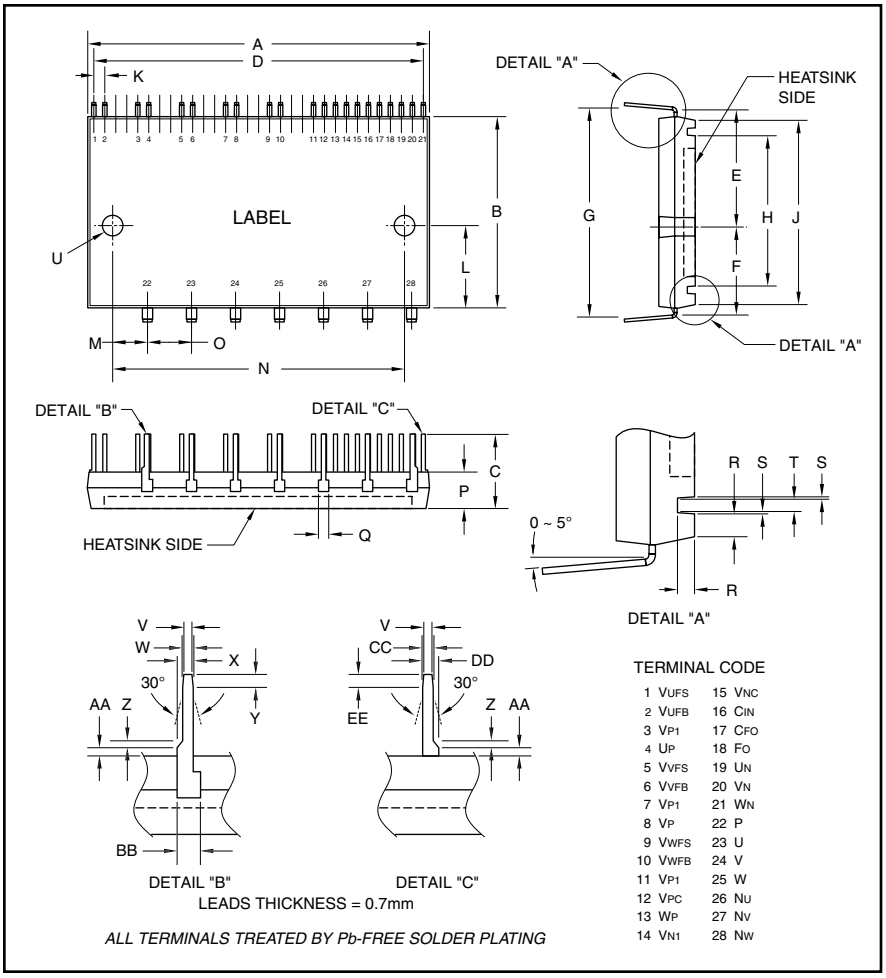
Powerex, Inc., 200 E. Hillis Street, Youngwood, Pennsylvania 15697-1800 (724) 925-7272

# Intellimod™ Module

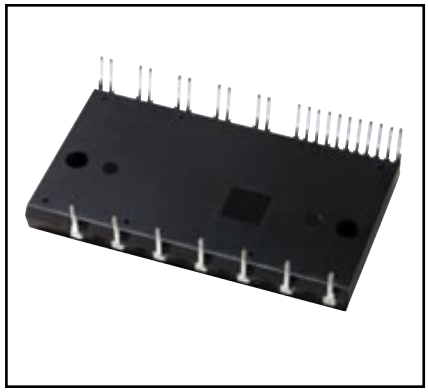
***Dual-In-Line Intelligent Power Module***
***5 Amperes/1200 Volts***




**Outline Drawing and Circuit Diagram**

| Dimensions | Inches | Millimeters |
|---|---|---|
| A | 3.11±0.02 | 79.0±0.5 |
| B | 1.73±0.02 | 44.0±0.5 |
| C | 0.63±0.01 | 16.1±0.3 |
| D | 3.0 | 76.2 |
| E | 1.08±0.02 | 27.4±0.5 |
| F | 0.80±0.02 | 20.4±0.5 |
| G | 1.91±0.02 | 48.6±0.5 |
| H | 1.34±0.02 | 34.0±0.5 |
| J | 1.67±0.02 | 42.5±0.5 |
| K | 0.10±0.01 | 2.54±0.3 |
| L | 0.73±0.02 | 18.5±0.5 |
| M | 0.31±0.01 | 8.0±0.3 |
| N | 2.64±0.01 | 67.0±0.3 |
| O | 0.40±0.01 | 10.16±0.3 |
| P | 0.32±0.02 | 8.2±0.5 |

| Dimensions | Inches | Millimeters |
|---|---|---|
| Q | 0.09 | 2.5 |
| R | 0.08 | 2.0 |
| S | 0.01 | 0.3 |
| T | 0.07 | 1.7 |
| U | 0.18±0.008 Dia. | 4.5±0.2 Dia. |
| V | 0.024 | 0.6 |
| W | 0.039±0.008 | 1.0±0.2 |
| X | 0.06±0.008 | 1.5±0.2 |
| Y | 0.05 | 1.2 |
| Z | 0.02 | 0.5 |
| AA | 0.024±0.02 | 0.6±0.5 |
| BB | 0.098 | 2.5 |
| CC | 0.031±0.008 | 0.8±0.2 |
| DD | 0.051±0.008 | 1.3±0.2 |
| EE | 0.04 | 1.0 |



**Description:**
DIP-IPMs are intelligent power modules that integrate power devices, drivers, and protection circuitry in an ultra compact dual-in-line transfer-mold package for use in driving small three phase motors. Use of 4th generation IGBTs, DIP packaging, and application specific HVICs allow the designer to reduce inverter size and overall design time.

**Features:**
- ☐ Compact Packages
- ☐ Single Power Supply
- ☐ Integrated HVICs
- ☐ Direct Connection to CPU

**Applications:**
- ☐ Washing Machines
- ☐ Refrigerators
- ☐ Air Conditioners
- ☐ Small Servo Motors
- ☐ Small Motor Control

**Ordering Information:**
PS22052 is a 1200V, 5 Ampere DIP Intelligent Power Module.

***PS22052***
***Intellimod™ Module***
***Dual-In-Line Intelligent Power Module***
*5 Amperes/1200 Volts*

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

| Characteristics | Symbol | PS22052 | Units |
|---|---|---|---|
| Power Device Junction Temperature* | $T_j$ | -20 to 125 | °C |
| Module Case Operation Temperature (See Note 1) | $T_C$ | -20 to 100 | °C |
| Storage Temperature | $T_{stg}$ | -40 to 125 | °C |
| Mounting Torque, M4 Mounting Screws | — | 13 | in-lb |
| Module Weight (Typical) | — | 77 | Grams |
| Self-protection Supply Voltage Limit (Short Circuit Protection Capability)** | $V_{CC(prot.)}$ | 800 | Volts |
| Heatsink Flatness (See Note 2) | | -50 to 100 | µm |
| Isolation Voltage, AC 1 minute, 60Hz Sinusoidal, Connection Pins to Heatsink Plate | $V_{ISO}$ | 2500 | Volts |

*The maximum junction temperature rating of the power chips integrated within the DIP-IPM is 150°C (@$T_C \leq 100$°C). However, to ensure safe operation of the DIP-IPM, the average junction temperature should be limited to $T_{j(avg)} \leq 125$°C (@$T_C \leq 100$°C).
**$V_D$ = 13.5 ~ 16.5V, Inverter Part, $T_j$ = 125°C, Non-repetitive, Less than 2µs

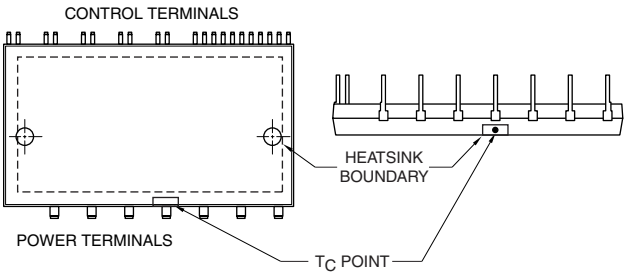
## IGBT Inverter Sector

| | | | |
|---|---|---|---|
| Collector-Emitter Voltage | $V_{CES}$ | 1200 | Volts |
| Collector Current ($T_C$ = 25°C) | $\pm I_C$ | 5 | Amperes |
| Peak Collector Current ($T_C$ = 25°C, <1ms) | $\pm I_{CP}$ | 10 | Amperes |
| 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 Dissipation ($T_C$ = 25°C, per 1 Chip) | $P_C$ | 38.3 | Watts |

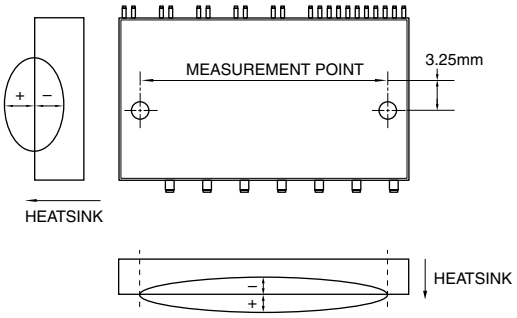
## Control Sector

| | | | |
|---|---|---|---|
| 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 |

Note 1 – $T_C$ Measure Point




Note 2 – Flatness Measurement Position



***PS22052***
***Intellimod™ Module***
***Dual-In-Line Intelligent Power Module***
*5 Amperes/1200 Volts*

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

| Characteristics | Symbol | Test Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| **IGBT Inverter Sector** | | | | | | |
| Collector-Emitter Saturation Voltage | $V_{CE(sat)}$ | $I_C$ = 5A, $T_j$ = 25°C, $V_D$ = $V_{DB}$ = 15V, $V_{IN}$ = 5V | — | 2.7 | 3.4 | Volts |
| | | $I_C$ = 5A, $T_j$ = 125°C, $V_D$ = $V_{DB}$ = 15V, $V_{IN}$ = 5V | — | 2.5 | 3.2 | Volts |
| Diode Forward Voltage | $V_{EC}$ | -$I_C$ = 5A, $V_{IN}$ = 0V | — | 2.4 | 2.9 | Volts |
| Inductive Load Switching Times | $t_{on}$ | $V_{CC}$ = 600V, $V_D$ = $V_{DB}$ = 15V, $I_C$ = 5A, $T_j$ = 125°C, $V_{IN}$ = 0 ⇔ 5V, Inductive Load (Upper-Lower Arm) | 0.8 | 1.5 | 2.2 | µs |
| | $t_{rr}$ | | — | 0.2 | — | µs |
| | $t_{C(on)}$ | | — | 0.4 | 0.7 | µs |
| | $t_{off}$ | | — | 2.8 | 3.8 | µs |
| | $t_{C(off)}$ | | — | 0.4 | 0.7 | 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** | | | | | | |
| Circuit Current $I_D$ | $V_{IN}$ = 5V | Total of $V_{P1}$-$V_{PC}$, $V_{N1}$-$V_{NC}$ | — | — | 3.70 | mA |
| $V_D$ = $V_{DB}$ = 15V | | $V_{UFB}$-$V_{UFS}$, $V_{VFB}$-$V_{VFS}$, $V_{WFB}$-$V_{WFS}$ | — | — | 1.30 | mA |
| | $V_{IN}$ = 0V | Total of $V_{P1}$-$V_{PC}$, $V_{N1}$-$V_{NC}$ | — | — | 3.50 | mA |
| | | $V_{UFB}$-$V_{UFS}$, $V_{VFB}$-$V_{VFS}$, $V_{WFB}$-$V_{WFS}$ | — | — | 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 | — | — | 1.10 | Volts |
| Input Current | $I_{IN}$ | $V_{IN}$ = 5V | 0.70 | 1.5 | 2.00 | mA |
| Short Circuit Trip Level* | $V_{SC(ref)}$ | $V_D$ = 15V | 0.43 | 0.48 | 0.53 | Volts |
| Supply Circuit Under-voltage | $UV_{DBt}$ | Trip Level, $T_j$ ≤ 125°C | 10.0 | — | 12.0 | Volts |
| | $UV_{DBr}$ | Reset Level, $T_j$ ≤ 125°C | 10.5 | — | 12.5 | Volts |
| | $UV_{Dt}$ | Trip Level, $T_j$ ≤ 125°C | 10.3 | — | 12.5 | Volts |
| | $UV_{Dr}$ | Reset Level, $T_j$ ≤ 125°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 $U_P$, $V_P$, $W_P$-$V_{PC}$, $U_N$, $V_N$, $W_N$-$V_{NC}$ | 2.5 | 3.0 | 4.2 | Volts |
| OFF Threshold Voltage | $V_{th(off)}$ | | 0.8 | 1.4 | 2.0 | Volts |

* Short Circuit protection is functioning only for N-side IGBTs. Please select the value of the external shunt resistance such that the SC trip level is less than 1.7 times the current rating.
**Fault output is asserted when the lower arms short circuit or control supply under-voltage protection function operates. The fault output pulse-width $t_{FO}$ depends on the capacitance value of $C_{FO}$ according to the following approximate equation: $C_{FO}$ = (9.3 x $10^{-6}$) x $t_{FO}$ {F} .

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

## Thermal Characteristics

| Characteristic | Symbol | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Junction to Case | $R_{th(j-c)Q}$ | IGBT Part (Per 1/6 Module) | — | — | 2.61 | °C/Watt |
| Thermal Resistance | $R_{th(j-c)D}$ | FWDi Part (Per 1/6 Module) | — | — | 3.81 | °C/Watt |
| Contact Thermal resistance | $R_{th(c-f)}$ | Per 1 Module | — | — | 0.047 | °C/Watt |

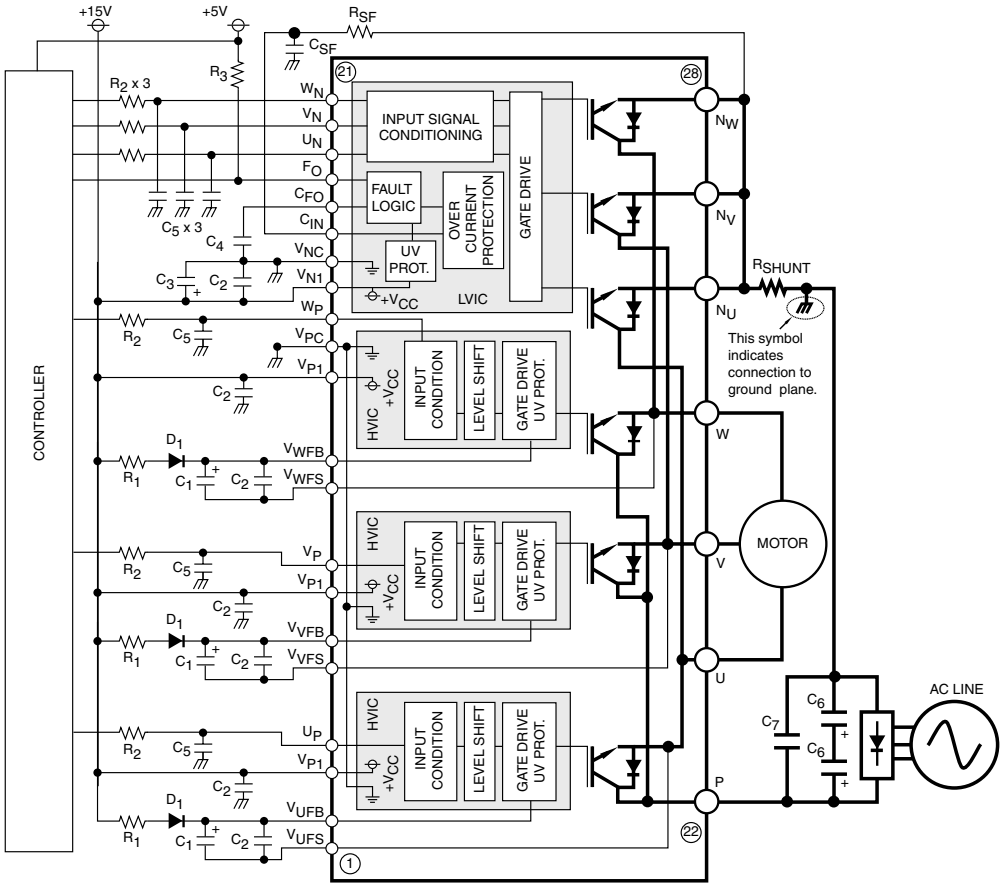
## Recommended Conditions for Use

| Characteristic | Symbol | Condition | Min. | Typ. | Value | 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 $V_{UFB}$-$V_{UFS}$, $V_{VFB}$-$V_{VFS}$, $V_{WFB}$-$V_{WFS}$ | 13.5 | 15.0 | 16.5 | Volts |
| Control Supply Variation | $dV_D$, $dV_{DB}$ | — | -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 | $f_{PWM}$ | $T_j \leq 125°C$, $T_C \leq 100°C$ | — | — | 15 | kHz |
| Output r.m.s. Current* | $I_O$ | $V_{CC}$ = 600V, $V_D$ = $V_{DB}$ = 15V, $f_C$ = 5kHz, P.F. = 0.8, Sinusoidal PWM, $T_j \leq 125°C$, $T_f \leq 100°C$ | — | — | 5.5 | $A_{rms}$ |
| | | $V_{CC}$ = 600V, $V_D$ = $V_{DB}$ = 15V, $f_C$ = 15kHz, P.F. = 0.8, Sinusoidal PWM, $T_j \leq 125°C$, $T_f \leq 100°C$ | — | — | 3.2 | $A_{rms}$ |
| Allowable Minimum Input Pulse Width | $P_{WIN(on)}$** | — | 1.5 | — | — | µs |
| | $P_{WIN(off)}$*** $I_C \leq 5A$ | 350 ≤ $V_{CC}$ ≤ 800V, 13.5 ≤ $V_D$ ≤ 16.5V, 13.5 ≤ $V_{DB}$ ≤ 16.5V, -20 ≤ $T_C$ ≤ 100°C, N Line Wiring Inductance Less than 10nH | 2.6 | — | — | µs |
| | $P_{WIN(off)}$*** 5 < $I_C \leq 8.5A$ | 350 ≤ $V_{CC}$ ≤ 800V, 13.5 ≤ $V_D$ ≤ 16.5V, 13.5 ≤ $V_{DB}$ ≤ 16.5V, -20 ≤ $T_C$ ≤ 100°C, N Line Wiring Inductance Less than 10nH | 2.8 | — | — | µs |
| $V_{NC}$ Voltage Variation | $V_{NC}$ | Between $V_{NC}$-NU, NV, NW (Including Surge) | -5.0 | — | 5.0 | Volts |

*The allowable r.m.s. current also depends on the user application conditions.
**DIP-IPM might make no response to the input ON signal with pulse width less than $P_{WIN(on)}$.
***DIP-IPM might make no response or not work properly if the input OFF signal pulse width is less than $P_{WIN(off)}$.

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## Application Circuit




Component Selection:

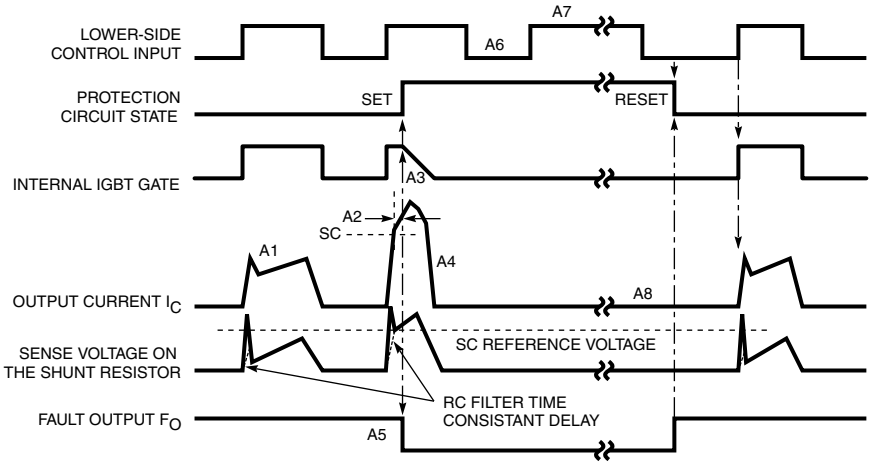
| Dsgn. | Typ. Value | Description |
|---|---|---|
| $D_1$ | 1A, 1200V | Boot strap supply diode – Ultra fast recovery |
| $C_1$ | 10-100uF, 50V | Boot strap supply reservoir – Electrolytic, long life, low impedance, 105°C (Note 5) |
| $C_2$ | 0.22-2.0uF, 50V | Local decoupling/High frequency noise filters – Multilayer ceramic (Note 8) |
| $C_3$ | 10-100uF, 50V | Control power supply filter – Electrolytic, long life, low Impedance, 105°C |
| $C_4$ | 22nF, 50V | Fault lock-out timing capacitor – Multilayer ceramic (Note 4) |
| $C_5$ | 100pF, 50V | Optional input signal noise filter – Multilayer ceramic (Note 1) |
| $C_6$ | 200-2000uF, 450V | Main DC bus filter capacitor – Electrolytic, long life, high ripple current, 105°C |
| $C_7$ | 0.1-0.22uF, 1000V | Surge voltage suppression capacitor – Polyester/polypropylene film (Note 9) |
| $C_{SF}$ | 1000pF, 50V | Short circuit detection filter capacitor – Multilayer ceramic (Note 6, Note 7) |
| $R_{SF}$ | 1.8k ohm | Short circuit detection filter resistor (Note 6, Note 7) |
| $R_{SHUNT}$ | 5-100 mohm | Current sensing resistor – Non-inductive, temperature stable, tight tolerance (Note 10) |
| $R_1$ | 10 ohm | Boot strap supply inrush limiting resistor (Note 5) |
| $R_2$ | 330 ohm | Optional control input noise filter (Note 1, Note 2) |
| $R_3$ | 10k ohm | Fault output signal pull-up resistor (Note 3) |

Notes:

1) To prevent input signal oscillations minimize wiring length to controller (~2cm). Additional RC filtering (C5 etc.) may be required. If filtering is added be careful to maintain proper dead time and voltage levels. See application notes for details.
2) Internal HVIC provides high voltage level shifting allowing direct connection of all six driving signals to the controller.
3) $F_O$ output is an open collector type. Pull up resistor (R3) should be adjusted to current sink capability of the controller.
4) C4 sets the fault output duration and lock-out time. C4 ≈ $9.3E^{-6}$ x $t_{FO}$, 22nF gives ~2.4ms.
5) Boot strap supply component values must be adjusted depending on the PWM frequency and technique.
6) Wiring length associated with $R_{SHUNT}$, $R_{SF}$, $C_{SF}$ must be minimized to avoid improper operation of the OC function.
7) $R_{SF}$, $C_{SF}$ set over circuit protection trip time. Recommend time constant is 1.5us-2.0us. See application notes.
8) Local decoupling/high frequency filter capacitors must be connected as close as possible to the modules pins.
9) The length of the DC link wiring between C6, C7, the DIP's P terminal and the shunt must be minimized to prevent excessive transient voltages. In particular, C7 should be mounted as close to the DIP as possible.
10) Use a high quality, tight tolorance current sensing resistor. Connect resistor as close as possible to the DIP's N terminal. Be careful to check for proper power rating. See application notes for calculation of resistance value.

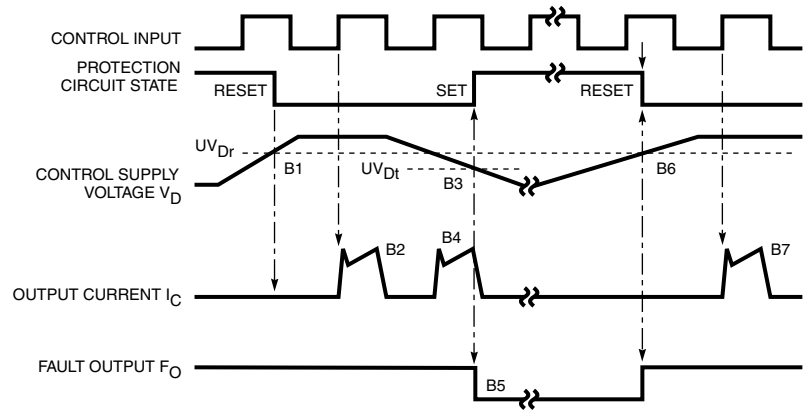
## Protection Function Timing Diagrams

**Short-Circuit Protection (N-side only, with external shunt resistor and CR filter)**




A1: Normal operation – IGBT turn on and conducting current.
A2: Short-circuit current detected (SC trigger).
A3: IGBT gate hard interrupted.
A4: IGBT 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 is blocked during the $F_O$ output period.
A8: IGBT stays in off state.

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

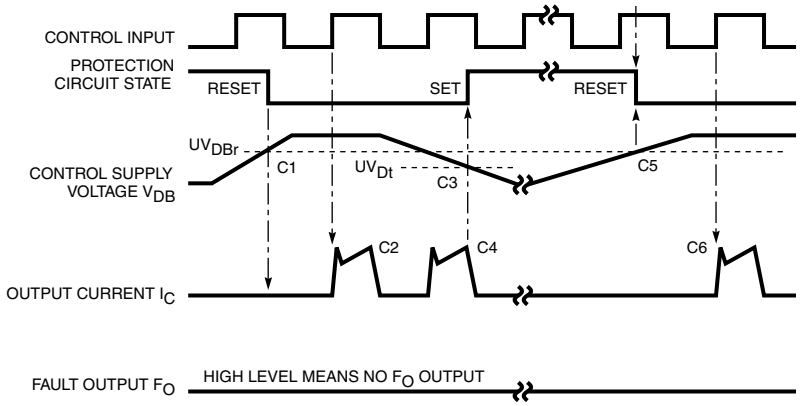



B1: Control supply voltage rise – After the voltage level reaches $UV_{Dr}$, the drive circuit begins to work at the rising edge of the next input signal.
B2 : Normal operation – IGBT turn on and conducting current.
B3: Under-voltage trip ($UV_{Dt}$).
B4: IGBT turn off regardless of the control input level.
B5: $F_O$ asserted during the period from minimum pulse width or until control supply recover to $UV_{Dr}$.
B6: Under-voltage reset ($UV_{Dr}$).
B7: Normal operation – IGBT turn on and conducting current.

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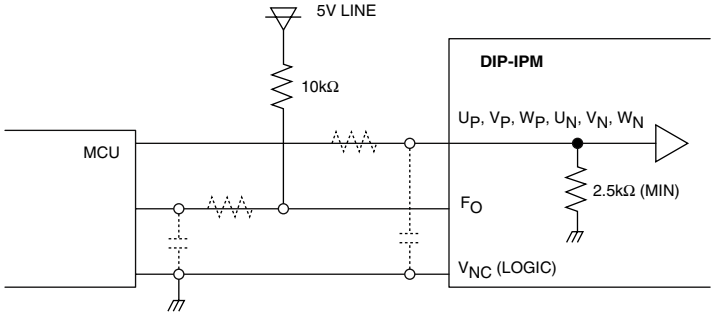
## Protection Function Timing Diagrams

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



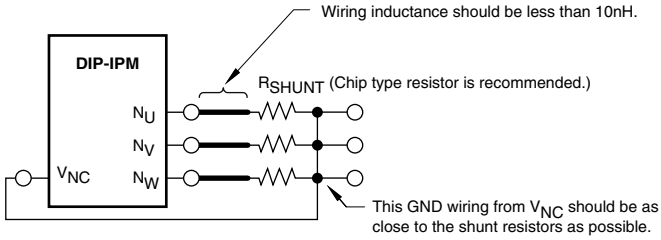

C1: Control supply voltage rises – After the voltage level reaches $UV_{DBr}$, the drive circuit begins to work at the rising edge of the next input signal.
C2: Normal operation – IGBT turn on and conducting current.
C3: Under-voltage trip ($UV_{DBt}$).
C4: IGBT stays off regardless of the control input level, but there is no $F_O$ signal output.
C5: Under-voltage reset ($UV_{Dr}$).
C6: Normal operation – IGBT turn on and conducting current.

## Typical Interface Circuit



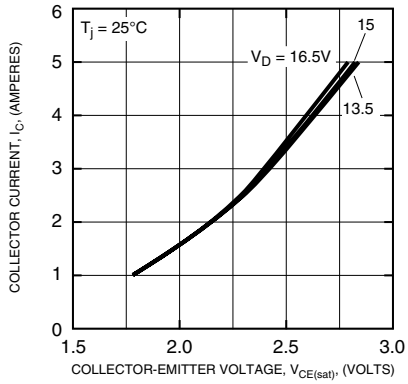

NOTE: RC coupling at each input (parts shown dotted) may change depending on the PWM control scheme used in the application and the wiring impedance of the printed circuit board. The DIP-IPM input signal section integrates a 2.5kΩ (min) pull-down resistor. Therefore, when using an external filtering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

## Wiring Method Around Shunt Resistor

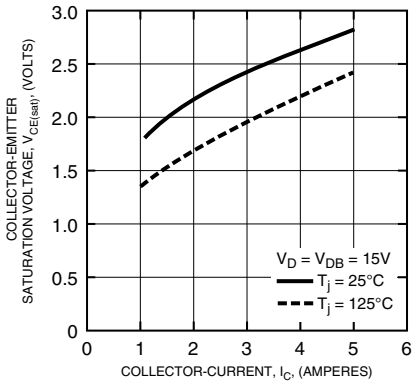


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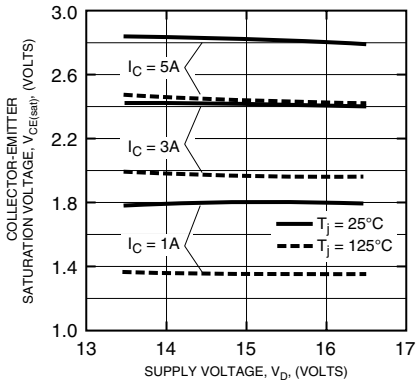
**OUTPUT CHARACTERISTICS (TYPICAL - INVERTER PART)**



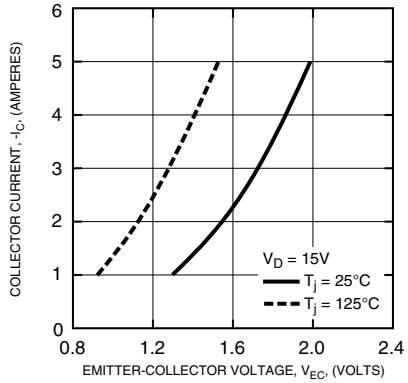

**COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS (TYPICAL - INVERTER PART)**



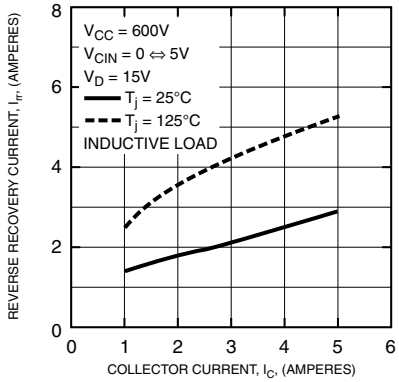

**COLLECTOR-EMITTER SATURATION VOLTAGE VS. SUPPLY VOLTAGE CHARACTERISTICS (TYPICAL - INVERTER PART)**



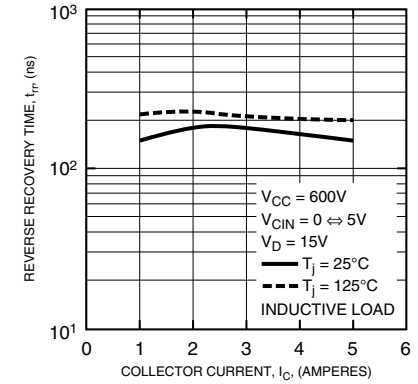

**FREE-WHEEL DIODE FORWARD CHARACTERISTICS (TYPICAL - INVERTER PART)**



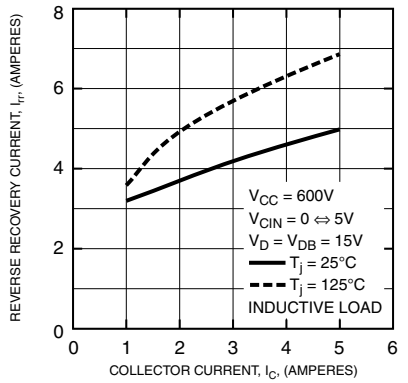

**REVERSE RECOVERY CHARACTERISTICS (TYPICAL - INVERTER PART N-SIDE)**



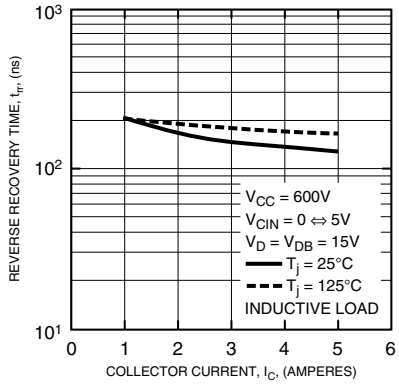

**REVERSE RECOVERY CHARACTERISTICS (TYPICAL - INVERTER PART N-SIDE)**



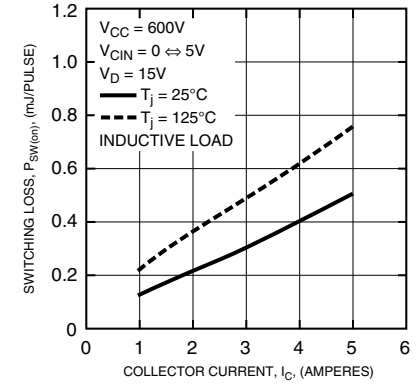

**REVERSE RECOVERY CHARACTERISTICS (TYPICAL - INVERTER PART P-SIDE)**



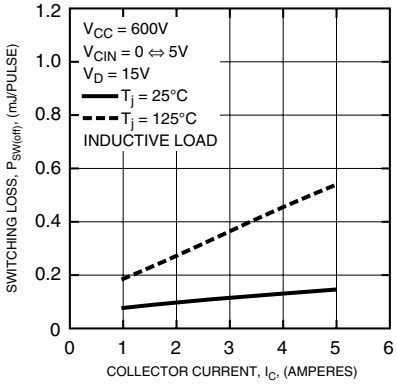

**REVERSE RECOVERY CHARACTERISTICS (TYPICAL - INVERTER PART P-SIDE)**



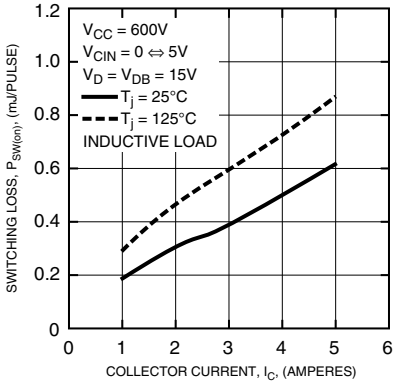

**SWITCHING LOSS (ON) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART N-SIDE)**



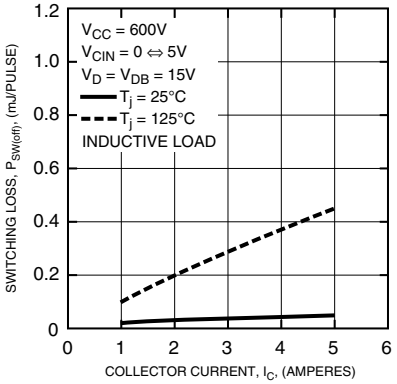
**SWITCHING LOSS (OFF) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART N-SIDE)**



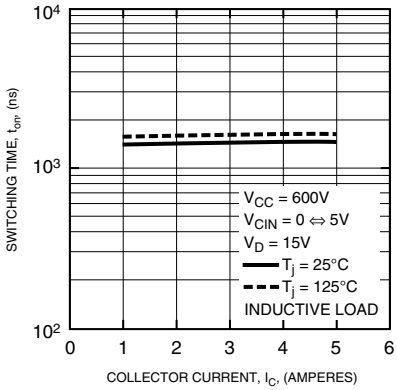

**SWITCHING LOSS (ON) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART P-SIDE)**



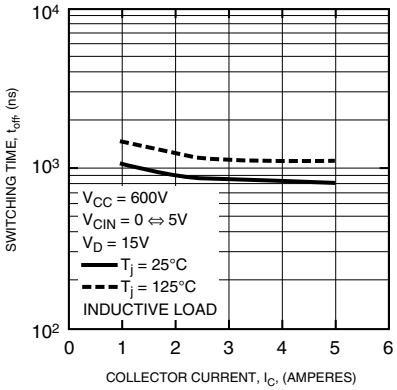

**SWITCHING LOSS (OFF) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART P-SIDE)**



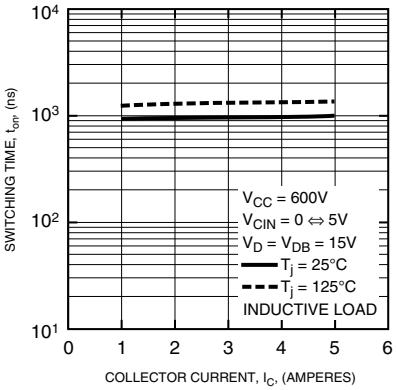

**SWITCHING TIME (ON) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART N-SIDE)**



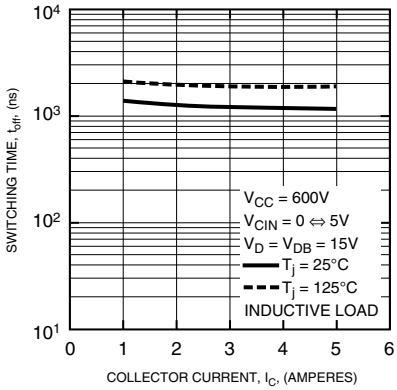

**SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART N-SIDE)**



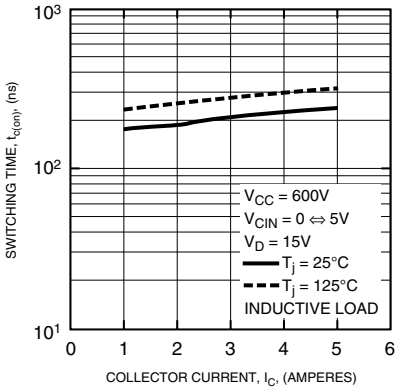

**SWITCHING TIME (ON) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART P-SIDE)**



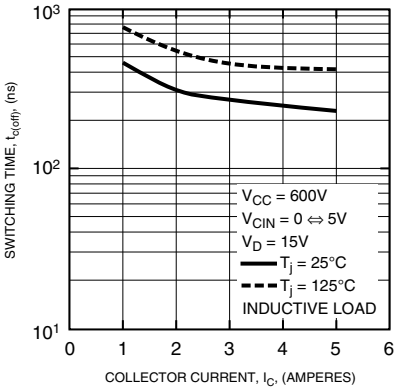

**SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART P-SIDE)**




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

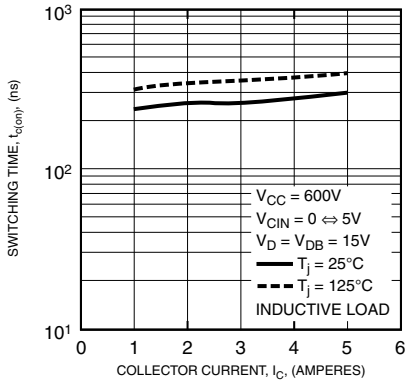



**SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART N-SIDE)**

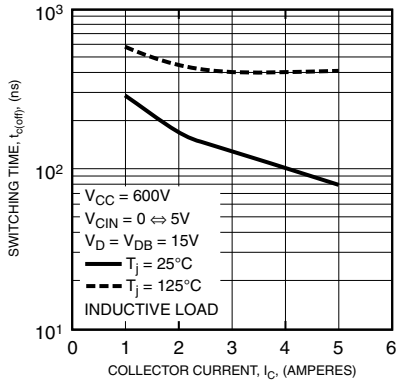


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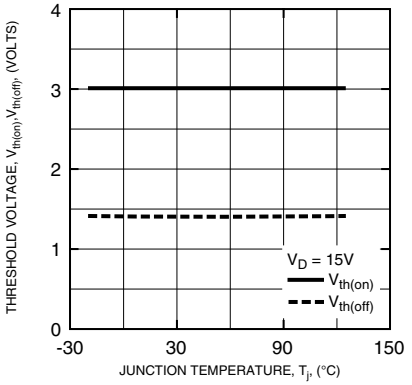
**SWITCHING TIME (ON) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART P-SIDE)**



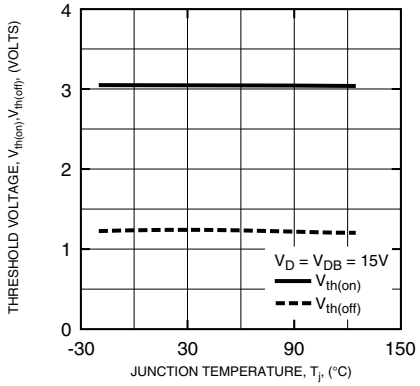

**SWITCHING TIME (OFF) VS. COLLECTOR CURRENT (TYPICAL - INVERTER PART P-SIDE)**



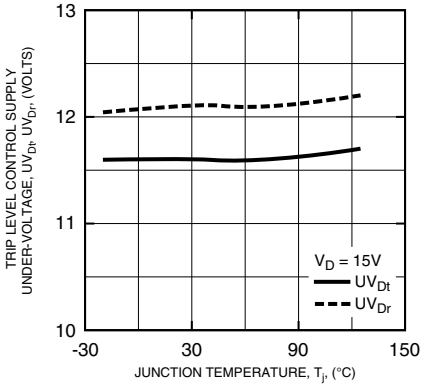

**THRESHOLD VOLTAGE VS. JUNCTION TEMPERATURE CHARACTERISTICS (TYPICAL - CONTROL PART N-SIDE)**



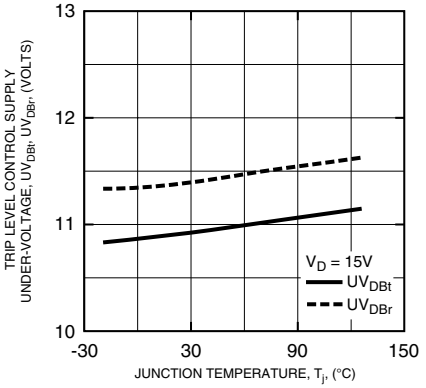

**THRESHOLD VOLTAGE VS. JUNCTION TEMPERATURE (TYPICAL - CONTROL PART P-SIDE)**



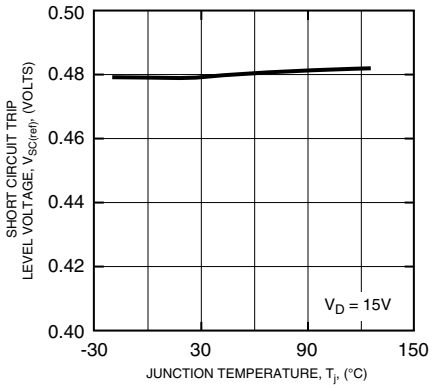

**TRIP LEVEL CONTROL SUPPLY UNDER-VOLTAGE VS. JUNCTION TEMPERATURE (TYPICAL - CONTROL PART N-SIDE)**



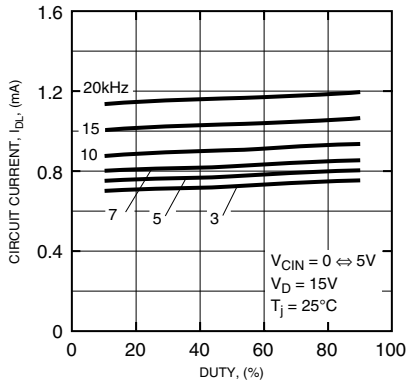

**TRIP LEVEL CONTROL SUPPLY UNDER-VOLTAGE VS. JUNCTION TEMPERATURE (TYPICAL - CONTROL PART P-SIDE)**



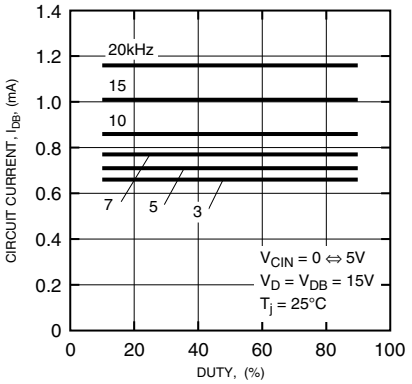

**SHORT CIRCUIT TRIP LEVEL VOLTAGE VS. JUNCTION TEMPERATURE (TYPICAL - CONTROL PART N-SIDE)**




**CIRCUIT CURRENT VS. DUTY CHARACTERISTICS (TYPICAL - CONTROL PART)**




**CIRCUIT CURRENT VS. DUTY CHARACTERISTICS (TYPICAL - CONTROL PART)**



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