TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR4DG series

420 mA CMOS Low Dropout Regulator with inrush current protection circuit

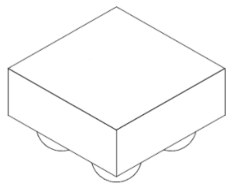
1. Description

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 ΔV_{OUT} = ±115 mV (I_{OUT} = 1 mA ⇔ 420 mA, C_{OUT} = 1.0 μF).



WCSP4E

Weight: 0.34 mg (typ.)

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.

2. Features

- Low Drop-Out voltage
  V_{DO} = 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 ≤ f ≤ 100 kHz
- Fast load transient response (ΔV_{OUT} = ±115 mV (typ.) at I_{OUT} = 1 ⇔ 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} = 1.0μF, 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

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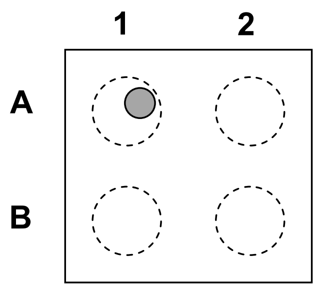
3. Absolute Maximum Ratings (Note) (Ta = 25°C)

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 pcs

4. Pin Assignment (Top view)



	1	2
A	VIN	VOUT
B	CONTROL	GND

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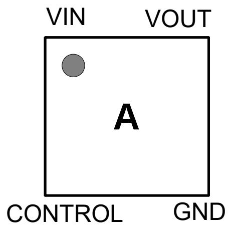
5. List of Products Number, Output voltage and Marking

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

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

Top Marking (Top view)

Example: TCR4DG10 (1.0 V output)



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6. Electrical Characteristics

(Unless otherwise specified, V_{IN} = V_{OUT} + 1 V, I_{OUT} = 50 mA, C_{IN} = 1.0 μF, C_{OUT} = 1.0 μF, T_j = 25°C)

Characteristics	Symbol	Test Condition		Min	Typ.	Max	Unit
Output voltage accuracy	V_{OUT}	I_{OUT} = 50 mA (Note 2)	V_{OUT} < 1.8 V	-18	—	+18	mV
			1.8 V ≤ V_{OUT}	-1.0	—	+1.0	%
Input voltage	V_{IN}	I_{OUT} = 1 mA (Note 3)		V_{OUT} + V_{DO}	—	5.5	V
Line regulation	Reg·line	V_{OUT} + 0.5 V ≤ V_{IN} ≤ 5.5 V, I_{OUT} = 1 mA		—	1	15	mV
Load regulation	Reg·load	1 mA ≤ I_{OUT} ≤ 420 mA		—	6	35	mV
Quiescent current	I_B	I_{OUT} = 0 mA	V_{OUT} = 1.0 V	—	65	—	μA
			V_{OUT} = 1.8 V	—	65	—	
			V_{OUT} = 2.5 V	—	68	—	
			V_{OUT} = 4.5 V	—	78	125	
Stand-by current	$I_{B (OFF)}$	V_{CT} = 0 V		—	0.1	1	μA
Drop-out voltage	V_{DO}	I_{OUT} = 420 mA (Note 4)		—	193	263	mV
Temperature coefficient	T_{CVO}	-40°C ≤ T_{opr} ≤ 85°C		—	75	—	ppm/°C
Output noise voltage	V_{NO}	V_{IN} = V_{OUT} + 1 V, I_{OUT} = 10 mA, 10 Hz ≤ f ≤ 100 kHz, Ta = 25°C (Note 5)		—	38	—	$μV_{rms}$
Ripple rejection ratio	R.R.	V_{IN} = V_{OUT} + 1 V, I_{OUT} = 10 mA, f = 1 kHz, V_{Ripple} = 500 mV_{p-p}, Ta = 25°C (Note 5)		—	70	—	dB
Load transient response	ΔV_{OUT}	I_{OUT} = 1 ⇔ 420 mA, C_{OUT} = 1.0 μF		—	±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.

7. Dropout voltage

(I_{OUT} = 420 mA, C_{IN} = 1.0 μF, C_{OUT} = 1.0 μF, T_j = 25°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 V ≤ V_{OUT} < 1.8 V		—	431	571	
1.8 V ≤ V_{OUT} < 2.1 V		—	319	473	
2.1 V ≤ V_{OUT} < 2.5 V		—	277	403	
2.5 V ≤ V_{OUT} < 2.8 V		—	235	347	
2.8 V ≤ V_{OUT} < 3.2 V		—	221	291	
3.2 V ≤ V_{OUT} < 3.6 V		—	193	263	
3.6 V ≤ V_{OUT} ≤ 4.5 V		—	151	221	

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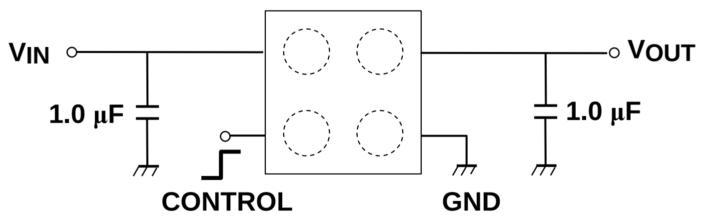
8. Application Note

8.1. Example of Application Circuit



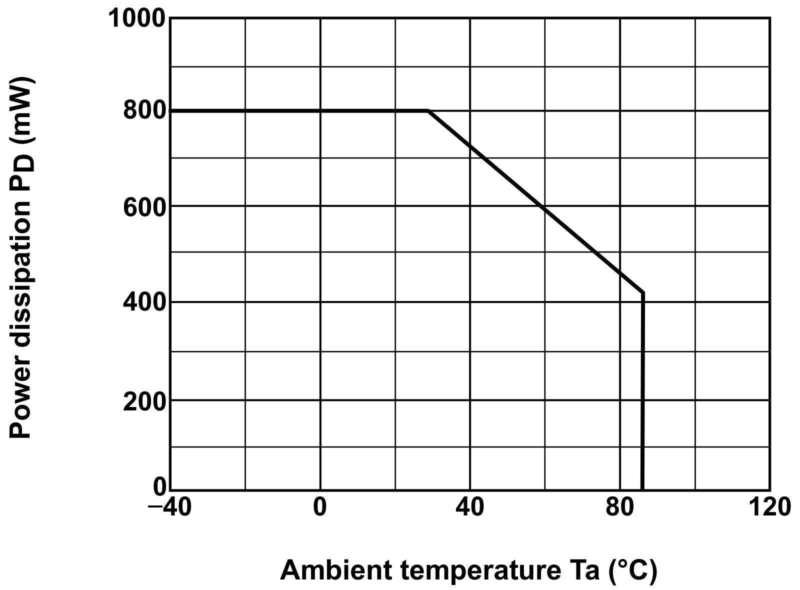
CONTROL voltage	Output voltage
HIGH	ON
LOW	OFF
OPEN	OFF

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).

8.2. 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: 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 0.5mm x 24 pcs



8.3. 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 Ω. For stable operation, we recommend over 1 μF.

- 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.

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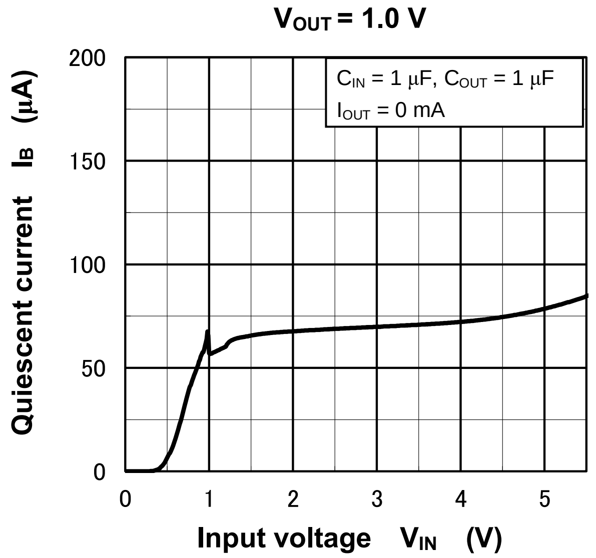
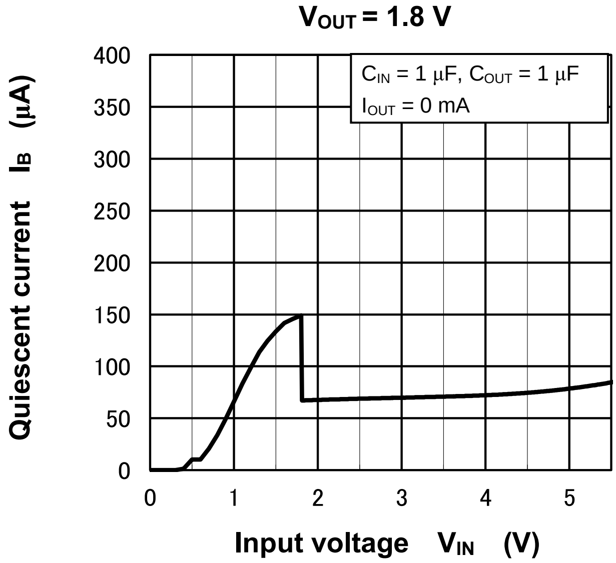
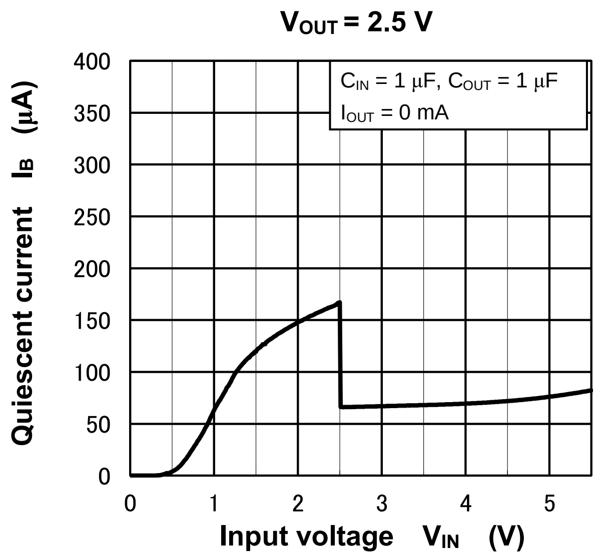
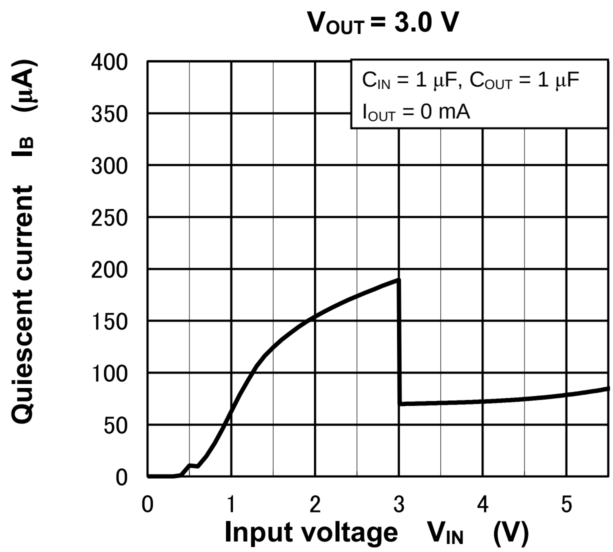
9. Representative Typical Characteristics (Note)

9.1. Output Current vs. Input Voltage

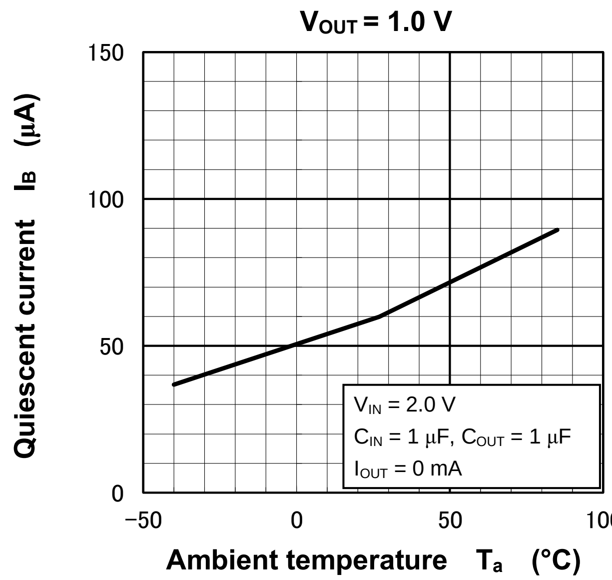


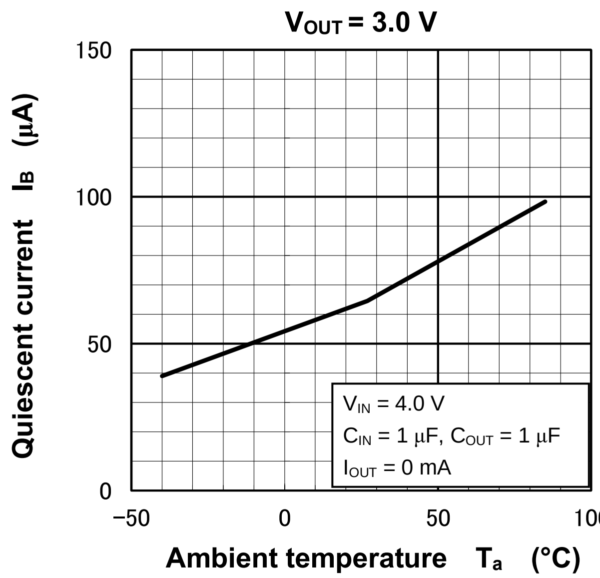






9.2. Quiescent Current vs. Ambient Temperature





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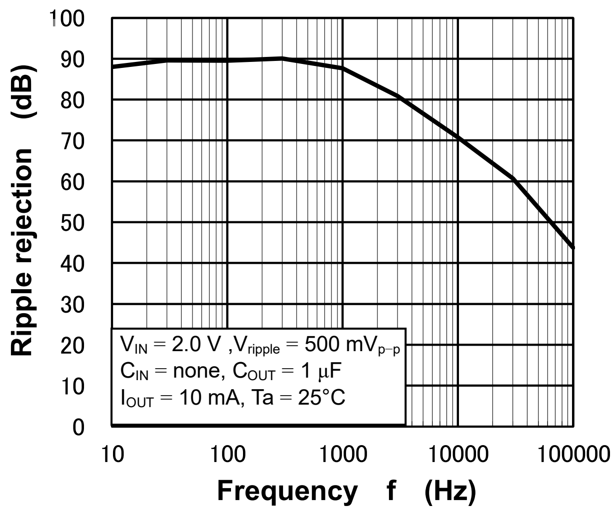
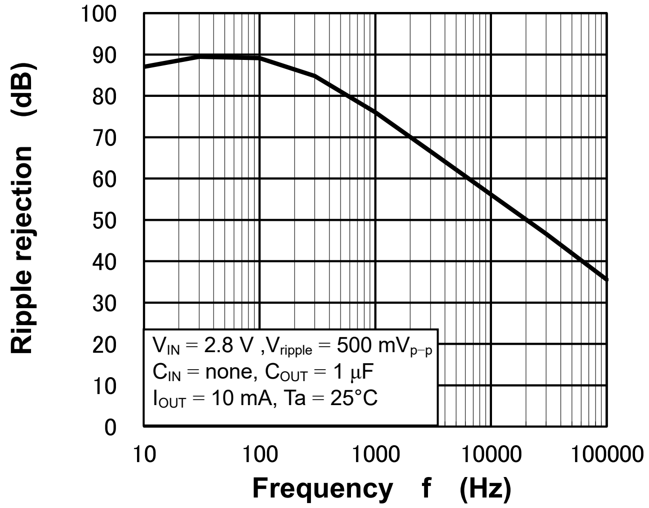
9.3. Ripple Rejection Ratio vs. Frequency

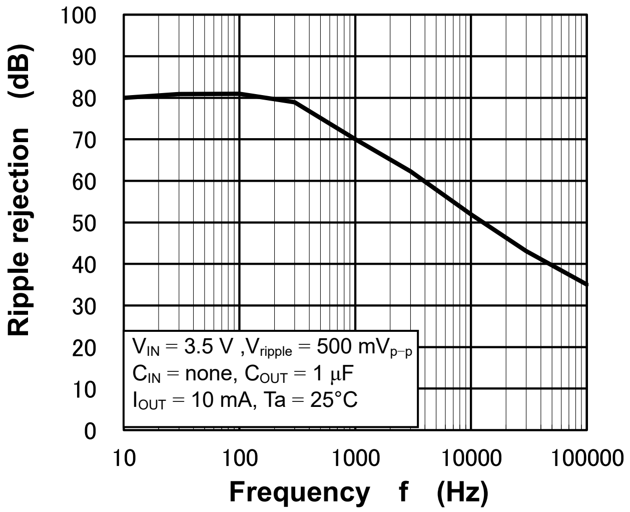
V_{OUT} = 1.0 V



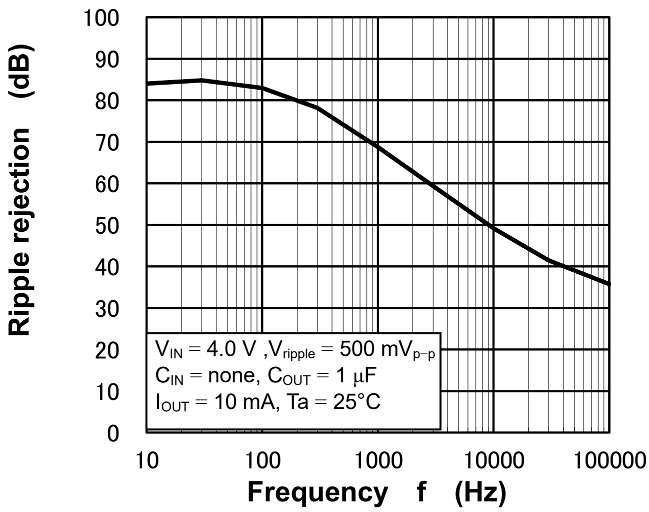
V_{OUT} = 1.8 V



V_{OUT} = 2.5 V

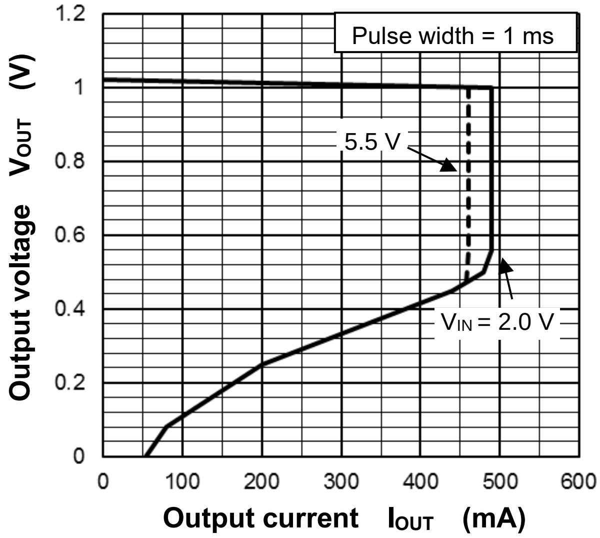


V_{OUT} = 3.0 V

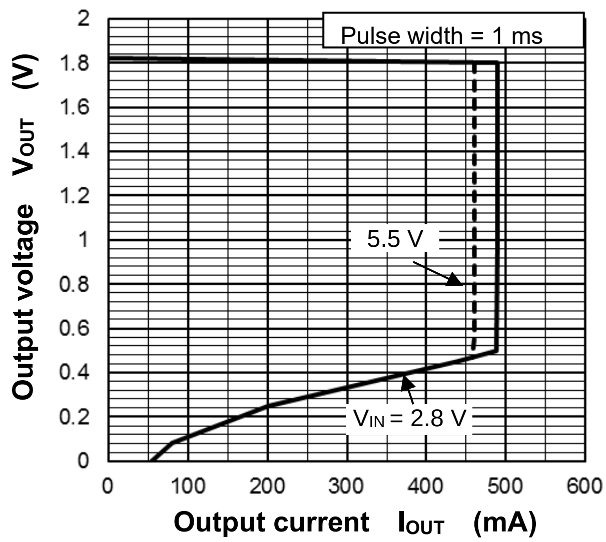


9.4. Output Voltage vs. Output Current

V_{OUT} = 1.0 V



V_{OUT} = 1.8 V



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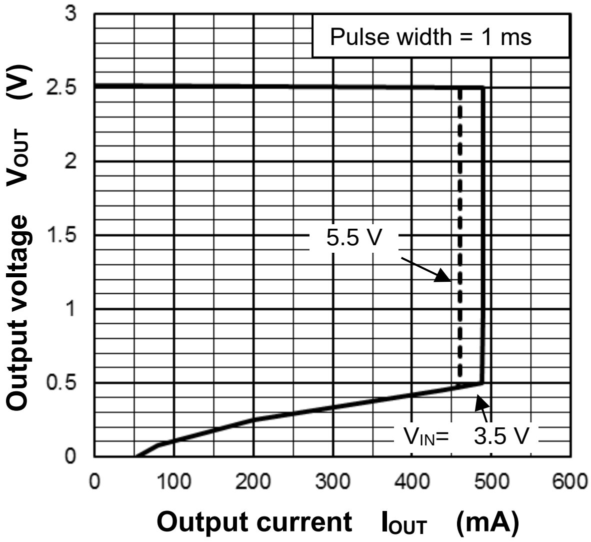
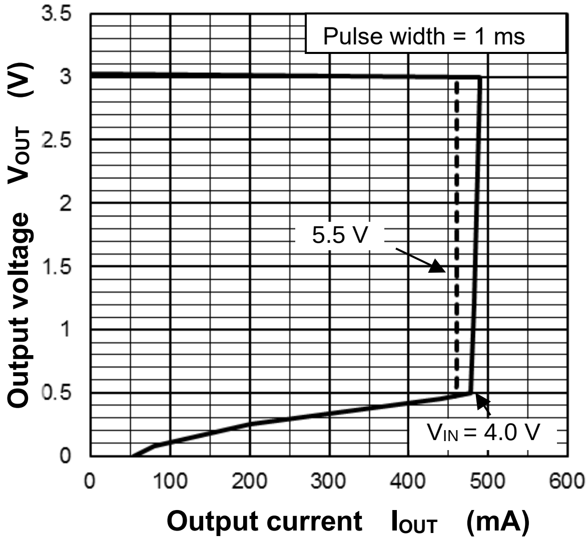
V_{OUT} = 2.5 V



V_{OUT} = 3.0 V

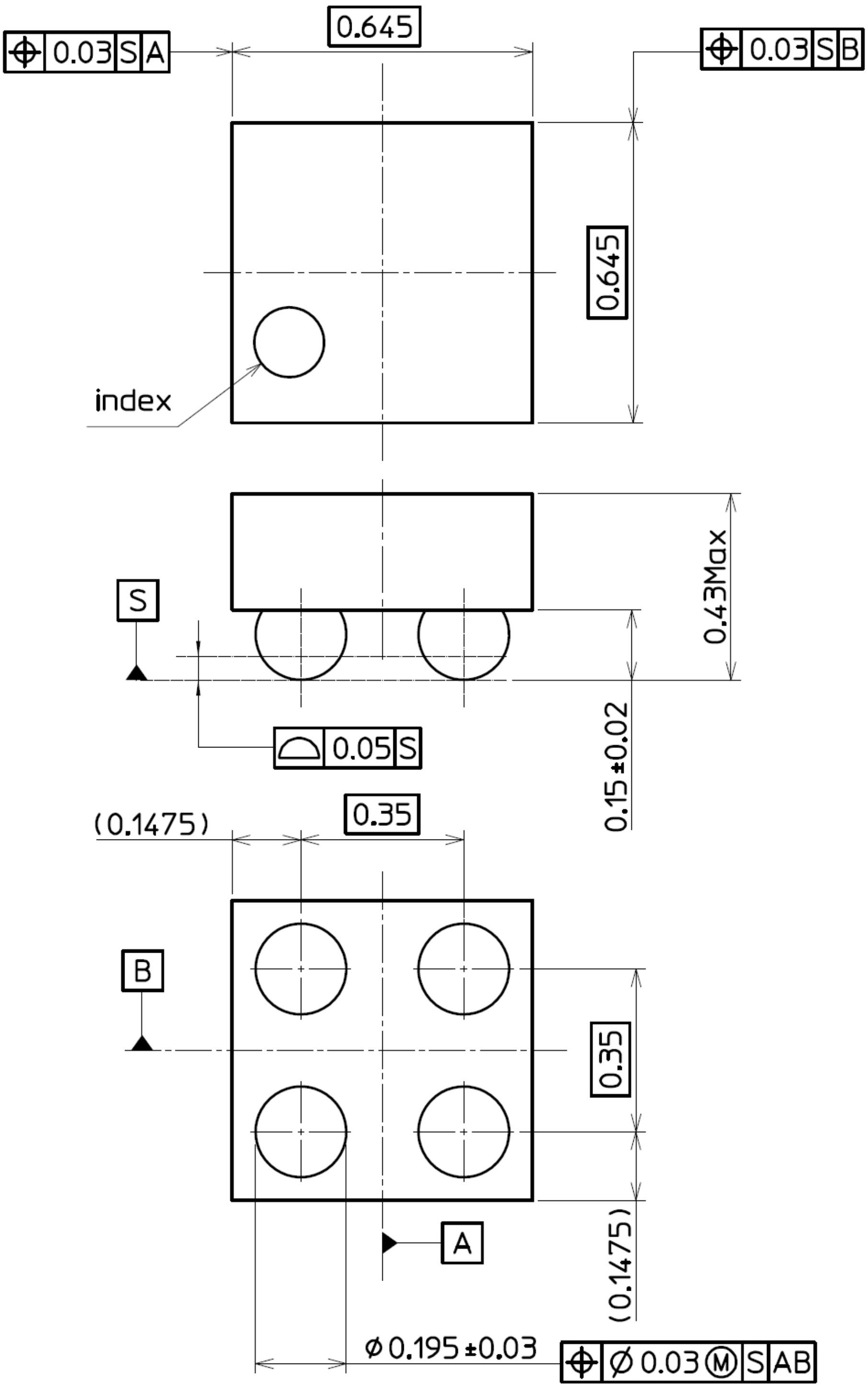


Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

10. Package Information

WCSP4E

Unit: mm



Weight: 0.34 mg (typ.)

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