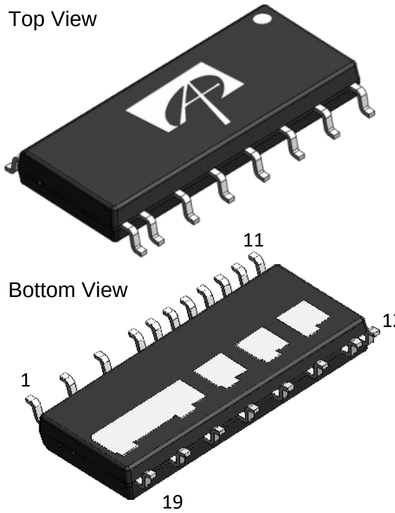
AIM7E1AR60V1

Intelligent Power Module

External View



Size: 17.9 x 7.5 x 2.5 mm

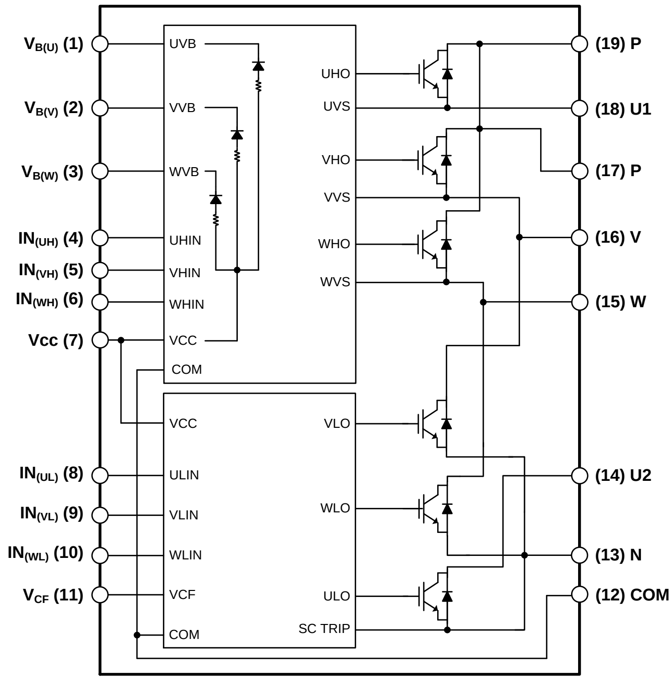
Features

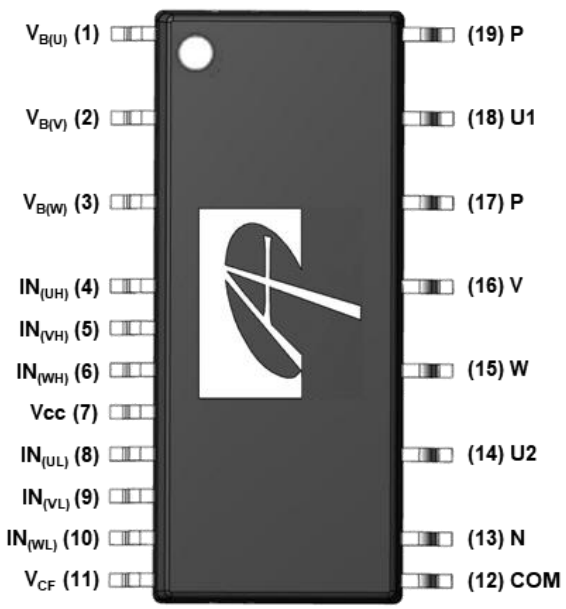
- 600V-1A RC IGBT
- Fully functional 3-phase IGBT-IPM
- Reverse conducting IGBT with monolithic body diode
- SMD package with exposed-pad
- Wide input interface (3-18V) with Schmitt-trigger input circuit
- Built-in bootstrap diodes with current-limiting resistor
- Control supply under-voltage lockout protection (UVLO)
- Over-temperature (OT) protection
- Short-circuit current protection
- Controllable fault out signal (V_{CF}) corresponding to SC, UV, OT fault
- Isolation ratings of 1500Vrms/min

Applications

- AC 100~240Vrms low power motor drives
- Fan motors

Internal Equivalent Circuit





Ordering Information

Part Number	Package	Description
AIM7E1AR60V1	IPM-7A	N/A

AOS Green Products use reduced levels of Halogens, and are also RoHS compliant.
Please visit https://aosmd.com/sites/default/files/media/AOSGreenPolicy.pdf for additional information.

Pin Description

Pin Number	Pin Name	Pin Function
1	$V_{B(U)}$	High-side control supply voltage for U-phase IGBT
2	$V_{B(V)}$	High-side control supply voltage for V-phase IGBT
3	$V_{B(W)}$	High-side control supply voltage for W-phase IGBT
4	$IN_{(UH)}$	Control signal input for high-side U-phase
5	$IN_{(VH)}$	Control signal input for high-side V-phase
6	$IN_{(WH)}$	Control signal input for high-side W-phase
7	V_{CC}	Control supply voltage
8	$IN_{(UL)}$	Control signal input for low-side U-phase
9	$IN_{(VL)}$	Control signal input for low-side V-phase
10	$IN_{(WL)}$	Control signal input for low-side W-phase
11	V_{CF}	Controllable fault signal output
12	COM	Common ground for control circuit
13	N	Common Emitter for U/V/W-phase IGBTs connecting to short-circuit current protection input, which can sense short-circuit current through connecting a sensing resistor.
14	U2	U-phase output 2. This pin should be connected to U1(pin 18)
15	W	W-phase output
16	V	V-phase output
17	P	DC-link bus positive input
18	U1	U-phase output 1. This pin should be connected to U2(pin 14)
19	P	DC-link Bus positive input

Absolute Maximum Ratings (T_J=25°C, unless otherwise specified)

Symbol	Parameter	Conditions	Ratings	Units
Inverter				
BV_{CES}	IGBT Breakdown Voltage	T_J=25°C	600	V
I_C	IGBT Collector Current (Continuous)	T_C=25°C	1	A
		T_C=80°C	0.5	A
I_{CP}	IGBT Collector Current (Pulsed)	T_C=25°C, <100µs pulse width	1.5	A
P_D	Maximum Power Dissipation	per IGBT T_C=25°C	33.4	W
T_J	Operating Junction Temperature		-40 to 150	°C
Control (Protection)				
V_{CC}	Control Supply Voltage	V_{CC}-COM	-0.3 ~ 20	V
V_{BS}	High-side Control Supply Voltage	$V_{B(U)}$-U, $V_{B(V)}$-V, $V_{B(W)}$-W	-0.3 ~ 20	V
V_{IN}	Control Signal Input Voltage	$IN_{(UH)}$, $IN_{(VH)}$, $IN_{(WH)}$, $IN_{(UL)}$, $IN_{(VL)}$, $IN_{(WL)}$-COM	-0.3 ~ V_{CC}+0.5	V
V_{CF}	Fault Output Voltage	V_{CF}-COM	-0.3 ~ 5.5	V
Thermal Resistance				
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance	Single RC-IGBT	3.0	°C/W
$R_{th(j-c)F}$		Single Diode	4.3	°C/W
Module				
T_C	Module Case Operation Temperature		-30 to 125	°C
T_{STG}	Storage Temperature		-40 to 150	°C
V_{ISO}	Isolation Voltage	60Hz, sinusoidal, AC 1min, between connected all pins and package top-center	1500	V_{rms}

Recommended Operation Conditions

Symbol	Parameter	Conditions	Min.	Typ.	Max	Units
V_{PN}	Bus Supply Voltage	V_P-V_N	0	300	450	V
V_{CC}	Control Supply Voltage	V_{CC}-COM	13.5	15.0	16.5	V
V_{BS}	High-side Control Supply Voltage	$V_{B(U)}$-U, $V_{B(V)}$-V, $V_{B(W)}$-W	13.5	15.0	16.5	V
dV_{CC}/dt, dV_{BS}/dt	Control Supply Voltage Variation		-1	-	1	V/µs
t_{dead}	Dead time	Control signals between high-side and low-side	1.5	-	-	µs
f_{PWM}	PWM Input Frequency		-	16	-	kHz
$PW_{IN(ON)}$	Minimum Input Pulse Width	(Note 1)	0.7	-	-	µs
$PW_{IN(OFF)}$			0.7	-	-	µs

Note:

1. IPM may not respond if the input pulse width is less than $PW_{IN(ON)}$, $PW_{IN(OFF)}$.

Electrical Characteristics (T_J=25°C, unless otherwise specified)

Symbol	Parameter	Conditions		Min.	Typ.	Max	Units
Inverter							
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	$V_{CC}=V_{BS}$=15V, V_{IN}=5V	I_C=1A	-	2.0	2.6	V
V_F	Emitter-Collector Forward Voltage	$V_{CC}=V_{BS}$=15V, V_{IN}=0	I_C=1A	-	2.4	2.9	V
t_{OFF}	Switching Times	V_{PN}=300V, $V_{CC}=V_{BS}$=15V I_C=1A, V_{IN}=0V↔5V Inductive load (high-side)		-	1000	-	ns
t_f				-	90	-	ns
t_{ON}				-	600	-	ns
t_r				-	50	-	ns
t_{rr}				-	210	-	ns
I_{CES}	Collector-Emitter Leakage Current	V_{IN}=0V, V_{CE}=600V		-	-	1	mA
Control (Protection)							
I_{QCC}	Quiescent V_{CC} Supply Current	V_{CC}=15V, $IN_{(UL, VL, WL)}$=0V	V_{CC}-COM	-	-	1.5	mA
I_{QBS}	Quiescent V_{BS} Supply Current	V_{BS}=15V, $IN_{(UH, VH, WH)}$=0V	$V_{B(U)}$-U, $V_{B(V)}$-V, $V_{B(W)}$-W	-	-	0.3	mA
UV_{CCT}	Supply Circuit Under-voltage Protection	Trip Level		10.3	11.4	12.5	V
UV_{CCR}		Reset Level		10.8	11.9	13.0	V
UV_{BST}		Trip Level		9.0	10.0	11.0	V
UV_{BSR}		Reset Level		10.0	11.0	12.0	V
I_{IN}	Input Bias Current	V_{IN}=5V		-	650	850	μA
$V_{IN,TH(ON)}$	ON Threshold Voltage	$IN_{(UH)}$, $IN_{(VH)}$, $IN_{(WH)}$, $IN_{(UL)}$, $IN_{(VL)}$, $IN_{(WL)}$ – COM		-	-	2.5	V
$V_{IN,TH (OFF)}$	OFF Threshold Voltage			0.8	-	-	V
V_{SC}	Short-circuit Trip Level	V_{CC}=15V		0.9	1	1.1	V
OT_T	Over-temperature Protection	V_{CC}=15V	Trip Level	110	130	150	°C
OT_{HYS}			Hysteresis of Trip Reset	-	30	-	°C
V_{CFH}	Fault Output Voltage	V_N=0V		4.9	-	-	V
V_{CFL}		V_N=1V		-	-	0.5	V
V_{CF+}	V_{CF} positive going threshold			-	1.9	2.2	V
V_{CF-}	V_{CF} negative going threshold			0.8	1.1	-	V
t_{FO}	Fault Output Pulse Width (Note 2)	When C_{CF} is not connected		20	-	-	μs
Bootstrap Diode							
$V_{F(BSD)}$	Bootstrap Diode Forward Voltage	I_F=10mA including voltage drop by limiting resistor		-	3.6	-	V
R_{BSD}	Bootstrap Diode Equivalent Resistance			-	360	-	Ω

Note:

2. Fault output signal V_{CF} becomes low when one of protections OT, SC or UVLO is triggered. When failures happen like UV or OT, V_{CF} keeps low continuously until recovering from UV or OT state. 20μs indicates min. fault output duration time without pull-down capacitor. It can be controlled by the capacitor value as shown in Figure 1.

Functional Description

Controllable Fault Output Circuit

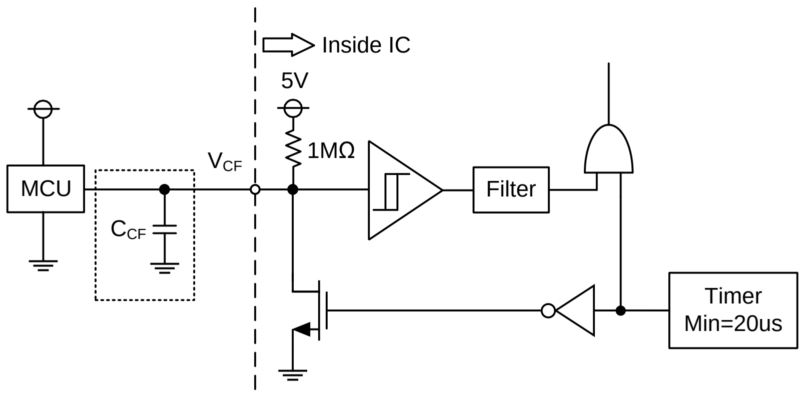


Figure 1. V_{CF} Output Circuit

V_{CF} pin provides an enable functionality that enables to shut down all low side IGBTs, besides it can be controlled with external MCU. When V_{CF} is in the high state, the IPM is able to operate normally. Meanwhile, V_{CF} is in a low state, the low-side IGBTs are turned off until V_{CF} recovers to the high state. In addition, the V_{CF} pin provides fixed or adjustable pulse width of fault output signal using external capacitor. If V_{CF} pin is left, the fault output pulse width t_{FO} is maintained as the low state for minimum 20us. If a capacitor is connected, the pulse width can be increased depending on to the capacitance.

The pulse width can be determined by the following formula;

$$t_{FO} = -(1M\Omega \cdot C_{CF}) \cdot ln\left(1 - \frac{V_{CF+}}{5V}\right) + 20usec$$

$$\approx 478k \cdot C_{CF} + 20usec$$

for example, adding C_{CF}=1nF, t_{FO}≈500us.

Short-Circuit (SC) Protection and Time Chart

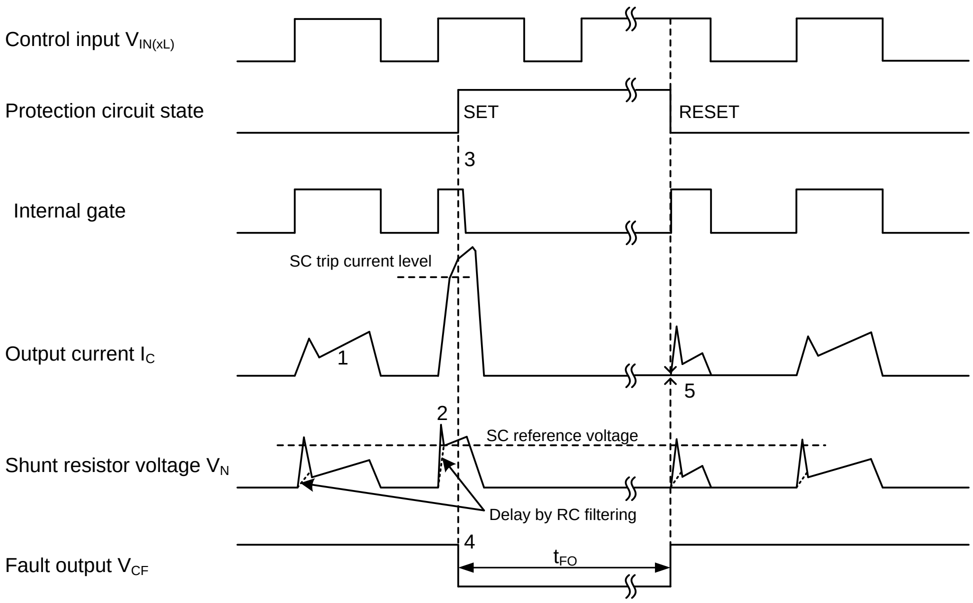


Figure 2. Short-Circuit Protection

Adding shunt resistors between terminal N (Pin 13) and COM (Pin 12), SC protection can be operable. SC protection operational time chart can be described in Figure 2.

(1) In normal operation, IGBT turns on and normal collector current I_C happens.

(2) Once over current touches to SC trip level, SC protection is triggered.

(3) All low-side IGBTs' gate are turned off. Accordingly, all low-side IGBTs are turned off.

(4) Fault signal V_{CF} becomes from high to low and sustains low for t_{FO} (minimum 20μs).

(5) V_{CF} recovers to high, normal operation restarts according to the input control signal.

V_{CC} Under-voltage Lock-out (UVLO) Protection and Time Chart

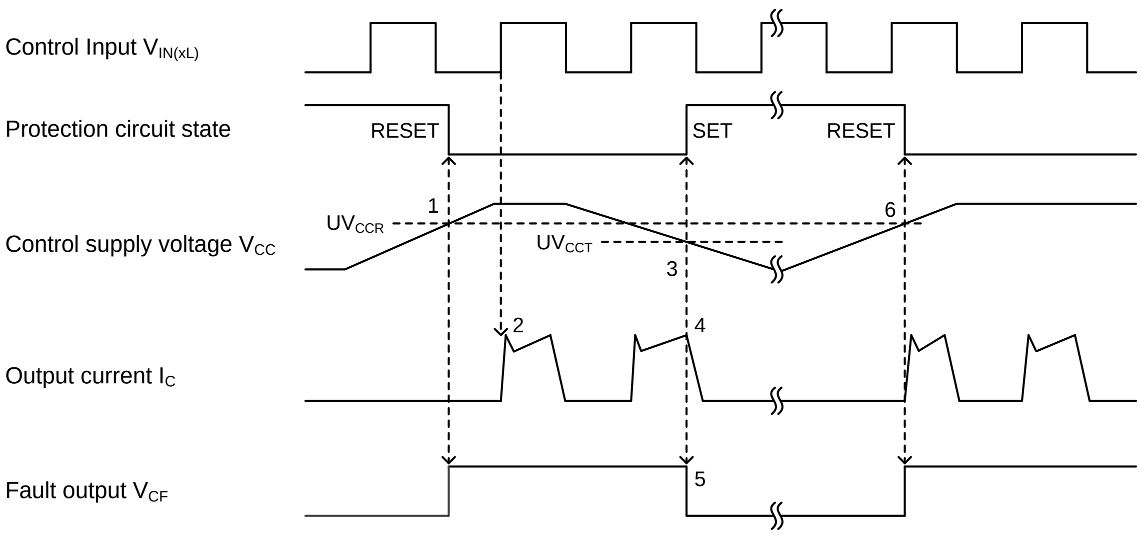


Figure 3. Under-Voltage Protection (Low-side, V_{CC})

(1) Supply voltage V_{CC} becomes higher than under-voltage reset level (UV_{CCR}), and IGBTs are turned on by the next ON signal.

(2) Normal operation: IGBTs turn-on and output current.

(3) V_{CC} level drops to under-voltage trip level (UV_{CCT}).

(4) All low-side IGBTs are turned off regardless of control input condition.

(5) V_{CF} output becomes low and stays as long as V_{CC} is below UV_{CCR}.

(6) Once V_{CC} level reaches UV_{CCR}, IGBTs restart working normally according to the input control signal.

V_{BS} Under-voltage Lock-out (UVLO) Protection and Time Chart

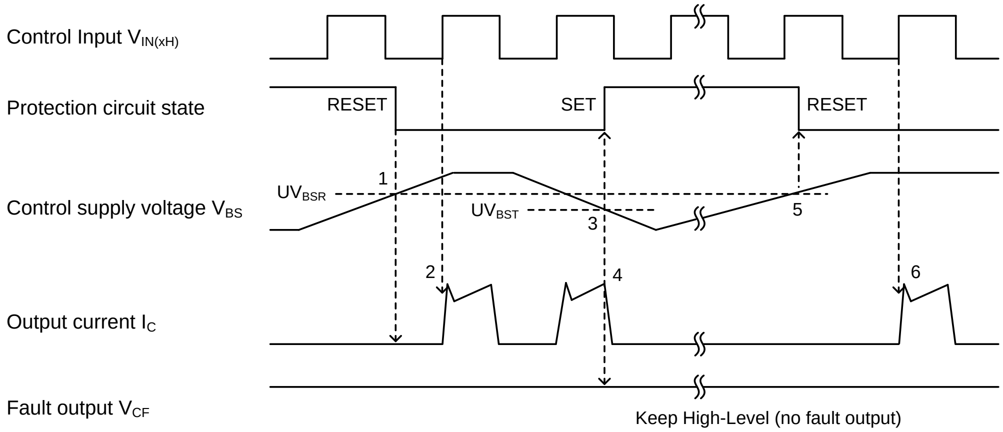


Figure 4. Under-Voltage Protection (High-side, V_{BS})

(1) Control supply voltage V_{BS} rises. After the voltage reaches under-voltage reset level (UV_{BSR}), IGBTs are turned on by the next ON signal.
(2) Normal operation: IGBTs turn on and output current.
(3) V_{BS} level drops to under-voltage trip level (UV_{BST}).
(4) All high-side IGBTs are turned off regardless of control input condition.
(5) V_{BS} level reaches UV_{BSR}.
(6) Normal operation starts according to the input control signal.

Over Temperature (OT) Protection and Time Chart

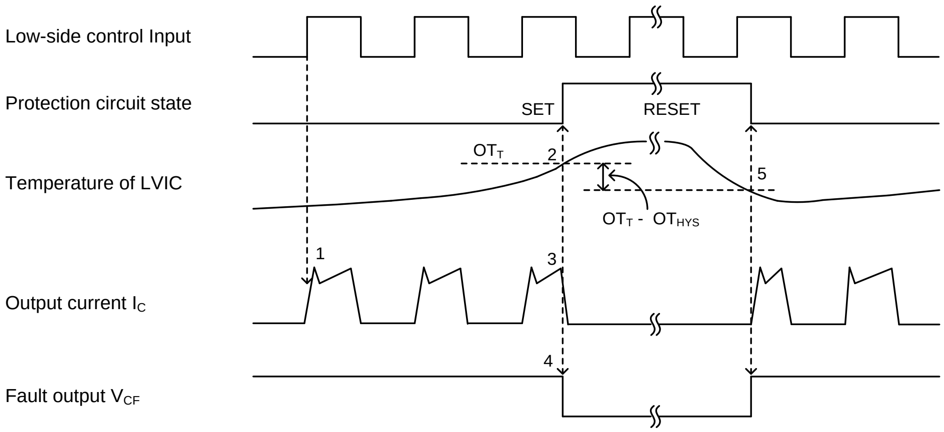
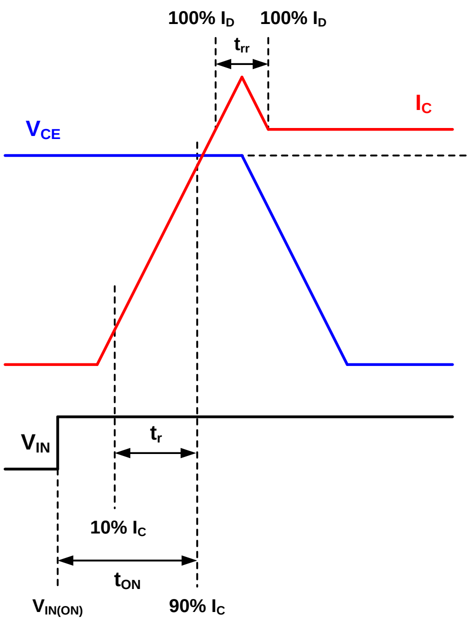


Figure 5. Over-Temperature Protection

(1) Normal operation: IGBTs turn on and output current.
(2) LVIC temperature exceeds over-temperature trip level (OT_T).
(3) All low-side IGBTs are turned off regardless of control input condition.
(4) V_{CF} output becomes low and stays as long as LVIC temperature is over OT_T.
(5) LVIC temperature drops to over-temperature reset level ($OT_{T-OTHYS}$). Normal operation starts according to the input control signal.

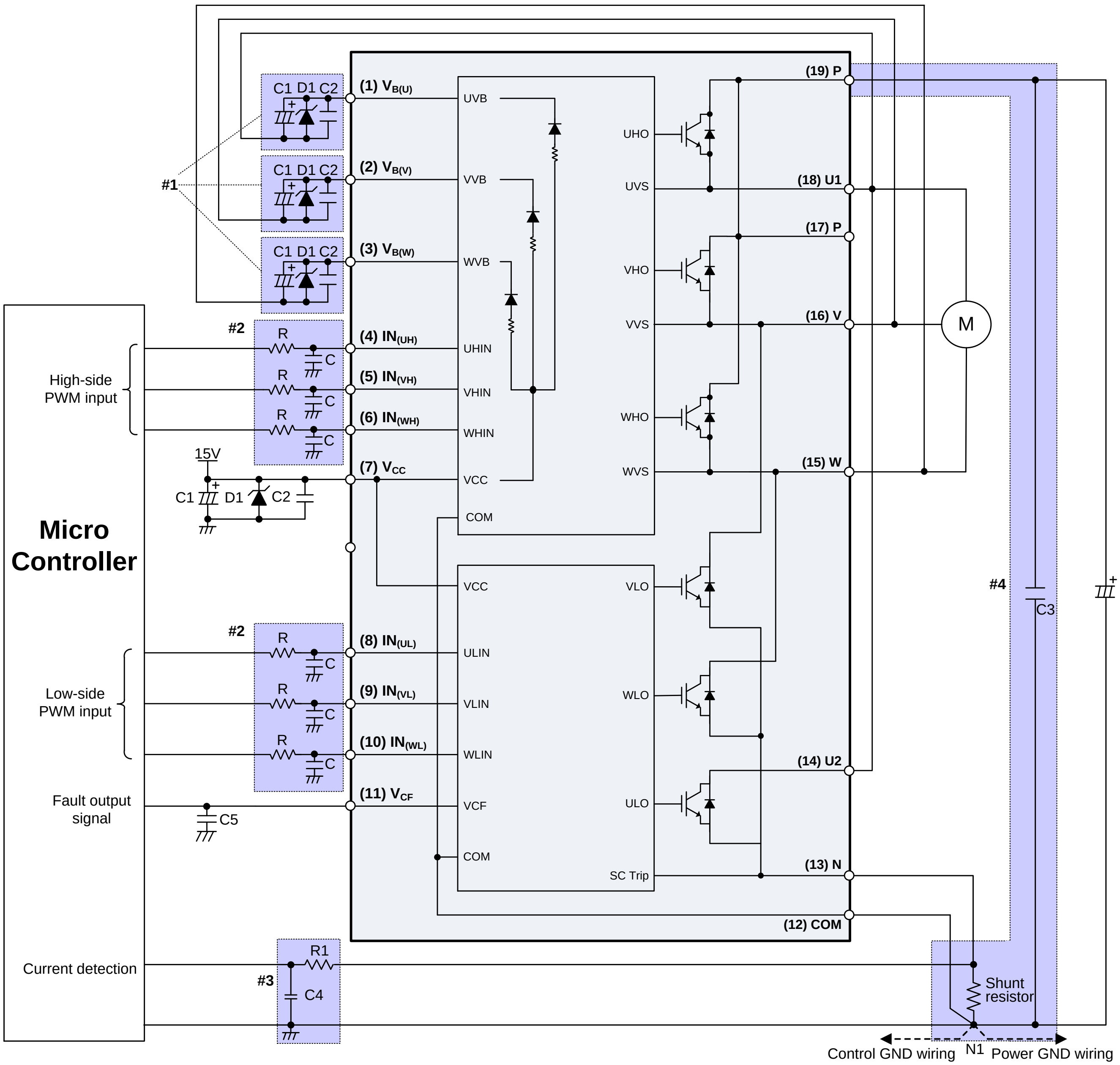
Switching Time Definition



(a) Turn-on Waveform (b) Turn-off Waveform

Figure 6. Switching Times Definition

Typical Application Circuit and Design Guide



Recommended Component Values:

(#1) C1:1~3.3µF, C2:100nF, D1:20V (#2) R:100Ω, C:1nF

(#3) R1:1kΩ, C4:2nF (#4) C3:0.1~0.22µF

Figure 7. Typical Application Circuit

#1: Filter circuits for V_{CC} and V_{BS}

It is recommended that all capacitors are placed as close to the IPM as possible. C1 is recommended to electrolytic type with good temperature and frequency characteristics. C2 should be ceramic type with 0.1-2µF, good temperature, frequency and DC bias characteristics. A zener diode D1 (20V/1W) is recommended between each pair of control supply pins to avoid damage by external surge.

#2: Filter circuits for IN terminal

IN pins work with active-high and there is a minimum 3.5kΩ pull-down resistor IPM inside. To prevent malfunction, the layout of each IN pins from MCU should be as short as possible. Recommended RC filter is 100ns of time constant, which can be adjusted considering amount of noise.

#3: Filter circuits for SC and V_{CF}

Selection of the R1*C4 filter components for short-circuit protection is recommended to have tight tolerance and temperature-compensated type. The R1*C4 time constant should be set such that SC current is shut down within 2µs; (typically 1.5-2µs). R1 and C4 should be placed as close to N pin as possible. SC interrupting time may vary with layout patterns and components selections, therefore thorough evaluation in the system is necessary.

Capacitor C5 can adjust fault output pulse duration time V_{CF}. Without C5, V_{CF} has fixed minimum 20us pulse width. For the design guide, please refer to the Figure 1.

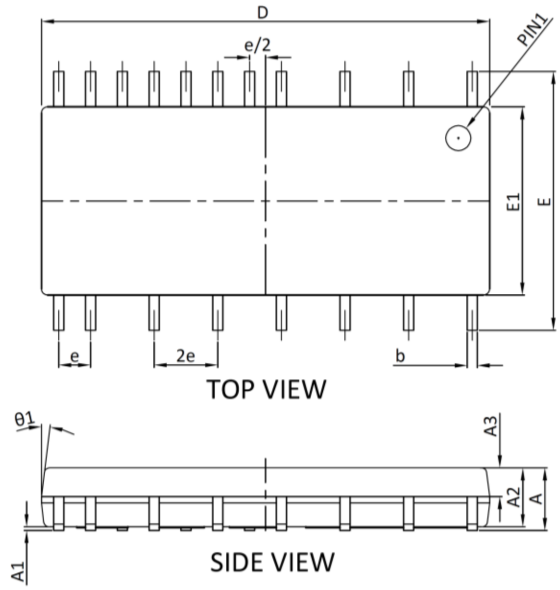
#4: Shunt resistance, GND layout and snubber capacitor

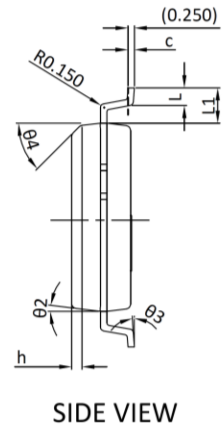
For designing a shunt resistor, it is recommended that short circuit trip level should be set less than 1.6 times of the rated current and the shunt resistor should be selected non-inductive and high accurate characteristic.

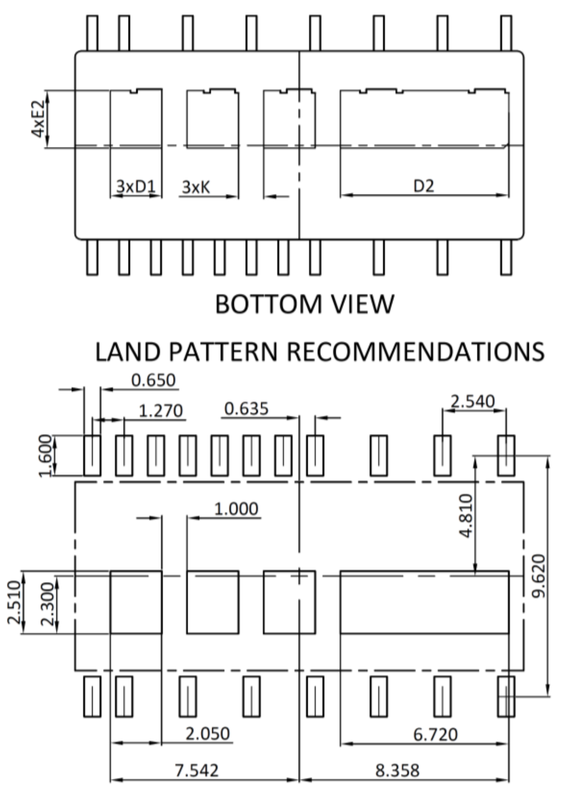
It is recommended to connect the control GND and power GND at a single point (N1) near the terminal of the shunt resistor. Control-related components such as V_{CC}, IN and V_{CF} should be connected to control GND and power-related components of C3 and dc-link capacitor should be connected to power GND to avoid noise interference from power GND to control GND.

The snubber capacitor C3 plays a role of absorbing high spike voltage on dc-link during switching operation so that it should be placed as close to pin P and pin N as possible. Generally a 0.1-0.22µF snubber capacitor is recommended.

Package Dimensions, IPM-7A







SYMBOLS	DIMENSION IN MILLIMETRES			DIMENSION IN INCHS		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	2.304	2.504	2.704	0.091	0.099	0.106
A1	0.050	0.150	0.250	0.002	0.006	0.010
A2	2.254	2.354	2.454	0.089	0.093	0.097
A3	1.050	1.150	1.250	0.041	0.045	0.049
D	17.800	17.900	18.000	0.701	0.705	0.709
D1	1.960	2.060	2.160	0.077	0.081	0.085
D2	6.620	6.720	6.820	0.261	0.265	0.269
E	10.140	10.340	10.540	0.399	0.407	0.415
E1	7.420	7.520	7.620	0.292	0.296	0.300
E2	2.200	2.300	2.400	0.087	0.091	0.094
L	0.505	0.705	0.905	0.020	0.028	0.036
L1	1.210	1.410	1.610	0.048	0.056	0.063
K	1.000	-	-	0.039	-	-
e	1.270TYP.			0.050TYP.		
b	0.410TYP.			0.016TYP.		
c	0.254TYP.			0.010TYP.		
θ1	7°TYP.			7°TYP.		
θ2	7°TYP.			7°TYP.		
θ3	0°	---	8°	0°	---	8°
θ4	45°TYP.			45°TYP.		
h	0.381TYP.			0.015TYP.		

UNIT: mm

NOTES

1. PACKAGE BODY SIZES EXCLUDE MOLD FLASH AND GATE BURRS, MOLD FLASH SHOULD BE LESS THAN 6 MIL.
2. TOLERANCE 0.100 MILLIMETERS UNLESS OTHERWISE SPECIFIED.
3. CONTROLLING DIMENSION IS MILLIMETER, CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.

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