## Fuji IGBT Module V Series 1200V Family Technical Notes

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Reverse bias safe operating area
[1200V Inverter IGBT]
+Vge=15V, -Vge≤15V, Rg≥Rg(spec.) Tj=150°C

RBSOA (Repetitive pulse)
SCSOA (Non-repetitive pulse)

Fig. RBSOA and SCSOA
Fuji IGBT Module V Series 1200V Family

High current output characteristics

V series 1200V product family
Conditions:  \( T_j = 25^\circ C, 125^\circ C \) and \( 150^\circ C \)

\( V_{ge} = 15 \) V

Note: This data shows the typical waveforms of chip characteristics. The effect of the internal resistance of the module is not included

Technical data: MT5F24326
- Fuji IGBT Module V Series 1200V Family -

Switching energy and Reverse recovery dv/dt with combination of Rg and Cge

Type name: 2MBI600VN-120-50

Conditions: Vdc=600V, Ic, If=40A and/or 600A, Vge=+/−15V, Cge=0, 47, 94nF,
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.

Technical data: MT5F21212
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 application have chances of low temperature operation and/or start-up.

Technical data: MT5F24327
Fuji IGBT Module V Series 1200V Family

-Vge and switching loss characteristics

Type name: 2MBI300VN-120-50
Conditions: Vdc=600V, Ic=300A, Vge=+15V, Rg=0.92Ω

Technical data: MT5F21212
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 curves have peaks depending on the junction temperature. Although detailed reasons for this relation are not described here, the background of such behaviors have already been analyzed and published. 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.

This chart also indicates that the increasing the gate resistance is not only the method to solve turn-off spike voltage issue. The decrease of the gate resistance may also have an effect.

Reference:
- Fuji IGBT Module V Series 1200V Family -

- $dV/dt$ at turn-off and Tj characteristics

- 2MBI600VN-120-50

Fig. $dV/dt$ at Turn-Off and Tj Characteristics

- $V_{cc}=600V$
- $I_c=600A$
- $V_{ge}=+15V/-15V$
- $R_g=0.68\,\text{ohm}$

Technical data: MT5F24329
Type name: 2MBI600VN-120-50

Fig. Dynamic Avalanche Voltage (Vav) as function of Tj

Technical data: MT5F24330
Parallel connection of 2in1 package modules

Circuit configuration and formula

$\Delta V_{on} = |V_{on2} - V_{on1}| \ (V_{on2} > V_{on1})$

$I_{c\ (ave)} = \frac{(I_1 + I_2)}{2}$

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.

$$\alpha = \left( \frac{I_1}{I_{c\ (ave)}} - 1 \right) \times 100 \ (%)$$

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.

$$\sum I = I_{c\ (max)} \left[ 1 + (n-1) \left( \frac{1 - \frac{\alpha}{100}}{1 + \frac{\alpha}{100}} \right) \right]$$

Technical data: MT5F24335
- Fuji IGBT Module V Series 1200V Family -

Short-circuit capacity

Fig. Relation between applied voltage and short-circuit capacity (1200V Family)

Technical data: MT5F24336
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 shows 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\cite{Reference1}.

Reference:

Technical data: MT5F26530
 Radiation noise comparison by the difference in a gate capacitance connection position

Type name: 2MBI300VH-120-50

As shown in the above figure, the higher noise reduction effect is acquired by connecting Cge to the module terminal side.

Technical data: MT5F25003
Fuji IGBT module S,U,V-series 1200V

Rg-dV/dt dependency of S,U,V-series

Test module: 2MBI75S-120, 2MBI75U4A-120, 2MBI75VA-120-50
Test condition: Vdc=600V, Ic=7.5A (turn on, reverse recovery), 75A (turn off), Vge=+/−15V, Tj=25deg.C, Rg=vari.

Rgon vs. Turn on dV/dt
Rgoff vs. Turn off dV/dt
Rgon vs. Reverse recovery dV/dt
Test module: 2MBI100S-120, 2MBI100SC-120, 2MBI100U4A-120-50, 2MBI100VA-120-50

Test condition: Vdc=600V, Ic=10A (turn on, reverse recovery), 100A (turn off), Vge=+/-15V, Tj=25deg.C, Rg=vari.

Test module: 2MBI150S-120, 2MBI150SC-120, 2MBI150U4A-120-50, 2MBI150VA-120-50, 2MBI150VB-120-50

Test condition: Vdc=600V, Ic=15A (turn on, reverse recovery), 150A (turn off), Vge=+/-15V, Tj=25deg.C, Rg=vari.
Test condition: Vdc=600V, Ic=20A(turn on, reverse recovery), 200A(tum off), Vge=+/-15V, Tj=25deg.C, Rg=vari.

Test condition: Vdc=600V, Ic=22.5A(turn on, reverse recovery), 225A(tum off), Vge=+/-15V, Tj=25deg.C, Rg=vari.

Test condition: Vdc=600V, Ic=30A (turn on, reverse recovery), 300A (turn off), Vge=+/-15V, Tj=25deg.C, Rg=vari.

Test module: 2MB1400U4H-120-50, 2MB1400VD-120-50

Test condition: Vdc=600V, Ic=40A (turn on, reverse recovery), 400A (turn off), Vge=+/-15V, Tj=25deg.C, Rg=vari.
Test module: 2MBI450U4E-120, 2MBI450U4J-120-50, 2MBI450U4N-120-50, 2MBI450VE-120-50, 2MBI450VH-120-50, 2MBI450VJ-120-50, 2MBI450VN-120-50
Test condition: Vdc=600V, Ic=45A (turn on, reverse recovery), 450A (turn off), Vge=+/-15V, Tj=25deg.C, Rg=vari.

- Rgon vs. Turn on dV/dt
- Rgoff vs. Turn off dV/dt
- Rgon vs. Reverse recovery dV/dt
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