

TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

# TCR2EN series

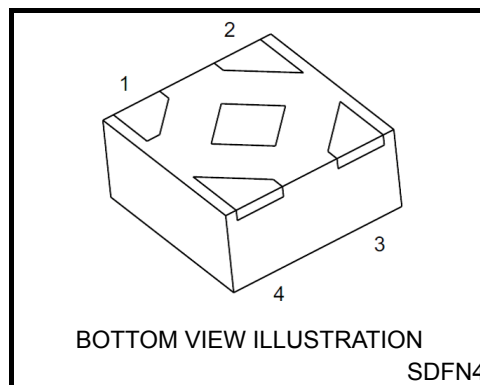
## 200 mA CMOS Low Drop-Out Regulator in ultra small package

The TCR2EN 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 1.0 V and 3.6 V and capable of driving up to 200 mA. They feature overcurrent protection and an Auto-discharge function.

The TCR2EN series is offered in the ultra small plastic mold package SDFN4 (0.8 mm x 0.8 mm x 0.38 mm). It has a low dropout voltage of 160 mV ( 2.5 V output,  $I_{OUT} = 150$  mA) with low output noise voltage of  $35 \mu V_{rms}$  (2.5 V output) and a load transient response of only  $\Delta V_{OUT} = \pm 55$  mV (  $I_{OUT} = 1$  mA  $\leftrightarrow$  150 mA,  $C_{OUT} = 1.0 \mu F$ ).

As small ceramic input and output capacitors can be used with the TCR2EN series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones.



Weight: 0.6 mg (typ.)

## Features

- Low Drop-Out voltage
  - $V_{IN}-V_{OUT} = 160$  mV (typ.) at 2.5 V-output,  $I_{OUT} = 150$  mA
  - $V_{IN}-V_{OUT} = 210$  mV (typ.) at 1.8 V-output,  $I_{OUT} = 150$  mA
  - $V_{IN}-V_{OUT} = 360$  mV (typ.) at 1.2 V-output,  $I_{OUT} = 150$  mA
  - $V_{IN}-V_{OUT} = 490$  mV (typ.) at 1.0 V-output,  $I_{OUT} = 150$  mA
- Low output noise voltage
  - $V_{NO} = 35 \mu V_{rms}$  (typ.) at 2.5 V-output,  $I_{OUT} = 10$  mA,  $10 \text{ Hz} < f < 100 \text{ kHz}$
  - $V_{NO} = 30 \mu V_{rms}$  (typ.) at 1.8 V-output,  $I_{OUT} = 10$  mA,  $10 \text{ Hz} < f < 100 \text{ kHz}$
  - $V_{NO} = 23 \mu V_{rms}$  (typ.) at 1.2 V-output,  $I_{OUT} = 10$  mA,  $10 \text{ Hz} < f < 100 \text{ kHz}$
  - $V_{NO} = 18 \mu V_{rms}$  (typ.) at 1.0 V-output,  $I_{OUT} = 10$  mA,  $10 \text{ Hz} < f < 100 \text{ kHz}$
- Fast load transient response ( $\Delta V_{OUT} = \pm 55$  mV (typ.) at  $I_{OUT} = 1$  mA  $\leftrightarrow$  150 mA,  $C_{OUT} = 1.0 \mu F$  )
- Low quiescent bias current (  $I_B = 35 \mu A$  (typ.) at  $I_{OUT} = 0$  mA )
- High ripple rejection ( R.R = 73 dB (typ.) at 2.5 V-output,  $I_{OUT} = 10$  mA,  $f = 1$  kHz )
- Wide range Output Voltage line up (  $V_{OUT} = 1.0$  to 3.6 V )
- High  $V_{OUT}$  accuracy  $\pm 1.0\%$  (  $1.8 \text{ V} \leq V_{OUT}$  )
- Overcurrent protection
- Auto-discharge
- Pull down connection between CONTROL and GND
- Ceramic capacitors can be used (  $C_{IN} = 0.1 \mu F$ ,  $C_{OUT} = 1.0 \mu F$  )
- Ultra Small package SDFN4 (0.8 mm x 0.8 mm x 0.38 mm )

Start of commercial production  
2013-11

## 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           | $P_D$     | 300 (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).

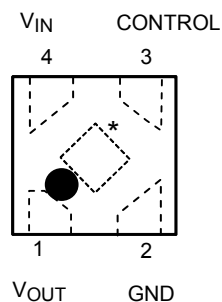
Note1: Rating at mounting on a board

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

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

Through hole: diameter 0.5mm x 24

## Pin Assignment (top view)



\*Center electrode should be connected to GND or Open

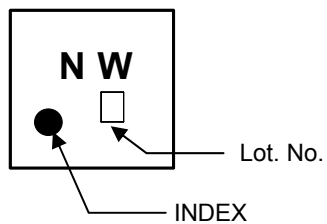
## List of Products Number, Output voltage and Marking

| Product No. | Output voltage(V)<br>(typ.) | Marking | Product No. | Output voltage(V)<br>(typ.) | Marking |
|-------------|-----------------------------|---------|-------------|-----------------------------|---------|
| TCR2EN10    | 1.0                         | NJ      | TCR2EN27    | 2.7                         | NO      |
| TCR2EN105   | 1.05                        | NU      | TCR2EN28    | 2.8                         | NP      |
| TCR2EN11    | 1.1                         | N2      | TCR2EN285   | 2.85                        | N7      |
| TCR2EN115   | 1.15                        | NC      | TCR2EN29    | 2.9                         | NR      |
| TCR2EN12    | 1.2                         | N3      | TCR2EN30    | 3.0                         | NS      |
| TCR2EN125   | 1.25                        | NQ      | TCR2EN31    | 3.1                         | NT      |
| TCR2EN13    | 1.3                         | N4      | TCR2EN32    | 3.2                         | NV      |
| TCR2EN15    | 1.5                         | NA      | TCR2EN33    | 3.3                         | NW      |
| TCR2EN18    | 1.8                         | NE      | TCR2EN34    | 3.4                         | NX      |
| TCR2EN19    | 1.9                         | NF      | TCR2EN35    | 3.5                         | NY      |
| TCR2EN21    | 2.1                         | NH      | TCR2EN36    | 3.6                         | NZ      |
| TCR2EN25    | 2.5                         | NM      |             |                             |         |

Please ask your local retailer about the devices with other output voltages.

## Marking (top view)

Example: TCR2EN33 (3.3 V output)



## Electrical Characteristics

(Unless otherwise specified,

$V_{IN} = V_{OUT} + 1\text{ V}$ ,  $I_{OUT} = 50\text{ mA}$ ,  $C_{IN} = 0.1\text{ }\mu\text{F}$ ,  $C_{OUT} = 1.0\text{ }\mu\text{F}$ ,  $T_j = 25^\circ\text{C}$ )

| Characteristics         | Symbol             | Test Condition   | Min                         | Typ.     | Max | Unit                  |    |
|-------------------------|--------------------|--|-----------------------------|----------|-----|-----------------------|----|
| Output voltage accuracy | $V_{OUT}$          | $I_{OUT} = 50\text{ mA}$ (Note2)   | $V_{OUT} < 1.8\text{ V}$    | -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 | V                     |    |
| Line regulation         | Reg·line           | $V_{OUT} + 0.5\text{ V} \leq V_{IN} \leq 5.5\text{ V}$ , $I_{OUT} = 1\text{ mA}$   | —                           | 1        | 15  | mV                    |    |
| Load regulation         | Reg·load           | $1\text{ mA} \leq I_{OUT} \leq 150\text{ mA}$  | —                           | 15       | 30  | mV                    |    |
| Quiescent current       | $I_B$              | $I_{OUT} = 0\text{ mA}$  | —                           | 35       | 60  | $\mu\text{A}$         |    |
| Stand-by current        | $I_B$ (OFF)        | $V_{CT} = 0\text{ V}$  | —                           | 0.1      | 1.0 | $\mu\text{A}$         |    |
| Drop-out voltage        | $V_{IN} - V_{OUT}$ | $I_{OUT} = 150\text{ mA}$ (Note 3)   | —                           | 160      | 210 | mV                    |    |
| Temperature coefficient | $T_{CVO}$          | $-40^\circ\text{C} \leq T_{opr} \leq 85^\circ\text{C}$   | —                           | 75       | —   | ppm/ $^\circ\text{C}$ |    |
| Output noise voltage    | $V_{NO}$           | $V_{IN} = V_{OUT} + 1\text{ V}$ , $I_{OUT} = 10\text{ mA}$ ,<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$ , $T_a = 25^\circ\text{C}$ (Note 3)                  | —                           | 35       | —   | $\mu\text{V}_{rms}$   |    |
| Ripple rejection ratio  | R.R.               | $V_{IN} = V_{OUT} + 1\text{ V}$ , $I_{OUT} = 10\text{ mA}$ ,<br>$f = 1\text{ kHz}$ , $V_{Ripple} = 500\text{ mV}_{p-p}$ ,<br>$T_a = 25^\circ\text{C}$ (Note 3) | —                           | 73       | —   | dB                    |    |
| Load transient response | $\Delta V_{OUT}$   | $I_{OUT} = 1\text{ mA} \leftrightarrow 150\text{ mA}$ , $C_{OUT} = 1.0\text{ }\mu\text{F}$   | —                           | $\pm 55$ | —   | mV                    |    |
| Control voltage (ON)    | $V_{CT}$ (ON)      | —  | 1.0                         | —        | 5.5 | V                     |    |
| Control voltage (OFF)   | $V_{CT}$ (OFF)     | —  | 0                           | —        | 0.4 | V                     |    |

Note 2: Stable state with fixed  $I_{OUT}$  condition

Note 3: The 2.5 V output product

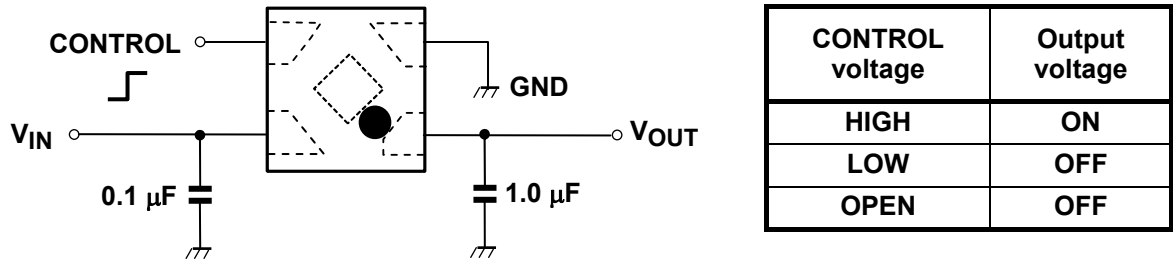
## Drop-out voltage for different output voltages

( $I_{OUT} = 150\text{ mA}$ ,  $C_{IN} = 0.1\text{ }\mu\text{F}$ ,  $C_{OUT} = 1.0\text{ }\mu\text{F}$ ,  $T_j = 25^\circ\text{C}$ )

| Output voltages                               | Symbol             | Min | Typ. | Max | Unit |
|---|--------------------|-----|------|-----|------|
| 1.0 V, 1.05 V                                 | $V_{IN} - V_{OUT}$ | —   | 490  | 750 | mV   |
| 1.1 V, 1.15 V                                 |                    | —   | 420  | 650 |      |
| 1.2 V, 1.25 V                                 |                    | —   | 360  | 550 |      |
| 1.3 V   |                    | —   | 330  | 450 |      |
| 1.4 V   |                    | —   | 290  | 400 |      |
| $1.5\text{ V} \leq V_{OUT} < 1.8\text{ V}$    |                    | —   | 270  | 370 |      |
| $1.8\text{ V} \leq V_{OUT} < 2.5\text{ V}$    |                    | —   | 210  | 290 |      |
| $2.5\text{ V} \leq V_{OUT} < 3.0\text{ V}$    |                    | —   | 160  | 210 |      |
| $3.0\text{ V} \leq V_{OUT} \leq 3.6\text{ V}$ |                    | —   | 130  | 180 |      |

**Application Note**

**1. Recommended Application Circuit**



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

**2. Power Dissipation**

Power dissipation is measured on the board condition shown below.

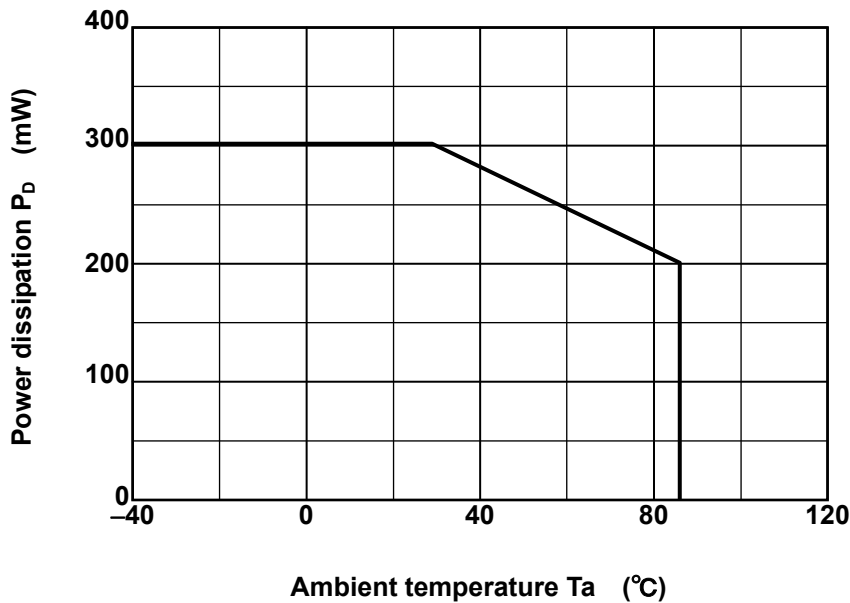
[The Board Condition]

Board material: Glass epoxy(FR4)

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

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

Through hole: diameter 0.5mm x 24

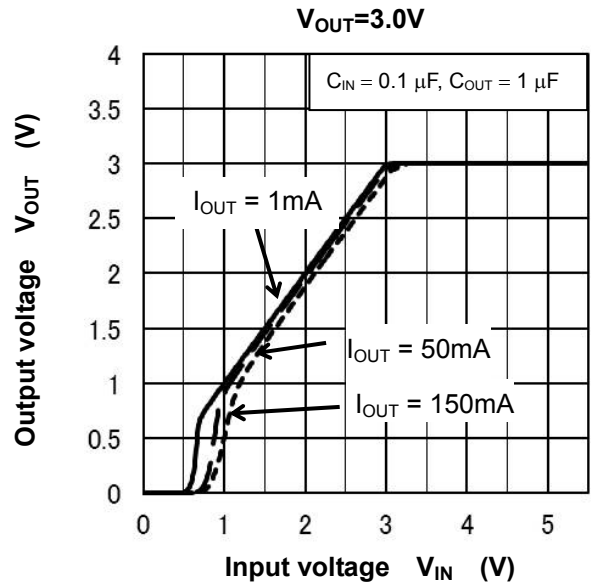
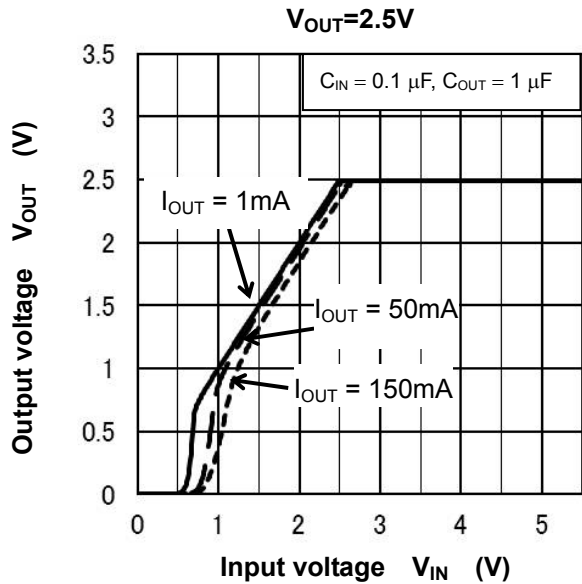
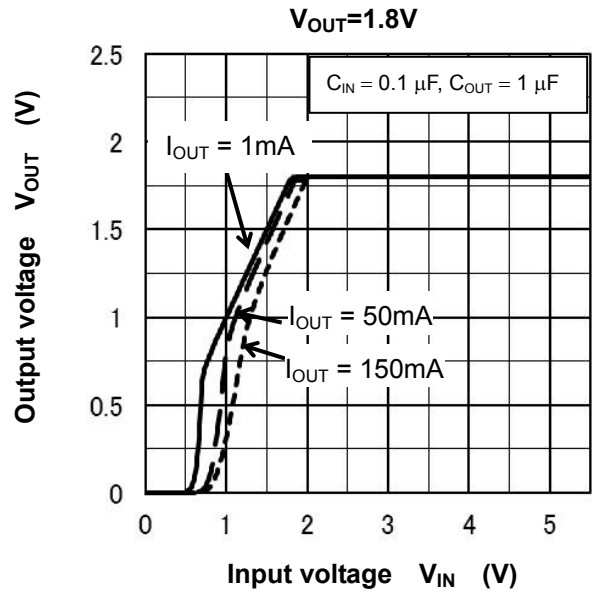
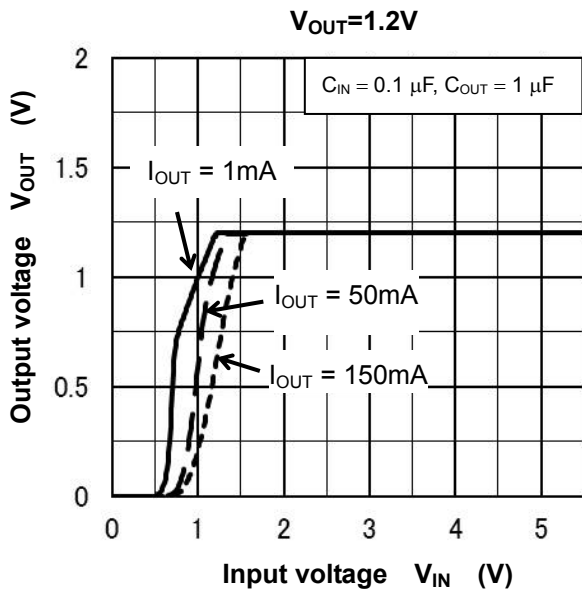


## Usage Considerations

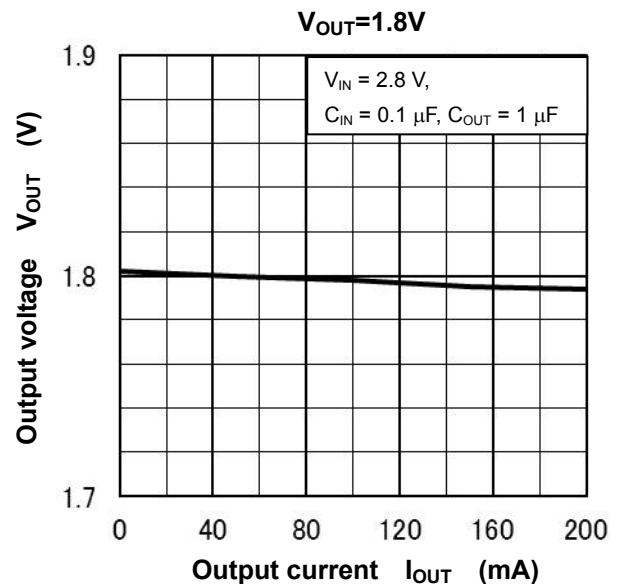
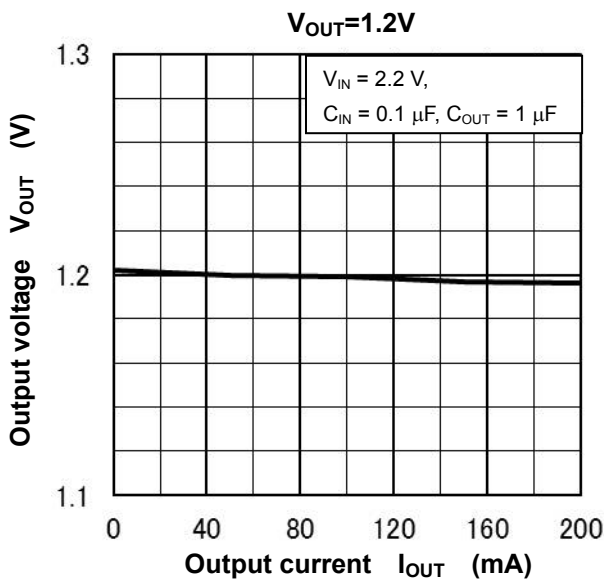
- **Output Capacitors**  
Ceramic capacitors can be used for these devices. However, because of the type of the capacitors, there might be unexpected thermal features. Please consider application condition for selecting capacitors. And Toshiba recommend the ESR of ceramic capacitor is under 10  $\Omega$ .
- **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 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 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.
- **Overcurrent Protection Circuit**  
Overcurrent protection circuit is designed in these products, but this does not assure for the suppression of uprising device operation. If output pins and GND pins are shorted out, these products might be break down. 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.

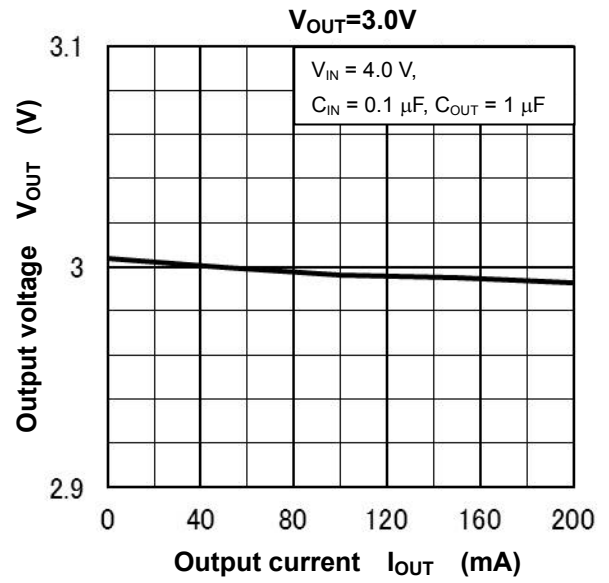
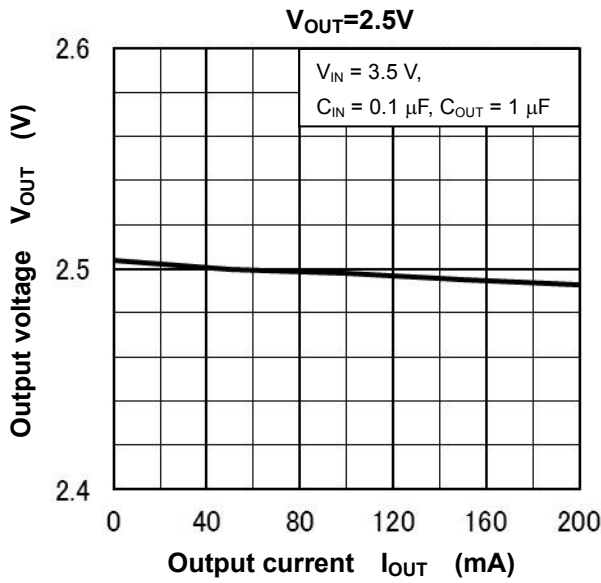
**Representative Typical Characteristics**

**1) Output Voltage vs. Input Voltage**

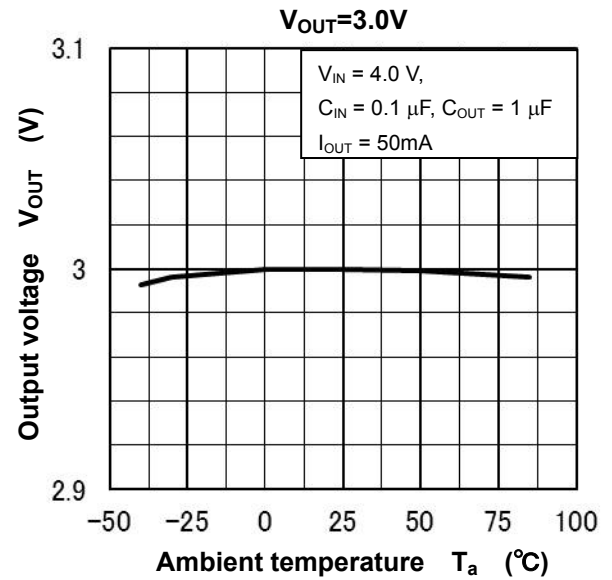
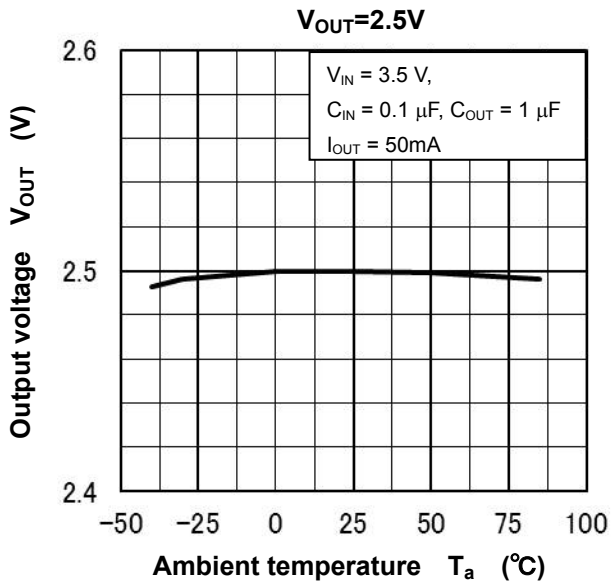
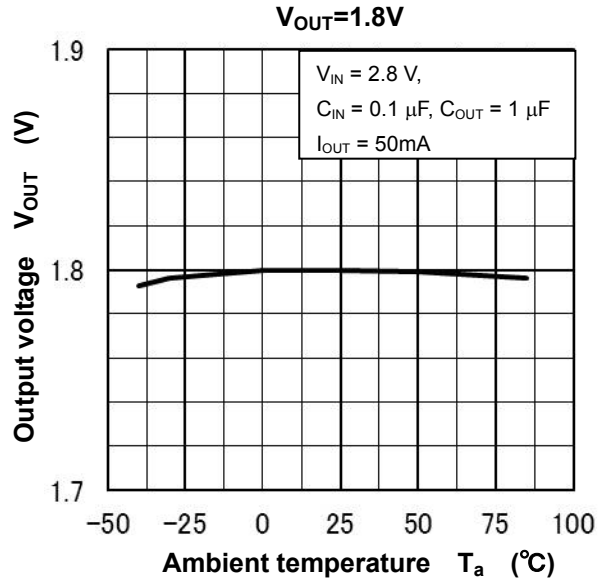
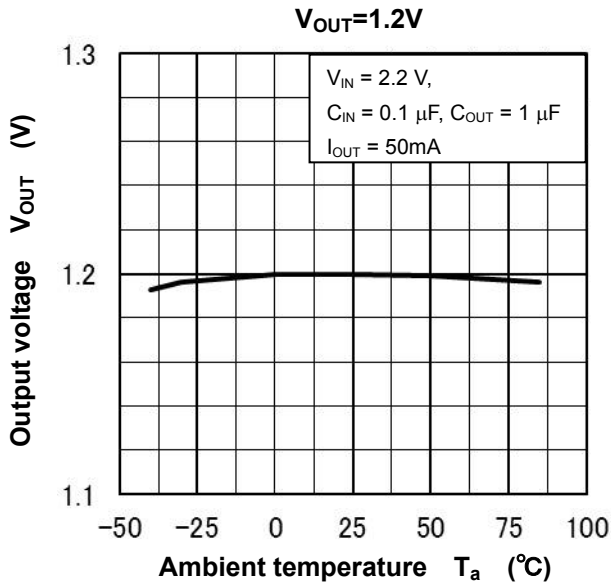


**2) Output Voltage vs. Output Current**



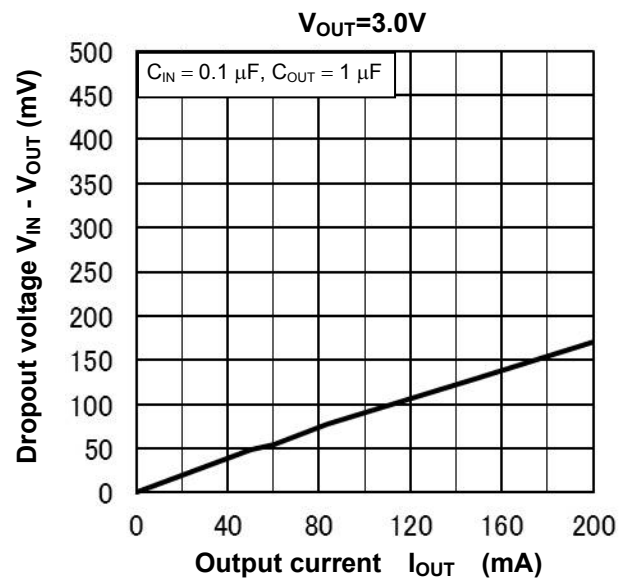
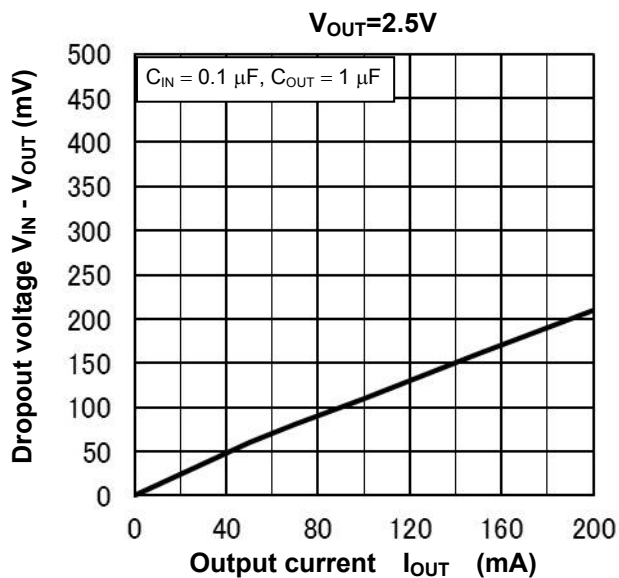
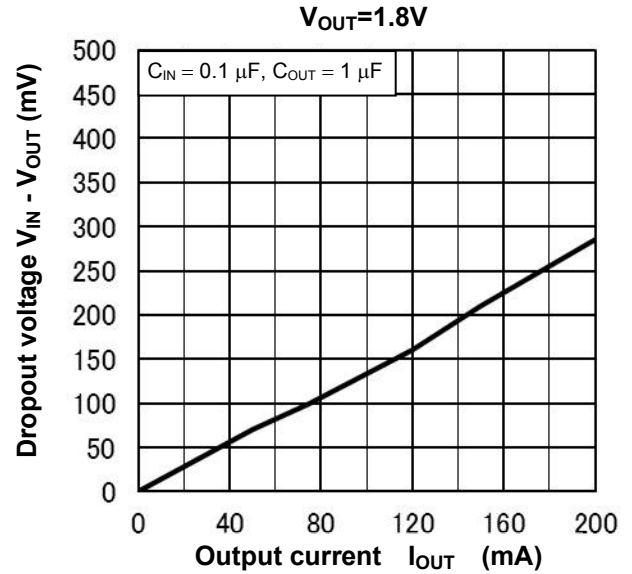
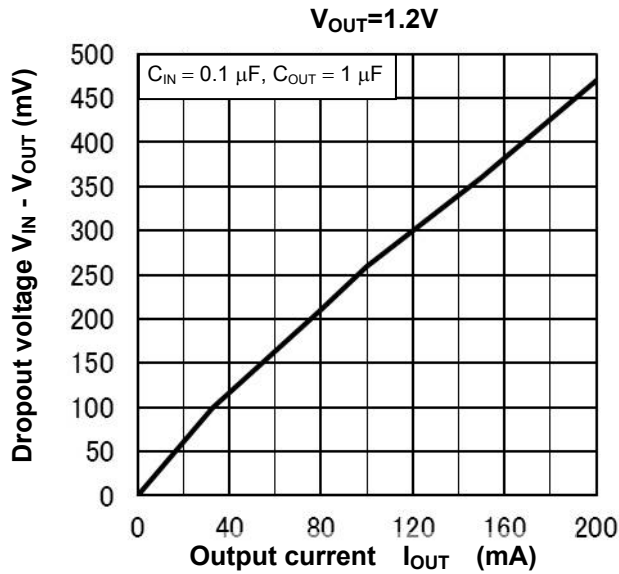


**3) Output Voltage vs. Ambient Temperature**

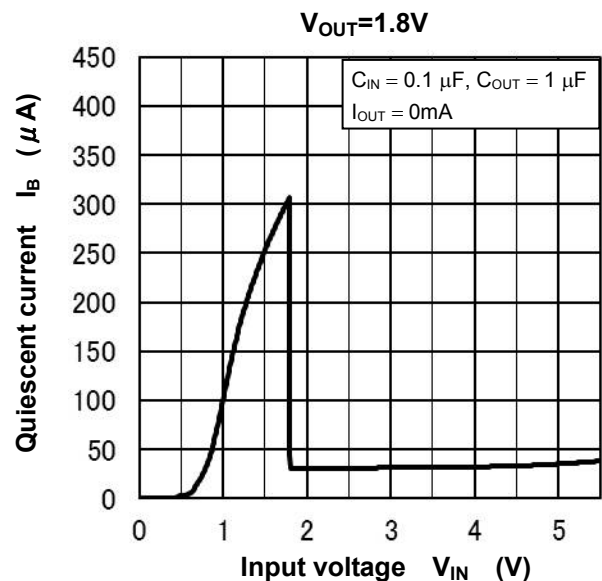
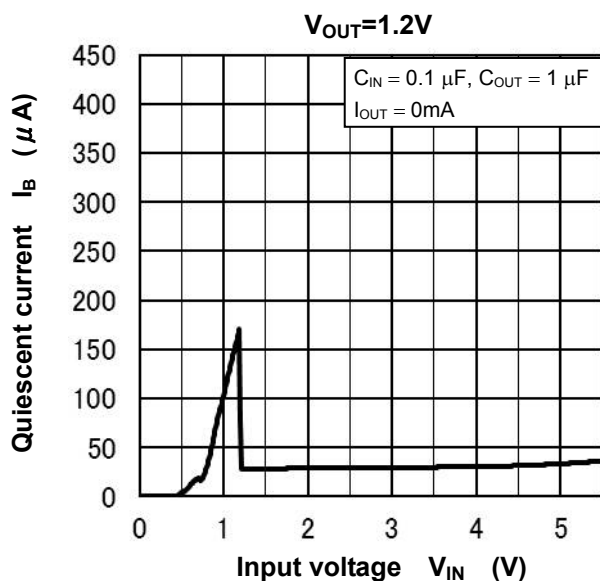


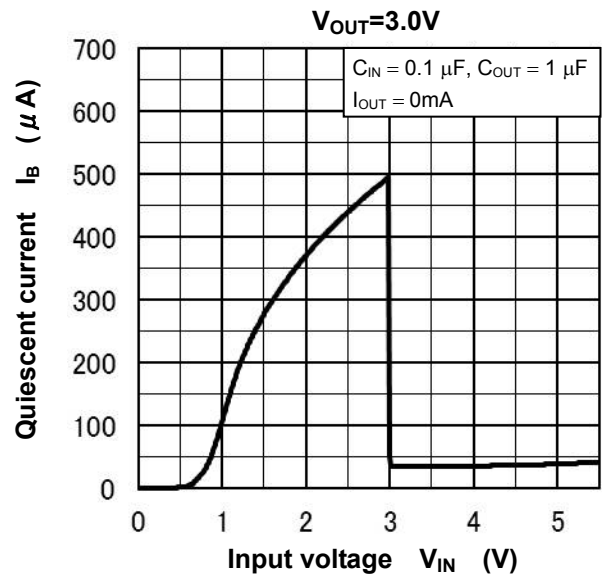
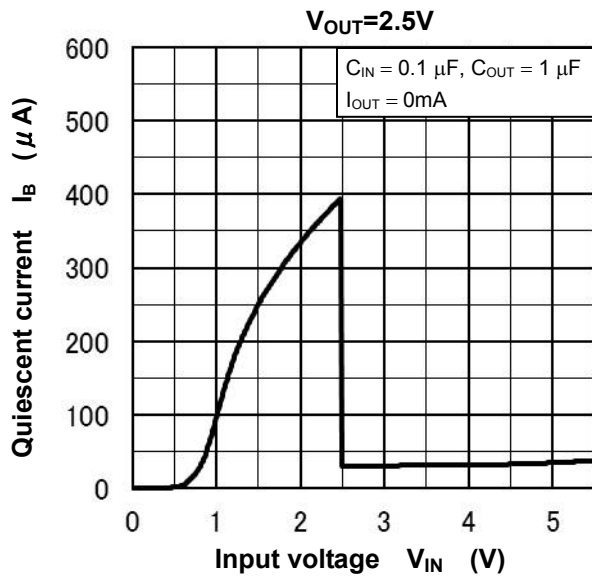


### 4) Dropout Voltage vs. Output Current

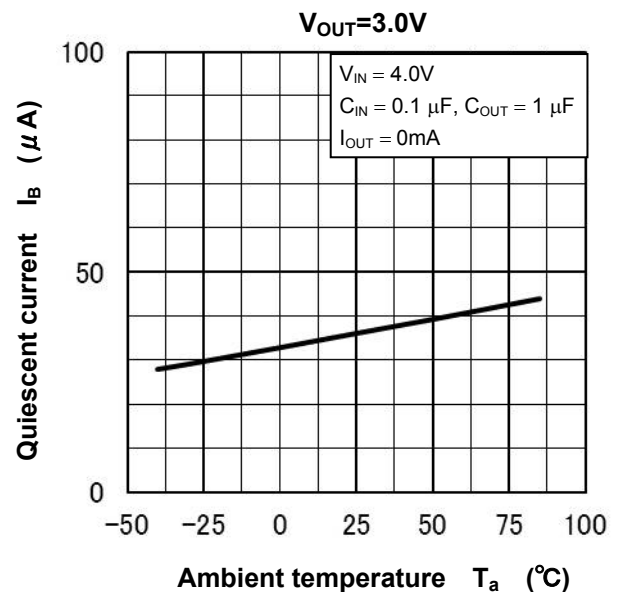
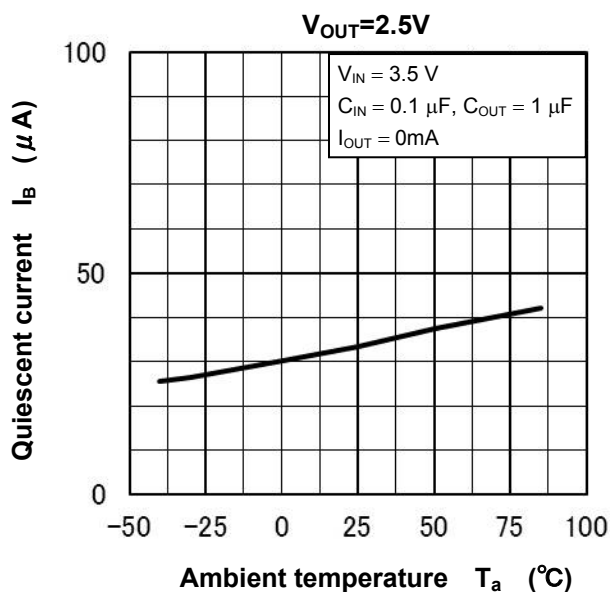
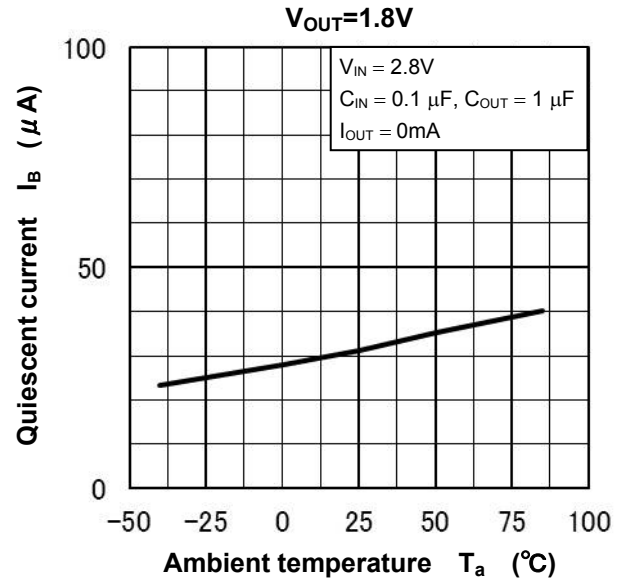
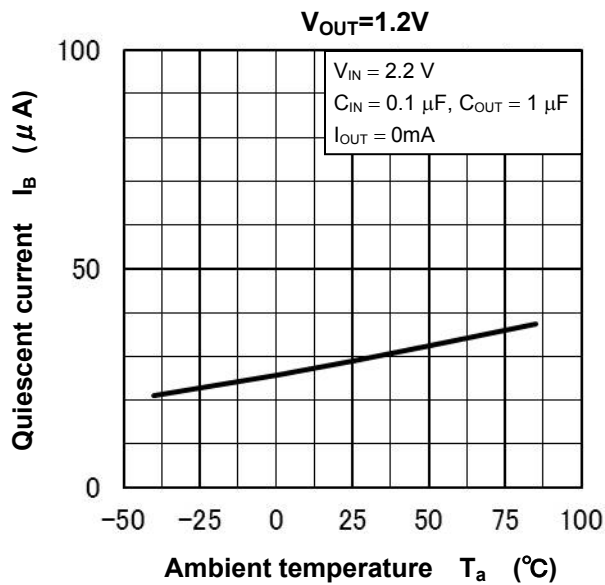


### 5) Quiescent Current vs. Input Voltage

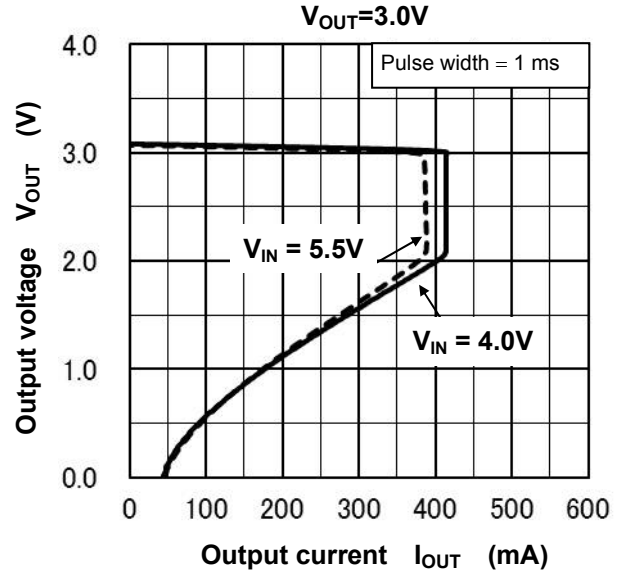
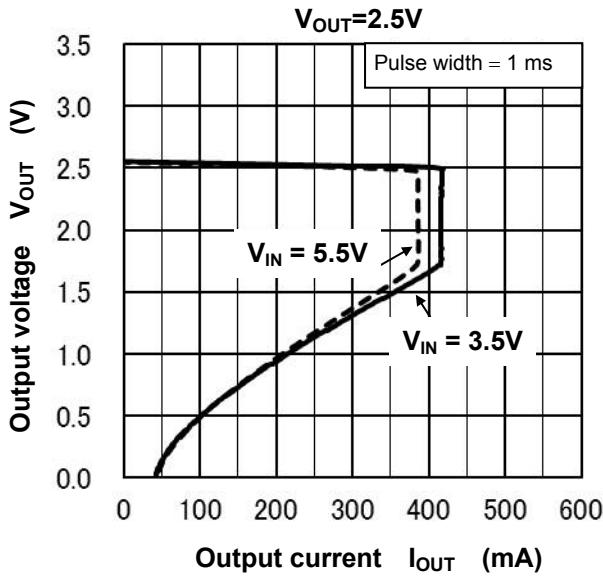
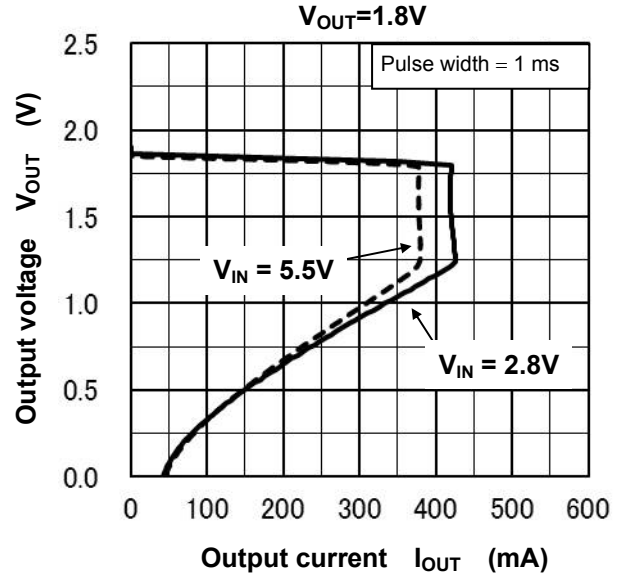
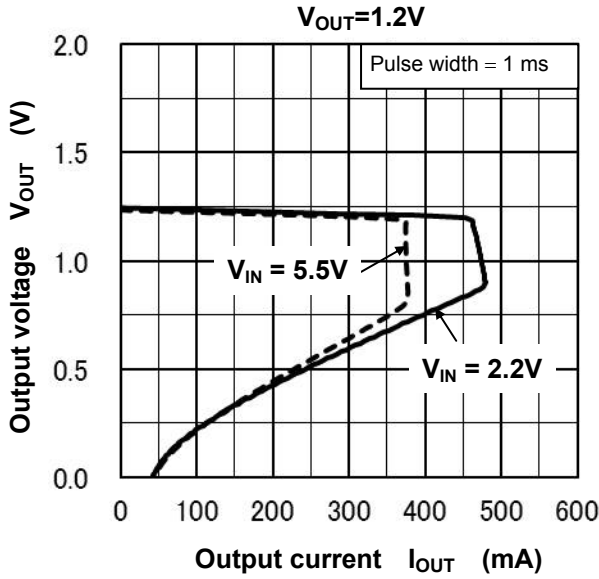




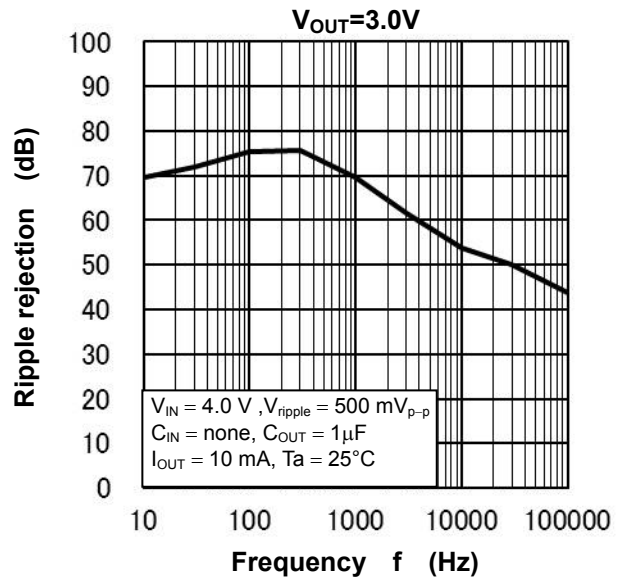
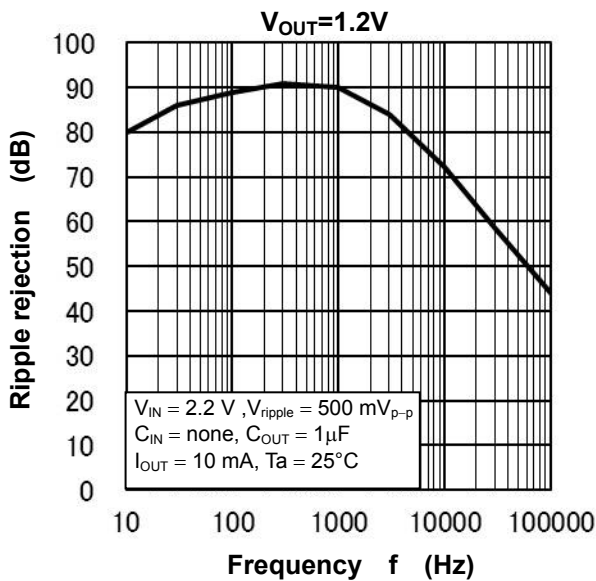
## 6) Quiescent Current vs. Ambient Temperature



7) Output Voltage vs. Output Current

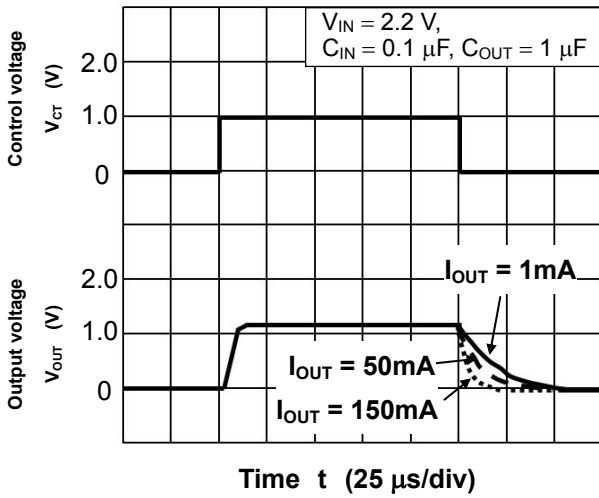


8) Ripple Rejection Ratio vs. Frequency

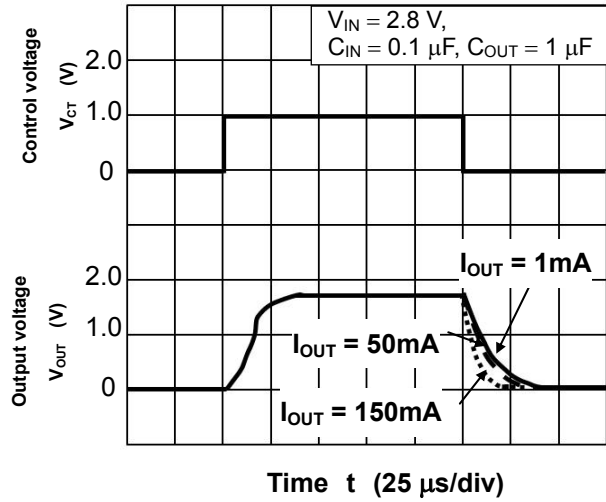


## 9) Control Transient Response

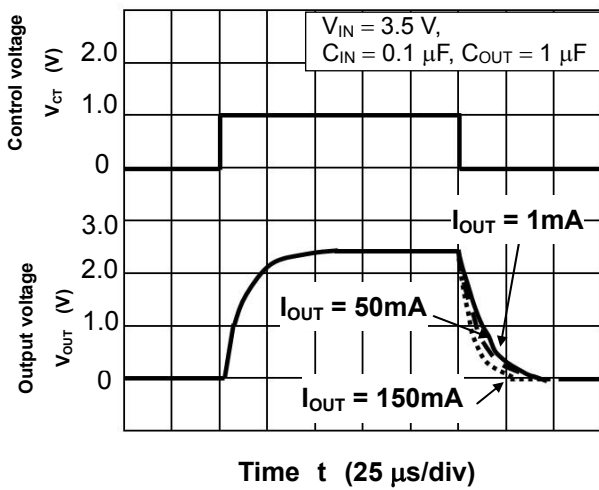
$V_{OUT}=1.2V$



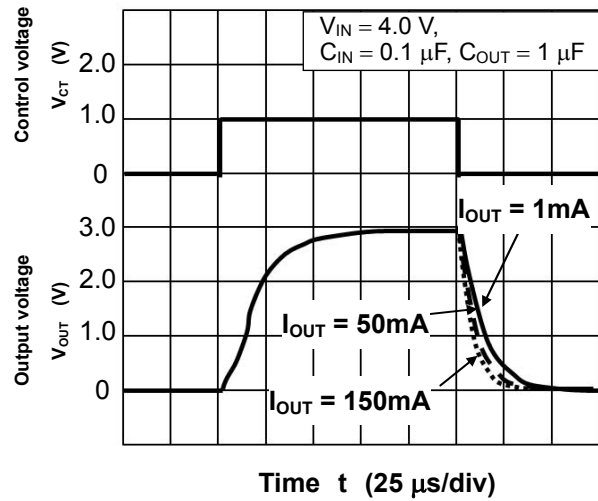
$V_{OUT}=1.8V$



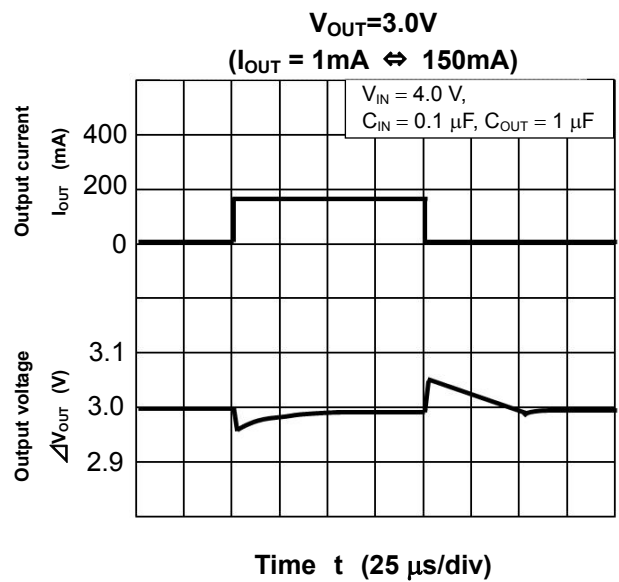
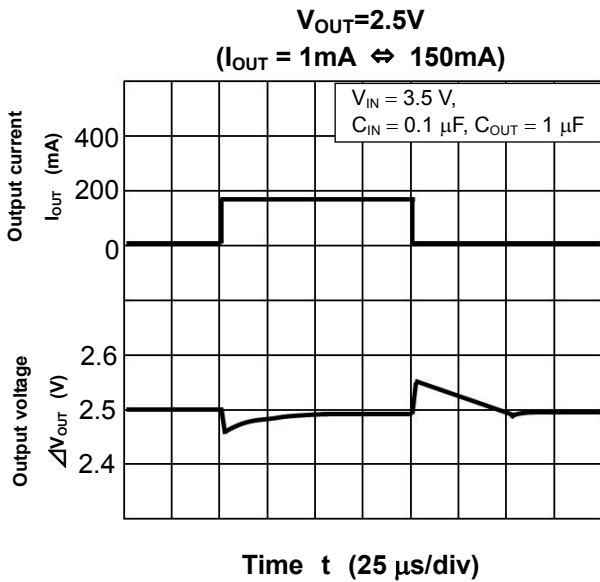
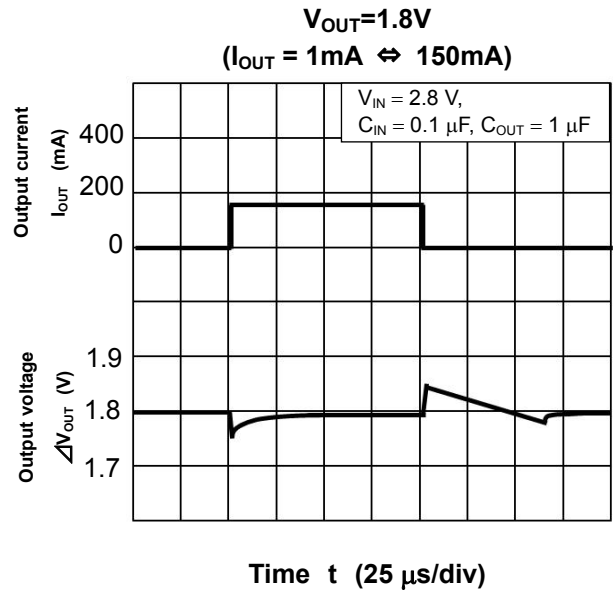
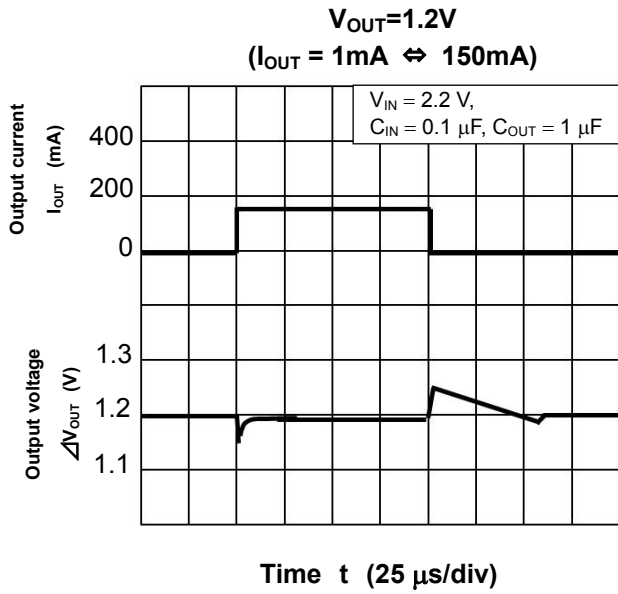
$V_{OUT}=2.5V$



$V_{OUT}=3.0V$



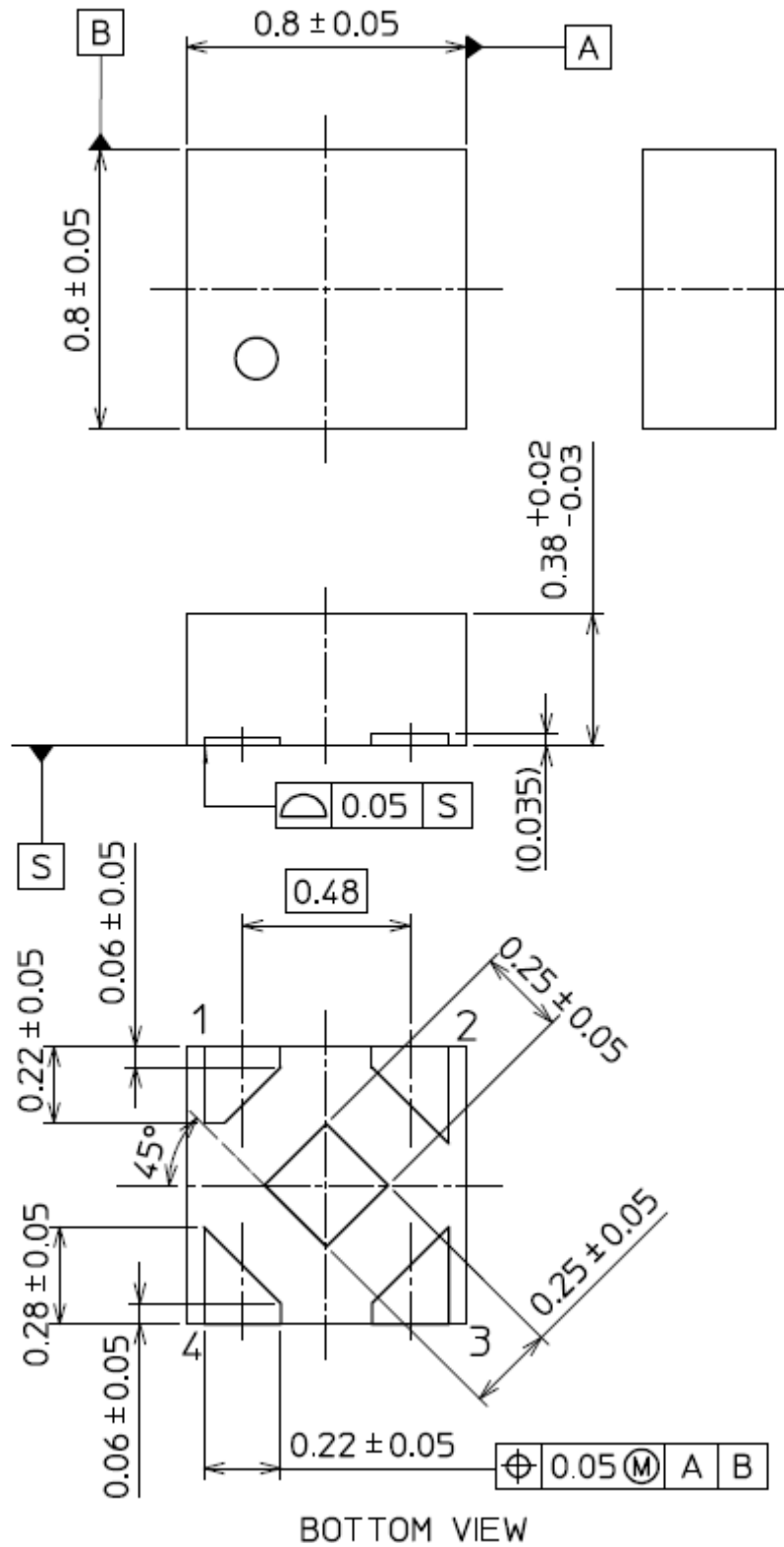
## 10) Load Transient Response



**Package Dimensions**

SDFN4

Unit:mm



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

Weight : 0.6 mg ( typ.)

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