

# TK2R9E10PL

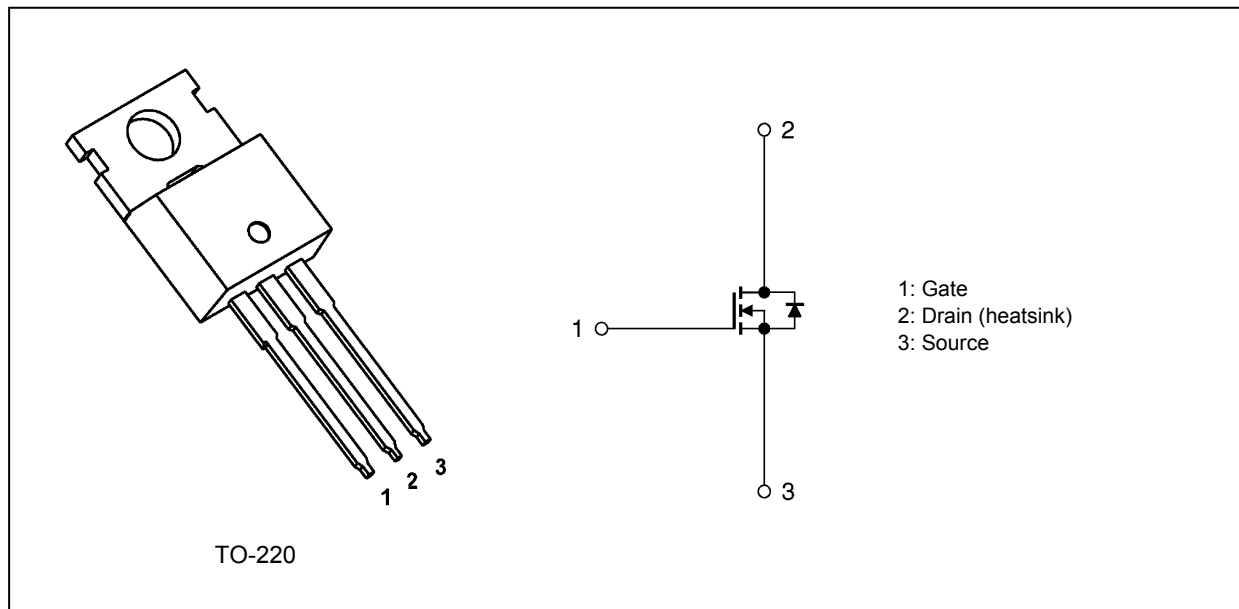
## 1. Applications

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

## 2. Features

- (1) High-speed switching
- (2) Small gate charge:  $Q_{SW} = 48 \text{ nC (typ.)}$
- (3) Small output charge:  $Q_{OSS} = 164 \text{ nC (typ.)}$
- (4) Low drain-source on-resistance:  $R_{DS(ON)} = 2.4 \text{ m}\Omega \text{ (typ.)}$  ( $V_{GS} = 10 \text{ V}$ )
- (5) Low leakage current:  $I_{DSS} = 10 \text{ }\mu\text{A (max)}$  ( $V_{DS} = 100 \text{ V}$ )
- (6) Enhancement mode:  $V_{th} = 1.5 \text{ to } 2.5 \text{ V}$  ( $V_{DS} = 10 \text{ V}$ ,  $I_D = 1 \text{ mA}$ )

## 3. Packaging and Internal Circuit



Start of commercial production

2018-01

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

Characteristics	Symbol	Rating	Unit
Drain-source voltage	$V_{DS}$	100	V
Gate-source voltage	$V_{GS}$	$\pm 20$	
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)	$I_D$	240	
Drain current (pulsed) ( $t = 100\text{ }\mu\text{s}$ ) (Note 1)	$I_{DP}$	500	
Power dissipation ( $T_c = 25\text{ }^{\circ}\text{C}$ )	$P_D$	306	W
Single-pulse avalanche energy (Note 3)	$E_{AS}$	278	mJ
Single-pulse avalanche current (Note 3)	$I_{AS}$	86	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 ( $T_c = 25\text{ }^{\circ}\text{C}$ )	$R_{th(ch-c)}$	0.49	$^{\circ}\text{C/W}$
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  $175\text{ }^{\circ}\text{C}$ .

Note 2: Limited 100 A by package capability.

Note 3:  $V_{DD} = 80\text{ V}$ ,  $T_{ch} = 25\text{ }^{\circ}\text{C}$  (initial),  $L = 29\text{ }\mu\text{H}$ ,  $I_{AS} = 86\text{ A}$

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

## 6. Electrical Characteristics

### 6.1. Static Characteristics ( $T_a = 25^\circ\text{C}$ 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	$I_{DSS}$	$V_{DS} = 100\text{ V}, V_{GS} = 0\text{ V}$	—	—	10	
Drain-source breakdown voltage	$V_{(BR)DSS}$	$I_D = 10\text{ mA}, V_{GS} = 0\text{ V}$	100	—	—	V
Drain-source breakdown voltage (Note 4)	$V_{(BR)DSX}$	$I_D = 10\text{ mA}, V_{GS} = -20\text{ V}$	65	—	—	
Gate threshold voltage	$V_{th}$	$V_{DS} = 10\text{ V}, I_D = 1\text{ mA}$	1.5	—	2.5	
Drain-source on-resistance	$R_{DS(ON)}$	$V_{GS} = 4.5\text{ V}, I_D = 50\text{ A}$	—	2.9	4.1	$\text{m}\Omega$
		$V_{GS} = 10\text{ V}, I_D = 50\text{ A}$	—	2.4	2.9	

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Input capacitance	$C_{iss}$	$V_{DS} = 50\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	9500	—	$\text{pF}$
Reverse transfer capacitance	$C_{rss}$		—	65	—	
Output capacitance	$C_{oss}$		—	1500	—	
Gate resistance	$r_g$	—	—	2.2	—	$\Omega$
Switching time (rise time)	$t_r$	See Fig. 6.2.1	—	22	—	ns
Switching time (turn-on time)	$t_{on}$		—	46	—	
Switching time (fall time)	$t_f$		—	46	—	
Switching time (turn-off time)	$t_{off}$		—	147	—	

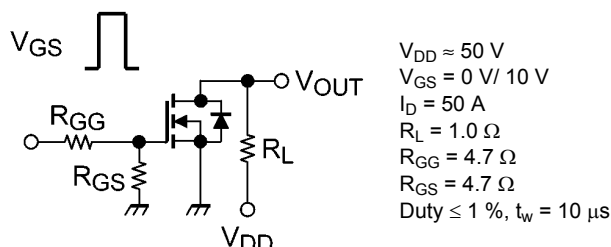


Fig. 6.2.1 Switching Time Test Circuit

### 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)	$Q_g$	$V_{DD} \approx 50\text{ V}, V_{GS} = 10\text{ V}, I_D = 50\text{ A}$	—	161	—	nC
		$V_{DD} \approx 50\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 50\text{ A}$	—	83	—	
Gate-source charge 1	$Q_{gs1}$	$V_{DD} \approx 50\text{ V}, V_{GS} = 10\text{ V}, I_D = 50\text{ A}$	—	30	—	
Gate-drain charge	$Q_{gd}$		—	37	—	
Gate switch charge	$Q_{SW}$		—	48	—	
Output charge	$Q_{oss}$	$V_{DS} = 50\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	164	—	

6.4. Source-Drain Characteristics (T<sub>a</sub> = 25 °C unless otherwise specified)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Reverse drain current (pulsed) (Note 5)	I <sub>DRP</sub> (t = 100 μs)	—	—	—	500	A
Diode forward voltage	V <sub>DSF</sub>	I <sub>DR</sub> = 100 A, V <sub>GS</sub> = 0 V	—	—	-1.5	V
Reverse recovery time	t <sub>rr</sub>	I <sub>DR</sub> = 25 A, V <sub>GS</sub> = 0 V, -dI <sub>DR</sub> /dt = 100 A/μs	—	75	—	ns
Reverse recovery charge	Q <sub>rr</sub>		—	150	—	nC

Note 5: Ensure that the channel temperature does not exceed 175 °C.

7. Marking

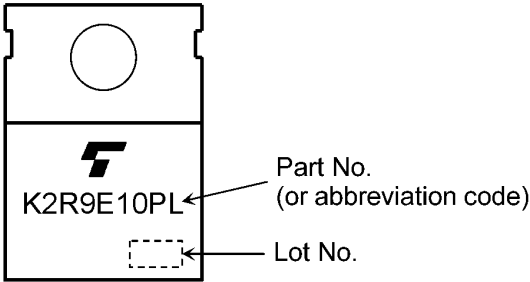


Fig. 7.1 Marking

## 8. Characteristics Curves (Note)

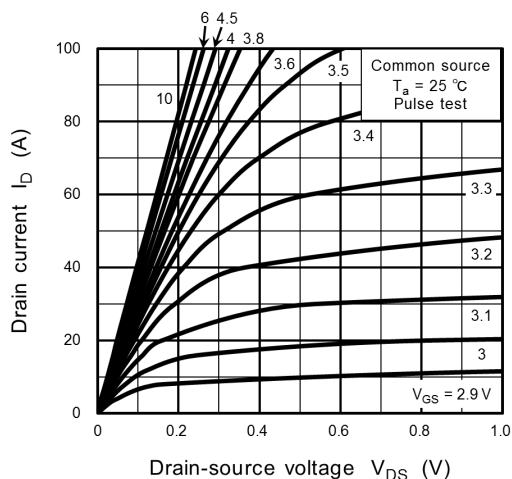


Fig. 8.1  $I_D - V_{DS}$

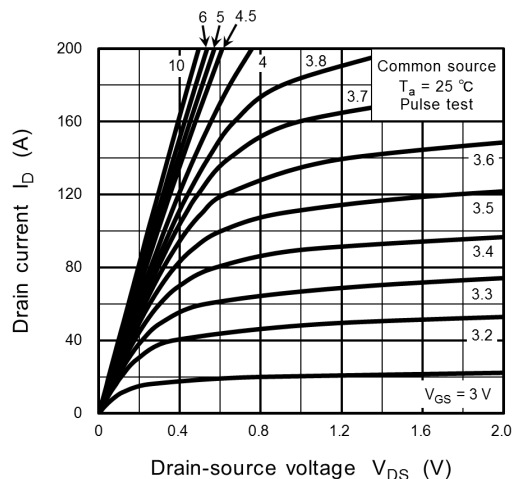


Fig. 8.2  $I_D - V_{DS}$

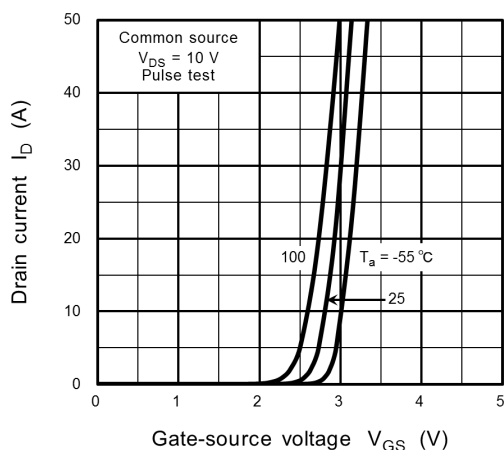


Fig. 8.3  $I_D - V_{GS}$

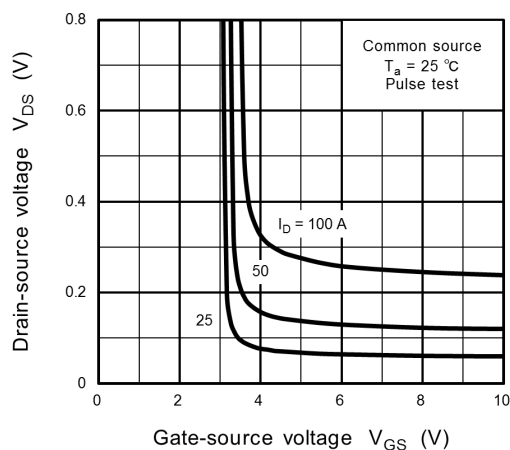


Fig. 8.4  $V_{DS} - V_{GS}$

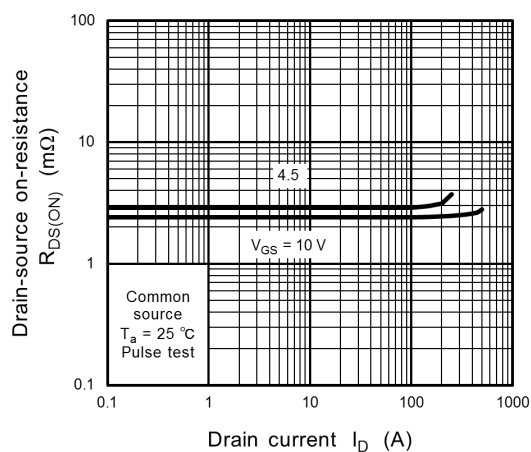


Fig. 8.5  $R_{DS(ON)} - I_D$

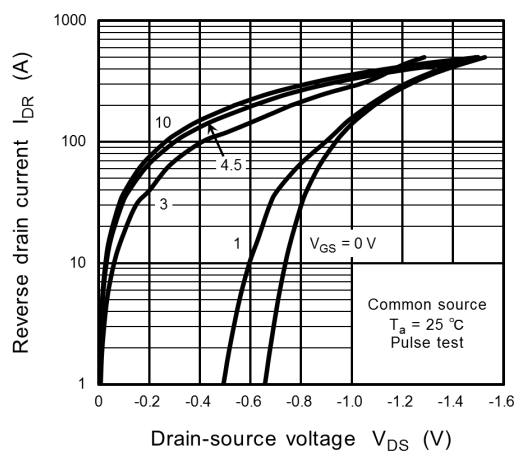
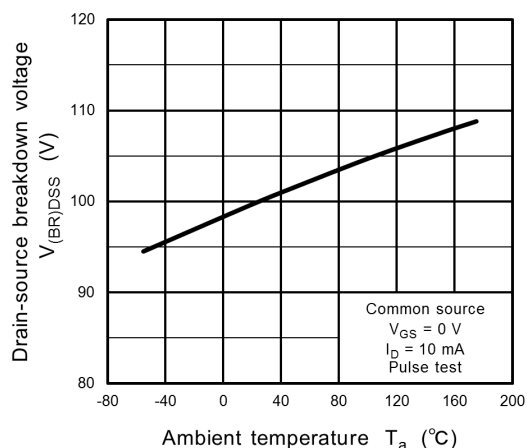
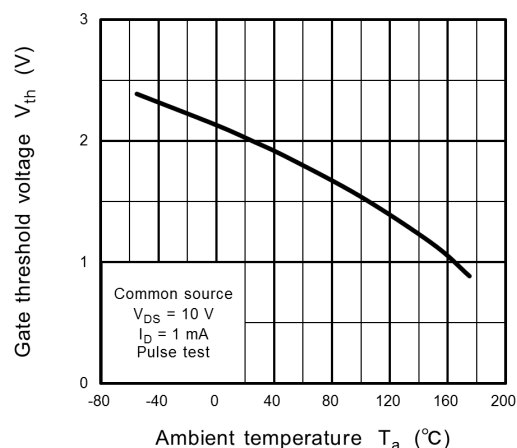


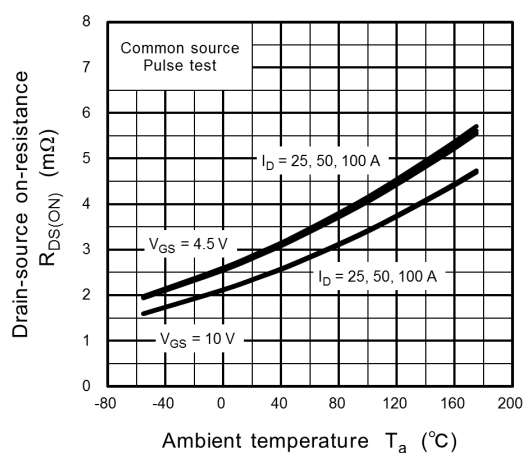
Fig. 8.6  $I_{DR} - V_{DS}$



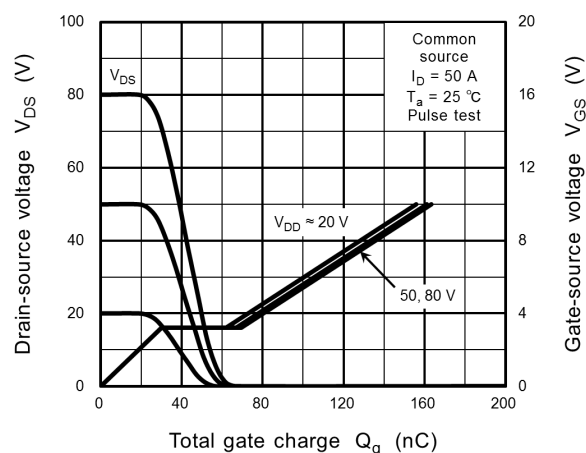
**Fig. 8.7  $V_{(BR)DSS} - T_a$**



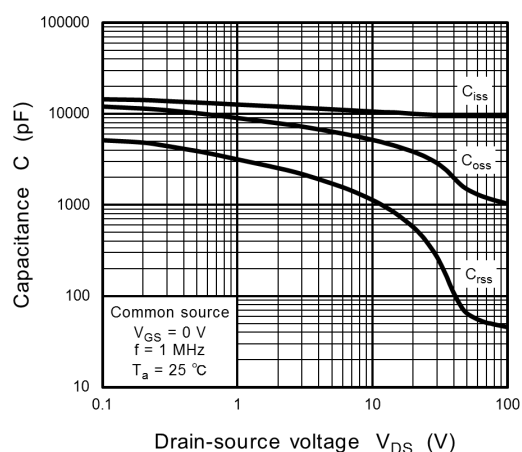
**Fig. 8.8  $V_{th} - T_a$**



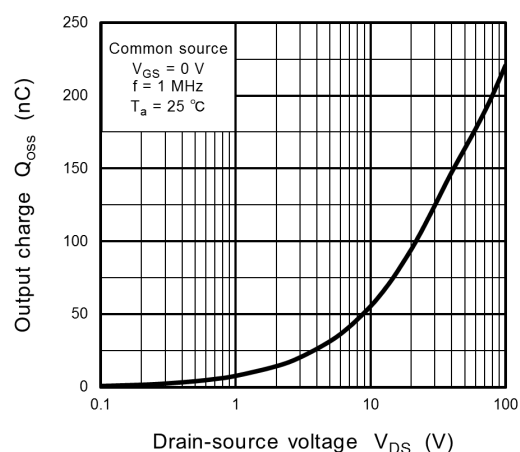
**Fig. 8.9  $R_{DS(ON)} - T_a$**



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



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



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

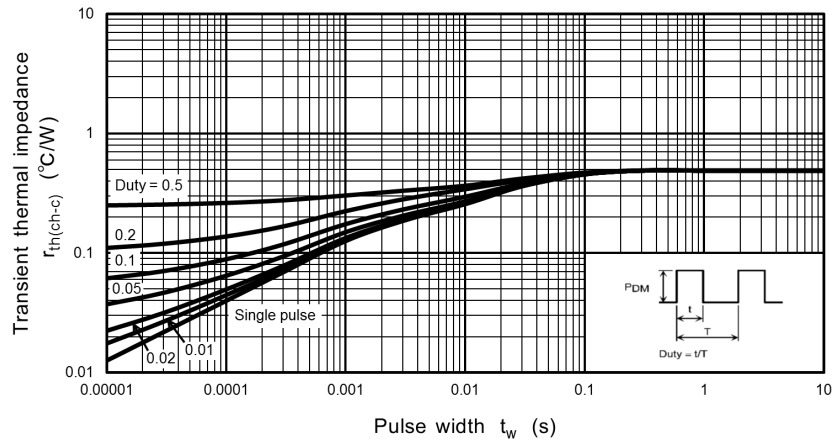


Fig. 8.13  $r_{th} - t_w$   
(Guaranteed Maximum)

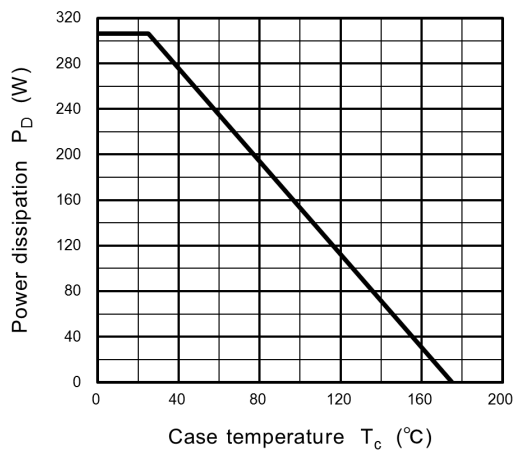


Fig. 8.14  $P_D - T_c$   
(Guaranteed Maximum)

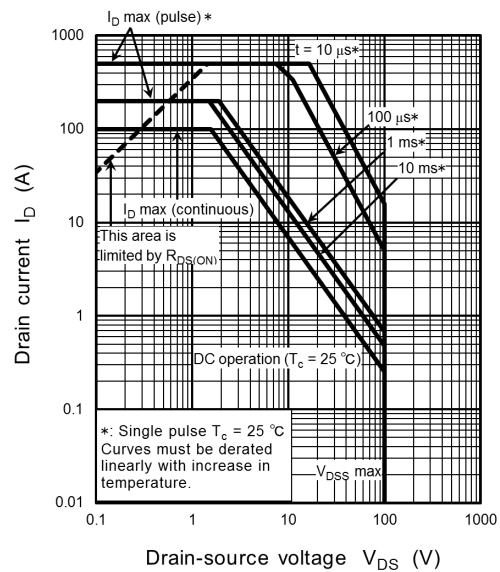
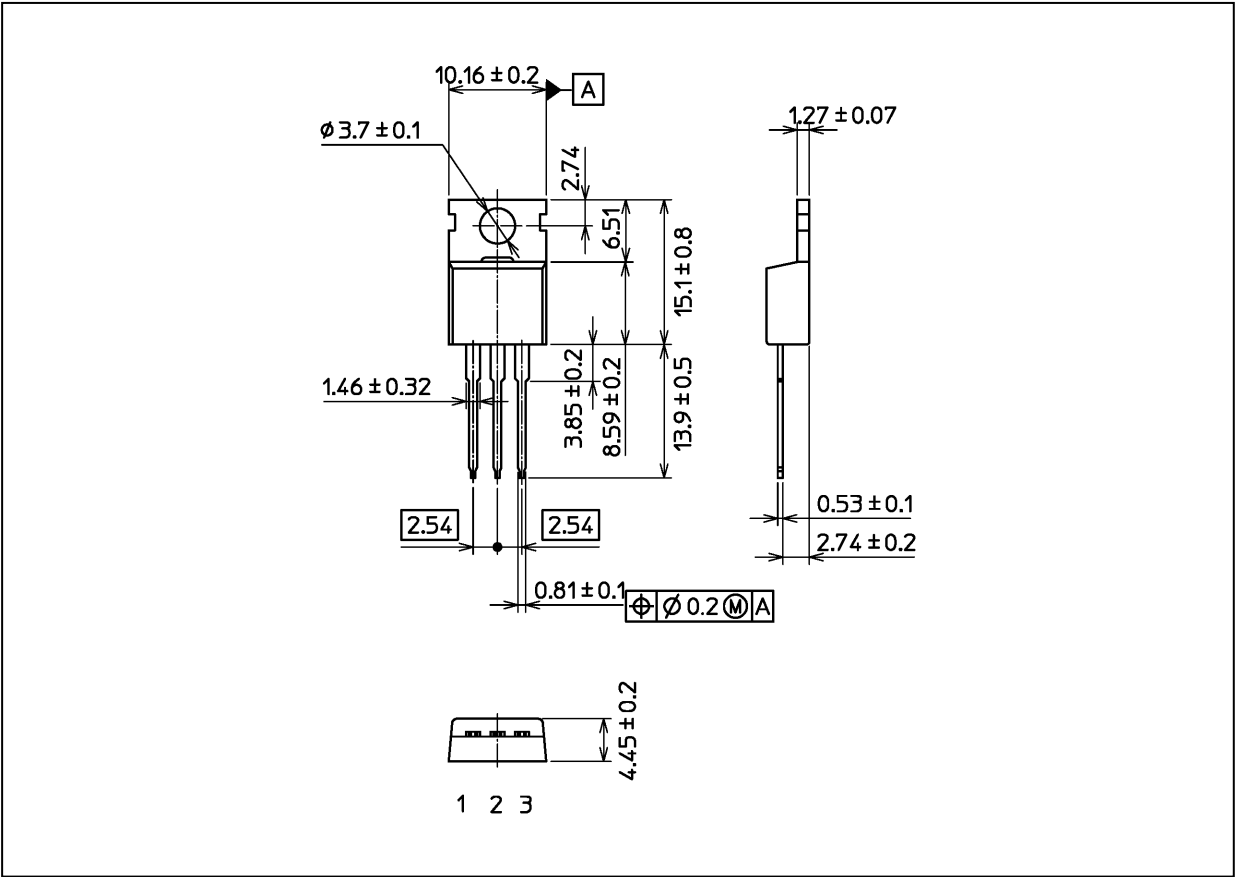


Fig. 8.15 Safe Operating Area  
(Guaranteed Maximum)

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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