

MOSFETs Silicon N-channel MOS (U-MOS<sup>III</sup>-H)

# TPHR9003NL1

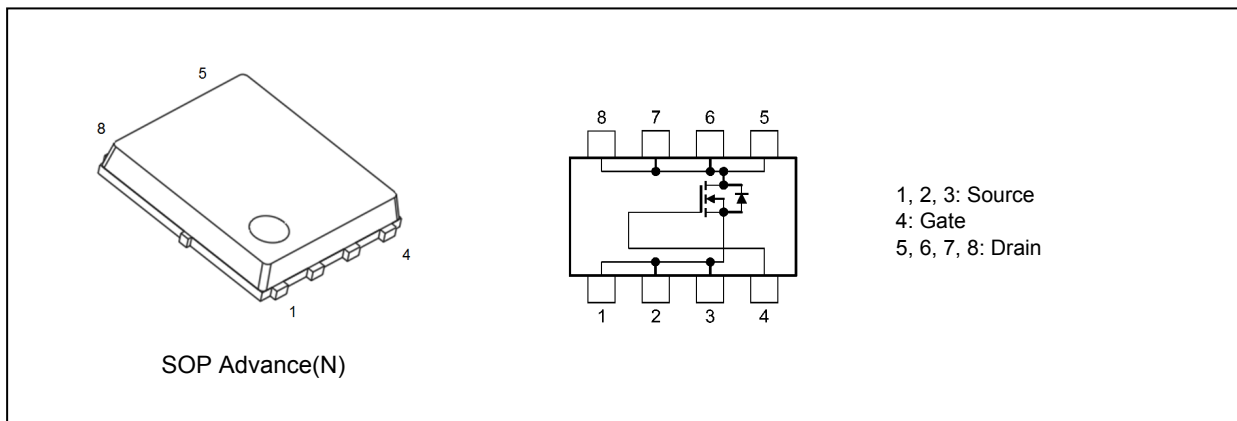
## 1. Applications

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

## 2. Features

- (1) High-speed switching
- (2) Small gate charge:  $Q_{SW} = 16 \text{ nC}$  (typ.)
- (3) Small output charge:  $Q_{OSS} = 74 \text{ nC}$  (typ.)
- (4) Low drain-source on-resistance:  $R_{DS(ON)} = 0.77 \text{ m}\Omega$  (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:  $V_{th} = 1.3 \text{ to } 2.3 \text{ V}$  ( $V_{DS} = 10 \text{ V}$ ,  $I_D = 1 \text{ mA}$ )

## 3. Packaging and Internal Circuit



Start of commercial production  
2020-03

## 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	$V_{GSS}$	$\pm 20$	
Drain current (DC) ( $T_c = 25\text{ }^\circ\text{C}$ ) (Note 1)	$I_D$	150	A
Drain current (DC) (Silicon limit) (Note 1), (Note 2)	$I_D$	320	A
Drain current (pulsed) ( $t = 100\text{ }\mu\text{s}$ ) (Note 1)	$I_{DP}$	500	A
Power dissipation ( $T_c = 25\text{ }^\circ\text{C}$ )	$P_D$	170	W
Power dissipation (Note 3)	$P_D$	2.5	W
Power dissipation (Note 4)	$P_D$	0.8	W
Single-pulse avalanche energy (Note 5)	$E_{AS}$	262	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	$^\circ\text{C}$

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 ( $T_c = 25\text{ }^\circ\text{C}$ )	$R_{th(ch-c)}$	0.71	$^\circ\text{C}/\text{W}$
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 320 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),  $L = 0.014\text{ mH}$ ,  $I_{AS} = 120\text{ A}$



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

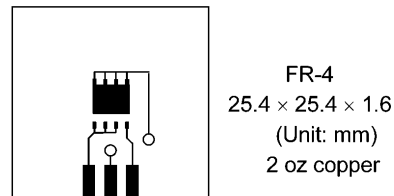


Fig. 5.2 Device Mounted on a Glass-Epoxy Board (b)

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	$I_{GSS}$	$V_{GS} = \pm 20\text{ V}, V_{DS} = 0\text{ V}$	—	—	$\pm 0.1$	$\mu\text{A}$
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
Drain-source breakdown voltage (Note 6)	$V_{(BR)DSX}$	$I_D = 10\text{ mA}, V_{GS} = -20\text{ V}$	15	—	—	
Gate threshold voltage	$V_{th}$	$V_{DS} = 10\text{ V}, I_D = 1\text{ mA}$	1.3	—	2.3	
Drain-source on-resistance	$R_{DS(ON)}$	$V_{GS} = 4.5\text{ V}, I_D = 50\text{ A}$	—	1.1	1.4	$\text{m}\Omega$
		$V_{GS} = 10\text{ V}, I_D = 50\text{ A}$	—	0.77	0.9	

Note 6: If a reverse bias is applied between gate and source, this device enters  $V_{(BR)DSX}$  mode. Note that the drain-source breakdown voltage is lowered in this mode.

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Input capacitance	$C_{iss}$	$V_{DS} = 15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	5300	6900	$\text{pF}$
Reverse transfer capacitance	$C_{rss}$		—	130	270	
Output capacitance	$C_{oss}$		—	2700	—	
Gate resistance	$r_g$	—	—	1.2	1.8	$\Omega$
Switching time (rise time)	$t_r$	See Fig. 6.2.1	—	9.6	—	ns
Switching time (turn-on time)	$t_{on}$		—	23	—	
Switching time (fall time)	$t_f$		—	15	—	
Switching time (turn-off time)	$t_{off}$		—	89	—	

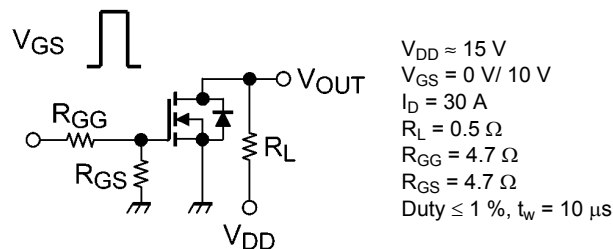


Fig. 6.2.1 Switching Time Test Circuit

### 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)	$Q_g$	$V_{DD} \approx 15\text{ V}, V_{GS} = 10\text{ V}, I_D = 60\text{ A}$	—	74	—	nC
		$V_{DD} \approx 15\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 60\text{ A}$	—	32	—	
Gate-source charge 1	$Q_{gs1}$	$V_{DD} \approx 15\text{ V}, V_{GS} = 10\text{ V}, I_D = 60\text{ A}$	—	19	—	
Gate-drain charge	$Q_{gd}$		—	6.5	—	
Gate switch charge	$Q_{SW}$		—	16	—	
Output charge	$Q_{oss}$	$V_{DS} = 15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	74	—	

## 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 7)	$I_{DRP}$ ( $t = 100\text{ }\mu\text{s}$ )	—	—	—	500	A
Diode forward voltage	$V_{DSF}$	$I_{DR} = 150\text{ A}$ , $V_{GS} = 0\text{ V}$	—	—	-1.2	V
Reverse recovery time	$t_{rr}$	$V_R = 15\text{ V}$ , $I_{DR} = 37.5\text{ A}$ , $V_{GS} = 0\text{ V}$ , $-di_{DR}/dt = 100\text{ A}/\mu\text{s}$	—	58	—	ns
Reverse recovery charge	$Q_{rr}$		—	72	—	nC

Note 7: Ensure that the channel temperature does not exceed  $150\text{ }^\circ\text{C}$ .

## 7. Marking

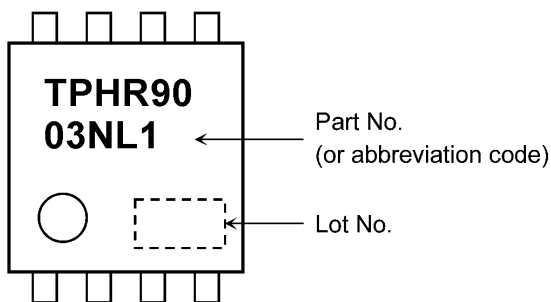
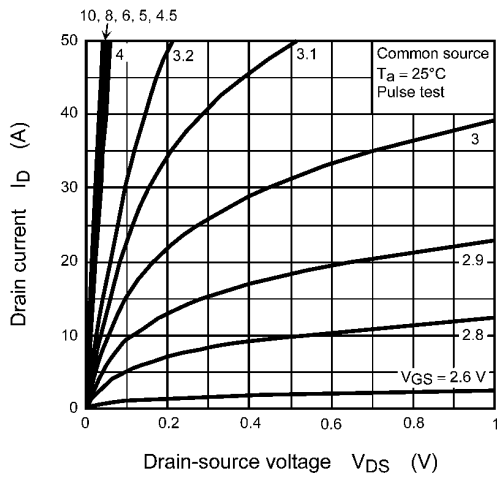
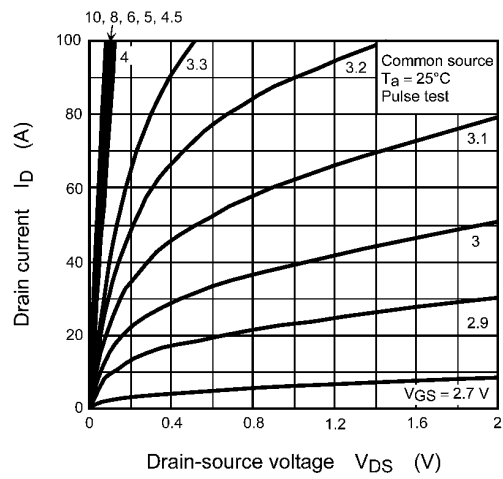


Fig. 7.1 Marking

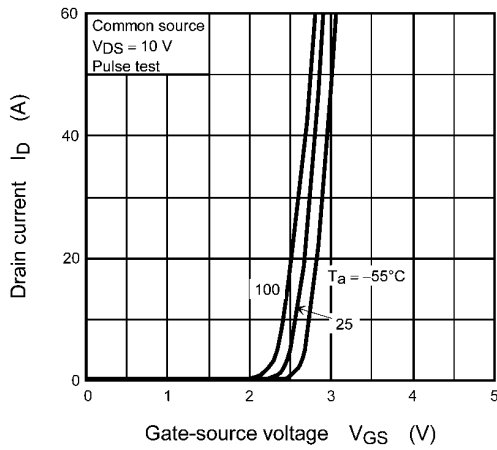
## 8. Characteristics Curves (Note)



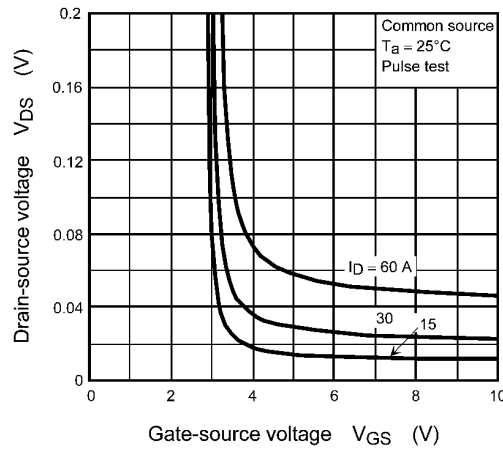
**Fig. 8.1**  $I_D - V_{DS}$



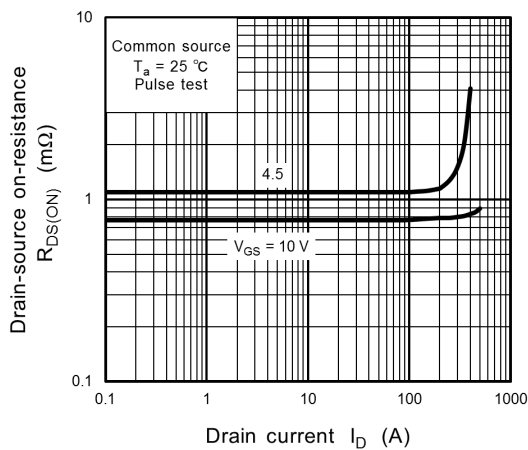
**Fig. 8.2**  $I_D - V_{DS}$



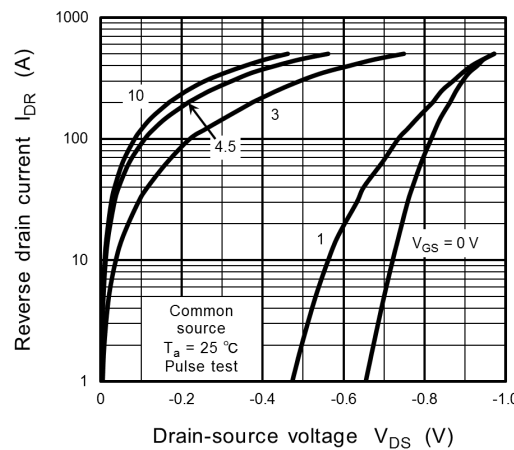
**Fig. 8.3**  $I_D - V_{GS}$



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



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



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

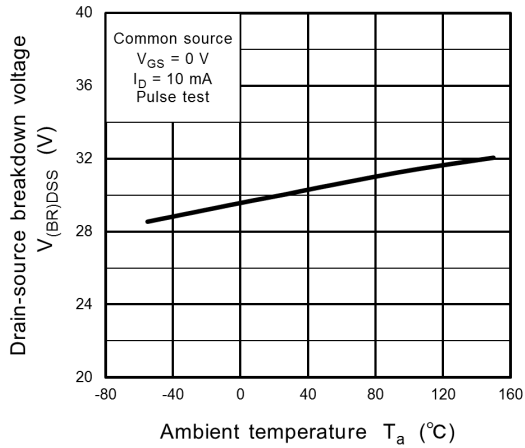


Fig. 8.7  $V_{(BR)DSS} - T_a$

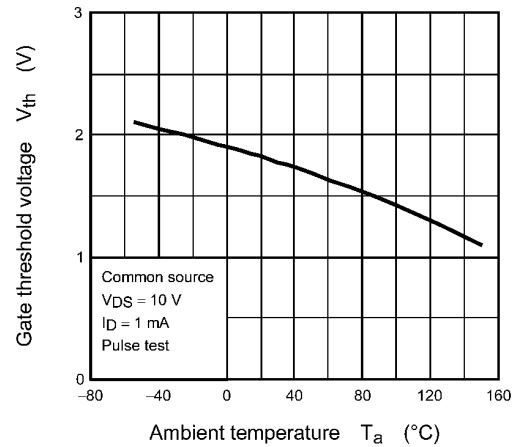


Fig. 8.8  $V_{th} - T_a$

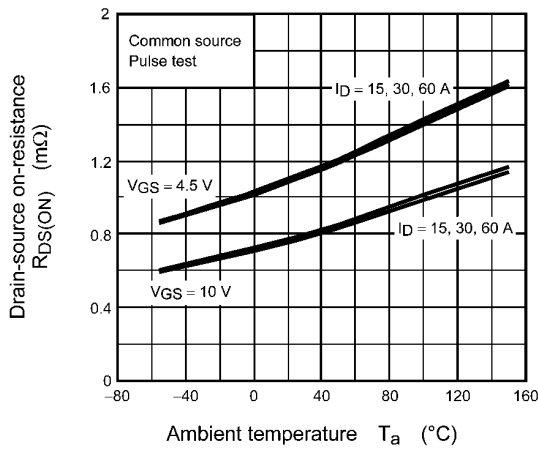


Fig. 8.9  $R_{DS(ON)} - T_a$

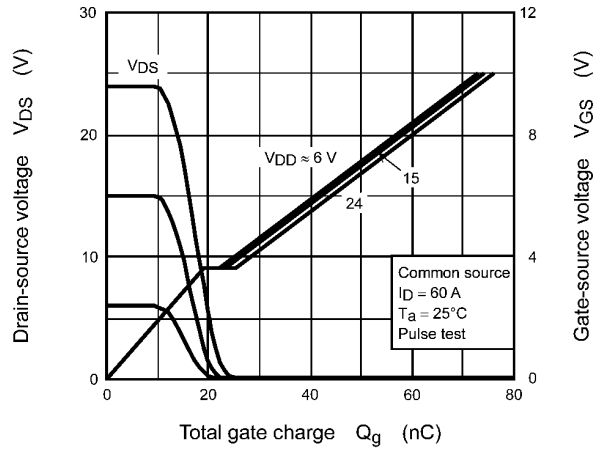


Fig. 8.10 Dynamic Input/Output Characteristics

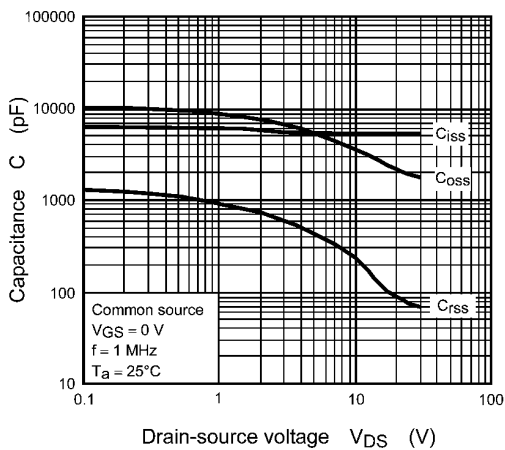


Fig. 8.11 Capacitance -  $V_{DS}$

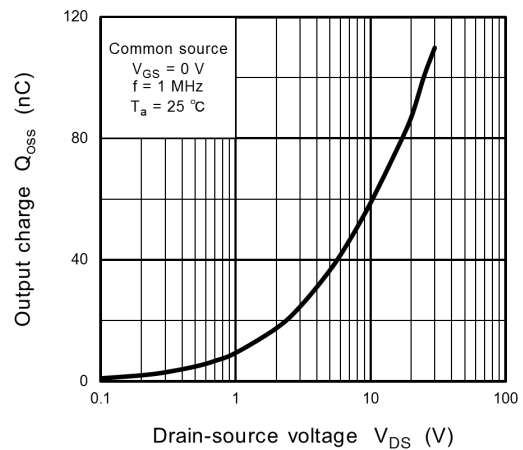
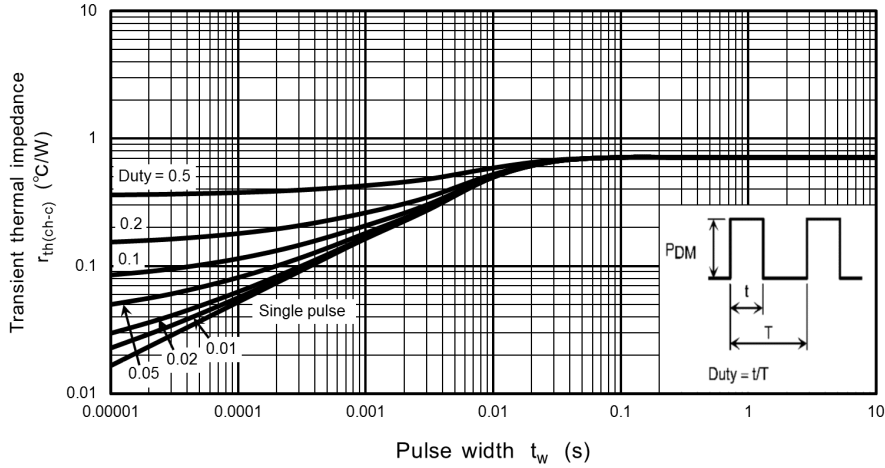
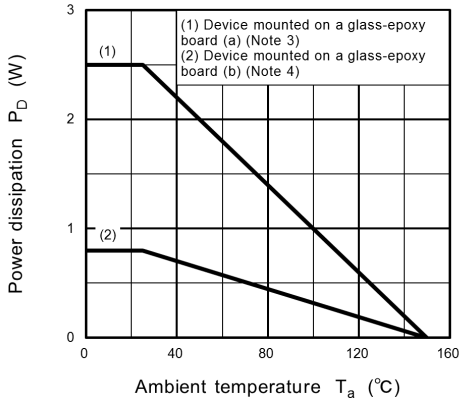


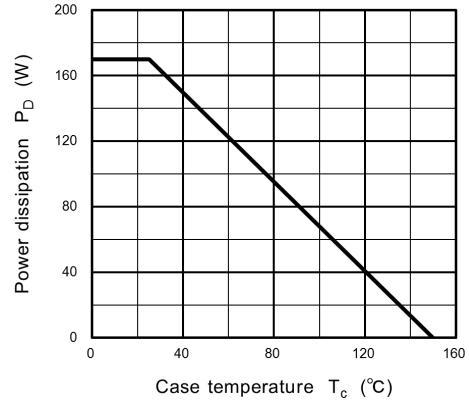
Fig. 8.12  $Q_{oss} - V_{DS}$



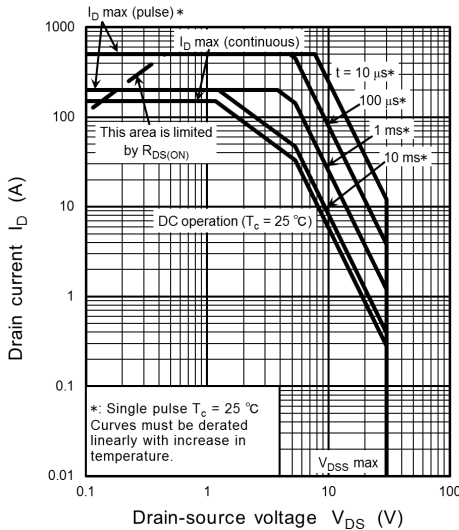
**Fig. 8.13  $r_{th} - t_w$**   
(Guaranteed Maximum)



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



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

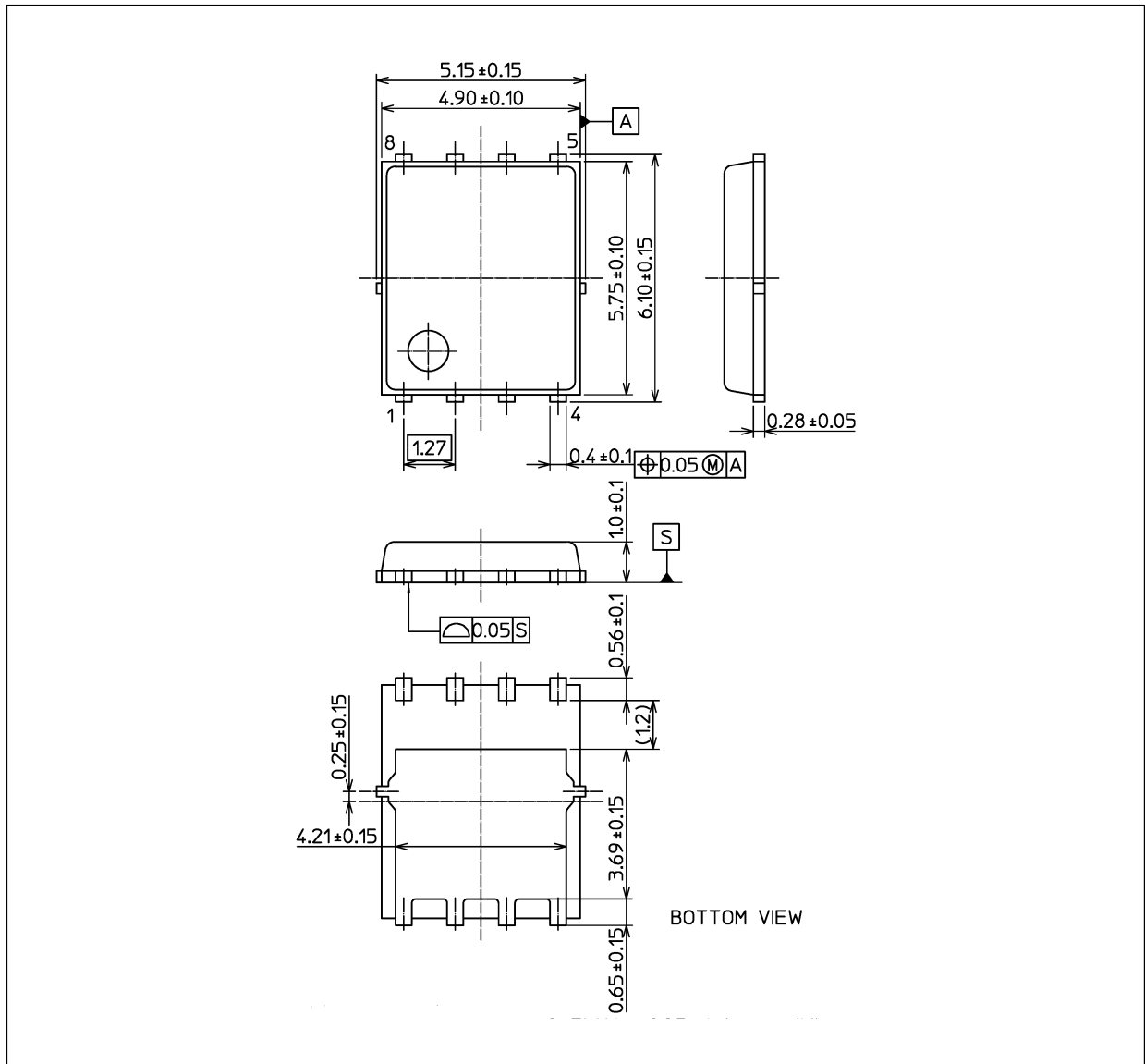


**Fig. 8.16 Safe Operating Area**  
(Guaranteed Maximum)

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

## Package Dimensions

Unit: mm



Weight: 0.111 g (typ.)

Package Name(s)
TOSHIBA: 2-5W1A
Nickname: SOP Advance(N)

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