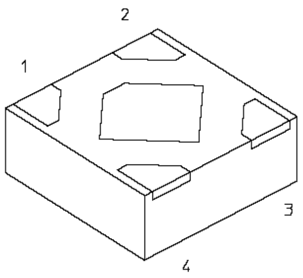
TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR3RM series

Ultra high Ripple rejection ratio, 300 mA CMOS Low Dropout Regulator in ultra small package

1. Description



DFN4C

The TCR3RM series are CMOS general-purpose single-output voltage regulators with an on/off control input, featuring low output voltage noise and ultra-high Ripple rejection ratio.

These voltage regulators are available in fixed output voltages between 0.9 V and 4.5 V and capable of driving up to 300 mA. They feature Overcurrent protection, Thermal shutdown and Auto-discharge.

The TCR3RM series is offered in the ultra small plastic mold package DFN4C (1.0 mm x 1.0 mm; t 0.38 mm (Typ.)) and has a high ripple rejection ratio of 100 dB (f = 1 kHz, 2.8 V output). As small ceramic input and output capacitors 1μF can be used with the TCR3RM series, these devices are ideal for portable applications that require high-density board assembly such as cellular phones.

2. Applications

Power IC developed for portable applications

3. Features

- Ultra small package DFN4C (1.0 mm x 1.0 mm; t 0.38 mm (Typ.)).
- High Ripple rejection ratio 100 dB (Typ.) @1 kHz (V_{OUT} = 2.8 V)
- High Ripple rejection ratio 93 dB (Typ.) @10 kHz (V_{OUT} = 2.8 V)
- High Ripple rejection ratio 68 dB (Typ.) @100 kHz (V_{OUT} = 2.8 V)
- High Ripple rejection ratio 68 dB (Typ.) @1 MHz (V_{OUT} = 2.8 V)
- Low output noise voltage (V_{NO} = 5 μV_{rms} (Typ.) at 10 Hz ≤ f ≤ 100 kHz)
- Low quiescent current (I_B = 7 μA (Typ.) at I_{OUT} = 0 mA)
- Overcurrent protection
- Thermal shutdown
- Auto-discharge
- Low Dropout voltage
  V_{DO} = 130 mV (Typ.), V_{OUT} = 2.8 V, I_{OUT} = 300 mA
- Wide range output voltage line up (V_{OUT} = 0.9 to 4.5 V)
- Pull down connection between CONTROL and GND
- Ceramic capacitors can be used (C_{IN} = 1 μF, C_{OUT} =1 μF)

Start of commercial production
2020-09

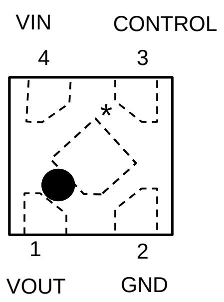
4. Absolute Maximum Ratings (Ta = 25°C)

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
Output current	I_{OUT}	300	mA
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: 40mm x 40mm x 1.6mm, both sides of board.
Metal pattern ratio: a surface approximately 50%, the reverse side approximately 50%

5. Pin Assignment (top view)



*Center electrode should be connected to GND or Open

6. Operating Ranges

Characteristics	Symbol	Ranges		Unit
Input voltage	V_{IN}	1.8 to 5.5 (Note 2)		V
Control voltage	V_{CT}	0 to V_{IN}		V
Output voltage	V_{OUT}	0.9 to 4.5		V
Output current	I_{OUT}	DC	300	mA
Operating Temperature	T_{opr}	-40 to 85		°C
Output Capacitance	C_{OUT}	≥ 1.0 μF		—
Input Capacitance	C_{IN}	≥ 1.0 μF		—

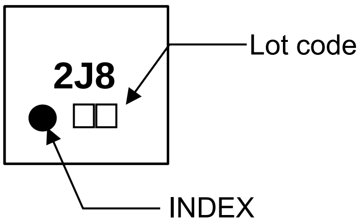
Note 2: Please refer to Dropout Voltage table(Page 6) and use it within Absolute Maximum Ratings Junction temperature and Operating Temperature Ranges.

7. List of Products Number, Output voltage and Marking

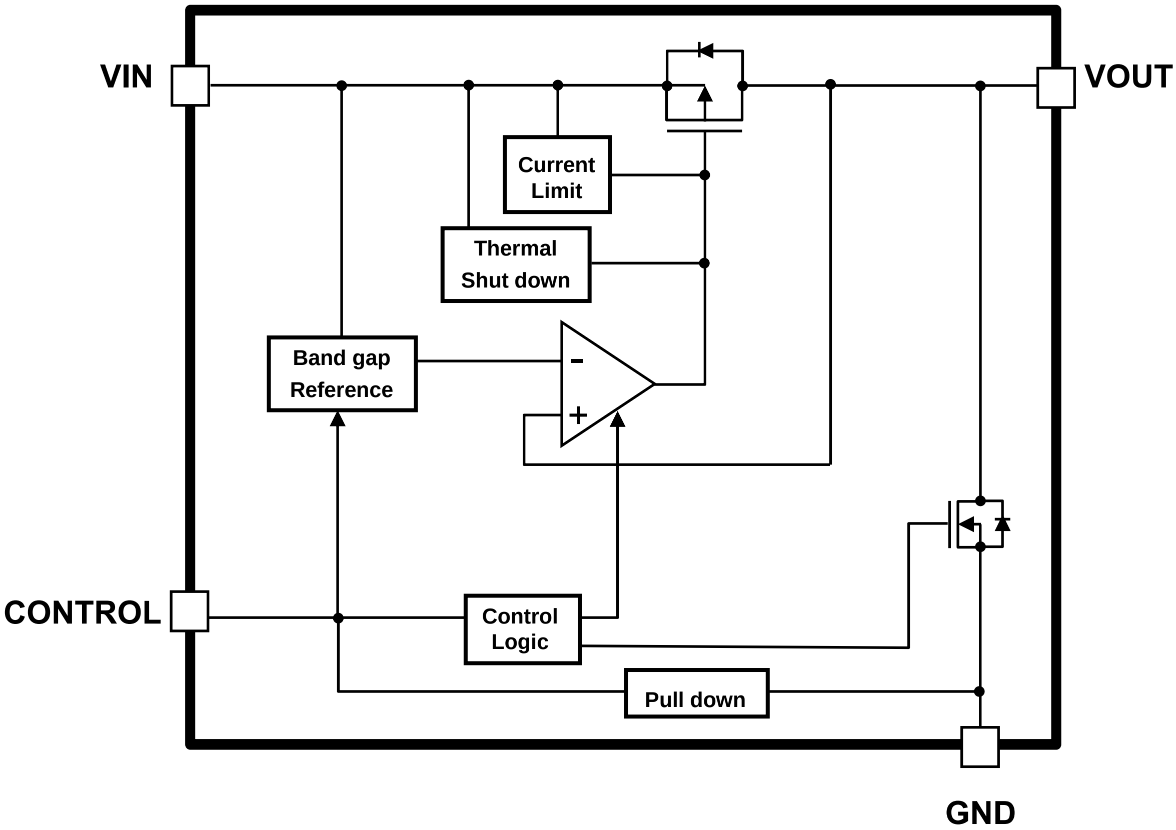
Product No.	Output voltage(V)	Marking
TCR3RM09A	0.9	0J9
TCR3RM095A	0.95	0JB
TCR3RM10A	1.0	1J0
TCR3RM105A	1.05	1JC
TCR3RM11A	1.1	1J1
TCR3RM115A	1.15	1JD
TCR3RM12A	1.2	1J2
TCR3RM13A	1.3	1J3
TCR3RM15A	1.5	1J5
TCR3RM16A	1.6	1J6
TCR3RM17A	1.7	1J7
TCR3RM18A	1.8	1J8
TCR3RM1825A	1.825	1JG
TCR3RM185A	1.85	1JH
TCR3RM19A	1.9	1J9
TCR3RM20A	2.0	2J0
TCR3RM22A	2.2	2J2
TCR3RM25A	2.5	2J5
TCR3RM26A	2.6	2J6
TCR3RM27A	2.7	2J7
TCR3RM28A	2.8	2J8
TCR3RM285A	2.85	2JJ
TCR3RM29A	2.9	2J9
TCR3RM30A	3.0	3J0
TCR3RM31A	3.1	3J1
TCR3RM32A	3.2	3J2
TCR3RM33A	3.3	3J3
TCR3RM35A	3.5	3J5
TCR3RM36A	3.6	3J6
TCR3RM40A	4.0	4J0
TCR3RM41A	4.1	4J1
TCR3RM42A	4.2	4J2
TCR3RM43A	4.3	4J3
TCR3RM45A	4.5	4J5

Top Marking (top view)

Example: TCR3RM28A (2.8 V output)



Block Diagram



8. Electrical Characteristics

(Unless otherwise specified, V_{IN} = V_{OUT} + 1 V (V_{OUT} ≥ 1 V), V_{IN} = 2 V (V_{OUT} ≤ 1 V), C_{IN} = C_{OUT} = 1 μF)

Characteristics	Symbol	Test Condition		T_j = 25°C Min	T_j = 25°C Typ.	T_j = 25°C Max	T_j = -40 to 85°C (Note 6) Min	T_j = -40 to 85°C (Note 6) Max	Unit
Output voltage accuracy	V_{OUT}	I_{OUT} = 1 to 300 mA, V_{IN} = V_{OUT}+ 1 V to 5.5 V (Note 3)	V_{OUT} < 1.8 V	—	—	—	-36	+36	mV
			1.8V ≤ V_{OUT}	—	—	—	-2	+2	%
Line regulation	Reg·line	V_{OUT} + 1 V ≤ V_{IN} ≤ 5.5 V, I_{OUT} = 1 mA		—	0.025	—	—	—	%/V
Load regulation	Reg·load	1 mA ≤ I_{OUT} ≤ 300 mA		—	12	—	—	—	mV
Quiescent current	$I_{B(ON)}$	I_{OUT} = 0 mA (Note 5)		—	7	—	—	12	μA
Stand-by current	$I_{B\ (OFF)}$	V_{CT} = 0 V		—	0.1	—	—	1.0	μA
Control pull down current	I_{CT}	—		—	0.1	—	—	0.2	μA
Drop-out voltage (Note 7)	V_{DO}	I_{OUT} = 300 mA	V_{OUT} = 1.8 V	—	180	—	—	220	mV
			V_{OUT} = 2.8 V	—	130	—	—	150	mV
			V_{OUT} = 4.5 V	—	98	—	—	125	mV
Output noise voltage	V_{NO}	I_{OUT} = 10 mA, 10 Hz ≤ f ≤ 100 kHz, Ta = 25°C (Note 4)		—	5	—	—	—	$μV_{rms}$
Ripple rejection ratio	R.R.	I_{OUT} = 10 mA, V_{Ripple} = 200 mV_{p-p}, Ta = 25°C (Note 4)	f = 1 kHz	—	100	—	—	—	dB
			f = 10 kHz	—	93	—	—	—	dB
			f = 100 kHz	—	68	—	—	—	dB
			f = 1 MHz	—	68	—	—	—	dB
Load transient response	$⊿V_{OUT}$	I_{OUT} = 1 mA → 300 mA, t_r = 1 μs		—	-30	—	—	—	mV
		I_{OUT} = 300 mA → 1 mA, t_f = 1 μs		—	+30	—	—	—	mV
Output voltage slew rate	V_{OUTSR}	(Note 4)		—	4	—	—	—	mV/μs
Output current limit	I_{CL}	—		—	—	—	400	700	mA
Thermal shutdown threshold	T_{SDH}	T_j rising		—	160	—	—	—	°C
	T_{SDL}	T_j falling		—	140	—	—	—	°C
Control pin threshold voltage	V_{CTH}	Control pin input voltage "HIGH"		—	—	—	1.0	V_{IN}	V
	V_{CTL}	Control pin input voltage "LOW"		—	—	—	0	0.4	V
Discharge on resistance	R_{SD}	(Note 4)		—	20	—	—	—	Ω

Note 3: stable state with fixed I_{OUT} condition

Note 4: V_{OUT} = 2.8 V

Note 5: except Control pull down current (I_{CT})

Note 6: This parameter is warranted by design.

Note 7: V_{DO} = V_{IN1} - (V_{OUT1} x 0.97)

V_{OUT1} is the nominal output voltage.

V_{IN1} is the input voltage at which the output voltage becomes 97% of V_{OUT1} after gradually decreasing the input voltage.

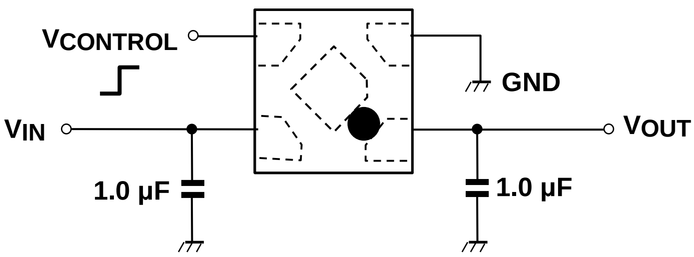
Dropout voltage table
(C_{IN} = 1.0 μF, C_{OUT} = 1.0 μF)

Output voltages	I_{OUT} = 300 mA			Unit
	Min	Typ.	Max (Note 8)	
0.9 V ≤ V_{OUT} ≤ 1.5 V	—	(Note 9)	(Note 9)	mV
1.5 V	—	225 (Note 9)	280 (Note 9)	mV
1.6 V	—	210	255	mV
1.7 V	—	190	235	mV
1.8 V, 1.825 V, 1.85 V	—	180	220	mV
1.9 V	—	175	210	mV
2.0 V	—	170	200	mV
2.2 V	—	160	185	mV
2.5 V, 2.6 V	—	140	165	mV
2.7 V	—	130	155	mV
2.8 V	—	130	150	mV
2.85 V, 2.9 V	—	125	150	mV
3.0 V, 3.1 V, 3.2 V	—	120	145	mV
3.3 V	—	115	140	mV
3.5 V, 3.6 V	—	110	140	mV
4.0 V	—	100	138	mV
4.1 V	—	100	135	mV
4.2 V, 4.3 V	—	100	133	mV
4.5 V	—	98	125	mV

Note 8: T_j = -40 to 85 °C. This parameter is guaranteed by design
Note 9: Operating Voltage of V_{IN} should be over 1.8 V.

9. Application Note

9.1. Recommended Application Circuit



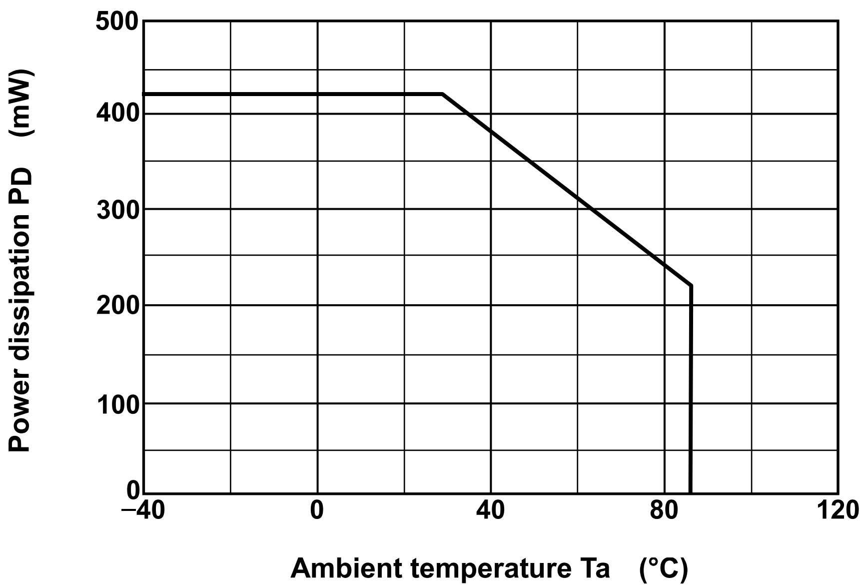
CONTROL voltage	Output voltage
HIGH	ON
LOW	OFF
OPEN	OFF

The figure above shows the recommended configuration for using a Low-Dropout regulator. Insert a capacitor at VOUT and VIN pins for stable input/output operation. (Ceramic capacitors can be used.)

9.2. Power Dissipation

Board-mounted power dissipation ratings for TCR3RM 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: 40mm x 40mm (both sides of board), t= 1.6 mm
Metal pattern ratio: a surface approximately 50%, the reverse side approximately 50%



9.3. 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 ceramic capacitor.

- Bias current characteristics
  TCR3RM series has Bias current; $I_{B(ON)}$ characteristic that controlled depending on I_{OUT}.
  When the output current required is very low, TCR3RM series operates with low $I_{B(ON)}$. In this state, PSRR characteristic and load transient response characteristic are inferior than normal characteristics.
  Regarding output current that switches $I_{B(ON)}$ state, TCR3RM series has hysteresis to control. When output current is increased, good PSRR characteristics and good load transient response characteristics are provided with $I_{B(ON)}$ becoming high. In the case of decreasing the I_{OUT}, TCR3RM series keeps good characteristics until the $I_{B(ON)}$ switches to a low state.

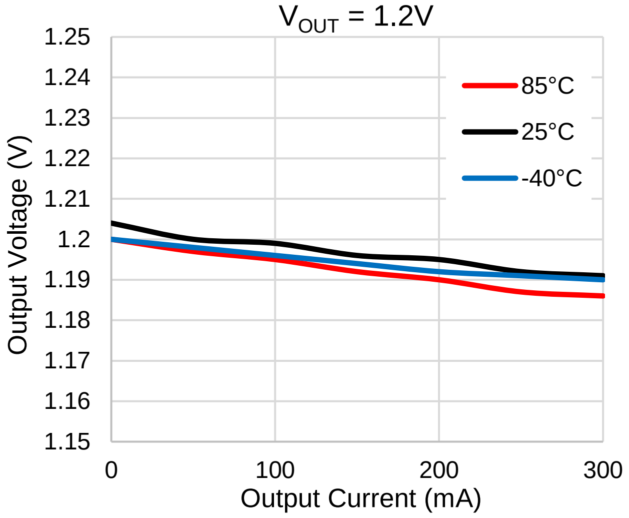
- Mounting
  The long distance between IC and output capacitor might affect phase compensation by impedance in wire and inductor. For stable power supply, output capacitor need to mount near IC as much as possible. Also VIN and GND pattern need to be large and make the wire impedance small as possible.

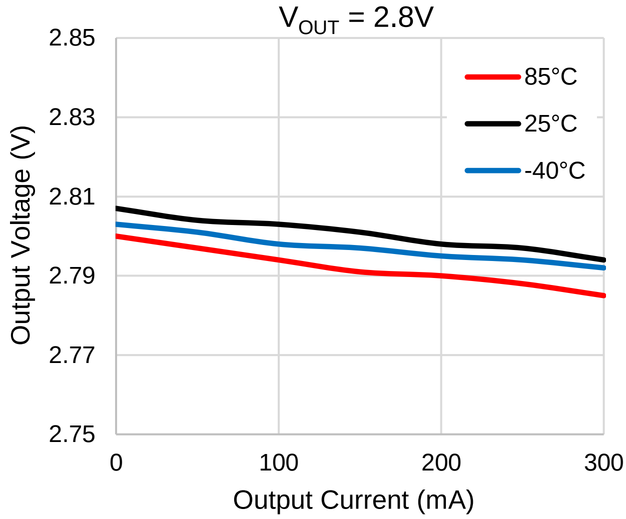
- Permissible Loss
  Please have enough design patterns for expected maximum permissible loss. And under consideration of surrounding temperature, input voltage, output current etc., we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70 to 80%.

- 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 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 recommends inserting failsafe system into the design.

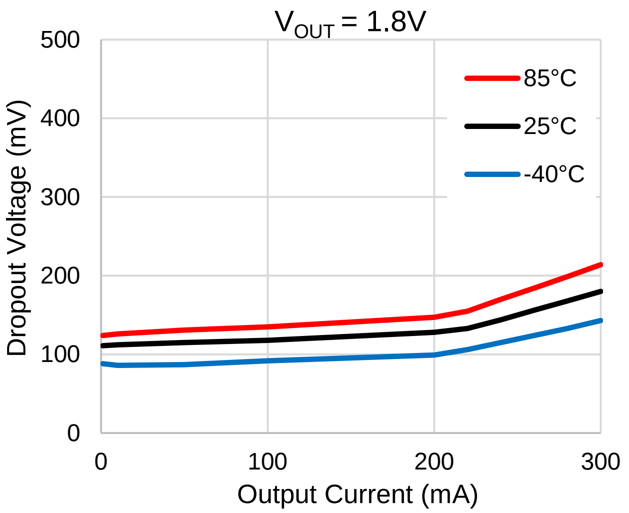
10. Representative Typical Characteristics

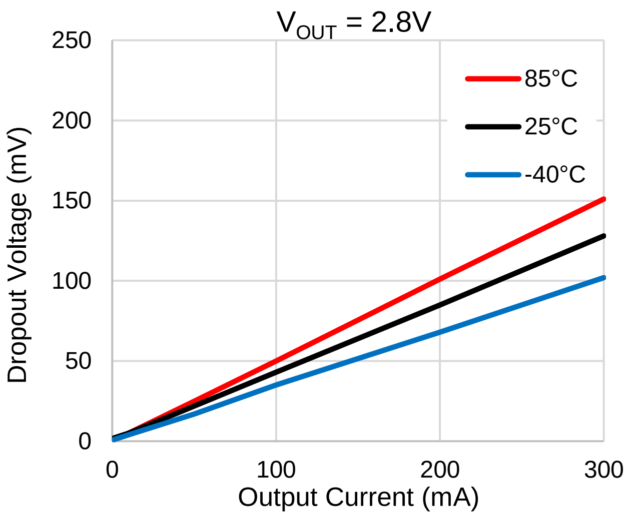
10.1. Output Voltage vs. Output Current ($V_{IN} = V_{OUT} + 1V$)

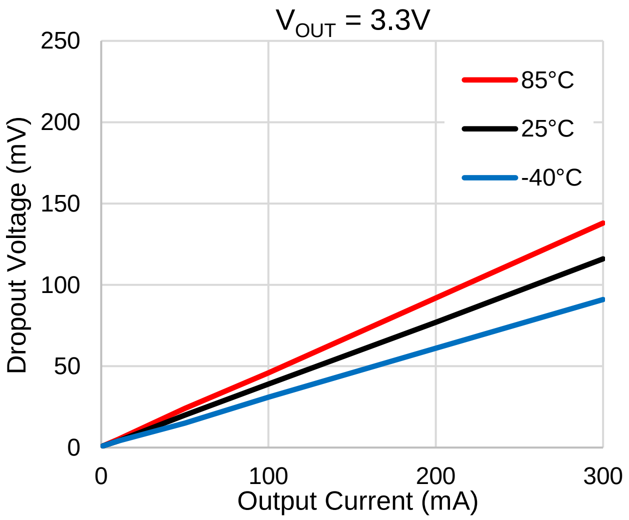


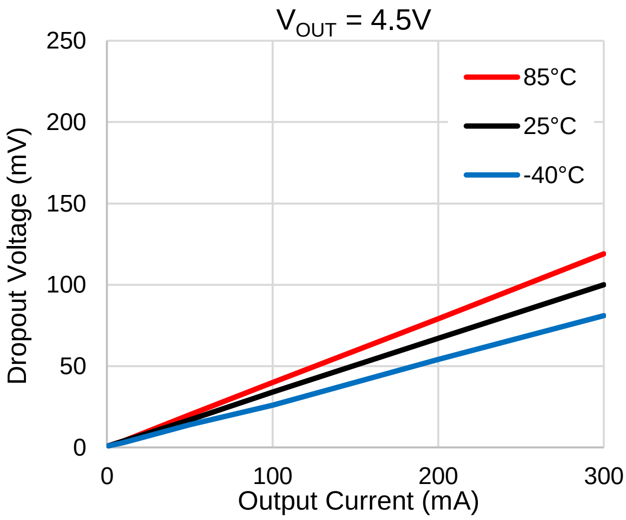


10.2. Dropout Voltage vs. Output Current

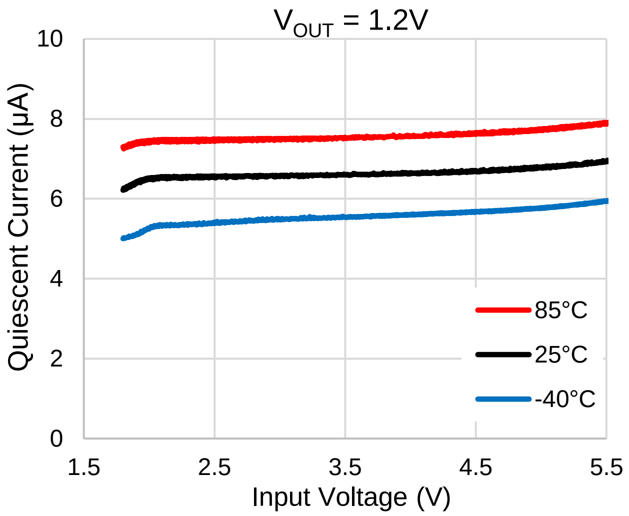


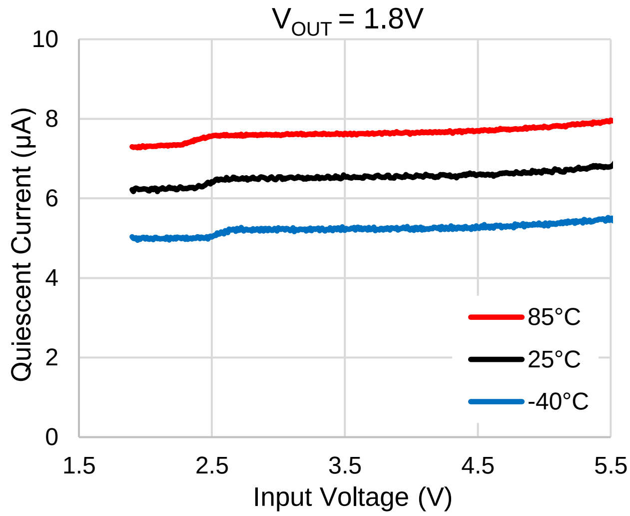


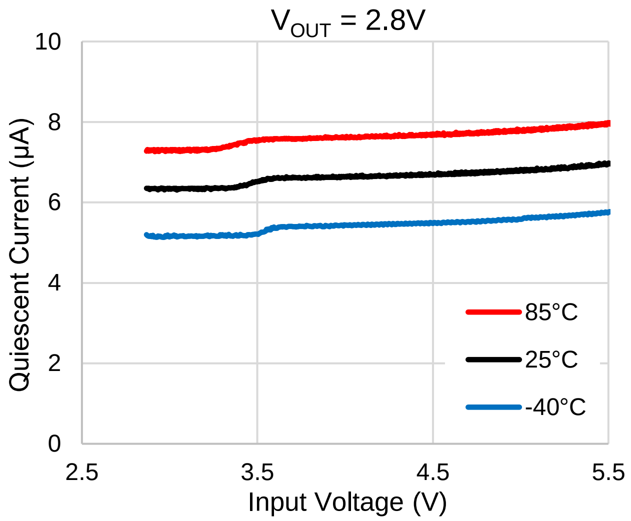




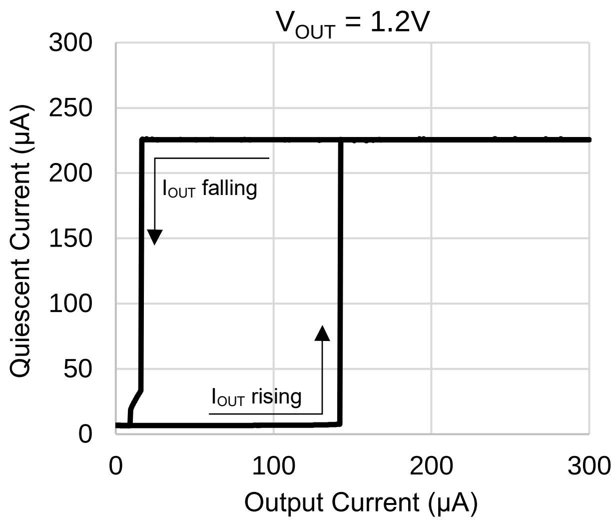
10.3. Quiescent Current vs. Input Voltage (I_{OUT} = 0mA)

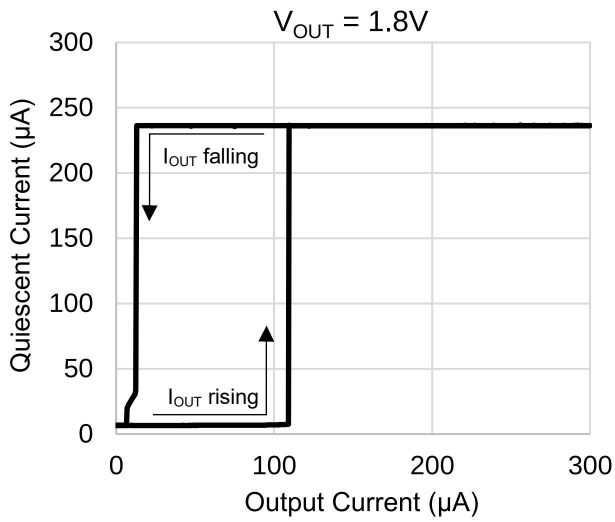


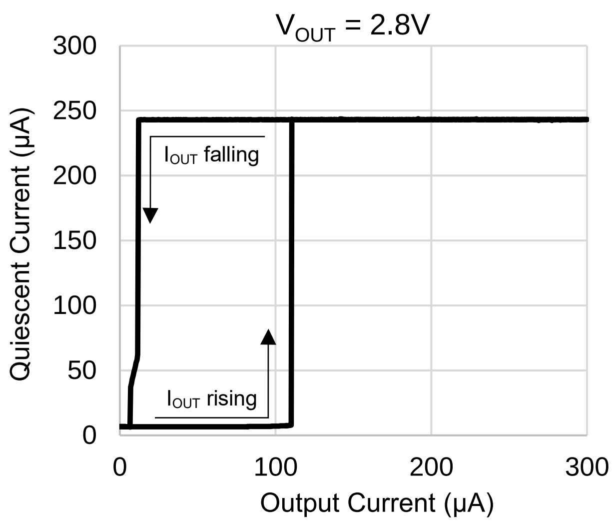




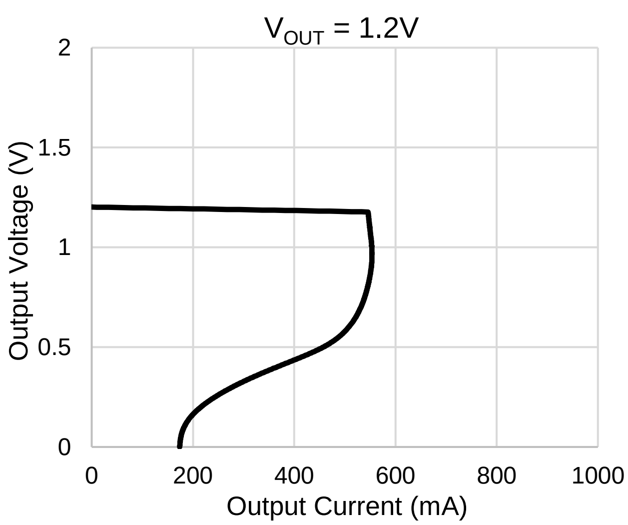
10.4. Quiescent Current vs. Output Current (V_{IN} = V_{OUT} + 1V, I_{OUT} = 0↔300μA, Ta=25°C)

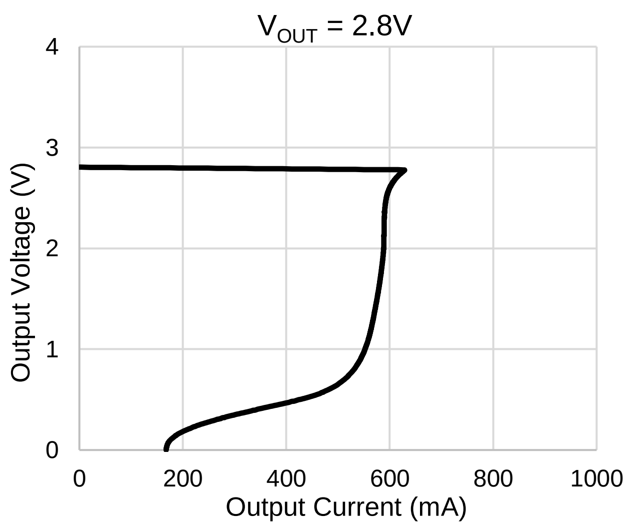






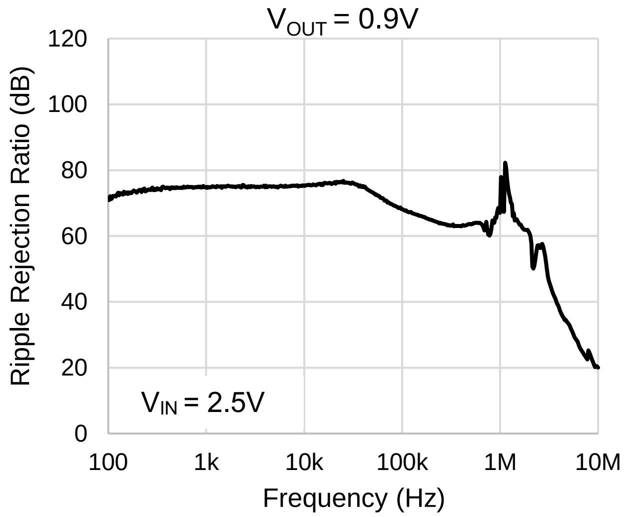
10.5. Output Current Limit (V_{IN} = V_{OUT} + 1V, Ta = 25°C)

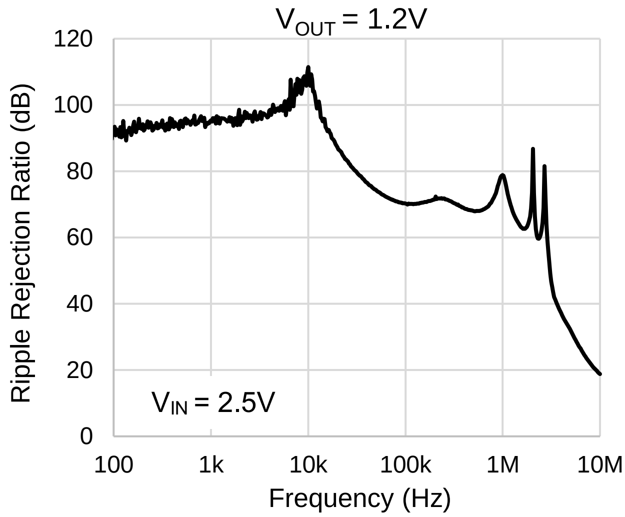


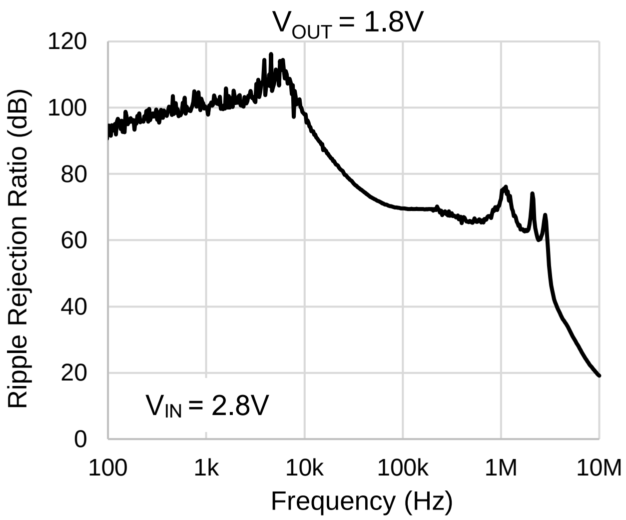


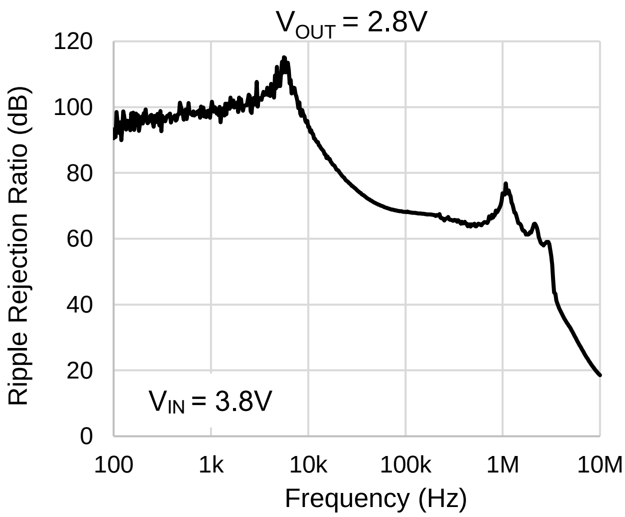
10.6. Ripple rejection Ratio vs. Frequency

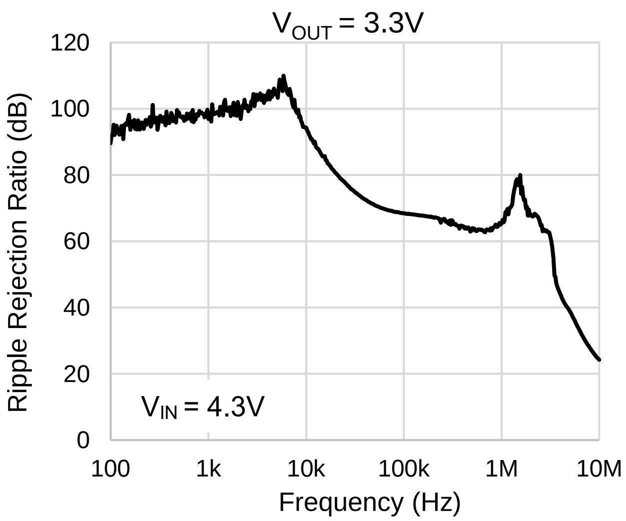
(C_{IN} = none, C_{OUT} = 1μF, $V_{IN\ Ripple}$ = 200m$V_{p\text{-}p}$, I_{OUT} = 10mA, Ta = 25°C)

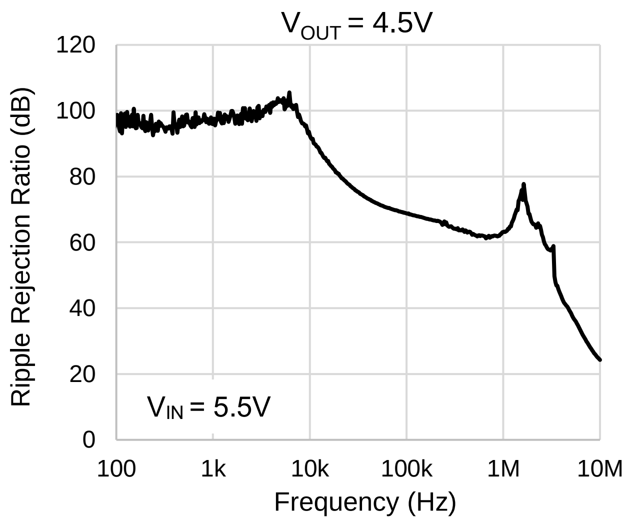








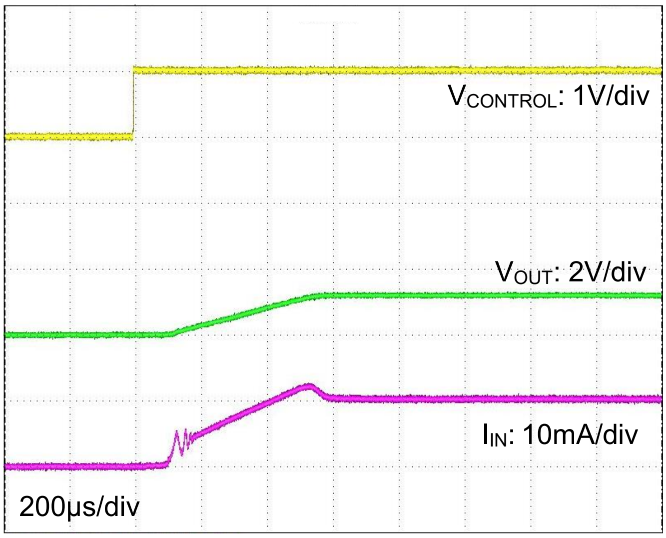


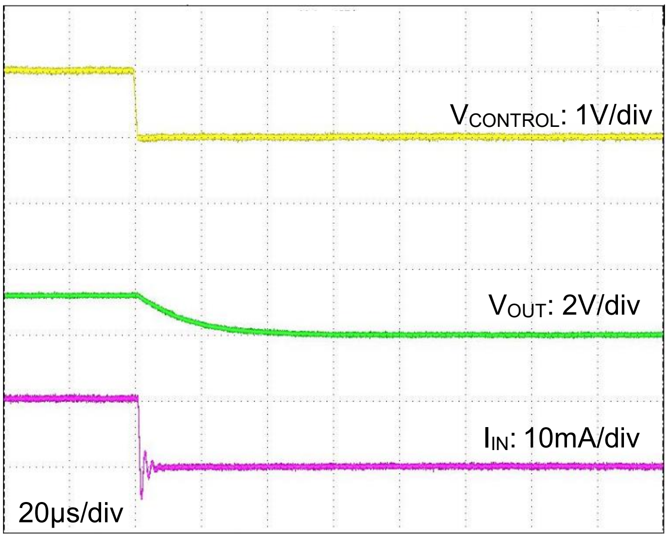


10.7. t_{ON} / t_{OFF} Response (C_{IN} = 1μF, V_{IN} = V_{OUT} + 1V, $V_{CONTROL}$ = 0V↔1V, Ta = 25°C)

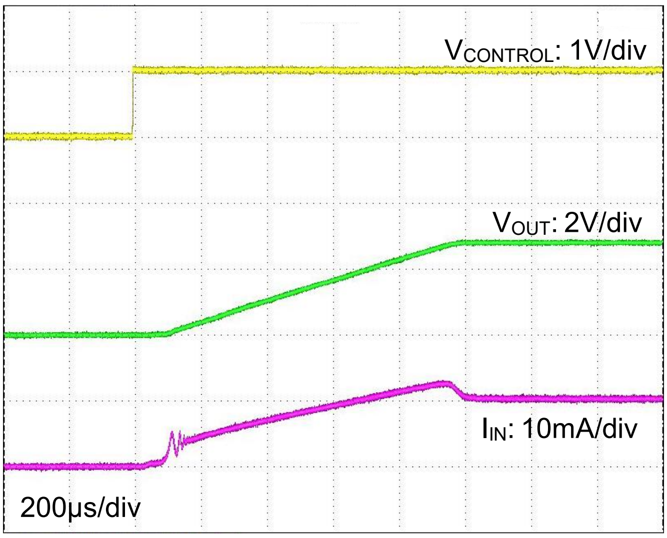
- **C_{OUT} = 1μF, I_{OUT} = 10mA**

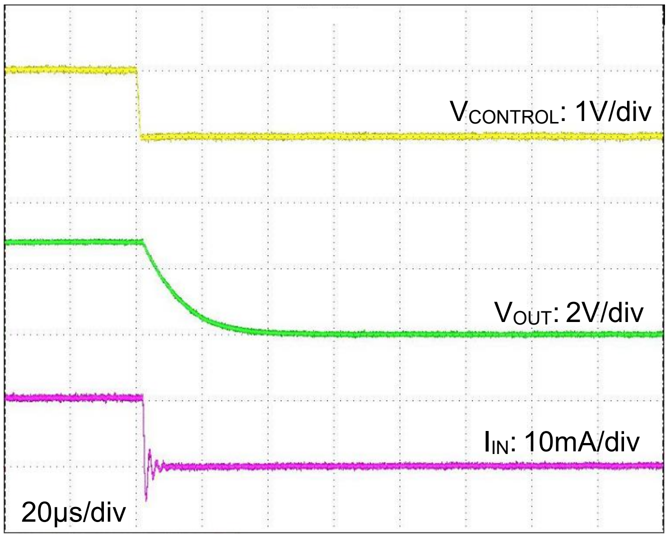
V_{OUT} = 1.2V





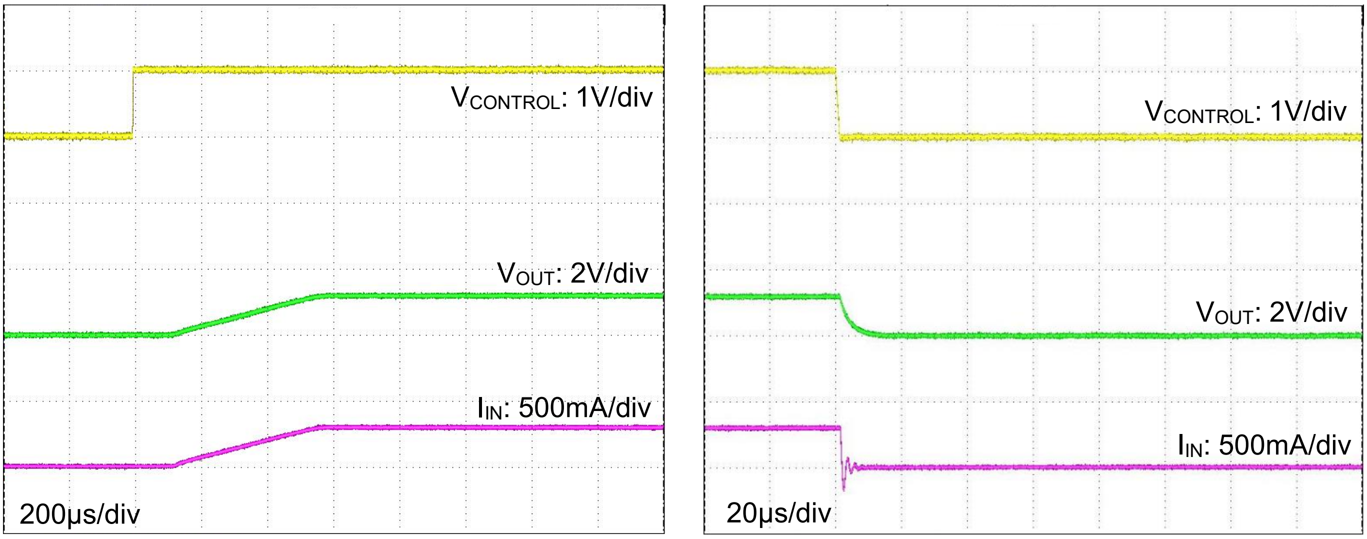
V_{OUT} = 2.8V



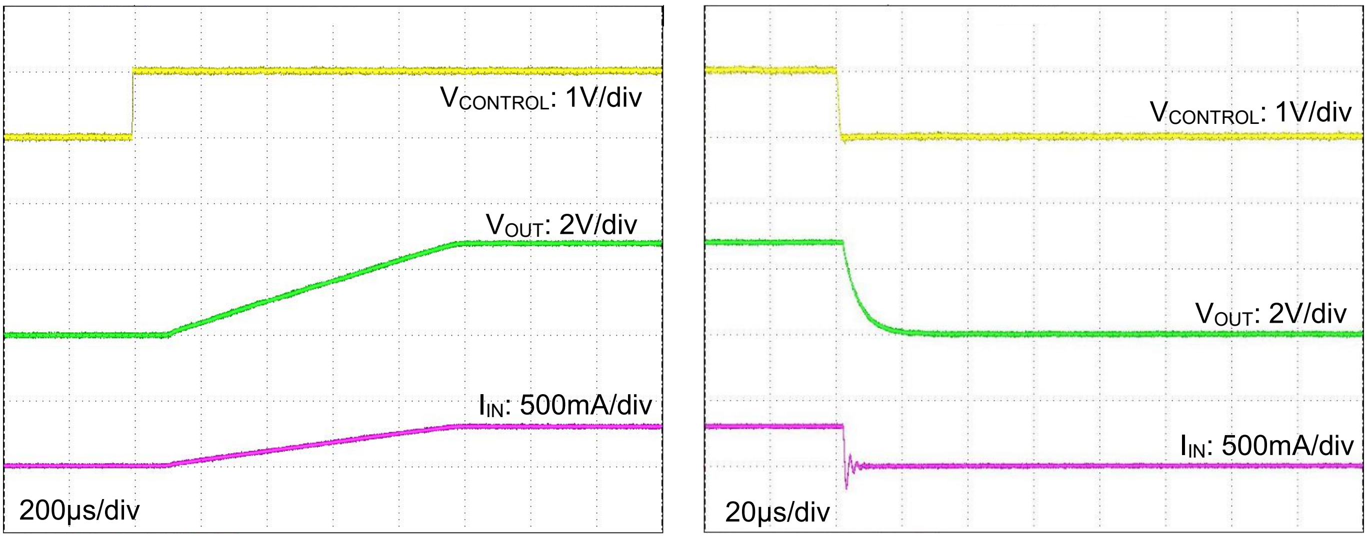


- **C_{OUT} = 1µF, I_{OUT} = 300mA**

V_{OUT} = 1.2V

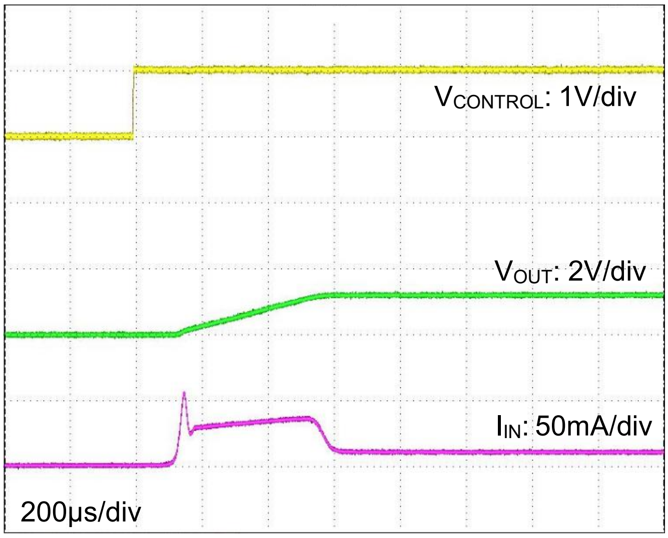


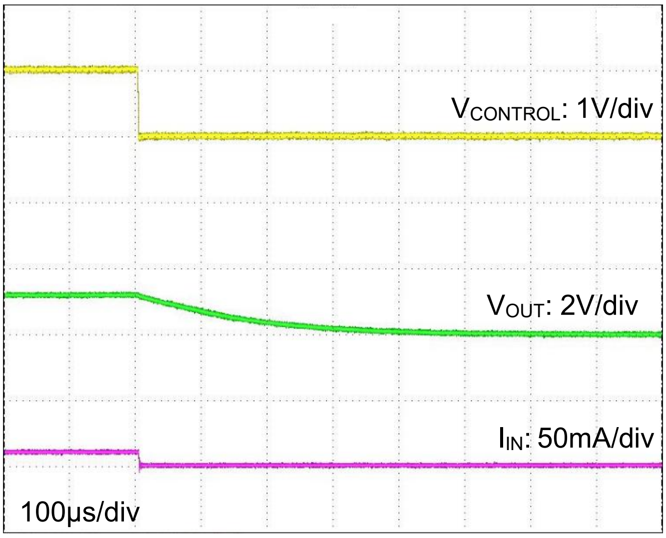
V_{OUT} = 2.8V



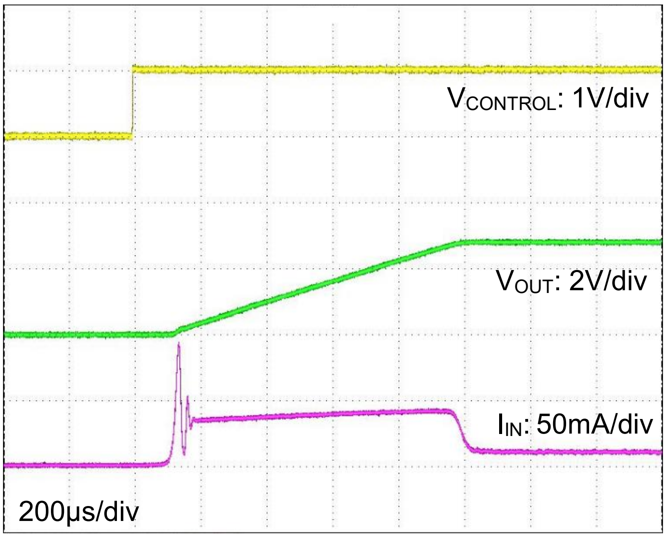
- **C_{OUT} = 10µF, I_{OUT} = 10mA**

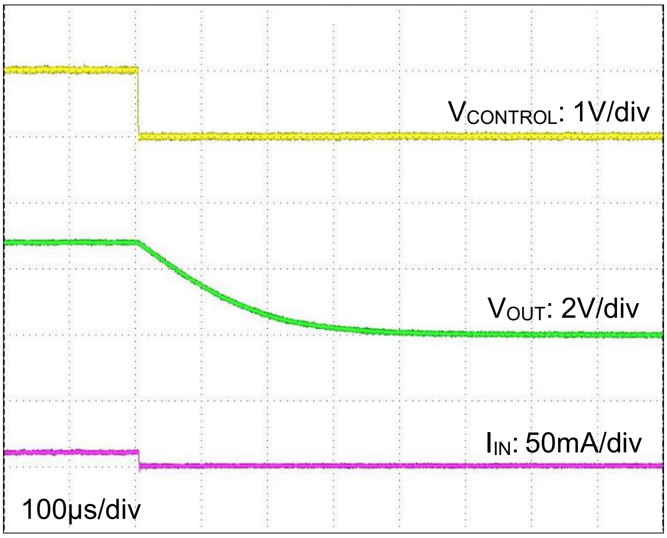
V_{OUT} = 1.2V





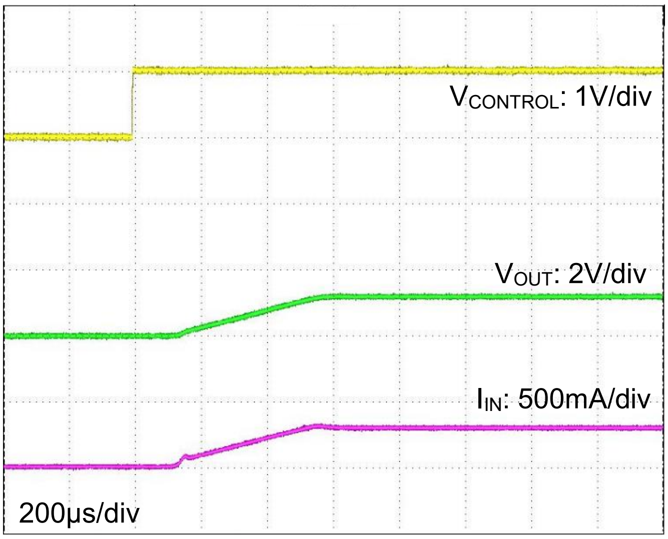
V_{OUT} = 2.8V

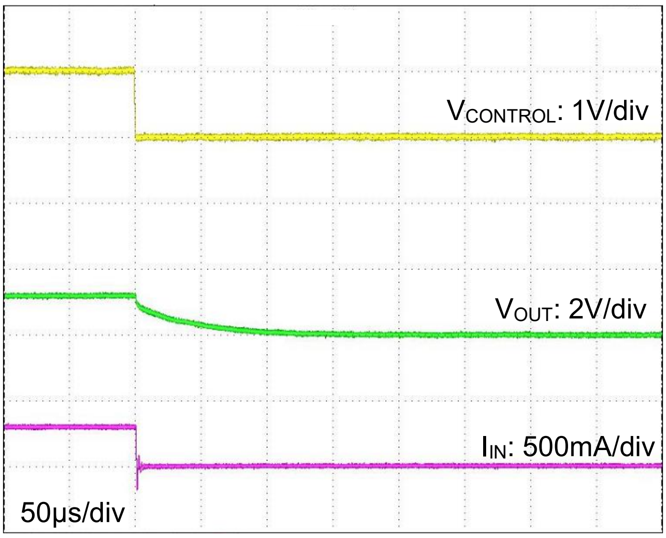




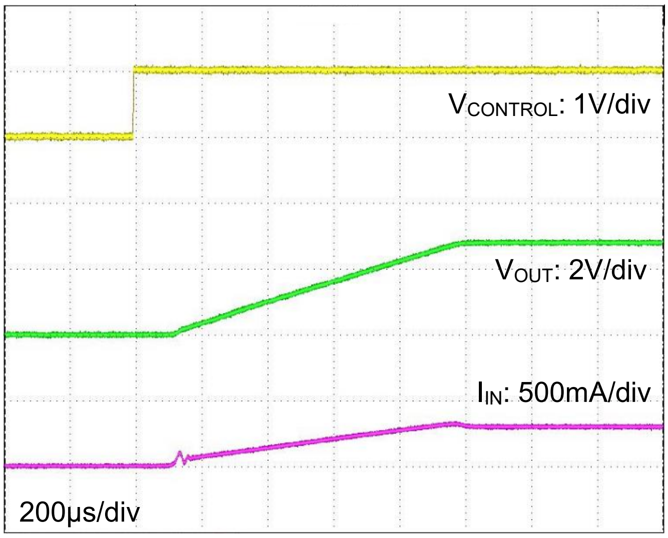
- **C_{OUT} = 10μF, I_{OUT} = 300mA**

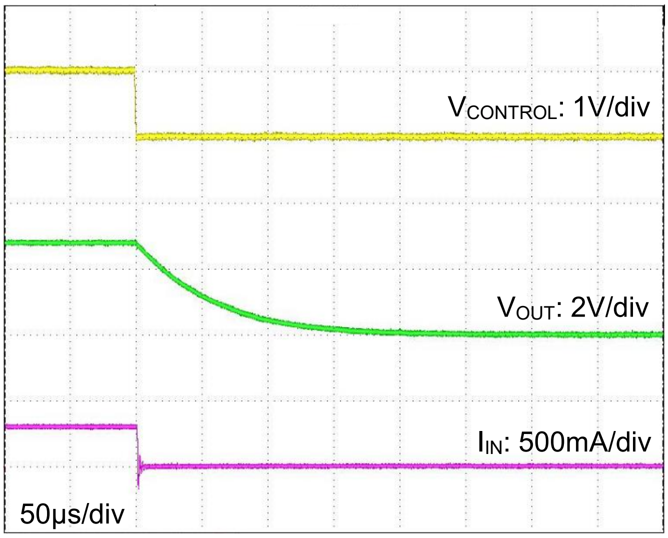
V_{OUT} = 1.2V





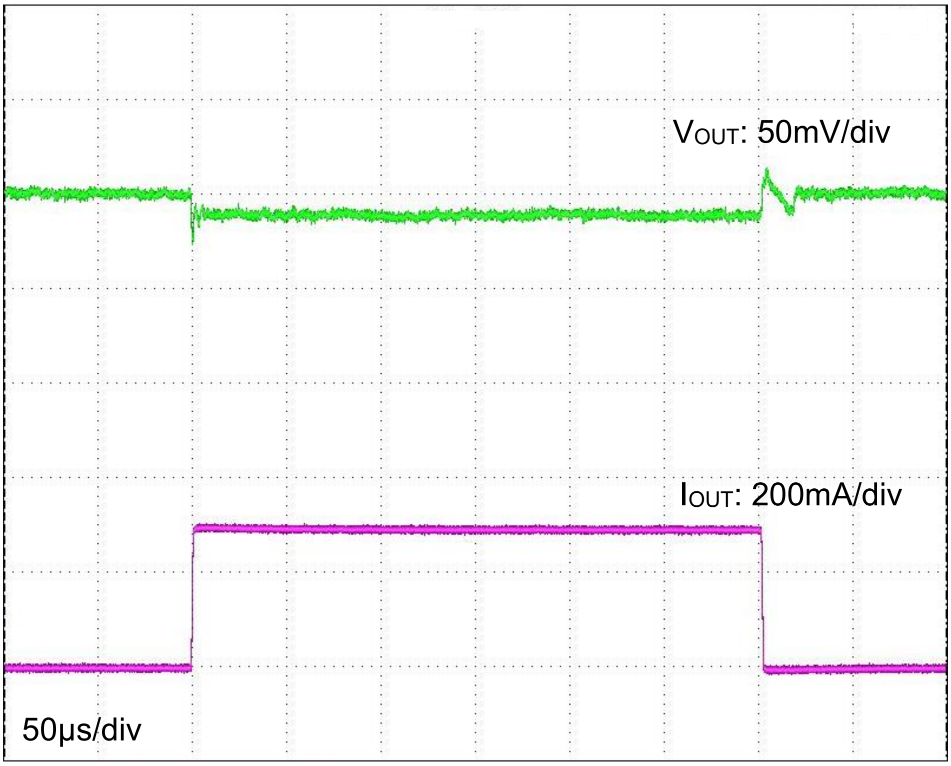
V_{OUT} = 2.8V



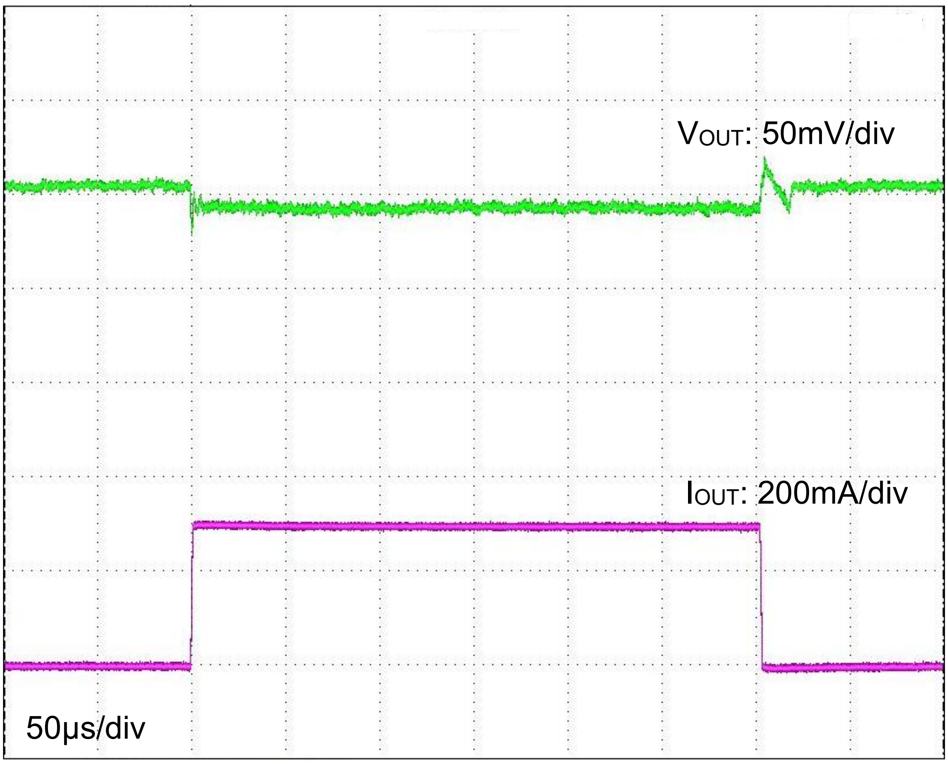


10.8. **Load Transient Response**
(C_{IN} = 1μF, C_{OUT} = 1μF, V_{IN} = V_{OUT} + 1V, I_{OUT} = 1mA↔300mA, t_r = 1μs, t_f = 1μs, Ta = 25°C)

V_{OUT} = 1.2V



V_{OUT} = 2.8V

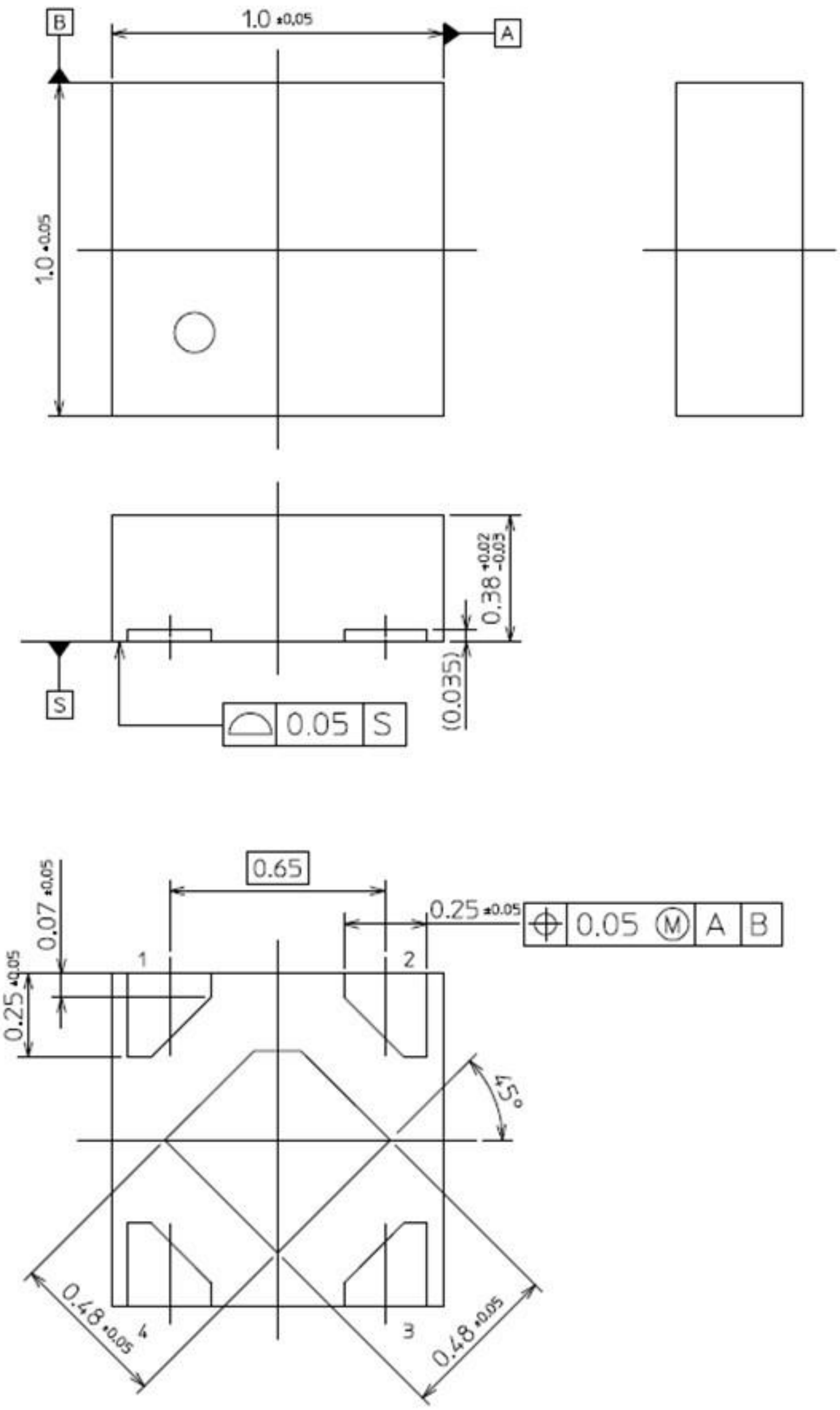


The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

11. Package Information

11.1. DFN4C

Unit : mm



Weight : 0.93 mg (typ.)

Figure 11.1 Package Dimensions

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