

High-Power Module Silicon Carbide N-Channel MOSFET

# MG600Q2YMS3

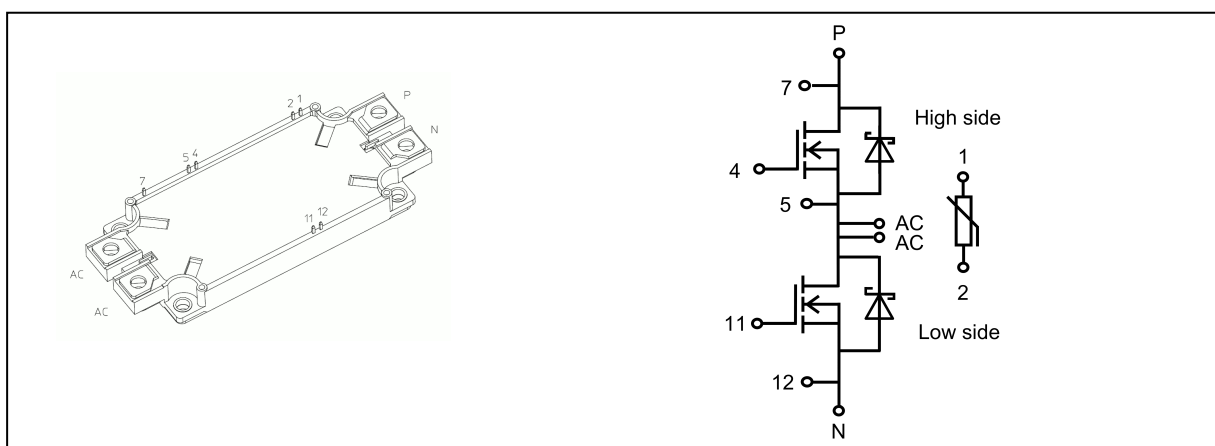
## 1. Applications

- High-Power Switching
- Motor Controllers (including rail traction)

## 2. Features

- (1)  $V_{DSS} = 1200\text{ V}$ ,  $I_D = 600\text{ A}$  All SiC MOSFET Module(Low loss & High speed switching)
- (2) Low stray inductance, low thermal resistance, maximum  $T_{ch} = 150\text{ }^\circ\text{C}$ , built in thermistor.
- (3) Enhancement mode.
- (4) Electrodes are isolated from metal base plate.

## 3. Packaging and Internal Circuit (Note)



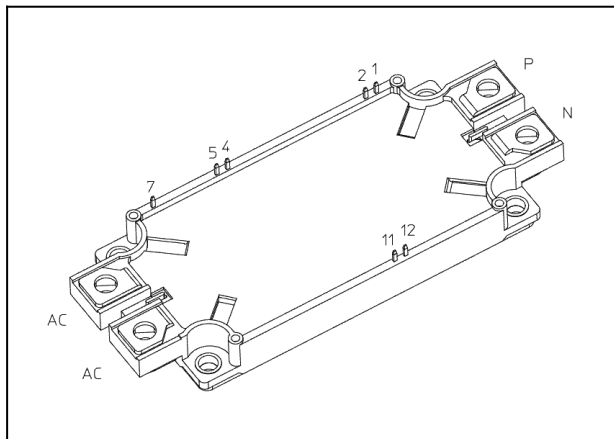
Note: P and N terminal should use one screw to fasten in each and AC terminal should use two screws to fasten. When the thermistor is not used, pin 1 and pin 2 should be electrically connected to pin 12.

Start of commercial production

2021-11

## 4. Terminal

Symbol & No.	Terminal name
P	P(main terminal)
N	N(main terminal)
AC	AC(main terminals)
1	Thermistor
2	Thermistor
4	High side gate
5	High side source sense / Low side drain sense
7	High side drain sense
11	Low side gate
12	Low side source sense



**Fig. 4.1 Terminal image**

### 5. Absolute Maximum Ratings (Note)(T<sub>c</sub> = 25 °C unless otherwise specified)

Characteristics	Symbol	Note	Test Condition	Rating	Unit
Drain-source voltage	V <sub>DSS</sub>			1200	V
Gate-source voltage	V <sub>GSS</sub>			+ 25 / - 10	V
Drain current (DC)	I <sub>D</sub>	(Note 1)		600	A
Drain current (pulsed)	I <sub>DP</sub>	(Note 1)	1 ms	1200	A
Drain power dissipation	P <sub>D</sub>	(Note 1)		2000	W
Source current (DC)	I <sub>S</sub>	(Note 1)		600	A
Source current (pulsed)	I <sub>SP</sub>	(Note 1)	1 ms	1200	A
Channel temperature	T <sub>ch</sub>			150	°C
Storage temperature	T <sub>stg</sub>			-40 to 150	°C
Isolation voltage	V <sub>isol</sub>		AC , 60 s	4000	Vrms
Isolation voltage (thermistor terminal-other terminals)	V <sub>isol(therm)</sub>		AC , 60 s	4000	Vrms
Mounting torque	TOR	(Note 2)	Main terminal: M6	4.5	N · m
		(Note 3)	Mounting: M5	3.5	N · m

Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note: Refer to the application notes.

Note 1: Ensure that the channel temperature does not exceed 150 °C.

Note 2: The recommended tightening torque for the main terminal (M6) is 4.0 N · m.

Note 3: The recommended tightening torque for mounting (M5) is 3.0 N · m.

### 6. Thermal-resistance

Characteristics	Symbol	Note	Min	Typ.	Max	Unit
Thermal resistance (channel-to-case)	R <sub>th(ch-c)</sub>	(Note 1)	—	—	0.060	K/W
Thermal resistance (case-to-fin)	R <sub>th(c-f)</sub>	(Note 2)	—	0.013	—	K/W

Note 1: The value per half a module.

Note 2: The value per module.

Apply 50 μm of 3 W/m · K grease between the case and fin while taking care not to create a void, and tighten to the recommended torque before use.

### 7. Electrical Characteristics (T<sub>c</sub> = 25 °C unless otherwise specified)

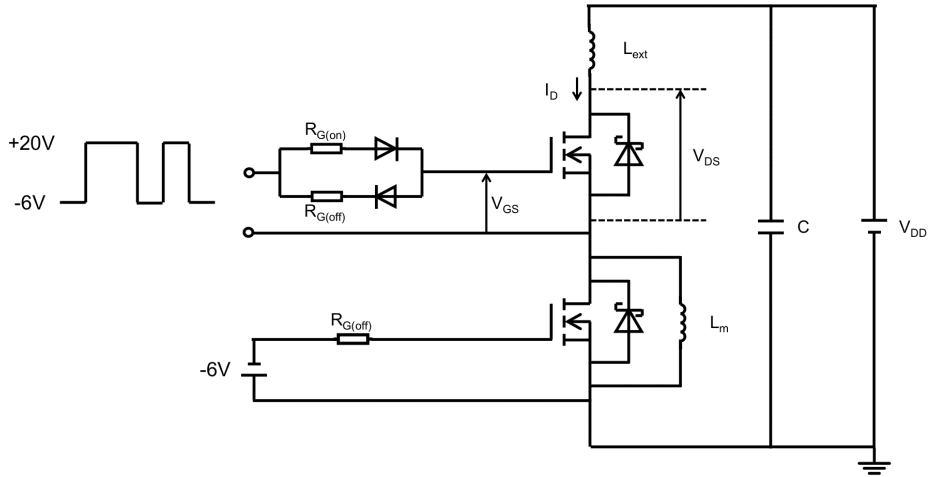
Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit	Fig.
Gate-source leakage current	I <sub>GSS</sub>		V <sub>GS</sub> = +25 V / -10 V, V <sub>DS</sub> = 0 V	—	—	±30	nA	—
Drain-source cut-off current	I <sub>DSS</sub>		V <sub>DS</sub> = 1200V, V <sub>GS</sub> = 0 V	—	—	250	μA	—
Gate threshold voltage	V <sub>th</sub>	(Note 4)	I <sub>D</sub> = 600 mA, V <sub>DS</sub> = 10 V	3.6	4.6	5.6	V	—
Drain-source on-voltage (sense)	V <sub>DS(on)</sub> sense	(Note 3)	I <sub>D</sub> = 600 A, V <sub>GS</sub> = + 20 V, T <sub>ch</sub> = 25 °C	—	0.9	—	V	—
			I <sub>D</sub> = 600 A, V <sub>GS</sub> = + 20 V, T <sub>ch</sub> = 150 °C	—	1.4	2.1	V	—
Drain-source on-voltage (terminal)	V <sub>DS(on)</sub> terminal	(Note 2)	I <sub>D</sub> = 600 A, V <sub>GS</sub> = + 20 V, T <sub>ch</sub> = 25 °C	—	1.4	—	V	—
Input capacitance	C <sub>iss</sub>		V <sub>DS</sub> = 600 V, V <sub>GS</sub> = 0 V, f = 10 kHz	—	53	—	nF	—
Internal gate resistance	r <sub>ig</sub>		V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 0 V, f = 1 MHz	—	2.7	—	Ω	—
Switching time (turn-on delay time)	t <sub>d(on)</sub>	(Note 1)	Inductive load, V <sub>DD</sub> = 600 V, I <sub>D</sub> = 600 A, V <sub>GS</sub> = + 20 V / - 6 V, R <sub>G(on)</sub> = 3.9 Ω, R <sub>G(off)</sub> = 3.9 Ω, T <sub>ch</sub> = 150 °C, L <sub>S</sub> ≈ 40 nH	—	0.23	—	μs	7.1
Switching time (rise time)	t <sub>r</sub>			—	0.10	—	μs	7.2
Switching time (turn-on time)	t <sub>on</sub>			—	0.33	—	μs	7.3
Switching time (turn-off delay time)	t <sub>d(off)</sub>			—	0.48	—	μs	
Switching time (fall time)	t <sub>f</sub>			—	0.07	—	μs	
Switching time (turn-off time)	t <sub>off</sub>			—	0.55	—	μs	
Turn-on switching loss	E <sub>on</sub>			—	25	37	mJ	
Turn-off switching loss	E <sub>off</sub>			—	28	41	mJ	
Source-drain on-voltage (sense)	V <sub>SD(on)</sub> sense	(Note 3)	I <sub>S</sub> = 600 A, V <sub>GS</sub> = + 20 V, T <sub>ch</sub> = 25 °C	—	0.8	—	V	—
			I <sub>S</sub> = 600 A, V <sub>GS</sub> = + 20 V, T <sub>ch</sub> = 150 °C	—	1.3	1.9	V	—
Source-drain on-voltage (terminal)	V <sub>SD(on)</sub> terminal	(Note 2)	I <sub>S</sub> = 600 A, V <sub>GS</sub> = + 20 V, T <sub>ch</sub> = 25 °C	—	1.3	—	V	—
Source-drain off-voltage (sense)	V <sub>SD(off)</sub> sense	(Note 3)	I <sub>S</sub> = 600 A, V <sub>GS</sub> = - 6 V, T <sub>ch</sub> = 25 °C	—	1.6	—	V	—
			I <sub>S</sub> = 600 A, V <sub>GS</sub> = - 6 V, T <sub>ch</sub> = 150 °C	—	2.2	3.2	V	—
Source-drain off-voltage (terminal)	V <sub>SD(off)</sub> terminal	(Note 2)	I <sub>S</sub> = 600 A, V <sub>GS</sub> = - 6 V, T <sub>ch</sub> = 25 °C	—	2.1	—	V	—
Reverse recovery time	t <sub>rr</sub>	(Note 1)	Inductive load, V <sub>DD</sub> = 600 V, I <sub>S</sub> = 600 A, V <sub>GS</sub> = - 6 V, Drive side R <sub>G(on)</sub> = 3.9 Ω, T <sub>ch</sub> = 150 °C, L <sub>S</sub> ≈ 40 nH	—	45	—	ns	7.4
Reverse recovery loss	E <sub>rr</sub>			—	0.8	—	mJ	7.5 7.6
Stray inductance	L <sub>sPN</sub>		P terminal-N terminal	—	12	—	nH	—
Rated NTC resistance	R		T <sub>C</sub> =25 °C	3.5	5.0	6.5	kΩ	—
			T <sub>C</sub> =150 °C	125	165	205	Ω	—
NTC B value	B		T <sub>NTC</sub> = 25 to 150 °C	—	3375	—	K	—

Note 1: L<sub>s</sub> is a sum of the stray inductance between the P and N terminals (L<sub>sPN</sub>) and the stray inductance of external circuitry (L<sub>ext</sub>). (L<sub>ext</sub> is shown in Fig. 7.1,7.2,7.4,7.5)

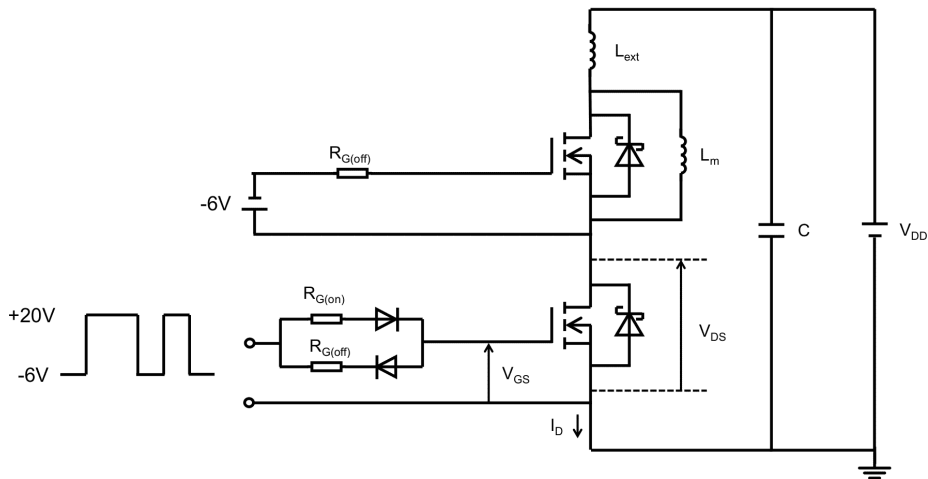
Note 2: The value shown are when two AC terminals are connected.

Note 3: The values are measured between drain sense and source sense.

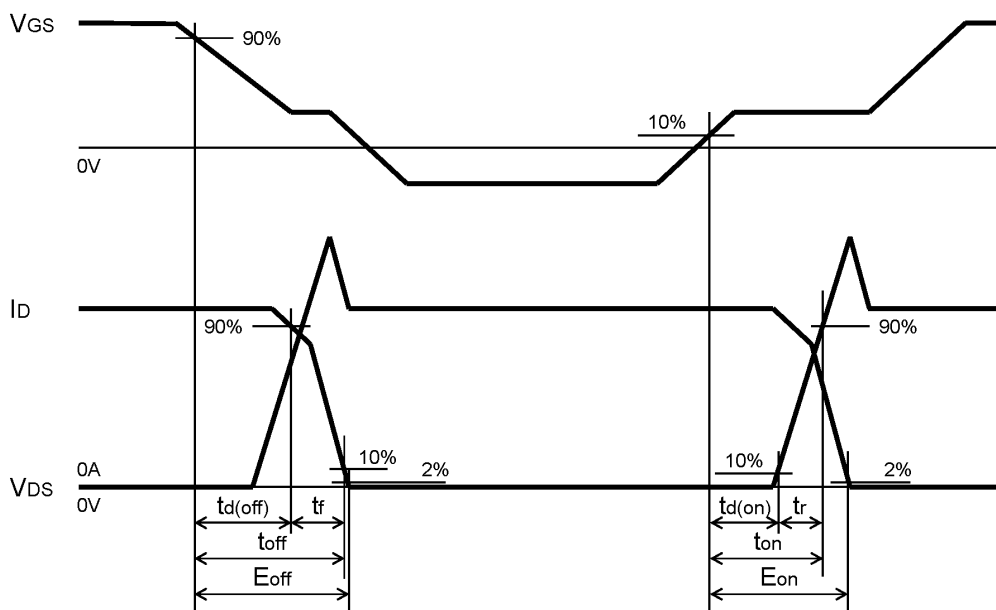
Note 4: Gate-source voltage (-10V) is applied 5ms before measurement.



**Fig. 7.1 Inductive Load Switching Test Circuit (High side Switching)**



**Fig. 7.2 Inductive Load Switching Test Circuit (Low side Switching)**



**Fig. 7.3 Timing Chart (MOSFET part)**

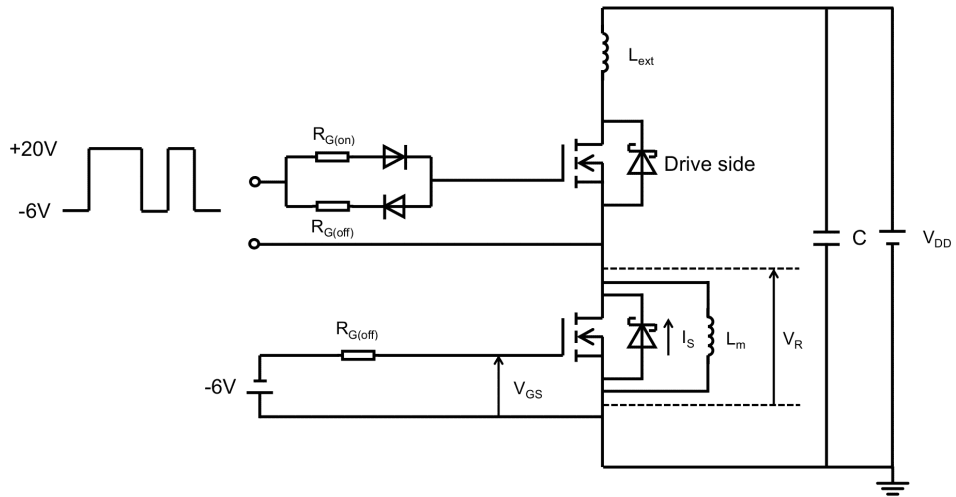


Fig. 7.4 Inductive Load Reverse Recovery Test Circuit (High side Switching)

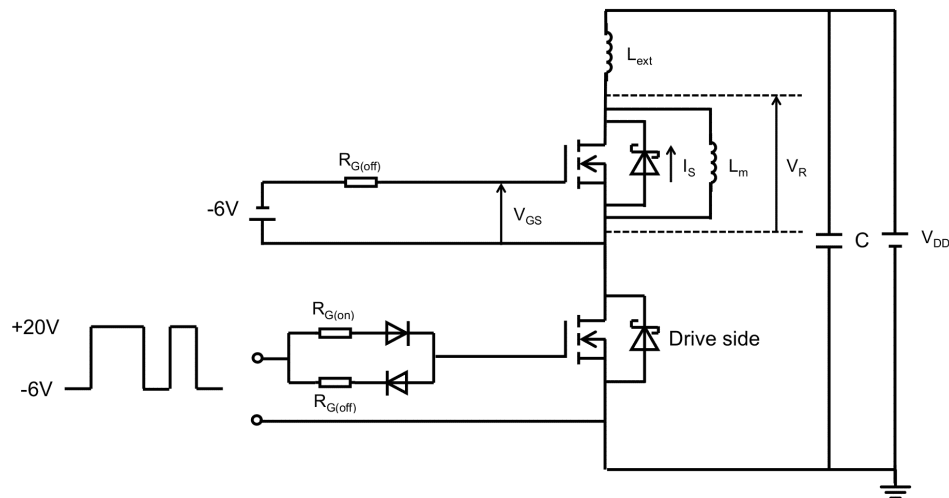


Fig. 7.5 Inductive Load Reverse Recovery Test Circuit (Low side Switching)

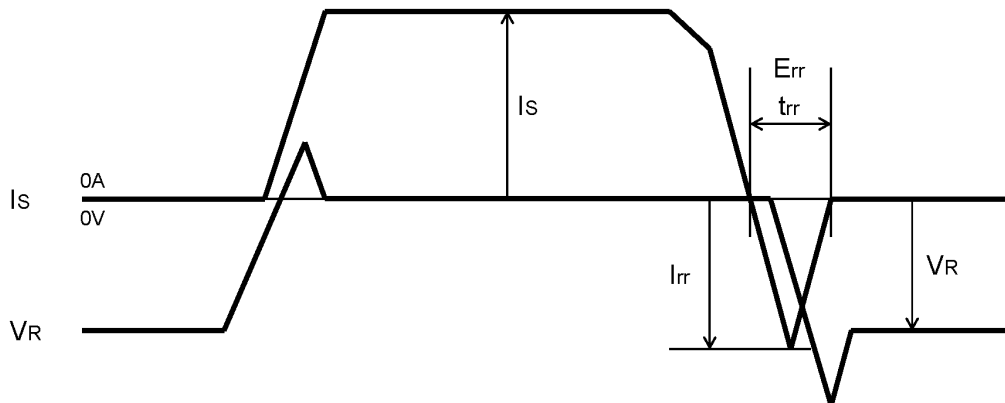
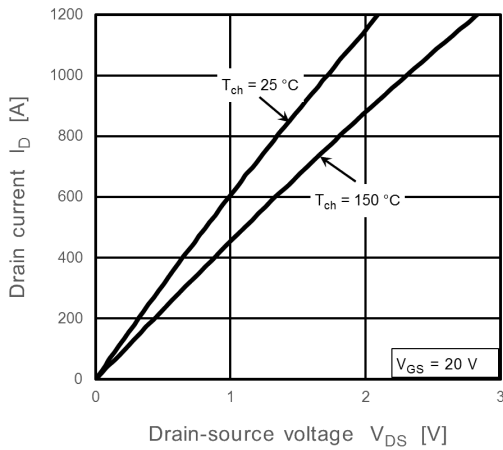
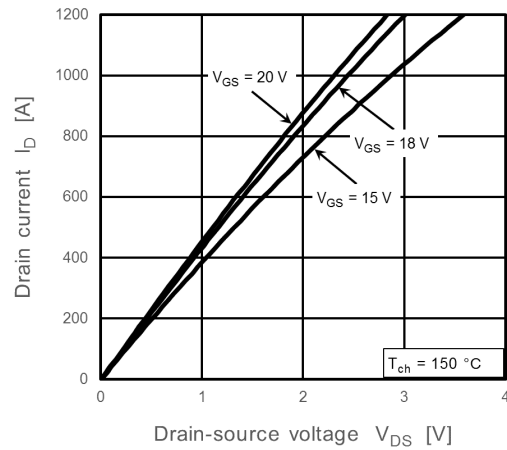


Fig. 7.6 Timing Chart (Diode part)

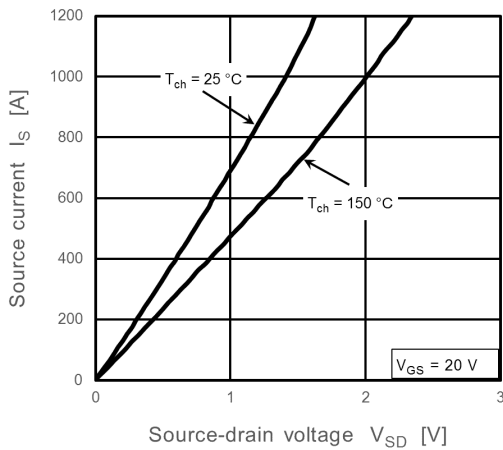
### 8. Characteristics Curves (Note)



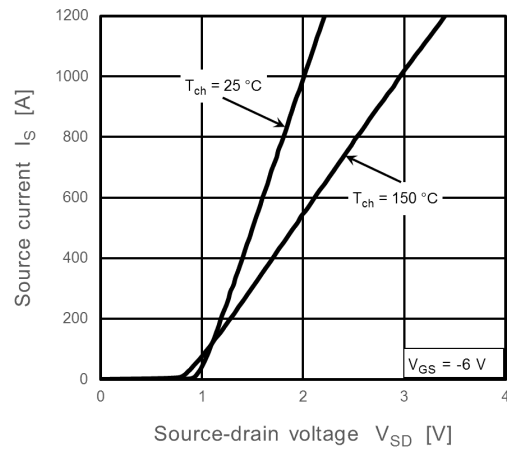
**Fig. 8.1  $I_D - V_{DS}$ (Note 1)**



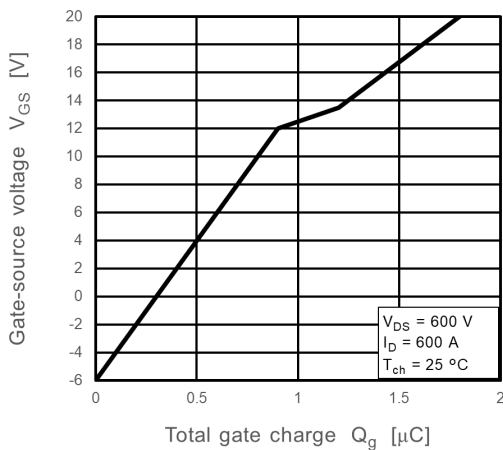
**Fig. 8.2  $I_D - V_{DS}$ (Note 1)**



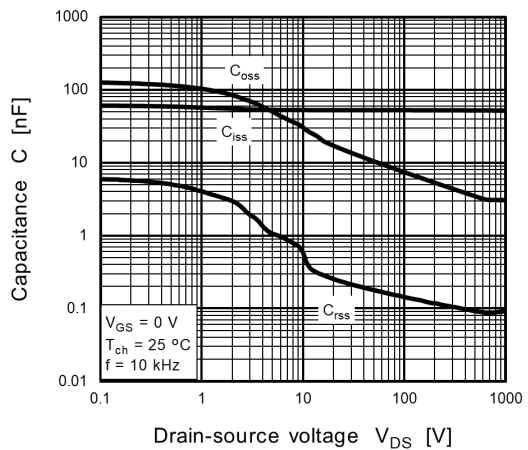
**Fig. 8.3  $I_S - V_{SD}$ (Note 1)**



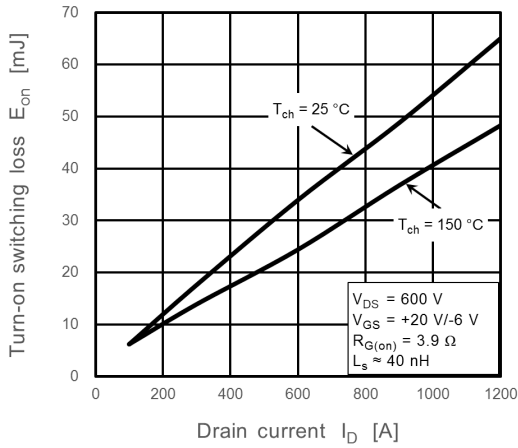
**Fig. 8.4  $I_S - V_{SD}$ (Note 1)**



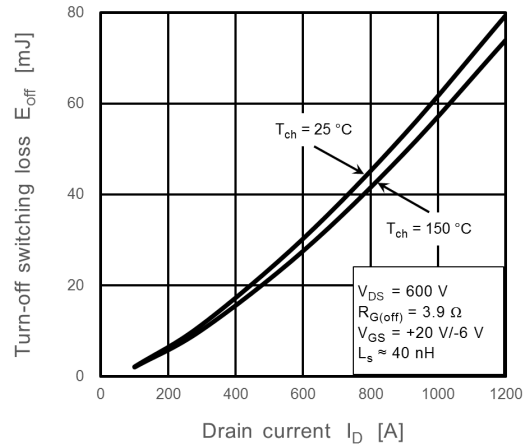
**Fig. 8.5  $V_{GS} - Q_g$**



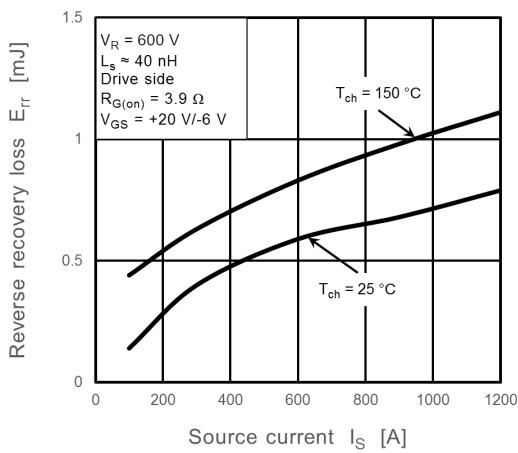
**Fig. 8.6  $C_{iss}, C_{oss}, C_{rss} - V_{DS}$**



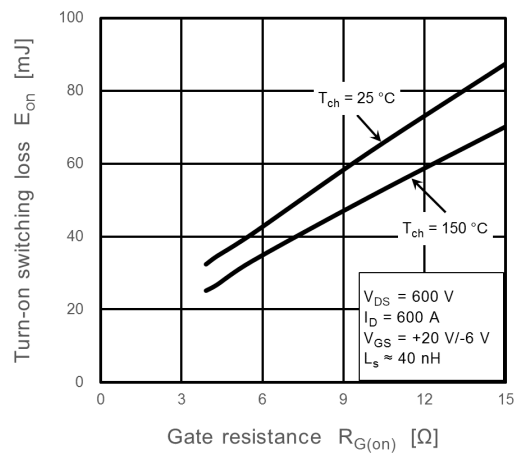
**Fig. 8.7  $E_{on} - I_D$**



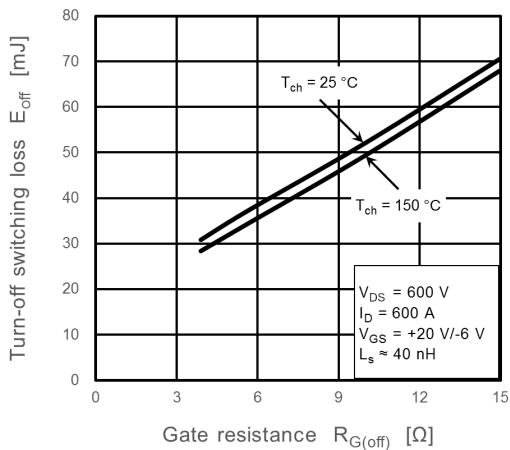
**Fig. 8.8  $E_{off} - I_D$**



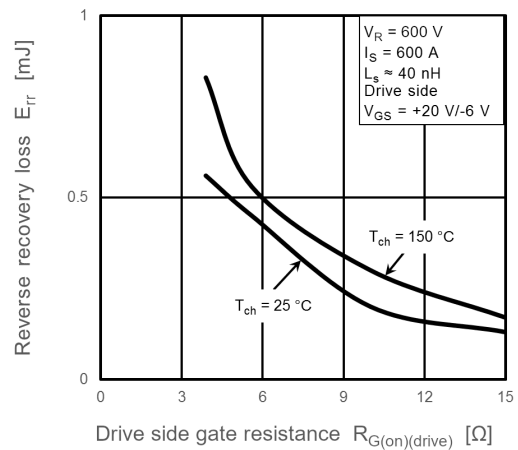
**Fig. 8.9  $E_{rr} - I_S$**



**Fig. 8.10  $E_{on} - R_{G(on)}$**

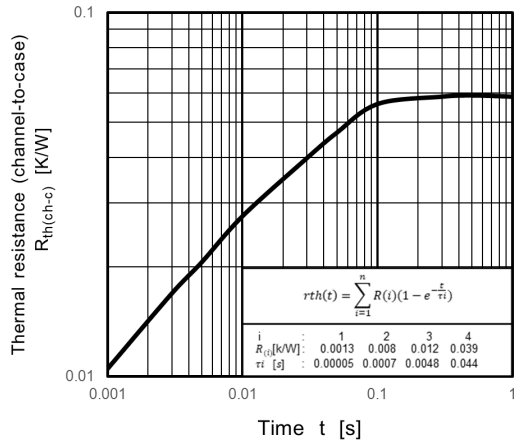


**Fig. 8.11  $E_{off} - R_{G(off)}$**

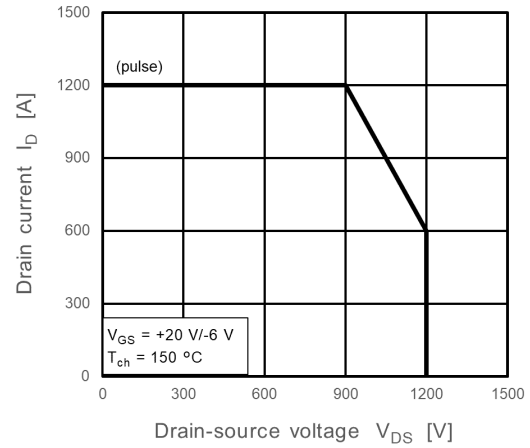


**Fig. 8.12  $E_{rr} - R_{G(on)}$**





**Fig. 8.13  $R_{th(ch-c)} - t$   
(Guaranteed Maximum)**



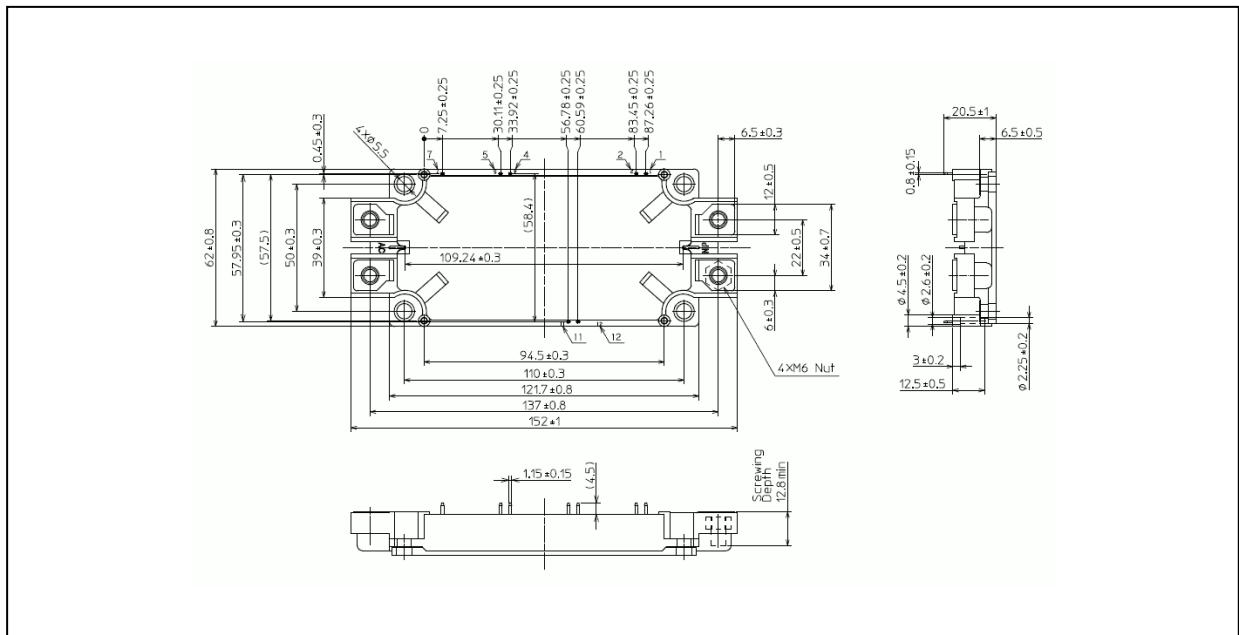
**Fig. 8.14 Reverse bias safe operating area  
(RBSOA)  
(Guaranteed Maximum)**

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

Note1: Source - drain voltage and Drain - source voltage are measured at sense terminals.

### Package Dimensions

Unit: mm



Weight: 350 g (typ.)

Package Name(s)
TOSHIBA: 2-153A1A

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