

**TPH9R506PL**

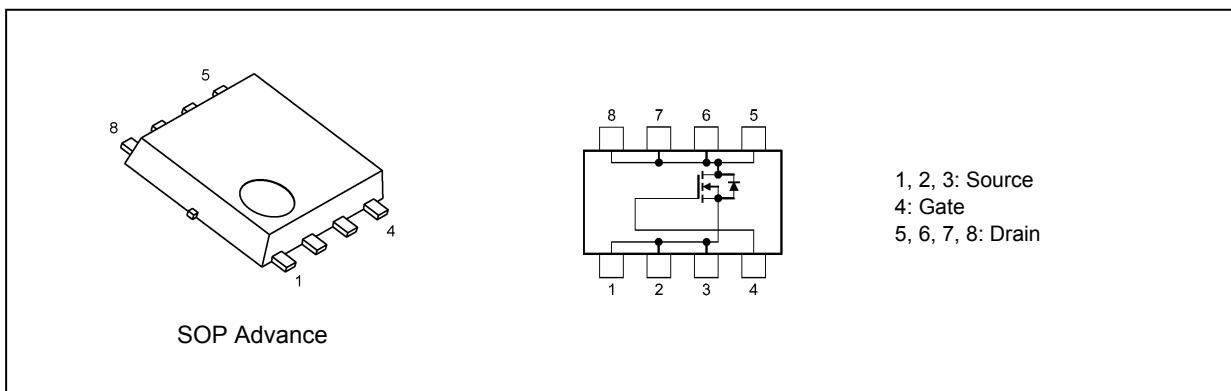
## 1. Applications

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

## 2. Features

- (1) High-speed switching
- (2) Small gate charge:  $Q_{SW} = 6.6 \text{ nC}$  (typ.)
- (3) Small output charge:  $Q_{oss} = 18 \text{ nC}$  (typ.)
- (4) Low drain-source on-resistance:  $R_{DS(ON)} = 7.3 \text{ m}\Omega$  (typ.) ( $V_{GS} = 10 \text{ V}$ )
- (5) Low leakage current:  $I_{DSS} = 10 \mu\text{A}$  (max) ( $V_{DS} = 60 \text{ V}$ )
- (6) Enhancement mode:  $V_{th} = 1.5 \text{ to } 2.5 \text{ V}$  ( $V_{DS} = 10 \text{ V}$ ,  $I_D = 0.2 \text{ mA}$ )

### 3. Packaging and Internal Circuit



1, 2, 3: Source  
4: Gate  
5, 6, 7, 8: Drain

Start of commercial production  
2016-10

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

Characteristics	Symbol	Rating	Unit
Drain-source voltage	$V_{DSS}$	60	V
Gate-source voltage	$V_{GSS}$	$\pm 20$	
Drain current (DC) ( $T_c = 25^\circ\text{C}$ ) (Note 1)	$I_D$	34	A
Drain current (DC) (Silicon limit) (Note 1), (Note 2)	$I_D$	68	
Drain current (pulsed) ( $t = 100\ \mu\text{s}$ ) (Note 1)	$I_{DP}$	150	W
Power dissipation ( $T_c = 25^\circ\text{C}$ )	$P_D$	81	
Power dissipation (Note 3)	$P_D$	1.8	
Power dissipation (Note 4)	$P_D$	0.83	
Single-pulse avalanche energy	$E_{AS}$	25	mJ
Single-pulse avalanche current	$I_{AS}$	34	A
Channel temperature	$T_{ch}$	175	°C
Storage temperature	$T_{stg}$	-55 to 175	

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 ( $T_c = 25^\circ\text{C}$ )	$R_{th(ch-c)}$	1.83	°C/W
Channel-to-ambient thermal resistance ( $T_a = 25^\circ\text{C}$ ) (Note 3)	$R_{th(ch-a)}$	83	
Channel-to-ambient thermal resistance ( $T_a = 25^\circ\text{C}$ ) (Note 4)	$R_{th(ch-a)}$	180	

Note 1: Ensure that the channel temperature does not exceed 175 °C.

Note 2: Limited by silicon chip capability.

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:  $V_{DD} = 48\text{ V}$ ,  $T_{ch} = 25^\circ\text{C}$  (initial),  $L = 17\ \mu\text{H}$ ,  $I_{AS} = 34\text{ A}$

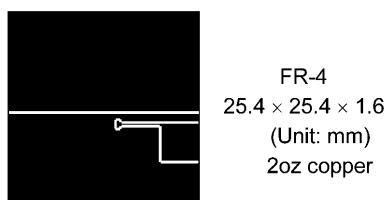


Fig. 5.1 Device Mounted on a Glass-Epoxy Board (a)

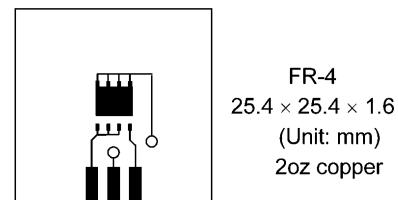


Fig. 5.2 Device Mounted on a Glass-Epoxy Board (b)

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

## 6. Electrical Characteristics

### 6.1. Static Characteristics ( $T_a = 25^\circ\text{C}$ 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	$I_{DSS}$	$V_{DS} = 60\text{ V}$ , $V_{GS} = 0\text{ V}$	—	—	10	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$I_D = 10\text{ mA}$ , $V_{GS} = 0\text{ V}$	60	—	—	
Drain-source breakdown voltage (Note 6)	$V_{(BR)DSX}$	$I_D = 10\text{ mA}$ , $V_{GS} = -20\text{ V}$	45	—	—	
Gate threshold voltage	$V_{th}$	$V_{DS} = 10\text{ V}$ , $I_D = 0.2\text{ mA}$	1.5	—	2.5	
Drain-source on-resistance	$R_{DS(ON)}$	$V_{GS} = 4.5\text{ V}$ , $I_D = 8\text{ A}$	—	10.2	15.0	
		$V_{GS} = 10\text{ V}$ , $I_D = 17\text{ A}$	—	7.3	9.5	$\text{m}\Omega$

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Input capacitance	$C_{iss}$	$V_{DS} = 30\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 1\text{ MHz}$	—	1470	1910	$\text{pF}$
Reverse transfer capacitance	$C_{rss}$		—	30	65	
Output capacitance	$C_{oss}$		—	270	—	
Gate resistance	$r_g$	—	—	0.7	1.2	$\Omega$
Switching time (rise time)	$t_r$	See Fig. 6.2.1	—	4.4	—	$\text{ns}$
Switching time (turn-on time)	$t_{on}$		—	13	—	
Switching time (fall time)	$t_f$		—	5.2	—	
Switching time (turn-off time)	$t_{off}$		—	21	—	

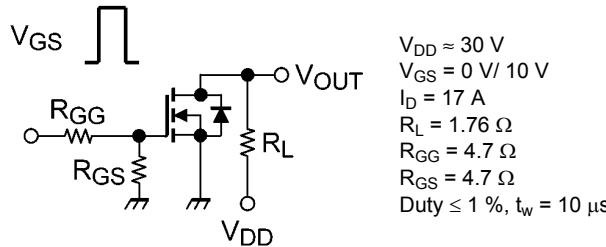


Fig. 6.2.1 Switching Time Test Circuit

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Total gate charge (gate-source plus gate-drain)	$Q_g$	$V_{DD} \approx 30\text{ V}$ , $V_{GS} = 10\text{ V}$ , $I_D = 17\text{ A}$	—	21	—	$\text{nC}$
		$V_{DD} \approx 30\text{ V}$ , $V_{GS} = 4.5\text{ V}$ , $I_D = 17\text{ A}$	—	11	—	
Gate-source charge 1	$Q_{gs1}$	$V_{DD} \approx 30\text{ V}$ , $V_{GS} = 10\text{ V}$ , $I_D = 17\text{ A}$	—	5.6	—	$\text{nC}$
Gate-drain charge	$Q_{gd}$		—	3.9	—	
Gate switch charge	$Q_{SW}$		—	6.6	—	
Output charge	$Q_{oss}$	$V_{DS} = 30\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 1\text{ MHz}$	—	18	—	

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Reverse drain current (pulsed) (Note 7)	$I_{DRP}$	( $t = 100\ \mu\text{s}$ )	—	—	150	A
Diode forward voltage	$V_{DSF}$	$I_{DR} = 34\text{ A}, V_{GS} = 0\text{ V}$	—	—	-1.2	V
Reverse recovery time	$t_{rr}$	$I_{DR} = 8.5\text{ A}, V_{GS} = 0\text{ V},$ $-dI_{DR}/dt = 100\text{ A}/\mu\text{s}$	—	27	—	ns
Reverse recovery charge	$Q_{rr}$		—	20	—	nC

Note 7: Ensure that the channel temperature does not exceed  $175^\circ\text{C}$ .

#### 7. Marking

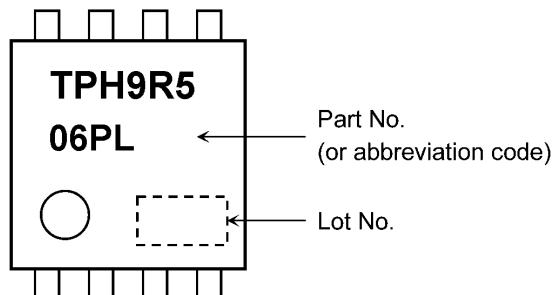


Fig. 7.1 Marking

## 8. Characteristics Curves (Note)

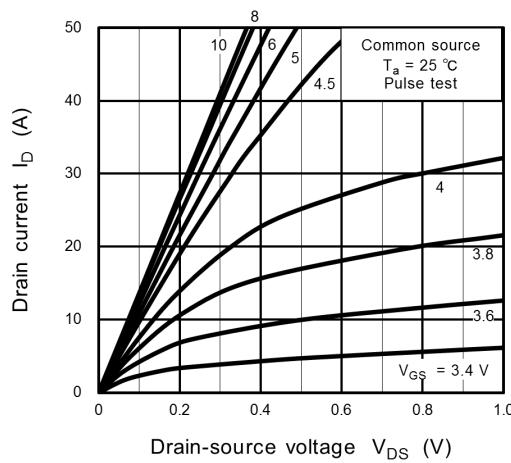


Fig. 8.1  $I_D$  -  $V_{DS}$

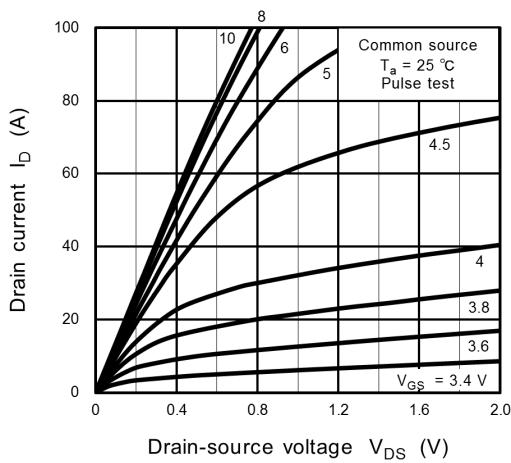


Fig. 8.2  $I_D$  -  $V_{DS}$

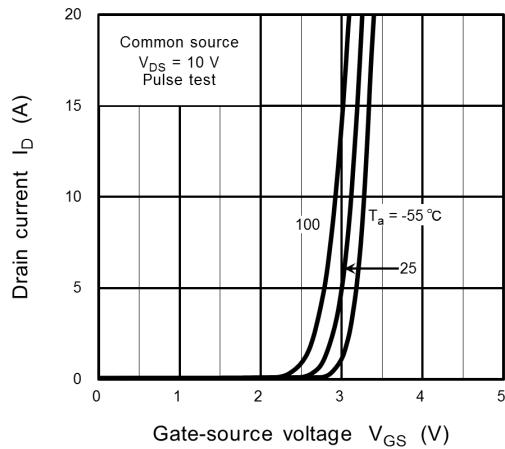


Fig. 8.3  $I_D$  -  $V_{GS}$

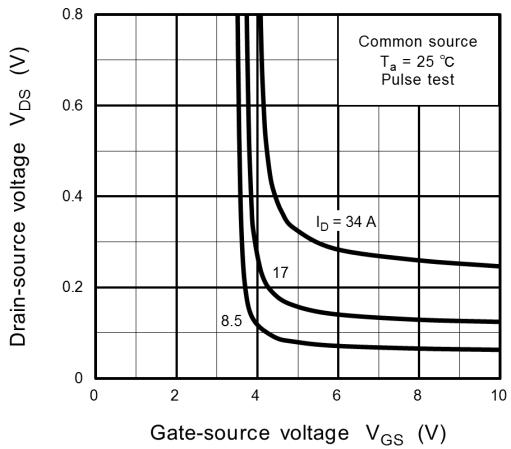


Fig. 8.4  $V_{DS}$  -  $V_{GS}$

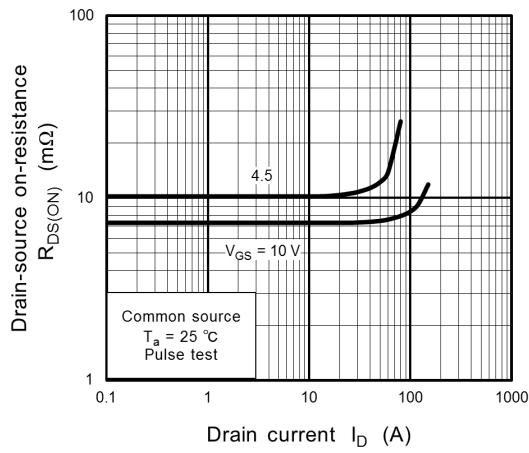


Fig. 8.5  $R_{DS(ON)}$  -  $I_D$

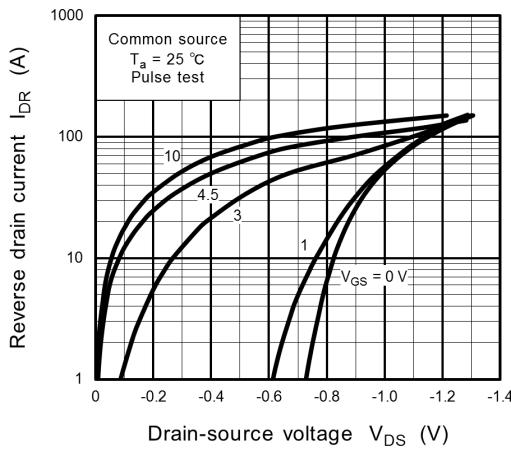


Fig. 8.6  $I_{DR}$  -  $V_{DS}$

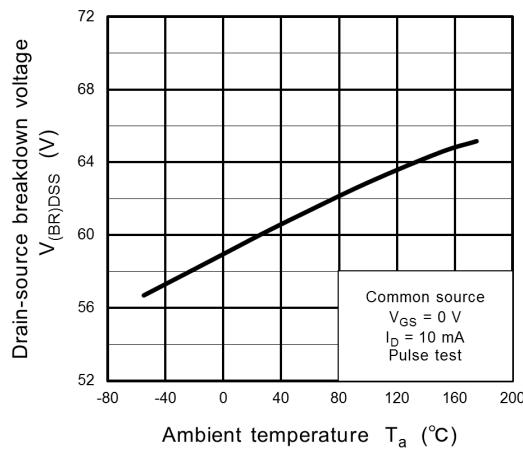
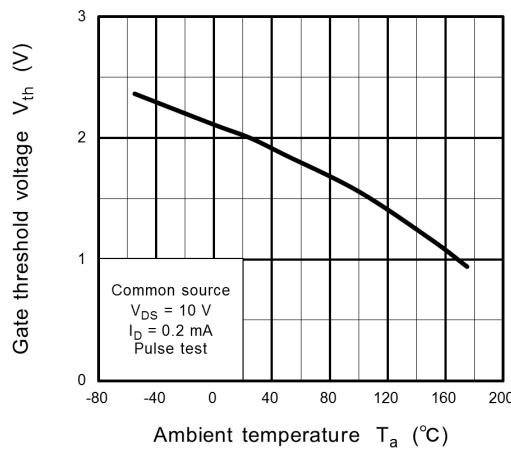
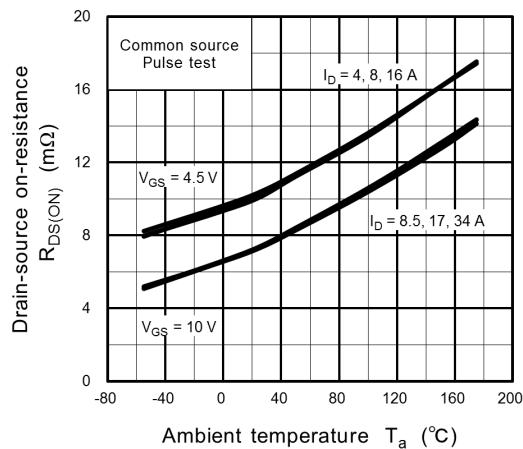
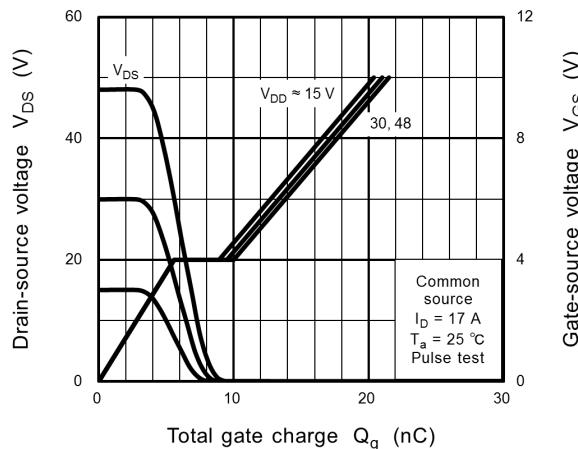
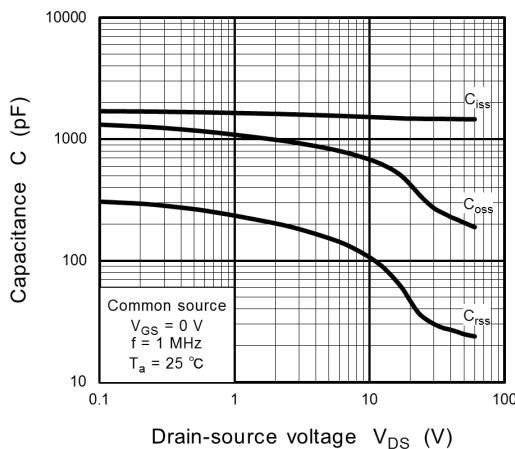
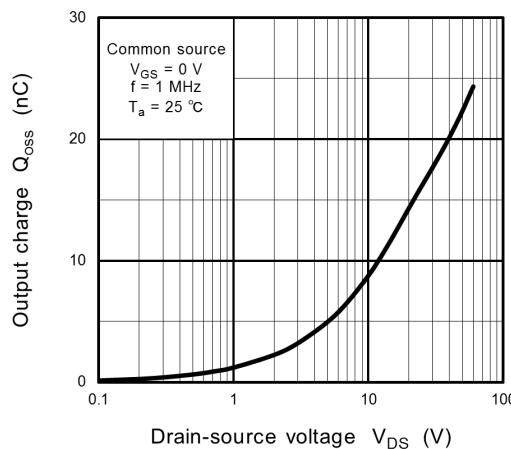
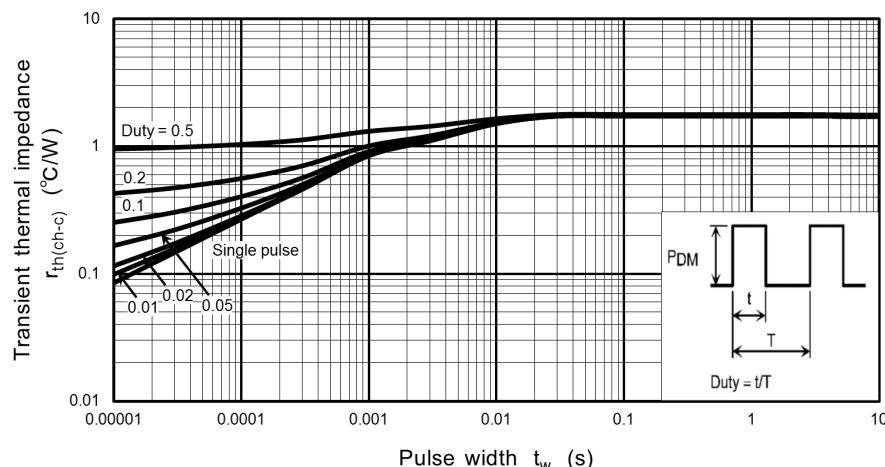
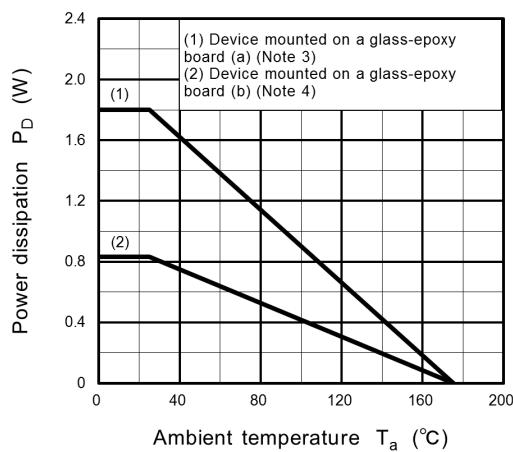
Fig. 8.7  $V_{(BR)DSS}$  -  $T_a$ Fig. 8.8  $V_{th}$  -  $T_a$ Fig. 8.9  $R_{DS(ON)}$  -  $T_a$ 

Fig. 8.10 Dynamic Input/Output Characteristics

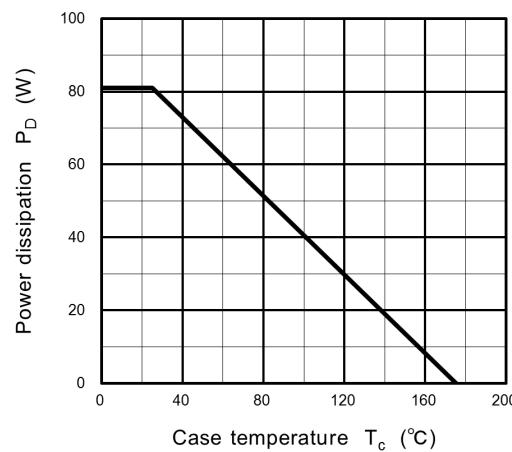
Fig. 8.11 Capacitance -  $V_{DS}$ Fig. 8.12  $Q_{oss}$  -  $V_{DS}$



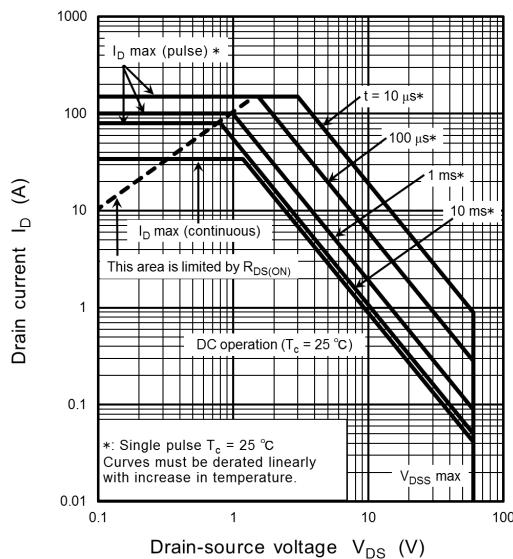
**Fig. 8.13  $r_{th}$  -  $t_w$   
(Guaranteed Maximum)**



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



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

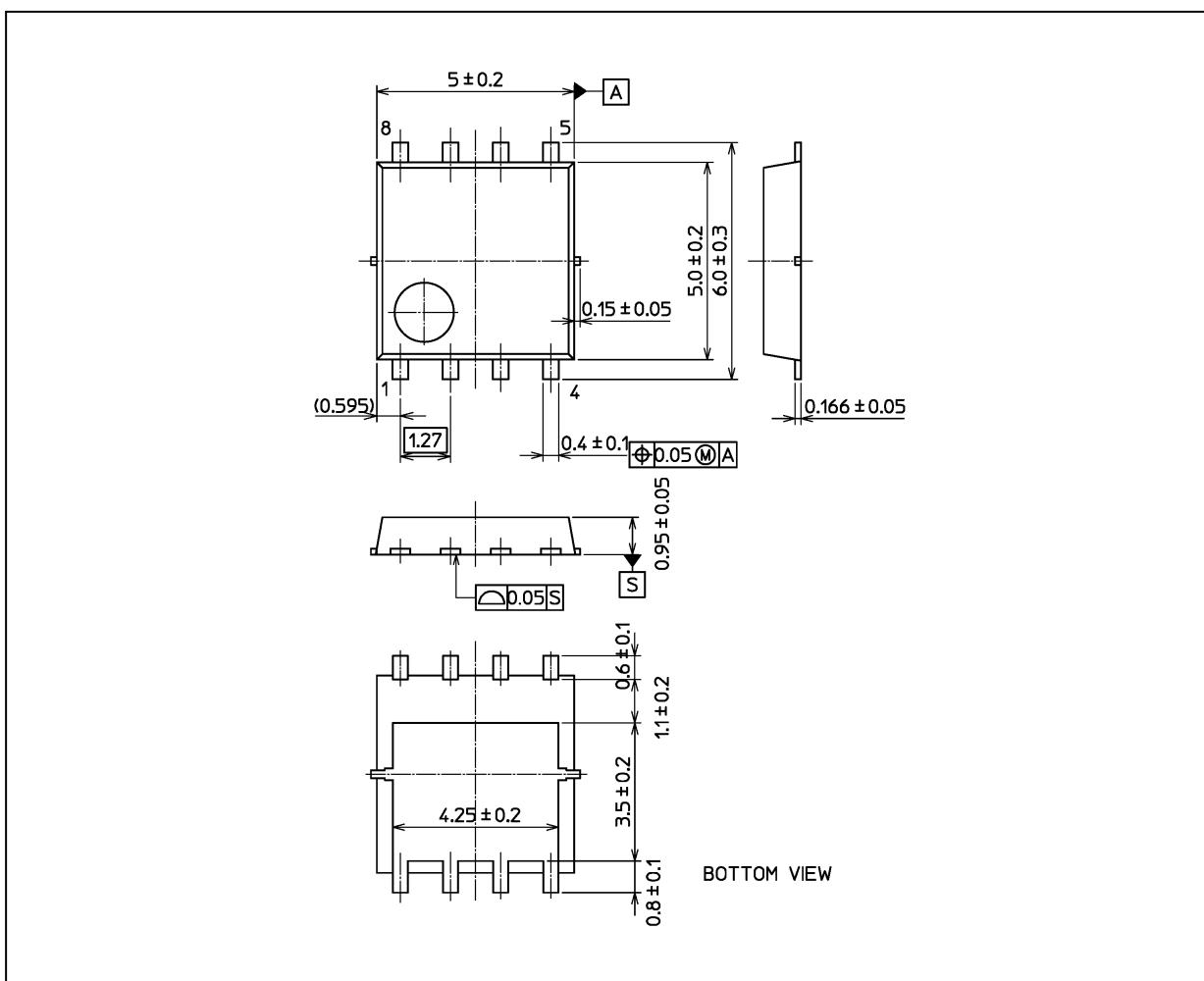


**Fig. 8.16 Safe Operating Area  
(Guaranteed Maximum)**

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

## Package Dimensions

Unit: mm



Weight: 0.069 g (typ.)

Package Name(s)
TOSHIBA: 2-5Q1S
Nickname: SOP Advance

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