

# TK65S04K3L

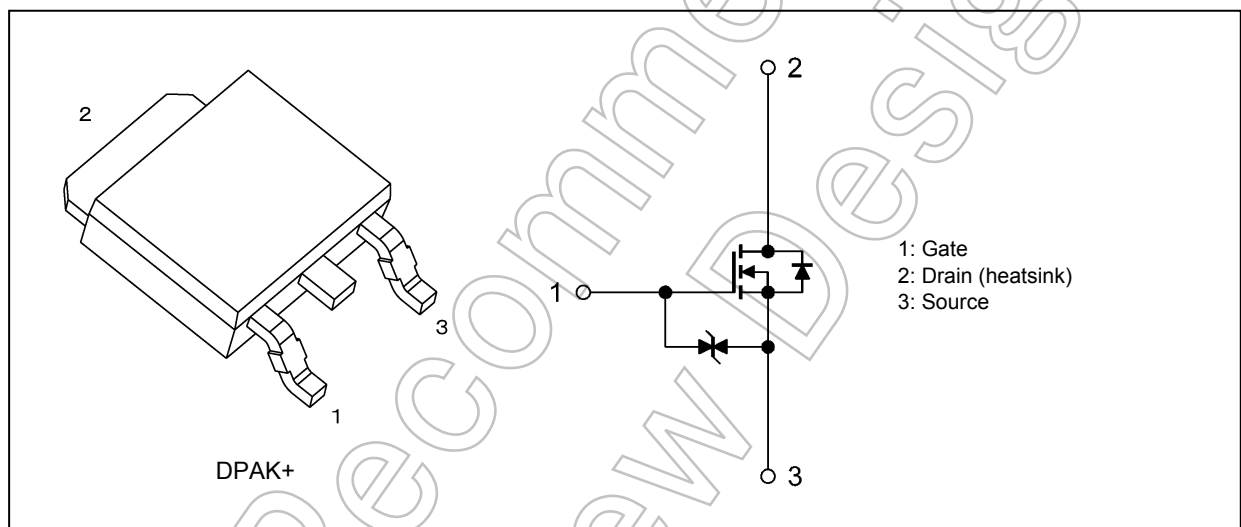
## 1. Applications

- Automotive
- Motor Drivers
- DC-DC Converters
- Switching Voltage Regulators

## 2. Features

- (1) AEC-Q101 qualified
- (2) Low drain-source on-resistance:  $R_{DS(ON)} = 3.6 \text{ m}\Omega$  (typ.) ( $V_{GS} = 10 \text{ V}$ )
- (3) Low leakage current:  $I_{DSS} = 10 \text{ }\mu\text{A}$  (max) ( $V_{DS} = 40 \text{ V}$ )
- (4) Enhancement mode:  $V_{th} = 2.0 \text{ to } 3.0 \text{ V}$  ( $V_{DS} = 10 \text{ V}$ ,  $I_D = 1 \text{ mA}$ )

## 3. Packaging and Internal Circuit



Start of commercial production

2011-04

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

Characteristics	Symbol	Rating	Unit
Drain-source voltage	$V_{DSS}$	40	V
Gate-source voltage	$V_{GSS}$	$\pm 20$	
Drain current (DC) (Note 1)	$I_D$	65	A
Drain current (pulsed) (Note 1)	$I_{DP}$	130	
Power dissipation ( $T_c = 25^\circ\text{C}$ )	$P_D$	88	W
Single-pulse avalanche energy (Note 2)	$E_{AS}$	130	mJ
Avalanche current	$I_{AR}$	65	A
Channel temperature (Note 3)	$T_{ch}$	175	$^\circ\text{C}$
Storage temperature (Note 3)	$T_{stg}$	-55 to 175	

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	$R_{th(ch-c)}$	1.7	$^\circ\text{C}/\text{W}$

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

Note 2:  $V_{DD} = 25\text{ V}$ ,  $T_{ch} = 25^\circ\text{C}$  (initial),  $L = 32\ \mu\text{H}$ ,  $R_G = 1\ \Omega$ ,  $I_{AR} = 65\text{ A}$

Note 3: The definitions of the absolute maximum channel and storage temperatures are qualified per AEC-Q101.

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

Not Recommended for New Design

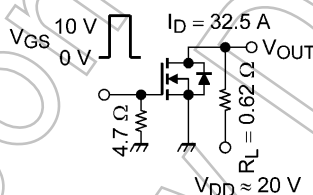
**6. Electrical Characteristics**

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Gate leakage current	$I_{GSS}$	$V_{GS} = \pm 16\text{ V}, V_{DS} = 0\text{ V}$	—	—	$\pm 10$	$\mu\text{A}$
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
	$V_{(BR)DSX}$	$I_D = 10\text{ mA}, V_{GS} = -20\text{ V}$	20	—	—	
Gate threshold voltage	$V_{th}$	$V_{DS} = 10\text{ V}, I_D = 1\text{ mA}$	2.0	—	3.0	
Drain-source on-resistance	$R_{DS(ON)}$	$V_{GS} = 6\text{ V}, I_D = 32.5\text{ A}$	—	4.9	7.9	$\text{m}\Omega$
		$V_{GS} = 10\text{ V}, I_D = 32.5\text{ A}$	—	3.6	4.5	

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Input capacitance	$C_{iss}$	$V_{DS} = 10\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	—	2800	—	$\text{pF}$
Reverse transfer capacitance	$C_{rss}$		—	440	—	
Output capacitance	$C_{oss}$		—	680	—	
Switching time (rise time)	$t_r$	See Figure 6.2.1.	—	11	—	ns
Switching time (turn-on time)	$t_{on}$		—	24	—	
Switching time (fall time)	$t_f$		—	16	—	
Switching time (turn-off time)	$t_{off}$		—	59	—	



**Fig. 6.2.1 Switching Time Test Circuit**

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

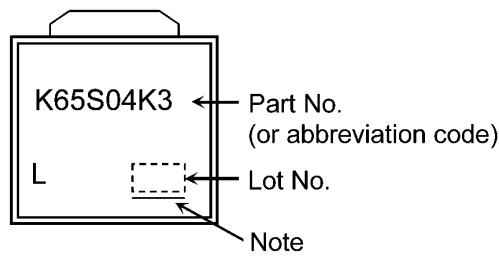
Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Total gate charge (gate-source plus gate-drain)	$Q_g$	$V_{DD} \approx 32\text{ V}, V_{GS} = 10\text{ V}, I_D = 65\text{ A}$	—	63	—	nC
Gate-source charge	$Q_{gs}$		—	39	—	
Gate-drain charge	$Q_{gd}$		—	24	—	

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

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Reverse drain current (DC)	(Note 4) $I_{DR}$	—	—	—	65	A
Reverse drain current (pulsed)	(Note 4) $I_{DRP}$		—	—	130	
Diode forward voltage	$V_{DSF}$	$I_{DR} = 65\text{ A}, V_{GS} = 0\text{ V}$	—	—	-1.2	V
Reverse recovery time	$t_{rr}$	$I_{DR} = 65\text{ A}, V_{GS} = 0\text{ V}$	—	51	—	ns
Reverse recovery charge	$Q_{rr}$	$-dI_{DR}/dt = 50\text{ A}/\mu\text{s}$	—	33	—	nC

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

**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

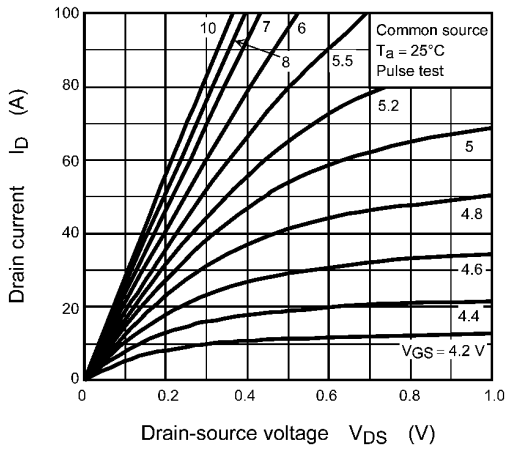
Underlined: [[G]]/RoHS COMPATIBLE or [[G]]/RoHS [[Pb]]

Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product.

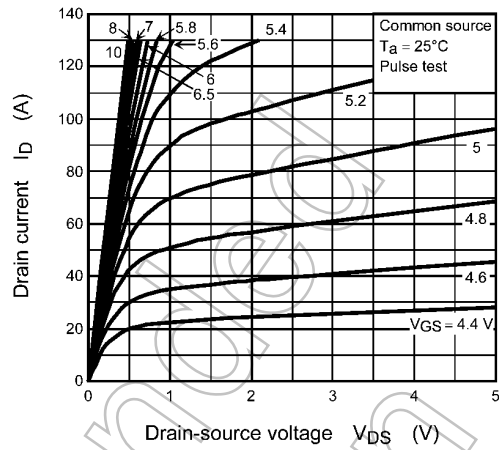
The RoHS is the Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

Not Recommended for New Design

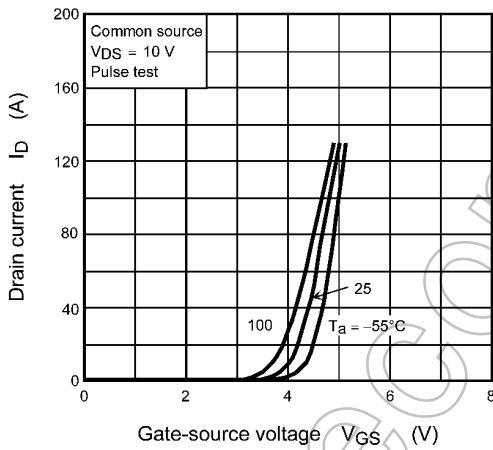
**8. Characteristics Curves (Note)**



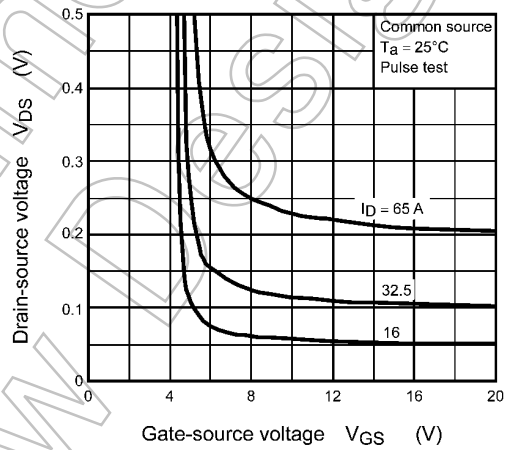
**Fig. 8.1  $I_D - V_{DS}$**



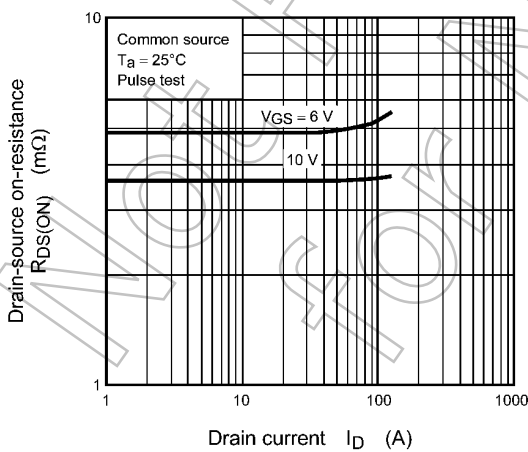
**Fig. 8.2  $I_D - V_{DS}$**



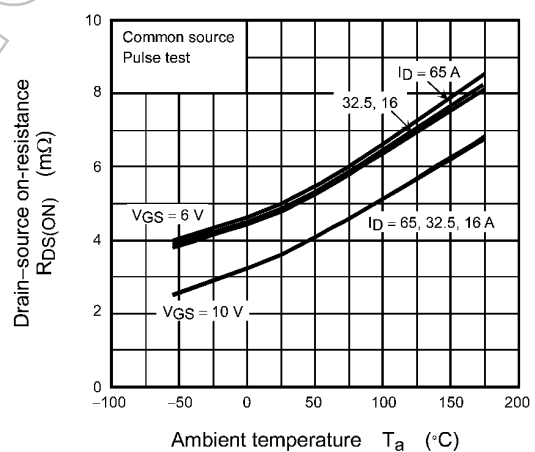
**Fig. 8.3  $I_D - V_{GS}$**



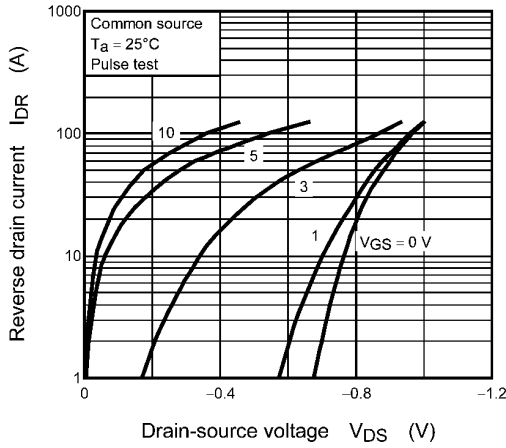
**Fig. 8.4  $V_{DS} - V_{GS}$**



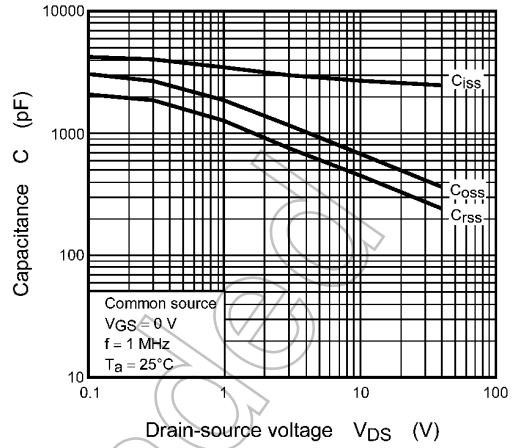
**Fig. 8.5  $R_{DS(ON)} - I_D$**



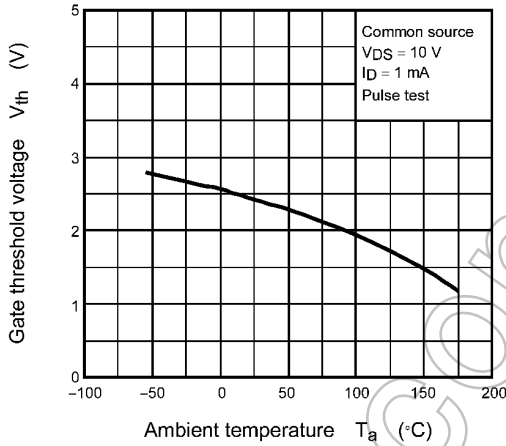
**Fig. 8.6  $R_{DS(ON)} - T_a$**



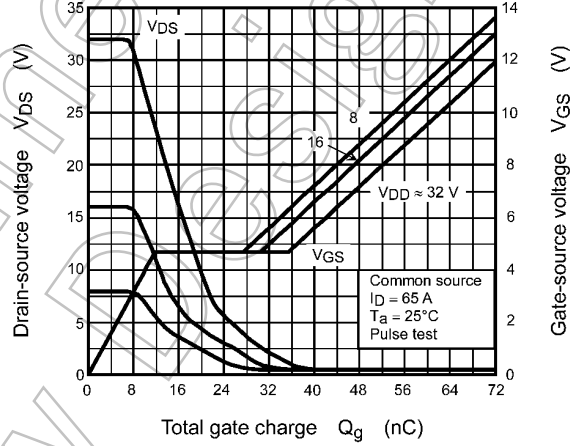
**Fig. 8.7  $I_{DR} - V_{DS}$**



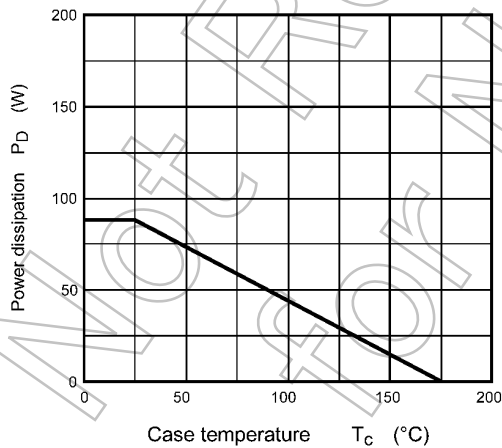
**Fig. 8.8 Capacitance -  $V_{DS}$**



**Fig. 8.9  $V_{th} - T_a$**



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



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

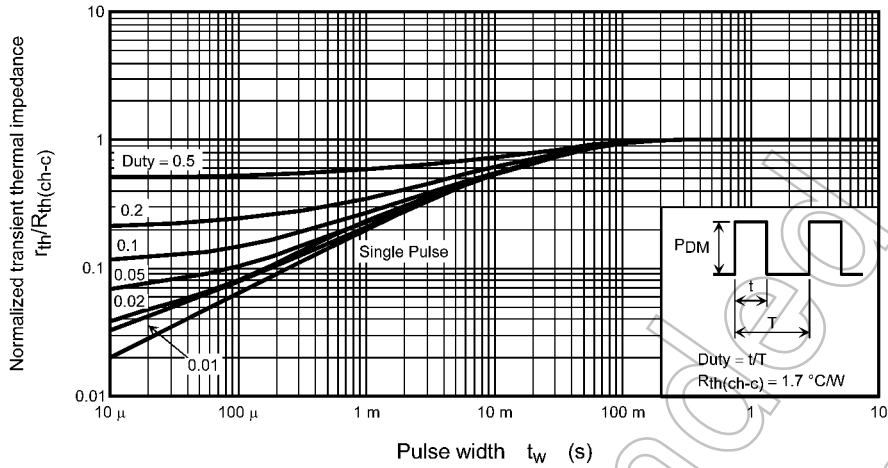


Fig. 8.12  $r_{th}/R_{th}(ch-c) - t_w$   
(Guaranteed Maximum)

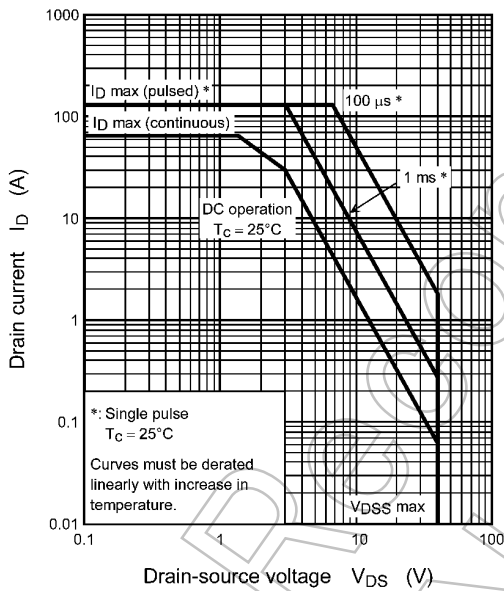


Fig. 8.13 Safe Operating Area  
(Guaranteed Maximum)

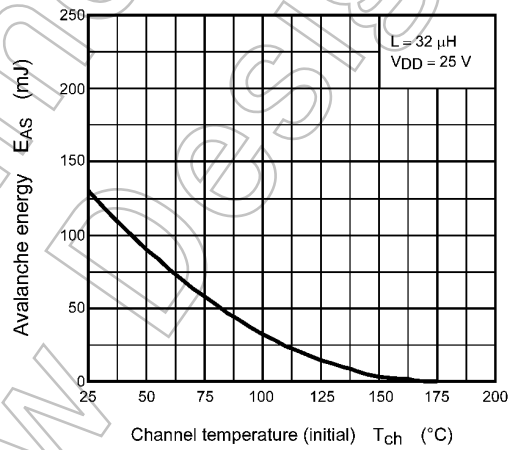
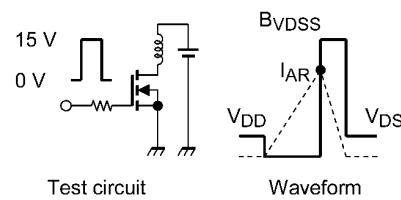


Fig. 8.14  $E_{AS} - T_{ch}$   
(Guaranteed Maximum)



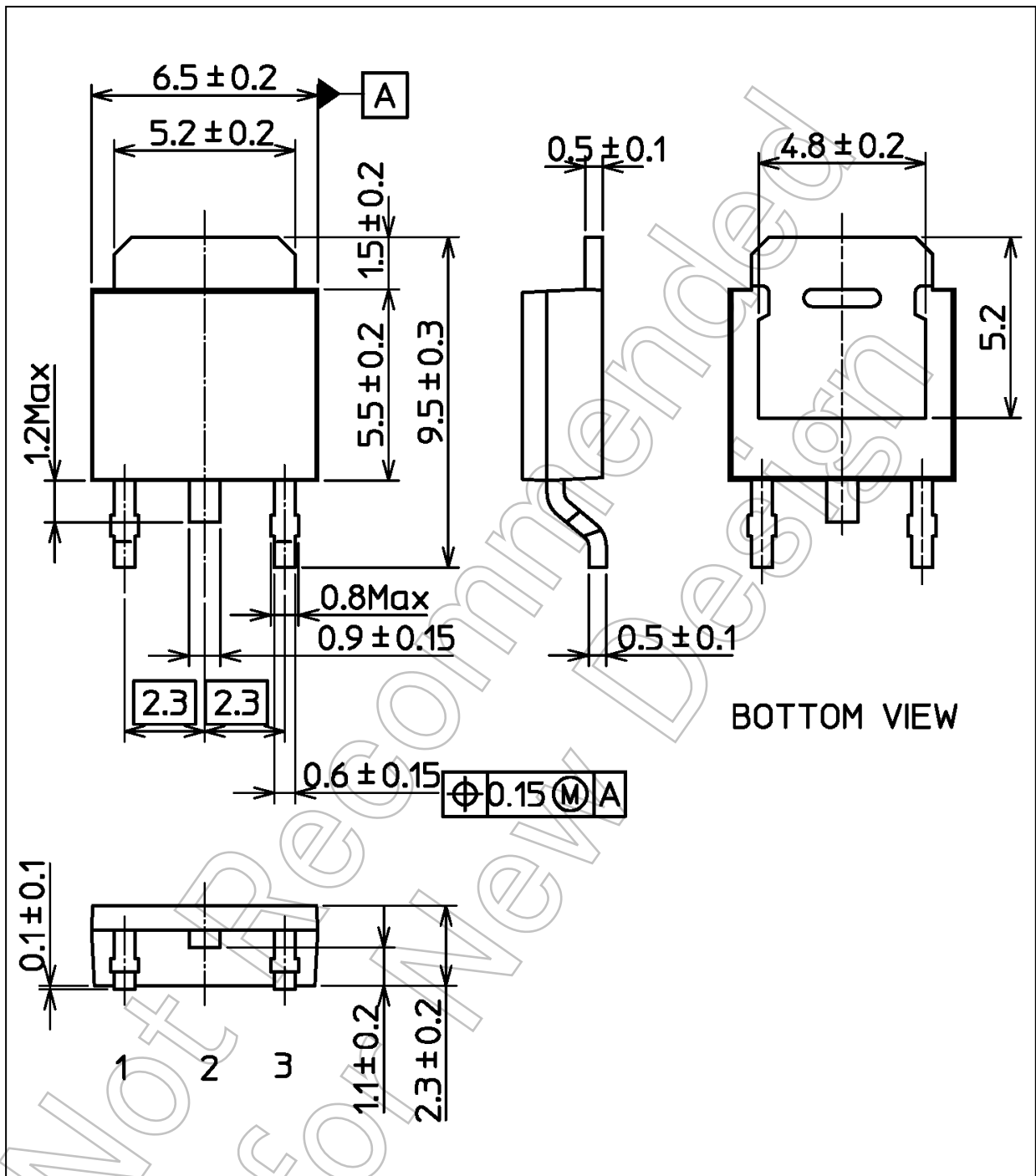
$$R_G = 1 \Omega, V_{DD} = 25 \text{ V}, L = 32 \mu\text{H} \quad E_{AS} = \frac{1}{2} \cdot L \cdot I_{AR}^2 \cdot \left( \frac{B_{VDSS}}{B_{VDSS} - V_{DD}} \right)$$

Fig. 8.15 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



Weight: 0.36 g (typ.)

Package Name(s)
TOSHIBA: 2-7M1A
Nickname: DPAK+



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