

TK3R1E04PL

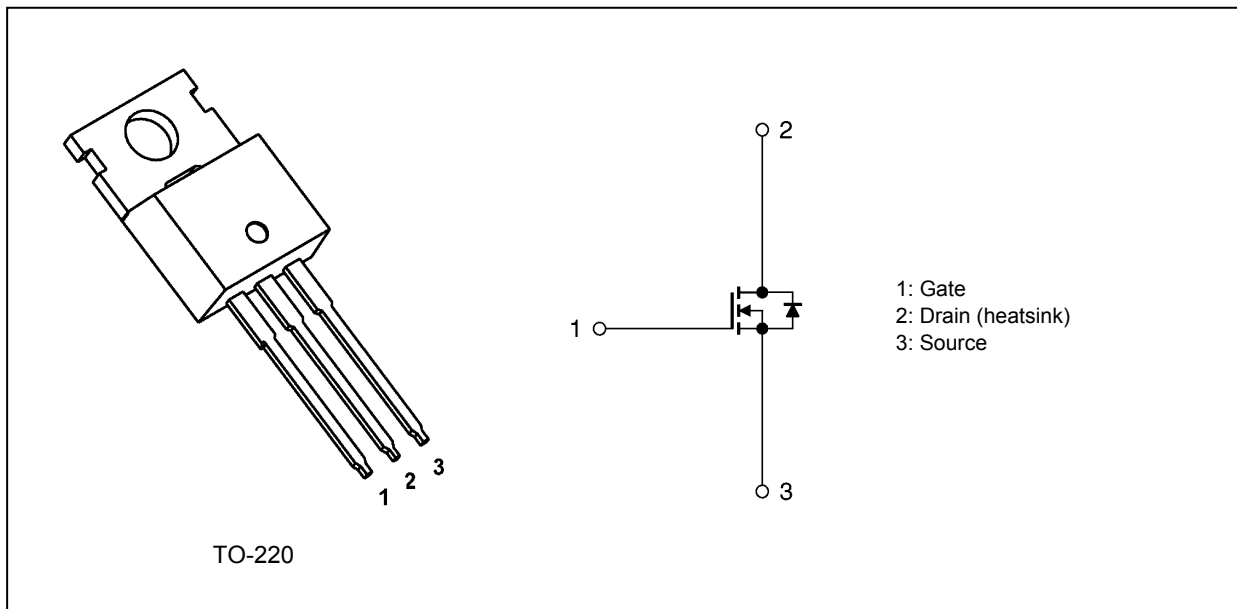
1. Applications

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

Characteristics	Symbol	Rating	Unit
Drain-source voltage	V_{DSS}	40	V
Gate-source voltage	V_{GSS}	± 20	
Drain current (DC) ($T_c = 25\text{ }^\circ\text{C}$) (Note 1)	I_D	100	A
Drain current (DC) (Silicon limit) (Note 1), (Note 2)	I_D	128	
Drain current (pulsed) ($t = 100\text{ }\mu\text{s}$) (Note 1)	I_{DP}	400	
Power dissipation ($T_c = 25\text{ }^\circ\text{C}$)	P_D	87	W
Single-pulse avalanche energy (Note 3)	E_{AS}	35	mJ
Single-pulse avalanche current (Note 3)	I_{AS}	100	A
Channel temperature	T_{ch}	175	$^\circ\text{C}$
Storage temperature	T_{stg}	-55 to 175	$^\circ\text{C}$
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 ($T_c = 25\text{ }^\circ\text{C}$)	$R_{th(ch-c)}$	1.72	$^\circ\text{C}/\text{W}$
Channel-to-ambient thermal resistance ($T_a = 25\text{ }^\circ\text{C}$)	$R_{th(ch-a)}$	83.3	

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

Note 2: Limited 100 A by package capability.

Note 3: $V_{DD} = 32\text{ V}$, $T_{ch} = 25\text{ }^\circ\text{C}$ (initial), $L = 2.7\text{ }\mu\text{H}$, $I_{AS} = 100\text{ A}$

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}	$V_{GS} = \pm 20\text{ V}, V_{DS} = 0\text{ V}$	—	—	± 0.1	μA
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 4)	$V_{(BR)DSX}$	$I_D = 10\text{ mA}, V_{GS} = -20\text{ V}$	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	$\text{m}\Omega$
		$V_{GS} = 10\text{ V}, I_D = 41\text{ A}$	—	2.5	3.1	

Note 4: 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	—	Ω
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	—	

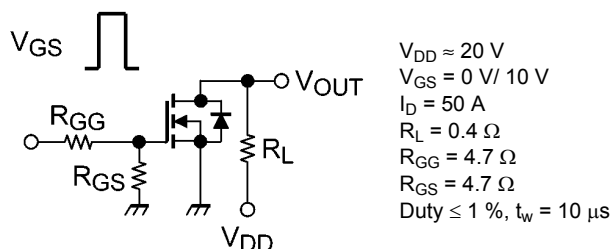


Fig. 6.2.1 Switching Time Test Circuit

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	$V_{DD} \approx 20\text{ V}, V_{GS} = 10\text{ V}, I_D = 50\text{ A}$	—	63.4	—	nC
		$V_{DD} \approx 20\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 50\text{ A}$	—	29.7	—	
Gate-source charge 1	Q_{gs1}	$V_{DD} \approx 20\text{ V}, V_{GS} = 10\text{ V}, I_D = 50\text{ A}$	—	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 5)	I_{DRP} ($t = 100\text{ }\mu\text{s}$)	—	—	—	400	A
Diode forward voltage	V_{DSF}	$I_{DR} = 100\text{ A}$, $V_{GS} = 0\text{ V}$	—	—	-1.5	V
Reverse recovery time	t_{rr}	$V_R = 20\text{ V}$, $I_{DR} = 25\text{ A}$, $V_{GS} = 0\text{ V}$, $-dI_{DR}/dt = 100\text{ A}/\mu\text{s}$	—	50	—	ns
Reverse recovery charge	Q_{rr}	$V_{GS} = 0\text{ V}$, $-dI_{DR}/dt = 100\text{ A}/\mu\text{s}$	—	50	—	nC

Note 5: Ensure that the channel temperature does not exceed $175\text{ }^\circ\text{C}$.

7. Marking

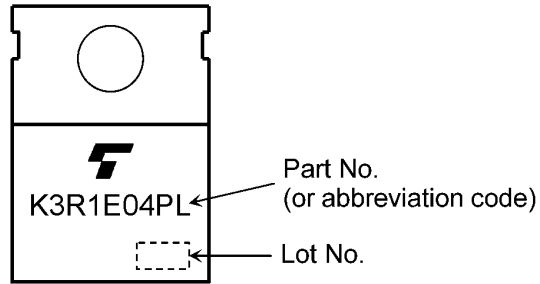


Fig. 7.1 Marking

8. Characteristics Curves (Note)

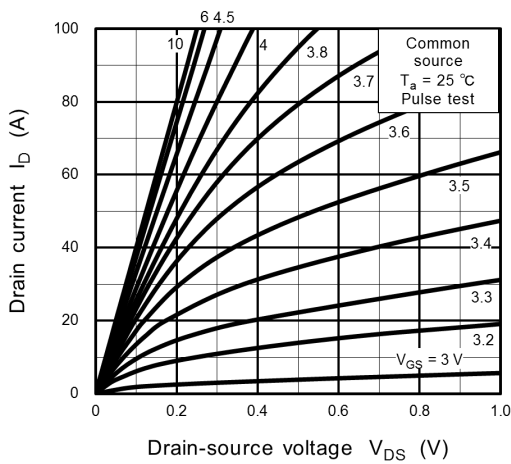


Fig. 8.1 $I_D - V_{DS}$

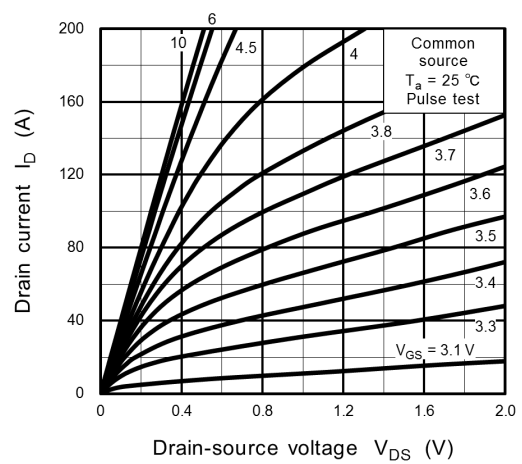


Fig. 8.2 $I_D - V_{DS}$

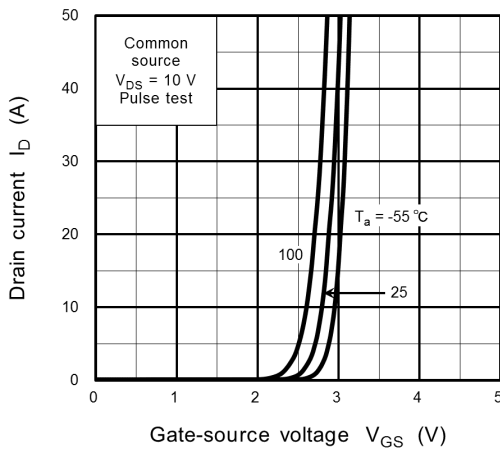


Fig. 8.3 $I_D - V_{GS}$

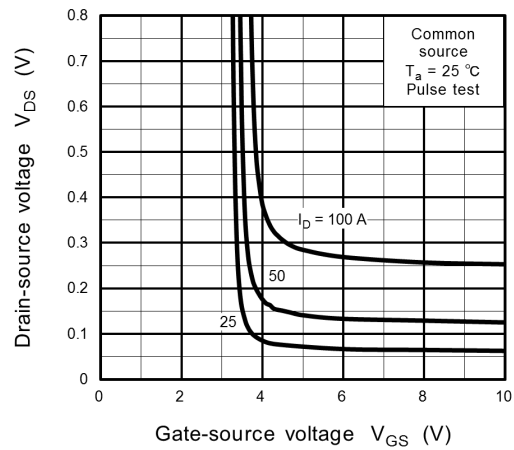


Fig. 8.4 $V_{DS} - V_{GS}$

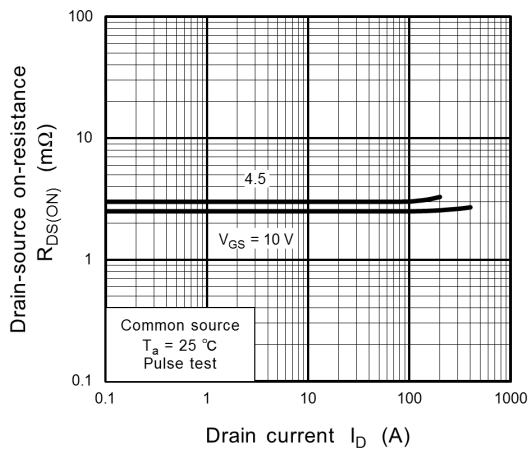


Fig. 8.5 $R_{DS(ON)} - I_D$

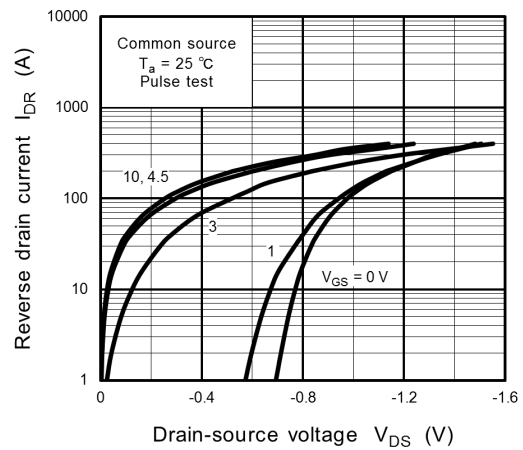


Fig. 8.6 $I_{DR} - V_{DS}$

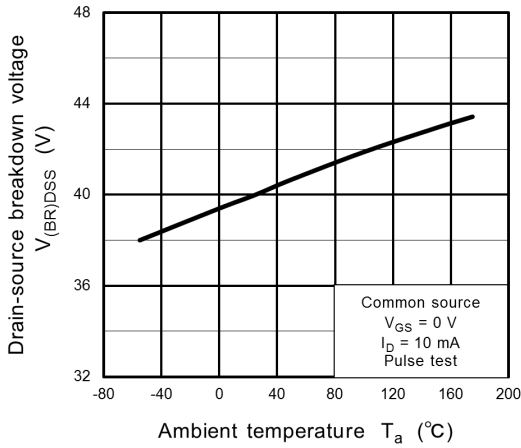


Fig. 8.7 $V_{(BR)DSS} - T_a$

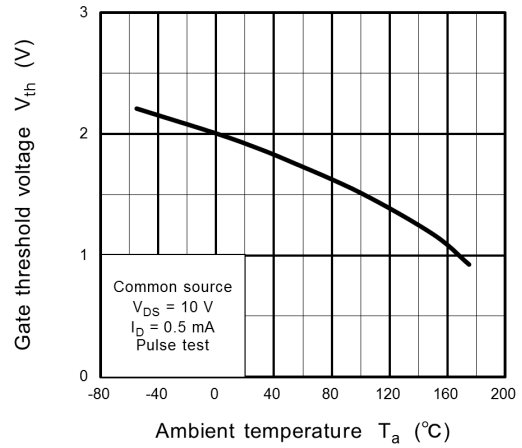


Fig. 8.8 $V_{th} - T_a$

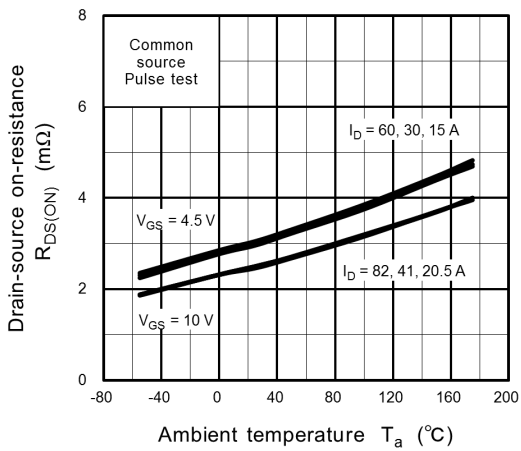


Fig. 8.9 $R_{DS(ON)} - T_a$

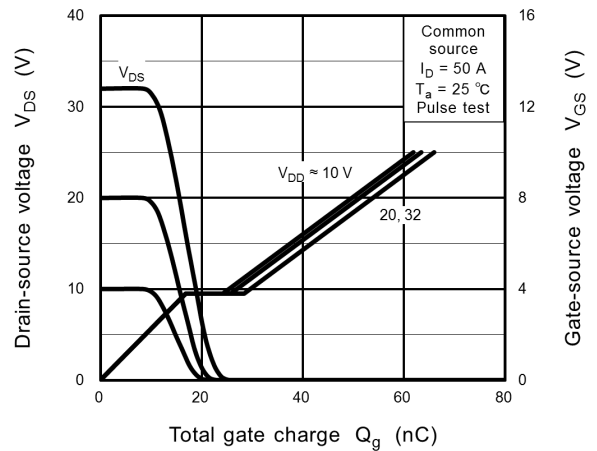


Fig. 8.10 Dynamic Input/Output Characteristics

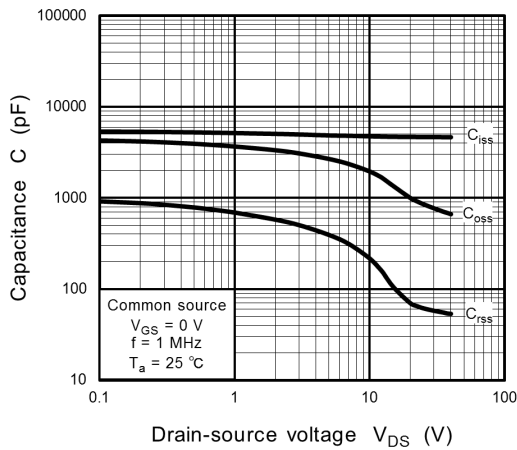


Fig. 8.11 Capacitance - V_{DS}

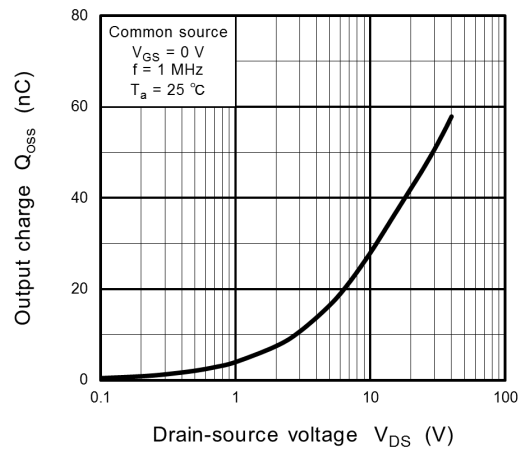
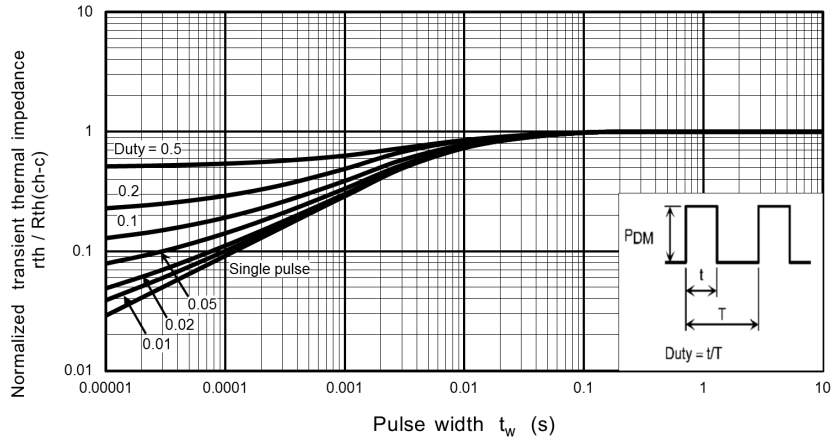
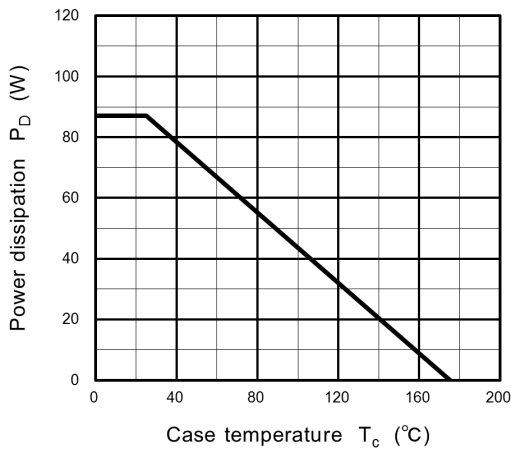


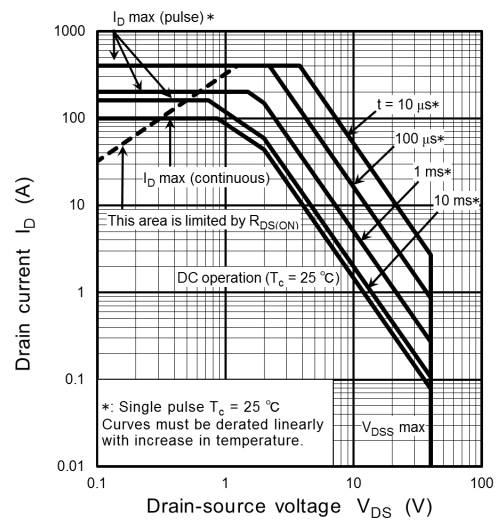
Fig. 8.12 $Q_{oss} - V_{DS}$



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



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

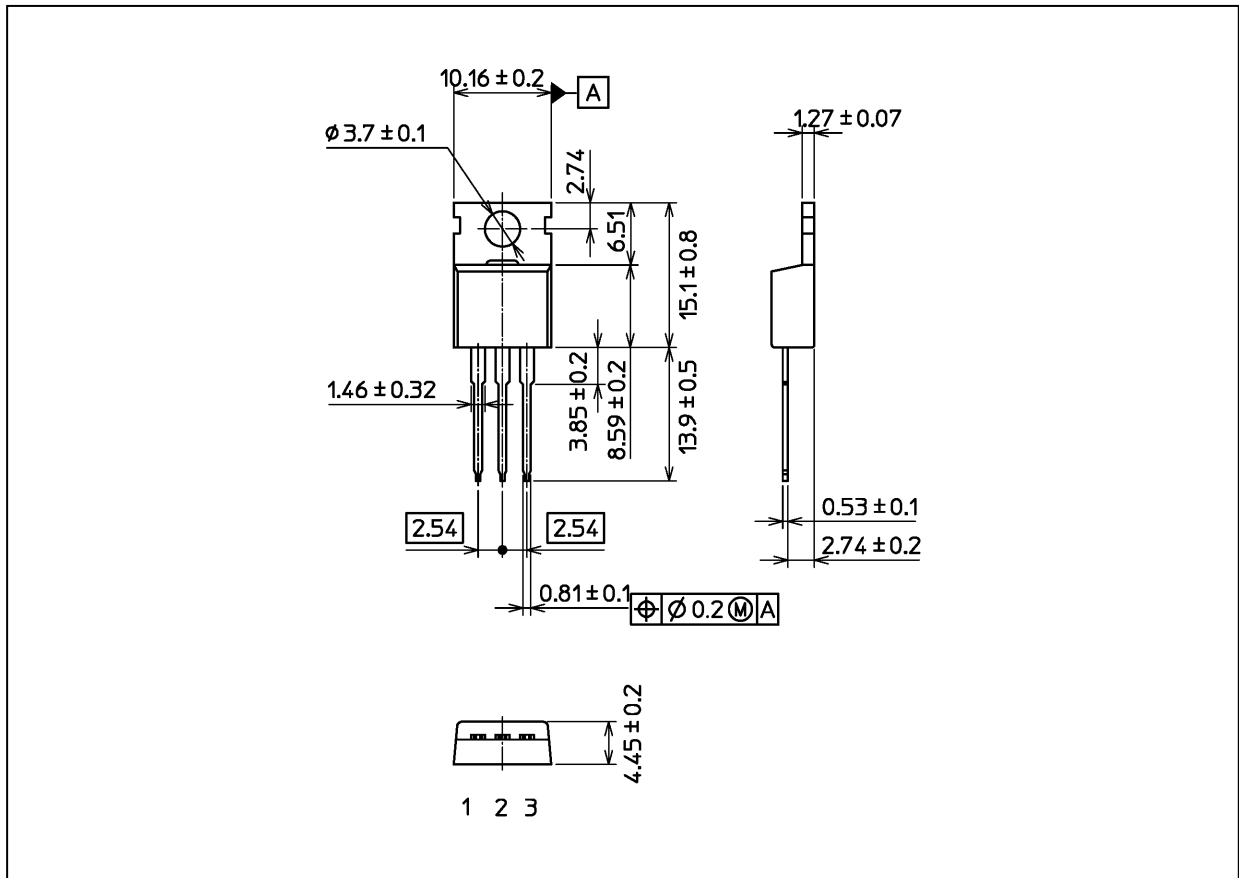


**Fig. 8.15 Safe Operating Area
(Guaranteed Maximum)**

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

Package Dimensions

Unit: mm



Weight: 1.93 g (typ.)

Package Name(s)
TOSHIBA: 2-10X1A
Nickname: TO-220

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