Messrs. Rockwell Automation

# SPECIFICATION

Device Name : Diode Module with Brake

Type Name : 6R1MBi125LP-160-04

Spec. No. : MS5T00207

Date : Nov -17-'03



| | DATE | NAME | APPROVED |
|---|---|---|---|
| DRAWN | Nov-17-'03 | H. Haneda | Y. Seki |
| CHECKED | NOV-17-'03 | T. Miyasoka | |
| CHECKED | - - | K. Yamada | |

Fuji Electric Device Technology Co., Ltd.

DWG.NO. MS5T00207 1/12

# Revised Records

| Date | Classi-fication | Ind. | Content | Applied date | Drawn | Checked | Checked | Approved |
|---|---|---|---|---|---|---|---|---|
| Nov -17 -'03 | Enactment | — | ———— | Issued date | —— | K.Yamada T.Miyata | | Y.Seki |
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# Ratings and characteristics of diode module with Brake

## Type : 6R1MBi125LP-160-04

1.Maxmum rating(at Tj=25℃ / Tc=25℃ unless otherwise specified)

| | Item | Symbol | Condition | | Max. | Unit |
|---|---|---|---|---|---|---|
| Converter | Repetitive peak reverse voltage | $V_{RRM}$ | | | 1600 | V |
| | Non-repetitive peak reverse voltage | $V_{RSM}$ | | | 1900 | V |
| | Average output current | Io | 50Hz/60Hz sine wave Tc=103℃ | | 125 | A |
| | One cycle surge current (50Hz) | $I_{FSM}$ | From rated load | | 1200 | A |
| | $I^2t$ | $I^2t$ | From rated load | | 6000 | $A^2s$ |
| | Operation junction temperature | Tj | | | -40 to +150 | ℃ |
| Brake | Collector-Emitter voltage | $V_{CES}$ | | | 1200 | V |
| | Gate-Emitter voltage | $V_{GES}$ | | | ±20 | V |
| | Collector current | Ic | DC | Tc=25℃ | 110 | A |
| | | | | Tc=44℃ | 100 | |
| | | Icp | 1ms | Tc=25℃ | - | A |
| | | | | Tc=44℃ | - | |
| | Collector power dissipation | Pc | | | 280 | W |
| | Repetitive peak reverse voltage | $V_{RRM}$ | | | 1400 | V |
| | Operation junction temperature | Tj | | | -40 to +150 | ℃ |
| Storage junction temperature | | Tstg | | | -40 to +125 | ℃ |
| Isolation voltage | | Viso | AC:1min | | 3000 | V |
| Mounting screw torque | | | M5 screw | | 2.0 to 2.5 | N·m |

2.electrical characteristics (at Tj=25℃ / Tc=25℃ unless otherwise specified)

| | Item | Symbol | Condition | min. | typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Co. | Forward voltage | $V_{FM}$ | $I_{FM}$=125A | - | - | 1.35 | V |
| | Reverse current | $I_{RRM}$ | Tj=150℃, $V_R=V_{RRM}$ | - | - | 10.0 | mA |
| Brake | Zero gate voltage Collector current | $I_{CES}$ | $V_{GE}$=0V, $V_{CE}$=1200V | - | - | 1.0 | mA |
| | Gate-Emitter leakage current | $I_{GES}$ | $V_{CE}$=0V, $V_{GE}$=±20V | - | - | 200 | nA |
| | Collector-Emitter saturation voltage | $V_{CE(sat)}$ | $V_{GE}$=15V, Ic=100A | - | 2.10 | 2.45 | V |
| | Turn-on time | ton | Vcc=600V | - | 0.36 | 1.20 | us |
| | | tr | Ic=100A | - | 0.21 | 0.60 | |
| | Turn-off time | toff | $V_{GE}$=±15V | - | 0.37 | 1.00 | |
| | | tf | $R_G$=5.6Ω | - | 0.07 | 0.30 | |
| | Reverse current | $I_{RRM}$ | $V_R=V_{RRM}$ | - | - | 1.0 | mA |
| | Forward voltage | $V_{FM}$ | $I_{FM}$=35A | - | 2.0 | 3.0 | V |

3. Thermal characteristics

| Item | Symbol | Condition | | min. | typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Thermal resistance | $Rth_{(j-c)}$ | Converter | Per total loss | - | - | 0.13 | ℃/W |
| | | | Per each device | - | - | 0.78 | |
| | | Brake IGBT (1device) | | - | - | 0.44 | |
| | | Brake FWD (1device) | | - | - | 1.50 | |
| Thermal resistance (case to fin) | $Rth_{(c-f)}$ | with thermal compound | | - | 0.08 | - | ℃/W |

4. Outline drawing and equivalent circuit are shown in page P5/12

5. Applicable category

This specification is applied to Diode module with Brake named 6R1MBi125LP-160-04.
This product is selection version of $V_{RSM}$=1900V from $V_{RRM}$=1600V / $V_{RSM}$=1760V device.
All of reliability test condition at Conv-diode is also based on $V_{RRM}$=1600V / $V_{RSM}$=1760V device.

6. Storage and transportation notes

6.1 The module should be stored at a standard temperature of 5 to 35℃ and humidity of 45 to 75%

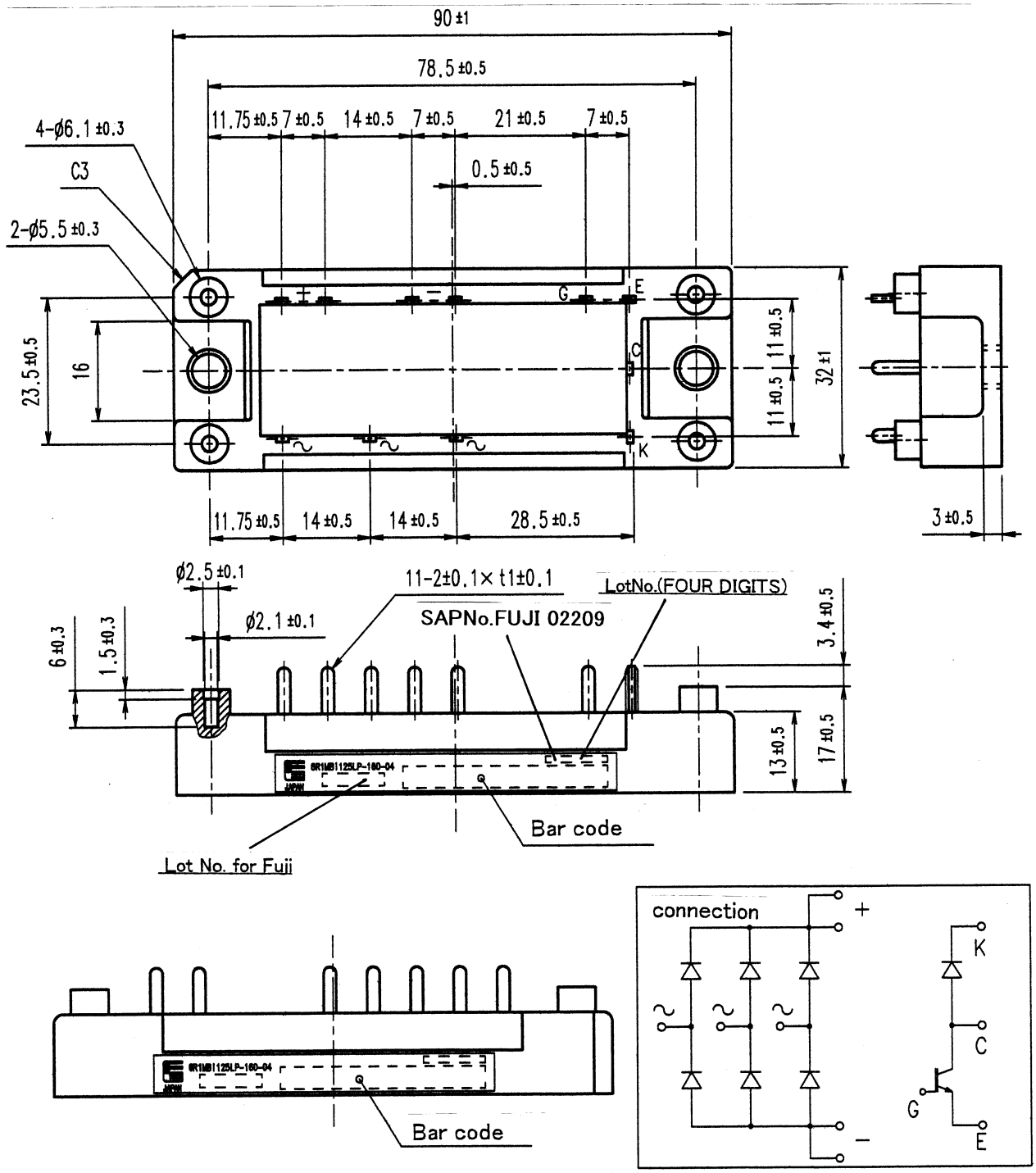
6.2 Store modules in a place with few temperature changes in order to avoid condensation on the module surface.

6.3 Avoid exposure to corrosive gases and dust.

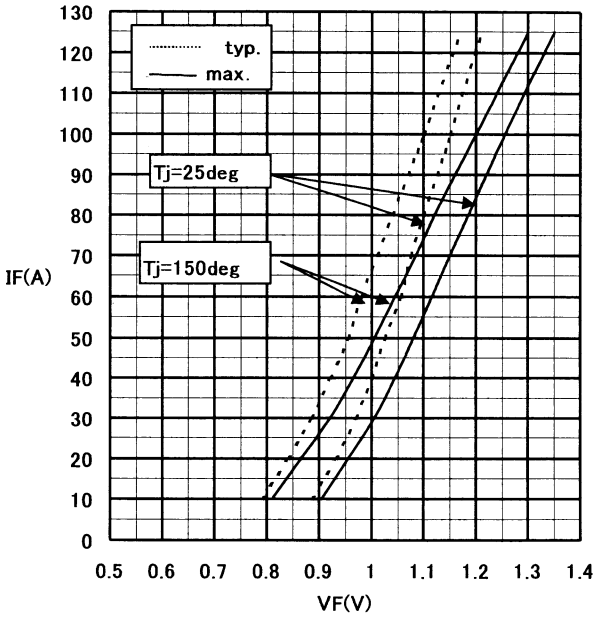
6.4 Avoid excessive external force on the module

6.5 Store module with unprocessed terminals.

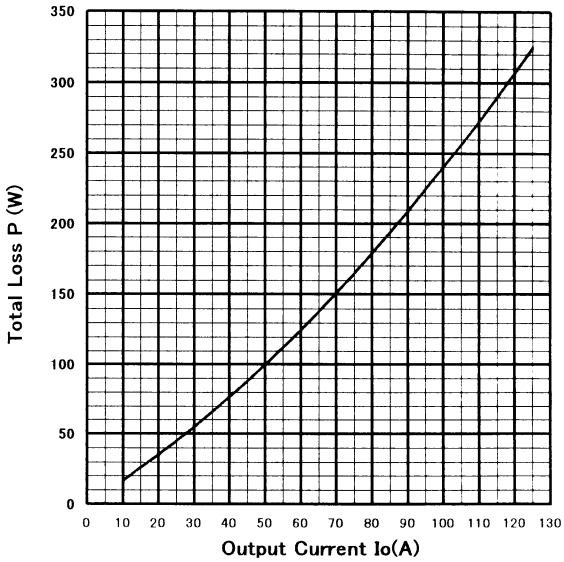
6.6 Do not drop or otherwise shock the modules when transporting.



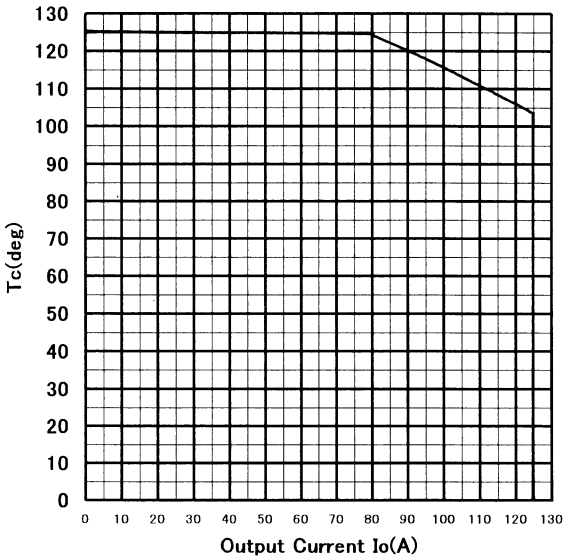
## Forward characteristics



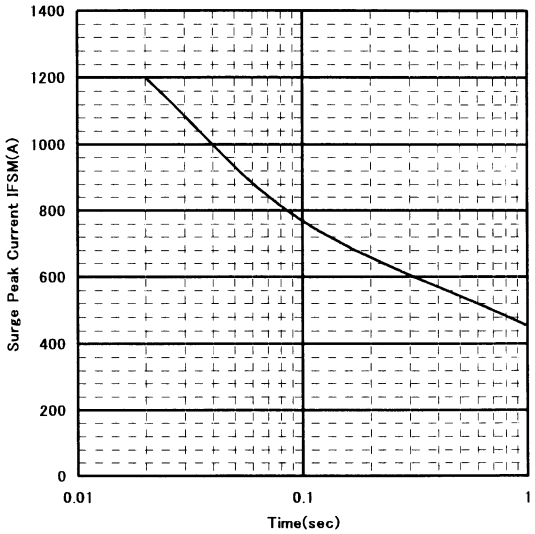

## Output Current vs Total Loss



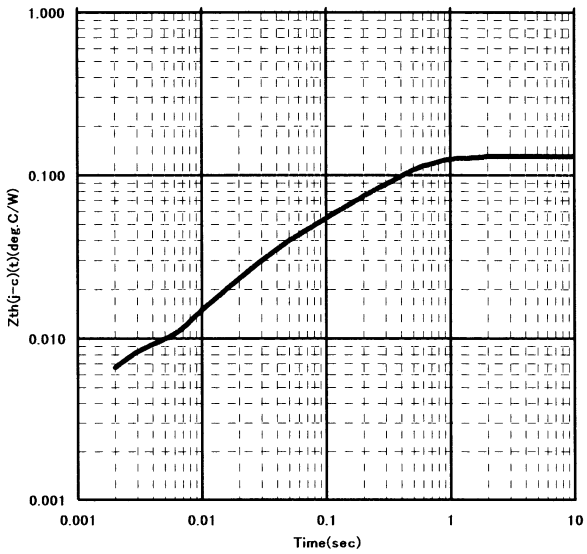

## Output Current vs. Tc



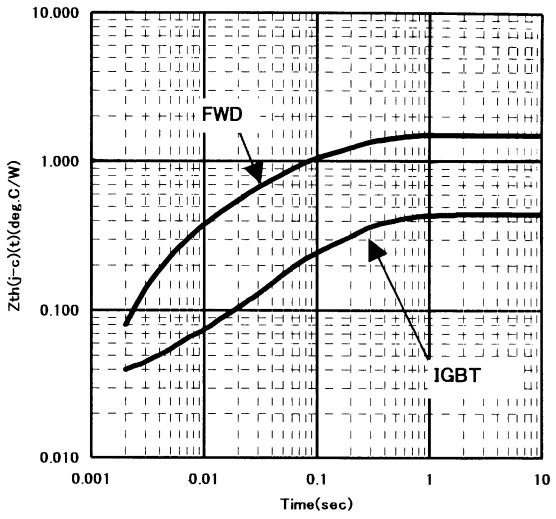

## Surge Current




## Transent Thermal Impedance

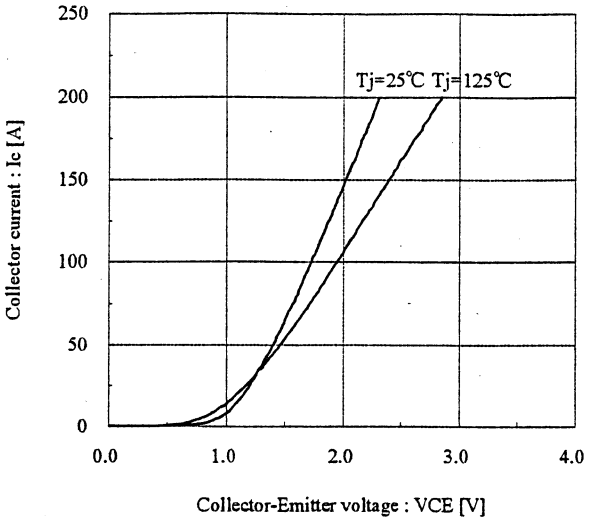



## [Brake] Transient Thermal Impedance



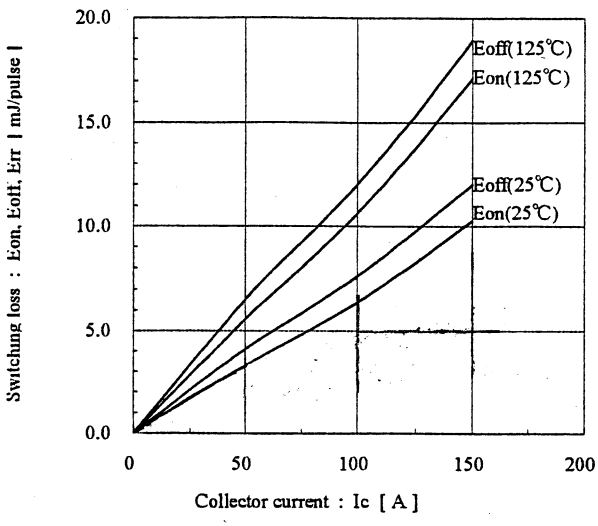
Collector current vs. Collector-Emitter voltage

VGE=15V (typ.) / chip



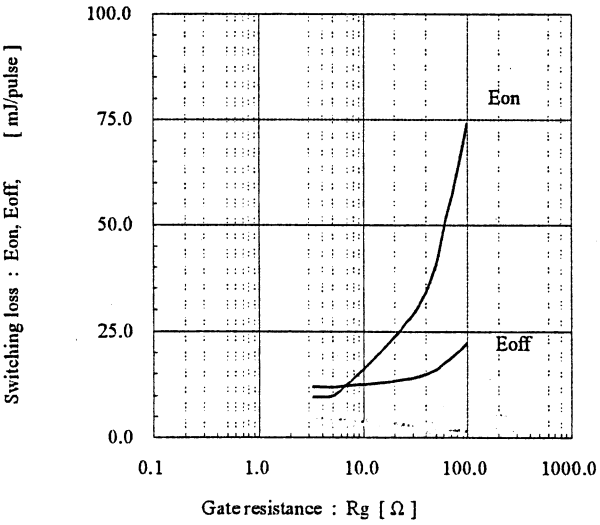

Switching loss vs. Collector current (typ.)

Vcc=600V, VGE=±15V, Rg=5.6Ω



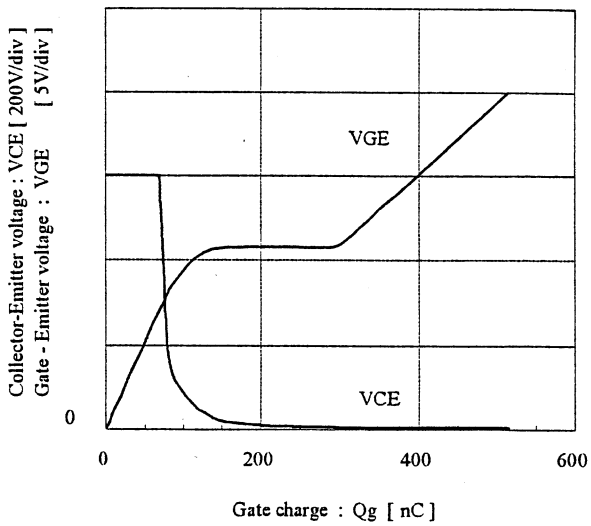

Switching loss vs. Gate resistance (typ.)

Vcc=600V, Ic=100A, VGE=±15V, Tj= 125℃




Dynamic Gate charge (typ.)

Vcc=600V, Ic=100A, Tj= 25℃



# Reliability Test Items

| Test categories | | Test items | Test methods and conditions | Reference norms EIAJ ED-4701 (Aug.-2001 edition) | Number of sample | Acceptance number |
|---|---|---|---|---|---|---|
| Mechanical Tests | 1 | Terminal Strength (Pull test) | Pull force : 40N<br>Test time : 10±1 sec. | Test Method 401 Method 1 | 5 | ( 1 : 0 ) |
| | 2 | Mounting Strength | Screw torque : 2.0 ~ 2.5 N·m (M5)<br>Test time : 10±1 sec. | Test Method 402 Method 2 | 5 | ( 1 : 0 ) |
| | 3 | Vibration | Range of frequency : 10 ~ 500Hz<br>Sweeping time : 15 min.<br>Acceleration : 10G<br>Sweeping direction : Each X,Y,Z axis<br>Test time : 6 hr. (2hr./direction) | Test Method 403 Reference 1 Condition code B | 5 | ( 1 : 0 ) |
| | 4 | Shock | Maximum acceleratior : 1000G<br>Pulse width : 0.5msec.<br>Direction : Each X,Y,Z axis<br>Test time : 3 times/direction | Test Method 404 Condition code B | 5 | ( 1 : 0 ) |
| | 5 | Solderabitlity | Solder temp. : 235±5 °C<br>Immersion time : 5±1sec.<br>Test time : 1 time<br>Each terminal should be Immersed in solder within 1~1.5mm from the body. | Test Method 303 Condition code A | 5 | ( 1 : 0 ) |
| | 6 | Resistance to Soldering Heat | 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 Condition code A | 5 | ( 1 : 0 ) |
| Environment Tests | 1 | High Temperature Storage | Storage temp. : 125±5 °C<br>Test duration : 1000hr. | Test Method 201 | 5 | ( 1 : 0 ) |
| | 2 | Low Temperature Storage | Storage temp. : -40±5 °C<br>Test duration : 1000hr. | Test Method 202 | 5 | ( 1 : 0 ) |
| | 3 | Temperature Humidity Storage | Storage temp. : 85±2 °C<br>Relative humidity : 85±5%<br>Test duration : 1000hr. | Test Method 103 Test code C | 5 | ( 1 : 0 ) |
| | 4 | Unsaturated Pressure Cooker | Test temp. : 120±2 °C<br>Atmospheric pressure : $1.7\times10^5$ Pa<br>Test humidity : 85±5%<br>Test duration : 20hr. | Test Method 103 Test code E | 5 | ( 1 : 0 ) |
| | 5 | Temperature Cycle | Test temp. : Low temp. -40±5°C / High temp. 125±5°C / RT 5 ~ 35 °C<br>Dwell time : High ~ RT ~ Low ~ RT<br>1hr. 0.5hr. 1hr. 0.5hr.<br>Number of cycles : 100 cycles | Test Method 105 | 5 | ( 1 : 0 ) |
| | 6 | Thermal Shock | Test temp. : High temp. $100^{+0}_{-5}$ °C / Low temp. $0^{+5}_{-0}$ °C<br>Used liquid : Water with ice and boiling water<br>Dipping time : 5 min. par each temp.<br>Transfer time : 10 sec.<br>Number of cycles : 10 cycles | Test Method 307 method I Condition code A | 5 | ( 1 : 0 ) |

# Reliability Test Items

| Test categories | | Test items | Test methods and conditions | | Reference norms EIAJ ED-4701 (Aug.-2001 edition) | Number of sample | Acceptance number |
|---|---|---|---|---|---|---|---|
| Endurance Tests | 1 | High temperature Reverse Bias | Test temp.<br>Bias Voltage<br><br><br>Bias Method<br><br><br><br>Test duration | : Ta = 125±5℃<br>(Tj ≦ 150 ℃)<br>: VC= 0.8×VRRM(Conv.part Di)<br>VC= 0.8×VCES(Brake IGBT)<br>VC= 0.8×VRRM(Brake FWD)<br>: Conv.Part Di<br>Applied AC voltage to A-K<br>Brake IGBT / Brake FWD<br>Applied DC voltage to C-E / A-K<br>VGE = 0V<br>: 1000hr. | Test Method 101 | 5 | ( 1 : 0 ) |
| | 2 | High temperature Bias | Test temp.<br>Bias Voltage<br>Bias Method<br><br>Test duration | : Ta = 125±5℃<br>(Tj ≦ 150 ℃)<br>: VC = VGE = +20V or -20V<br>: Applied DC voltage to G-E<br>VCE = 0V<br>: 1000hr. | Test Method 101 | 5 | ( 1 : 0 ) |
| | 3 | Intermitted Operating Life (Power cycle) ( for IGBT ) | ON time<br>OFF time<br>Test temp.<br><br>Number of cycles | : 1 sec.<br>: 9 sec.<br>: Δ Tj=100±5deg(visual temperature)<br>Tj ≦ 150 ℃, Ta=25±5 ℃<br>: 45,000 cycles | Test Method 106 | 5 | ( 1 : 0 ) |
| | 4 | Intermitted Operating Life (Power cycle) ( for Conv.Di ) | Test temp.<br><br>Number of cycles | : Δ Tf=60±5 deg<br>Tj ≦ 150 ℃, Tfmin≦30 ℃<br>: 5000 cycles | Test Method 106 | 5 | ( 1 : 0 ) |

# Failure Criteria

| Item | Characteristic | | Symbol | Failure criteria | | Unit | Note |
|---|---|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit | | |
| Electrical characteristic | Leakage current | | IRRM | - | USL×1.2 | mA | Conv.Part Di,Tj=Tjmax |
| | | | ICES | - | USL×2 | mA | |
| | | | ±IGES | - | USL×2 | μA | |
| | | | IRRM | - | USL×2 | mA | |
| | Gate threshold voltage | | VGE(th) | LSL×0.8 | USL×1.2 | mA | |
| | Saturation voltage | | VCE(sat) | - | USL×1.2 | V | |
| | Forward voltage | | VF | - | USL×1.2 | V | Conv.Di.Brake FWD |
| | Thermal resistance | Conv.Di | ΔVF | - | USL×1.2 | mV | |
| | | IGBT | ΔVGE or ΔVCE | - | USL×1.2 | mV | |
| | | FWD | ΔVF | - | USL×1.2 | mV | |
| | Isolation voltage | | Viso | Broken insulation | | - | |
| Visual inspection | 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.

# Reliability Test Results

| Test categories | | Test items | Reference norms EIAJ ED-4701 (Aug.-2001 edition) | Number of test sample | Number of failure sample |
|---|---|---|---|---|---|
| Mechanical Tests | 1 | Terminal Strength (Pull test) | Test Method 401 Method 1 | 5 | 0 |
| | 2 | Mounting Strength | Test Method 402 Method 2 | 5 | 0 |
| | 3 | Vibration | Test Method 403 Condition code B | 5 | 0 |
| | 4 | Shock | Test Method 404 Condition code B | 5 | 0 |
| | 5 | Solderabitlity | Test Method 303 Condition code B | 5 | 0 |
| | 6 | Resistance to Soldering Heat | Test Method 302 Condition code A | 5 | 0 |
| Environment Tests | 1 | High Temperature Storage | Test Method 201 | 5 | 0 |
| | 2 | Low Temperature Storage | Test Method 202 | 5 | 0 |
| | 3 | Temperature Humidity Storage | Test Method 103 Test code C | 5 | 0 |
| | 4 | Unsaturated Pressure Cooker | Test Method 103 Test code E | 5 | 0 |
| | 5 | Temperature Cycle | Test Method 105 | 5 | 0 |
| | 6 | Thermal Shock | Test Method 307 method I Codition code A | 5 | 0 |
| Endurance Tests | 1 | High temperature Reverse Bias | Test Method 101 | 5 | 0 |
| | 2 | High temperature Bias ( for gate ) | Test Method 101 | 5 | 0 |
| | 3 | Intermitted Operating Life (Power cycling) (for IGBT) | Test Method 106 | 5 | 0 |
| | 4 | Intermitted Operating Life (Power cycling) ( for Conv.Di ) | Test Method 106 | 5 | 0 |

## Warnings

- This product shall be used within its abusolute maximun rating (voltage, current, and temperature). This product may be broken in case of using beyond the ratings.
- Conect adequate fuse or protector of circuit between three-phase line and this product to prevent the equipment from causing secondary destruction.
- 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.
- If the product had been used in the environment with acid, organic matter, and corrosive gas (hydrogen sulfide,sulfurous acid gas), the product's performance and appearance can not be ensured easily.
- Use this product within the power cycle curve (Ref,MT5T02259)
- Never add mechanical stress to deform the main or control terminal. The deformed terminal may cause poor contact probrem.
- Use this product with keeping the cooling fin's flatness between screw holes within 100um and the rouphness within 10um. Also keep the tightening torque within the limits of this specification. Improper handling may cause isolation breakdown and this may lead to a cirtical accident.
- It shall be confirmed that IGBT's operating locus of the turn-off voltage and current are within the RBSOA specification. This product may be broken if the locus is out of the RBSOA.
- If excessive static electricity is applied to the control terminals, the devices can be broken. Implement some countermeasures against static electricity.

## Cautions

- 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 injuly ot 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.
- The application examples described in this specification only explain typical ones that used the Fuji Electric products. This specification never ensure to enforce the industrial property and other rights, nor license the enforcement rights.
- 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 ralaying equipment or systems, please apply after confirmation of this product to be satisfied about system construction and required reliability.

If there is any unclear matter in this specification, please contact Fuji Electric Co.,Ltd.