MITSUBISHI ELECTRIC

<Intelligent Power Modules>

# PM50CG1AP065/PM50CG1APL065

**FLAT-BASE TYPE**
**INSULATED PACKAGE**

## FEATURE

a) Adopting Full-Gate CSTBT™ chip.

b) The over-temperature protection which detects the chip surface temperature of CSTBT™ is adopted.

c) Error output signal is available from each protection upper and lower arm of IPM.

d) Outputting an error signal corresponding to the abnormal state (error mode identification)

UL Recognized under UL1557, File No. E323585

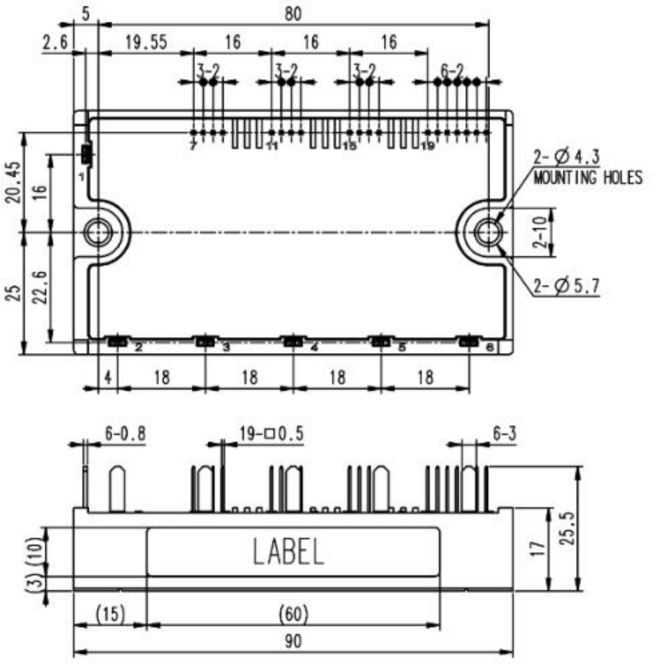
This product is compliant with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) directive 2011/65/EU and (EU)2015/863.

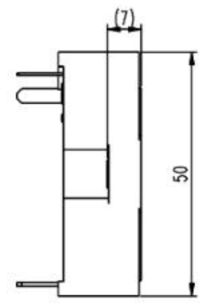
## APPLICATION

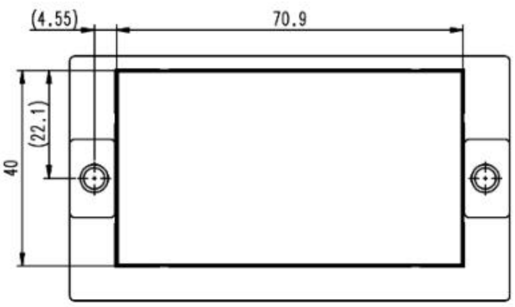
General purpose inverter, servo drives and other motor controls

## PACKAGE OUTLINES

**Dimensions in mm**




Tolerance otherwise specified

| Division of Dimension | | | Tolerance |
|---|---|---|---|
| 0.5 | to | 3 | ±0.2 |
| over 3 | to | 6 | ±0.3 |
| over 6 | to | 30 | ±0.5 |
| over 30 | to | 120 | ±0.8 |
| over 120 | to | 400 | ±1.2 |

## TERMINAL CODE

----CG1AP type----

1.NC, 2.P, 3.N, 4.U, 5.V, 6.W, 7.$V_{UPC}$, 8.$U_{FO}$, 9.$U_P$, 10.$V_{UP1}$, 11.$V_{VPC}$, 12.$V_{FO}$, 13.$V_P$, 14.$V_{VP1}$, 15.$V_{WPC}$, 16.$W_{FO}$, 17.$W_P$, 18.$V_{WP1}$, 19.$V_{NC}$, 20.$V_{N1}$, 21.NC, 22.$U_N$, 23.$V_N$, 24.$W_N$, 25.$F_O$

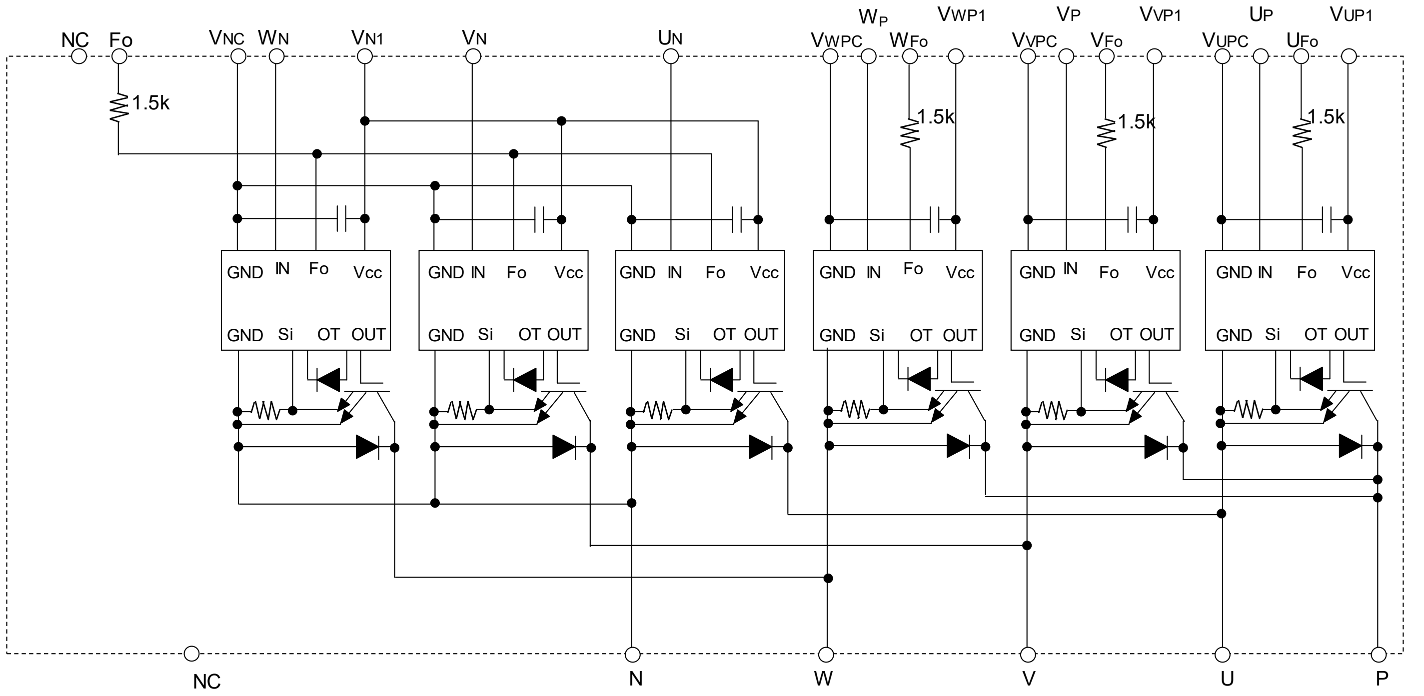
----CG1APL type----

1.N, 2.P, 3.NC, 4.U, 5.V, 6.W, 7.$V_{UPC}$, 8.$U_{FO}$, 9.$U_P$, 10.$V_{UP1}$, 11.$V_{VPC}$, 12.$V_{FO}$, 13.$V_P$, 14.$V_{VP1}$, 15.$V_{WPC}$, 16.$W_{FO}$, 17.$W_P$, 18.$V_{WP1}$, 19.$V_{NC}$, 20.$V_{N1}$, 21.NC, 22.$U_N$, 23.$V_N$, 24.$W_N$, 25.$F_O$



Publication date : December, 2020

**INTERNAL FUNCTIONS BLOCK DIAGRAM**




**MAXIMUM RATINGS** (Tvj = 25°C, unless otherwise noted)

**INVERTER PART**

| Symbol | Parameter | Conditions | Ratings | Unit |
|---|---|---|---|---|
| $V_{CES}$ | Collector-Emitter Voltage | $V_D$=15 V, $V_{CIN}$=15 V | 650 | V |
| $I_C$ | Collector Current | $T_C$=25 °C | 50 | A |
| $I_{CRM}$ | | Pulse | 100 | |
| $P_{tot}$ | Total Power Dissipation | $T_C$=25 °C | 240 | W |
| $I_E$ | Emitter Current | $T_C$=25 °C | 50 | A |
| $I_{ERM}$ | (Free-wheeling Diode Forward current) | Pulse | 100 | |
| Tvj | Junction Temperature | (Note5) | -20 ~ +150 | °C |

*: Tc measurement point is just under the chip.

**CONTROL PART**

| Symbol | Parameter | Conditions | Ratings | Unit |
|---|---|---|---|---|
| $V_D$ | Supply Voltage | Applied between: $V_{UP1}$-$V_{UPC}$, $V_{VP1}$-$V_{VPC}$, $V_{WP1}$-$V_{WPC}$, $V_{N1}$-$V_{NC}$ | 20 | V |
| $V_{CIN}$ | Input Voltage | Applied between: $U_P$-$V_{UPC}$, $V_P$-$V_{VPC}$, $W_P$-$V_{WPC}$, $U_N$, $V_N$, $W_N$-$V_{NC}$ | 20 | V |
| $V_{FO}$ | Fault Output Supply Voltage | Applied between: $U_{FO}$-$V_{UPC}$, $V_{FO}$-$V_{VPC}$, $W_{FO}$-$V_{WPC}$, Fo-$V_{NC}$ | 20 | V |
| $I_{FO}$ | Fault Output Current | Sink current at $U_{FO}$, $V_{FO}$, $W_{FO}$, Fo terminals | 20 | mA |

**TOTAL SYSTEM**

| Symbol | Parameter | Conditions | Ratings | Unit |
|---|---|---|---|---|
| $V_{CC(PROT)}$ | Supply Voltage Protected by SC | $V_D$ =13.5 V~16.5 V, Inverter Part, Tvj=+125°C start | 400 | V |
| $T_{stg}$ | Storage Temperature | - | -40 ~ +125 | °C |
| $T_C$ | Operating Case Temperature | (Note5) | -20 ~ +125 | °C |
| $V_{isol}$ | Isolation Voltage | 60Hz, Sinusoidal, Charged part to Base plate, AC 1min, RMS | 2500 | V |

*: Tc measurement point is just under the chip.

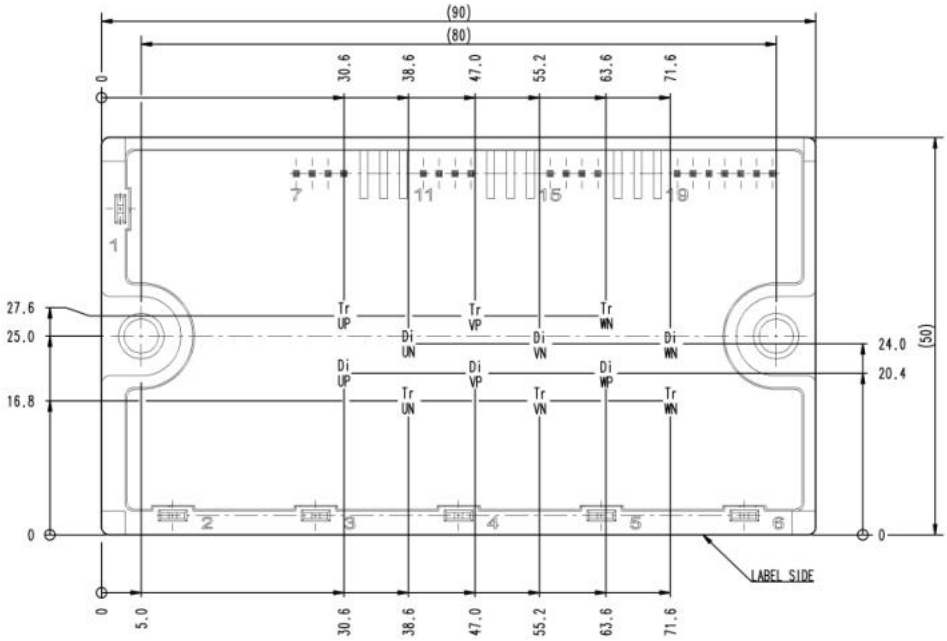
## THERMAL RESISTANCE

| Symbol | Parameter | Conditions | Limits Min. | Limits Typ. | Limits Max. | Unit |
|---|---|---|---|---|---|---|
| $R_{th(j-c)Q}$ | Thermal Resistance | Junction to case, IGBT, per 1 element (Note1) | - | - | 0.52 | K/W |
| $R_{th(j-c)D}$ | | Junction to case, FWD, per 1 element (Note1) | - | - | 0.88 | |
| $R_{th(c-s)}$ | Contact Thermal Resistance | Case to heat sink, per 1 module, Thermal grease applied (Note.1, 2, 5) | - | 19.1 | - | K/kW |

Note1. If you use this value, $R_{th(s-a)}$ should be measured just under the chips.

Note2. Typical value is by thermally conductive grease of λ=0.9W/(m·K), $D_{(C-S)}$=50 μm.

**CHIP LOCATION (Top view)** Dimension in mm, torelance: ±1mm




Tr** : IGBT
Di** : FWD

## ELECTRICAL CHARACTERISTICS (Tvj= 25°C, unless otherwise noted)

### INVERTER PART

| Symbol | Parameter | Conditions | | | Limits Min. | Limits Typ. | Limits Max. | Unit |
|---|---|---|---|---|---|---|---|---|
| $V_{CEsat}$ | Collector-Emitter Saturation Voltage | $V_D$=15 V, $I_C$=50 A | Tvj=25 °C | Terminal | - | - | 1.7 | V |
| | | | | Chip | - | 1.25 | - | |
| | | $V_{CIN}$=0 V, Pulsed, (Fig.1) | Tvj=125 °C | Terminal | - | - | 1.95 | |
| | | | | Chip | - | 1.33 | - | |
| $V_{EC}$ | Emitter-Collector Voltage | $V_D$=15 V, $I_E$=50 A, | Tvj=25 °C | Terminal | - | - | 1.9 | V |
| | | | | Chip | - | 1.40 | - | |
| | | $V_{CIN}$= 15 V, pulsed, (Fig.2) | Tvj=125 °C | Terminal | - | - | 2.0 | |
| | | | | Chip | - | 1.45 | - | |
| $t_{on}$ | Switching Time | $V_D$=15 V, $V_{CIN}$=0 V⟷15 V, | | | 0.3 | 0.6 | 1.2 | μs |
| $t_{rr}$ | | $V_{CC}$=300 V, $I_C$=50A, | | | - | 0.2 | 0.65 | |
| $t_{c(on)}$ | | Tvj=125 °C, | | | - | 0.17 | 0.75 | |
| $t_{off}$ | | Inductive Load | | | - | 1.0 | 2.3 | |
| $t_{c(off)}$ | | (Fig.3, 4) | | | - | 0.13 | 0.4 | |
| $I_{CES}$ | Collector-Emitter Cut-off Current | $V_{CE}$=$V_{CES}$, $V_D$=15 V, $V_{CIN}$=15 V (Fig.5) | | Tvj=25 °C | - | - | 1 | mA |
| | | | | Tvj=125 °C | - | - | 10 | |

**ELECTRICAL CHARACTERISTICS** (Tvj = 25°C, unless otherwise noted)

**CONTROL PART**

| Symbol | Parameter | Conditions | | Limits Min. | Limits Typ. | Limits Max. | Unit |
|---|---|---|---|---|---|---|---|
| $I_D$ | Circuit Current | $V_D$=15 V, $V_{CIN}$=15 V | $V_{P1}$-$V_{PC}$ | - | 4 | 6 | mA |
| | | | $V_{N1}$-$V_{NC}$ | - | 12 | 18 | |
| | | $V_D$=15 V, $V_{CIN}$=0 V⟷15 V, $V_{CC}$=400 V<br>$I_C$=0A, Tvj=125 °C, $f_C$≤20kHz | $V_{P1}$-$V_{PC}$ | - | 10 | 12 | |
| | | | $V_{N1}$-$V_{NC}$ | - | 29 | 35 | |
| $V_{th(ON)}$ | Input ON Threshold Voltage | Applied between:<br>$U_P$-$V_{UPC}$, $V_P$-$V_{VPC}$, $W_P$-$V_{WPC}$, $U_N$, $V_N$, $W_N$-$V_{NC}$ | | 1.2 | 1.5 | 1.8 | V |
| $V_{th(OFF)}$ | Input OFF Threshold Voltage | | | 1.7 | 2.0 | 2.3 | |
| SC | Short Circuit Trip Level | -20≤Tvj≤125 °C, $V_D$=15 V (Fig.3, 6) | | 100 | - | - | A |
| $t_{d(SC)}$ | Short Circuit Current Delay Time | $V_D$=15 V, Tvj=125 °C (Fig.3, 6) | | - | 2.0 | - | μs |
| OT | Over Temperature Protection | Detect temperature of IGBT chip surface | Trip level | 150 | - | - | °C |
| $OT_{(hys)}$ | | | Hysteresis | - | 20 | - | |
| $UV_t$ | Supply Circuit Under-Voltage Protection | - | Trip level | 11.0 | 12.0 | 12.7 | V |
| $UV_r$ | | | Reset level | - | 12.5 | - | |
| $I_{FO(H)}$ | Fault Output Current | $V_D$=15 V, $V_{FO}$=15 V (Note3) | | - | - | 0.01 | mA |
| $I_{FO(L)}$ | | | | - | 10 | 15 | |
| $t_{FO}$ | Fault Output Pulse Width | $V_D$=15 V (Note3) | OT | - | 8.0 | - | ms |
| | | | UV | - | 4.0 | - | |
| | | | SC | - | 2.0 | - | |

Note3. Fault output is given only when the internal SC, OT & UV protections schemes of either upper or lower arm device operate to protect it.

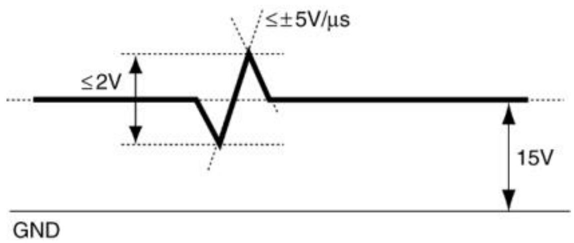
**MECHANICAL RATINGS AND CHARACTERISTICS**

| Symbol | Parameter | Conditions | Limits Min. | Limits Typ. | Limits Max. | Unit |
|---|---|---|---|---|---|---|
| $M_s$ | Mounting Torque | Mounting part screw : M4 | 1.5 | 1.7 | 2.0 | N•m |
| m | mass | - | - | 175 | - | g |

**RECOMMENDED CONDITIONS FOR USE**

| Symbol | Parameter | Conditions | Recommended value | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage | Applied across P-N terminals | ≤ 400 | V |
| $V_D$ | Control Supply Voltage | Applied between :<br>$V_{UP1}$-$V_{UPC}$, $V_{VP1}$-$V_{VPC}$, $V_{WP1}$-$V_{WPC}$,$V_{N1}$-$V_{NC}$ (Note4) | 15.0±1.5 | V |
| $V_{CIN(ON)}$ | Input ON Voltage | Applied between :<br>$U_P$-$V_{UPC}$, $V_P$-$V_{VPC}$, $W_P$-$V_{WPC}$, $U_N$, $V_N$, $W_N$-$V_{NC}$ | ≤ 0.8 | V |
| $V_{CIN(OFF)}$ | Input OFF Voltage | | ≥ 9.0 | |
| $f_{PWM}$ | PWM Input Frequency | Using Application Circuit of Fig. 8 | ≤ 20 | kHz |
| $t_{dead}$ | Arm Shoot-through Blocking Time | For IPM's each input signals (Fig.7) | ≥ 2.0 | μs |

Note4. With ripple satisfying the following conditions: dv/dt swing ≤ ±5 V/μs, Variation ≤ 2 V peak to peak




Note5. Long term performance related to thermal conductive material such as thermal grease (including but not limited to aspects such as the increase of thermal resistance due to pumping out, etc.) should be verified under your specific application conditions. Each temperature condition (Tvj, Tc) must be maintained below the maximum rated temperature throughout consideration of the temperature rise even for long term usage.

**PRECAUTIONS FOR TESTING**

1. Before applying any control supply voltage ($V_D$), the input terminals should be pulled up by resistors, etc. to their corresponding supply voltage and each input signal should be kept off state.
   After this, the specified ON and OFF level setting for each input signal should be done.
2. When performing “SC” tests, the turn-off surge voltage spike at the corresponding protection operation should not be allowed to rise above $V_{CES}$ rating of the device.
   (These test should not be done by using a curve tracer or its equivalent.)

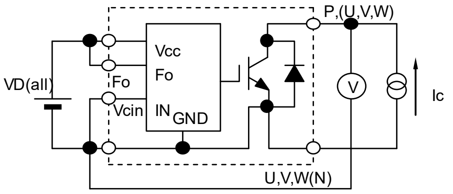



Fig.1 $V_{CEsat}$ Test

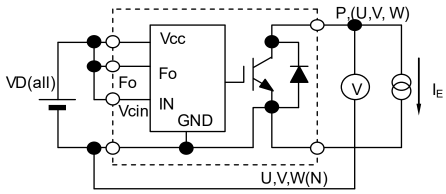



Fig.2 $V_{EC}$ Test

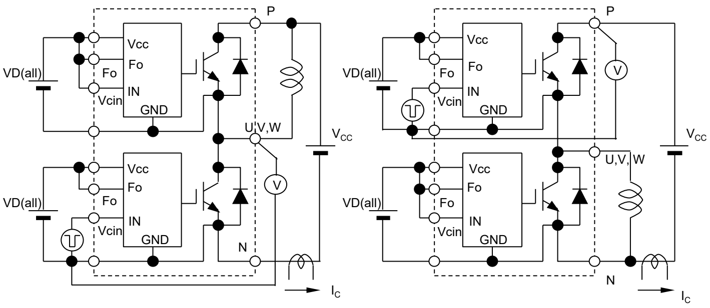



Fig.3 Switching time and SC test circuit

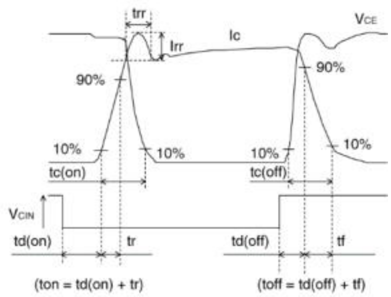



Fig.4 Switching time test waveform

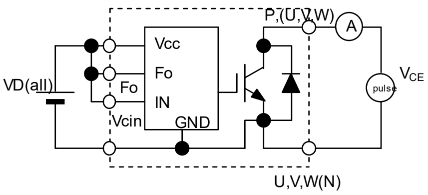



Fig.5 $I_{CES}$ Test

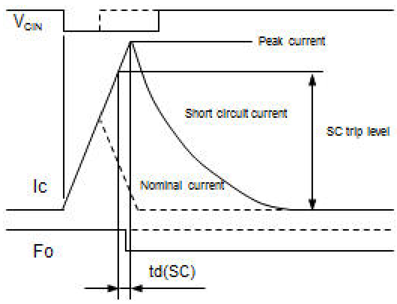
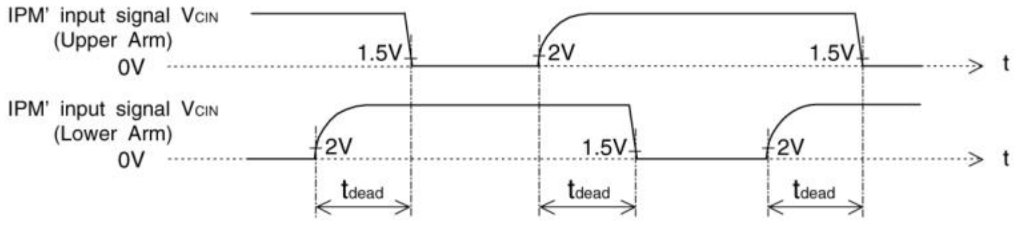
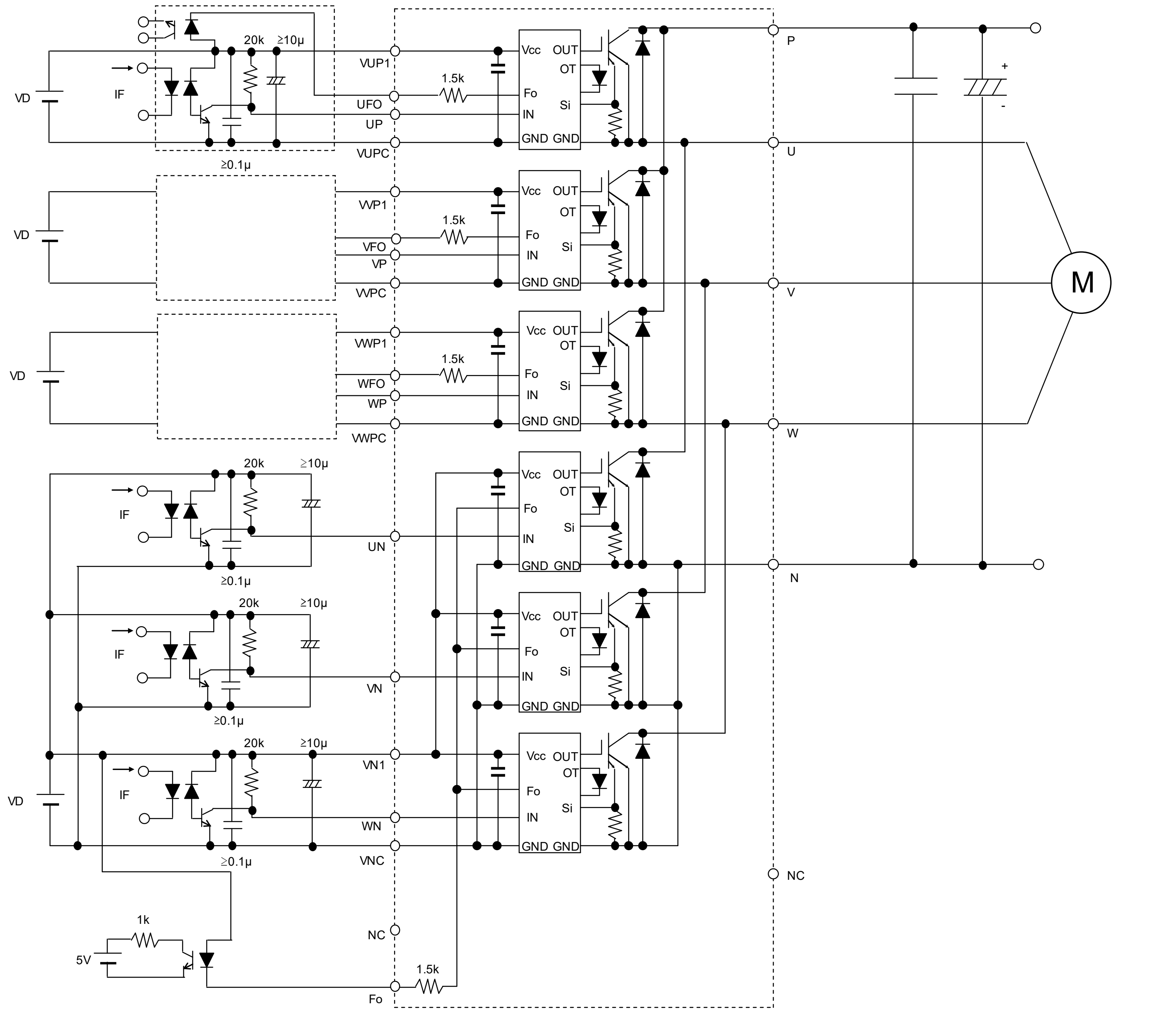



Fig.6 SC test waveform




1.5V: Input on threshold voltage Vth(on) typical value, 2V: Input off threshold voltage Vth(off) typical value

Fig. 7 Dead time measurement point example




: Interface which is the same as the U-phase

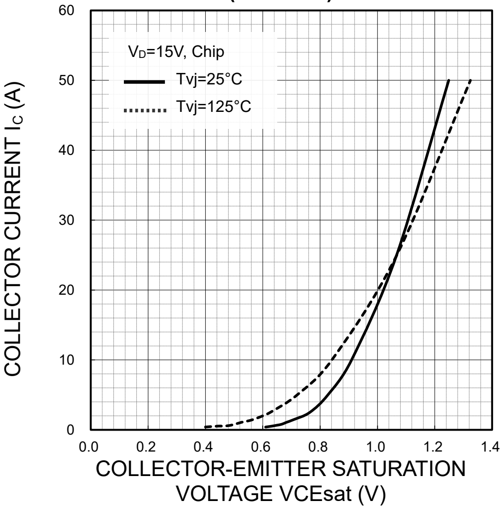
Fig. 8 Application Example Circuit

**NOTES FOR STABLE AND SAFE OPERATION ;**

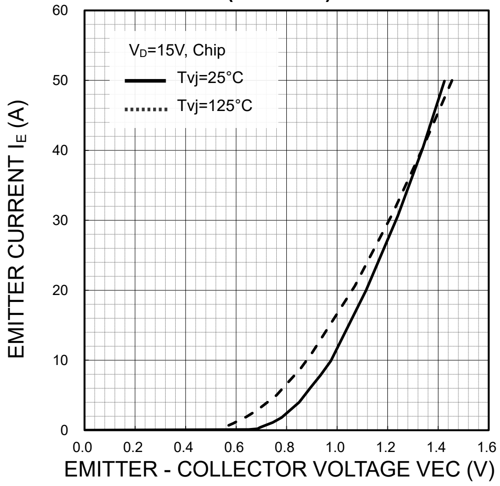
- Design the PCB pattern to minimize wiring length between opto-coupler and IPM's input terminal, and also to minimize the stray capacity between the input and output wirings of opto-coupler.
- Connect low impedance capacitor between the Vcc and GND terminal of each fast switching opto-coupler.
- Fast switching opto-couplers: $t_{PLH}$, $t_{PHL}$ ≤ 0.8μs, Use High CMR type.
- Slow switching opto-coupler: CTR > 100%
- Use 4 isolated control power supplies ($V_D$). Also, care should be taken to minimize the instantaneous voltage charge of the power supply.
- Make inductance of DC bus line as small as possible, and minimize surge voltage using snubber capacitor between P and N terminal.

**PERFORMANCE CURVES**

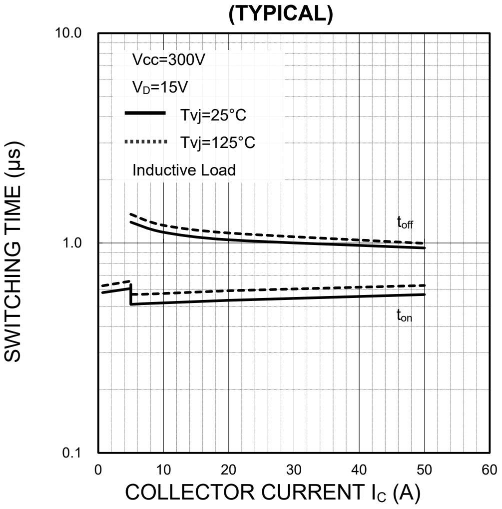
**COLLECTOR-EMITTER SATURATION VOLTAGE (VS. Ic) CHARACTERISTICS (TYPICAL)**



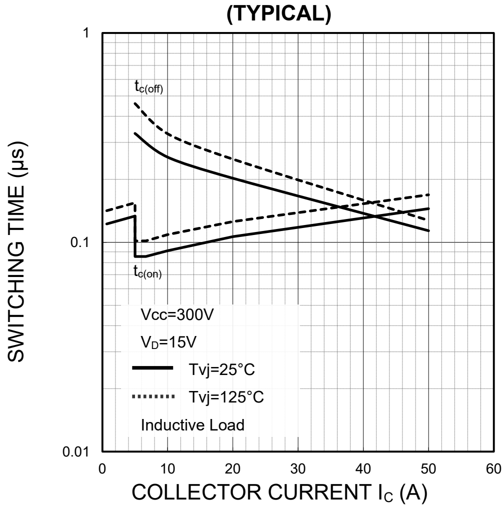

**FREE WHEELING DIODE FORWARD CHARACTERISTICS (TYPICAL)**



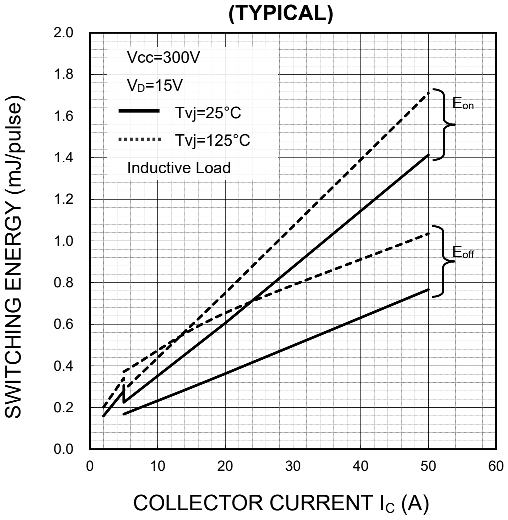

**SWITCHING TIME ($t_{on}$, $t_{off}$) CHARACTERISTICS (TYPICAL)**



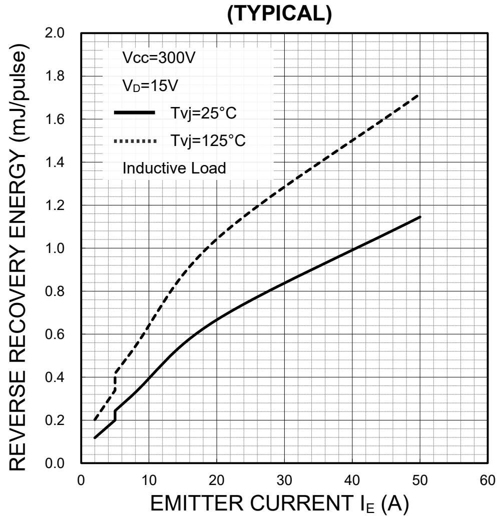

**SWITCHING TIME ($t_{c(on)}$, $t_{c(off)}$) CHARACTERISTICS (TYPICAL)**



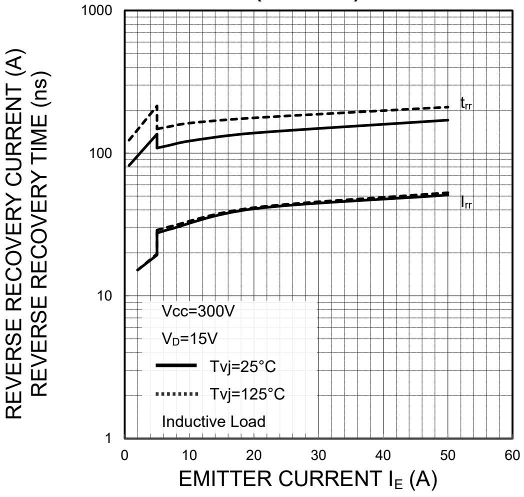

**SWITCHING ENERGY CHARACTERISTICS (TYPICAL)**



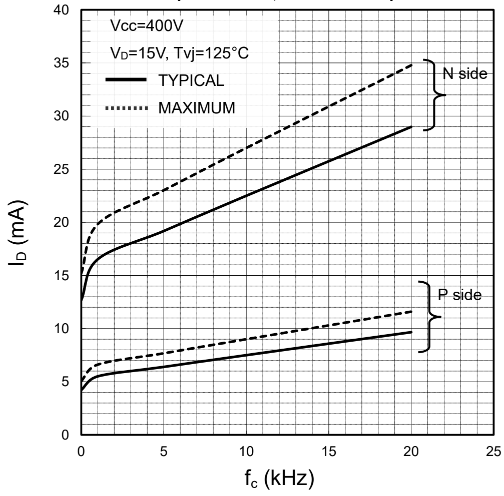

**FREE WHEELING DIODE REVERSE RECOVERY ENERGY CHARACTERISTICS (TYPICAL)**



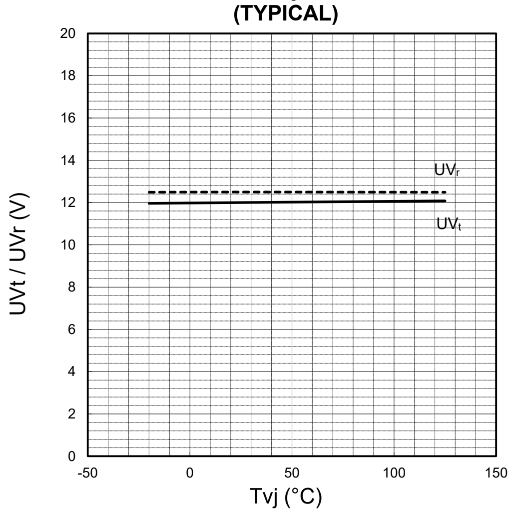
**FREE WHEELING DIODE REVERSE RECOVERY CHARACTERISTICS (TYPICAL)**



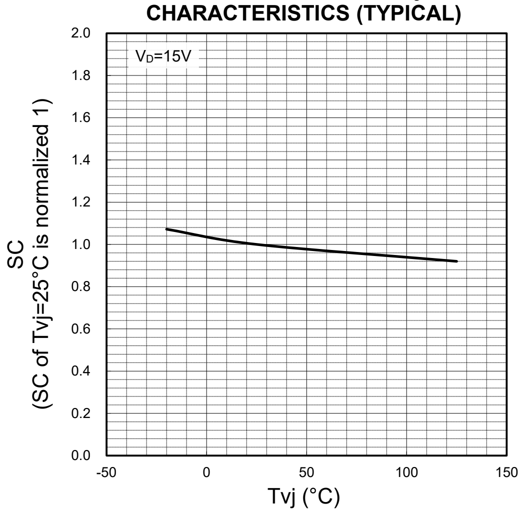

**$I_D$ VS. $f_c$ CHARACTERISTICS (TYPICAL, MAXIMUM)**




**UV TRIP LEVEL VS. Tvj CHARACTERISTICS (TYPICAL)**

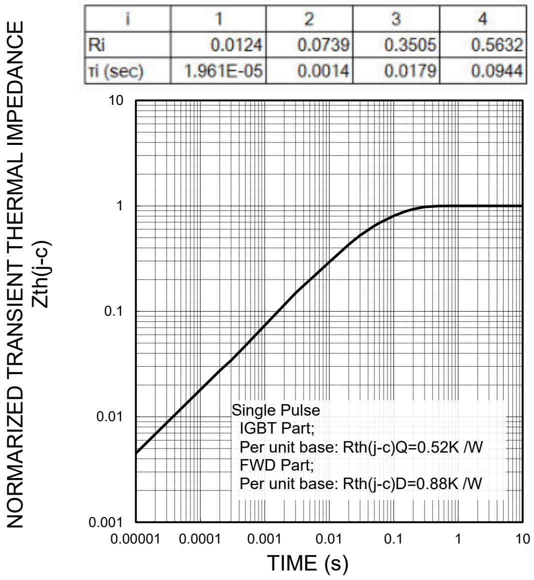



**SC TRIP LEVEL VS. Tvj CHARACTERISTICS (TYPICAL)**




**TRANSIENT THERMAL IMPEDANCE CHARACTERISTICS (TYPICAL)**

| i | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Ri | 0.0124 | 0.0739 | 0.3505 | 0.5632 |
| τi (sec) | 1.961E-05 | 0.0014 | 0.0179 | 0.0944 |




Note: The characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

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