

TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR4DG series

420 mA CMOS Low Drop-Out Regulator with inrush current protection circuit

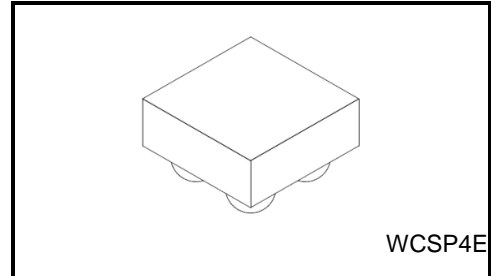
The TCR4DG series are CMOS general-purpose single-output voltage regulators with an on/off control input, featuring low dropout voltage, low output noise voltage and low inrush current.

These voltage regulators are available in fixed output voltages between 1.0 V and 4.5 V and capable of driving up to 420 mA.

They feature over-current protection, over-temperature protection, Inrush current protection circuit and Auto-discharge function.

The TCR4DG series are offered in the ultra small plastic mold package WCSP4E (0.645 mm x 0.645 mm; t 0.43 mm (max)). It has a low dropout voltage of 193 mV (3.3 V output, $I_{OUT} = 420$ mA) with low output noise voltage of 38 μV_{rms} (2.5 V output) and a load transient response of only $\Delta V_{OUT} = \pm 115$ mV ($I_{OUT} = 1$ mA \leftrightarrow 420 mA, $C_{OUT} = 1.0$ μF).

As small ceramic input and output capacitors can be used with the TCR4DG series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones.



Weight: 0.34 mg (typ.)

Features

- Low Drop-Out voltage
VDO = 193 mV (typ.) at 3.3 V-output, $I_{OUT} = 420$ mA
- Low output noise voltage
 $V_{NO} = 38$ μV_{rms} (typ.) at 2.5 V-output, $I_{OUT} = 10$ mA, 10 Hz $\leq f \leq 100$ kHz
- Fast load transient response ($\Delta V_{OUT} = \pm 115$ mV (typ.) at $I_{OUT} = 1 \leftrightarrow 420$ mA, $C_{OUT} = 1.0$ μF)
- High ripple rejection (R.R = 70 dB (typ.) at 2.5 V-output, $I_{OUT} = 10$ mA, $f = 1$ kHz)
- Over-current protection
- Over-temperature protection
- Inrush current protection circuit
- Auto-discharge function
- Pull down connection between CONTROL and GND
- Ceramic capacitors can be used ($C_{IN} = 1.0$ μF , $C_{OUT} = 1.0$ μF)
- Ultra small package WCSP4E (0.645 mm x 0.645 mm ; t 0.43 mm (max))

Start of commercial production
2017-04

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 current | I _{OUT} | 420 | 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

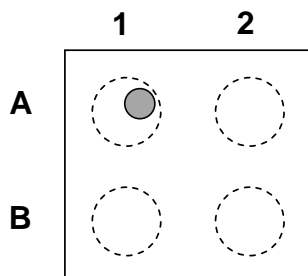
Board material: Glass epoxy(FR4)

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: diameter 0.5 mm x 24

Pin Assignment (Top view)



| | 1 | 2 |
|---|-----------------|------------------|
| A | V _{IN} | V _{OUT} |
| B | CONTROL | GND |

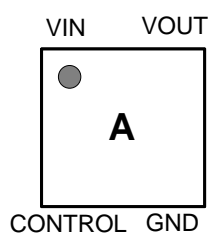
List of Products Number, Output voltage and Marking

| Product No. | Output voltage (V)(typ.) | Marking | Product No. | Output voltage (V)(typ.) | Marking |
|-------------|-----------------------------|---------|-------------|-----------------------------|---------|
| TCR4DG10 | 1.0 | A | TCR4DG25 | 2.5 | T |
| TCR4DG105 | 1.05 | B | TCR4DG27 | 2.7 | U |
| TCR4DG11 | 1.1 | C | TCR4DG275 | 2.75 | V |
| TCR4DG115 | 1.15 | D | TCR4DG28 | 2.8 | W |
| TCR4DG12 | 1.2 | E | TCR4DG285 | 2.85 | X |
| TCR4DG125 | 1.25 | F | TCR4DG29 | 2.9 | Y |
| TCR4DG13 | 1.3 | H | TCR4DG30 | 3.0 | 0 |
| TCR4DG135 | 1.35 | J | TCR4DG31 | 3.1 | 1 |
| TCR4DG15 | 1.5 | K | TCR4DG32 | 3.2 | 2 |
| TCR4DG175 | 1.75 | L | TCR4DG325 | 3.25 | 3 |
| TCR4DG18 | 1.8 | M | TCR4DG33 | 3.3 | 4 |
| TCR4DG185 | 1.85 | N | TCR4DG35 | 3.5 | 5 |
| TCR4DG19 | 1.9 | P | TCR4DG36 | 3.6 | 6 |
| TCR4DG23 | 2.3 | R | TCR4DG42 | 4.2 | 7 |
| TCR4DG245 | 2.45 | S | TCR4DG45 | 4.5 | 8 |

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

Top Marking (top view)

Example: TCR4DG10 (1.0 V output)



Electrical Characteristics

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

| Characteristics | Symbol | Test Condition | Min | Typ. | Max | Unit | |
|-------------------------|------------------|--|-----------------------------|-----------|-----|-----------------------|---------------|
| Output voltage accuracy | V_{OUT} | $I_{OUT} = 50\text{ mA}$ (Note 2) | $V_{OUT} < 1.8\text{ V}$ | -18 | — | +18 | mV |
| | | | $1.8\text{ V} \leq V_{OUT}$ | -1.0 | — | +1.0 | % |
| Input voltage | V_{IN} | $I_{OUT} = 1\text{ mA}$ (Note 3) | $V_{OUT} + V_{DO}$ | — | 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 | $1\text{ mA} \leq I_{OUT} \leq 420\text{ mA}$ | — | 6 | 35 | mV | |
| Quiescent current | I_B | $I_{OUT} = 0\text{ mA}$ | $V_{OUT} = 1.0\text{ V}$ | — | 65 | — | μA |
| | | | $V_{OUT} = 1.8\text{ V}$ | — | 65 | — | |
| | | | $V_{OUT} = 2.5\text{ V}$ | — | 68 | — | |
| | | | $V_{OUT} = 4.5\text{ V}$ | — | 78 | 125 | |
| Stand-by current | I_B (OFF) | $V_{CT} = 0\text{ V}$ | — | 0.1 | 1 | μA | |
| Drop-out voltage | V_{DO} | $I_{OUT} = 420\text{ mA}$ (Note 4) | — | 193 | 263 | 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} | $V_{IN} = V_{OUT} + 1\text{ V}$, $I_{OUT} = 10\text{ mA}$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$, $T_a = 25^\circ\text{C}$ (Note 5) | — | 38 | — | μV_{rms} | |
| Ripple rejection ratio | R.R. | $V_{IN} = V_{OUT} + 1\text{ V}$, $I_{OUT} = 10\text{ mA}$, $f = 1\text{ kHz}$, $V_{Ripple} = 500\text{ mV}_{p-p}$, $T_a = 25^\circ\text{C}$ (Note 5) | — | 70 | — | dB | |
| Load transient response | ΔV_{OUT} | $I_{OUT} = 1 \Leftrightarrow 420\text{ mA}$, $C_{OUT} = 1.0\text{ }\mu\text{F}$ | — | ± 115 | — | 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: Please refer to Dropout Voltage table (Page 4), and use it within the limits of absolute maximum rating T_{opr} and T_j .

Note 4: The 3.3 V output product. Dropout voltage is the voltage difference between the V_{IN} and V_{OUT} at which V_{OUT} drops to 2% below its nominal value.

Note 5: The 2.5 V output product.

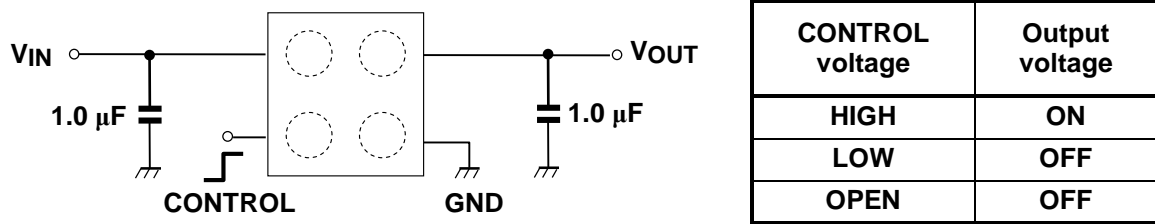
Drop-out voltage

($I_{OUT} = 420\text{ mA}$, $C_{IN} = 1.0\text{ }\mu\text{F}$, $C_{OUT} = 1.0\text{ }\mu\text{F}$, $T_j = 25^\circ\text{C}$)

| Output voltages | Symbol | Min | Typ. | Max | Unit |
|---|----------|-----|------|-----|------|
| 1.0 V, 1.05 V | V_{DO} | — | 767 | 991 | mV |
| 1.1 V, 1.15V | | — | 711 | 851 | |
| 1.2 V, 1.25V | | — | 627 | 781 | |
| 1.3 V | | — | 571 | 711 | |
| 1.35 V | | — | 515 | 683 | |
| 1.4 V | | — | 487 | 669 | |
| $1.5\text{ V} \leq V_{OUT} < 1.8\text{ V}$ | | — | 431 | 571 | |
| $1.8\text{ V} \leq V_{OUT} < 2.1\text{ V}$ | | — | 319 | 473 | |
| $2.1\text{ V} \leq V_{OUT} < 2.5\text{ V}$ | | — | 277 | 403 | |
| $2.5\text{ V} \leq V_{OUT} < 2.8\text{ V}$ | | — | 235 | 347 | |
| $2.8\text{ V} \leq V_{OUT} < 3.2\text{ V}$ | | — | 221 | 291 | |
| $3.2\text{ V} \leq V_{OUT} < 3.6\text{ V}$ | | — | 193 | 263 | |
| $3.6\text{ V} \leq V_{OUT} \leq 4.5\text{ V}$ | | — | 151 | 221 | |

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

Board-mounted power dissipation ratings for TCR4DG series are available in the Absolute Maximum Ratings table. Power dissipation is measured on the board condition shown below.

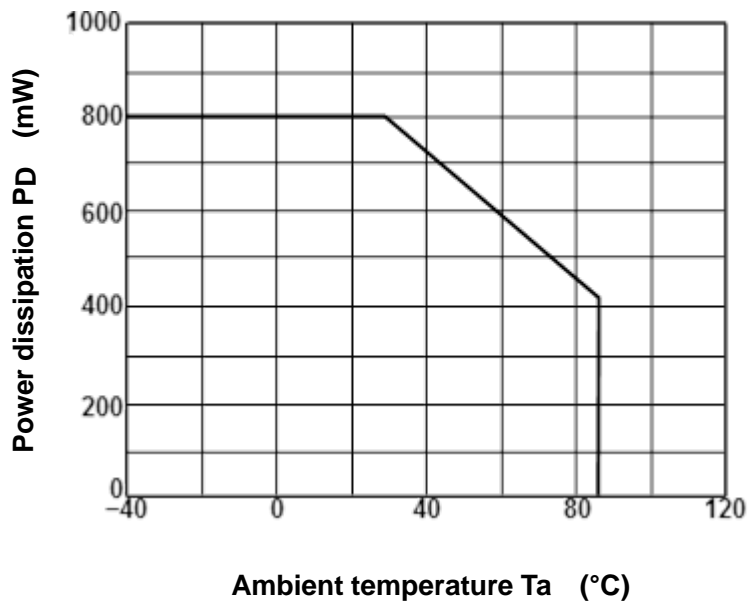
[The Board Condition]

Board material: Glass epoxy(FR4)

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

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

Through hole hall: diameter 0.5mm x 24



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 Ω .

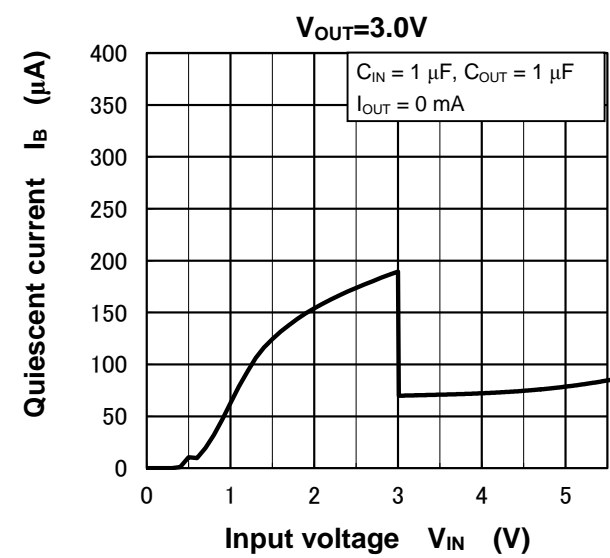
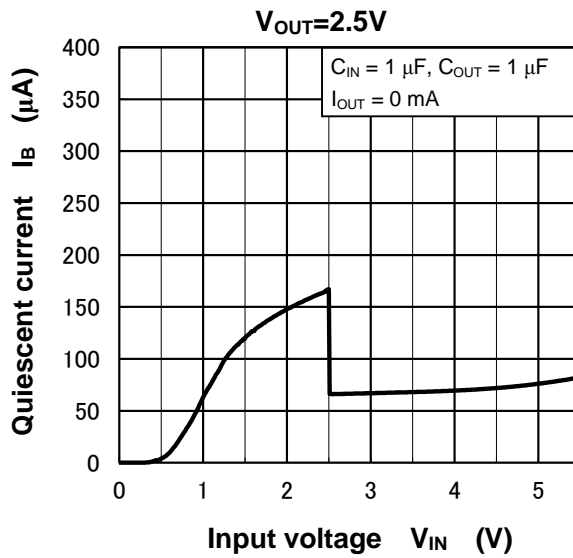
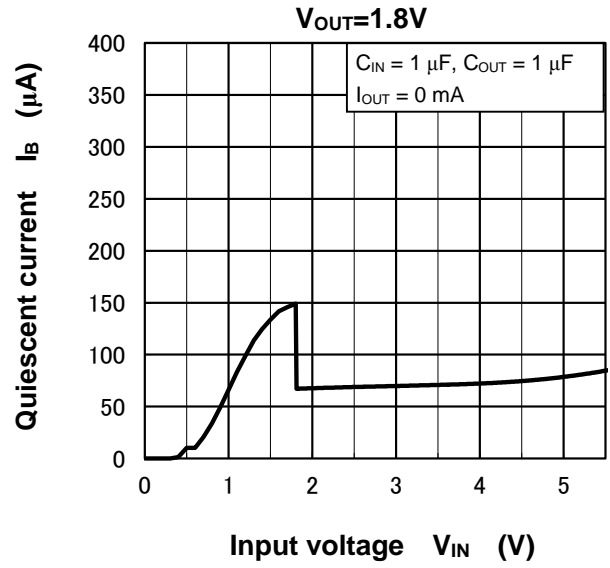
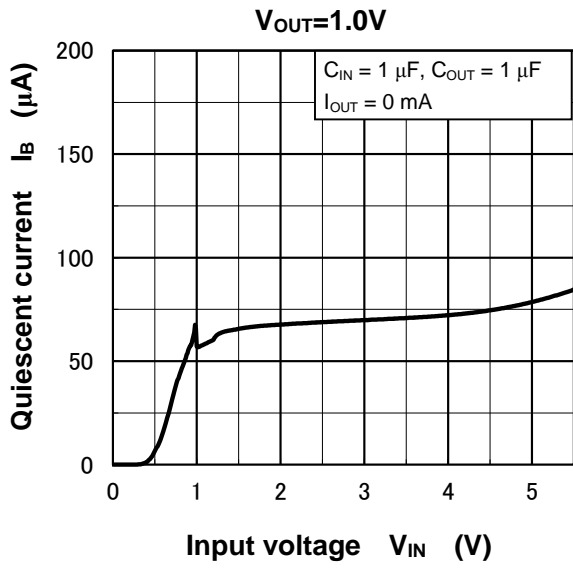
- **Mounting**
The long distance between IC and output capacitor might affect phase assurance by impedance in wire and inductor. For stable power supply, output capacitor need to mount near IC as much as possible. Also VIN and GND pattern need to be large and make the wire impedance small as possible.

- **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.

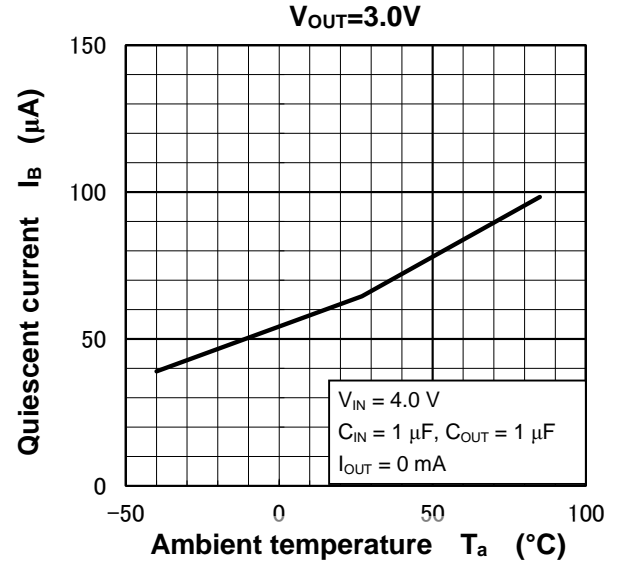
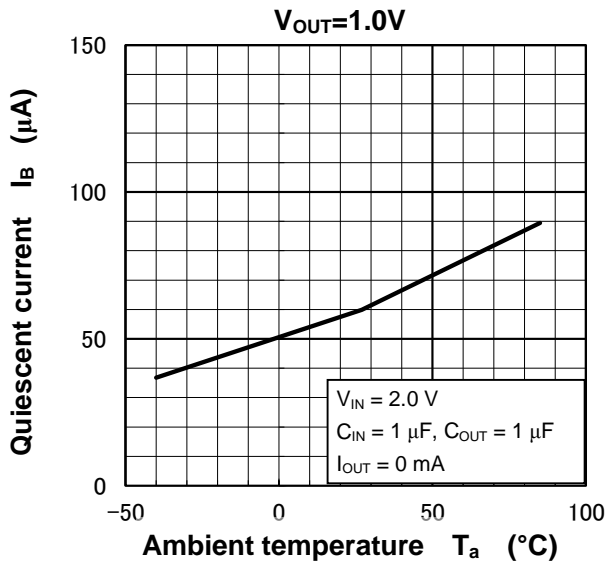
- **Over current Protection and Thermal shut down function**
Over current protection and Thermal shut down function are designed in these products, but these are not designed to constantly ensure the suppression of the device within operation limits. Depending on the condition during actual usage, it 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 be 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 recommend inserting failsafe system into the design.

Representative Typical Characteristics

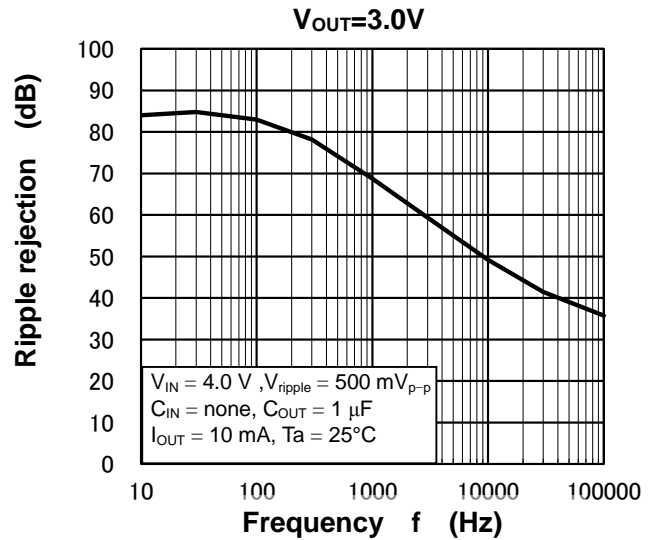
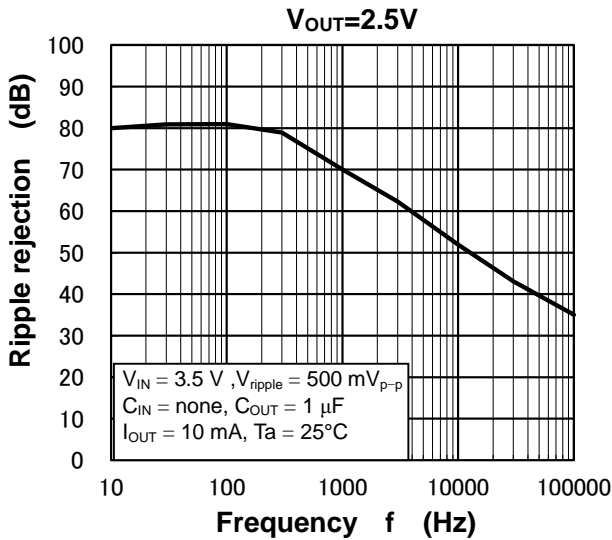
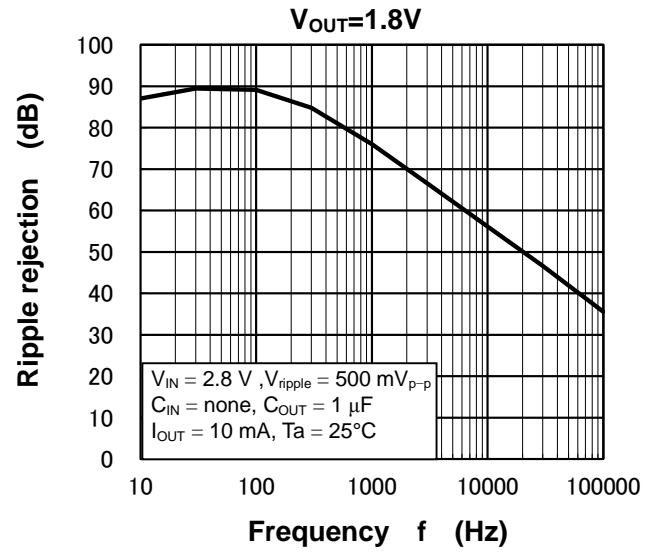
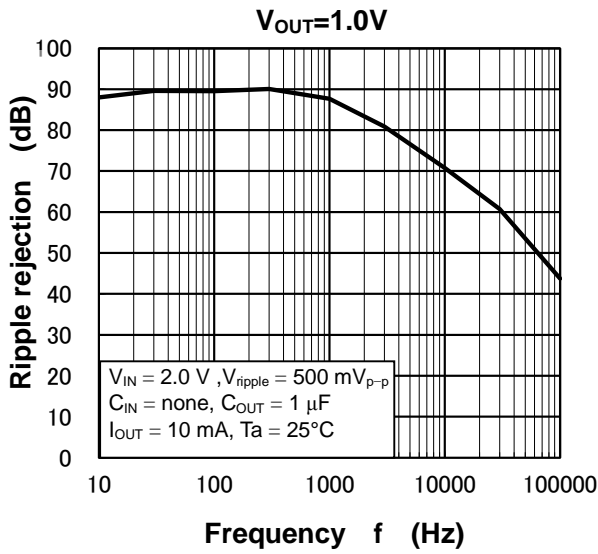
Quiescent Current vs. Input Voltage



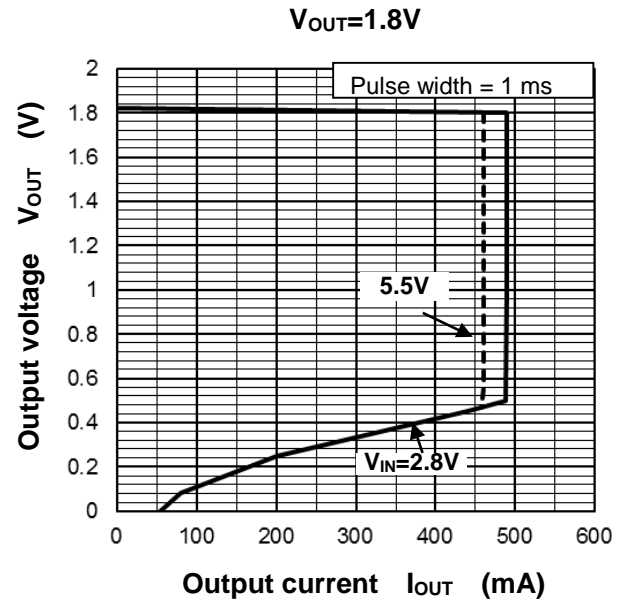
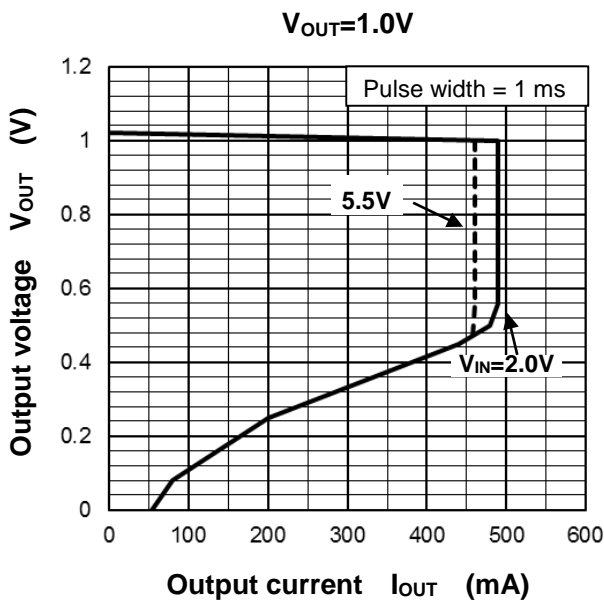
Quiescent Current vs. Ambient Temperature

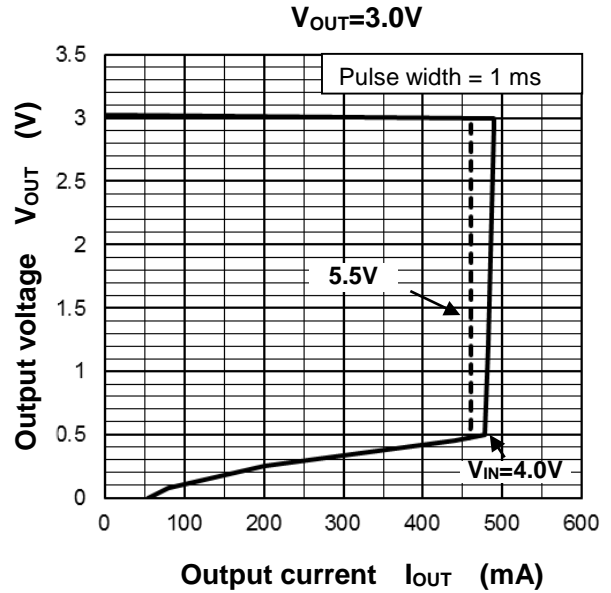
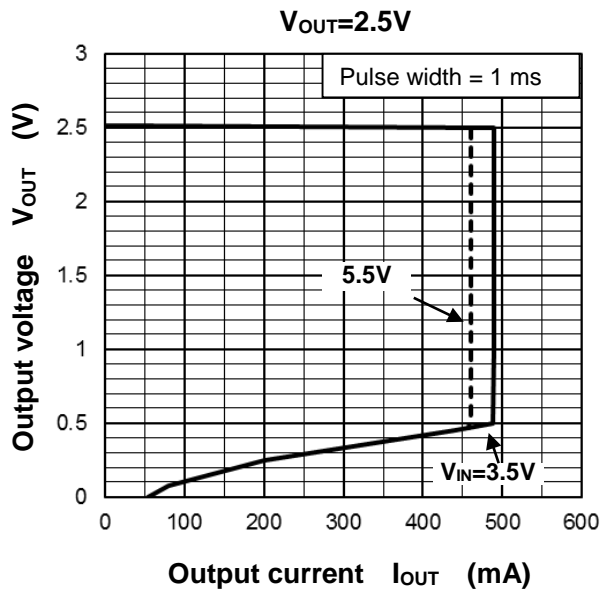


Ripple Rejection Ratio vs. Frequency



Output Voltage vs. Output Current



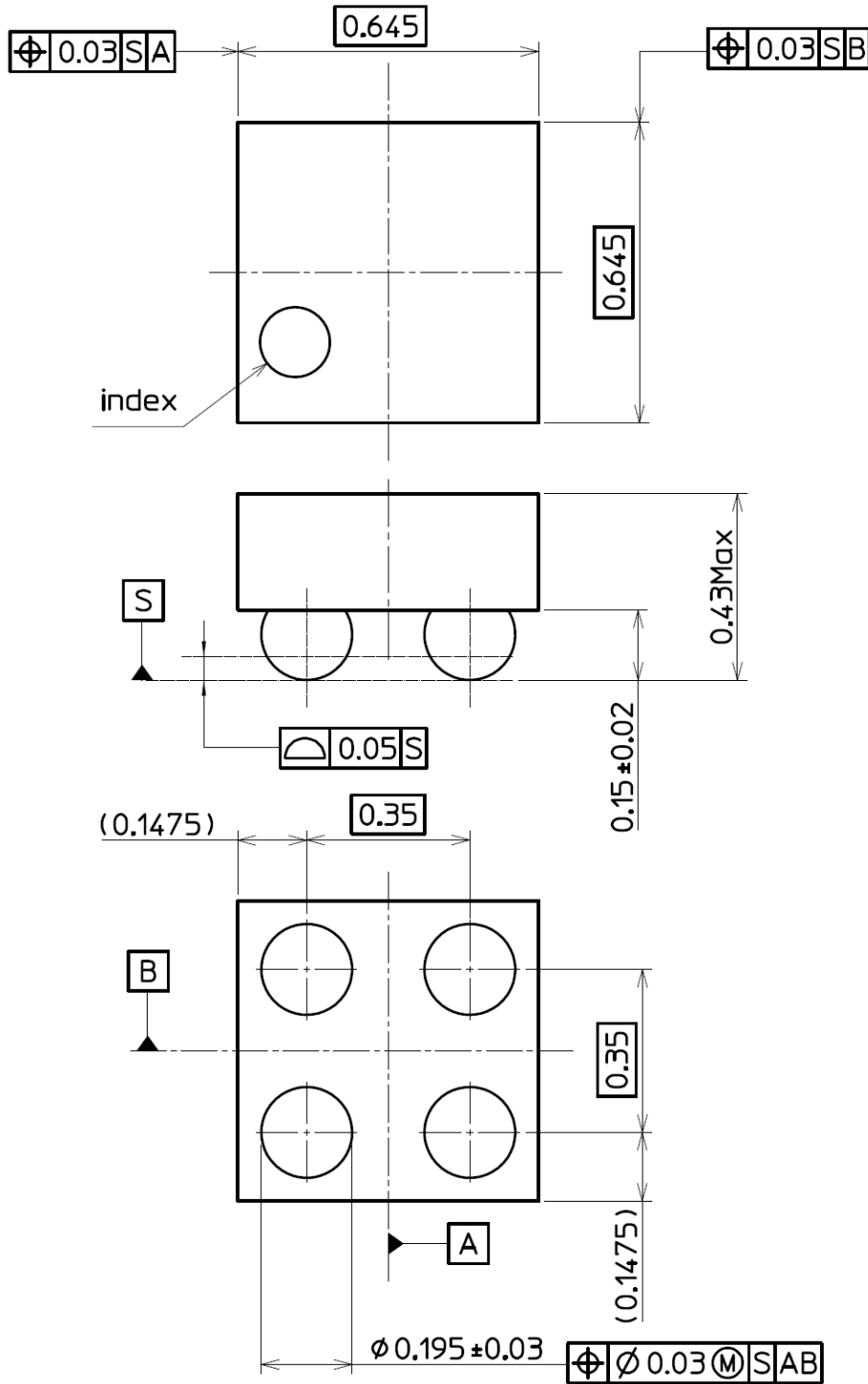


Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

Package Dimensions

WCSP4E

Unit: mm



Weight: 0.34 mg (typ.)

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