

# TCR3UM series

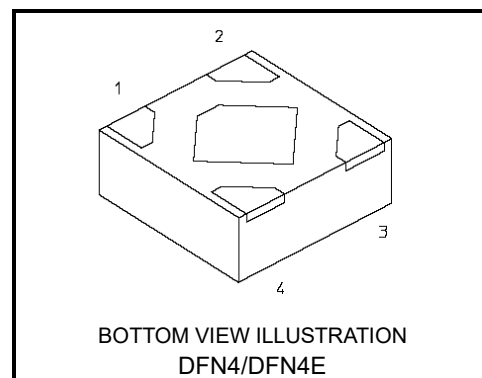
Ultra low quiescent current, Fast Load Transient 300 mA CMOS Low Dropout Regulator in ultra small package

## 1. Description

The TCR3UM series are CMOS general-purpose single-output voltage regulators with an on/off control input, featuring ultra low quiescent bias current and low dropout voltage.

These voltage regulators are available in fixed output voltages between 0.8 V and 5.0 V and capable of driving up to 300 mA. They feature Over-current protection, Thermal Shutdown function and Auto-discharge.

The TCR3UM series is offered in the ultra small plastic mold package DFN4/DFN4E (1.0 mm x 1.0 mm; t 0.60 mm (max)) and has a low dropout voltage of 196 mV (3.3 V output,  $I_{OUT} = 300$  mA). As small ceramic input and output capacitors 1  $\mu$ F can be used with the TCR3UM series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones, IoT equipment and wearable devices.



Weight: 1.3 mg (typ.)

## 2. Applications

Power IC developed for portable applications, IoT equipment and wearable devices

## 3. Features

- Ultra small package DFN4/DFN4E (1.0 mm x 1.0 mm; t 0.60 mm (max)).
- Low quiescent bias current (  $I_B = 0.34$   $\mu$ A (typ.) at  $I_{OUT} = 0$  mA, output voltage up to 1.5 V)
- High Ripple rejection ratio 70 dB (typ.) at 0.8 V-output
- Fast Load transient response -51/+36 mV at 0.8 V-output,  $I_{OUT} = 1$  mA  $\Leftrightarrow$  50 mA
- Low Dropout voltage  
VDO = 196 mV (typ.) at 3.3 V-output,  $I_{OUT} = 300$  mA
- Wide range output voltage line up ( $V_{OUT} = 0.8$  to 5.0 V)
- High  $V_{OUT}$  accuracy  $\pm 1.0$  % ( $1.8$  V  $\leq V_{OUT}$ )
- Overcurrent protection
- Thermal Shutdown function
- Auto-discharge
- Inrush current protection circuit
- Pull down connection between CONTROL and GND
- Ceramic capacitors can be used ( $C_{IN} = 1$   $\mu$ F,  $C_{OUT} = 1$   $\mu$ F)

Start of commercial production  
2018-08

## 4. Absolute Maximum Ratings (Note) (Ta = 25°C)

| Characteristics           | Symbol           | Rating                              | Unit |
|---------------------------|------------------|-------------------------------------|------|
| Input voltage             | V <sub>IN</sub>  | -0.3 to 6.0                         | V    |
| Control voltage           | V <sub>CT</sub>  | -0.3 to V <sub>IN</sub> + 0.3 ≤ 6.0 | V    |
| Output voltage            | V <sub>OUT</sub> | -0.3 to V <sub>IN</sub> + 0.3 ≤ 6.0 | V    |
| Power dissipation         | P <sub>D</sub>   | 420 (Note1)                         | mW   |
| Junction temperature      | T <sub>j</sub>   | 150                                 | °C   |
| Storage temperature range | T <sub>stg</sub> | -55 to 150                          | °C   |

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 and the operating ranges.

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).

Note1: Rating at mounting on a board

Glass epoxy (FR4) board dimension: 40 mm x 40 mm (both sides of board), t = 1.6 mm

Metal pattern ratio: a surface approximately 50 %, the reverse side approximately 50 %

Through hole : diameter 0.5 mm x 24 pcs

## 5. Operating Ranges

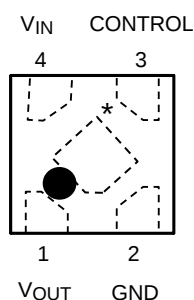
| Characteristics       | Symbol           | Rating               | Unit |
|-----------------------|------------------|----------------------|------|
| Input voltage         | V <sub>IN</sub>  | 1.5 to 5.5 (Note 2)  | V    |
| Control voltage       | V <sub>CT</sub>  | 0 to V <sub>IN</sub> | V    |
| Output voltage        | V <sub>OUT</sub> | 0.8 to 5.0           | V    |
| Output current        | I <sub>OUT</sub> | DC 300 (Note 3)      | mA   |
| Operating Temperature | T <sub>opr</sub> | -40 to 85            | °C   |
| Output Capacitance    | C <sub>OUT</sub> | ≥ 1.0 μF             | —    |
| Input Capacitance     | C <sub>IN</sub>  | ≥ 1.0 μF             | —    |

Note 2: I<sub>OUT</sub> = 1 mA.

Please refer to Dropout Voltage (Page 6) and use it within Absolute Maximum Ratings Junction temperature and Operating Temperature Ranges.

Note 3: Do not operate at or near the maximum ratings of operating ranges for extended periods of time. Exposure to such conditions may adversely impact product reliability and results in failures not covered by warranty.

## 6. Pin Assignment (Top view)



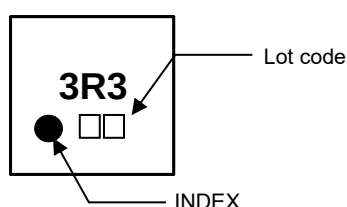
\*Center electrode should be connected to GND or Open

### 7. List of Products Number, Output voltage and Marking

| Product No.  | Output voltage(V) | Auto dis-charge | Marking |
|--------------|-------------------|-----------------|---------|
| TCR3UM08A    | 0.8               | Yes             | 0R8     |
| TCR3UM085A*  | 0.85              |                 | 0RA     |
| TCR3UM09A    | 0.9               |                 | 0R9     |
| TCR3UM095A*  | 0.95              |                 | 0RB     |
| TCR3UM10A    | 1.0               |                 | 1R0     |
| TCR3UM105A*  | 1.05              |                 | 1RC     |
| TCR3UM11A    | 1.1               |                 | 1R1     |
| TCR3UM115A*  | 1.15              |                 | 1RE     |
| TCR3UM12A    | 1.2               |                 | 1R2     |
| TCR3UM13A*   | 1.3               |                 | 1R3     |
| TCR3UM135A*  | 1.35              |                 | 1RF     |
| TCR3UM14A*   | 1.4               |                 | 1R4     |
| TCR3UM15A    | 1.5               |                 | 1R5     |
| TCR3UM16A*   | 1.6               |                 | 1R6     |
| TCR3UM175A   | 1.75              |                 | 1RG     |
| TCR3UM18A    | 1.8               |                 | 1R8     |
| TCR3UM1825A* | 1.825             |                 | 1RH     |
| TCR3UM185A   | 1.85              |                 | 1RJ     |
| TCR3UM19A*   | 1.9               |                 | 1R9     |
| TCR3UM25A*   | 2.5               |                 | 2R5     |
| TCR3UM26A*   | 2.6               |                 | 2R6     |
| TCR3UM27A*   | 2.7               |                 | 2R7     |
| TCR3UM28A    | 2.8               |                 | 2R8     |
| TCR3UM285A*  | 2.85              |                 | 2RK     |
| TCR3UM29A*   | 2.9               |                 | 2R9     |
| TCR3UM2925A  | 2.925             |                 | 2RL     |
| TCR3UM30A    | 3.0               |                 | 3R0     |
| TCR3UM31A*   | 3.1               |                 | 3R1     |
| TCR3UM32A*   | 3.2               |                 | 3R2     |
| TCR3UM33A    | 3.3               |                 | 3R3     |
| TCR3UM35A*   | 3.5               |                 | 3R5     |
| TCR3UM36A*   | 3.6               |                 | 3R6     |
| TCR3UM41A*   | 4.1               |                 | 4R1     |
| TCR3UM42A*   | 4.2               |                 | 4R2     |
| TCR3UM45A*   | 4.5               |                 | 4R5     |
| TCR3UM50A*   | 5.0               |                 | 5R0     |

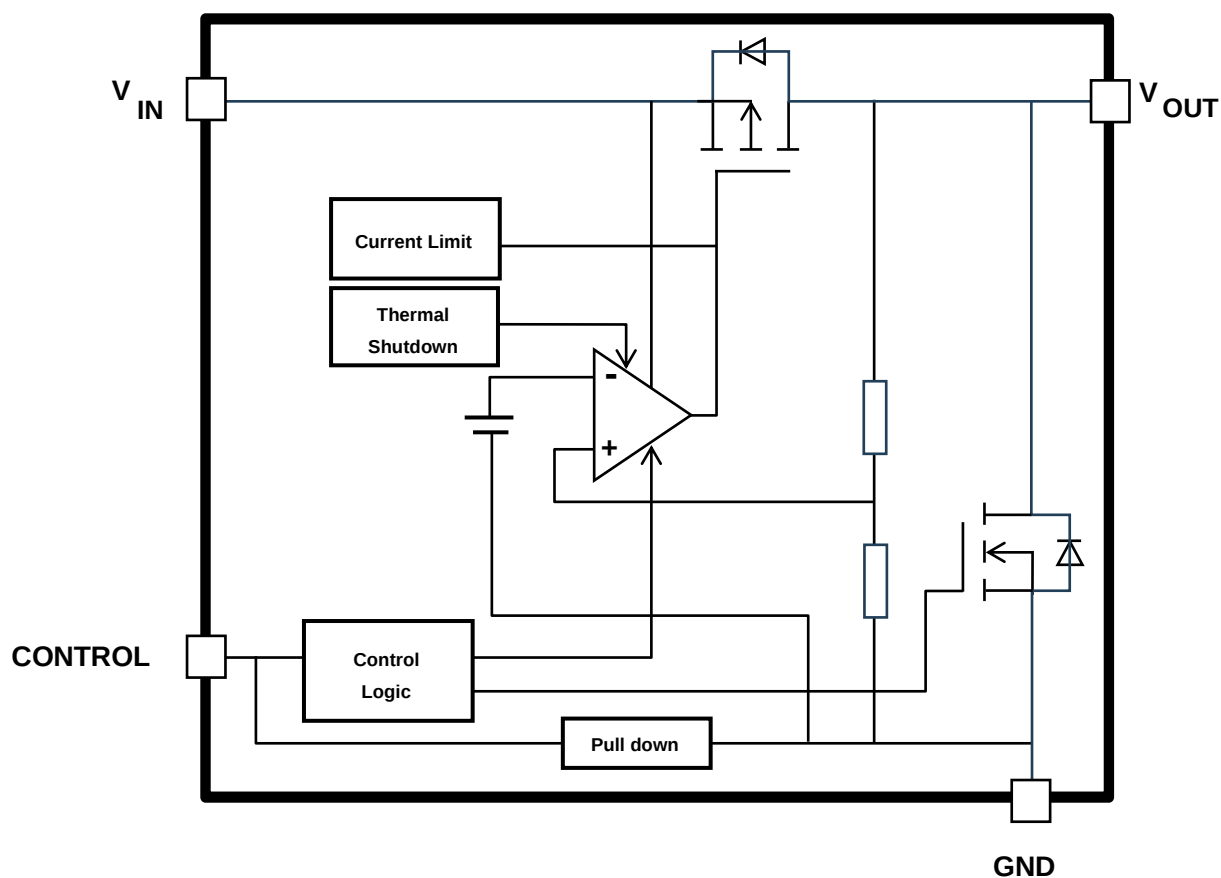
#### Top Marking (Top view)

Example: TCR3UM33A (3.3 V output)



Please ask your local retailer about the devices with (\*) or other output voltages.

## 8. Block Diagram



## 9. Electrical Characteristics

(Unless otherwise specified,

$V_{IN} = V_{OUT} + 1\text{ V}$  ( $V_{OUT} > 1.5\text{ V}$ ),  $V_{IN} = 2.5\text{ V}$  ( $V_{OUT} \leq 1.5\text{ V}$ ),  $I_{OUT} = 50\text{ mA}$ ,  $C_{IN} = C_{OUT} = 1\text{ }\mu\text{F}$ )

| Characteristics              | Symbol           | Test Condition                                                                                                               | $T_j = 25^\circ\text{C}$    |      |     | $T_j = -40\text{ to }85^\circ\text{C}$<br>(Note 9) |      | Unit                  |
|------------------------------|------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------|------|-----|----------------------------------------------------|------|-----------------------|
|                              |                  |                                                                                                                              | Min                         | Typ. | Max | Min                                                | Max  |                       |
| Output voltage accuracy      | $V_{OUT}$        | $I_{OUT} = 50\text{ mA}$<br>(Note 4)                                                                                         | $V_{OUT} < 1.8\text{ V}$    | -18  | —   | +18                                                | —    | mV                    |
|                              |                  |                                                                                                                              | $1.8\text{ V} \leq V_{OUT}$ | -1.0 | —   | +1.0                                               | —    | %                     |
| Input voltage                | $V_{IN}$         | $I_{OUT} = 1\text{ mA}$                                                                                                      | 1.5                         | —    | 5.5 | 1.5                                                | 5.5  | V                     |
| Line regulation              | Reg·line         | $I_{OUT} = 1\text{ mA}$ (Note 5)                                                                                             | —                           | 1    | 15  | —                                                  | —    | mV                    |
| Load regulation              | Reg·load         | $1\text{ mA} \leq I_{OUT} \leq 300\text{ mA}$ (Note 6)                                                                       | —                           | 17   | 30  | —                                                  | —    | mV                    |
| Quiescent current            | $I_{B(ON1)}$     | $I_{OUT} = 0\text{ mA}$ , $V_{OUT} \leq 1.5\text{ V}$ (Note 7)                                                               | —                           | 0.34 | —   | —                                                  | 0.58 | $\mu\text{A}$         |
|                              | $I_{B(ON2)}$     | $I_{OUT} = 0\text{ mA}$ ,<br>$1.5\text{ V} < V_{OUT} \leq 5\text{ V}$ (Note 7)                                               | —                           | 0.38 | —   | —                                                  | 0.68 | $\mu\text{A}$         |
| Stand-by current             | $I_{B(OFF1)}$    | $V_{CT} = 0\text{ V}$ , $V_{IN} = 2.5\text{ V}$                                                                              | —                           | 0.03 | —   | —                                                  | 0.16 | $\mu\text{A}$         |
|                              | $I_{B(OFF2)}$    | $V_{CT} = 0\text{ V}$ , $V_{IN} = 5.5\text{ V}$                                                                              | —                           | 0.03 | —   | —                                                  | 0.20 | $\mu\text{A}$         |
| Control pull down current    | $I_{CT}$         | —                                                                                                                            | —                           | 0.1  | —   | —                                                  | —    | $\mu\text{A}$         |
| Drop-out voltage             | $V_{DO}$         | $I_{OUT} = 300\text{ mA}$                                                                                                    | $V_{OUT} = 1.8\text{ V}$    | —    | 336 | —                                                  | —    | mV                    |
|                              |                  |                                                                                                                              | $V_{OUT} = 3.3\text{ V}$    | —    | 196 | —                                                  | —    | mV                    |
| Output current limit         | $I_{CL}$         | $V_{OUT} = V_{OUT(NOM)} * 90\%$ (Note 9)                                                                                     | —                           | 545  | —   | 400                                                | —    | mA                    |
| Output noise voltage         | $V_{NO}$         | $I_{OUT} = 10\text{ mA}$ ,<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$ , $T_a = 25^\circ\text{C}$<br>(Note 6)               | —                           | 41   | —   | —                                                  | —    | $\mu\text{V}_{rms}$   |
| Ripple rejection ratio       | R.R.             | $I_{OUT} = 10\text{ mA}$ ,<br>$f = 1\text{ kHz}$ , $V_{Ripple} = 200\text{ mV}_{p-p}$ ,<br>$T_a = 25^\circ\text{C}$ (Note 6) | —                           | 70   | —   | —                                                  | —    | dB                    |
| Load transient response      | $\Delta V_{OUT}$ | $I_{OUT} = 1\text{ mA} \rightarrow 50\text{ mA}$ (Note 8)                                                                    | —                           | -51  | —   | —                                                  | —    | mV                    |
|                              |                  | $I_{OUT} = 50\text{ mA} \rightarrow 1\text{ mA}$ (Note 8)                                                                    | —                           | +36  | —   | —                                                  | —    | mV                    |
| Temperature coefficient      | $T_{CVO}$        | $-40^\circ\text{C} \leq T_{opr} \leq 85^\circ\text{C}$                                                                       | —                           | 75   | —   | —                                                  | —    | ppm/ $^\circ\text{C}$ |
| Control voltage (ON)         | $V_{CT(ON)}$     | —                                                                                                                            | 1.0                         | —    | 5.5 | 1.0                                                | 5.5  | V                     |
| Control voltage (OFF)        | $V_{CT(OFF)}$    | —                                                                                                                            | 0                           | —    | 0.4 | 0                                                  | 0.4  | V                     |
| Discharge on resistance      | $R_{SD}$         | —                                                                                                                            | —                           | 7    | —   | —                                                  | —    | $\Omega$              |
| Thermal shutdown temperature | $T_{SD}$         | (Note 9) (Note 10)                                                                                                           | —                           | 158  | —   | —                                                  | —    | $^\circ\text{C}$      |
| Thermal shutdown hysteresis  | $T_{SDH}$        | (Note 9) (Note 10)                                                                                                           | —                           | 28   | —   | —                                                  | —    | $^\circ\text{C}$      |

Note 4: stable state with fixed  $I_{OUT}$  condition

Note 5:  $V_{OUT} \leq 1.5\text{ V}$ ,  $2.5\text{ V} \leq V_{IN} \leq 5.5\text{ V}$

$1.75\text{ V} \leq V_{OUT} \leq 4.2\text{ V}$ ,  $V_{OUT} + 1\text{ V} \leq V_{IN} \leq 5.5\text{ V}$

$V_{OUT} = 4.5\text{ V}$ ,  $V_{OUT} = 5.0\text{ V}$ , not applicable

Note 6:  $V_{OUT} = 0.8\text{ V}$

Note 7: except Control pull down current ( $I_{CT}$ )

Note 8:  $V_{OUT} = 0.8\text{ V}$ ,  $V_{IN} = 3.3\text{ V}$

Note 9: This parameter is warranted by design

Note 10:  $V_{OUT} = 0.8\text{ V}$ ,  $V_{IN} = 2.5\text{ V}$

## 10. Dropout voltage

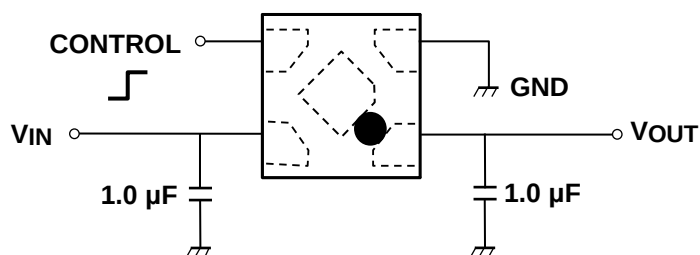
( $I_{OUT} = 300 \text{ mA}$ ,  $C_{IN} = C_{OUT} = 1 \text{ }\mu\text{F}$ )

| Output voltages                                 | Symbol          | Min | Typ.<br>$T_j = 25^\circ\text{C}$ | Max<br>(Note 11) | Unit |
|-------------------------------------------------|-----------------|-----|----------------------------------|------------------|------|
| $0.8 \text{ V} \leq V_{OUT} < 0.9 \text{ V}$    | V <sub>DO</sub> | —   | 1020                             | 1257             | mV   |
| $0.9 \text{ V} \leq V_{OUT} < 1.0 \text{ V}$    |                 | —   | 933                              | 1157             |      |
| $1.0 \text{ V} \leq V_{OUT} < 1.1 \text{ V}$    |                 | —   | 848                              | 1057             |      |
| $1.1 \text{ V} \leq V_{OUT} < 1.2 \text{ V}$    |                 | —   | 760                              | 957              |      |
| $1.2 \text{ V} \leq V_{OUT} < 1.3 \text{ V}$    |                 | —   | 667                              | 857              |      |
| $1.3 \text{ V} \leq V_{OUT} < 1.5 \text{ V}$    |                 | —   | 580                              | 757              |      |
| $1.5 \text{ V} \leq V_{OUT} < 1.6 \text{ V}$    |                 | —   | 462                              | 617              |      |
| $1.6 \text{ V} \leq V_{OUT} < 1.8 \text{ V}$    |                 | —   | 420                              | 537              |      |
| $1.8 \text{ V} \leq V_{OUT} < 2.0 \text{ V}$    |                 | —   | 336                              | 457              |      |
| $2.0 \text{ V} \leq V_{OUT} < 2.5 \text{ V}$    |                 | —   | 292                              | 405              |      |
| $2.5 \text{ V} \leq V_{OUT} < 3.0 \text{ V}$    |                 | —   | 216                              | 327              |      |
| $3.0 \text{ V} \leq V_{OUT} < 3.6 \text{ V}$    |                 | —   | 196                              | 273              |      |
| $3.6 \text{ V} \leq V_{OUT} < 4.5 \text{ V}$    |                 | —   | 174                              | 232              |      |
| $4.5 \text{ V} \leq V_{OUT} \leq 5.0 \text{ V}$ |                 | —   | 149                              | 210              |      |

Note 11:  $T_j = -40$  to  $85^\circ\text{C}$ . This parameter is warranted by design

## 11. Application Note

### 11.1. Example of Application Circuit



| CONTROL voltage | Output voltage |
|-----------------|----------------|
| HIGH            | ON             |
| LOW             | OFF            |
| OPEN            | OFF            |

The figure above shows the example of configuration for using a Low-Dropout regulator. Insert a capacitor at VOUT and VIN pins for stable input/output operation. (Ceramic capacitors can be used.)

### 11.2. Power Dissipation

Board mounted power dissipation ratings for TCR3UM series are available in the Absolute Maximum Ratings table. Power dissipation is measured on the board condition shown below.

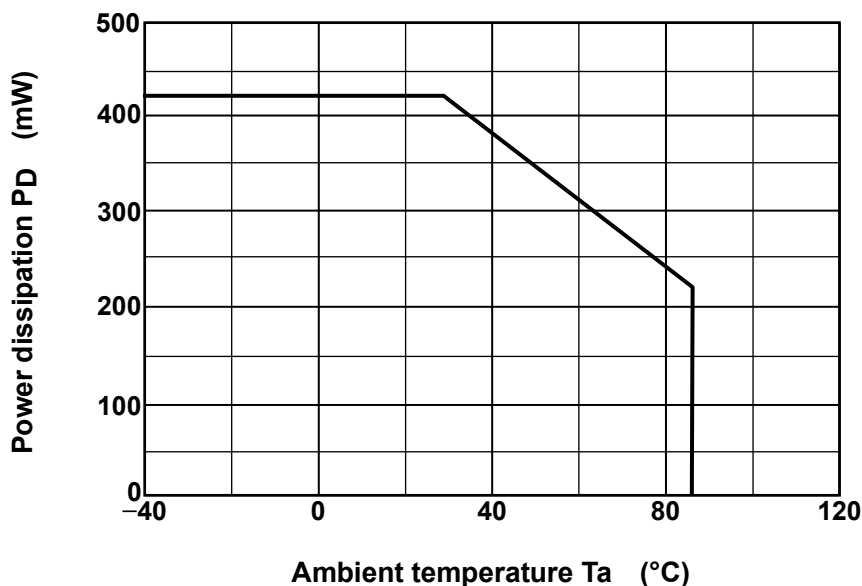
[The Board Condition]

Board material: Glass epoxy (FR4)

Board dimension: 40 mm x 40 mm (both sides of board), t = 1.6 mm

Metal pattern ratio: a surface approximately 50 %, the reverse side approximately 50 %

Through hole hall: diameter 0.5 mm x 24 pcs



## 12. Attention in Use

- Output Capacitors

Ceramic capacitors can be used for these devices. However, because of the type of the capacitors, there might be unexpected thermal features. Please consider application condition for selecting capacitors. And Toshiba recommends the ESR of ceramic capacitor is under 10  $\Omega$ . For stable operation, we recommend over 1  $\mu\text{F}$ .

- Mounting

The long distance between IC and input output capacitor might affect phase compensation by impedance in wire and inductor. For stable power supply, input output capacitor need to mount near IC as much as possible. Also VIN and GND pattern need to be large and make the wire impedance small as possible.

- Permissible Loss

Please have enough design patterns for expected maximum permissible loss. And under consideration of ambient temperature, input voltage, output current etc., we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70 to 80 %.

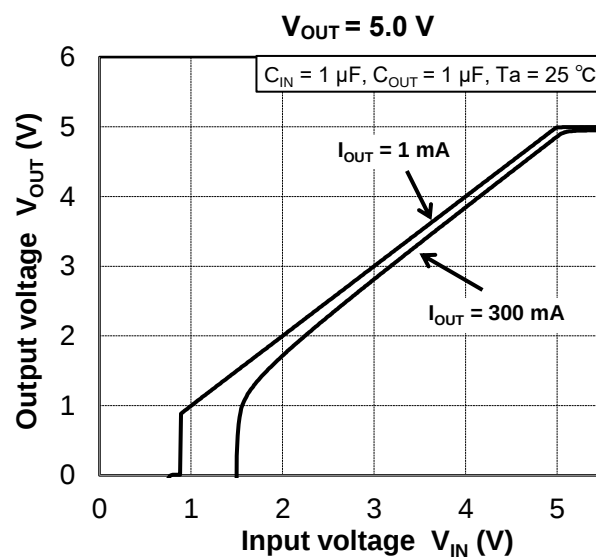
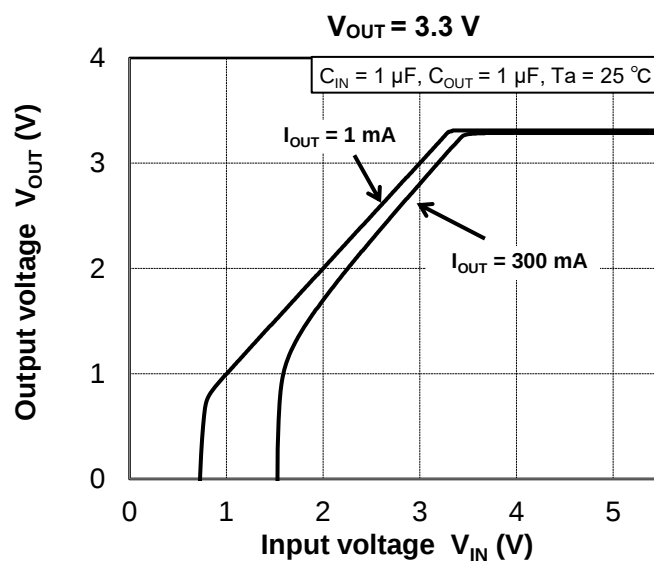
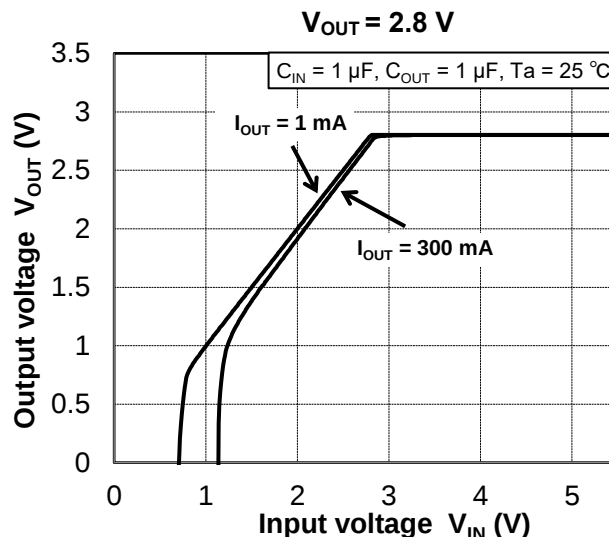
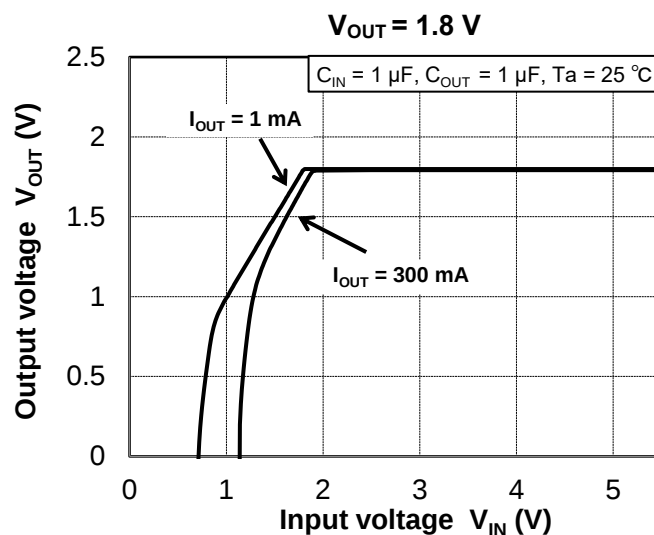
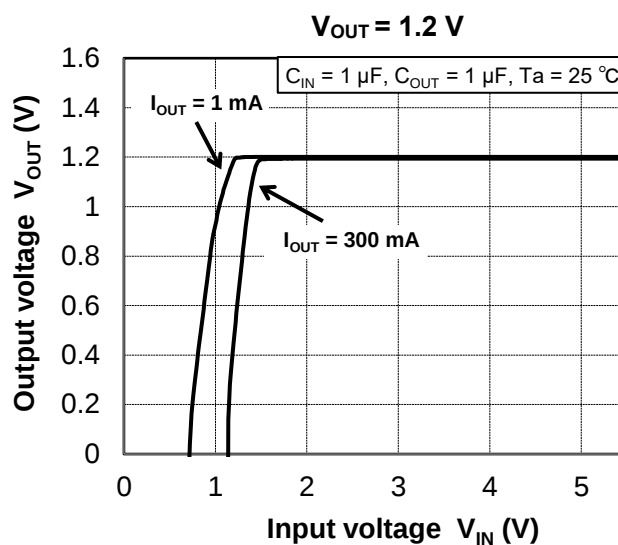
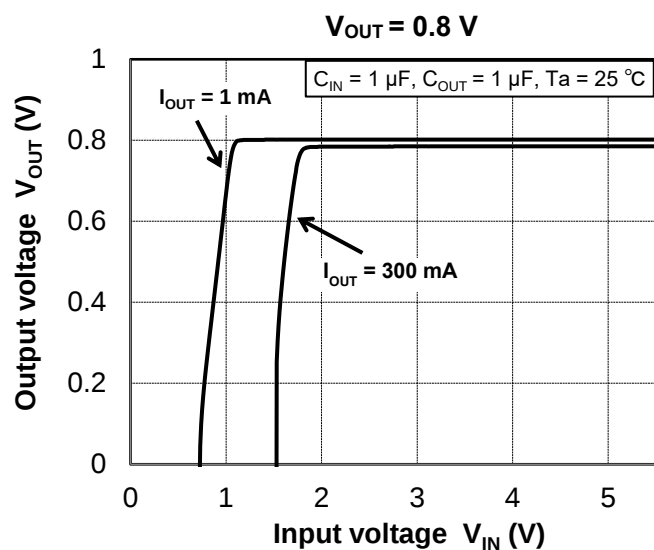
- Over current Protection and Thermal shutdown function

Over current protection and Thermal shutdown function are designed in these products, but these are not designed to constantly ensure the suppression of the device within operation limits. Depending on the condition during actual usage, it could affect the electrical characteristic specification and reliability. Also note that if output pins and GND pins are not completely shorted out, these products might break down.

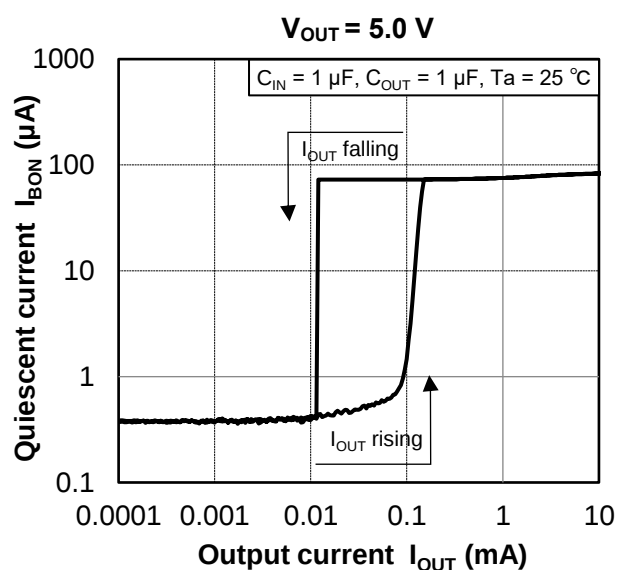
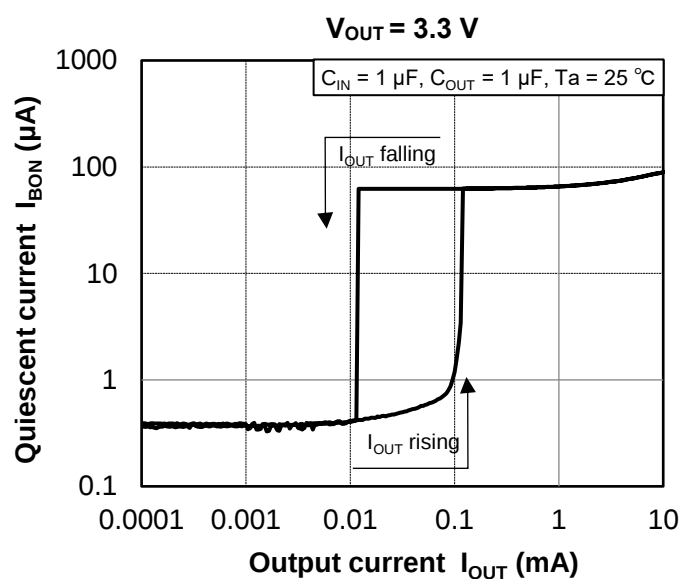
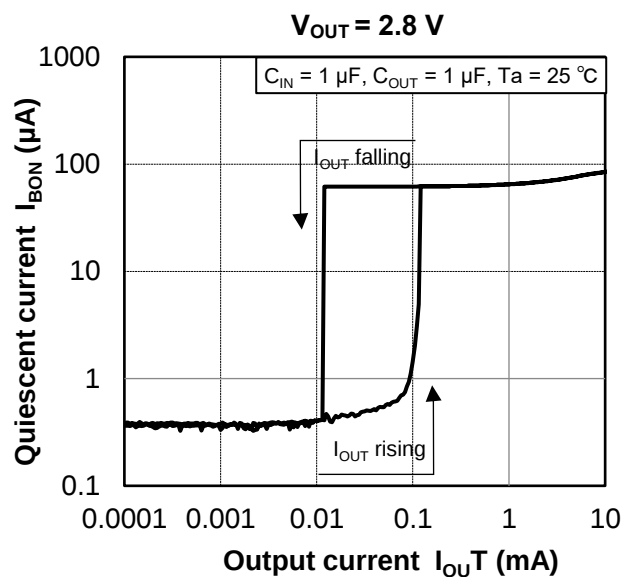
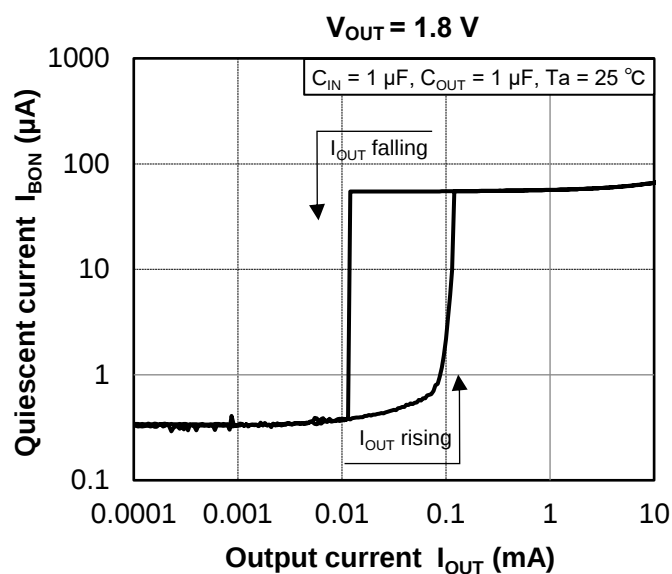
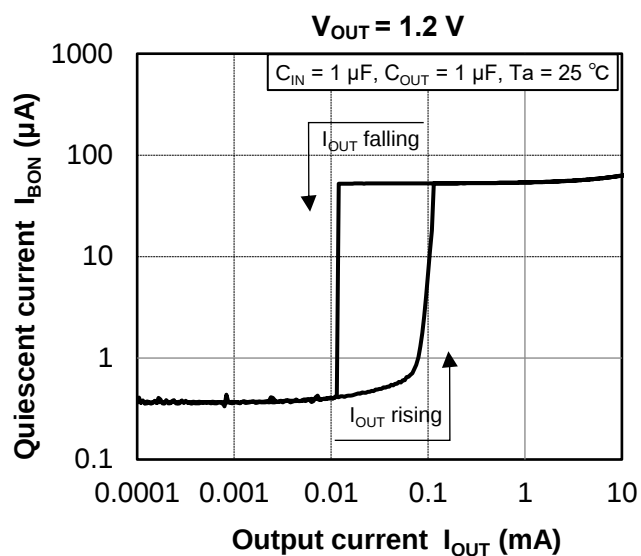
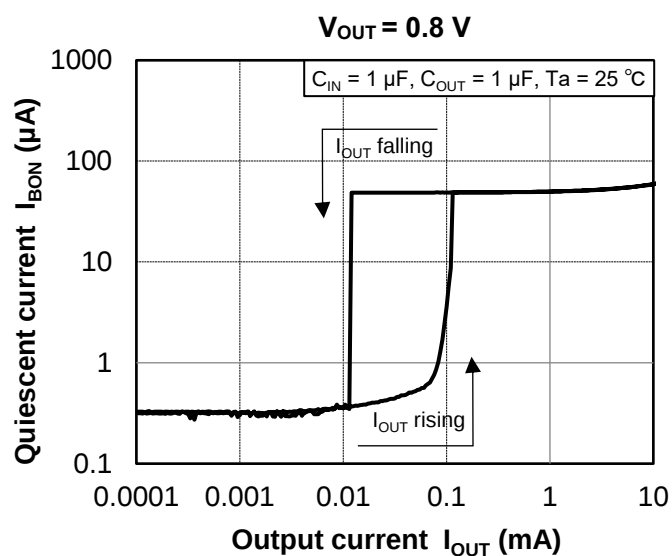
When using these products, please read through and understand the concept of dissipation for absolute maximum ratings from the above mention or our 'Semiconductor Reliability Handbook'. Then use these products under absolute maximum ratings in any condition. Furthermore, Toshiba recommends inserting failsafe system into the design.

## 13. Representative Typical Characteristics (Note)

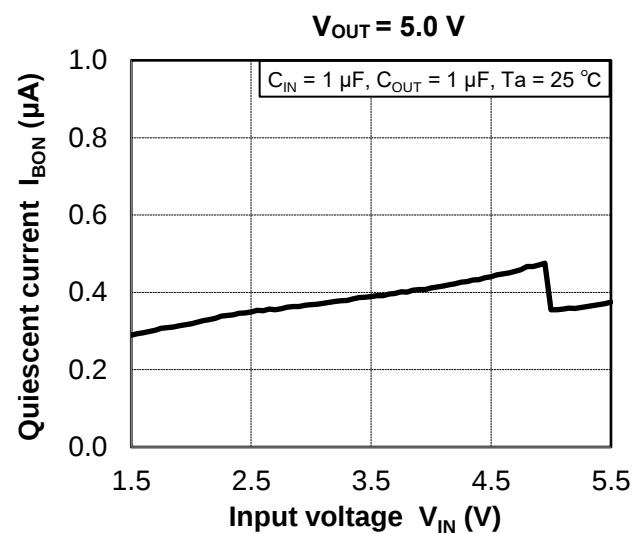
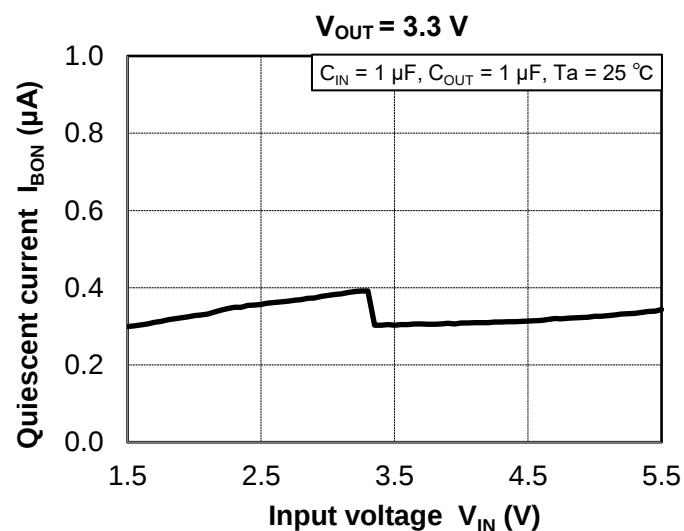
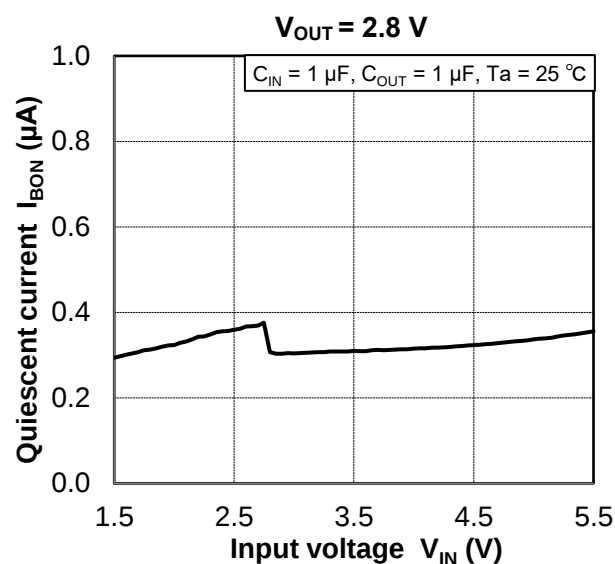
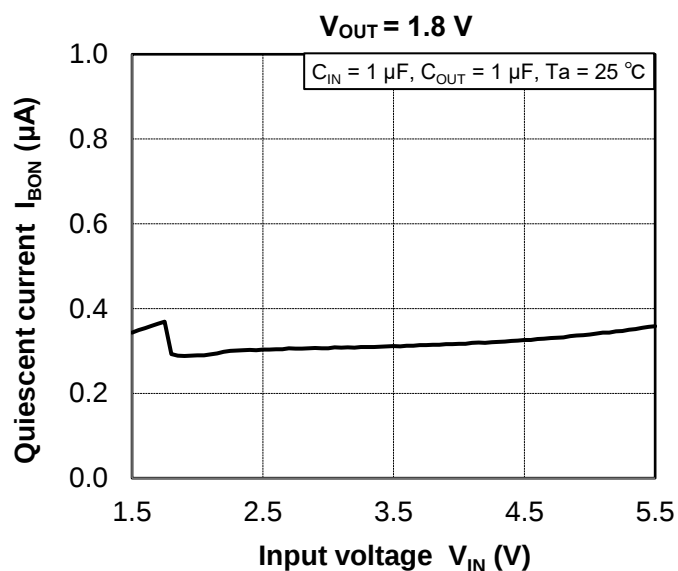
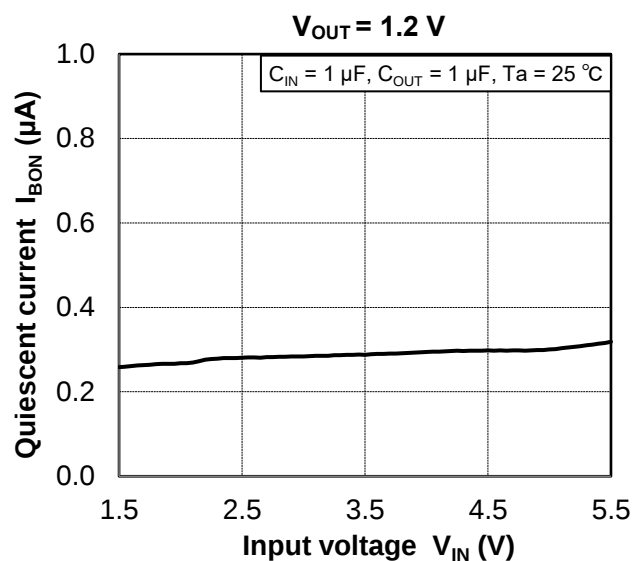
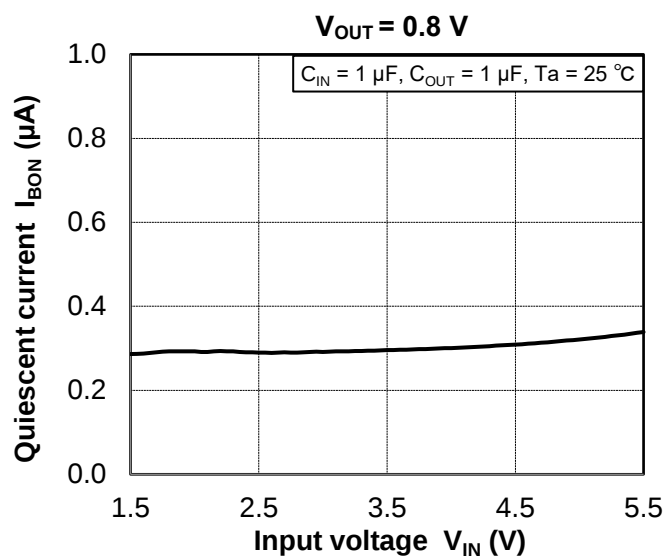
### 13.1. Output Voltage vs. Input Voltage



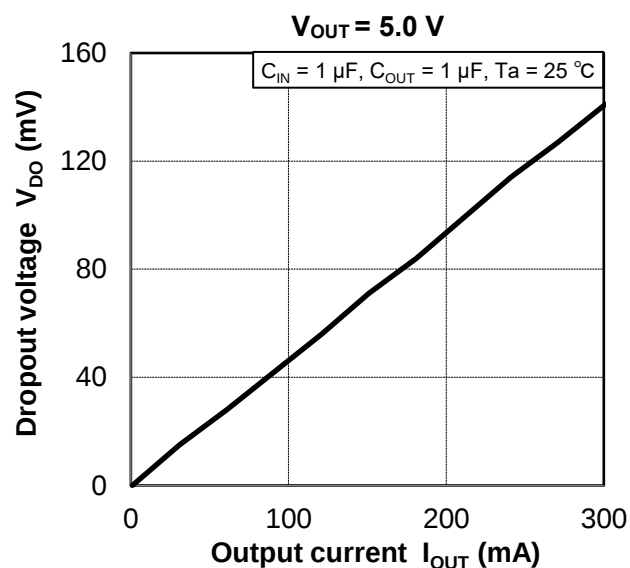
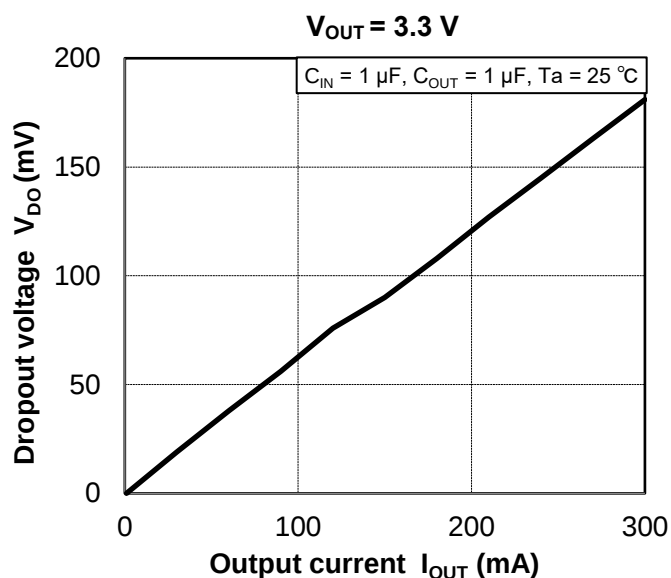
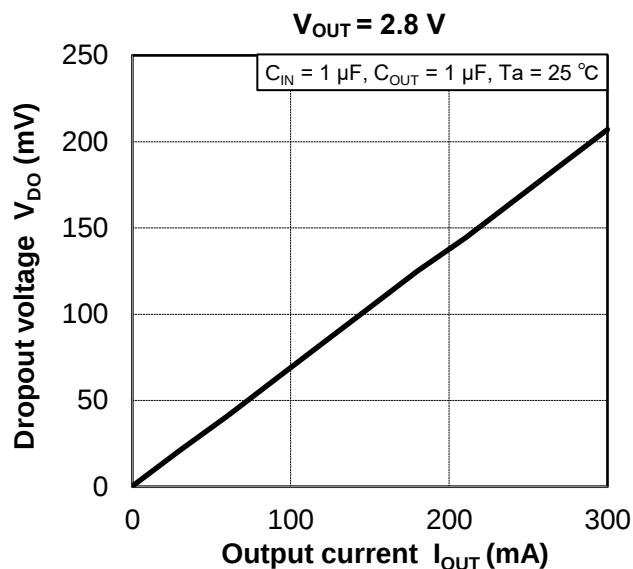
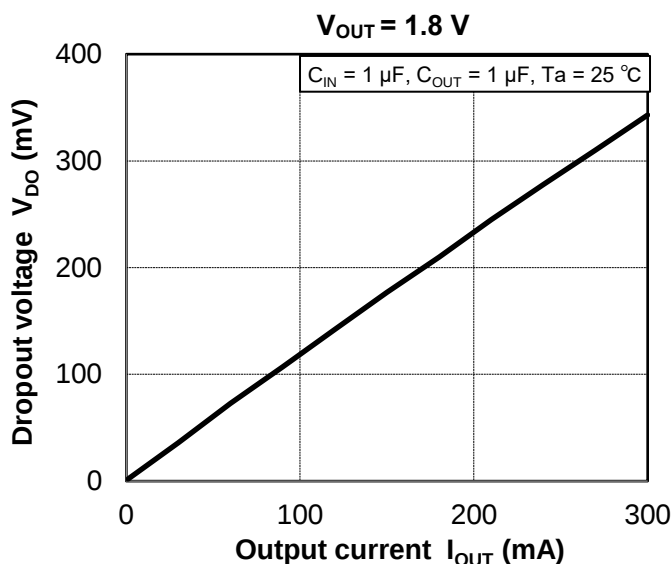
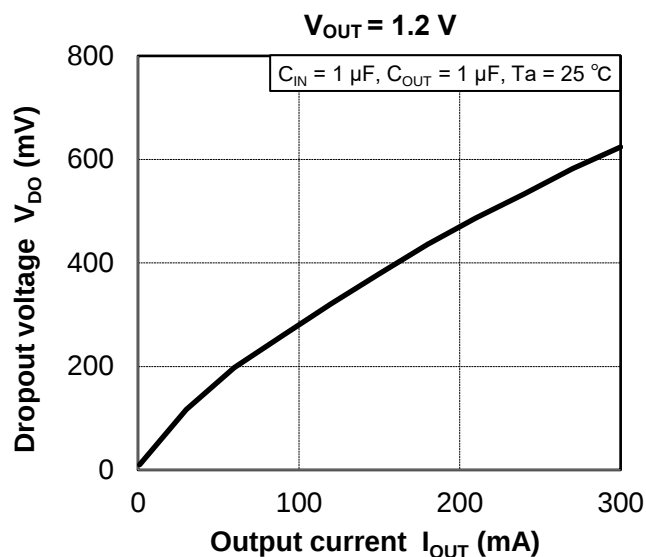
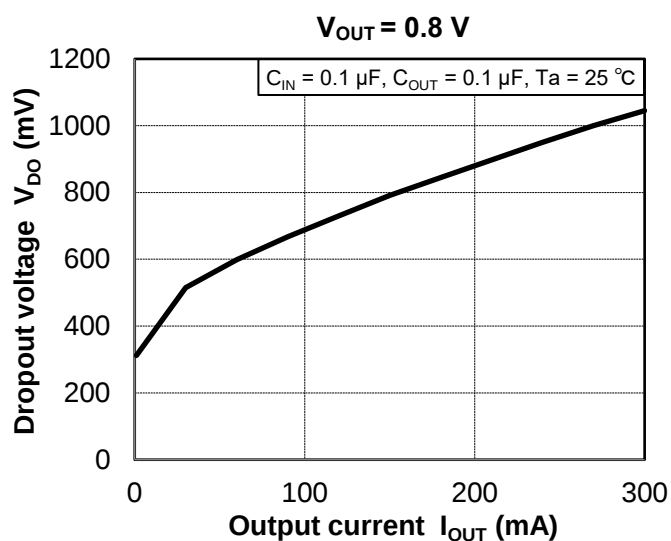
### 13.2. Quiescent Current vs. Output Current



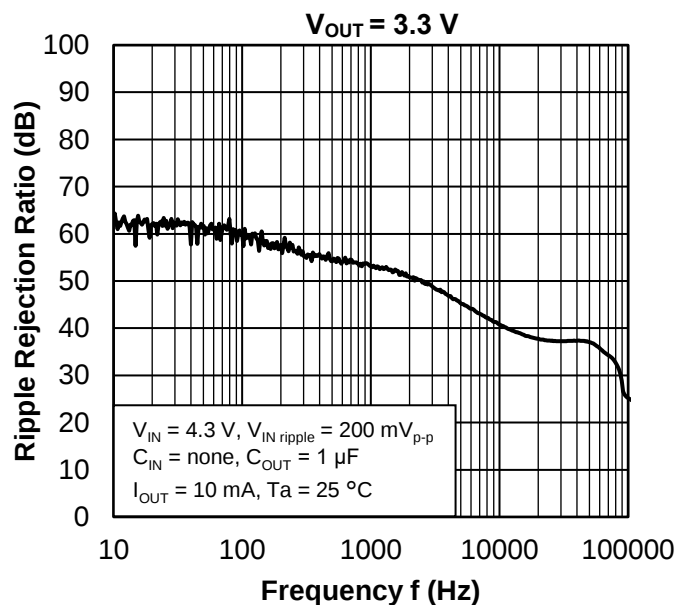
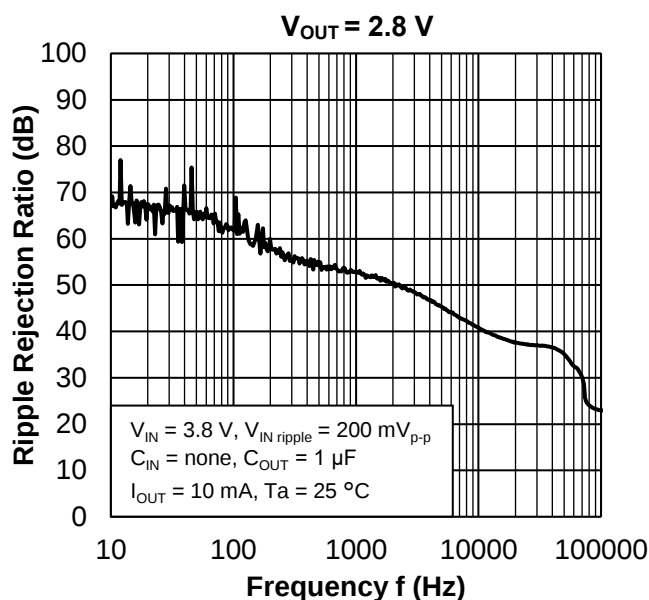
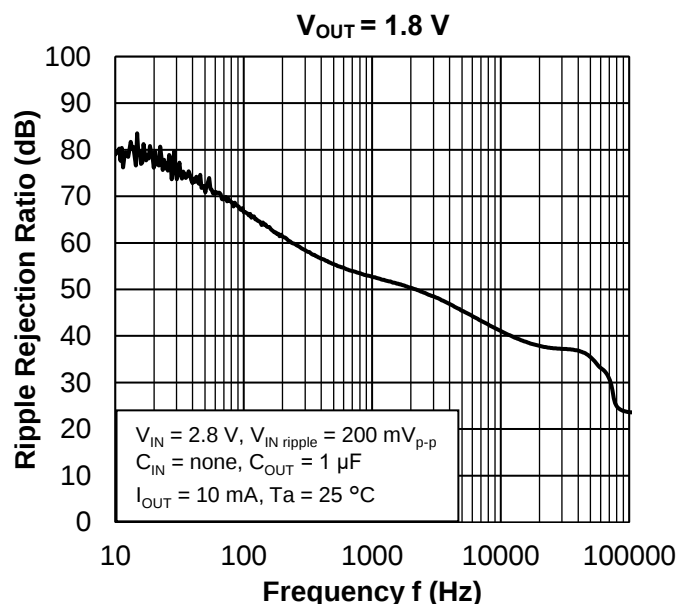
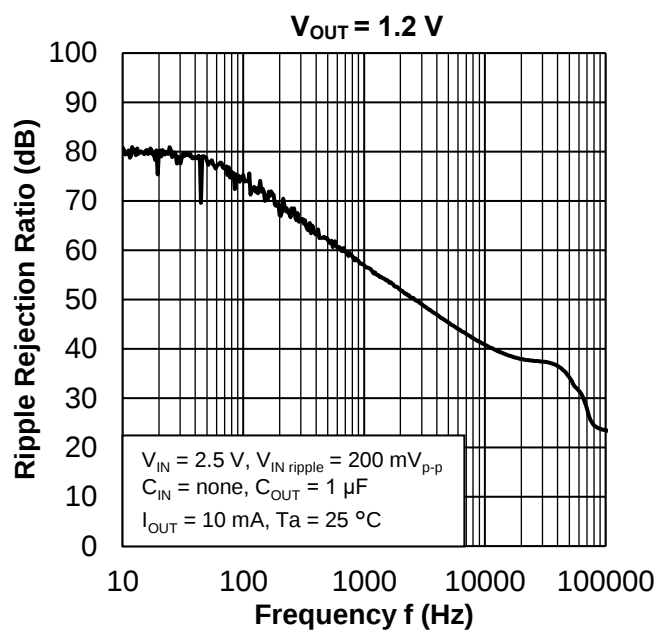
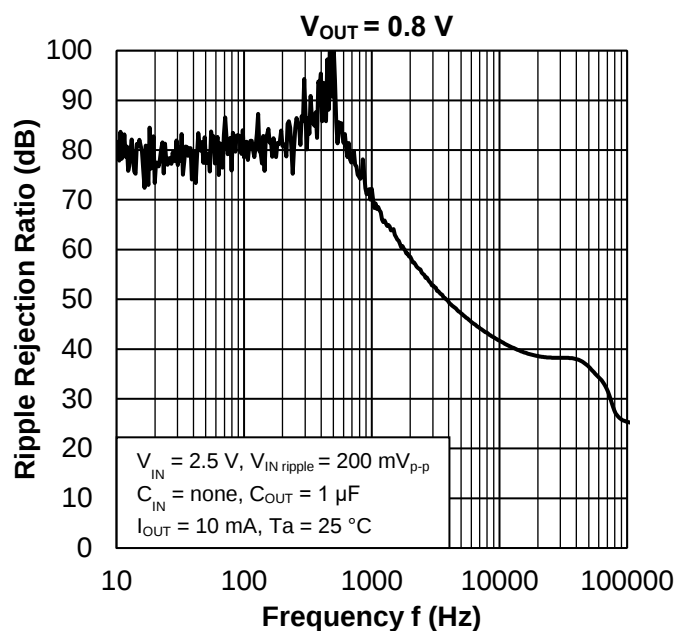
### 13.3. Quiescent Current vs. Input Voltage



### 13.4. Dropout Voltage vs. Output Current

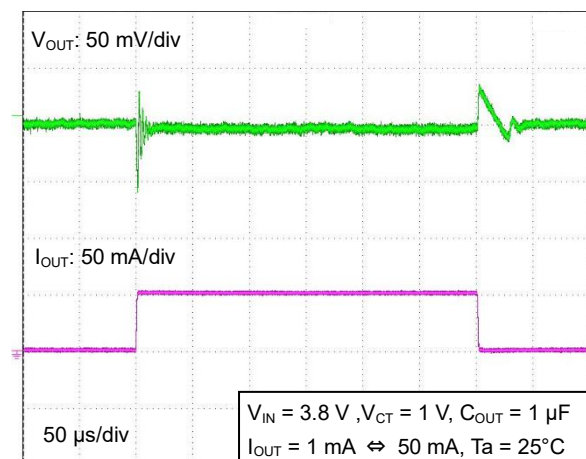


## 13.5. Ripple Rejection Ratio vs. Frequency

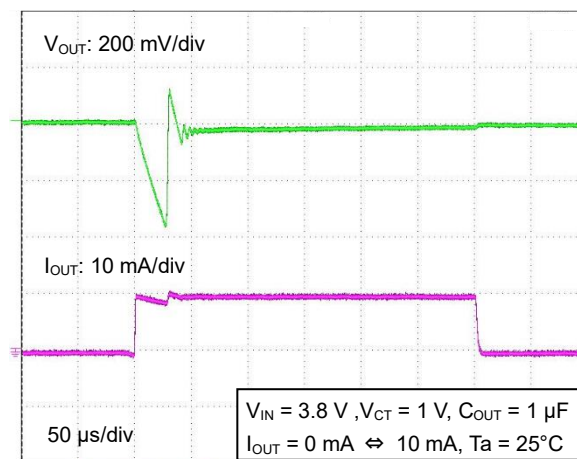


### 13.6. Load Transient Response

$V_{OUT} = 2.8 \text{ V}$

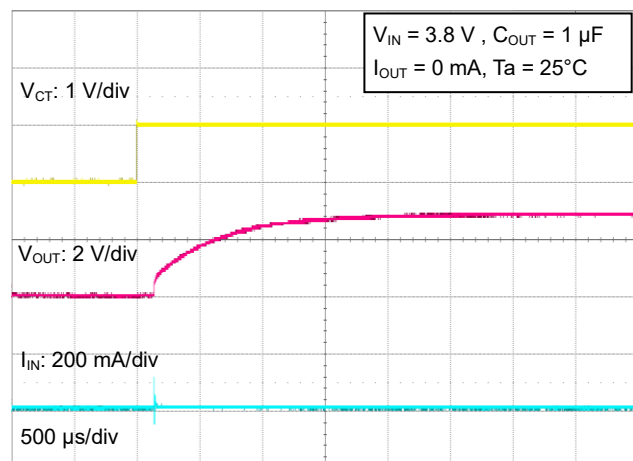


$V_{OUT} = 2.8 \text{ V}$

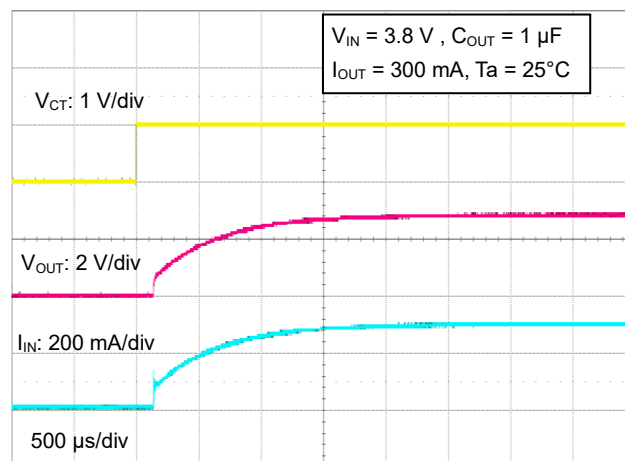


### 13.7. $t_{ON}$ Response

$V_{OUT} = 2.8 \text{ V}$

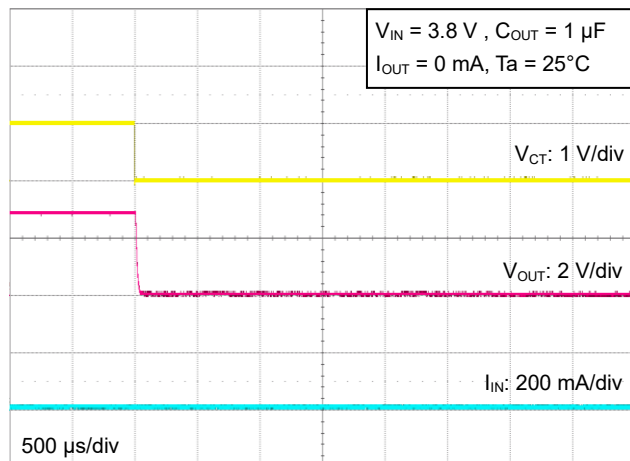


$V_{OUT} = 2.8 \text{ V}$

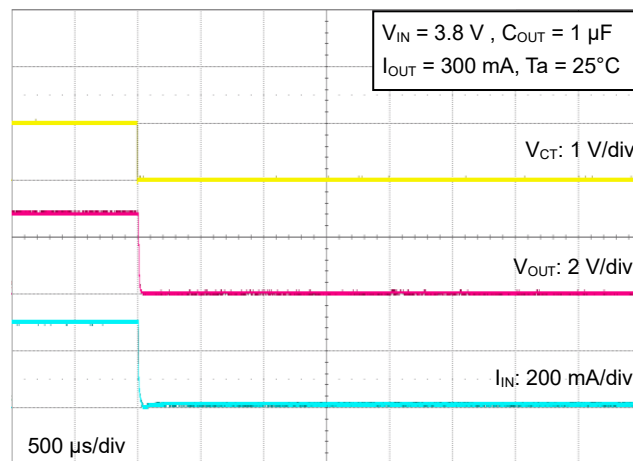


### 13.8. $t_{OFF}$ Response (Auto-discharge)

$V_{OUT} = 2.8 \text{ V}$



$V_{OUT} = 2.8 \text{ V}$

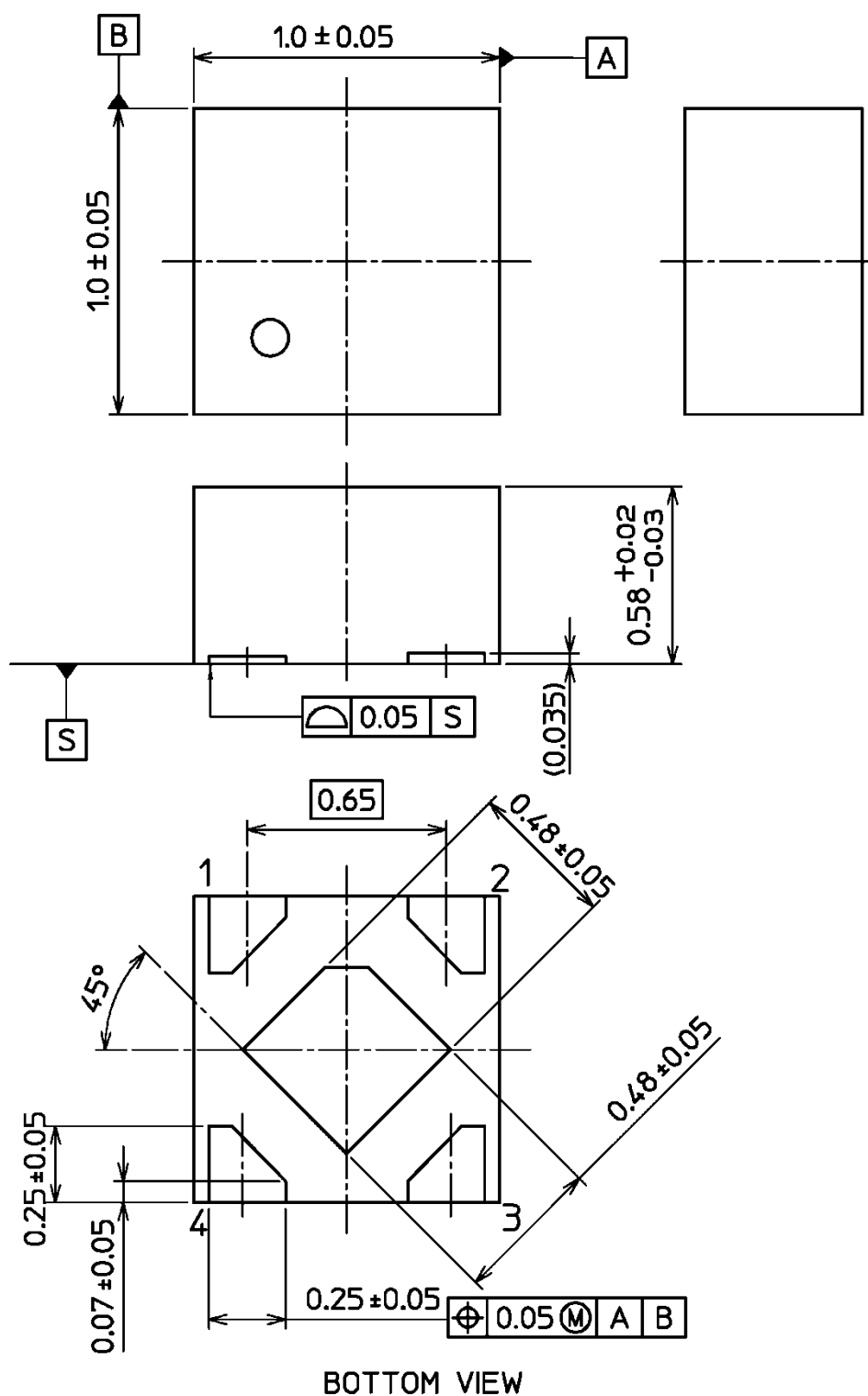


Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

## 14. Package Information

### 14.1. DFN4

Unit: mm

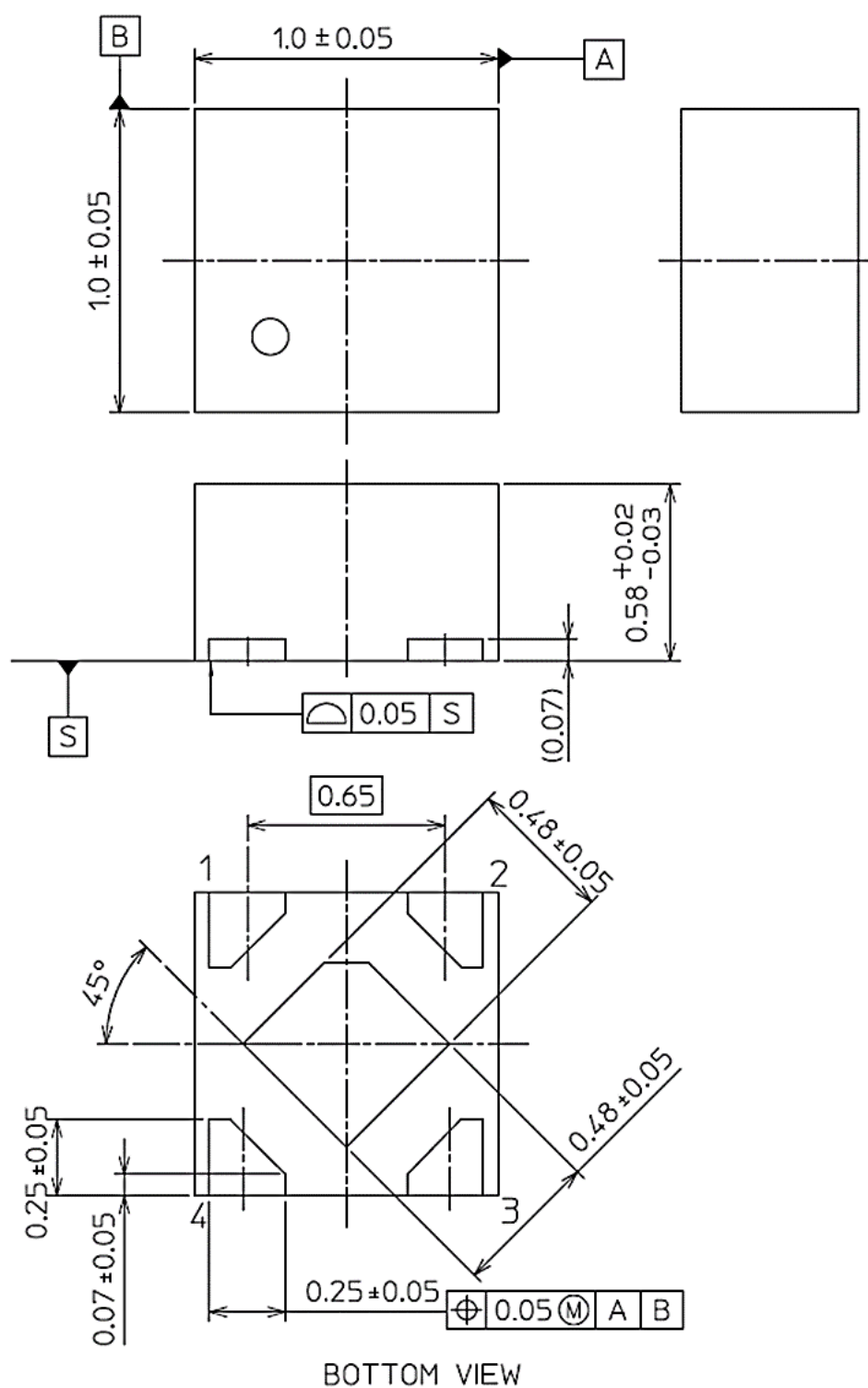


0.04 mm (typ.) unevenness exists along the edges of the back electrode to increase shear after soldering.

Weight: 1.3 mg (typ.)

## 14.2. DFN4E

Unit: mm



Weight: 1.3 mg (typ.)

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