

TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

# TCR2DG series

## Low Noise 200 mA CMOS Low Drop-Out Regulator in ultra small package

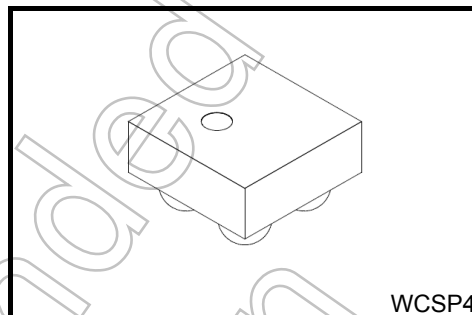
The TCR2DG series are CMOS general-purpose single-output voltage regulators with an on/off control input, featuring low dropout voltage, low quiescent bias current and fast load transient response.

These voltage regulators are available in fixed output voltages between 1.2 V and 3.6 V and capable of driving up to 200 mA. They feature overcurrent protection and thermal shut down function.

The TCR2DG series is offered in the ultra small package WCSP4 ( 0.79 mm x 0.79 mm x 0.5 mm). It has a low dropout voltage of 75 mV ( 2.5 V output,  $I_{OUT} = 100$  mA) with low output noise voltage of 18  $\mu V_{rms}$  (2.5 V output) and a load transient response of only

$$\Delta V_{OUT} = \pm 65 \text{ mV ( } I_{OUT} = 1 \text{ mA} \leftrightarrow 150 \text{ mA, } C_{OUT} = 1.0 \mu\text{F) .}$$

As small ceramic input and output capacitors can be used with the TCR2DG series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones.



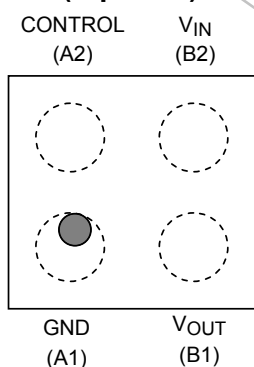
WCSP4

Weight : 0.7 mg (typ.)

### Features

- Low Drop-out Voltage (  $V_{IN}-V_{OUT} = 75$  mV (typ.) at 2.5 V-output,  $I_{OUT} = 100$  mA )
- Low quiescent bias current (  $I_B = 45$   $\mu$ A (typ.) at  $I_{OUT} = 0$  mA )
- Low stand-by current (  $I_{B(OFF)} = 0.1$   $\mu$ A (typ.) at Stand-by mode )
- Low output noise voltage  
 $V_{NO} = 22$   $\mu V_{rms}$  (typ.) at 3.0 V-output,  $I_{OUT} = 10$  mA,  $10 \text{ Hz} < f < 100 \text{ kHz}$   
 $V_{NO} = 18$   $\mu V_{rms}$  (typ.) at 2.5 V-output,  $I_{OUT} = 10$  mA,  $10 \text{ Hz} < f < 100 \text{ kHz}$   
 $V_{NO} = 14$   $\mu V_{rms}$  (typ.) at 1.2 V-output,  $I_{OUT} = 10$  mA,  $10 \text{ Hz} < f < 100 \text{ kHz}$
- High ripple rejection ratio  
 $R.R = 75$  dB (typ.) at 2.5 V-output,  $I_{OUT} = 10$  mA,  $f = 1$  kHz  
 $R.R = 62$  dB (typ.) at 2.5 V-output,  $I_{OUT} = 10$  mA,  $f = 10$  kHz  
 $R.R = 50$  dB (typ.) at 2.5 V-output,  $I_{OUT} = 10$  mA,  $f = 100$  kHz
- Fast load transient response (  $\Delta V_{OUT} = \pm 65$  mV (typ.) at  $I_{OUT} = 1$  mA  $\leftrightarrow$  150 mA,  $C_{OUT} = 1.0$   $\mu$ F )
- Output voltage accuracy  $\pm 1.0$  %
- Over current protection
- Thermal shut down function
- Built-in inrush current reduction circuit
- Pull down connection between CONTROL and GND
- Ceramic capacitors can be used (  $C_{IN} = 0.47$   $\mu$ F,  $C_{OUT} = 1.0$   $\mu$ F )
- Ultra small package, WCSP4 ( 0.79 mm x 0.79 mm x 0.50 mm )

### Pin Assignment (top view)


 Start of commercial production  
2013-01

**Absolute Maximum Ratings (Ta = 25°C)**

| Characteristics             | Symbol    | Rating                 | Unit |
|-----------------------------|-----------|------------------------|------|
| Input voltage               | $V_{IN}$  | 6.0                    | V    |
| Control voltage             | $V_{CT}$  | -0.3 to 6.0            | V    |
| Output voltage              | $V_{OUT}$ | -0.3 to $V_{IN} + 0.3$ | V    |
| Output current              | $I_{OUT}$ | 200                    | mA   |
| Power dissipation           | $P_D$     | 800 (Note1)            | mW   |
| Operation temperature range | $T_{opr}$ | -40 to 85              | °C   |
| Junction temperature        | $T_j$     | 150                    | °C   |
| Storage temperature range   | $T_{stg}$ | -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: 40mm x 40mm x 1.8mm, both sides of board

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

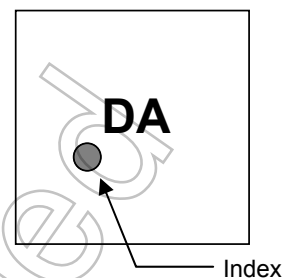
Through hole: diameter 0.5mm x 28

## List of Products Number, Marking and Output voltage

## Top Marking

| Products No. | Marking | Output voltage (V) |
|--------------|---------|--------------------|
| TCR2DG12     | D3      | 1.2                |
| TCR2DG125    | D8      | 1.25*              |
| TCR2DG13     | D4      | 1.3*               |
| TCR2DG14     | D5      | 1.4*               |
| TCR2DG15     | DA      | 1.5                |
| TCR2DG16     | DB      | 1.6*               |
| TCR2DG17     | DD      | 1.7*               |
| TCR2DG18     | DE      | 1.8                |
| TCR2DG19     | DF      | 1.9*               |
| TCR2DG20     | DG      | 2.0*               |
| TCR2DG21     | DH      | 2.1*               |
| TCR2DG22     | DI      | 2.2*               |
| TCR2DG23     | DK      | 2.3*               |
| TCR2DG24     | DL      | 2.4*               |
| TCR2DG25     | DM      | 2.5                |
| TCR2DG26     | DN      | 2.6*               |
| TCR2DG27     | DO      | 2.7*               |
| TCR2DG28     | DP      | 2.8                |
| TCR2DG285    | D7      | 2.85*              |
| TCR2DG29     | DR      | 2.9*               |
| TCR2DG295    | D6      | 2.95*              |
| TCR2DG30     | DS      | 3.0                |
| TCR2DG31     | DT      | 3.1*               |
| TCR2DG32     | DV      | 3.2*               |
| TCR2DG33     | DW      | 3.3                |
| TCR2DG34     | DX      | 3.4*               |
| TCR2DG35     | DY      | 3.5*               |
| TCR2DG36     | DZ      | 3.6                |

Example: TCR2DG15 (1.5 V output)



\* Please contact your local Toshiba representative if you are interested in products with \* sign

## Electrical Characteristics

(Unless otherwise specified,

$V_{IN} = V_{OUT} + 1\text{ V}$ ,  $I_{OUT} = 50\text{ mA}$ ,  $C_{IN} = 0.47\text{ }\mu\text{F}$ ,  $C_{OUT} = 1.0\text{ }\mu\text{F}$ ,  $T_j = 25^\circ\text{C}$ )

| Characteristics         | Symbol                            | Test Condition                                                                                                                      |                          | Min                      | Typ. | Max  | Unit              |    |
|-------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------|------|------|-------------------|----|
| Output voltage accuracy | V <sub>OUT</sub>                  | —                                                                                                                                   |                          | -1.0                     | —    | +1.0 | %                 |    |
| Input voltage           | V <sub>IN</sub>                   | —                                                                                                                                   |                          | 2.0                      | —    | 5.5  | V                 |    |
| Line regulation         | Reg·line                          | 2.0 V ≤ V <sub>IN</sub> ≤ 5.5 V, I <sub>OUT</sub> = 1 mA                                                                            |                          | —                        | 0.1  | 5    | mV                |    |
| Load regulation         | Reg·load                          | 1 mA ≤ I <sub>OUT</sub> ≤ 150 mA                                                                                                    |                          | —                        | 5    | 10   | mV                |    |
| Quiescent current       | I <sub>B</sub>                    | I <sub>OUT</sub> = 0 mA                                                                                                             |                          | —                        | 45   | 70   | μA                |    |
| Stand-by current        | I <sub>B</sub> (OFF)              | V <sub>CT</sub> = 0 V                                                                                                               |                          | —                        | 0.1  | 0.7  | μA                |    |
| Drop-out voltage        | V <sub>IN</sub> -V <sub>OUT</sub> | I <sub>OUT</sub> = 100 mA (Note 2)                                                                                                  |                          | —                        | 75   | 130  | mV                |    |
| Temperature coefficient | T <sub>CVO</sub>                  | -40°C ≤ T <sub>opr</sub> ≤ 85°C                                                                                                     |                          | —                        | 70   | —    | ppm/°C            |    |
| Output noise voltage    | V <sub>NO</sub>                   | V <sub>IN</sub> = V <sub>OUT</sub> + 1 V,<br>I <sub>OUT</sub> = 10 mA,<br>10 Hz ≤ f ≤ 100 kHz,<br>Ta = 25°C                         | V <sub>OUT</sub> = 1.2 V | —                        | 14   | —    | μV <sub>rms</sub> |    |
|                         |                                   |                                                                                                                                     | V <sub>OUT</sub> = 2.5 V | —                        | 18   | —    |                   |    |
|                         |                                   |                                                                                                                                     | V <sub>OUT</sub> = 3.0 V | —                        | 22   | —    |                   |    |
| Ripple rejection ratio  | R.R.                              | V <sub>IN</sub> = V <sub>OUT</sub> + 1 V,<br>I <sub>OUT</sub> = 10 mA,<br>V <sub>Ripple</sub> = 500mV <sub>p-p</sub> ,<br>Ta = 25°C | f = 1 kHz                | V <sub>OUT</sub> = 1.2 V | —    | 85   | —                 | dB |
|                         |                                   |                                                                                                                                     |                          | V <sub>OUT</sub> = 2.5 V | —    | 75   | —                 |    |
|                         |                                   |                                                                                                                                     |                          | V <sub>OUT</sub> = 3.0 V | —    | 73   | —                 |    |
|                         |                                   |                                                                                                                                     | f = 10 kHz               | V <sub>OUT</sub> = 1.2 V | —    | 68   | —                 |    |
|                         |                                   |                                                                                                                                     |                          | V <sub>OUT</sub> = 2.5 V | —    | 62   | —                 |    |
|                         |                                   |                                                                                                                                     |                          | V <sub>OUT</sub> = 3.0 V | —    | 60   | —                 |    |
|                         |                                   |                                                                                                                                     | f = 100 kHz              | V <sub>OUT</sub> = 1.2 V | —    | 50   | —                 |    |
|                         |                                   |                                                                                                                                     |                          | V <sub>OUT</sub> = 2.5 V | —    | 50   | —                 |    |
|                         |                                   |                                                                                                                                     |                          | V <sub>OUT</sub> = 3.0 V | —    | 50   | —                 |    |
| Load transient response | ΔV <sub>OUT</sub>                 | I <sub>OUT</sub> = 1mA ⇔ 150mA, C <sub>OUT</sub> = 1.0 μF                                                                           |                          | —                        | ±65  | —    | mV                |    |
| Control voltage (ON)    | V <sub>CT</sub> (ON)              | —                                                                                                                                   |                          | 1.1                      | —    | 5.5  | V                 |    |
| Control voltage (OFF)   | V <sub>CT</sub> (OFF)             | —                                                                                                                                   |                          | 0                        | —    | 0.5  | V                 |    |

Note 2: The 2.5 V output product.

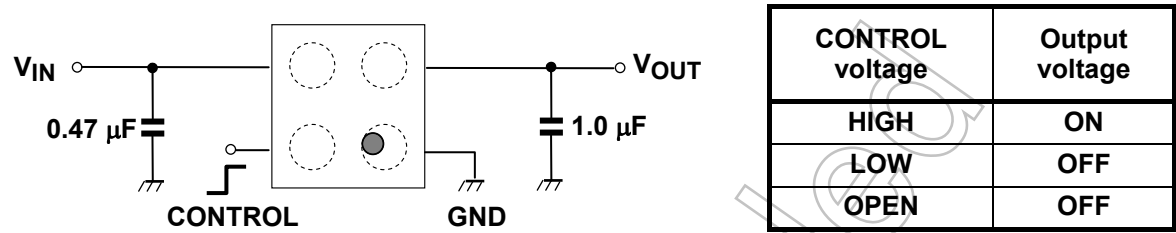
**Drop-out voltage**

 ( $I_{OUT} = 100 \text{ mA}$ ,  $C_{IN} = 0.47 \text{ } \mu\text{F}$ ,  $C_{OUT} = 1.0 \text{ } \mu\text{F}$ ,  $T_j = 25^\circ\text{C}$ )

| Output voltages                               | Symbol             | Min | Typ. | Max | Unit |
|-----------------------------------------------|--------------------|-----|------|-----|------|
| 1.2 V                                         | $V_{IN} - V_{OUT}$ | —   | 193  | 800 | mV   |
| 1.25 V                                        |                    | —   | 181  | 750 |      |
| 1.3 V                                         |                    | —   | 168  | 700 |      |
| 1.4 V                                         |                    | —   | 148  | 600 |      |
| 1.5 V                                         |                    | —   | 133  | 500 |      |
| 1.6 V                                         |                    | —   | 121  | 400 |      |
| 1.7 V                                         |                    | —   | 112  | 300 |      |
| 1.8 V                                         |                    | —   | 104  | 200 |      |
| 1.85 V                                        |                    | —   | 101  | 190 |      |
| 1.9 V                                         |                    | —   | 98   | 170 |      |
| 2.0 V                                         |                    | —   | 92   | 160 |      |
| 2.1 V                                         |                    | —   | 87   | 150 |      |
| 2.2 V, 2.3 V                                  |                    | —   | 82   | 140 |      |
| $2.4\text{V} \leq V_{OUT} \leq 2.6 \text{ V}$ |                    | —   | 78   | 130 |      |
| $2.7\text{V} \leq V_{OUT} \leq 2.95\text{V}$  |                    | —   | 69   | 120 |      |
| $3.0\text{V} \leq V_{OUT} \leq 3.6 \text{ V}$ |                    | —   | 64   | 110 |      |

Application Note

1. Recommended Application Circuit

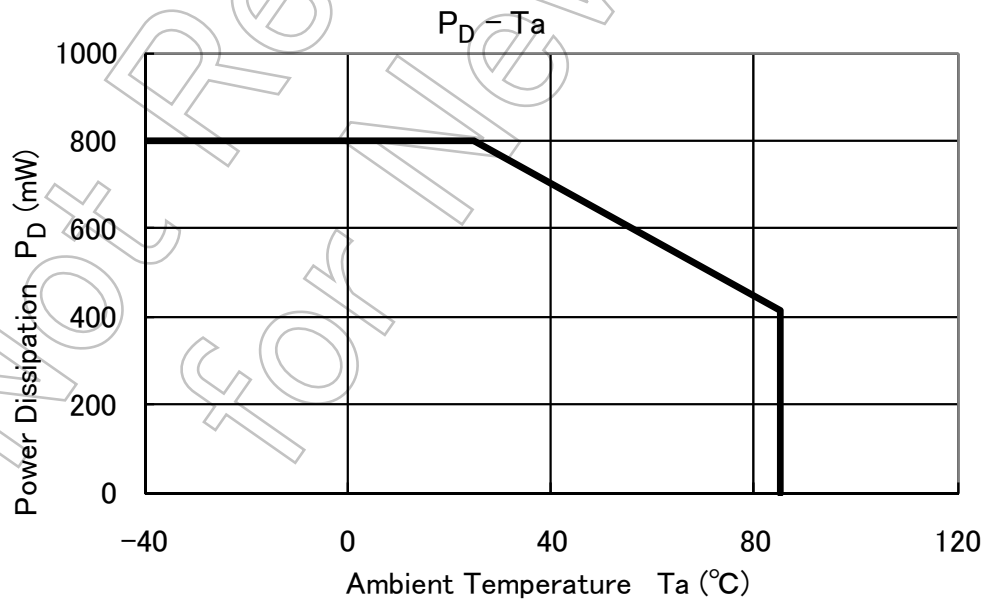


The figure above shows the recommended configuration for using a Low-Dropout regulator. Insert a capacitor at VOUT and VIN pins for stable input/output operation. (Ceramic capacitors can be used).

2. Power Dissipation

Power dissipation is measured on the board condition shown below.

[The Board Condition]  
Board material: Glass epoxy (FR4)  
Board dimension: 40mm x 40mm (both sides of board), t=1.8mm  
Metal pattern ratio: a surface approximately 50%, the reverse side approximately 50%  
Through hole: diameter 0.5mm x 28



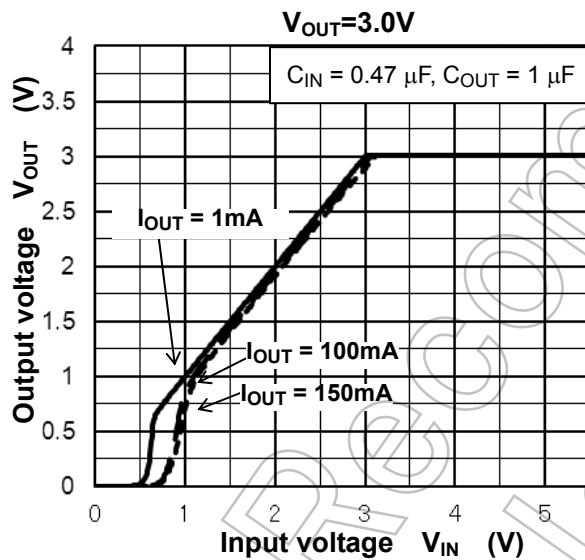
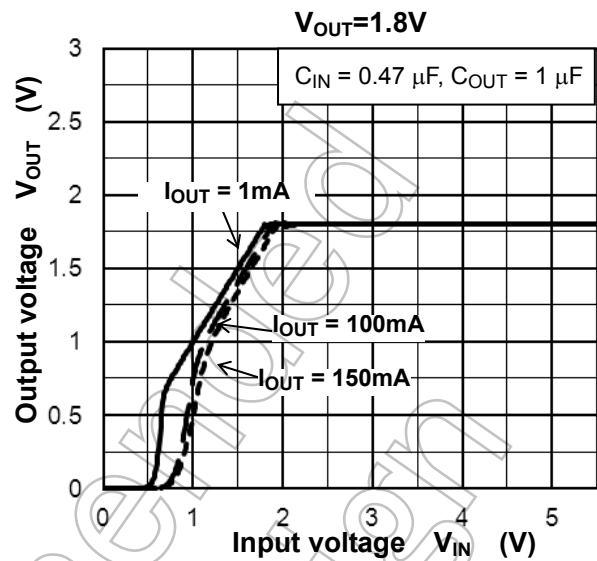
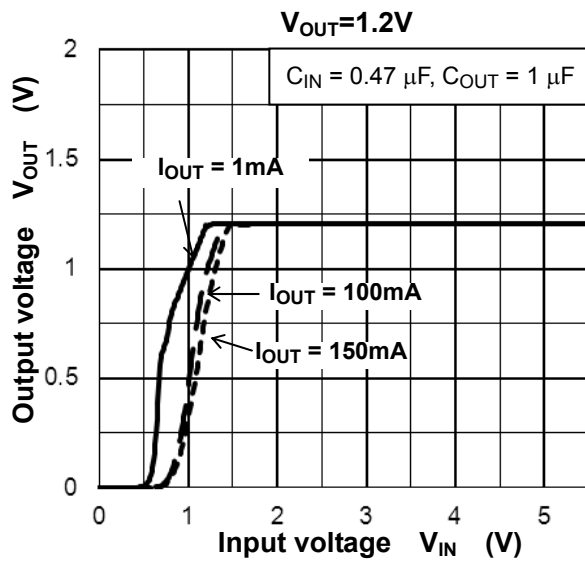
**Attention in Use**

- **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 recommend the ESR of ceramic capacitor is under 10  $\Omega$ .
- **Mounting**  
The long distance between IC and output capacitor might affect phase assurance by impedance in wire and inductor. For stable power supply, output capacitor need to mount near IC as much as possible. Also 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 surrounding temperature, input voltage, and output current etc, we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70 to 80 percent.
- **Over current Protection and Thermal shut down function**  
Over current protection and Thermal shut down function are designed in these products, but these does not assure for the suppression of uprising device operation.  
In use of these products, please read through and understand dissipation idea 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 recommend inserting failsafe system into the design.

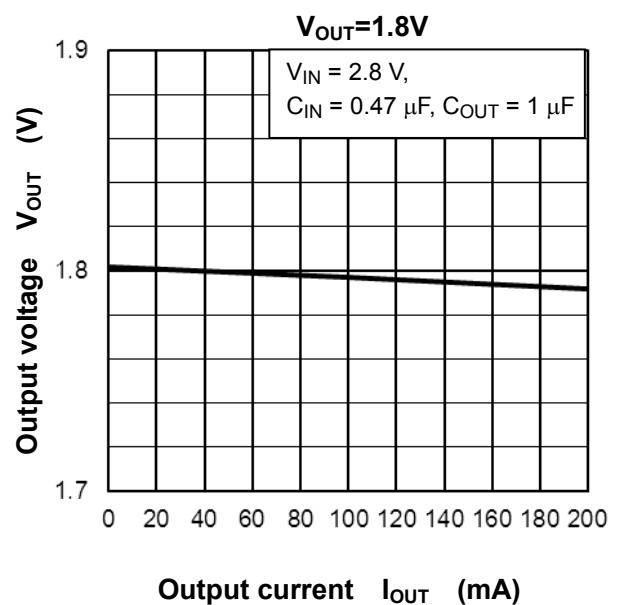
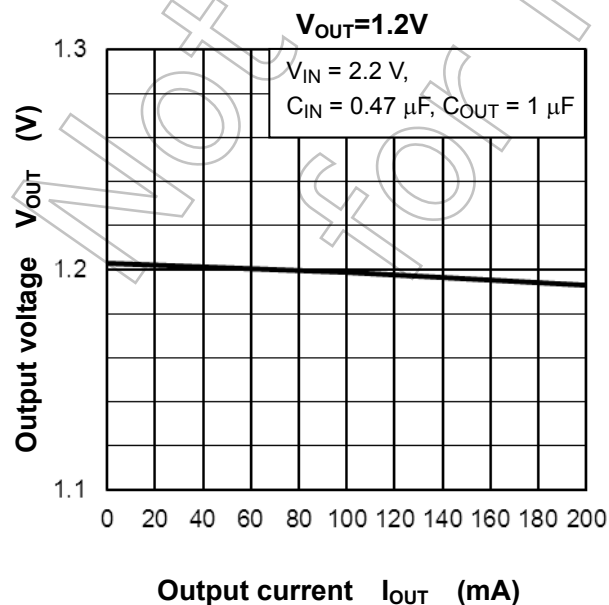
Not Recommended for New Design

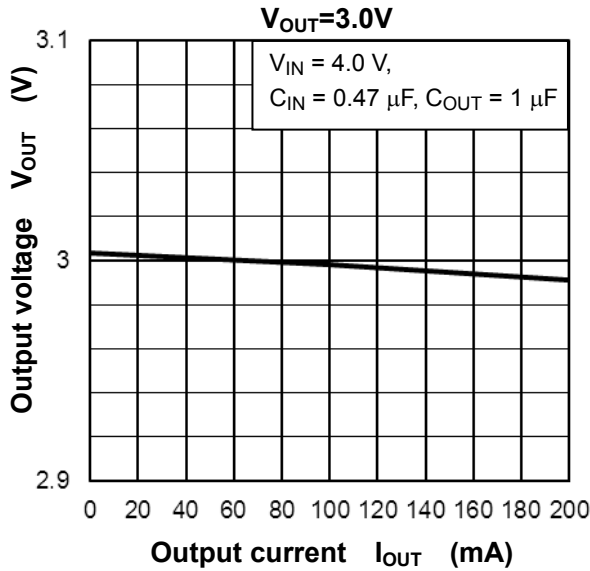
## Representative Typical Characteristics

### 1) Output Voltage vs. Input Voltage

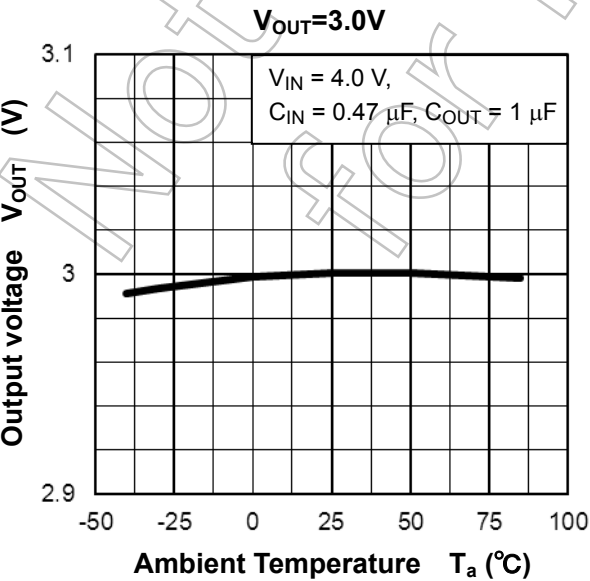
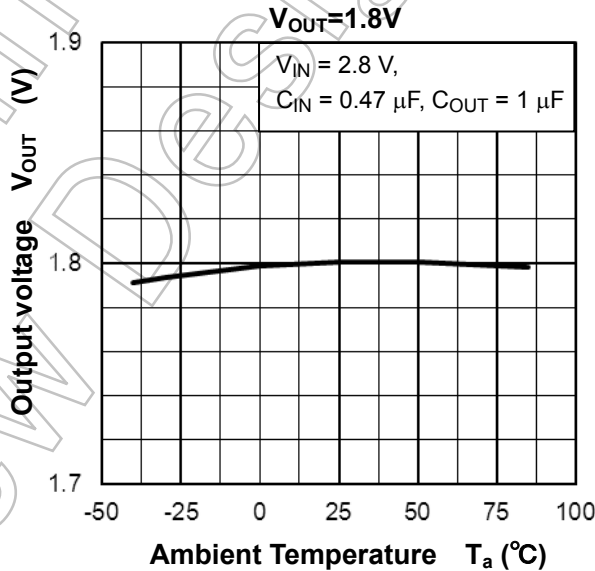
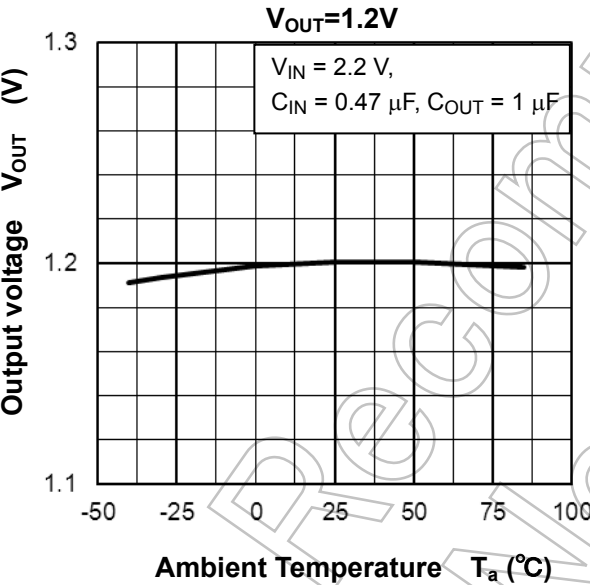


### 2) Output Voltage vs. Output Current

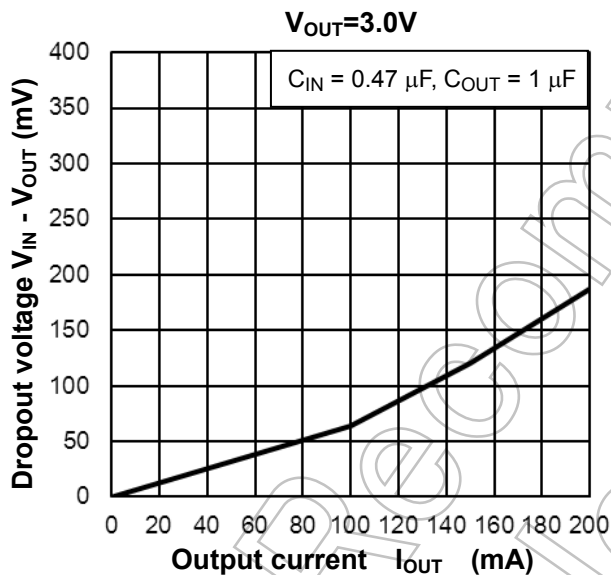
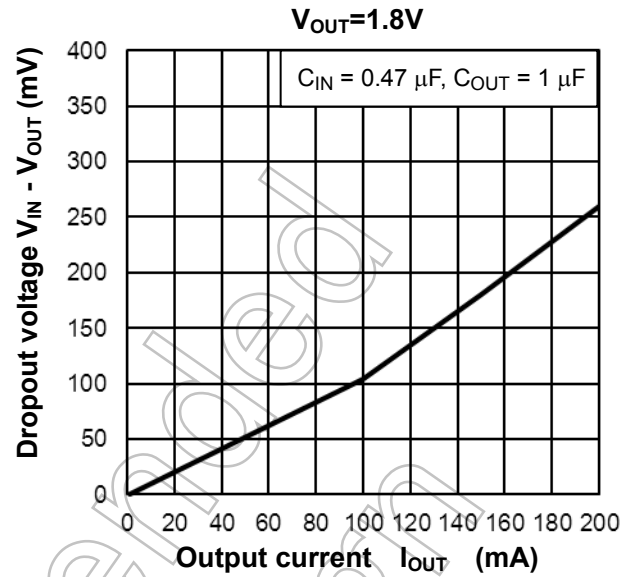
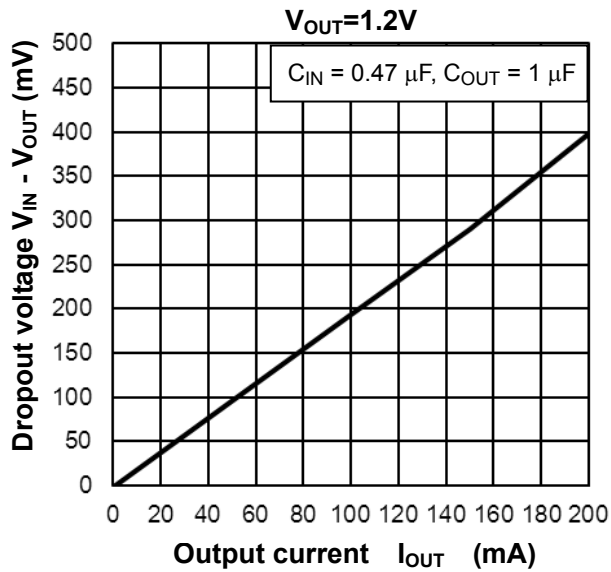




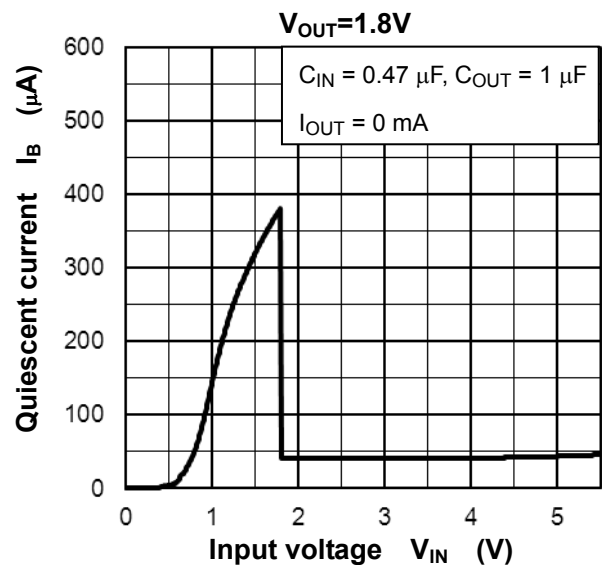
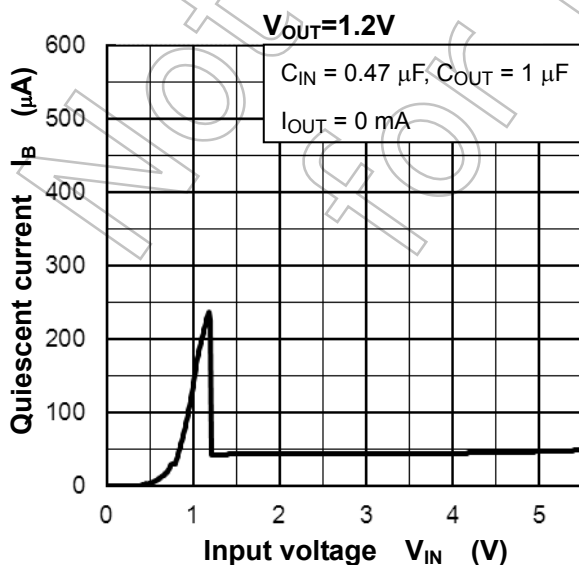
3) Output Voltage vs. Ambient Temperature

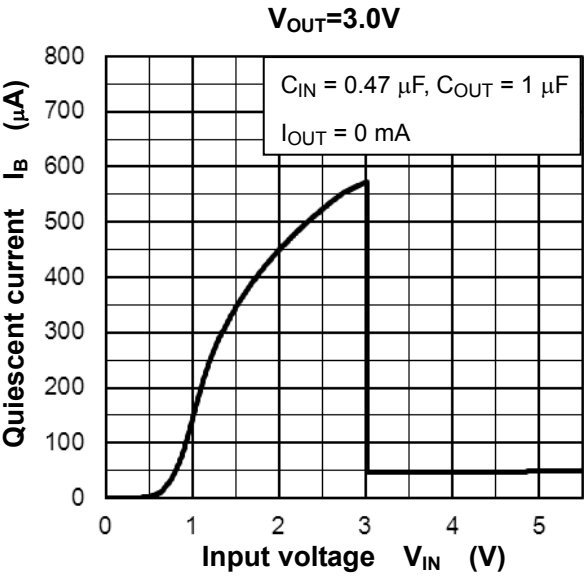


4) Dropout Voltage vs. Output Current

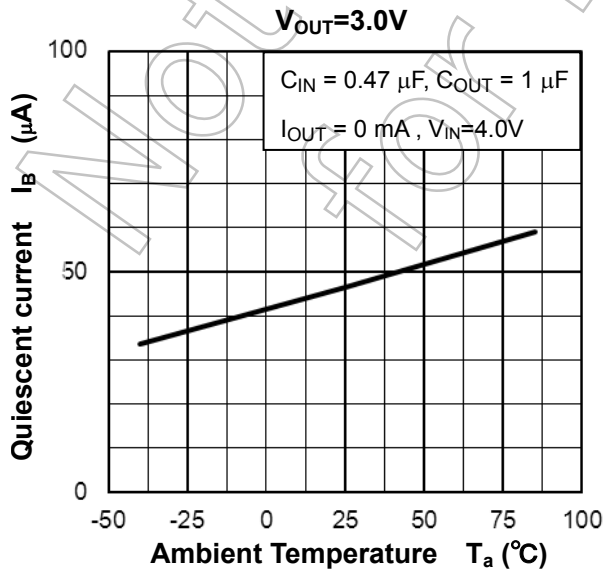
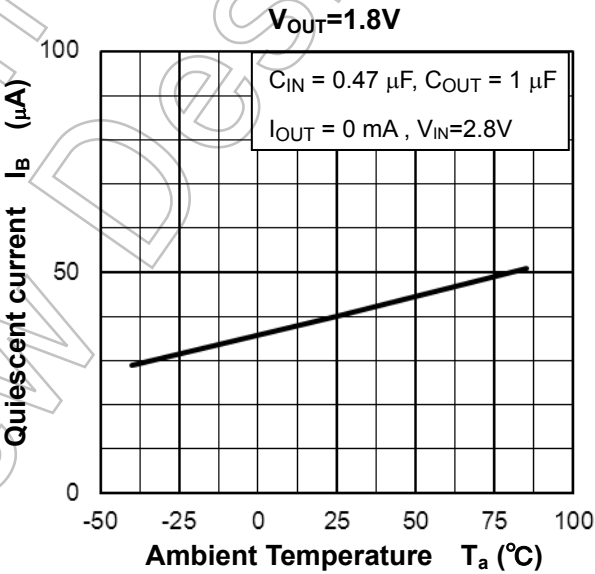
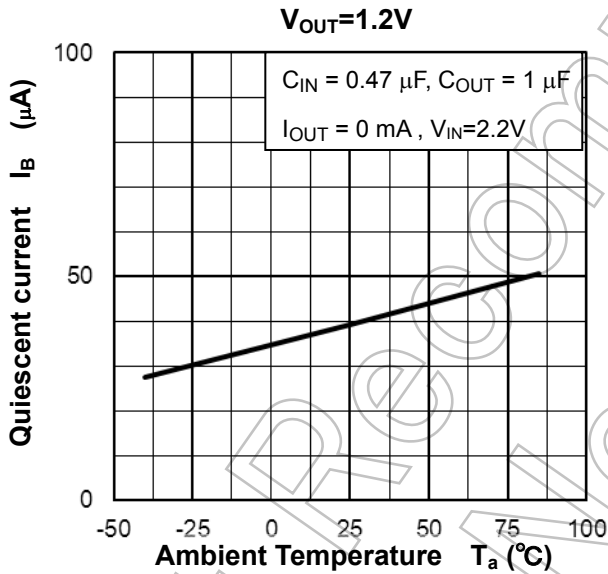


5) Quiescent Current vs. Input Voltage

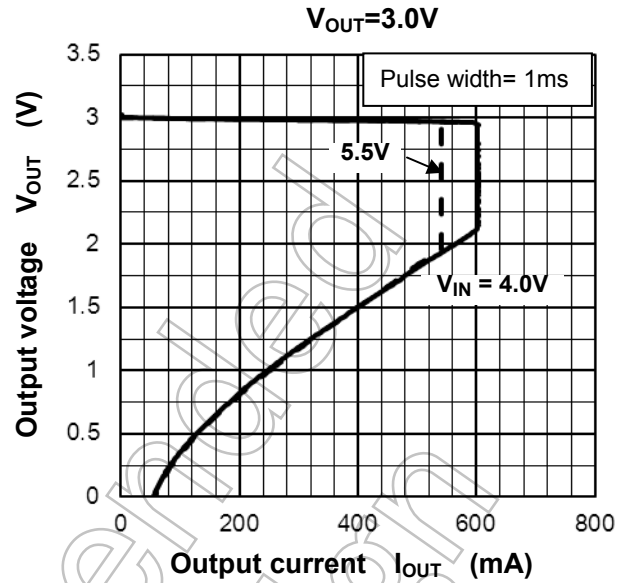
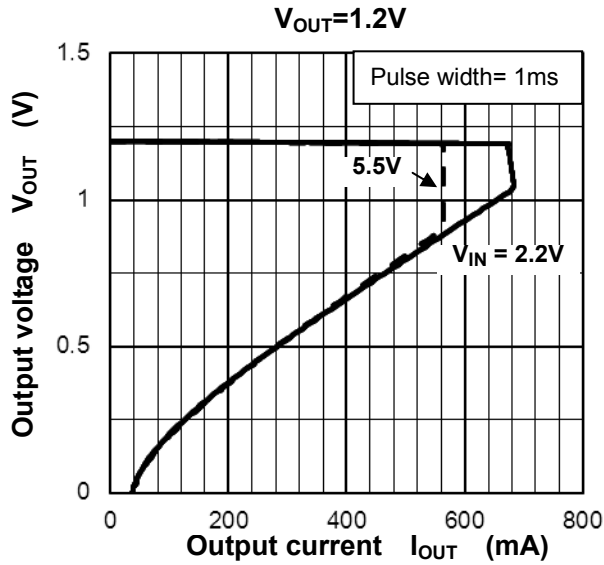




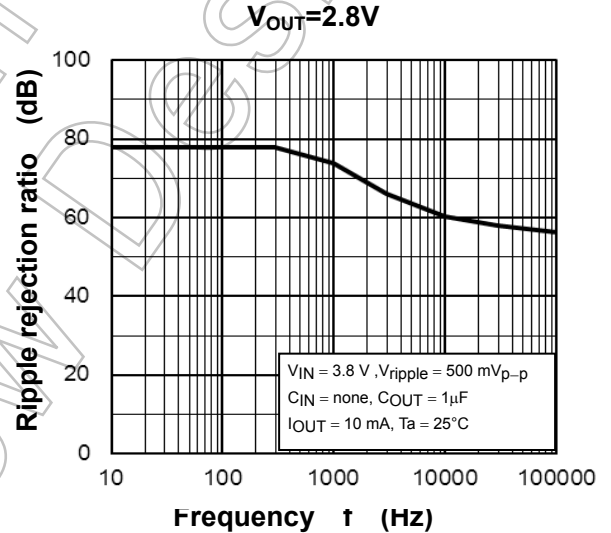
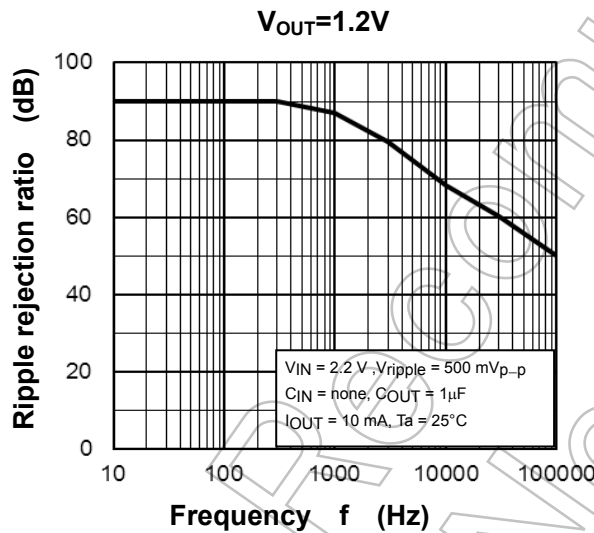
6) Quiescent Current vs. Ambient Temperature



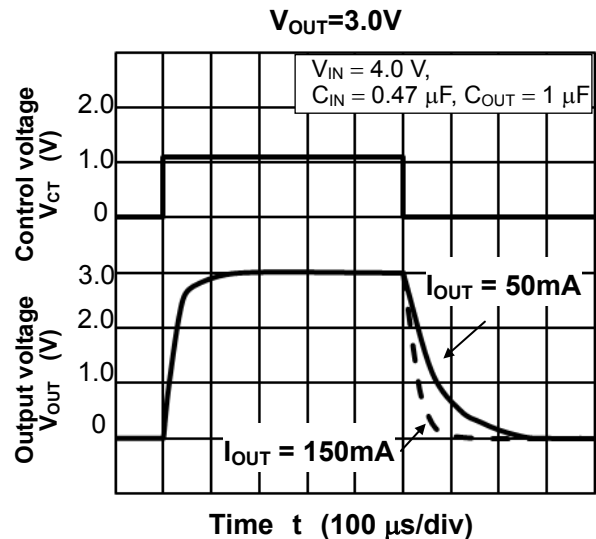
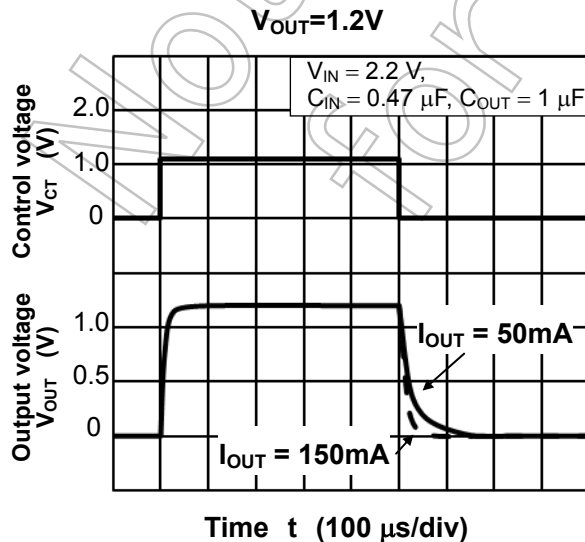
## 7) Output Voltage vs. Output Current



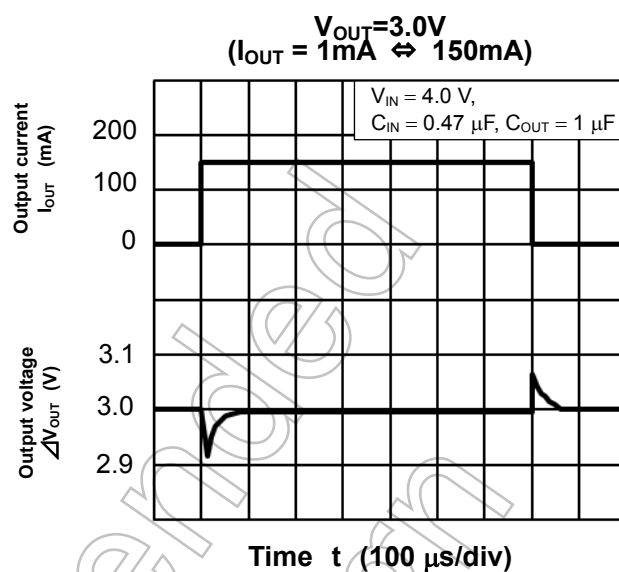
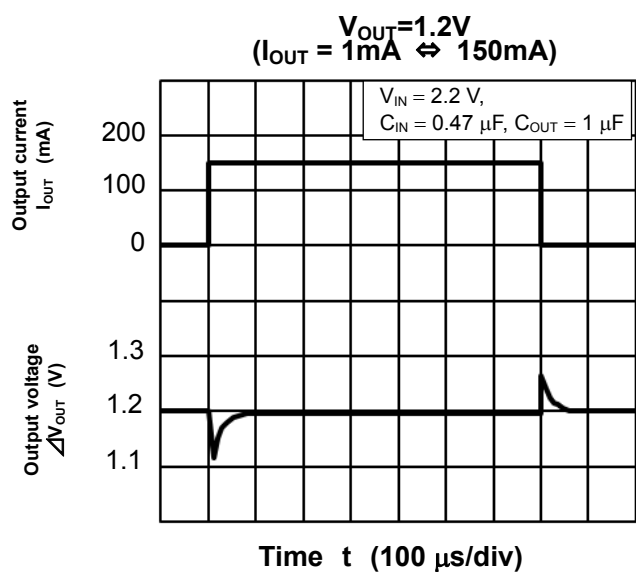
## 8) Ripple Rejection Ratio vs. Frequency



## 9) Control Transient vs. Response



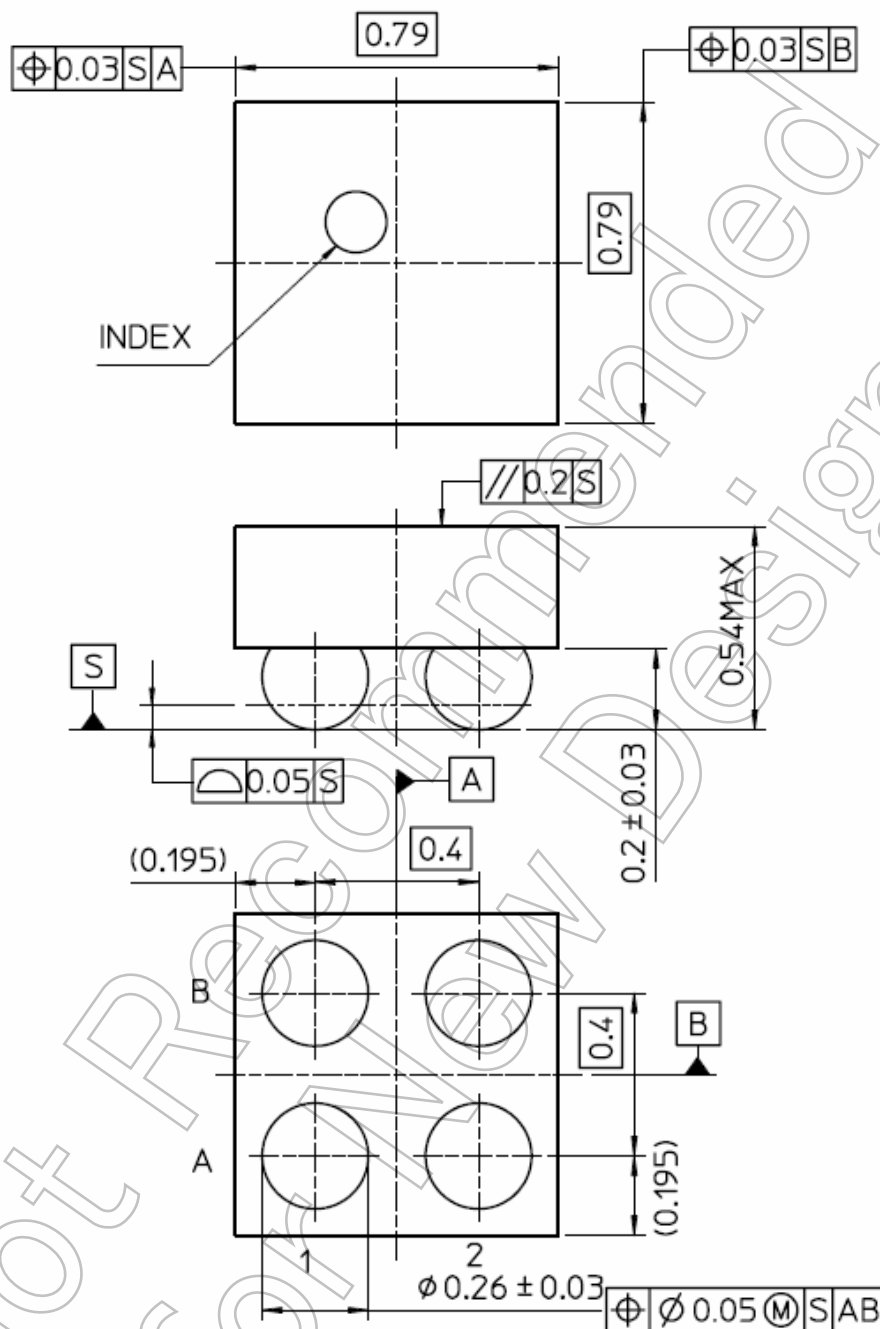
## 10) Load Transient Response



## Package Dimensions

WCSP4

Unit : mm



Weight : 0.7 mg ( typ.)

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