

<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**

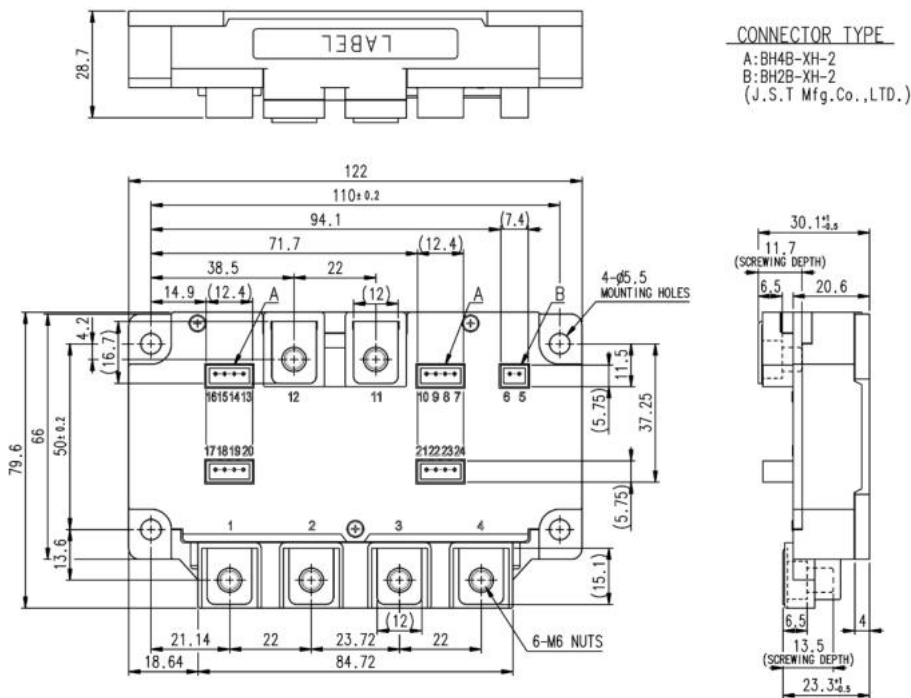
- Silicon Carbide MOSFET + Silicon Carbide Schottky Barrier Diode
- Flat base Type
- Copper base plate
- RoHS Directive compliant
- Recognized under UL1557, File E323585

APPLICATION

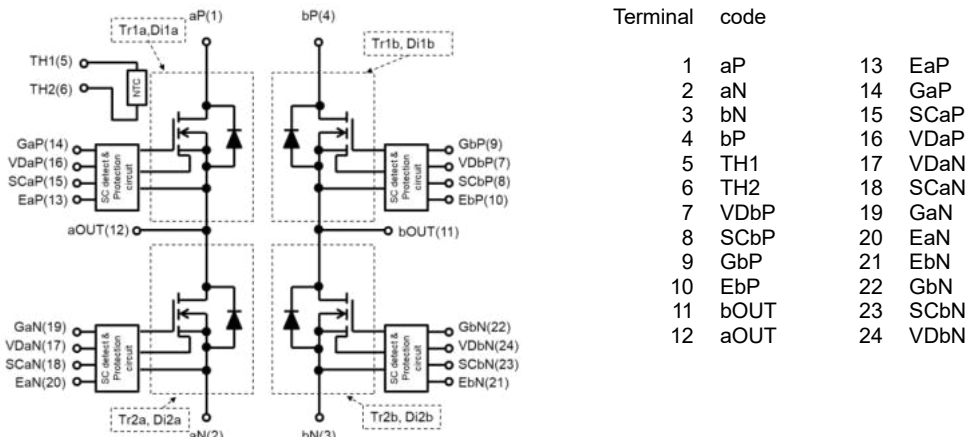
AC Motor Control, Motion/Servo Control, Power supply, etc.

OUTLINE DRAWING & INTERNAL CONNECTION

Dimension in mm



INTERNAL CONNECTION



FMF400BXZ-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, $T_C=60\text{ }^{\circ}\text{C}$ (Note.2)	400	A
I_{DRM}		Pulse, Repetitive (Note.3), $T_{vj}=150\text{ }^{\circ}\text{C}$ (Note.4)	600	
P_{tot}	Total power dissipation	$T_C=25\text{ }^{\circ}\text{C}$ (Note.2)	1560	W
I_S (Note.1)	Source current	DC	400	A
I_{SRM} (Note.1)		Pulse, Repetitive (Note.3), $T_{vj}=150\text{ }^{\circ}\text{C}$	600	
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 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°C, 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-EaP, bP-EbP, aOUT-EaN, bOUT-EbN terminals, per switch		-	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	$T_C=25\text{ }^{\circ}\text{C}$ ^(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.

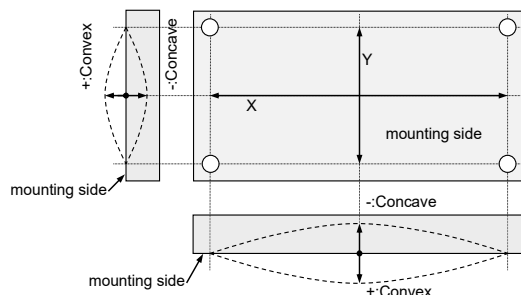
Note1. Represent ratings and characteristics of the anti-parallel, source-drain free wheeling diode (FWD).

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 $T_{vj\max}$ rating.

4. Junction temperature (T_{vj}) should not increase beyond $T_{vj\max}$ 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.

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

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

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

8. Typical value is measured by using thermally conductive grease of $\lambda=0.9\text{ W/(m}\cdot\text{K)}/D_{(C-S)}=100\mu\text{m}$.

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

FMF400BXZ-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 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	$V_{GS(+)}=15V, R_G=3.0\Omega,$ $V_{DD}=600V, T_{vj}=150^\circ C$	$V_{GS(-)} < -10V$	-	50	kHz
			$V_{GS(-)} \geq -10V$	-	100	
$t_{d(SCoff)}$	Gate cutoff delay time after SC output	$V_{GS}=15V, R_G=3.0\Omega, V_{DD}=600V, T_{vj}=150^\circ C$	-	-	3	μs

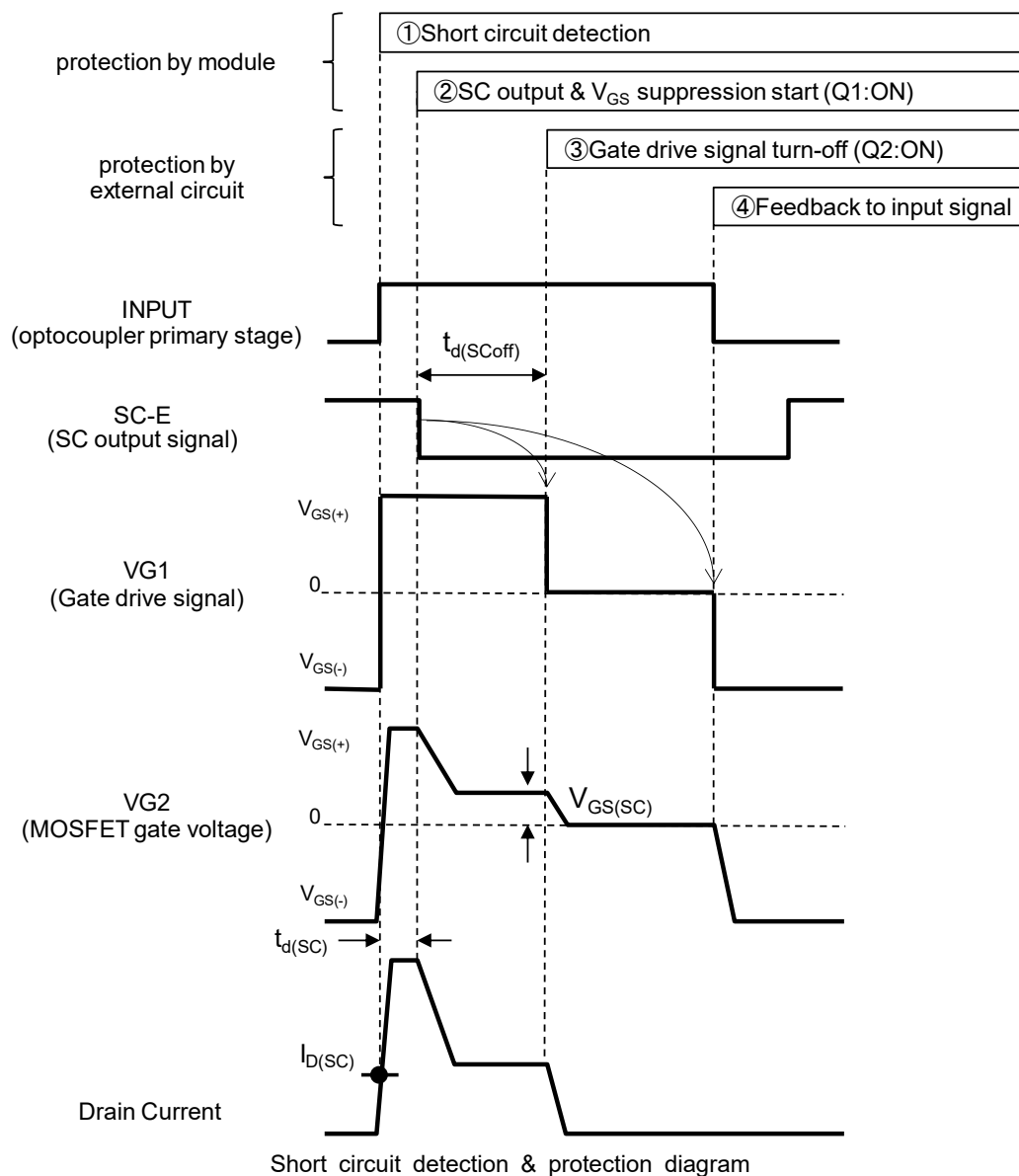
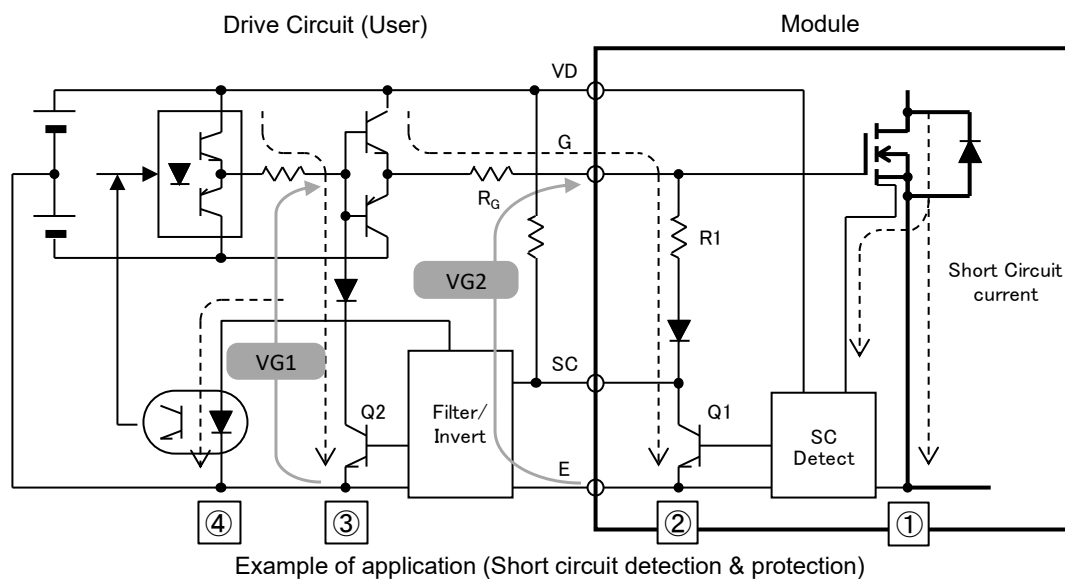
Note 11. The value of external gate resistance should be considered the surge voltage not to exceed the rating voltage in the worst system condition.

SHORT CIRCUIT DETECTION & PROTECTION CHARACTERISTICS

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

Refer to the circuit in page.5

SHORT CIRCUIT DETECTION & PROTECTION

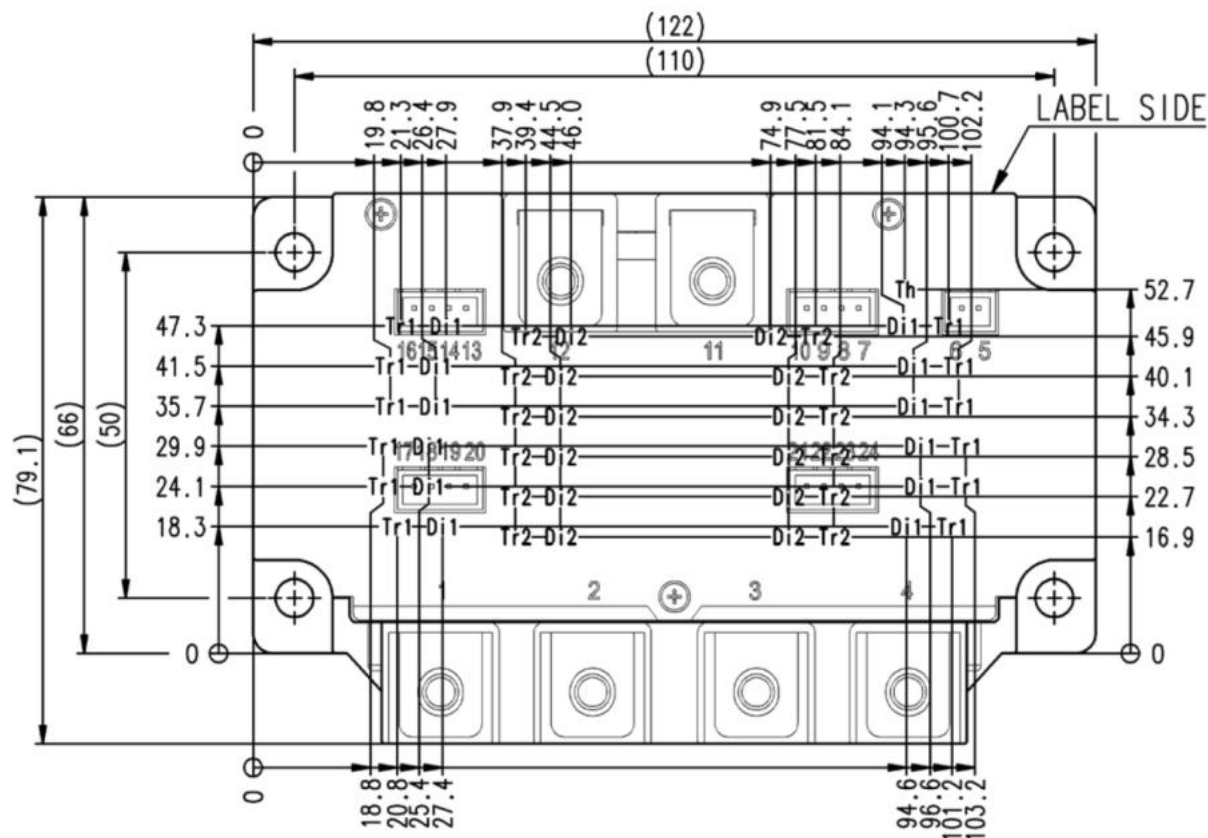


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HIGH POWER SWITCHING USE
INSULATED TYPE

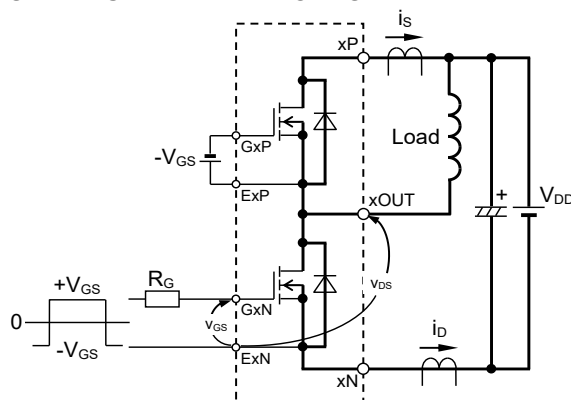
CHIP LOCATION (Top view)

Dimension in mm, tolerance: ± 1 mm

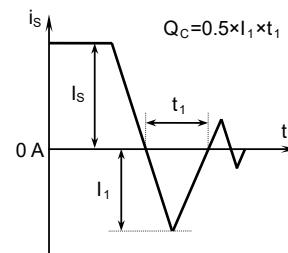
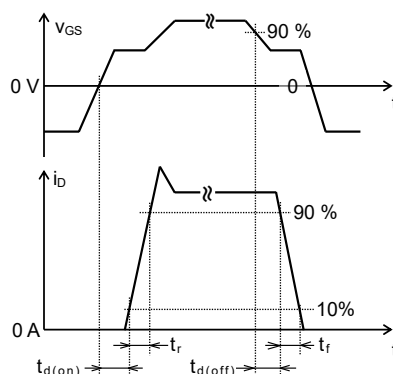


Tr1,Tr2: SiC-MOSFET, Di1,Di2: SiC-SBD, Th: NTC thermistor

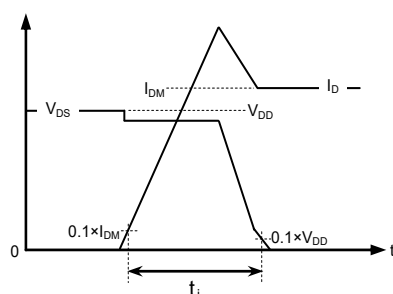
TEST CIRCUIT AND WAVEFORMS



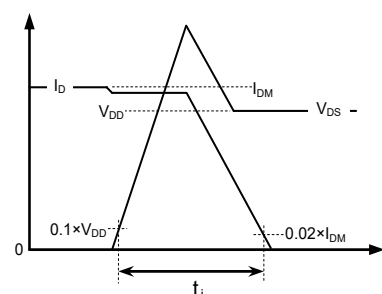
Switching characteristics test circuit and waveforms(x: a or b)



Qc test waveform



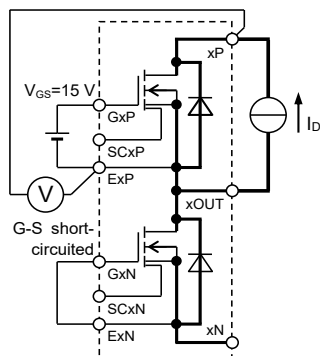
MOSFET Turn-on switching energy



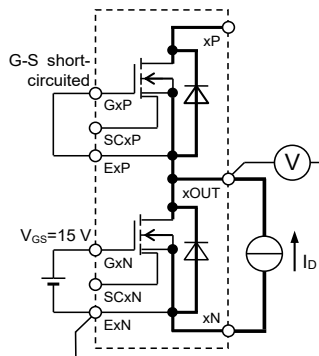
MOSFET Turn-off switching energy

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

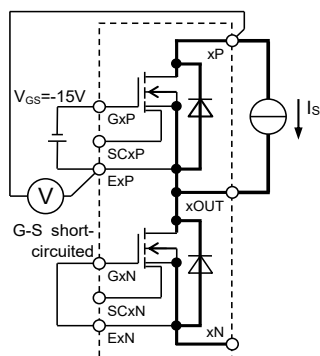
TEST CIRCUIT



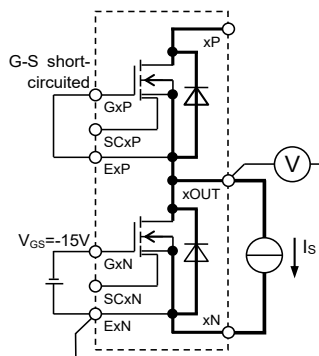
Tr1



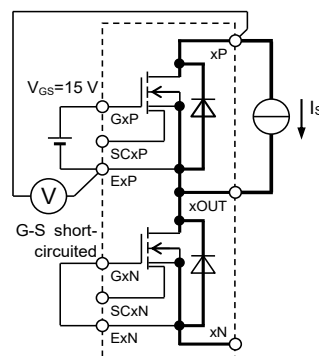
Tr2

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

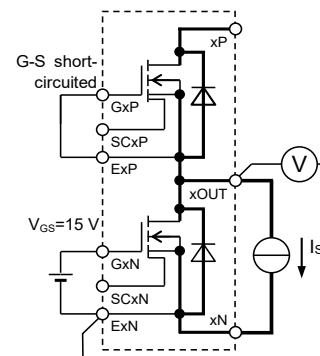
Di1



Di2

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

Tr1 & Di1



Tr2 & Di2

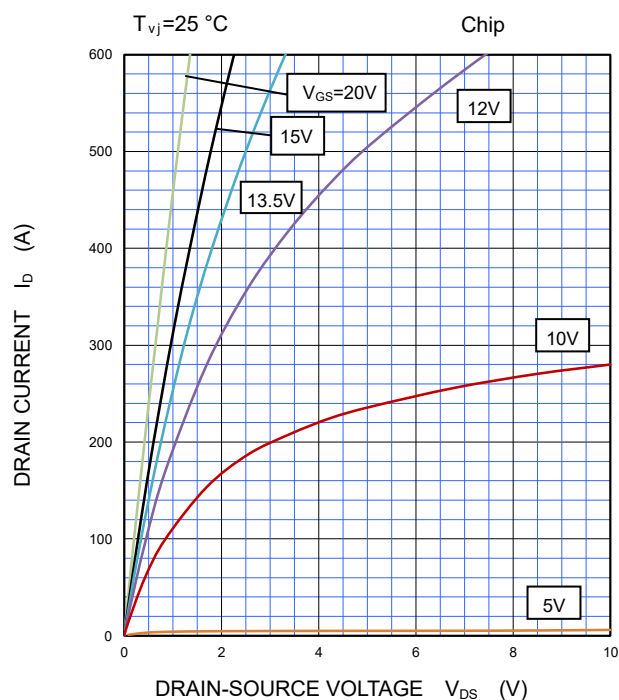
 V_{SD} test circuit, $V_{GS} = 15V$ (x: a or b)

FMF400BXZ-24B

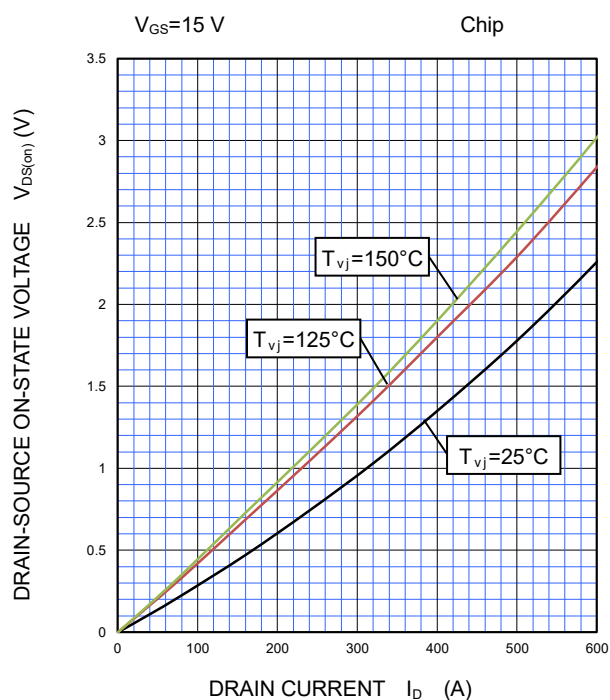
HIGH POWER SWITCHING USE
INSULATED TYPE

PERFORMANCE CURVES

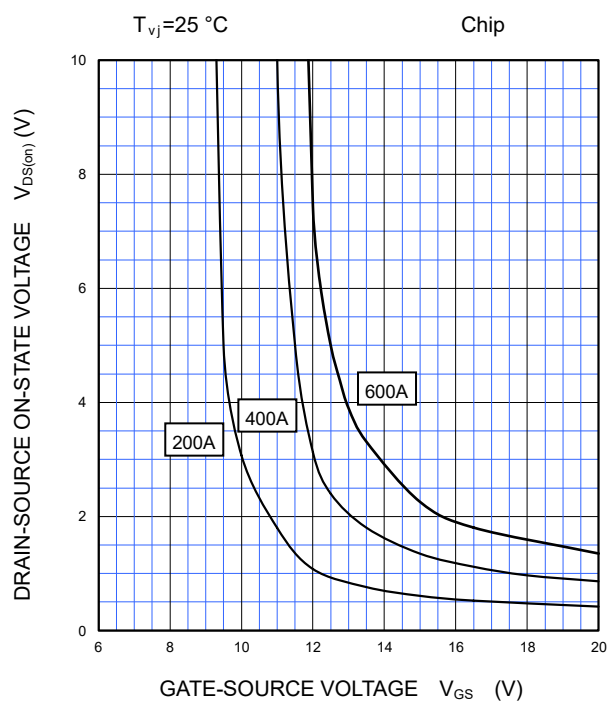
OUTPUT
CHARACTERISTICS
(TYPICAL)



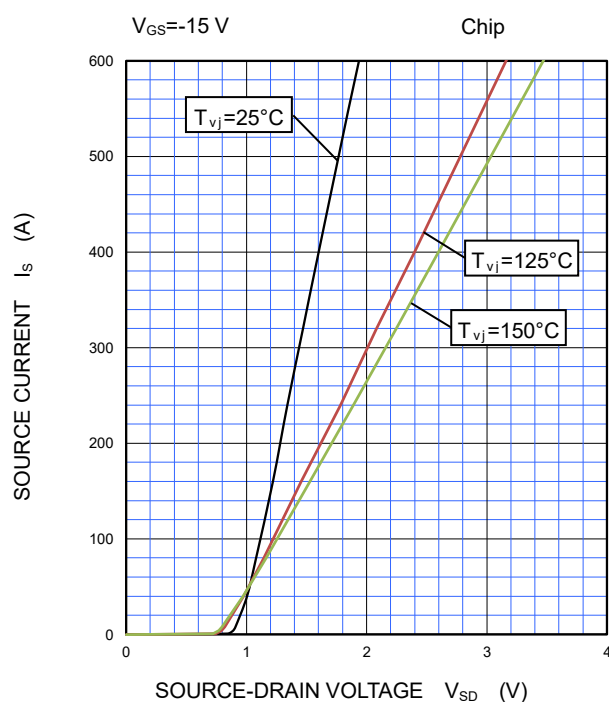
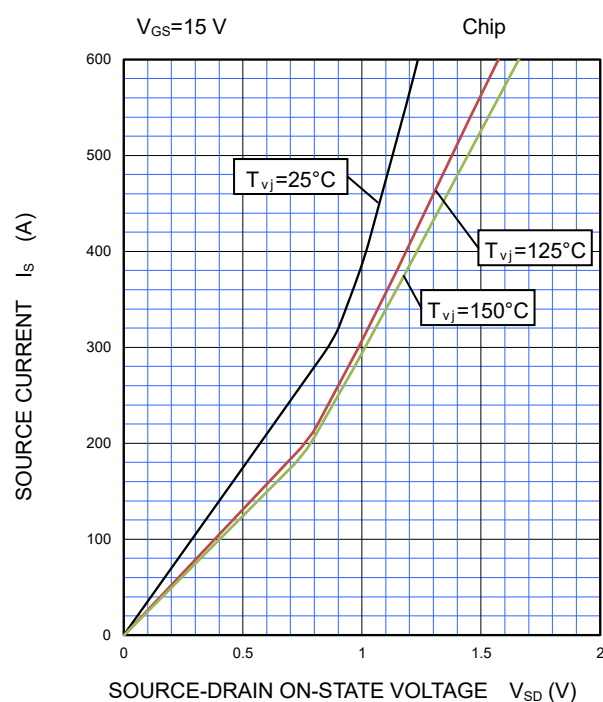
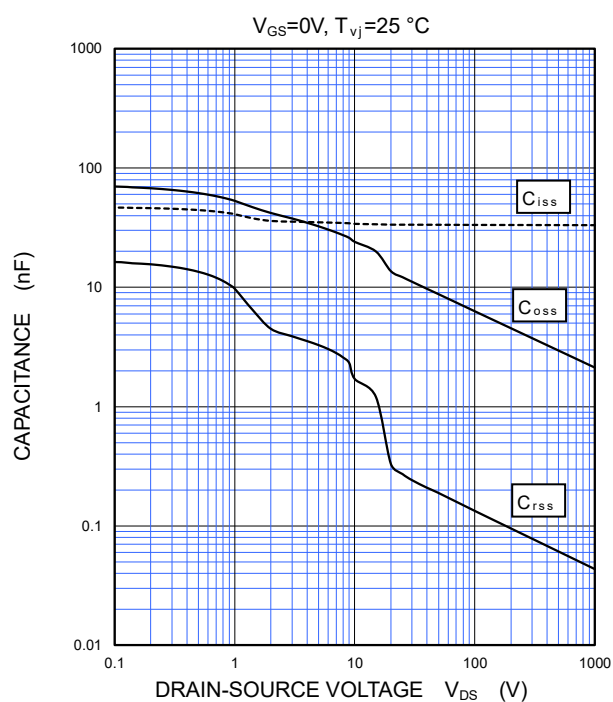
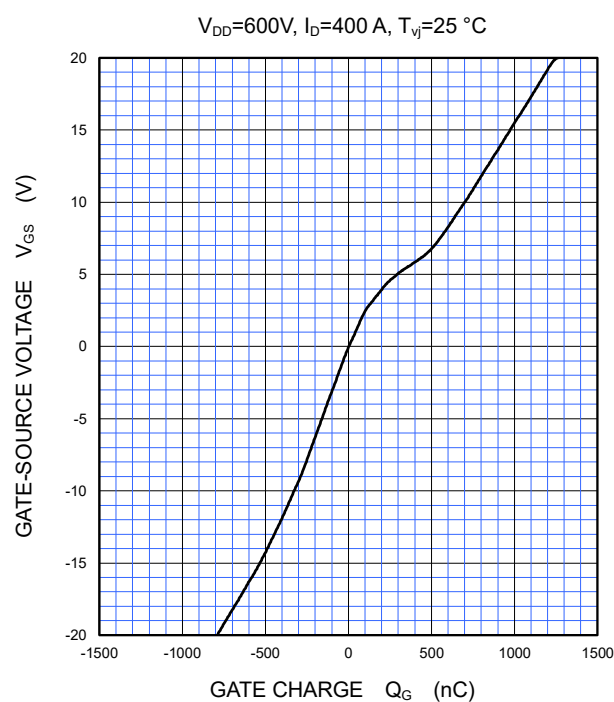
DRAIN-SOURCE ON STATE VOLTAGE
CHARACTERISTICS
(TYPICAL)



DRAIN-SOURCE ON STATE VOLTAGE
CHARACTERISTICS
(TYPICAL)



PERFORMANCE CURVES

FREE WHEELING DIODE
FORWARD CHARACTERISTICS
(TYPICAL)SOURCE-DRAIN ON STATE VOLTAGE
CHARACTERISTICS
(TYPICAL)CAPACITANCE
CHARACTERISTICS
(TYPICAL)GATE CHARGE
CHARACTERISTICS
(TYPICAL)

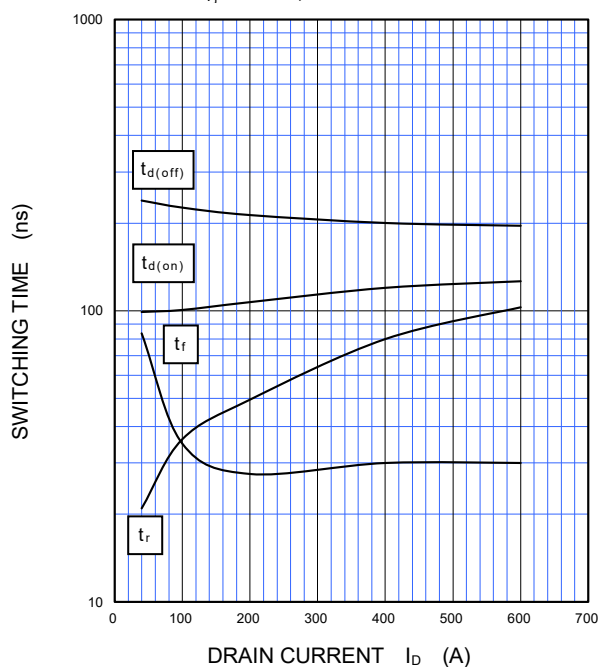
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HIGH POWER SWITCHING USE
INSULATED TYPE

PERFORMANCE CURVES

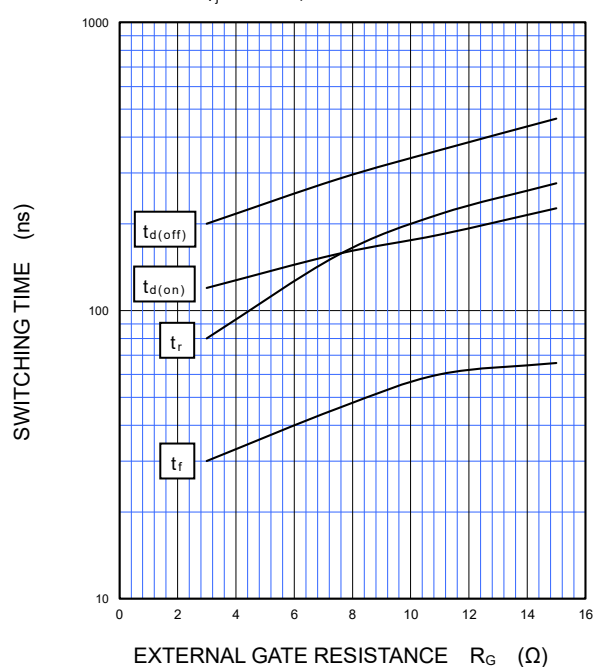
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

$V_{DD}=600\text{ V}$, $V_{GS}=\pm 15\text{ V}$, $R_G=3.0\Omega$, $L_{s_ext}=25\text{ nH}$
 $T_{vj}=150\text{ }^\circ\text{C}$, INDUCTIVE LOAD



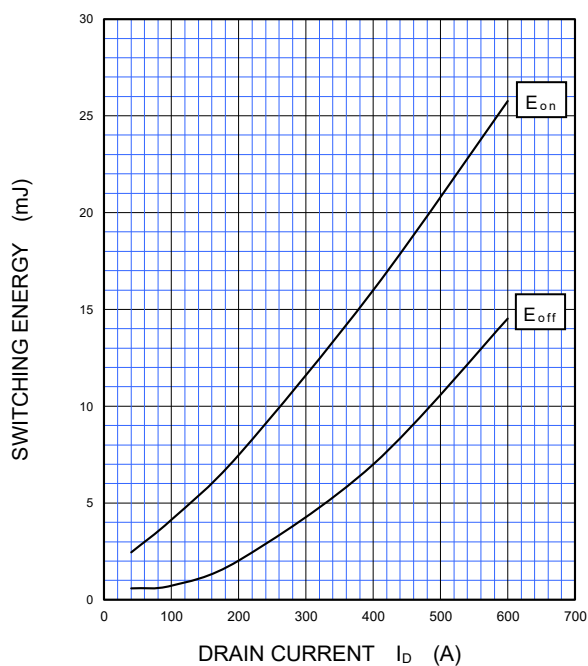
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

$V_{DD}=600\text{ V}$, $V_{GS}=\pm 15\text{ V}$, $I_D=400\text{ A}$, $L_{s_ext}=25\text{ nH}$
 $T_{vj}=150\text{ }^\circ\text{C}$, INDUCTIVE LOAD



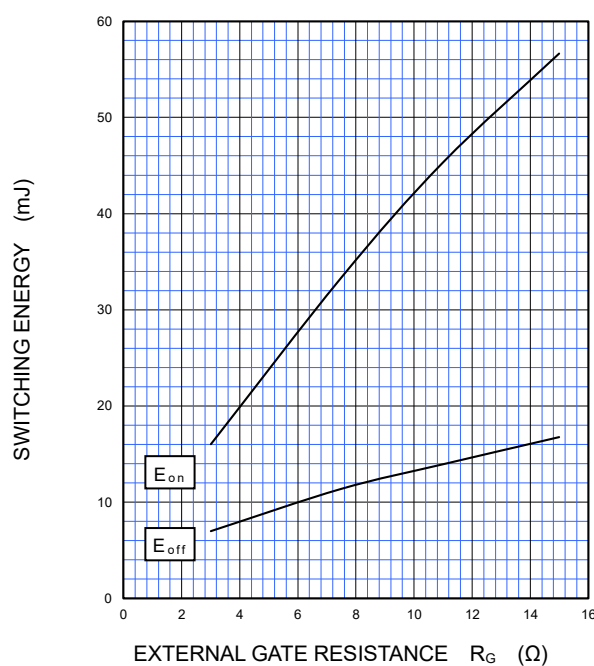
HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

$V_{DD}=600\text{ V}$, $V_{GS}=\pm 15\text{ V}$, $R_G=3.0\Omega$, $T_{vj}=150\text{ }^\circ\text{C}$, $L_{s_ext}=25\text{ nH}$
INDUCTIVE LOAD, PER PULSE



HALF-BRIDGE
SWITCHING CHARACTERISTICS
(TYPICAL)

$V_{DD}=600\text{ V}$, $V_{GS}=\pm 15\text{ V}$, $I_D=400\text{ A}$, $T_{vj}=150\text{ }^\circ\text{C}$, $L_{s_ext}=25\text{ nH}$
INDUCTIVE LOAD, PER PULSE

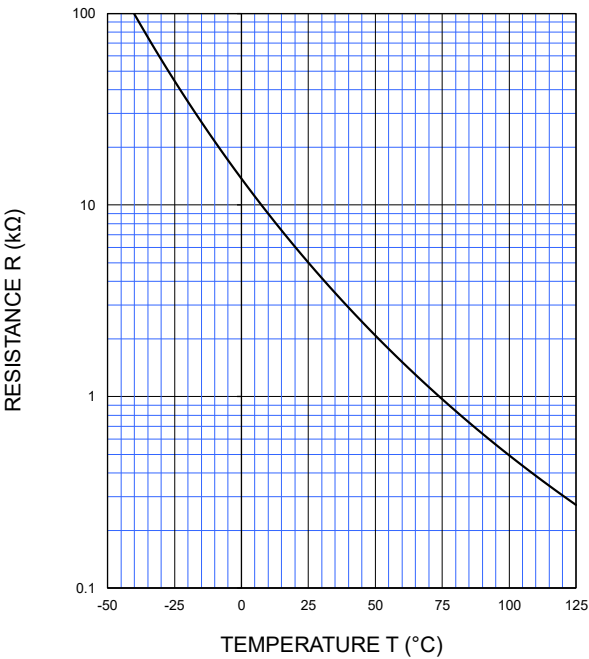
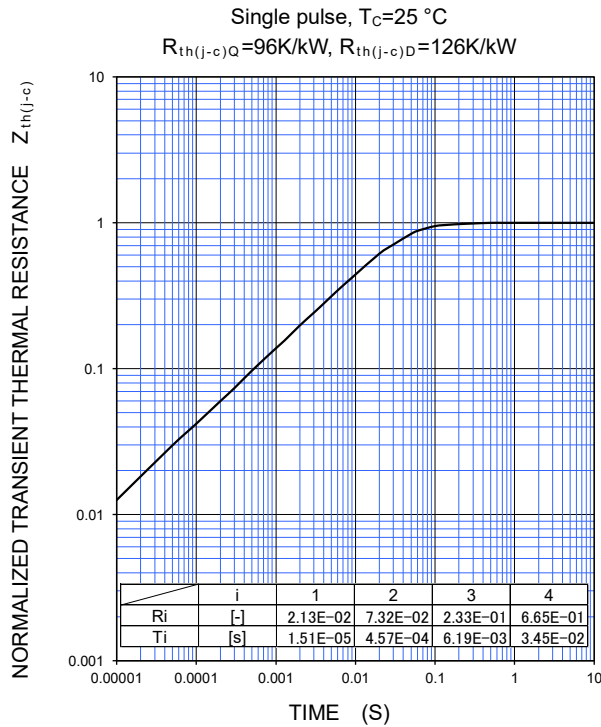


PERFORMANCE CURVES

NTC thermistor part

TRANSIENT THERMAL IMPEDANCE
CHARACTERISTICS
(MAXIMUM)

TEMPERATURE
CHARACTERISTICS
(TYPICAL)



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

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