TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR5AM series

500 mA CMOS Ultra Low Drop-Out Regulator

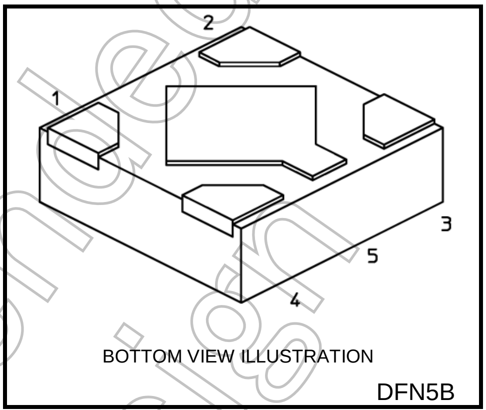
The TCR5AM series are CMOS single-output voltage regulators with an on/off control input, featuring Ultra low dropout voltage, low inrush current and fast load transient response.

A differentiating feature is the use of a secondary bias rail as a reference voltage that allows ultra-low drop-out of 90 mV (Typ.) at I_{OUT} = 300 mA (1.1 V output, V_{BAT} = 3.3 V).

These voltage regulators are available in fixed output voltages between 0.55 V and 3.6 V, and capable of driving up to 500 mA. Other features include over-current protection, over-temperature protection, Under-voltage-lockout and Auto-discharge function.

The TCR5AM series are offered in the ultra small plastic mold package DFN5B (1.2 mm x 1.2 mm; t 0.38 mm).

As small ceramic input and output capacitors can be used with the TCR5AM series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones.



Weight : 1.4 mg (Typ.)

Features

- Low Drop-Out voltage
  V_{IN}-V_{OUT} = 90 mV (Typ.) at 1.1 V output, V_{BAT} = 3.3 V , I_{OUT} = 300 mA
- Low stand-by current ($I_{B(OFF)}$ = 2 μA (Max) at V_{BAT} = 5.5 V, V_{CT} = 0 V)
- Low quiescent bias current (I_B = 40μA (Typ.) at V_{BAT} = 5.5 V, I_{OUT} = 0 mA)
- Wide range Output Voltage line up (V_{OUT} = 0.55 to 3.6 V)
- Over-current protection
- Over-temperature protection
- Inrush current protection circuit
- Under-voltage-lockout function
- Auto-discharge function
- Pull down connection between CONTROL and GND
- Ultra small package DFN5B (1.2 mm x 1.2 mm ; t 0.38 mm)

Start of commercial production
2014-12

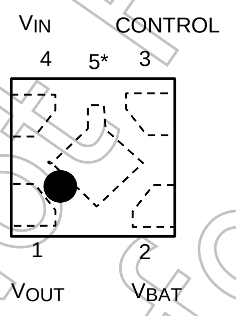
Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating		Unit
Bias voltage	V_{BAT}	6.0		V
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}	DC	500	mA
		Pulse	600 (Note 1)	
Power dissipation	P_D	600 (Note 2)		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).

Note 1: 100 ms pulse, 50% duty cycle
Note 2: Rating at mounting on a board
Glass epoxy (FR4) board dimension: 40 mm x 40 mm x 1.6 mm, both sides of board
Metal pattern ratio: a surface approximately 50%, the reverse side approximately 50%
Through hole hall: diameter 0.5 mm x 24

Pin Assignment (top view)



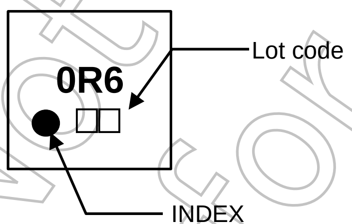
*Center electrode is GND

List of Products Number, Output voltage and Marking

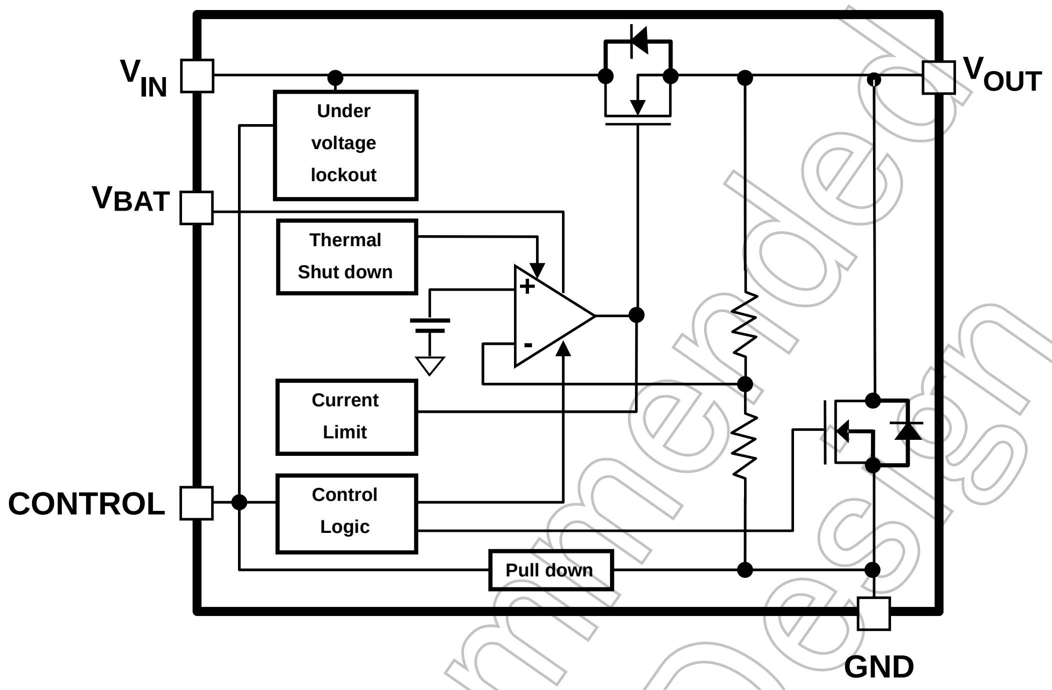
Product No.	V_{OUT}(V)(Typ.)	Marking	Product No.	V_{OUT}(V)(Typ.)	Marking
TCR5AM055	0.55	0RF	TCR5AM19	1.9	1R9
TCR5AM06	0.6	0R6	TCR5AM20	2.0	2R0
TCR5AM065	0.65	0RG	TCR5AM21	2.1	2R1
TCR5AM07	0.7	0R7	TCR5AM22	2.2	2R2
TCR5AM075	0.75	0RH	TCR5AM23	2.3	2R3
TCR5AM08	0.8	0R8	TCR5AM24	2.4	2R4
TCR5AM085	0.85	0RJ	TCR5AM25	2.5	2R5
TCR5AM09	0.9	0R9	TCR5AM26	2.6	2R6
TCR5AM095	0.95	0RK	TCR5AM27	2.7	2R7
TCR5AM10	1.0	1R0	TCR5AM28	2.8	2R8
TCR5AM105	1.05	1RA	TCR5AM285	2.85	2RJ
TCR5AM11	1.1	1R1	TCR5AM29	2.9	2R9
TCR5AM115	1.15	1RB	TCR5AM295	2.95	2RK
TCR5AM12	1.2	1R2	TCR5AM30	3.0	3R0
TCR5AM125	1.25	1RC	TCR5AM31	3.1	3R1
TCR5AM13	1.3	1R3	TCR5AM32	3.2	3R2
TCR5AM14	1.4	1R4	TCR5AM33	3.3	3R3
TCR5AM15	1.5	1R5	TCR5AM34	3.4	3R4
TCR5AM16	1.6	1R6	TCR5AM35	3.5	3R5
TCR5AM17	1.7	1R7	TCR5AM36	3.6	3R6
TCR5AM18	1.8	1R8			

Top Marking (top view)

Example: TCR5AM06 (0.6 V output)



Block Diagram



Electrical Characteristics

(Unless otherwise specified, V_{IN} = V_{OUT} + 0.5 V, I_{OUT} = 50 mA, C_{IN}=C_{BAT} = 1.0 μF, C_{OUT} = 2.2 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 3), V_{OUT} <1.8 V	-18	—	+18	—	—	mV
		I_{OUT} = 50 mA (Note 3), 1.8 V ≦ V_{OUT}	-1.0	—	+1.0	—	—	%
Bias voltage	V_{BAT}	V_{OUT} ≦ 1.1 V, I_{OUT} = 1 mA	2.5	—	5.5	2.5	5.5	V
		V_{OUT} > 1.1 V, I_{OUT} = 1 mA	V_{OUT} + 1.4V	—	5.5	V_{OUT} + 1.4V	5.5	V
Input voltage	V_{IN}	I_{OUT} = 1 mA,	V_{OUT} + 0.1V	—	V_{BAT}	V_{OUT} + 0.1V	V_{BAT}	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} ≦ 500 mA	—	15	70	—	—	mV
Quiescent current	I_B	I_{OUT} = 0 mA, V_{BAT} = 5.5 V (Note 4)(Note 5)	—	40	—	—	68	μA
		I_{OUT} = 0 mA, V_{BAT} = 4.2 V (Note 4)(Note 6)	—	38	—	—	55	
Stand-by current	$I_{B (OFF)}$	V_{CT} = 0 V	—	0.1	—	—	2.0	μA
Control pull down current	I_{CT}	—	—	0.1	—	—	—	μA
Drop-out voltage	V_{IN}-V_{OUT}	I_{OUT} = 300 mA, V_{BAT} = 3.3 V (Note 7)(Note 8)	—	90	—	—	130	mV
Under voltage lockout	V_{UVLO}	V_{IN} voltage	—	0.5	—	—	0.65	V
Temperature coefficient	T_{CVO}	−40°C ≦ T_{opr} ≦ 85°C	—	60	—	—	—	ppm/°C
Output noise voltage	V_{NO}	V_{BAT} = 5.5 V, V_{IN} = V_{OUT} + 1 V, I_{OUT} = 10 mA, 10 Hz ≦ f ≦ 100 kHz, Ta = 25°C (Note 7)	—	40	—	—	—	μV_{rms}
Ripple rejection ratio	R.R.	V_{BAT} = 5.5 V, V_{IN} = V_{OUT} + 1 V, I_{OUT} = 10 mA, f = 1 kHz, $V_{IN\ Ripple}$ = 200 mV_{p-p}, Ta = 25°C (Note 7)	—	70	—	—	—	dB
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
Output discharge on resistance	R_{SD}	—	—	20	—	—	—	Ω

Note 3: Stable state with fixed I_{OUT} condition
Note 4: Except Control pull down current
Note 5: Over 2.8 V output products
Note 6: 2.8 V and under output products
Note 7: The 0.6 V output product.
Note 8: V_{IN}-V_{OUT} = V_{IN1} - (V_{OUT1} x 0.98)
V_{OUT1} is the output voltage when V_{IN} = V_{OUT} + 0.5 V.
V_{IN1} is the input voltage at which the output voltage becomes 98% of V_{OUT1} after gradually decreasing the input voltage
Note 9: This parameter is guaranteed by design.

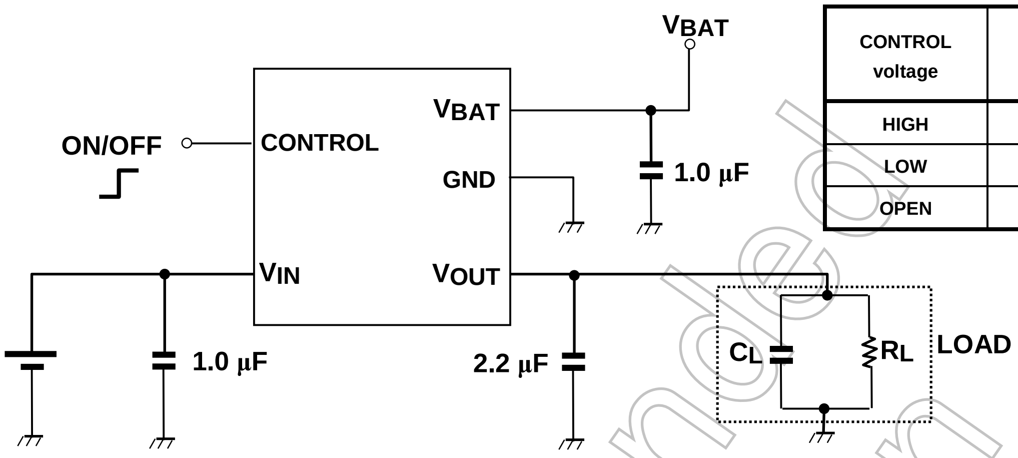
Drop-out voltage
(C_{IN} = 1.0 μF, C_{OUT} = 2.2 μF, C_{BAT} = 1.0 μF, T_j = 25°C)

Output voltages	V_{BAT} input voltage	I_{OUT} = 300 mA			I_{OUT} = 500 mA			Unit
		Min	Typ.	Max (Note 10)	Min	Typ.	Max (Note 10)	
0.55 V ≦ V_{OUT} < 0.7 V	3.3 V	—	90	130	—	150	200	mV
0.7 V ≦ V_{OUT} < 0.8 V	3.3 V	—	90	140	—	150	210	mV
0.8 V ≦ V_{OUT} < 0.9 V	3.3 V	—	90	140	—	150	220	mV
0.9 V ≦ V_{OUT} < 1.0 V	3.3 V	—	90	140	—	150	230	mV
1.0 V ≦ V_{OUT} < 1.2 V	3.3 V	—	90	150	—	150	250	mV
1.2 V ≦ V_{OUT} < 1.3 V	3.3 V	—	140	170	—	230	270	mV
1.3 V	3.3 V	—	150	180	—	250	300	mV
1.4 V	3.3 V	—	160	190	—	260	330	mV
1.5 V	3.3 V	—	170	200	—	280	350	mV
1.6 V	V_{OUT} + 1.7 V	—	180	220	—	290	400	mV
1.7 V	V_{OUT} + 1.7 V	—	190	240	—	310	420	mV
1.8 V ≦ V_{OUT} ≦ 3.6 V	V_{OUT} + 1.7 V	—	190	250	—	330	430	mV

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

Application Note

1. Recommended Application Circuit



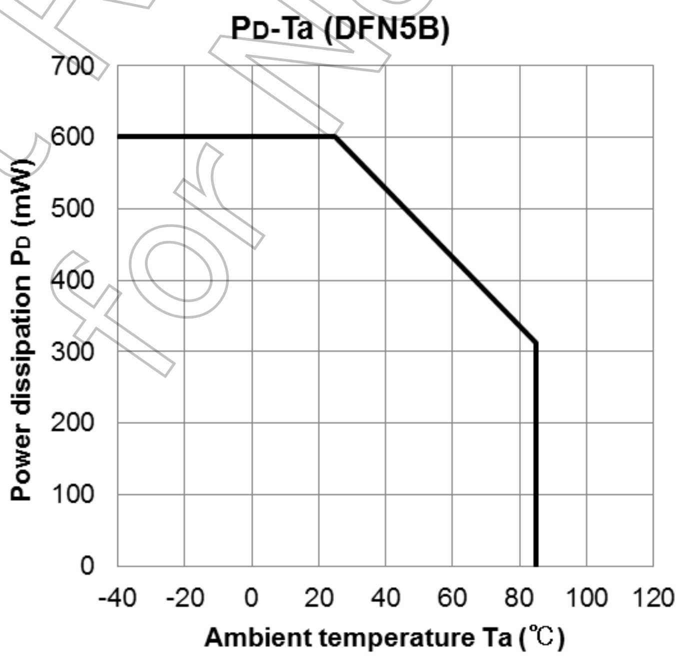
CONTROL voltage	Output voltage
HIGH	ON
LOW	OFF
OPEN	OFF

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

2. Power Dissipation

Board-mounted power dissipation ratings for TCR5AM 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 whole hall: diameter 0.5 mm x 24



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 VIN and GND pattern need to be large and make the wire impedance small as possible.

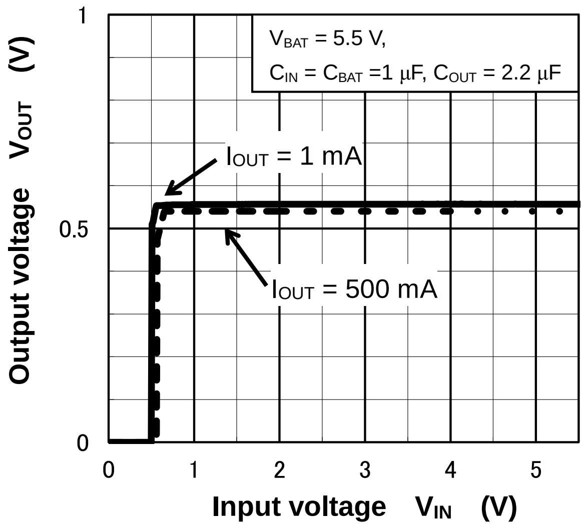
- Permissible Loss
  Please have enough design patterns for expected maximum permissible loss. And under consideration of surrounding temperature, input voltage, and output current etc, we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70 to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

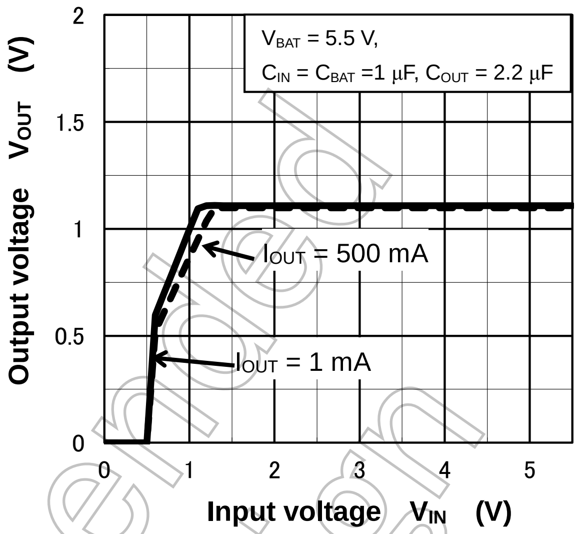
Representative Typical Characteristics

Output Voltage vs. Input Voltage

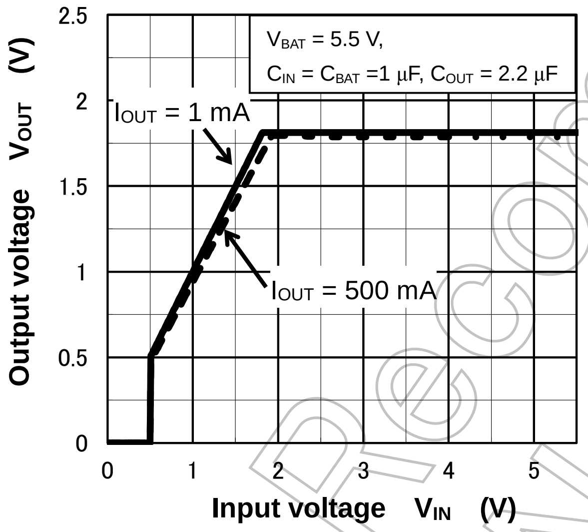
V_{OUT} = 0.55 V



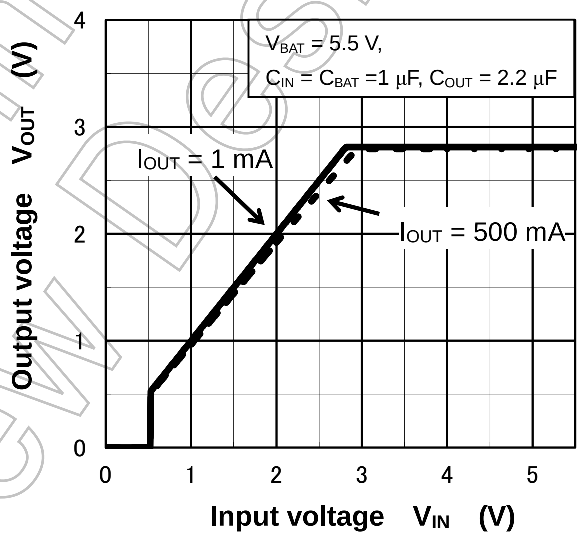
V_{OUT} = 1.1 V



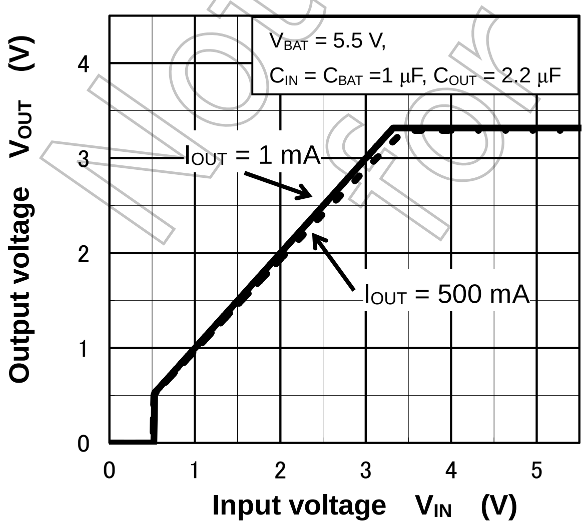
V_{OUT} = 1.8 V



V_{OUT} = 2.8 V

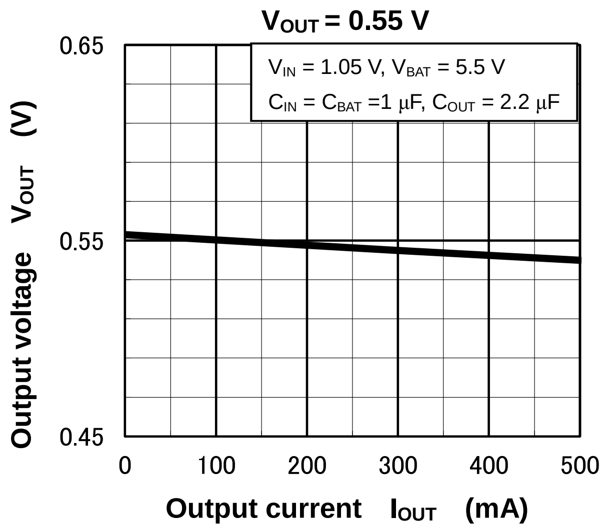


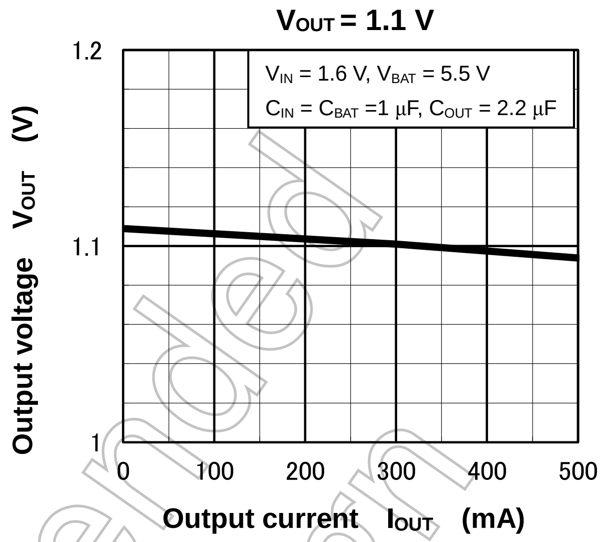
V_{OUT} = 3.3 V

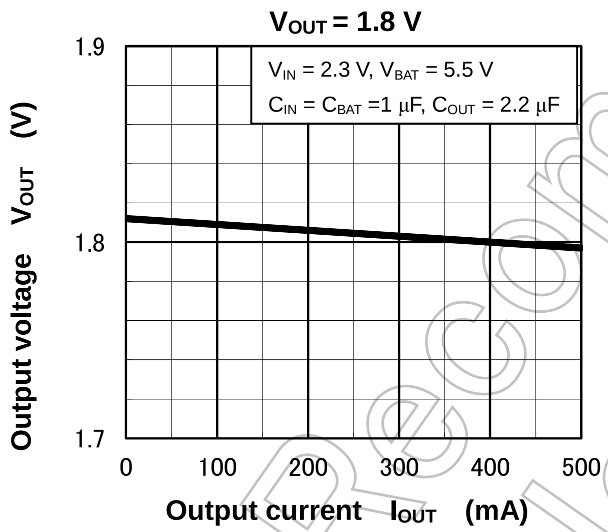


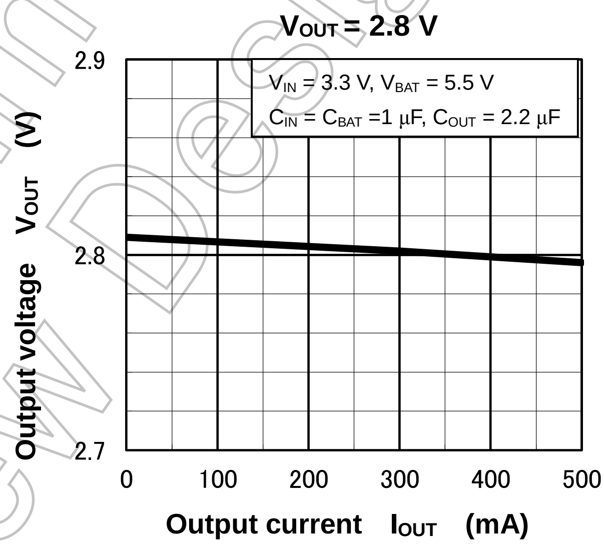
Representative Typical Characteristics

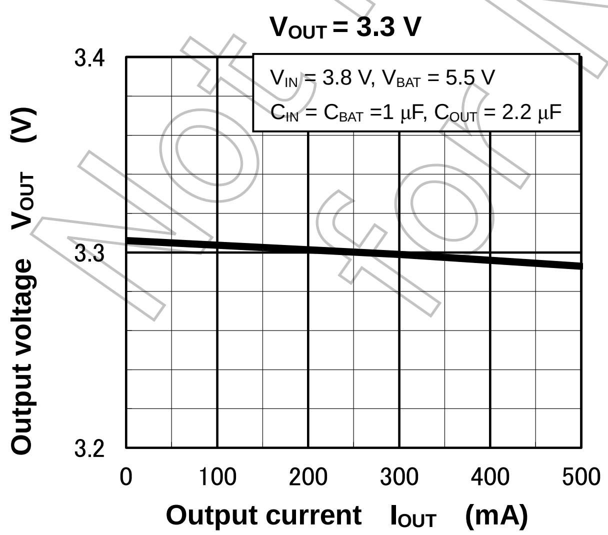
Output Voltage vs. Output Current





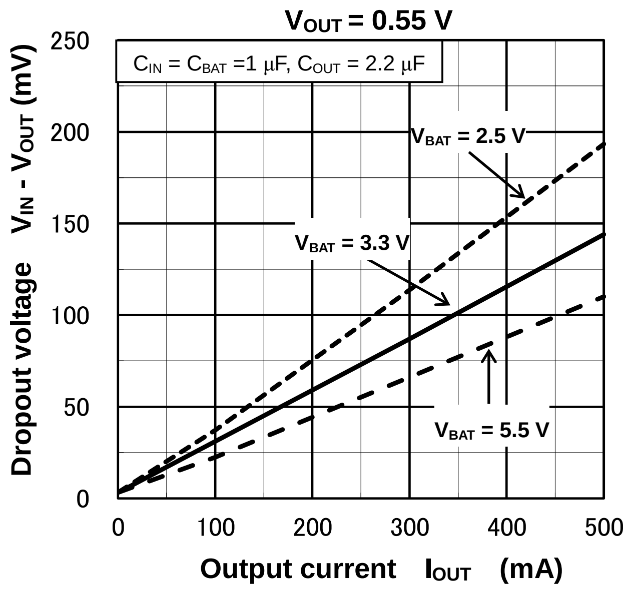


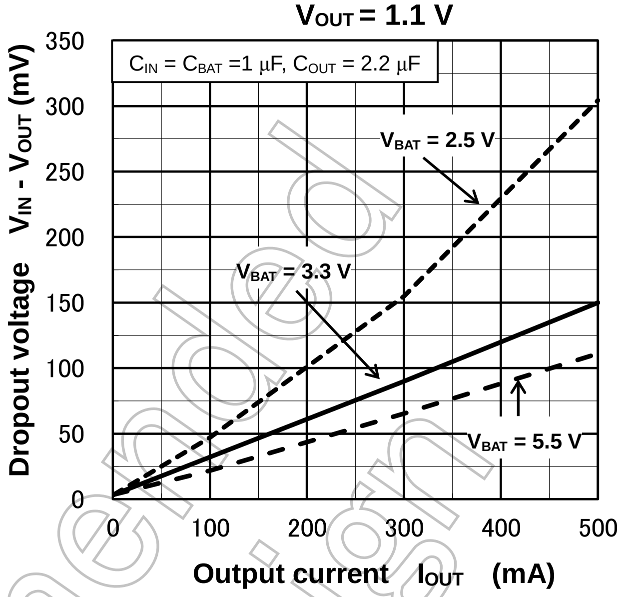


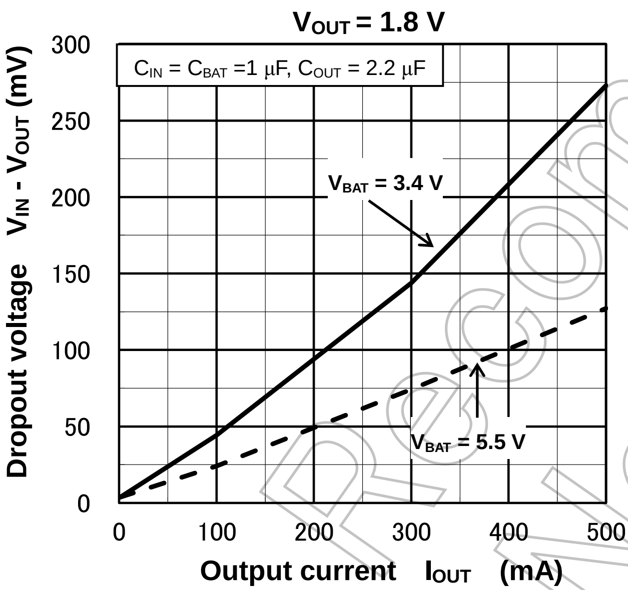


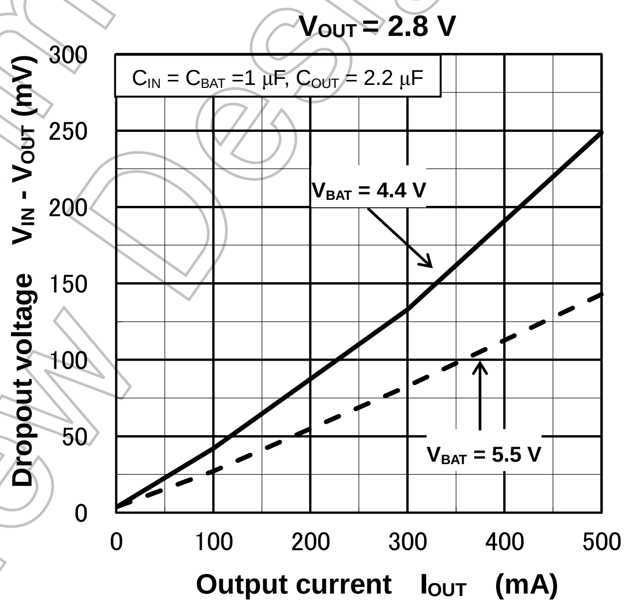
Representative Typical Characteristics

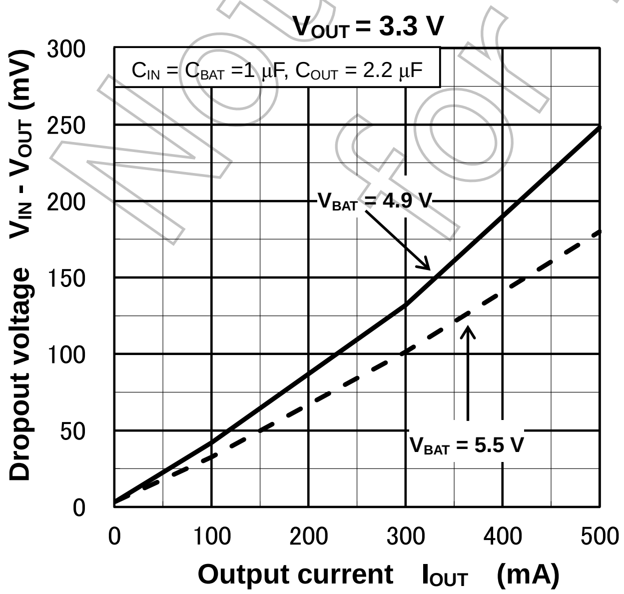
Dropout Voltage vs. Output Current







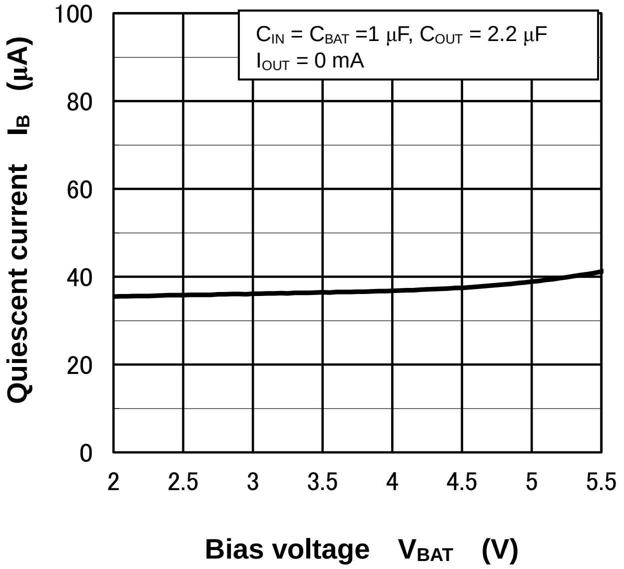




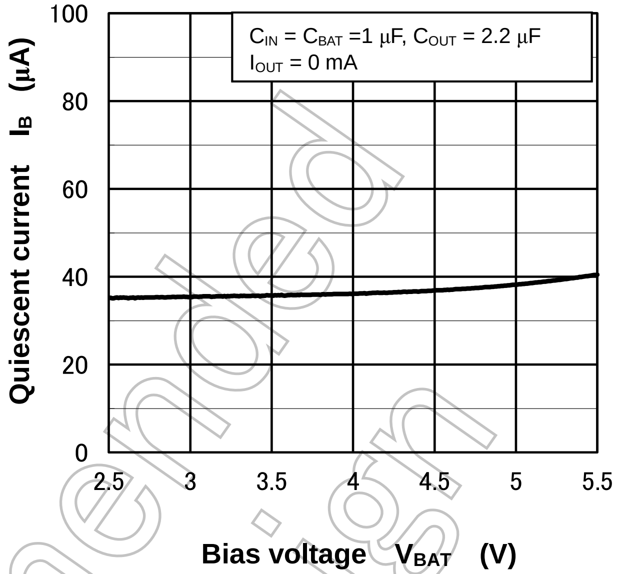
Representative Typical Characteristics

Quiescent Current vs. Input Voltage

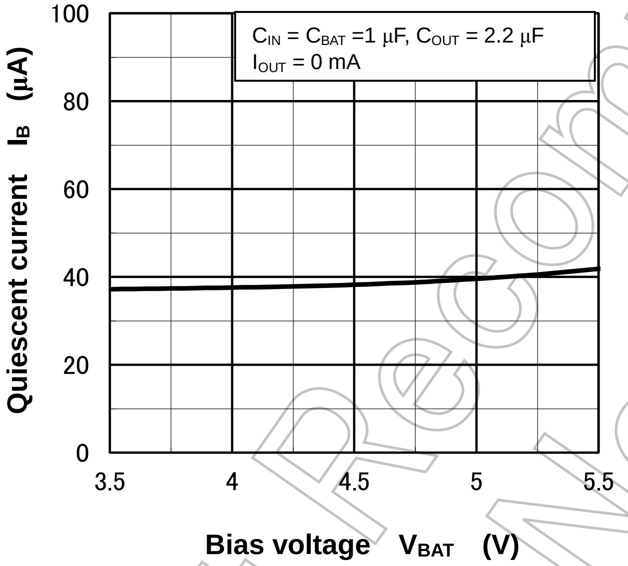
V_{OUT} = 0.55 V



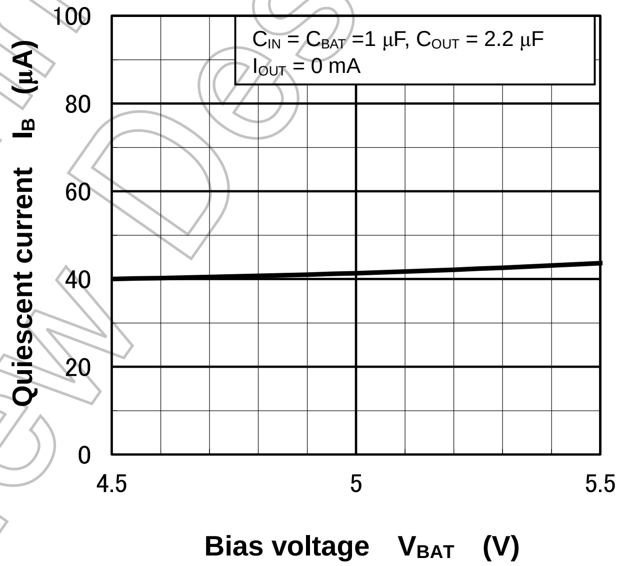
V_{OUT} = 1.1 V



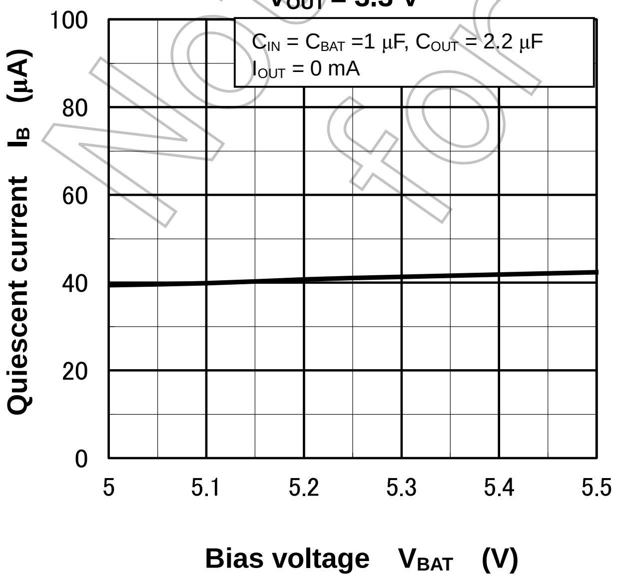
V_{OUT} = 1.8 V



V_{OUT} = 2.8 V

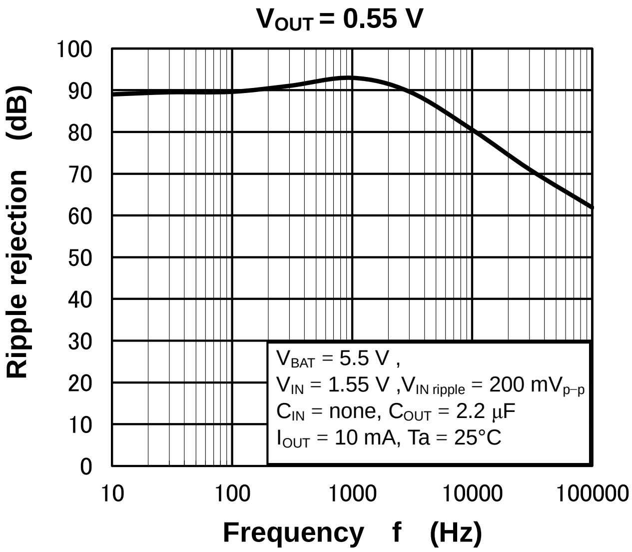


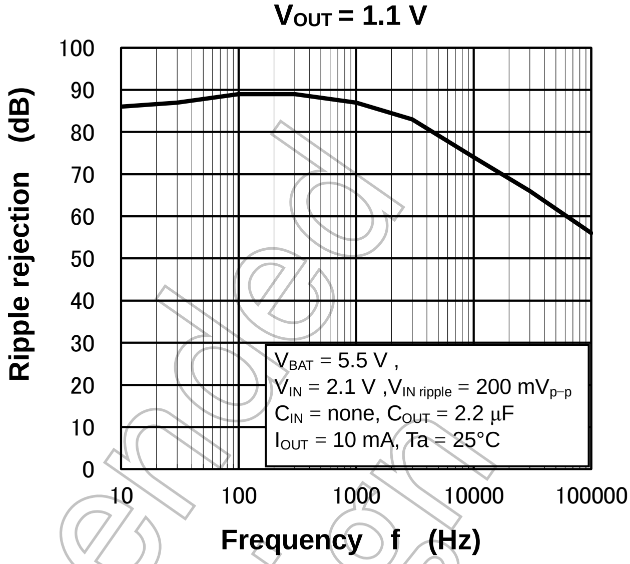
V_{OUT} = 3.3 V

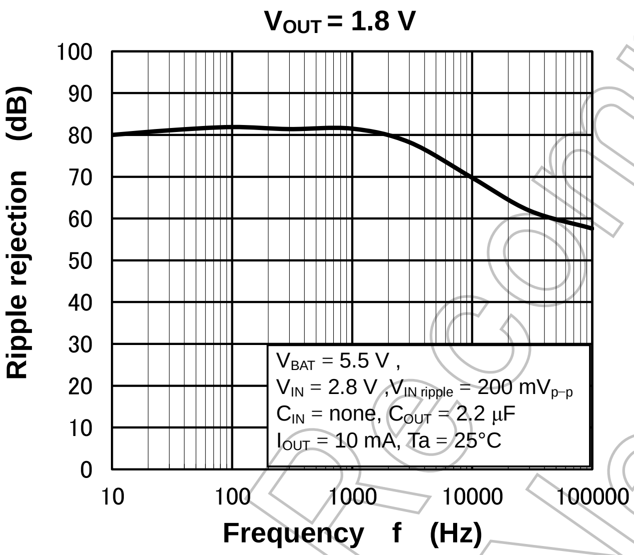


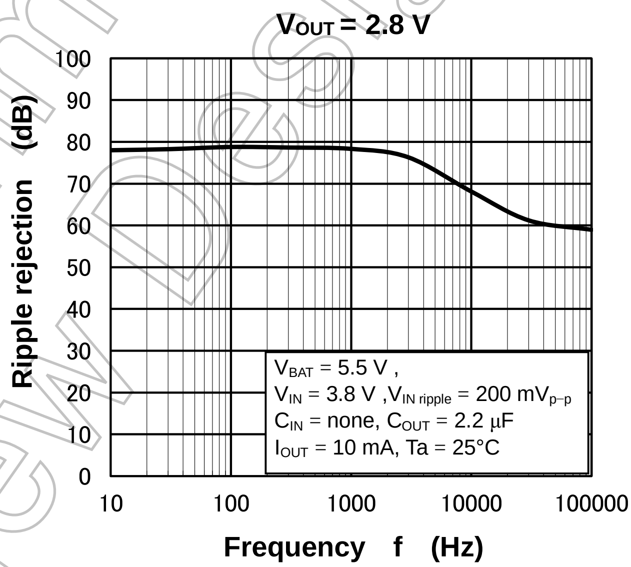
Representative Typical Characteristics

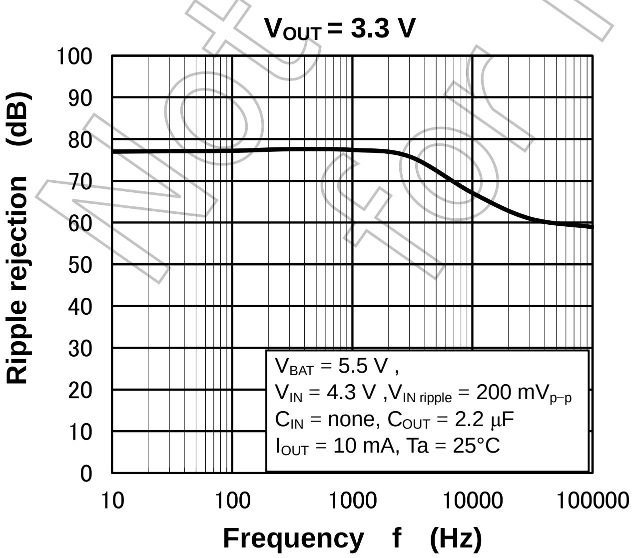
Ripple Rejection Ratio vs. Frequency





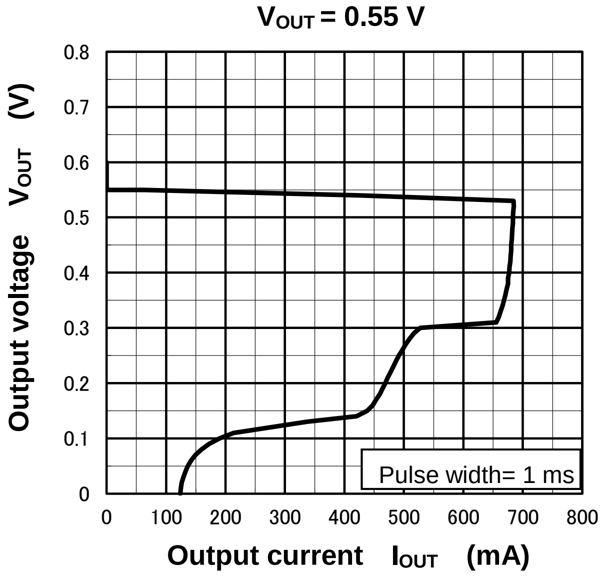


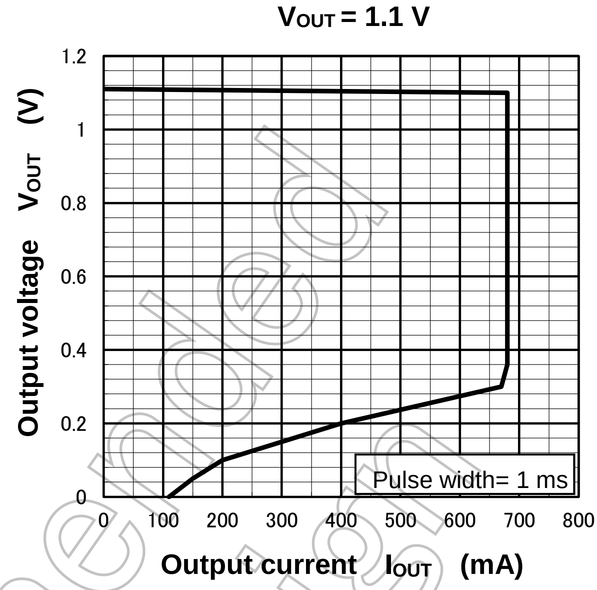


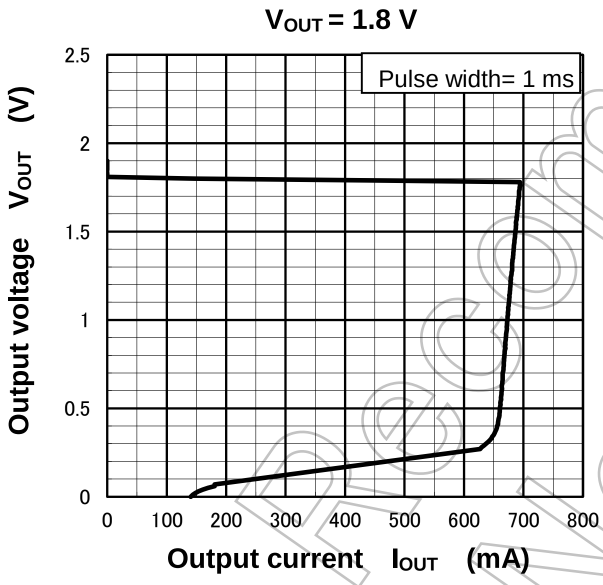


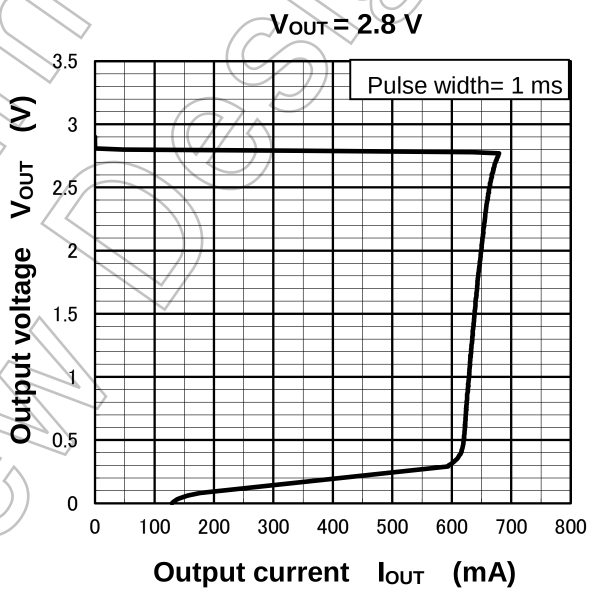
Representative Typical Characteristics

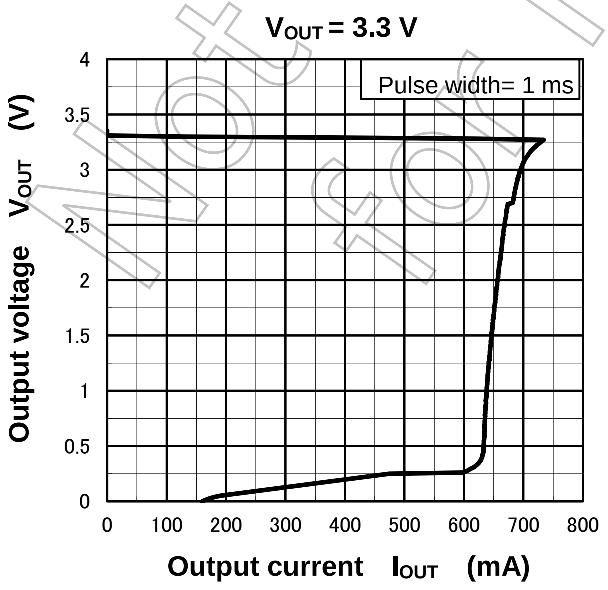
Output Voltage vs. Output Current



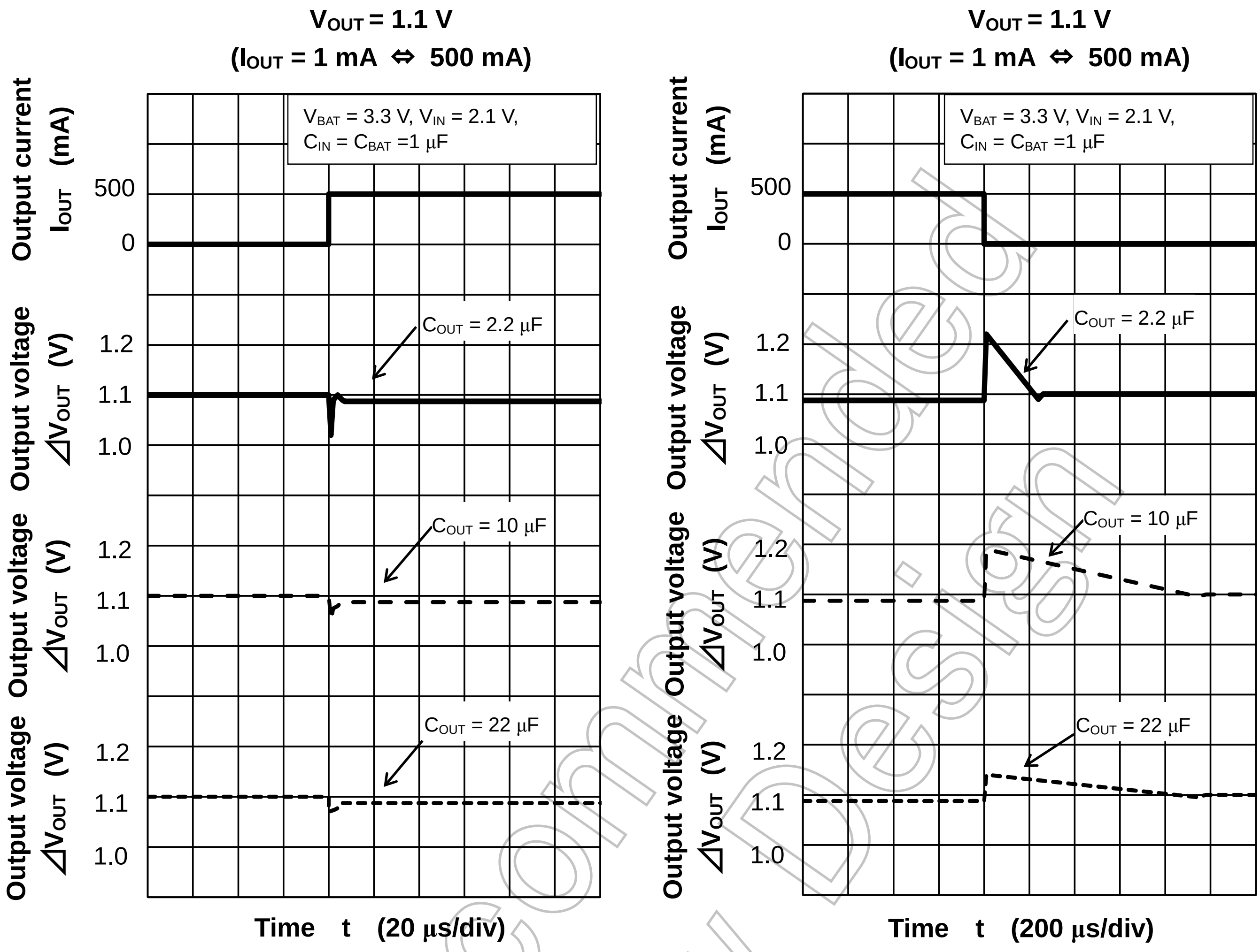




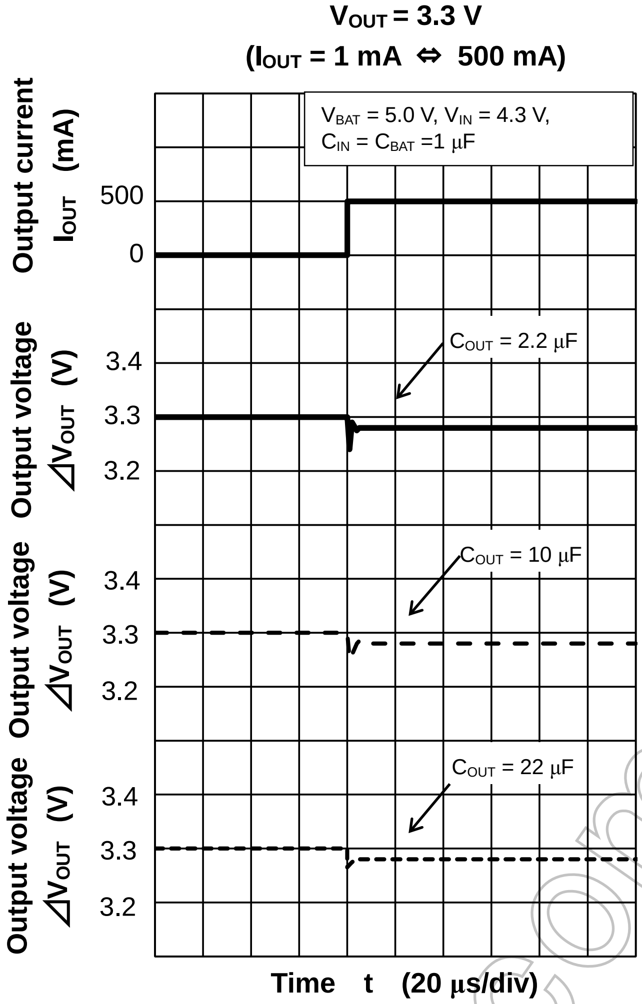


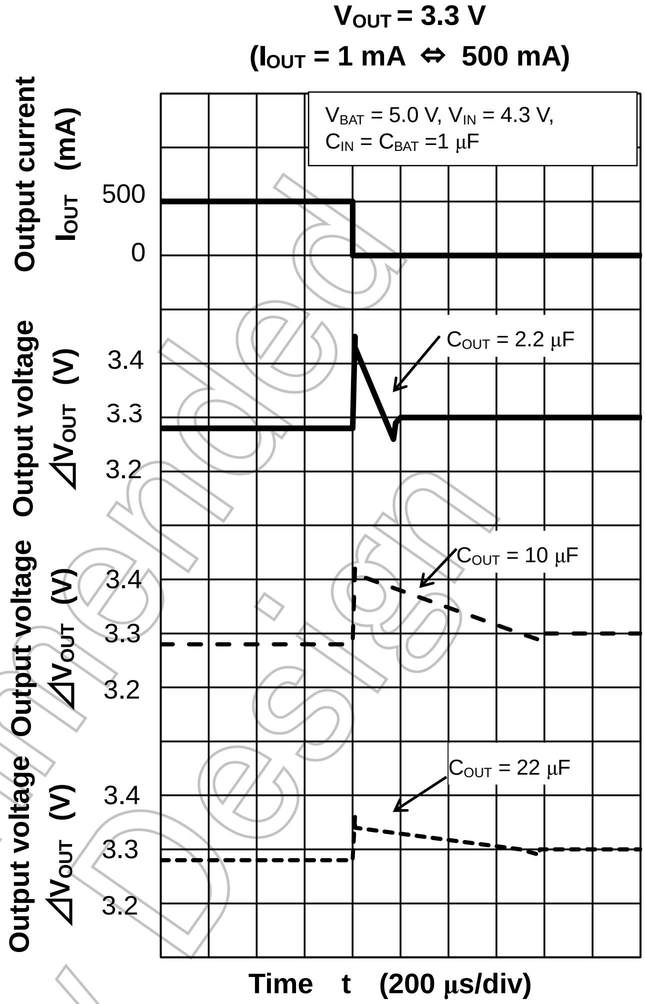


Load Transient Response



Load Transient Response

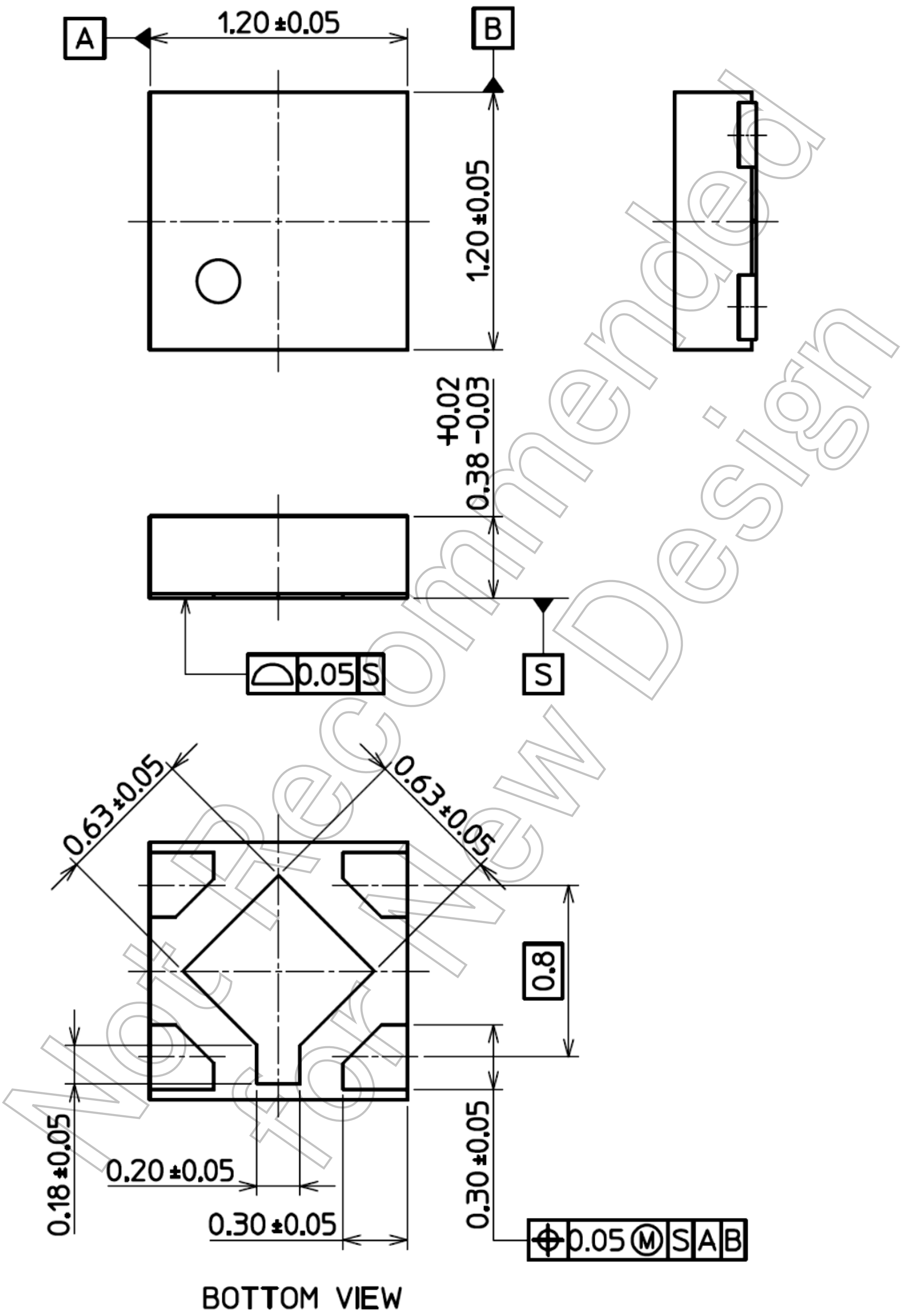




Package Dimensions

DFN5B

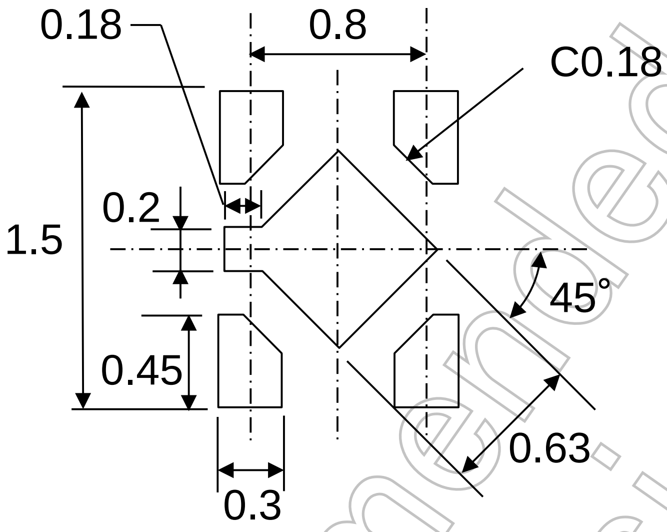
Unit: mm



Weight : 1.4 mg (Typ.)

Land pattern dimensions for reference only

DFN5B Unit: mm



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