TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR2DG series

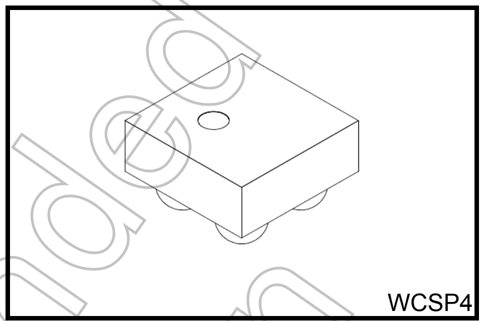
Low Noise 200 mA CMOS Low Drop-Out Regulator in ultra small package

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 μV_{rms} (2.5 V output) and a load transient response of only $\triangle V_{OUT}$ = ±65 mV (I_{OUT} = 1 mA⇔150 mA, C_{OUT} =1.0 μF).

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.

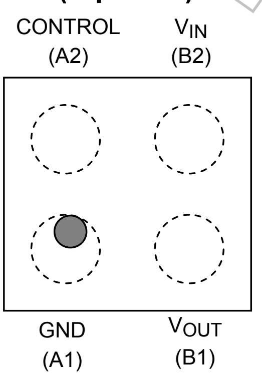


Weight : 0.7 mg (typ.)

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 μA (typ.) at I_{OUT} = 0 mA)
- Low stand-by current ($I_{B(OFF)}$ = 0.1 μA (typ.) at Stand-by mode)
- Low output noise voltage
  V_{NO} = 22 μV_{rms} (typ.) at 3.0 V-output, I_{OUT} = 10 mA, 10 Hz < f < 100 kHz
  V_{NO} = 18 μV_{rms} (typ.) at 2.5 V-output, I_{OUT} = 10 mA, 10 Hz < f < 100 kHz
  V_{NO} = 14 μV_{rms} (typ.) at 1.2 V-output, I_{OUT} = 10 mA, 10 Hz < f < 100 kHz
- High ripple rejection ratio
  R.R = 75 dB (typ.) at 2.5 V-output, I_{OUT} = 10 mA, f =1kHz
  R.R = 62 dB (typ.) at 2.5 V-output, I_{OUT} = 10 mA, f =10kHz
  R.R = 50 dB (typ.) at 2.5 V-output, I_{OUT} = 10 mA, f =100kHz
- Fast load transient response ($\triangle V_{OUT}$ = ±65 mV (typ.) at I_{OUT} = 1mA ⇔ 150 mA, C_{OUT} =1.0 μF)
- Output voltage accuracy ±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} = 0.47μF, C_{OUT} =1.0 μF)
- 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 to150	°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

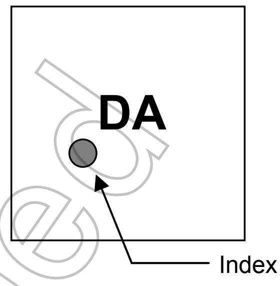
List of Products Number, Marking and Output voltage

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

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

Top Marking

Example: TCR2DG15 (1.5 V output)



Electrical Characteristics

(Unless otherwise specified,

V_{IN} = V_{OUT} + 1 V, I_{OUT} = 50 mA, C_{IN} = 0.47 μF, C_{OUT} = 1.0 μF, T_j = 25°C)

Characteristics	Symbol	Test Condition			Min	Typ.	Max	Unit
Output voltage accuracy	V_{OUT}	—			-1.0	—	+1.0	%
Input voltage	V_{IN}	—			2.0	—	5.5	V
Line regulation	Reg·line	2.0 V ≤ V_{IN} ≤ 5.5 V, I_{OUT} = 1 mA			—	0.1	5	mV
Load regulation	Reg·load	1 mA ≤ I_{OUT} ≤ 150 mA			—	5	10	mV
Quiescent current	I_B	I_{OUT} = 0 mA			—	45	70	μA
Stand-by current	$I_{B (OFF)}$	V_{CT} = 0 V			—	0.1	0.7	μA
Drop-out voltage	V_{IN}-V_{OUT}	I_{OUT} = 100 mA (Note 2)			—	75	130	mV
Temperature coefficient	T_{CVO}	–40°C ≤ T_{opr} ≤ 85°C			—	70	—	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	V_{OUT} = 1.2 V		—	14	—	μV_{rms}
			V_{OUT} = 2.5 V		—	18	—	
			V_{OUT} = 3.0 V		—	22	—	
Ripple rejection ratio	R.R.	V_{IN} = V_{OUT} + 1 V, I_{OUT} = 10 mA, V_{Ripple} =500$mV_{p\text{-}p}$, Ta = 25°C	f = 1 kHz	V_{OUT} = 1.2 V	—	85	—	dB
				V_{OUT} = 2.5 V	—	75	—	
				V_{OUT} = 3.0 V	—	73	—	
			f = 10 kHz	V_{OUT} = 1.2 V	—	68	—	
				V_{OUT} = 2.5 V	—	62	—	
				V_{OUT} = 3.0 V	—	60	—	
			f = 100 kHz	V_{OUT} = 1.2 V	—	50	—	
				V_{OUT} = 2.5 V	—	50	—	
				V_{OUT} = 3.0 V	—	50	—	
Load transient response	ΔV_{OUT}	I_{OUT} = 1mA ⇔150mA, C_{OUT} = 1.0 μF			—	±65	—	mV
Control voltage (ON)	$V_{CT (ON)}$	—			1.1	—	5.5	V
Control voltage (OFF)	$V_{CT (OFF)}$	—			0	—	0.5	V

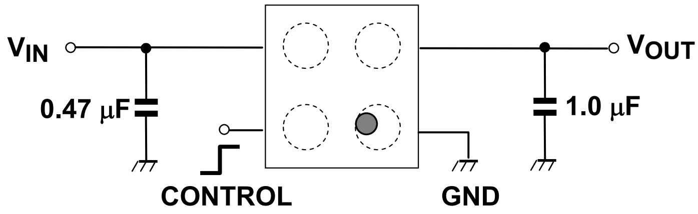
Note 2: The 2.5 V output product.

Drop-out voltage
(I_{OUT} = 100 mA, C_{IN} = 0.47 μF, C_{OUT} = 1.0 μF, T_j = 25°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	
2.4V ≤ V_{OUT} ≤ 2.6 V		—	78	130	
2.7V ≤ V_{OUT} ≤ 2.95V		—	69	120	
3.0V ≤ V_{OUT} ≤ 3.6 V		—	64	110	

Application Note

1. Recommended Application Circuit



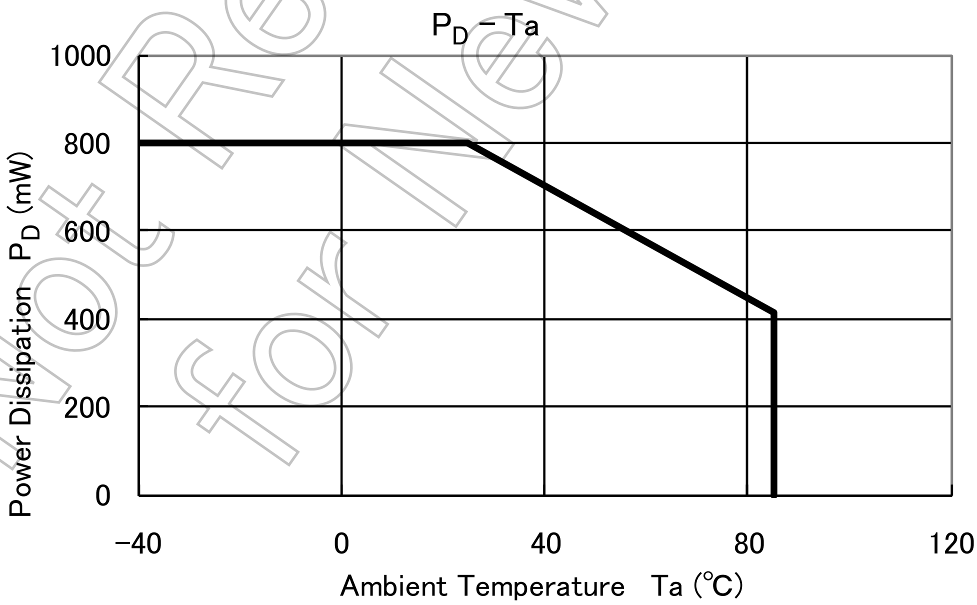
CONTROL voltage	Output voltage
HIGH	ON
LOW	OFF
OPEN	OFF

The figure above shows the recommended configuration for using a Low-Dropout regulator. Insert a capacitor at V_{OUT} and V_{IN} 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 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 GND pattern need to be large and make the wire impedance small as possible.

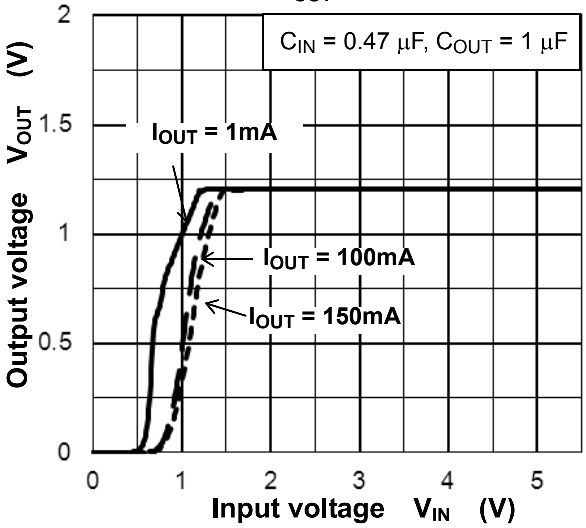
- Permissible Loss
  Please have enough design patterns for expected maximum permissible loss. And under consideration of surrounding temperature, input voltage, and output current etc, we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70 to 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.

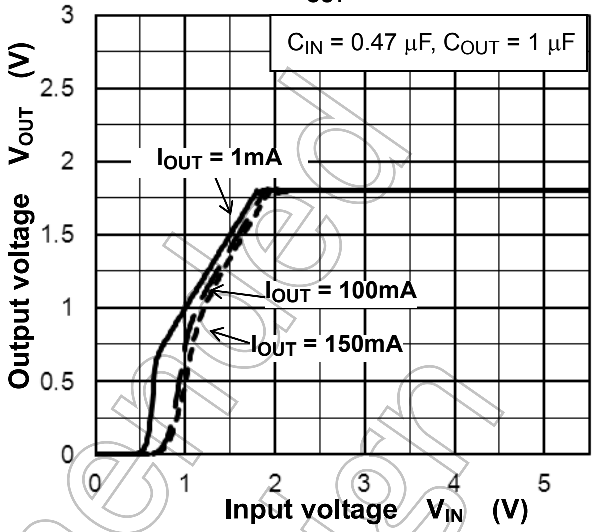
Representative Typical Characteristics

1) Output Voltage vs. Input Voltage

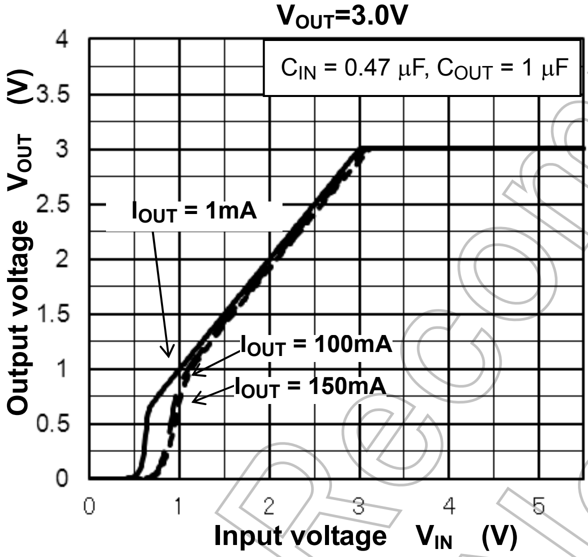
V_{OUT}=1.2V



V_{OUT}=1.8V

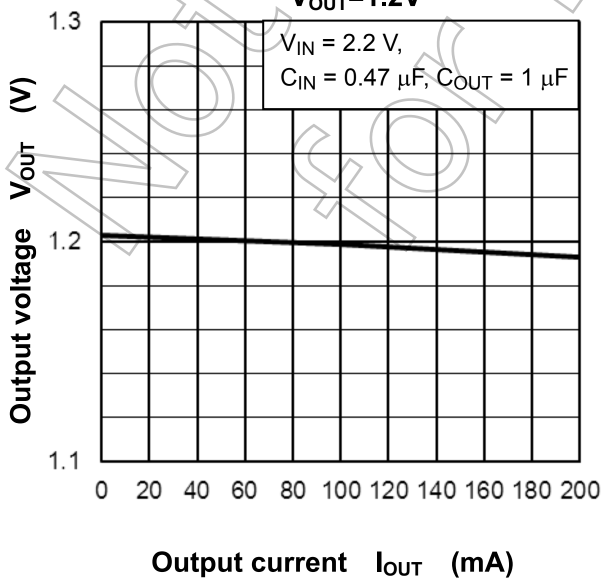


V_{OUT}=3.0V

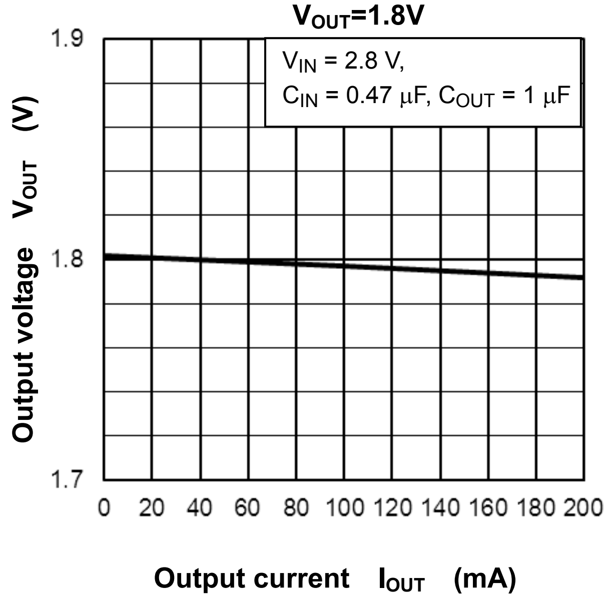


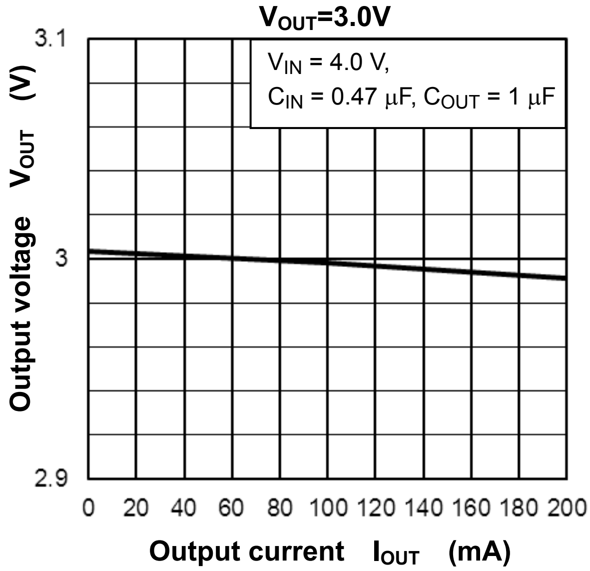
2) Output Voltage vs. Output Current

V_{OUT}=1.2V

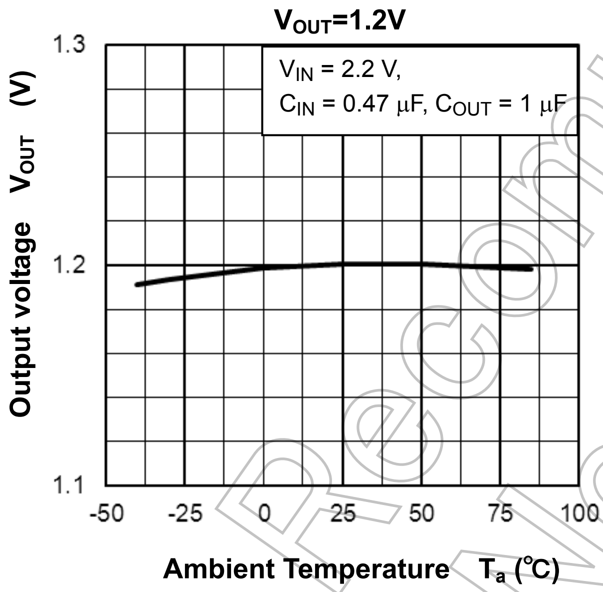


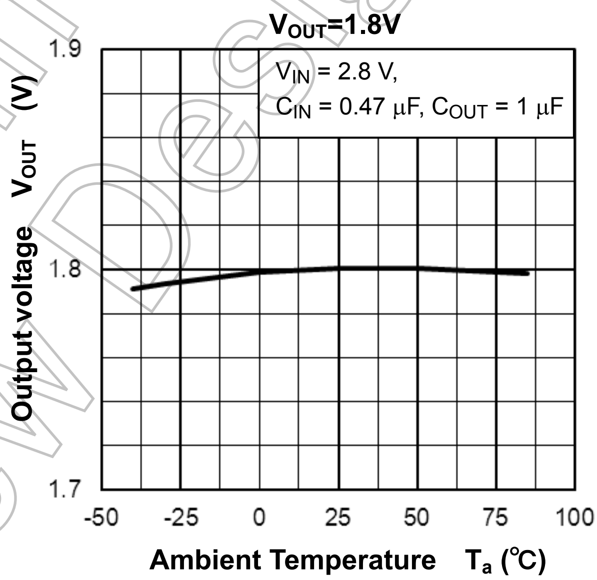
V_{OUT}=1.8V

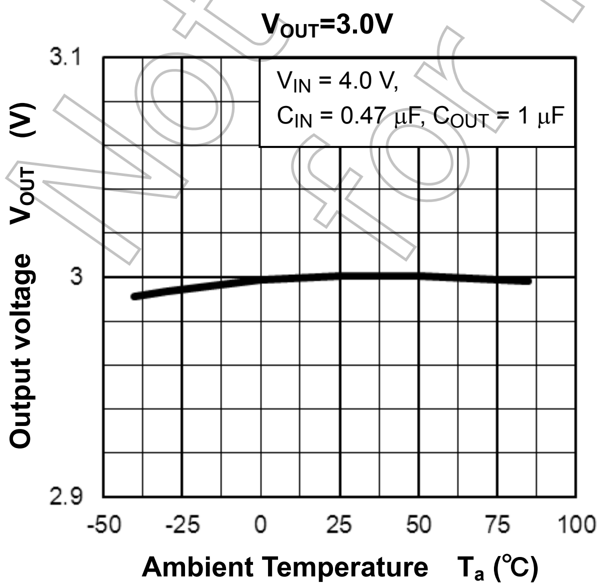




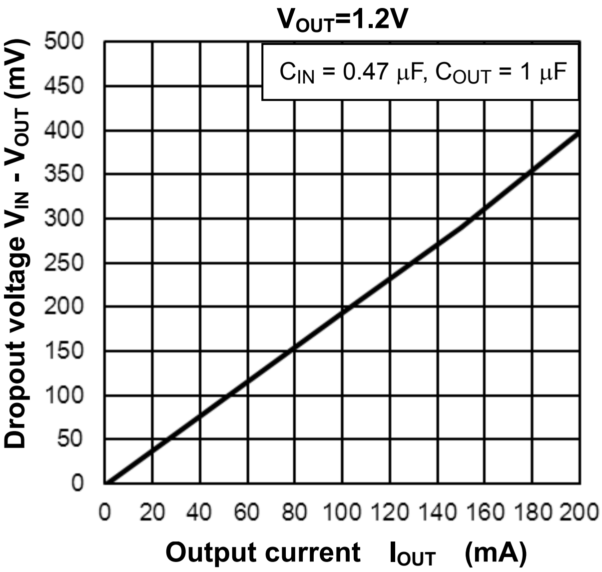
3) Output Voltage vs. Ambient Temperature

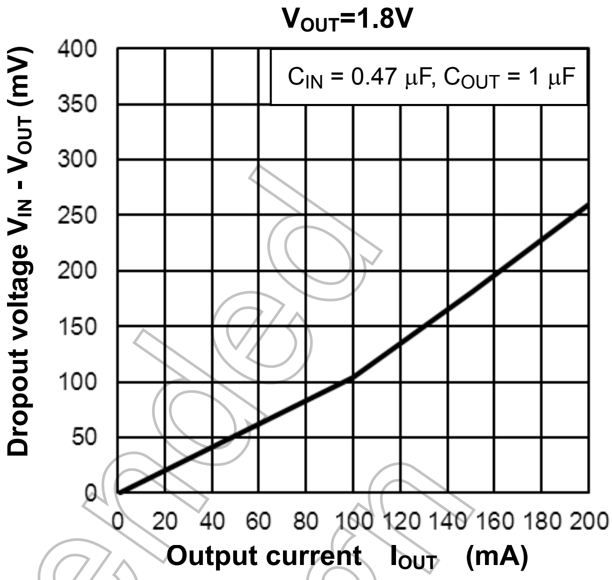


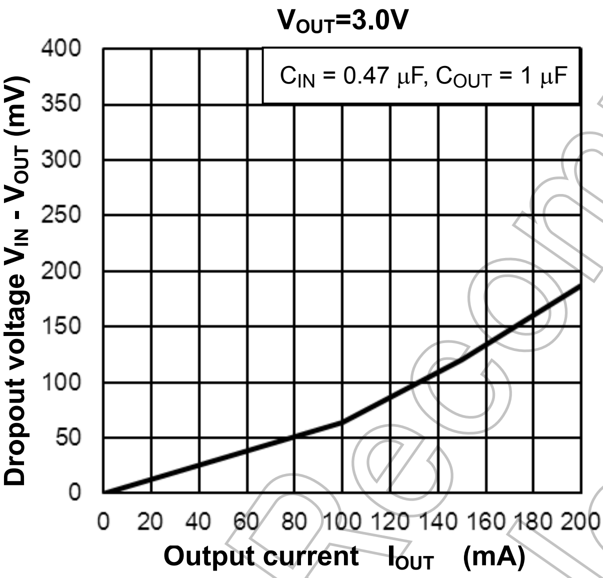




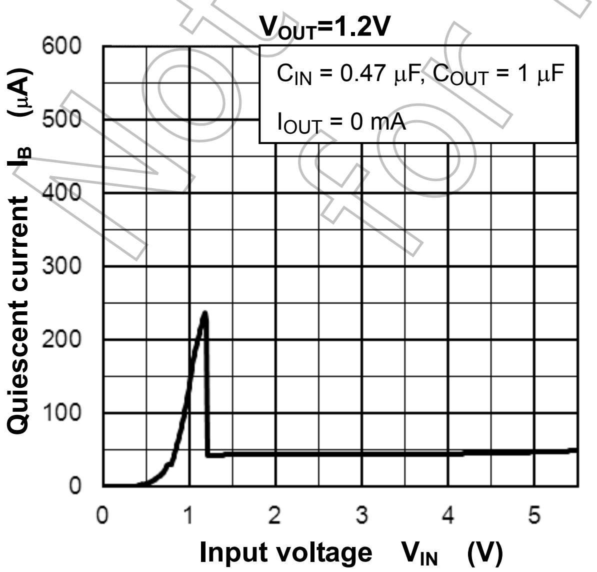
4) Dropout Voltage vs. Output Current

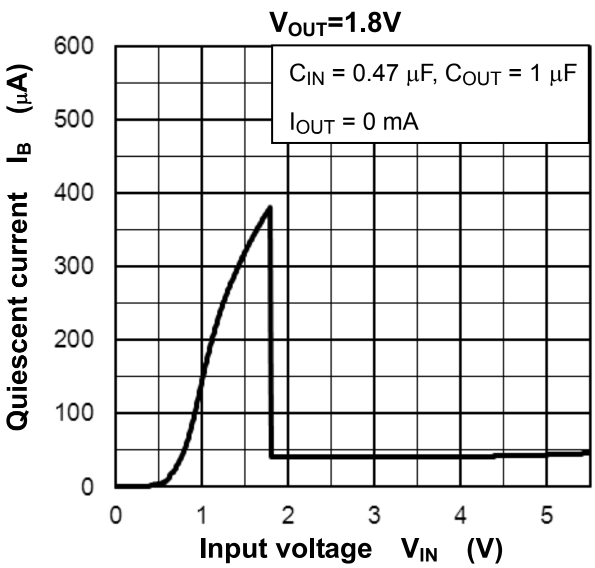


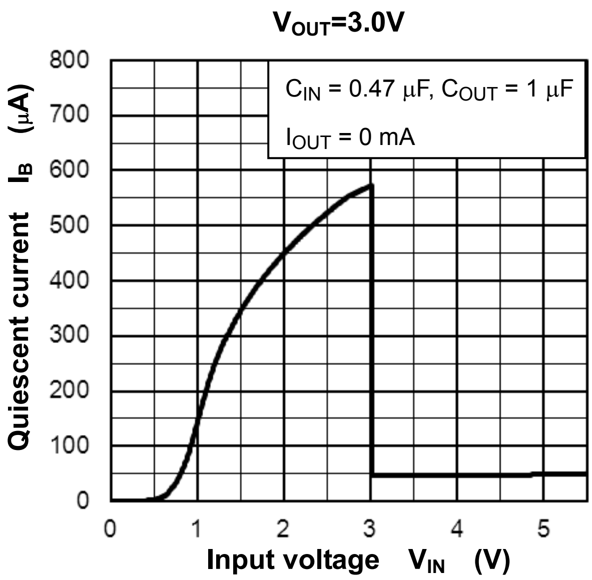




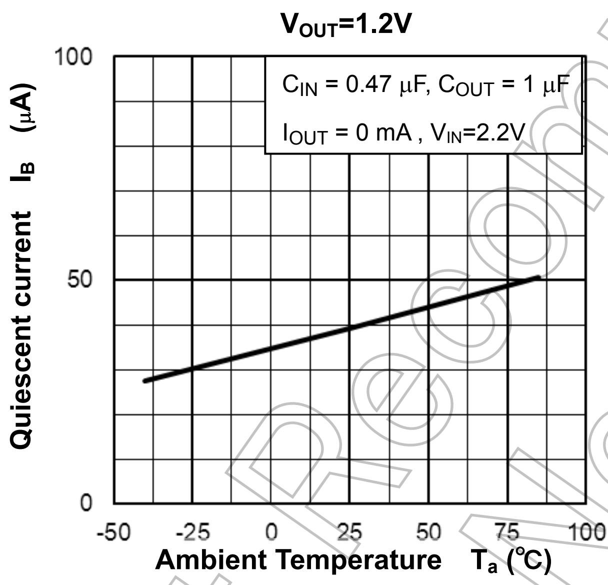
5) Quiescent Current vs. Input Voltage

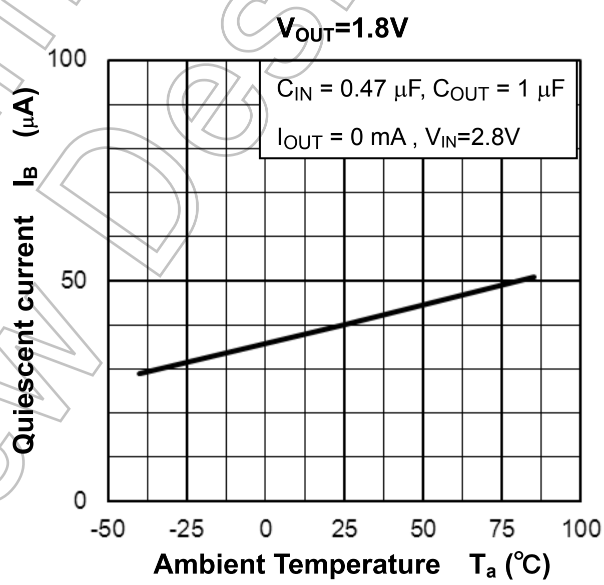


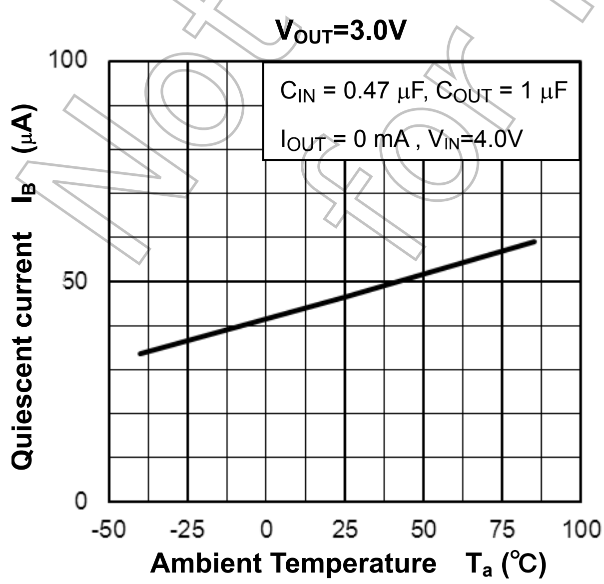




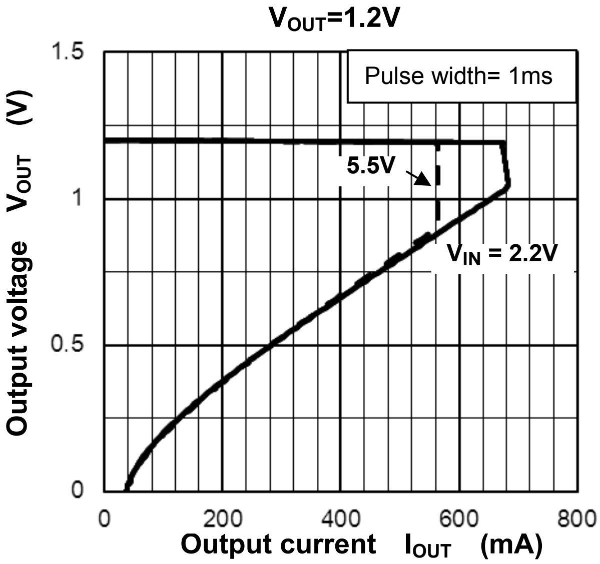
6) Quiescent Current vs. Ambient Temperature

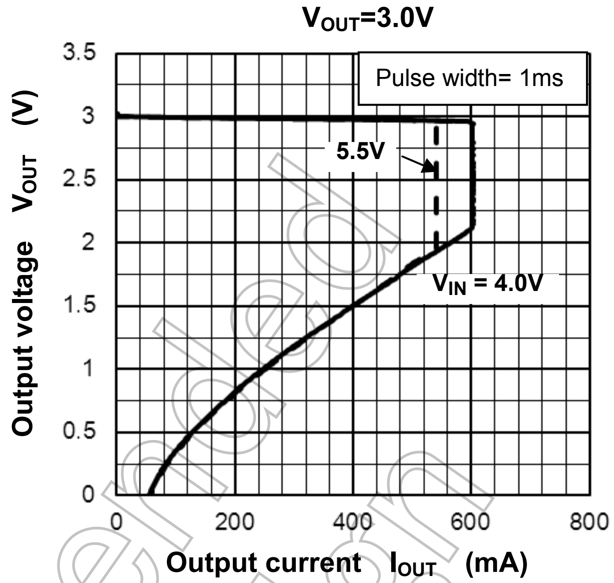




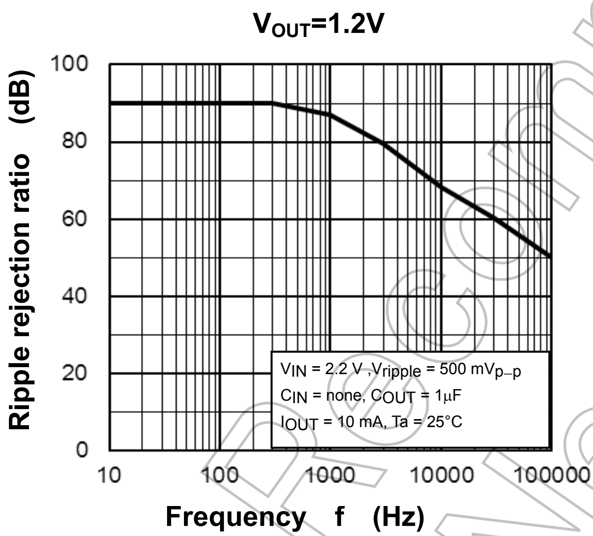


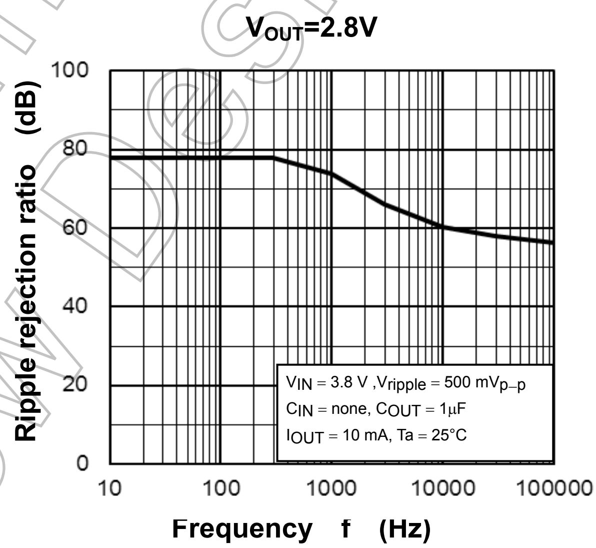
7) Output Voltage vs. Output Current



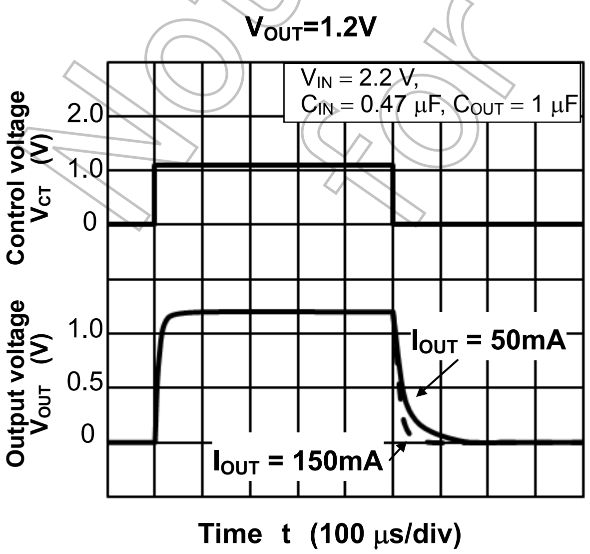


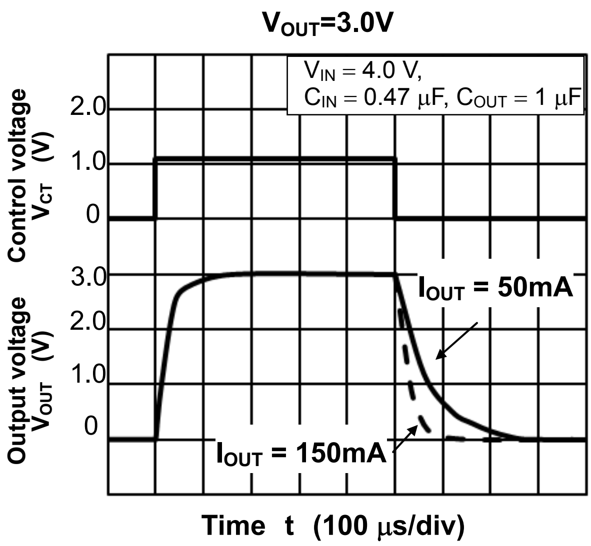
8) Ripple Rejection Ratio vs. Frequency



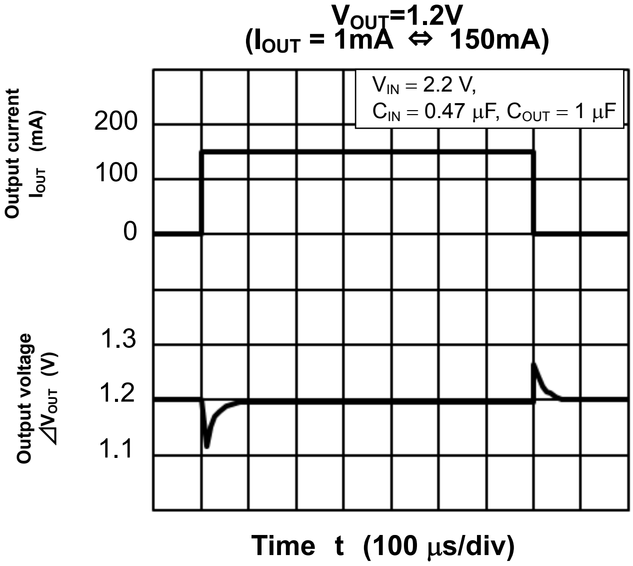


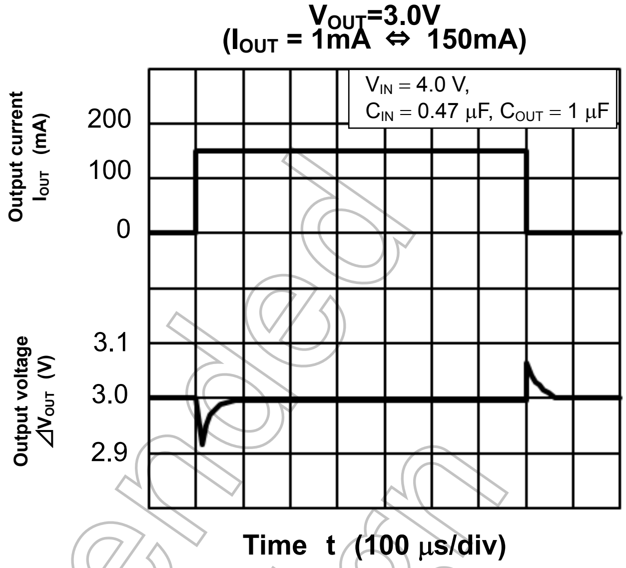
9) Control Transient vs. Response





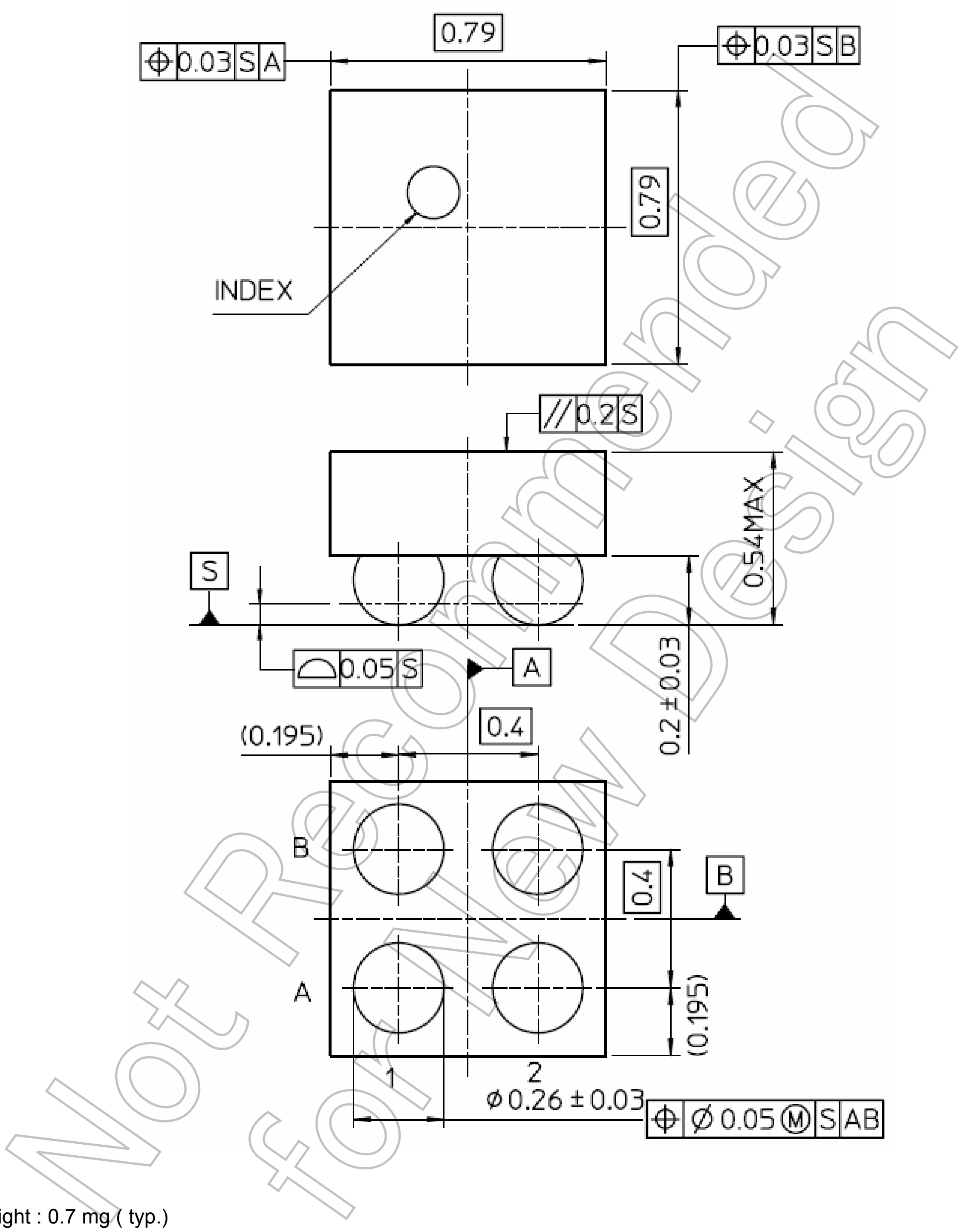
10) Load Transient Response





Package Dimensions

WCSP4 Unit : mm



Weight : 0.7 mg (typ.)

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