TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR3UM series

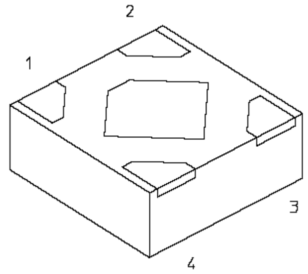
Ultra low quiescent current, Fast Load Transient 300 mA CMOS Low Dropout Regulator in ultra small package

1. Description

The TCR3UM 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.

The TCR3UM series is offered in the ultra small plastic mold package DFN4/DFN4E (1.0 mm x 1.0 mm; t 0.60 mm (max)) and has a low dropout voltage of 196 mV (3.3 V output, I_{OUT} = 300 mA). As small ceramic input and output capacitors 1 μF can be used with the TCR3UM series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones, IoT equipment and wearable devices.



BOTTOM VIEW ILLUSTRATION

DFN4/DFN4E

Weight: 1.3 mg (typ.)

2. Applications

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

3. Features

- Ultra small package DFN4/DFN4E (1.0 mm x 1.0 mm; t 0.60 mm (max)).
- Low quiescent bias current (I_B = 0.34 μA (typ.) at I_{OUT} = 0 mA, output voltage up to 1.5 V)
- High Ripple rejection ratio 70 dB (typ.) at 0.8 V-output
- Fast Load transient response -51/+36 mV at 0.8 V-output, I_{OUT} = 1 mA ⇔ 50 mA
- Low Dropout voltage
  V_{DO} = 196 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})
- Overcurrent protection
- Thermal Shutdown function
- Auto-discharge
- 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
2018-08

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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	420 (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

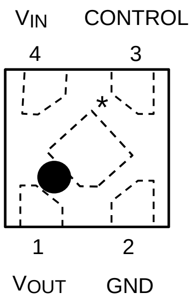
5. Operating Ranges

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)



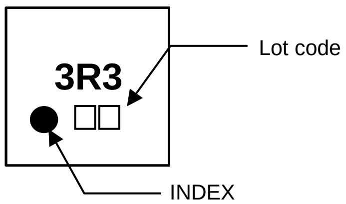
*Center electrode should be connected to GND or Open

7. List of Products Number, Output voltage and Marking

Product No.	Output voltage(V)	Auto dis-charge	Marking
TCR3UM08A	0.8	Yes	0R8
TCR3UM085A	0.85		0RA
TCR3UM09A	0.9		0R9
TCR3UM095A	0.95		0RB
TCR3UM10A	1.0		1R0
TCR3UM105A	1.05		1RC
TCR3UM11A	1.1		1R1
TCR3UM115A	1.15		1RE
TCR3UM12A	1.2		1R2
TCR3UM13A	1.3		1R3
TCR3UM135A	1.35		1RF
TCR3UM14A	1.4		1R4
TCR3UM15A	1.5		1R5
TCR3UM16A	1.6		1R6
TCR3UM175A	1.75		1RG
TCR3UM18A	1.8		1R8
TCR3UM1825A	1.825		1RH
TCR3UM185A	1.85		1RJ
TCR3UM19A	1.9		1R9
TCR3UM25A	2.5		2R5
TCR3UM26A	2.6		2R6
TCR3UM27A	2.7		2R7
TCR3UM28A	2.8		2R8
TCR3UM285A	2.85		2RK
TCR3UM29A	2.9		2R9
TCR3UM2925A	2.925		2RL
TCR3UM30A	3.0		3R0
TCR3UM31A	3.1		3R1
TCR3UM32A	3.2		3R2
TCR3UM33A	3.3		3R3
TCR3UM35A	3.5		3R5
TCR3UM36A	3.6		3R6
TCR3UM41A	4.1		4R1
TCR3UM42A	4.2		4R2
TCR3UM45A	4.5		4R5
TCR3UM50A	5.0		5R0

Top Marking (top view)

Example: TCR3UM33A (3.3 V output)



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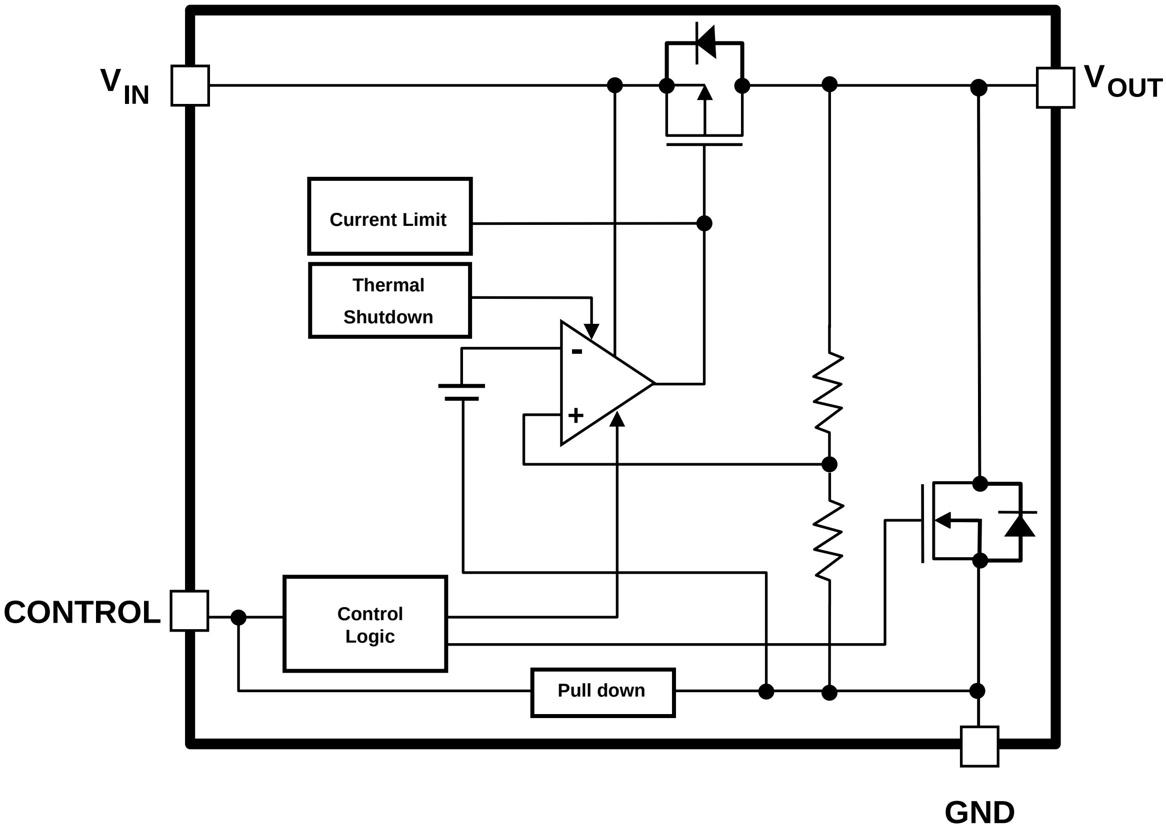
8. Block Diagram



9. Electrical Characteristics

(Unless otherwise specified,
V_{IN} = V_{OUT} + 1 V (V_{OUT} > 1.5 V), V_{IN} = 2.5 V (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
			1.8V ≤ 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)		—	17	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
Drop-out voltage	V_{DO}	I_{OUT} = 300 mA	V_{OUT} = 1.8 V	—	336	—	—	457	mV
			V_{OUT} = 3.3 V	—	196	—	—	273	mV
Output current limit	I_{CL}	V_{OUT} = $V_{OUT(NOM)}$*90% (Note 9)		—	545	—	400	—	mA
Output noise voltage	V_{NO}	I_{OUT} = 10 mA, 10 Hz ≤ f ≤ 100 kHz, Ta = 25°C (Note 6)		—	41	—	—	—	$μV_{rms}$
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)		—	-51	—	—	—	mV
		I_{OUT} = 50 mA → 1 mA (Note 8)		—	+36	—	—	—	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}	—		—	7	—	—	—	Ω
Thermal shutdown temperature	T_{SD}	(Note 9) (Note 10)		—	158	—	—	—	°C
Thermal shutdown hysteresis	T_{SDH}	(Note 9) (Note 10)		—	28	—	—	—	°C

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
Note 10: V_{OUT} = 0.8 V, V_{IN} = 2.5 V

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10. Dropout voltage

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

Output voltages	Symbol	Min	Typ. T_j = 25°C	Max (Note 11)	Unit
0.8 V ≤ V_{OUT} < 0.9 V	V_{DO}	—	1020	1257	mV
0.9 V ≤ V_{OUT} < 1.0 V		—	933	1157	
1.0 V ≤ V_{OUT} < 1.1 V		—	848	1057	
1.1 V ≤ V_{OUT} < 1.2 V		—	760	957	
1.2 V ≤ V_{OUT} < 1.3 V		—	667	857	
1.3 V ≤ V_{OUT} < 1.5 V		—	580	757	
1.5 V ≤ V_{OUT} < 1.6 V		—	462	617	
1.6 V ≤ V_{OUT} < 1.8 V		—	420	537	
1.8 V ≤ V_{OUT} < 2.0 V		—	336	457	
2.0 V ≤ V_{OUT} < 2.5 V		—	292	405	
2.5 V ≤ V_{OUT} < 3.0 V		—	216	327	
3.0 V ≤ V_{OUT} < 3.6 V		—	196	273	
3.6 V ≤ V_{OUT} < 4.5 V		—	174	232	
4.5 V ≤ V_{OUT} ≤ 5.0 V		—	149	210	

Note 11: T_j = -40 to 85 °C. This parameter is warranted by design

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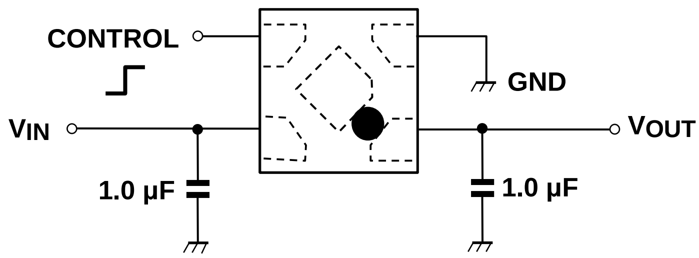
11. Application Note

11.1. Example of Application Circuit



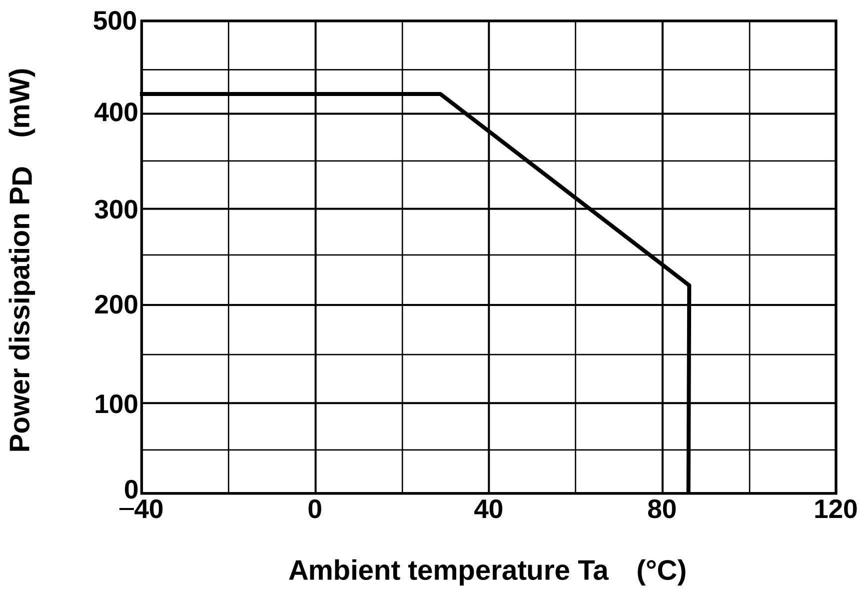
CONTROL voltage	Output voltage
HIGH	ON
LOW	OFF
OPEN	OFF

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.)

11.2. Power Dissipation

Board mounted power dissipation ratings for TCR3UM 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 0.5 mm x 24



12. 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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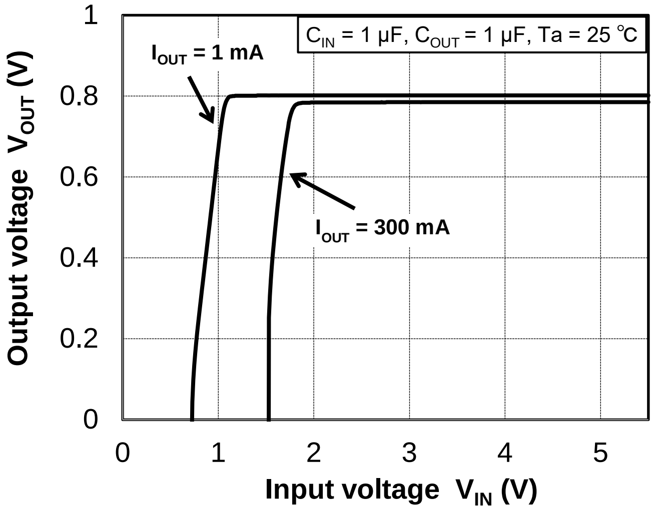
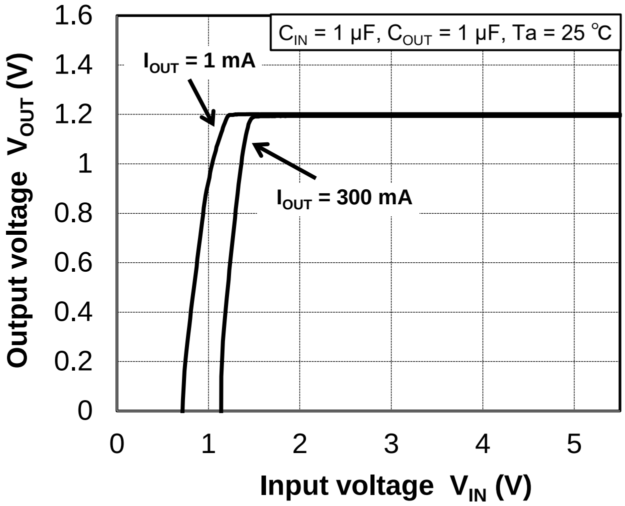
13. Representative Typical Characteristics

13.1. Output Voltage vs. Input Voltage

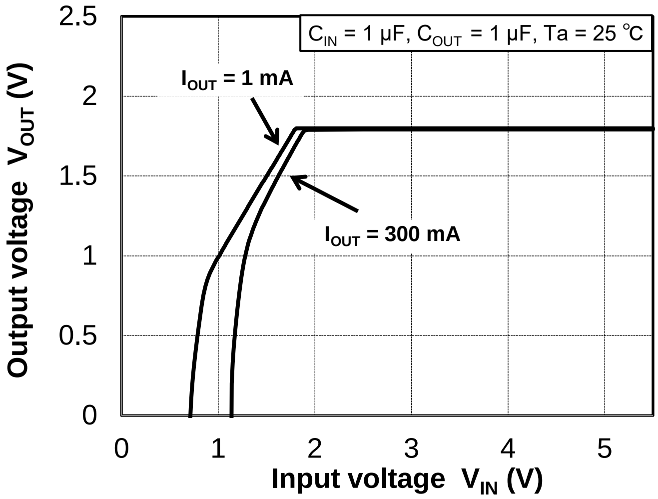
V_{OUT} = 0.8 V



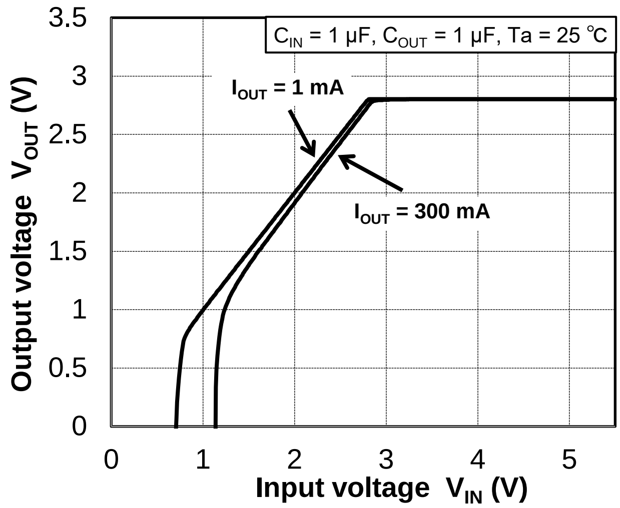
V_{OUT} = 1.2 V



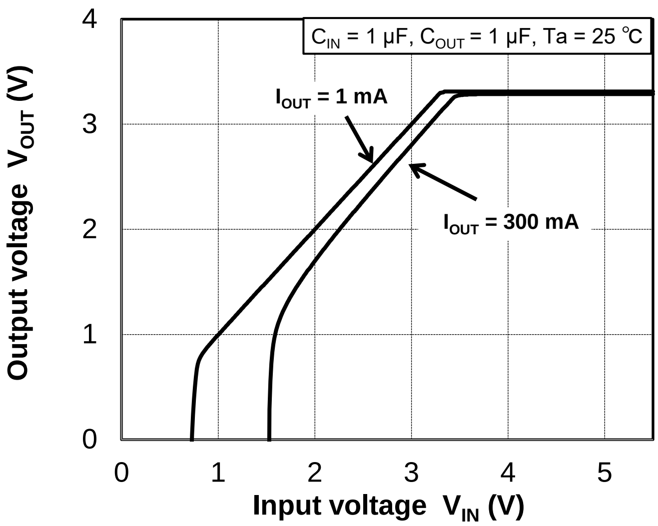
V_{OUT} = 1.8 V



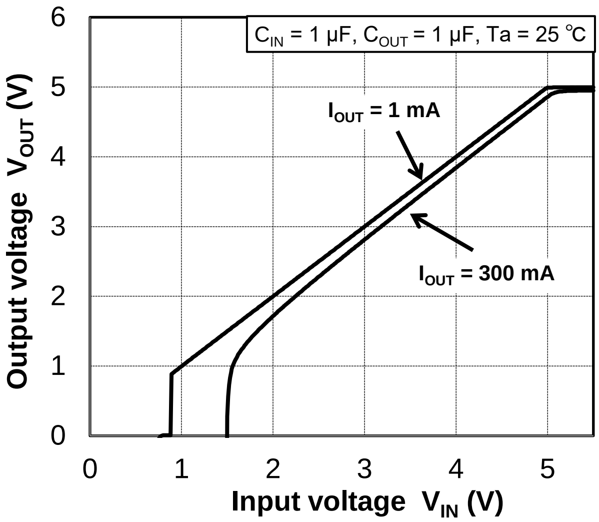
V_{OUT} = 2.8 V



V_{OUT} = 3.3 V



V_{OUT} = 5.0 V



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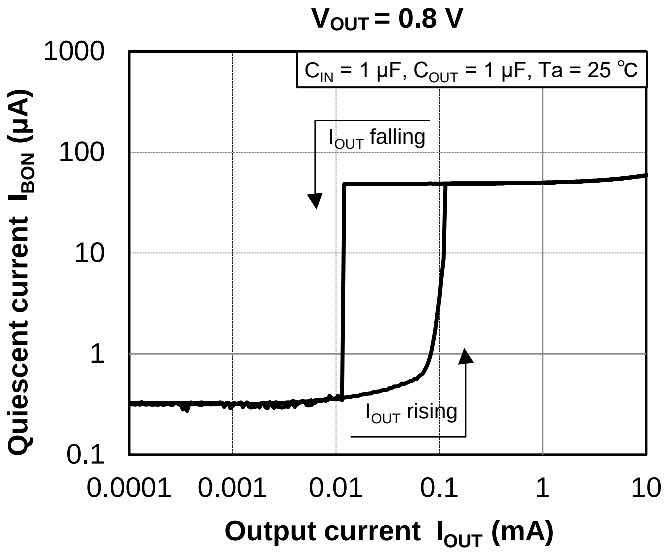
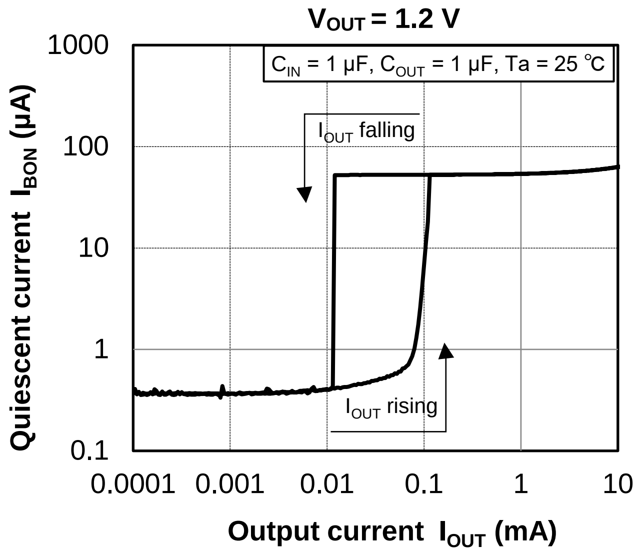
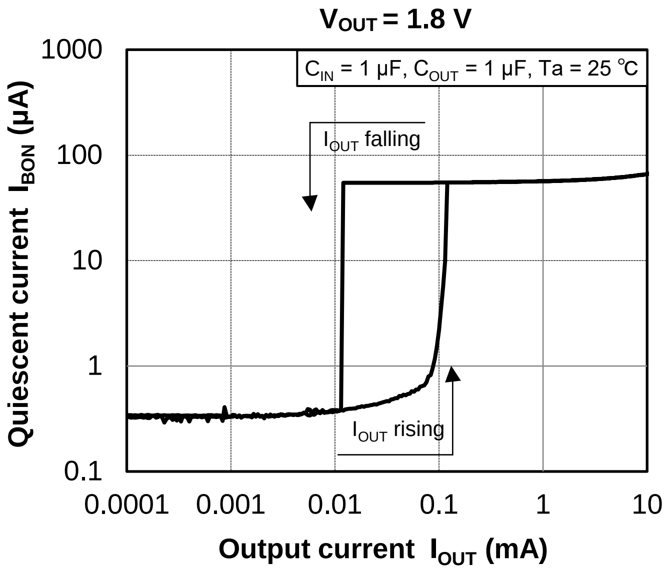
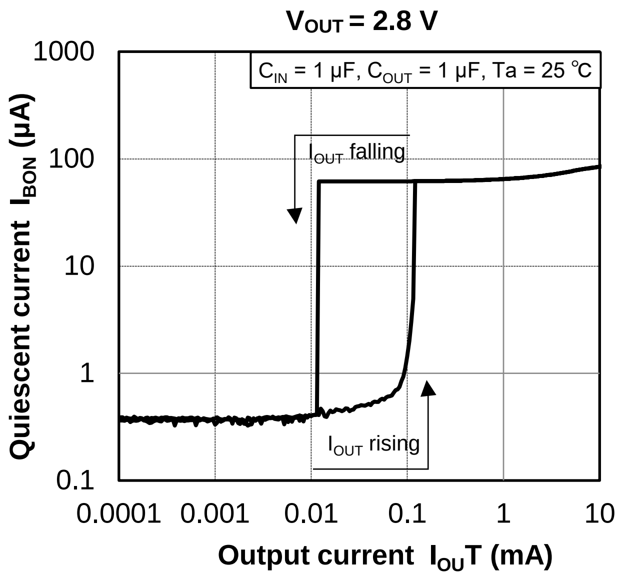
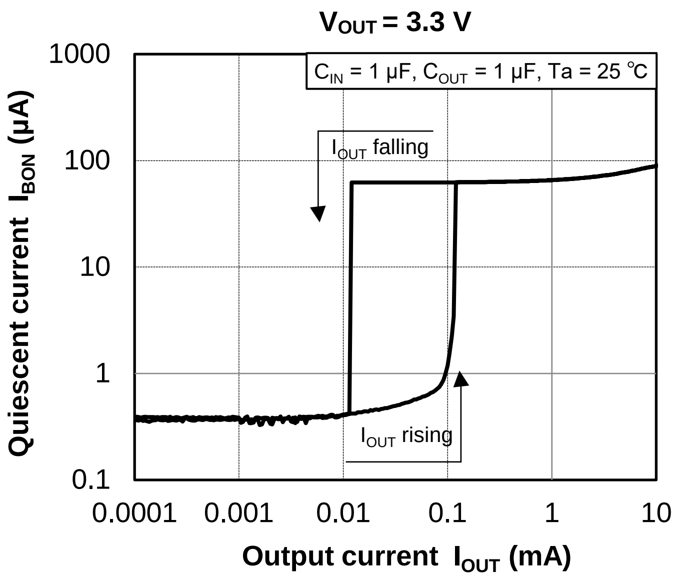
13.2. Quiescent Current vs. Output Current

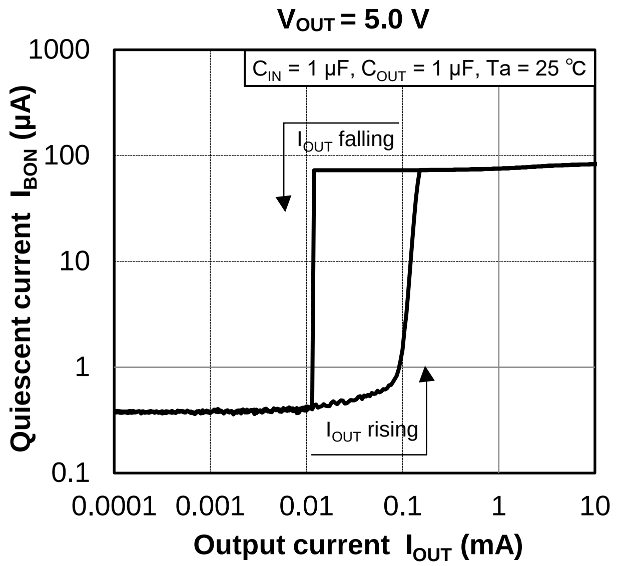












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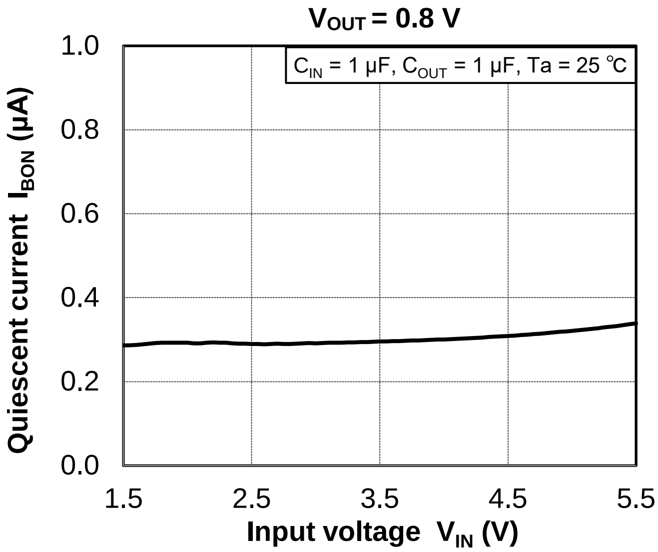
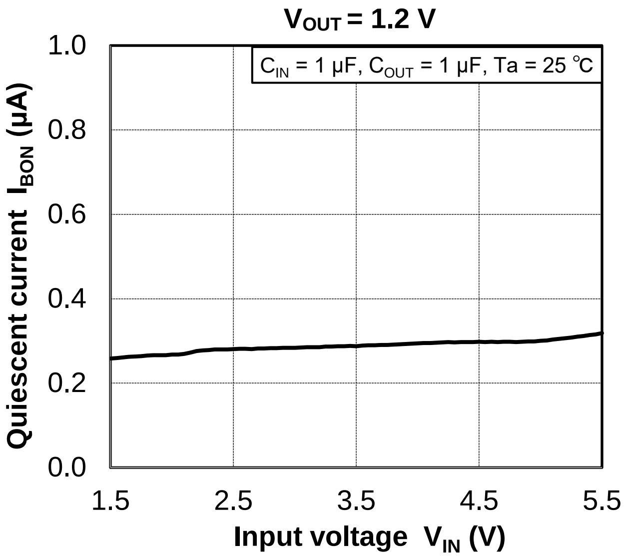
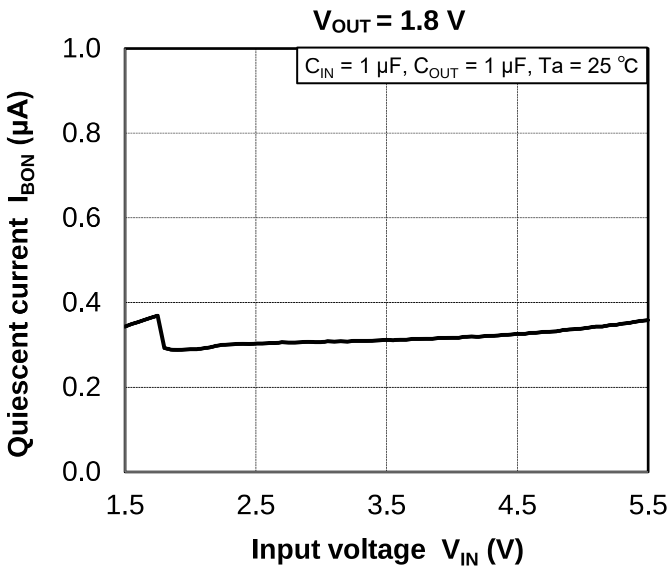
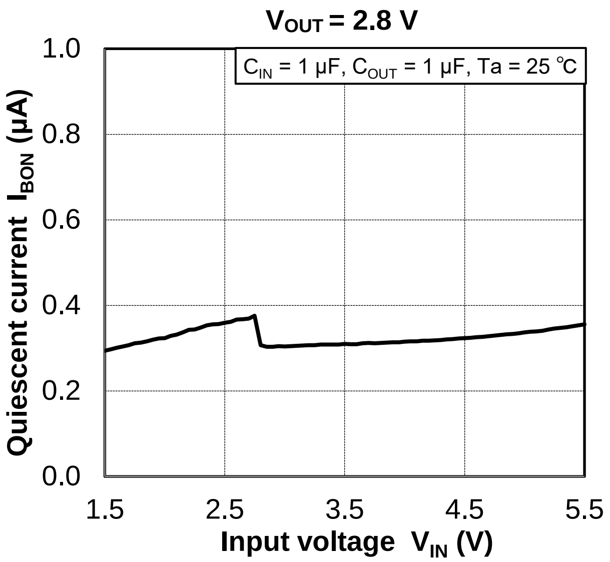
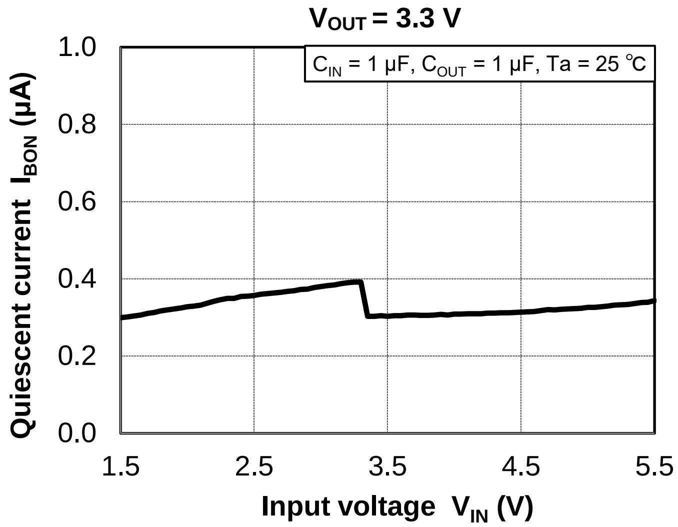
13.3. Quiescent Current vs. Input Voltage

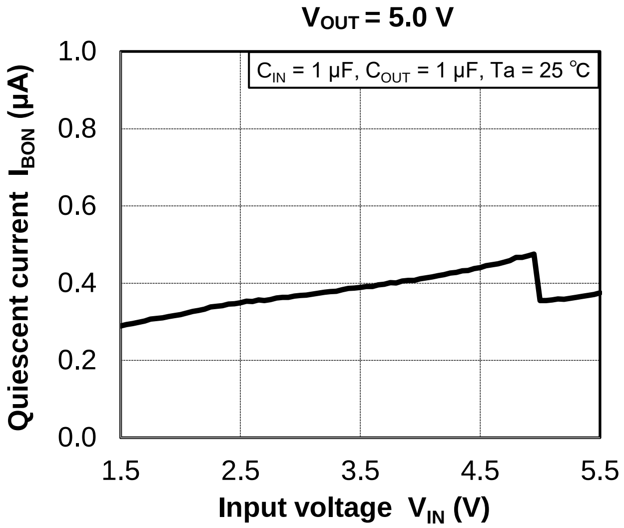












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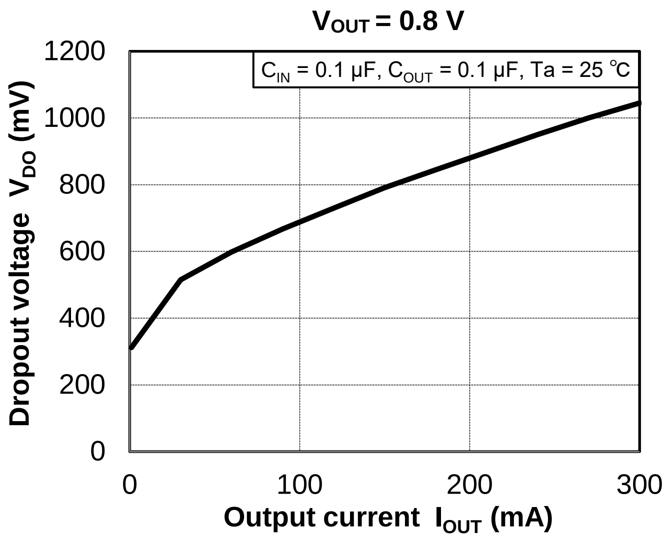
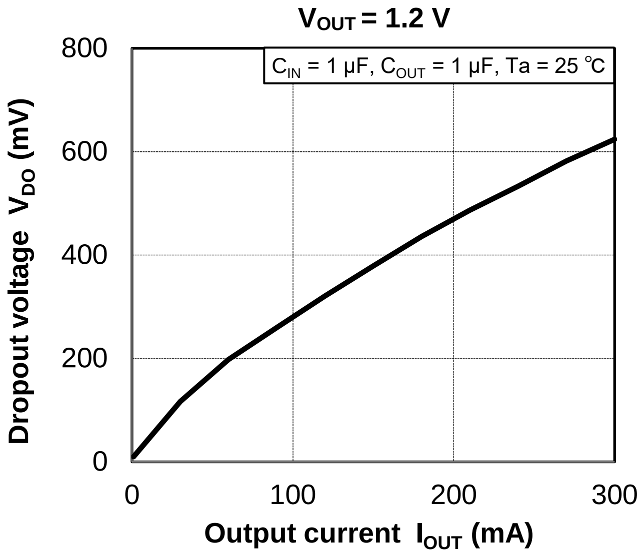
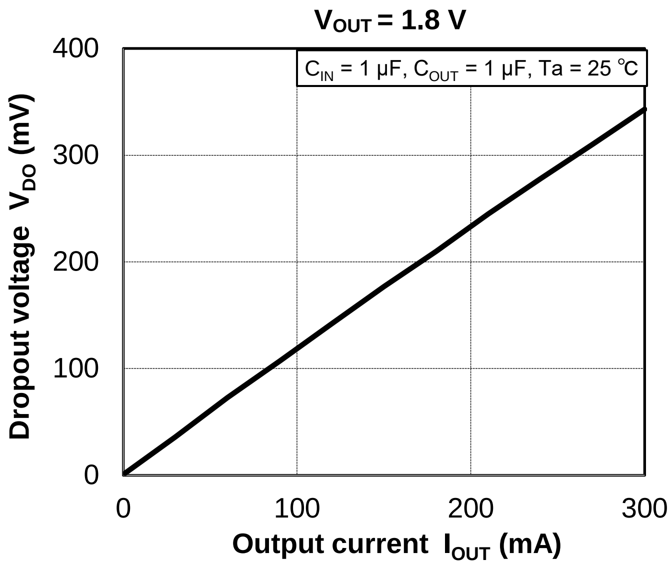
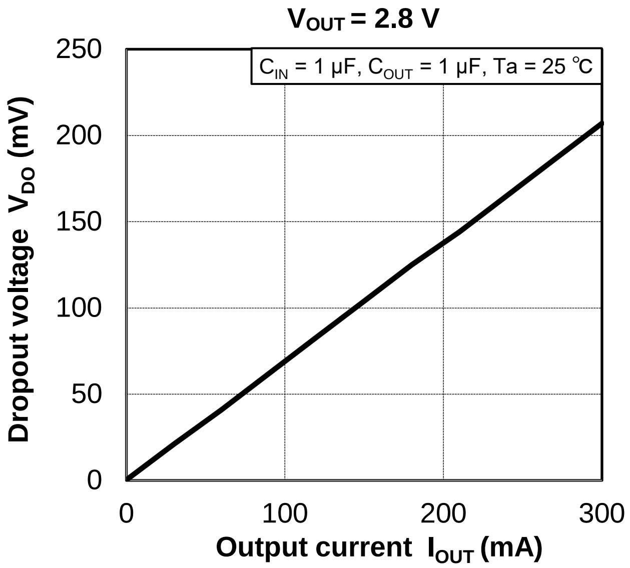
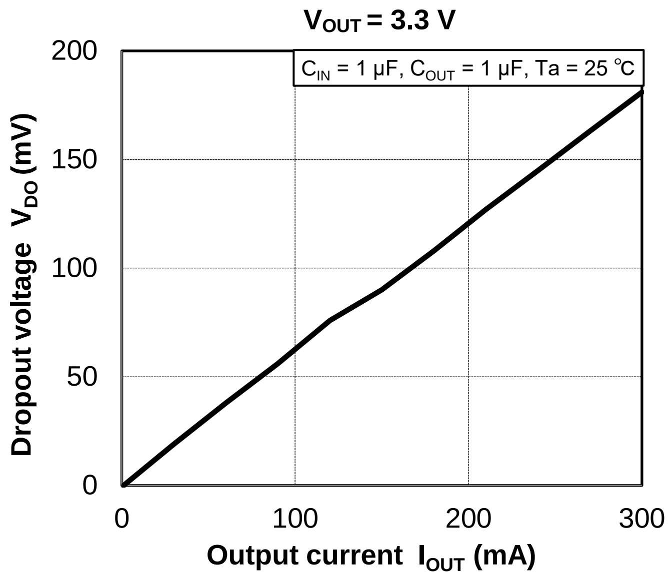
13.4. Dropout Voltage vs. Output Current

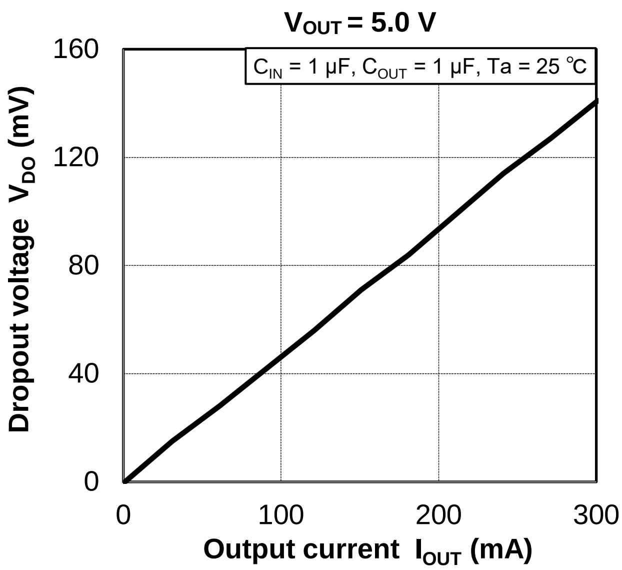












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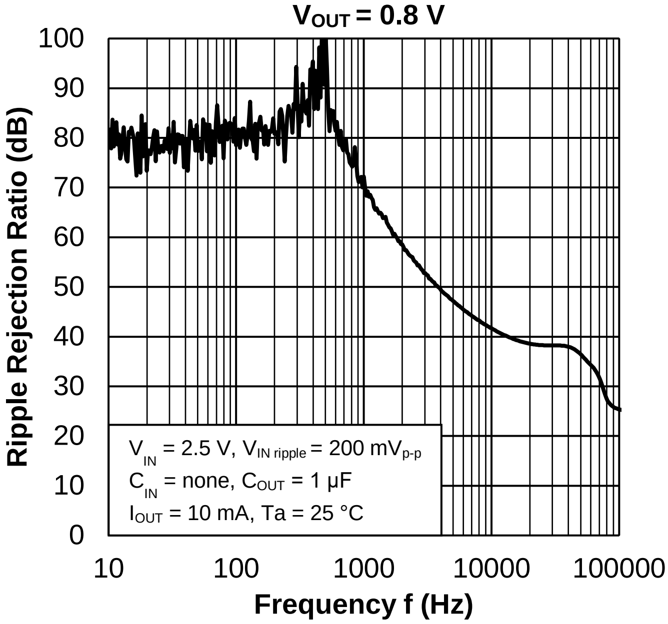
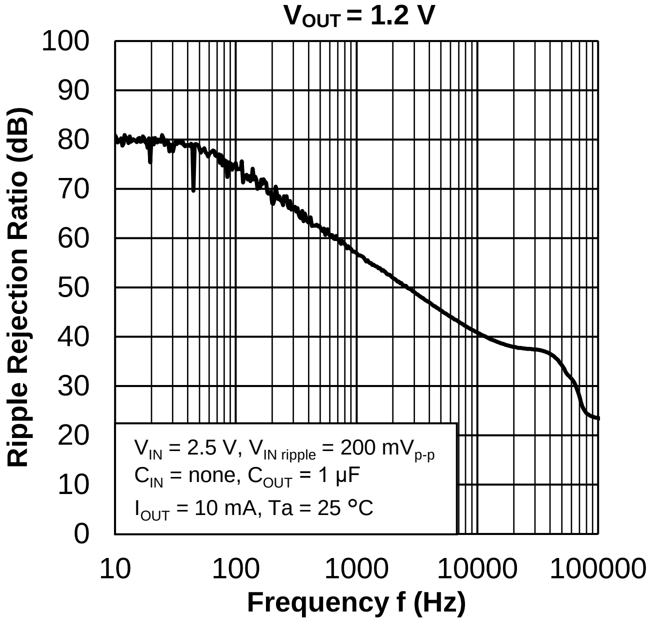
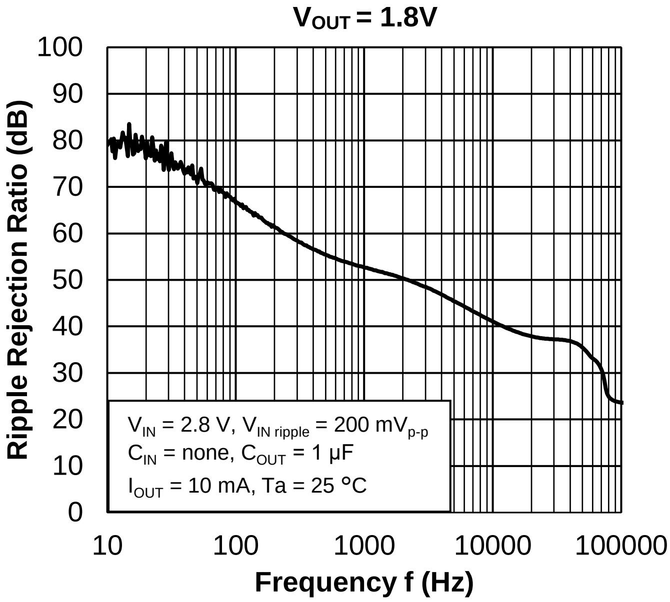
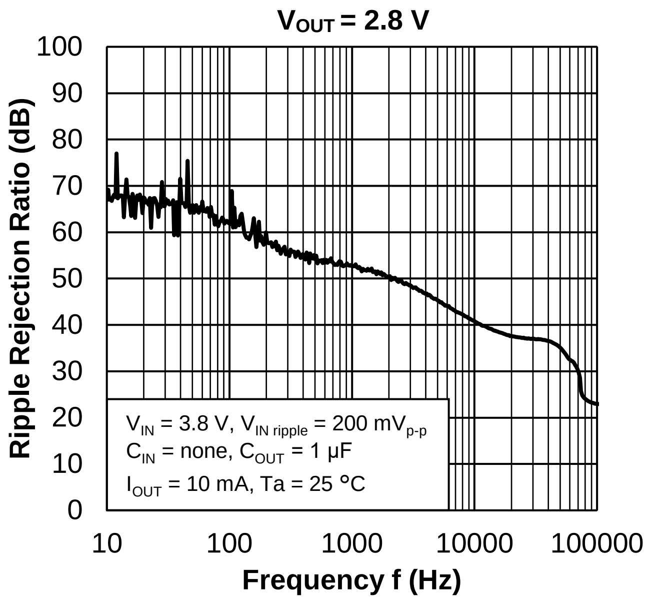
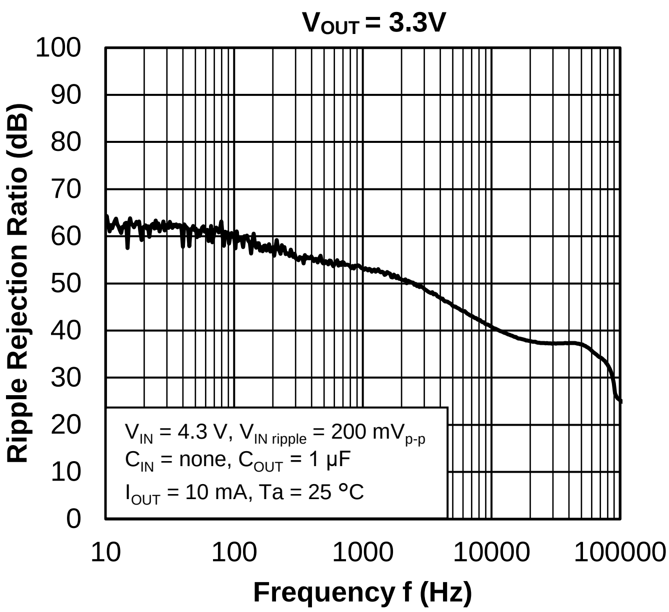
13.5. Ripple Rejection Ratio vs. Frequency





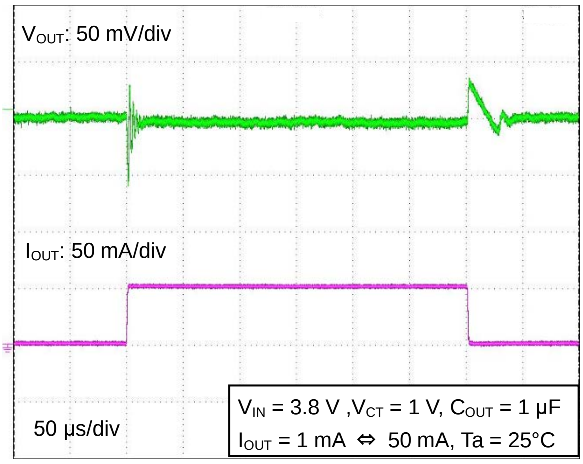




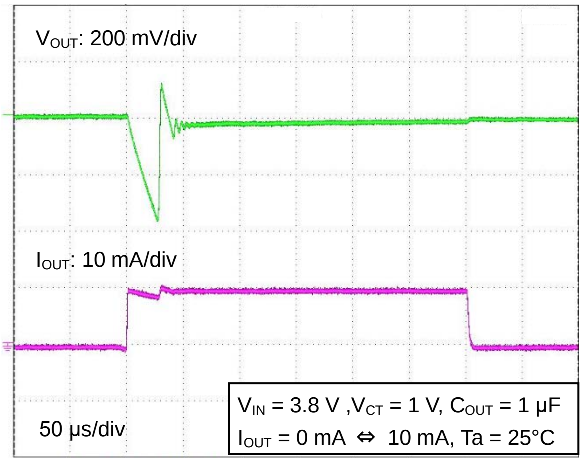


13.6. Load Transient Response

V_{OUT} = 2.8V

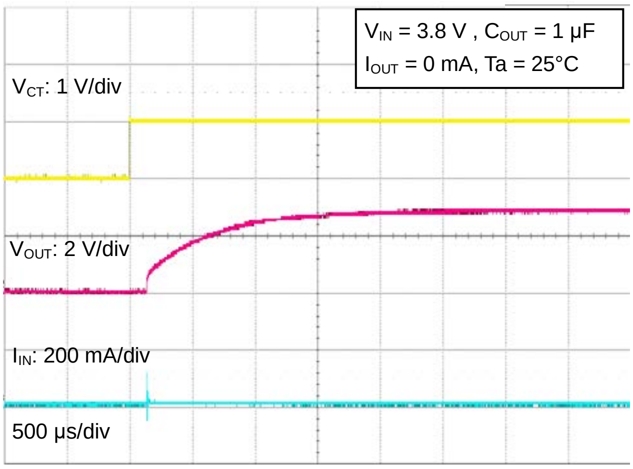


V_{OUT} = 2.8V

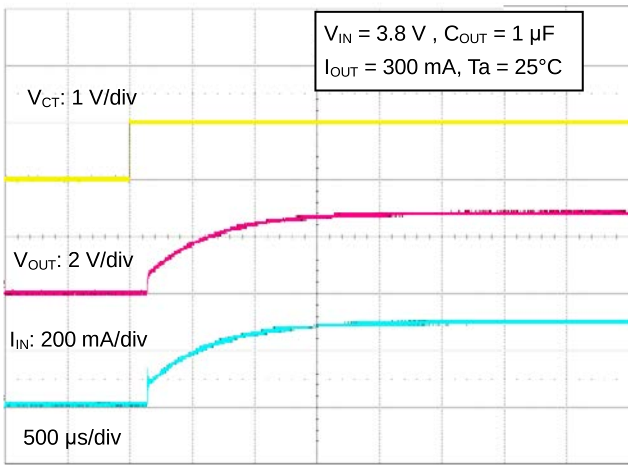


13.7. t_{ON} Response

V_{OUT} = 2.8V

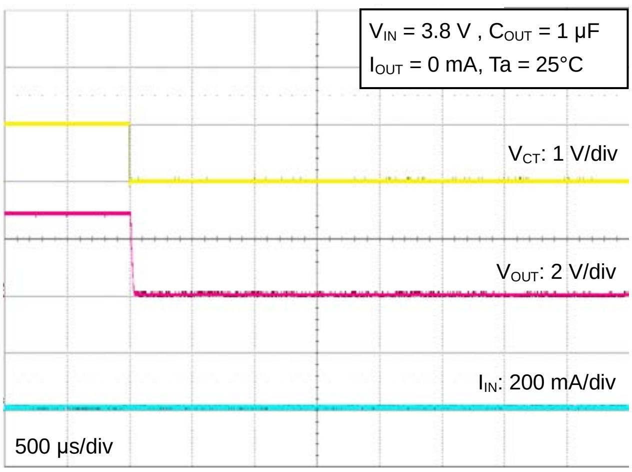


V_{OUT} = 2.8V

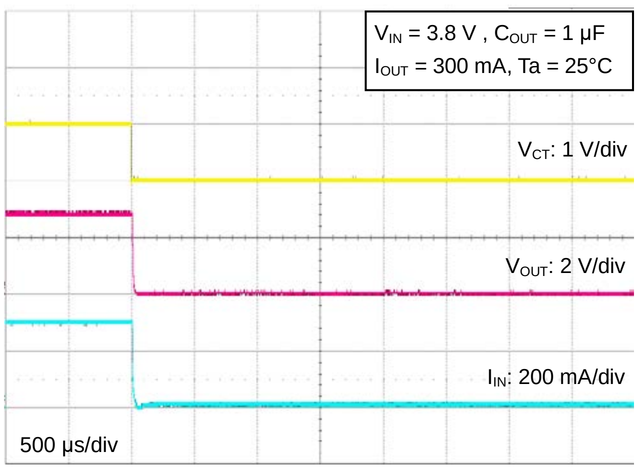


13.8. t_{OFF} Response (Auto-discharge)

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.

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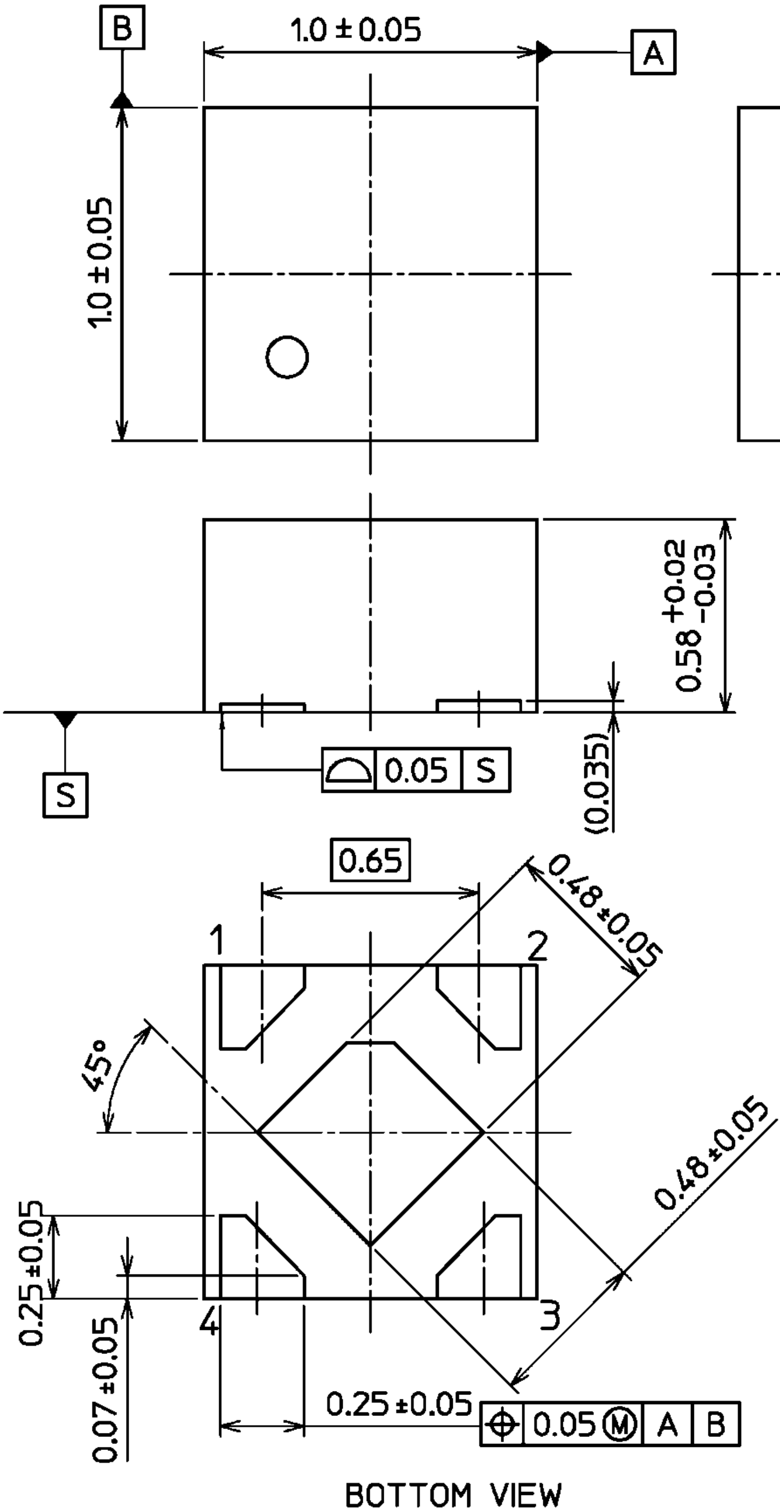
14. Package Information

14.1. DFN4

Unit: mm

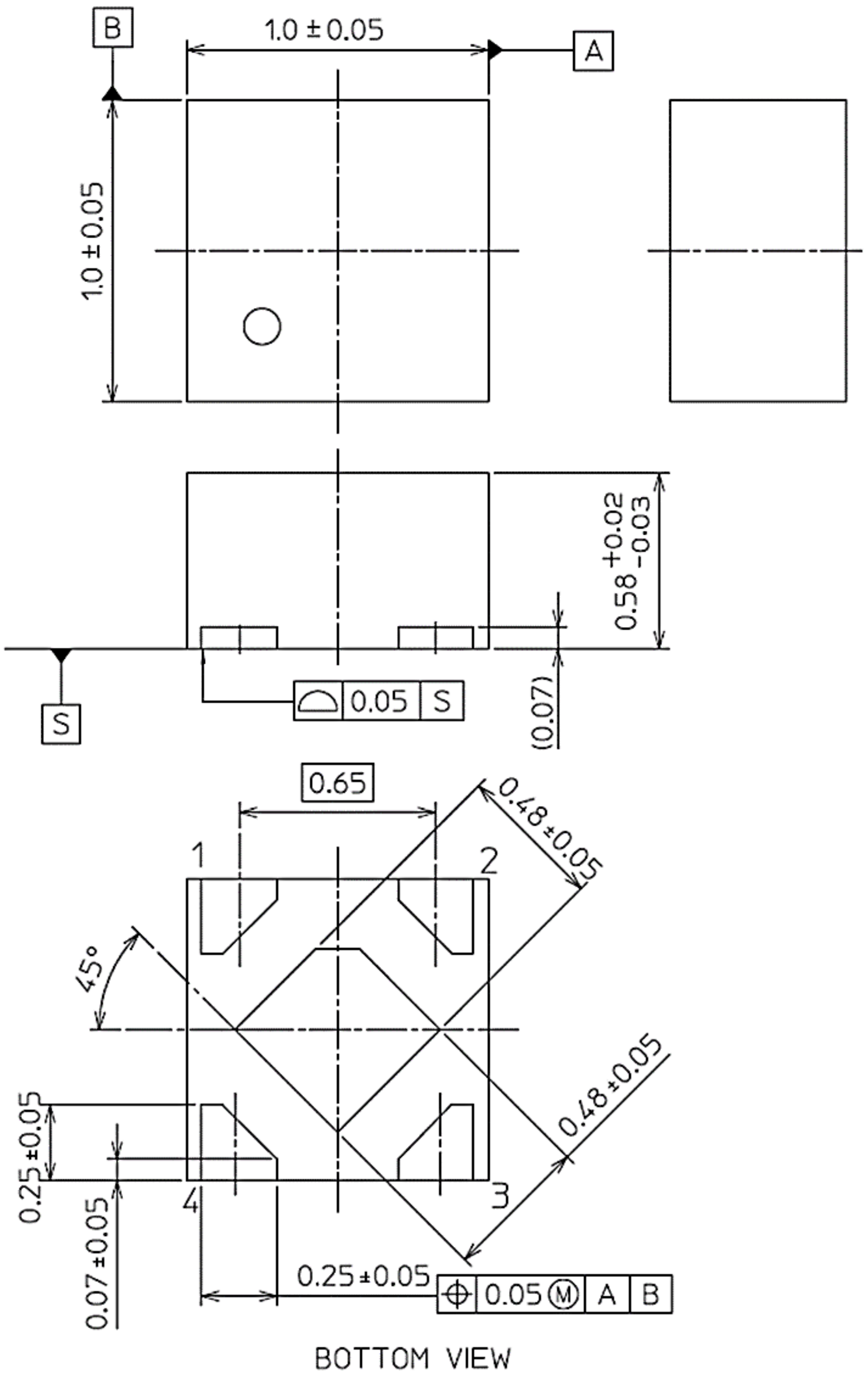


0.04 mm (typ.) unevenness exists along the edges of the back electrode to increase shear after soldering.

Weight: 1.3 mg (typ.)

14.2. DFN4E

Unit: mm



Weight: 1.3 mg (typ.)

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