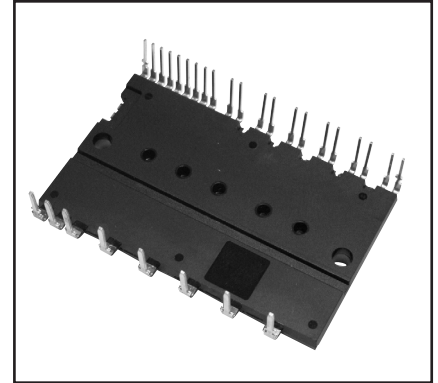
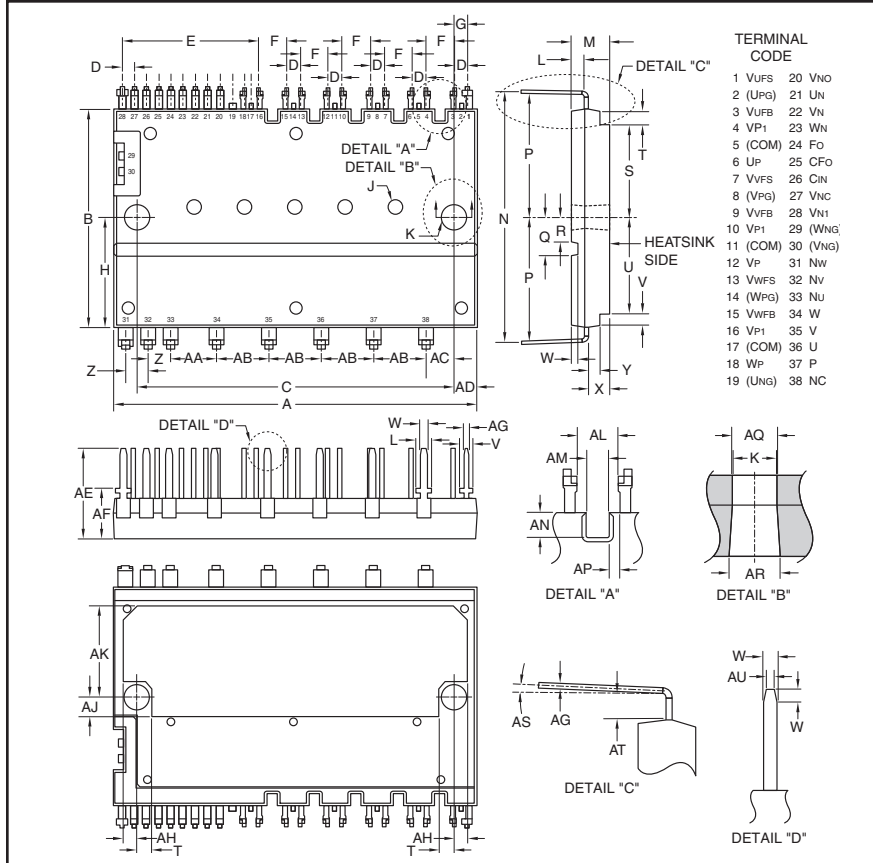


Intellimod™ Module Dual-In-Line Intelligent Power Module 20 Amperes/600 Volts



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 5th 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
- Reduced R_{th}

Applications:

- Refrigerators
- Air Conditioners
- Small Servo Motors
- Small Motor Control

Ordering Information:

PS21765 is a 600V, 20 Ampere short pin DIP Intelligent Power Module.

Outline Drawing and Circuit Diagram

| Dimensions | Inches | Millimeters |
|------------|--------------------------|-------------------------|
| A | 2.07 | 52.5 |
| B | 1.22 | 31.0 |
| C | 1.81±0.008 | 46.0±0.2 |
| D | 0.07±0.008 | 1.78±0.2 |
| E | 0.77 | 19.58 |
| F | 0.17±0.008 | 4.32±0.2 |
| G | 0.08±0.019 | 2.04±0.3 |
| H | 0.61 | 15.5 |
| J | 0.09 Dia. x 0.1 Depth | 2.2 Dia. x 2.6 Depth |
| K | 0.13 Dia. | 3.3 Dia. |
| L | 0.08 | 2.0 |
| M | 0.22 | 5.6 |
| N | 1.41±0.02 | 35.9±0.5 |
| P | 0.69 | 17.7 |
| Q | 0.216 | 5.5 |
| R | 0.14 | 3.5 |
| S | 0.503 | 12.78 |
| T | 0.09 | 2.2 |
| U | 0.53 | 13.5 |
| V | 0.06 | 1.5 |
| W | 0.04 | 1.0 |

| Dimensions | Inches | Millimeters |
|------------|------------|-------------|
| X | 0.06 | 1.55 |
| Y | 0.12 | 3.1±0.1 |
| Z | 0.13±0.019 | 3.3±0.3 |
| AA | 0.26±0.019 | 6.6±0.3 |
| AB | 0.3±0.019 | 7.62±0.3 |
| AC | 0.15±0.019 | 3.95±0.3 |
| AD | 0.13 | 3.25 |
| AE | 0.5 | 12.7 |
| AF | 0.28 | 7.1 |
| AG | 0.02 | 0.5 |
| AH | 0.067 | 1.7 |
| AJ | 0.11 | 2.8 |
| AK | 0.51 | 13.0 |
| AL | 0.114 | 2.9 |
| AM | 0.063 | 1.6 |
| AN | 0.068 | 1.75 |
| AP | 0.03 | 0.75 |
| AQ | 0.14 Dia. | 3.5 Dia. |
| AR | 0.145 Dia. | 3.7 Dia. |
| AS | 0° ~ 5° | |
| AT | 0.078 | 1.96 |
| AU | 0.023 | 0.6 |

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Absolute Maximum Ratings, $T_j = 25^\circ\text{C}$ unless otherwise specified

| Characteristics | Symbol | PS21765 | Units |
|--|------------------------|------------|------------------|
| Power Device Junction Temperature* | T_j | -20 to 150 | $^\circ\text{C}$ |
| Storage Temperature | T_{stg} | -40 to 125 | $^\circ\text{C}$ |
| Case Operating Temperature (Note 1) | T_C | -20 to 100 | $^\circ\text{C}$ |
| Mounting Torque, M3 Mounting Screws | — | 8.7 | in-lb |
| Module Weight (Typical) | — | 20 | Grams |
| Heatsink Flatness (Note 2) | — | -50 to 100 | μm |
| Self-protection Supply Voltage Limit (Short Circuit Protection Capability)** | $V_{\text{CC(prot.)}}$ | 400 | Volts |
| 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 ($@T_C \leq 100^\circ\text{C}$).

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

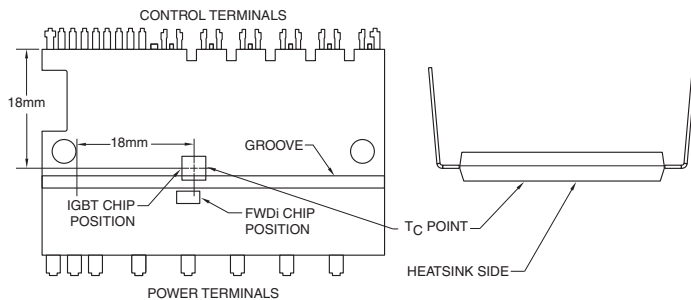
IGBT Inverter Sector

| | | | |
|--|------------------------|------|---------|
| Collector-Emitter Voltage | V_{CES} | 600 | Volts |
| Each Collector Current, \pm ($T_C = 25^\circ\text{C}$) | I_C | 20 | Amperes |
| Each Peak Collector Current, \pm ($T_C = 25^\circ\text{C}$, Less than 1ms) | I_{CP} | 40 | Amperes |
| Supply Voltage (Applied between P-NU, N_V , N_W) | V_{CC} | 450 | Volts |
| Supply Voltage, Surge (Applied between P-NU, N_V , N_W) | $V_{\text{CC(surge)}}$ | 500 | Volts |
| Collector Dissipation ($T_C = 25^\circ\text{C}$, per 1 Chip) | P_C | 76.9 | Watts |

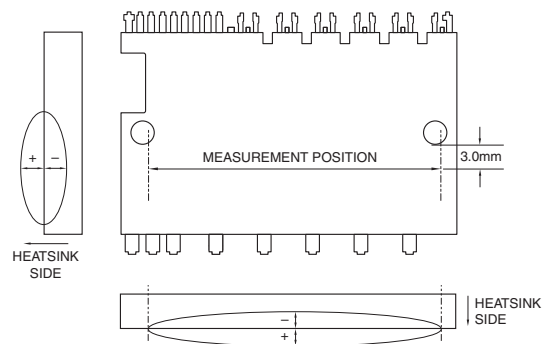
Control Sector

| | | | |
|--|-----------------|------------------|-------|
| Supply Voltage (Applied between $V_{P1-V_{NC}}$, $V_{N1-V_{NC}}$) | V_D | 20 | Volts |
| Supply Voltage (Applied between $V_{UFB-U_{UFS}}$, $V_{VFB-V_{VFS}}$, $V_{WFB-W_{WFS}}$) | V_{DB} | 20 | Volts |
| Input Voltage (Applied between U_P , V_P , W_P-V_{NC} , 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 $C_{\text{IN}}-V_{\text{NC}}$) | V_{SC} | -0.5 ~ $V_D+0.5$ | Volts |

Note 1 – T_C Measure Point



Note 2 – Flatness Measurement Position



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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 | |
|---|---------------|--|---|------|------|---------------|----|
| IGBT Inverter Sector | | | | | | | |
| Collector-Emitter Saturation Voltage | $V_{CE(sat)}$ | $V_D = V_{DB} = 15\text{V}, I_C = 20\text{A}, V_{IN} = 5\text{V}, T_j = 25^\circ\text{C}$ | — | 1.60 | 2.10 | Volts | |
| | | $V_D = V_{DB} = 15\text{V}, I_C = 20\text{A}, V_{IN} = 5\text{V}, T_j = 125^\circ\text{C}$ | — | 1.70 | 2.20 | Volts | |
| Diode Forward Voltage | V_{EC} | $-I_C = 20\text{A}, V_{IN} = 0\text{V}$ | — | 1.50 | 2.00 | Volts | |
| Inductive Load Switching Times | t_{on} | | 0.70 | 1.30 | 1.90 | μS | |
| | t_{rr} | $V_{CC} = 300\text{V}, V_D = V_{DB} = 15\text{V},$ | — | 0.30 | — | μS | |
| | $t_{C(on)}$ | $I_C = 20\text{A}, T_j = 125^\circ\text{C},$ | — | 0.50 | 0.80 | μS | |
| | t_{off} | $V_{IN} = 0 - 5\text{V}, \text{Inductive Load}$ | — | 1.30 | 1.90 | μS | |
| | $t_{C(off)}$ | | — | 0.40 | 0.60 | μS | |
| Collector 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 | |
| Control Sector | | | | | | | |
| Circuit Current | I_D | $V_{IN} = 5\text{V}$ | Total of $V_{P1-V_{NC}}, V_{N1-V_{NC}}$ | — | — | 7.00 | mA |
| | | | $V_{UFB-U}, V_{VFB-V}, V_{WFB-W}$ | — | — | 0.55 | mA |
| | | $V_{IN} = 0\text{V}$ | Total of $V_{P1-V_{NC}}, V_{N1-V_{NC}}$ | — | — | 7.00 | mA |
| | | | $V_{UFB-V_{UFS}}, V_{VFB-V_{VFS}}, V_{WFB-V_{WFS}}$ | — | — | 0.55 | mA |
| Fault Output Voltage | V_{FOH} | $V_{SC} = 0\text{V}, F_O$ Terminal Pull-up to 5V by 10k Ω | 4.9 | — | — | Volts | |
| | | $V_{SC} = 1\text{V}, I_{FO} = 1\text{mA}$ | — | — | 0.95 | Volts | |
| Short Circuit Trip Level* | $V_{SC(ref)}$ | $V_D = 15\text{V}$ | 0.43 | 0.48 | 0.53 | Volts | |
| Input Current | I_{IN} | $V_{IN} = 5\text{V}$ | 1.0 | 1.5 | 2.0 | mA | |
| Supply Circuit Under-voltage Protection | UV_{DBt} | Trip Level, $T_j \leq 125^\circ\text{C}$ | 10.0 | — | 12.0 | Volts | |
| | UV_{DBr} | Reset Level, $T_j \leq 125^\circ\text{C}$ | 10.5 | — | 12.5 | Volts | |
| | | Trip Level, $T_j \leq 125^\circ\text{C}$ | 10.3 | — | 12.5 | Volts | |
| | | Reset Level, $T_j \leq 125^\circ\text{C}$ | 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 | — | 2.3 | 2.6 | Volts | |
| OFF Threshold Voltage | $V_{th(off)}$ | $U_P, V_P, W_P - V_{NC},$ | 0.8 | 1.4 | — | Volts | |
| ON/OFF Threshold Hysteresis Voltage | $V_{th(hys)}$ | $U_N, V_N, W_N - V_{NC}$ | 0.5 | 0.9 | — | Volts | |

* Short Circuit protection is only for the lower-arms. Please select the external shunt resistance such that the S_C trip level is less than 1.7 times the current rating.

**Fault signal is output when the low-arms short circuit or control supply under-voltage protective function works. The fault output pulse-width, t_{FO} , depends on the capacitance of C_{FO} according to the following approximate equation: $C_{FO} = 12.2 \times 10^{-6} \times t_{FO} [F]$.

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Thermal Characteristics

| Characteristic | Symbol | Condition | Min. | Typ. | Max. | Units |
|------------------|----------------|--------------------------------|------|------|------|---------|
| Junction to Case | $R_{th(j-c)Q}$ | Inverter IGBT (Per 1/6 Module) | — | — | 1.3 | °C/Watt |
| | $R_{th(j-c)D}$ | Inverter FWDi (Per 1/6 Module) | — | — | 3.0 | °C/Watt |

Recommended Conditions for Use

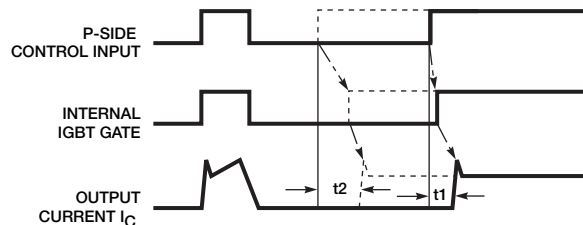
| Characteristic | Symbol | Condition | Min. | Typ. | Value | Units |
|----------------------------|----------------------|--|-------------------------------------|------|-------|------------|
| Supply Voltage | V_{CC} | Applied between P- N_U , N_V , N_W | 0 | 300 | 400 | Volts |
| Control Supply Voltage | V_D | Applied between V_{P1} - V_{NC} , 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 | dV_D , dV_{DB} | — | -1 | — | 1 | V/ μ s |
| Arm Shoot-through | t_{DEAD} | For Each Input Signal, $T_C \leq 100^\circ\text{C}$ | 2.0 | — | — | μ s |
| Blocking Time | | $T_C \leq 100^\circ\text{C}$ | | | | |
| PWM Input Frequency | f_{PWM} | $T_C \leq 100^\circ\text{C}$, $T_j \leq 125^\circ\text{C}$ | — | — | 20 | kHz |
| Allowable Minimum | $P_{WIN(on)}^{**}$ | — | 0.3 | — | — | μ s |
| Input Pulse Width | $P_{WIN(off)}^{***}$ | Below Rated | 200V $\leq V_{CC} \leq$ 350V, | 1.4 | — | μ s |
| | | Current | 13.5V $\leq V_D \leq$ 16.5V, | | | |
| | | Between Rated | 13.0V $\leq V_{DB} \leq$ 18.5V, | 2.5 | — | μ s |
| | | Current and 1.7 | -20°C $\leq T_C \leq$ 100°C, N-line | | | |
| | | Times Rated Current | Wiring Inductance < 10nH | | | |
| V_{NC} Voltage Variation | V_{NC} | Between V_{NC} - N_U , N_V , N_W , (Including Surge) | -5.0 | — | 5.0 | Volts |
| Junction Temperature | T_j | — | -20 | — | 125 | °C |

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

**The input signal with ON pulse less than $P_{WIN(on)}$ may make no response.

***DIP-IPM may make a delayed response (less than about 2 μ sec) or no response for the input signal with OFF pulse width less than $P_{WIN(off)}$. Refer to About Delayed Response Against Shorter Input OFF Signal than $P_{WIN(off)}$ (P-side Only) and Recommended Wiring Around the Shunt Resistor for details about N-line inductance.

Delayed Response Against Shorter Input OFF Signal than $P_{WIN(off)}$ (P-side Only)

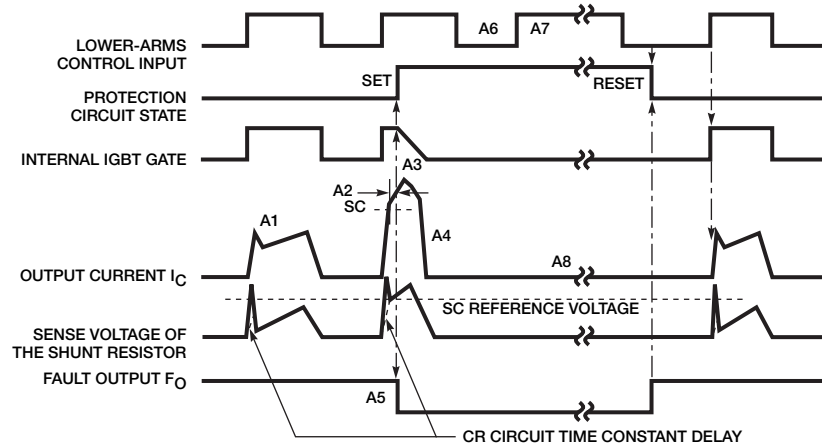


Solid Line – OFF Pulse Width > $P_{WIN(off)}$: Turn ON time t1.

Dotted Line – OFF Pulse Width < $P_{WIN(off)}$: Turn ON time t2.

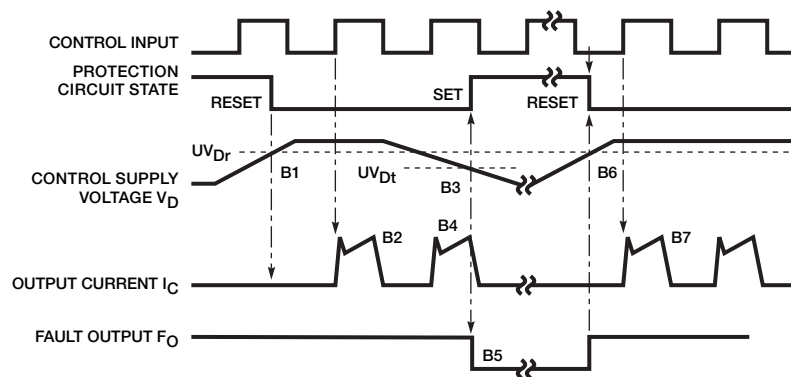
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Short Circuit Protection (Lower-arms Only with External Shunt Resistor and RC Filter)



- A1: Normal operation – IGBT ON and carrying current.
- A2: Short Circuit current detection (SC trigger).
- A3: IGBT gate hard interruption.
- A4: IGBT turns OFF.
- A5: F_O timer operation starts. The pulse width of the F_O signal is set by the external capacitor C_{FO} .
- A6: Input "L" – IGBT OFF.
- A7: Input "H"
- A8: IGBT OFF state in spite of input "H".

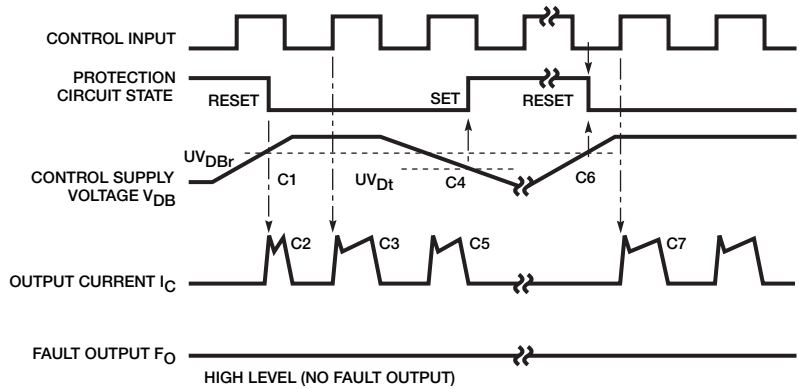
Under-Voltage Protection (Lower-arm, UV_D)



- B1: Control supply voltage rising – 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 ON and conducting current.
- B3: Under-voltage trip (UV_{Dt}).
- B4: IGBT turns OFF regardless of the control input level.
- B5: F_O operation starts.
- B6: Under-voltage reset (UV_{Dr}).
- B7: Normal operation – IGBT ON and conducting current.

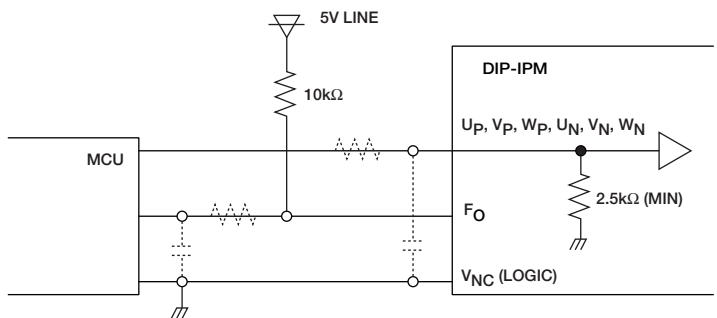
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Under-Voltage Protection (Upper-arm, UV_{DB})



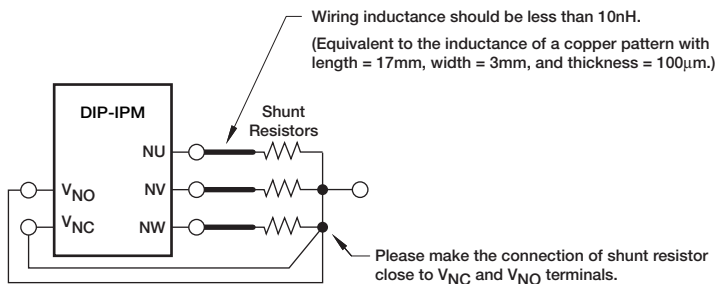
- C1: Control supply voltage rises – After the voltage level reaches UV_{DBr}, the drive circuit begins to work at the rising edge of the next input signal.
- C2: Protection circuit state reset – IGBT ON and conducting current.
- C3: Normal operation – IGBT ON and conducting current.
- C4: Under-voltage trip (UV_{DBt}).
- C5: IGBT OFF regardless of the control input level, but there is no F_O signal output.
- C6: Under-voltage reset (UV_{Dp}).
- C7: Normal operation – IGBT ON and conducting current.

Recommended MCU I/O Interface Circuit



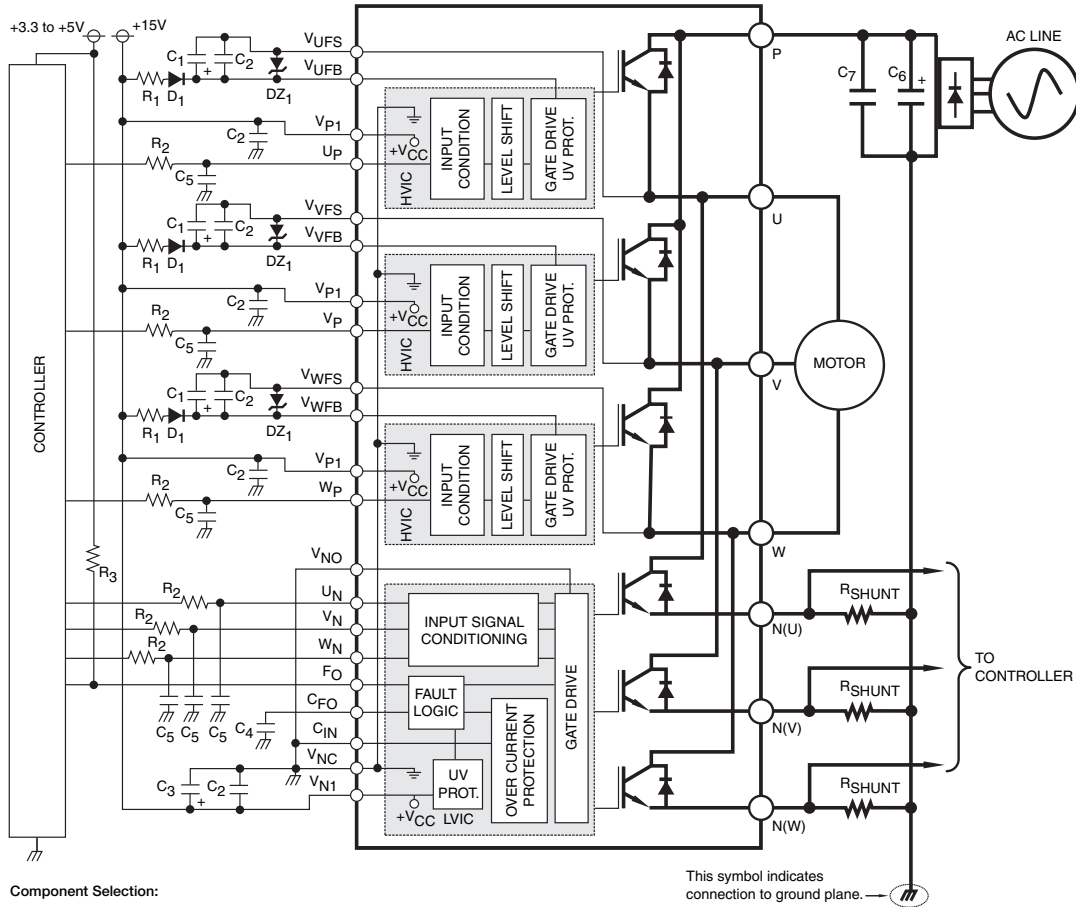
NOTE: RC coupling at each input (parts shown dotted) may change depending on the PWM control scheme used in the application and the wiring impedance of the printed circuit board. The DIP-IPM input signal section integrates a 2.5kΩ (min) pull-down resistor. Therefore, when using an external filtering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

Recommended Wiring Around the Shunt Resistor



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Application Circuit



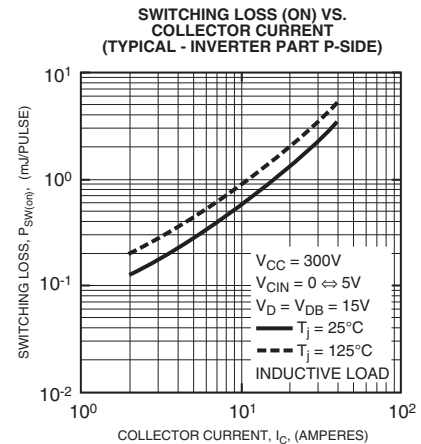
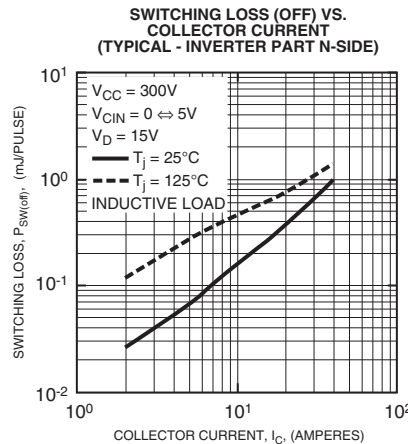
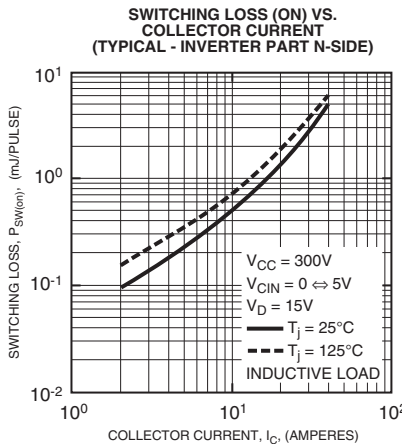
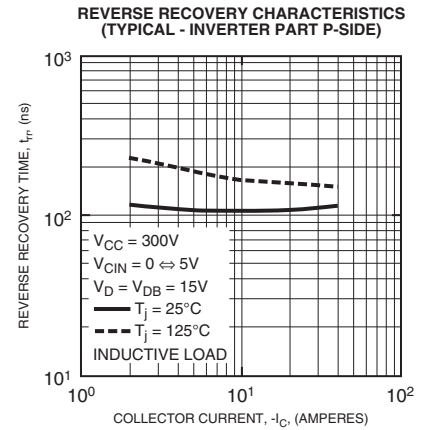
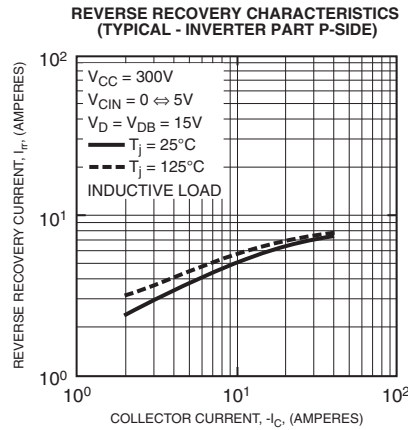
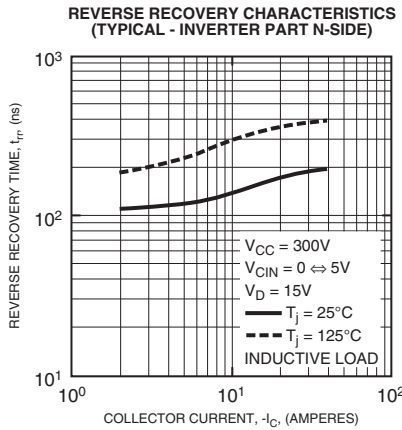
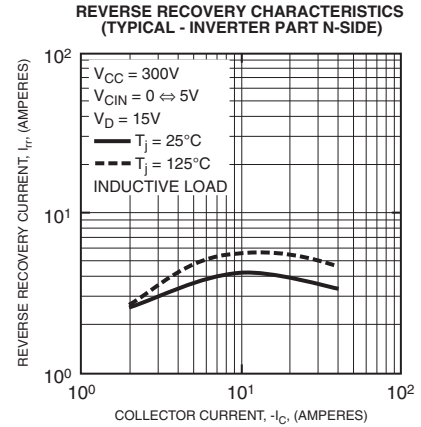
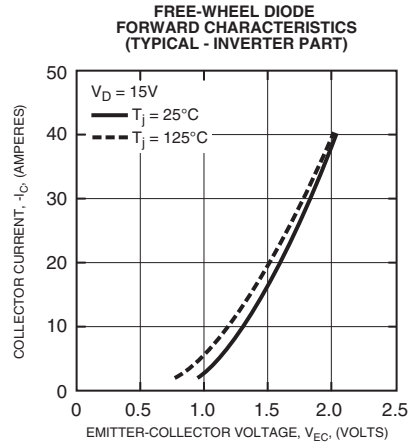
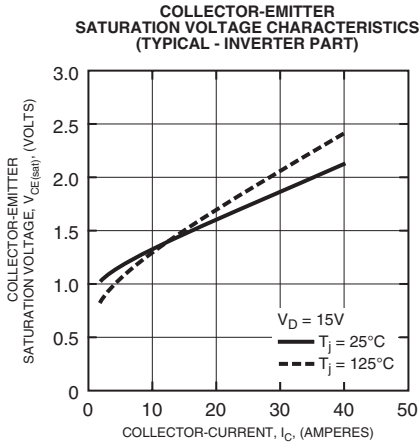
Component Selection:

| Dsgn. | Typ. Value | Description |
|--------|------------------|--|
| D1 | 1A, 600V | Boot strap supply diode – Ultra fast recovery |
| DZ1 | 16V, 0.25W | Control and boot strap supply over voltage suppression |
| C1 | 10-100uF, 50V | Boot strap supply reservoir – Electrolytic, long life, low Impedance, 105°C (Note 5) |
| C2 | 0.22-2.0uF, 50V | Local decoupling/High frequency noise filters – Multilayer ceramic (Note 5) |
| C3 | 10-100uF, 50V | Control power supply filter – Electrolytic, long life, low Impedance, 105°C (Note 5) |
| C4 | 22nF, 50V | Fault output timer capacitor |
| C5 | 100pF, 50V | Optional Input signal noise filter – Multilayer ceramic (Note 1) |
| C6 | 200-2000uF, 450V | Main DC bus filter capacitor – Electrolytic, long life, high ripple current, 105°C |
| C7 | 0.1-0.22uF, 450V | Surge voltage suppression capacitor – Polyester/Polypropylene film (Note 8) |
| RSHUNT | 5-100mohm | Current sensing resistor – Non-inductive, temperature stable, tight tolerance (Note 9) |
| R1 | 10 ohm | Boot strap supply inrush limiting resistor |
| R2 | 330 ohm | Optional control input noise filter (Note 1, Note 2) |
| R3 | 10k ohm | Fault output signal pull-up resistor (Note 3) |

Notes:

- Input drive is active-high type. There is a 2.5kΩ(min.) pull-down resistor integrated in the IC input circuit. To prevent malfunction, the wiring of each input should be as short as possible. When using RC coupling circuit, make sure the input signal level meets the turn-on and turn-off threshold voltage. See application notes for details.
- Internal HVIC provides high voltage level shifting allowing direct connection of all six driving signals to the controller.
- FO output is an open collector type. Pull up resistor (R3) should be adjusted to current sink capability of the controller.
- To prevent input signal oscillations, minimize wire 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.
- All capacitors should be mounted as close to the terminals as possible. (C1: good temperature, frequency characteristic electrolytic type, and C2, C3: good temperature, frequency and DC bias characteristic ceramic type are recommended.)
- Shows short circuit protection disabled. See application notes for use of short circuit protection.
- Local decoupling frequency filter capacitors must be connected as close as possible to the module's pins.
- The length of the DC link wiring between C5, C6, the DIP's P terminal and the shunt must be minimized to prevent excessive transient voltages. In particular C6 should be mounted as close to the DIP as possible.
- Use high quality, tight tolerance 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.
- Inserting a Zener diode (24V/1W) between each pair of control supply terminals to prevent surge destruction is recommended.

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