

# TPN6R003NL

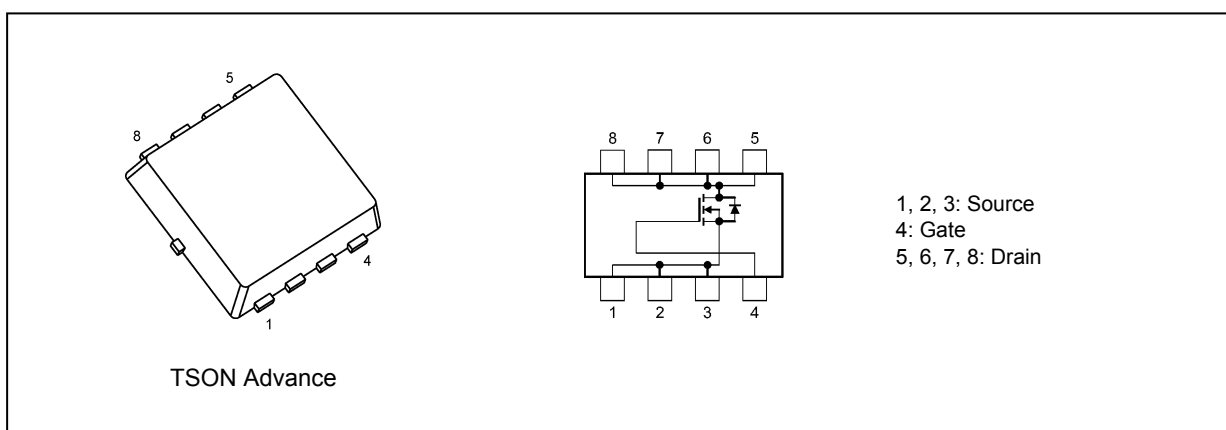
## 1. Applications

- Switching Voltage Regulators
- DC-DC Converters

## 2. Features

- (1) High-speed switching
- (2) Small gate charge:  $Q_{SW} = 4.3 \text{ nC}$  (typ.)
- (3) Low drain-source on-resistance:  $R_{DS(ON)} = 6.8 \text{ m}\Omega$  (typ.) ( $V_{GS} = 4.5 \text{ V}$ )
- (4) Low leakage current:  $I_{DSS} = 10 \text{ }\mu\text{A}$  (max) ( $V_{DS} = 30 \text{ V}$ )
- (5) Enhancement mode:  $V_{th} = 1.3 \text{ to } 2.3 \text{ V}$  ( $V_{DS} = 10 \text{ V}$ ,  $I_D = 0.2 \text{ mA}$ )

## 3. Packaging and Internal Circuit



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

| Characteristics                                                   | Symbol    | Rating     | Unit             |
|-------------------------------------------------------------------|-----------|------------|------------------|
| Drain-source voltage                                              | $V_{DS}$  | 30         | V                |
| Gate-source voltage                                               | $V_{GS}$  | $\pm 20$   |                  |
| Drain current (DC) (Silicon limit) (Note 1), (Note 2)             | $I_D$     | 56         | A                |
| Drain current (DC) ( $T_c = 25 \text{ }^\circ\text{C}$ ) (Note 1) | $I_D$     | 27         |                  |
| Drain current (pulsed) ( $t = 1 \text{ ms}$ ) (Note 1)            | $I_{DP}$  | 116        |                  |
| Power dissipation ( $T_c = 25 \text{ }^\circ\text{C}$ )           | $P_D$     | 32         | W                |
| Power dissipation ( $t = 10 \text{ s}$ ) (Note 3)                 | $P_D$     | 1.9        |                  |
| Power dissipation ( $t = 10 \text{ s}$ ) (Note 4)                 | $P_D$     | 0.7        |                  |
| Single-pulse avalanche energy (Note 5)                            | $E_{AS}$  | 39         | mJ               |
| Avalanche current                                                 | $I_{AR}$  | 27         | A                |
| 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).

Start of commercial production

2013-07

## 5. Thermal Characteristics

| Characteristics                                                              | Symbol         | Max  | Unit                 |
|------------------------------------------------------------------------------|----------------|------|----------------------|
| Channel-to-case thermal resistance<br>( $T_c = 25\text{ }^{\circ}\text{C}$ ) | $R_{th(ch-c)}$ | 3.9  | $^{\circ}\text{C/W}$ |
| Channel-to-ambient thermal resistance<br>( $t = 10\text{ s}$ ) (Note 3)      | $R_{th(ch-a)}$ | 65.7 |                      |
| Channel-to-ambient thermal resistance<br>( $t = 10\text{ s}$ ) (Note 4)      | $R_{th(ch-a)}$ | 178  |                      |

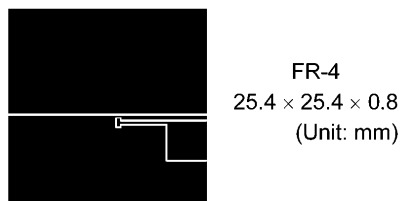
Note 1: Ensure that the channel temperature does not exceed  $150\text{ }^{\circ}\text{C}$ .

Note 2: Limited by silicon chip capability.

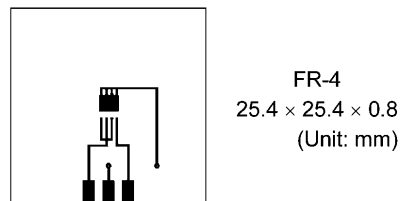
Note 3: Device mounted on a glass-epoxy board (a), Figure 5.1

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

Note 5:  $V_{DD} = 24\text{ V}$ ,  $T_{ch} = 25\text{ }^{\circ}\text{C}$  (initial),  $L = 42\text{ }\mu\text{H}$ ,  $I_{AR} = 27\text{ A}$



**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.

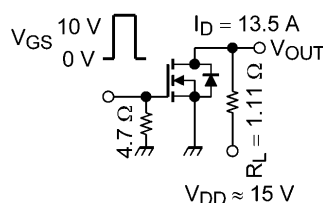
## 6. Electrical Characteristics

### 6.1. Static Characteristics ( $T_a = 25\text{ }^{\circ}\text{C}$ 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                |
|                                | $V_{(BR)DSX}$ | $I_D = 10\text{ mA}$ , $V_{GS} = -20\text{ V}$     | 15  | —    | —         |                  |
| Gate threshold voltage         | $V_{th}$      | $V_{DS} = 10\text{ V}$ , $I_D = 0.2\text{ mA}$     | 1.3 | —    | 2.3       |                  |
| Drain-source on-resistance     | $R_{DS(ON)}$  | $V_{GS} = 4.5\text{ V}$ , $I_D = 8\text{ A}$       | —   | 6.8  | 8.3       | $\text{m}\Omega$ |
|                                |               | $V_{GS} = 10\text{ V}$ , $I_D = 13.5\text{ A}$     | —   | 5.2  | 6.0       |                  |

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

| Characteristics                | Symbol    | Test Condition                                                      | Min | Typ. | Max  | Unit        |
|--------------------------------|-----------|---------------------------------------------------------------------|-----|------|------|-------------|
| Input capacitance              | $C_{iss}$ | $V_{DS} = 15\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 1\text{ MHz}$ | —   | 1050 | 1400 | $\text{pF}$ |
| Reverse transfer capacitance   | $C_{rss}$ |                                                                     | —   | 37   | 84   |             |
| Output capacitance             | $C_{oss}$ |                                                                     | —   | 600  | —    |             |
| Gate resistance                | $r_g$     | —                                                                   | —   | 1.1  | 1.7  | $\Omega$    |
| Switching time (rise time)     | $t_r$     | See Fig. 6.2.1                                                      | —   | 4.1  | —    | ns          |
| Switching time (turn-on time)  | $t_{on}$  |                                                                     | —   | 11   | —    |             |
| Switching time (fall time)     | $t_f$     |                                                                     | —   | 3.3  | —    |             |
| Switching time (turn-off time) | $t_{off}$ |                                                                     | —   | 18   | —    |             |



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

Fig. 6.2.1 Switching Time Test Circuit

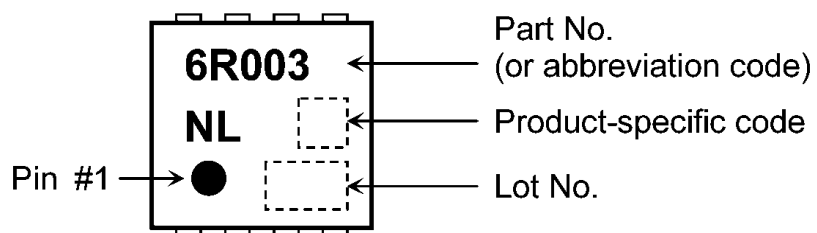
### 6.3. Gate Charge Characteristics ( $T_a = 25\text{ }^{\circ}\text{C}$ unless otherwise specified)

| Characteristics                                 | Symbol    | Test Condition                                                               | Min | Typ. | Max | Unit |
|-------------------------------------------------|-----------|------------------------------------------------------------------------------|-----|------|-----|------|
| Total gate charge (gate-source plus gate-drain) | $Q_g$     | $V_{DD} \approx 15\text{ V}$ , $V_{GS} = 10\text{ V}$ , $I_D = 27\text{ A}$  | —   | 17   | —   | nC   |
|                                                 |           | $V_{DD} \approx 15\text{ V}$ , $V_{GS} = 4.5\text{ V}$ , $I_D = 27\text{ A}$ | —   | 8.2  | —   |      |
| Gate-source charge 1                            | $Q_{gs1}$ | $V_{DD} \approx 15\text{ V}$ , $V_{GS} = 10\text{ V}$ , $I_D = 27\text{ A}$  | —   | 3.7  | —   |      |
| Gate-drain charge                               | $Q_{gd}$  |                                                                              | —   | 2.3  | —   |      |
| Gate switch charge                              | $Q_{SW}$  |                                                                              | —   | 4.3  | —   |      |

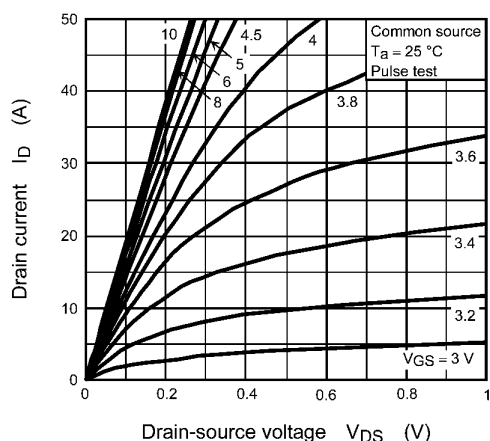
### 6.4. Source-Drain Characteristics ( $T_a = 25\text{ }^{\circ}\text{C}$ unless otherwise specified)

| Characteristics                         | Symbol    | Test Condition                                 | Min | Typ. | Max  | Unit |
|-----------------------------------------|-----------|------------------------------------------------|-----|------|------|------|
| Reverse drain current (pulsed) (Note 6) | $I_{DRP}$ | —                                              | —   | —    | 116  | A    |
| Diode forward voltage                   | $V_{DSF}$ | $I_{DR} = 27\text{ A}$ , $V_{GS} = 0\text{ V}$ | —   | —    | -1.2 | V    |

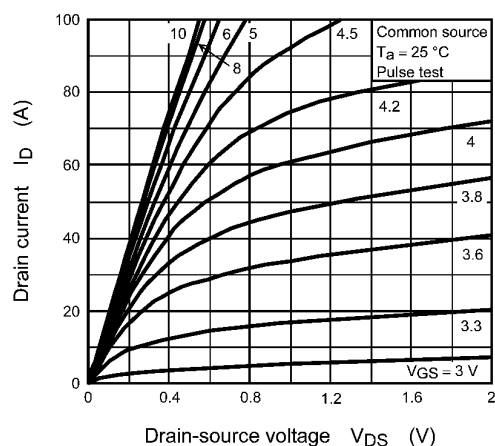
Note 6: Ensure that the channel temperature does not exceed  $150\text{ }^{\circ}\text{C}$ .

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

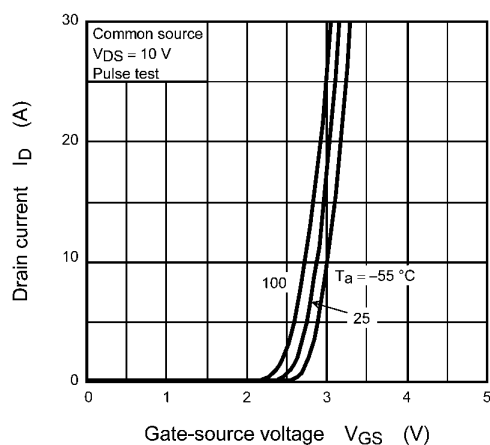
# 8. Characteristics Curves (Note)



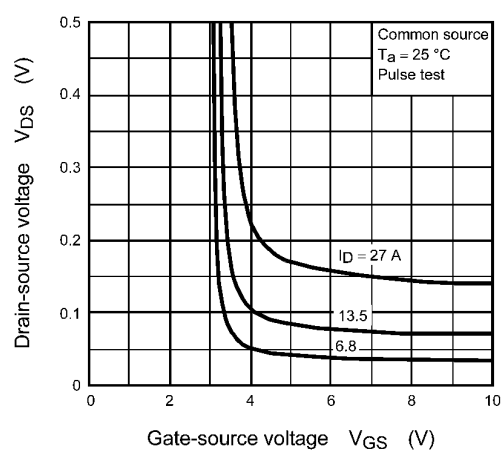
**Fig. 8.1**  $I_D - V_{DS}$



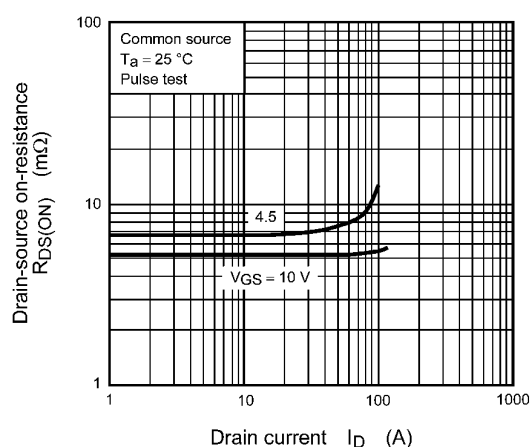
**Fig. 8.2**  $I_D - V_{DS}$



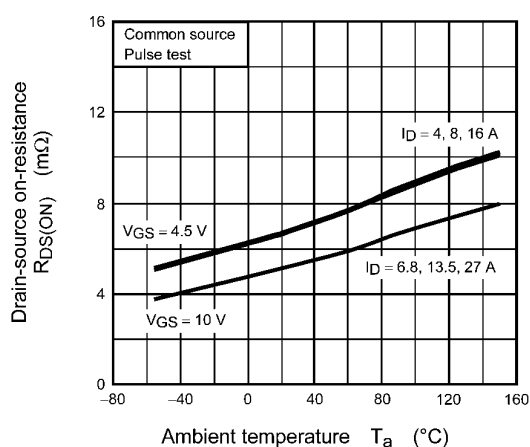
**Fig. 8.3**  $I_D - V_{GS}$



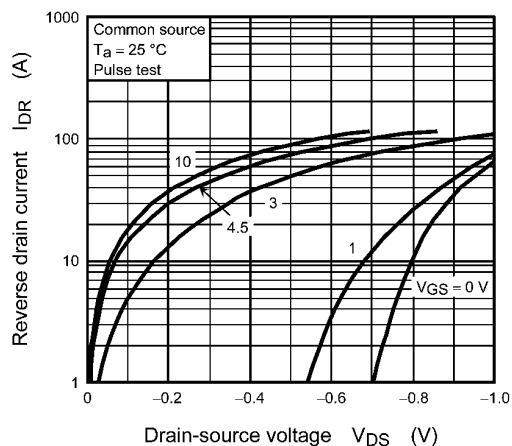
**Fig. 8.4**  $V_{DS} - V_{GS}$



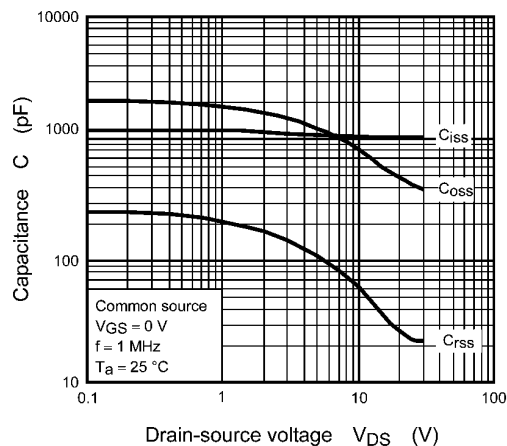
**Fig. 8.5**  $R_{DS(ON)} - I_D$



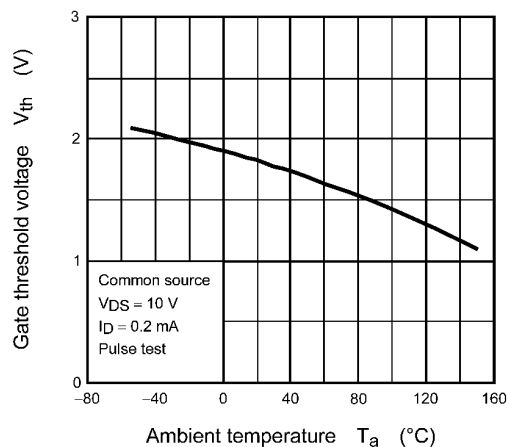
**Fig. 8.6**  $R_{DS(ON)} - T_a$



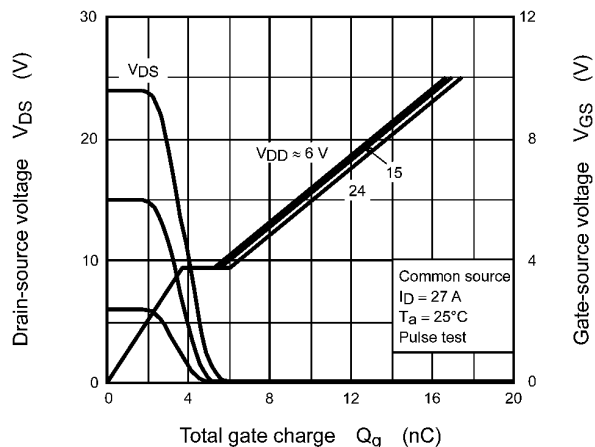
**Fig. 8.7  $I_{DR} - V_{DS}$**



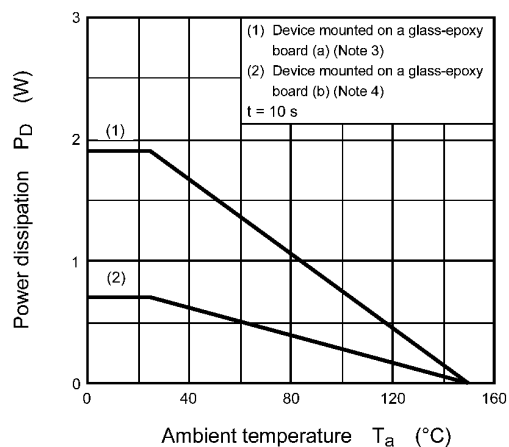
**Fig. 8.8 Capacitance -  $V_{DS}$**



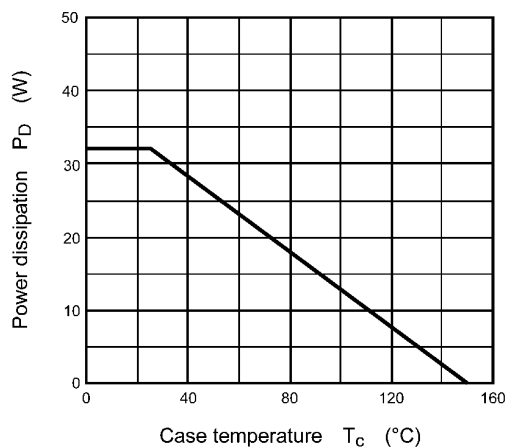
**Fig. 8.9  $V_{th} - T_a$**



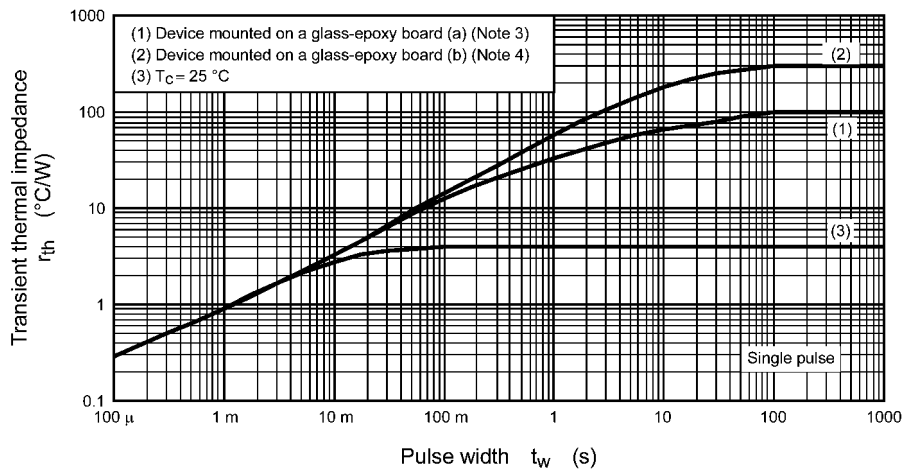
**Fig. 8.10 Dynamic Input/Output Characteristics**



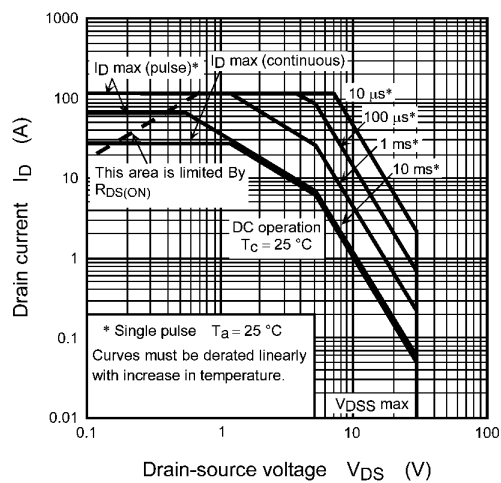
**Fig. 8.11  $P_D - T_a$   
(Guaranteed Maximum)**



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



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

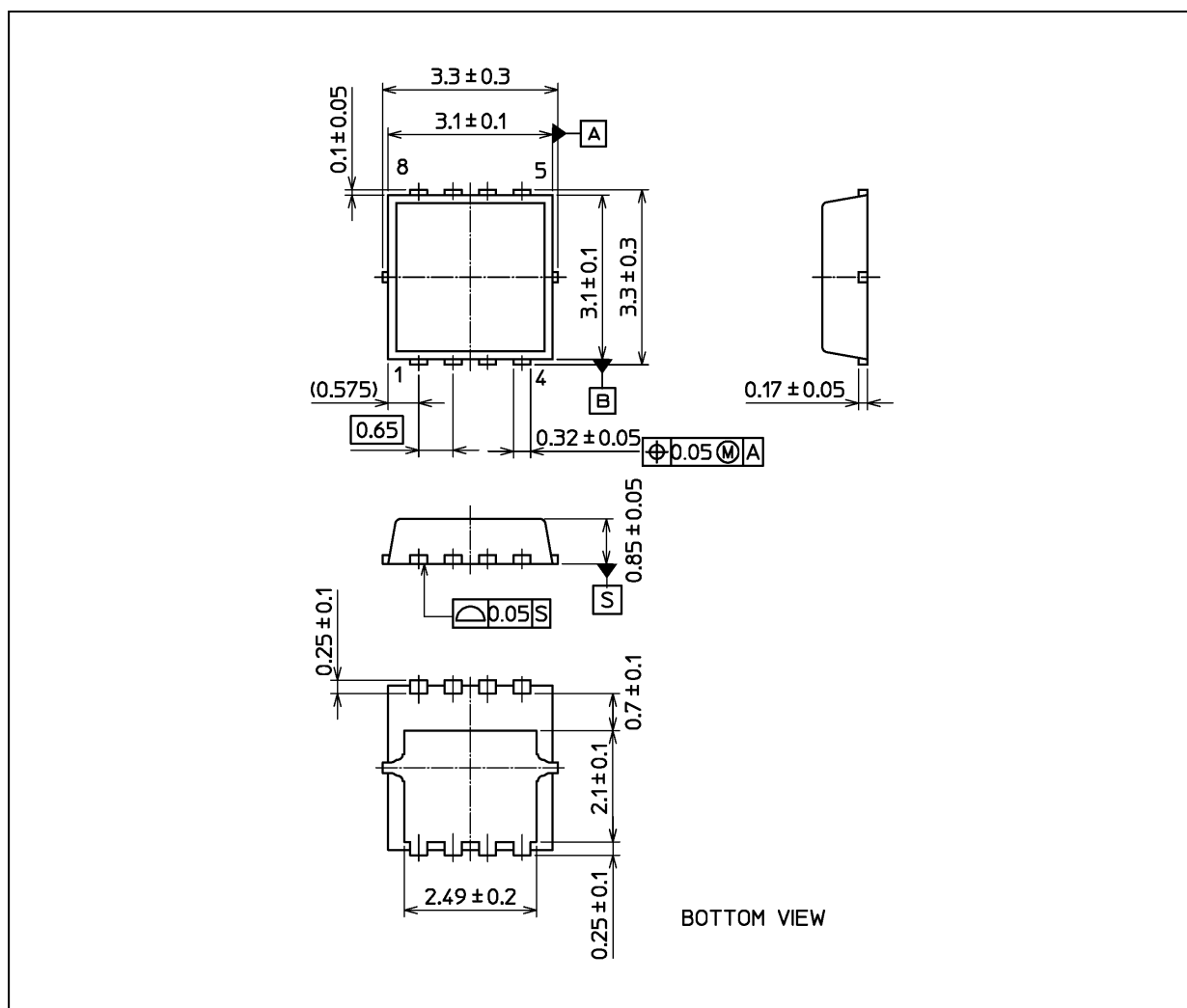


**Fig. 8.14 Safe Operating Area**  
(Guaranteed Maximum)

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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