

<Full SiC Power Modules>

FMF600DXZ-24B

HIGH POWER SWITCHING USE
INSULATED TYPE



Dual switch (Half-Bridge)

Drain current I_D **600 A**
 Drain-Source voltage V_{DSX} **1200 V**
 Maximum junction temperature T_{vjmax} **175 °C**

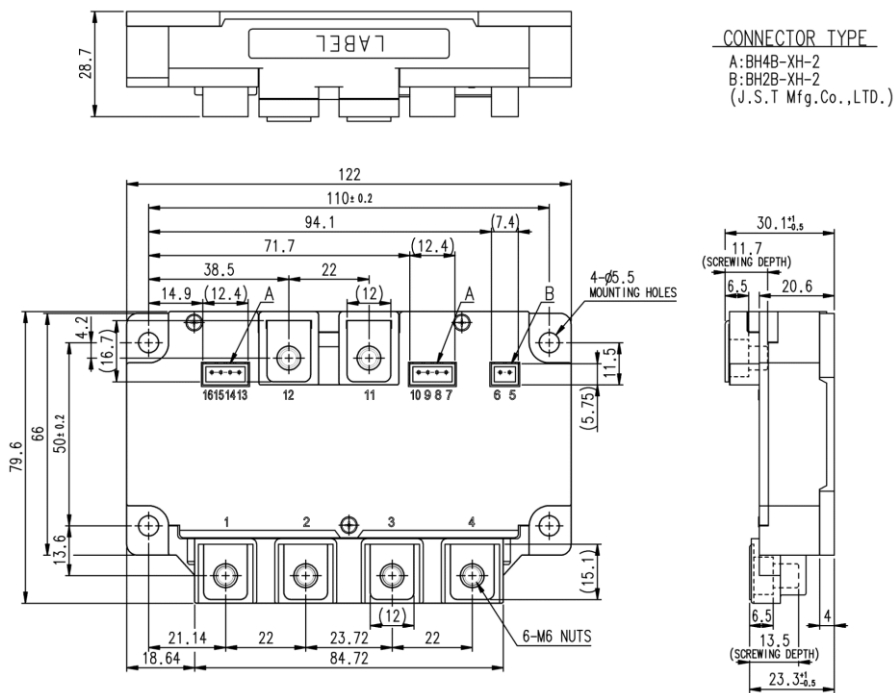
- Silicon Carbide MOSFET + Silicon Carbide Schottky Barrier Diode
- Flat base Type
- Copper base plate
- RoHS Directive compliant
- Recognized under UL1557, File E323585

APPLICATION

AC Motor Control, Motion/Servo Control, Power supply, etc.

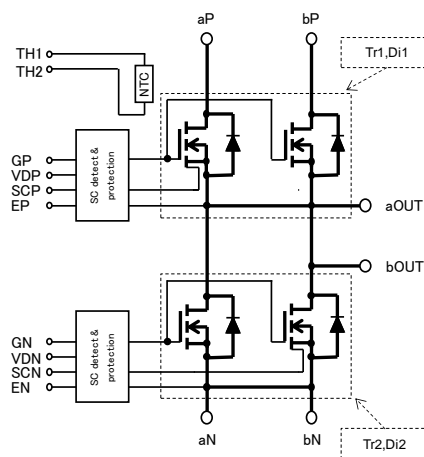
OUTLINE DRAWING & INTERNAL CONNECTION

Dimension in mm



CONNECTOR TYPE
 A: BH4B-XH-2
 B: BH2B-XH-2
 (J.S.T Mfg.Co.,LTD.)

INTERNAL CONNECTION



Terminal code

- | | |
|----|------|
| 1 | aP |
| 2 | aN |
| 3 | bN |
| 4 | bP |
| 5 | TH1 |
| 6 | TH2 |
| 7 | VDN |
| 8 | SCN |
| 9 | GN |
| 10 | EN |
| 11 | bOUT |
| 12 | aOUT |
| 13 | EP |
| 14 | GP |
| 15 | SCP |
| 16 | VDP |

Tolerance otherwise specified

| Division of Dimension | Tolerance |
|-----------------------|-----------|
| 0.5 to 3 | ±0.2 |
| over 3 to 6 | ±0.3 |
| over 6 to 30 | ±0.5 |
| over 30 to 120 | ±0.8 |
| over 120 to 400 | ±1.2 |

aP and bP, aN and bN, aOUT-bOUT must be connected externally.

FMF600DXZ-24B

HIGH POWER SWITCHING USE
INSULATED TYPEMAXIMUM RATINGS ($T_{vj}=25\text{ }^{\circ}\text{C}$, unless otherwise specified)

| Symbol | Item | Conditions | Rating | Unit |
|--------------------|--------------------------------|---|---------------|--------------------|
| V_{DSX} | Drain-source voltage | $V_{GS}=-15\text{ V}$ | 1200 | V |
| V_{GSS} | Gate-source voltage | D-S short-circuited | ± 20 | V |
| I_D | Drain current | DC, $T_C=62\text{ }^{\circ}\text{C}$ (Note.2) | 600 | A |
| I_{DRM} | | Pulse, Repetitive (Note.3), $T_{vj}=150\text{ }^{\circ}\text{C}$ (Note.4) | 900 | |
| P_{tot} | Total power dissipation | $T_C=25\text{ }^{\circ}\text{C}$ (Note. 2) | 2380 | W |
| I_S (Note.1) | Source current | DC | 600 | A |
| I_{SRM} (Note.1) | | Pulse, Repetitive (Note.3), $T_{vj}=150\text{ }^{\circ}\text{C}$ | 900 | |
| V_{isol} | Isolation voltage | Terminals to base plate, RMS, $f=60\text{ Hz}$, AC 1 min | 5000 | V |
| T_{vjmax} | Maximum junction temperature | Instantaneous event (overload) (Note.10) | 175 | $^{\circ}\text{C}$ |
| T_{vjop} | Operating junction temperature | Continuous operation (under switching) (Note.10) | $-40\sim+150$ | $^{\circ}\text{C}$ |
| T_{cmax} | Maximum case temperature | (Note.2, 10) | 125 | $^{\circ}\text{C}$ |
| T_{stg} | Storage temperature | - | $-40\sim+125$ | $^{\circ}\text{C}$ |

ELECTRICAL CHARACTERISTICS ($T_{vj}=25\text{ }^{\circ}\text{C}$, unless otherwise specified)

| Symbol | Item | Conditions (note9) | Limits | | | Unit | |
|---------------------------------|----------------------------------|---|--------------------------------------|------|------|---------------|---------------|
| | | | Min. | Typ. | Max. | | |
| I_{DSX} | Drain-source cut-off current | $V_{DS}=V_{DSX}$, $V_{GS}=-15\text{ V}$ | - | - | 6 | mA | |
| | | $V_{DS}=800\text{ V}$, $V_{GS}=-15\text{ V}$ | - | - | 0.6 | | |
| $V_{GS(th)}$ | Gate-source threshold voltage | $I_D=171\text{ mA}$, $V_{DS}=10\text{ V}$ | 1.8 | 2.5 | 3.2 | V | |
| I_{GSS} | Gate-source leakage current | $V_{GS}=V_{GSS}$, D-S short-circuited | - | - | 0.5 | μA | |
| $V_{DS(on)}$ (terminal) | Drain-source on-state voltage | $I_D=600\text{ A}$, $V_{GS}=15\text{ V}$ (Note.6) | $T_{vj}=25\text{ }^{\circ}\text{C}$ | - | 1.65 | 2.30 | V |
| | | | $T_{vj}=125\text{ }^{\circ}\text{C}$ | - | 2.10 | - | |
| | | | $T_{vj}=150\text{ }^{\circ}\text{C}$ | - | 2.20 | - | |
| $V_{DS(on)}$ (chip) | Drain-source on-state voltage | $I_D=600\text{ A}$, $V_{GS}=15\text{ V}$ (Note.6) | $T_{vj}=25\text{ }^{\circ}\text{C}$ | - | 1.35 | - | V |
| | | | $T_{vj}=125\text{ }^{\circ}\text{C}$ | - | 1.80 | - | |
| | | | $T_{vj}=150\text{ }^{\circ}\text{C}$ | - | 1.90 | - | |
| $r_{DS(on)}$ (chip) | Drain-source on-state resistance | $I_D=600\text{ A}$, $V_{GS}=15\text{ V}$ (Note.6) | $T_{vj}=25\text{ }^{\circ}\text{C}$ | - | 2.3 | - | m Ω |
| | | | $T_{vj}=125\text{ }^{\circ}\text{C}$ | - | 3.0 | - | |
| | | | $T_{vj}=150\text{ }^{\circ}\text{C}$ | - | 3.2 | - | |
| C_{iss} | Input capacitance | $V_{DS}=10\text{ V}$, $V_{GS}=0\text{ V}$ | - | 51 | - | nF | |
| C_{oss} | Output capacitance | | - | 37 | - | | |
| C_{rss} | Reverse transfer capacitance | | - | 2.6 | - | | |
| Q_G | Gate charge | $V_{DD}=600\text{ V}$, $I_D=600\text{ A}$, $V_{GS}=0\rightarrow 15\text{ V}$ | - | 1463 | - | nC | |
| $t_{d(on)}$ | Turn-on delay time | $V_{DD}=600\text{ V}$, $I_D=600\text{ A}$, $V_{GS}=\pm 15\text{ V}$, $T_{vj}=150\text{ }^{\circ}\text{C}$, $R_G=1.5\Omega$, $L_{s_ext}=16\text{ nH}$, Inductive load, per pulse | - | 170 | - | ns | |
| t_r | Rise time | | - | 70 | - | | |
| $t_{d(off)}$ | Turn-off delay time | | - | 350 | - | | |
| t_f | Fall time | | - | 40 | - | | |
| E_{on} | Turn-on switching energy | | - | 17 | - | | mJ |
| E_{off} | Turn-off switching energy | | - | 16 | - | | |
| Q_C | Drain-source charge | | - | 3 | - | | μC |
| V_{SD} (Note.1) (terminal) | Source-drain voltage | $I_S=600\text{ A}$ (Note.6) $V_{GS}=-15\text{ V}$ | $T_{vj}=25\text{ }^{\circ}\text{C}$ | - | 1.90 | 2.45 | V |
| | | | $T_{vj}=125\text{ }^{\circ}\text{C}$ | - | 2.70 | - | |
| | | | $T_{vj}=150\text{ }^{\circ}\text{C}$ | - | 2.90 | - | |
| V_{SD} (Note.1) (chip) | Source-drain voltage | $I_S=600\text{ A}$ (Note.6) $V_{GS}=-15\text{ V}$ | $T_{vj}=25\text{ }^{\circ}\text{C}$ | - | 1.60 | - | V |
| | | | $T_{vj}=125\text{ }^{\circ}\text{C}$ | - | 2.40 | - | |
| | | | $T_{vj}=150\text{ }^{\circ}\text{C}$ | - | 2.60 | - | |
| $R_{DD+SS'}$ | Internal lead resistance | P-EP, OUT-EN terminals, per switch | - | 0.5 | - | m Ω | |
| L_s | Internal stray inductance | P-N | - | 10 | - | nH | |
| $r_{g(on)}$ | Internal gate resistance (on) | Per switch | - | 1.32 | - | Ω | |
| $r_{g(off)}$ | Internal gate resistance (off) | Per switch | - | 6.15 | - | Ω | |

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HIGH POWER SWITCHING USE
INSULATED TYPE

THERMAL RESISTANCE CHARACTERISTICS

| Symbol | Item | Conditions | Limits | | | Unit |
|----------------|--|--|--------|------|------|------|
| | | | Min. | Typ. | Max. | |
| $R_{th(j-c)Q}$ | Thermal resistance ^(Note. 2) | Junction to case, per inverter switch | - | - | 63 | K/kW |
| $R_{th(j-c)D}$ | | Junction to case, per inverter FWD | - | - | 75 | |
| $R_{th(c-s)}$ | Contact thermal resistance ^(Note.2) | Case to heat sink, per 1 module, Thermal grease applied ^(Note.8, 10) | - | 12 | - | K/kW |

NTC THERMISTOR PART

| Symbol | Item | Conditions | Limits | | | Unit |
|---------------|-------------------------|---|--------|------|------|------|
| | | | Min. | Typ. | Max. | |
| R_{25} | Zero-power resistance | $T_C=25\text{ }^\circ\text{C}$ ^(Note.2) | 4.85 | 5.00 | 5.15 | kΩ |
| $\Delta R/R$ | Deviation of resistance | $T_C=100\text{ }^\circ\text{C}$ ^(Note.2) , $R_{100}=493\text{ }\Omega$ | -7.3 | - | +7.8 | % |
| $B_{(25/50)}$ | B-constant | Approximate by equation ^(Note.7) | - | 3375 | - | K |
| P_{25} | Power dissipation | $T_C=25\text{ }^\circ\text{C}$ ^(Note.2) | - | - | 10 | mW |

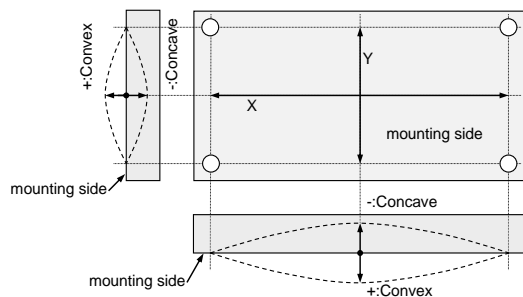
MECHANICAL CHARACTERISTICS

| Symbol | Item | Conditions | Limits | | | Unit |
|--------|---------------------------|--|--------|------|------|------|
| | | | Min. | Typ. | Max. | |
| M_t | Mounting torque | Main terminals M 6 screw | 3.5 | 4.0 | 4.5 | N·m |
| M_s | | Mounting to heat sink M 5 screw | 2.5 | 3.0 | 6.0 | |
| m | mass | - | - | 500 | - | g |
| d_a | Clearance | - | 10 | - | - | mm |
| d_s | Creepage distance | - | 17 | - | - | mm |
| e_c | Flatness of base plate | On the centerline X, Y ^(Note.5) | -100 | - | +100 | μm |
| - | Connector insertion force | 2 pin type | 0 | - | 25 | N |
| - | | 4 pin type | 0 | - | 35 | N |

*: This product is compliant with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) directive 2011/65/EU and (EU)2015/863.

Note1. Represent ratings and characteristics of the anti-parallel, source-drain free wheeling diode (FWD).

- Case temperature (T_C) and heat sink temperature (T_s) are defined on the each surface (mounting side) of base plate and heat sink just under the chips. Refer to the figure of chip location.
- Pulse width and repetition rate should be such that the device junction temperature (T_{vj}) does not exceed T_{vjmax} rating.
- Junction temperature (T_{vj}) should not increase beyond T_{vjmax} rating.
- The base plate (mounting side) flatness measurement points (X, Y) are as follows of the following figure.



- Pulse width and repetition rate should be such as to cause negligible temperature rise.

$$7. B_{(25/50)} = \ln\left(\frac{R_{25}}{R_{50}}\right) / \left(\frac{1}{T_{25}} - \frac{1}{T_{50}}\right)$$

R_{25} : resistance at absolute temperature T_{25} [K]; $T_{25}=25\text{ }^\circ\text{C}+273.15=298.15$ [K]

R_{50} : resistance at absolute temperature T_{50} [K]; $T_{50}=50\text{ }^\circ\text{C}+273.15=323.15$ [K]

- Typical value is measured by using thermally conductive grease of $\lambda=0.9\text{ W}/(\text{m}\cdot\text{K})/D_{(c-s)}=100\mu\text{m}$.
- Per switch (ex. Tr1 chips total in page.6)

- Long term performance related to thermal conductive grease (including but not limited to aspects such as the increase of thermal resistance due to pumping out, etc.) should be verified under your specific application conditions. Each temperature condition (T_{vjmax} , T_{vjop} , T_{Cmax}) must be maintained below the maximum rated temperature throughout consideration of the temperature rise even for long term usage.

FMF600DXZ-24BHIGH POWER SWITCHING USE
INSULATED TYPE**RECOMMENDED OPERATING CONDITIONS**

| Symbol | Item | Conditions | Limits | | | Unit |
|----------------|---|---|--------|-------|------|----------|
| | | | Min. | Typ. | Max. | |
| V_{DD} | (DC) Supply voltage | Applied across aP -aN, bP-bN terminals | - | 600 | 850 | V |
| V_D | DC supply voltage (control) | Applied across VDP-EP, VDN-EN terminals | 13.5 | 15.0 | 16.5 | V |
| $V_{GS(+)}$ | Gate-Source positive drive voltage | Applied across GP-EP, GN-EN terminals | 13.5 | 15.0 | 16.5 | V |
| $V_{GS(-)}$ | Gate-Source negative drive voltage | Applied across GP-EP, GN-EN terminals | -16.5 | -15.0 | -7.0 | V |
| R_G | External gate resistance ^(Note.11) | Per switch | 1.5 | - | 7.5 | Ω |
| f_c | Switching frequency | $V_{GS}=\pm 15V$, $R_G=1.5\Omega$, $V_{DD}=600V$, $T_{vj}=150^\circ C$ | - | - | 50 | kHz |
| $t_{d(SCoff)}$ | Gate cutoff delay time after SC output | $V_{GS}=15V$, $R_G=1.5\Omega$, $V_{DD}=600V$, $T_{vj}=150^\circ C$ | - | - | 3 | μs |

Note 11. The value of external gate resistance should be considered the surge voltage not to exceed the rating voltage in the worst system condition.

SHORT CIRCUIT DETECTION & PROTECTION CHARACTERISTICS

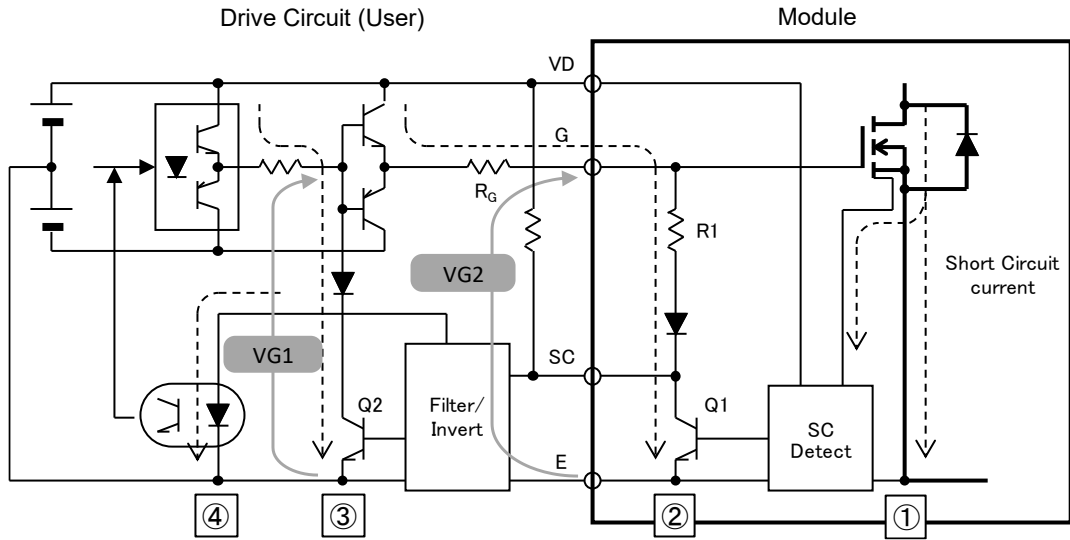
| Symbol | Item | Conditions | Limits | | | Unit |
|--------------|-------------------------------------|---|--------|------|------|----------|
| | | | Min. | Typ. | Max. | |
| $I_{D(SC)}$ | SC detect drain current | $T_{vj}=150^\circ C$, $V_{GS}=15V$ | 900 | 1200 | - | A |
| $t_{d(SC)}$ | SC detect delay time | $T_{vj}=150^\circ C$, $V_{GS}=15V$, $R_G=1.5\Omega$ | - | 1 | - | μs |
| $V_{GS(SC)}$ | SC protection gate limit voltage | $T_{vj}=150^\circ C$, $V_{GS}=15V$, $R_G=1.5\Omega$ | - | 10 | - | V |
| R1 | SC protection gate limit resistance | - | - | 2.35 | - | Ω |

Refer to the circuit in page.5

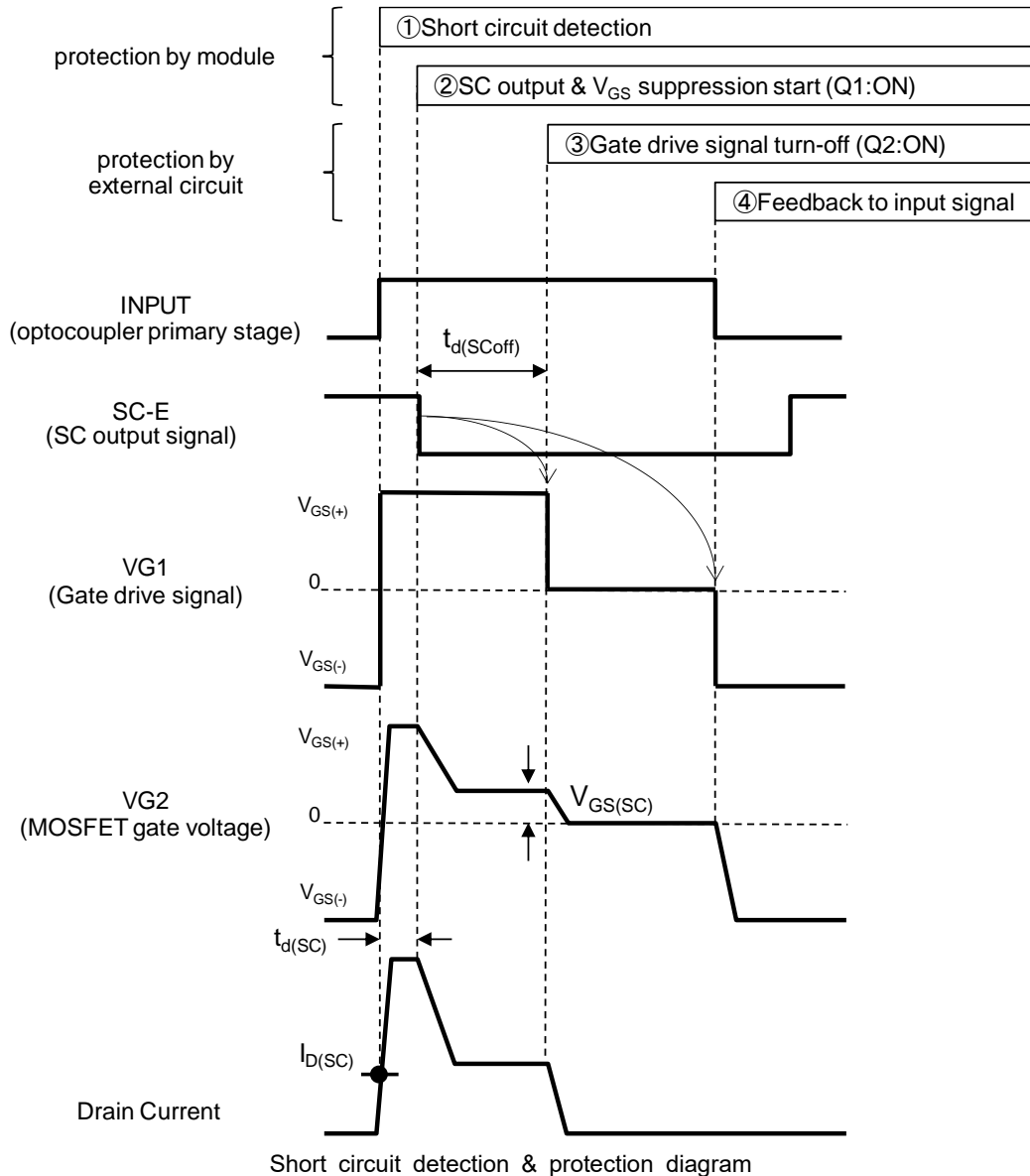
FMF600DXZ-24B

HIGH POWER SWITCHING USE
INSULATED TYPE

SHORT CIRCUIT DETECTION & PROTECTION



Example of application (Short circuit detection & protection)



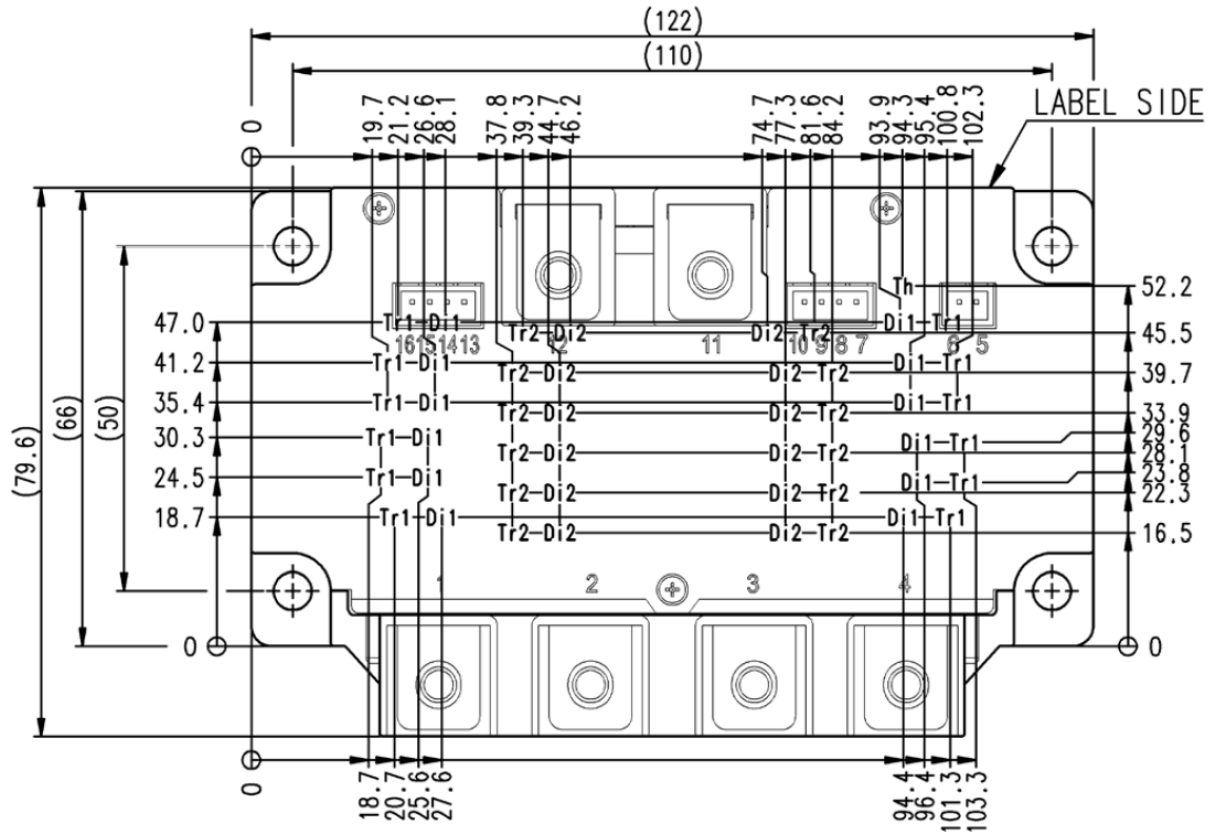
Short circuit detection & protection diagram

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HIGH POWER SWITCHING USE
INSULATED TYPE

CHIP LOCATION (Top view)

Dimension in mm, tolerance: ± 1 mm

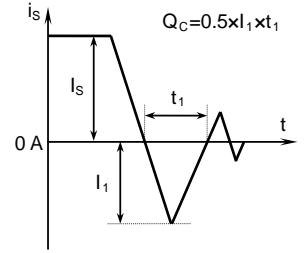
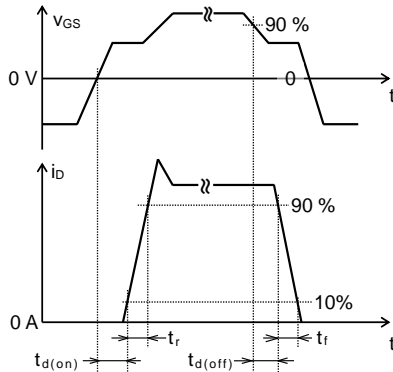
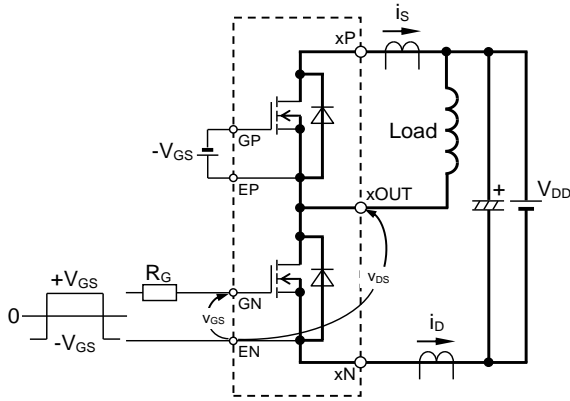


Tr1,Tr2: SiC-MOSFET, Di1,Di2: SiC-SBD, Th: NTC thermistor

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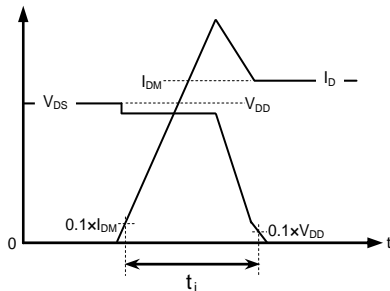
HIGH POWER SWITCHING USE
INSULATED TYPE

TEST CIRCUIT AND WAVEFORMS

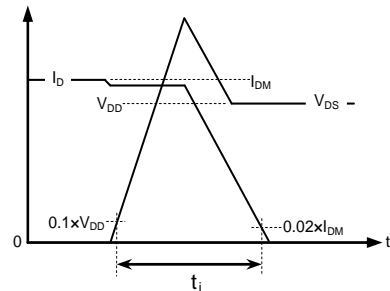


Switching characteristics test circuit and waveforms(x: connected a* and b*)

Q_C test waveform



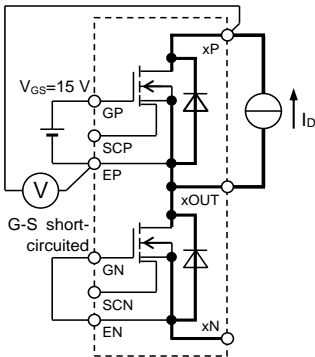
MOSFET Turn-on switching energy



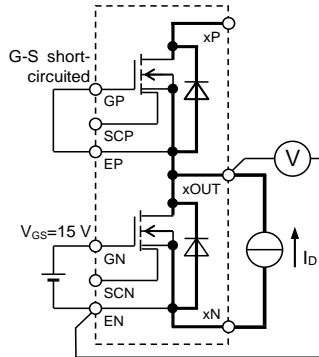
MOSFET Turn-off switching energy

Turn-on / Turn-off switching energy test waveforms (Integral time instruction drawing)

TEST CIRCUIT

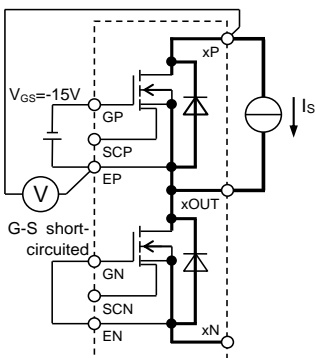


Tr1

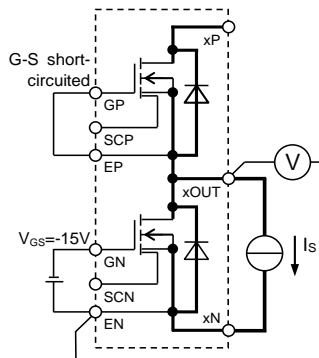


Tr2

V_{DS(on)} test circuit (x: Connected a* and b*)

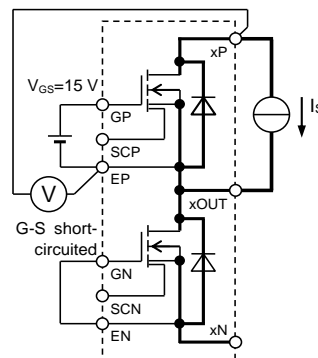


Di1

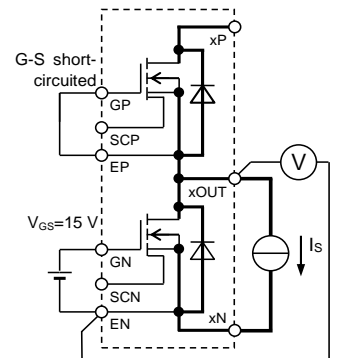


Di2

V_{SD} test circuit, V_{GS} = -15V (x: Connected a* and b*)



Tr1&Di1



Tr2&Di2

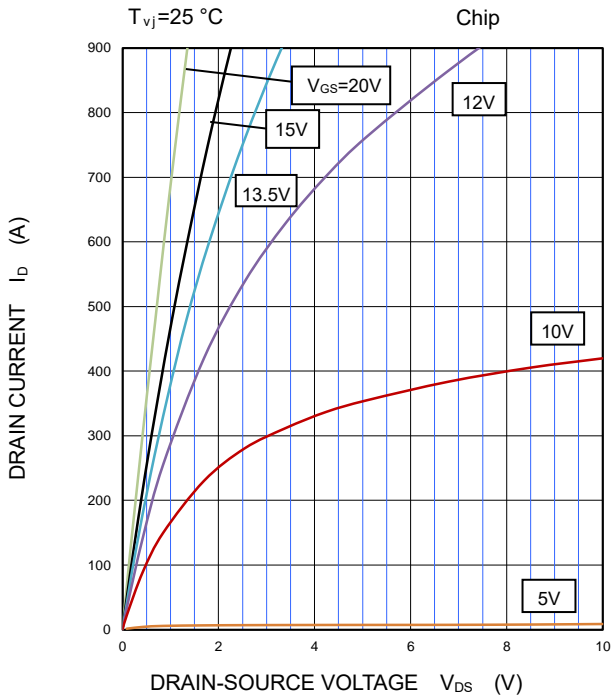
V_{SD} test circuit, V_{GS} = 15V (x: Connected a* and b*)

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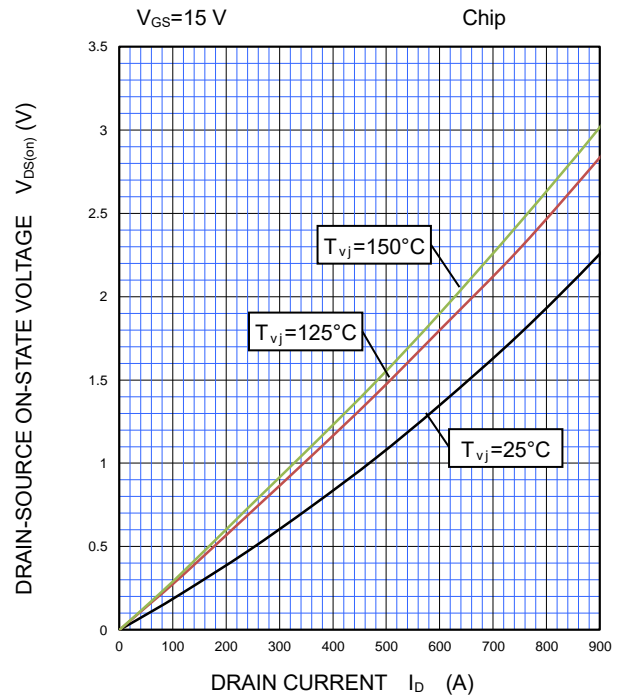
HIGH POWER SWITCHING USE
INSULATED TYPE

PERFORMANCE CURVES

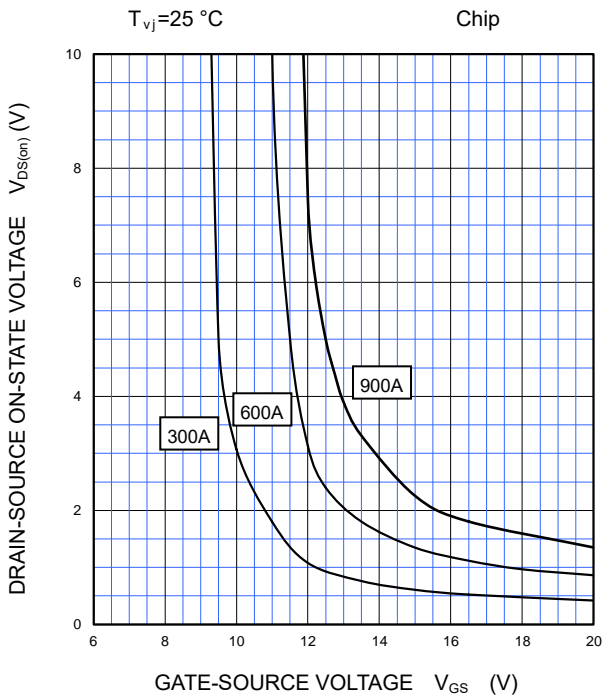
OUTPUT CHARACTERISTICS (TYPICAL)



DRAIN-SOURCE ON STATE VOLTAGE CHARACTERISTICS (TYPICAL)



DRAIN-SOURCE ON STATE VOLTAGE CHARACTERISTICS (TYPICAL)

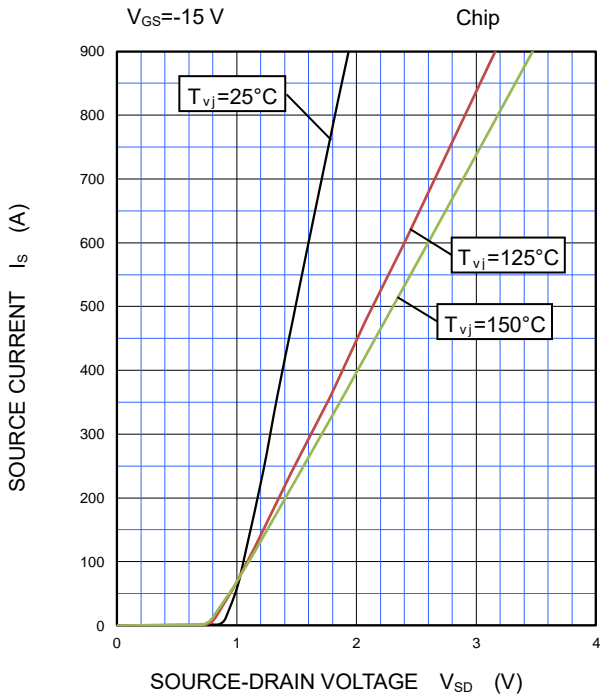


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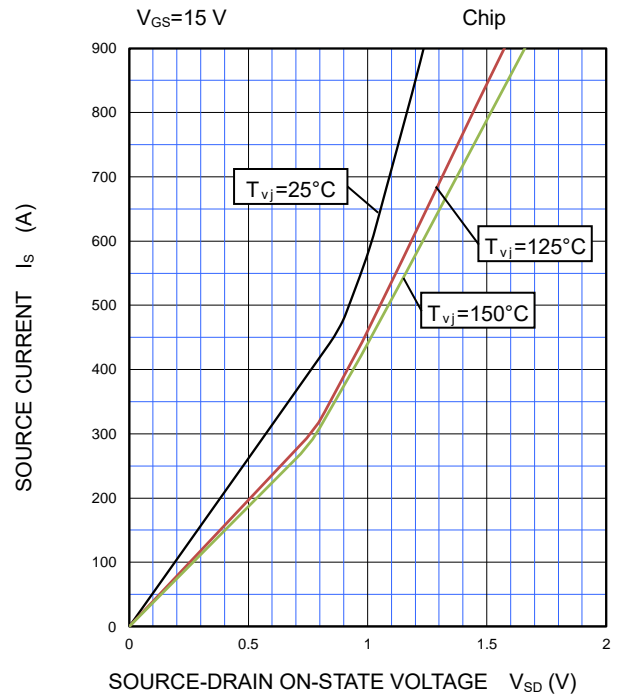
HIGH POWER SWITCHING USE
INSULATED TYPE

PERFORMANCE CURVES

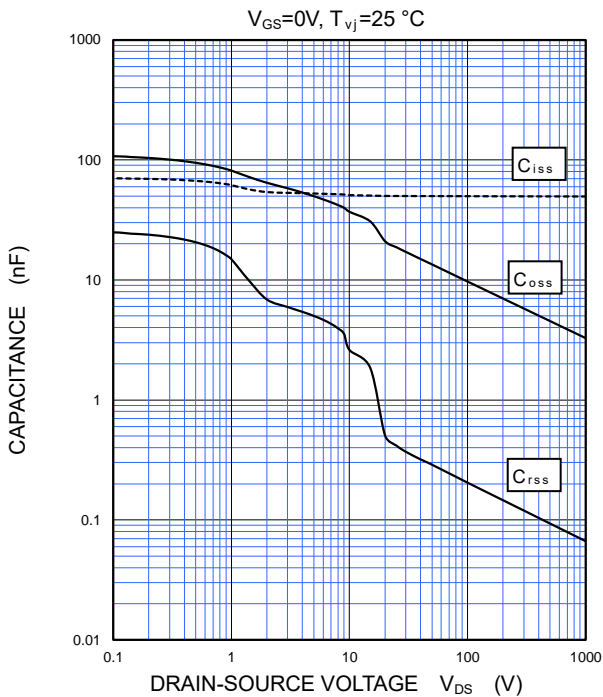
FREE WHEELING DIODE
FORWARD CHARACTERISTICS
(TYPICAL)



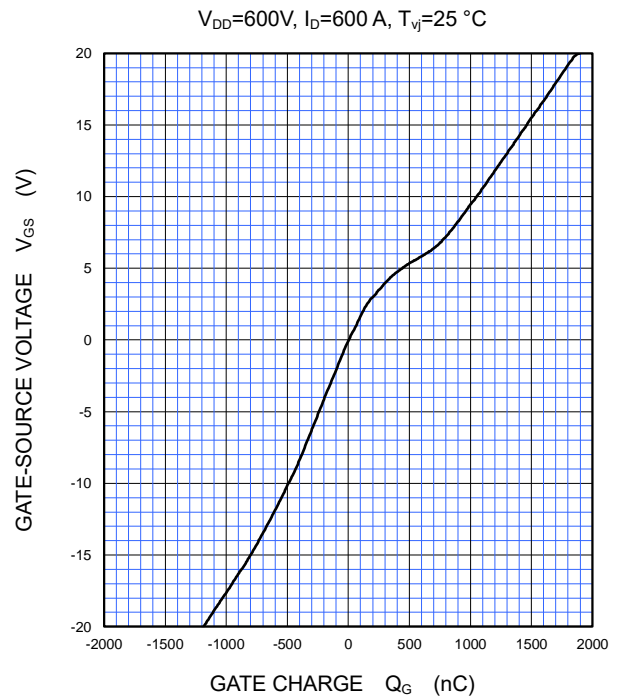
SOURCE-DRAIN ON STATE VOLTAGE
CHARACTERISTICS
(TYPICAL)



CAPACITANCE
CHARACTERISTICS
(TYPICAL)



GATE CHARGE
CHARACTERISTICS
(TYPICAL)



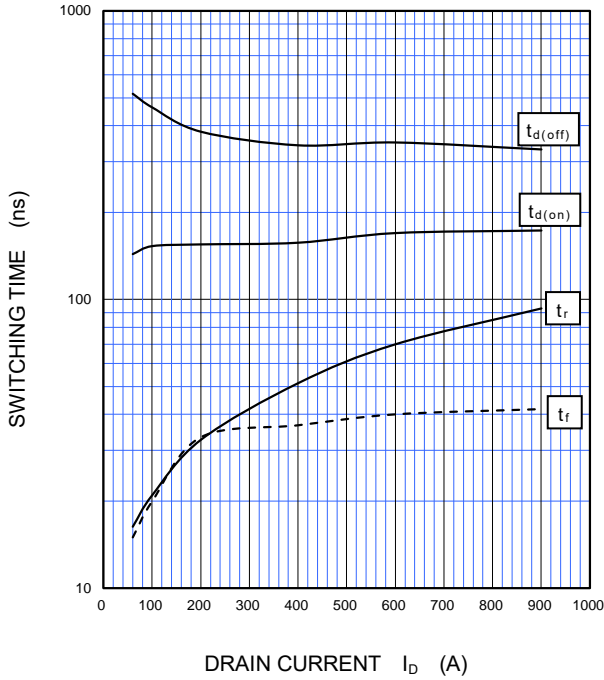
FMF600DXZ-24B

HIGH POWER SWITCHING USE
INSULATED TYPE

PERFORMANCE CURVES

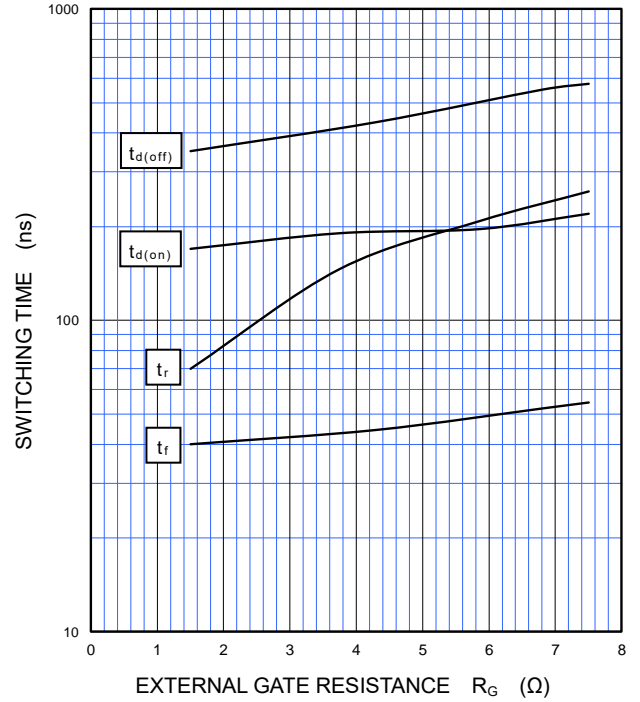
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

$V_{DD}=600\text{ V}$, $V_{GS}=\pm 15\text{ V}$, $R_G=1.5\ \Omega$, $L_{s_ext}=16\text{ nH}$
 $T_{vj}=150\text{ }^\circ\text{C}$, INDUCTIVE LOAD



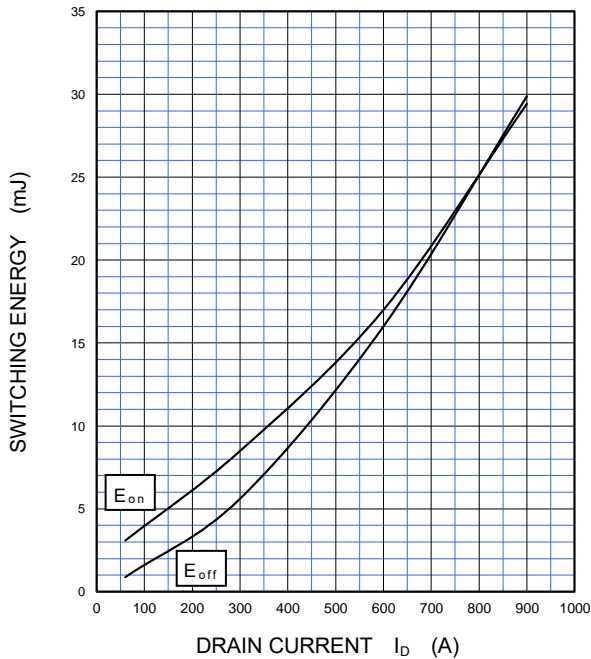
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

$V_{DD}=600\text{ V}$, $V_{GS}=\pm 15\text{ V}$, $I_D=600\text{ A}$, $L_{s_ext}=16\text{ nH}$
 $T_{vj}=150\text{ }^\circ\text{C}$, INDUCTIVE LOAD



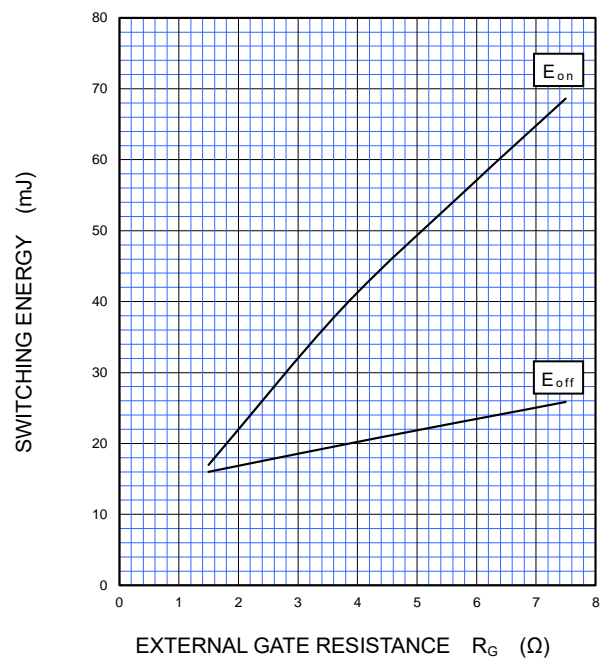
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

$V_{DD}=600\text{ V}$, $V_{GS}=\pm 15\text{ V}$, $R_G=1.5\ \Omega$, $T_{vj}=150\text{ }^\circ\text{C}$, $L_{s_ext}=16\text{ nH}$
INDUCTIVE LOAD, PER PULSE



HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

$V_{DD}=600\text{ V}$, $V_{GS}=\pm 15\text{ V}$, $I_D=600\text{ A}$, $T_{vj}=150\text{ }^\circ\text{C}$, $L_{s_ext}=16\text{ nH}$
INDUCTIVE LOAD, PER PULSE



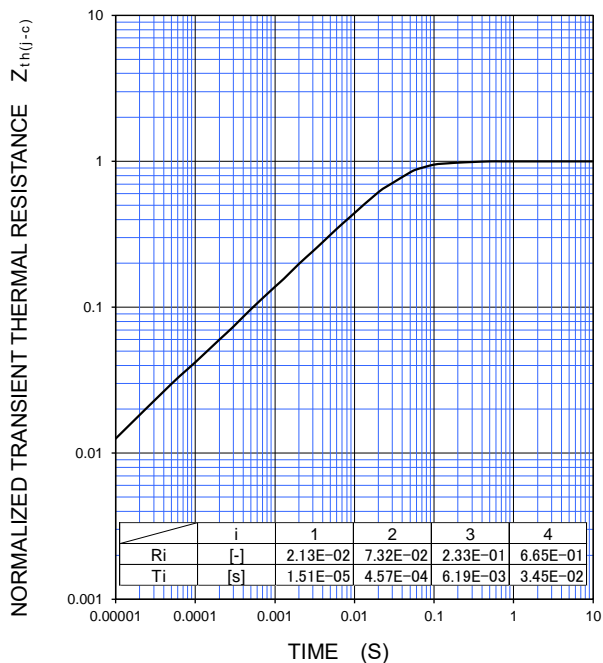
FMF600DXZ-24B

HIGH POWER SWITCHING USE
INSULATED TYPE

PERFORMANCE CURVES

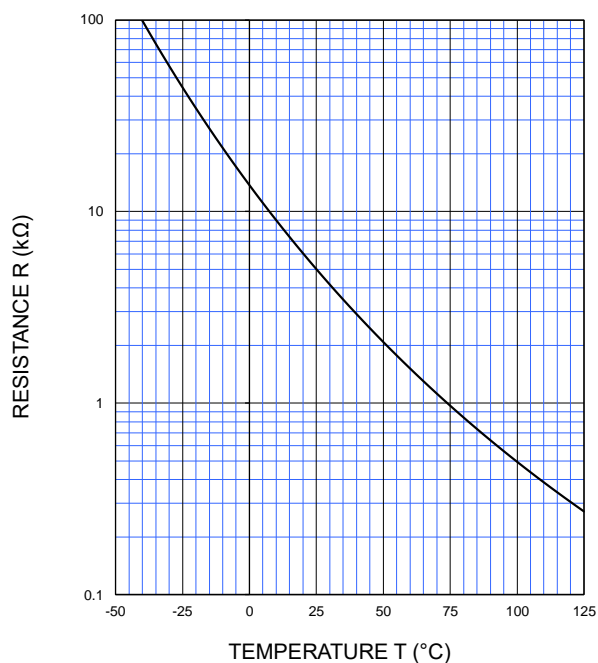
TRANSIENT THERMAL IMPEDANCE CHARACTERISTICS (MAXIMUM)

Single pulse, $T_c=25\text{ }^\circ\text{C}$
 $R_{th(j-c)Q}=63\text{K/kW}$, $R_{th(j-c)D}=75\text{K/kW}$



NTC thermistor part

TEMPERATURE CHARACTERISTICS (TYPICAL)



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

Important Notice

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