	12.8	V
	$\text{UVH}$	Hysteresis	-	1.6	-	V
$\text{IN}_{(\text{UL}, \text{VL}, \text{WL})}$ Input filter time	$t_{\text{IN, FIL}}$	$V_{\text{IN}} = 0 \text{ \& \ } 5\text{V}$ (Note 3)	100	200	-	ns
Temperature Output	$V_{\text{OT}}$	LVIC temperature= $90^\circ\text{C}$	-	2.77	-	V
		LVIC temperature= $25^\circ\text{C}$	-	1.13	-	V
Over temperature protection	$\text{OT}_t$	Trip level	100	120	140	$^\circ\text{C}$
	$\text{OT}_{\text{rh}}$	Hysteresis of trip-reset	-	10	-	$^\circ\text{C}$
VF	Bootstrap diode forward voltage	$I_f = 10\text{mA}, T_j = 25^\circ\text{C}$	0.8	-	1.1	V
R	Limiting resistance	Individual resistor	-	25	-	Ohm

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

**Note 3:** For high side PWM,  $\text{IN}_{(\text{UH}, \text{VH}, \text{WH})}$  pulse width must be  $\geq 1 \text{ us}$ .

**Input Filter Function**

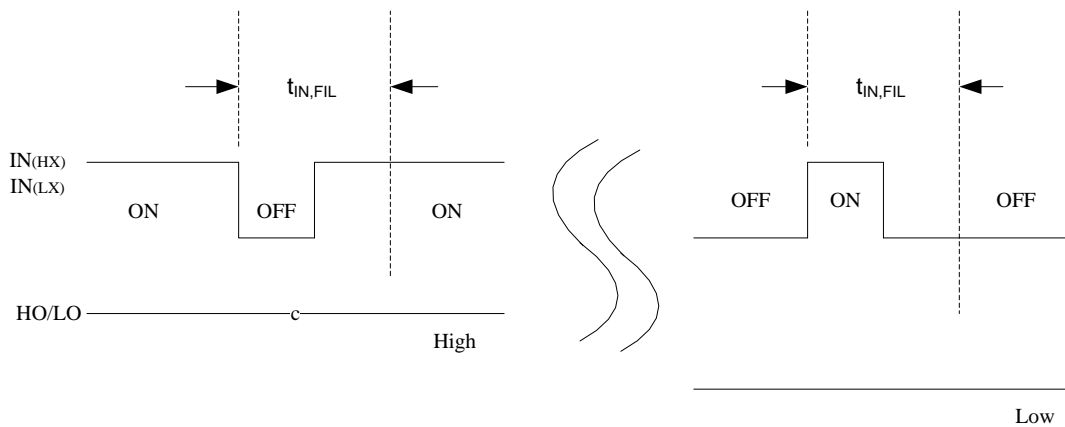


Figure 6. Input Filter Function

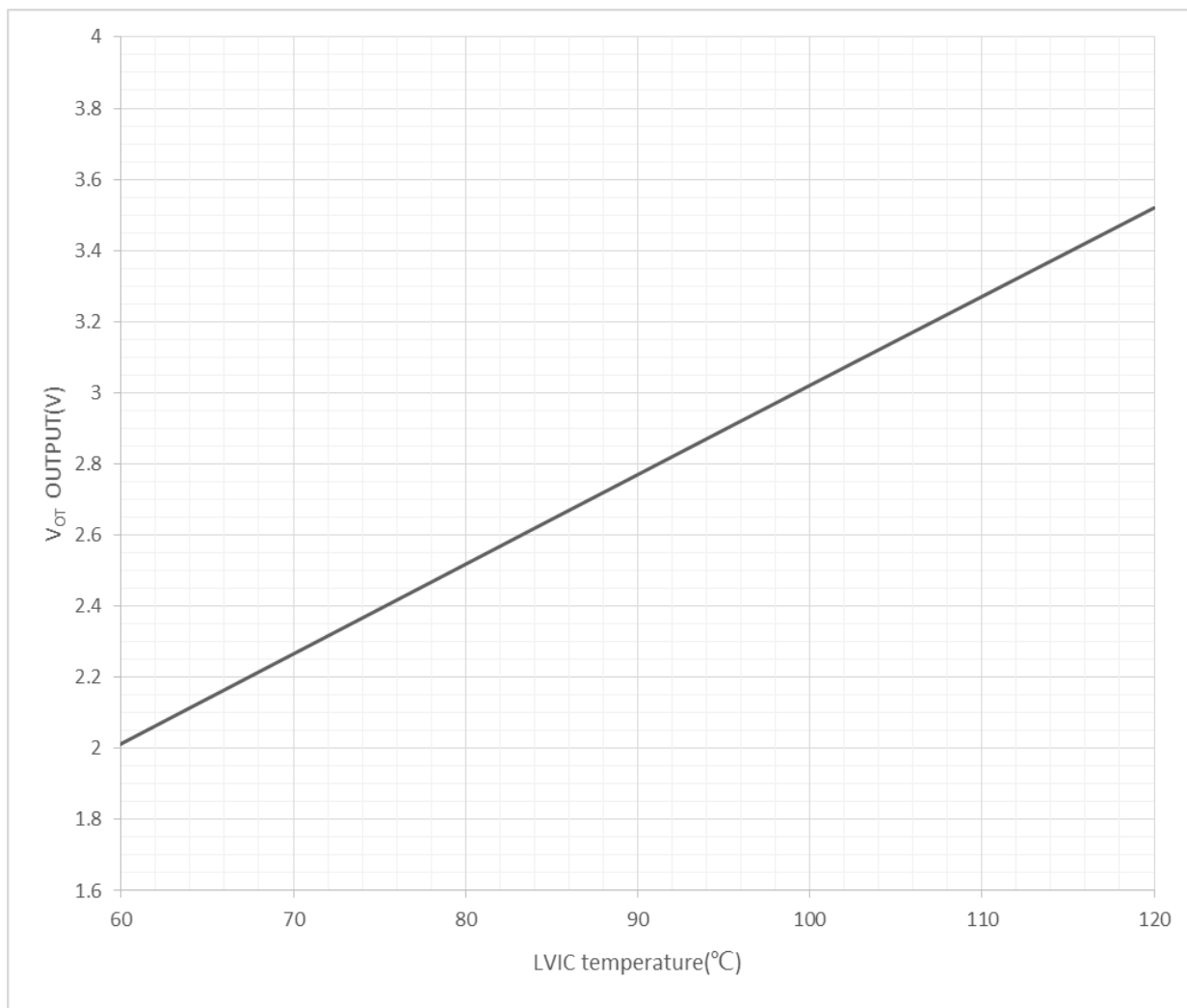


Figure 7.  $V_{OT}$  output characteristics (typical value)



**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			V
Input OFF threshold voltage	$V_{sc(OFF)}$		4.0 ~ 5.5			V
Supply voltage ripple	$\Delta V_D, \Delta V_{DB}$		-1	-	1	V/ $\mu$ s
Arm shoot-through blocking time	$t_{dead}$		1	-	-	$\mu$ s
PWM input frequency	$f_{PWM}$	$T_C \leq 100^\circ C, T_j \leq 125^\circ C$	-	15	-	kHz

**MECHANICAL CHARACTERISTICS AND RATINGS**

Item	Condition		Min.	Typ.	Max.	Unit
Mounting torque	Mounting screw: M3	Recommended 0.65N•m	0.60	0.65	0.70	N•m
Weight		--	-	9.5	-	g
Heat-sink flatness		--	-50	-	100	$\mu$ m

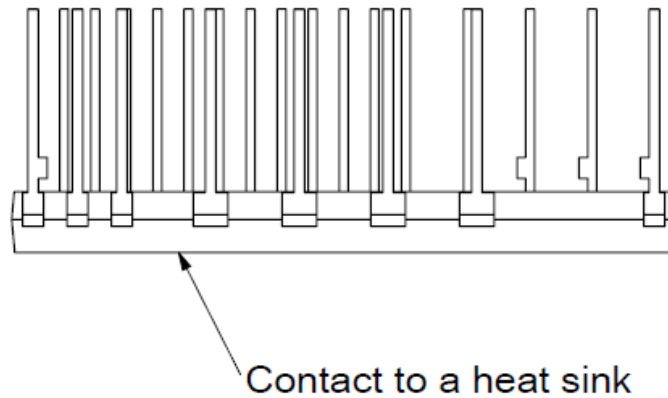


Figure 8. Measurement Location of Heat-sink Flatness

Input/Output Timing Diagram

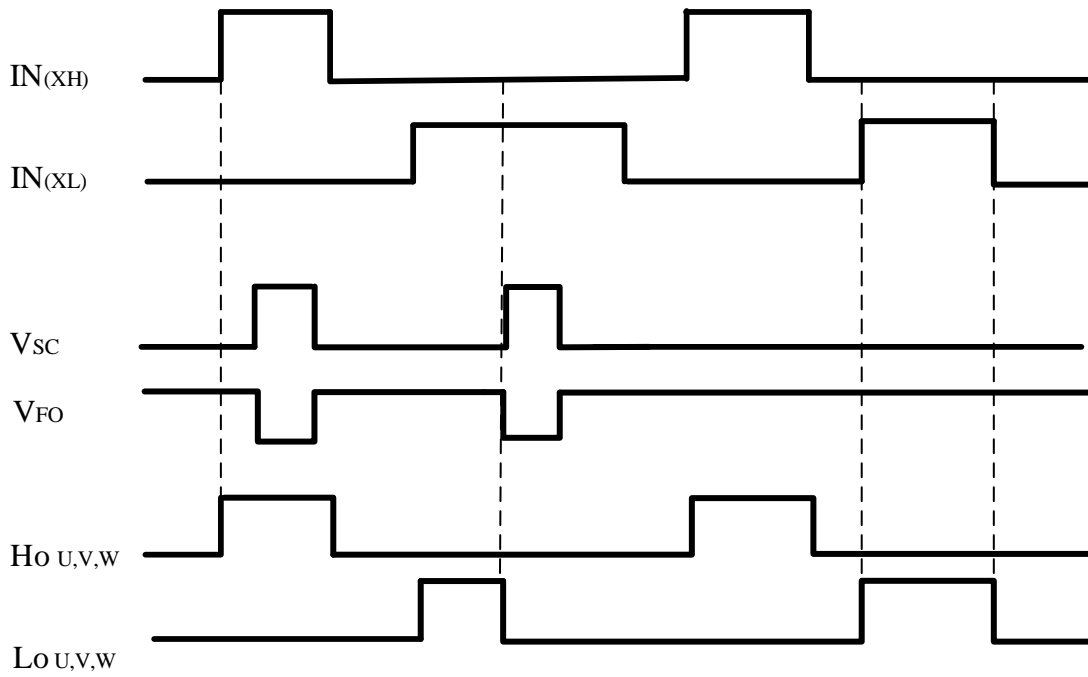


Figure 9. Input/Output Timing Diagram

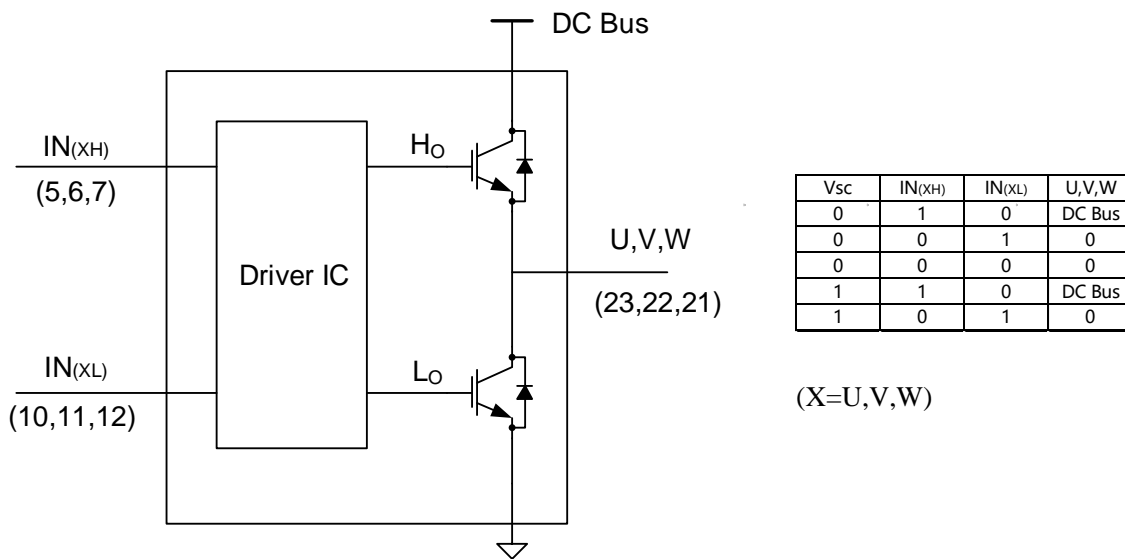


Figure 10. Input/Output Signal Circuit

**IPM Short-Circuit Protection Function  
(N-side only with the external shunt resistor and RC filter)**

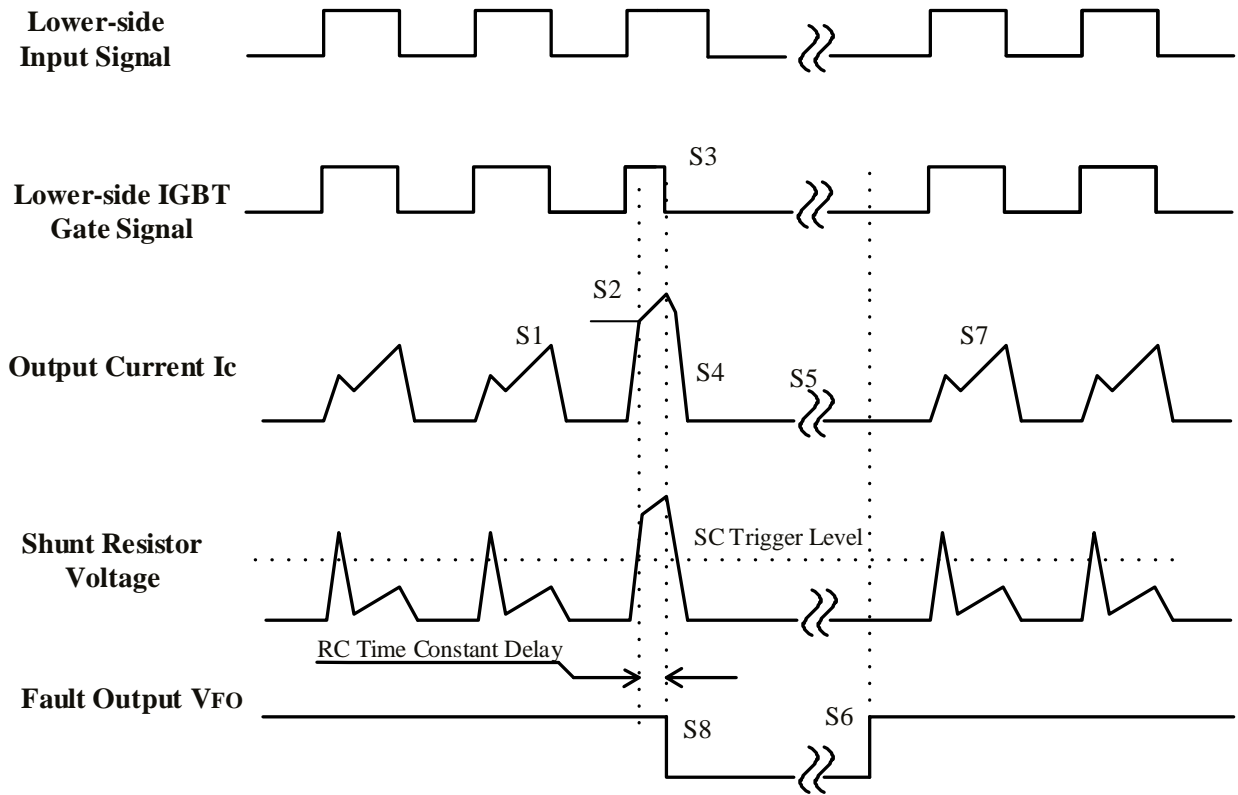


Figure 11. Timing Chart of SC Operation

- S1. The Lower-side IGBT's are controlled by input PWM signal.(Normal operation)
- S2. Short circuit event occurs and reaches the limited level. (SC protection is trigger.)
- S3. All N-side IGBT gate driving signals are disabled.
- S4. Current is cut off caused by IGBT turns OFF.
- S5. Disabled state.
- S6. Fo finishes output, but IGBT of each phase returns to normal state until inputting next ON signal(L→H).
- S7. IGBT returns for normal operation when fault state is reset.
- S8. Fault output starts once SC protection is trigger.

**IPM Under-Voltage Protection Function**

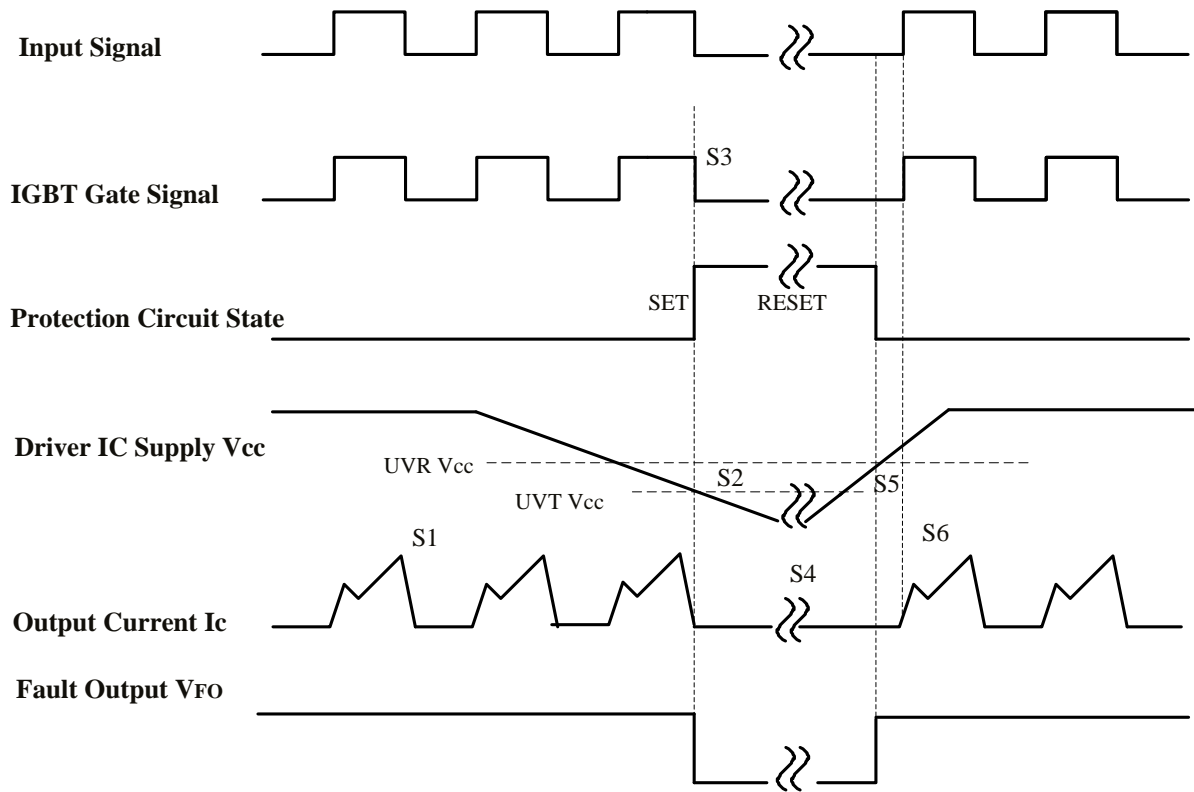


Figure 12. Timing Chart of Under-Voltage Operation

- 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.

**IPM Over Temperature Protection Function**

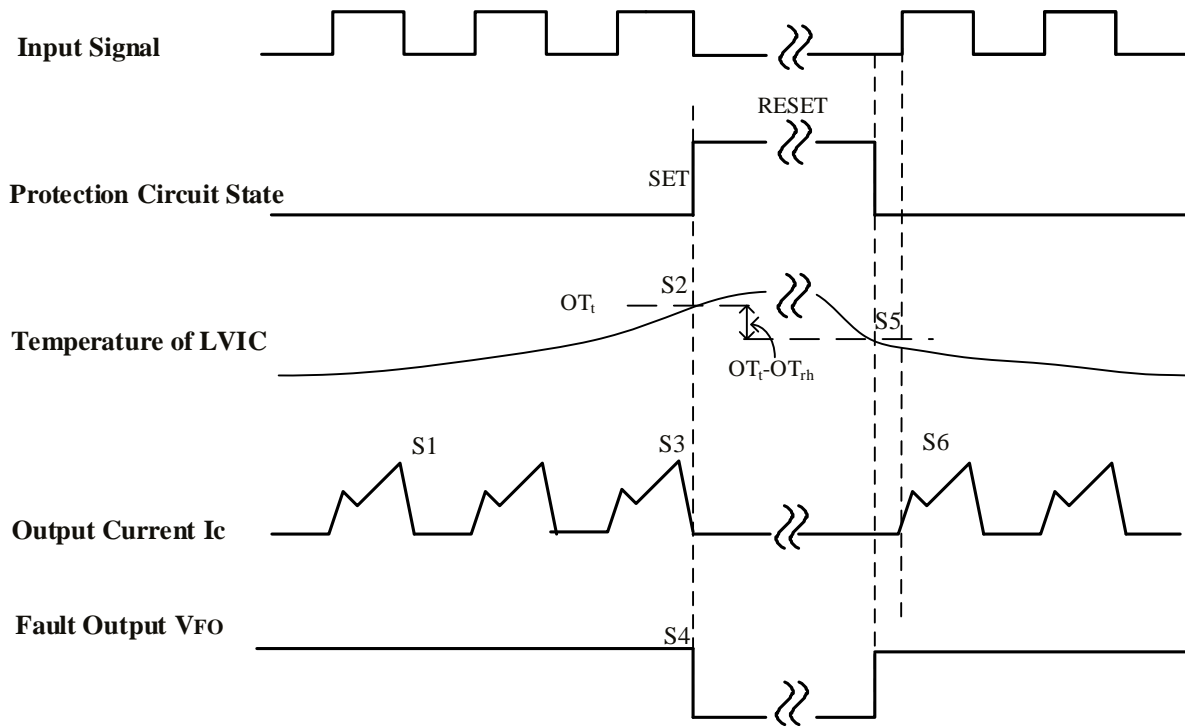


Figure 13. Timing Chart of Over Temperature Protection Operation

- S1. The IGBT's are controlled by input PWM signal.(Normal operation)
- S2. LVIC temperature exceeds over temperature trip level( $OT_t$ ).
- S3. All N-side IGBTs turn OFF in spite of control input condition.
- S4. Fo outputs for  $t_{FO}$ =minimum 20 $\mu$ s but output is extended during LVIC temperature keeps over  $OT_t$ .
- S5. LVIC temperature drops to over temperature reset level.
- S6. Normal operation: IGBT turns on by next ON signal (L->H).  
(IGBT of each phase can return to normal state by inputting ON signal to each phase.)

### Direct Input (without Photo Coupler) Interface Example

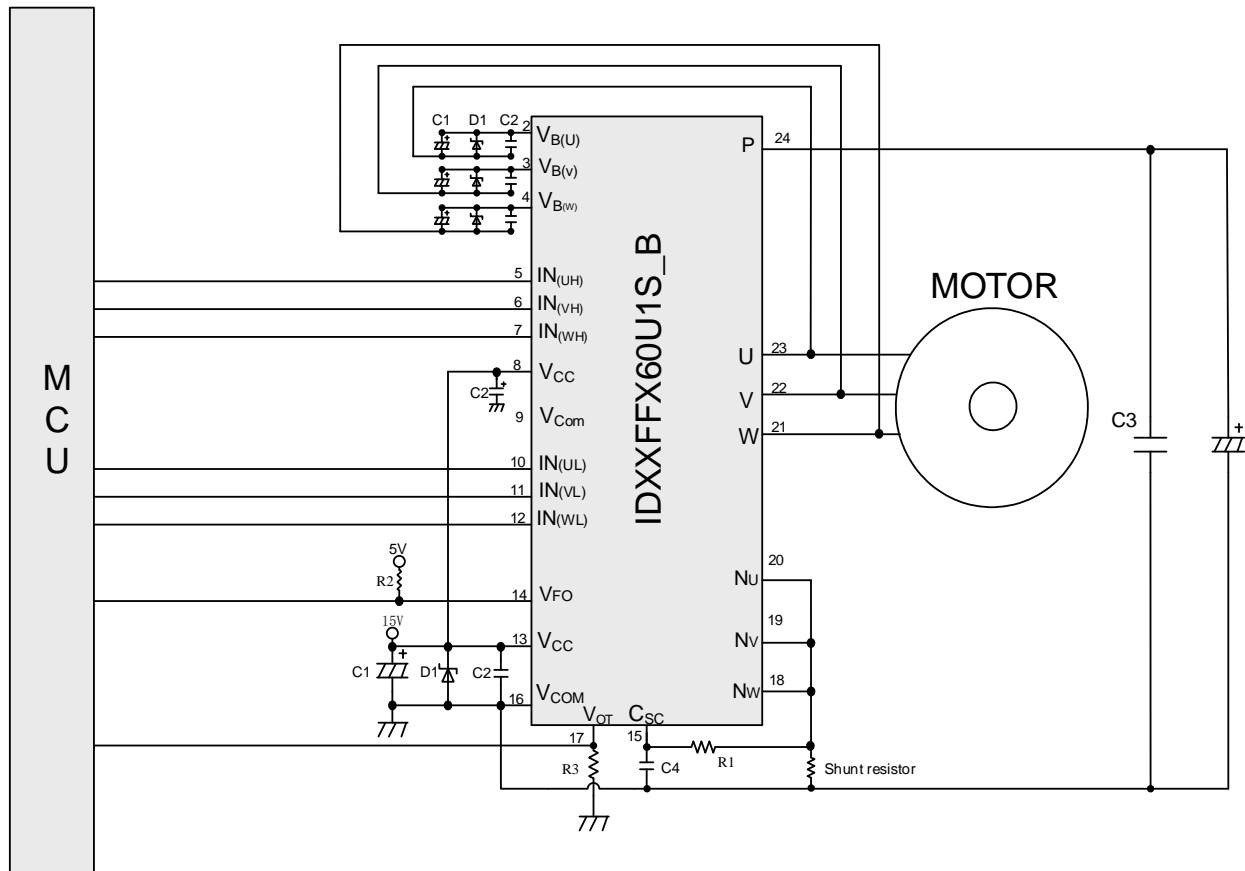


Figure 14. Typical Application Circuit Interface Example without Photo-Coupler

**Design reference:**

1. R1 : 100Ω
2. R2 : 4.7KΩ ( VFO output is open collector so to have a pull high resistor is needed. )
3. R3 : 5k-200k pull down resistor for getting linear output characteristics at low temperature below room temperature.
4. C1 : 10 ~ 100μF ( Electrolytic, low impedance )
5. C2 : 100 ~ 1000pF ( Ceramic ) ( The capacitor could filter the noise, but should be careful to the dead time)
6. C3 : 220μF ( Electrolytic, low impedance )
7. D1 : Zener diode ( It is recommended to insert a Zener diode to prevent gate lifting and surge destruction)
8. Only connect either pin 9 or pin 16 to ground, do not connect both together to form the ground loop internally.

## Current Sense Scheme

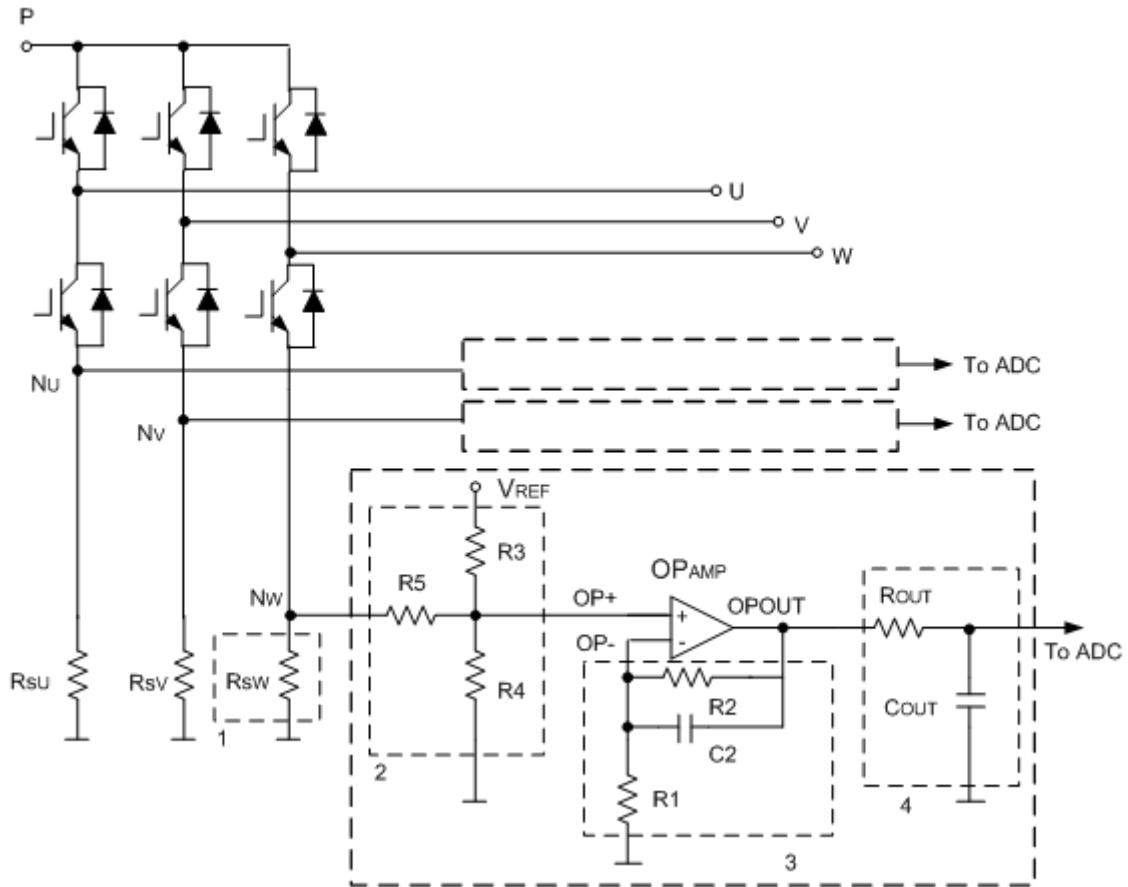


Figure 15. Current Sense Scheme

### 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.  $R_1$  : 1.0 K $\Omega$
2.  $R_2$  : 5.6 K $\Omega$
3.  $R_3$  : 4.7 K $\Omega$
4.  $R_4$  : 910  $\Omega$
5.  $R_5$  : 910  $\Omega$
6.  $R_{OUT}$  : 1.0 K $\Omega$
7.  $C_2$  : 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 M $\Omega$ .
- (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<sup>4</sup> to 10<sup>8</sup> $\Omega$ ).
- (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<sup>8</sup> $\Omega$  or less).
- (9) Equipment safety covers installed near devices should have resistance ratings of 10<sup>9</sup> $\Omega$  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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