Fuji IGBT Module V Series 1700V  Family  
Technical Notes

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RBSOA, SCSOA</td>
<td>MT5F24382</td>
</tr>
<tr>
<td>2</td>
<td>High current output characteristics</td>
<td>MT5F24040</td>
</tr>
<tr>
<td>3</td>
<td>Switching energy and Reverse recovery dV/dt with combination of Rg and Cge</td>
<td>MT5F27844</td>
</tr>
<tr>
<td>4</td>
<td>Junction breakdown voltage VCES and junction temperature Tj</td>
<td>MT5F27807</td>
</tr>
<tr>
<td>5</td>
<td>-Vge and switching loss characteristics</td>
<td>MT5F27813</td>
</tr>
<tr>
<td>6</td>
<td>Gate resistance dependence of surge voltage</td>
<td>MT5F27829</td>
</tr>
<tr>
<td>7</td>
<td>-dlc/dt at turn-off and Tj characteristics</td>
<td>MT5F27831</td>
</tr>
<tr>
<td>8</td>
<td>Parallel connection of 2in1 package modules</td>
<td>MT5F27805</td>
</tr>
<tr>
<td>9</td>
<td>Short-circuit capacity</td>
<td>MT5F27809</td>
</tr>
</tbody>
</table>
Reverse bias safe operating area
[1700V Inverter IGBT]

$V_{ge}=15V$, $V_{ge} \leq 15V$, $R_g \geq R_g(\text{spec.})$ $T_j=150^\circ C$

**Fig. RBSOA and SCOSA**
V series 1700V product family
Conditions: Tj=25°C, 125°C and 150°C
Vge=15V

same as 1200V

Note 1: This data shows the typical waveform of 2MBl650VXA-170E-50 and the values of chips that do not include the internal resistance of the module.
Type name: 2MBI550VN-170-50
Conditions: Vdc=900V, Ic, If=550A, Vge=±15V, Rg=vari., Cge=0, 47, 100nF
Tj=25°C or 125°C

(a) Rg dependence of reverse recovery dv/dt
(b) Rg dependence of turn-on loss
(c) Rg dependence of turn-off loss
(d) Rg dependence of reverse recovery loss
Additional external capacitance between IGBT gate and emitter terminals has an effect of improving the trade off between reverse recovery dv/dt and total switching energy as shown in above chart. However, simply add Cge slows down the IGBT significantly and it results penalty of increasing the switching loss. Therefore, the combination of extra-Cge and reduction of the gate resistance (Rg) is recommended to achieve the highest performance of lower dV/dt as well as keep switching energy low. Typical Cge and Rg values for initial guess are : 2x of Cies in our datasheet and 1/2 Rg of your original design, however, experimental confirmation in practical application is recommended.
In general, the breakdown voltage of power semiconductor devices have linear function to the junction temperature if "Impact ionization" and "Avalanche multiplication" are dominant physics of junction breakdown. At low temperature, the carriers in drift region are relatively easier to have high velocity because of less scattering due to lattice vibration so that the impact ionization ratio increases. Therefore, the breakdown voltage of the power semiconductor device becomes lower at low temperature. The temperature effect shown in the above figure should be taken into account into practical design not to exceed breakdown voltage if the target applications have chances of low temperature operation and/or start-up.
 Fuji IGBT Module V Series 1700V Family –

-Vge and switching loss characteristics

Type name : 2MBI550VN-170-50
Conditions : Vcc=900V, Vge=+15V, -Vge=vari., Rg=3.3Ω, Tj=125°C, Ic=550A

Fig. –Vge and switching loss characteristics
The surge voltage, especially at IGBT turn off, depends on the gate resistance. As shown in the figure above, the surge voltage is able to control with the gate resistance but the curve shave peaks depending on the junction temperature. The primary reason of such behavior is the interaction of two silicon physics in IGBT chip: 1) the carriers stored in the drift region and 2) Current through MOS channel.

Reference:
Type name: 2MBI550VN-170-50
Conditions: Vcc=900V, Vge=+15V/-15V, Rg=3.3Ω, Tj=vari., Ic=550A

Fig. –dIc/dt at Turn-off and Tj Characteristics
Circuit configuration and formula

\[ \Delta V_{on} = |V_{on2} - V_{on1}| \quad (V_{on2} > V_{on1}) \]

\[ I_{c\, (ave)} = \frac{I_1 + I_2}{2} \]

Current imbalance is caused by the difference between \( V_{on1} \) and \( V_{on2} \), and current is divided into \( I_1 \) and \( I_2 \). In this case, the current imbalance can be obtained from the following calculating formula.

\[
\alpha = \left( \frac{I_i}{I_{c\,(ave)}} - 1 \right) \times 100 \quad (\%)
\]

When \( n \) IGBT modules are connected in parallel, the maximum allowable current \( \Sigma I \) can be expressed in the following formula by using the current imbalance rate \( \alpha \) at two-parallel connection. This maximum allowable current \( \Sigma I \) is used for reference only.

\[
\sum I = I_{c\,(max)} \left[ 1 + (n - 1) \left( \frac{1 - \frac{\alpha}{100}}{1 + \frac{\alpha}{100}} \right) \right]
\]
Fuji IGBT module V series 1700V Family

Short circuit capability

Fig. Relation between applied voltage and short-circuit capacity (1700V Family)
1. This Catalog contains the product specifications, characteristics, data, materials, and structures as of January 2014. The contents are subject to change without notice for specification changes or other reasons. When using a product listed in this Catalog, be sure to obtain the latest specifications.

2. All applications described in this Catalog exemplify the use of Fuji’s products for your reference only. No right or license, either express or implied, under any patent, copyright, trade secret or other intellectual property right owned by Fuji Electric Co., Ltd. is (or shall be deemed) granted. Fuji Electric Co., Ltd. makes no representation or warranty, whether express or implied, relating to the infringement or alleged infringement of other’s intellectual property rights which may arise from the use of the applications described herein.

3. Although Fuji Electric Co., Ltd. is enhancing product quality and reliability, a small percentage of semiconductor products may become faulty. When using Fuji Electric semiconductor products in your equipment, you are requested to take adequate safety measures to prevent the equipment from causing a physical injury, fire, or other problem if any of the products become faulty. It is recommended to make your design failsafe, flame retardant, and free of malfunction.

4. The products introduced in this Catalog are intended for use in the following electronic and electrical equipment which has normal reliability requirements.
   - Computers
   - OA equipment
   - Communications equipment (terminal devices)
   - Measurement equipment
   - Machine tools
   - Audiovisual equipment
   - Electrical home appliances
   - Personal equipment
   - Industrial robots etc.

5. If you need to use a product in this Catalog for equipment requiring higher reliability than normal, such as for the equipment listed below, it is imperative to contact Fuji Electric Co., Ltd. to obtain prior approval. When using these products for such equipment, take adequate measures such as a backup system to prevent the equipment from malfunctioning even if a Fuji’s product incorporated in the equipment becomes faulty.
   - Transportation equipment (mounted on cars and ships)
   - Traffic-signal control equipment
   - Emergency equipment for responding to disasters and anti-burglary devices
   - Medical equipment
   - Trunk communications equipment
   - Gas leakage detectors with an auto-shut-off feature
   - Safety devices

6. Do not use products in this Catalog for the equipment requiring strict reliability such as the following and equivalents to strategic equipment (without limitation).
   - Space equipment
   - Submarine repeater equipment
   - Aeronautic equipment
   - Nuclear control equipment

7. Copyright ©1996-2014 by Fuji Electric Co., Ltd. All rights reserved. No part of this Catalog may be reproduced in any form or by any means without the express permission of Fuji Electric Co., Ltd.

8. If you have any question about any portion in this Catalog, ask Fuji Electric Co., Ltd. or its sales agents before using the product. Neither Fuji Electric Co., Ltd. nor its agents shall be liable for any injury caused by any use of the products not in accordance with instructions set forth herein.