

# TK3R1A04PL

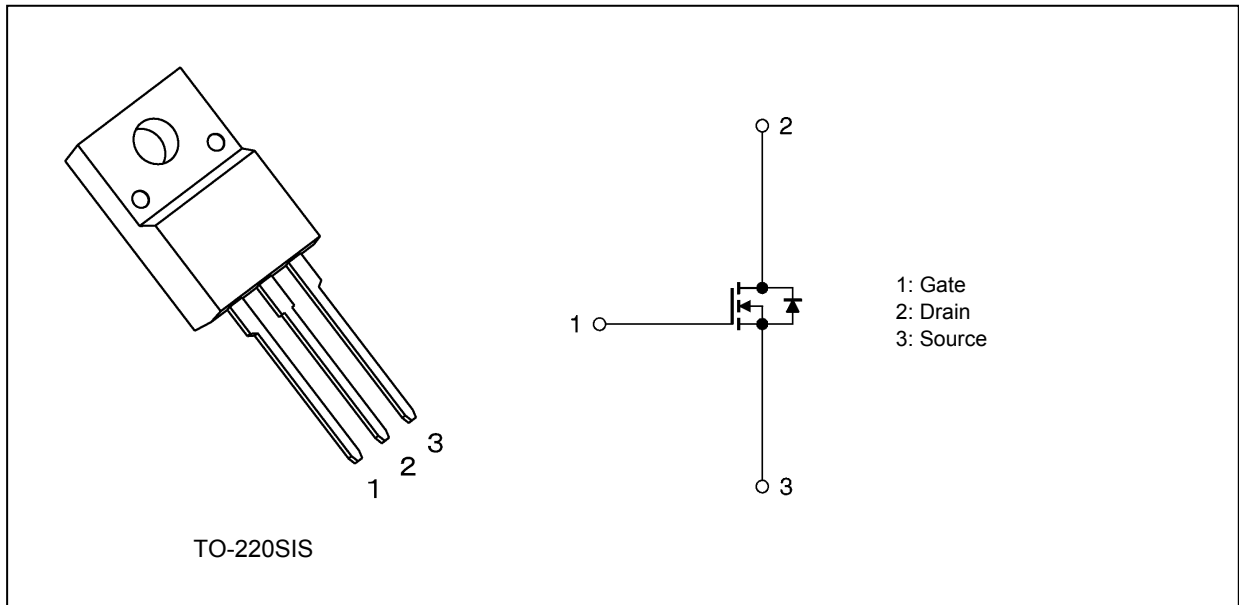
## 1. Applications

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

## 2. Features

- (1) High-speed switching
- (2) Small gate charge:  $Q_{SW} = 17.5 \text{ nC (typ.)}$
- (3) Small output charge:  $Q_{OSS} = 42 \text{ nC (typ.)}$
- (4) Low drain-source on-resistance:  $R_{DS(ON)} = 2.5 \text{ m}\Omega \text{ (typ.) (} V_{GS} = 10 \text{ V)}$
- (5) Low leakage current:  $I_{DSS} = 10 \text{ }\mu\text{A (max) (} V_{DS} = 40 \text{ V)}$
- (6) Enhancement mode:  $V_{th} = 1.4 \text{ to } 2.4 \text{ V (} V_{DS} = 10 \text{ V, } I_D = 0.5 \text{ mA)}$

## 3. Packaging and Internal Circuit



Start of commercial production

2016-07

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

Characteristics	Symbol	Rating	Unit
Drain-source voltage	$V_{DSS}$	40	V
Gate-source voltage	$V_{GSS}$	$\pm 20$	
Drain current (DC) <span style="float:right"><math>(T_c = 25\text{ °C})</math> (Note 1)</span>	$I_D$	82	A
Drain current (pulsed) <span style="float:right"><math>(t = 100\ \mu\text{s})</math> (Note 1)</span>	$I_{DP}$	400	A
Power dissipation <span style="float:right"><math>(T_c = 25\text{ °C})</math></span>	$P_D$	36	W
Single-pulse avalanche energy <span style="float:right">(Note 2)</span>	$E_{AS}$	43	mJ
Single-pulse avalanche current <span style="float:right">(Note 2)</span>	$I_{AS}$	82	A
Channel temperature	$T_{ch}$	175	$^{\circ}\text{C}$
Storage temperature	$T_{stg}$	-55 to 175	$^{\circ}\text{C}$
Isolation voltage (RMS) <span style="float:right"><math>(t = 1.0\ \text{s})</math></span>	$V_{ISO(RMS)}$	2000	V
Mounting torque	TOR	0.6	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).

**5. Thermal Characteristics**

Characteristics	Symbol	Max	Unit
Channel-to-case thermal resistance <span style="float:right"><math>(T_c = 25\text{ °C})</math></span>	$R_{th(ch-c)}$	4.16	$^{\circ}\text{C}/\text{W}$
Channel-to-ambient thermal resistance <span style="float:right"><math>(T_a = 25\text{ °C})</math></span>	$R_{th(ch-a)}$	62.5	

Note 1: Ensure that the channel temperature does not exceed 175  $^{\circ}\text{C}$ .

Note 2:  $V_{DD} = 32\ \text{V}$ ,  $T_{ch} = 25\text{ °C}$  (initial),  $L = 4.9\ \mu\text{H}$ ,  $I_{AS} = 82\ \text{A}$

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

**6. Electrical Characteristics**

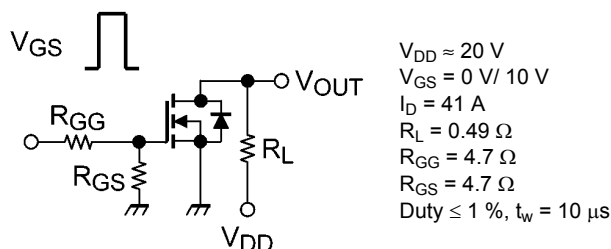
**6.1. Static Characteristics ( $T_a = 25\text{ }^\circ\text{C}$  unless otherwise specified)**

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	$I_{DSS}$	$V_{DS} = 40\text{ V}, V_{GS} = 0\text{ V}$	—	—	10	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$I_D = 10\text{ mA}, V_{GS} = 0\text{ V}$	40	—	—	V
Drain-source breakdown voltage (Note 3)	$V_{(BR)DSX}$	$I_D = 10\text{ mA}, V_{GS} = -20\text{ V}$	25	—	—	
Gate threshold voltage	$V_{th}$	$V_{DS} = 10\text{ V}, I_D = 0.5\text{ mA}$	1.4	—	2.4	
Drain-source on-resistance	$R_{DS(ON)}$	$V_{GS} = 4.5\text{ V}, I_D = 30\text{ A}$	—	3.0	3.8	m $\Omega$
		$V_{GS} = 10\text{ V}, I_D = 41\text{ A}$	—	2.5	3.1	

Note 3: 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	$C_{iss}$	$V_{DS} = 20\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	4670	—	pF
Reverse transfer capacitance	$C_{rss}$		—	70	—	
Output capacitance	$C_{oss}$		—	1000	—	
Gate resistance	$r_g$	—	—	2.2	—	$\Omega$
Switching time (rise time)	$t_r$	See Fig. 6.2.1	—	12	—	ns
Switching time (turn-on time)	$t_{on}$		—	28	—	
Switching time (fall time)	$t_f$		—	27	—	
Switching time (turn-off time)	$t_{off}$		—	83	—	



**Fig. 6.2.1 Switching Time Test Circuit**

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

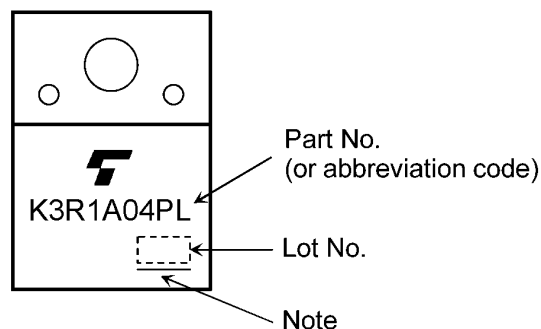
Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Total gate charge (gate-source plus gate-drain)	$Q_g$	$V_{DD} \approx 20\text{ V}, V_{GS} = 10\text{ V}, I_D = 41\text{ A}$	—	63.4	—	nC
		$V_{DD} \approx 20\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 41\text{ A}$	—	29.7	—	
Gate-source charge 1	$Q_{gs1}$	$V_{DD} \approx 20\text{ V}, V_{GS} = 10\text{ V}, I_D = 41\text{ A}$	—	16.8	—	
Gate-drain charge	$Q_{gd}$		—	8.9	—	
Gate switch charge	$Q_{SW}$		—	17.5	—	
Output charge	$Q_{oss}$	$V_{DS} = 20\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	42	—	

**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 4)	$I_{DRP}$ ( $t = 100\text{ }\mu\text{s}$ )	—	—	—	400	A
Diode forward voltage	$V_{DSF}$	$I_{DR} = 82\text{ A}, V_{GS} = 0\text{ V}$	—	—	-1.5	V
Reverse recovery time	$t_{rr}$	$I_{DR} = 21\text{ A}, V_{GS} = 0\text{ V},$ $-di_{DR}/dt = 100\text{ A}/\mu\text{s}$	—	50	—	ns
Reverse recovery charge	$Q_{rr}$		—	50	—	nC

Note 4: Ensure that the channel temperature does not exceed  $175\text{ }^\circ\text{C}$ .

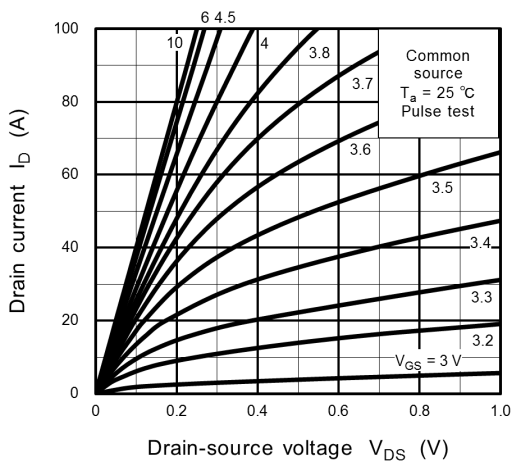
**7. Marking (Note)**



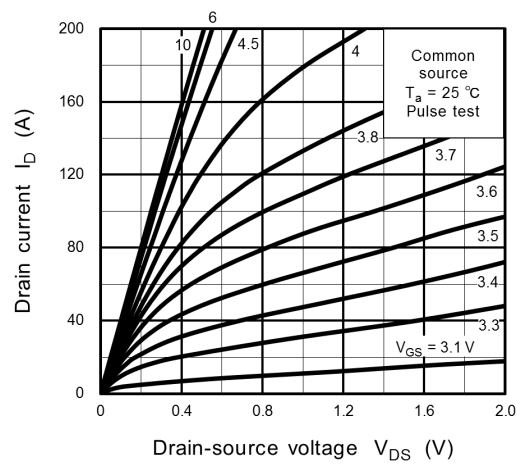
**Fig. 7.1 Marking**

Note: A line under a Lot No. identifies the indication of product Labels.  
 Not underlined: [[Pb]]/INCLUDES > MCV  
 Underlined: [[G]]/RoHS COMPATIBLE or [[G]]/RoHS [[Pb]]  
 Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product.  
 The RoHS is the Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

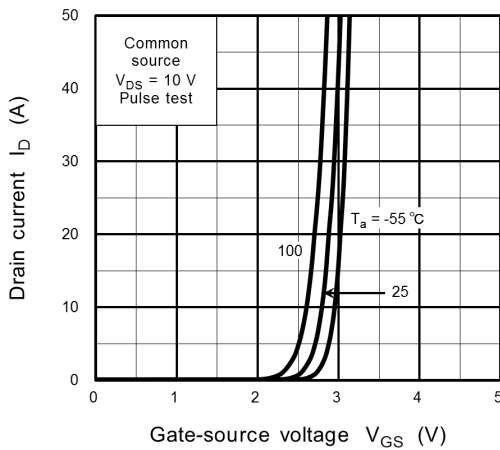
**8. Characteristics Curves (Note)**



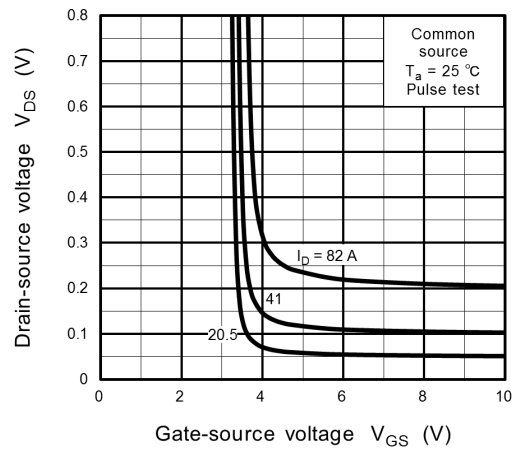
**Fig. 8.1  $I_D - V_{DS}$**



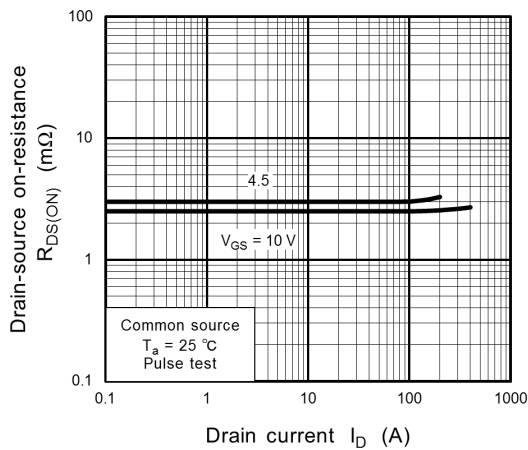
**Fig. 8.2  $I_D - V_{DS}$**



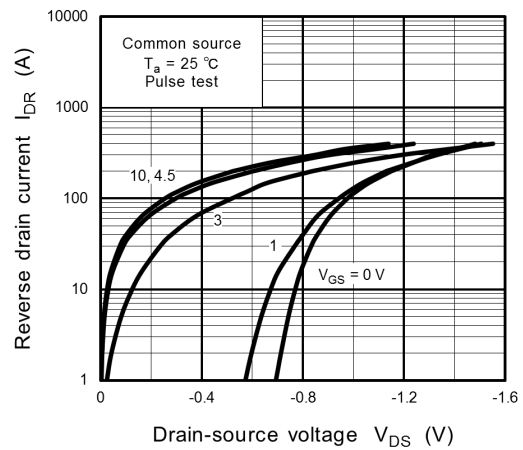
**Fig. 8.3  $I_D - V_{GS}$**



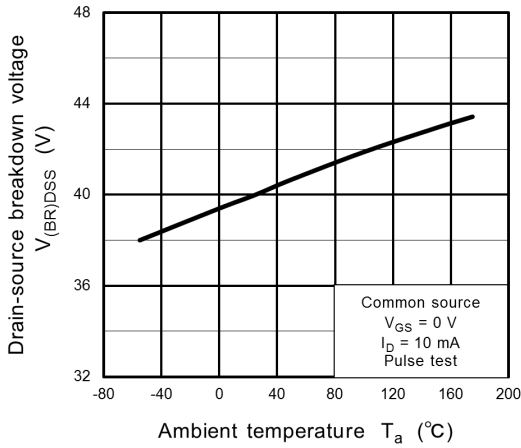
**Fig. 8.4  $V_{DS} - V_{GS}$**



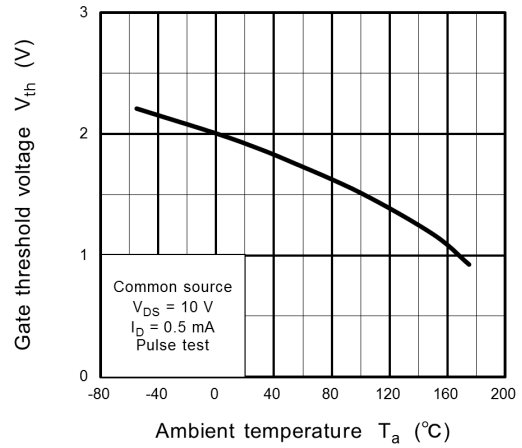
**Fig. 8.5  $R_{DS(ON)} - I_D$**



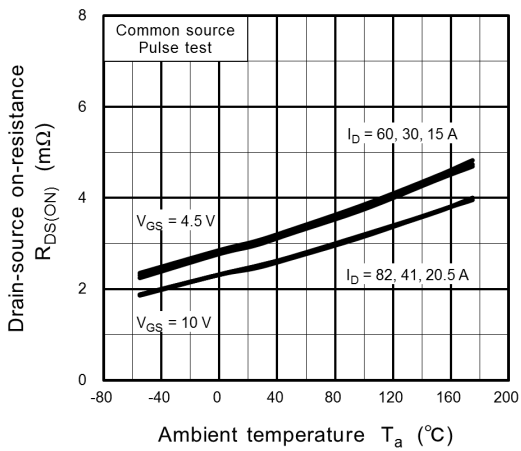
**Fig. 8.6  $I_{DR} - V_{DS}$**



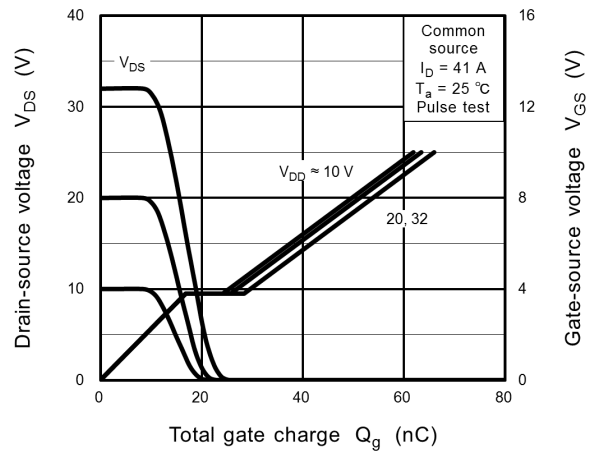
**Fig. 8.7  $V_{(BR)DSS} - T_a$**



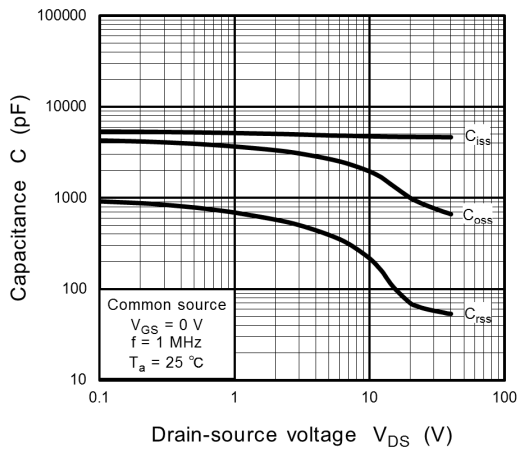
**Fig. 8.8  $V_{th} - T_a$**



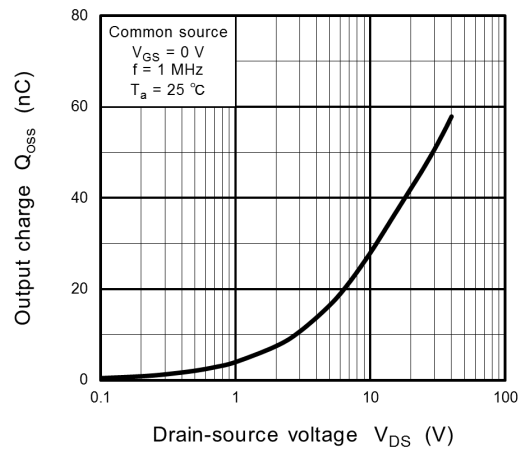
**Fig. 8.9  $R_{DS(ON)} - T_a$**



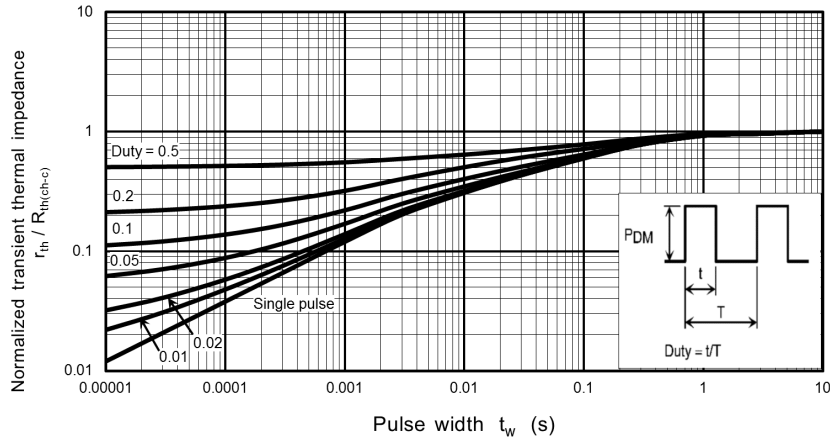
**Fig. 8.10 Dynamic Input/Output Characteristics**



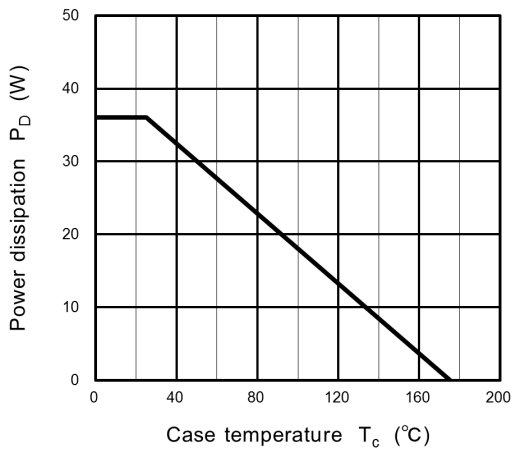
**Fig. 8.11 Capacitance -  $V_{DS}$**



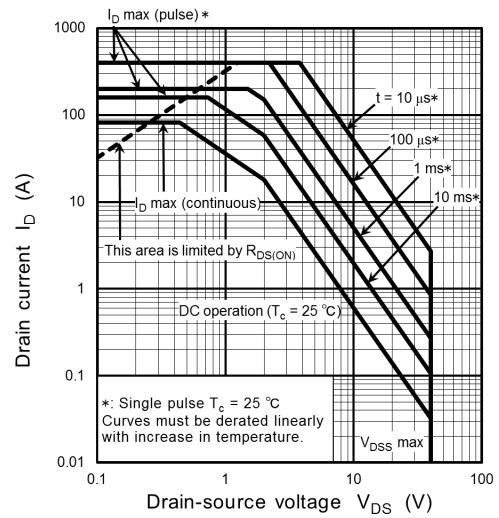
**Fig. 8.12  $Q_{oss} - V_{DS}$**



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



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



**Fig. 8.15 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: 1.7 g (typ.)

Package Name(s)
TOSHIBA: 2-10U1S
Nickname: TO-220SIS



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