TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR3UG series

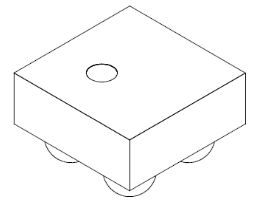
Ultra low quiescent current, Fast Load Transient 300 mA CMOS Low Dropout Regulator in ultra small package

1. Description

The TCR3UG series are CMOS general-purpose single-output voltage regulators with an on/off control input, featuring ultra low quiescent bias current and low dropout voltage.

These voltage regulators are available in fixed output voltages between 0.8 V and 5.0 V and capable of driving up to 300 mA. They feature Over-current protection, Thermal Shutdown function and Auto-discharge option.

The TCR3UG series is offered in the ultra small plastic mold package WCSP4F (0.645 mm x 0.645 mm (typ.); t 0.33 mm (max)) and has a low dropout voltage of 155 mV (3.3 V output, I_{OUT} = 300 mA). As small ceramic input and output capacitors 1 μF can be used with the TCR3UG series, these devices are ideal for portable applications that require high-density board assembly
such as cellular phones, IoT equipment and wearable devices.



WCSP4F

Weight: 0.26 mg (typ.)

2. Applications

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

3. Features

- Ultra small package WCSP4F (0.645 mm x 0.645 mm (typ.); t 0.33 mm (max)).
- Low quiescent bias current ($I_{B(ON)}$ = 0.34 μA (typ.) at I_{OUT} = 0 mA, output voltage up to 1.5 V)
- High ripple rejection ratio 70 dB at 0.8 V-output
- Fast load transient response ± 60 mV at 0.8 V-output, I_{OUT} = 1 mA ⇔ 50 mA
- Low dropout voltage

  $V_{DO} = V_{IN} - V_{OUT}$ = 140 mV (typ.) at 3.3 V-output, I_{OUT} = 300 mA
- Wide range output voltage line up (V_{OUT} = 0.8 to 5.0 V)
- High V_{OUT} accuracy ± 1.0 % (1.8 V ≤ V_{OUT})
- Auto-discharge (TCR3UGxxA series)/ Non-discharge (TCR3UGxxB series) line up
- Overcurrent protection
- Thermal shutdown function
- Inrush current protection circuit
- Pull down connection between CONTROL and GND
- Ceramic capacitors can be used (C_{IN} = 1 μF, C_{OUT} = 1 μF)

Start of commercial production
2017-10

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

Characteristics	Symbol	Rating	Unit
Input voltage	V_{IN}	-0.3 to 6.0	V
Control voltage	V_{CT}	-0.3 to V_{IN} + 0.3 ≤ 6.0	V
Output voltage	V_{OUT}	-0.3 to V_{IN} + 0.3 ≤ 6.0	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
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

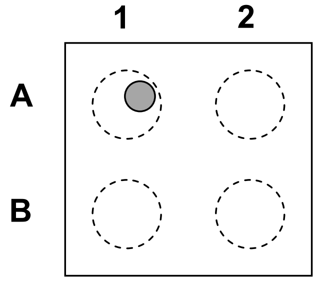
5. Operating Ranges

Characteristics	Symbol	Rating		Unit
Input voltage	V_{IN}	1.5 to 5.5 (Note 2)		V
Control voltage	V_{CT}	0 to V_{IN}		V
Output voltage	V_{OUT}	0.8 to 5.0		V
Output current	I_{OUT}	DC	300 (Note 3)	mA
Operating 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 13) and use it within Absolute Maximum Ratings Junction temperature and Operating 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.

6. Pin Assignment (top view)



	1	2
A	VIN	VOUT
B	CONTROL	GND

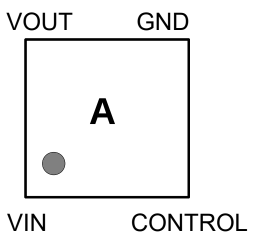
7. List of Products Number, Output voltage and Marking

Product No.	Output voltage(V)	Auto dis-charge	Marking	Product No.	Output voltage(V)	Auto dis-charge	Marking**
TCR3UG08A	0.8	Yes	A	TCR3UG08B	0.8	No	A
TCR3UG085A	0.85		B	TCR3UG085B	0.85		B
TCR3UG09A	0.9		C	TCR3UG09B	0.9		C
TCR3UG095A	0.95		D	TCR3UG095B	0.95		D
TCR3UG10A	1.0		E	TCR3UG10B	1.0		E
TCR3UG105A	1.05		F	TCR3UG105B	1.05		F
TCR3UG11A	1.1		H	TCR3UG11B	1.1		H
TCR3UG115A	1.15		J	TCR3UG115B	1.15		J
TCR3UG12A	1.2		K	TCR3UG12B	1.2		K
TCR3UG13A	1.3		L	TCR3UG13B	1.3		L
TCR3UG135A	1.35		M	TCR3UG135B	1.35		M
TCR3UG15A	1.5		N	TCR3UG15B	1.5		N
TCR3UG175A	1.75		P	TCR3UG175B	1.75		P
TCR3UG18A	1.8		R	TCR3UG18B	1.8		R
TCR3UG1825A	1.825		G	TCR3UG185B	1.85		S
TCR3UG185A	1.85		S	TCR3UG19B	1.9		T
TCR3UG19A	1.9		T	TCR3UG25B	2.5		U
TCR3UG25A	2.5		U	TCR3UG26B	2.6		V
TCR3UG26A	2.6		V	TCR3UG27B	2.7		W
TCR3UG27A	2.7		W	TCR3UG28B	2.8		X
TCR3UG28A	2.8		X	TCR3UG285B	2.85		Y
TCR3UG285A	2.85		Y	TCR3UG30B	3.0		0
TCR3UG30A	3.0		0	TCR3UG31B	3.1		1
TCR3UG31A	3.1		1	TCR3UG32B	3.2		2
TCR3UG32A	3.2		2	TCR3UG33B	3.3		3
TCR3UG33A	3.3		3	TCR3UG35B	3.5		4
TCR3UG35A	3.5		4	TCR3UG36B	3.6		5
TCR3UG36A	3.6		5	TCR3UG41B	4.1		9
TCR3UG41A	4.1		9	TCR3UG42B	4.2		6
TCR3UG42A	4.2		6	TCR3UG45B	4.5		7
TCR3UG45A	4.5		7	TCR3UG50B	5.0		8
TCR3UG50A	5.0		8				

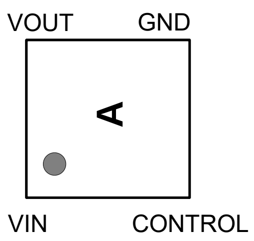
**Marking is rotated 90 degrees to the left.

Top Marking (top view)

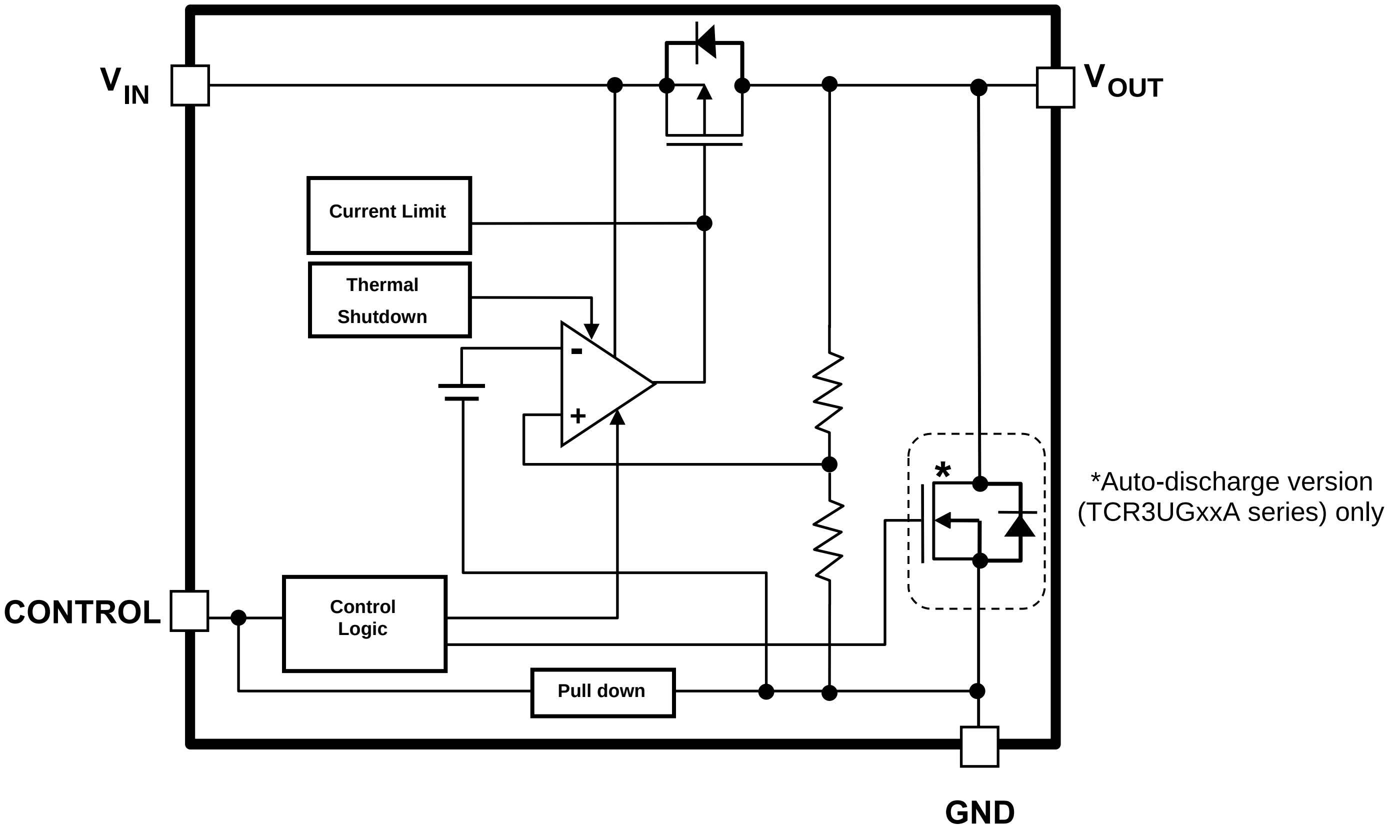
Example: TCR3UG08A (0.8 V output)



Example: TCR3UG08B (0.8 V output)



8. Block Diagram



9. Electrical Characteristics

(Unless otherwise specified,
V_{IN} = V_{OUT}+1 V (V_{OUT}>1.5V), V_{IN}=2.5V (V_{OUT}≤1.5V), I_{OUT} = 50 mA, C_{IN} = C_{OUT} = 1 μF)

Characteristics	Symbol	Test Condition		T_j = 25°C			T_j = -40 to 85°C (Note 9)		Unit
				Min	Typ.	Max	Min	Max	
Output voltage accuracy	V_{OUT}	I_{OUT} = 50 mA (Note 4)	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		1.5	—	5.5	1.5	5.5	V
Line regulation	Reg·line	I_{OUT} = 1 mA (Note 5)		—	1	15	—	—	mV
Load regulation	Reg·load	1 mA ≤ I_{OUT} ≤ 300 mA (Note 6)		—	10	30	—	—	mV
Quiescent current	$I_{B(ON1)}$	I_{OUT} = 0 mA, V_{OUT} ≤ 1.5V (Note 7)		—	0.34	—	—	0.58	μA
	$I_{B(ON2)}$	I_{OUT} = 0 mA, 1.75 V ≤ V_{OUT} ≤ 5 V (Note 7)		—	0.38	—	—	0.68	μA
Stand-by current	$I_{B\ (OFF1)}$	V_{CT} = 0 V, V_{IN} = 2.5 V		—	0.03	—	—	0.16	μA
	$I_{B\ (OFF2)}$	V_{CT} = 0 V, V_{IN} = 5.5 V		—	0.03	—	—	0.20	μA
Control pull down current	I_{CT}	—		—	0.1	—	—	—	μA
Dropout voltage	V_{DO}	I_{OUT} = 300 mA	V_{OUT} = 1.8 V	—	335	—	—	457	mV
			V_{OUT} = 3.3 V	—	140	—	—	273	mV
Output noise voltage	V_{NO}	I_{OUT} = 10 mA, 10 Hz ≤ f ≤ 100 kHz, Ta = 25°C (Note 6)		—	50	—	—	—	$μV_{rms}$
Ripple rejection ratio	R.R.	I_{OUT} = 10 mA, f = 1 kHz, V_{Ripple} = 200 mV_{p-p}, Ta = 25°C (Note 6)		—	70	—	—	—	dB
Load transient response	⊿V_{OUT}	I_{OUT} = 1 mA → 50 mA (Note 8)		—	-60	—	—	—	mV
		I_{OUT} = 50 mA → 1 mA (Note 8)		—	+60	—	—	—	mV
Temperature coefficient	T_{CVO}	−40°C ≤ T_{opr} ≤ 85°C		—	75	—	—	—	ppm/°C
Control voltage (ON)	$V_{CT\ (ON)}$	—		1.0	—	5.5	1.0	5.5	V
Control voltage (OFF)	$V_{CT\ (OFF)}$	—		0	—	0.4	0	0.4	V
Discharge on resistance	R_{SD}	—		—	10	—	—	—	Ω

Note 4: stable state with fixed I_{OUT} condition
Note 5: V_{OUT} ≤ 1.5 V, 2.5 V ≤ V_{IN} ≤ 5.5 V
1.75 V ≤ V_{OUT} ≤ 4.2 V, V_{OUT} + 1 V ≤ V_{IN} ≤ 5.5 V
V_{OUT} = 4.5 V, V_{OUT} = 5.0 V, not applicable
Note 6: V_{OUT} = 0.8V
Note 7: except Control pull down current (I_{CT})
Note 8: V_{OUT} = 0.8 V, V_{IN} = 3.3 V
Note 9: This parameter is warranted by design

10. Dropout voltage

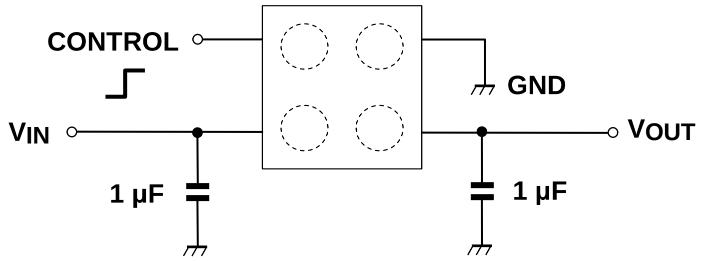
(I_{OUT} = 300 mA, C_{IN} = C_{OUT} = 1 μF)

Output voltages	Symbol	Min	Typ. T_j = 25°C	Max (Note 10)	Unit
0.8 V ≤ V_{OUT} < 0.9 V	V_{DO}	—	1025	1257	mV
0.9 V ≤ V_{OUT} < 1.0 V		—	930	1157	
1.0 V ≤ V_{OUT} < 1.1 V		—	835	1057	
1.1 V ≤ V_{OUT} < 1.2 V		—	740	957	
1.2 V ≤ V_{OUT} < 1.3 V		—	660	857	
1.3 V ≤ V_{OUT} < 1.5 V		—	580	757	
1.5 V ≤ V_{OUT} < 1.6 V		—	450	617	
1.6 V ≤ V_{OUT} < 1.8 V		—	400	537	
1.8 V ≤ V_{OUT} < 2.0 V		—	335	457	
2.0 V ≤ V_{OUT} < 2.5 V		—	260	405	
2.5 V ≤ V_{OUT} < 3.0 V		—	185	327	
3.0 V ≤ V_{OUT} < 3.6 V		—	140	273	
3.6 V ≤ V_{OUT} < 4.5 V		—	130	228	
4.5 V ≤ V_{OUT} ≤ 5.0 V		—	120	195	

Note 10: T_j = -40 to 85 °C. This parameter is warranted by design

11. Application Note

11.1. Example of Application Circuit



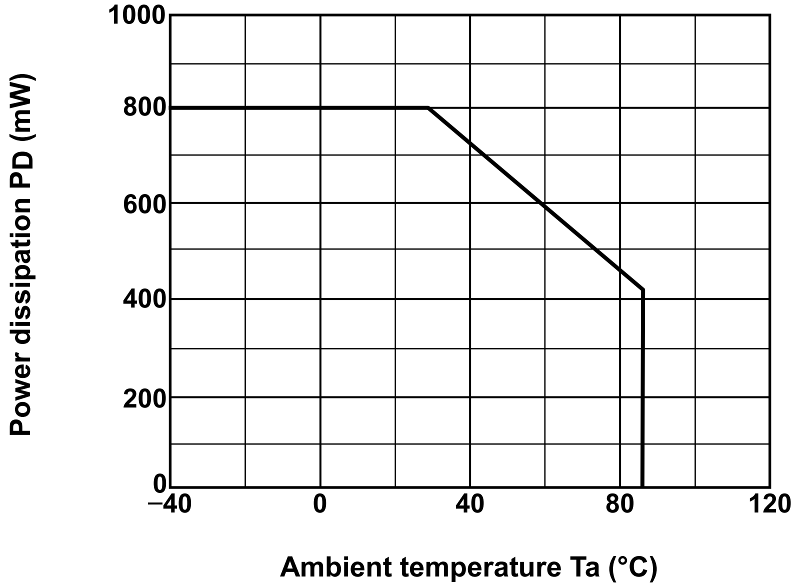
CONTROL voltage	VOUT voltage
HIGH	ON
LOW	OFF
OPEN	OFF

The figure above shows the Example of configuration for using a Low-Dropout regulator. Insert a capacitor at V_{OUT} and V_{IN} pins for stable input/output operation. (Ceramic capacitors can be used).

11.2. Power Dissipation

Board-mounted power dissipation ratings 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



11.3. 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.

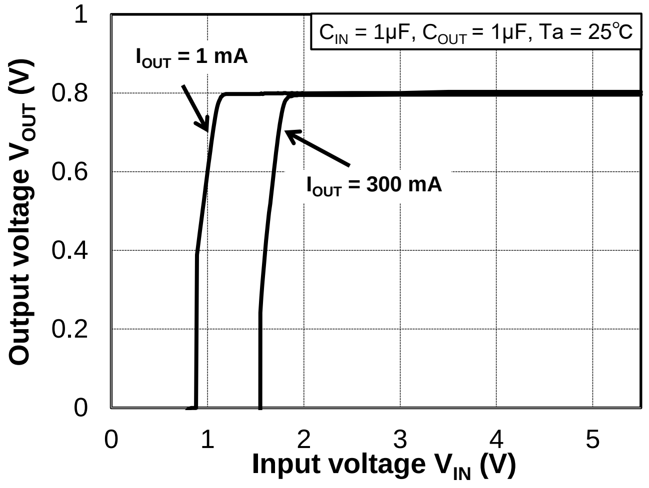
- Permissible Loss
  Please have enough design patterns for expected maximum permissible loss. And under consideration of ambient temperature, input voltage, output current etc., we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70 to 80 %.

- 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.

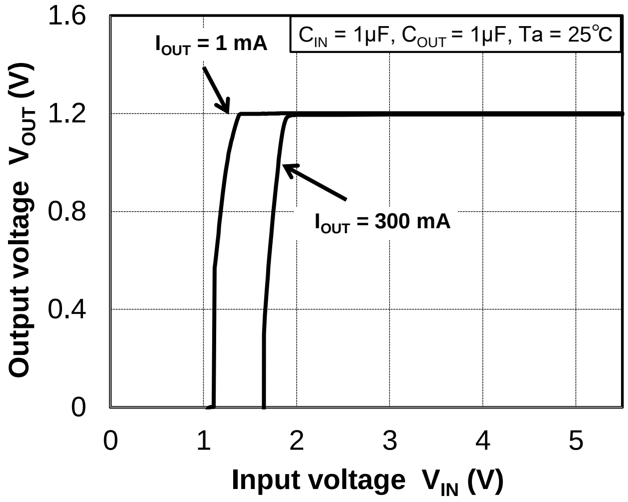
12. Representative Typical Characteristics

12.1. Output Voltage vs. Input Voltage

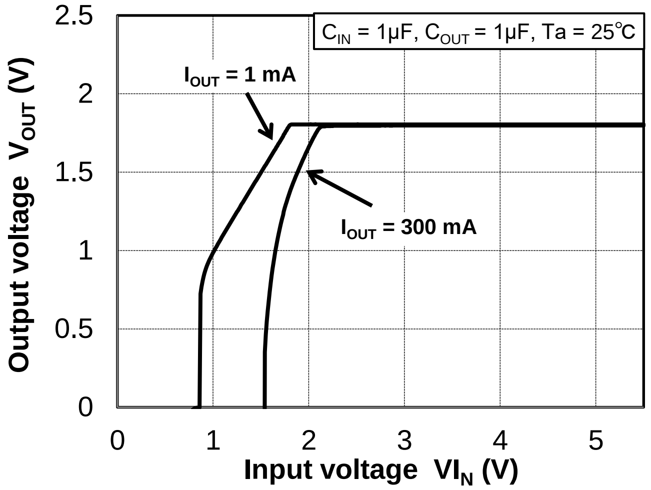
V_{OUT} = 0.8 V



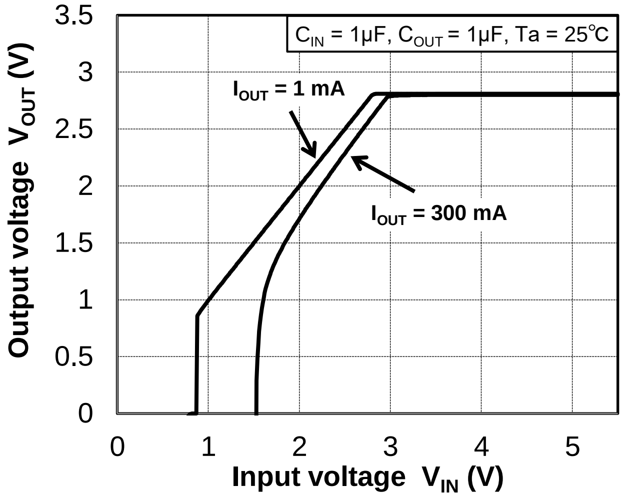
V_{OUT} = 1.2 V



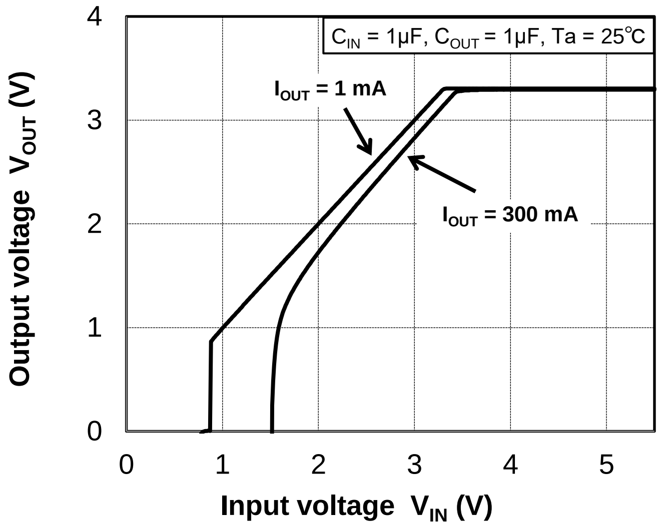
V_{OUT} = 1.8 V



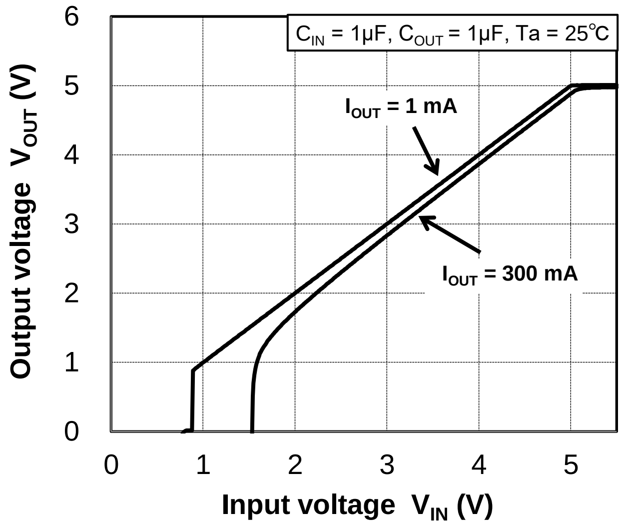
V_{OUT} = 2.8 V



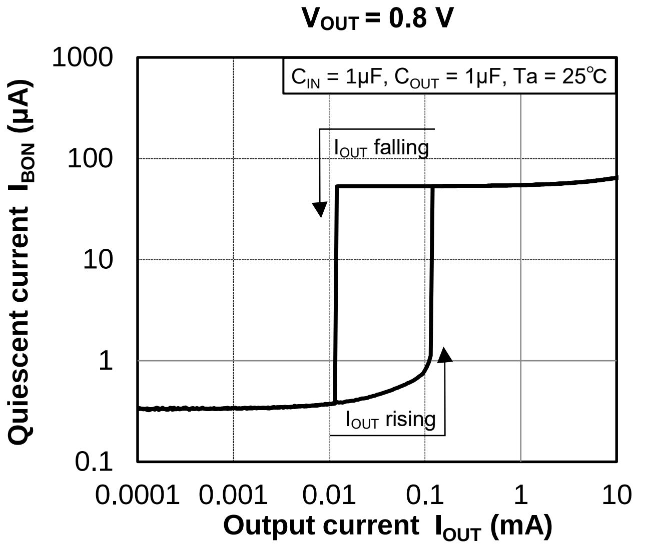
V_{OUT} = 3.3 V

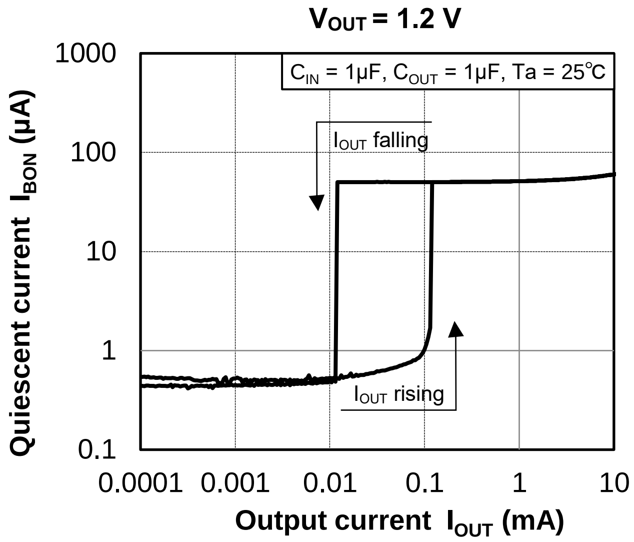


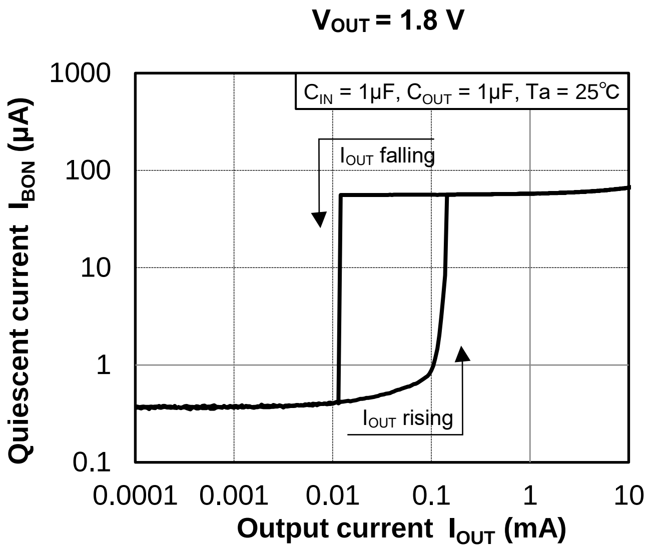
V_{OUT} = 5.0 V

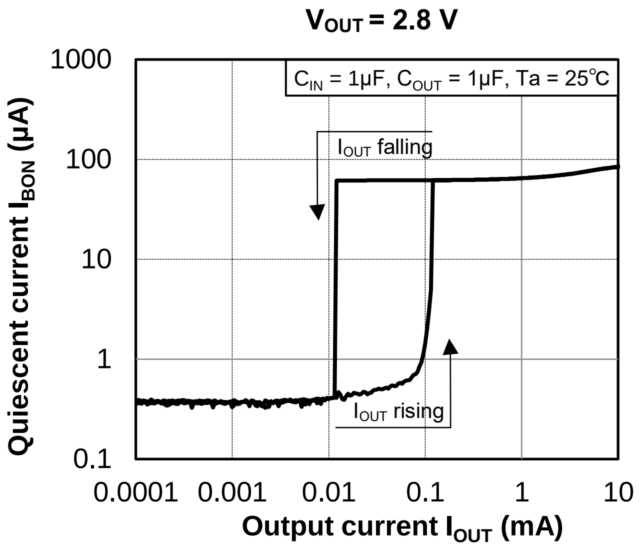


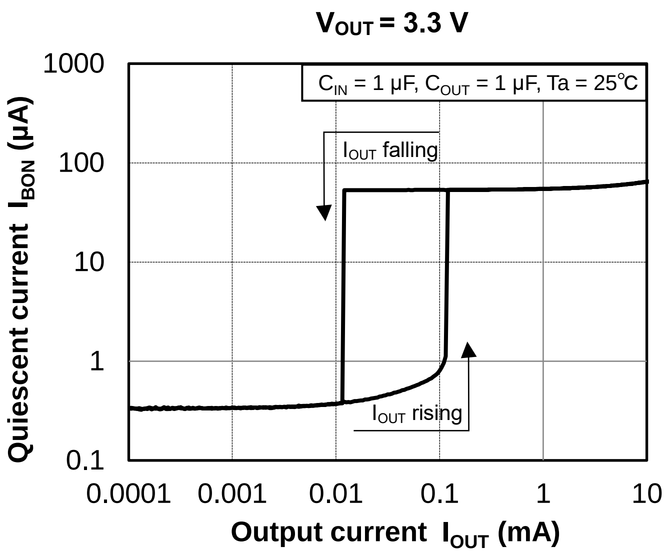
12.2. Output Voltage vs. Output Current

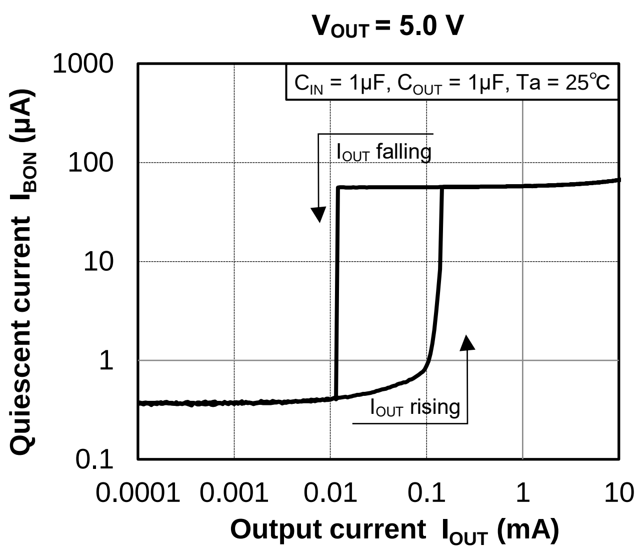




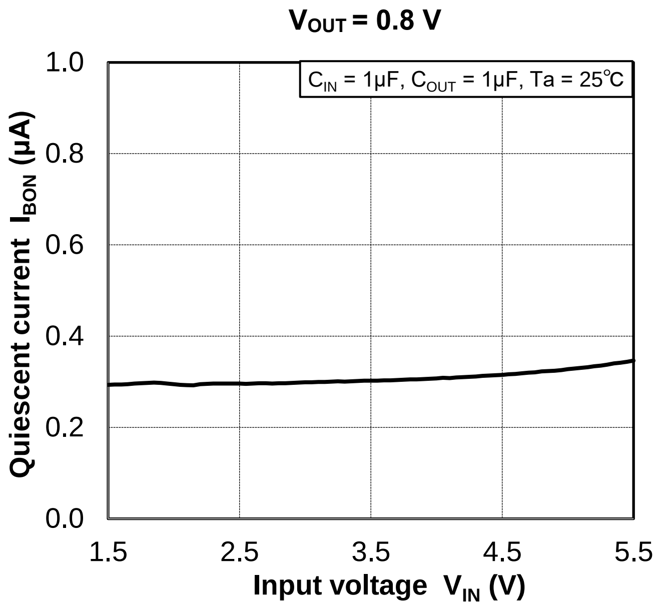


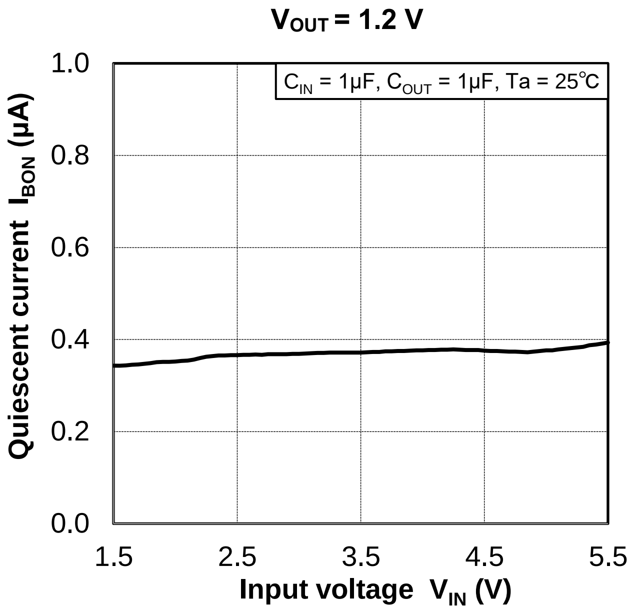


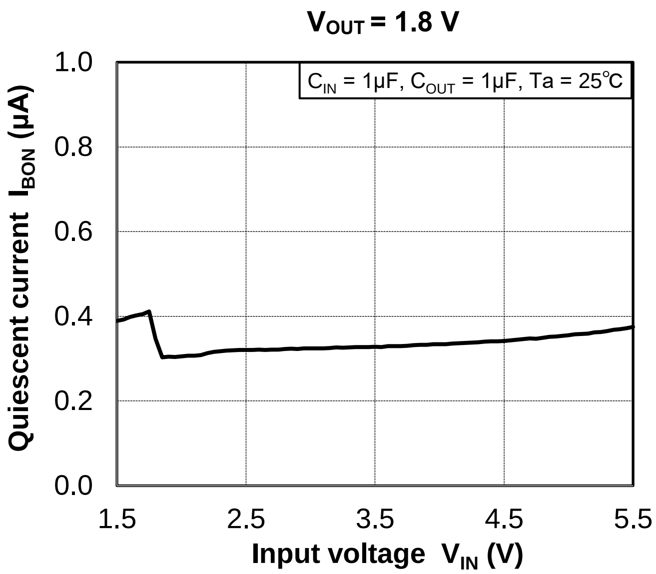


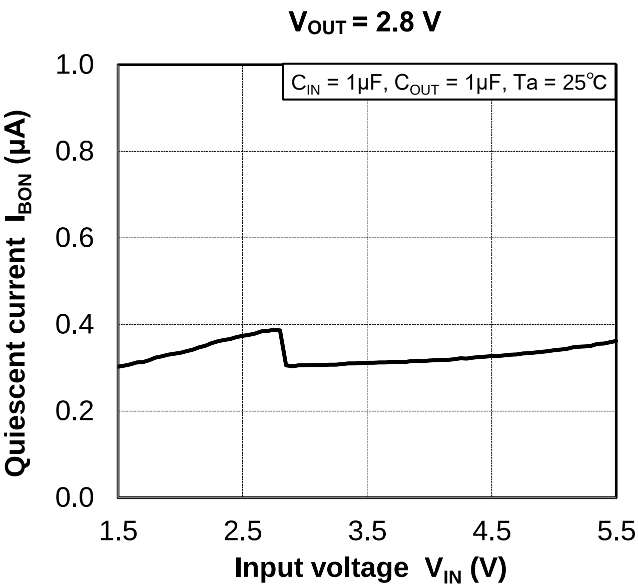


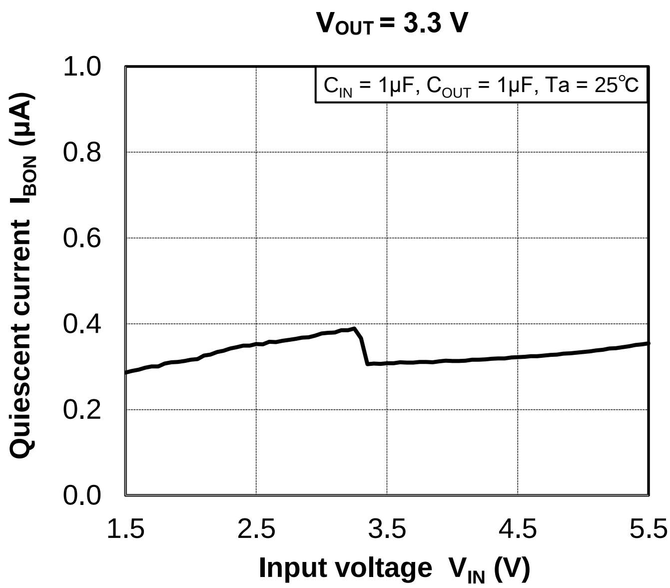
12.3. Quiescent Current vs. Input Voltage

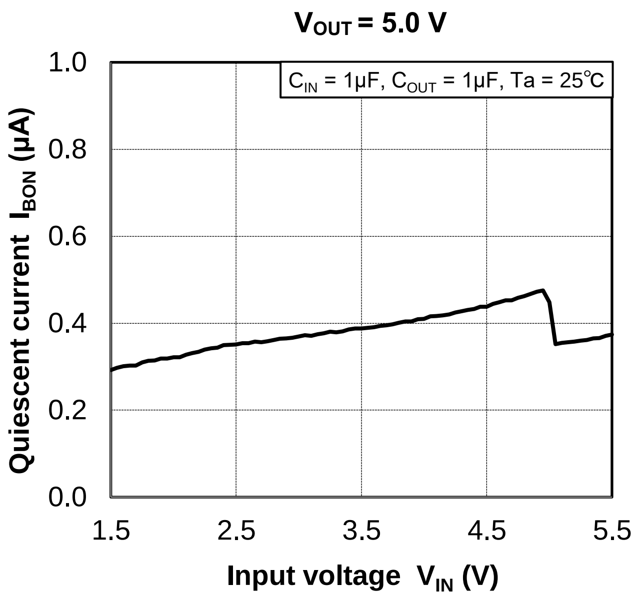




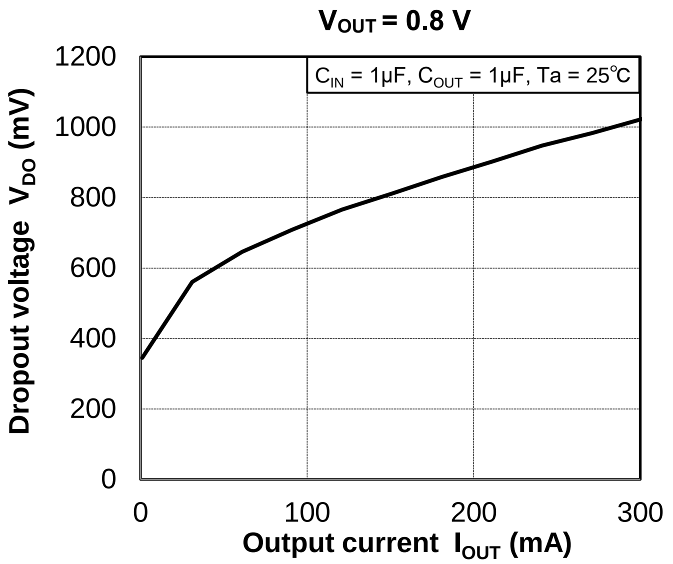


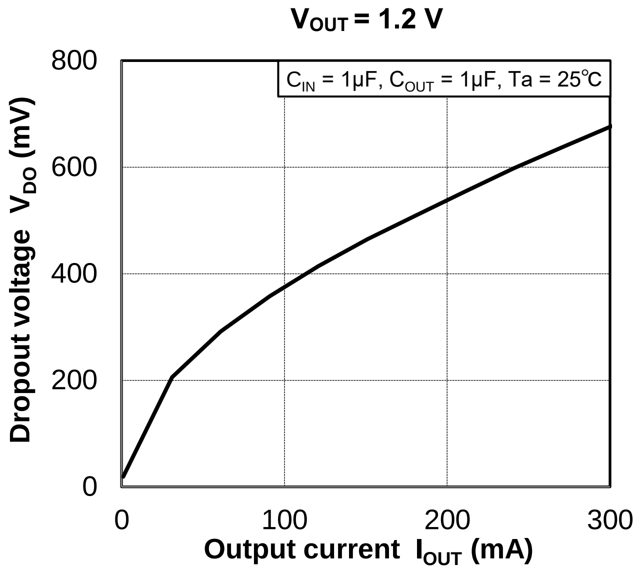


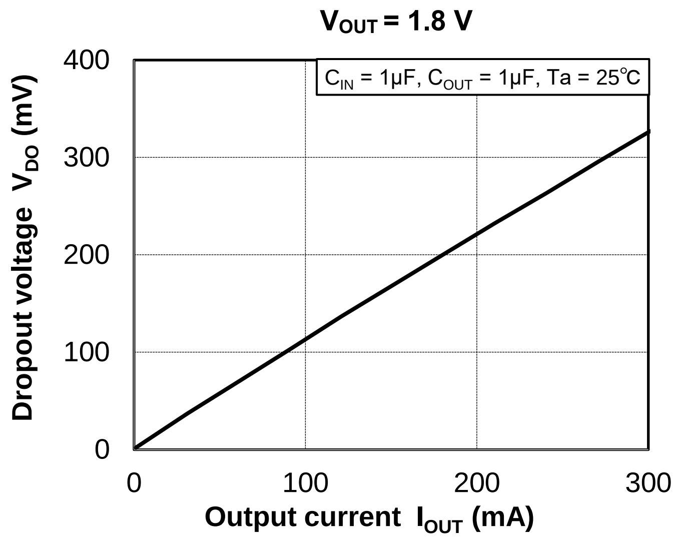


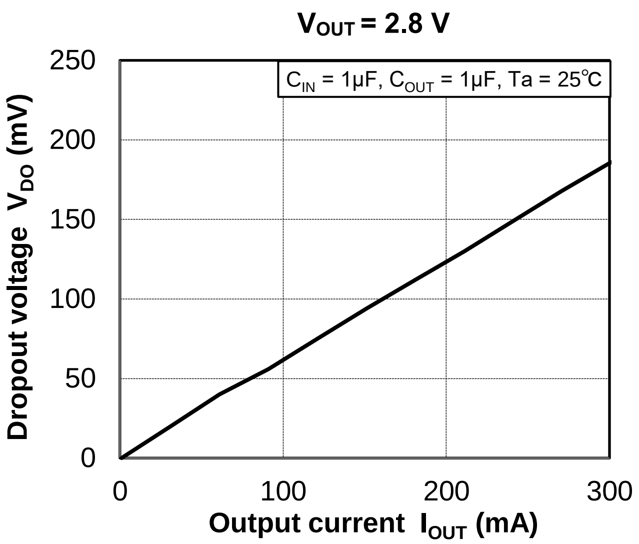


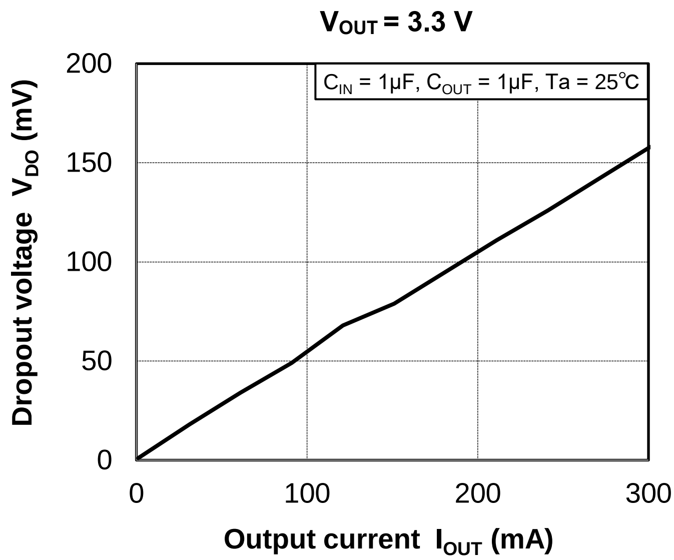
12.4. Dropout Voltage vs. Output current

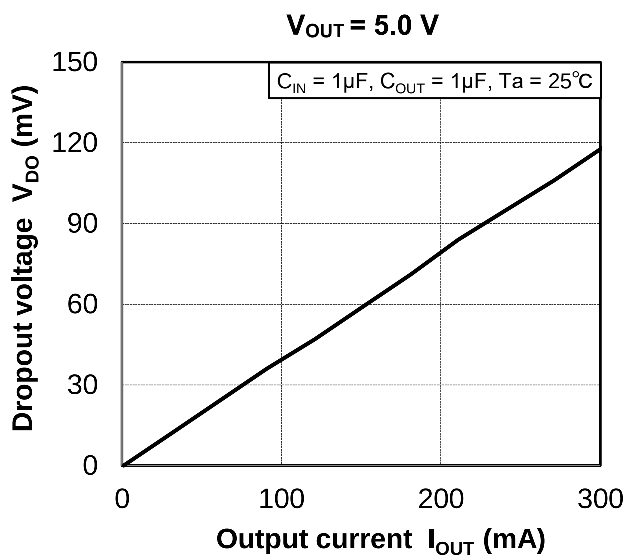




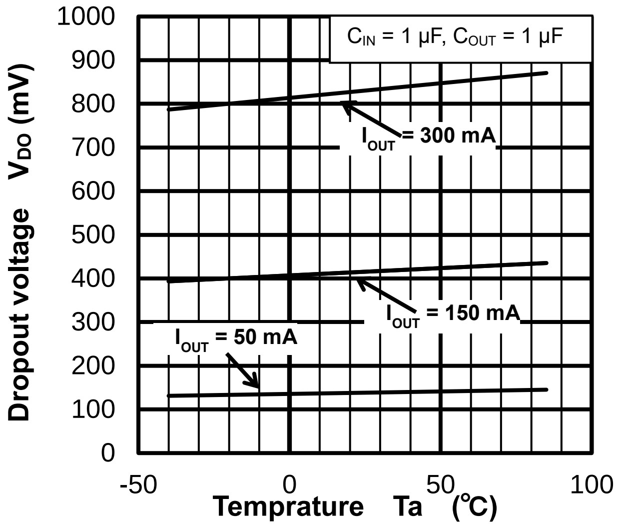


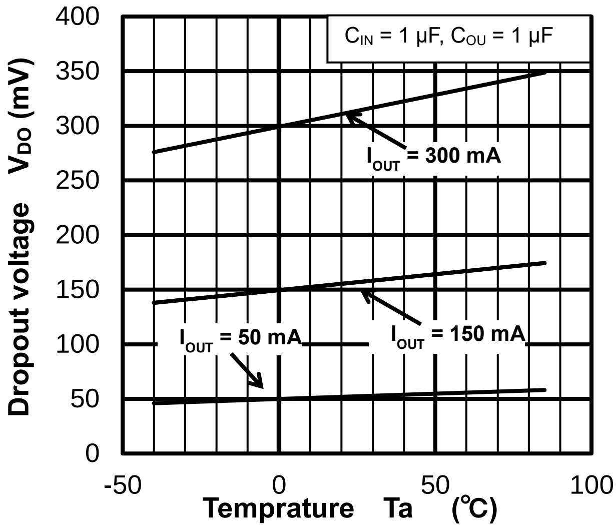


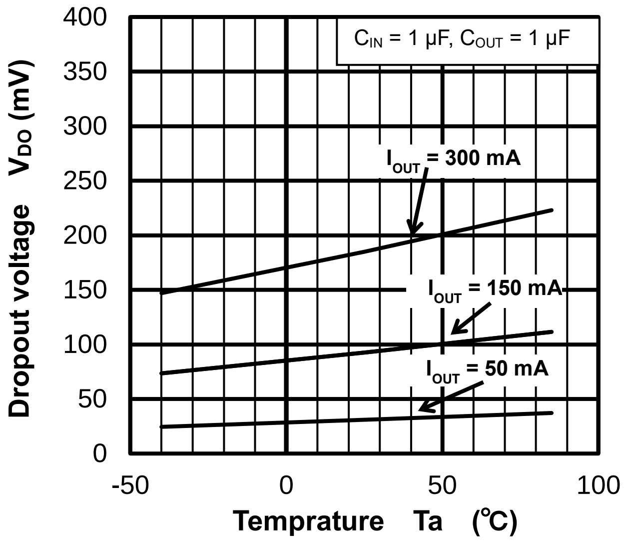




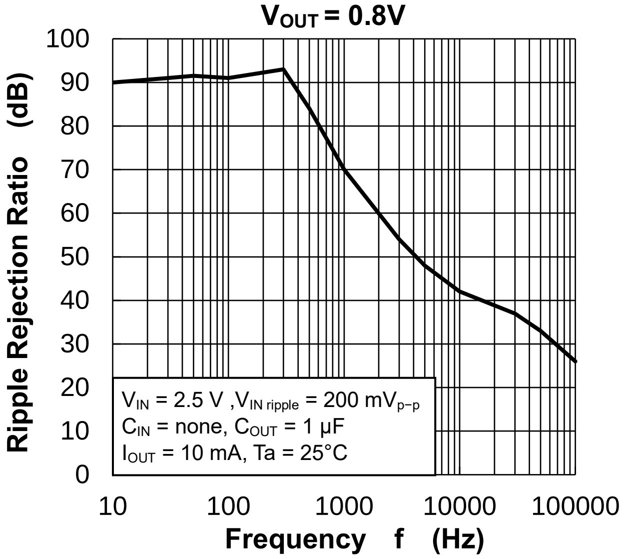
12.5. Dropout Voltage vs. Temprature

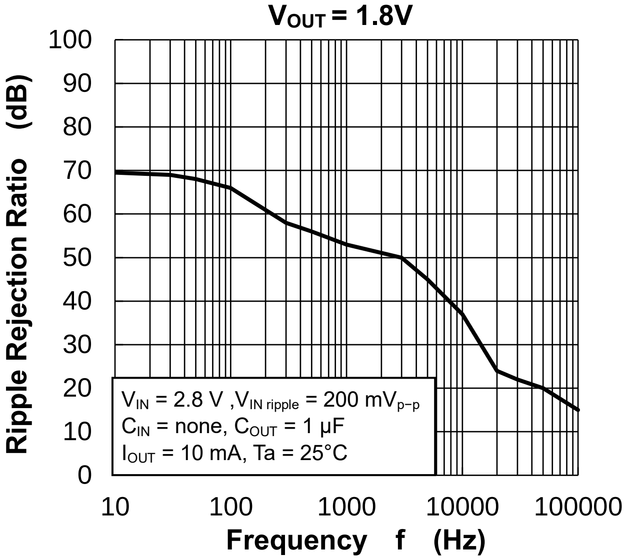


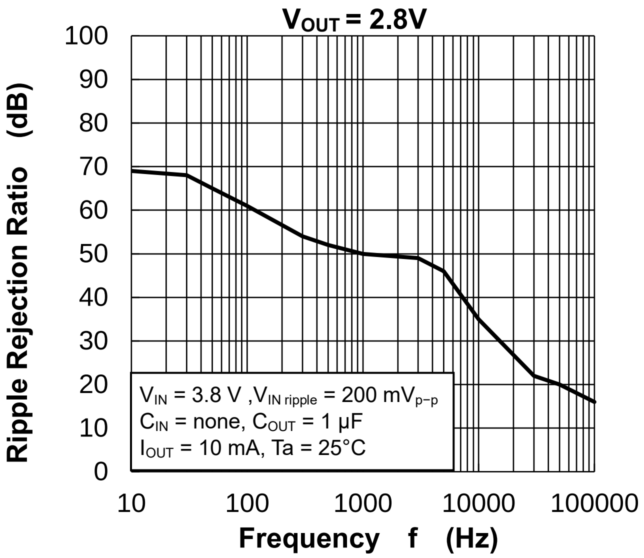




12.6. Ripple Rejection Ratio vs. Frequency

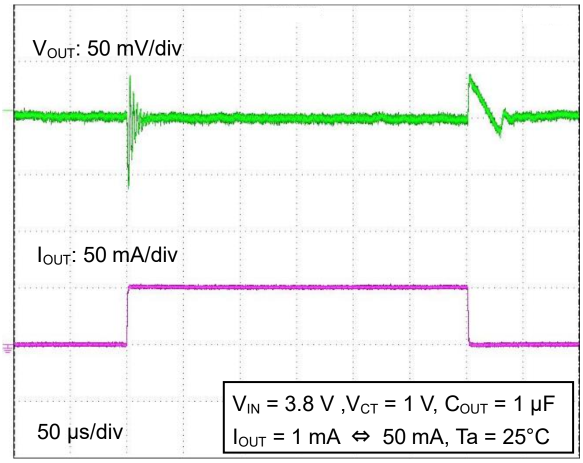




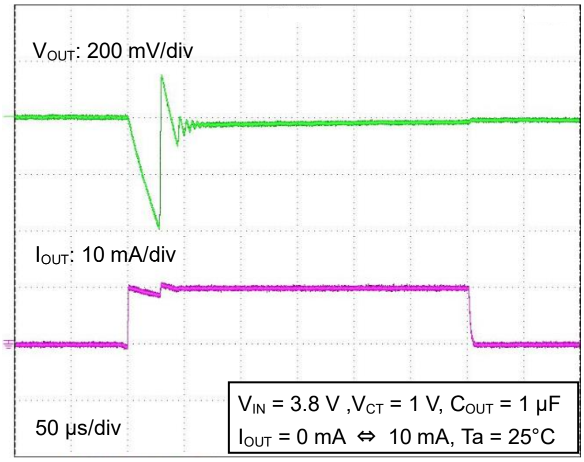


12.7. Load Transient Response

V_{OUT} = 2.8V

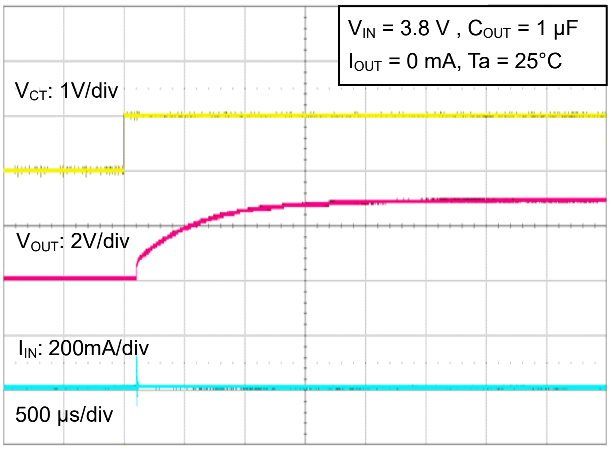


V_{OUT} = 2.8V

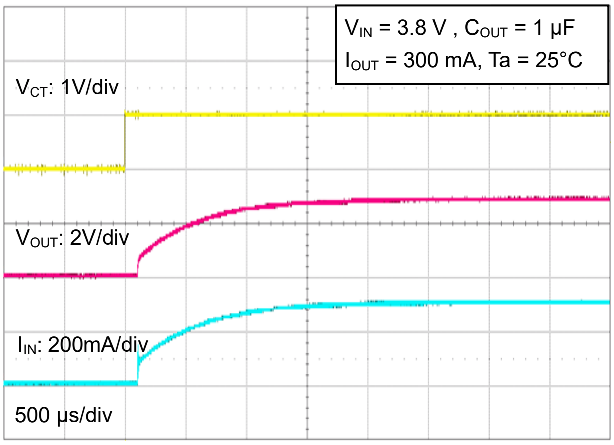


12.8. t_{ON} Response

V_{OUT} = 2.8V

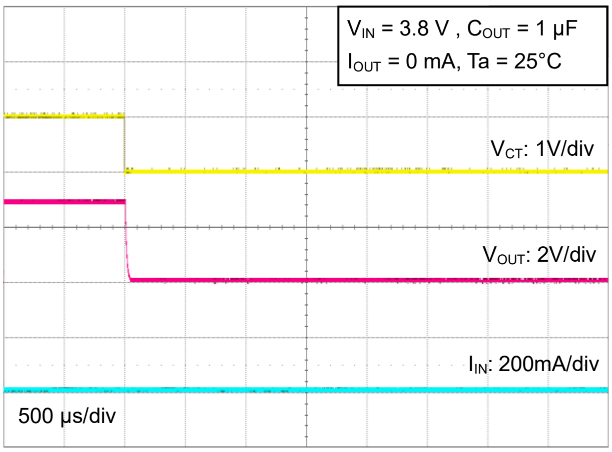


V_{OUT} = 2.8V

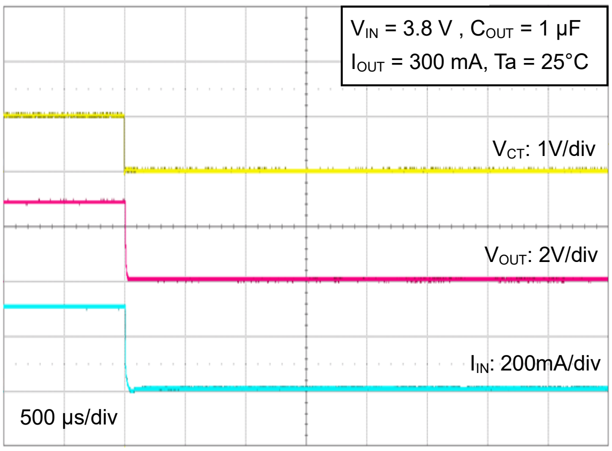


12.9. t_{OFF} Response (Auto-discharge)

V_{OUT} = 2.8V



V_{OUT} = 2.8V

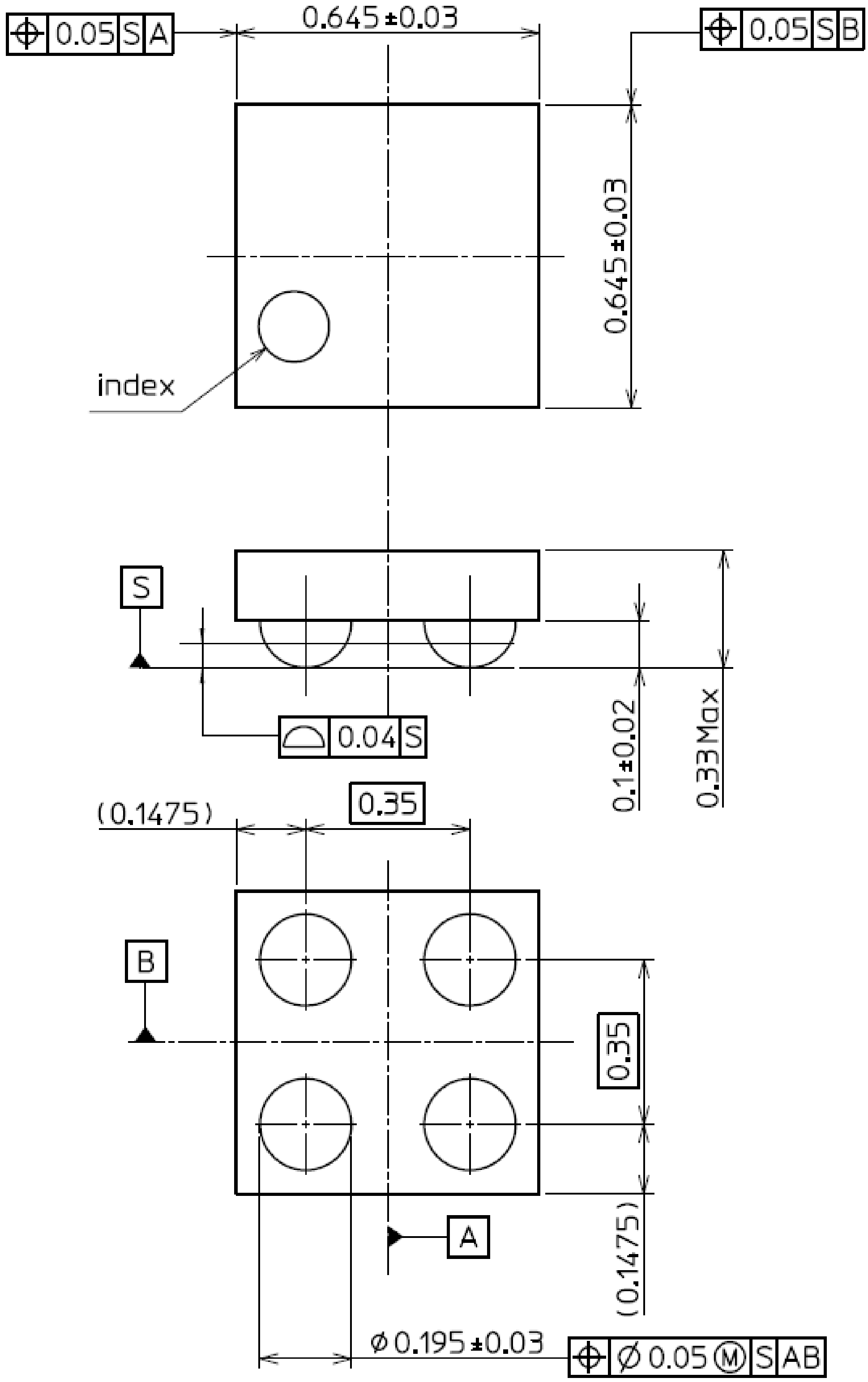


Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

13. Package Information

WCSP4F

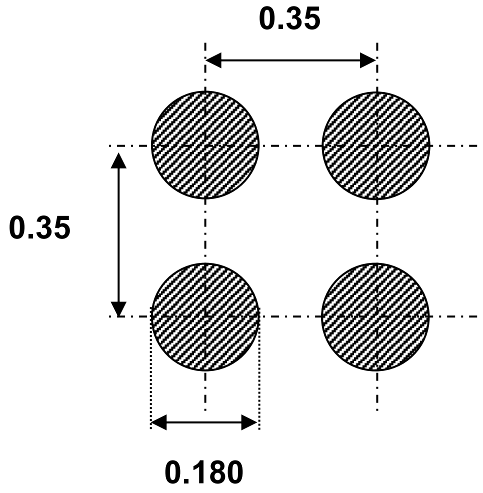
Unit: mm



Weight: 0.26 mg (typ.)

Land pattern dimensions for reference only

Unit: mm



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