

# TPN2R503NC

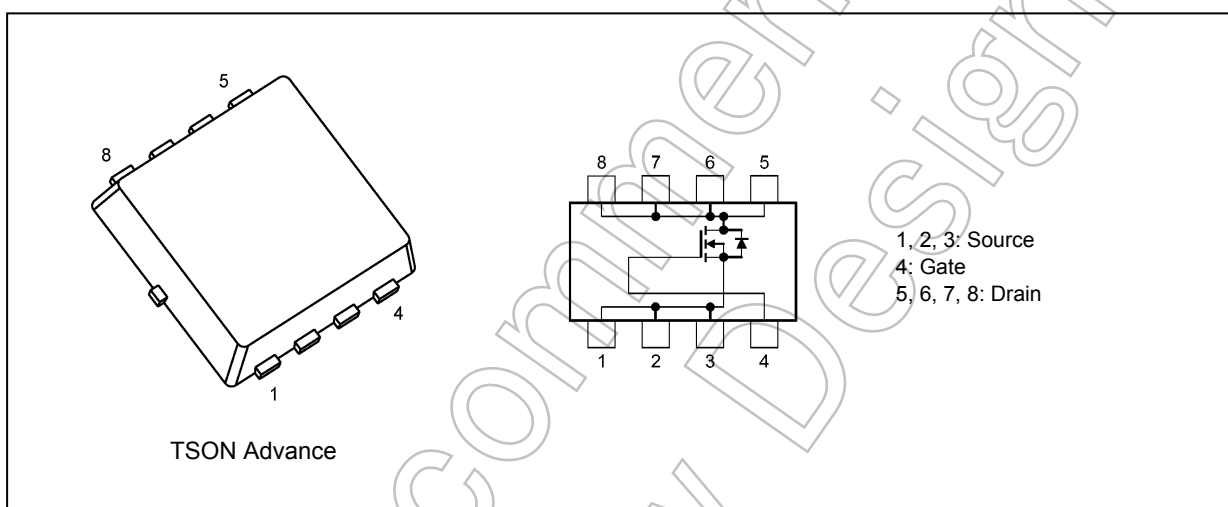
## 1. Applications

- Power Management Switches

## 2. Features

- (1) Small footprint due to a small and thin package
- (2) Low drain-source on-resistance:  $R_{DS(ON)} = 2.1 \text{ m}\Omega$  (typ.) ( $V_{GS} = 10 \text{ V}$ )
- (3) Low leakage current:  $I_{DSS} = 10 \text{ }\mu\text{A}$  (max) ( $V_{DS} = 30 \text{ V}$ )
- (4) Enhancement mode:  $V_{th} = 1.3 \text{ to } 2.3 \text{ V}$  ( $V_{DS} = 10 \text{ V}$ ,  $I_D = 0.5 \text{ mA}$ )

## 3. Packaging and Internal Circuit



Start of commercial production

2012-11

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

| Characteristics                                        | Symbol           | Rating     | Unit             |
|--------------------------------------------------------|------------------|------------|------------------|
| Drain-source voltage                                   | $V_{\text{DSS}}$ | 30         | V                |
| Gate-source voltage                                    | $V_{\text{GSS}}$ | $\pm 20$   |                  |
| Drain current (DC) (Silicon limit) (Note 1), (Note 2)  | $I_{\text{D}}$   | 85         | A                |
| Drain current (DC) (Note 1)                            | $I_{\text{D}}$   | 40         |                  |
| Drain current (pulsed) ( $t = 1 \text{ ms}$ ) (Note 1) | $I_{\text{DP}}$  | 120        |                  |
| Power dissipation ( $T_c = 25^\circ\text{C}$ )         | $P_{\text{D}}$   | 35         | W                |
| Power dissipation ( $t = 10 \text{ s}$ ) (Note 3)      | $P_{\text{D}}$   | 1.9        | W                |
| Power dissipation ( $t = 10 \text{ s}$ ) (Note 4)      | $P_{\text{D}}$   | 0.7        | W                |
| Single-pulse avalanche energy (Note 5)                 | $E_{\text{AS}}$  | 62         | mJ               |
| Avalanche current                                      | $I_{\text{AR}}$  | 40         | A                |
| Channel temperature                                    | $T_{\text{ch}}$  | 150        | $^\circ\text{C}$ |
| Storage temperature                                    | $T_{\text{stg}}$ | -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 ( $T_c = 25^\circ\text{C}$ )       | $R_{\text{th(ch-c)}}$ | 3.57 | $^\circ\text{C/W}$ |
| Channel-to-ambient thermal resistance ( $t = 10 \text{ s}$ ) (Note 3) | $R_{\text{th(ch-a)}}$ | 65.7 | $^\circ\text{C/W}$ |
| Channel-to-ambient thermal resistance ( $t = 10 \text{ s}$ ) (Note 4) | $R_{\text{th(ch-a)}}$ | 178  | $^\circ\text{C/W}$ |

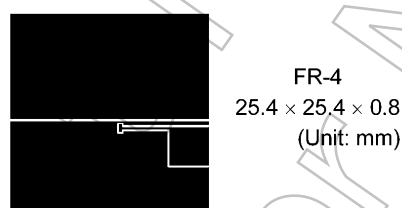
Note 1: Ensure that the channel temperature does not exceed  $150^\circ\text{C}$ .

Note 2: Limited by silicon capability. Package limit is 45 A.

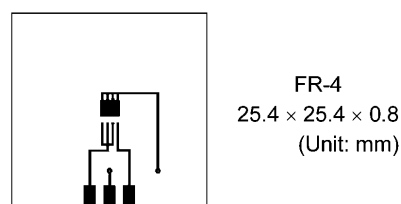
Note 3: Device mounted on a glass-epoxy board (a), Figure 5.1

Note 4: Device mounted on a glass-epoxy board (b), Figure 5.2

Note 5:  $V_{\text{DD}} = 24 \text{ V}$ ,  $T_{\text{ch}} = 25^\circ\text{C}$  (initial),  $L = 30 \mu\text{H}$ ,  $R_{\text{G}} = 1 \Omega$ ,  $I_{\text{AR}} = 40 \text{ A}$



**Fig. 5.1 Device Mounted on a Glass-Epoxy Board (a)**



**Fig. 5.2 Device Mounted on a Glass-Epoxy Board (b)**

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                   | $I_{DSS}$     | $V_{DS} = 30\text{ V}, V_{GS} = 0\text{ V}$     | —   | —    | 10        |                  |
| Drain-source breakdown voltage          | $V_{(BR)DSS}$ | $I_D = 10\text{ mA}, V_{GS} = 0\text{ V}$       | 30  | —    | —         | V                |
| Drain-source breakdown voltage (Note 6) | $V_{(BR)DSX}$ | $I_D = 10\text{ mA}, V_{GS} = -20\text{ V}$     | 15  | —    | —         |                  |
| Gate threshold voltage                  | $V_{th}$      | $V_{DS} = 10\text{ V}, I_D = 0.5\text{ mA}$     | 1.3 | —    | 2.3       |                  |
| Drain-source on-resistance              | $R_{DS(ON)}$  | $V_{GS} = 4.5\text{ V}, I_D = 20\text{ A}$      | —   | 3.2  | 4.1       | $\text{m}\Omega$ |
|                                         |               | $V_{GS} = 10\text{ V}, I_D = 20\text{ A}$       | —   | 2.1  | 2.5       |                  |

Note 6: 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              | $C_{iss}$ | $V_{DS} = 15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$ | —   | 2230 | —   | $\text{pF}$ |
| Reverse transfer capacitance   | $C_{rss}$ |                                                               | —   | 160  | —   |             |
| Output capacitance             | $C_{oss}$ |                                                               | —   | 650  | —   |             |
| Switching time (rise time)     | $t_r$     | See Figure 6.2.1.                                             | —   | 9    | —   | $\text{ns}$ |
| Switching time (turn-on time)  | $t_{on}$  |                                                               | —   | 14   | —   |             |
| Switching time (fall time)     | $t_f$     |                                                               | —   | 24   | —   |             |
| Switching time (turn-off time) | $t_{off}$ |                                                               | —   | 68   | —   |             |

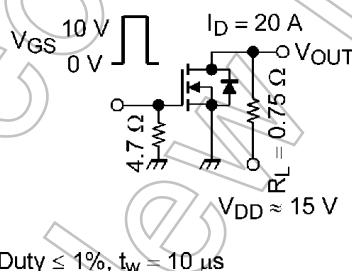


Fig. 6.2.1 Switching Time Test Circuit

### 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) | $Q_g$     | $V_{DD} \approx 24\text{ V}, V_{GS} = 10\text{ V}, I_D = 40\text{ A}$ | —   | 40   | —   | $\text{nC}$ |
| Gate-source charge 1                            | $Q_{gs1}$ |                                                                       | —   | 10   | —   |             |
| Gate-drain charge                               | $Q_{gd}$  |                                                                       | —   | 10   | —   |             |

### 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 (pulsed) (Note 7) | $I_{DRP}$ | —                                           | —   | —    | 120  | A    |
| Diode forward voltage                   | $V_{DSF}$ | $I_{DR} = 40\text{ A}, V_{GS} = 0\text{ V}$ | —   | —    | -1.2 | V    |

Note 7: Ensure that the channel temperature does not exceed  $150^\circ\text{C}$ .

## 7. Marking

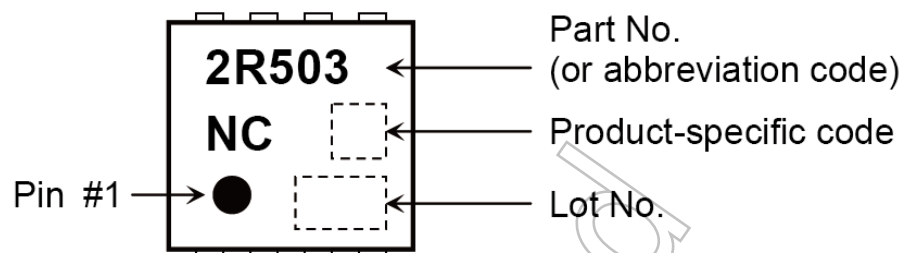
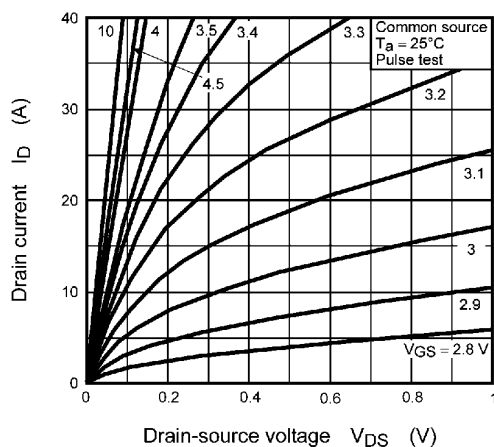
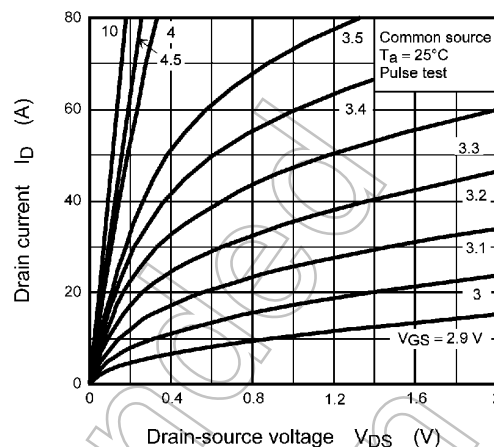


Fig. 7.1 Marking

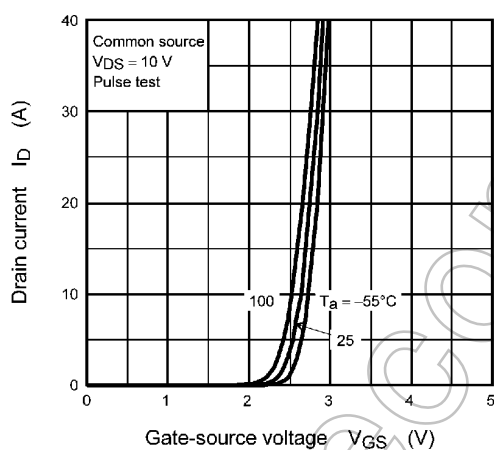
# 8. Characteristics Curves (Note)



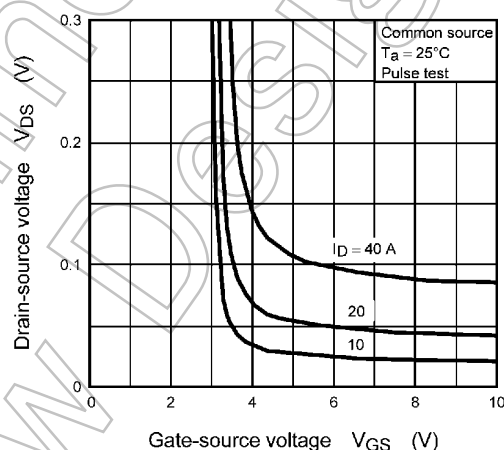
**Fig. 8.1  $I_D - V_{DS}$**



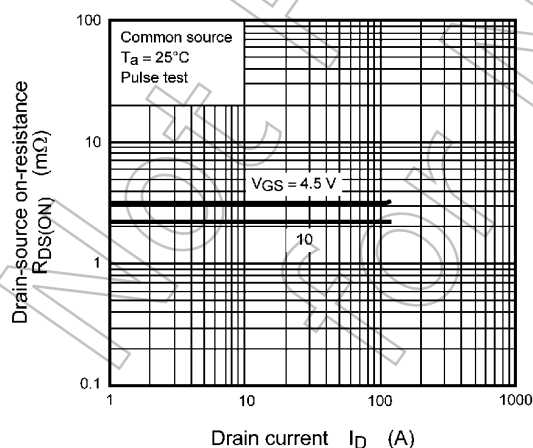
**Fig. 8.2  $I_D - V_{DS}$**



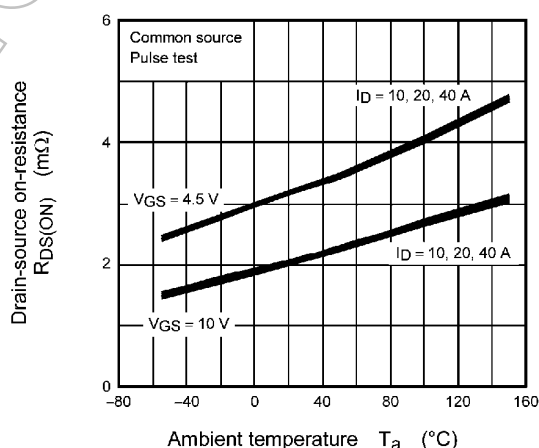
**Fig. 8.3  $I_D - V_{GS}$**



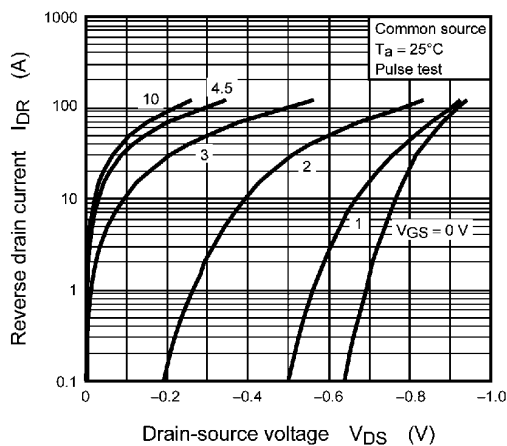
**Fig. 8.4  $V_{DS} - V_{GS}$**



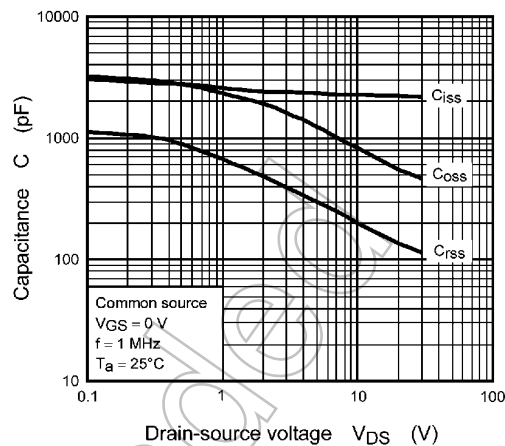
**Fig. 8.5  $R_{DS(ON)} - I_D$**



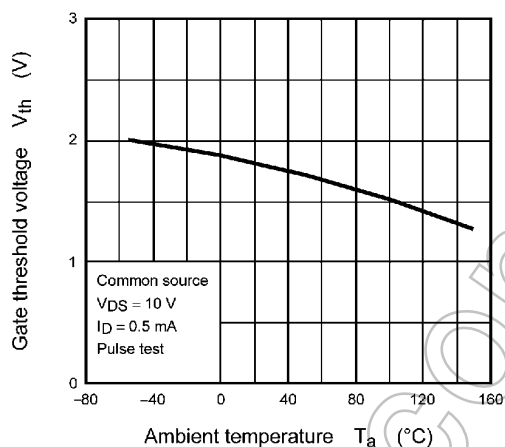
**Fig. 8.6  $R_{DS(ON)} - T_a$**



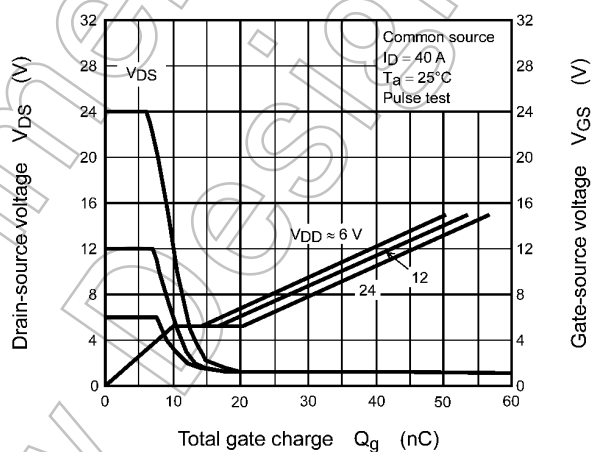
**Fig. 8.7  $I_{DR} - V_{DS}$**



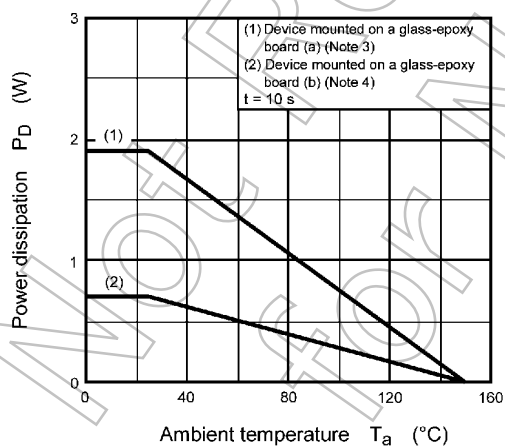
**Fig. 8.8 Capacitance -  $V_{DS}$**



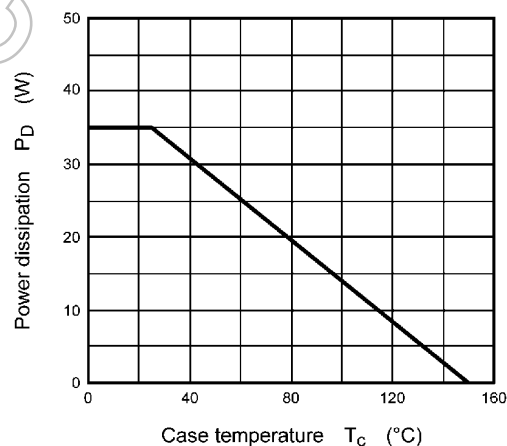
**Fig. 8.9  $V_{th} - T_a$**



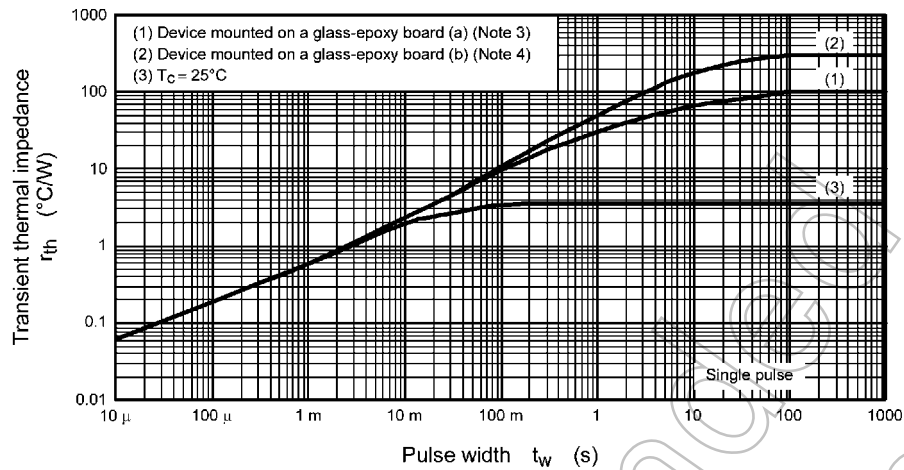
**Fig. 8.10 Dynamic Input/Output Characteristics**



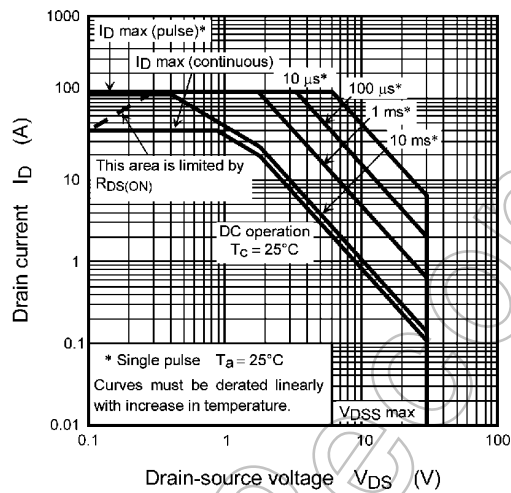
**Fig. 8.11  $P_D - T_a$   
(Guaranteed Maximum)**



**Fig. 8.12  $P_D - T_c$   
(Guaranteed Maximum)**



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

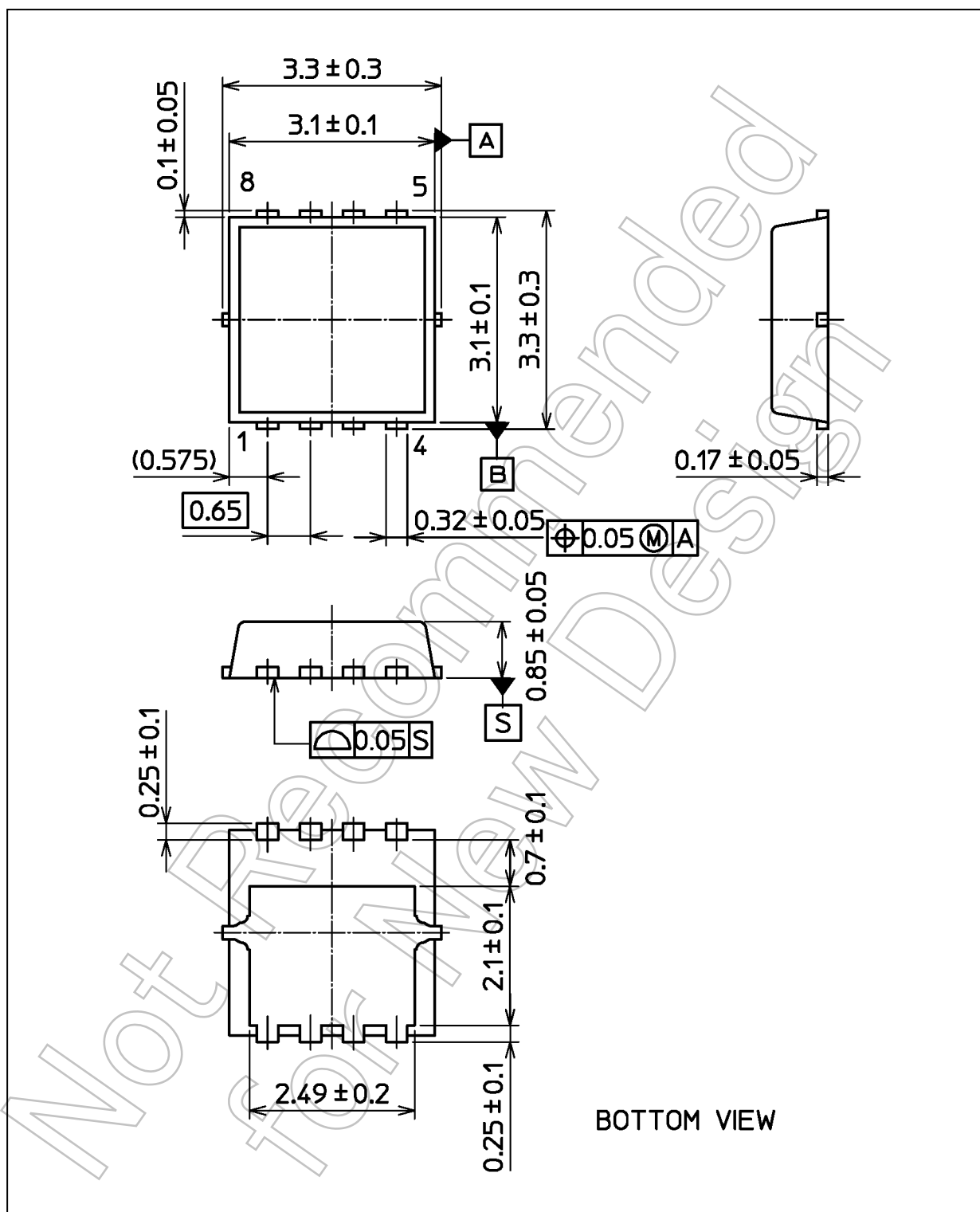


**Fig. 8.14 Safe Operating Area**  
(Guaranteed Maximum)

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

## Package Dimensions

Unit: mm



Weight: 0.02 g (typ.)

| Package Name(s)        |
|------------------------|
| TOSHIBA: 2-3X1S        |
| Nickname: TSON Advance |



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