TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR3DG series

300 mA CMOS Low Dropout Regulator with inrush current protection circuit

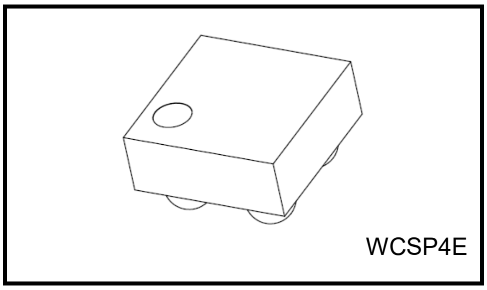
1. Description

The TCR3DG 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 300 mA.

They feature overcurrent protection, thermal shutdown, Inrush current reduction and Auto-discharge.

The TCR3DG series are offered in the ultra small package WCSP4E (0.645 mm x 0.645 mm; t 0.40 mm). It has a low dropout voltage of 160 mV (3.2 V output, I_{OUT} = 300 mA) with low output noise voltage of 38 μV_{rms} (2.5 V output) and a load transient response of only ⊿V_{OUT} = ±80 mV (I_{OUT} = 1 mA⇔300 mA, C_{OUT} = 1.0 μF).



Weight : 0.34 mg (Typ.)

As small ceramic input and output capacitors can be used with the TCR3DG series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones.

2. Applications

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

3. Features

- Low Dropout voltage
  V_{DO} = 160 mV (Typ.) at 3.2 V output, I_{OUT} = 300 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 (⊿V_{OUT} = ±80 mV (Typ.) at I_{OUT} = 1 ⇔ 300 mA, C_{OUT} = 1.0 μF)
- High ripple rejection ratio (70 dB (Typ.) at 2.5 V output, I_{OUT} = 10 mA, f = 1 kHz)
- Overcurrent protection
- Thermal shutdown
- Inrush current reduction
- Auto-discharge
- 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 0.40 mm)

Start of commercial production
2016-03

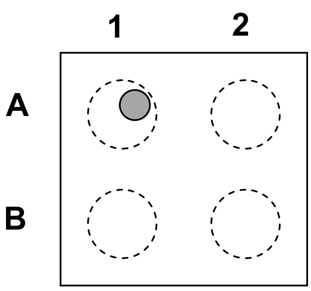
4. Absolute Maximum Ratings (Ta = 25°C)

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
Power dissipation	P_D	800 (Note1)	mW
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

5. Pin Assignment (top view)



	1	2
A	VIN	VOUT
B	CONTROL	GND

6. Operating Ranges

Characteristics	Symbol	Rating		Unit
Input voltage	V_{IN}	V_{OUT} + 0.1 to 5.5 V (Note 2)		V
Control voltage	V_{CT}	0 to V_{IN}		V
Output voltage	V_{OUT}	1.0 to 4.5		V
Output current	I_{OUT}	DC	300 (Note 3)	mA
Operation Temperature	T_{opr}	-40 to 85		°C
Output Capacitance	C_{OUT}	≥ 1.0 μF		—
Input Capacitance	C_{IN}	≥ 1.0 μF		—

Note 2: I_{OUT} = 1 mA.
Please refer to Dropout Voltage (Page 4) and use it within Absolute Maximum Ratings Junction temperature and Operation 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.

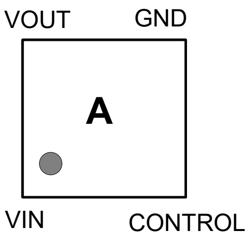
7. List of Products Number, Output voltage and Marking

Product No.	Output voltage (V)(Typ.)	Marking	Product No.	Output voltage (V)(Typ.)	Marking
TCR3DG10	1.0	E	TCR3DG285*	2.85	R
TCR3DG11*	1.1	F	TCR3DG30*	3.0	T
TCR3DG12	1.2	H	TCR3DG31*	3.1	U
TCR3DG13*	1.3	J	TCR3DG32	3.2	A
TCR3DG135*	1.35	K	TCR3DG33	3.3	B
TCR3DG18*	1.8	L	TCR3DG35*	3.5	V
TCR3DG25*	2.5	P	TCR3DG36*	3.6	C
TCR3DG28*	2.8	W	TCR3DG45*	4.5	D

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

Top Marking (top view)

Example: TCR3DG32 (3.2 V output)



8. 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, $T_a = 25$°C)

Characteristics	Symbol	Test Condition		Min	Typ.	Max	Unit
Output voltage accuracy	V_{OUT}	$I_{OUT} = 50$ mA (Note 4)	$V_{OUT} < 1.8$ V	-18	—	+18	mV
			1.8V ≤ V_{OUT}	-1.0	—	+1.0	%
Input voltage	V_{IN}	$I_{OUT} = 300$ mA		1.75	—	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} ≤ 300 mA		—	8	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
Dropout voltage	V_{DO}	$I_{OUT} = 300$ mA (Note 5)		—	195	275	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, (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}, (Note 5)		—	70	—	dB
Load transient response	ΔV_{OUT}	$I_{OUT} = 1$⇔300mA, $C_{OUT} = 1.0$ μF		—	±80	—	mV
Control voltage (ON)	$V_{CT\ (ON)}$	—		1.0	—	5.5	V
Control voltage (OFF)	$V_{CT\ (OFF)}$	—		0	—	0.4	V

Note 4: Stable state with fixed I_{OUT} condition.
Note 5: The 2.5 V output product.

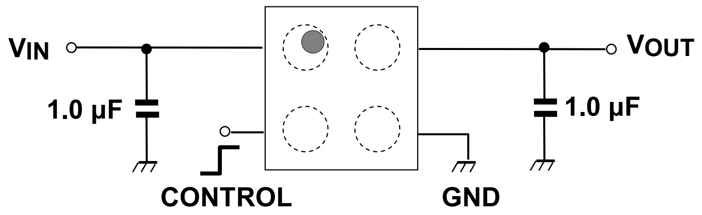
Dropout voltage table

($I_{OUT} = 300$ mA, $C_{IN} = 1.0$ μF, $C_{OUT} = 1.0$ μF, $T_a = 25$°C)

Output voltages	Symbol	Min	Typ.	Max	Unit
1.0 V, 1.05 V	V_{DO}	—	575	735	mV
1.1 V		—	535	635	
1.2 V		—	475	585	
1.3 V		—	435	535	
1.35V		—	395	515	
1.4 V		—	375	505	
1.5 V ≤ V_{OUT} < 1.8 V		—	335	435	
1.8 V ≤ V_{OUT} < 2.1 V		—	255	365	
2.1 V ≤ V_{OUT} < 2.5 V		—	225	315	
2.5 V ≤ V_{OUT} < 2.8 V		—	195	275	
2.8 V ≤ V_{OUT} < 3.2 V		—	185	235	
3.2 V		—	165	215	
3.2 V ≤ V_{OUT} < 3.6 V		—	165	215	
3.6 V ≤ V_{OUT} ≦ 4.5 V		—	135	185	

9. Application Note

9.1. Example of Application Circuit



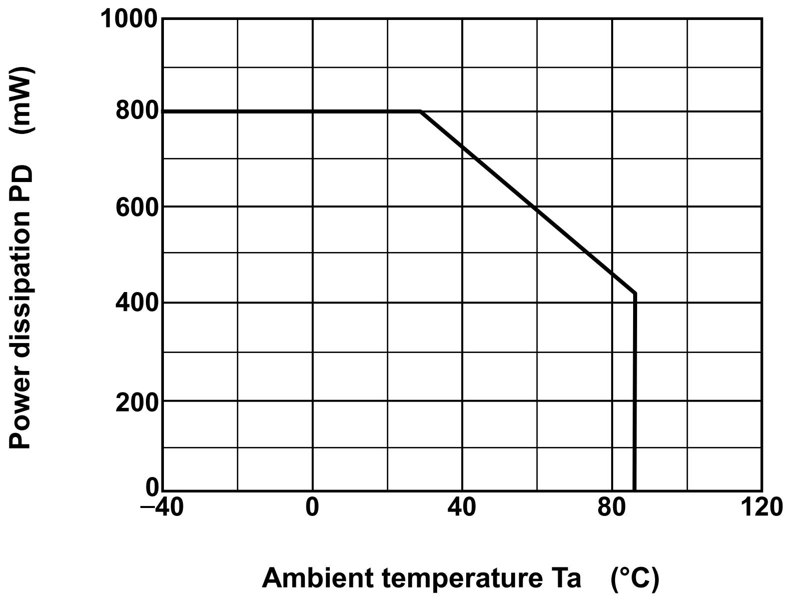
CONTROL voltage	Output voltage
HIGH	ON
LOW	OFF
OPEN	OFF

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).

9.2. Power Dissipation

Board-mounted power dissipation ratings for TCR3DG 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: diameter 0.5 mm x 24



9.3. 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 recommend the ESR of ceramic capacitor is under 10 Ω. For stable operation, please use over 1.0 μF.

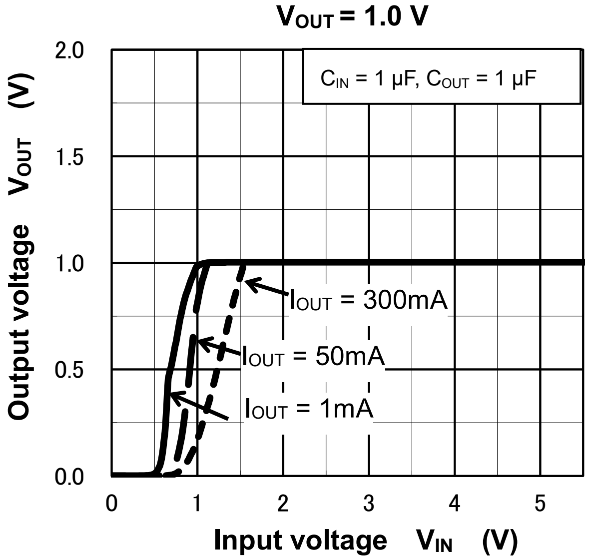
- Mounting
  The long distance between IC and output capacitor might affect phase compensation by impedance in wire and inductor. For stable power supply, output capacitor need to mount near IC as much as possible. Also V_{IN} and GND pattern need to be large and make the wire impedance small as possible.

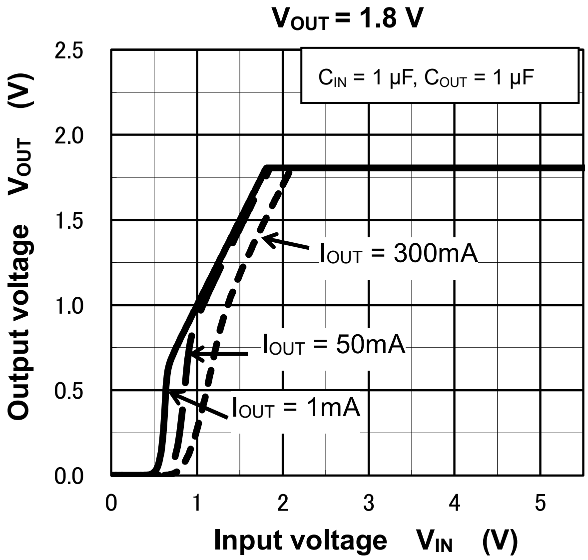
- Power Dissipation
  Please have enough design patterns for expected maximum power dissipation. And under consideration of ambient temperature, input voltage, and output current etc, we recommend proper dissipation ratings for maximum power dissipation; in general maximum dissipation rating is 70 to 80 percent.

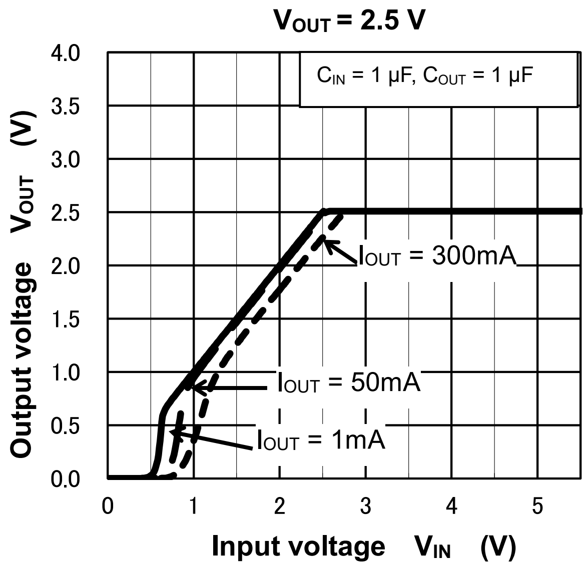
- Overcurrent Protection and Thermal shutdown
  Overcurrent protection and Thermal shutdown are designed in these products, but these are not designed to constantly ensure the suppression of the device within operation limits. Depending on the condition during actual usage, it could affect the electrical 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.

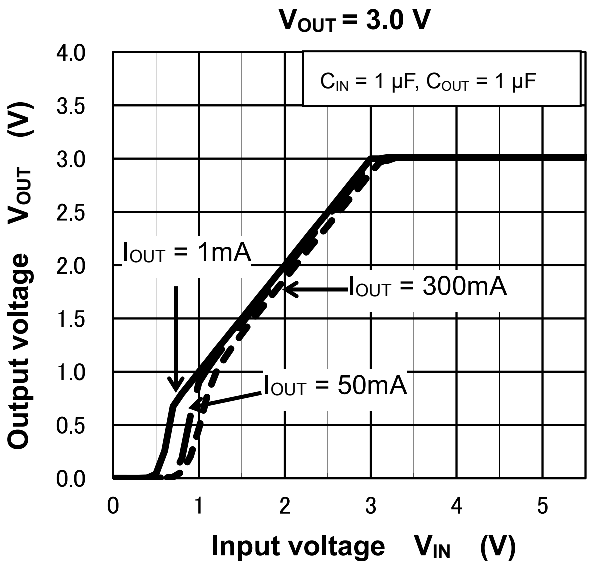
10. Representative Typical Characteristics

10.1. Output Voltage vs. Input Voltage

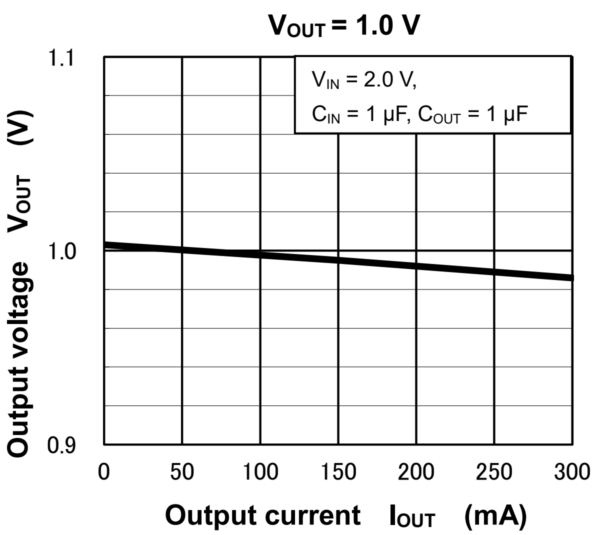


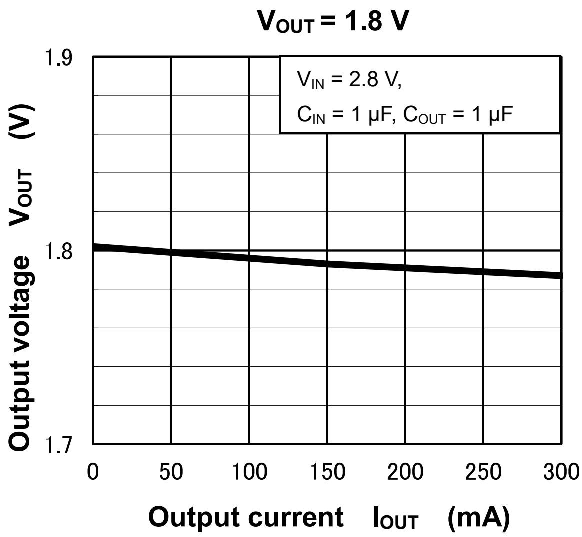


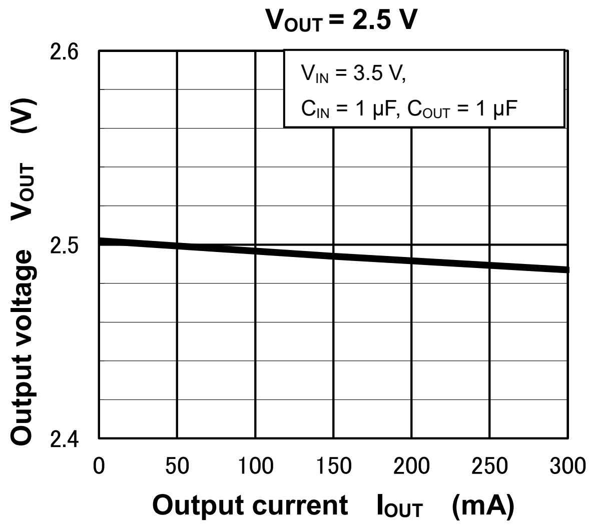


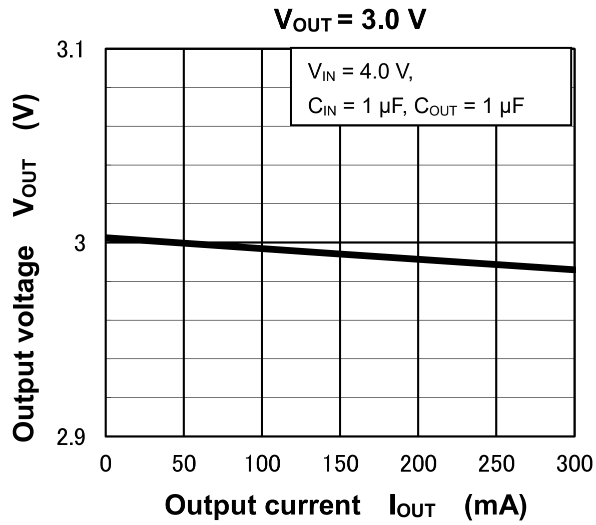


10.2. Output Voltage vs. Output Current

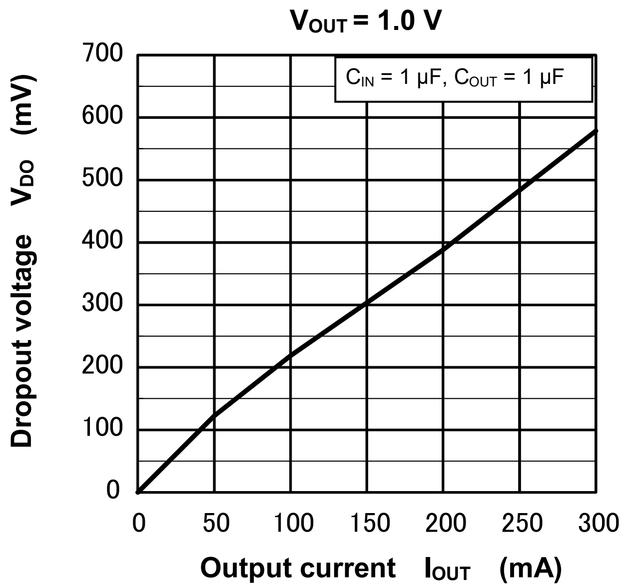


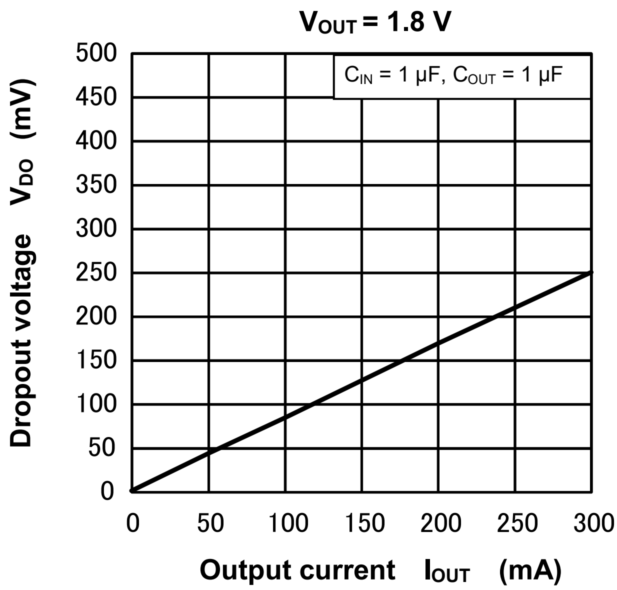


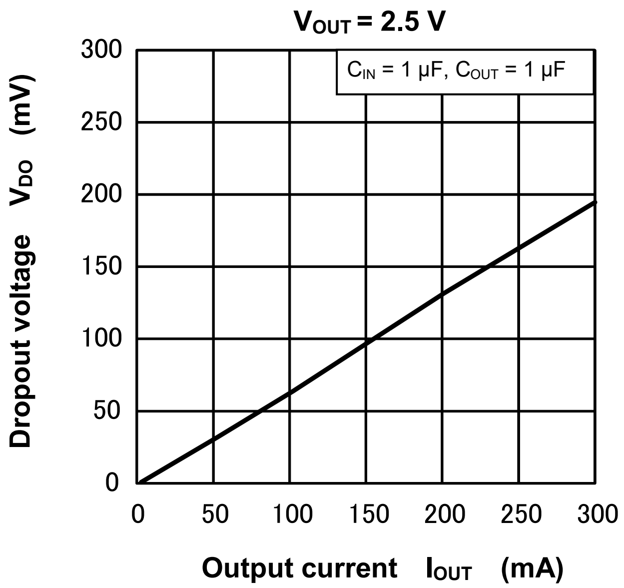


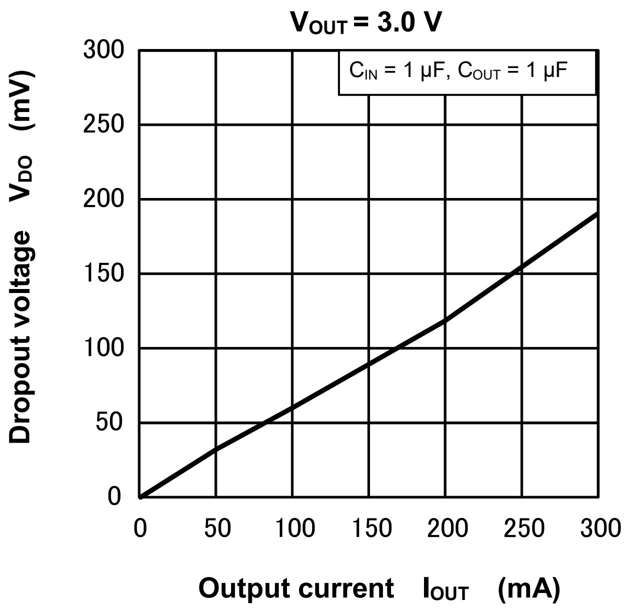


10.3. Dropout voltage vs. Output current



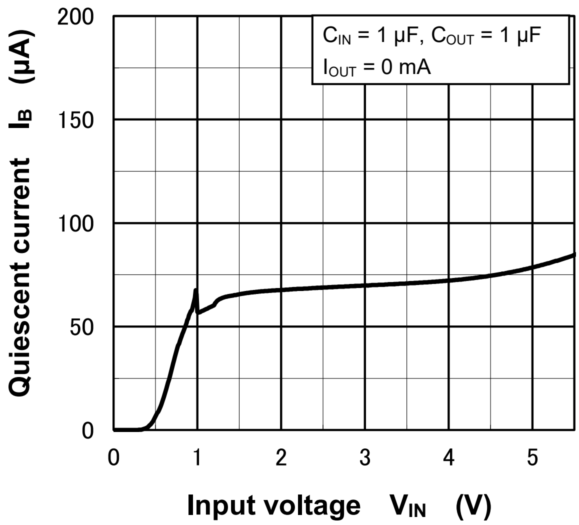




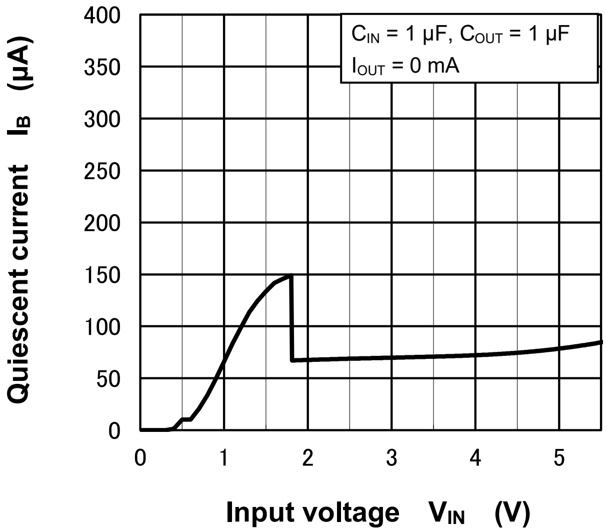


10.4. Quiescent Current vs. Input voltage

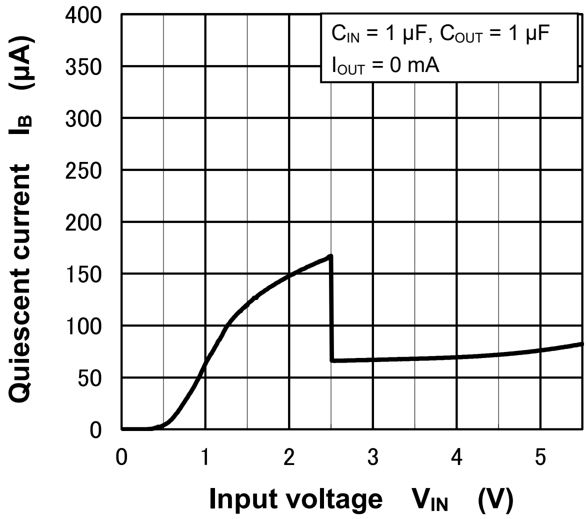
V_{OUT} = 1.0 V



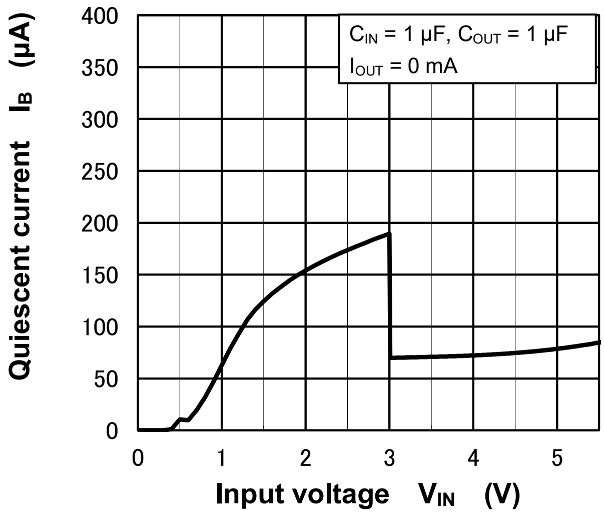
V_{OUT} = 1.8 V



V_{OUT} = 2.5 V

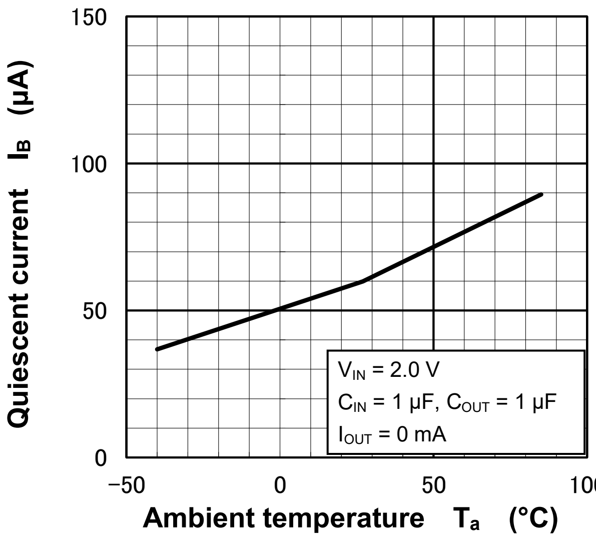


V_{OUT} = 3.0 V

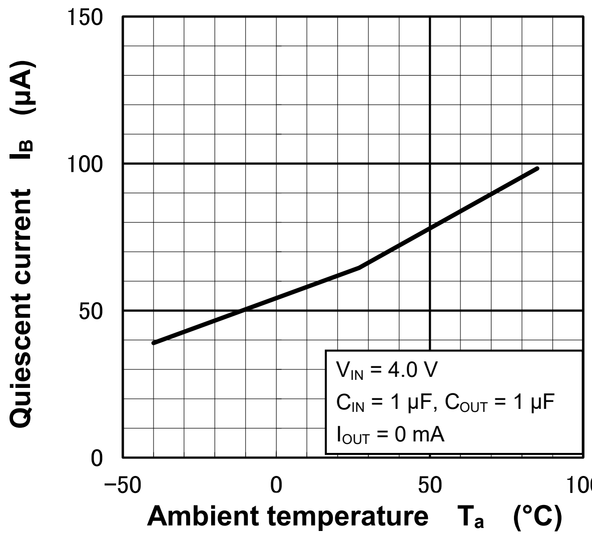


10.5. Quiescent Current vs Ambient temperature,

V_{OUT} = 1.0 V

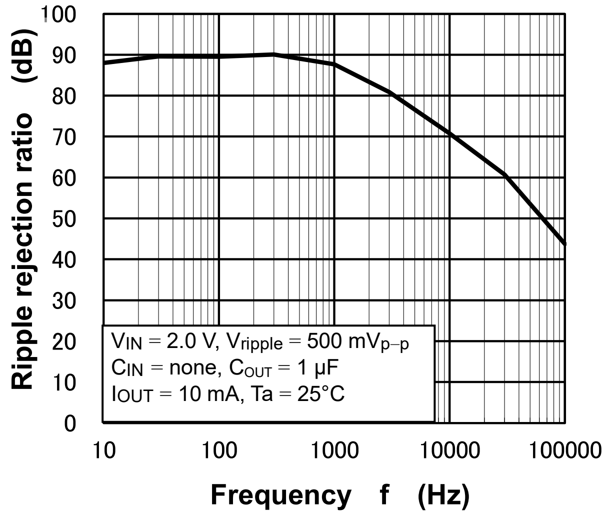


V_{OUT} = 3.0 V

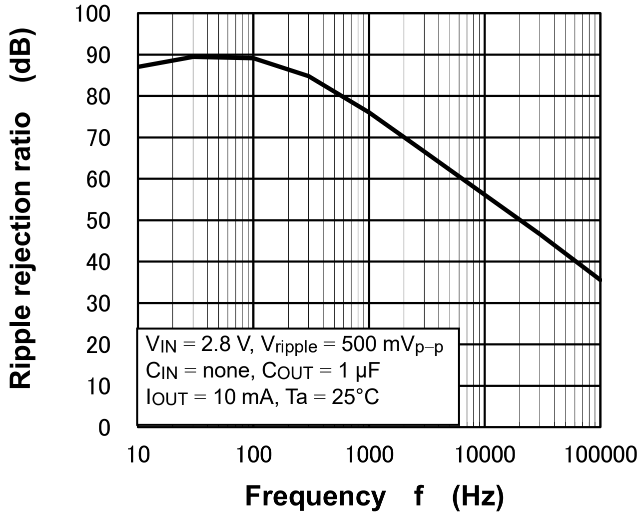


10.6. Ripple rejection ratio vs. Frequency

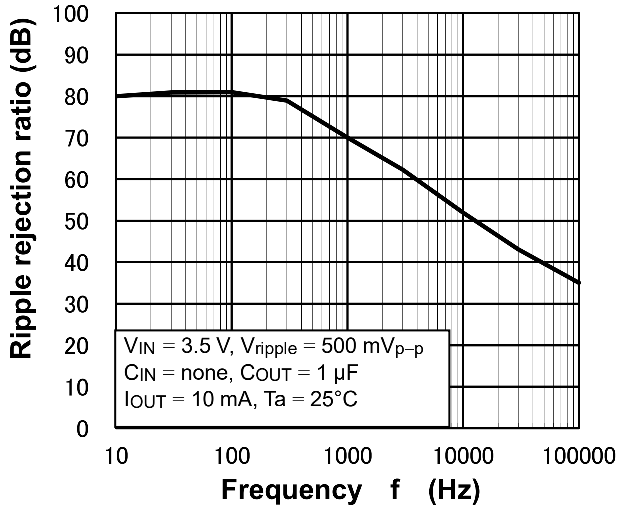
V_{OUT} = 1.0 V



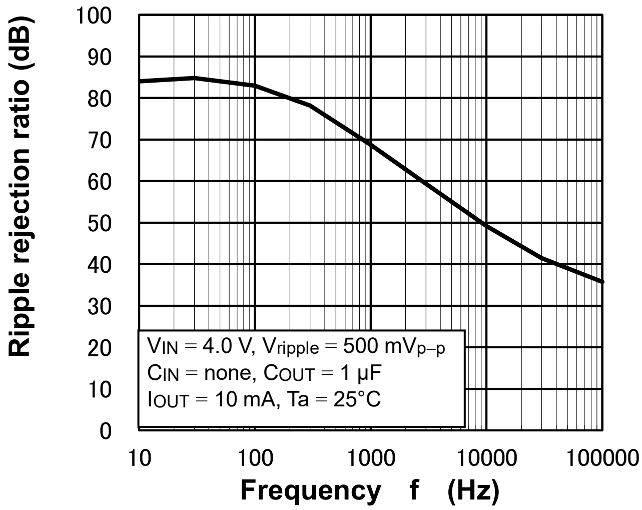
V_{OUT} = 1.8 V



V_{OUT} = 2.5 V

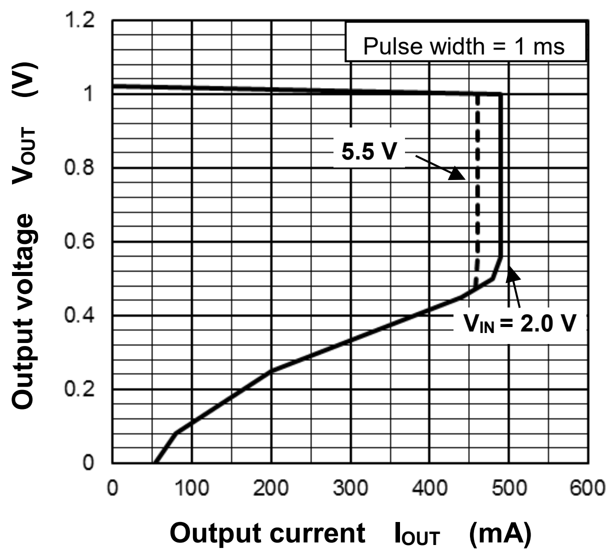


V_{OUT} = 3.0 V

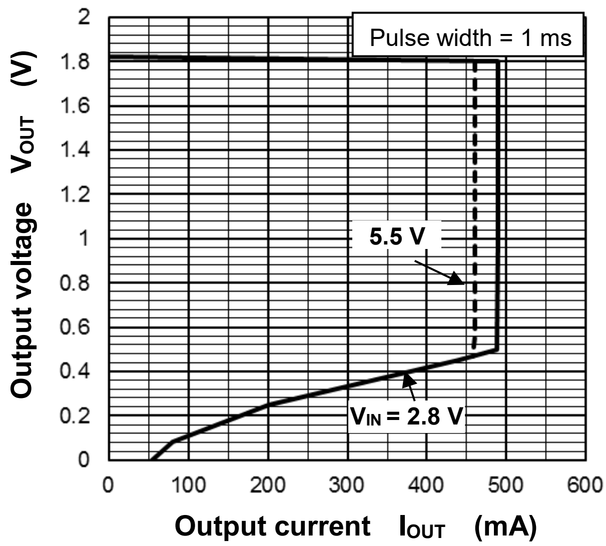


10.7. Output Voltage vs. Output Current

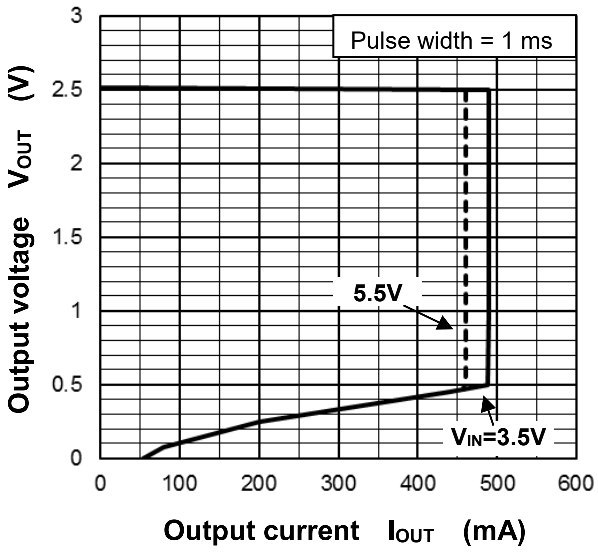
V_{OUT} = 1.0 V



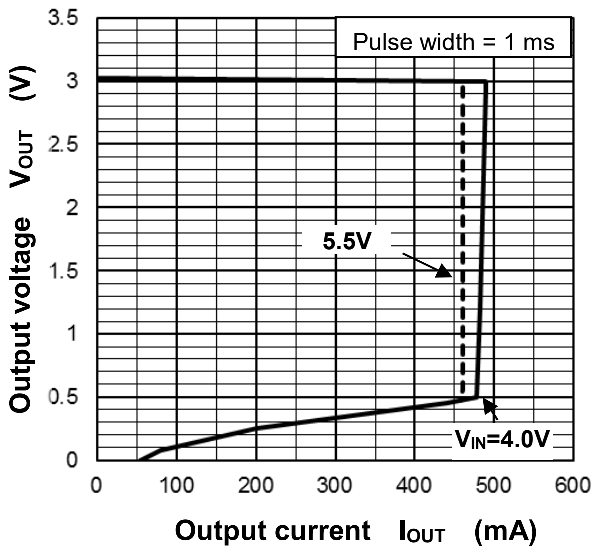
V_{OUT} = 1.8 V



V_{OUT} = 2.5 V

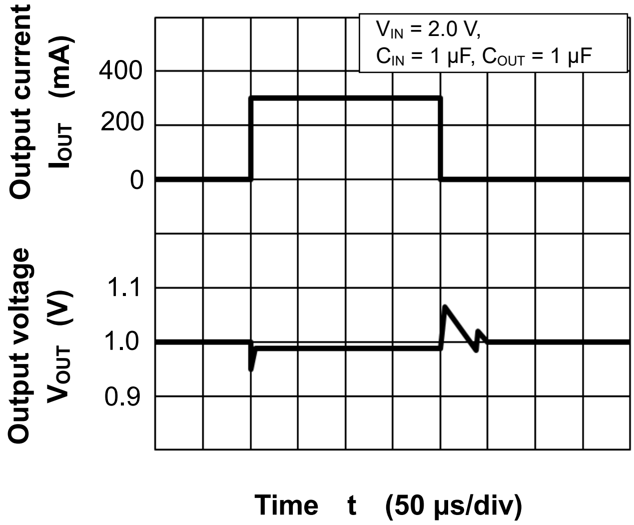


V_{OUT} = 3.0 V

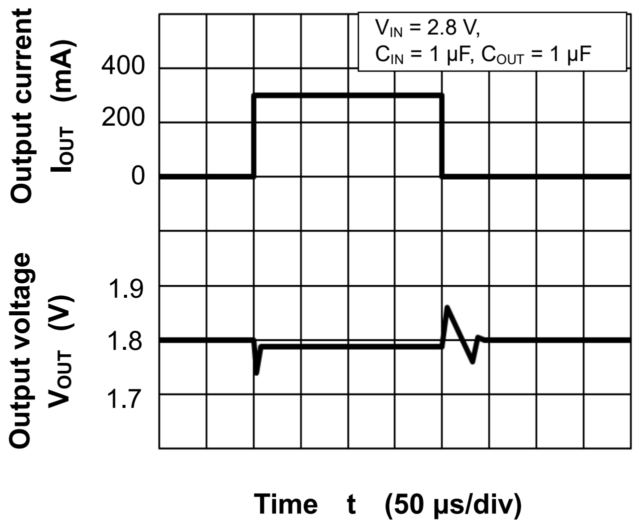


10.8. Load Transient Response

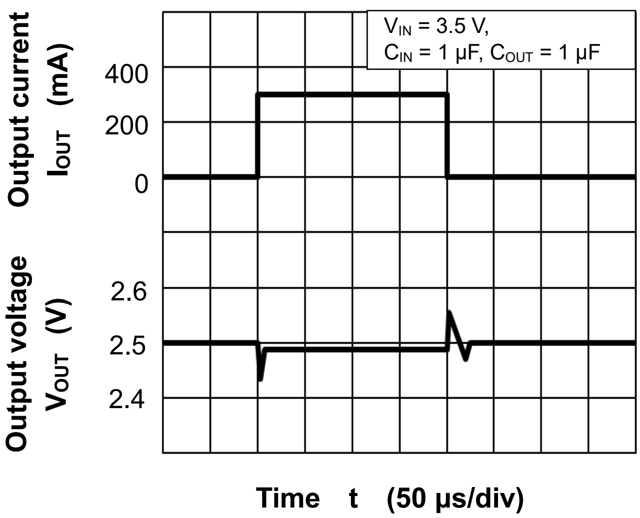
V_{OUT} = 1.0 V
(I_{OUT} = 1 mA ⇔ 300 mA)



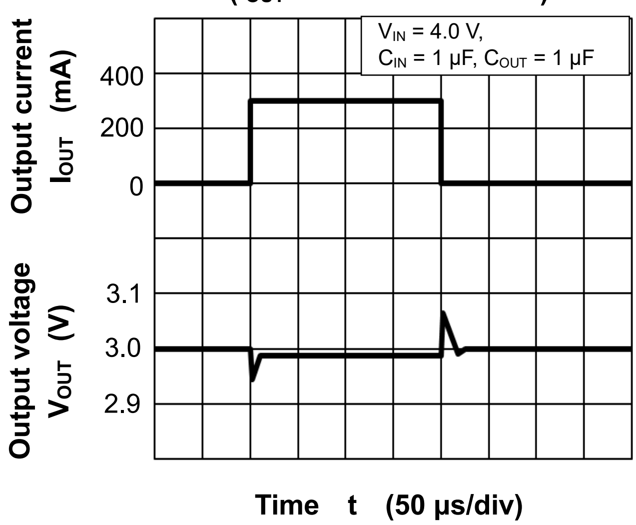
V_{OUT} = 1.8 V
(I_{OUT} = 1 mA ⇔ 300 mA)



V_{OUT} = 2.5 V
(I_{OUT} = 1 mA ⇔ 300 mA)

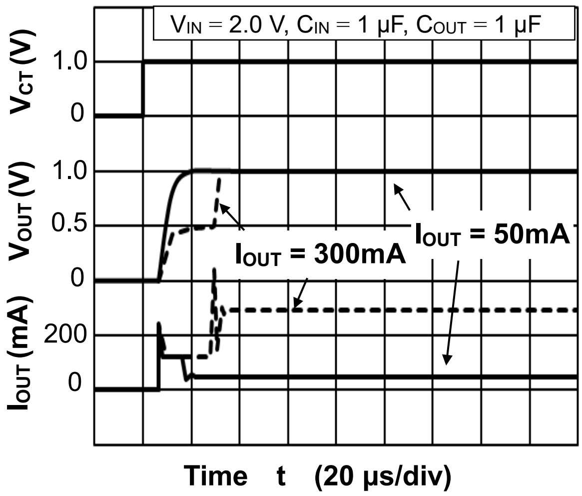


V_{OUT} = 3.0 V
(I_{OUT} = 1 mA ⇔ 300 mA)

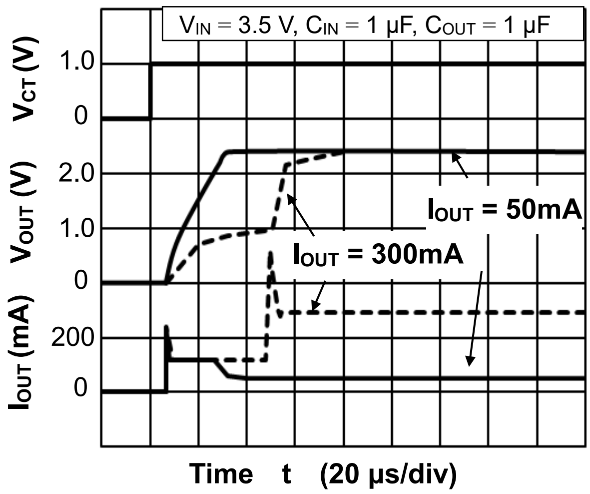


10.9. t_{ON} Response

V_{OUT} = 1.0 V

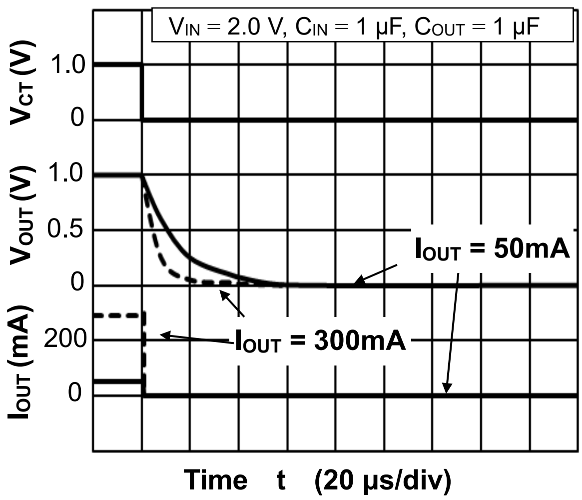


V_{OUT} = 2.5 V

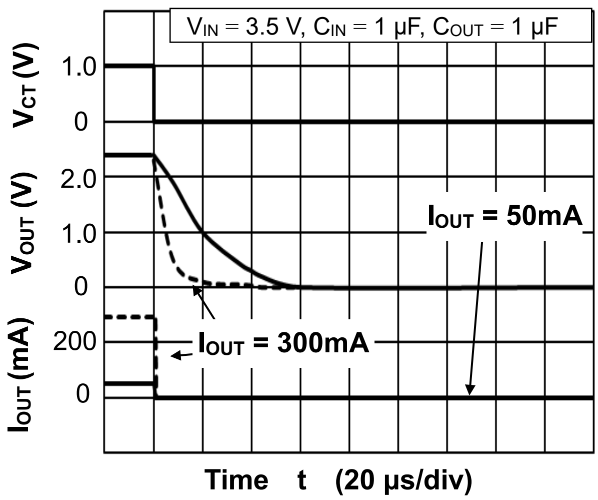


10.10. t_{OFF} Response

V_{OUT} = 1.0 V



V_{OUT} = 2.5V

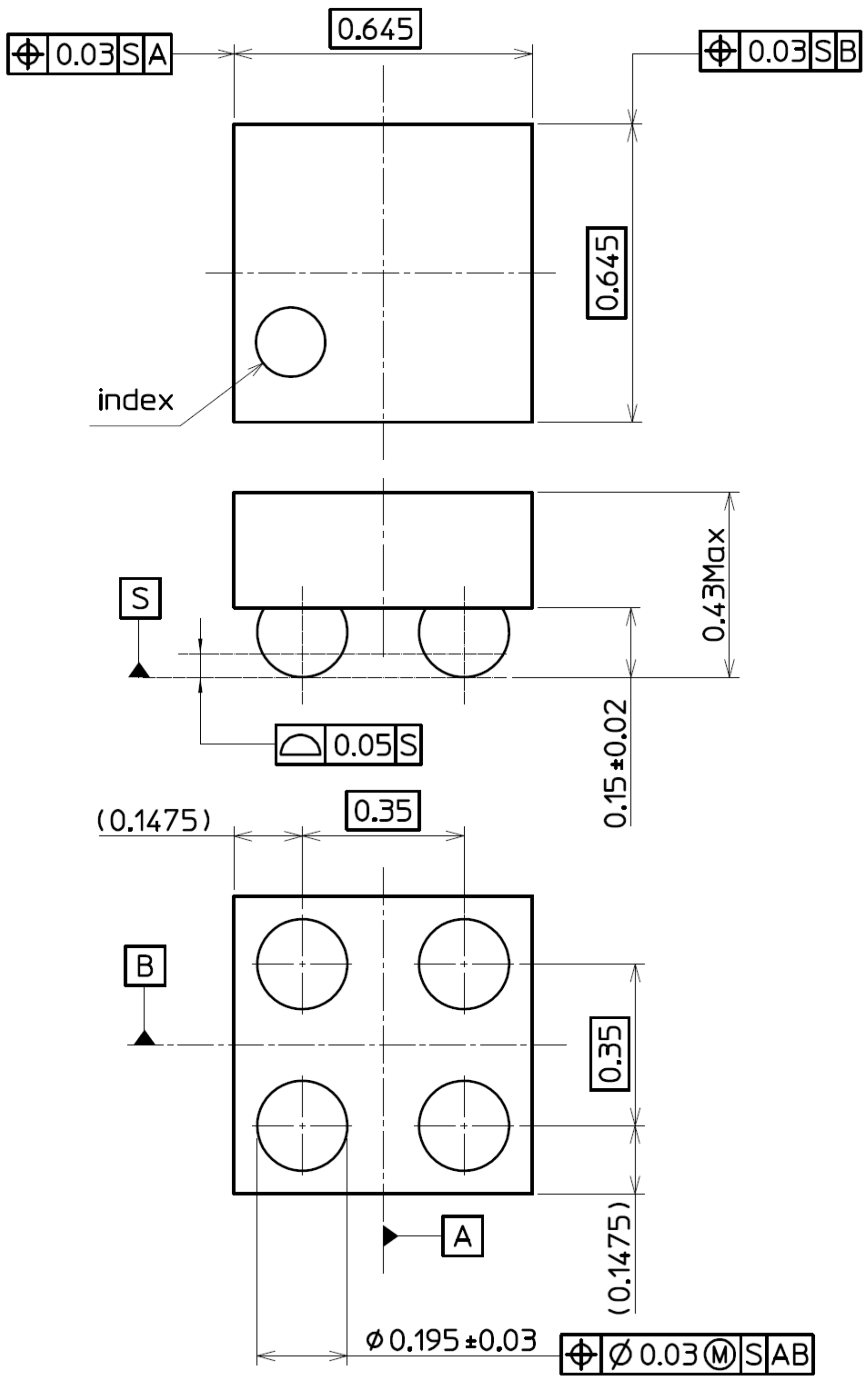


The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

Package Information

WCSP4E

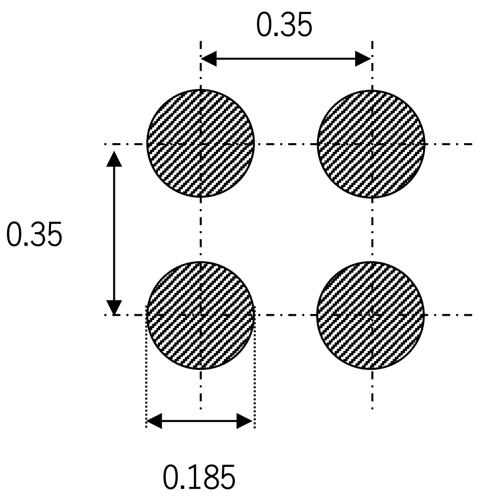
Unit : mm



Weight : 0.34 mg (typ.)

Land pattern dimensions for reference only

Unit : mm



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