TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR5BM series

500 mA CMOS Ultra Low Dropout Regulator

1. Description

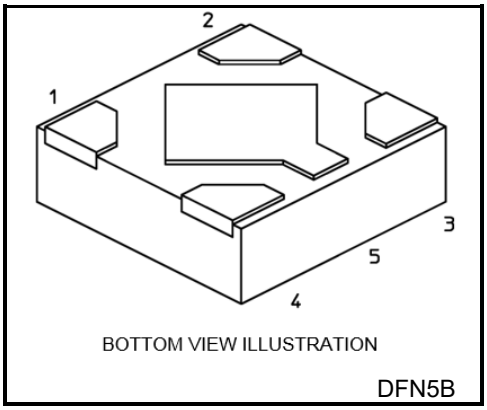
The TCR5BM series are CMOS single-output voltage regulators with an on/off control input, featuring ultra low dropout voltage, high PSRR, low inrush current and fast load transient response.

A differentiating feature is the use of a secondary bias rail as a reference voltage that allows ultra low dropout of 100 mV (Typ.) at I_{OUT} = 500 mA (1.1 V output, V_{BIAS} = 3.3 V).

These voltage regulators are available in fixed output voltages between 0.8 V and 3.6 V, and capable of driving up to 500 mA. Other features include overcurrent protection, thermal shutdown, and Auto-discharge.

The TCR5BM 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 TCR5BM series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones.



BOTTOM VIEW ILLUSTRATION

DFN5B

Weight : 1.4 mg (Typ.)

2. Application

Power IC developed for portable applications

3. Features

- Low dropout voltage
  V_{DO} = 100 mV (Typ.) at 1.1 V output, V_{BIAS} = 3.3 V, I_{OUT} = 500 mA
- Low stand-by current ($I_{BIAS(OFF)}$ = 1 μA (Max))
- Low quiescent bias current ($I_{BIAS(ON)}$ = 19 μA (Typ.) at V_{BIAS} = 5.3 V, I_{OUT} = 0 mA)
- Wide range output voltage line up V_{OUT} = 0.8 to 3.6 V
- Overcurrent protection
- Thermal shutdown
- Inrush current reduction
- Under voltage lockout (TCR5BMxxA products)
- Auto-discharge
- 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
2018-08

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

Characteristics	Symbol	Rating	Unit
Bias voltage	V_{BIAS}	-0.3 to 6.0	V
Input voltage	V_{IN}	-0.3 to 6.0	V
Control voltage	V_{CT}	-0.3 to 6.0	V
Output voltage	V_{OUT}	-0.3 to V_{IN} + 0.3 ≤ 6.0	V
Power dissipation	P_D	600 (Note 1)	mW
Junction temperature	T_j	-40 to 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).

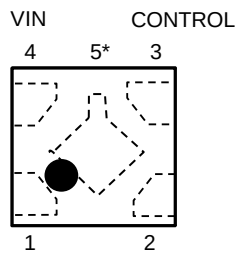
Note 1: Rating at mounting on a board
(Glass epoxy board dimension : 40 mm x 40 mm (4layer), t = 1.8 mm
Metal pattern ratio : approximately 70 % each layer)

5. Operating Ranges

Characteristics	Symbol	Rating	Unit
Bias voltage	V_{BIAS}	(V_{OUT} + 1.4 ≥ 2.5) to 5.5	V
Input voltage	V_{IN}	V_{OUT} + V_{DO} to V_{BIAS}	V
Control voltage	V_{CT}	0 to V_{BIAS}	V
Output voltage	V_{OUT}	0.8 to 3.6	V
Output current	I_{OUT}	0 to 0.5 (Note 2)	A
Operation Temperature	T_{opr}	−40 to 85	°C
COUT	C_{OUT}	≥ 2.2 μF	—
CIN	C_{IN}	≥ 1.0 μF	—
CBIAS	C_{BIAS}	≥ 0.1 μF	—

Note 2: 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.
Maximum operating ranges output current specification defined as lifetime average junction temperature of +45°C where max rated DC current = lifetime average current to avoid electro migration.

6. Pin Assignment (top view)



*Center electrode is GND

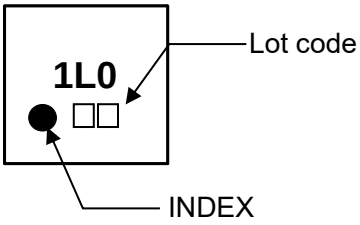
7. List of Products Number, Output voltage and Marking

Product No.	V_{OUT}(V) (Typ.)	Marking	Product No.	V_{OUT}(V) (Typ.)	Marking
TCR5BM08A*	0.8	0N8	TCR5BM19A*	1.9	1N9
TCR5BM085A*	0.85	0NJ	TCR5BM20A*	2.0	2N0
TCR5BM09A*	0.9	0N9	TCR5BM21A*	2.1	2N1
TCR5BM095A*	0.95	0NK	TCR5BM22A*	2.2	2N2
TCR5BM10	1.0	1L0	TCR5BM23A*	2.3	2N3
TCR5BM10A*	1.0	1N0	TCR5BM24A*	2.4	2N4
TCR5BM105	1.05	1LA	TCR5BM25A*	2.5	2N5
TCR5BM105A*	1.05	1NA	TCR5BM26A*	2.6	2N6
TCR5BM11	1.1	1L1	TCR5BM27A*	2.7	2N7
TCR5BM11A*	1.1	1N1	TCR5BM28A*	2.8	2N8
TCR5BM115A*	1.15	1NB	TCR5BM285A*	2.85	2NJ
TCR5BM12	1.2	1L2	TCR5BM29A*	2.9	2N9
TCR5BM12A*	1.2	1N2	TCR5BM295A*	2.95	2NK
TCR5BM125A*	1.25	1NC	TCR5BM30A*	3.0	3N0
TCR5BM13A*	1.3	1N3	TCR5BM31A*	3.1	3N1
TCR5BM14A*	1.4	1N4	TCR5BM32A*	3.2	3N2
TCR5BM15A*	1.5	1N5	TCR5BM33A*	3.3	3N3
TCR5BM16A*	1.6	1N6	TCR5BM34A*	3.4	3N4
TCR5BM17A*	1.7	1N7	TCR5BM35A*	3.5	3N5
TCR5BM18A*	1.8	1N8	TCR5BM36A*	3.6	3N6

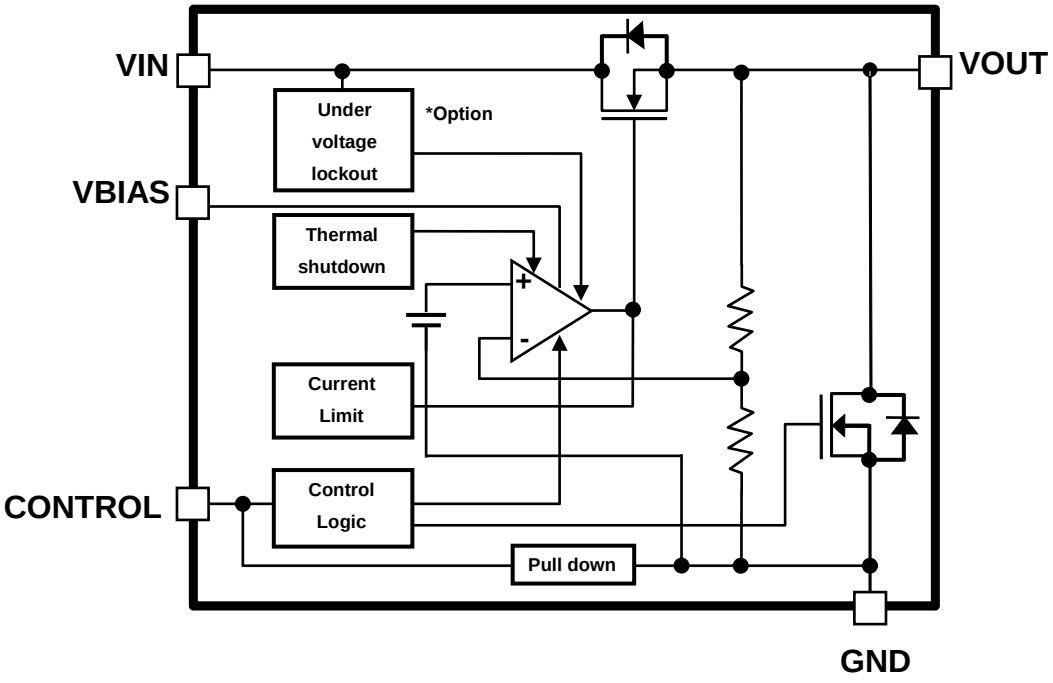
* Please contact your local Toshiba representative if you are interested in products with * sign
TCR5BMxxA products have under voltage lockout function.

Top Marking (top view)

Example: TCR5BM10 (1.0 V output)



8. Block Diagram



* Under voltage lockout is applied TCR5BMxxA products.

9. Electrical Characteristics

(Unless otherwise specified, V_{BIAS} = 3.3 V or V_{OUT} + 1.7 V whichever is greater, V_{IN} = V_{OUT} + 0.5 V, C_{IN} = 1.0 µF, C_{OUT} = 2.2 µF, C_{BIAS} = 0.1 µF)

Characteristics	Symbol	Test Condition		T_j = 25°C			T_j = -40 to 85°C (Note 8)		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
			1.8 V ≤ V_{OUT}	-1.0	—	+1.0	—	—	%
Line regulation	Reg·line	V_{OUT} + 0.5 V ≤ V_{IN} ≤ 5.5 V, I_{OUT} = 1 mA		—	0.1	—	—	—	mV
Load regulation	Reg·load	1 mA ≤ I_{OUT} ≤ 500 mA (Note 5)		—	7	—	—	—	mV
Quiescent current (Note 4)	$I_{BIAS\ (ON)}$	I_{OUT} = 0 mA, V_{BIAS} current		—	19	—	—	36	µA
	$I_{IN\ (ON)}$	I_{OUT} = 0 mA, V_{IN} current		—	3	—	—	6	
Stand-by current	$I_{BIAS\ (OFF)}$	V_{CT} = 0 V, V_{BIAS} current		—	0.1	—	—	1.0	µA
	$I_{IN\ (OFF)}$	V_{CT} = 0 V, V_{IN} current		—	—	0.5	—	—	µA
Control pull down current	I_{CT}	—		—	0.1	—	—	—	µA
Dropout voltage	V_{DO}	I_{OUT} = 500 mA, V_{BIAS} = 3.3 V V_{OUT} = 1.1 V (Note 6)		—	100	—	—	140	mV
Under voltage lockout (Note 9)	V_{UVLO}	V_{IN} voltage		—	0.6	—	—	0.75	V
Temperature coefficient	T_{CVO}	−40°C ≤ T_{opr} ≤ 85°C		—	70	—	—	—	ppm/°C
Output noise voltage	V_{NO}	V_{BIAS} = 3.3 V, V_{IN} = V_{OUT} + 0.5 V I_{OUT} = 10 mA, 10 Hz ≤ f ≤ 100 kHz (Note 7)		—	40	—	—	—	μV_{rms}
Ripple rejection ratio	R.R.	V_{BIAS} = 3.3 V, V_{IN} = V_{OUT} + 1 V I_{OUT} = 10 mA, f = 1 kHz $V_{IN\ Ripple}$ = 200 mV_{p-p} (Note 7)		—	98	—	—	—	dB
Load transient response	ΔV_{OUT}	I_{OUT} = 1 mA to 500 mA (Note 5)		—	-60	—	—	—	mV
		I_{OUT} = 500 mA to 1 mA (Note 5)		—	+60	—	—	—	
Control voltage (ON)	$V_{CT\ (ON)}$	—		0.9	—	V_{BIAS}	1.0	V_{BIAS}	V
Control voltage (OFF)	$V_{CT\ (OFF)}$	—		0	—	0.4	0	0.4	V
Current limit	I_{CL}	—		—	900	—	550	—	mA
Output discharge on resistance	R_{SD}	—		—	10	—	—	—	Ω

Note 3: Stable state with fixed I_{OUT} condition
Note 4: Except Control pull down current
Note 5: The 1.0 V output product
Note 6: V_{DO} = V_{IN1} - (V_{OUT1} x 0.97)
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 97% of V_{OUT1} after gradually decreasing the input voltage.
Note 7: The 0.8 V output product
Note 8: This parameter is warranted by design.
Note 9: Under voltage lockout is applied TCR5BMxxA products.

10. Dropout voltage

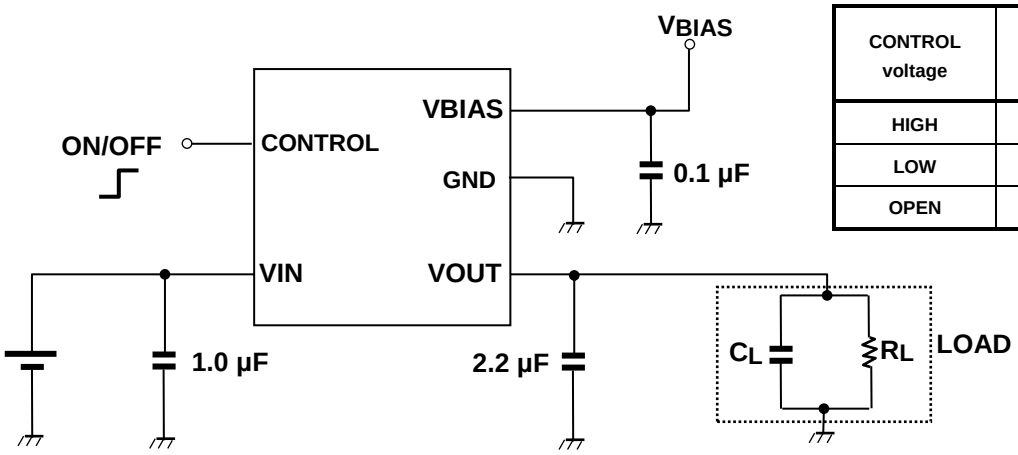
(C_{IN} = 1.0 µF, C_{OUT} = 2.2 µF, C_{BIAS} = 0.1 µF, T_j = 25°C)

Output voltages	V_{BIAS} input voltage	I_{OUT} = 500 mA			Unit
		Min	Typ.	Max (Note 10)	
0.8 V, 0.85 V	3.3 V	—	90	125	mV
0.9 V, 0.95 V	3.3 V	—	95	130	mV
1.0 V	3.3 V	—	95	135	mV
1.05 V, 1.1 V	3.3 V	—	100	140	mV
1.15 V	3.3 V	—	100	145	mV
1.2 V	3.3 V	—	105	150	mV
1.25 V	3.3 V	—	110	155	mV
1.3 V	3.3 V	—	110	160	mV
1.4 V	3.3 V	—	120	170	mV
1.5 V	3.3 V	—	125	190	mV
1.6 V	3.3 V	—	140	215	mV
1.7 V ≤ V_{OUT} ≤ 1.9 V	V_{OUT} + 1.7 V	—	135	210	mV
2.0 V, 2.1 V	V_{OUT} + 1.7 V	—	135	205	mV
2.2 V ≤ V_{OUT} ≤ 2.7 V	V_{OUT} + 1.7 V	—	135	200	mV
2.8 V ≤ V_{OUT} ≤ 3.6 V	V_{OUT} + 1.7 V	—	130	195	mV

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

11. Application Note

11.1. Example of Application Circuit



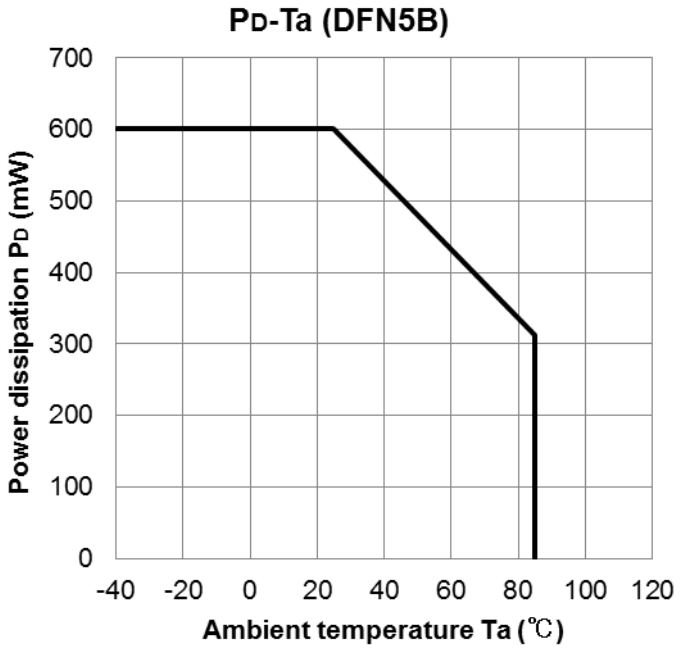
CONTROL voltage	Output voltage
HIGH	ON
LOW	OFF
OPEN	OFF

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

11.2. Power Dissipation

Board-mounted power dissipation ratings for TCR5BM series are available in the Absolute Maximum Ratings table. Power dissipation is measured on the board condition shown in below.

[The Board Condition]
Board material: Glass epoxy (FR4)
Board dimension: 40 mm x 40 mm (4layer), t = 1.8 mm
Metal pattern ratio: approximately 70 % each layer



11.3. Attention in Use

- Capacitors(Output, Input, and Bias Capacitor)
  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. For stable operation, please use over 1.0 μF input capacitor, 0.1 μF bias capacitor and 2.2 μF output ceramic capacitor.

- Recommending for Control Pin Operation
  This device is optimized to operate the best performance when turn on and off with control pin. Especially the rush current and bias current can be suppressed by using control pin after applying V_{IN} and V_{BIAS}.
  TCR5BMxxA products have V_{IN} under voltage lockout function, bias current is suppressed at low V_{IN} even when V_{BIAS} and V_{CT} are applied.

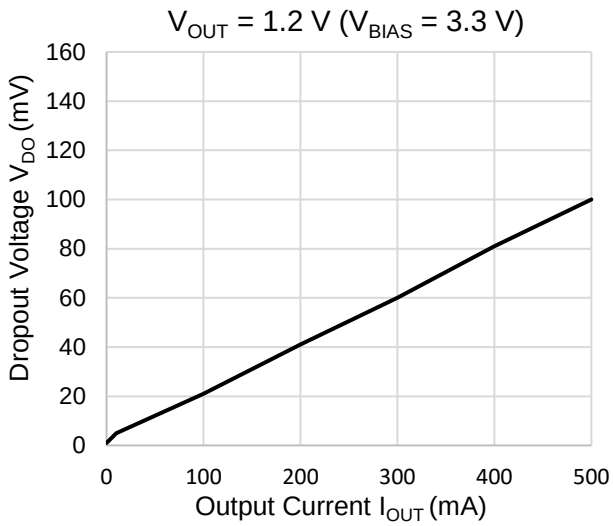
- Mounting
  The long distance between IC and output capacitor might affect phase compensation by impedance in wire and inductor. For stable power supply, output capacitor need to mount near IC as much as possible. Also V_{IN} and GND pattern need to be large and make the wire impedance small as possible.

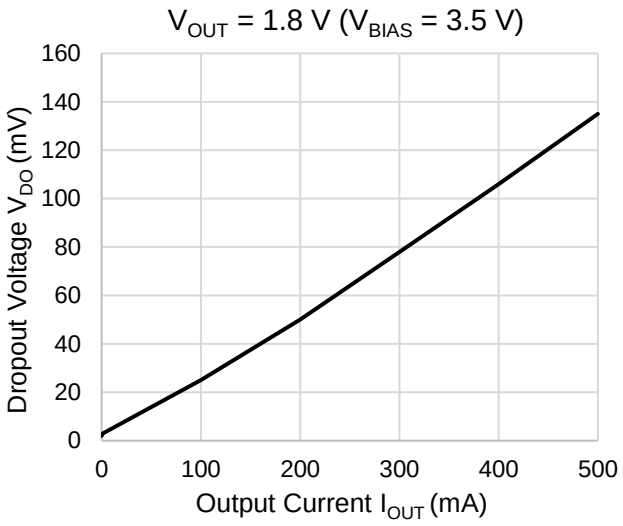
- Permissible Loss
  Please have enough design patterns for expected maximum permissible loss. And under consideration of ambient temperature, input voltage, and output current etc, we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70 to 80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

- 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.

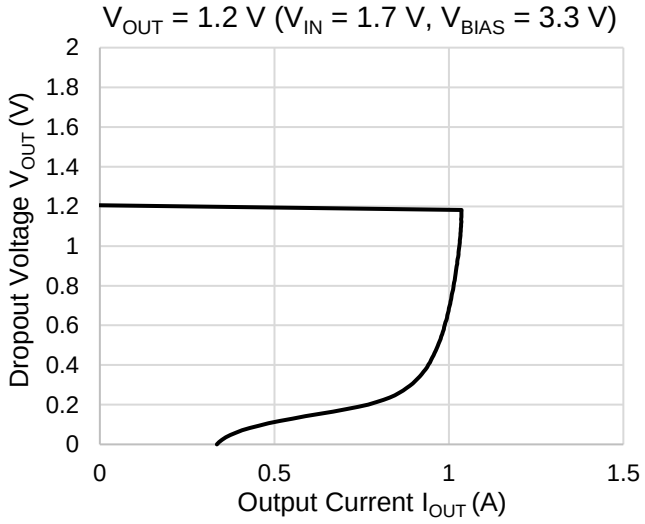
12. Representative Typical Characteristics

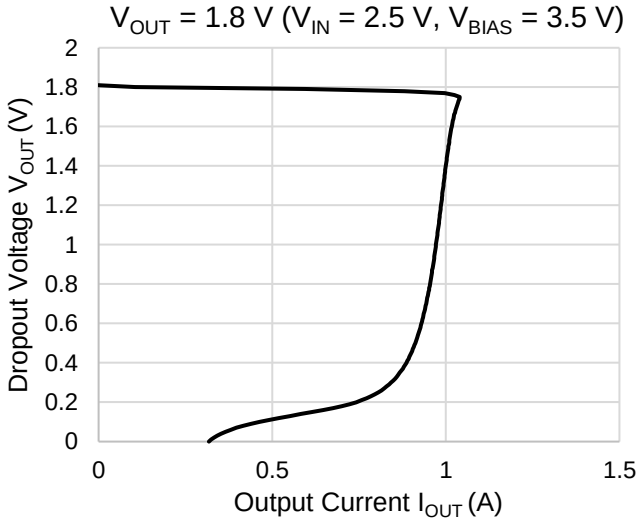
12.1. Dropout Voltage vs. Output Current (Ta = 25°C)





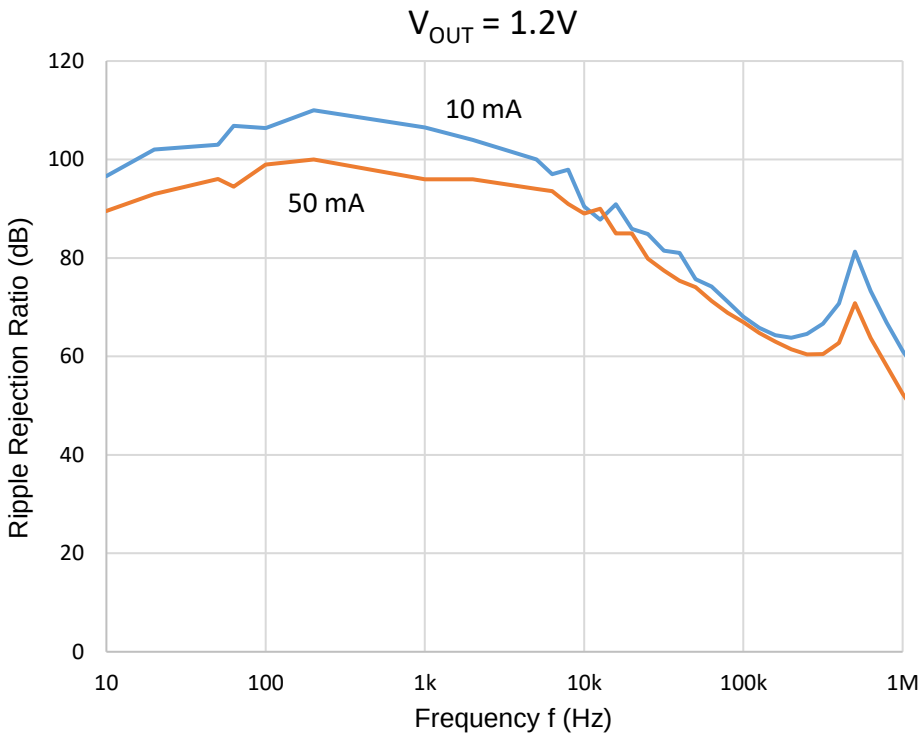
12.2. Output Current Limit (Ta = 25°C)





12.3. Ripple rejection Ratio vs. Frequency

(C_{IN} = none, C_{OUT} = 2.2 µF, V_{IN} = 2.2 V, V_{BIAS} = 3.3 V, $V_{IN\ Ripple}$ = 200 mV_{p-p}, Ta = 25°C)

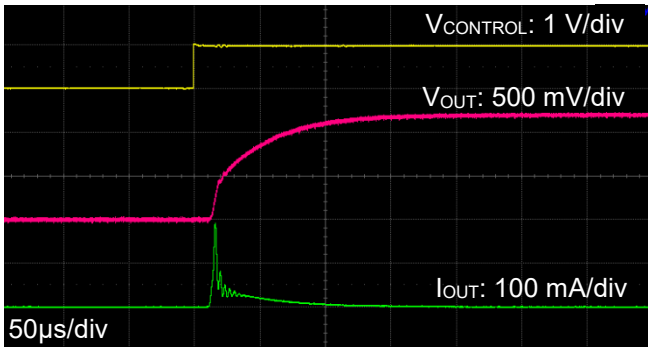


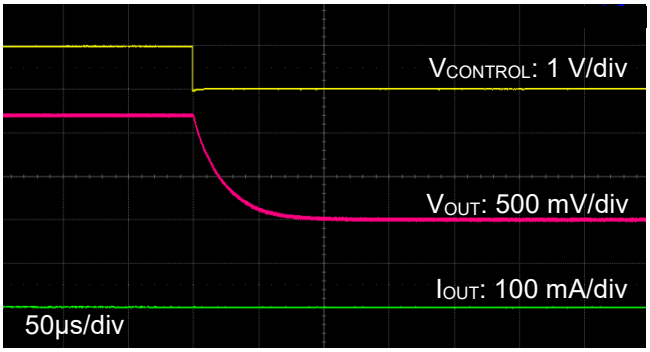
12.4. t_{ON} / t_{OFF} Response

(C_{IN} = 1.0 µF, C_{OUT} = 2.2 µF, $V_{CONTROL}$ = 0 V ⇔ 1 V, Ta = 25°C)

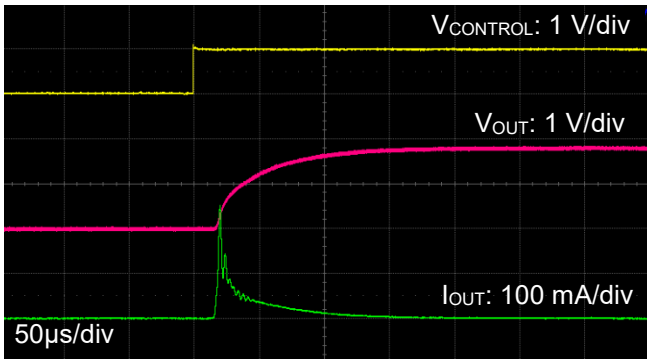
- **I_{OUT} = 0 mA**

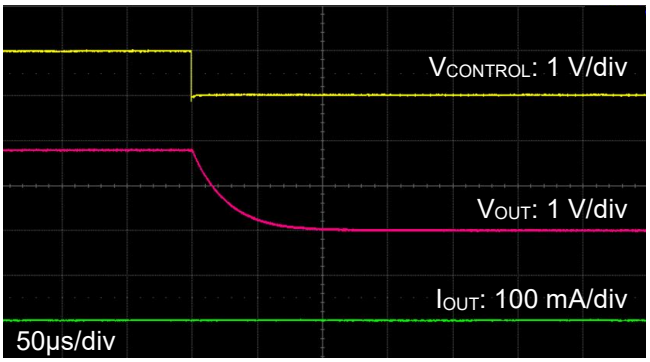
V_{OUT} = 1.2 V (V_{IN} = 1.7 V, V_{BIAS} = 3.3 V)





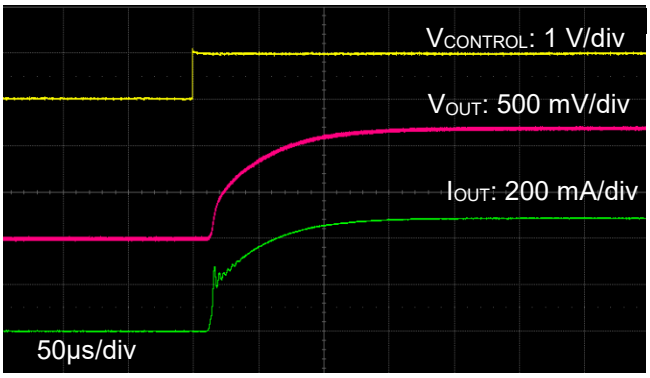
V_{OUT} = 1.8 V (V_{IN} = 2.5 V, V_{BIAS} = 3.5 V)

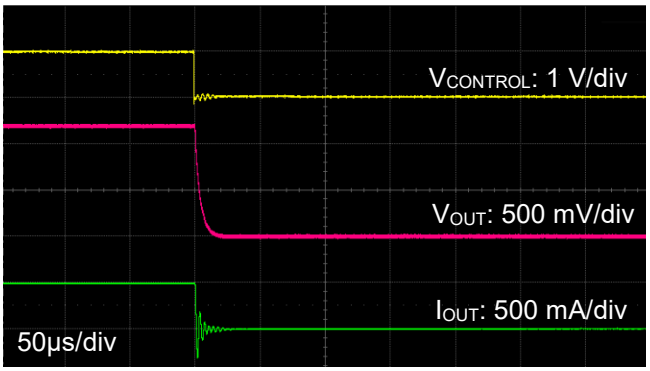




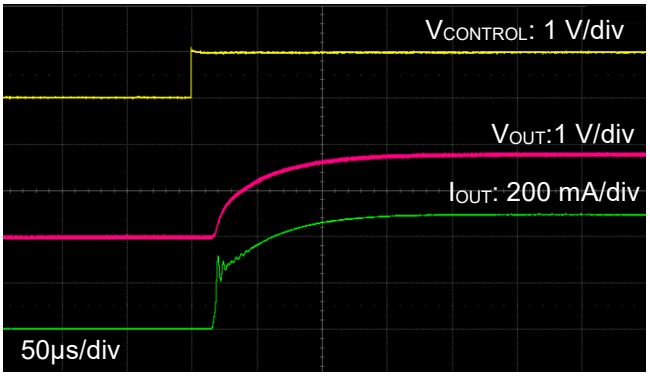
- **I_{OUT} = 500 mA**

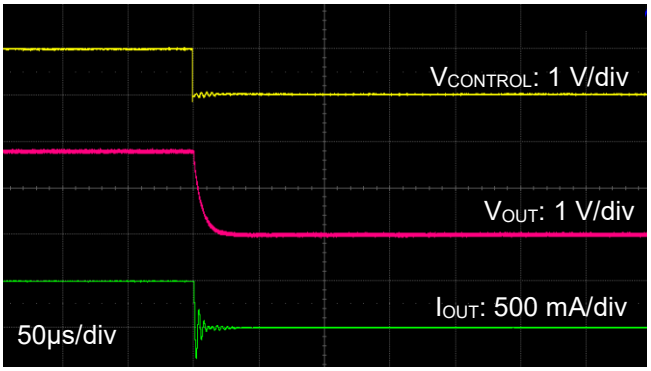
V_{OUT} = 1.2 V (V_{IN} = 1.7 V, V_{BIAS} = 3.3 V)





V_{OUT} = 1.8 V (V_{IN} = 2.5 V, V_{BIAS} = 3.5 V)

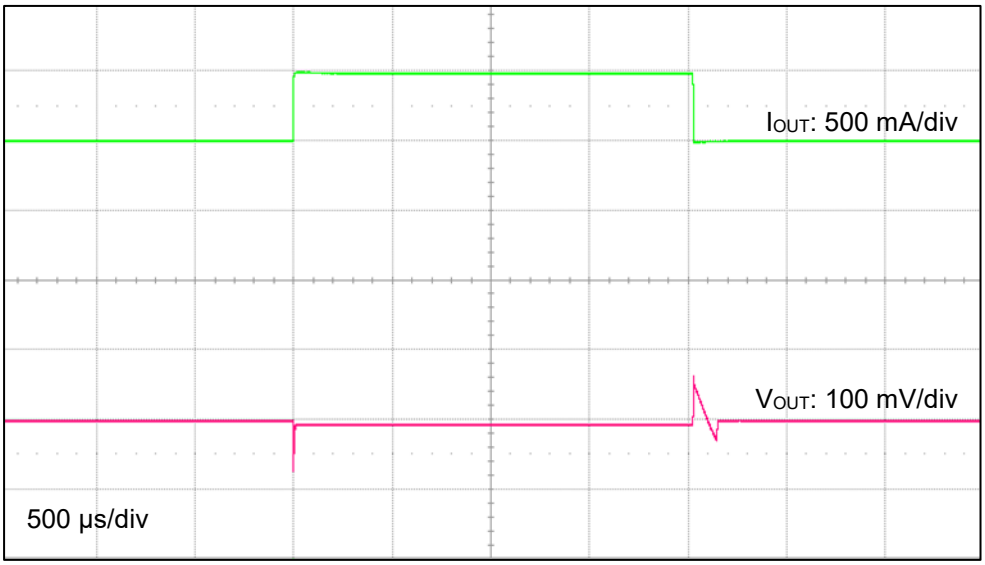




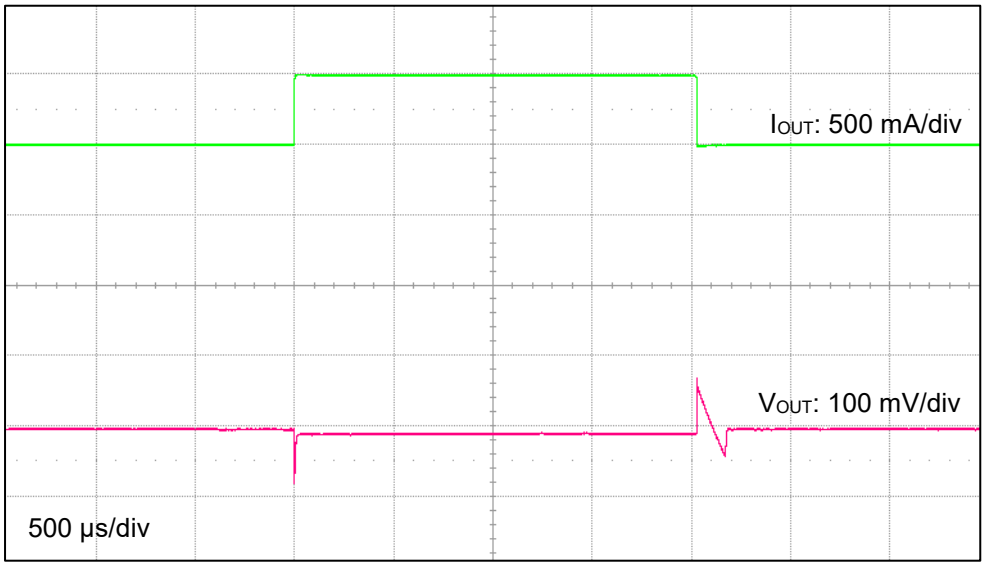
12.5. Load Transient Response

(C_{IN} = 1 µF, C_{OUT} = 2.2 µF, I_{OUT} = 1 mA ⇔ 500 mA, t_r = 1µs, t_f = 1µs, Ta = 25°C)

V_{OUT} = 1.2V (V_{IN} = 1.7 V, V_{BIAS} = 3.3 V)



V_{OUT} = 1.8 V (V_{IN} = 2.5 V, V_{BIAS} = 3.5 V)

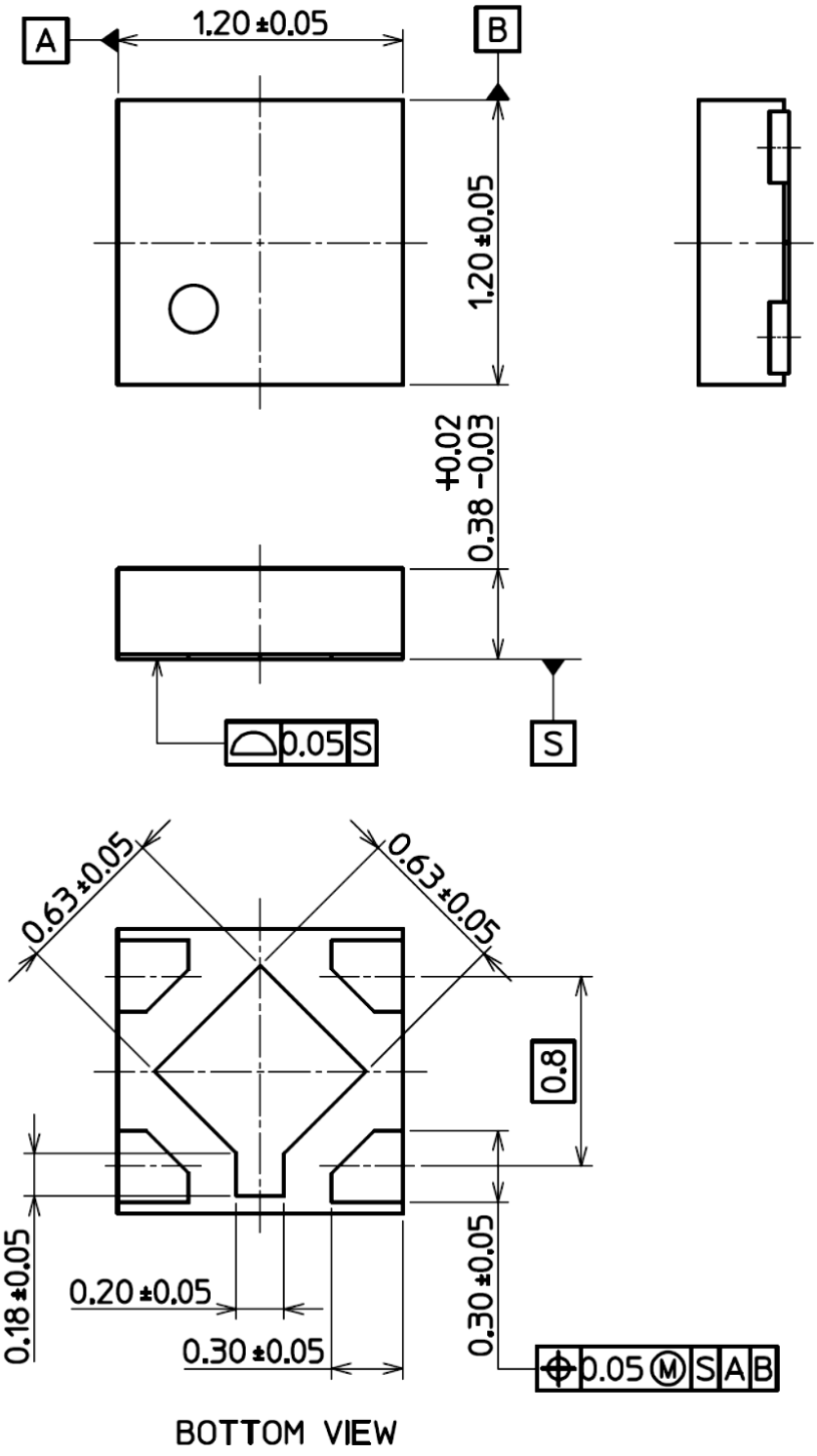


The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

13. Package Dimensions

DFN5B

Unit: mm

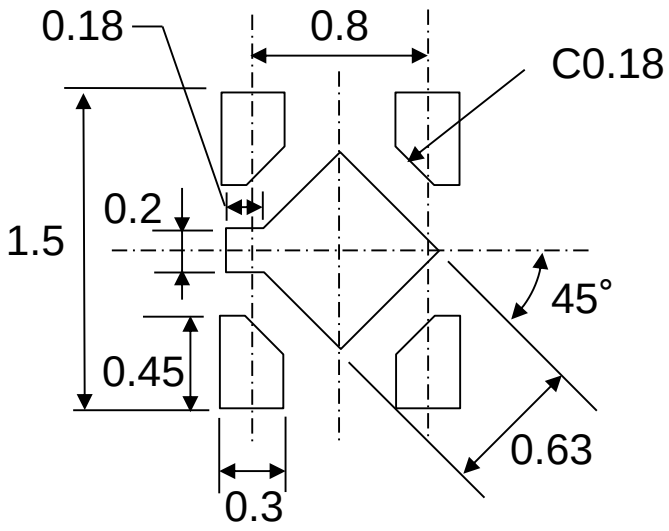


Weight : 1.4 mg (Typ.)

14. Land pattern dimensions for reference only

DFN5B

Unit: mm



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