

# TK16E60W

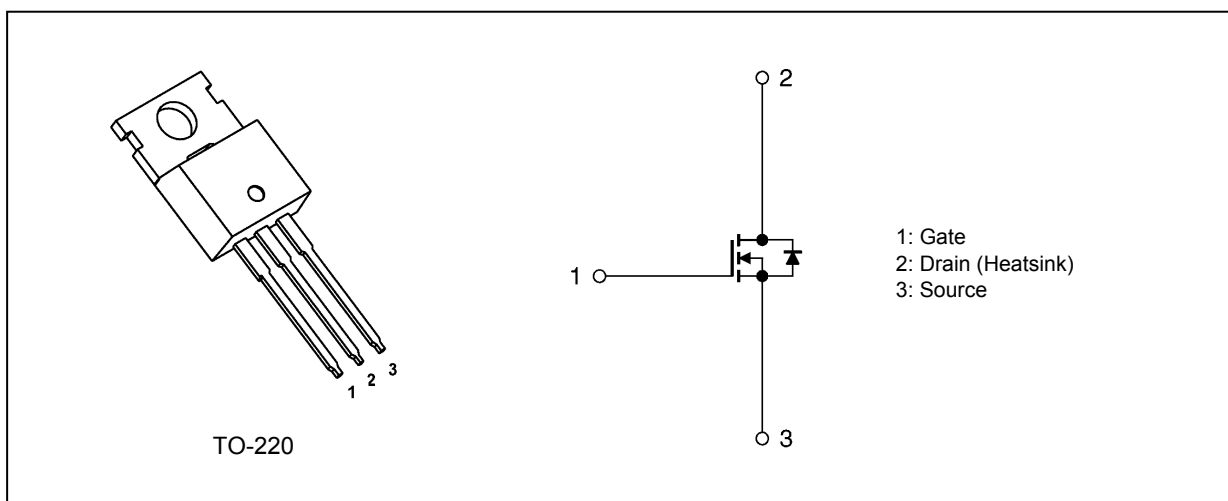
## 1. Applications

- Switching Voltage Regulators

## 2. Features

- (1) Low drain-source on-resistance:  $R_{DS(ON)} = 0.16 \Omega$  (typ.)  
by used to Super Junction Structure : DTMOS
- (2) Easy to control Gate switching
- (3) Enhancement mode:  $V_{th} = 2.7$  to  $3.7$  V ( $V_{DS} = 10$  V,  $I_D = 0.79$  mA)

## 3. Packaging and Internal Circuit



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

| Characteristics                                | Symbol    | Rating     | Unit             |
|------------------------------------------------|-----------|------------|------------------|
| Drain-source voltage                           | $V_{DSS}$ | 600        | V                |
| Gate-source voltage                            | $V_{GSS}$ | $\pm 30$   |                  |
| Drain current (DC) (Note 1)                    | $I_D$     | 15.8       | A                |
| Drain current (pulsed) (Note 1)                | $I_{DP}$  | 63.2       |                  |
| Power dissipation ( $T_c = 25^\circ\text{C}$ ) | $P_D$     | 130        | W                |
| Single-pulse avalanche energy (Note 2)         | $E_{AS}$  | 194        | mJ               |
| Avalanche current                              | $I_{AR}$  | 4.0        | A                |
| Reverse drain current (DC) (Note 1)            | $I_{DR}$  | 15.8       |                  |
| Reverse drain current (pulsed) (Note 1)        | $I_{DRP}$ | 63.2       |                  |
| Channel temperature                            | $T_{ch}$  | 150        | $^\circ\text{C}$ |
| Storage temperature                            | $T_{stg}$ | -55 to 150 |                  |
| 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).

Start of commercial production

2012-09

## 5. Thermal Characteristics

| Characteristics                       | Symbol         | Max   | Unit |
|---------------------------------------|----------------|-------|------|
| Channel-to-case thermal resistance    | $R_{th(ch-c)}$ | 0.962 | °C/W |
| Channel-to-ambient thermal resistance | $R_{th(ch-a)}$ | 83.3  |      |

Note 1: Ensure that the channel temperature does not exceed 150°C.

Note 2:  $V_{DD} = 90\text{ V}$ ,  $T_{ch} = 25^\circ\text{C}$  (initial),  $L = 21.2\text{ mH}$ ,  $R_G = 25\ \Omega$ ,  $I_{AR} = 4.0\text{ A}$

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

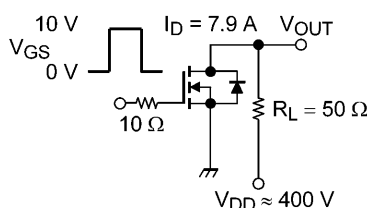
## 6. Electrical Characteristics

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

| Characteristics                | Symbol        | Test Condition                                     | Min | Typ. | Max     | Unit          |
|--------------------------------|---------------|----------------------------------------------------|-----|------|---------|---------------|
| Gate leakage current           | $I_{GSS}$     | $V_{GS} = \pm 30\text{ V}$ , $V_{DS} = 0\text{ V}$ | —   | —    | $\pm 1$ | $\mu\text{A}$ |
| Drain cut-off current          | $I_{DSS}$     | $V_{DS} = 600\text{ V}$ , $V_{GS} = 0\text{ V}$    | —   | —    | 10      |               |
| Drain-source breakdown voltage | $V_{(BR)DSS}$ | $I_D = 10\text{ mA}$ , $V_{GS} = 0\text{ V}$       | 600 | —    | —       | V             |
| Gate threshold voltage         | $V_{th}$      | $V_{DS} = 10\text{ V}$ , $I_D = 0.79\text{ mA}$    | 2.7 | —    | 3.7     |               |
| Drain-source on-resistance     | $R_{DS(ON)}$  | $V_{GS} = 10\text{ V}$ , $I_D = 7.9\text{ A}$      | —   | 0.16 | 0.19    | $\Omega$      |

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

| Characteristics                | Symbol      | Test Condition                                                       | Min | Typ. | Max | Unit          |
|--------------------------------|-------------|----------------------------------------------------------------------|-----|------|-----|---------------|
| Input capacitance              | $C_{iss}$   | $V_{DS} = 300\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 1\text{ MHz}$ | —   | 1350 | —   | $\text{pF}$   |
| Reverse transfer capacitance   | $C_{rss}$   |                                                                      | —   | 4    | —   |               |
| Output capacitance             | $C_{oss}$   |                                                                      | —   | 35   | —   |               |
| Effective output capacitance   | $C_{o(er)}$ | $V_{DS} = 0\text{ to }400\text{ V}$ , $V_{GS} = 0\text{ V}$          | —   | 55   | —   |               |
| Gate resistance                | $r_g$       | $V_{DS} = \text{OPEN}$ , $f = 1\text{ MHz}$                          | —   | 6    | —   | $\Omega$      |
| Switching time (rise time)     | $t_r$       | See Figure 6.2.1                                                     | —   | 25   | —   | $\text{ns}$   |
| Switching time (turn-on time)  | $t_{on}$    |                                                                      | —   | 50   | —   |               |
| Switching time (fall time)     | $t_f$       |                                                                      | —   | 5    | —   |               |
| Switching time (turn-off time) | $t_{off}$   |                                                                      | —   | 100  | —   |               |
| MOSFET dv/dt ruggedness        | dv/dt       | $V_{DD} = 0\text{ to }400\text{ V}$ , $I_D = 7.9\text{ A}$           | 50  | —    | —   | $\text{V/ns}$ |



Duty  $\leq 1\%$ ,  $t_w = 10\text{ }\mu\text{s}$

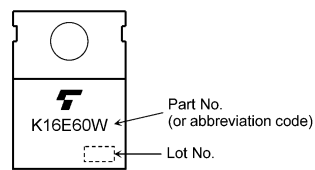
Fig. 6.2.1 Switching Time Test Circuit

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

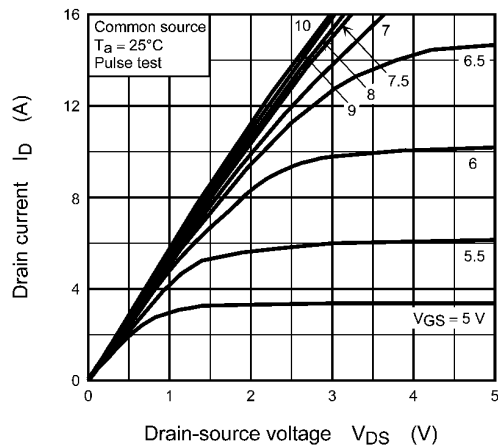
| Characteristics                                 | Symbol    | Test Condition                                                                 | Min | Typ. | Max | Unit        |
|-------------------------------------------------|-----------|--------------------------------------------------------------------------------|-----|------|-----|-------------|
| Total gate charge (gate-source plus gate-drain) | $Q_g$     | $V_{DD} \approx 400\text{ V}$ , $V_{GS} = 10\text{ V}$ , $I_D = 15.8\text{ A}$ | —   | 38   | —   | $\text{nC}$ |
| Gate-source charge 1                            | $Q_{gs1}$ |                                                                                | —   | 9    | —   |             |
| Gate-drain charge                               | $Q_{gd}$  |                                                                                | —   | 16   | —   |             |

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

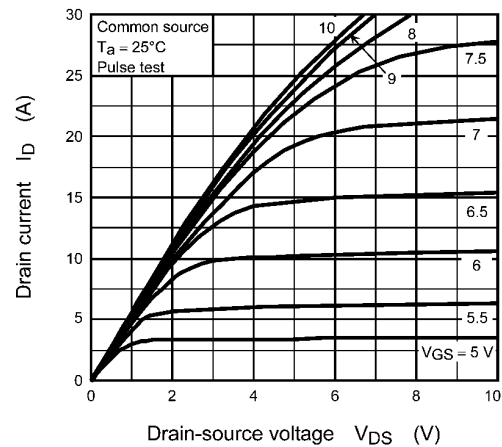
| Characteristics               | Symbol    | Test Condition                                                                              | Min | Typ. | Max  | Unit          |
|-------------------------------|-----------|---------------------------------------------------------------------------------------------|-----|------|------|---------------|
| Diode forward voltage         | $V_{DSF}$ | $I_{DR} = 15.8\text{ A}$ , $V_{GS} = 0\text{ V}$                                            | —   | —    | -1.7 | V             |
| Reverse recovery time         | $t_{rr}$  | $I_{DR} = 7.9\text{ A}$ , $V_{GS} = 0\text{ V}$<br>$-dI_{DR}/dt = 100\text{ A}/\mu\text{s}$ | —   | 280  | —    | $\text{ns}$   |
| Reverse recovery charge       | $Q_{rr}$  |                                                                                             | —   | 2.9  | —    | $\mu\text{C}$ |
| Peak reverse recovery current | $I_{rr}$  |                                                                                             | —   | 23   | —    | A             |
| Diode dv/dt ruggedness        | dv/dt     | $I_{DR} = 7.9\text{ A}$ , $V_{GS} = 0\text{ V}$ , $V_{DD} = 400\text{ V}$                   | 15  | —    | —    | $\text{V/ns}$ |

**7. Marking****Fig. 7.1 Marking**

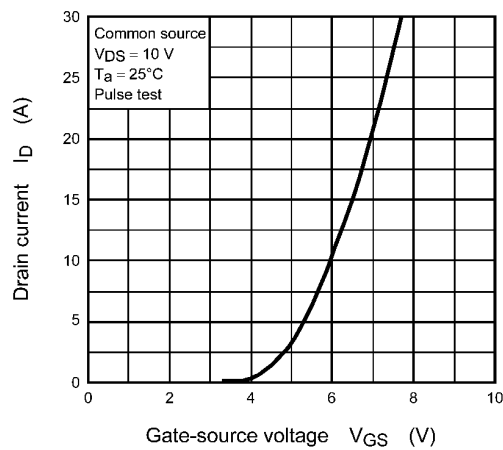
## 8. Characteristics Curves (Note)



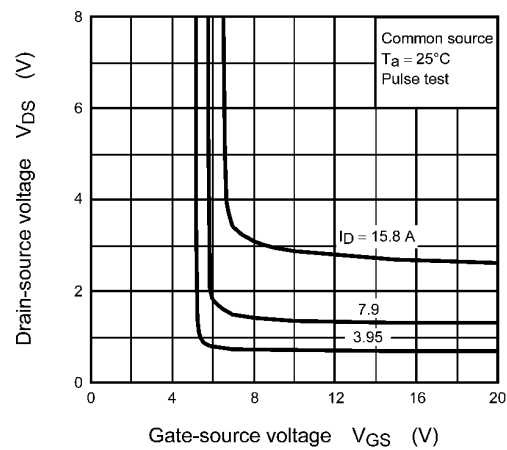
**Fig. 8.1  $I_D - V_{DS}$**



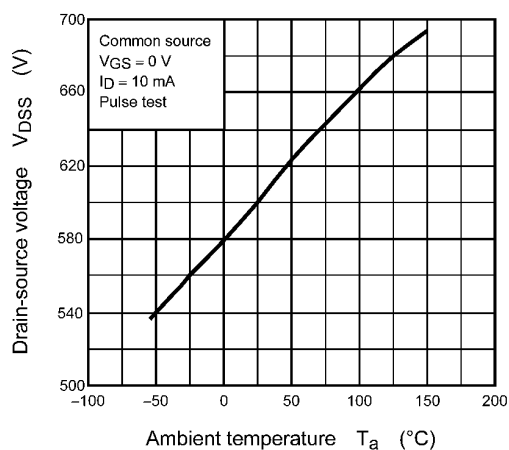
**Fig. 8.2  $I_D - V_{DS}$**



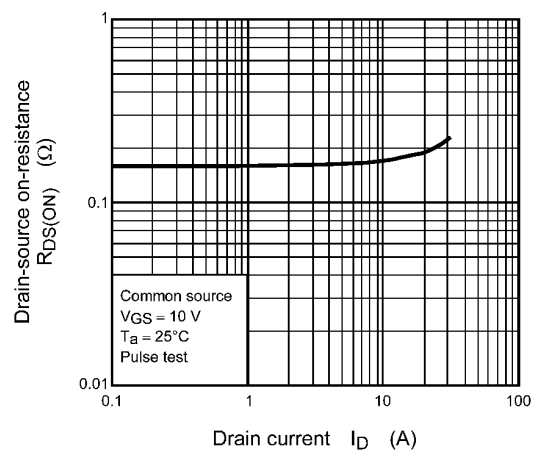
**Fig. 8.3  $I_D - V_{GS}$**



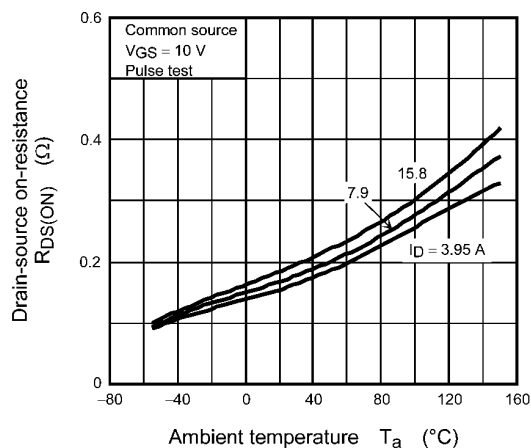
**Fig. 8.4  $V_{DS} - V_{GS}$**



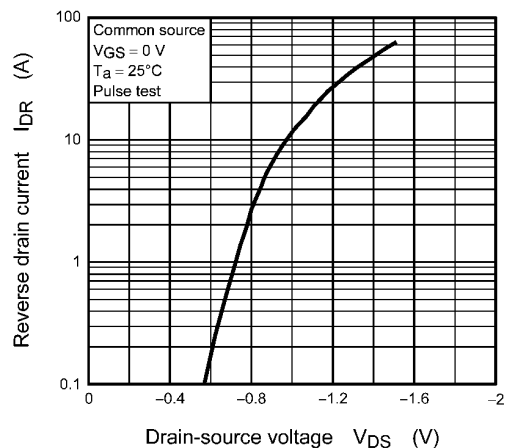
**Fig. 8.5  $V_{DS} - T_a$**



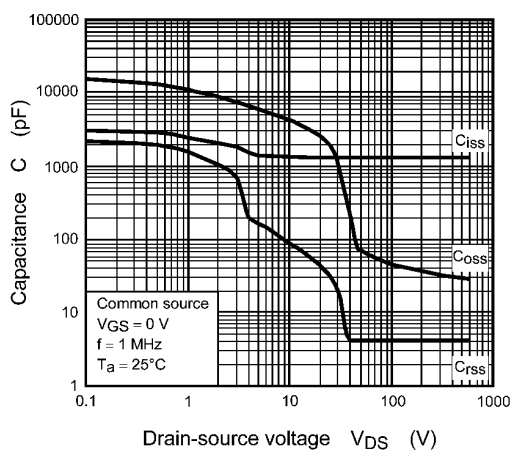
**Fig. 8.6  $R_{DS(ON)} - I_D$**



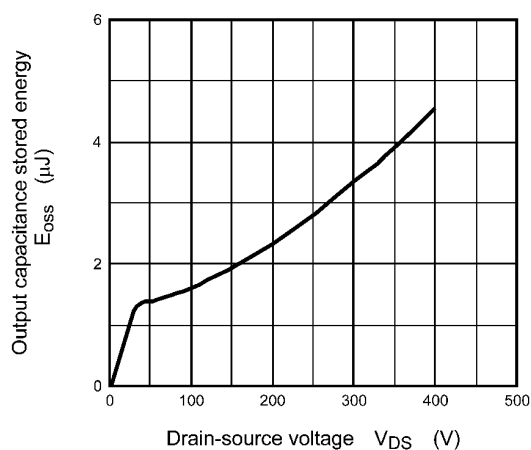
**Fig. 8.7  $R_{DS(ON)} - T_a$**



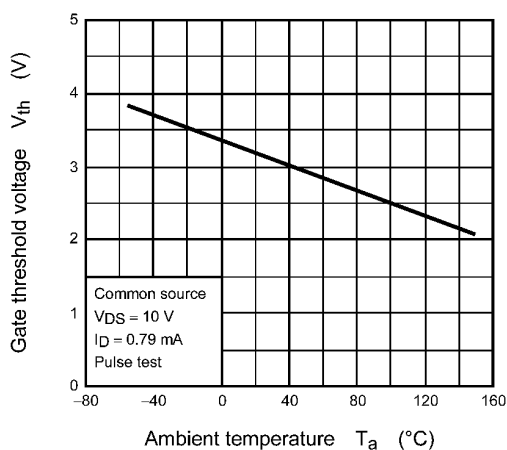
**Fig. 8.8  $I_{DR} - V_{DS}$**



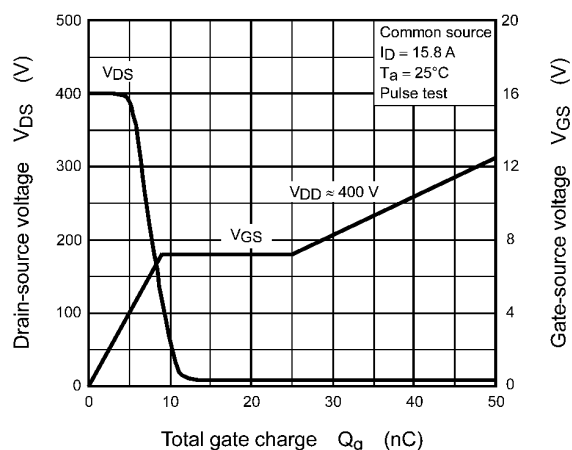
**Fig. 8.9  $C - V_{DS}$**



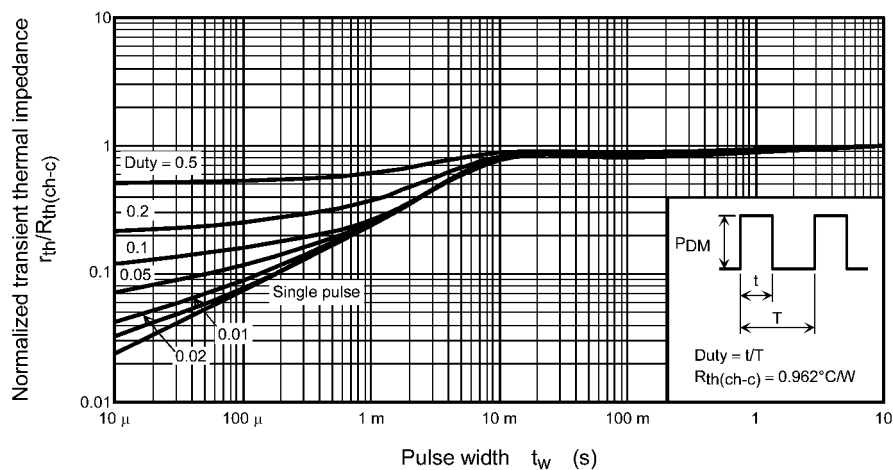
**Fig. 8.10  $E_{oss} - V_{DS}$**



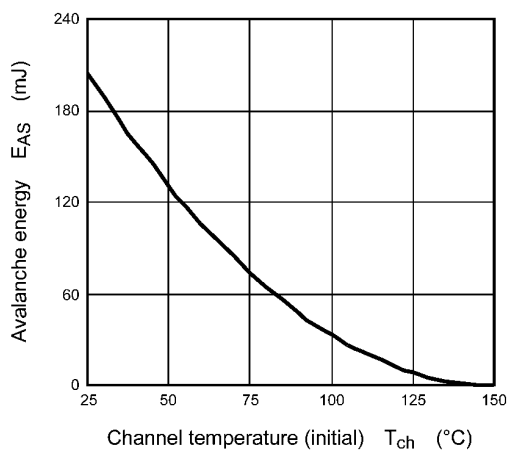
**Fig. 8.11  $V_{th} - T_a$**



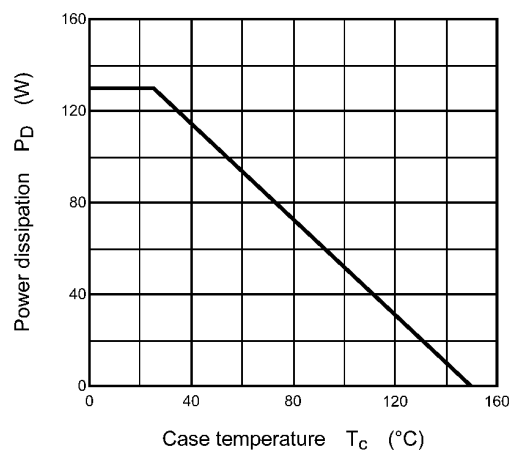
**Fig. 8.12 Dynamic Input/Output Characteristics**



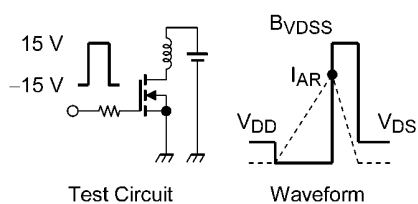
**Fig. 8.13  $r_{th} - t_w$**   
(Guaranteed Maximum)



**Fig. 8.14  $E_{AS} - T_{ch}$**   
(Guaranteed Maximum)

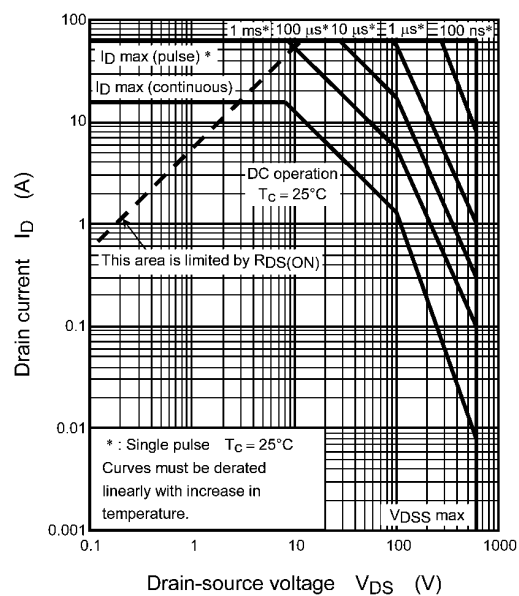


**Fig. 8.15  $P_D - T_c$**   
(Guaranteed Maximum)



$$R_G = 25 \, \Omega, V_{DD} = 90 \, V \quad E_{AS} = \frac{1}{2} \cdot L \cdot I_{AR}^2 \cdot \left( \frac{B_{VDSS}}{B_{VDSS} - V_{DD}} \right)$$

**Fig. 8.16 Test Circuit/Waveform**

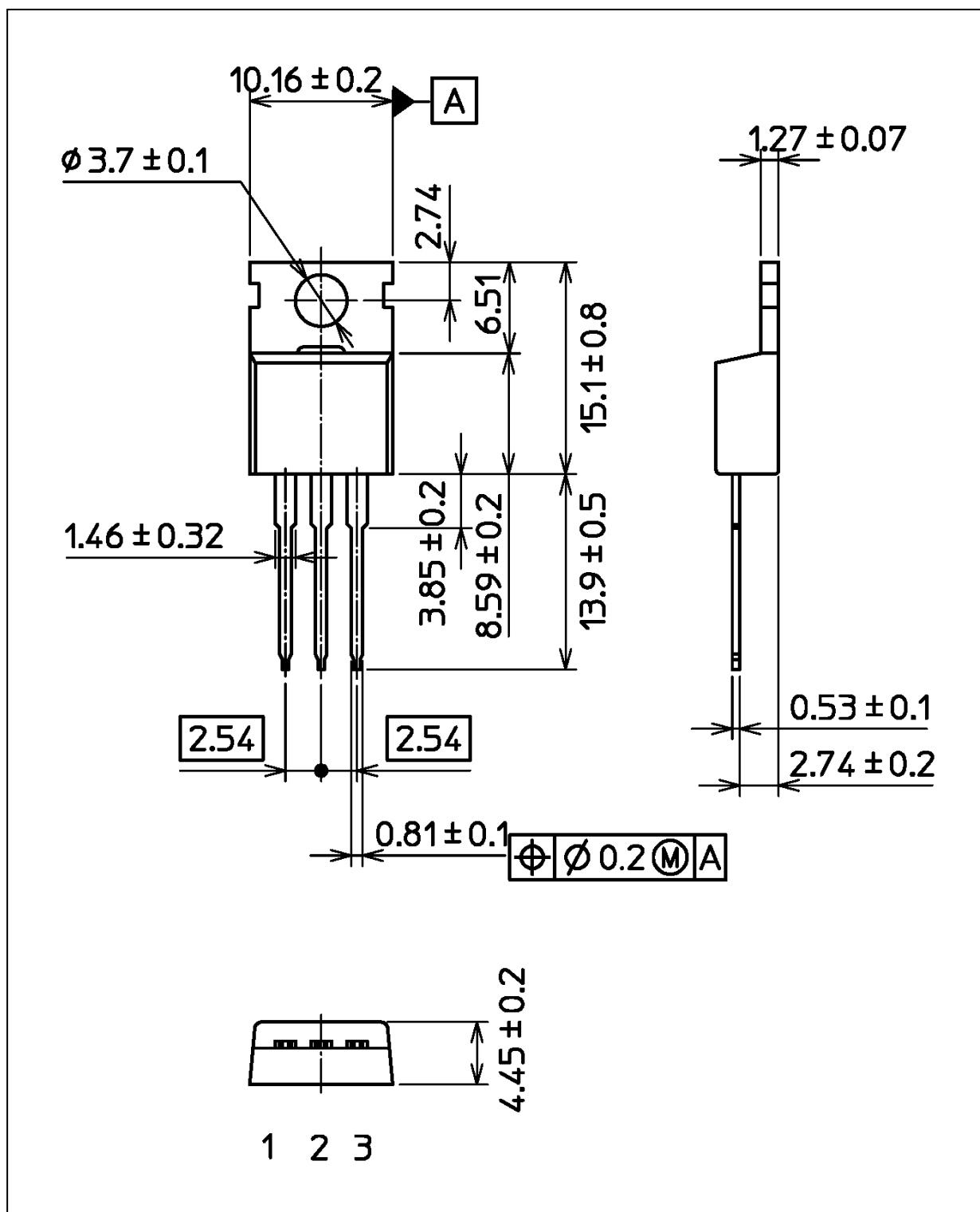


**Fig. 8.17 Safe Operating Area  
(Guaranteed Maximum)**

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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