Innovative Power Devices for a Sustainable Future

Traction, industrial equipment, building facilities, electric vehicles, renewable energies, home appliances...

Power devices are a key component in power electronics products for contributing to the realization of a low-carbon society. Attracting attention as the most energy-efficient power device is one made using new material, silicon-carbide (SiC). The material characteristics of SiC have led to a dramatic reduction in power loss and significant energy savings for power electronics devices. Mitsubishi Electric began the development of elemental SiC technologies in the early 1990s and has since introduced them to achieve practical energy-saving effects for products manufactured using SiC. Innovative SiC power modules are contributing to the realization of a low-carbon society and more affluent lifestyles.

SiC: Silicon Carbide-Compound that fuses silicon and carbon at a ratio of one-to-one.

Merits of Incorporating SiC Power Modules

- **Traction**
  - Size and weight of traction inverters reduced
  - Repetitive performance enhanced
  - Noise reduced

- **Home appliances**
  - Energy savings increased
  - Cooling system more compact
  - Equipment more compact/thinner

- **Electric/Hybrid vehicles**
  - Power loss reduced
  - Regenerative power used efficiently

- **Building facilities**
  - Power loss reduced
  - Greater layout freedom as the result of smaller equipment

- **Industrial equipment**
  - High torque, high speed, size reduced
  - Cooling system more compact
  - Manufacturing productivity enhanced

- **Renewable energies**
  - Energy conversion efficiency improved
  - Passive components downsized
  - Quieter high-speed operation

- **Si MOSFET structure**

- **FW-SW Tr-I Buttons Switching Loss**

- **High-frequency Switching**

- **SiC with superior characteristics**

- **High-temperature operation**

- **Heat dissipation**

- **Use of the carrier cumulative effect**

- **Barrier Diodes (SBDs)**

- **With SiC, owing to the high dielectric breakdown, power loss is reduced**

- **Furthermore, the drift layer that is a main cause of electrical resistance is one-tenth of the thickness. This allows a large reduction in electrical resistance and, in turn, reduces power loss. This SiC characteristic enables dramatic reductions in conductivity loss and switching loss in the flow of leakage current and enabling operation at high temperatures.**

- **However, SiC has three times the band gap width of silicon, preventing use of the carrier cumulative effect.**

- **High-temperature operation**

- **Heat dissipation**

- **dissipation.**

- **High-temperature operation**

- **Heat dissipation**

- **dissipation.**

- **High-temperature operation**

- **Heat dissipation**

- **dissipation.**
SiC with superior characteristics

**Power loss reduced**
SiC has approximately 10 times the critical breakdown strength of silicon. Furthermore, the drift layer that is a main cause of electrical resistance is one-tenth of the thickness. This allows a large reduction in electrical resistance and, in turn, reduces power loss. This SiC characteristic enables dramatic reductions in conductivity loss and switching loss in power devices.

**High-speed operation**
With SiC, owing to the high dielectric breakdown, power loss is reduced and high-voltage is easier to achieve, it is possible to use Schottky Barrier Diodes (SBDs), which cannot be used with Si. SBDs can realize high-speed switching operation because they don’t have accumulation carriers. As a result, high-speed switching can be realized.

**High-temperature operation**
When the temperature increases, electrons are exited to the conduction band and the leakage current increases. At times, this results in abnormal operation. However, SiC has three times the band gap with of silicon, preventing the flow of leakage current and enabling operation at high temperatures.

**Heat dissipation**
SiC has three times the heat conductivity of silicon, which improves heat dissipation.

### SiC power modules appropriated by application

<table>
<thead>
<tr>
<th>Application</th>
<th>Product name</th>
<th>Model</th>
<th>Voltage[V]</th>
<th>Current[A]</th>
<th>Connection</th>
<th>States</th>
<th>Insert pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home appliances</td>
<td>SiC-SBD</td>
<td>BD0060T</td>
<td>600</td>
<td>20</td>
<td>Under development</td>
<td>P3</td>
<td></td>
</tr>
<tr>
<td>Industrial equipment</td>
<td>Hybrid SiC-IPM</td>
<td>PMH8000C150D080</td>
<td>600</td>
<td>200</td>
<td>6 in 1</td>
<td>Sample available</td>
<td>P4</td>
</tr>
<tr>
<td>Full SiC Power Modules</td>
<td>PMP75CL1A120</td>
<td>1200</td>
<td>75</td>
<td>6 in 1</td>
<td>Under development</td>
<td>P5</td>
<td></td>
</tr>
<tr>
<td>Full SiC Power Modules</td>
<td>CMH150DY-24NFH</td>
<td>1200</td>
<td>150</td>
<td>2 in 1</td>
<td>Commercially available</td>
<td>P6</td>
<td></td>
</tr>
<tr>
<td>Hybrid SiC Power Modules for High-Frequency Switching Applications</td>
<td>CMH1200DY-24NFH</td>
<td>1200</td>
<td>150</td>
<td>2 in 1</td>
<td>Commercially available</td>
<td>P7</td>
<td></td>
</tr>
<tr>
<td>Home appliances</td>
<td>Hybrid SiC Power Modules</td>
<td>CMH200DY-24NFH</td>
<td>1200</td>
<td>150</td>
<td>2 in 1</td>
<td>Commercially available</td>
<td>P8</td>
</tr>
<tr>
<td>Traction</td>
<td>Super-mini Full SiC DIPPFC™</td>
<td>PSH25L91A6-A</td>
<td>600</td>
<td>20arms</td>
<td>Interleaved</td>
<td>P9</td>
<td></td>
</tr>
<tr>
<td>Traction</td>
<td>Super-mini Hybrid SiC DIPPFC™</td>
<td>PSH200T2A56-A</td>
<td>600</td>
<td>20arms</td>
<td>Interleaved</td>
<td>P10</td>
<td></td>
</tr>
</tbody>
</table>

### Terminology
- **SiC**: Silicon Carbide
- **IPM**: Intelligent Power Module
- **DIPPIM™**: Dual-In-Line Package Intelligent Power Module
- **DIPPFC™**: Dual-In-Line Package Power Factor Correction
- **SBD**: Schottky Barrier Diode
- **MOSFET**: Metal Oxide Semiconductor Field Effect Transistor
- **IGBT**: Insulated Gate Bipolar Transistor
- **Tr**: Transistor
- **FW-SW**: Freewheeling switching loss
Contribute to reducing power loss and the size of power supply systems

**Features**
- Power loss is reduced by approx. 21% compared to silicon (Si) products, contributing to energy conversion.
- The SiC-SBD allows high frequency switching and contributes to downsizing the reactor, heat sink and other peripheral components.
- JBS structure allows high forward surge capability and contributes to improving reliability.

**Product lineup**

<table>
<thead>
<tr>
<th>Model</th>
<th>Rated voltage</th>
<th>Rated current</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>BD20060T</td>
<td>600V</td>
<td>20A</td>
<td>TO-220-2L</td>
</tr>
<tr>
<td>BD20060S**</td>
<td>600V</td>
<td>10A</td>
<td>TO-247-3L</td>
</tr>
<tr>
<td>BD20060A**</td>
<td>1200V</td>
<td>20A</td>
<td>TO-283S-3L</td>
</tr>
<tr>
<td>BD10120S**</td>
<td>600V</td>
<td>20A</td>
<td>TO-247-3L</td>
</tr>
<tr>
<td>BD20120SJ**</td>
<td>600V</td>
<td>20A</td>
<td>TO-247-3L</td>
</tr>
</tbody>
</table>

**Power loss comparison**

Contribute to reducing power loss and the size of power supply systems

**Features**
- Hybrid combination of SiC-SBD and IGBT with current and temperature sensors implemented for IPM supplies high functionality and low loss enabling high torque and motor speed.
- Recovery loss (Err) reduced by 95% compared to the conventional product*.
- Package compatible with the conventional product* making replacement possible.

* Conventional product: Mitsubishi Electric S1 Series PM200SC1D060

**Internal circuit diagram**

**Power loss comparison**

SiC-SBD incorporated in an IPM with a built-in drive circuit and protection functions

Power loss reduction of approx. 20% contributes to enhancing the performance of industrial machinery

**Features**
- Hybrid combination of SiC-SBD and IGBT with current and temperature sensors implemented for IPM supplies high functionality and low loss enabling high torque and motor speed.
- Recovery loss (Err) reduced by 95% compared to the conventional product*.
- Package compatible with the conventional product* making replacement possible.

* Conventional product: Mitsubishi Electric IPM L1 Series PM75CL1A120

**Internal circuit diagram**

**Power loss comparison**
Built-in drive circuit and protection functions realize high functionality

**Features**
- Incorporates SiC-MOSFET with current sensor and built-in drive circuit and protection functions to deliver high functionality
- Significant reduction in power loss compared to the conventional product*  
- Package compatible with the conventional product *

* Conventional product: Mitsubishi Electric IPM L1 Series PM75CL1A120

**Main specifications**

<table>
<thead>
<tr>
<th></th>
<th>Rating</th>
<th>Mounted Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1200V/75A 6in1</td>
<td>• Built-in drive circuit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Under-voltage protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Short-circuit protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Over-temperature protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Monitoring IGBT chip surface)</td>
</tr>
</tbody>
</table>

**Internal circuit diagram**

- SiC-MOSFET with current sense terminal
- Gate
- Sense
- Source
- Drain
- Full Si-IPM

**Power loss comparison**

- Si-IPM
- Hybrid SiC-IPM
- Full Si-IPM

Condition: Vcc=600V, Io=31Ams (assuming a 15kW inverter), fc=15kHz, P.F=0.9, Modulation=1, Three-phase modulation, Tj=125˚C

**Power loss**
- 25% reduction
- 70% reduction

**Product lineup**

<table>
<thead>
<tr>
<th>Applications</th>
<th>Rated voltage</th>
<th>Rated current</th>
<th>Circuit configuration</th>
<th>Package size (D x W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial equipment</td>
<td>1200V</td>
<td>400A</td>
<td>4-in-1</td>
<td>92.3 x 121.7mm</td>
</tr>
<tr>
<td></td>
<td>800A</td>
<td>2-in-1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comparison with conventional product package**

- Si power module 1200V/400A (2-in-1) 2pcs
- Full SiC power module 1200V/400A (4-in-1) 1pcs or 1200V/800A (2-in-1) 1pcs

**Power loss comparison**

- IGBT module (Si)
- Full SiC module

Condition: Vcc=600V, Io=222Ams (assuming a 110kW inverter), fc=15kHz, P.F=0.8, Modulation=1, Three-phase modulation, Tj=125˚C

**Features**
- Power loss reduced approx. 70% compared to the conventional product*
- Low-inductance package adopted to deliver full SiC performance
- Contributes to realizing smaller/lighter inverter equipment by significantly reducing the package size and realizing a mounting area approx. 60% smaller compared to the conventional product*

* Conventional product: Mitsubishi Electric CM400DY-24NF 1200V/400A 2in1 2pcs

**Contributes to reducing size/weight of industrial-use inverters with the mounting area reduced by approx. 60%**
Contoributes to enhancing the performance of industrial-use inverters thanks to built-in protection function for short circuit

**Features**
- By using short circuit monitoring circuit in the module it is possible to transfer a short circuit detection signal to the system side
- Power loss reduced approx.70% compared to the conventional product*
- Low-inductance package adopted to deliver full SiC performance

* Conventional product : Mitsubishi Electric CM400DY-24NF (1200V/400A 2in1) 2pcs

**Product lineup**

<table>
<thead>
<tr>
<th>Model</th>
<th>Rated voltage</th>
<th>Rated current</th>
<th>External size (D x W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMF600DX2-24A**</td>
<td>1200V</td>
<td>600A</td>
<td>80x110mm</td>
</tr>
<tr>
<td>CMH600DU-24NFH**</td>
<td>1200V</td>
<td>600A</td>
<td>79.6x122mm</td>
</tr>
</tbody>
</table>

**Power loss comparison**

For optimal operation of power electronics devices that conduct high-frequency switching

**Features**
- Power loss reduction of approx. 40% contributes to higher efficiency, smaller size and weight reduction of total system
- Suppresses surge voltage by reducing internal inductance
- Package compatible with the conventional product*
- Conventional product: Mitsubishi Electric NFH Series IGBT Modules

**Product lineup**

<table>
<thead>
<tr>
<th>Applications</th>
<th>Model</th>
<th>Rated voltage</th>
<th>Rated current</th>
<th>Circuit configuration</th>
<th>External size (D x W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial equipment</td>
<td>FMF600DX2-24A</td>
<td>1200V</td>
<td>600A</td>
<td>48 x 94mm</td>
<td>80 x 110mm</td>
</tr>
<tr>
<td>CMH1200DC-34S</td>
<td>1200V/1200A</td>
<td>600A</td>
<td>48 x 94mm</td>
<td>80 x 110mm</td>
<td></td>
</tr>
</tbody>
</table>

**Power loss comparison**

For optimal operation of power electronics devices that conduct high-frequency switching

**Features**
- Power loss reduction of approx. 40% contributes to higher efficiency, smaller size and weight reduction of total system
- Suppresses surge voltage by reducing internal inductance
- Package compatible with the conventional product*
- Conventional product: Mitsubishi Electric NFH Series IGBT Modules

**Product lineup**

<table>
<thead>
<tr>
<th>Applications</th>
<th>Model</th>
<th>Rated voltage</th>
<th>Rated current</th>
<th>Circuit configuration</th>
<th>External size (D x W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial equipment</td>
<td>CMR1000DY-24NFP</td>
<td>1000V</td>
<td>150A</td>
<td>48 x 94mm</td>
<td>80 x 110mm</td>
</tr>
<tr>
<td>CMR1200DY-24NFP</td>
<td>1200V/1200A</td>
<td>600A</td>
<td>48 x 94mm</td>
<td>80 x 110mm</td>
<td></td>
</tr>
</tbody>
</table>

**Power loss comparison**
High-power/low-loss/highly reliable modules appropriate for use in traction inverters

- **Features**
  - Power loss reduced approximately 30% compared to the conventional product*
  - Highly reliable design appropriate for use in traction
  - Package compatible with the conventional product*
  - Approximately 70% reduction in power loss compared to the conventional product*

* Conventional product: Mitsubishi Electric CM1200DC-34N

**Main specifications**

<table>
<thead>
<tr>
<th>Module</th>
<th>Max operating temperature</th>
<th>Isolation voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si-IGBT</td>
<td>150°C</td>
<td>4000Vrms</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>2.3V</td>
<td></td>
</tr>
<tr>
<td>Switching loss</td>
<td>turn-on</td>
<td>140μs</td>
</tr>
<tr>
<td>turn-off</td>
<td>350ms</td>
<td></td>
</tr>
<tr>
<td>SiC-SBD</td>
<td>150°C</td>
<td></td>
</tr>
<tr>
<td>Emitter-collector voltage</td>
<td>2.3V</td>
<td></td>
</tr>
<tr>
<td>Capacitive charge</td>
<td>9.0μF</td>
<td></td>
</tr>
</tbody>
</table>

**Internal circuit diagram**

**Power loss comparison**

- **600V/50A Large Hybrid SiC DIPIPM™ for PV Applications**
  - Commercially available

More efficient power modules for PV power conditioner applications

- **Features**
  - Hybrid structure achieved with SiC Schottky barrier diode and 7th-generation IGBT chips
  - Power loss reduction of approx. 25% compared to the conventional product*
  - Helps downsize PV inverter system thanks to modified short-circuit protection scheme

* Conventional product: Mitsubishi Electric Large DIPIPM™ PS61A99

**Internal circuit diagram**

**Power loss comparison**

- **1700V/1200A Hybrid SiC Power Modules for Traction Inverters CMH1200DC-34S Commercially available**

- **600V/50A Large Hybrid SiC DIPIPM™ for PV Applications PSH50YA2A6 Commercially available**

- **Power loss comparison**

Condition: Vcc=850V, Io=600Arms, fc=1kHz, P.F=1, Modulation=1, Three-phase modulation, Tj=125°C

Condition: Vcc=300V, Io=25Arms, P.F=0.8, fc=10kHz, Tj=125°C
15A/25A Super-mini Full SiC DIPIPMTM for Home Appliances
PSF15S92F6-A/PSF25S92F6-A Commercially available

Contributes to extremely high power-efficiency in air conditioners, and easily applicable to industrial equipment

- **Features**
  - SiC-MOSFET achieves reduction in ON resistance, power loss reduced approx. 70% compared to conventional product*
  - Construct low-noise system by reducing recovery current
  - Numerous built-in functions: Bootstrap diode for power supply to drive P-side, temperature information output, etc.
  - Unnecessary minus-bias gate drive circuit using original high Vth SiC-MOSFET technology
  - As package and pin layout compatibility with conventional products* is ensured, simply replace with this product to improve performance

*Conventional product: Mitsubishi Electric Super-mini DIPIPMTM Series

- **Internal block diagram**

 ![Internal block diagram](image)

- **Power loss comparison**

 ![Power loss comparison](image)

Super-mini Hybrid / Full SiC DIPFCTM for Home Appliances
PSH20L91A6-A / PSF20L91A6-A Commercially available

Utilizing SiC enables high-frequency switching and contributes to reducing the size of peripheral components

- **Features**
  - Incorporating SiC chip in the Super-mini package widely used in home appliances
  - The SiC chip allows high-frequency switching (up to 40kHz) and contributes to downsizing the reactor, heat sink and other peripheral components
  - Adopts the same package as the Super mini DIPIPMTM to eliminate the need for a spacer between the inverter and heat sink, and to facilitate its implementation

- **Internal block diagram (Full SiC DIPFCTM)**

 ![Internal block diagram](image)

- **Power loss comparison**

 ![Power loss comparison](image)
and easily applicable to industrial equipment
• As package and pin layout compatibility with conventional products* is ensured, simply replace
• Numerous built-in functions: Bootstrap diode for power supply to drive P-side, temperature
• Construct low-noise system by reducing recovery current
• SiC-MOSFET achieves reduction in ON resistance, power loss reduced approx. 70% compared
• Adopts the same package as the Super mini DIPIPMTM to eliminate the need for a
• The SiC chip allows high-frequency switching (up to 40kHz) and contributes to
reducing the size of peripheral components
information output, etc.

*Conventional product: Mitsubishi Electric Super-mini DIPIPM™ Series

SiC Power Module Lineup

---

### 600V/200A Hybrid SiC-IPM for Industrial Use
PMH200CS1D060

### 1200V/75A Hybrid/Full SiC-IPM for Industrial Equipment
PMH75CL1A120/PMF75CL1A120

### 1200V/400A, 1200V/800A Full SiC Power Modules for Industrial Use
FMF600BX-24A

### Adopts the same package as the Super mini DIPIPMTM to eliminate the need for a

---

### PSF15S92F6-A / PSF25S92F6-A
Super-mini Hybrid / Full SiC DIPPFC™

### PSH20L91A6-A / PSF20L91A6-A
Long
Development of Mitsubishi Electric SiC Power Devices and Power Electronics Equipment Incorporating Them

Mitsubishi Electric began developing SiC as a new material in the early 1990s. Pursuing special characteristics, we succeeded in developing various elemental technologies. In 2010, we commercialized the first air conditioner in the world equipped with a SiC power device. Furthermore, substantial energy-saving effects have been achieved for traction and FA machinery. We will continue to provide competitive SiC power modules with advanced development and achievements from now on.

- Early 1990s: Developed new material, silicon-carbide (SiC) power semiconductor, maintaining a lead over other companies
- 2006: January 2006 - Successfully developed SiC inverter for driving motor rated at 3.7kW
- 2009: February 2009 - Verified 11kW SiC inverter, world's highest value\(^1\) with approx. 70% reduction in power loss
- November 2009 - Verified 20kW SiC inverter, world's highest value\(^1\) with approx. 90% reduction in power loss
- 2010: January 2010 - Developed large-capacity power module equipped with SiC diode
- October 2010 - Launched "Kirigamine" inverter air conditioner
- 2011: January 2011 - Verified highest power conversion efficiency\(^1\) for solar power generation system power conditioner (domestic industry)
- October 2011 - Commercialized SiC inverter for use in railcars
- 2012: March 2012 - Developed motor system with built-in SiC inverter\(^2\)
- September 2012 - Verified built-in main circuit system for railcars
- December 2012 - Launched CNC drive unit equipped with SiC power module
- July 2012 - Began shipping samples of hybrid SiC power modules
- 2013: February 2013 - Developed SiC for application in elevator control systems\(^2\)
- March 2013 - Delivered auxiliary power supply systems for railcars

Development of these modules and applications has been partially supported by Japan’s Ministry of Economy, Trade and Industry (METI) and New Energy and Industrial Technology Development Organization (NEDO).
Contribution to the realization of a low-carbon society and more affluent lifestyles

2014
- February 2014: Developed EV motor drive system with built-in SiC inverter.
- May 2014: Began shipping samples of hybrid SiC power modules for high-frequency switching applications.
- November 2014: Launched Large Hybrid SiC DIPIM™ for PV Applications.

2015
- January 2015: Launched power conditioner for PV equipped with full SiC-IPM.
- June 2015: Railcar traction system with full SiC power modules installed in Shinkansen bullet trains.

2016
- April 2016: Launched Super-mini Full SiC DIPIM™.
- May 2016: Launched room air conditioners with full SiC DIPIM™ in Japan.
- October 2016: Launched package air conditioners with full SiC DIPIM™ in Japan.

2017
- March 2017: Launched SiC-SBD.
- September 2017: Develops SiC Power Device with Record Power Efficiency.
- December 2017: Mitsubishi Electric and the University of Tokyo Quantify Factors for Reducing SiC Power Semiconductor Resistance by Two-Thirds.

2018

Development of Mitsubishi Electric SiC Power Devices and Power Electronics Equipment Incorporating Them
Mitsubishi Electric began developing SiC as a new material in the early 1990s. Pursuing special characteristics, we succeeded in developing various elemental technologies.

In 2010, we commercialized the first air conditioner in the world equipped with a SiC power device. Furthermore, substantial energy-saving effects have been achieved for traction and FA machinery.

We will continue to provide competitive SiC power modules with advanced development and achievements from now on.

Contributing to the realization of a low-carbon society and more affluent lifestyles

*1 Researched in press releases by Mitsubishi Electric. *2 Currently under development, as of April 2018.
* The year and month listed are based on press releases or information released during the product launch month in Japan.
SiC POWER DEVICES

Please visit our website for further details.
www.MitsubishiElectric.com

Keep safety first in your circuit designs!

- Mitsubishi Electric Corporation urges the maximum effort to make semiconductor products better and more reliable, but the risks of failure that may occur. Trouble with semiconductors may lead to personal injury, fire, or property damage. Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as [placement of substitutes, auxiliary circuits, the use of nonflammable material, or prevention against any malfunction or misfire.]

Notes regarding these materials

- These materials are intended as a reference to assist our customers in the selection of the Mitsubishi semiconductor product best suited to the customer's application; they do not convey any license or any intellectual property rights to any of Mitsubishi Electric Corporation or third parties.
- Mitsubishi Electric Corporation assumes no responsibility for any damages, infringement of any intellectual property rights, originating in the use of any product data, diagrams, charts, programs, algorithms, or circuit application examples contained in these materials.
- All information contained in these materials, including product data, diagrams, charts, programs, and algorithms, represents information on products at the time of publication of these materials, and are subject to change by Mitsubishi Electric Corporation without notice due to product improvements or other reasons. It is therefore recommended that customers contact Mitsubishi Electric Corporation or an authorized Mitsubishi semiconductor product distributor for the latest information on these materials.
- The information described here may contain technical inaccuracies or typographical errors. Mitsubishi Electric Corporation assumes no responsibility for any damages, liability, or other loss arising from these inaccuracies or errors. Please also pay attention to information published by Mitsubishi Electric Corporation on the Mitsubishi Electric Co. website (http://www.mitsubishielectric.co.jp/semiconductors/).
- When using any or all of the information contained in these materials, including product data, diagrams, charts, programs, and algorithms, please be sure to evaluate all information as a final decision or applicability of the information and products. Mitsubishi Electric Corporation assumes no responsibility for any damage, liability, or other loss resulting from the information contained herein.
- Mitsubishi Electric Corporation semiconductor products are not designed or manufactured for use in a device or system that is used under circumstances in which human life is potentially at stake. Please contact Mitsubishi Electric Corporation or an authorized Mitsubishi semiconductor product distributor when considering the use of a product contained herein for any specific purposes, such as apparatus or systems for transportation, vehicular, medical, aerospace, nuclear, or underwater purposes.
- The prior written approval of Mitsubishi Electric Corporation is necessary to reprints or reproduces in whole or in part these materials.
- If these products or technologies are subject to the Japanese export control regulations, they must be exported under a license from the Japanese government and cannot be imported into a country other than the approved destination.
- Any discussion or export contrary to the export control laws are prohibited.
- Please contact Mitsubishi Electric Corporation for further details on these materials and the products contained therein.

Eco Changes is the Mitsubishi Electric Group's environmental statement, and expresses the Group's stance on environmental management. Through a wide range of businesses, we are helping contribute to the realization of a sustainable society.

MITSUBISHI ELECTRIC CORPORATION
HEAD OFFICE: TOKYO BLDG., 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN
www.MitsubishiElectric.com

Revised publication, effective Apr. 2018.
Superseding publication of HG-802F Apr. 2018.
Specifications subject to change without notice.

©2018 Mitsubishi Electric Corporation