

# TK4P60DA

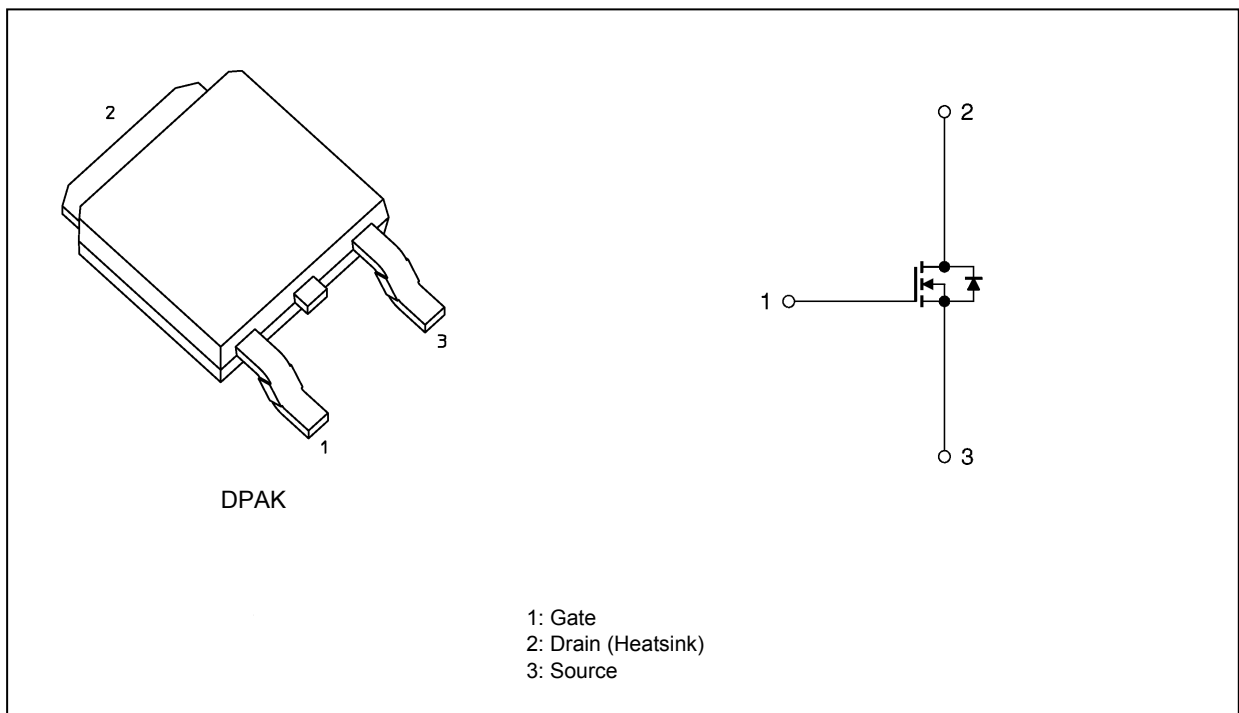
## 1. Applications

- Switching Voltage Regulators

## 2. Features

- (1) Low drain-source on-resistance:  $R_{DS(ON)} = 1.7 \Omega$  (typ.) ( $V_{GS} = 10 \text{ V}$ )
- (2) High forward transfer admittance:  $|Y_{fs}| = 2.2 \text{ S}$  (typ.)
- (3) Low leakage current:  $I_{DSS} = 10 \mu\text{A}$  (max) ( $V_{DS} = 600 \text{ V}$ )
- (4) Enhancement mode:  $V_{th} = 2.4 \text{ to } 4.4 \text{ V}$  ( $V_{DS} = 10 \text{ V}$ ,  $I_D = 1 \text{ mA}$ )

## 3. Packaging and Internal Circuit



Start of commercial production

2009-12

**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)	$I_D$	3.5	A
Drain current (pulsed) (Note 1)	$I_{DP}$	14	
Power dissipation ( $T_c = 25^\circ\text{C}$ )	$P_D$	80	W
Single-pulse avalanche energy (Note 2)	$E_{AS}$	132	mJ
Avalanche current (Note 3)	$I_{AR}$	3.5	A
Repetitive avalanche energy (Note 3)	$E_{AR}$	8	mJ
Reverse drain current (DC) (Note 1)	$I_{DR}$	3.5	A
Reverse drain current (pulsed) (Note 1)	$I_{DRP}$	14	
Channel temperature	$T_{ch}$	150	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-55 to 150	

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	$R_{th(ch-c)}$	1.56	$^\circ\text{C/W}$
Channel-to-ambient thermal resistance	$R_{th(ch-a)}$	125	

Note 1: Ensure that the channel temperature does not exceed  $150^\circ\text{C}$ .

Note 2:  $V_{DD} = 90\text{ V}$ ,  $T_{ch} = 25^\circ\text{C}$  (initial),  $L = 18.9\text{ mH}$ ,  $R_G = 25\ \Omega$ ,  $I_{AR} = 3.5\text{ A}$

Note 3: Repetitive rating; pulse width limited by maximum channel temperature.

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

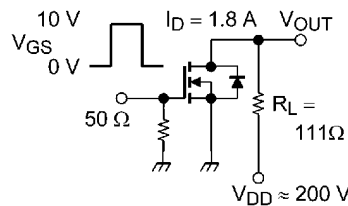
**6. Electrical Characteristics**

**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	$V_{th}$	$V_{DS} = 10\text{ V}, I_D = 1\text{ mA}$	2.4	—	4.4	
Drain-source on-resistance	$R_{DS(ON)}$	$V_{GS} = 10\text{ V}, I_D = 1.8\text{ A}$	—	1.7	2.2	$\Omega$
Forward transfer admittance	$ Y_{fs} $	$V_{DS} = 10\text{ V}, I_D = 1.8\text{ A}$	0.6	2.2	—	S

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Input capacitance	$C_{iss}$	$V_{DS} = 25\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	490	—	$\mu\text{F}$
Reverse transfer capacitance	$C_{rss}$		—	3	—	
Output capacitance	$C_{oss}$		—	55	—	
Switching time (rise time)	$t_r$	See Figure 6.2.1	—	18	—	ns
Switching time (turn-on time)	$t_{on}$		—	40	—	
Switching time (fall time)	$t_f$		—	8	—	
Switching time (turn-off time)	$t_{off}$		—	55	—	



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

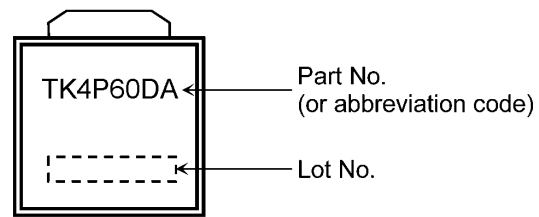
**Fig. 6.2.1 Switching Time Test Circuit**

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

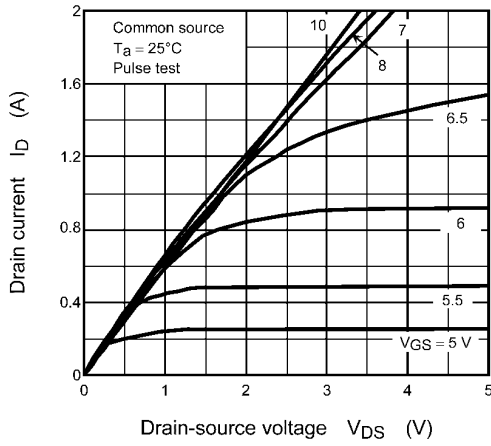
Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Total gate charge (gate-source plus gate-drain)	$Q_g$	$V_{DD} \approx 400\text{ V}, V_{GS} = 10\text{ V}, I_D = 3.5\text{ A}$	—	11	—	nC
Gate-source charge	$Q_{gs}$		—	6	—	
Gate-drain charge	$Q_{gd}$		—	5	—	

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

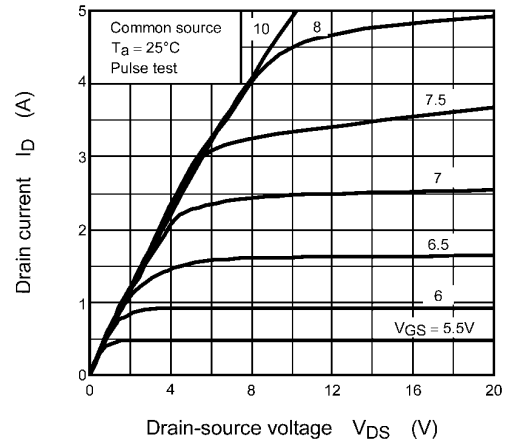
Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Diode forward voltage	$V_{DSF}$	$I_{DR} = 3.5\text{ A}, V_{GS} = 0\text{ V}$	—	—	-1.7	V
Reverse recovery time	$t_{rr}$	$I_{DR} = 3.5\text{ A}, V_{GS} = 0\text{ V}$ $dI_{DR}/dt = 100\text{ A}/\mu\text{s}$	—	1000	—	ns
Reverse recovery charge	$Q_{rr}$		—	5.0	—	$\mu\text{C}$

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

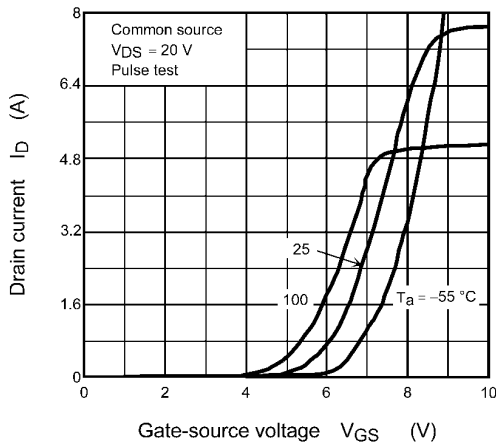
**8. Characteristics Curves (Note)**



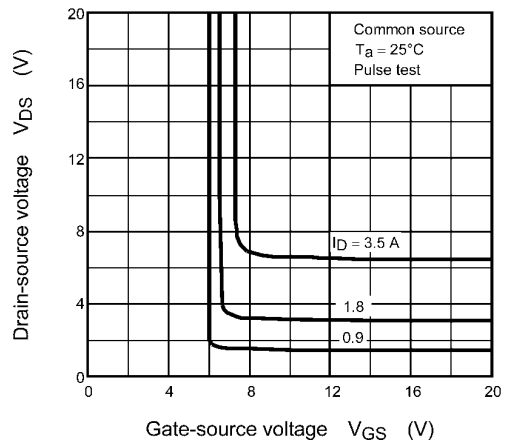
**Fig. 8.1  $I_D - V_{DS}$**



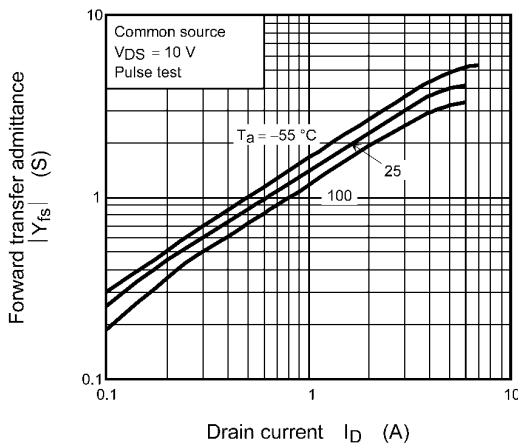
**Fig. 8.2  $I_D - V_{DS}$**



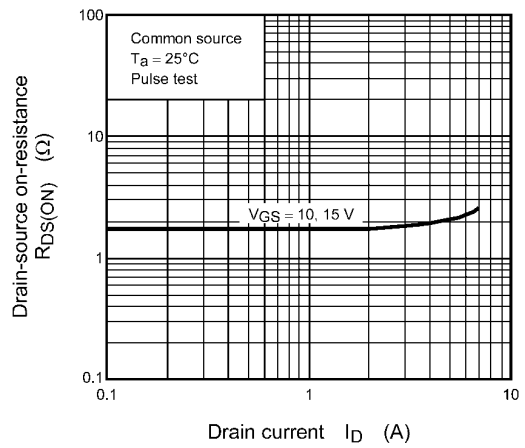
**Fig. 8.3  $I_D - V_{GS}$**



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



**Fig. 8.5  $|Y_{fs}| - I_D$**



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

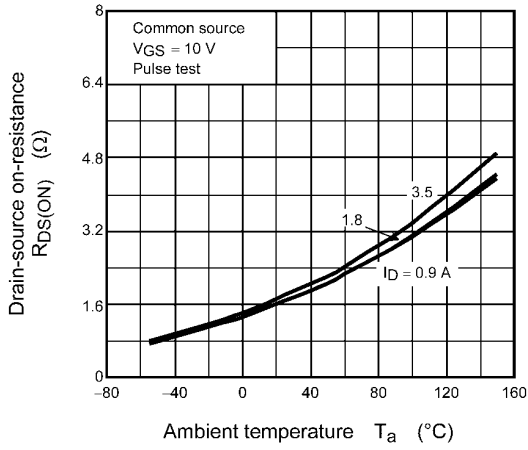


Fig. 8.7  $R_{DS(ON)} - T_a$

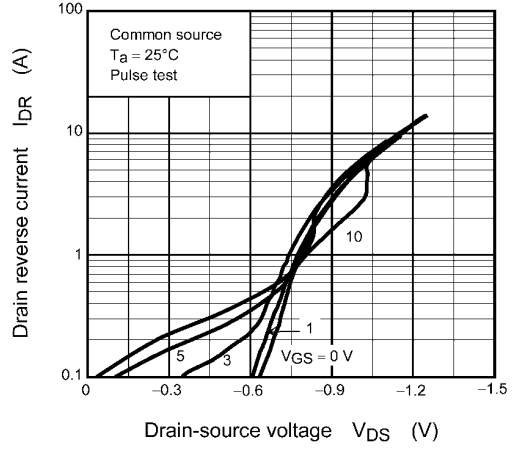


Fig. 8.8  $I_{DR} - V_{DS}$

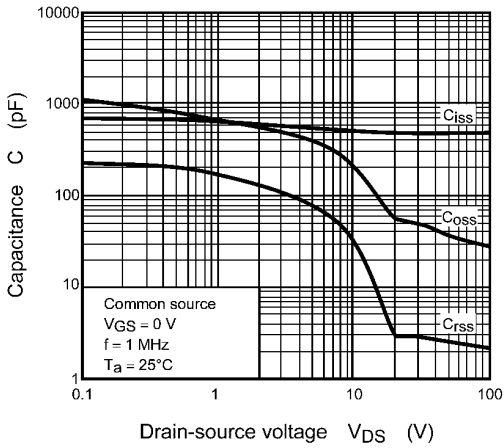


Fig. 8.9 Capacitance -  $V_{DS}$

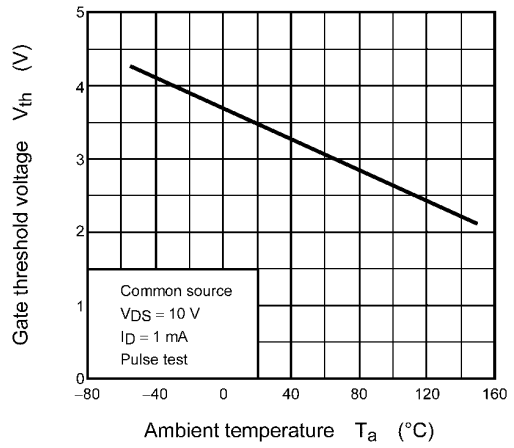


Fig. 8.10  $V_{th} - T_a$

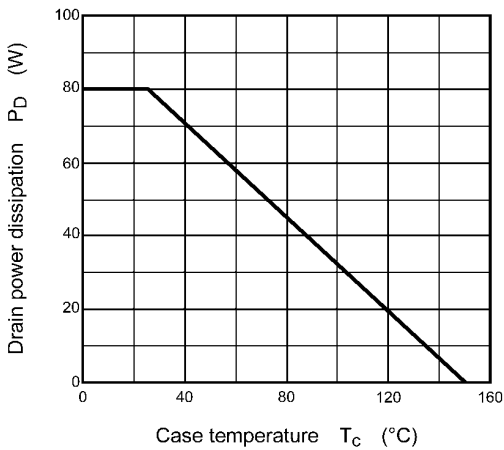


Fig. 8.11  $P_D - T_C$   
(Guaranteed Maximum)

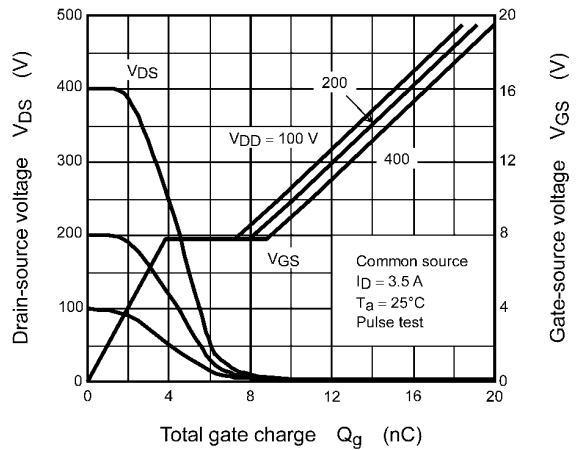
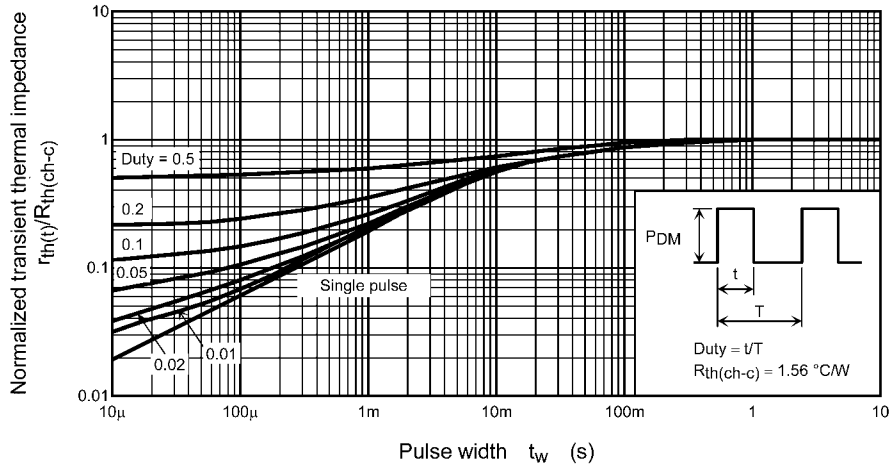
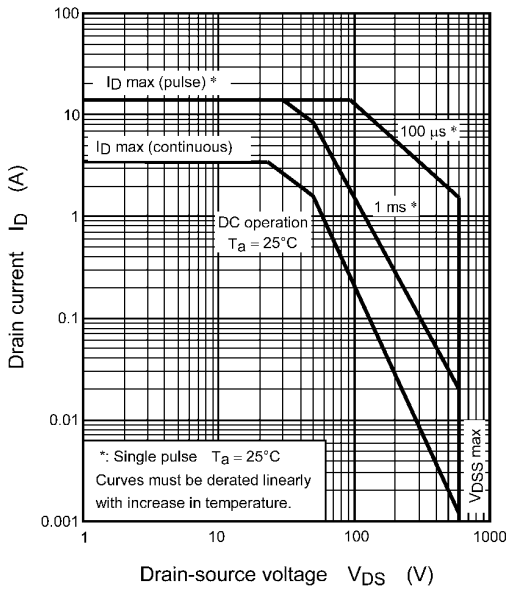


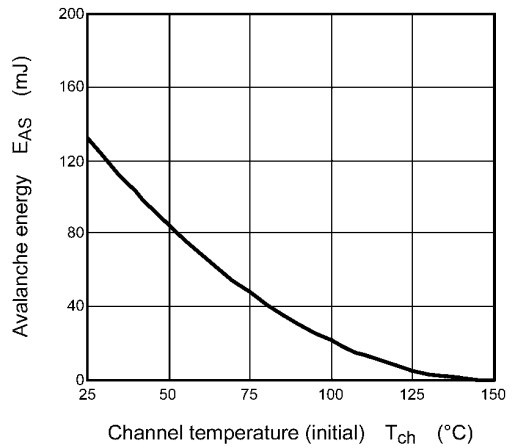
Fig. 8.12 Dynamic Input/Output Characteristics



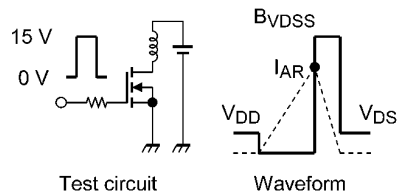
**Fig. 8.13**  $r_{th}(t)/R_{th}(ch-c) - t_w$   
(Guaranteed Maximum)



**Fig. 8.14** Safe Operating Area  
(Guaranteed Maximum)



**Fig. 8.15**  $E_{AS} - T_{ch}$   
(Guaranteed Maximum)



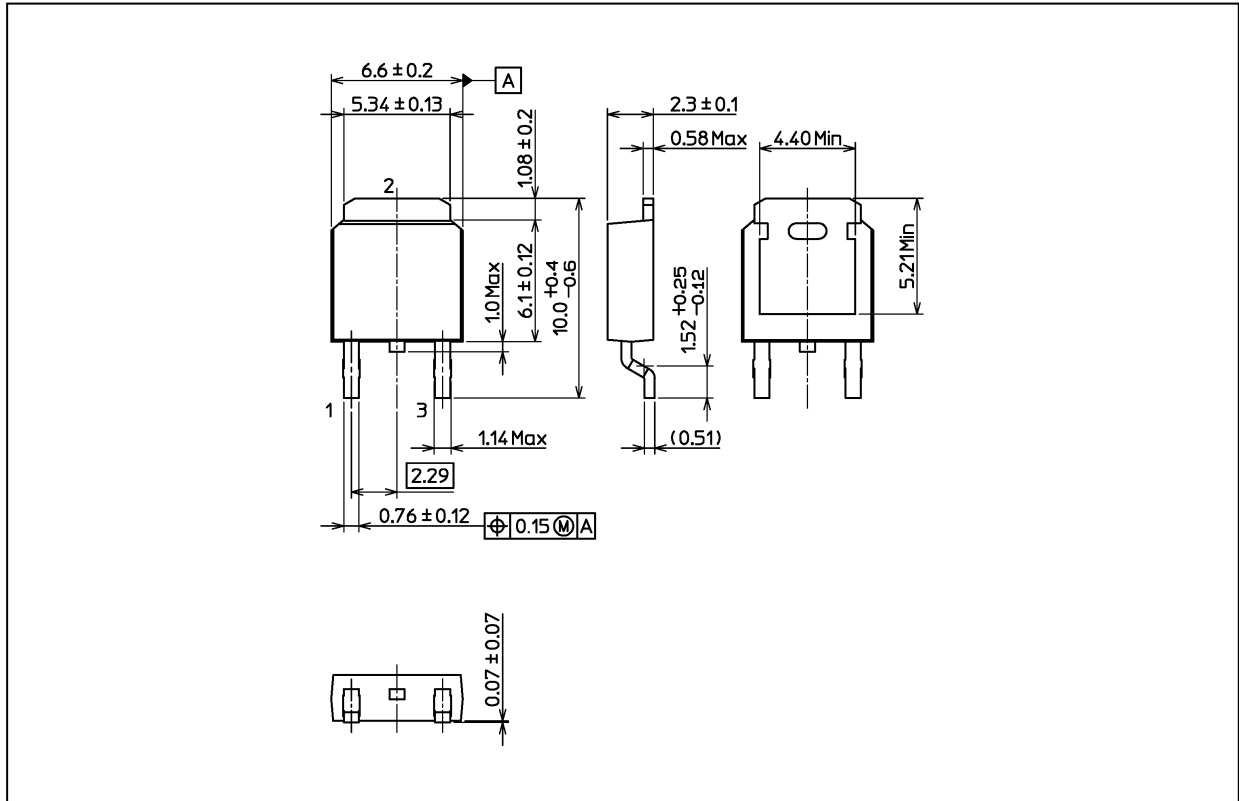
$$R_G = 25 \Omega, V_{DD} = 90 \text{ V} \quad E_{AS} = \frac{1}{2} \cdot L \cdot I_{AR}^2 \cdot \left( \frac{B_{VDSS}}{B_{VDSS} - V_{DD}} \right)$$

**Fig. 8.16** Test Circuit/Waveform

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

**Package Dimensions**

Unit: mm



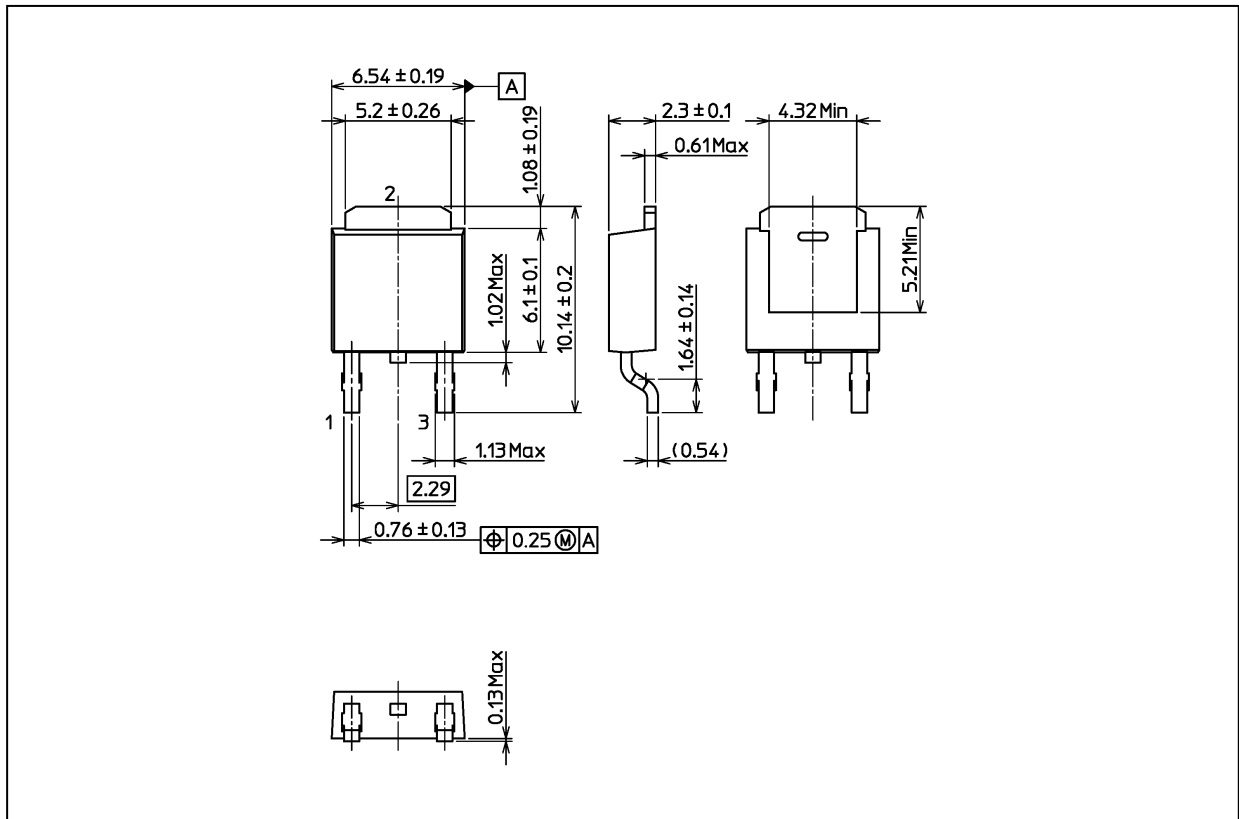
Both products are compliant with the JEDEC: TO-252 Package specification. Please contact the Toshiba sales representative for further details.

Weight: 0.36 g (typ.)

Package Name(s)
JEDEC: TO-252
TOSHIBA: 2-7K1S
Nickname: DPAK

**Package Dimensions**

Unit: mm



Both products are compliant with the JEDEC: TO-252 Package specification. Please contact the Toshiba sales representative for further details.

Weight: 0.389 g (typ.)



Package Name(s)
JEDEC: TO-252
TOSHIBA: 2-7N1S
Nickname: DPAK

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