<IGBT Modules>

6.1\textsuperscript{th} Gen. S1 SERIES NX TYPE /
6\textsuperscript{th} Gen. S SERIES NX TYPE / 5\textsuperscript{th} Gen .NX SERIES

APPLICATION NOTE
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</table>

The company name and product names herein are the trademarks and registered trademarks of the respective companies.
2. Features (except for 6.1\textsuperscript{th} S1 series NX type)

- Common Platform (Basic structure)
- Sevenpack
- Single switch
- Dual switch
- M size base plate
- M size case
- Pin
- Bush
- Double terminal
- Substrate
- Cover
- Terminal
3. Product line-up

(a) IGBT Modules 6th Gen. S1 series NX type

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>1200 V</th>
<th>1200 V</th>
<th>1200 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual</td>
<td>CM225DX-24S</td>
<td>CM100TX-24S</td>
<td>CM100RX-24S</td>
</tr>
<tr>
<td></td>
<td>CM300DX-24S</td>
<td>CM150TX-24S</td>
<td>CM150RX-24S</td>
</tr>
<tr>
<td></td>
<td>CM450DX-24S</td>
<td>CM200TX-24S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CM600DX-24S</td>
<td>CM300TX-24S</td>
<td></td>
</tr>
</tbody>
</table>

(b) IGBT Modules 6th Gen. S series NX type

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>1200 V</th>
<th>1200 V</th>
<th>1200 V</th>
<th>1200 V</th>
<th>1200 V</th>
<th>1200 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual</td>
<td>CM150DX-24S</td>
<td>CM75TX-24S</td>
<td>CM75RX-24S</td>
<td>CM35MXA-24S</td>
<td>CM150EXS-24S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CM200DX-24S</td>
<td>CM100TX-24S</td>
<td>CM100RX-24S</td>
<td>CM50MXA-24S</td>
<td>CM200EXS-24S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CM300DX-24S</td>
<td>CM150TX-24S</td>
<td>CM150RX-24S</td>
<td>CM75MXA-24S</td>
<td>CM300EXS-24S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CM450DX-24S</td>
<td>CM200RX-24S</td>
<td>CM200EXS-24S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CM600DXL-24S</td>
<td>CM300EXS-24S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CM1000DXL-24S</td>
<td>CM300EXS-24S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(c) IGBT Modules 5th Gen. NX series

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>600 V</th>
<th>600 V</th>
<th>600 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual</td>
<td>CM300DX-12A</td>
<td>CM100RX-12A</td>
<td>CM75MX-12A</td>
</tr>
<tr>
<td></td>
<td>CM400DX-12A</td>
<td>CM150RX-12A</td>
<td>CM100MX-12A</td>
</tr>
<tr>
<td></td>
<td>CM200DX-12A</td>
<td>CM200RX-12A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CM450DX-12A</td>
<td>CM300RX-12A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>1200 V</th>
<th>1200 V</th>
<th>1200 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual</td>
<td>CM150DX-24A</td>
<td>CM75RX-24A</td>
<td>CM35MXA-24S</td>
</tr>
<tr>
<td></td>
<td>CM200DX-24A</td>
<td>CM100RX-24A</td>
<td>CM50MXA-24S</td>
</tr>
<tr>
<td></td>
<td>CM300DX-24A</td>
<td>CM200RX-24A</td>
<td>CM75MXA-24S</td>
</tr>
<tr>
<td></td>
<td>CM450DX-24A</td>
<td>CM300RX-24A</td>
<td>CM400HX-24A</td>
</tr>
</tbody>
</table>

Table A Connection Diagram: without mark on Label

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>Single Switch</th>
<th>Dual Switch</th>
<th>Brake Chopper</th>
</tr>
</thead>
<tbody>
<tr>
<td>H: single switch</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
</tr>
<tr>
<td>D: dual switch</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
</tr>
<tr>
<td>E: brake chopper</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
</tr>
</tbody>
</table>
4. Label marking

(a) A marking example with 2D code and rank symbol

(b) A marking example with rank symbol for 5th Gen. IGBT modules

(c) Date code formation

(d) Label position and parts name
### 2D code specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbology</td>
<td>Data Matrix (ECC200)</td>
</tr>
<tr>
<td>Data type</td>
<td>alphanumeric (ASCII) characters</td>
</tr>
<tr>
<td>Error correction ability</td>
<td>20 - 35 %</td>
</tr>
<tr>
<td>Symbol size</td>
<td>6.0 mm × 6.0 mm</td>
</tr>
<tr>
<td>Code size</td>
<td>24 cell × 24 cell</td>
</tr>
<tr>
<td>Cell size</td>
<td>0.25 mm</td>
</tr>
<tr>
<td>Data size</td>
<td>32, 35 letters</td>
</tr>
</tbody>
</table>

**Data item** | **Letter size**
---|---
Part number       | 20
Space             | 2
Date code        | 8
Space             | 2
Total             | 32

**Data item** | **Letter size**
---|---
Part number       | 20
Space             | 2
Date code        | 8
Space             | 1
Rank symbol      | 3
Space             | 1
Total             | 35

Data contents example ("SP" means space, equivalent to ASCII code number 32)

```
CM100RX-24S
SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP M12HA1G
```

```
CM300DX-24S
SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP SP M12HA1G
```
6. Safety Standard (UL)
Compliance with international standard UL1557 has already been certified (File No. E323585).
Please refer the certified modules to UL website.
We do not apply the certification, the authorization about other security standards (TUV, VDE, and CSA).
(And do not do a design in consideration of correspondence to the reinforcement insulation of the CE marking.)

(a) Certified modules can be searched through the following website (2013/8/20), click the [Online Certifications Directory], and input the file number E323585 in frame of UL File number, then click the [SEARCH] button.
Or directly input the following URL into address bar of IE "http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/gfilenbr.html"

(b) In the search results page as in the below figure, click QQQX2.E323585 shown in cell of Link to File, then the certified module table will be displayed (refer to the next page).
**Electrically Isolated Semiconductor Devices - Component**

See General Information for Electrically Isolated Semiconductor Devices - Component

**MITSUBISHI ELECTRIC CORP.**

**E3235B5**

**POWER DEVICE WORKS**

1-1 IMABARI KOGANAMI, NISHT-JU

FUKUOKA-SHI, FUKUOKA 819-0192 JAPAN

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**Safety Standard (UL)**

*There is a case of the omission of the update delay and the authorization article according to the convenience of the update of Homepage.*

*When a corresponding article isn't found out, please contact us.*

*At present, Mitsubishi Electric Corporation don't supply yellow card "E323585".*

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**Publication Date : April 2014**
7. Internal structure

(a) Pin terminal types (ex. CIB type)

(b) Screw terminal type (ex. sevenpack type)

About the flammable
The epoxy in IGBT module complies with standard of UL 94V-0, but the silicone gel is combustible and does not comply with 94V-0.
- The breakdown strength after the hardening is using the product of the characteristics above 10 kV/mm at the 340 °C flash point, the 450 °C ignition point.
Because there is not self extinguish-ability, too, in case of the fire, a fire must be extinguished using the dry chemicals, the carbon dioxide extinguishing agent and the bubble extinguishing agent and so on.
Because epoxy has self extinguish-ability, if a burning source is cut off, there is not live danger.
There is not a fireproof standard of UL which corresponds to the other silicon chip, the copper base board and so on.
8. How to use Power Module properly and safely

Unsuitable operation (such as electrical, mechanical stress and so on) may lead to damage of power modules. Please pay attention to the following descriptions and use Mitsubishi Electric’s IGBT modules according to the guidance.

<table>
<thead>
<tr>
<th>Cautions</th>
<th></th>
</tr>
</thead>
</table>
| **During Transit**| • Keep shipping cartons right side up. If stress is applied by either placing a carton upside down or by leaning a box against something, terminals can be bent and/or resin packages can be damaged.  
• Tossing or dropping of a carton may damage devices inside.  
• If a device gets wet with water, malfunctioning and failure may result. Special care should be taken during rain or snow to prevent the devices from getting wet. |
| **Storage**       | • The temperature and humidity of the storage place should be 5 ~ 35 °C and 45 ~ 75 % respectively. The performance and reliability of devices may be jeopardized if devices are stored in an environment far above or below the range indicated above. |
| **Prolonged Storage** | • When storing devices more than one year, dehumidifying measures should be provided for the storage place. When using devices after a long period of storage, make sure to check the exterior of the devices is free from scratches, dirt, rust, and so on. |
| **Operating Environment** | • Devices should not be exposed to water, organic solvents, corrosive gases, explosive gases, fine particles, or corrosive agents, since any of those can lead to a serious accident. |
| **Flame Resistance** | • Although the epoxy resin and case materials are in conformity with UL94 V-0 standards, it should be noted that those are not non-flammable. |
| **Electrostatic Discharge** | • Following precautions should be taken for MOS-gated devices such as IGBT modules (CM*** series), to prevent electrostatic build up which could damage the devices.  
(1) Precautions against the device rupture caused by static electrostatic electricity of human bodies and cartons and/or excessive voltage applied across the gate to emitter may damage and rupture devices. The basis of anti-electro static build-up and quick dissipation of the charged electricity.  
* Containers that are susceptible to static electricity should not be used for transit or for storage.  
* Gate to emitter should be always shorted with a carbon cloth or the like until right before a module is used. Never touch the gate terminals with bare hands.  
* Always ground the equipment and your body during installation (after removing a carbon cloth or the like. It is advisable to cover the workstation and its surrounding floor with conductive mats and ground them.  
* It should be noted that the static electricity charged to a printed circuit board might damage devices if the gate to emitter of the circuit board is open.  
* Use soldering irons with grounded tips which are low voltage (DC 12 V - 24 V) types for semiconductor. |
# How to use power module Properly and Safely

<table>
<thead>
<tr>
<th>Anti-electrostatic Measures</th>
<th>(2) Precautions when the gate to emitter is open</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>* Voltage should not be applied across the collector to emitter when the gate to emitter is open.</td>
</tr>
<tr>
<td></td>
<td>* The gate to emitter should be shorted before removing a device from a unit.</td>
</tr>
<tr>
<td>(3) IGBT modules &quot;NX&quot; series</td>
<td>We use conductive cardboard box for interior packing box. The product abolishes the use of conductive sponge, which is used for the short circuit between the gate and emitter.</td>
</tr>
<tr>
<td></td>
<td>* This conductive cardboard box completely short-circuits between gate emitters like a conventional conductive sponge, and it is not an electrostatic measures parts clamping over voltage.</td>
</tr>
<tr>
<td></td>
<td>* During an installation process (after taking out a module from a packing box to the installation to an apparatus), please take enough static electricity measures such as the use of ground band on the worker and/or using static-eliminator.</td>
</tr>
<tr>
<td></td>
<td>* If storage with the containers excepts the interior cardboard box, take any electrostatic measures such as the use of a conductive container.</td>
</tr>
<tr>
<td></td>
<td>* The modules are not fixed in the interior cardboard box. Please be careful about the handling enough not to drop a module at the time of takeoff and unpacking the interior cardboard box and unpacking the interior cardboard box.</td>
</tr>
</tbody>
</table>

* IGBT modules "NX" series
  Representative part number: CM35MX-24A, CM100RX-12A, CM300DX-24A
  Product appearance example:

<table>
<thead>
<tr>
<th>Electrically-charged measure</th>
<th>- When applying the voltage to gate-emitter test for acceptance as saturated voltage test, after the test and before collecting the modules to the storage (conductivity) container or a packing box, let it discharge electricity by high resistance (extent of 10 kΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiring method</td>
<td>- Do not add the over stress to the screw terminals or terminal structure when mounting modules. It might cause the damage to terminal structure or jointing part between case and terminals. (mainly in IGBT module &quot;NX series&quot;)</td>
</tr>
<tr>
<td></td>
<td>- Do not add the over stress to the pin terminals when use the printed circuit board for wiring. It might cause the bent (or snap) of pin terminals.</td>
</tr>
<tr>
<td></td>
<td>- Be careful about the size of the screw and the mounting process when fixing the printed circuit board to the module case part with a self-tapping screw. The case of the module may be damaged when using the wrong size screw and/or the wrong mounting process.</td>
</tr>
</tbody>
</table>
Cautions

Mounting

- When mounting a module on a heat sink, a device could get damage if a sudden torque ("one side tightening") is applied at only one mounting terminal, since stress is applied on a ceramic plate and silicon chips inside the module.

Shown in Fig.1 is the recommended torquing order for mounting screws.

**Fig.1 Recommended torquing order for mounting screws**

- Temporary tightening torque should be set at 20 – 30 % of maximum rating.

- Also, care must be taken to achieve maximum contact (i.e. minimum contact thermal resistance) for the best heat dissipation.

The flatness of heat sink ($e_h$) where a module is mounted should be as follows.

- Copper base plate; IGBT module "NX" series (S series NX type) :
  - ±$0 \ \mu m \sim +100 \ \mu m$ on a length of 100 mm

Also, the surface finish should be as follows.

- Less than $10 \ \mu m$ of roughness on a length of 100 mm

Please apply good thermal conductivity grease (termed hereinafter called grease) for heat radiation to the contact surface of the module and heat sink evenly as follows.

- $+50 \ \mu m \sim +100 \ \mu m$

Grease on the contact surface prevents the corrosion of the contact surface.

However, use the kind of grease that has a stable characteristic over the whole operating temperature range and does not change its properties for several years.

A torque wrench shall be used in tightening mounting screws and tighten screws to the specified torque. Excessive torquing may result in damage or degradation of a device.

- The edge line of base plate

-Grease applied area

-Specified range of heat sink flatness

- Convex

- Concave

- Fig.2 Flatness of heat sink

(For the non-plating base plate of entire surface)

Because there are already the adoption results in IPM and the long-term market use results, we think there are no problems in reliability about the non-plating base plate of entire surface adoption in the NX series.

The surface oxidation layer of the base plate does not have influence on thermal resistance specification. In addition, we do not regard the pattern to occur on the base plate surface by the oxidation as a problem in the appearance either.

This is a similar point of view about the nickel plating base plate.
9. Installation of Power Module

9.1 Installing Capacitor

During switching, voltage is induced in power circuit stray inductance by the high di/dt of the main current when the stray inductance is too large. This voltage can appear on the IGBT module and cause damage. In order to avoid this problem, guidelines that should be followed in designing the circuit layout are:

- Locate the smoothing capacitor as close as possible to the IGBT module.
- Use bypass capacitor (ceramic capacitor or film capacitor) near the IGBT module to bypass high frequency current.
- Adopt low impedance electrolytic capacitor as smoothing capacitor.
- Use snubber circuit to absorb surge voltage.
- Decrease switching speed in order to lower di/dt.

○ and E are the most effective to reduce surge voltage. The stray inductance of snubber circuit generally is not considered to avoid complicating the circuit. In addition, combination of ○, E, ○ is needed since there is a limit to shorten the length of wiring. The bypass capacitor of approach ○ should be replaced with snubber circuit (RC, RCD) when oscillation.

\[ L_1: \text{Stray inductance between the smoothing (electrolytic) capacitor and the IGBT module.} \]
\[ L_2: \text{Stray inductance between the bypass (or snubber) capacitor and the IGBT module.} \]
\[ L_3: \text{Stray inductance between the load and the power circuit's output stage.} \]

9.2 Mounting instructions

When mounting IGBT modules on a heat sink, uneven mounting can cause the module ceramic isolation destroy.

To achieve the best thermal radiation effect, the larger the contact area is, the smaller the thermal resistance is. Heat sink should have a surface finish in range of Rz6 - Rz12, warpage within 100 μm (for 24A series products, heat sink should have a surface roughness within 10 μm, warpage within 20 μm corresponding to 100 mm length).

Uniform coating of grease between the module and heat sink can prevent corrosion of contact parts. Select a compound, which has stable characteristics over the whole operating temperature range and does not change its properties over the life of the equipment. (See Table1 for suggested type).

Use a uniform coating of thermal interface compound.

The thickness of grease should be in the range +50 μm-+100 μm according to the surface finish.

Mounting screws should be tightened by using a torque wrench until the prescribed torque. As mentioned before, over torque terminal or mounting screws may result in damage of IGBT modules. When an electric screwdriver is used, grease with low viscosity is recommended and extra grease shall be extruded before final tightening screws.

* For the recommended torque order for mounting screws, refer to "Mounting" in the section of "How to Use Power Module Properly and Safely."

Note) Maximum torque specifications are provided in device data sheets. The type and quantity of grease having an effect on the thermal resistance are determined by consideration of both grease and heat sink. Typical value given in datasheet is measured by using grease produced by Shin-Etsu Chemical Co., Ltd. (Thermal conductivity grease of λ=0.9 W/(m·K)).
Installation of Power Module

Table 1

<table>
<thead>
<tr>
<th>Size</th>
<th>Type</th>
<th>Manufacturer</th>
<th>(2012/08/22 to present)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5×12</td>
<td>Cross recessed hexagon head bolts with captive washer</td>
<td>FC-TEC CO.,LTD.</td>
<td></td>
</tr>
<tr>
<td>M6×12</td>
<td>Cross recessed nuts and Hexagon head bolts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: M5-M6 hexagon head bolt: JIS B 1187

Table 2 Terminal screwing hole depth and thickness (Unit in mm tolerance: ±0.3 mm)

<table>
<thead>
<tr>
<th>VCES (V)</th>
<th>Part number</th>
<th>Screw size</th>
<th>A</th>
<th>B</th>
<th>thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>CM100RX-12A, CM150RX-12A, CM200RX-12A</td>
<td>M5</td>
<td>12.5</td>
<td>6.5</td>
<td>1.0</td>
</tr>
<tr>
<td>1200</td>
<td>CM75RX-24A, CM100RX-24A, CM75RX-24S, CM100RX-24S, CM150RX-24S</td>
<td>Main Terminal</td>
<td>13.4</td>
<td>5.9</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>CM150EXS-24S, CM200EXS-24S, CM300EXS-24S</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>600</td>
<td>CM300DX-12A, CM400DX-12A, CM600HX-12A</td>
<td>M6</td>
<td>13.5</td>
<td>6.5</td>
<td>1.0</td>
</tr>
<tr>
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<td>CM600DXL-24S, CM1000DXL-24S</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CM225DX-24S1, CM300DX-24S1, CM450DX-24S1</td>
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</tr>
</tbody>
</table>

Note: Not including the float of the terminal in size A and B.

The minimum valid depth for the main terminal

The formula to calculate the minimum valid depth is as the following.

\[ A - \text{tolerance} = 12.5 - 0.3 = 12.2 \text{ mm} \]
9.3 Additional Instructions

9.3.1 Mounting the printed circuit board (PCB) on the standoffs

Use the following screws when mounting the printed circuit board (PCB) on the standoffs.

The length of the screw depends on the PCB thickness (t1.6-t2.0).

9.3.1.1 6.1st Gen. S1 and 6th Gen. S series NX type

"φ2.6×10 or φ2.6×12 B1 tapping screw"

9.3.1.2 5th Gen. NX series

"φ2.3×10 or φ2.3×12 B1 tapping screw"

<table>
<thead>
<tr>
<th>Item</th>
<th>5th</th>
<th>6.1th</th>
<th>6th</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>d [mm]</td>
<td>1.7</td>
<td>2</td>
<td></td>
<td>±0</td>
</tr>
<tr>
<td>D [mm]</td>
<td>2.3</td>
<td>2.6</td>
<td></td>
<td>±0.1</td>
</tr>
<tr>
<td>P [mm]</td>
<td>0.79</td>
<td>0.91</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>L [mm]</td>
<td>8 or 10</td>
<td>10 or 12</td>
<td></td>
<td>±0.8</td>
</tr>
<tr>
<td>Max. tightening torque [N·m]</td>
<td>0.25</td>
<td>0.5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>tightening method</td>
<td>By hand work</td>
<td>By hand work</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>The mounting / disbmounting permission times</td>
<td>once</td>
<td>once</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

9.3.2 Pin terminals

9.3.2.1 Pin terminal specifications (6.1st and 6th Gen.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>Copper (Cu)</td>
</tr>
<tr>
<td>Plating materials</td>
<td>Tin (Sn)</td>
</tr>
<tr>
<td></td>
<td>Nickel (Ni) grounding plating</td>
</tr>
<tr>
<td>Plating thickness</td>
<td>Sn 4 - 10 μm</td>
</tr>
<tr>
<td></td>
<td>Ni 1 - 6 μm</td>
</tr>
</tbody>
</table>

9.3.2.2 Pin terminal specifications (5th Gen.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>Copper (Cu)</td>
</tr>
<tr>
<td>Plating materials</td>
<td>Nickel (Ni)</td>
</tr>
<tr>
<td>Plating thickness</td>
<td>2 - 6 μm</td>
</tr>
</tbody>
</table>

9.3.2.3 Soldering conditions

a. Dip soldering

<table>
<thead>
<tr>
<th>Item</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solder temperature</td>
<td>260 °C ± 5 °C</td>
</tr>
<tr>
<td>Immersion time</td>
<td>10 s ± 1 s</td>
</tr>
</tbody>
</table>

b. Soldering iron

<table>
<thead>
<tr>
<th>Item</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tip temperature</td>
<td>360 °C ± 10 °C</td>
</tr>
<tr>
<td>Heat time</td>
<td>5 s ± 1 s</td>
</tr>
</tbody>
</table>
9.4 Explanation of Thermal resistance

6.1\textsuperscript{th} Gen. S1 series NX type
\begin{itemize}
  \item dual switch : pp. 17 - 18
  \item sixpack : p. 19
  \item sevenpack : p. 20
\end{itemize}

6\textsuperscript{th} Gen. S series NX type
\begin{itemize}
  \item dual switch : pp. 21 - 23
  \item sixpack : p. 24
  \item sevenpack : pp. 25 - 26
  \item CIB : pp. 27 - 28
  \item brake chopper : p. 29
\end{itemize}

5\textsuperscript{th} Gen. NX series
\begin{itemize}
  \item 600 V single switch : p. 30
  \item 1200 V single switch : p. 30
  \item 600 V dual switch : p. 31
  \item 600 V sevenpack : p. 32
  \item 600 V CIB : p. 33
  \item 1200 V dual switch : pp. 34 - 35
  \item 1200 V sevenpack : p. 36
  \item 1200 V CIB : p. 37
\end{itemize}

The notice
\begin{itemize}
  \item With the thickness of the heat sink to use, the thermal resistance \( R_{th(f-a)} \) of the heat sink sometimes changes. The smaller the size of is in the heat sink is the thinner the thickness of it becomes, the larger the thermal resistance becomes under the same metal material.
  \item If the amount of coating of grease, contact thermal resistance \( R_{th(c-s)} \) sometimes changes.
  \item Because the use of a naturally-air-cooled or forced-air-cooled heat sink is assumed for the general industrial power modules, when using a water-cooled heat sink, thermal resistance \( R_{th(j-c)} \) and/or contact thermal resistance \( R_{th(j-c)} \) sometimes change. Significantly from the values of specification due to the difference of the heat transfer characteristics.
  \item Because the packages of the: general industrial power modules are not hermetically sealed structure, it is possible for liquid to infiltrate easily inside the module.
  \item Because we design the general industrial power modules on the assumption that the package materials and the semiconductor chips do not have long-range contact with anything except the silicone gel to be used, after pulling the modules in the silicone oil and so on, the characteristics and the reliability is not guaranteed.
\end{itemize}
9.5 Chip location 6.1th Gen.

Chip location – 1200 V class dual switch

(Dimension: mm)

CM225DX-24S1

CM300DX-24S1
Chip location – 1200 V class dual switch

CM450DX-24S1

CM600DX-24S1

Publication Date: April 2014
Chip locations

Chip location – 1200 V class sixpack

CM100TX-24S1

CM150TX-24S1

(Di/UN,VN) 43.9
(Di/UP,VN) 42.8
(Di/UP,VP,WP) 42.1
(Tr/UN,VN) 35.0
(Tr/Up,UN,VN) 33.9
(Tr/VP,WP) 33.2

(Di/UN,VN,WN) 41.8
(Di/UP,VP,WP) 40.5
(Tr/UN,VN,WN) 30.3
(Tr/Up,VP,WP) 29.1

(Dimension: mm)
Chip locations

Chip location – 1200 V class sevenpack

(Dimension: mm)

CM100RX-24S1

CM150RX-24S1
9.6 Chip location 6th Gen.

Chip location – 1200 V class dual switch

CM150DX-24S

CM200DX-24S

Publication Date: April 2014
Chip location – 1200 V class dual switch

(Dimension: mm)

**CM300DX-24S**

**CM450DX-24S**
Chip locations

Chip location – 1200 V class dual switch

(CM600DXL-24S)

(CM1000DXL-24S)

Publication Date: April 2014
< IGBT Modules >
6.1<sup>th</sup> Gen. S1 SERIES NX TYPE /
6<sup>th</sup> Gen. S SERIES NX TYPE / 5<sup>th</sup> Gen. NX SERIES

APPLICATION NOTE

Chip locations

CHIP LOCATIONS – 1200 V class sixpack

CM75TX-24S

CM100TX-24S

CM150TX-24S

Publication Date: April 2014

MITSUBISHI ELECTRIC CORPORATION
Chip locations

Chip location – 1200 V class sevenpack

**CM75RX-24S**

**CM100RX-24S**

**CM150RX-24S**
Chip location – 1200 V class sevenpack

CM200RXL-24S

Chip locations

Publication Date: April 2014
Chip locations

Chip location – 1200 V class CIB

CM35MXA-24S

CM50MXA-24S

(Dimension: mm)
Chip locations

Chip location – 1200 V class CIB

CM75MXA-24S

CM100MXA-24S

Publication Date: April 2014
Chip locations

Chip location – 1200 V class brake chopper

(Dimension: mm)

CM150EXS-24S

CM200EXS-24S

CM300EXS-24S
9.7 Chip location 5th Gen.

Chip location – 600 V class single switches

**CM600HX-12A**

- Dimension: mm
- Tr-Di: 21.8
- Th: 35.2
- 44.2

**CM600HX-24A**

- Dimension: mm
- Tr-Di: 21.8
- Th: 45.0

Chip location – 1200 V class single switches

**CM400HX-24A**

- Dimension: mm
- Tr-Di: 21.8
- Th: 45.0

**CM600HX-24A**

- Dimension: mm
- Tr-Di: 30.0
- 40.5
- 45.2

Publication Date: April 2014
Chip location – 600 V class dual switches

(Dimension: mm)

CM300DX-12A

CM400DX-12A
Chip locations

Chip location – 600 V class CIB

(Dimension: mm)

CM75MX-12A

CM100MX-12A

Publication Date: April 2014
Chip locations – 1200 V class dual switches

CM150DX-24A

CM200DX-24A

Dimension: mm
Chip location – 1200 V class dual switches

**CM300DX-24A**

- Chip location – 1200 V class dual switches
- (Dimension: mm)

**CM450DX-24A**

- Chip location – 1200 V class dual switches
- (Dimension: mm)
Chip locations

Chip location – 1200 V class sevenpack

CM75RX-24A

CM100RX-24A

Publication Date: April 2014
Chip locations

Chip location – 1200 V class CIB (Dimension: mm)

CM35MX-24A

CM50MX-24A

CM75MX-24A

Publication Date: April 2014
10. Switching energy

When it performs instruction load half (full) bridge movement at a high temperature that switching energy becomes maximum and wiring inductance is small enough.

We show typical examples of switching energy under the conditions described below in Fig.3-11.

\[ V_{CC}=600 \, \text{V(6.1th Gen.)}, V_{GE}=\pm 15 \, \text{V}, \quad \text{T}_j=150^\circ \text{C}, \quad \text{---} : \text{T}_j=125^\circ \text{C} \]

---

Fig.3-1 Half-bridge Inductive load switching energy of 6th Gen. dual switch
Switching energy

\[ V_{CC} = 600 \text{V (6.1th Gen.)}, V_{GE} = \pm 15 \text{V}, \quad \text{Tj} = 150 \, ^\circ \text{C}, \quad \text{Tj} = 125 \, ^\circ \text{C} \]

Collector current \( I_C \) (A)
Emitter current \( I_E \) (A)
CM100TX/RX-24S1 Inverter part
CM150TX/RX-24S1 Inverter part

Fig.3-2 Half-bridge Inductive load switching energy of 6.1th Gen. sixpack / sevenpack
Fig.3 Half-bridge Inductive load switching energy of 6.1th Gen.
 Conditions: $T_j=150 \, ^\circ\mathrm{C}$, $V_{CC}=600 \, \mathrm{V}$ (6th Gen.), $V_{GE}=\pm 15 \, \mathrm{V}$, $R_G$: Table 4
Switching energy

Conditions: \( T_j = 150 \, ^\circ C, V_{CC} = 600 \, V \) (6\(^{th}\) Gen.), \( V_{GE} = \pm 15 \, V, R_G \): Table 4

Switching energy \( E_{on} (\text{mJ/pulse}) \)

<table>
<thead>
<tr>
<th>Collector current ( I_C ) (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>CM150TX-24S</td>
</tr>
<tr>
<td>CM100TX-24S</td>
</tr>
<tr>
<td>CM75TX-24S</td>
</tr>
</tbody>
</table>

Fig. 5-1 IGBT Turn-on switching energy

Switching energy \( E_{off} (\text{mJ/pulse}) \)

<table>
<thead>
<tr>
<th>Collector current ( I_C ) (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>CM150TX-24S</td>
</tr>
<tr>
<td>CM100TX-24S</td>
</tr>
<tr>
<td>CM75TX-24S</td>
</tr>
</tbody>
</table>

Fig. 5-2 IGBT Turn-off switching energy

Reverse recovery energy \( E_{rr} (\text{mJ/pulse}) \)

<table>
<thead>
<tr>
<th>Emitter current ( I_E ) (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>CM150TX-24S</td>
</tr>
<tr>
<td>CM100TX-24S</td>
</tr>
<tr>
<td>CM75TX-24S</td>
</tr>
</tbody>
</table>

Fig. 5-3 Diode Reverse recovery energy

CM200RXL-24S

Switching energy \( E_{on} (\text{mJ/pulse}) \)

<table>
<thead>
<tr>
<th>Collector current ( I_C ) (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>CM150TX-24S</td>
</tr>
<tr>
<td>CM100TX-24S</td>
</tr>
<tr>
<td>CM75TX-24S</td>
</tr>
</tbody>
</table>

Fig. 5 Half-bridge Inductive load switching energy of 6\(^{th}\) Gen. sixpack / sevenpack

Publication Date: April 2014
Switching energy

Conditions: $T_j=150 \, ^\circ\text{C}$, $V_{CC}=600 \, \text{V}$ (6th Gen.), $V_{GE}=\pm15 \, \text{V}$, $R_G$: Table 4

Fig. 6-1 IGBT Turn-on switching energy

Fig. 6-2 IGBT Turn-off switching energy

Fig. 6-3 Diode Reverse recovery energy

Fig. 6 Half-bridge Inductive load switching energy of 6th Gen. CIB
Switching energy

Conditions: $T_J=150 \, ^\circ C$, $V_{CC}=600 \, V$ (6th Gen.), $V_{GE}=\pm 15 \, V$, $R_G$: Table 4

![Switching energy graphs](image)

Switching energy ($\mu J$/pulse)

Reverse recovery energy $E_{rr}$ ($\mu J$/pulse)

Collector current $I_C$ (A)

Forward current $I_F$ (A)

Fig.7-1 CM150EXS-24S

Fig.7-2 CM200EXS-24S

Fig.7-3 CM300EXS-24S

Fig.7 Half-bridge Inductive load switching energy of 6th Gen. brake chopper
Switching energy

Conditions: \( T_J = 125 \, ^\circ\text{C} \), \( V_{CC} = 300 \, \text{V} \) (5th Gen. 600 V class) / 600 V (5th Gen. 1200 V class), \( V_{GE} = \pm 15 \, \text{V} \), \( R_D \): Table 4

Fig. 8-1 IGBT Turn-on switching energy

Fig. 8-2 IGBT Turn-off switching energy

Fig. 8-3 Diode Reverse recovery energy

Fig. 8 Half-bridge Inductive load switching energy of 5th Gen. 600 V class single / dual switch
Switching energy

Conditions: $T_j=125 $ °C, $V_{CC}=300 $ V (5th Gen. 600 V class) / 600 V (5th Gen. 1200 V class), $V_{GE}=\pm 15 $ V, $R_G$: Table 4

**Fig. 9-1** IGBT Turn-on switching energy

**Fig. 9-2** IGBT Turn-off switching energy

**Fig. 9-3** Diode Reverse recovery energy

Fig. 9 Half-bridge Inductive load switching energy of 5th Gen. 600 V class sevenpack / CiB
Switching energy

Conditions: $T_j=125 \, ^\circ\text{C}$, $V_{CC}=300 \, \text{V (5th Gen. 600 V class)} / 600 \, \text{V (5th Gen. 1200 V class)}$, $V_{GE}=\pm15 \, \text{V}$, $R_G$: Table 4

Fig. 10-1 IGBT Turn-on switching energy

Fig. 10-2 IGBT Turn-off switching energy

Fig. 10-3 Diode Reverse recovery energy

Fig. 10 Half-bridge Inductive load switching energy of 5th Gen. 1200 V class single / dual switch
Conditions: $T_j=125$ °C, $V_{CC}=300$ V (5th Gen. 600 V class) / 600 V (5th Gen. 1200 V class), $V_{GE}=\pm 15$ V, $R_G$: Table 4

**Fig. 11-1 IGBT Turn-on switching energy**

- Collector current $I_C$ (A)
- Switching energy $E_{on}$ (mJ/pulse)

**Fig. 11-2 IGBT Turn-off switching energy**

- Collector current $I_C$ (A)
- Switching energy $E_{off}$ (mJ/pulse)

**Fig. 11-3 Diode Reverse recovery energy**

- Emitter current $I_E$ (A)
- Reverse recovery energy $E_{rr}$ (mJ/pulse)

---

CM35MX-24A
CM50MX-24A
CM75MX/MX-24A
CM100RX-24A

**Fig. 11 Half-bridge Inductive load switching energy of 5th Gen. 1200 V class sevenpack, CIB**
Table 5 Internal gate resistance

The internal gate resistance of the 5th Gen. NX series uses semiconductor chip resistors.

* The semiconductor resistor has max. 200 % of temperature coefficient of 125 °C for 25 °C and ±30 % of resistance variation.
11 Parallel specifications

The following sub-sections outline the basic requirements and considerations for parallel operation of single or dual switch IGBT modules with ratings of 200 A or more.

With proper attention to circuit design and device selection several modules can be reliably operated in parallel.

- We deliver the classified modules which are in the same saturation rank according to the paralleled number of modules on the orders received.
- The saturation voltage rank symbol (C, D, E etc.) is marked on the module label.

Table 6 the saturation voltage rank symbol for parallel applications (Ic=rated current, VGE=15 V, Tj=25 °C)

<table>
<thead>
<tr>
<th>Rank symbol</th>
<th>VCEsat (V)</th>
<th>Rank symbol</th>
<th>VCEsat (V)</th>
<th>Rank symbol</th>
<th>VCEsat (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>1.44 - 1.59</td>
<td>B</td>
<td>1.64 - 1.74</td>
<td>A</td>
<td>1.46 - 1.67</td>
</tr>
<tr>
<td>C</td>
<td>1.55 - 1.72</td>
<td>C</td>
<td>1.70 - 1.83</td>
<td>B</td>
<td>1.58 - 1.81</td>
</tr>
<tr>
<td>D</td>
<td>1.68 - 1.87</td>
<td>D</td>
<td>1.79 - 1.99</td>
<td>C</td>
<td>1.67 - 1.95</td>
</tr>
<tr>
<td>E</td>
<td>1.83 - 2.04</td>
<td>E</td>
<td>1.95 - 2.24</td>
<td>D</td>
<td>1.81 - 2.15</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>F</td>
<td>2.20 - 2.60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This table is settled from the view point of keeping current imbalance within ±15% at its Tj=150 °C.

Notes
1. Modules of same rank should be applied only for each paralleled connection, and it permits to use the different rank modules to the different phase outputs or axis in the one equipment.
2. This rank specification is useful for the static balance at DC current point, and this is not effective for dynamic balance at switching transition.

As the switching balance is mainly dominated by wiring inductance in the equipment, take care of the symmetric circuit design and layout about this wiring for parallel operation with these modules.

3 Target imbalances

When modules of the same saturation voltage rank are paralleled, the static current imbalance will be minimized so that the following imbalance rate can be applied: 10% for 600 V class, 15% for 1200 V class.

The imbalance rate is defined when more than two modules are paralleled. The collector current easily concentrates on one element with the parallel number increasing. Therefore, derating is important for parallel operation.

When more than two modules are paralleled the derating factor can be calculated using the following formula:

\[(1-(n-1)×(1-x)/(1+x))\times100\%\], where \(x\times100\%\) is the imbalance rate described above.

For example, in case of four IGBT modules of 600V class connected in parallel, the current derating factor is

\[(1-(4-1)/(1+0.1))\times100\%\]=13.6%.

so the allowable current with 4 parallel 300 A modules is

300×(1-0.136)×4=1036 A

<table>
<thead>
<tr>
<th>Parallel No.</th>
<th>derating factors (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>600 V class</td>
</tr>
<tr>
<td>2</td>
<td>10.0</td>
</tr>
<tr>
<td>3</td>
<td>12.1</td>
</tr>
<tr>
<td>4</td>
<td>13.6</td>
</tr>
</tbody>
</table>
12 Test circuit and waveforms

Half-bridge switching test circuit and waveforms

Fig.12-1 In case of CM600/1000DXL-24S

Fig.12-2 In case of CM***DX

Fig.12 Half-bridge switching test circuit and waveforms

IGBT Turn-on switching energy

IGBT Turn-off switching energy

Diode Reverse recovery energy

Fig.13 IGBT turn-on/turn-off switching energy and Diode reverse recovery test waveforms.

(Integral time instruction drawing)

100% of parameter to fix each 10% and 2% doesn’t include the current which is caused by Diode reverse recovery or the stray capacitance of load and a surge voltage and a voltage drop which is caused by the stray inductance.

100% of VCE is VCC.

An influence over the switching loss by the corrugated change, which is caused by these, is reflected in the switching loss just as it is.

Also, for the reactive-power, we included it in the integration value because it is impossible to separate.

Strictly, 0% of the Ic is not Ic=0 A and it is Ices. 0% of VCE is not VCE=0 V and it is VCEsat.

When it isn’t possible to sufficiently remove the vibration, which is caused by the wiring inductance, a range is fixed based on the line, which estimated the center line of the vibration.

But, when the same estimation above is difficult, we sometimes suppose that the range is fixed based on the time which the waveform reaches the criterion first.
13. Safe operating area (SOA)

6.1\textsuperscript{th} Gen. S series NX type

**Turn-off switching SOA (Reverse Bias SOA)**

**Short-circuit SOA**

**Table 1. External Gate resistance \( R_G \)**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>( R_G ) (kΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM1007X-2451</td>
<td>0.2 – 0.6</td>
</tr>
<tr>
<td>CM1007X-2551</td>
<td>0 – 3.0</td>
</tr>
<tr>
<td>CM1009X-2451</td>
<td>0.2 – 0.6</td>
</tr>
<tr>
<td>CM1009X-2551</td>
<td>0 – 3.0</td>
</tr>
<tr>
<td>CM20G2X-2451</td>
<td>1.5 – 15</td>
</tr>
<tr>
<td>CM30G2X-2451</td>
<td>5 – 15</td>
</tr>
<tr>
<td>CM40G2X-2451</td>
<td>5 – 15</td>
</tr>
<tr>
<td>CM50G2X-2451</td>
<td>0 – 6.8</td>
</tr>
</tbody>
</table>

**Note:** For suppressing \( V_{CE} \) at short-circuit turn-off below this SC-SOA curve we recommend to use a soft turn-off technique for \( -dI/dt \) (off) decreasing control. SOA is 99% guaranteed by extremal probability.
6th Gen. S series NX type

**Safe operating area (SOA)**

**Turn-off switching SOA (Reverse Bias SOA)**

**Short-circuit SOA**

*Note: For suppressing $V_{CE}$ at short-circuit turn-off below this SCSOA curve. We recommend to use a soft turn-off technique for $-di/dt$ (off) decreasing control. SOA is 99% guarantee by extremal probability.*
5th Gen. NX series

**Turn-off switching SOA (Reverse Bias SOA)**

**Conditions:**
- $V_{CC} \leq 400V (12A)/600V (24A)$
- $T_j = 25 \sim 125^\circ C$
- $V_{GE} = \pm 15V$

**Gate resistance ($R_g$) value list**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>$R_g$ (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM75MX-12A</td>
<td>6.0 ~ 83</td>
</tr>
<tr>
<td>CM100MX-12A</td>
<td>6.0 ~ 62</td>
</tr>
<tr>
<td>CM100RX-12A</td>
<td>6.0 ~ 62</td>
</tr>
<tr>
<td>CM150RX-12A</td>
<td>4.1 ~ 41</td>
</tr>
<tr>
<td>CM200RX-12A</td>
<td>3.0 ~ 31</td>
</tr>
<tr>
<td>CM300DX-12A</td>
<td>2.0 ~ 21</td>
</tr>
<tr>
<td>CM400DX-12A</td>
<td>1.6 ~ 16</td>
</tr>
<tr>
<td>CM600HX-12A</td>
<td>1.0 ~ 10</td>
</tr>
</tbody>
</table>

**Note:**
- For suppressing $V_{CE}$ at Short Circuit turn-off below this SC SOA curve, we recommend to use a soft turn-off technique for $-\frac{dV}{dt}(off)$ decreasing control. SOA is 99% guaranteed by extremal probability.

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**Short-circuit SOA (SCSOA)**

**Conditions:**
- $V_{CC} \leq 600V$
- $T_j = 25 \sim 125^\circ C$
- $V_{GE} = \pm 15V$
- $t_{sw} = 10\mu s$

**Gate resistance ($R_g$) value list**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>$R_g$ (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM75MX-24A</td>
<td>8.0 ~ 83</td>
</tr>
<tr>
<td>CM100MX-24A</td>
<td>6.0 ~ 62</td>
</tr>
<tr>
<td>CM150RX-24A</td>
<td>4.1 ~ 41</td>
</tr>
<tr>
<td>CM200RX-24A</td>
<td>3.0 ~ 31</td>
</tr>
<tr>
<td>CM300DX-24A</td>
<td>2.0 ~ 21</td>
</tr>
<tr>
<td>CM400DX-24A</td>
<td>1.6 ~ 16</td>
</tr>
<tr>
<td>CM600HX-24A</td>
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