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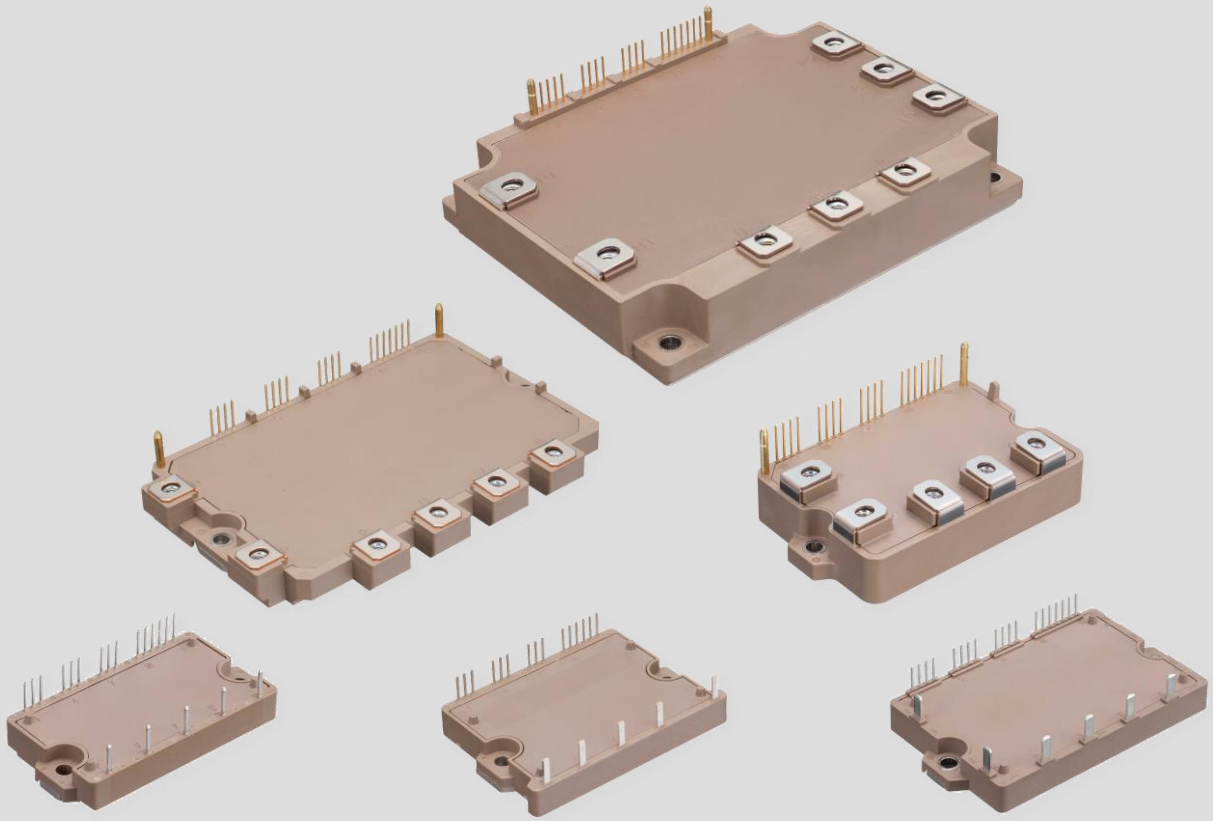

Fuji 7th Generation IGBT-IPM
X Series

Application Manual

Oct. 2021

Fuji Electric Co., Ltd.

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Warning:

This manual contains the product specifications, characteristics, data, materials, and structures as of October 2021.

The contents are subject to change without notice for specification changes or other reasons. When using a product listed in this manual, be sure to obtain the latest specifications.

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⚠Cautions

(1) During transportation and storage

Keep locating the shipping carton boxes to suitable side up. Otherwise, unexpected stress might affect to the boxes. For example, bend the terminal pins, deform the inner resin case, and so on.

When you throw or drop the product, it gives the product damage.

If the product is wet with water, that it may be broken or malfunctions, please subjected to sufficient measures to rain or condensation.

Temperature and humidity of an environment during transportation are described in the specification sheet. There conditions shall be kept under the specification.

(2)Assembly environment

Since this power module device is very weak against electro static discharge, the ESD countermeasure in the assembly environment shall be suitable within the specification described in specification sheet. Especially, when the conducting pad is removed from control pins, the product is most likely to get electrical damage.

(3)Operating environment

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.

Chapter 5 Cooling Design

This chapter describes the cooling design of the X series IPM.

1. Guidelines for heat sink selection

- To safely operate the IGBT, it is necessary that the junction temperature T_{vj} should not exceed 175°C.
- Additionally, the case temperature T_c should not exceed 125°C.
- Carry out thermal design with sufficient margins so that the junction temperature T_{vj} never exceeds 175°C even during an abnormality such as overload.
- There is a risk of thermal destruction if the IGBT is operated at a temperature above 175°C. Although the T_{jOH} protection function in the IPM activates when the junction temperature exceeds 175°C, however, there is a possibility that the protection cannot work if the temperature rises rapidly. As with the IGBT, junction temperature of FWD should not exceed 175°C too.
- The heat sink temperature should be measured just below the center of the chip. Please refer to the IPM specification sheet for the chip layout drawing. In addition, please refer to the following documents.

  [IGBT Module Application Manual RH984]
  - Power dissipation loss calculation
  - Selecting heat sinks
  - Heat sink mounting precautions
  - Troubleshooting

2. Notice for heat sink selection

Although a guideline for heat sink selection is described in the IGBT Module Application Manual (RH984), please pay attention to the flatness of the heat sink surface.

It is recommended that flatness of the heat sink surface is within ±50μm per 100mm between the screw mounting points and the surface roughness is within 10μm.

If the heat sink surface is concave or convex, the contact thermal resistance ($R_{th(c-s)}$) will be increased.

[Reason]
- Concave: There will be a gap between the heat sink surface and the base plate of the IPM, and the heat transfer performance becomes worse (contact thermal resistance $R_{th(c-s)}$ increases).
- Convex (larger than +50μm): The copper base of the IPM may be deformed and the internal insulation substrate may crack due to mechanical stress.

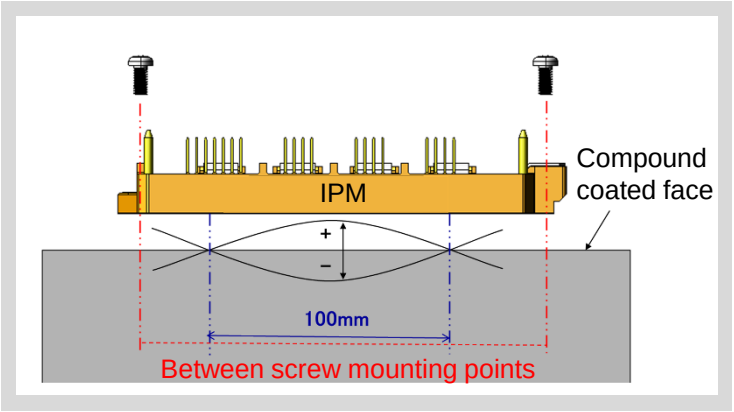


Fig.5-1 Flatness of heat sink surface

3. Mounting instruction of the IPM

3.1 Layout of IPMs on a heat sink

The thermal resistance varies depending on the IPM mounting position. Please note the following :

- When one IPM is mounted to a heat sink, it is recommended to place the IPM on the center of the heat sink to minimize the thermal resistance.
- When multiple IPMs are mounted to a single heat sink, the IPMs location and layout should be designed in consideration of the generated losses and the spread and flow of heat on the heat sink. Allocate the largest area to the IPM which generates the largest loss.

3.2 Application of thermal grease

To reduce the contact thermal resistance, apply thermal grease between the IPM and the heat sink mounting surface.

The general methods of applying thermal grease is applying using a stencil mask and applying with a roller.

The purpose of the thermal grease is to promote heat transmission to the heat sink, but the grease has a limited thermal capacity. Therefore, if the thermal grease thickness is larger than the appropriate thickness, the grease layer prevents the heat transfer from the IPM to the heat sink and the junction temperature will be increased. On the other hand, if the thermal grease thickness is less than the appropriate thickness, non contact part such as a void area, a gap or space may be generated and cause an increase of the contact thermal resistance. Therefore thermal grease should be applied in appropriate thickness.

If the thermal grease thickness is inadequate, the thermal dissipation will be poor, and in the worst case, there is a possibility of IPM breakdown due to the junction temperature exceeding 175°C.

Application of thermal grease using a stencil mask is recommended so that uniform thickness can be achieved. Figure 5-2 shows an example of thermal grease application using a stencil mask. The basis of this method is applying specified weight of thermal grease to the base plate of the IPM using a stencil mask.

It is possible to achieve a uniform thermal grease thickness by mounting the IPM with thermal grease to the heat sink and tightening screws with the recommended torque for each product.

Fuji Electric can provide recommended stencil mask designs upon customer’s request.

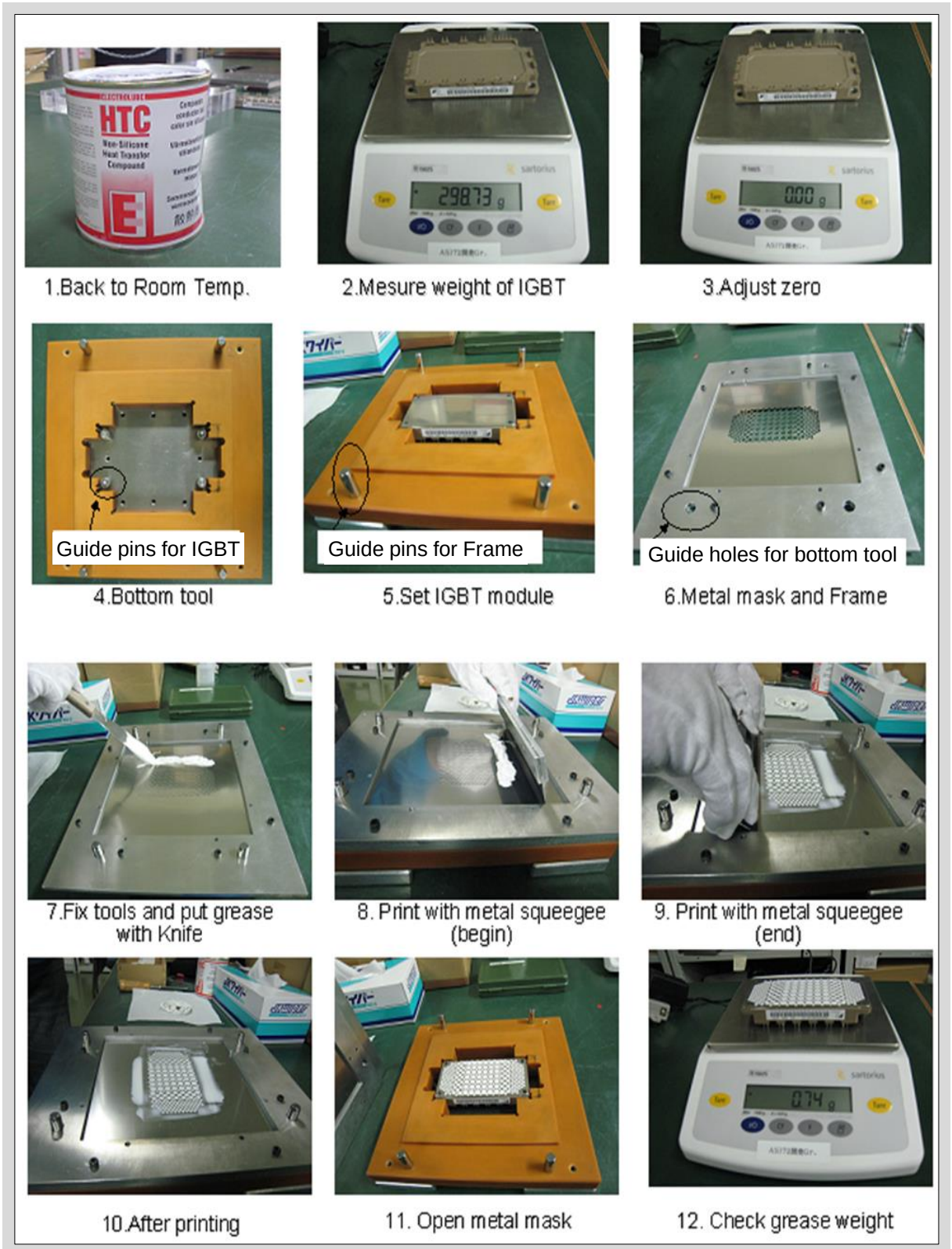


Fig.5-2 Outline of a thermal grease application method

Assuming that the thermal grease thickness is uniform, the required thermal grease weight is given by the following equation.

$$\text{Thermal grease weight (g)} \times 10^4 = \text{Thermal grease thickness (μm)} \times \text{Base plate area of module (cm}^2\text{)} \times \text{Density of thermal grease (g/cm}^3\text{)}$$

Calculate the thermal grease weight that corresponds to the required thermal grease thickness from this equation, and apply the thermal grease. The recommended thermal grease thickness after spreading of thermal grease is 100μm. Also please note that the optimum thermal grease thickness varies depending on the characteristics of the thermal grease used and the application method.

Table 5-1 shows the base plate area of IPMs.

Table5-1 Base plate area of IPM

Package	Base plate area (cm^2)
P639	14.74
P629	21.71
P626, P644	22.77
P636, P638	41.17
P630	55.67
P631	141.24

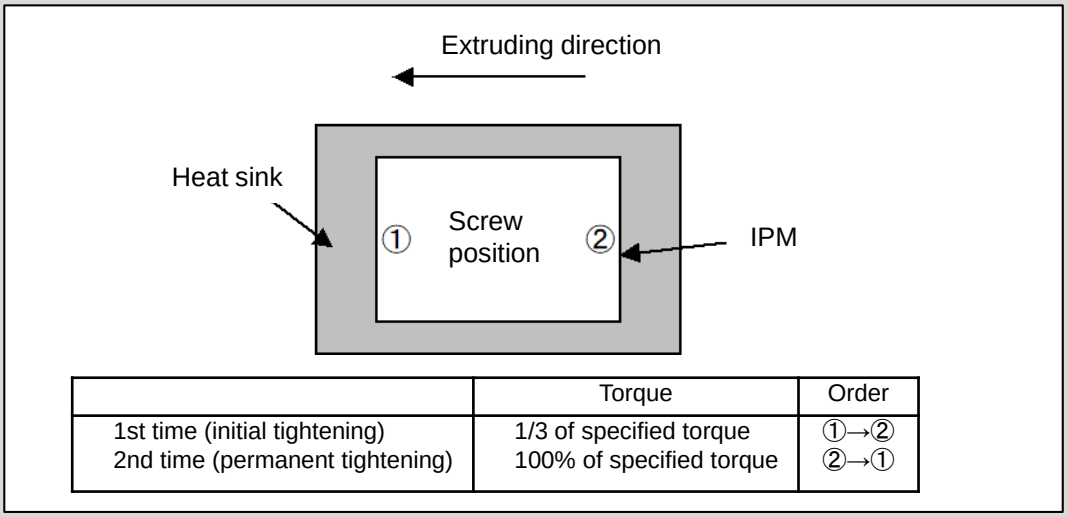
3.3 Screw tightening

Figure 5-3 shows screw-tightening procedures when mounting an IPM to a heat sink. It is recommended to tighten all screws with the specified tightening torque.

The specified tightening torque is described in the specification. If the screw tightening torque is insufficient, the contact thermal resistance may increase and screws loosening may occur during operation. On the other hand, if the screw tightening torque is excessive, the case may be damaged.

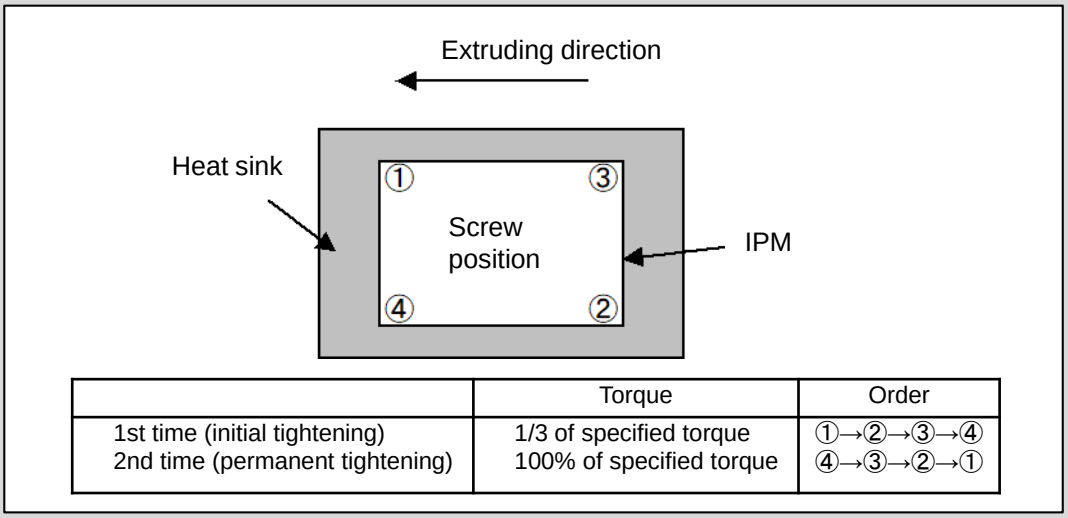
3.4 IPM mounting direction

When an IPM is mounted on an extruded heat sink, it is recommended that the IPM is mounted in parallel to the extrusion direction as shown in Figure 5-3. The purpose is to reduce the effect of heat sink deformation.



	Torque	Order
1st time (initial tightening)	1/3 of specified torque	①→②
2nd time (permanent tightening)	100% of specified torque	②→①

(a) IPM with 2-points mounting



	Torque	Order
1st time (initial tightening)	1/3 of specified torque	①→②→③→④
2nd time (permanent tightening)	100% of specified torque	④→③→②→①

(b) IPM with 4-points mounting

Fig.5-3 IPM mounting method

3.5 Verification of chip temperature

After selecting a heat sink and the IPM mounting position is decided, measure the T_c (directly below the chip) and T_f (directly below the chip), and verify the chip junction temperature (T_{vj}).

Figure 5-4 shows an example of how to accurately measure the case temperature (T_c). Please measure the case temperature directly below the chip. The chip location is described in the specification.

Please verify that the case temperature does not exceed 125°C, the chip junction temperature does not exceed 175°C and the thermal design meets the required life time of the system.

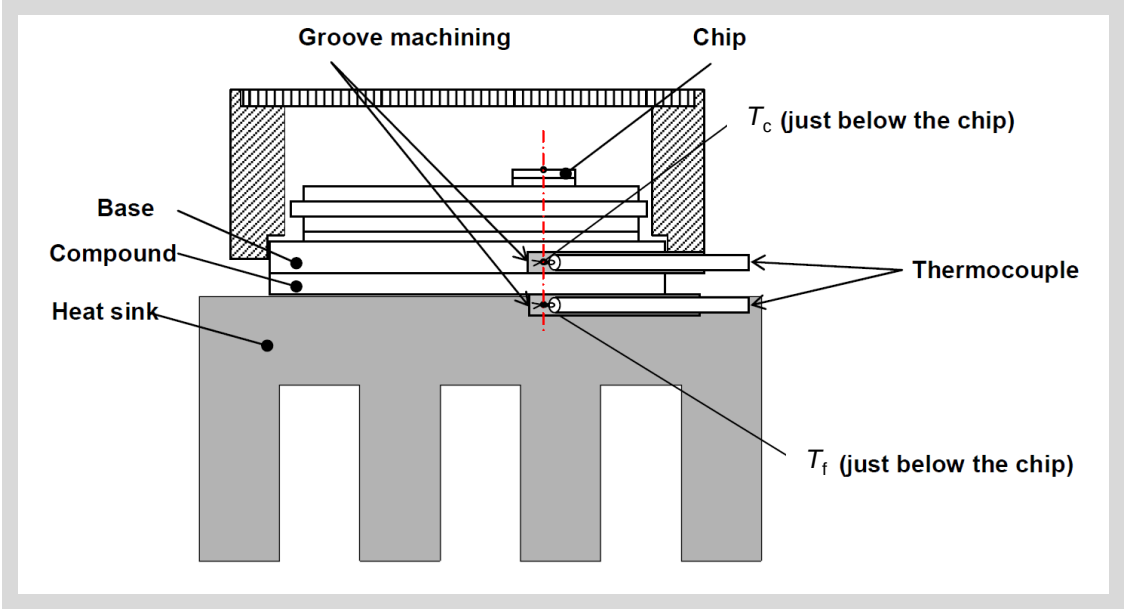


Fig.5-4 Measuring the case temperature