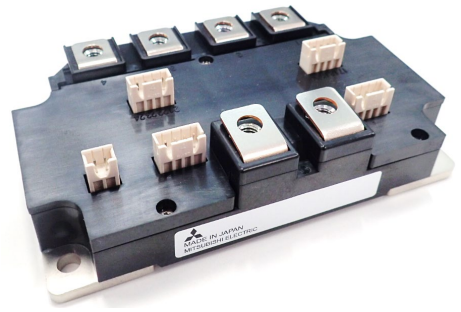
MITSUBISHI ELECTRIC

<Full SiC Power Modules>

FMF400BXZ-24B

HIGH POWER SWITCHING USE
INSULATED TYPE



fourpack

Drain current I_D ..... **400** A

Drain-Source voltage V_{DSX} ..... **1200** V

Maximum junction temperature T_{vjmax} ..... **175** °C

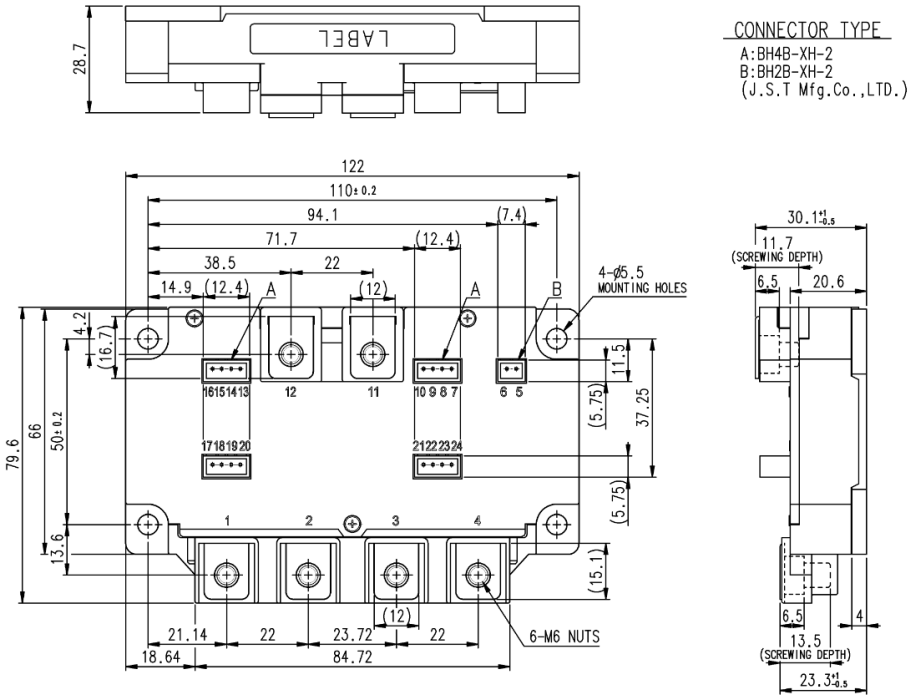
- Silicon Carbide MOSFET + Silicon Carbide Schottky Barrier Diode
- Flat base Type
- Copper base plate
- RoHS Directive compliant
- Recognized under UL1557, File E323585

APPLICATION

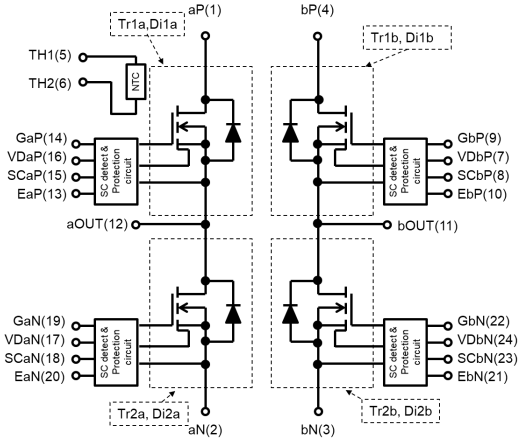
AC Motor Control, Motion/Servo Control, Power supply, etc.

OUTLINE DRAWING & INTERNAL CONNECTION

Dimension in mm



INTERNAL CONNECTION



Terminal code

1	aP	13	EaP
2	aN	14	GaP
3	bN	15	SCaP
4	bP	16	VDaP
5	TH1	17	VDaN
6	TH2	18	SCaN
7	VDbP	19	GaN
8	SCbP	20	EaN
9	GbP	21	EbN
10	EbP	22	GbN
11	bOUT	23	SCbN
12	aOUT	24	VDbN

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>

FMF400BXZ-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=60℃ (Note.2)	400	A
I_{DRM}		Pulse, Repetitive (Note.3), T_{vj}=150℃(Note.4)	600	
P_{tot}	Total power dissipation	T_C=25 °C (Note. 2)	1560	W
I_S (Note.1)	Source current	DC	400	A
I_{SRM} (Note.1)		Pulse, Repetitive (Note.3), T_{vj}=150℃	600	
V_{isol}	Isolation voltage	Terminals to base plate, RMS, f=60 Hz, AC 1 min	5000	V
T_{vjmax}	Maximum junction temperature	Instantaneous event (overload) (Note.10)	175	°C
T_{vjop}	Operating junction temperature	Continuous operation (under switching) (Note.10)	-40～+150	°C
T_{cmax}	Maximum case temperature	(Note.2, 10)	125	°C
T_{stg}	Storage temperature	-	-40～+125	°C

ELECTRICAL CHARACTERISTICS (T_{vj}=25 °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 V		-	-	4	mA
		V_{DS}=800V, V_{GS}=-15 V		-	-	0.4	
$V_{GS(th)}$	Gate-source threshold voltage	I_D=113mA, 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	-	1.65	2.30	V
			T_{vj}=125 °C	-	2.10	-	
			T_{vj}=150 °C	-	2.20	-	
$V_{DS(on)}$ (chip)	Drain-source on-state voltage	I_D=400 A, V_{GS}=15V (Note.6)	T_{vj}=25 °C	-	1.35	-	V
			T_{vj}=125 °C	-	1.80	-	
			T_{vj}=150 °C	-	1.90	-	
$r_{DS(on)}$ (chip)	Drain-source on-state resistance	I_D=400 A, V_{GS}=15V (Note.6)	T_{vj}=25 °C	-	3.4	-	mΩ
			T_{vj}=125 °C	-	4.5	-	
			T_{vj}=150 °C	-	4.8	-	
C_{iss}	Input capacitance	V_{DS}=10 V, V_{GS}=0V		-	34	-	nF
C_{oss}	Output capacitance			-	24	-	
C_{rss}	Reverse transfer capacitance			-	1.7	-	
Q_G	Gate charge	V_{DD}=600 V, I_D=400 A, V_{GS}=0→15 V		-	975	-	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=3.0Ω, L_{s_ext}=25nH, Inductive load, per pulse		-	120	-	ns
t_r	Rise time			-	80	-	
$t_{d(off)}$	Turn-off delay time			-	200	-	
t_f	Fall time			-	30	-	
E_{on}	Turn-on switching energy			-	16	-	mJ
E_{off}	Turn-off switching energy			-	7	-	
Q_C	Drain-source charge			-	2	-	μC
V_{SD} (Note.1) (terminal)	Source-drain voltage	I_S=400 A(Note.6) V_{GS}=-15 V	T_{vj}=25 °C	-	1.90	2.45	V
			T_{vj}=125 °C	-	2.70	-	
			T_{vj}=150 °C	-	2.90	-	
V_{SD} (Note.1) (chip)	Source-drain voltage	I_S=400 A (Note.6) V_{GS}=-15 V	T_{vj}=25 °C	-	1.60	-	V
			T_{vj}=125 °C	-	2.40	-	
			T_{vj}=150 °C	-	2.60	-	
$R_{DD'+SS'}$	Internal lead resistance	aP-aN/ bP-bN, T_C=25℃(Note.2)		-	0.75	-	mΩ
L_s	Internal stray inductance	aP-aN/ bP-bN		-	18	-	nH
r_g	Internal gate resistance	Per switch		-	1.75	-	Ω

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	-	-	96	K/kW
$R_{th(j-c)D}$		Junction to case, per inverter FWD	-	-	126	
$R_{th(c-s)}$	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 °C (Note.2)	4.85	5.00	5.15	kΩ
ΔR/R	Deviation of resistance	T_C=100 °C (Note.2) ,R_{100}=493 Ω	-7.3	-	+7.8	%
$B_{(25/50)}$	B-constant	Approximate by equation (Note.7)	-	3375	-	K
P_{25}	Power dissipation	T_C=25 °C (Note.2)	-	-	10	mW

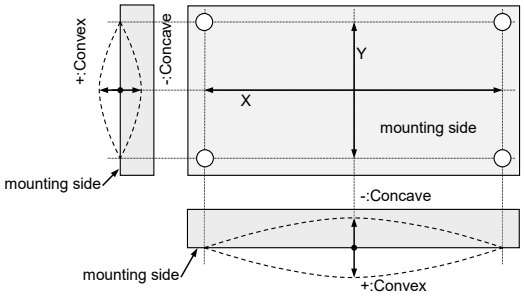
MECHANICAL CHARACTERISTICS

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).

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

   R_{25}: resistance at absolute temperature T_{25} [K]; T_{25}=25 [°C]+273.15=298.15 [K]
   R_{50}: resistance at absolute temperature T_{50} [K]; T_{50}=50 [°C]+273.15=323.15 [K]
8. Typical value is measured by using thermally conductive grease of λ=0.9 W/(m·K)/$D_{(C-S)}$=100μm.
9. Per switch
10. 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 aP -aN/ bP-bN terminals		-	600	850	V
V_D	DC supply voltage (control)	Applied across VDaP-EaP/ VDaN-EaN/ VDbP-EbP / VDbN-EbN terminals		13.5	15.0	16.5	V
$V_{GS(+)}$	Gate-Source positive drive voltage	Applied across GaP-EaP/ GaN-EaN/ GbP-EbP / GbN-EbN terminals		13.5	15.0	16.5	V
$V_{GS(-)}$	Gate-Source negative drive voltage	Applied across GaP-EaP/ GaN-EaN/ GbP-EbP / GbN-EbN terminals		-16.5	-15.0	-7.0	V
R_G	External gate resistance (Note.11)	Per switch		3.0	-	15.0	Ω
f_c	Switching frequency	$V_{GS(+)}$=15V, R_G=3.0Ω,	$V_{GS(-)}$＜-10V	-	-	50	kHz
		V_{DD}=600V, T_{vj}=150℃	$V_{GS(-)}$≧-10V	-	-	100	
$t_{d(SCoff)}$	Gate cutoff delay time after SC output	V_{GS}=15V, R_G=3.0Ω, V_{DD}=600V, T_{vj}=150℃		-	-	3	μs

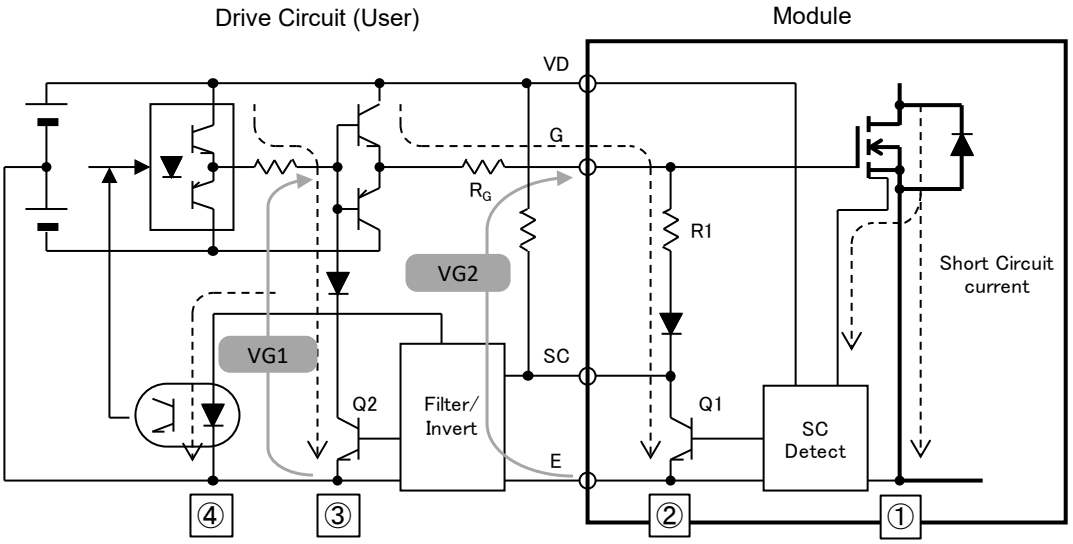
Note 11. The value of external gate resistance should be considered the surge voltage not to exceed the rating voltage in the worst system condition.

SHORT CIRCUIT DETECTION & PROTECTION CHARACTERISTICS

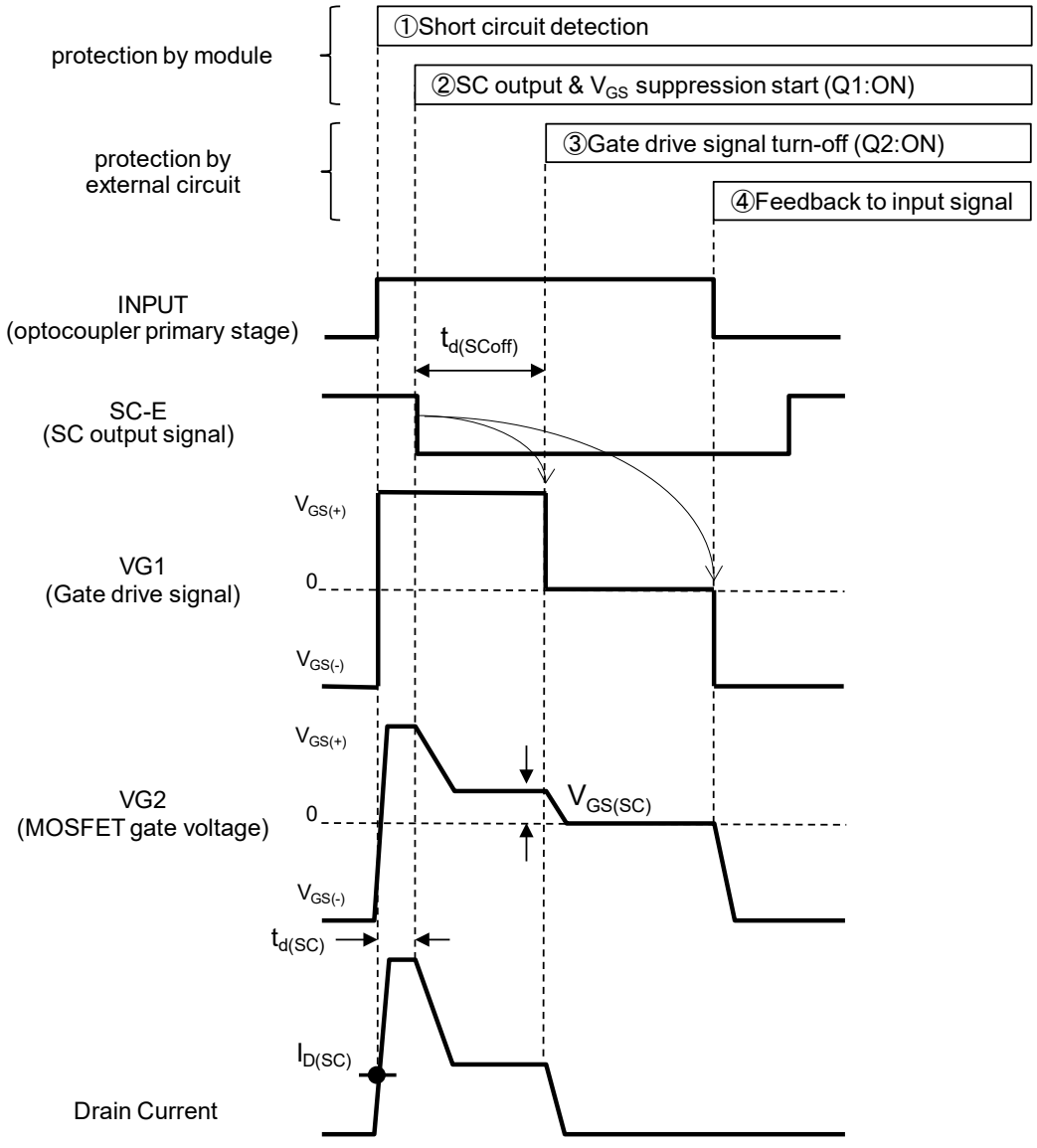
Symbol	Item	Conditions	Limits			Unit
			Min.	Typ.	Max.	
$I_{D(SC)}$	SC detect drain current	T_{vj}=150℃, V_{GS}=15V	600	800	-	A
$t_{d(SC)}$	SC detect delay time	T_{vj}=150℃, V_{GS}=15V, R_G=3.0Ω	-	1	-	μs
$V_{GS(SC)}$	SC protection gate limit voltage	T_{vj}=150℃, V_{GS}=15V, R_G=3.0Ω	-	10.9	-	V
R1	SC protection gate limit resistance	-	-	6.2	-	Ω

Refer to the circuit in page.5

SHORT CIRCUIT DETECTION & PROTECTION



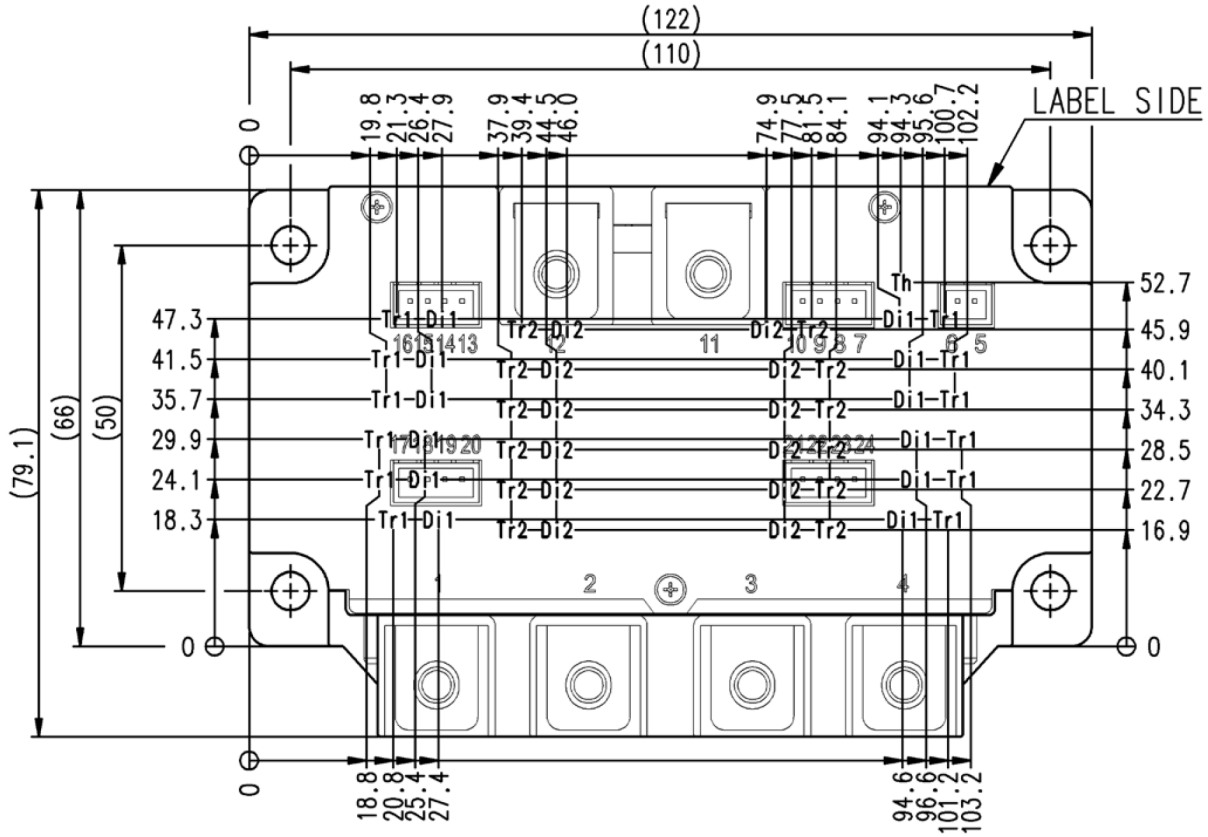
Example of application (Short circuit detection & protection)



Short circuit detection & protection diagram

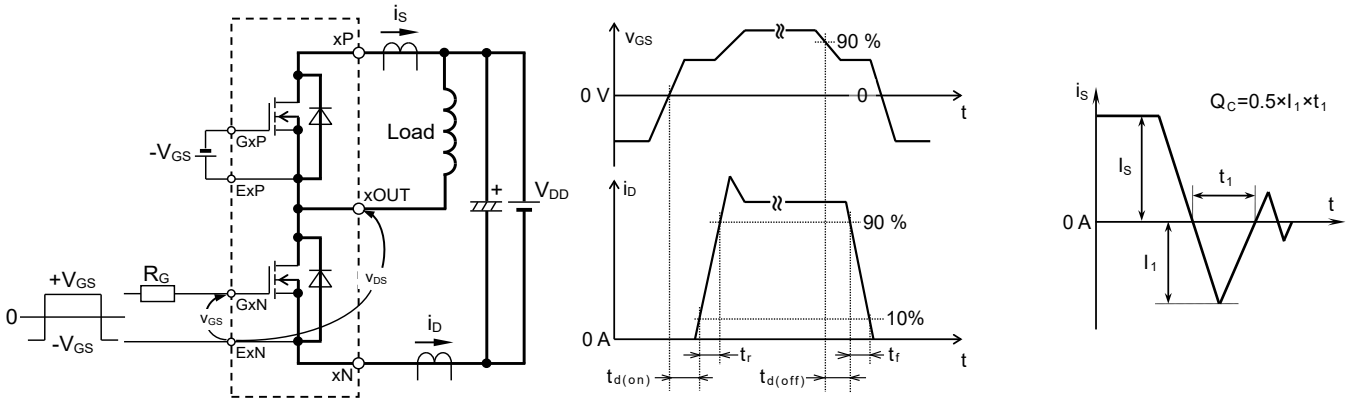
CHIP LOCATION (Top view)

Dimension in mm, tolerance: ±1 mm



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

TEST CIRCUIT AND WAVEFORMS



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

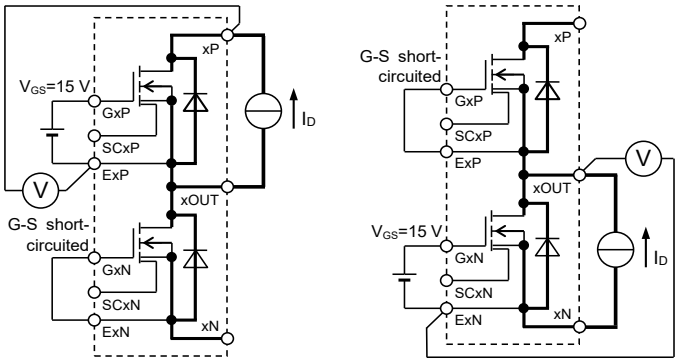
Q_C test waveform

MOSFET Turn-on switching energy

MOSFET Turn-off switching energy

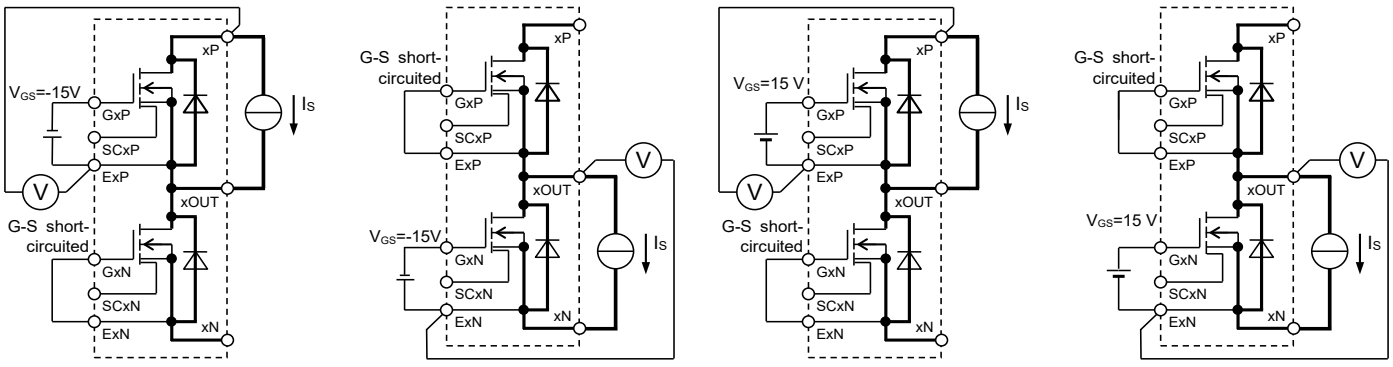
Turn-on / Turn-off switching energy test waveforms (Integral time instruction drawing)

TEST CIRCUIT



Tr1 Tr2

$V_{DS(on)}$ test circuit (x: a or b)



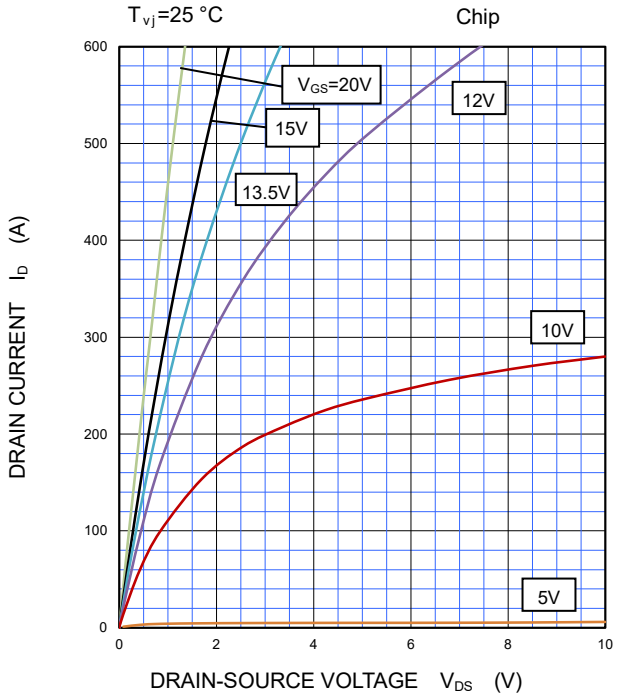
Di1 Di2 Tr1&Di1 Tr2&Di2

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

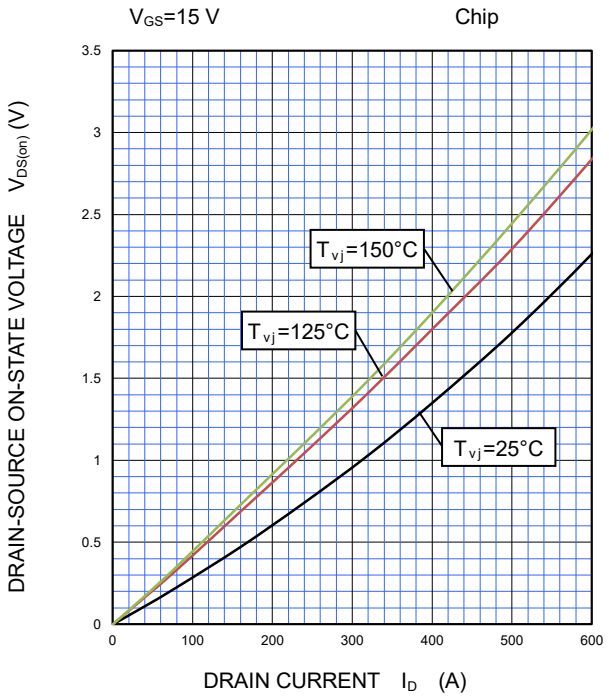
V_{SD} test circuit, V_{GS}=15V (x: a or b)

PERFORMANCE CURVES

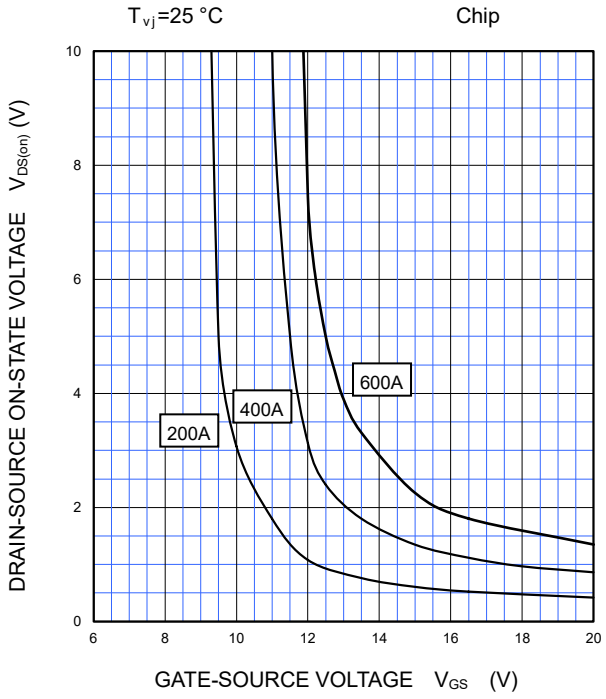
OUTPUT CHARACTERISTICS (TYPICAL)



DRAIN-SOURCE ON STATE VOLTAGE CHARACTERISTICS (TYPICAL)

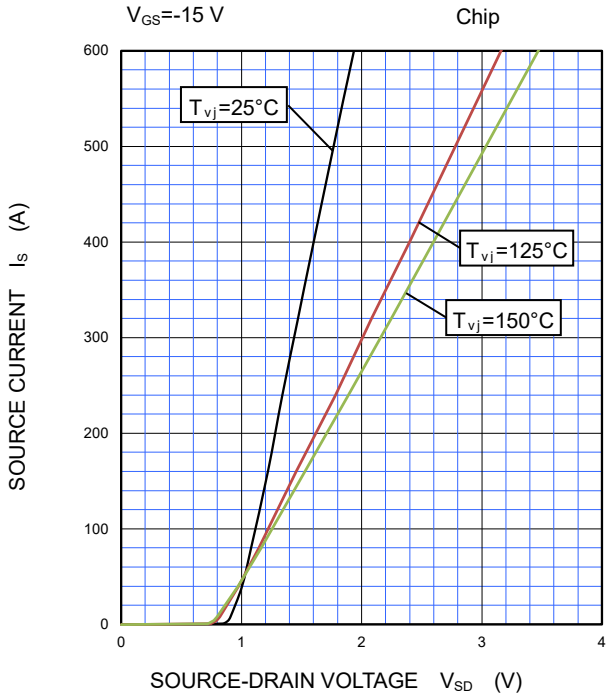


DRAIN-SOURCE ON STATE VOLTAGE CHARACTERISTICS (TYPICAL)

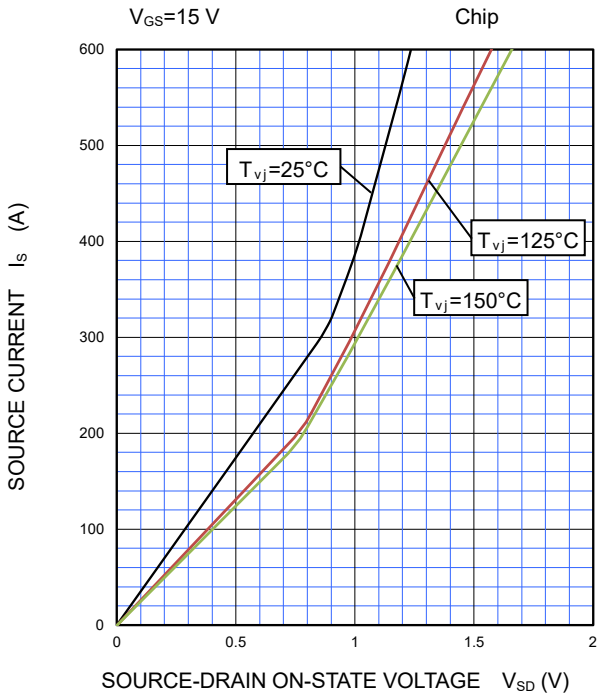


PERFORMANCE CURVES

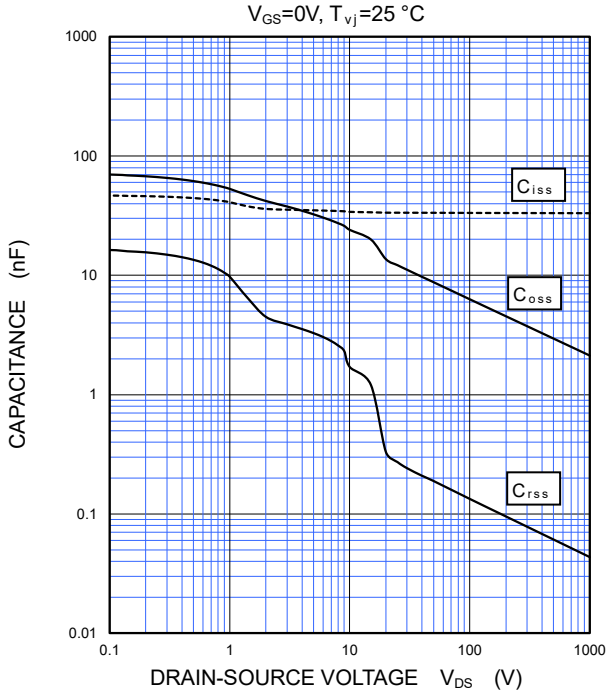
FREE WHEELING DIODE
FORWARD CHARACTERISTICS
(TYPICAL)



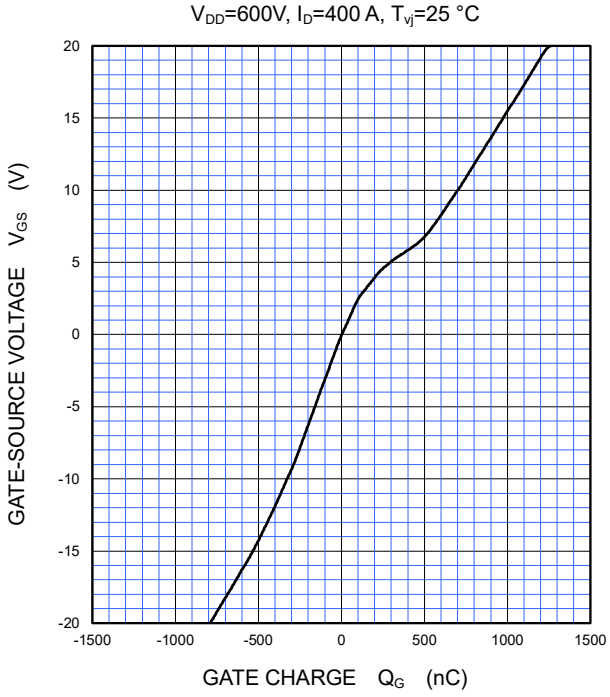
SOURCE-DRAIN ON STATE VOLTAGE
CHARACTERISTICS
(TYPICAL)



CAPACITANCE
CHARACTERISTICS
(TYPICAL)



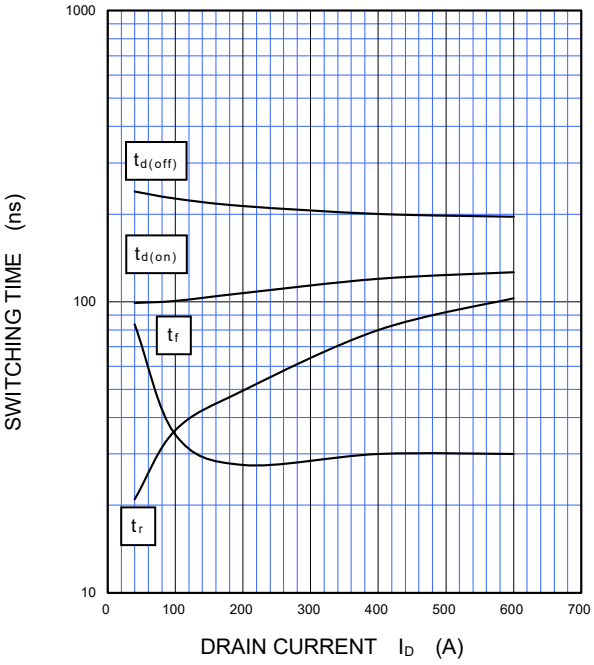
GATE CHARGE
CHARACTERISTICS
(TYPICAL)



PERFORMANCE CURVES

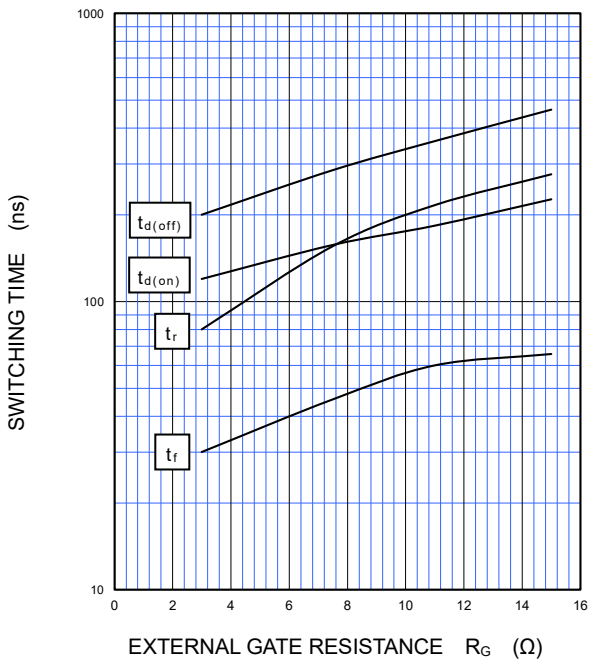
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

V_{DD}=600 V, V_{GS}=±15 V, R_G=3.0Ω, L_{s_ext}=25nH
T_{vj}=150 °C, INDUCTIVE LOAD



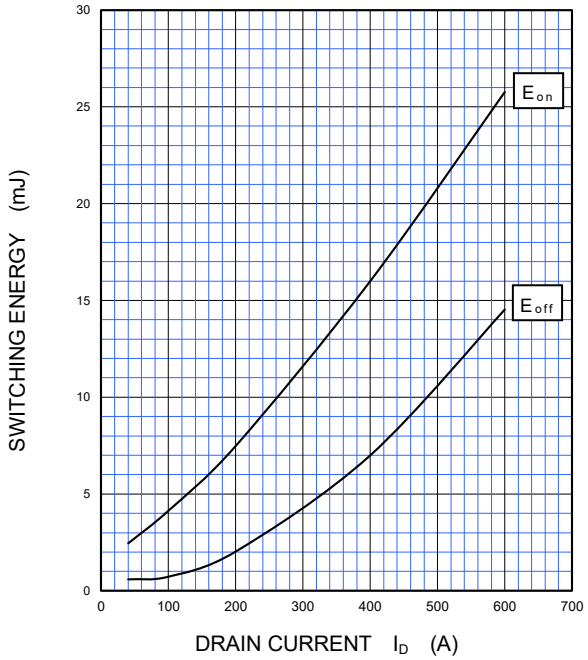
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

V_{DD}=600 V, V_{GS}=±15 V, I_D=400 A, L_{s_ext}=25nH
T_{vj}=150 °C, INDUCTIVE LOAD



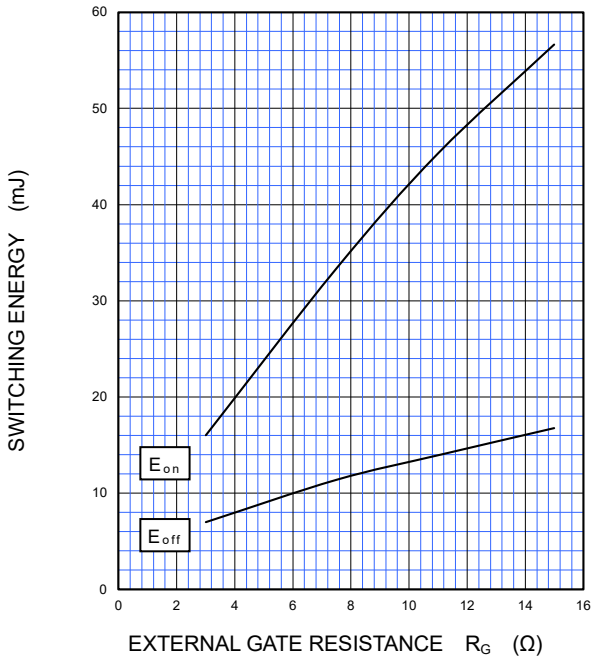
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

V_{DD}=600 V, V_{GS}=±15 V, R_G=3.0Ω, T_{vj}=150 °C, 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, T_{vj}=150 °C, L_{s_ext}=25nH
INDUCTIVE LOAD, PER PULSE

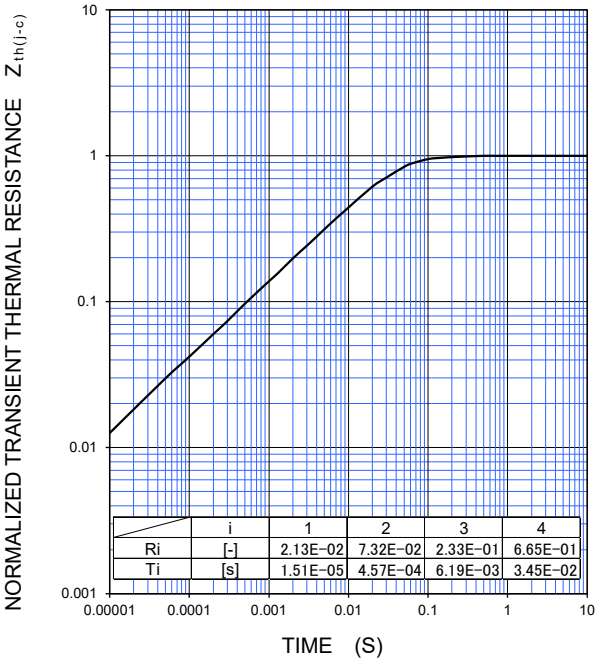


PERFORMANCE CURVES

TRANSIENT THERMAL IMPEDANCE CHARACTERISTICS (MAXIMUM)

Single pulse, T_C=25 °C

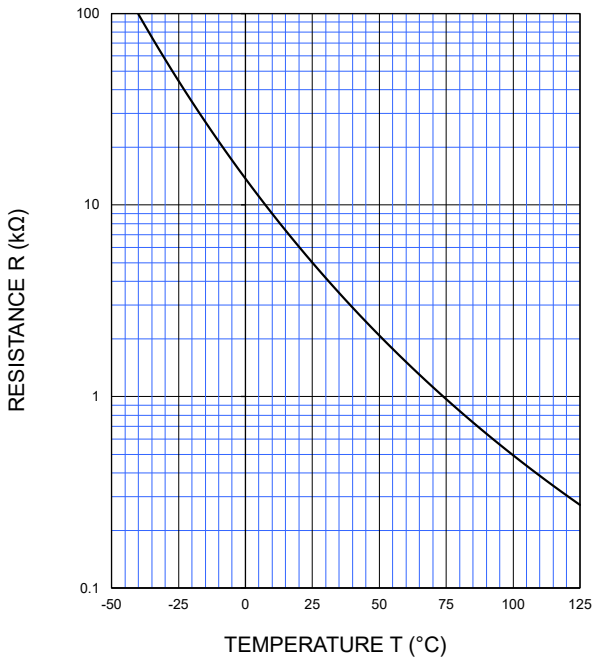
$R_{th(j-c)Q}$=96K/kW, $R_{th(j-c)D}$=126K/kW



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

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

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!

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