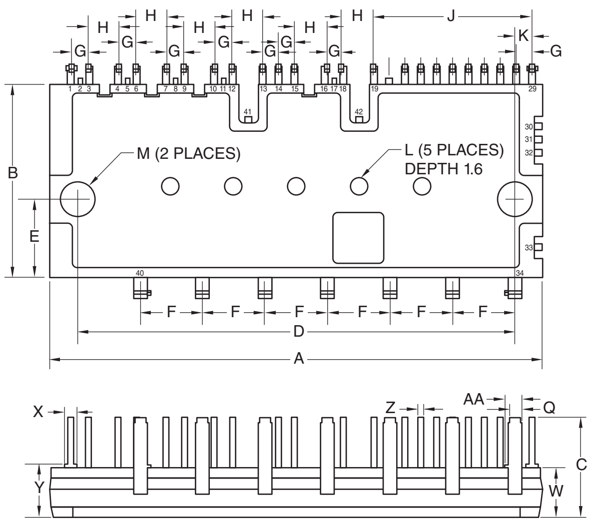
POWEREX

PS22A78-E

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

Intellimod™ Module

Dual-In-Line Intelligent Power Module
35 Amperes/1200 Volts



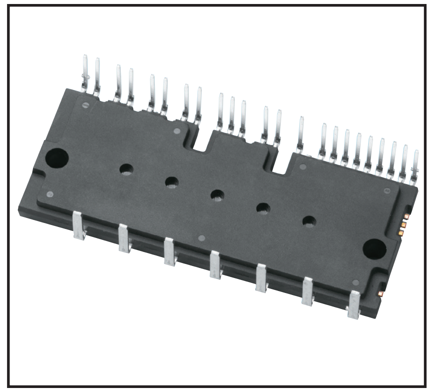
TERMINAL CODE

1 U_P	8 V_{PC}	15 V_{PC}	22 V_{NC}	29 W_N	36 N_U
2 (V_{PC})	9 V_{P1}	16 V_{WFB}	23 V_{OT}	30 V_{NC}	37 W
3 V_{P1}	10 V_{VFB}	17 W_{PG}	24 C_{IN}	31 W_{NG}	38 V
4 V_{UFB}	11 V_{PG}	18 V_{WFS}	25 C_{FO}	32 V_{NG}	39 U
5 (U_{PG})	12 V_{VFS}	19 V_{SC}	26 FO	33 W	40 P
6 V_{UFS}	13 W_P	20 U_{NG}	27 U_N	34 N_W	41 U
7 V_P	14 V_{P1}	21 V_{N1}	28 V_N	35 N_V	42 V

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



Description:

DIPIPMs 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:

PS22A78-E is a 1200V, 35 Ampere DIP Intelligent Power Module.

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Intellimod™ Module
Dual-In-Line Intelligent Power Module
35 Amperes/1200 Volts

Absolute Maximum Ratings, T_j = 25°C unless otherwise specified

Characteristics	Symbol	PS22A78-E	Units
Self-protection Supply Voltage Limit (Short Circuit Protection Capability)*	$V_{CC(prot.)}$	800	Volts
Module Case Operation Temperature (See T_C Measurement Point Below)	T_C	-20 to 100	°C
Storage Temperature	T_{stg}	-40 to 125	°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_{ISO}	2500	Volts

IGBT Inverter Sector

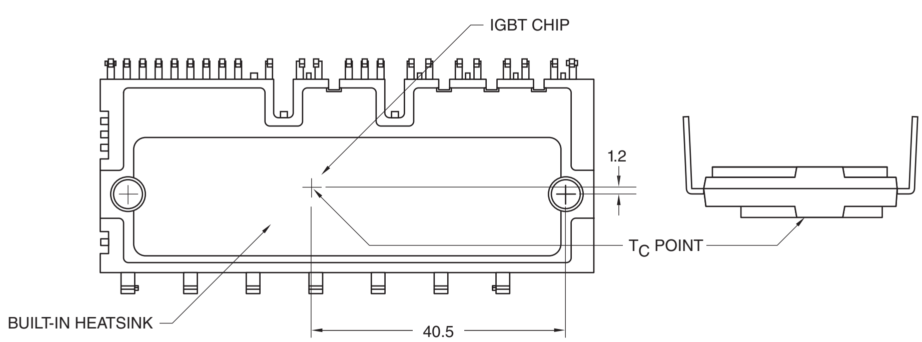
Supply Voltage (Applied between P-NU, NV, NW)	V_{CC}	900	Volts
Supply Voltage, Surge (Applied between P-NU, NV, NW)	$V_{CC(surge)}$	1000	Volts
Collector-Emitter Voltage (T_C = 25°C)	V_{CES}	1200	Volts
Collector Current (T_C = 25°C)	$\pm I_C$	35	Amperes
Peak Collector Current (T_C = 25°C, <1ms)	$\pm I_{CP}$	70	Amperes
Collector Dissipation (T_C = 25°C, per 1 Chip)	P_C	129.9	Watts
Power Device Junction Temperature**	T_j	-20 to 150	°C

Control Sector

Supply Voltage (Applied between V_{P1}-V_{PC}, V_{N1}-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 ~ 16.5V, Inverter Part, T_j = 125°C, Non-repetitive, Less than 2μs
**The maximum junction temperature rating of the power chips integrated within the DIPIPM is 150°C (@$T_f \leq$ 100°C). However, to ensure safe operation of the DIPIPM, the average junction temperature should be limited to $T_{j(avg)} \leq$ 125°C (@$T_f \leq$ 100°C).

T_C Measurement Point



 Rev. 08/09

Electrical and Mechanical Characteristics, T_j = 25°C unless otherwise specified

IGBT Inverter Sector

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 35A, T_j = 25°C, V_D = V_{DB} = 15V, V_{IN} = 5V	—	1.9	2.6	Volts
		I_C = 35A, T_j = 125°C, V_D = V_{DB} = 15V, V_{IN} = 5V	—	2.0	2.7	Volts
Diode Forward Voltage	V_{EC}	T_j = 25°C, $-I_C$ = 35A, V_{IN} = 0V	—	2.8	3.3	Volts
Inductive Load Switching Times	t_{on}	V_{CC} = 600V, V_D = V_{DB} = 15V, I_C = 35A, T_j = 125°C, V_{IN} = 0 ⇔ 5V, Inductive Load (Upper-Lower Arm)	0.8	1.5	2.2	μs
	t_{rr}		—	0.3	—	μs
	$t_{C(on)}$		—	0.6	0.9	μs
	t_{off}		—	2.8	3.8	μs
	$t_{C(off)}$		—	0.7	1.0	μs
Collector-Emitter Cutoff Current	I_{CES}	V_{CE} = V_{CES}, T_j = 25°C	—	—	1.0	mA
		V_{CE} = V_{CES}, T_j = 125°C	—	—	10	mA

Control Sector

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Circuit Current	I_D	V_D = V_{DB} = 15V, V_{IN} = 5V, Total of V_{P1}-V_{PC}, V_{N1}-V_{NC}	—	—	3.70	mA
		V_D = V_{DB} = 15V, V_{IN} = 5V, V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS}, V_{WFB}-V_{WFS}	—	—	1.30	mA
		V_D = V_{DB} = 15V, V_{IN} = 0V, Total of V_{P1}-V_{PC}, V_{N1}-V_{NC}	—	—	3.50	mA
		V_D = V_{DB} = 15V, V_{IN} = 0V, V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS}, V_{WFB}-V_{WFS}	—	—	1.30	mA
Fault Output Voltage	V_{FOH}	V_{SC} = 0V, F_O Terminal Pull-up to 5V by 10kΩ	4.9	—	—	Volts
	V_{FOL}	V_{SC} = 1V, I_{FO} = 1mA	—	—	1.1	Volts
Input Current	I_{IN}	V_{IN} = 5V	0.7	1.5	2.0	mA
Short-Circuit Trip Level*	I_{SC}	-20°C ≤ T_C ≤ 100°C, V_D = 15V	59.5	—	—	Amps
Supply Circuit Undervoltage Protection	UV_{DBt}	Trip Level, T_C ≤ 100°C	10.0	—	12.0	Volts
	UV_{DBr}	Reset Level, T_C ≤ 100°C	10.5	—	12.5	Volts
	UV_{Dt}	Trip Level, T_C ≤ 100°C	10.3	—	12.5	Volts
	UV_{Dr}	Reset Level, T_C ≤ 100°C	10.8	—	13.0	Volts
Fault Output Pulse Width**	t_{FO}	C_{FO} = 22nF	1.6	2.4	—	ms
ON Threshold Voltage	$V_{th(on)}$	Applied between U_P, V_P, W_P-V_{PC}, U_N, V_N, W_N-V_{NC}	—	—	3.5	Volts
OFF Threshold Voltage	$V_{th(off)}$		0.8	—	—	Volts
Temperature Output***	V_{OT}	At LVIC Temperature = 85°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 x 10^{-6} x t_{FO} [F]).
***When the temperature rises excessively, the controller (MCU) should stop the DIPIPM.

Thermal Characteristics, T_j = 25°C unless otherwise specified

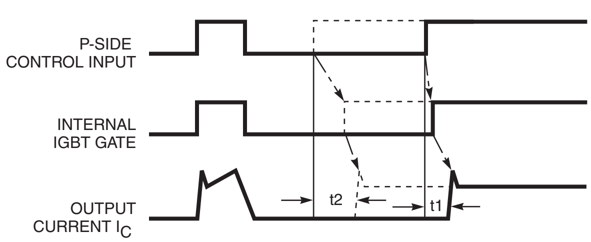
Characteristic	Symbol	Condition	Min.	Typ.	Max.	Units
Thermal Resistance Junction to Case	$R_{th(j\text{-}C)Q}$	IGBT Part (Per 1/6 Module)	—	—	0.77	°C/Watt
Thermal Resistance Junction to Case	$R_{th(j\text{-}C)D}$	FWDi Part (Per 1/6 Module)	—	—	1.25	°C/Watt

Recommended Conditions for Use

Characteristic	Symbol	Condition	Min.	Typ.	Max.	Units
Supply Voltage	V_{CC}	Applied between P-NU, NV, NW	350	600	800	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	ΔV_D, ΔV_{DB}		-1	—	1	V/µs
Arm Shoot-through Blocking Time	t_{DEAD}	For Each Input Signal, $T_C \leq 100°C$	3.3	—	—	µs
PWM Input Frequency	f_{PWM}	$T_C \leq 100°C$, $T_j \leq 125°C$	—	—	15	kHz
Allowable rms Current*	I_O	V_{CC} = 600V, V_D = 15V, f_C = 15kHz, PF = 0.8, Sinusoidal PWM, $T_j \leq 125°C$, $T_C \leq 100°C$	—	—	12.8	Arms
Minimum Input Pulse Width	$P_{WIN(on)}$**		—	—	—	µs
	$P_{WIN(off)}$*** $I_C \leq 35A$	$350 \leq V_{CC} \leq 800V$, $13.5 \leq V_D \leq 16.5V$, $13.5 \leq V_{DB} \leq 16.5V$, $-20°C \leq T_C \leq 100°C$, N-line Wiring Inductance Less Than 10nH	—	—	—	µs
	$35 \leq I_C \leq 59.5A$		—	—	—	µs
V_{NC} Variation	V_{NC}	Between V_{NC}-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 t1.
Dotted Line – OFF Pulse Width < $P_{WIN(off)}$: Turn ON time t2.

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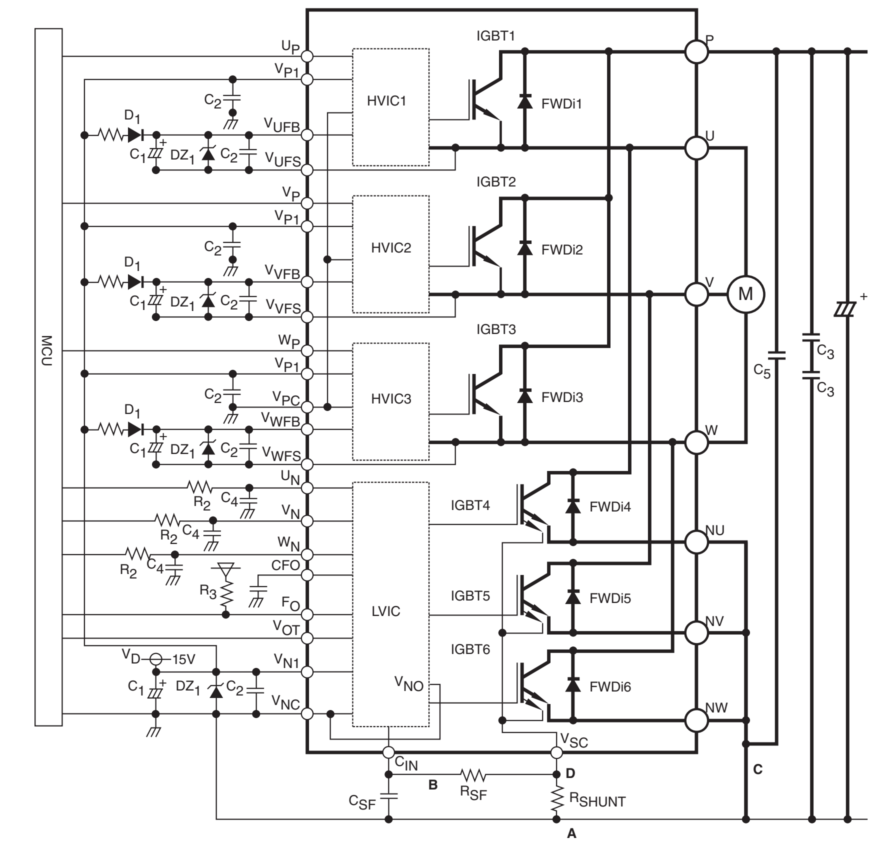
Application Circuit



Component Selection:

Dsgn.	Typ. Value	Description
D_1	1A, 600V	Control and boot strap supply overvoltage suppression
DZ_1	24V, 1W	Control and boot strap supply over voltage suppression
C_1	10-100µF, 50V	Boot strap supply reservoir – electrolytic long lifem low impedance, 105°C
C_2	0.22-2.0µF, 50V	Local decoupling/High frequency noise filters – multilayer ceramic (Note 4)
C_3	200 to 2500µF, 450V	Main DC bus filter capacitor – electrolytic, long life, high ripple current, 105°C
C_4	100pF, 50V	Optional input signal noise filter – multilayer ceramic (Note 11)
C_5	0.1-0.22µF, 1000V	Surge voltage suppression (Note 2)
C_{SF}	1000pF, 50V	Short circuit detection filter capacitor – multilayer ceramic
R_{SF}	1.8kΩ	Short circuit detection filter resistor
R_{SHUNT}	20ohm-500ohm	Current sensing resistor
R_1	1-10Ω	Boot strap supply inrush limiting resistor – non-inductive, temperature stable, tight tolerance (Note 5)
R_2	330Ω	Optional input signal noise filter (Note 11)
R_3	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_3 between the P-N1 terminals is recommended.
3) The time constant R_1,C_4 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_1,C_4.
4) All capacitors should be mounted as close to the terminals of the DIPIPM as possible. (C_1: good temperature, frequency characteristics electrolytic type, and C_2 : good temperature, frequency and DC bias characteristic ceramic type are recommended.)
5) It is recommended to insert a Zener diode DZ_1 (24V/1W) between each pair of control supply terminals to prevent surge destruction.
6) To prevent erroneous SC protection, the wiring from V_{SC} terminals to C_{IN} 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_O 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_O sink current (I_{FO}) under 1mA. (Over 5.1kΩ is needed and 10kΩ is recommended for 5V supply.)
10) Error signal output width (t_{FO}) can be set by the capacitor connected to the C_{FO} terminal. $t_{FO(typ)} = C_{FO} / 9.1 \times 10^{-6}$ (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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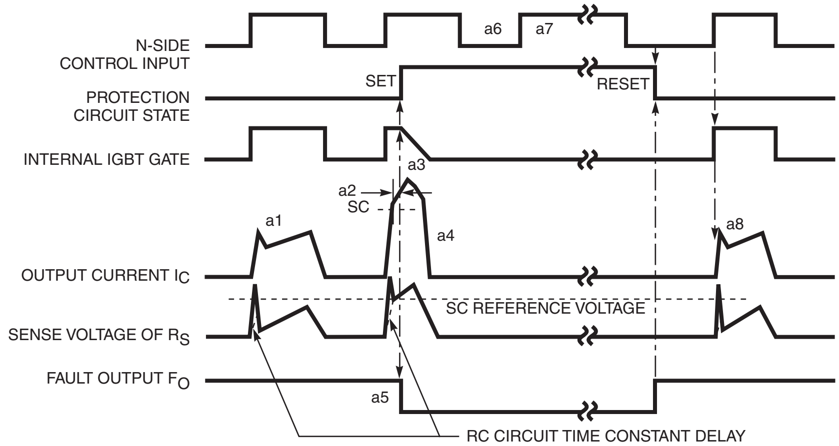
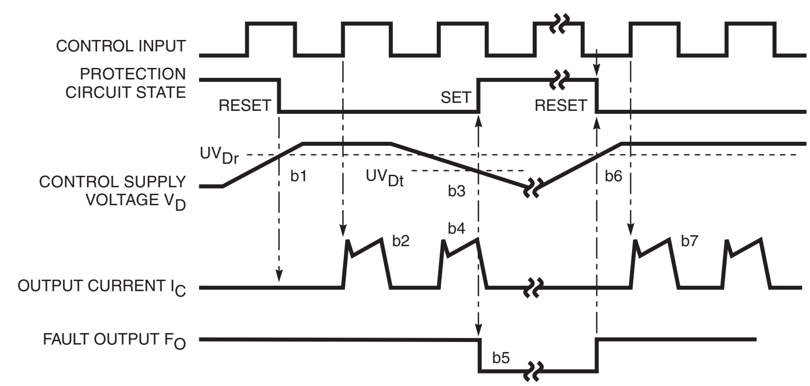
Protection Function Timing Diagrams

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 wirh 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 perid 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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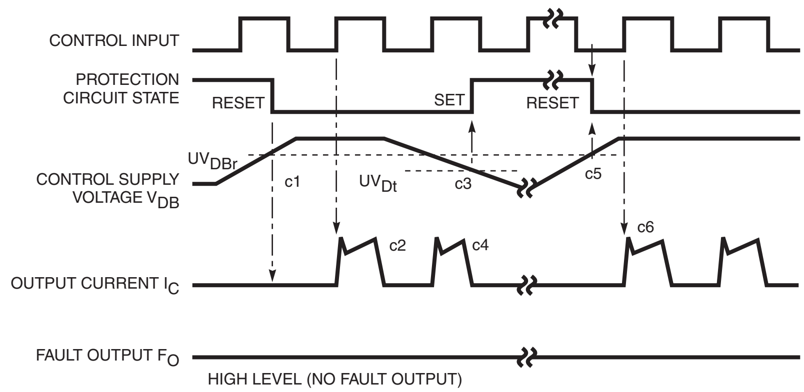
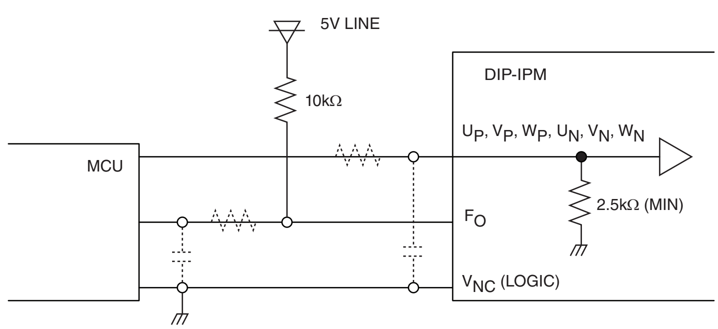
Protection Function Timing Diagrams

Under-Voltage Protection (P-side, UV_{DB})



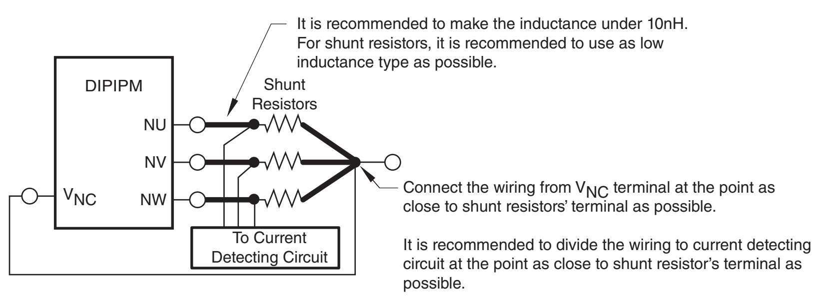
c1: Control supply voltage V_{DB} rises – After V_{DB} level reaches under voltage reset level (UV_{DBr}), the circuits starts to operate when next input is applied.
c2: Normal operation – IGBT turns on and carries current.
c3: V_{DB} level dips to under voltage trip level (UV_{DBt}).
c4: P-side IGBT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



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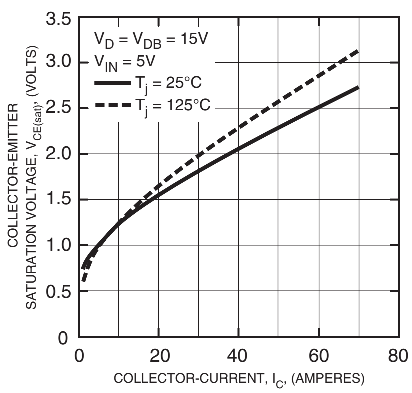
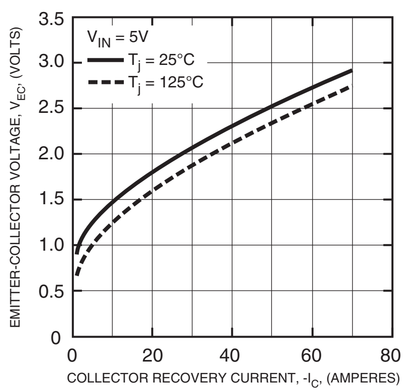
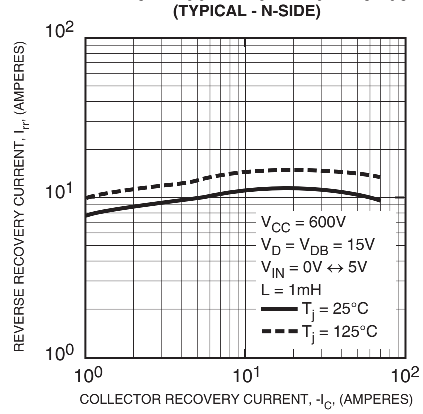
COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS (TYPICAL)



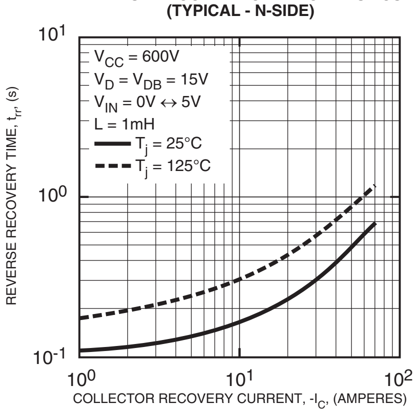
FREE-WHEEL DIODE FORWARD CHARACTERISTICS (TYPICAL)



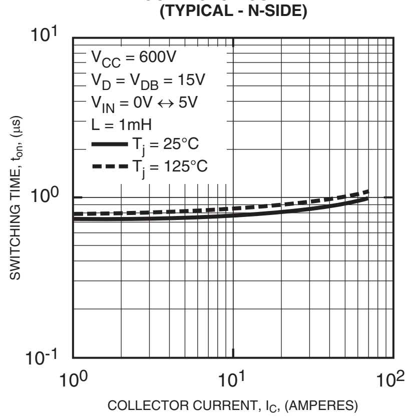
REVERSE RECOVERY CHARACTERISTICS (TYPICAL - N-SIDE)



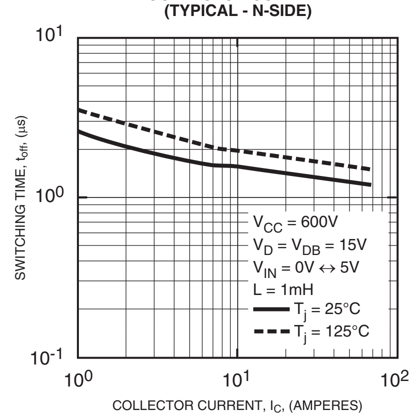
REVERSE RECOVERY CHARACTERISTICS (TYPICAL - N-SIDE)



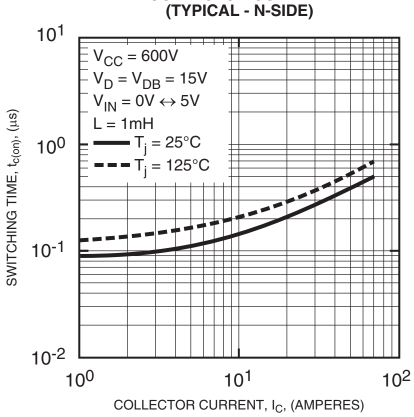
SWITCHING TIME (ON) VS. COLLECTOR CURRENT (TYPICAL - N-SIDE)



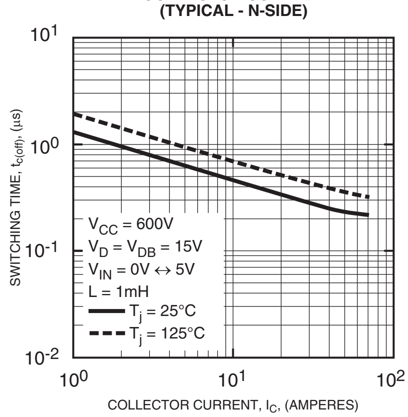
SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - N-SIDE)



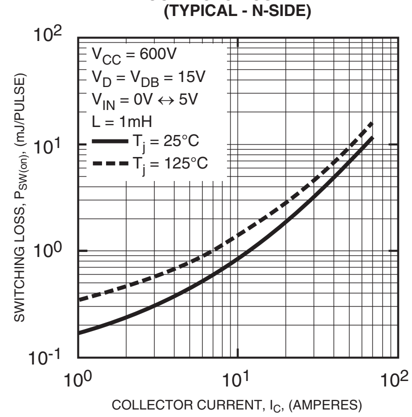
SWITCHING TIME (ON) VS. COLLECTOR CURRENT (TYPICAL - N-SIDE)



SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - N-SIDE)



SWITCHING LOSS (ON) VS. COLLECTOR CURRENT (TYPICAL - N-SIDE)



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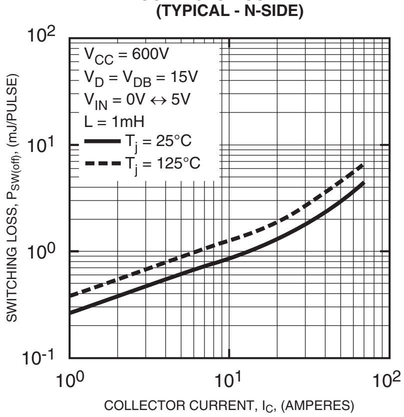
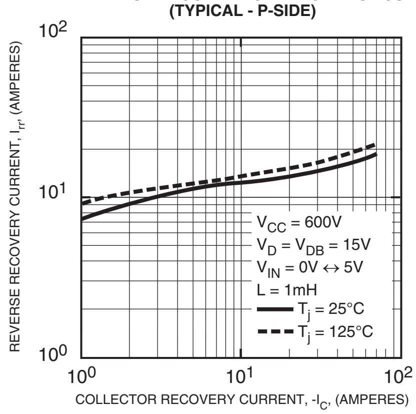
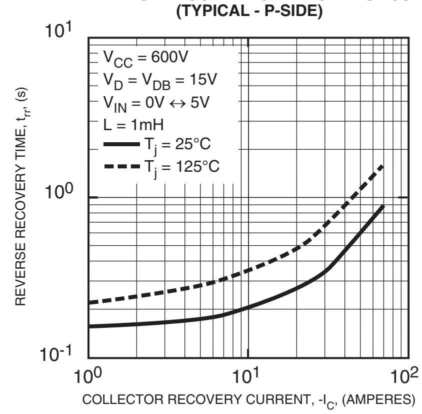
SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - N-SIDE)



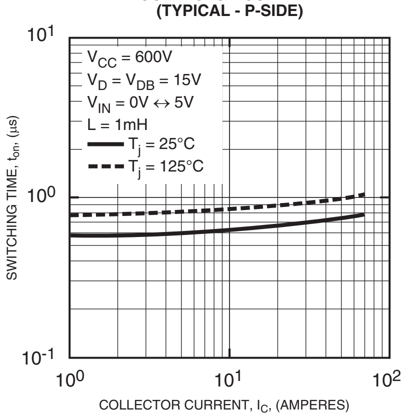
REVERSE RECOVERY CHARACTERISTICS (TYPICAL - P-SIDE)



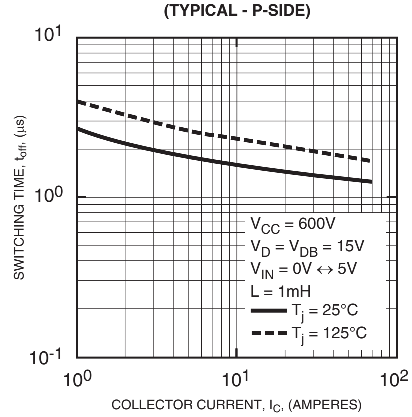
REVERSE RECOVERY CHARACTERISTICS (TYPICAL - P-SIDE)



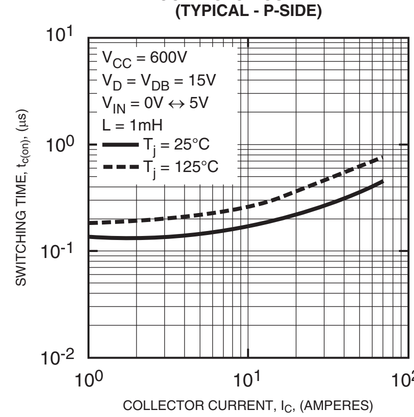
SWITCHING TIME (ON) VS. COLLECTOR CURRENT (TYPICAL - P-SIDE)



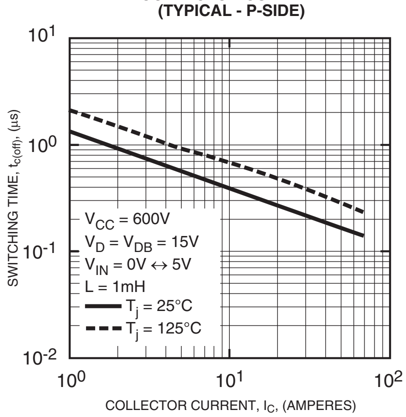
SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - P-SIDE)



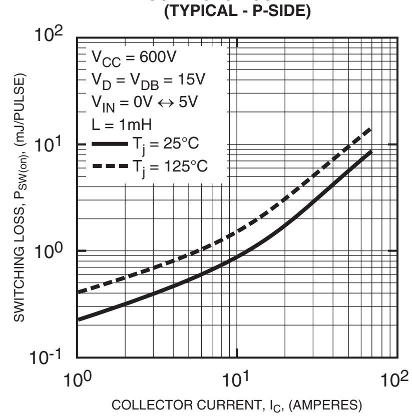
SWITCHING TIME (ON) VS. COLLECTOR CURRENT (TYPICAL - P-SIDE)



SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - P-SIDE)



SWITCHING LOSS (ON) VS. COLLECTOR CURRENT (TYPICAL - P-SIDE)



SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - P-SIDE)