

MOSFETs Silicon N-channel MOS (U-MOS^{III}-H)

TPH1R403NL1

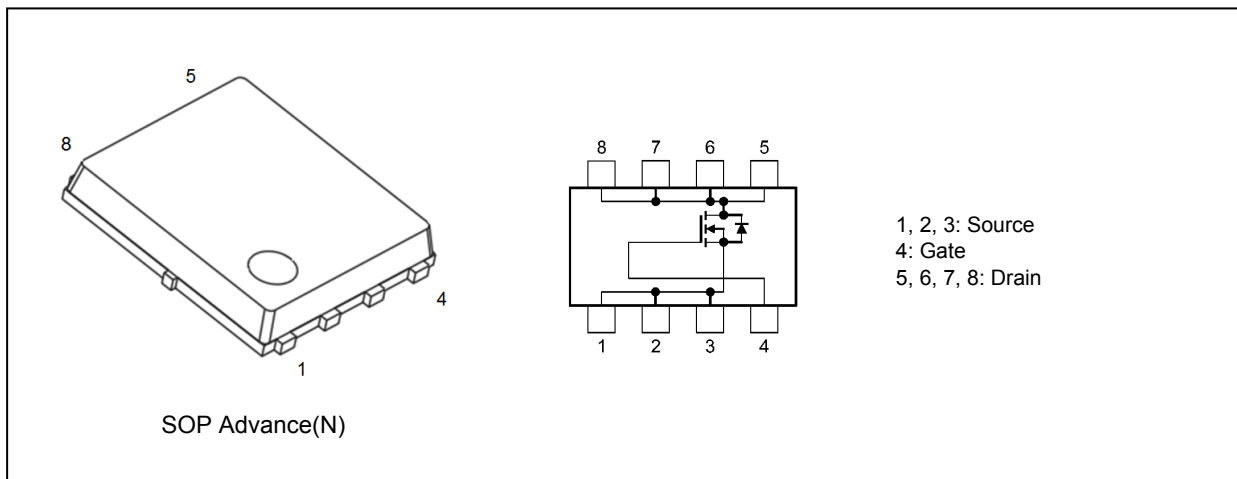
1. Applications

- High-Efficiency DC-DC Converters
- Switching Voltage Regulators

2. Features

- (1) High-speed switching
- (2) Small gate charge: $Q_{SW} = 10.6 \text{ nC (typ.)}$
- (3) Small output charge: $Q_{OSS} = 50 \text{ nC (typ.)}$
- (4) Low drain-source on-resistance: $R_{DS(ON)} = 1.2 \text{ m}\Omega \text{ (typ.) (} V_{GS} = 10 \text{ V)}$
- (5) Low leakage current: $I_{DSS} = 10 \text{ }\mu\text{A (max) (} V_{DS} = 30 \text{ V)}$
- (6) Enhancement mode: $V_{th} = 1.3 \text{ to } 2.3 \text{ V (} V_{DS} = 10 \text{ V, } I_D = 0.5 \text{ mA)}$

3. Packaging and Internal Circuit



Start of commercial production
2020-04

4. Absolute Maximum Ratings (Note) ($T_a = 25\text{ }^\circ\text{C}$ unless otherwise specified)

Characteristics	Symbol	Rating	Unit
Drain-source voltage	V_{DSS}	30	V
Gate-source voltage	V_{GSS}	± 20	
Drain current (DC) ($T_c = 25\text{ }^\circ\text{C}$) (Note 1), (Note 2)	I_D	150	A
Drain current (DC) (Silicon limit) (Note 1), (Note 2)	I_D	230	
Drain current (pulsed) ($t = 100\text{ }\mu\text{s}$) (Note 1)	I_{DP}	500	
Power dissipation ($T_c = 25\text{ }^\circ\text{C}$)	P_D	142	W
Power dissipation (Note 3)	P_D	2.5	
Power dissipation (Note 4)	P_D	0.8	
Single-pulse avalanche energy (Note 5)	E_{AS}	117	mJ
Single-pulse avalanche current (Note 5)	I_{AS}	120	A
Channel temperature	T_{ch}	150	$^\circ\text{C}$
Storage temperature	T_{stg}	-55 to 150	

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).

5. Thermal Characteristics

Characteristics	Symbol	Max	Unit
Channel-to-case thermal resistance ($T_c = 25\text{ }^\circ\text{C}$)	$R_{th(ch-c)}$	0.88	$^\circ\text{C}/\text{W}$
Channel-to-ambient thermal resistance ($T_a = 25\text{ }^\circ\text{C}$) (Note 3)	$R_{th(ch-a)}$	50	
Channel-to-ambient thermal resistance ($T_a = 25\text{ }^\circ\text{C}$) (Note 4)	$R_{th(ch-a)}$	156	

Note 1: Ensure that the channel temperature does not exceed $150\text{ }^\circ\text{C}$.

Note 2: Limited by package limit. Silicon chip capability is 230 A ($T_c = 25\text{ }^\circ\text{C}$).

Note 3: Device mounted on a glass-epoxy board (a), Figure 5.1

Note 4: Device mounted on a glass-epoxy board (b), Figure 5.2

Note 5: $V_{DD} = 24\text{ V}$, $T_{ch} = 25\text{ }^\circ\text{C}$ (initial), $L = 6.3\text{ }\mu\text{H}$, $I_{AS} = 120\text{ A}$



Fig. 5.1 Device Mounted on a Glass-Epoxy Board (a)

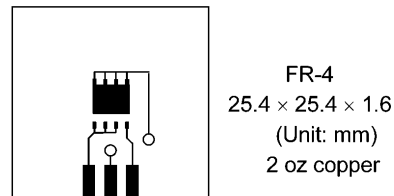


Fig. 5.2 Device Mounted on a Glass-Epoxy Board (b)

Note: This transistor is sensitive to electrostatic discharge and should be handled with care.

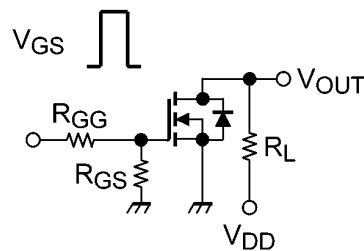
6. Electrical Characteristics

6.1. Static Characteristics ($T_a = 25\text{ }^\circ\text{C}$ unless otherwise specified)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Gate leakage current	I_{GSS}	$V_{GS} = \pm 20\text{ V}, V_{DS} = 0\text{ V}$	—	—	± 0.1	μA
Drain cut-off current	I_{DSS}	$V_{DS} = 30\text{ V}, V_{GS} = 0\text{ V}$	—	—	10	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$I_D = 10\text{ mA}, V_{GS} = 0\text{ V}$	30	—	—	V
	$V_{(BR)DSX}$	$I_D = 10\text{ mA}, V_{GS} = -20\text{ V}$	15	—	—	
Gate threshold voltage	V_{th}	$V_{DS} = 10\text{ V}, I_D = 0.5\text{ mA}$	1.3	—	2.3	
Drain-source on-resistance	$R_{DS(ON)}$	$V_{GS} = 4.5\text{ V}, I_D = 41\text{ A}$	—	1.7	2.1	$\text{m}\Omega$
		$V_{GS} = 10\text{ V}, I_D = 50\text{ A}$	—	1.2	1.4	

6.2. Dynamic Characteristics ($T_a = 25\text{ }^\circ\text{C}$ unless otherwise specified)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Input capacitance	C_{iss}	$V_{DS} = 15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	3400	4400	pF
Reverse transfer capacitance	C_{rss}		—	93	200	
Output capacitance	C_{oss}		—	1800	—	
Gate resistance	r_g	—	—	1.1	1.7	Ω
Switching time (rise time)	t_r	See Fig. 6.2.1	—	5.6	—	ns
Switching time (turn-on time)	t_{on}		—	16	—	
Switching time (fall time)	t_f		—	8.9	—	
Switching time (turn-off time)	t_{off}		—	50	—	



$V_{DD} \approx 15\text{ V}$
 $V_{GS} = 0\text{ V} / 10\text{ V}$
 $I_D = 30\text{ A}$
 $R_L = 0.5\ \Omega$
 $R_{GG} = 4.7\ \Omega$
 $R_{GS} = 4.7\ \Omega$
 Duty $\leq 1\%$, $t_w = 10\ \mu\text{s}$

Fig. 6.2.1 Switching Time Test Circuit

6.3. Gate Charge Characteristics ($T_a = 25\text{ }^\circ\text{C}$ unless otherwise specified)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Total gate charge (gate-source plus gate-drain)	Q_g	$V_{DD} \approx 15\text{ V}, V_{GS} = 10\text{ V}, I_D = 60\text{ A}$	—	46	—	nC
		$V_{DD} \approx 15\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 41\text{ A}$	—	20	—	
Gate-source charge 1	Q_{gs1}	$V_{DD} \approx 15\text{ V}, V_{GS} = 10\text{ V}, I_D = 60\text{ A}$	—	12.1	—	
Gate-drain charge	Q_{gd}		—	4.3	—	
Gate switch charge	Q_{sw}		—	10.6	—	
Output charge	Q_{oss}	$V_{DS} = 15\text{ V}, V_{GS} = 0\text{ V}$	—	50	—	

6.4. Source-Drain Characteristics ($T_a = 25\text{ }^\circ\text{C}$ unless otherwise specified)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Reverse drain current (pulsed)	(Note 6) I_{DRP}	$(t = 100\ \mu\text{s})$	—	—	500	A
Diode forward voltage	V_{DSF}	$I_{DR} = 150\text{ A}, V_{GS} = 0\text{ V}$	—	—	-1.2	V
Reverse recovery time	t_{rr}	$V_R = 15\text{ V}, I_{DR} = 30\text{ A}, V_{GS} = 0\text{ V}, -dI_{DR}/dt = 100\text{ A}/\mu\text{s}$	—	47	—	ns
Reverse recovery charge	Q_{rr}		—	52	—	nC

Note 6: Ensure that the channel temperature does not exceed $150\text{ }^\circ\text{C}$.

7. Marking

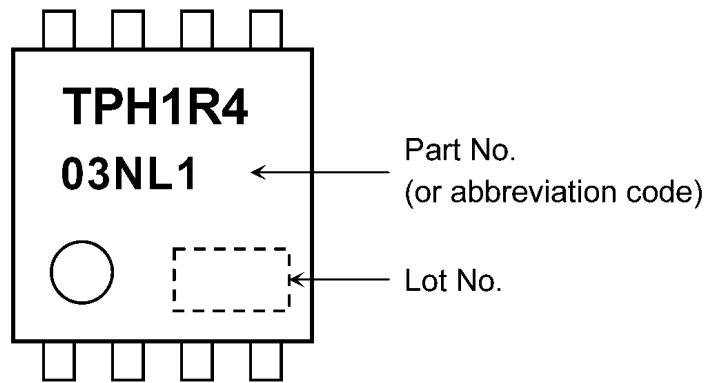


Fig. 7.1 Marking

8. Characteristics Curves (Note)

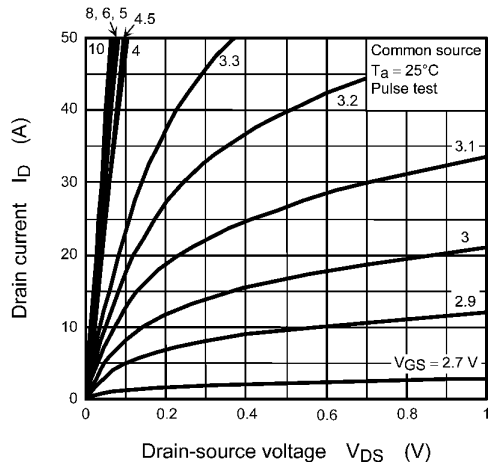


Fig. 8.1 $I_D - V_{DS}$

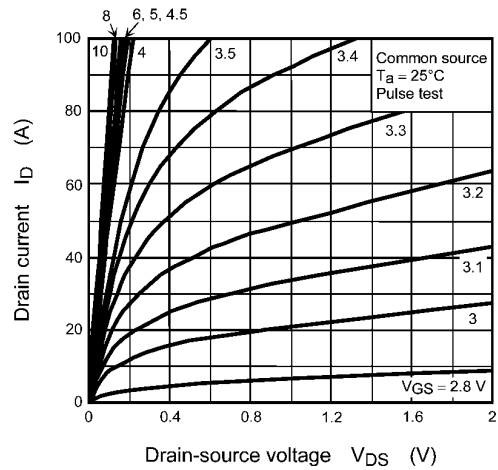


Fig. 8.2 $I_D - V_{DS}$

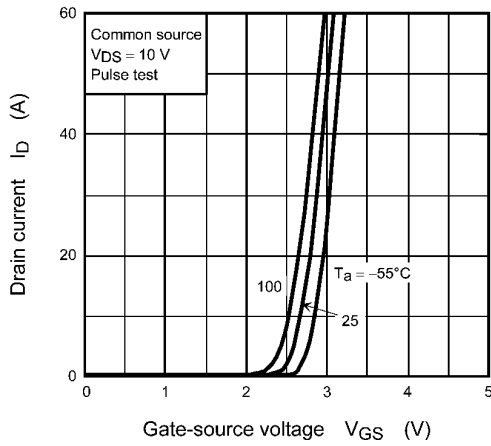


Fig. 8.3 $I_D - V_{GS}$

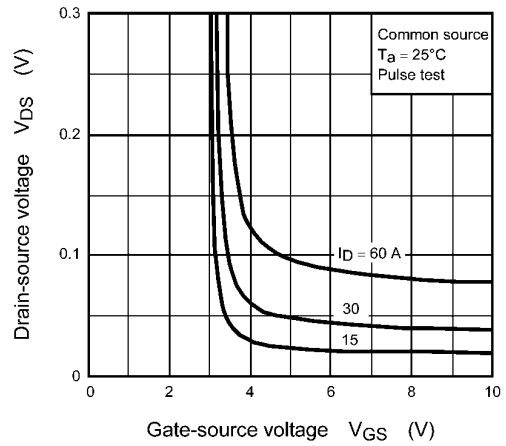


Fig. 8.4 $V_{DS} - V_{GS}$

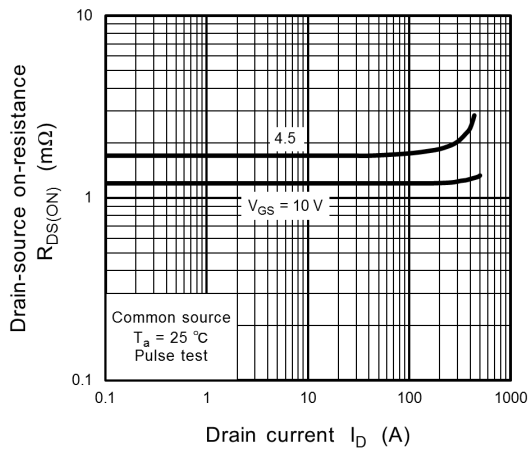


Fig. 8.5 $R_{DS(ON)} - I_D$

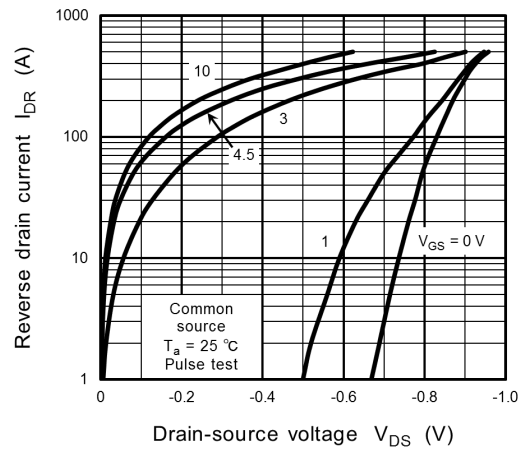


Fig. 8.6 $I_{DR} - V_{DS}$

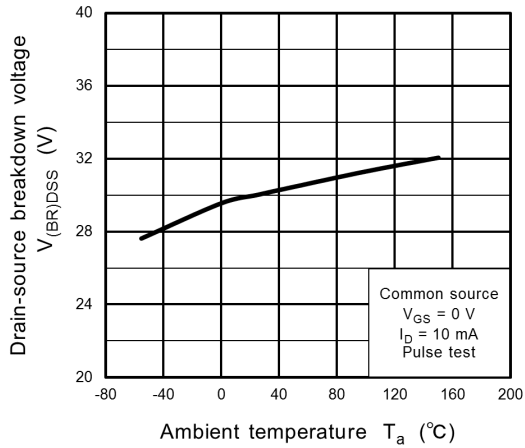


Fig. 8.7 $V_{(BR)DSS} - T_a$

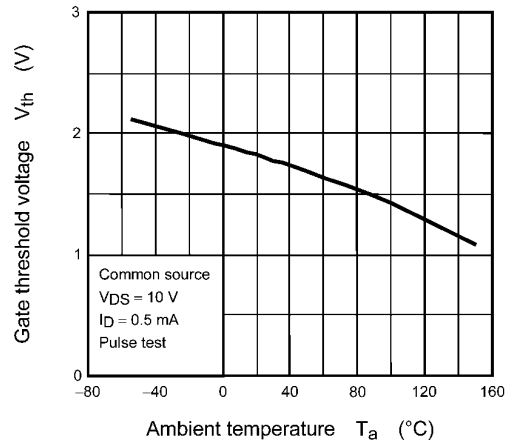


Fig. 8.8 $V_{th} - T_a$

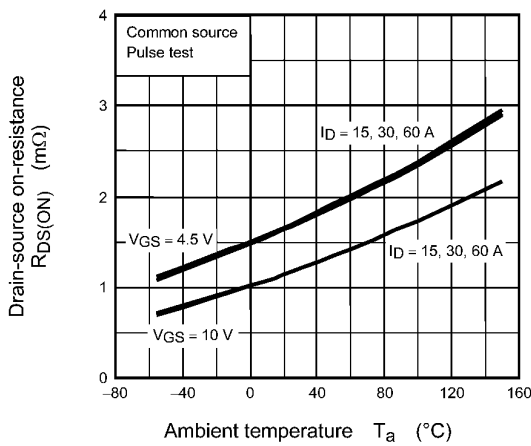


Fig. 8.9 $R_{DS(ON)} - T_a$

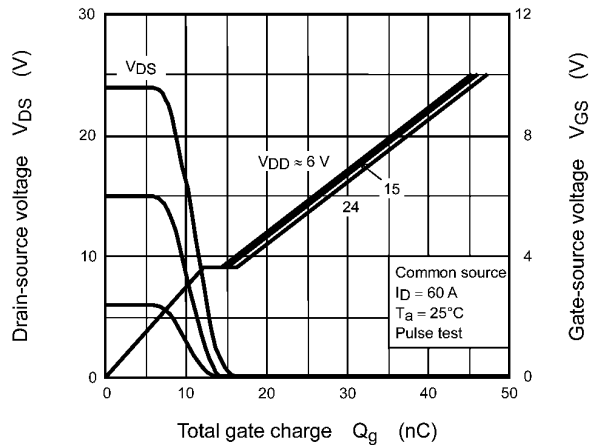


Fig. 8.10 Dynamic Input/Output Characteristics

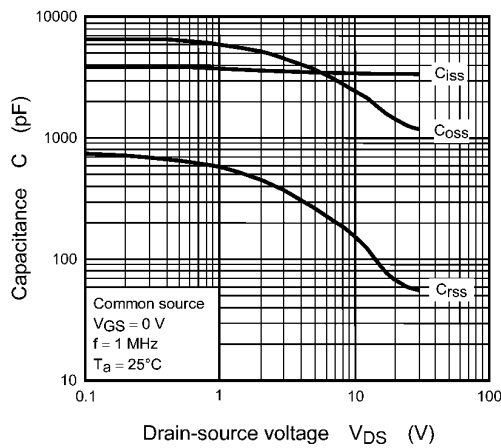


Fig. 8.11 Capacitance - V_{DS}

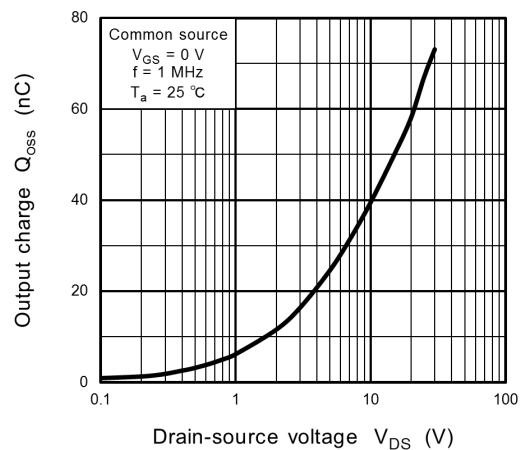


Fig. 8.12 $Q_{oss} - V_{DS}$

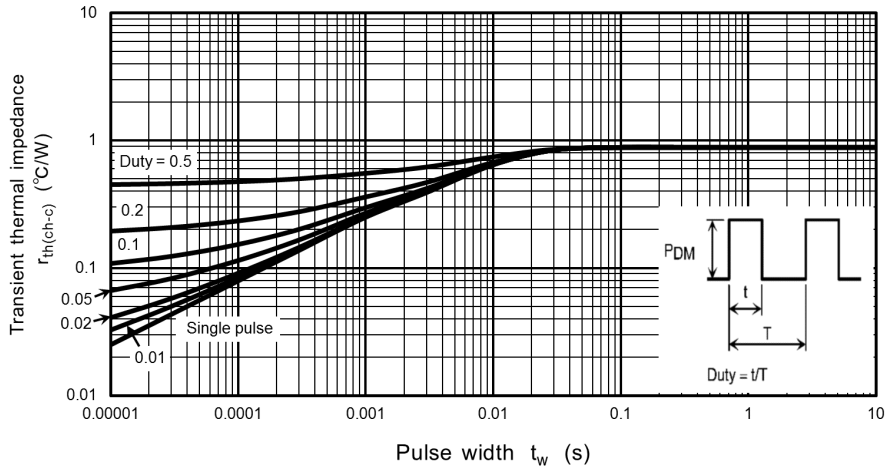


Fig. 8.13 $r_{th} - t_w$
(Guaranteed Maximum)

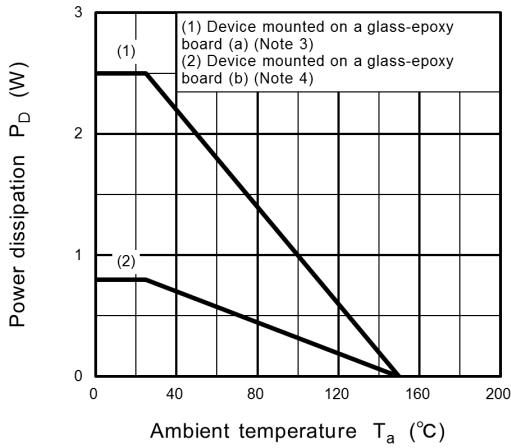


Fig. 8.14 $P_D - T_a$
(Guaranteed Maximum)

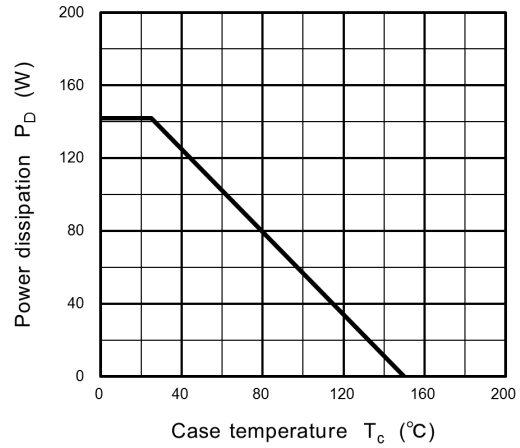


Fig. 8.15 $P_D - T_c$
(Guaranteed Maximum)

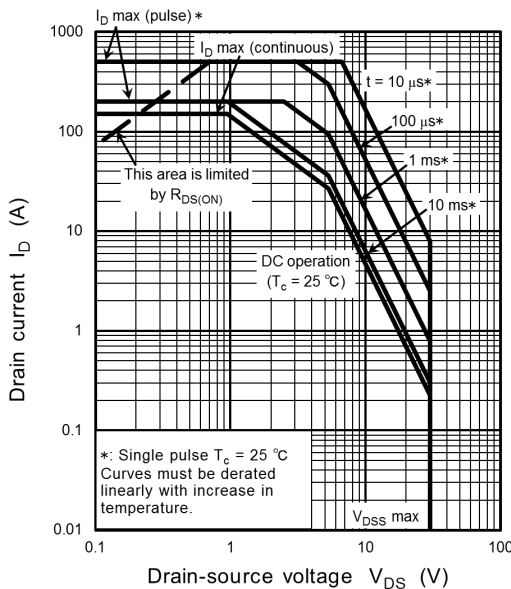


Fig. 8.16 Safe Operating Area
(Guaranteed Maximum)

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

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