<Full SiC Power Modules>

FMF400DY-24B

HIGH POWER SWITCHING USE
INSULATED TYPE

Dual switch (Half-Bridge)

Drain current I_D ..... **400** A
Drain-Source voltage V_{DSX} ..... **1200** V
Maximum junction temperature T_{vjmax} ..... **175** °C

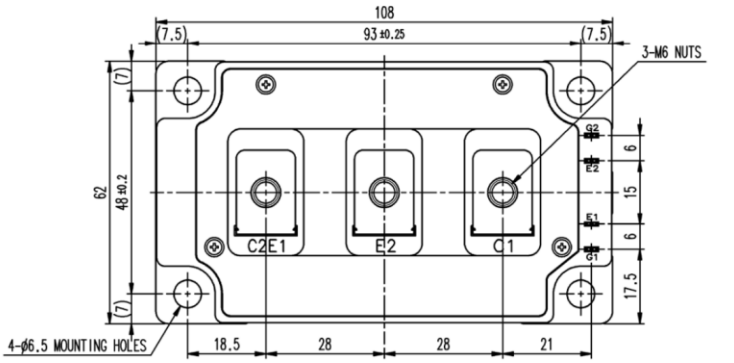
- ●Silicon Carbide MOSFET + Silicon Carbide Schottky Barrier Diode
- ●Flat base Type
- ●Copper base plate
- ●RoHS Directive compliant
- ●Recognized under UL1557, File E323585

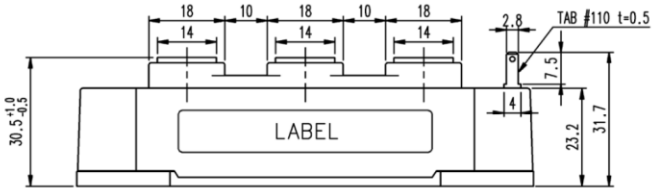
APPLICATION

Power supply, etc.

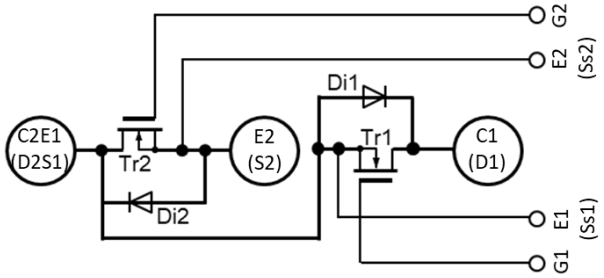
OUTLINE DRAWING & INTERNAL CONNECTION

Dimension in mm





INTERNAL CONNECTION



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

<Full SiC Power Modules>

FMF400DY-24B

HIGH POWER SWITCHING USE
INSULATED TYPE

MAXIMUM RATINGS (T_{vj} =25 °C, unless otherwise specified)

Symbol	Item	Conditions	Rating	Unit
V_{DSX}	Drain-source voltage	V_{GS}=-15 V	1200	V
V_{GSS}	Gate-source voltage	D-S short-circuited	±20	V
I_D	Drain current	DC, T_C=36℃ (Note.2)	400	A
I_{DRM}		Pulse, Repetitive (Note.3)	800	
P_{tot}	Total power dissipation	T_C=25 °C (Note. 2)	1360	W
I_S (Note.1)	Source current	DC	400	A
I_{SRM} (Note.1)		Pulse, Repetitive (Note.3)	800	
V_{isol}	Isolation voltage	Terminals to base plate, RMS, f=60 Hz, AC 1 min	4000	V
T_{vjmax}	Maximum junction temperature	Instantaneous event (overload) (Note.9)	175	°C
T_{vjop}	Operating junction temperature	Continuous operation (under switching) (Note.9)	-40～+150	°C
T_{cmax}	Maximum case temperature	(Note.2,9)	125	°C
T_{stg}	Storage temperature	-	-40～+125	°C

ELECTRICAL CHARACTERISTICS (T_{vj}=25 °C, unless otherwise specified)

Symbol	Item	Conditions (note. 8)		Limits			Unit
				Min.	Typ.	Max.	
I_{DSX}	Drain-source cut-off current	V_{DS}=V_{DSX}, V_{GS}=-15 V		-	-	4	mA
		V_{DS}=800V, V_{GS}=-15 V		-	-	0.4	
$V_{GS(th)}$	Gate-source threshold voltage	I_D=107 mA, V_{DS}=10 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=400 A, V_{GS}=15V (Note.6)	T_{vj}=25 °C	-	1.75	2.45	V
			T_{vj}=125 °C	-	2.25	-	
			T_{vj}=150 °C	-	2.35	-	
$V_{DS(on)}$ (chip)	Drain-source on-state voltage	I_D=400 A, V_{GS}=15V (Note.6)	T_{vj}=25 °C	-	1.45	-	V
			T_{vj}=125 °C	-	1.95	-	
			T_{vj}=150 °C	-	2.05	-	
$r_{DS(on)}$ (chip)	Drain-source on-state resistance	I_D=400 A, V_{GS}=15V (Note.6)	T_{vj}=25 °C	-	3.6	-	mΩ
			T_{vj}=125 °C	-	4.9	-	
			T_{vj}=150 °C	-	5.1	-	
C_{iss}	Input capacitance	V_{DS}=10 V, V_{GS}=0V		-	32	-	nF
C_{oss}	Output capacitance			-	23	-	
C_{rss}	Reverse transfer capacitance			-	1.6	-	
Q_G	Gate charge	V_{DD}=600 V, I_D=400 A, V_{GS}=0→15 V		-	914	-	nC
$t_{d(on)}$	Turn-on delay time	V_{DD}=600 V, I_D=400 A, V_{GS}=±15 V, T_{vj}=150℃, $R_{G(on)}$=1.5Ω, $R_{G(off)}$=2.2Ω, L_{s_ext}=25nH, Inductive load, per pulse		-	140	-	ns
t_r	Rise time			-	65	-	
$t_{d(off)}$	Turn-off delay time			-	185	-	
t_f	Fall time			-	40	-	
E_{on}	Turn-on switching energy			-	12	-	mJ
E_{off}	Turn-off switching energy			-	9	-	
Q_C	Drain-source charge			-	3	-	μC
V_{SD} (Note.1) (terminal)	Source-drain voltage	I_S=400 A(Note.6) V_{GS}=-15 V	T_{vj}=25 °C	-	1.95	2.60	V
			T_{vj}=125 °C	-	2.80	-	
			T_{vj}=150 °C	-	3.00	-	
V_{SD} (Note.1) (chip)	Source-drain voltage	I_S=400 A (Note.6) V_{GS}=-15 V	T_{vj}=25 °C	-	1.65	-	V
			T_{vj}=125 °C	-	2.50	-	
			T_{vj}=150 °C	-	2.70	-	
$R_{DD'+SS'}$	Internal lead resistance	Across P-N terminals, (Note.2)		-	0.75	-	mΩ
L_s	Internal stray inductance	Across P-N terminals		-	21	-	nH
r_g	Internal gate resistance	Per switch		-	2.5	-	Ω

Caution: Short-circuit capability is not designed.

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	-	-	110	K/kW
$R_{th(j-c)D}$		Junction to case, per inverter FWD	-	-	150	
$R_{th(c-s)}$	Contact thermal resistance(Note.2)	Case to heat sink, per 1 module, Thermal grease applied (Note.7, 9)	-	10	-	K/kW

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 6 screw	3.5	3.0	4.5	
m	mass	-		-	400	-	g
d_a	Clearance	Terminal to terminal		11	-	-	mm
		Terminal to base plate		29	-	-	
d_s	Creepage distance	Terminal to terminal		20	-	-	mm
		Terminal to base plate		37	-	-	
e_c	Flatness of base plate	On the centerline X, Y (Note.5)		-100	-	100	μm

*: 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.

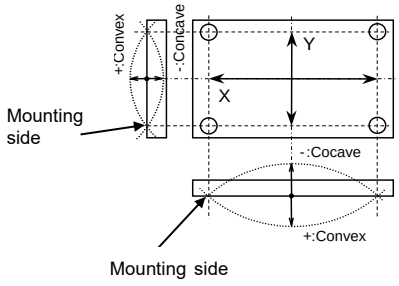
Note1. Represent ratings and characteristics of the anti-parallel, source-drain free wheeling diode (FWD).

2. 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.

3. Pulse width and repetition rate should be such that the device junction temperature (T_{vj}) does not exceed T_{vjmax} rating.

4. Junction temperature (T_{vj}) should not increase beyond T_{vjmax} rating.

5. The base plate (mounting side) flatness measurement points (X, Y) are as follows of the following figure.



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

7. Typical value is by thermally conductive grease of λ=0.9 W/(m·K)/$D_{(C-S)}$=100μm.

8. Per switch

9. 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 ($T_{vj\,max}$, $T_{vj\,op}$, $T_{C\,max}$) must be maintained below the maximum rated temperature throughout consideration of the temperature rise even for long term usage.

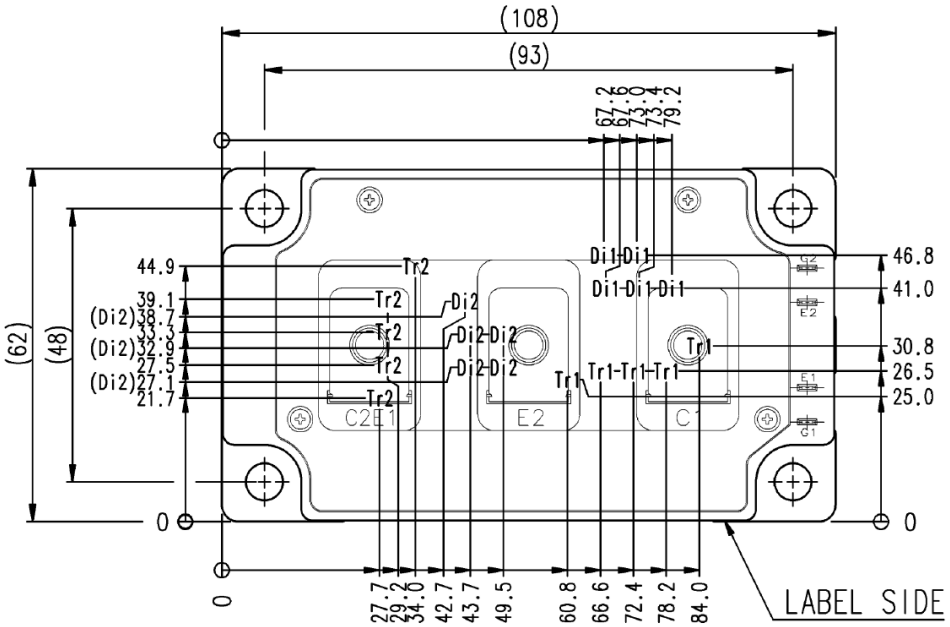
RECOMMENDED OPERATING CONDITIONS

Symbol	Item	Conditions		Limits			Unit
				Min.	Typ.	Max.	
V_{DD}	(DC) Supply voltage	Applied across D1-S2 terminals		-	600	850	V
$V_{GS(+)}$	Gate-Source positive drive voltage	Applied across G1-Ss1, G2-Ss2 terminals		13.5	15.0	16.5	V
$V_{GS(-)}$	Gate-Source negative drive voltage	Applied across G1-Ss1, G2-Ss2 terminals		-16.5	-15.0	-7.0	V
$R_{G(on)}$	External gate resistance (Note.10)	Per switch		1.5	-	7.5	Ω
$R_{G(off)}$				2.2	-	11.0	
f_c	Switching frequency	$V_{GS(+)}$=15V, $R_{G(on)}$=1.5Ω, $R_{G(off)}$=2.2Ω	$V_{GS(-)}$<-10V	-	-	50	kHz
		V_{DD}=600V, T_{vj}=150℃	$V_{GS(-)}$≧-10V	-	-	100	

Note 10. The value of external gate resistance should be considered the surge voltage not to exceed the rating voltage in the worst system condition.

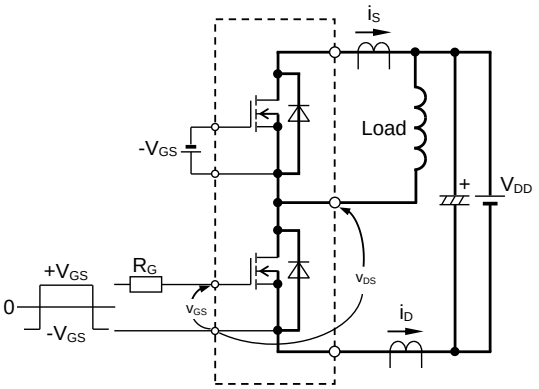
CHIP LOCATION (Top view)

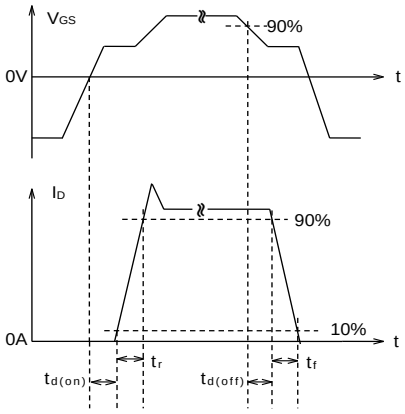
Dimension in mm, tolerance: ±1 mm

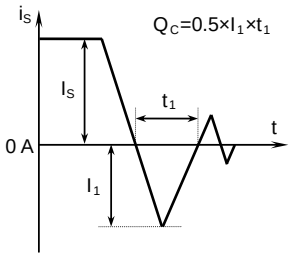


Tr1,Tr2: SiC-MOSFET, Di1,Di2: SiC-SBD

TEST CIRCUIT AND WAVEFORMS

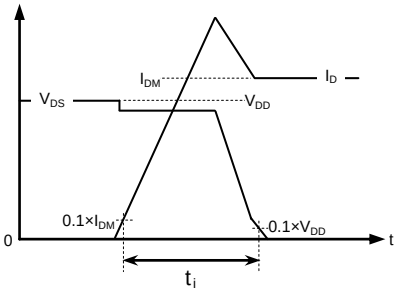


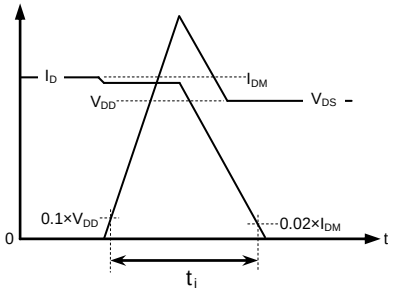




Switching characteristics test circuit and waveforms

Q_C test waveform



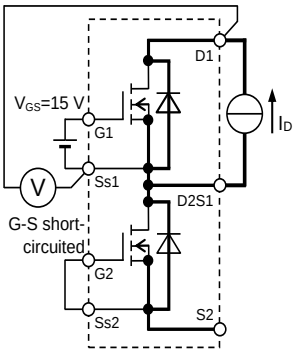


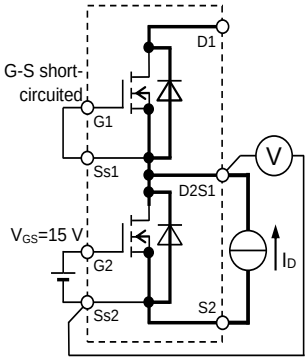
MOSFET Turn-on switching energy

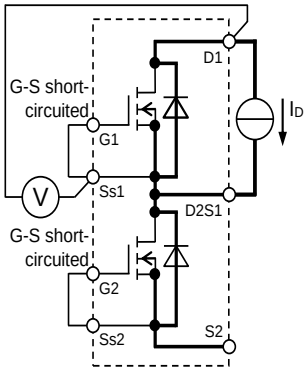
MOSFET Turn-off switching energy

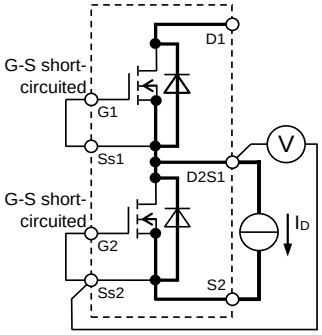
Turn-on / Turn-off switching energy test waveforms (Integral time instruction drawing)

TEST CIRCUIT









Tr1

Tr2

Di1

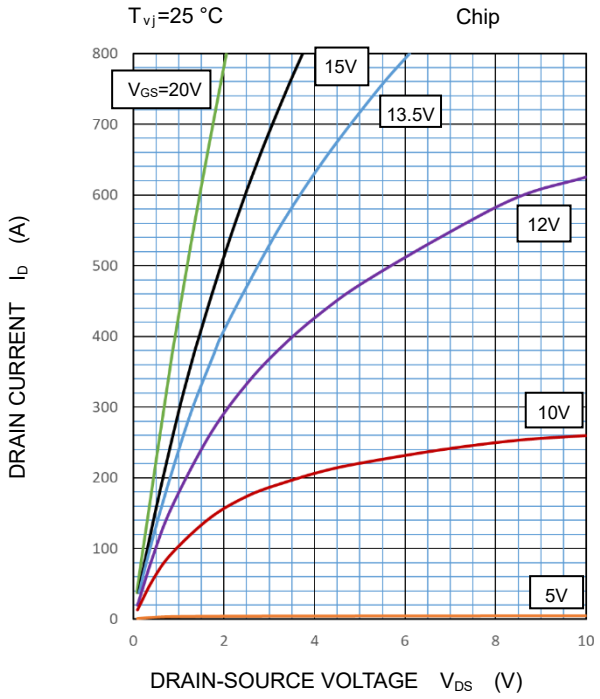
Di2

$V_{DS(on)}$ test circuit

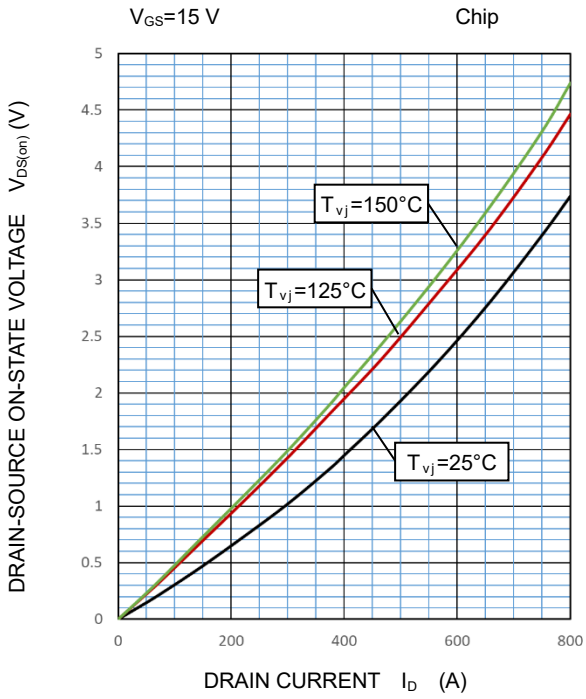
V_{SD} test circuit

PERFORMANCE CURVES

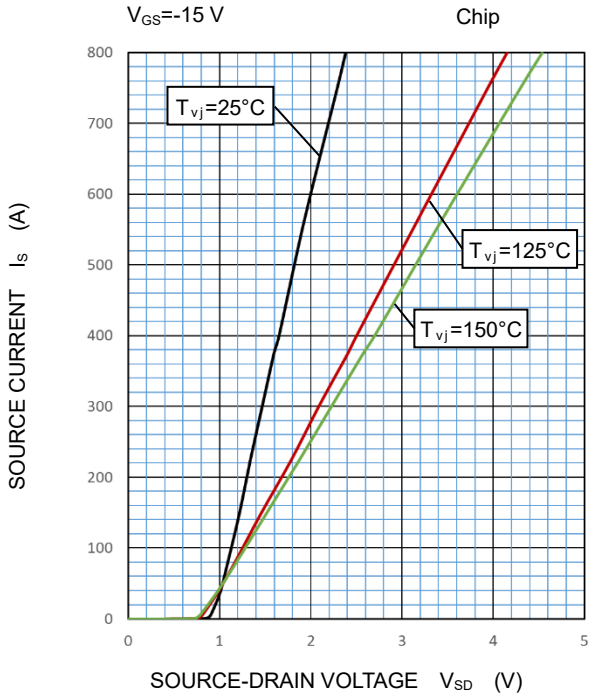
OUTPUT CHARACTERISTICS (TYPICAL)



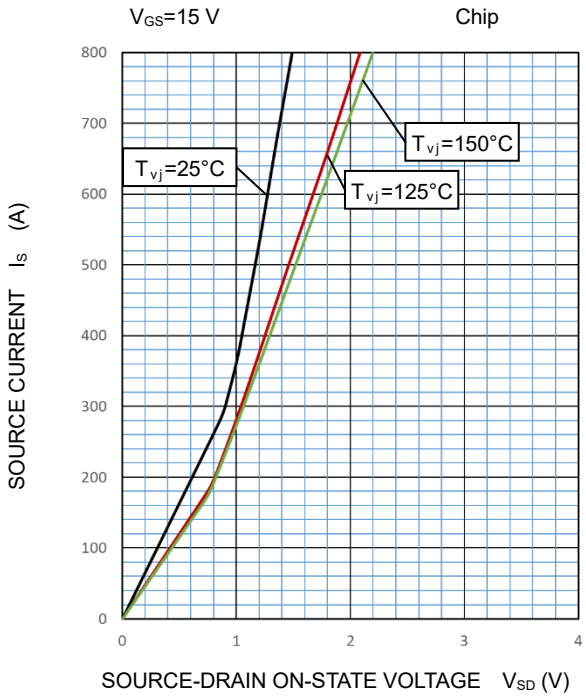
DRAIN-SOURCE ON STATE VOLTAGE CHARACTERISTICS (TYPICAL)



FREE WHEELING DIODE FORWARD CHARACTERISTICS (TYPICAL)



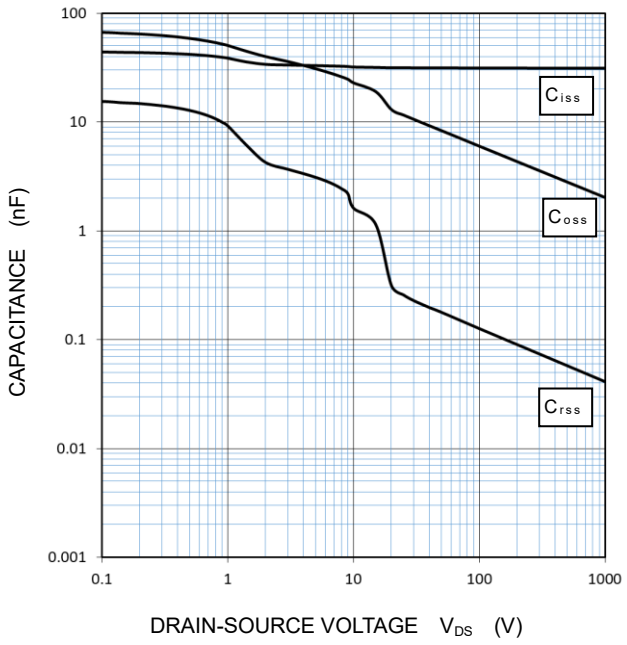
SOURCE-DRAIN ON STATE VOLTAGE CHARACTERISTICS (TYPICAL)



PERFORMANCE CURVES

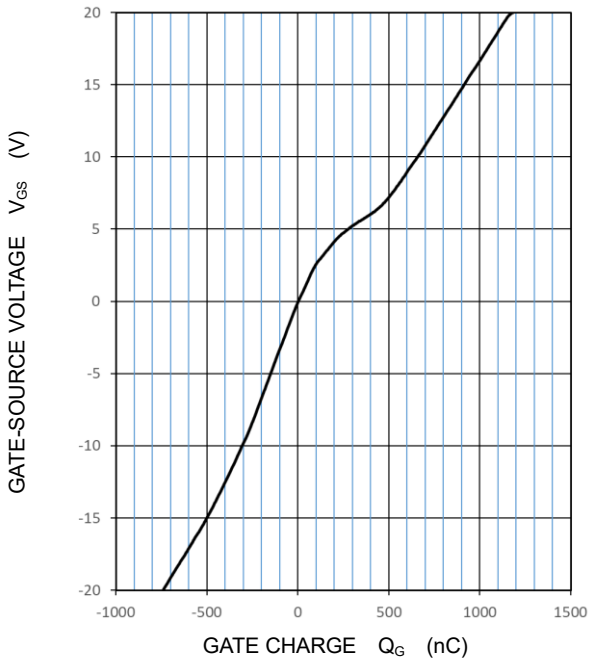
CAPACITANCE CHARACTERISTICS (TYPICAL)

V_{GS}=0V, T_{vj}=25 °C



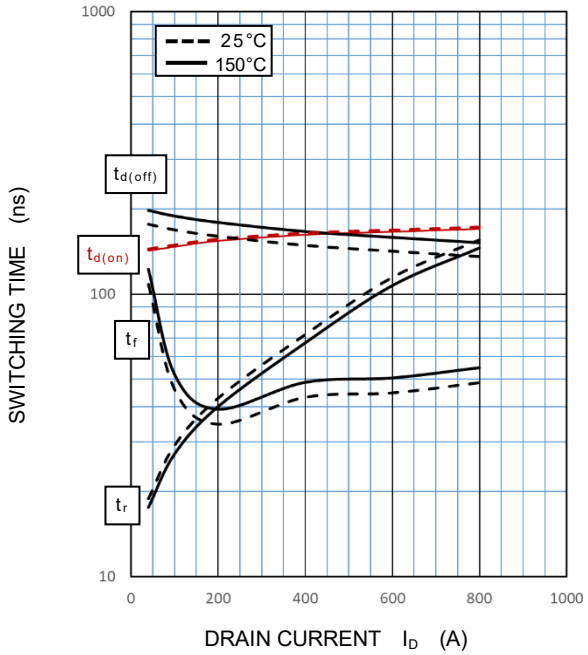
GATE CHARGE CHARACTERISTICS (TYPICAL)

V_{DD}=600V, I_D=400 A, T_{vj}=25 °C



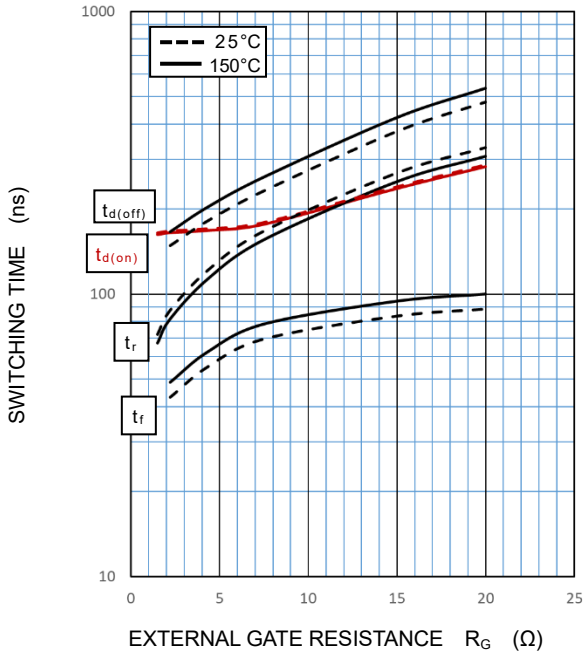
HALF-BRIDGE SWITCHING CHARACTERISTICS (TYPICAL)

V_{DD}=600 V, V_{GS}=±15 V, $R_{G(on)}$=1.5Ω, $R_{G(off)}$=2.2Ω, L_{s_ext}=25nH
INDUCTIVE LOAD



HALF-BRIDGE SWITCHING CHARACTERISTICS (TYPICAL)

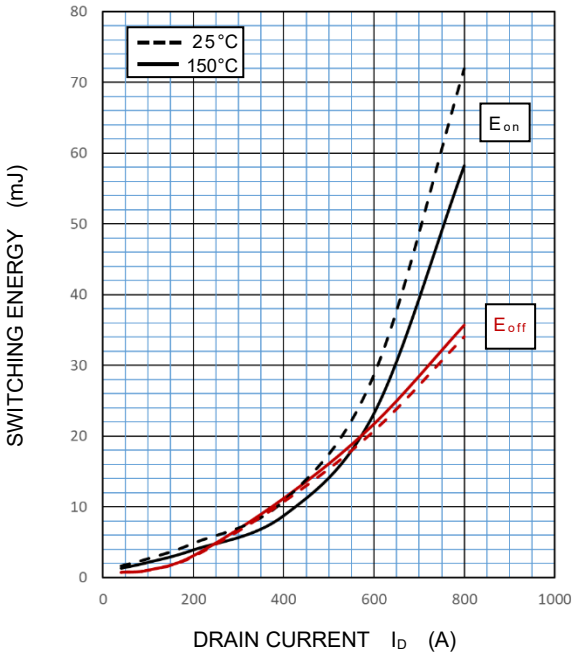
V_{DD}=600 V, V_{GS}=±15 V, I_D=400 A, L_{s_ext}=25nH
INDUCTIVE LOAD



PERFORMANCE CURVES

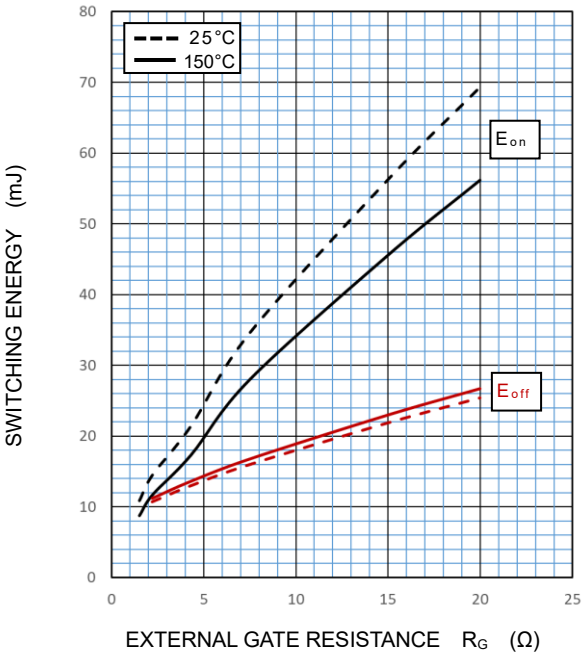
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

V_{DD}=600 V, V_{GS}=±15 V, $R_{G(on)}$=1.5Ω, $R_{G(off)}$=2.2Ω, L_{s_ext}=25nH
INDUCTIVE LOAD, PER PULSE



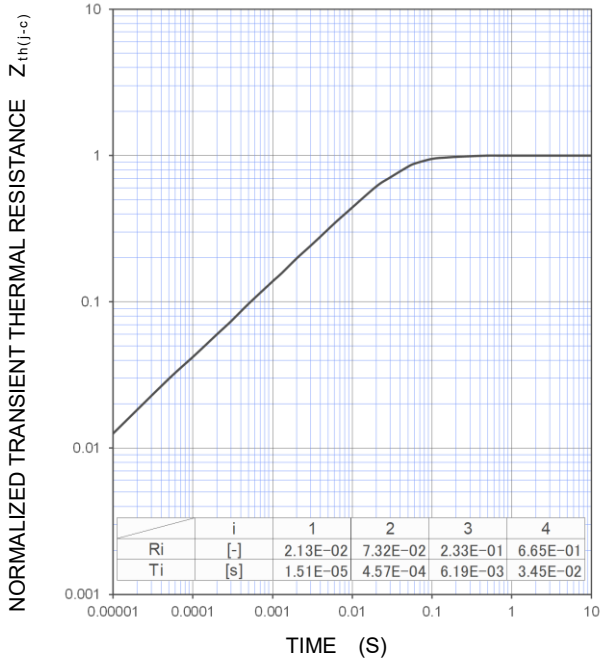
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

V_{DD}=600 V, V_{GS}=±15 V, I_D=400 A, L_{s_ext}=25nH
INDUCTIVE LOAD, PER PULSE



TRANSIENT THERMAL IMPEDANCE
CHARACTERISTICS
(MAXIMUM)

Single pulse, T_C=25 °C
$R_{th(j-c)Q}$=110K/kW, $R_{th(j-c)D}$=150K/kW



i	1	2	3	4
Ri [-]	2.13E-02	7.32E-02	2.33E-01	6.65E-01
Ti [s]	1.51E-05	4.57E-04	6.19E-03	3.45E-02

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

Important Notice

The information contained in this datasheet shall in no event be regarded as a guarantee of conditions or characteristics. This product has to be used within its specified maximum ratings, and is subject to customer's compliance with any applicable legal requirement, norms and standards.

Except as otherwise explicitly approved by Mitsubishi Electric Corporation in a written document signed by authorized representatives of Mitsubishi Electric Corporation, our products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.

In usage of power semiconductor, there is always the possibility that trouble may occur with them by the reliability lifetime such as Power Cycle, Thermal Cycle or others, or when used under special circumstances (e.g. condensation, high humidity, dusty, salty, highlands, environment with lots of organic matter / corrosive gas / explosive gas, or situations which terminals of semiconductor products receive strong mechanical stress). Therefore, please pay sufficient attention to such circumstances. Further, depending on the technical requirements, our semiconductor products may contain environmental regulation substances, etc. If there is necessity of detailed confirmation, please contact our nearest sales branch or distributor.

The contents or data contained in this datasheet are exclusively intended for technically trained staff. Customer's technical departments should take responsibility to evaluate the suitability of Mitsubishi Electric Corporation product for the intended application and the completeness of the product data with respect to such application. In the customer's research and development, please evaluate it not only with a single semiconductor product but also in the entire system, and judge whether it's applicable. As required, pay close attention to the safety design by installing appropriate fuse or circuit breaker between a power supply and semiconductor products to prevent secondary damage. Please also pay attention to the application note and the related technical information.

Keep safety first in your circuit designs!

Mitsubishi Electric Corporation puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. 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 (i) placement of substitutive, auxiliary circuits, (ii) use of non-flammable material or (iii) prevention against any malfunction or mishap.

Notes regarding these materials

- These materials are intended as a reference to assist our customers in the selection of the Mitsubishi Electric Semiconductor product best suited to the customer's application; they do not convey any license under any intellectual property rights, or any other rights, belonging to Mitsubishi Electric Corporation or a third party.
- Mitsubishi Electric Corporation assumes no responsibility for any damage, or infringement of any third-party's 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 Electric Semiconductor product distributor for the latest product information before purchasing a product listed herein.
  The information described here may contain technical inaccuracies or typographical errors. Mitsubishi Electric Corporation assumes no responsibility for any damage, liability, or other loss rising from these inaccuracies or errors.
  Please also pay attention to information published by Mitsubishi Electric Corporation by various means, including the Mitsubishi Electric Semiconductor home page (http://www.MitsubishiElectric.com/semiconductor/).
- 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 total system before making a final decision on the 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 semiconductors 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 Electric 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 undersea repeater use.
- The prior written approval of Mitsubishi Electric Corporation is necessary to reprint or reproduce in whole or in part these materials.
- If these products or technologies are subject to the Japanese export control restrictions, they must be exported under a license from the Japanese government and cannot be imported into a country other than the approved destination.
  Any diversion or re-export contrary to the export control laws and regulations of Japan and/or the country of destination is prohibited.
- Please contact Mitsubishi Electric Corporation or an authorized Mitsubishi Electric Semiconductor product distributor for further details on these materials or the products contained therein.