High-Power Module    Silicon Carbide N-Channel MOSFET, Silicon Carbide SBD

# MG800FXF1JMS3

## 1. Applications

- High-Power Switching
- Motor Controllers (including rail traction)

## 2. Features

(1)    $V_{DSS}$ = 3300 V, $I_D$ = 800 A All SiC MOSFET Module(Low loss & High speed switching)

(2)    This module is equipped with SiC SBD on the high side and SiC MOSFET on the low side.

(3)    Low stray inductance, low thermal resistance, maximum $T_{ch}$= 175 ℃

(4)    New genaration standard package(Compact & easily handled by paralleling)

(5)    Electrodes are isolated from metal base plate.

## 3. Packaging and Internal Circuit
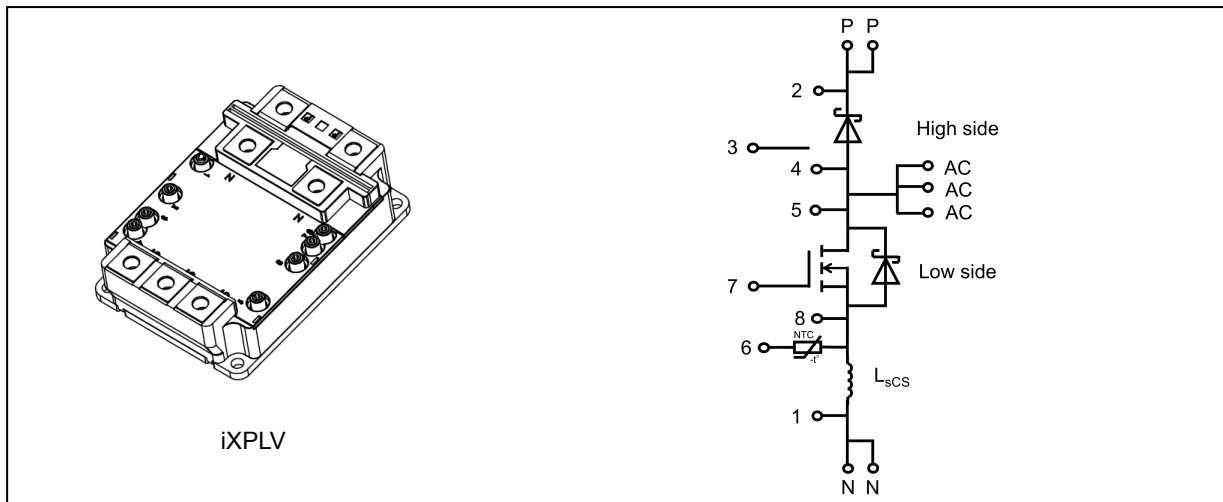


Note :   P and N terminal should use two screws fastened in each and AC terminal should use three screws fastened.

Start of commercial production
2023-10

2024-04-02
Rev.4.0

## 4. Terminal

| Terminal No. | Connection |
|---|---|
| P | P (main terminal) |
| N | N (main terminal) |
| AC | AC (main terminal) |
| 1 | N (sense) / Current sense |
| 2 | P (sense) |
| 3 | Non Conection |
| 4 | High side anode sense |
| 5 | AC (sense) |
| 6 | thermistor |
| 7 | Low side gate |
| 8 | low side source sense |

| Marking | High side | Low side |
|---|---|---|
| C | SBD | MOSFET |



Fig. 4.1    Terminal image
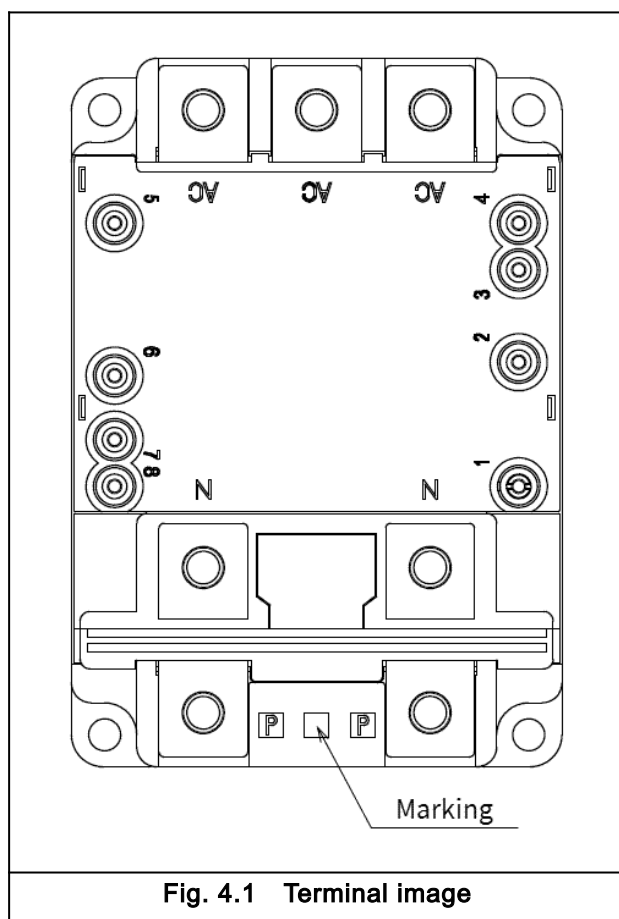
## 5. Absolute Maximum Ratings (Note,Note 1)

### 5.1. MOSFET Absolute Maximum Ratings ($T_C$ = 25℃,unless otherwise specified)

| Characteristics | Symbol | Note | Test Condition | Rating | Unit |
|---|---|---|---|---|---|
| Drain-source voltage | $V_{DSS}$ | | | 3300 | V |
| Gate-source voltage | $V_{GSS}$ | | | + 25 / - 10 | V |
| Drain current (DC) | $I_D$ | (Note 2) | | 800 | A |
| Drain current (pulsed) | $I_{DP}$ | (Note 2) | | 1600 | A |
| Drain power dissipation | $P_D$ | (Note 2) | | 4680 | W |
| Source current (DC) | $I_S$ | (Note 2) | | 800 | A |
| Source current (pulsed) | $I_{SP}$ | (Note 2) | | 1600 | A |
| Channel temperature | $T_{ch}$ | | | 175 | ℃ |

### 5.2. SBD Absolute Maximum Ratings ($T_C$ = 25℃,unless otherwise specified)

| Characteristics | Symbol | Note | Test Condition | Rating | Unit |
|---|---|---|---|---|---|
| Repetitive peak reverse voltage | $V_{RRM}$ | | | 3300 | V |
| Diode forward current (DC) | $I_F$ | | $T_j$ = -40 to 175℃ | 800 | A |
| Diode forward current (pulsed) | $I_{FP}$ | | $T_j$ = -40 to 150℃ | 1600 | A |
| | | | $T_j$ = 150 to 175℃ | 800 | A |
| Junction temperature | $T_j$ | | | 175 | ℃ |

### 5.3. Absolute Maximum Ratings (MOSFET,SBD common) ($T_C$ = 25℃,unless otherwise specified)

| Characteristics | Symbol | Note | Test Condition | Rating | Unit |
|---|---|---|---|---|---|
| Storage temperature | $T_{stg}$ | | | -40 to 150 | ℃ |
| Isolation voltage | $V_{isol}$ | | AC , 60 s | 6000 | V |
| Mounting torque | TOR | (Note 3) | Main terminal : M8 | 9.1 | N · m |
| | | (Note 4) | Signal terminal : M3 | 1.0 | N · m |
| | | (Note 5) | Mounting : M6 | 5.2 | N · m |

Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 1: Refer to the application notes.

Note 2: Ensure tht th channel temperature does not exceed 175℃.

Note 3: The recommended tightening torque for the main terminal (M8) is 7.0 N · m.

Note 4: The recommended tightening torque for the signal terminal (M3) is 0.8 N · m.

Note 5: The recommended tightening torque for installation (M6) is 4.0 N · m.

## 6. Thermal Chracteristics

| Characteristics | Symbol | Note | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Thermal resistance (channel-to-case) | $R_{th(ch-c)}$ | | — | — | 0.032 | K/W |
| Thermal resistance (junction-to-case) | $R_{th(j-c)}$ | | — | — | 0.04 | K/W |
| Thermal resistance (case-to-fin) | $R_{th(c-f)}$ | (Note) | — | 0.0026 | — | K/W |

Note: The value per module.

Apply 50 μm of 3 W/m · K grease between the case and fin while taking care not to create a void, and tighten to the recommended torque before use.

# 7. Electrical Characteristics

## 7.1. MOSFET Electrical Characteristics ($T_C$ = 25℃, unless otherwise specified)

| Characteristics | Symbol | Note | Test Condition | Min | Typ. | Max | Unit | Fig. |
|---|---|---|---|---|---|---|---|---|
| Gate-source leakage current | $I_{GSS}$ | | $V_{GS}$ = +25 V / -10 V, $V_{DS}$ = 0 V | — | — | ±100 | nA | — |
| Drain-source cut-off current | $I_{DSS}$ | | $V_{DS}$ = 3300V, $V_{GS}$ = 0 V | — | — | 1 | mA | — |
| Gate threshold voltage | $V_{th}$ | (Note 1) | $I_D$ = 0.8 A, $V_{DS}$ = 10 V | — | 4.8 | — | V | — |
| Drain-source on-voltage (sense) | $V_{DS(on)}$ sense | | $I_D$ = 800 A, $V_{GS}$ = + 20 V, $T_{ch}$ = 25 ℃ | — | 1.3 | — | V | — |
| | | | $I_D$ = 800 A, $V_{GS}$ = + 20 V, $T_{ch}$ = 175 ℃ | — | 3.6 | 5.2 | V | — |
| Drain-source on-voltage (terminal) | $V_{DS(on)}$ terminal | | $I_D$ = 800 A, $V_{GS}$ = + 20 V, $T_{ch}$ = 25 ℃ | — | 1.4 | — | V | — |
| Input capacitance | $C_{iss}$ | | $V_{DS}$ = 1800 V, $V_{GS}$ = 0 V, f = 100 kHz | — | 173 | — | nF | — |
| Internal gate resistance | $r_{ig}$ | | f = 1 MHz | — | 2.75 | — | Ω | — |
| Switching time (turn-on delay time) | $t_{d(on)}$ | (Note 2) | Inductive load, $V_{DD}$ = 1800 V, $I_D$ = 800 A, $V_{GS}$ = + 20 V / - 6 V, $R_{G(on)}$ = 1.5 Ω, $R_{G(off)}$ = 3.6 Ω, $C_{GS}$ = 100nF, $T_{ch}$ = 175 ℃, $L_S$ ≈ 70 nH | — | 0.58 | — | μs | 7.1 7.2 |
| Switching time (rise time) | $t_r$ | | | — | 0.17 | — | μs | |
| Switching time (turn-on time) | $t_{on}$ | | | — | 0.75 | — | μs | |
| Switching time (turn-off delay time) | $t_{d(off)}$ | | | — | 1.80 | — | μs | |
| Switching time (fall time) | $t_f$ | | | — | 0.15 | — | μs | |
| Switching time (turn-off time) | $t_{off}$ | | | — | 1.95 | — | μs | |
| Turn-on switching loss | $E_{on}$ | | | — | 230 | — | mJ | |
| Turn-off switching loss | $E_{off}$ | | | — | 230 | — | mJ | |
| Source-drain on-voltage (sense) | $V_{SD(on)}$ sense | | $I_S$ = 800 A, $V_{GS}$ = + 20 V, $T_{ch}$ = 25 ℃ | — | 1.3 | — | V | — |
| | $V_{SD(on)}$ sense | | $I_S$ = 800 A, $V_{GS}$ = + 20 V, $T_{ch}$ = 175 ℃ | — | 3.5 | 5.1 | V | — |
| Source-drain on-voltage (terminal) | $V_{SD(on)}$ terminal | | $I_S$ = 800 A, $V_{GS}$ = + 20 V, $T_{ch}$ = 25 ℃ | — | 1.4 | — | V | — |
| Source-drain off-voltage (sense) | $V_{SD(off)}$ sense | | $I_S$ = 800 A, $V_{GS}$ = - 6 V, $T_{ch}$ = 25 ℃ | — | 2.1 | — | V | — |
| | $V_{SD(off)}$ sense | | $I_S$ = 800 A, $V_{GS}$ = - 6 V, $T_{ch}$ = 175 ℃ | — | 4.3 | 6.3 | V | — |
| Source-drain off-voltage (terminal) | $V_{SD(off)}$ terminal | | $I_S$ = 800 A, $V_{GS}$ = - 6 V, $T_{ch}$ = 25 ℃ | — | 2.2 | — | V | — |
| Reverse recovery time | $t_{rr}$ | (Note 2) | Inductive Load, $V_{DD}$ = 1800 V, $I_S$ = 800 A, $V_{GS}$ = - 6 V, Drive side $R_{G(on)}$ = 2.2 Ω, $C_{GS}$ = 100nF, $T_{ch}$ = 175 ℃, $L_S$ ≈ 110 nH | — | 0.09 | — | μs | 7.3 7.5 |
| Reverse recovery loss | $E_{rr}$ | | | — | 18 | — | mJ | |
| Stray inductance | $L_{sPN}$ | | P terminal — N terminal | — | 12 | — | nH | — |
| Current sensing inductance | $L_{sCS}$ | | 1 terminal — 8 terminal | — | 2.7 | — | nH | — |
| Rated NTC resistance | R | | $T_c$ = 25 ℃ | 3.5 | 5.0 | 6.5 | kΩ | — |
| | R | | $T_c$ = 150 ℃ | 125 | 165 | 205 | Ω | — |
| NTC B value | B | | $T_{NTC}$ = 25 to 150 ℃ | — | 3375 | — | K | — |

Note 1: Gate-Source Voltage (-10V) is applied 5ms before measurement.

Note 2: $L_s$ is the sum of the stray inductance between the P and N terminals ($L_{sPN}$) and the stray inductance of external circuitry ($L_{ext}$) .

## 7.2. SBD Electrical Characteristics ($T_C$ = 25℃,unless otherwise specified)

| Characteristics | Symbol | Note | Test Condition | Min | Typ. | Max | Unit | Fig. |
|---|---|---|---|---|---|---|---|---|
| Repetitive peak reverse current | $I_{RRM}$ | | $V_R$ = 3300 V | — | — | 60 | μA | — |
| Forward voltage (sense) | $V_F$ sense | | $I_F$ = 800 A, $T_j$ = 25 ℃ | — | 2.0 | — | V | — |
| | | | $I_F$ = 800 A, $T_j$ = 175 ℃ | — | 3.9 | 5.0 | V | — |
| Forward voltage (terminal) | $V_F$ terminal | | $I_F$ = 800 A, $T_j$ = 25 ℃ | — | 2.2 | — | V | — |
| Reverse recovery charge | $Q_{rr}$ | (Note) | $V_R$ = 1800 V, $I_F$ = 800 A, Drive side $R_{G(on)}$ = 1.5 Ω, $T_j$ = 175 ℃,$L_s$ ≈ 70 nH | — | 10 | — | μC | 7.4 7.5 |
| Reverse recovery time | $t_{rr}$ | | | — | 0.08 | — | μs | |
| Reverse recovery loss | $E_{rr}$ | | | — | 10 | — | mJ | |

Note: $L_s$ is the sum of the stray inductance between the P and N terminals ($L_{sPN}$) and the stray inductance of external circuitry ($L_{ext}$) .
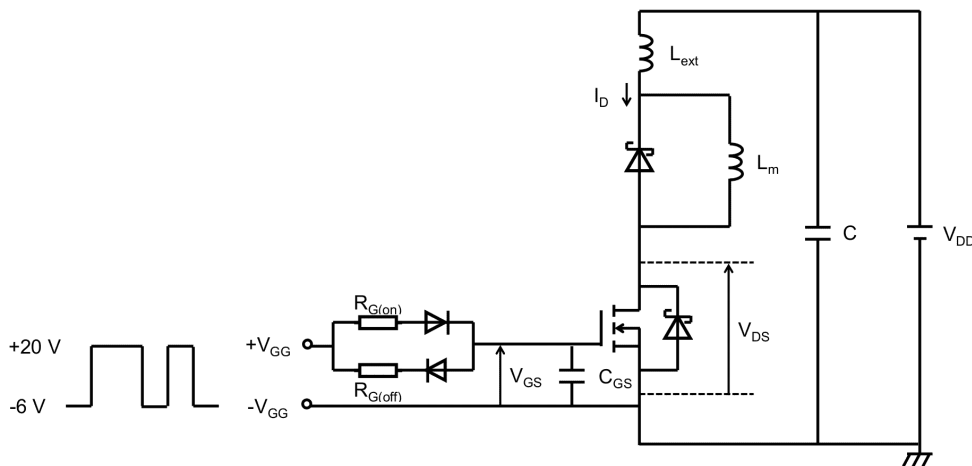


Fig. 7.1   Inductive Load Switching Test Circuit
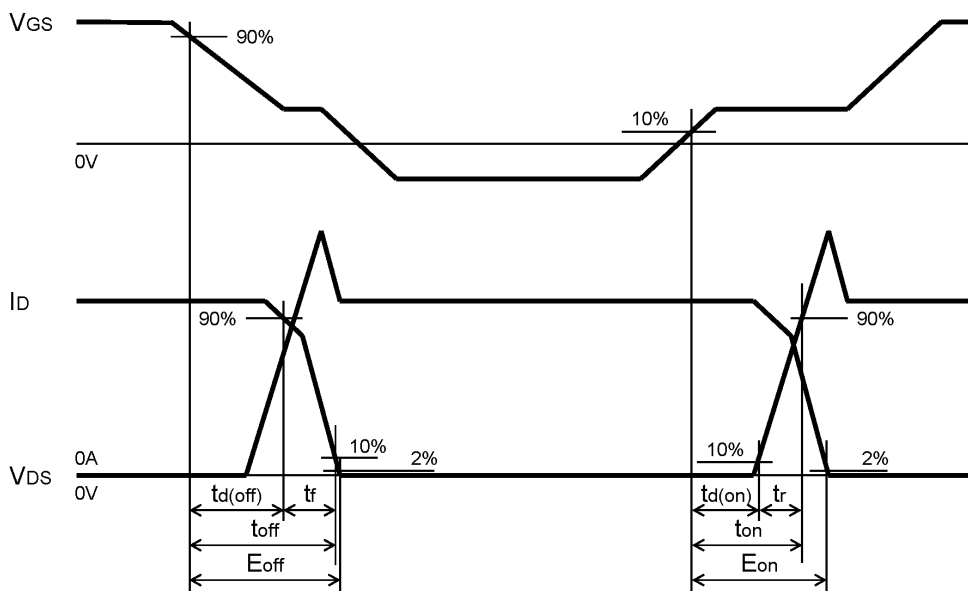


Fig. 7.2   Timing Chart (MOSFET part)
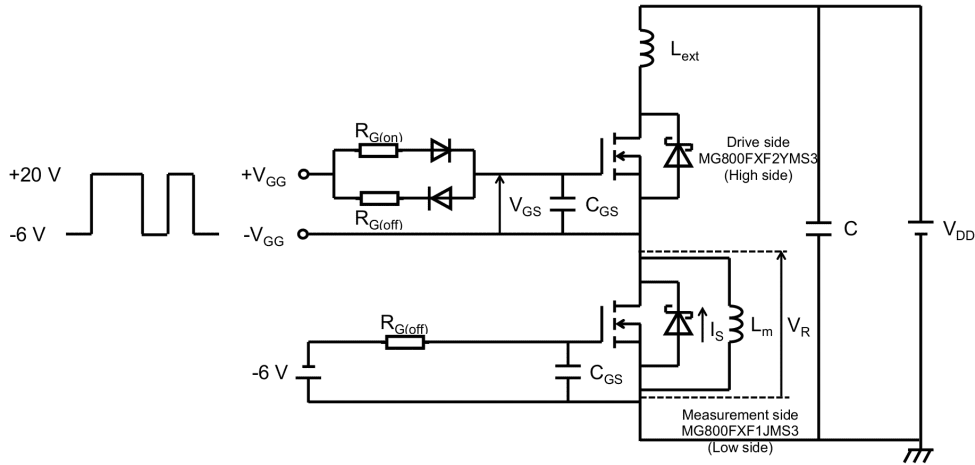
Fig. 7.3   MOSFET Reverse Inductive Load Switching Test Circuit
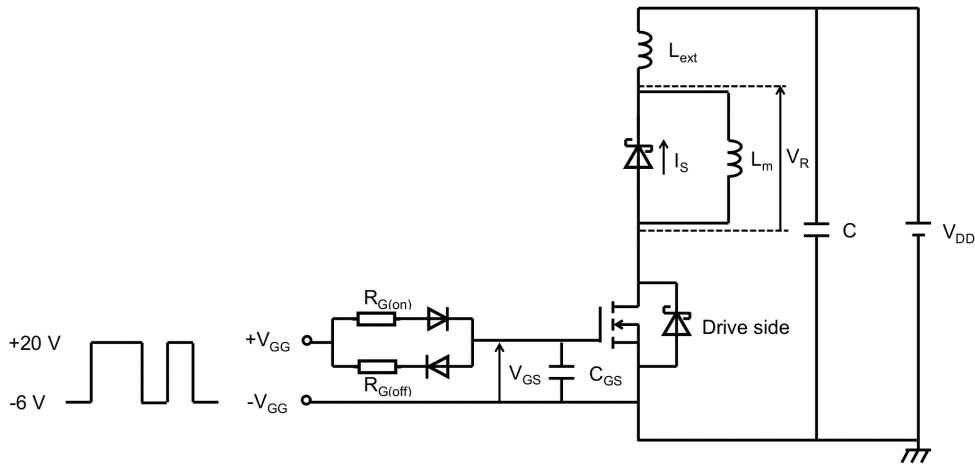


Fig. 7.4   SBD Reverse Inductive Load Switching Test Circuit
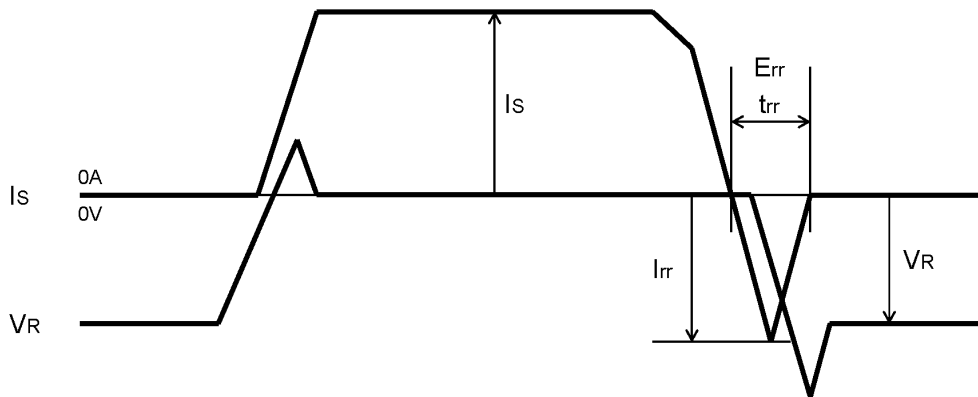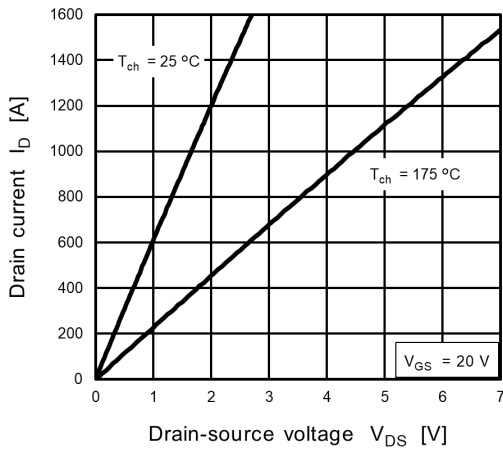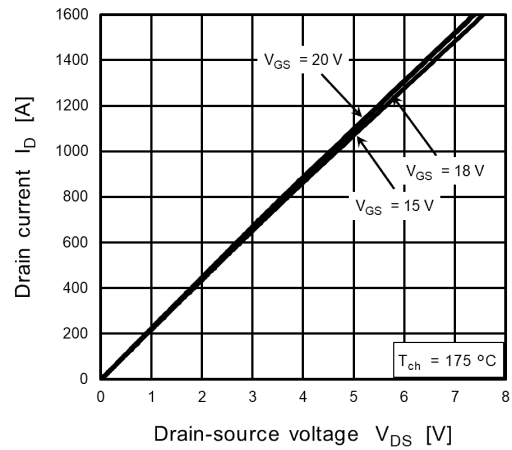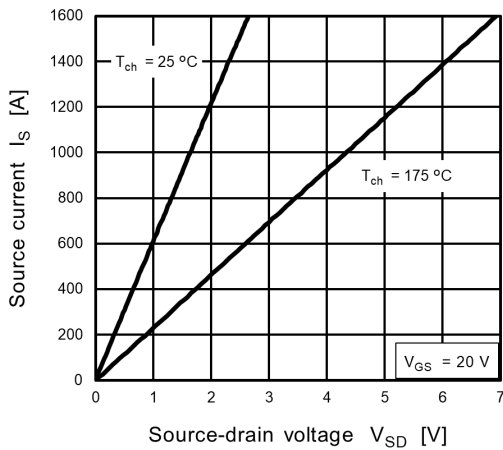


Fig. 7.5   Timing Chart (Diode part)

# 8. MOSFET Characteristics Curves (Note)
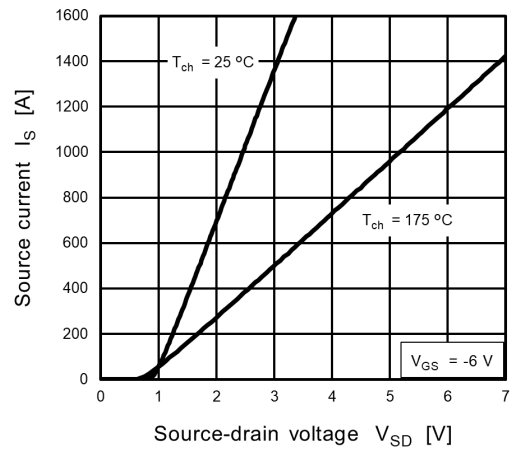


Fig. 8.1   $I_D$ - $V_{DS}$ (Note 1)
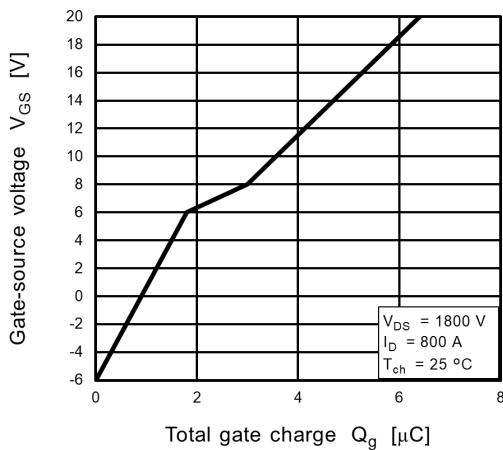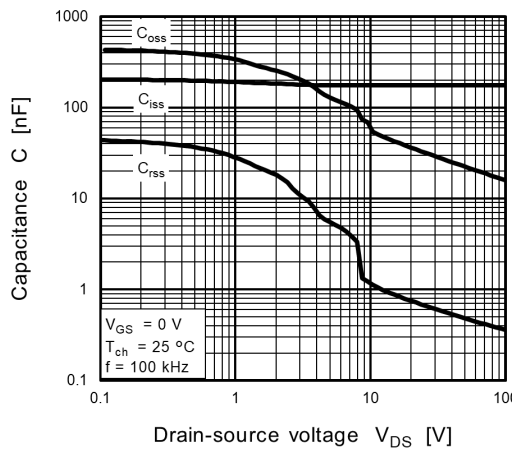


Fig. 8.2   $I_D$ - $V_{DS}$ (Note 1)
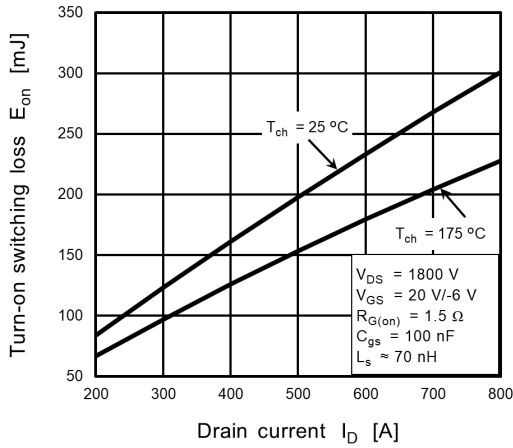


Fig. 8.3   $I_S$ - $V_{SD}$ (Note 1)



Fig. 8.4   $I_S$ - $V_{SD}$ (Note 1)
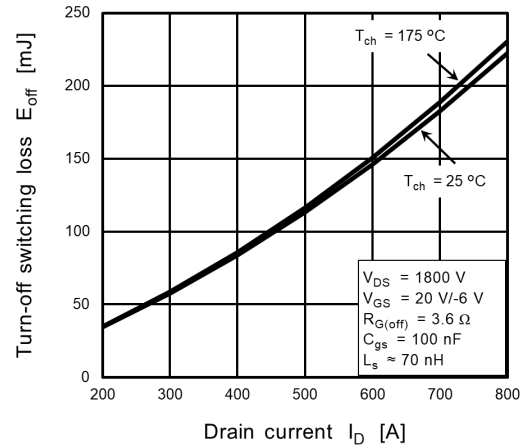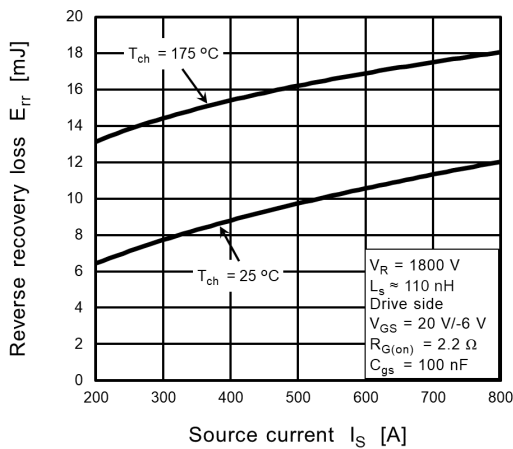


Fig. 8.5   $V_{GS}$ -$Q_g$



Fig. 8.6   $C_{iss}$, $C_{oss}$, $C_{rss}$ - $V_{DS}$

Fig. 8.7   E_on - I_D



Fig. 8.8   E_off - I_D



Fig. 8.9   E_rr - I_S
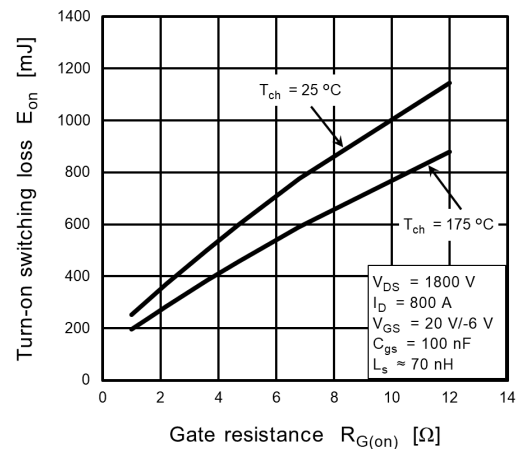


Fig. 8.10   E_on - R_G(on)
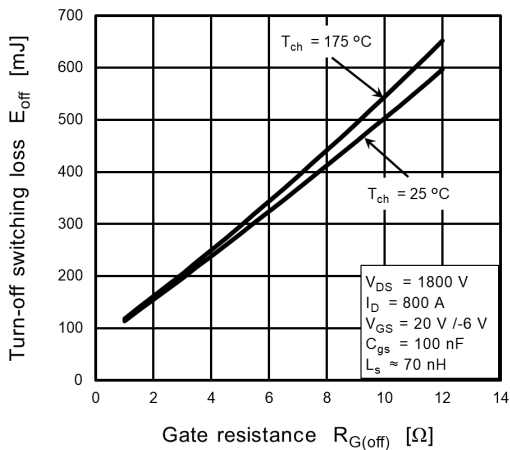


Fig. 8.11   E_off - R_G(off)



Fig. 8.12   E_rr - R_G(on)

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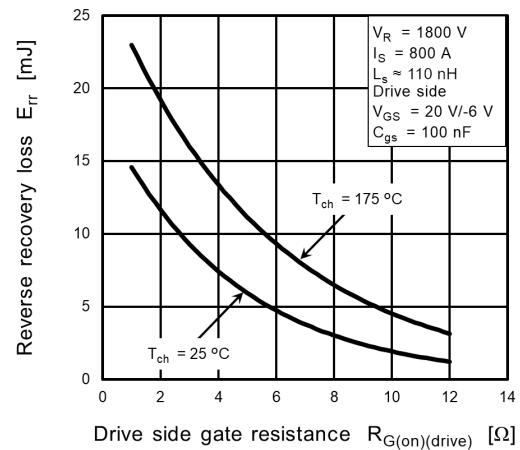
**Fig. 8.13  R<sub>th(ch-c)</sub> - t (Guarnteed Maximum)**
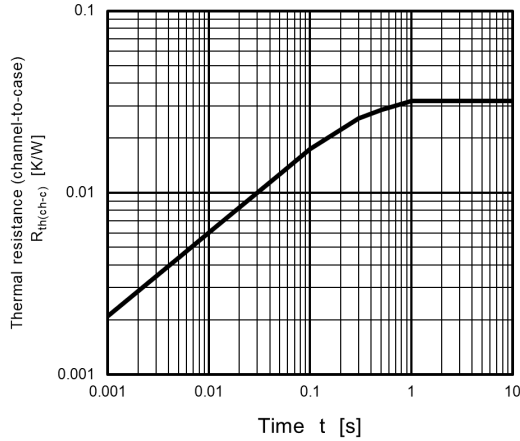
$$\text{Fig. 8.13 } R_{th(ch-c)} - t \text{ (Guarnteed Maximum)}$$
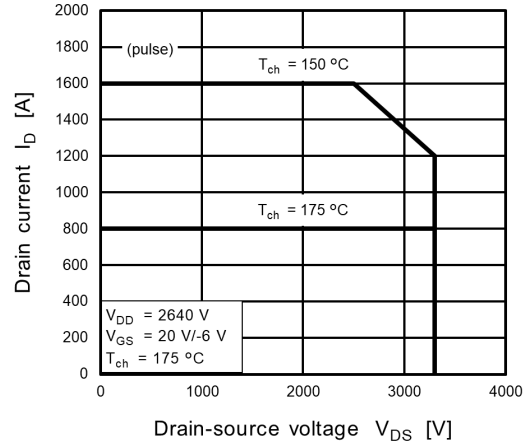


**Fig. 8.14  Reverse bias safe operating area (RBSOA)(Guaranteed Maximum)**

Note:   The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

Note 1: Source - drain voltage and Drain - source voltage are measured at sense terminals.

## 9.  SBD Characteristics Curves (note)
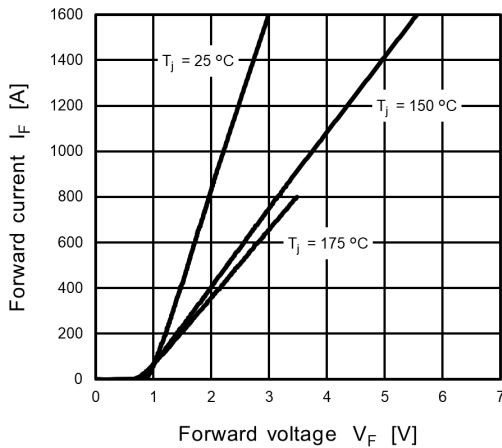


**Fig. 9.1    $I_F$ - $V_F$ (Note 1)**



**Fig. 9.2    $E_{rr}$ - $I_F$**
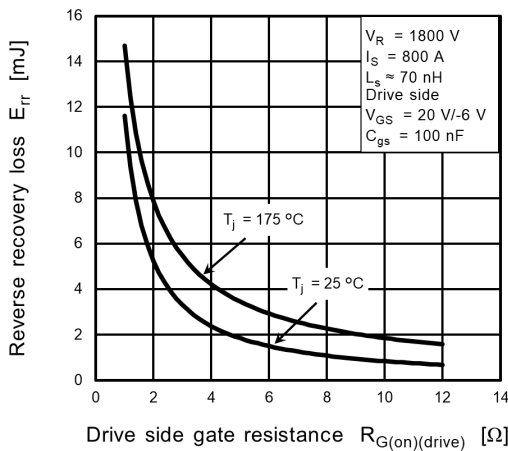


**Fig. 9.3    $E_{rr}$ - $R_{G(on)}$**



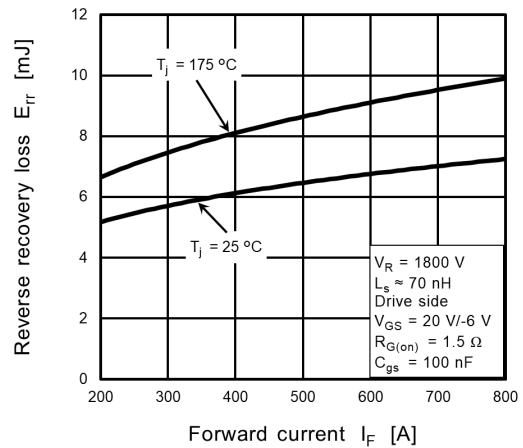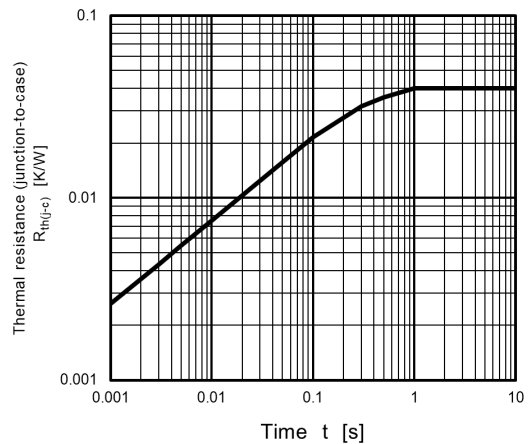**Fig. 9.4    $R_{th(j-c)}$ - t (Guaranteed Maximum)**

Note:   The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

Note 1: Forward voltage is measured at sense terminals.

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## Package Dimensions

Unit: mm
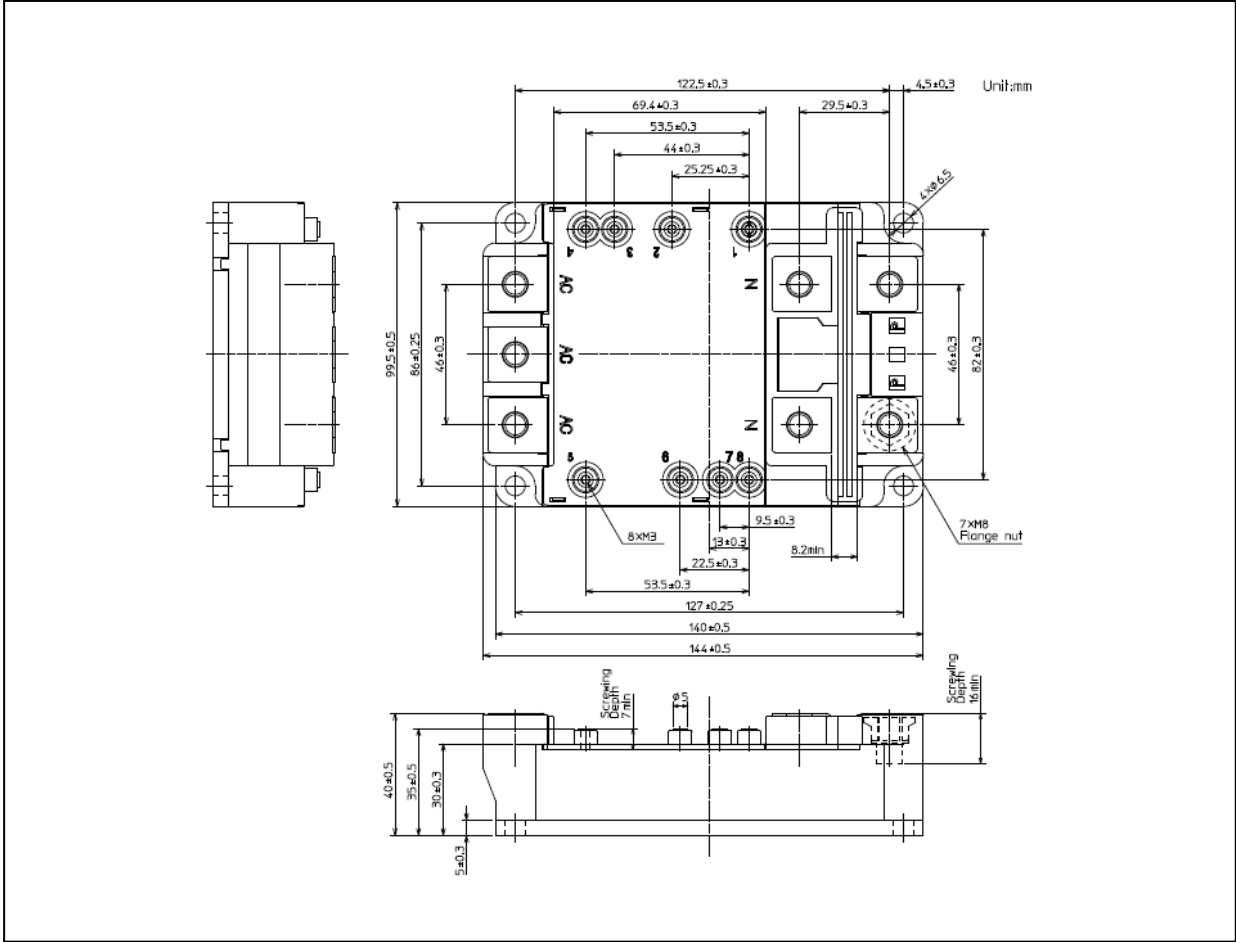


Weight: 840 g (typ.)

| Package Name(s) |
| --- |
| TOSHIBA: 2-144A1A |
| Nickname: iXPLV |

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