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# SPECIFICATION

Device Name : IGBT-IPM

Type Name : 6MBP20RTA060

Spec. No. : MS6M0713

Fuji Electric Co., Ltd.  
Matsumoto Factory

|         | DATE      | NAME         | APPROVED    | Fuji Electric Co., Ltd. |          |      |   |
|---------|-----------|--------------|-------------|-------------------------|----------|------|---|
| DRAWN   | May-3-'03 | N. Aizawa    | T. Fujihira | DWG. NO.                | MS6M0713 | 1/22 | a |
| CHECKED | - -       | A. Nishimura |             |                         |          |      | a |
| CHECKED | Mar-3-'03 | K. Yamada    |             |                         |          |      |   |

# Revised Records

[illegible]

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## 2. Pin Descriptions 端子定義

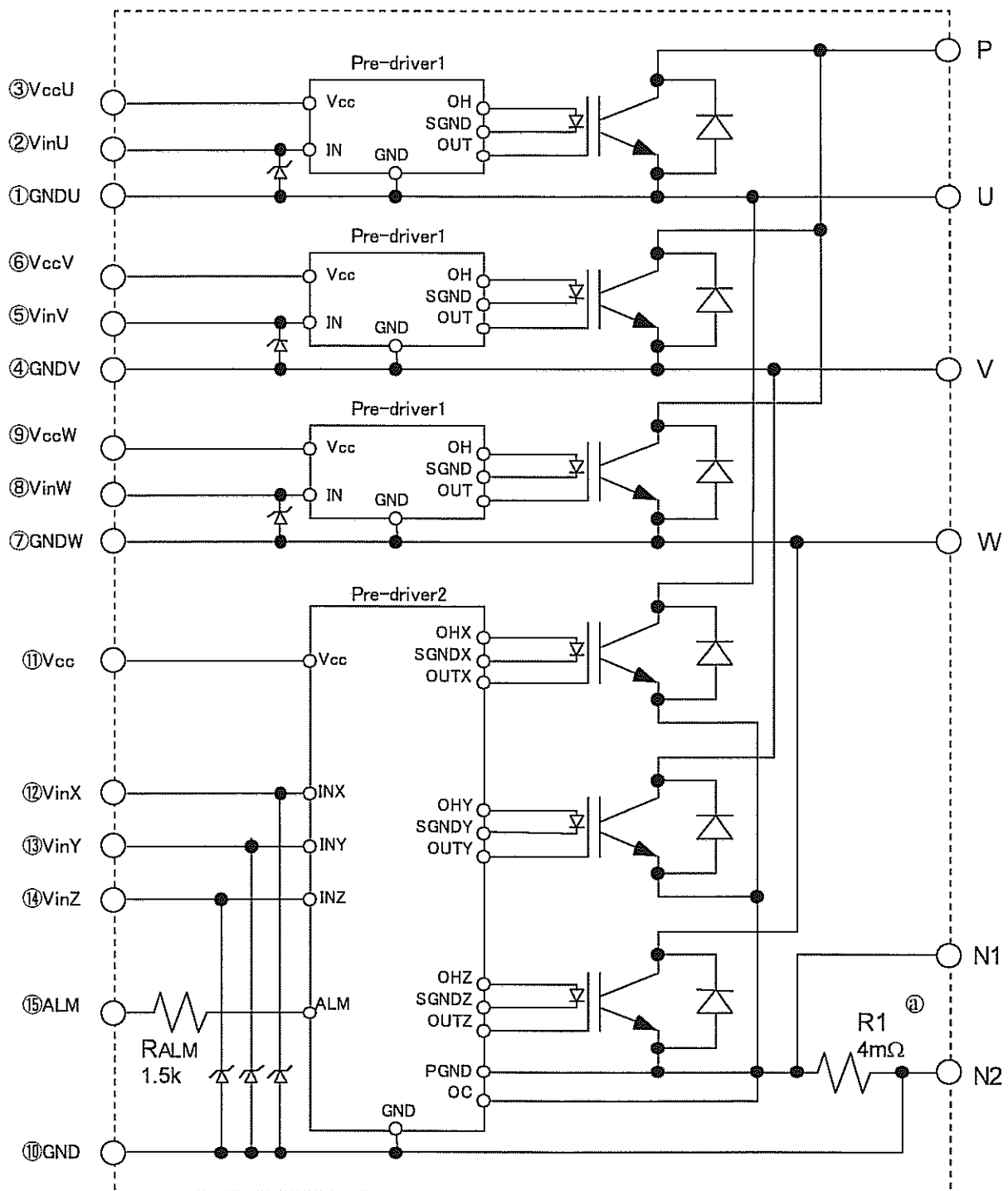
### Main circuit 主回路

| Symbol | Description                                 |
|--------|---------------------------------------------|
| P      | Positive input supply voltage.              |
| U      | Output (U).                                 |
| V      | Output (V).                                 |
| W      | Output (W).                                 |
| N1     | (For connection an external shunt-resistor) |
| N2     | Negative input supply voltage.              |

### Control circuit 制御回路

| No. | Symbol | Description                          |
|-----|--------|--------------------------------------|
| ①   | GNDU   | High side ground (U).                |
| ②   | VinU   | Logic input for IGBT gate drive (U). |
| ③   | VccU   | High side supply voltage (U).        |
|     |        |                                      |
| ④   | GNDV   | High side ground (V).                |
| ⑤   | VinV   | Logic input for IGBT gate drive (V). |
| ⑥   | VccV   | High side supply voltage (V).        |
|     |        |                                      |
| ⑦   | GNDW   | High side ground (W).                |
| ⑧   | VinW   | Logic input for IGBT gate drive (W). |
| ⑨   | VccW   | High side supply voltage (W).        |
|     |        |                                      |
| ⑩   | GND    | Low side ground.                     |
| ⑪   | Vcc    | Low side supply voltage.             |
| ⑫   | VinX   | Logic input for IGBT gate drive (X). |
| ⑬   | VinY   | Logic input for IGBT gate drive (Y). |
| ⑭   | VinZ   | Logic input for IGBT gate drive (Z). |
| ⑮   | ALM    | Low side alarm signal output.        |

### 3. Block Diagram ブロック図



Pre-driver1 includes following functions.

(P-side)

1. Amplifier for driver
2. Under voltage lockout circuit
3. IGBT chip over heating protection

Pre-driver2 includes following functions.

(N-side)

1. Amplifier for driver
2. Under voltage lockout circuit
3. IGBT chip over heating protection
4. Over current protection
5. Alarm signal output

#### 4. Absolute Maximum Ratings 絶対最大定格

Tc=25°C unless otherwise specified.

| Items                                                            |                   | Symbol                 | Min. | Max.                 | Units |
|------------------------------------------------------------------|-------------------|------------------------|------|----------------------|-------|
| Bus Voltage<br>(Between terminal P and N)                        | DC                | V <sub>dc</sub>        | 0    | 450                  | V     |
|                                                                  | Surge             | V <sub>DC(surge)</sub> | 0    | 500                  | V     |
|                                                                  | Short operating   | V <sub>sc</sub>        | 200  | 400                  | V     |
| Collector-Emitter Voltage *1                                     |                   | V <sub>ces</sub>       | 0    | 600                  | V     |
| Collector Current                                                | DC                | I <sub>c</sub>         | —    | 20                   | A     |
|                                                                  | 1ms               | I <sub>cp</sub>        | —    | 40                   | A     |
|                                                                  | Duty=89% *2       | -I <sub>c</sub>        | —    | 20                   | A     |
| Collector Power Dissipation                                      | One transistor *3 | P <sub>c</sub>         | —    | 103                  | W     |
| Supply Voltage of Pre-Driver *4                                  |                   | V <sub>cc</sub>        | -0.5 | 20                   | V     |
| Input Signal Voltage *5                                          |                   | V <sub>in</sub>        | -0.5 | V <sub>cc</sub> +0.5 | V     |
| Input Signal Current                                             |                   | I <sub>in</sub>        | —    | 1                    | mA    |
| Alarm Signal Voltage *6                                          |                   | V <sub>ALM</sub>       | -0.5 | V <sub>cc</sub>      | V     |
| Alarm Signal Current *7                                          |                   | I <sub>ALM</sub>       | —    | 20                   | mA    |
| Junction Temperature                                             |                   | T <sub>j</sub>         | —    | 150                  | °C    |
| Operating Case Temperature                                       |                   | T <sub>opr</sub>       | -20  | 100                  | °C    |
| Storage Temperature                                              |                   | T <sub>stg</sub>       | -40  | 125                  | °C    |
| Solder Temperature *8                                            |                   | T <sub>sol</sub>       | —    | 260                  | °C    |
| Isolating Voltage<br>(Terminal to base, 50/60Hz sine wave 1min.) |                   | V <sub>iso</sub>       | —    | AC2500               | V     |
| Screw Torque                                                     | Mounting (M4)     | —                      | —    | 2.0                  | Nm    |

#### Note 注意

- \*1 : V<sub>ces</sub> shall be applied to the input voltage between terminal P and U or V or W, N and U or V or W.
- \*2 : Duty= 125°C/FWD R<sub>th(j-c)</sub>/(I<sub>c</sub> × V<sub>F</sub> MAX)=125/2.7/(20 × 2.6) × 100=89%
- \*3 : P<sub>c</sub>=125°C/IGBT R<sub>th(j-c)</sub>=125/1.21=103W
- \*4 : V<sub>cc</sub> shall be applied to the input voltage between terminal No.3 and 1, No.6 and 4, No.9 and 7, No.11 and 10.
- \*5 : V<sub>in</sub> shall be applied to the input voltage between terminal No.2 and 1, No.5 and 4, No.8 and 7, No.12,13,14 and 10.
- \*6 : V<sub>ALM</sub> shall be applied to the voltage between terminal No.15 and 10.
- \*7 : I<sub>ALM</sub> shall be applied to the input current to terminal No.15.
- \*8 : Immersion time 10±1sec.

## 5. Electrical Characteristics 電気的特性

$T_j=25^{\circ}\text{C}$ ,  $V_{cc}=15\text{V}$  unless otherwise specified.

### 5.1 Main circuit 主回路

| Item                                        | Symbol        | Conditions                                                              | Min. | Typ. | Max. | Units |
|---------------------------------------------|---------------|-------------------------------------------------------------------------|------|------|------|-------|
| Collector Current at off signal input       | $I_{ces}$     | $V_{ce}=600\text{V}$<br>$V_{in}$ terminal open.                         | —    | —    | 1.0  | mA    |
| Collector-Emitter saturation voltage        | $V_{CE(sat)}$ | $I_c=20\text{A}$ Terminal                                               | —    | —    | 2.2  | V     |
|                                             |               | Chip                                                                    | —    | 1.75 | —    | V     |
| Forward voltage of FWD                      | $V_F$         | $-I_c=20\text{A}$ Terminal                                              | —    | —    | 2.6  | V     |
|                                             |               | Chip                                                                    | —    | 1.6  | —    | V     |
| Turn-on time                                | $t_{on}$      | $V_{DC}=300\text{V}$ , $T_j=125^{\circ}\text{C}$                        | 1.2  | —    | —    | us    |
| Turn-off time                               | $t_{off}$     | $I_c=20\text{A}$ Fig.1, Fig.6                                           | —    | —    | 3.6  | us    |
| Reverse recovery time                       | $t_{rr}$      | $V_{DC}=300\text{V}$<br>$I_F=20\text{A}$ Fig.1, Fig.6                   | —    | —    | 0.3  | us    |
| Maximum Avalanche Energy (A non-repetition) | $PAV$         | Internal wiring inductance=56nH<br>Main circuit wiring inductance=179nH | 20   | —    | —    | mJ    |

### 5.2 Control circuit 制御回路

| Item                                           | Symbol       | Conditions                                 | Min. | Typ. | Max. | Units      |
|------------------------------------------------|--------------|--------------------------------------------|------|------|------|------------|
| Supply current of P-side pre-driver (one unit) | $I_{ccp}$    | Switching Frequency:0~6kHz                 | 0.5  | —    | 9    | mA         |
| Supply current of N-side pre-driver            | $I_{ccn}$    | $T_c=-20\sim 100^{\circ}\text{C}$<br>Fig.7 | 0.8  | —    | 28   |            |
| Input signal threshold voltage                 | $V_{in(th)}$ | ON                                         | 1.00 | 1.35 | 1.70 | V          |
|                                                |              | OFF                                        | 1.25 | 1.60 | 1.95 |            |
| Input Zener Voltage                            | $V_z$        | $R_{in}=20\text{k}\Omega$                  | —    | 8.0  | —    | V          |
| Alarm Signal Hold Time                         | $t_{ALM}$    | $T_c=-20^{\circ}\text{C}$                  | 1.1  | —    | —    | ms         |
|                                                |              | $T_c=25^{\circ}\text{C}$                   | —    | 2.0  | —    |            |
|                                                |              | $T_c=125^{\circ}\text{C}$                  | —    | —    | 4.0  |            |
| Current Limit Resistor                         | $R_{ALM}$    | Alarm terminal                             | 1425 | 1500 | 1575 | $\Omega$   |
| Shunt-Resistor for over current sense          | $R_1$        | Between terminal N1 and N2                 | —    | 4.0  | —    | m $\Omega$ |

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### 5.3 Protection Section 保護部 (Vcc=15V)

| Item                                                 | Symbol | Conditions            | Min. | Typ. | Max. | Units |
|------------------------------------------------------|--------|-----------------------|------|------|------|-------|
| Over Current Protection Level of Inverter circuit    | Ioc    | Tj=125°C              | 30   | 40   | —    | A     |
| Over Current Protection Delay time                   | tdoc   | Tj=125°C              | —    | 5    | —    | us    |
| IGBT Chips Over Heating Protection Temperature Level | TjOH   | Surface of IGBT Chips | 150  | —    | —    | °C    |
| Over Heating Protection Hysteresis                   | TjH    |                       | —    | 20   | —    |       |
| Under Voltage Protection Level                       | VUV    |                       | 11.0 | —    | 12.5 | V     |
| Under Voltage Protection Hysteresis                  | VH     |                       | 0.2  | 0.5  | —    |       |

### 6. Thermal Characteristics 熱特性 (Tc=25°C)

| Item                                         |      | Symbol   | Min. | Typ. | Max. | Units |
|----------------------------------------------|------|----------|------|------|------|-------|
| Junction to Case Thermal Resistance *10      | IGBT | Rth(j-c) | —    | —    | 1.21 | °C/W  |
|                                              | FWD  | Rth(j-c) | —    | —    | 2.70 |       |
| Case to Fin Thermal Resistance with Compound |      | Rth(c-f) | —    | 0.05 | —    |       |

\*10:( For 1device , Case is under the device )

### 7. Noise Immunity ノイズ耐量 (Vdc=300V, Vcc=15V, Test Circuit Fig 5.)

| Item                          | Conditions                                                                                             | Min. | Typ. | Max. | Units |
|-------------------------------|--------------------------------------------------------------------------------------------------------|------|------|------|-------|
| Common mode rectangular noise | Pulse width 1us, polarity ±, 10 minutes<br>Judge: no over-current, no miss operating                   | ±2.0 | —    | —    | kV    |
| Common mode lightning surge   | Rise time 1.2us, Fall time 50us<br>Interval 20s, 10 times<br>Judge: no over-current, no miss operating | ±5.0 | —    | —    | kV    |

### 8. Recommended Operating Conditions 推奨動作条件

| Item                               | Symbol | Min. | Typ. | Max. | Units |
|------------------------------------|--------|------|------|------|-------|
| DC Bus Voltage                     | VDC    | —    | —    | 400  | V     |
| Power Supply Voltage of Pre-Driver | Vcc    | 13.5 | 15.0 | 16.5 | V     |
| Screw Torque (M4)                  | —      | 1.3  | —    | 1.7  | Nm    |

### 9. Weight 質量

| Item   | Symbol | Min. | Typ. | Max. | Units |
|--------|--------|------|------|------|-------|
| Weight | Wt     | —    | 85   | —    | g     |

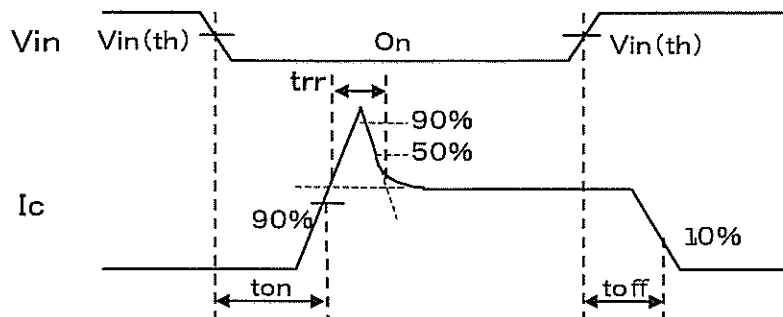
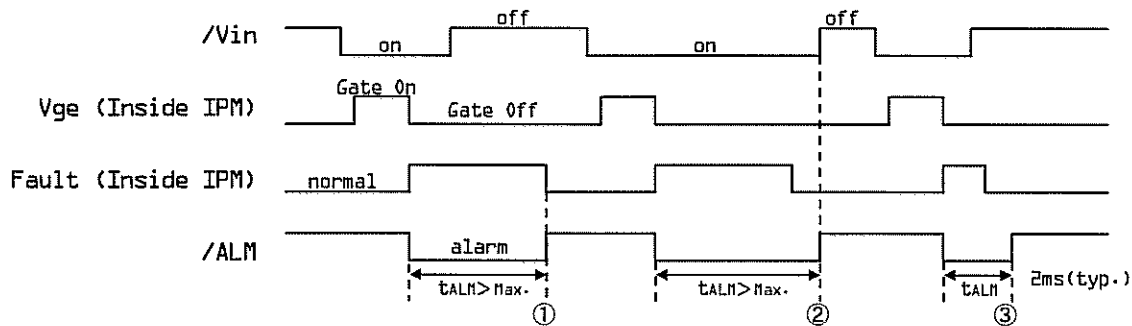


Figure 1. Switching Time Waveform Definitions  
スイッチング時間の定義



Fault: Over-current, Over-heat or Under-voltage

Figure 2. Input/Output Timing Diagram  
入出力信号タイミングチャート

Necessary conditions for alarm reset (refer to ① to ③ in figure2.)

- ① This represents the case when a failure-causing Fault lasts for a period more than  $t_{ALM}$ . The alarm resets when the input  $V_{in}$  is OFF and the Fault has disappeared.
- ② This represents the case when the ON condition of the input  $V_{in}$  lasts for a period more than  $t_{ALM}$ . The alarm resets when the  $V_{in}$  turns OFF under no Fault conditions.
- ③ This represents the case when the Fault disappears and the  $V_{in}$  turns OFF within  $t_{ALM}$ . The alarm resets after lasting for a period of the specified time  $t_{ALM}$ .

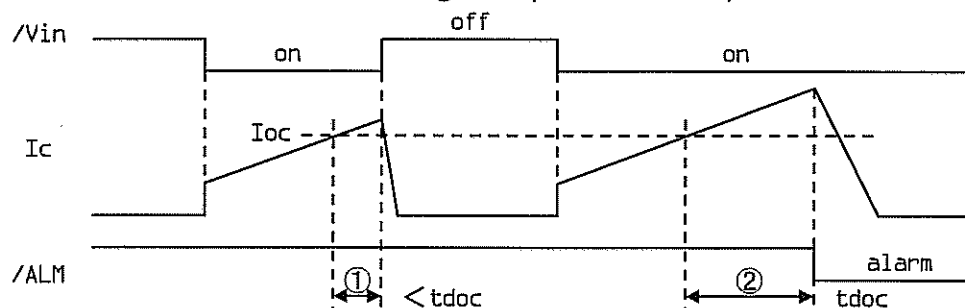


Figure 3. Over-current Protection Timing Diagram  
過電流保護タイミングチャート

- Period ①: When a collector current over the OC level flows and the OFF command is input within a period less than the trip delay time  $t_{doc}$ , the current is hard-interrupted and no alarm is output.
- Period ②: When a collector current over the OC level flows for a period more than the trip delay time  $t_{doc}$ , the current is soft-interrupted. If this is detected at the lower arm IGBTs, an alarm is output.

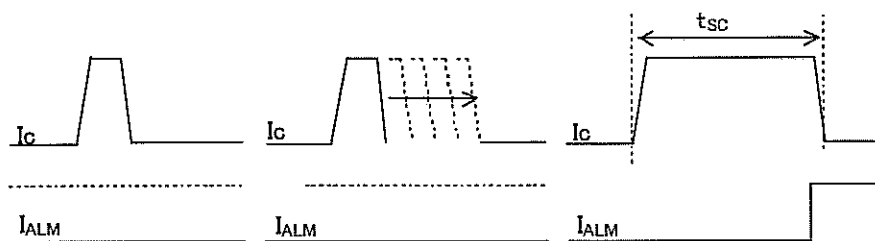


Figure.4 Definition of tsc

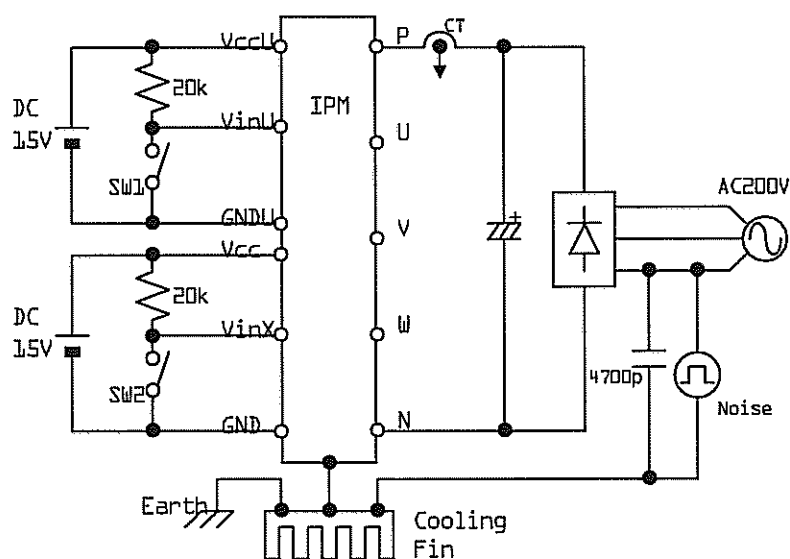


Figure 5. Noise Test Circuit

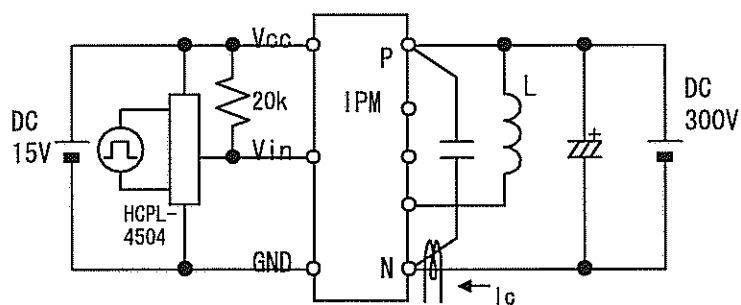


Figure 6. Switching Characteristics Test Circuit

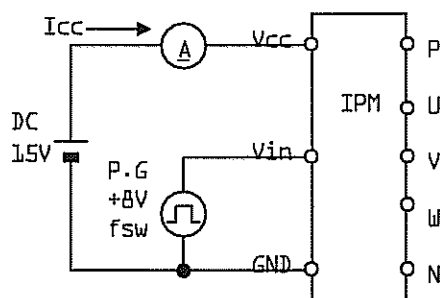


Figure 7. Icc Test Circuit

## 10. Truth table 真理値表

### 10.1 IGBT Control IGBT制御

The following table shows the IGBT ON/OFF status with respect to the input signal Vin. The IGBT turn-on when Vin is at "Low" level under no alarm condition  
入力信号Vinに対するIGBTのオン/オフを下表に示します。Vinが"Low"レベル、かつアラームが無い条件でIGBTはオンします。

| Input (Vin) | Alarm | Output (IGBT) |
|-------------|-------|---------------|
| Low         | High  | ON            |
| Low         | Low   | OFF           |
| High        | —     | OFF           |

### 10.2 Fault Detection 故障検出

- (1) When a fault is detected at the high side, only the detected arm stops its output.

At that time the IPM doesn't any alarm.

上アームで異常を検出した場合、検出したアームのみ出力を停止します。この場合、IPMからアラーム信号は出力しません。

- (2) When a fault is detected at the low side, all the lower arms stop their outputs and the IPM outputs an alarm of the low side.

下アームで異常を検出した場合、下アーム全ての出力を停止し、IPMからアラーム信号を出力します。

|                     | Cause of fault | I G B T             |                     |                     |          | Alarm Output |
|---------------------|----------------|---------------------|---------------------|---------------------|----------|--------------|
|                     |                | High side (U-phase) | High side (V-phase) | High side (W-phase) | Low side | ALM          |
| High side (U-phase) | UV             | OFF                 | *                   | *                   | *        | High         |
|                     | TjOH           | OFF                 | *                   | *                   | *        | High         |
| High side (V-phase) | UV             | *                   | OFF                 | *                   | *        | High         |
|                     | TjOH           | *                   | OFF                 | *                   | *        | High         |
| High side (W-phase) | UV             | *                   | *                   | OFF                 | *        | High         |
|                     | TjOH           | *                   | *                   | OFF                 | *        | High         |
| Low side            | OC             | *                   | *                   | *                   | OFF      | Low          |
|                     | UV             | *                   | *                   | *                   | OFF      | Low          |
|                     | TjOH           | *                   | *                   | *                   | OFF      | Low          |

\*: Depend on input logic.

## 11. Cautions for design and application 設計・適用に際しての注意点

- Trace routing layout should be designed with particular attention to least stray capacity between the primary and secondary sides of optical isolators by minimizing the wiring length between the optical isolators and the IPM input terminals as possible.

フォトカブラとIPMの入力端子間の配線は極力短くし、フォトカブラの一次側と二次側の浮遊容量を小さくしたパターンレイアウトにしてください。

- Mount a capacitor between Vcc and GND of each high-speed optical isolator as close to as possible.

高速フォトカブラの Vcc-GND 間に、コンデンサを出来るだけ近接して取り付けして下さい。

- For the high-speed optical isolator, use high-CMR type one with  $t_{pHL}, t_{pLH} \leq 0.8\mu s$ .

高速フォトカブラは、 $t_{pHL}, t_{pLH} \leq 0.8\mu s$ 、高 CMR タイプをご使用ください。

- For the alarm output circuit, use low-speed type optical isolators with  $CTR \geq 100\%$ .

アラーム出力回路は、低速フォトカブラ CTR $\geq 100\%$ のタイプをご使用ください。

- For the control power Vcc, use four power supplies isolated each. And they should be designed to reduce the voltage variations.

制御電源 Vcc は、絶縁された4電源を使用してください。また、電圧変動を抑えた設計として下さい。

- Suppress surge voltages as possible by reducing the inductance between the DC bus P and N, and connecting some capacitors between the P and N terminals

P-N間の直流母線は出来るだけ低インダクタンス化し、P-N端子間にコンデンサを接続するなどしてサージ電圧を低減して下さい。

- To prevent noise intrusion from the AC lines, connect a capacitor of some 4700pF between the three-phase lines each and the ground.

ACラインからのノイズ侵入を防ぐために、3相各線ーアース間に4700pF程のコンデンサを接続して下さい

- At the external circuit, never connect the control terminal GNDU to the main terminal U-phase, GNDV to V-phase, GNDW to W-phase, and GND to N-phase. Otherwise, malfunctions may be caused.

制御端子GNDUと主端子U相、制御端子GNDVと主端子V相、制御端子GNDWと主端子W相、制御端子GNDと主端子Nを外部回路で接続しないで下さい。誤動作の原因になります。

- Take note that an optical isolator's response to the primary input signal becomes slow if a capacitor is connected between the input terminal and GND.

入力端子-GND 間にコンデンサを接続すると、フォトカブラ一次側入力信号に対する応答時間が長くなりますのでご注意ください。

- Taking the used isolator's CTR into account, design with a sufficient allowance to decide the primary forward current of the optical isolator.

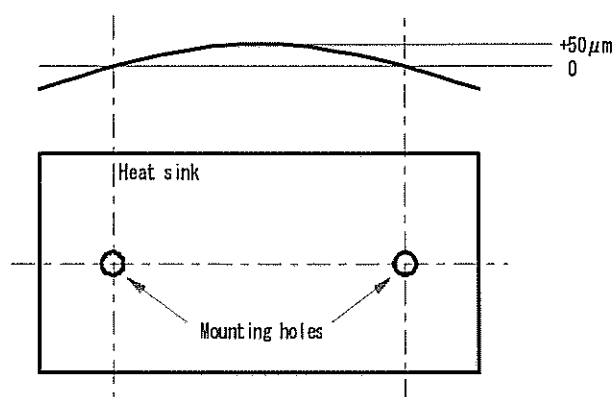
フォトカブラの一次側電流は、お使いのフォトカブラのCTRを考慮し、十分に余裕をもった設計にしてください。

11. Apply thermal compound to the surfaces between the IPM and its heat sink to reduce the thermal contact resistance.

接触熱抵抗を小さくするために、IPMとヒートシンクの間にサーマルコンパウンドを塗布して下さい。

12. Finish the heat sink surface within roughness of 10 $\mu$ m and flatness (camber) between screw positions of 0 to +50 $\mu$ m. If the flatness is minus, the heat radiation becomes worse due to a gap between the heat sink and the IPM. And, if the flatness is over +50 $\mu$ m, there is a danger that the IPM copper base may be deformed and this may cause a dielectric breakdown.

ヒートシンク表面の仕上げは、粗さ10 $\mu$ m以下、ネジ位置間での平坦度(反り)は、0～+50 $\mu$ mとして下さい。平坦度がマイナスの場合、ヒートシンクとIPMの間に隙間ができ放熱が悪化します。また、平坦度が+50 $\mu$ m以上の場合IPMの銅ベースが変形し絶縁破壊を起こす危険性があります。



13. This product is designed on the assumption that it applies to an inverter use. Sufficient examination is required when applying to a converter use. Please contact Fuji Electric Co., Ltd. if you would like to applying to converter use.

本製品は、インバータ用途への適用を前提に設計されております。コンバータ用途へ適用される場合は、十分な検討が必要です。もし、コンバータへ適用される場合は御連絡ください。

14. There is thermal interference between nearby power devices, because the P619 PKG. is a compact package. Therefore you measure the case temperature just under the IGBT chips that showed in report MT6M04858, and estimate the chip temperature.

パッケージを小型化しているため、パワー素子の熱干渉が考えられます。

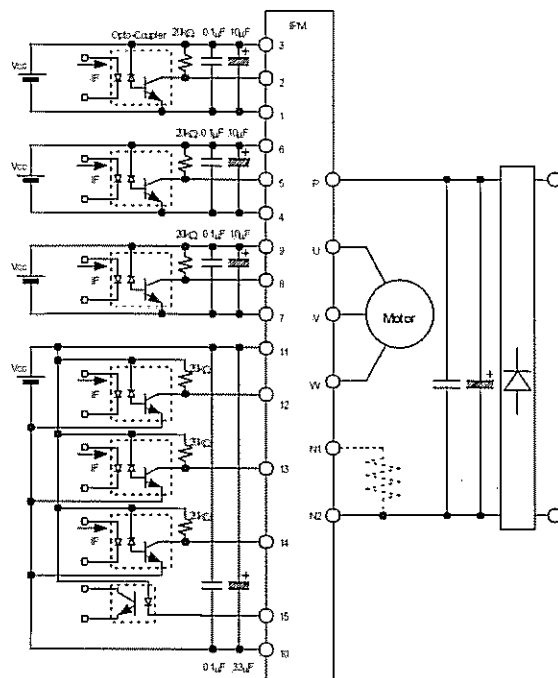
その為、チップ温度推定は必ず MT6M04858 に示すチップ直下のケース温度を測定して行って下さい。

④

15. Please see the 『Fuji IGBT-IPM R SERIES APPLICATION MANUAL RH983』 and 『Fuji IGBT MODULES N SERIES APPLICATION MANUAL RH982』.

『富士IGBT-IPM Rシリーズ アプリケーションマニュアル RH983』及び『IGBTモジュール Nシリーズ アプリケーションマニュアルRH982』を御参照ください。

## 12. Example of applied circuit 応用回路例 ②



## 13. Package and Marking 梱包仕様

Please see the MT6M04140 that is packing specification.

梱包仕様書 MT6M04140 を御参照ください。

## 14. Cautions for storage and transportation 保管、運搬上の注意

- Store the modules at the normal temperature and humidity (5 to 35°C, 45 to 75%).  
常温常湿(5~35°C、45~75%)で保存して下さい。
- Avoid a sudden change in ambient temperature to prevent condensation on the module surfaces.  
モジュールの表面が結露しないよう、急激な温度変化を避けて下さい。
- Avoid places where corrosive gas generates or much dust exists.  
腐食性ガスの発生場所、粉塵の多い場所は避けて下さい。
- Store the module terminals under unprocessed conditions  
モジュールの端子は未加工の状態での保管すること。
- Avoid physical shock or falls during the transportation.  
運搬時に衝撃を与えたり落下させないで下さい。

## 15. Scope of application 適用範囲

This specification is applied to the IGBT-IPM (type: 6MBP20RTA060).

本仕様書は、IGBT-IPM (型式: 6MBP20RTA060) に適用する。

## 16. Based safety standards 準拠安全規格

UL1557

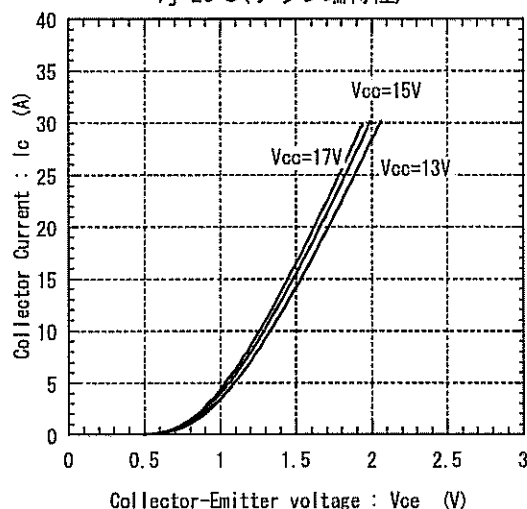
## 17. Characteristics(Representative)

### 特性カーブ (代表例)

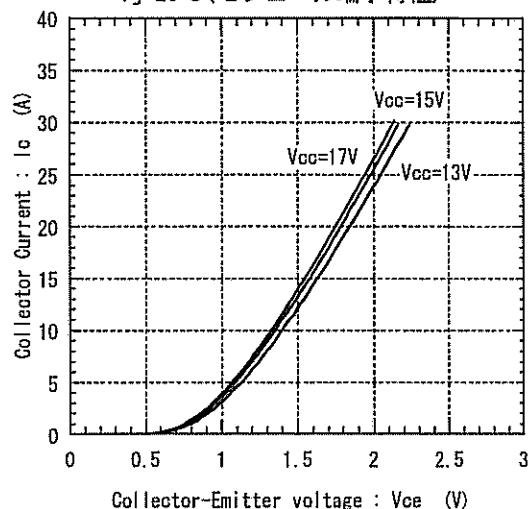
#### 17-1. Inverter

#### インバータ部

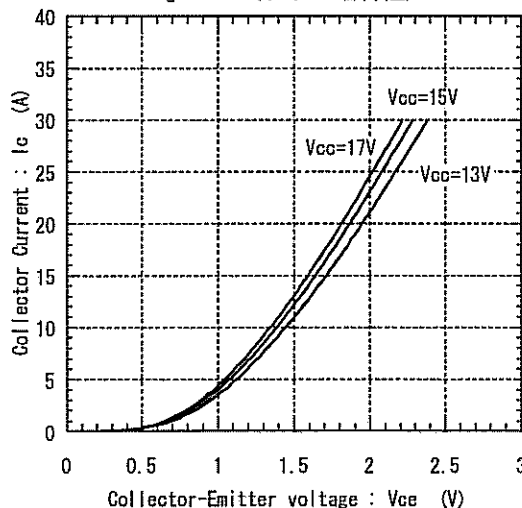
Collector current vs. Collector-Emitter voltage  
Tj=25°C (チップ端特性)



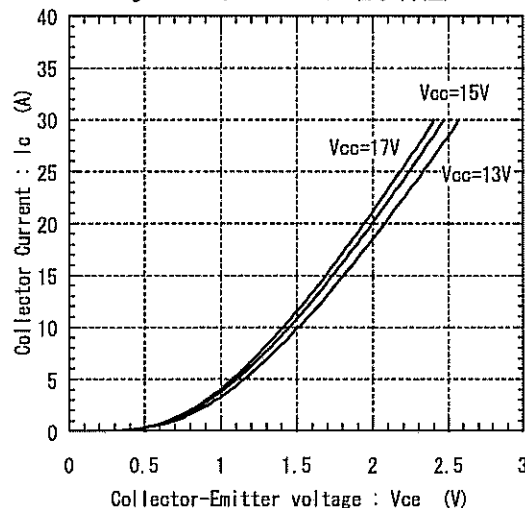
Collector current vs. Collector-Emitter voltage  
Tj=25°C (モジュール端子特性)



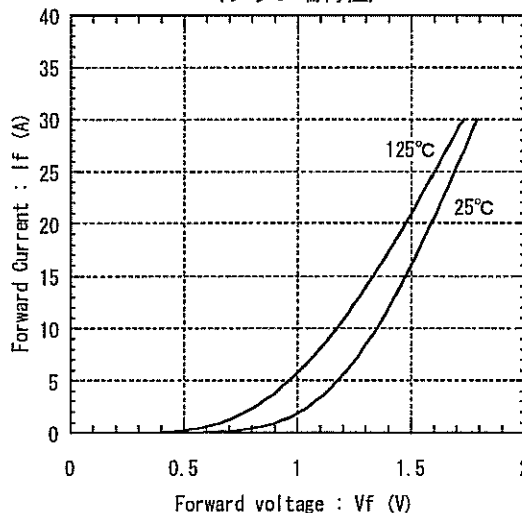
Collector current vs. Collector-Emitter voltage  
Tj=125°C (チップ端特性)



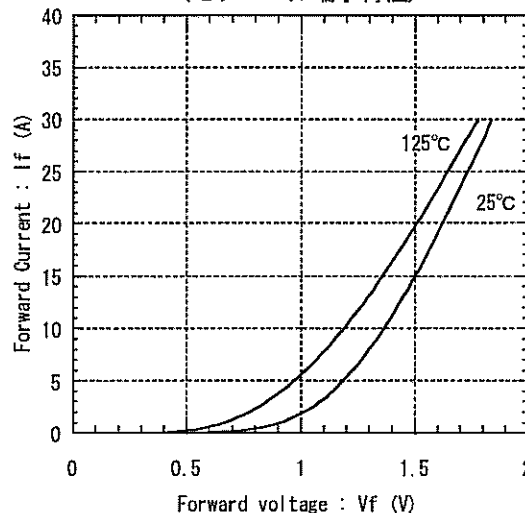
Collector current vs. Collector-Emitter voltage  
Tj=125°C (モジュール端子特性)



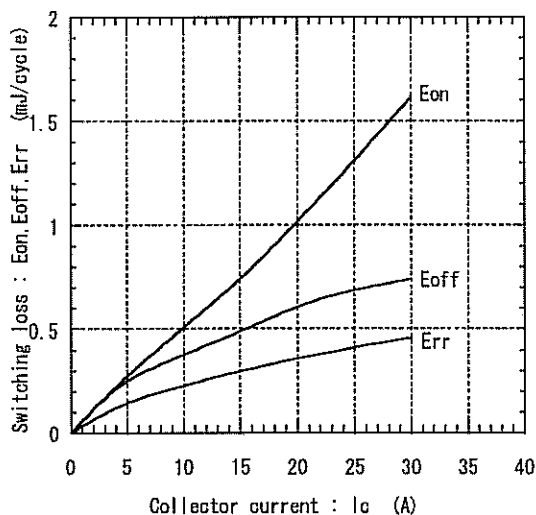
Forward current vs. Forward voltage  
(チップ端特性)



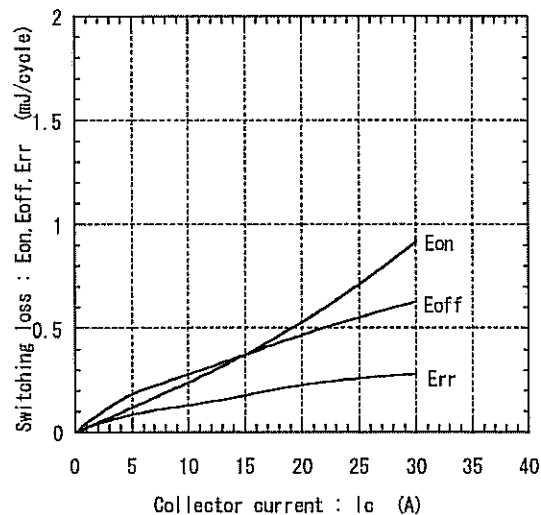
Forward current vs. Forward voltage  
(モジュール端子特性)



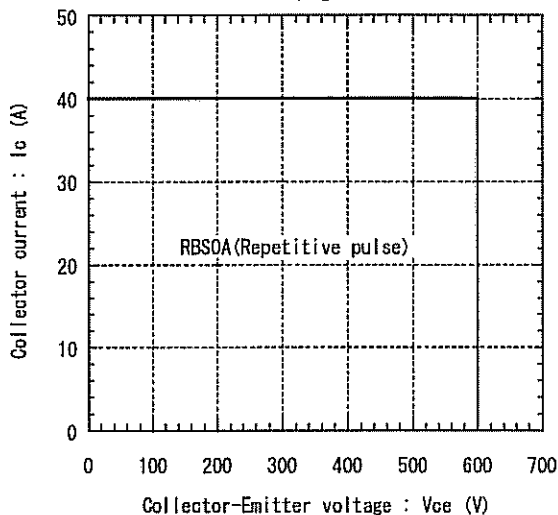
Switching Loss vs. Collector Current  
 $E_{dc}=300V, V_{cc}=15V, T_j=125^\circ C$



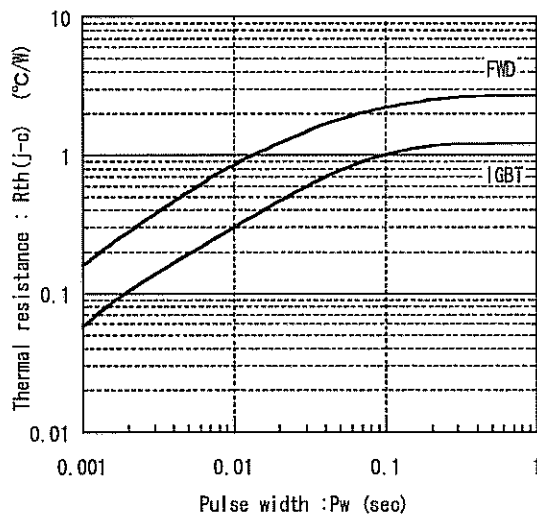
Switching Loss vs. Collector Current  
 $E_{dc}=300V, V_{cc}=15V, T_j=25^\circ C$



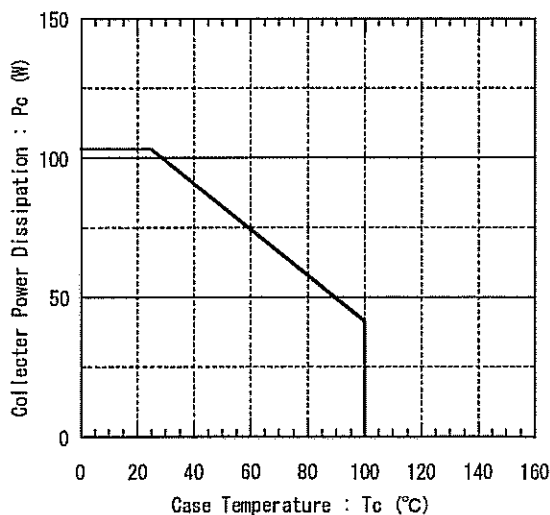
Reversed biased safe operating area  
 $V_{cc}=15V, T_j \leq 125^\circ C$



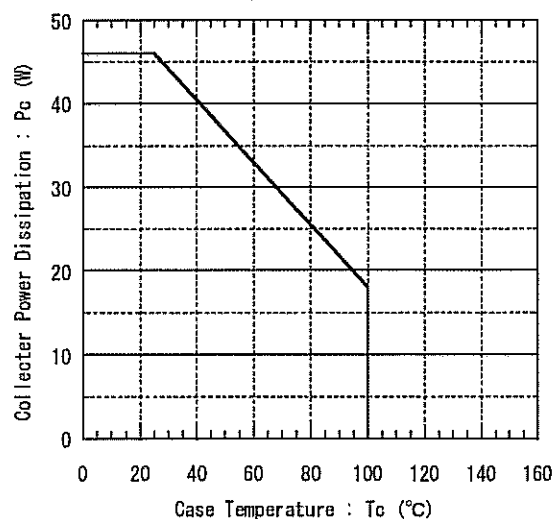
Transient thermal resistance



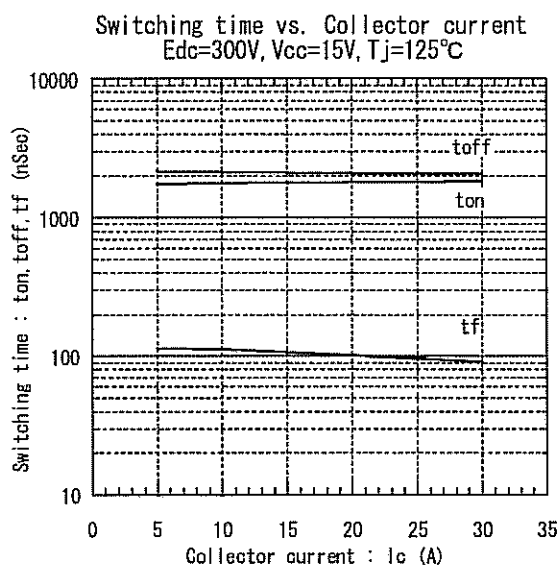
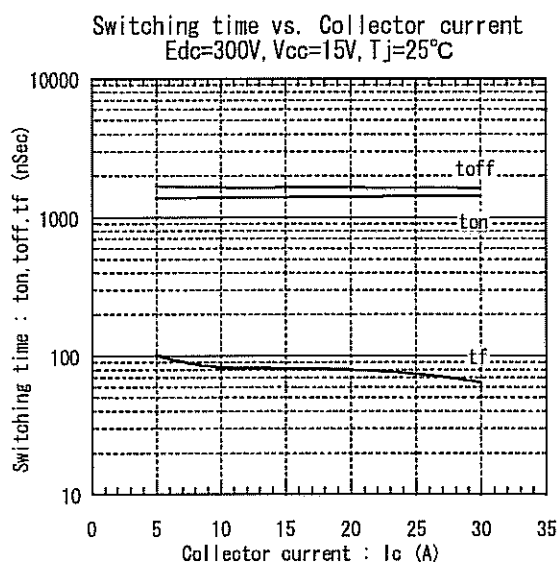
Power derating for IGBT  
(per device)



Power derating for FWD  
(per device)

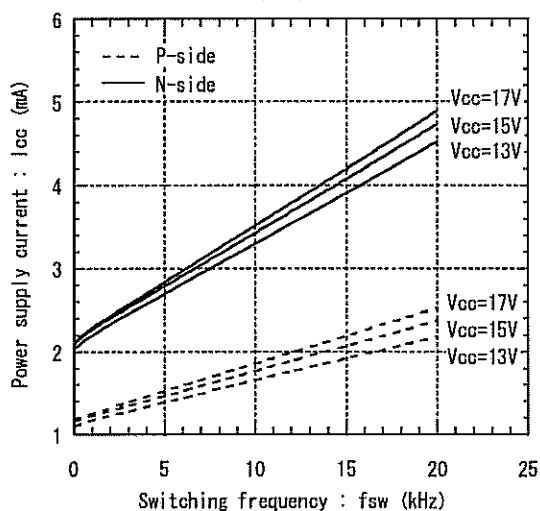


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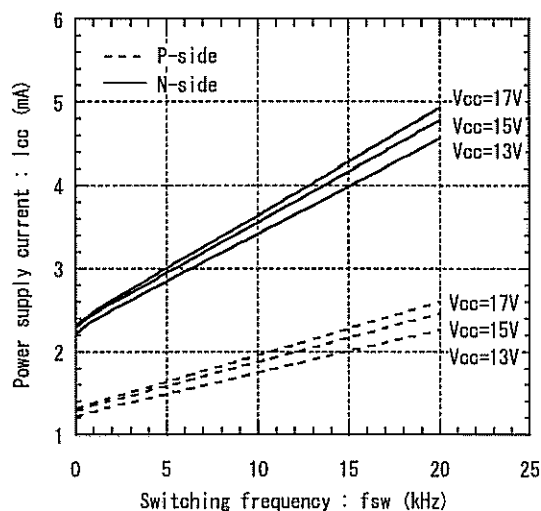


## 17-2. Control Circuit 制御部

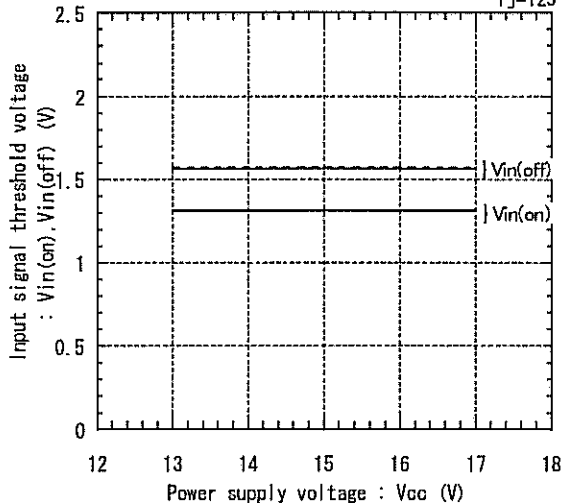
Power supply current vs. Switching frequency  
 $T_c=100^\circ\text{C}$



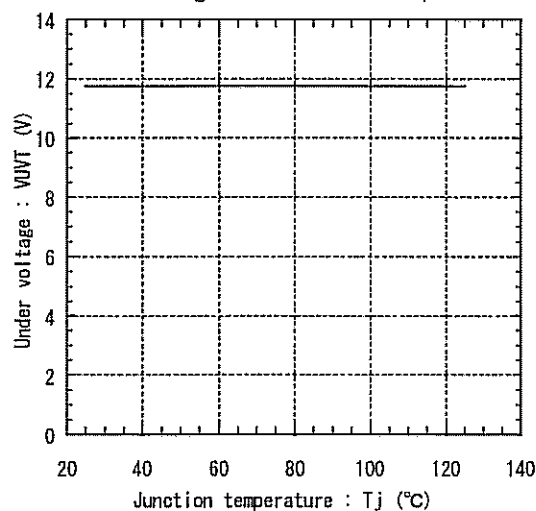
Power supply current vs. Switching frequency  
 $T_c=25^\circ\text{C}$



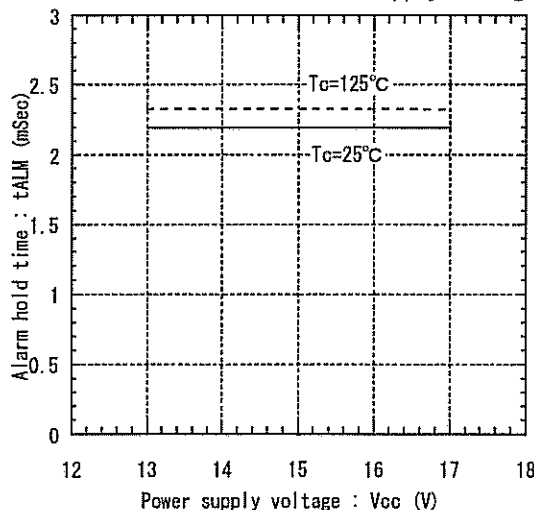
Input signal threshold voltage vs. Power supply voltage  
—  $T_j=25^\circ\text{C}$   
---  $T_j=125^\circ\text{C}$



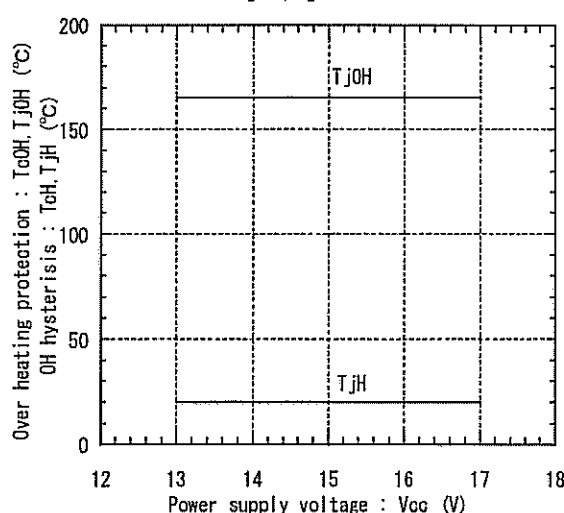
Under voltage vs. Junction temperature



Alarm hold time vs. Power supply voltage



Over heating characteristics  
 $T_{JOH}, T_{JH}$  vs.  $V_{cc}$



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# 18. Reliability Test Items 信頼性試験項目

| Test categories   | Test items                                  | Test methods and conditions                                                                                                                                                                                                          | Reference norms<br>EIAJ<br>ED-4701              | Number of sample | Acceptance number |
|-------------------|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|------------------|-------------------|
| Mechanical Tests  | 1 Terminal strength<br>端子強度<br>(Pull test)  | Pull force : 40N (main terminal)<br>10 N (control terminal)<br>Test time : 10 ±1 sec.                                                                                                                                                | Test Method 401<br>Method I                     | 5                | (1 : 0)           |
|                   | 2 Mounting Strength<br>締付け強度                | Screw torque : 1.3 ~ 1.7 N·m (M4)<br>Test time : 10 ±1 sec.                                                                                                                                                                          | Test Method 402<br>method II                    | 5                | (1 : 0)           |
|                   | 3 Vibration<br>振動                           | Range of frequency : 10~500 Hz<br>Sweeping time : 15 min.<br>Acceleration : 100 m/s <sup>2</sup><br>Sweeping direction : Each X,Y,Z axis<br>Test time : 6 hr. (2hr./direction)                                                       | Test Method 403<br>Condition code B             | 5                | (1 : 0)           |
|                   | 4 Shock<br>衝撃                               | Maximum acceleration : 5000 m/s <sup>2</sup><br>Pulse width : 1.0 ms<br>Direction : Each X,Y,Z axis<br>Test time : 3 times/direction                                                                                                 | Test Method 404<br>Condition code B             | 5                | (1 : 0)           |
|                   | 5 Solderability<br>はんだ付け性                   | Solder temp. : 235 ±5 °C<br>Immersion duration : 5.0 ±0.5 sec.<br>Test time : 1 time<br>Each terminal should be immersed in solder within 1~1.5mm from the body.                                                                     | Test Method 303<br>Condition code A             | 5                | (1 : 0)           |
|                   | 6 Resistance to soldering heat<br>はんだ耐熱性    | Solder temp. : 260 ±5 °C<br>Immersion time : 10 ±1sec.<br>Test time : 1 time<br>Each terminal should be immersed in solder within 1~1.5mm from the body.                                                                             | Test Method 302<br>Condition code A             | 5                | (1 : 0)           |
| Environment Tests | 1 High temperature storage 高温保存             | Storage temp. : 125 ±5 °C<br>Test duration : 1000 hr.                                                                                                                                                                                | Test Method 201                                 | 5                | (1 : 0)           |
|                   | 2 Low temperature storage 低温保存              | Storage temp. : -40 ±5 °C<br>Test duration : 1000 hr.                                                                                                                                                                                | Test Method 202                                 | 5                | (1 : 0)           |
|                   | 3 Temperature humidity storage 高温高湿保存       | Storage temp. : 85 ±2 °C<br>Relative humidity : 85 ±5%<br>Test duration : 1000hr.                                                                                                                                                    | Test Method 103<br>Test code C                  | 5                | (1 : 0)           |
|                   | 4 Unsaturated pressure cooker<br>プレッシャークッカー | Test temp. : 120 ±2 °C<br>Atmospheric pressure : 1.7x10 <sup>5</sup> Pa<br>Test humidity : 85 ±5%<br>Test duration : 96 hr.                                                                                                          | Test Method 103<br>Test code E                  | 5                | (1 : 0)           |
|                   | 5 Temperature cycle<br>温度サイクル               | Test temp. : Minimum storage temp. -40 ±5°C<br>Maximum storage temp. 125 ±5°C<br>Normal temp. 5 ~ 35°C<br>Dwell time : Tmin ~ T <sub>N</sub> ~ Tmax ~ T <sub>N</sub><br>1hr. 0.5hr. 1hr. 0.5hr.<br>Number of cycles : 100 cycles     | Test Method 105                                 | 5                | (1 : 0)           |
|                   | 6 Thermal shock<br>熱衝撃                      | Test temp. : High temp. side 100 <sup>+0</sup> °C<br>Low temp. side 0 <sup>+5</sup> °C<br>Fluid used : Pure water (running water)<br>Dipping time : 5 min. per each temp.<br>Transfer time : 10 sec.<br>Number of cycles : 10 cycles | Test Method 307<br>method I<br>Condition code A | 5                | (1 : 0)           |

| Test categories | Test items                                             | Test methods and conditions                                                                                                                                                                                                   | Reference norms<br>EIAJ<br>ED-4701  | Number of sample | Acceptance number |
|-----------------|--------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------------------|-------------------|
| Endurance Tests | 1 High temperature reverse bias<br>高温逆バイアス             | Test temp. : $T_a = 125 \pm 5^\circ\text{C}$<br>( $T_j \leq 150^\circ\text{C}$ )<br>Bias Voltage : $V_C = 0.8 \times V_{CES}$<br>Bias Method : Applied DC voltage to C-E<br>$V_{CC} = 15\text{V}$<br>Test duration : 1000 hr. | Test Method 101                     | 5                | (1:0)             |
|                 | 2 Temperature humidity bias<br>高温高湿バイアス                | Test temp. : $85 \pm 2^\circ\text{C}$<br>Relative humidity : $85 \pm 5\%$<br>Bias Voltage : $V_C = 0.8 \times V_{CES}$<br>$V_{CC} = 15\text{V}$<br>Bias Method : Applied DC voltage to C-E<br>Test duration : 1000 hr.        | Test Method 102<br>Condition code C | 5                | (1:0)             |
|                 | 3 Intermittent operating life<br>(Power cycle)<br>断続動作 | ON time : 2 sec.<br>OFF time : 18 sec.<br>Test temp. : $\Delta T_j = 100 \pm 5^\circ\text{deg}$<br>$T_j \leq 150^\circ\text{C}$ , $T_a = 25 \pm 5^\circ\text{C}$<br>Number of cycles : 15000 cycles                           | Test Method 106                     | 5                | (1:0)             |

## 19. Failure Criteria 故障判定

| Item                               | Characteristic                                            | Symbol        | Failure criteria  |                  | Unit               |
|------------------------------------|-----------------------------------------------------------|---------------|-------------------|------------------|--------------------|
|                                    |                                                           |               | Lower limit       | Upper limit      |                    |
| Electrical characteristic<br>電気的特性 | Leakage current                                           | ICES          | -                 | USL $\times$ 2.0 | mA                 |
|                                    | Saturation voltage                                        | VCE(sat)      | -                 | USL $\times$ 1.2 | V                  |
|                                    | Forward voltage                                           | VF            | -                 | USL $\times$ 1.2 | V                  |
|                                    | Thermal resistance                                        | IGBT Rth(j-c) | -                 | USL $\times$ 1.2 | $^\circ\text{C/W}$ |
|                                    |                                                           | FWD Rth(j-c)  | -                 | USL $\times$ 1.2 | $^\circ\text{C/W}$ |
|                                    | Over Current Protection                                   | Ioc           | LSL $\times$ 0.8  | USL $\times$ 1.2 | A                  |
|                                    | Alarm signal hold time                                    | tALM          | LSL $\times$ 0.8  | USL $\times$ 1.2 | ms                 |
| Visual inspection<br>外観検査          | Isolation voltage                                         | Viso          | Broken insulation |                  | -                  |
|                                    | Visual inspection<br>Peeling<br>Plating<br>and the others | -             | The visual sample |                  | -                  |

LSL : Lower specified limit.

USL : Upper specified limit.

Note : Each parameter measurement read-outs shall be made after stabilizing the components at room ambient for 2 hours minimum, 24 hours maximum after removal from the tests. And in case of the wetting tests, for example, moisture resistance tests, each component shall be made wipe or dry completely before the measurement.

## Warnings 警告

1. This product shall be used within its absolute maximum rating (voltage, current, and temperature).  
This product may be broken in case of using beyond the ratings.  
製品の絶対最大定格(電圧, 電流, 温度等)の範囲内で御使用下さい。絶対最大定格を超えて使用すると、素子が破壊する場合があります。
2. Connect adequate fuse or protector of circuit between three-phase line and this product to prevent the equipment from causing secondary destruction.  
万一の不慮の事故で素子が破壊した場合を考慮し、商用電源と本製品の間に適切な容量のヒューズ又はブレーカーを必ず付けて2次破壊を防いでください。
3. When studying the device at a normal turn-off action, make sure that working paths of the turn-off voltage and current are within the RBSOA specification. And, when studying the device duty at a short-circuit current non-repetitive interruption, make sure that the paths are also within the avalanche proof(PAV) specification which is calculated from the snubber inductance, the IPM inner inductance and the turn-off current. In case of use of IGBT-IPM over these specifications, it might be possible to be broken.  
通常のターンオフ動作における素子責務の検討の際には、ターンオフ電圧・電流の動作軌跡がRBSOA仕様内にあることを確認して下さい。また、非繰返しの短絡電流遮断における素子責務の検討に際しては、スナバーインダクタンスとIPM内部インダクタンス及びターンオフ電流から算出されるアバランシェ耐量(PAV)仕様内である事を確認して下さい。これらの仕様を越えて使用すると、素子が破壊する場合があります。
4. Use this product after realizing enough working on environment and considering of product's reliability life. This product may be broken before target life of the system in case of using beyond the product's reliability life.  
製品の使用環境を十分に把握し、製品の信頼性寿命が満足できるか検討の上、本製品を適用して下さい。製品の信頼性寿命を超えて使用した場合、装置の目標寿命より前に素子が破壊する場合があります。
5. If the product had been used in the environment with acid, organic matter, and corrosive gas (For example : hydrogen sulfide, sulfurous acid gas), the product's performance and appearance can not be ensured easily.  
酸・有機物・腐食性ガス(硫化水素, 亜硫酸ガス等)を含む環境下で使用された場合、製品機能・外観などの保証は致しかねます。
6. The thermal stress generated from rise and fall of  $T_j$  restricts the product lifetime.  
You should estimate the  $\Delta T_j$  from power losses and thermal resistance, and design the inverter lifetime within the number of cycles provided from the power cycle curve. (Technical Rep. No.: MT6M4057)  
製品の寿命は、接合温度の上昇と下降によって起こる熱ストレスで決まります。損失と熱抵抗から $\Delta T_j$ を推定し、パワーサイクル寿命カーブで決まるサイクル数以下で、インバータの寿命を設計して下さい(技術資料No.:MT6M4057)。
7. Never add mechanical stress to deform the main or control terminal.  
The deformed terminal may cause poor contact problem.  
主端子及び制御端子に応力を与えて変形させないで下さい。端子の変形により、接触不良などを引き起こす場合があります。
8. If excessive static electricity is applied to the control terminals, the devices can be broken.  
Implement some countermeasures against static electricity.  
制御端子に過大な静電気が印加された場合、素子が破壊する場合があります。取り扱い時は静電気対策を実施して下さい。

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## Caution 注意

1. Fuji Electric is constantly making every endeavor to improve the product quality and reliability. However, semiconductor products may rarely happen to fail or malfunction. To prevent accidents causing injury or death, damage to property like by fire, and other social damage resulted from a failure or malfunction of the Fuji Electric semiconductor products, take some measures to keep safety such as redundant design, spread-fire-preventive design, and malfunction-protective design..

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3. The product described in this specification is not designed nor made for being applied to the equipment or systems used under life-threatening situations. When you consider applying the product of this specification to particular used, such as vehicle-mounted units, shipboard equipment, aerospace equipment, medical devices, atomic control systems and submarine relaying equipment or systems, please apply after confirmation of this product to be satisfied about system construction and required reliability.

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