# MBL400E33D

Silicon N-channel IGBT

## FEATURES

- High thermal fatigue durability.(delta Tc=70oC, N>30,000cycles)
- High speed, low loss IGBT module.
- Low noise due to built-in free-wheeling diode
  – ultra soft fast recovery diode(USFD).
- Low driving power due to low input capacitance MOS gate.
- High reliability, high durability module.
- Isolated heat sink (terminal to base).

## ABSOLUTE MAXIMUM RATINGS ($T_C$=25°C )

| Item | | Symbol | Unit | MBL400E33D |
|---|---|---|---|---|
| Collector Emitter Voltage | | $V_{CES}$ | V | 3,300 |
| Gate Emitter Voltage | | $V_{GES}$ | V | ±20 |
| Collector Current | DC | $I_C$ | A | 400 |
| | 1ms | $I_{CRM}$ | | 800 |
| Forward Current | DC | $I_F$ | A | 400 |
| | 1ms | $I_{FRM}$ | | 800 |
| Junction Temperature | | $T_{vj\ op}$ | °C | -40 ~ +125 |
| Storage Temperature | | $T_{stg}$ | °C | -40 ~ +125 |
| Isolation Voltage | | $V_{ISO}$ | $V_{RMS}$ | 6,000(AC 1 minute) |
| Screw Torque | Terminals (M4/M8) | - | N·m | 2/22 (1) |
| | Mounting (M6) | - | | 6 (2) |

Notes: (1) Recommended Value 1.8±0.2/22±1N·m (2) Recommended Value 5.5±0.5N·m

## ELECTRICAL CHARACTERISTICS

### 1)IGBT+FWD

| Item | | Symbol | Unit | Min. | Typ. | Max. | Test Conditions |
|---|---|---|---|---|---|---|---|
| Collector Emitter Cut-Off Current | | $I_{CES}$ | mA | - | - | 12 | $V_{CE}$=3,300V, $V_{GE}$=0V, $T_{vj}$=25°C |
| Gate Emitter Leakage Current | | $I_{GES}$ | nA | -500 | - | +500 | $V_{GE}$=±20V, $V_{CE}$=0V, $T_{vj}$=25°C |
| Collector Emitter Saturation Voltage | | $V_{CEsat}$ | V | 3.5 | 4.2 | 5.0 | $I_C$=400A, $V_{GE}$=15V, $T_{vj}$=125°C |
| Gate Emitter Threshold Voltage | | $V_{GE(th)}$ | V | 4.5 | 6.0 | 7.0 | $V_{CE}$=10V, $I_C$=400mA, $T_{vj}$=25°C |
| Input Capacitance | | $C_{ies}$ | nF | - | 35 | - | $V_{CE}$=10V, $V_{GE}$=0V, f=100kHz, $T_{vj}$=25°C |
| Internal Gate Resistance | | $R_{G(int)}$ | Ω | - | 3.6 | - | $V_{CE}$=10V, $V_{GE}$=0V, f=100kHz, $T_{vj}$=25°C |
| Turn On Delay Time | | $t_{d(on)}$ | μs | - | 0.5 | - | $V_{CC}$=1,650V, $I_C$=400A |
| Rise Time | | $t_r$ | | 1.0 | 1.9 | 3.1 | $L_S$=150nH |
| Turn Off Delay Time | | $t_{d(off)}$ | | 1.5 | 2.0 | 2.6 | $R_G$=10Ω (3) |
| Fall Time | | $t_f$ | | 0.5 | 1.0 | 2.5 | $V_{GE}$=±15V, $T_{vj}$=125°C |
| Forward Voltage Drop | | $V_F$ | V | 2.0 | 2.5 | 3.0 | $I_F$=400A, $V_{GE}$=0V, $T_{vj}$=125°C |
| Reverse Recovery Time | | $t_{rr}$ | μs | - | 0.6 | - | $V_{CC}$=1,650V, $I_F$=400A, (4)<br>$L_S$=150nH, $T_{vj}$=125°C |
| Thermal Impedance | IGBT | $R_{th(j-c)}$ | K/W | - | - | 0.026 | Junction to case |
| | FWD | $R_{th(j-c)}$ | | - | | 0.052 | |
| Contact Thermal Impedance | | $R_{th(c-f)}$ | K/W | - | - | 0.016 | Case to fin |

### 2) Chopper Diode

| Item | Symbol | Unit | Min. | Typ. | Max. | Test Conditions |
|---|---|---|---|---|---|---|
| Collector Emitter Cut-Off Current | $I_{AKS}$ | mA | - | - | 12 | $V_{AK}$=3,300V, $T_{vj}$=25°C |
| Forward Voltage Drop | $V_F$ | V | 2.2 | 2.7 | 3.2 | $I_F$=400A,$T_{vj}$=125°C at main terminals (Terminal resistance:0.5mΩ typical) |
| Reverse Recovery Time | $t_{rr}$ | μs | 0.2 | 0.6 | 1.1 | $V_{CC}$=1,650V, $I_F$=400A, (4)<br>$L_S$=150nH, $T_{vj}$=125°C |
| Thermal Impedance | $R_{th(j-c)}$ | K/W | - | - | 0.052 | Junction to case |
| Contact Thermal Impedance | $R_{th(c-f)}$ | K/W | - | - | 0.016 | Case to fin |

Notes: (3) $R_G$ value is a test condition value for evaluation, not recommended value.
Please, determine the suitable $R_G$ value after the measurement of switching waveforms (overshoot voltage, etc.)with appliance mounted.
(4)Counter arm IGBT VGE=-15V

* Please contact our representatives at order.
* For improvement, specifications are subject to change without notice.
* For actual application, please confirm this spec sheet is the newest revision.

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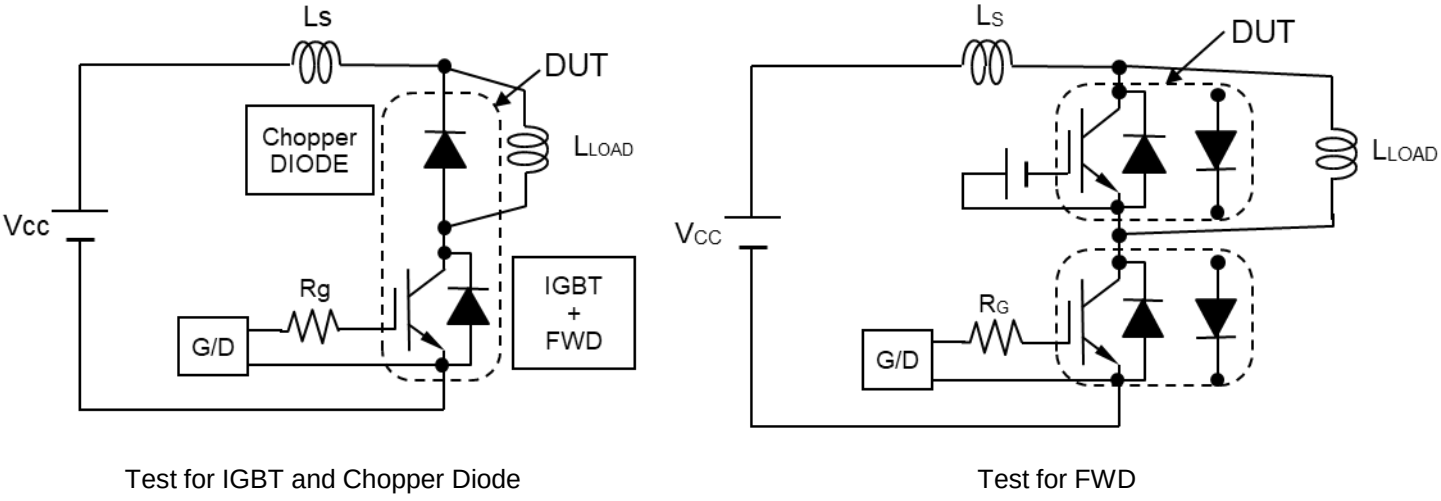
# MBL400E33D

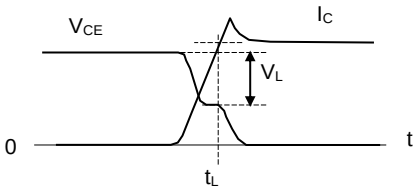
## DEFINITION OF TEST CIRCUIT




Test for IGBT and Chopper Diode

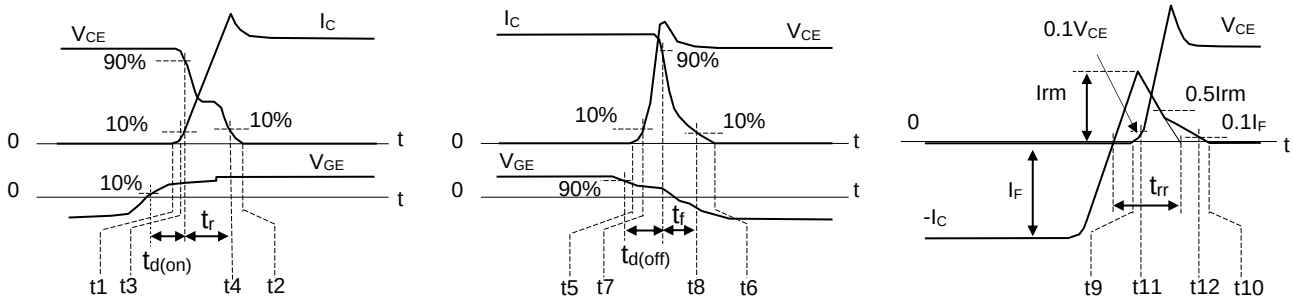
Test for FWD

Fig.1 Switching test circuit




$$L_S = \frac{V_L}{\left(\frac{dI_C}{dt}\right)_{t=t_L}}$$

Fig.2 Definition of stray inductance




$$E_{on(10\%)} = \int_{t3}^{t4} I_C \cdot V_{CE}\, dt \qquad E_{off(10\%)} = \int_{t7}^{t8} I_C \cdot V_{CE}\, dt \qquad E_{rr(10\%)} = \int_{t11}^{t12} I_F \cdot V_{CE}\, dt$$

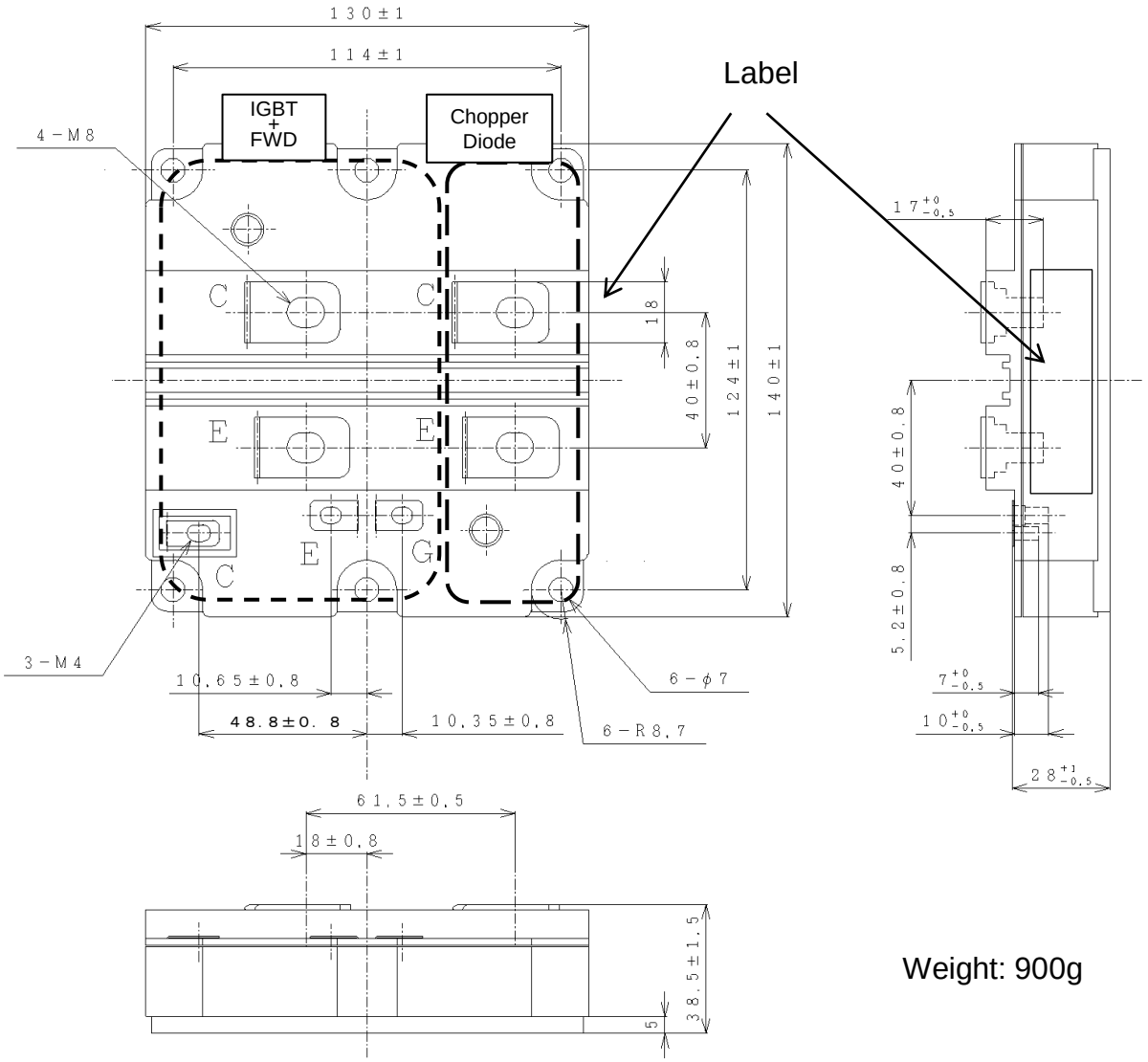
$$E_{on(Full)} = \int_{t1}^{t2} I_C \cdot V_{CE}\, dt \qquad E_{off(Full)} = \int_{t5}^{t6} I_C \cdot V_{CE}\, dt \qquad E_{rr(Full)} = \int_{t9}^{t10} I_F \cdot V_{CE}\, dt$$

Fig.3 Definition of switching loss

# MBL400E33D

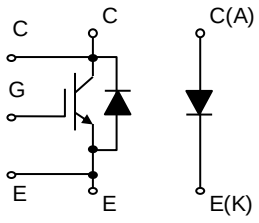
## OUTLINE DRAWING

Unit in mm

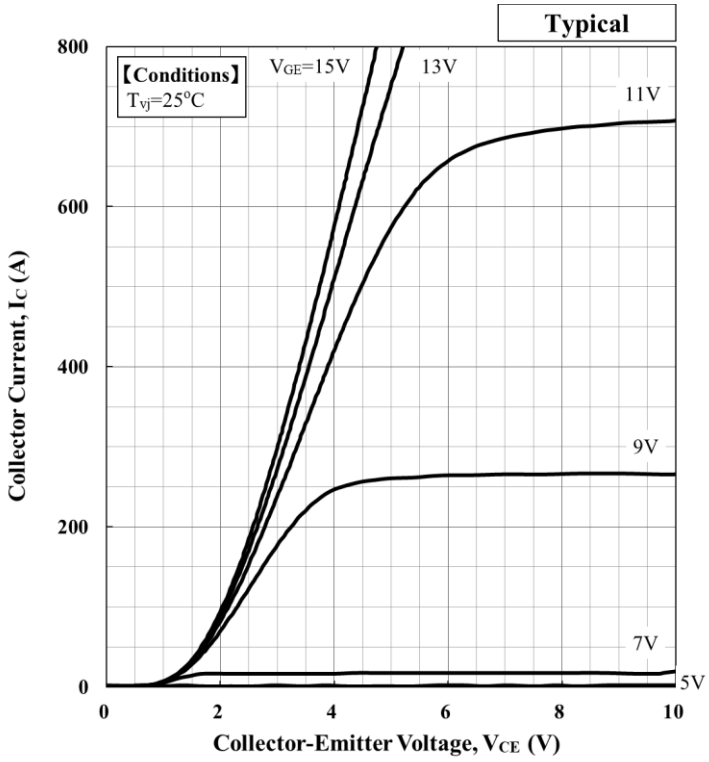



Weight: 900g

## CIRCUIT DIAGRAM

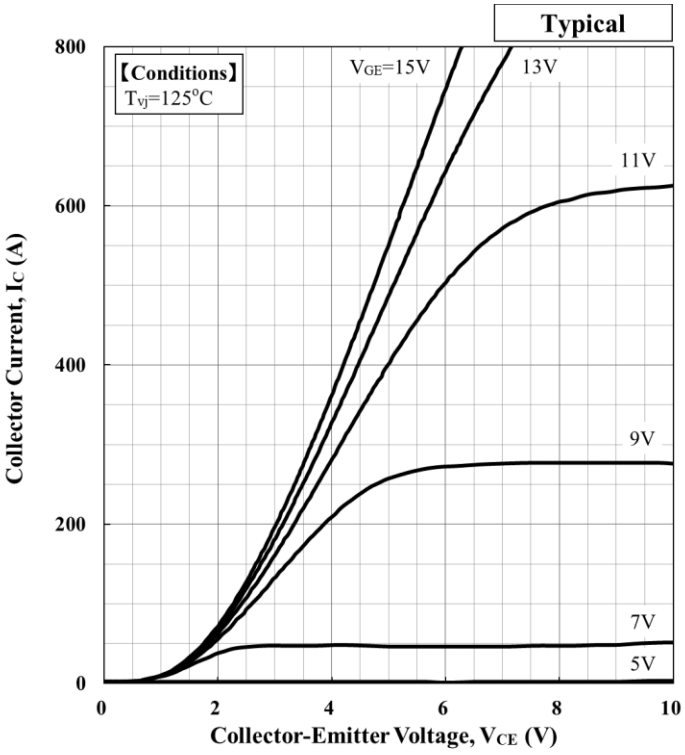


# MBL400E33D



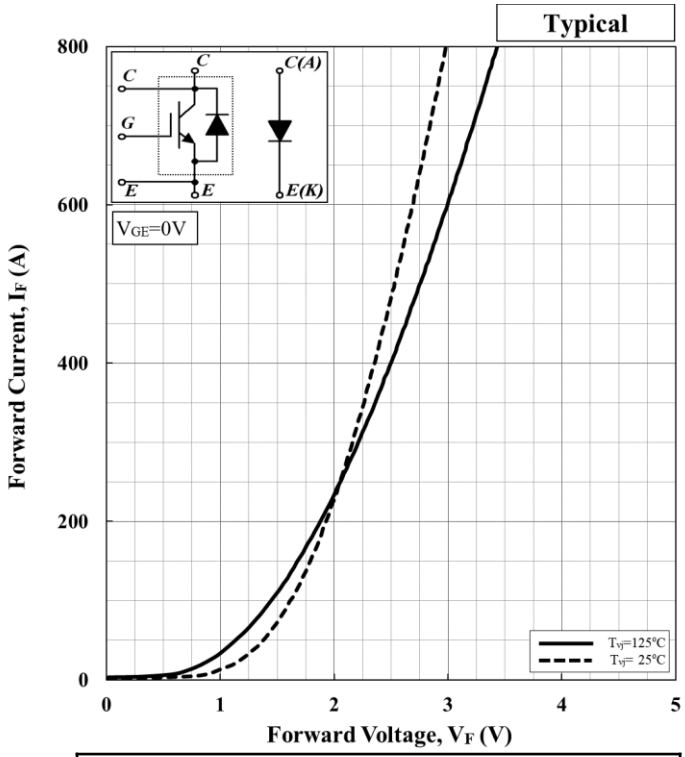

| $V_{CE}(sat)[V] = a_3 \cdot \lvert I_c \rvert^3 + a_2 \cdot \lvert I_c \rvert^2 + a_1 \cdot \lvert I_c \rvert + a_0$ | | | | | |
|---|---|---|---|---|---|
| Temp.[°C] | $V_{GE}$[V] | $a_3$ | $a_2$ | $a_1$ | $a_0$ |
| 25 | 15 | 4.31E-09 | -7.35E-06 | 7.41E-03 | 1.33E+00 |

Collector Current vs. Collector Emitter Voltage



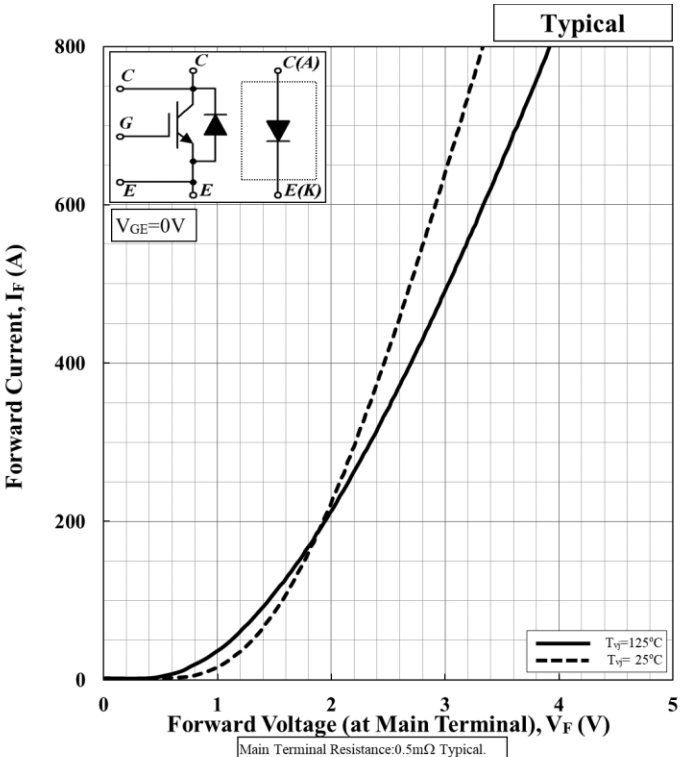

| $V_{CE}(sat)[V] = a_3 \cdot \lvert I_c \rvert^3 + a_2 \cdot \lvert I_c \rvert^2 + a_1 \cdot \lvert I_c \rvert + a_0$ | | | | | |
|---|---|---|---|---|---|
| Temp.[°C] | $V_{GE}$[V] | $a_3$ | $a_2$ | $a_1$ | $a_0$ |
| 125 | 15 | 6.25E-09 | -1.02E-05 | 1.04E-02 | 1.28E+00 |

Collector Current vs. Collector Emitter Voltage




| $V_F[V] = a_3 \cdot \lvert I_F \rvert^3 + a_2 \cdot \lvert I_F \rvert^2 + a_1 \cdot \lvert I_F \rvert + a_0$ | | | | |
|---|---|---|---|---|
| Temp.[°C] | $a_3$ | $a_2$ | $a_1$ | $a_0$ |
| 25 | 3.06E-09 | -5.35E-06 | 4.60E-03 | 1.19E+00 |
| 125 | 3.42E-09 | -6.22E-06 | 5.99E-03 | 8.92E-01 |

Forward Voltage of free-wheeling diode

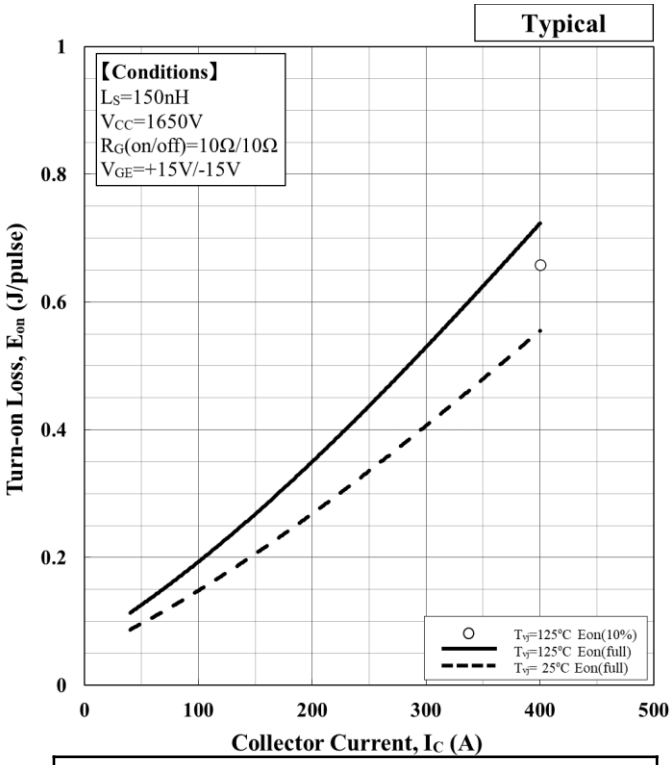



Main Terminal Resistance:0.5mΩ Typical.

| $V_F[V] = a_3 \cdot \lvert I_F \rvert^3 + a_2 \cdot \lvert I_F \rvert^2 + a_1 \cdot \lvert I_F \rvert + a_0$ | | | | |
|---|---|---|---|---|
| Temp.[°C] | $a_3$ | $a_2$ | $a_1$ | $a_0$ |
| 25 | 2.70E-09 | -4.82E-06 | 4.93E-03 | 1.10E+00 |
| 125 | 3.24E-09 | -5.94E-06 | 6.56E-03 | 8.29E-01 |

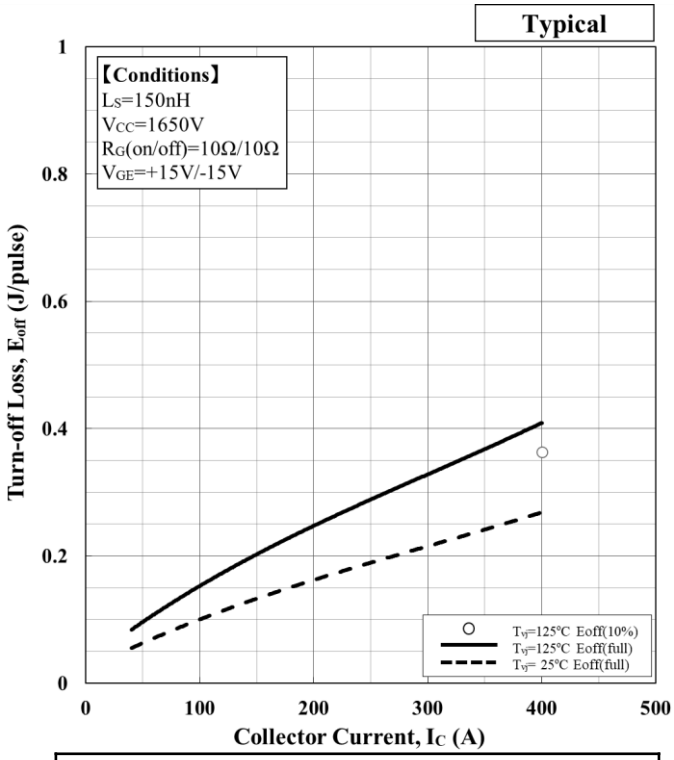
Forward Voltage of Chopper diode

# MBL400E33D



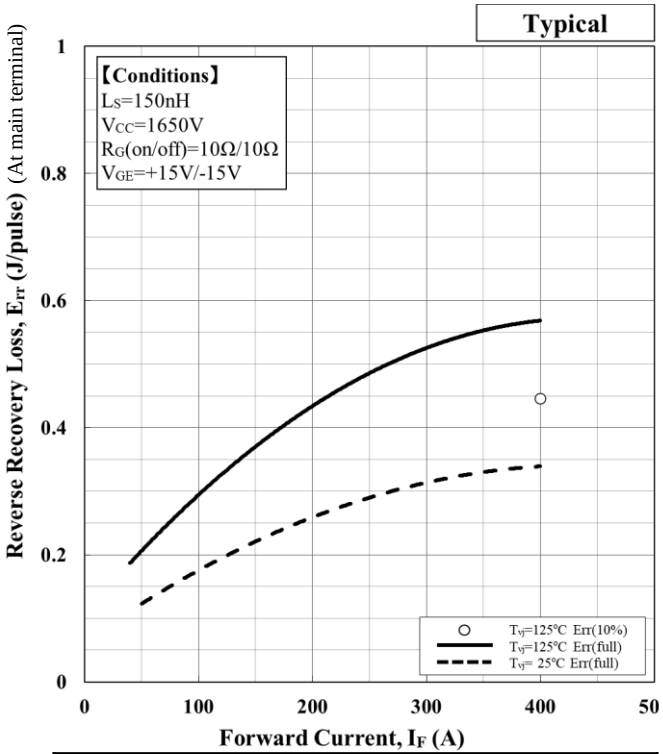

| $E\,[J] = a_3 \cdot \lvert I_c \rvert^3 + a_2 \cdot \lvert I_c \rvert^2 + a_1 \cdot \lvert I_c \rvert + a_0$ | | | | |
|---|---|---|---|---|
| Temp.[°C] | $a_3$ | $a_2$ | $a_1$ | $a_0$ |
| 25 | -1.07E-09 | 1.51E-06 | 8.25E-04 | 5.18E-02 |
| 125 | -1.40E-09 | 1.97E-06 | 1.08E-03 | 6.75E-02 |

**Turn-on loss vs. Collector current**



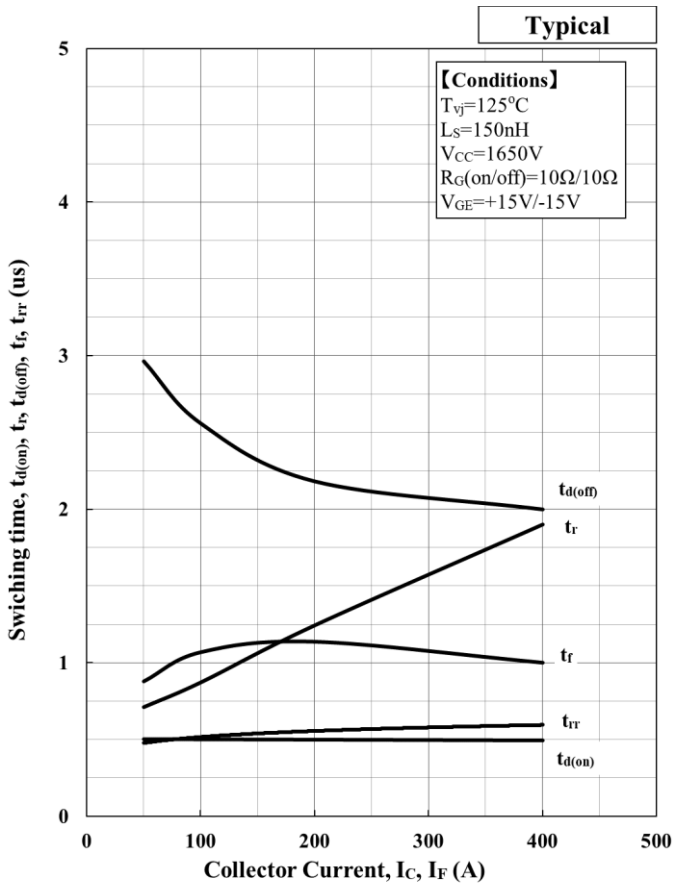

| $E\,[J] = a_3 \cdot \lvert I_c \rvert^3 + a_2 \cdot \lvert I_c \rvert^2 + a_1 \cdot \lvert I_c \rvert + a_0$ | | | | |
|---|---|---|---|---|
| Temp.[°C] | $a_3$ | $a_2$ | $a_1$ | $a_0$ |
| 25 | 1.48E-09 | -1.34E-06 | 9.17E-04 | 2.05E-02 |
| 125 | 2.26E-09 | -2.04E-06 | 1.40E-03 | 3.12E-02 |

**Turn-off loss vs. Collector current**




| $E\,[J] = a_3 \cdot \lvert I_F \rvert^3 + a_2 \cdot \lvert I_F \rvert^2 + a_1 \cdot \lvert I_F \rvert + a_0$ | | | | |
|---|---|---|---|---|
| Temp.[°C] | $a_3$ | $a_2$ | $a_1$ | $a_0$ |
| 25 | 0.00E+00 | -1.45E-06 | 1.27E-03 | 6.33E-02 |
| 125 | 0.00E+00 | -2.42E-06 | 2.12E-03 | 1.06E-01 |

**Recovery loss vs. Forward Current(Chopper Diode)**




**Switching time vs. Collector Current**

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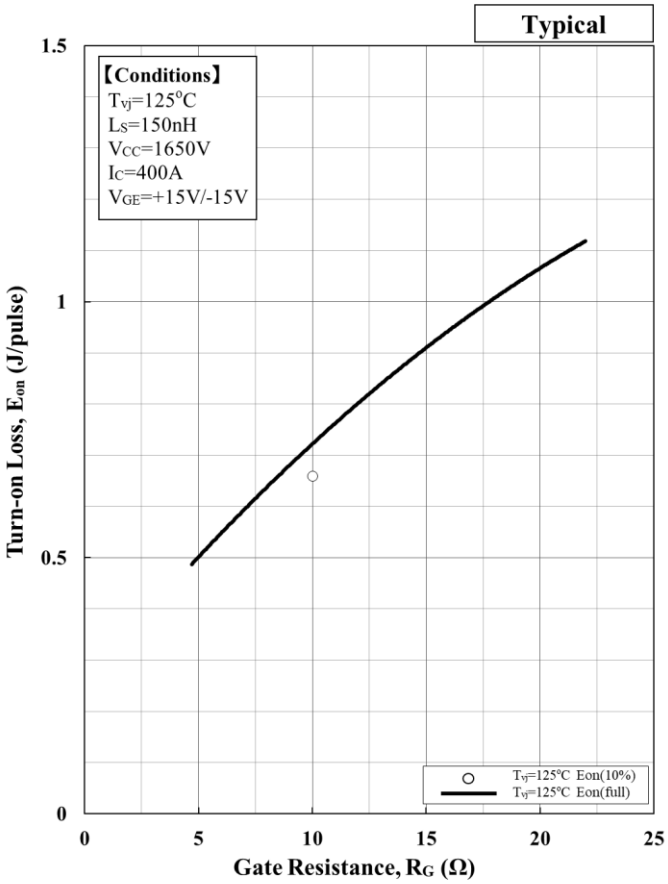
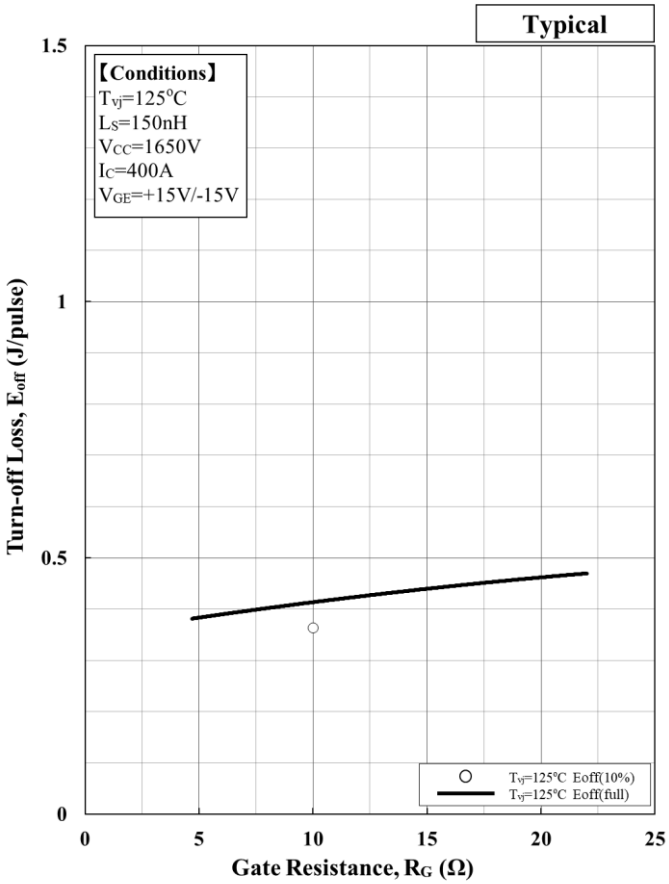
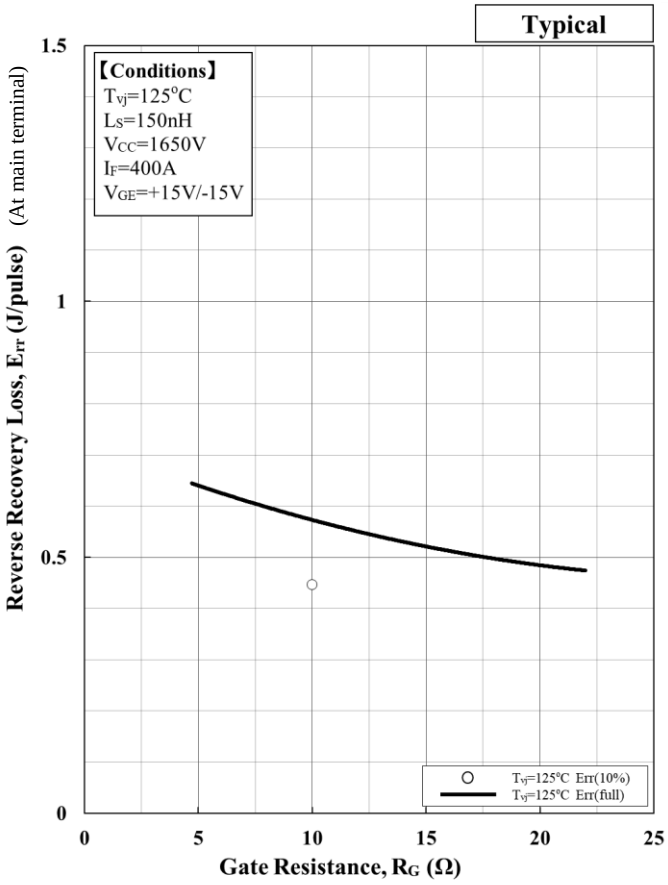


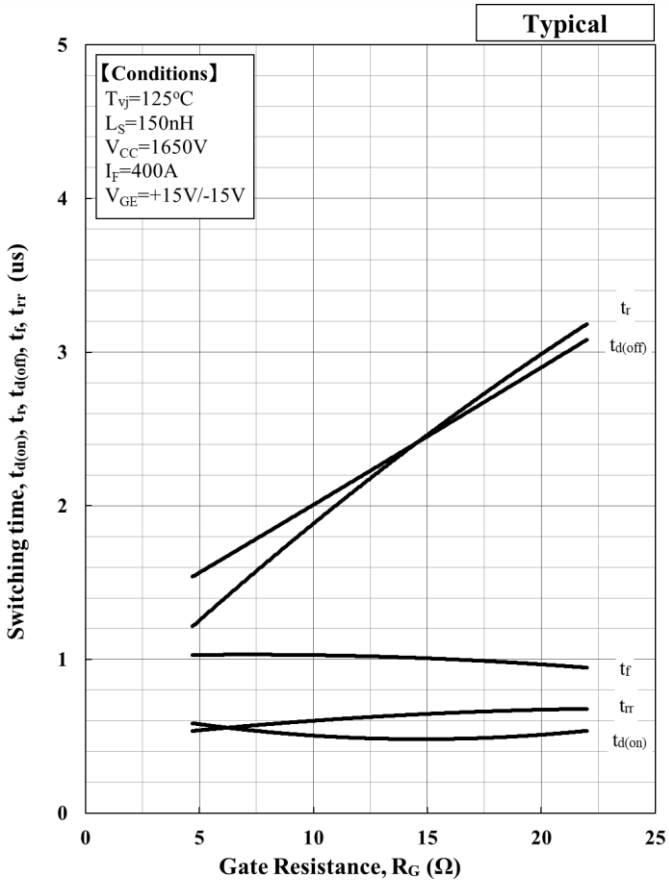

Turn-on loss vs. Gate Resistance




Turn-off loss vs. Gate Resistance




Reverse Recovery loss vs. Gate Resistance (Chopper Diode)




Switching time vs. Gate Resistance

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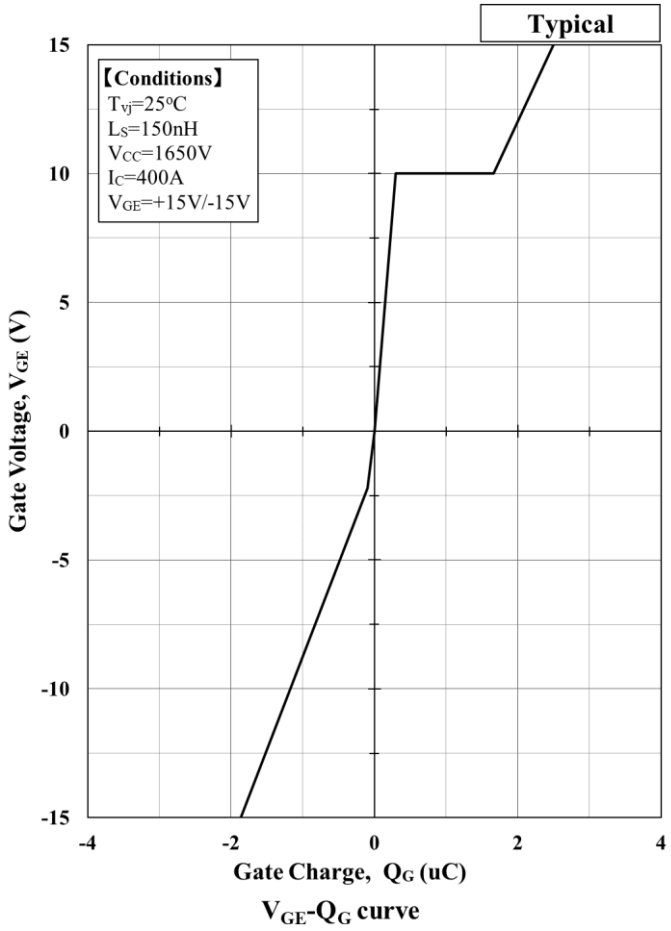
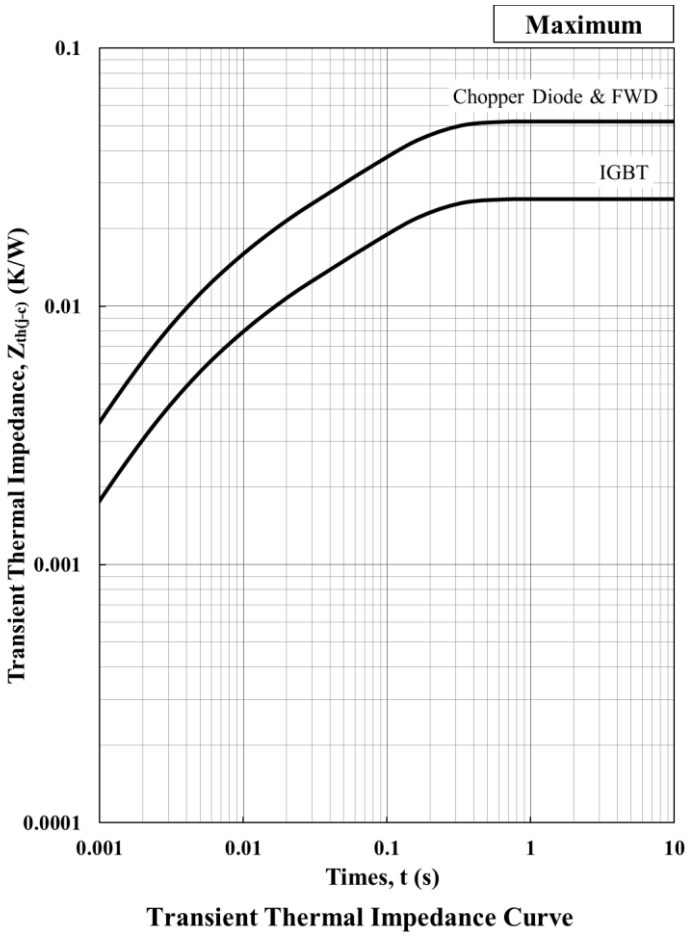



$V_{GE}$-$Q_G$ curve




Transient Thermal Impedance Curve

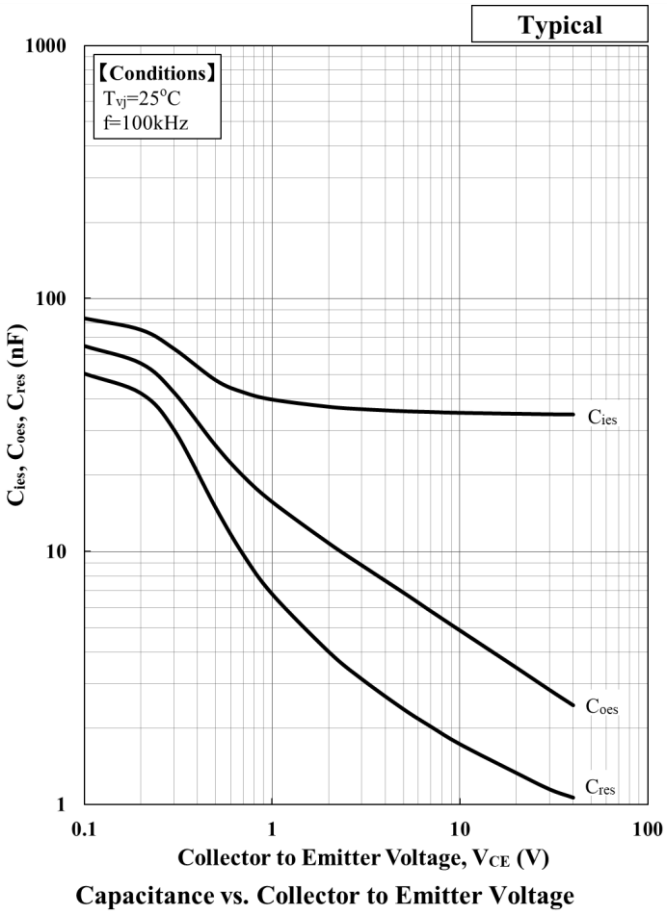
Foster model lumped circuit constant

| n | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| R th, IGBT [n] | 1.73E-02 | 2.67E-03 | 6.98E-05 | 6.00E-03 |
| C th, IGBT [n] | 6.43E+00 | 8.25E-01 | 2.23E+00 | 1.67E+00 |
| R th, Diode [n] | 3.46E-02 | 5.53E-03 | 1.29E-04 | 1.17E-02 |
| C th, Diode [n] | 3.20E+00 | 3.99E-01 | 1.21E+00 | 8.53E-01 |

Cauer model lumped circuit constant

| n | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| R th, IGBT [n] | 1.67E-03 | 4.95E-03 | 6.20E-03 | 1.32E-02 |
| C th, IGBT [n] | 4.14E-01 | 1.52E-01 | 1.47E+00 | 6.10E+00 |
| R th, Diode [n] | 3.53E-03 | 9.69E-03 | 1.24E-02 | 2.64E-02 |
| C th, Diode [n] | 2.07E-01 | 7.23E-02 | 7.50E-01 | 3.02E+00 |

# MBL400E33D




Capacitance vs. Collector to Emitter Voltage

**Material declaration**

Please note the following materials are contained in the product, in order to keep characteristic and reliability level.

| Material | Contained part |
|---|---|
| Lead (Pb) and its compounds | Solder |

# MBL400E33D

## HITACHI POWER SEMICONDUCTORS

## Notices

1. Since mishandling of semiconductor devices may cause malfunctions, please be sure to read "Precautions for Safe Use and Notices" in the individual brochure before use.
2. When designing an electronic circuit using semiconductor devices, please do not exceed the absolute maximum rating specified for the device under any external fluctuations. And for pulse applications, please also do not exceed the "Safe Operating Area (SOA)".
3. Semiconductor devices may sometimes break down by accidental or unexpected surge voltage, so please be careful about the safety design such as redundant design and malfunction prevention design which don't cause the damage expand even if they break down.
4. In cases where extremely high reliability is required (such as use in nuclear power control, aerospace and aviation, traffic equipment, life-support-related medical equipment, fuel control equipment and various kinds of safety equipment), safety should be ensured by using semiconductor devices that feature assured safety or by means of users' fail-safe precautions or other arrangement. Or consult with Hitachi's sales department staff. (When semiconductor devices fail, as a result the semiconductor devices or wiring, wiring pattern may smoke, ignite, or the semiconductor devices themselves may burst.)
5. A semi-processed article is done now using solder which contains lead inside the semiconductor devices. There is possibility of the regulation substance depend on the applied models, so please check before using.
6. This specification is a material for component selection, which describes specifications of power semiconductor devices (hereinafter referred to as products), characteristic charts, and external dimension drawings.
7. The information given herein, including the specifications and dimensions, is subject to change without prior notice to improve product characteristics. Before ordering, purchasers are advised to contact with Hitachi power semiconductor sales department for the latest version of this data sheets.
8. For handling other than described in this manual, follow the handling instructions (IGBT-HI-00002).

■ For inquiries relating to the products, please contact nearest representatives that is located "Inquiry" portion on the top page of a home page.

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## HITACHI POWER SEMICONDUCTORS

## Usage

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