MITSUBISHI ELECTRIC

**< HVMOSFET MODULE >**

# FMF185DC-66A

**HIGH POWER SWITCHING USE**
**INSULATED TYPE** 1st gen. HVMOSFET (High Voltage Metal Oxide Semiconductor Field Effect Transistor) Modules

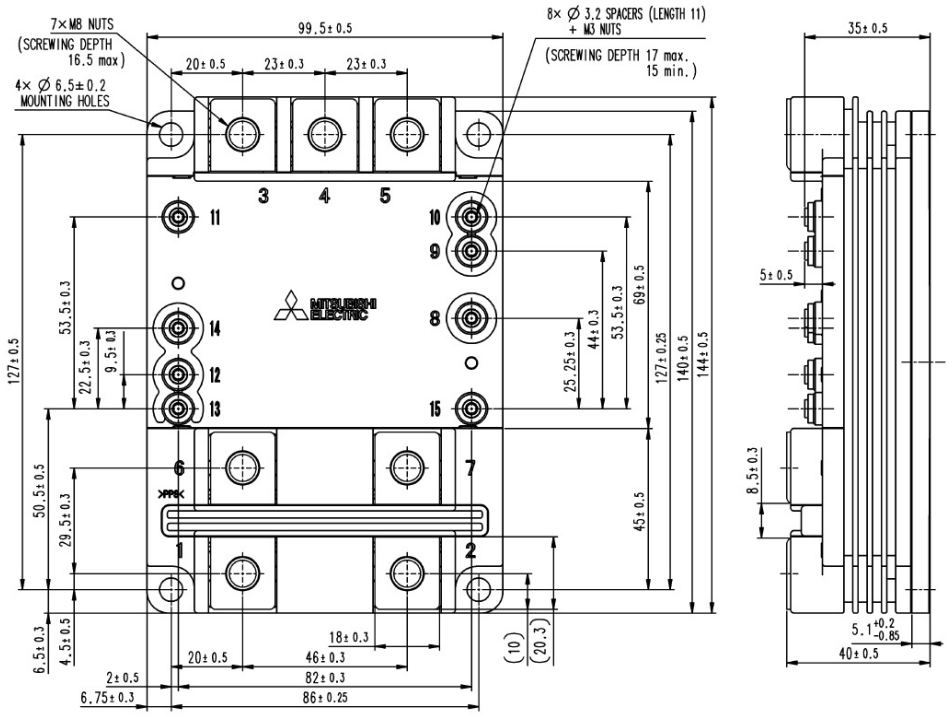
**FMF185DC-66A**

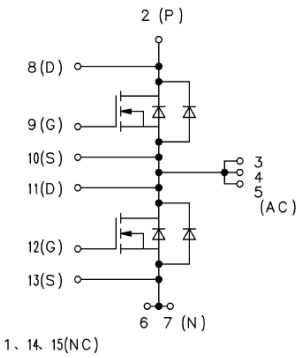
- $I_D$ ..... 185A
- $V_{DSX}$ ..... 3300V
- 2-element in a Pack
- Insulated Type
- SiC MOSFET
- JBS(Junction Barrier Schottky)

## APPLICATION

Traction drives, High Reliability Converters / Inverters, DC choppers

**OUTLINE DRAWING & CIRCUIT DIAGRAM** **Dimensions in mm**

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CIRCUIT DIAGRAM

| No. | Terminals |
|---|---|
| 1 | NC |
| 2 | DC+, D(P) |
| 3, 4, 5 | AC, S(P), D(N) |
| 6, 7 | DC-, S(N) |
| 8 | D(P) |
| 9 | G(P) |
| 10 | S(P) |
| 11 | D(N) / S(P) |
| 12 | G(N) |
| 13 | S(N) |
| 14, 15 | NC |

Note 1. Terminal 1 is not connected to the circuit, but must be shorted to terminal 2 when using the module.

**MAXIMUM RATINGS (Tj=25 °C, unless otherwise specified)**

| Symbol | Item | Conditions | Ratings | Unit |
|---|---|---|---|---|
| $V_{DSX}$ | Drain-source voltage | $V_{GS}$ = -5V | 3300 | V |
| $V_{GSS}$ | Gate-source voltage | $V_{DS}$ = 0V | ±20 | V |
| $I_D$ | Drain current | DC (Note 1) | 185 | A |
| $I_{DM}$ | | Pulse (Note 2) | 370 | A |
| $I_S$ | Source current (Note 3) | DC (Note 1) | 185 | A |
| $I_{SM}$ | | Pulse (Note 2) | 370 | A |
| $P_{tot}$ | Maximum power dissipation (Note 4) | $T_c$ = 25°C, MOSFET part | 1150 | W |
| $V_{iso}$ | Isolation voltage | RMS, sinusoidal, f = 60Hz, t = 1 min., $T_j$ = 25°C | 6000 | V |
| $V_e$ | Partial discharge extinction voltage | RMS, sinusoidal, f = 60Hz, $Q_{PD}$ ≤ 10 pC., $T_j$ = 25°C | 2600 | V |
| $T_j$ | Channel temperature | — | −40 ~ +175 | °C |
| $T_{op}$ | Operating channel temperature | — | −40 ~ +175 | °C |
| $T_{stg}$ | Storage temperature | — | −40 ~ +175 | °C |

**ELECTRICAL CHARACTERISTICS (Tj=25 °C, unless otherwise specified)**

| Symbol | Item | Conditions | | Limits | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | |
| $I_{GSS}$ | Gate leakage current | $V_{GS}$ = $V_{GSS}$, $V_{DS}$ = 0 V, $T_j$ = 25°C | | -0.5 | — | 0.5 | μA |
| $I_{DSX}$ | Drain-source cut-off current | $V_{DS}$ = $V_{DSX}$, $V_{GS}$ = −5 V | $T_j$ = 25°C | — | — | 0.7 | mA |
| | | | $T_j$ = 150°C | — | — | — | |
| | | | $T_j$ = 175°C | — | 0.8 | — | |
| $V_{GS(th)}$ | Gate-source threshold voltage | $V_{DS}$ = 10V, $I_C$ = 18.5mA | $T_j$ = 25°C | — | 2.1 | — | V |
| $r_{DS(on)}$ | Drain-source resistance | $V_{DS}$ = $V_{DS(on)}$<br>$V_{GS}$ = 17V | $T_j$ = 25°C | — | 9.5 | — | mΩ |
| | | | $T_j$ = 150°C | — | — | — | |
| | | | $T_j$ = 175°C | — | 21.1 | — | |
| $V_{DS(on)}$ | Drain-source on voltage | $V_{GS}$ = 17V, $I_D$ = 185A | $T_j$ = 25°C | — | 1.75 | — | V |
| | | | $T_j$ = 150°C | — | — | — | |
| | | | $T_j$ = 175°C | — | 3.90 | — | |
| $C_{iss}$ | Input capacitance | $V_{DS}$ = 10V, $V_{GS}$ = 0V,<br>f = 100kHz, $T_j$ = 25°C | | — | 52.5 | — | nF |
| $C_{oss}$ | Output capacitance | | | — | 8.5 | — | nF |
| $C_{rss}$ | Reverse transfer capacitance | | | — | 0.2 | — | nF |
| $Q_G$ | Total gate charge | $V_{DD}$ = 1800V, $I_D$ = 185A, $V_{GS}$ = +17V / -5V | | — | 1.68 | — | μC |
| $t_{d(on)}$ | Turn-on delay time | $V_{DD}$ = 1800V, $I_D$ = 185A<br>$V_{GS}$ = +17V / -5V<br>$R_{G(on)}$ = 2.0 Ω, $L_s$ = 60 nH<br>Inductive load | $T_j$ = 175°C | — | — | 1.2 | μs |
| $t_r$ | Rise time | | $T_j$ = 175°C | — | — | 0.72 | μs |
| $E_{on(10\%)}$ | Turn-on switching energy per pulse | | $T_j$ = 150°C | — | — | — | mJ |
| | | | $T_j$ = 175°C | — | 130 | — | |
| $t_{d(off)}$ | Turn-off delay time | $V_{DD}$ = 1800V<br>$I_D$ = 185 A<br>$V_{GS}$ = +17 V / -5V<br>$R_{G(off)}$ = 2.0 Ω<br>$L_s$ = 60 nH<br>Inductive load | $T_j$ = 150°C | — | — | — | μs |
| | | | $T_j$ = 175°C | — | 0.90 | — | |
| $t_f$ | Fall time | | $T_j$ = 150°C | — | — | — | μs |
| | | | $T_j$ = 175°C | — | 0.24 | — | |
| $E_{off(10\%)}$ | Turn-off switching energy per pulse | | $T_j$ = 150°C | — | — | — | mJ |
| | | | $T_j$ = 175°C | — | 45 | — | |

## ELECTRICAL CHARACTERISTICS

| Symbol | Item | Conditions | | Limits | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | |
| $V_{SD}$ | Source-drain voltage (Note 3) | $I_S$ = 185 A, $V_{GS}$ = 0 V | $T_j$ = 25°C | — | 2.50 | — | V |
| | | | $T_j$ = 150°C | — | — | — | |
| | | | $T_j$ = 175°C | — | 3.50 | — | |
| $V_{SD}$ | Source-drain voltage (Note 3) | $I_S$ = 185 A, $V_{GS}$ = +17 V | $T_j$ = 25°C | — | 1.20 | — | V |
| | | | $T_j$ = 150°C | — | — | — | |
| | | | $T_j$ = 175°C | — | 2.40 | — | |
| $Q_{C(10\%)}$ | Total capacitive charge (Note 3) | $V_{DD}$ = 1800V, $I_D$ = 185A, $V_{GS}$ = +17V / -5V, $R_{G(on)}$ = 2.0 Ω, $L_s$ = 60 nH, Inductive load | $T_j$ = 150°C | — | — | — | μC |
| | | | $T_j$ = 175°C | — | 10 | — | |
| $E_{off\_diode(10\%)}$ | Diode turn-off energy per pulse (Note 3) | | $T_j$ = 150°C | — | — | — | mJ |
| | | | $T_j$ = 175°C | — | 7.5 | — | |

## THERMAL CHARACTERISTICS

| Symbol | Item | Conditions | Limits | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| $R_{th(j-c)Q}$ | Thermal resistance | Junction to Case, MOSFET part,1/2 module | — | — | 128.0 | K/kW |
| $R_{th(j-c)D}$ | | Junction to Case, FWDi part,1/2 module | — | — | 218.0 | K/kW |
| $R_{th(c-s)}$ | Contact thermal resistance | Case to heat sink, $\lambda_{grease}$ = 1W/m·K, $D_{(c-s)}$ = 100μm, 1/2 module | — | 90.0 | — | K/kW |

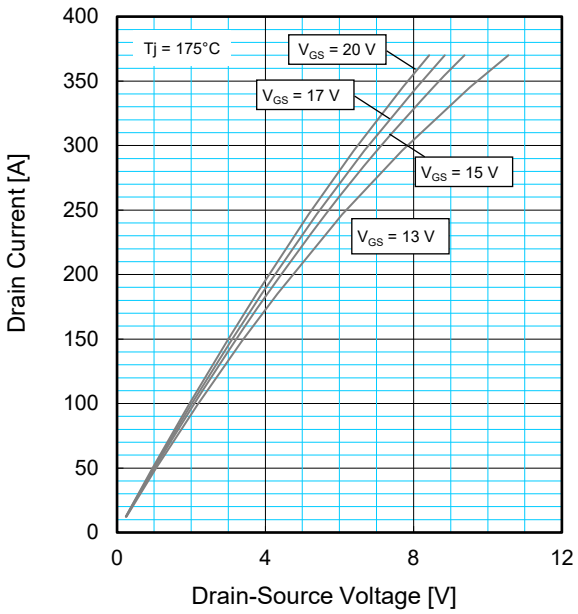
## MECHANICAL CHARACTERISTICS

| Symbol | Item | Conditions | Limits | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| $M_t$ | Mounting torque | Main terminals screw M8 (Note 5) | 7.0 | — | 14.0 | N·m |
| $M_s$ | | Mounting screw M6 | 3.0 | — | 6.0 | N·m |
| $M_t$ | | Auxiliary terminals screw M3 | 0.4 | — | 0.6 | N·m |
| m | Mass | - | — | 0.80 | — | kg |
| CTI | Comparative tracking index | - | 600 | — | — | — |
| $d_a$ | Clearance | Between terminals and baseplate | 19.2 | — | — | mm |
| $d_s$ | Creepage distance | - | 32 | — | — | mm |
| $L_{P\ P-N}$ | Parasitic stray inductance | Between terminal 2 and terminal 6,7 | — | 30.0 | — | nH |
| $L_{p\ s-ss}$ | Internal inductance | Between Auxiliary terminals (terminal 10-11) | — | — | — | nH |
| | | Between Auxiliary terminals and DC- (terminal 13-6,7) | — | — | — | |
| $R_{DD'+SS'}$ | Internal lead resistance | Between DC+ and DC- (terminal 2-6,7) | — | — | — | mΩ |
| | | Between DC+ and AC (terminal 2-3,4,5) | — | 0.66 | — | |
| | | Between AC and DC- (terminal 3,4,5-6,7) | — | 0.83 | — | |

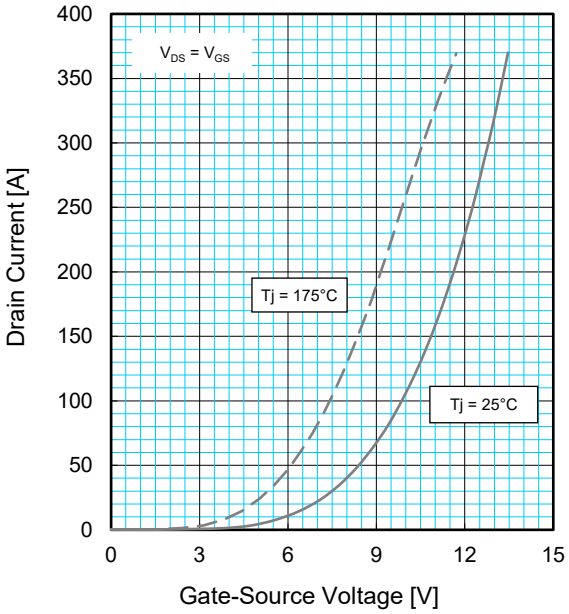
Note1. The energization time is a short time in which the internal electrode does not generate heat.
Note 2. Pulse width and repetition rate should be such that junction temperature ($T_j$) does not exceed $T_{jmax}$ rating.
Note 3. The symbols represent characteristics of the anti-parallel, source to drain free-wheel diode ($FWD_i$).
Note 4. Junction temperature ($T_j$) should not exceed $T_{jmax}$ rating.
Note 5. This is the case when installing the product on the bus bar

## PERFORMANCE CURVES

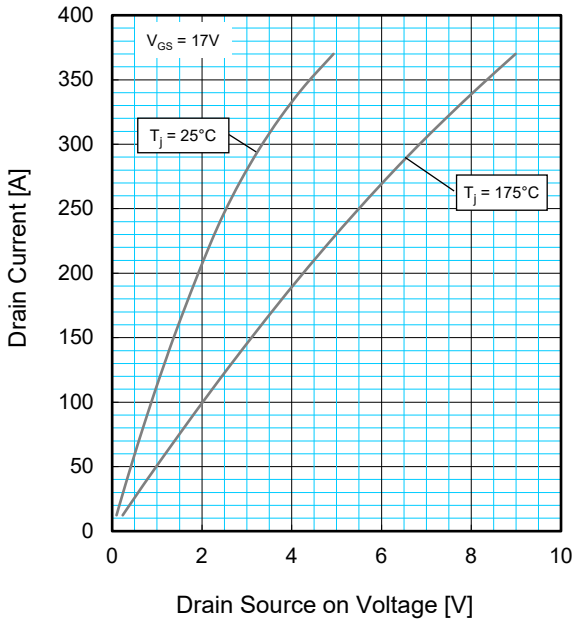
### OUTPUT CHARACTERISTICS (TYPICAL)



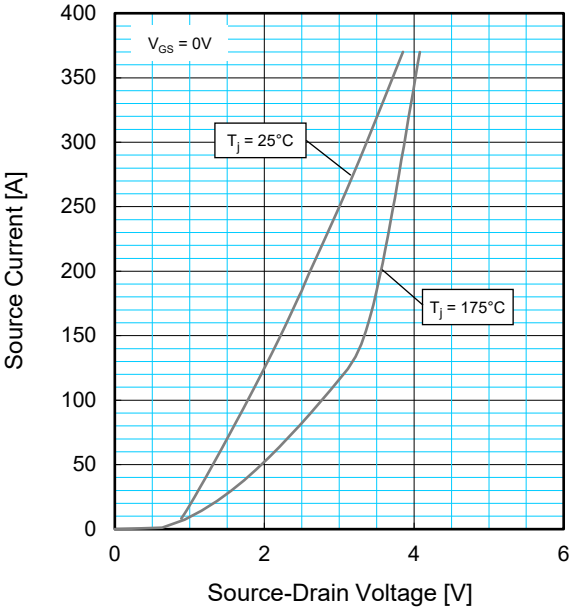

### TRANSFER CHARACTERISTICS (TYPICAL)




### DRAIN-SOURCE ON VOLTAGE CHARACTERISTICS (TYPICAL)

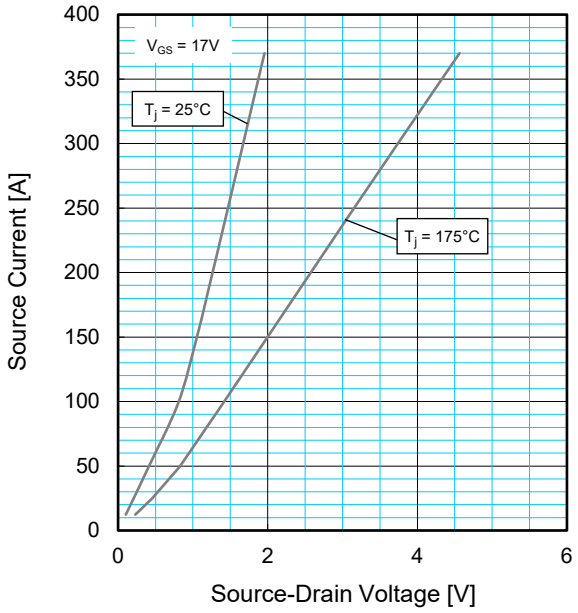



### FREE-WHEEL DIODE FORWARD CHARACTERISTICS (TYPICAL)

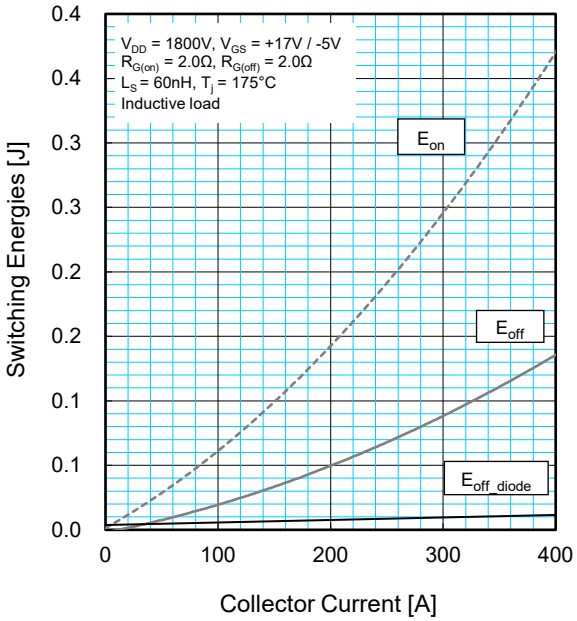


## PERFORMANCE CURVES

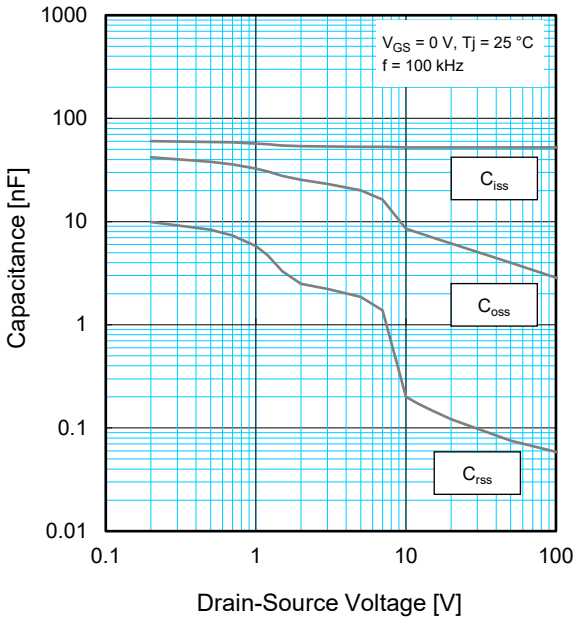
### FREE-WHEEL DIODE FORWARD CHARACTERISTICS (TYPICAL)



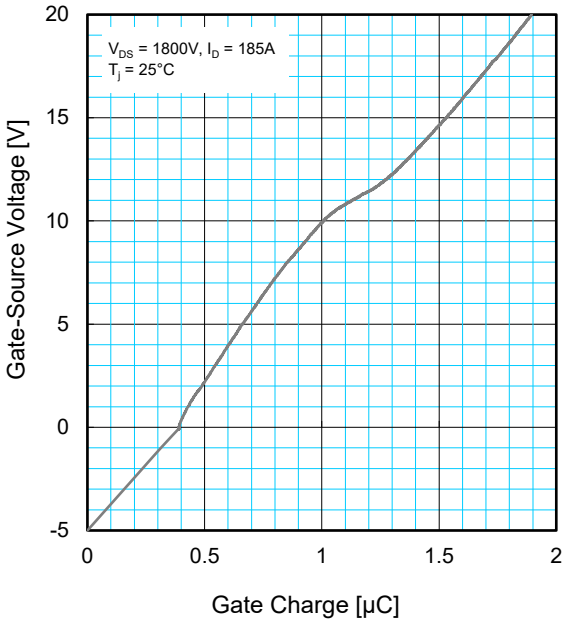

### HALF-BRIDGE SWITCHING ENERGY CHARACTERISTICS (TYPICAL)




### CAPACITANCE CHARACTERISTICS (TYPICAL)

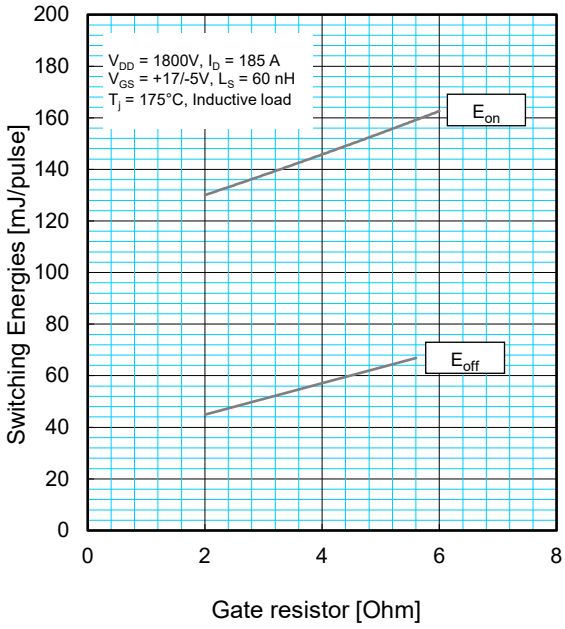



### GATE CHARGE CHARACTERISTICS (TYPICAL)

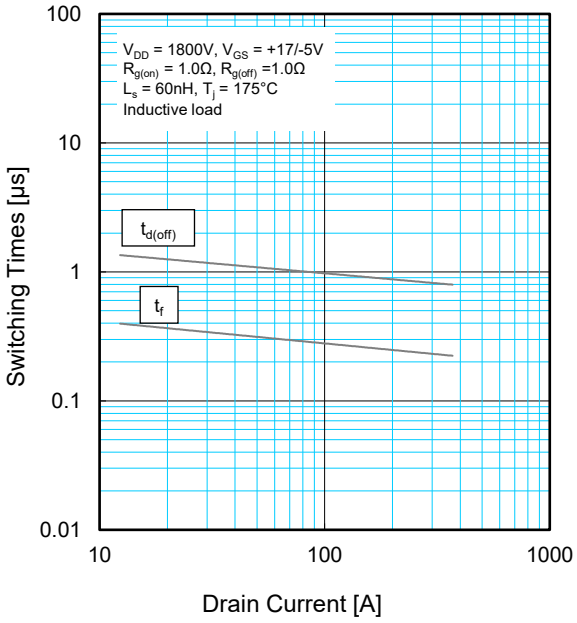


## PERFORMANCE CURVES

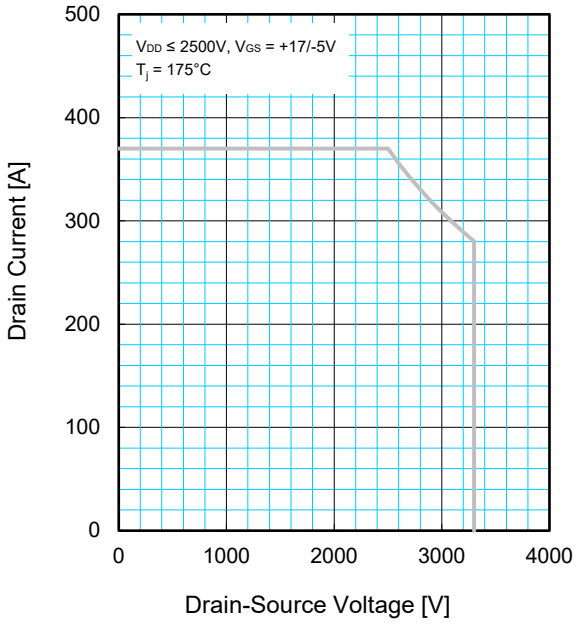
### HALF-BRIDGE SWITCHING ENERGY CHARACTERISTICS (TYPICAL)



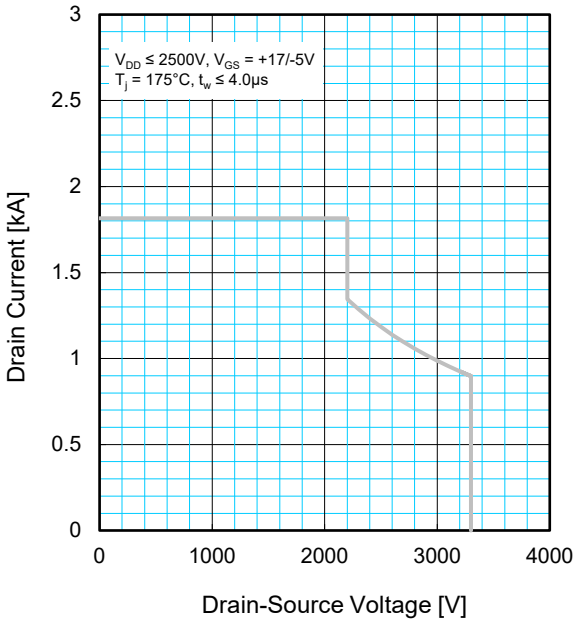

### HALF-BRIDGE SWITCHING TIME CHARACTERISTICS (TYPICAL)




### REVERSE BIAS SAFE OPERATING AREA (RBSOA)

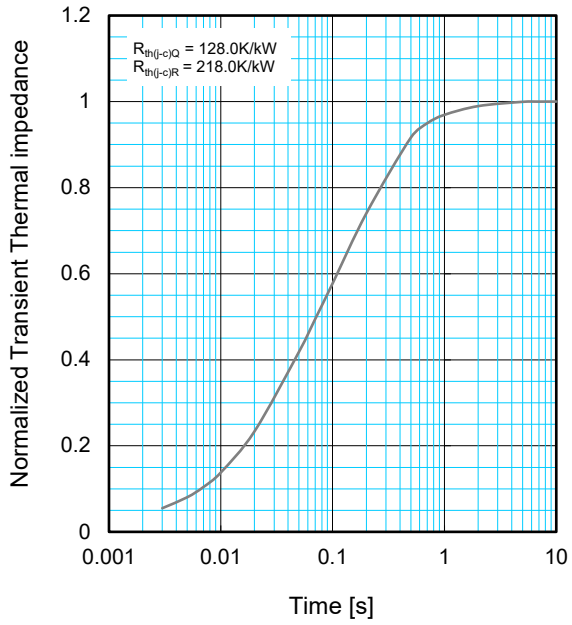



### SHORT CIRCUIT SAFE OPERATING AREA (SCSOA)



## PERFORMANCE CURVES

### TRANSIENT THERMAL IMPEDANCE CHARACTERISTICS




$$Z_{th(j-c)}(t) = \sum_{i=1}^{n} R_i \left\{ 1 - exp\left( -\frac{t}{\tau_i} \right) \right\}$$

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| $R_i$ / $R_{th}$ : | 0.0145 | 0.3107 | 0.5977 | 0.0772 |
| $\tau_i$ [sec.] : | 0.0001 | 0.0291 | 0.1797 | 1.0024 |

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