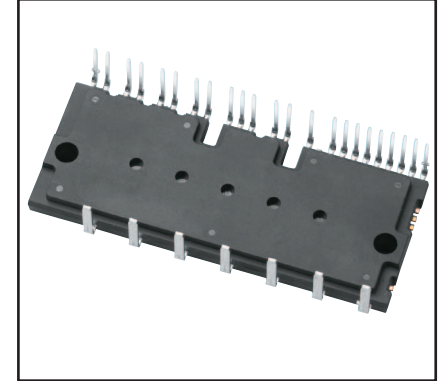
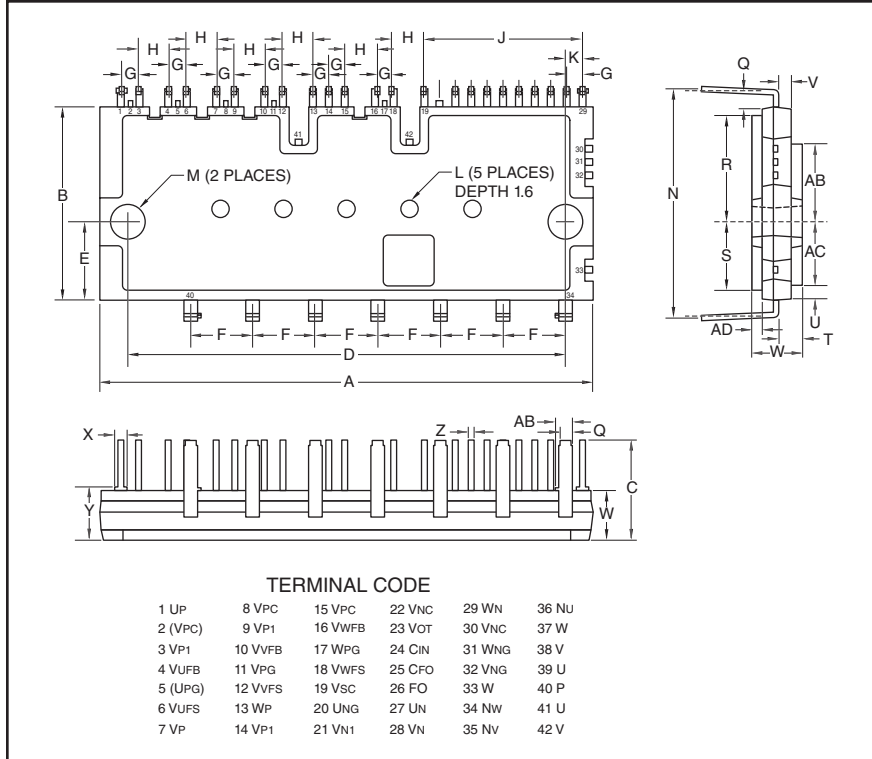


### Intellimod™ Module Dual-In-Line Intelligent Power Module 75 Amperes/600 Volts



#### Description:

DIPIMs are intelligent power modules that integrate power devices, drivers, and protection circuitry. Design time is reduced by the use of application-specific HVICs and value-added features such as linear temperature feedback. Overall efficiency and reliability are increased by the use of full gate CSTBT technology and low thermal impedance.

#### Features:

- Low-loss, Full Gate CSTBT IGBTs
- Single Power Supply
- Integrated HVICs
- Direct Connection to CPU

#### Applications:

- Variable Speed Pumps
- Variable Speed Compressors
- Small Motor Control

#### Ordering Information:

PS21A7A is a 600V, 75 Ampere DIP Intelligent Power Module.

#### Outline Drawing and Circuit Diagram

Dimensions	Inches	Millimeters
A	3.11±0.02	79.0±0.5
B	1.22±0.02	31.0±0.5
C	0.63	16.0
D	2.76±0.01	70.0±0.3
E	0.5	12.7
F	0.39±0.01	10.0±0.3
G	0.1±0.01	2.54±0.3
H	0.2±0.01	5.08±0.3
J	1.0	25.4
K	0.11	2.8
L	0.12 Dia.	2.9 Dia.
M	0.18±0.01 Dia.	4.5±0.2 Dia.
N	1.42±0.02	36.2±0.5
P	0.03	0.7

Dimensions	Inches	Millimeters
Q	0.08	2.0
R	0.66	16.73
S	0.44	11.13
T	0.15±0.04	3.8±1.0
U	0.082	2.1
V	0.086	2.2
W	0.31	8.0
X	0.07	1.8
Y	0.34	8.6
Z	0.03	0.8
AA	0.10	2.7
AB	0.48	12.33
AC	0.39	10.12
AD	0.068	1.75

**PS21A7A**  
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**Dual-In-Line Intelligent Power Module**  
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## Absolute Maximum Ratings, $T_j = 25^\circ\text{C}$ unless otherwise specified

Characteristics	Symbol	PS21A7A	Units
Self-protection Supply Voltage Limit (Short Circuit Protection Capability)*	$V_{CC(\text{prot.})}$	400	Volts
Module Case Operation Temperature (See $T_C$ Measurement Point Below)	$T_C$	-20 to 100	$^\circ\text{C}$
Storage Temperature	$T_{\text{stg}}$	-40 to 125	$^\circ\text{C}$
Mounting Torque, M4 Mounting Screws	—	13	in-lb
Module Weight (Typical)	—	65	Grams
Isolation Voltage, AC 1 minute, 60Hz Sinusoidal, Connection Pins to Heatsink Plate	$V_{\text{ISO}}$	2500	Volts

## IGBT Inverter Sector

Supply Voltage (Applied between P-NU, NV, NW)	$V_{CC}$	450	Volts
Supply Voltage, Surge (Applied between P-NU, NV, NW)	$V_{CC(\text{surge})}$	500	Volts
Collector-Emitter Voltage ( $T_C = 25^\circ\text{C}$ )	$V_{CES}$	600	Volts
Collector Current ( $T_C = 25^\circ\text{C}$ )	$\pm I_C$	75	Amperes
Peak Collector Current ( $T_C = 25^\circ\text{C}$ , <1ms)	$\pm I_{CP}$	150	Amperes
Collector Dissipation ( $T_C = 25^\circ\text{C}$ , per 1 Chip)	$P_C$	162	Watts
Power Device Junction Temperature**	$T_j$	-20 to 150	$^\circ\text{C}$

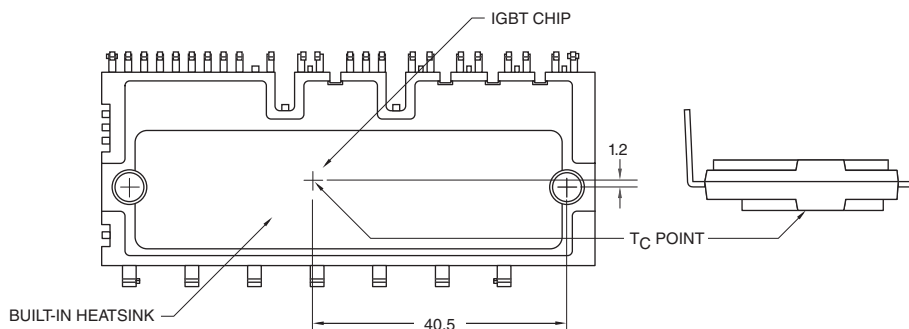
## Control Sector

Supply Voltage (Applied between $V_{P+}$ - $V_{PC}$ , $V_{N+}$ - $V_{NC}$ )	$V_D$	20	Volts
Supply Voltage (Applied between $V_{UFB}$ - $V_{UFS}$ , $V_{VFB}$ - $V_{VFS}$ , $V_{WFB}$ - $V_{WFS}$ )	$V_{DB}$	20	Volts
Input Voltage (Applied between $U_P$ , $V_P$ , $W_P$ - $V_{PC}$ , $U_N$ , $V_N$ , $W_N$ - $V_{NC}$ )	$V_{IN}$	-0.5 ~ $V_D+0.5$	Volts
Fault Output Supply Voltage (Applied between $F_O$ - $V_{NC}$ )	$V_{FO}$	-0.5 ~ $V_D+0.5$	Volts
Fault Output Current (Sink Current at $F_O$ Terminal)	$I_{FO}$	1	mA
Current Sensing Input Voltage (Applied between $C_{IN}$ - $V_{NC}$ )	$V_{SC}$	-0.5 ~ $V_D+0.5$	Volts

\* $V_D = 13.5 \sim 16.5\text{V}$ , Inverter Part,  $T_j = 125^\circ\text{C}$ , Non-repetitive, Less than 2 $\mu\text{s}$

\*\*The maximum junction temperature rating of the power chips integrated within the DIPIPM is  $150^\circ\text{C}$  (@  $T_f \leq 100^\circ\text{C}$ ). However, to ensure safe operation of the DIPIPM, the average junction temperature should be limited to  $T_{j(\text{avg})} \leq 125^\circ\text{C}$  (@  $T_f \leq 100^\circ\text{C}$ ).

## $T_C$ Measurement Point





Powerex, Inc., 173 Pavilion Lane, Youngwood, Pennsylvania 15697 (724) 925-7272

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**Electrical and Mechanical Characteristics,  $T_j = 25^\circ\text{C}$  unless otherwise specified**

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Units
<b>IGBT Inverter Sector</b>						
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 75\text{A}, T_j = 25^\circ\text{C}, V_D = V_{DB} = 15\text{V}, V_{IN} = 5\text{V}$	—	1.55	2.05	Volts
		$I_C = 75\text{A}, T_j = 125^\circ\text{C}, V_D = V_{DB} = 15\text{V}, V_{IN} = 5\text{V}$	—	1.65	2.10	Volts
Diode Forward Voltage	$V_{EC}$	$T_j = 25^\circ\text{C}, -I_C = 75\text{A}, V_{IN} = 0\text{V}$	—	1.70	2.20	Volts
Inductive Load Switching Times	$t_{on}$		1.80	2.40	—	$\mu\text{s}$
	$t_{rr}$	$V_{CC} = 300\text{V}, V_D = V_{DB} = 15\text{V},$	—	0.30	—	$\mu\text{s}$
	$t_{C(on)}$	$I_C = 75\text{A}, T_j = 125^\circ\text{C}, V_{IN} = 0 \leftrightarrow 5\text{V},$	—	0.40	—	$\mu\text{s}$
	$t_{off}$	Inductive Load (Upper-Lower Arm)	—	3.40	—	$\mu\text{s}$
	$t_{C(off)}$		—	0.65	—	$\mu\text{s}$
Collector-Emitter Cutoff Current	$I_{CES}$	$V_{CE} = V_{CES}, T_j = 25^\circ\text{C}$	—	—	1.0	mA
		$V_{CE} = V_{CES}, T_j = 125^\circ\text{C}$	—	—	10	mA
<b>Control Sector</b>						
Circuit Current	$I_D$	$V_D = V_{DB} = 15\text{V}, V_{IN} = 5\text{V},$ Total of $V_{P1}-V_{PC}, V_{N1}-V_{NC}$	—	—	7.00	mA
		$V_D = V_{DB} = 15\text{V}, V_{IN} = 5\text{V},$ $V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS}, V_{WFB}-V_{WFS}$	—	—	0.55	mA
		$V_D = V_{DB} = 15\text{V}, V_{IN} = 0\text{V},$ Total of $V_{P1}-V_{PC}, V_{N1}-V_{NC}$	—	—	7.00	mA
		$V_D = V_{DB} = 15\text{V}, V_{IN} = 0\text{V},$ $V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS}, V_{WFB}-V_{WFS}$	—	—	0.55	mA
Fault Output Voltage	$V_{FOH}$	$V_{SC} = 0\text{V}, F_O$ Terminal Pull-up to 5V by 10k $\Omega$	4.9	—	—	Volts
	$V_{FOL}$	$V_{SC} = 1\text{V}, I_{FO} = 1\text{mA}$	—	—	0.95	Volts
Input Current	$I_{IN}$	$V_{IN} = 5\text{V}$	1.0	1.5	2.0	mA
Short-Circuit Trip Level*	$I_{SC}$	$-20^\circ\text{C} \leq T_C \leq 100^\circ\text{C}, V_D = 15\text{V}, R_S = 18.7\Omega$	127.5	—	225.0	Amps
Supply Circuit Undervoltage Protection	$UV_{DBt}$	Trip Level, $T_C \leq 100^\circ\text{C}$	10.0	—	12.0	Volts
	$UV_{DBr}$	Reset Level, $T_C \leq 100^\circ\text{C}$	10.5	—	12.5	Volts
	$UV_{Dt}$	Trip Level, $T_C \leq 100^\circ\text{C}$	10.3	—	12.5	Volts
	$UV_{Dr}$	Reset Level, $T_C \leq 100^\circ\text{C}$	10.8	—	13.0	Volts
Fault Output Pulse Width**	$t_{FO}$	$C_{FO} = 22\text{nF}$	1.0	1.8	—	ms
ON Threshold Voltage	$V_{th(on)}$	Applied between $U_P, V_P, W_P-V_{PC},$	2.1	2.3	2.6	Volts
OFF Threshold Voltage	$V_{th(off)}$	$U_N, V_N, W_N-V_{NC}$	0.8	1.4	2.1	Volts
Temperature Output***	$V_{OT}$	At LVIC Temperature = $85^\circ\text{C}$	3.50	3.63	3.76	Volts

\* Short-Circuit protection is functioning only at the lower arms. Please select the value of the external shunt resistor such that the SC trip level is less than 85A.

\*\*Fault signal is asserted when the lower arm short circuit or control supply under-voltage protective functions operate. The fault output pulse-width  $t_{FO}$  depends on the capacitance value of  $C_{FO}$  according to the following approximate equation:  $C_{FO} = (12.2 \times 10^{-6} \times t_{FO} [F])$ .

\*\*\*When the temperature rises excessively, the controller (MCU) should stop the DIPIPM.

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## Thermal Characteristics, $T_j = 25^\circ\text{C}$ unless otherwise specified

Characteristic	Symbol	Condition	Min.	Typ.	Max.	Units
Thermal Resistance Junction to Case	$R_{th(j-c)Q}$	IGBT Part (Per 1/6 Module)	—	—	0.77	$^\circ\text{C}/\text{Watt}$
Thermal Resistance Junction to Case	$R_{th(j-c)D}$	FWDI Part (Per 1/6 Module)	—	—	1.25	$^\circ\text{C}/\text{Watt}$

## Recommended Conditions for Use

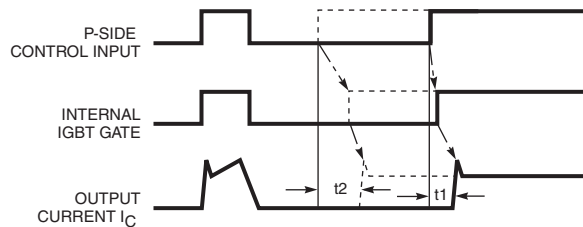
Characteristic	Symbol	Condition	Min.	Typ.	Max.	Units
Supply Voltage	$V_{CC}$	Applied between P-NU, NV, NW	0	300	400	Volts
Control Supply Voltage	$V_D$	Applied between $V_{P1}-V_{PC}$ , $V_{N1}-V_{NC}$	13.5	15.0	16.5	Volts
	$V_{DB}$	Applied between $V_{UFB}-V_{UFS}$ , $V_{VFB}-V_{VFS}$ , $V_{WFB}-V_{WFS}$	13.0	15.0	18.5	Volts
Control Supply Variation	$\Delta V_D$ , $\Delta V_{DB}$		-1	—	1	V/ $\mu\text{s}$
Arm Shoot-through Blocking Time	$t_{DEAD}$	For Each Input Signal, $T_C \leq 00^\circ\text{C}$	2.0	—	—	$\mu\text{s}$
PWM Input Frequency	$f_{PWM}$	$T_C \leq 100^\circ\text{C}$ , $T_j \leq 125^\circ\text{C}$	—	—	20	kHz
Allowable rms Current*	$I_O$	$V_{CC} = 300\text{V}$ , $V_D = 15\text{V}$ , $f_{PWM} = 5\text{kHz}$ , PF = 0.8, Sinusoidal PWM, $T_j \leq 125^\circ\text{C}$ , $T_C \leq 100^\circ\text{C}$	—	—	37.0	Arms
		$V_{CC} = 300\text{V}$ , $V_D = 15\text{V}$ , $f_{PWM} = 15\text{kHz}$ , PF = 0.8, Sinusoidal PWM, $T_j \leq 125^\circ\text{C}$ , $T_C \leq 100^\circ\text{C}$	—	—	17.0	Arms
Minimum Input Pulse Width	$P_{WIN(on)}^{**}$		0.3	—	—	$\mu\text{s}$
	$P_{WIN(off)}^{***}$	$I_C \leq 75\text{A}$	200 $\leq V_{CC} \leq 350\text{V}$ , 13.5 $\leq V_D \leq 16.5\text{V}$ ,	3.0	—	$\mu\text{s}$
		75 $\leq I_C \leq 127.5\text{A}$	13.5 $\leq V_{DB} \leq 18.5\text{V}$ , $-20^\circ\text{C} \leq T_C \leq 100^\circ\text{C}$ , N-line Wiring Inductance Less Than 10nH	5.0	—	$\mu\text{s}$
$V_{NC}$ Variation	$V_{NC}$	Between $V_{NC}-\text{NU}$ , NV, NW (Including Surge)	-5.0	—	5.0	Volts

\* The allowable rms current value depends on the actual application conditions.

\*\*If input signal ON pulse is less than  $P_{WIN(on)}$ , the device may not respond.

\*\*\*The IPM may fail to respond to an ON pulse if the preceeding OFF pulse is less than  $P_{WIN(off)}$ .

## Delayed Response Against Shorter Input OFF Signal Than $P_{WIN(off)}$ , P-side only

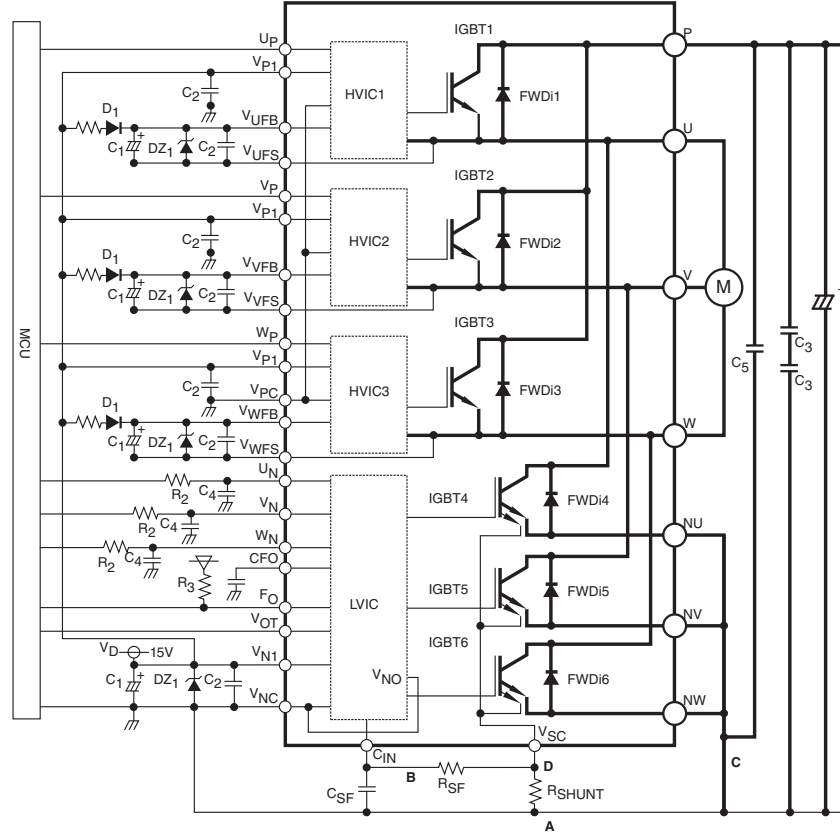


Solid Line – OFF Pulse Width  $> P_{WIN(off)}$ ; Turn ON time  $t_1$ .

Dotted Line – OFF Pulse Width  $< P_{WIN(off)}$ ; Turn ON time  $t_2$ .

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**Application Circuit**



**Component Selection:**

Dsgn.	Typ. Value	Description
D1	1A, 600V	Control and boot strap supply overvoltage suppression
DZ1	24V, 1W	Control and boot strap supply over voltage suppression
C1	10-100µF, 50V	Boot strap supply reservoir – electrolytic long life low impedance, 105°C
C2	0.22-2.0µF, 50V	Local decoupling/High frequency noise filters – multilayer ceramic (Note 4)
C3	200 to 2500µF, 450V	Main DC bus filter capacitor – electrolytic, long life, high ripple current, 105°C
C4	100pF, 50V	Optional input signal noise filter – multilayer ceramic (Note 11)
C5	0.1-0.22µF, 1000V	Surge voltage suppression (Note 2)
C <sub>SF</sub>	1000pF, 50V	Short circuit detection filter capacitor – multilayer ceramic
R <sub>SF</sub>	1.8kΩ	Short circuit detection filter resistor
R <sub>SHUNT</sub>	20ohm-500ohm	Current sensing resistor
R1	1-10Ω	Boot strap supply inrush limiting resistor – non-inductive, temperature stable, tight tolerance (Note 5)
R2	330Ω	Optional input signal noise filter (Note 11)
R3	10kΩ	Fault signal pull-up resistor (Note 9)

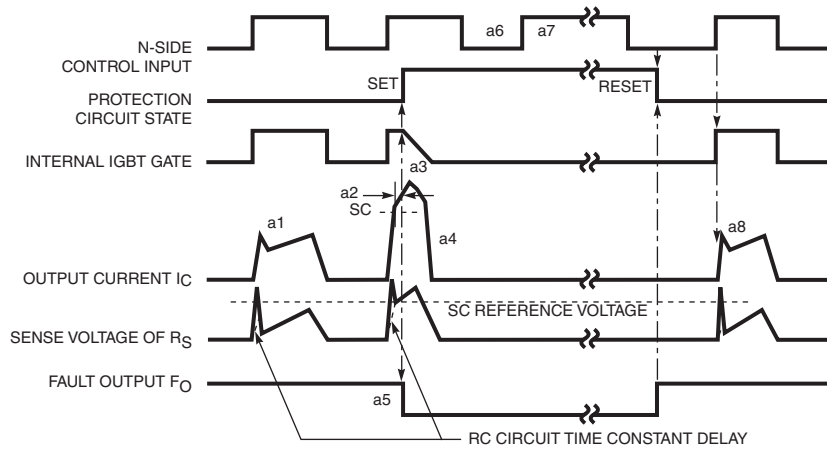
**Notes:**

- 1) If control GND is connected to power GND by broad pattern, it may cause malfunction by power GND fluctuation. It is recommended to connect control GND at only a point at which NU, NV, NW are connected to power GND line.
  - 2) To prevent surge destruction, the wiring between the smoothing capacitor and the P-N1 terminals should be as short as possible. Generally inserting a 0.1µ – 0.22µF snubber capacitor C<sub>3</sub> between the P-N1 terminals is recommended.
  - 3) The time constant R<sub>1</sub>,C<sub>4</sub> of RC filter for preventing the protection circuit malfunction should be selected in the range of 1.5µ – 2µs. SC interrupting time might vary with the wiring pattern. Tight tolerance, temp-compensated type is recommended for R<sub>1</sub>,C<sub>4</sub>.
  - 4) All capacitors should be mounted as close to the terminals of the DIPIMM as possible. (C<sub>1</sub>: good temperature, frequency characteristics electrolytic type, and C<sub>2</sub>: good temperature, frequency and DC bias characteristic ceramic type are recommended.)
  - 5) It is recommended to insert a Zener diode DZ<sub>1</sub> (24V/1W) between each pair of control supply terminals to prevent surge destruction.
  - 6) To prevent erroneous SC protection, the wiring from V<sub>SC</sub> terminals to C<sub>IN</sub> filter should be divided at the point D that is close to the terminal of sense resistor and the wiring should be patterned as short as possible.
  - 7) For sense resistor, the variation within 1% (including temperature characteristics), low inductance type is recommended. 1/8W is recommended, but an evaluation of your system is recommended.
  - 8) To prevent erroneous operation, wiring A, B, and C should be as short as possible.
  - 9) F<sub>0</sub> output is open drain type. It should be pulled up to the positive side of 5V or 15V power supply with a resistor that limits F<sub>0</sub> sink current (I<sub>F0</sub>) under 1mA. (Over 5.1kΩ is needed and 10kΩ is recommended for 5V supply.)
  - 10) Error signal output width (t<sub>F0</sub>) can be set by the capacitor connected to the C<sub>F0</sub> terminal. t<sub>F0(typ)</sub> = C<sub>F0</sub> / 9.1 x 10<sup>-6</sup> (s).
  - 11) Input drive is high-active type. There is a 3.3kΩ pull-down resistor integrated in the IC input circuit. To prevent malfunction, the wiring of each input should be patterned as short as possible. When inserting the RC filter, make sure the input signal level meets the turn-on and turn-off threshold voltage.
- Thanks to HVIC inside the module, connection to the MCU may be direct or with an opto-coupler.

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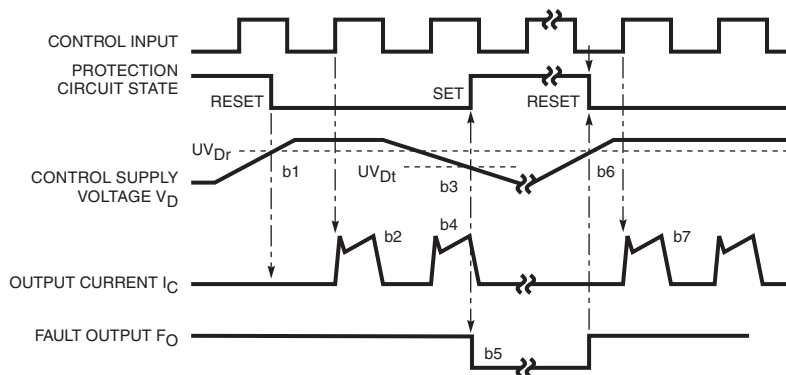
## Protection Function Timing Diagrams

Short Circuit Protection (N-side Only with External Shunt Resistor and RC Filter)



- a1: Normal operation – IGBT turns on and carries current.
- a2: Short circuit current is detected (SC trigger).
- a3: All N-side IGBT's gate are hard interrupted.
- a4: All N-side IGBT's turn off.
- a5:  $F_O$  output with a fixed pulse width (determined by the external capacitance  $C_{FO}$ ).
- a6: Input "L" – IGBT off.
- a7: Input "H" – IGBT on, but during the  $F_O$  output period the IGBT will not turn on.
- a8: IGBT turns on when L→H signal is input after  $F_O$  is reset.

Under-Voltage Protection (N-side ,  $UV_D$ )

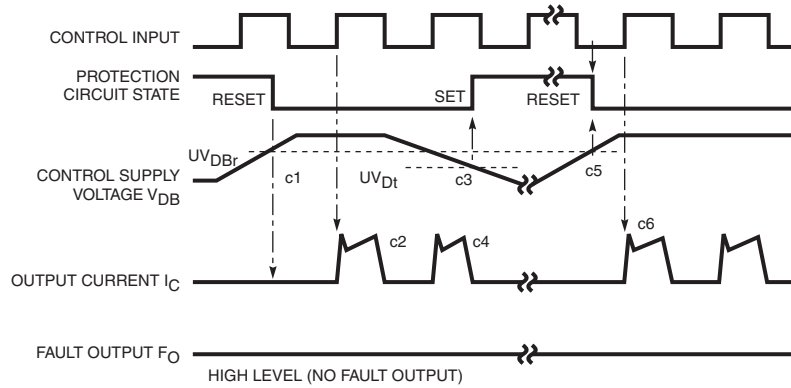


- b1: Control supply voltage  $V_D$  rises – After  $V_D$  level reaches under voltage reset level ( $UV_{Dr}$ ), the circuits start to operate when next input is applied.
- b2: Normal operation – IGBT turns on and carries current.
- b3:  $V_D$  level dips to under voltage trip level ( $UV_{Dt}$ ).
- b4: All N-side IGBT's turn off in spite of control input condition.
- b5:  $F_O$  is low for a minimum period determined by the capacitance  $C_{FO}$  but continuously during UV period.
- b6:  $V_D$  level reaches  $UV_{Dr}$ .
- b7: Normal operation – IGBT turns on and carries current.

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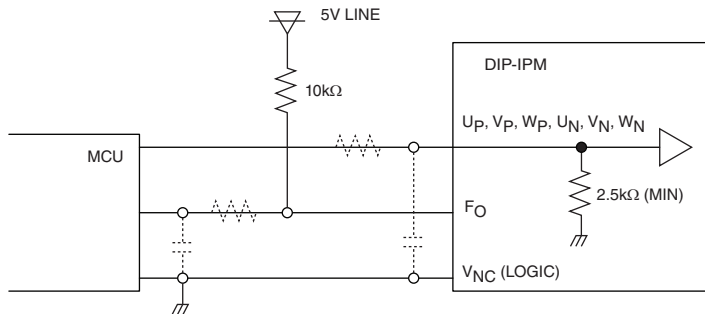
## Protection Function Timing Diagrams

Under-Voltage Protection (P-side, UV<sub>DB</sub>)



- c1: Control supply voltage  $V_{DB}$  rises – After  $V_{DB}$  level reaches under voltage reset level ( $UV_{DBr}$ ), the circuits starts to operate when next input is applied.
- c2: Normal operation – IGBT turns on and carries current.
- c3:  $V_{DB}$  level dips to under voltage trip level ( $UV_{DBt}$ ).
- c4: P-side IGBT 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 – IGBT on and carries current.

## Typical Interface Circuit



NOTE: RC coupling at each input (parts shown dotted) may change depending on the PWM control scheme used in the application and the wiring impedance of the printed circuit board. The DIP-IPM input signal section integrates a 2.5kΩ (min) pull-down resistor. Therefore, when using an external filtering resistor, care must be taken to satisfy the turn-on threshold voltage requirement.

## Wiring Method Around Shunt Resistor

