TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

TCR1HF Series

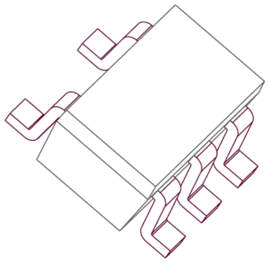
High voltage, Low quiescent current, Fast load transient CMOS Linear Regulator

1. Description

TCR1HF series are CMOS general-purpose single-output voltage regulators low quiescent current, high response load transient, an on/off control input.

These voltage regulators are available in fixed output voltages between 1.8 V and 5.0 V and capable of driving up to 150 mA. They feature Overcurrent protection and Thermal shutdown.

The TCR1HFxx series is offered in the standard small plastic mold package SMV (2.9 mm x 2.8 mm x 1.1 mm (Typ.)).



SMV

Weight: SMV (SOT-25) (SC-74A) : 16 mg (Typ.)

2. Applications

Power supply applications for mobile devices and home appliances that require low standby power with high voltage input

3. Features

- High input voltage 40 V (Absolute Maximum ratings), 4 V to 36 V (Operation input voltage)
- Low quiescent current I_{BON}: 1 μA (Typ.) @ I_{OUT} = 0 mA
- High response load transient

  -60 mV / +50 mV @ 3.3 V output, I_{OUT} = 0 mA ↔ 10 mA
- Wide range output voltage line up (V_{OUT} = 1.8 V to 5.0 V)
- High accuracy output voltage ± 1 % (Ta = 25 °C)
- Overcurrent protection
- Thermal shutdown
- In rush current reduction
- Pull up connection between CONTROL and VIN
- Ceramic capacitors can be used
- General package SMV (SOT-25) (2.8 mm x 2.9 mm x 1.1 mm)

Start of commercial production
2023-02

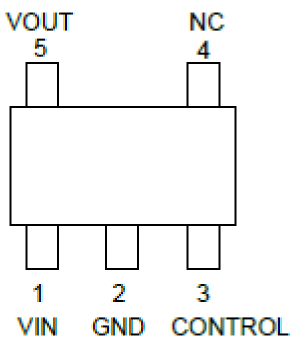
4. Absolute Maximum Ratings (Note) (Ta = 25 °C)

Characteristics	Symbol	Rating	Unit
Input voltage	V_{IN}	-0.3 to 40	V
Control voltage	V_{CT}	-0.3 to 40	V
Output voltage	V_{OUT}	-0.3 to 6	V
Output current	I_{OUT}	150	mA
Power dissipation	P_D	200 (Note1)	mW
		580 (Note2)	
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: Unit Rating
Note 2: Rating at mounting on a board
(FR4 board: 25.4 mm x 25.4 mm x 1.6 mm)

5. Pin Assignment (Top view)



Start of commercial production
2023-01

6. Operating Ranges

Characteristics	Symbol	Rating		Unit
Input voltage	V_{IN}	V_{OUT} ≤ 3.3 V	4.0 to 36.0 (Note 2)	V
		V_{OUT} > 3.3 V	V_{OUT} +1 to 36.0 (Note 2)	V
Control voltage	V_{CT}	0 to V_{IN}		V
Output voltage	V_{OUT}	1.8 to 5.0		V
Output current	I_{OUT}	DC	150 (Note 3)	mA
Operation Temperature	T_{opr}	-40 to 125		°C
Output Capacitance	C_{OUT}	≥ 0.47		μF

Note 2: Please refer to Dropout Voltage table(Page 5) and use it within Absolute Maximum Ratings Junction temperature and Operation Temperature Ranges

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Note 3: There is possibility for significant negative affect for reliability, if this product used long time on the state includes limit or very close condition on Operating ranges.

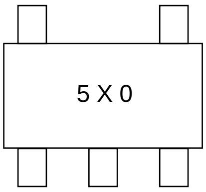
7. List of Products Number, Output voltage and Marking

Product No.	Output voltage(V)	Auto Discharge	Marking
TCR1HF18B	1.8	—	1X8
TCR1HF25B*	2.5		2X5
TCR1HF28B*	2.8		2X8
TCR1HF30B*	3.0		3X0
TCR1HF31B*	3.1		3X1
TCR1HF32B*	3.2		3X2
TCR1HF33B	3.3		3X3
TCR1HF50B	5.0		5X0

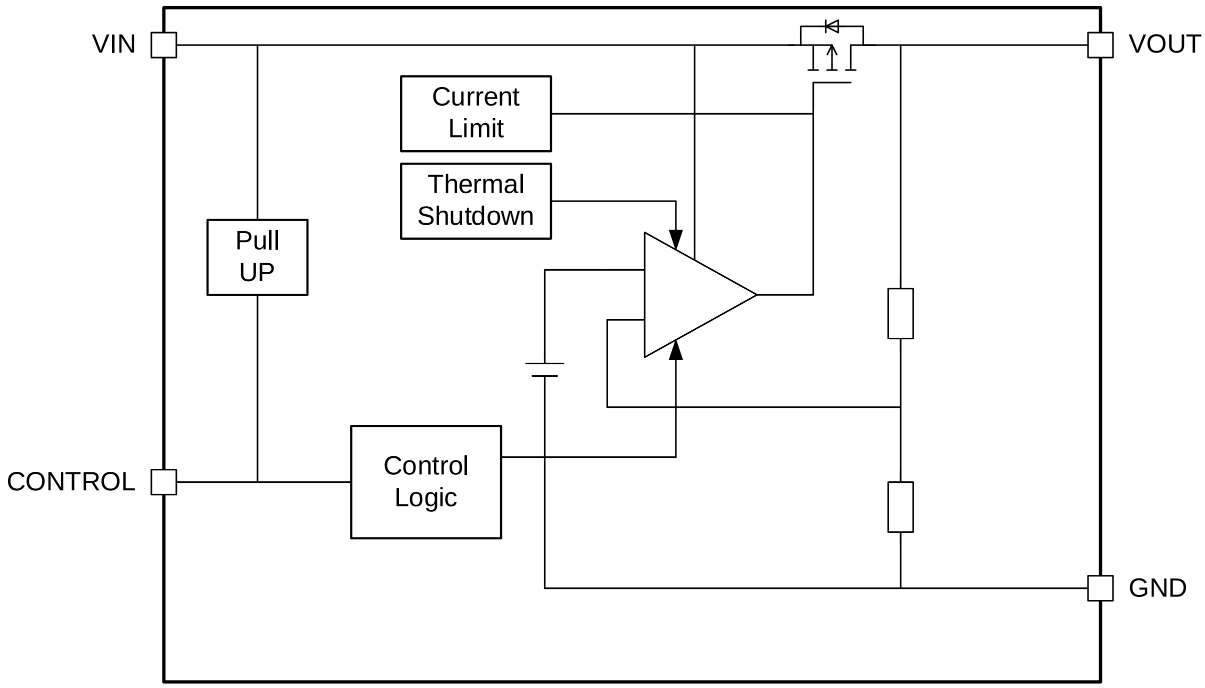
Please ask your local retailer about the devices with (*) or other output voltages.

Marking (Top view)

Example: TCR1HF50B (5.0 V output,)



Block Diagram



8. Electrical Characteristics

(Unless otherwise specified, V_{IN} = 24 V, I_{OUT} = 20 mA, C_{IN} = C_{OUT} = 0.47 μF)

Characteristics	Symbol	Test Condition	T_j = 25°C			T_j = -40 to 125°C (Note 8)		Unit
			Min	Typ.	Max	Min	Max	
Output voltage accuracy	V_{OUT}	I_{OUT} = 10 mA (Note 4)	-1.0	—	+1.0	-3.5	2.0	%
Input Voltage Range	V_{IN}	I_{OUT} = 1 mA, V_{OUT} ≤ 3.3 V	4	—	36	4	36	V
		I_{OUT} = 1 mA, V_{OUT} > 3.3 V	V_{OUT} + 1	—	36	V_{OUT} + 1	36	V
Line regulation	Reg·line	I_{OUT} = 1 mA (Note 5)	—	0	—	—	—	mV
Load regulation	Reg·load	0 mA ≤ I_{OUT} ≤ 40 mA (Note 6)	—	3.5	—	—	—	mV
Quiescent current	I_{BON}	I_{OUT} = 0 mA	—	1	1.4	—	1.6	μA
Stand-by current	$I_{B(OFF1)}$	V_{CT} = 0 V, V_{IN} = 4 V	—	0.24	0.39	—	0.45	μA
	$I_{B(OFF2)}$	V_{CT} = 0 V, V_{IN} = 24 V	—	0.27	0.42	—	0.48	μA
Control pull down current	I_{CT}	—	—	60	—	—	—	nA
Drop-out voltage	V_{DO}	I_{OUT} = 150 mA, V_{OUT} = 1.8 V	—	760	—	—	1060	mV
		V_{OUT} = 2.5 V	—	670	—	—	920	mV
		V_{OUT} = 2.8 V	—	580	—	—	855	mV
		V_{OUT} = 3.0 V	—	535	—	—	820	mV
		V_{OUT} = 3.1 V	—	520	—	—	790	mV
		V_{OUT} = 3.2 V	—	520	—	—	780	mV
		V_{OUT} = 3.3 V	—	510	—	—	760	mV
		V_{OUT} = 5.0 V	—	415	—	—	660	mV
Output current limit	ICL	V_{OUT} = V_{OUT}(NOM) * 90 % ,	300	—	—	200	—	mA
Output noise voltage	V_{NO}	I_{OUT} = 10 mA, 10 Hz ≤ f ≤ 100 kHz, Ta = 25 °C (Note 6)	—	100	—	—	—	$μV_{rms}$
Ripple rejection ratio	R.R.	V_{IN} = 4 V, I_{OUT} = 10 mA, f = 1 kHz, V_{IN}_Ripple = 100 mV p-p, Ta = 25 °C (Note 6)	—	60	—	—	—	dB
Output voltage slew rate	V_{OUTSR}	—	—	10	—	—	—	mV / μs
Load transient response	$ΔV_{OUT}$	I_{OUT} = 0 mA → 10 mA, 1 μs, C_{OUT} = 1 μF (Note 7)	—	-60	—	—	—	mV
		I_{OUT} = 10 mA → 0 mA, 1 μs, C_{OUT} = 1 μF (Note 7)	—	+50	—	—	—	mV
Control pin threshold voltage	$V_{CT(ON)}$	—	0.9	—	V_{IN}	1.0	V_{IN}	V
	$V_{CT(OFF)}$	—	0	—	0.47	0	0.4	V
Thermal shutdown threshold	T_{SDH}	T_j rising	—	155	—	—	—	°C
	T_{SDL}	T_j falling	—	145	—	—	—	°C

Note 4: stable state with fixed I_{OUT} condition

Note 5: 4 V ≤ V_{IN} ≤ 24 V (V_{OUT} ≤ 3.3 V)
V_{OUT} +1V ≤ V_{IN} ≤ 24 V (V_{OUT} > 3.3V)

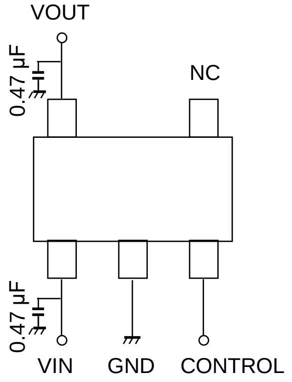
Note 6: V_{OUT} = 3.3 V

Note 7: V_{IN} = 4.0 V (V_{OUT} ≤ 3.3 V)
V_{IN} = V_{OUT} + 1 V (V_{OUT} > 3.3V)

Note 8: This parameter is warranted by design.

9. Application note

9.1. Recommended Application Circuit



CONTROL voltage	Output voltage
HIGH	ON
LOW	OFF
OPEN	ON

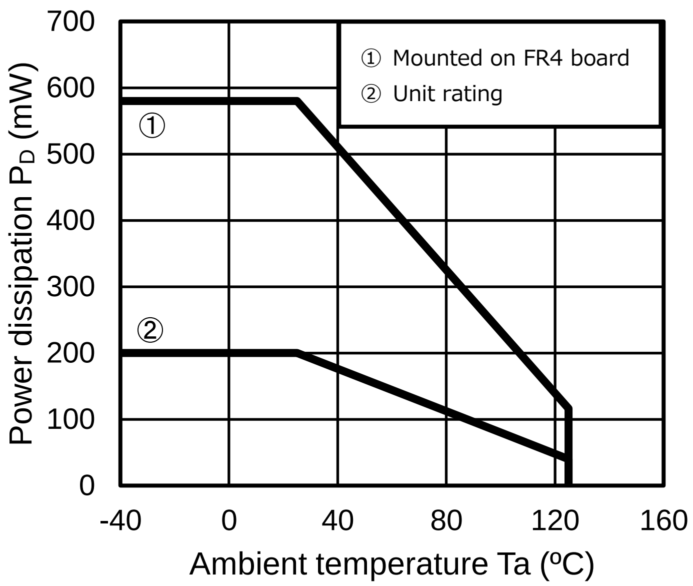
The figure above shows the recommended configuration for using this devise. Insert a capacitor at VOUT and VIN pins for stable input / output operation. (Ceramic capacitors can be used).

9.2. Power Dissipation

Both unit and board-mounted power dissipation ratings for TCR1HF series are available in the Absolute Maximum Ratings table.
Power dissipation is measured on the board shown below.

Board conditions

*Board material: FR4 board
Board dimension: 25.4 mm × 25.4 mm × 1.6 mm
Copper area: 645 mm^2



9.3. About VOUT output immediately after VIN is applied

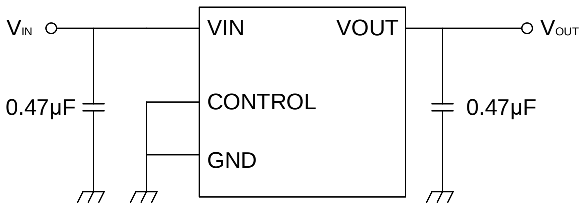
Depending on the VIN voltage and application speed, VOUT voltage may occur due to leakage current from VIN to VOUT even when CONTROL = L.

If VOUT voltage occurs and becomes a problem, it is necessary to take countermeasures such as changing the C_{OUT} capacitance or changing the power supply start-up speed.

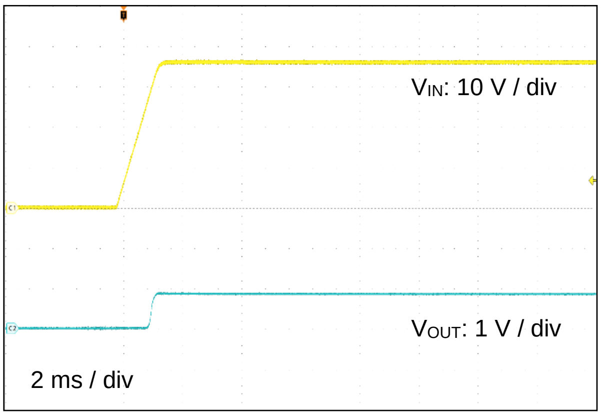
Is required. Make sure that there are no problems by performing thorough evaluations, including the temperature characteristics, in an actual application.

Make sure that there are no problems by performing thorough evaluations, including the temperature characteristics, in an actual application.

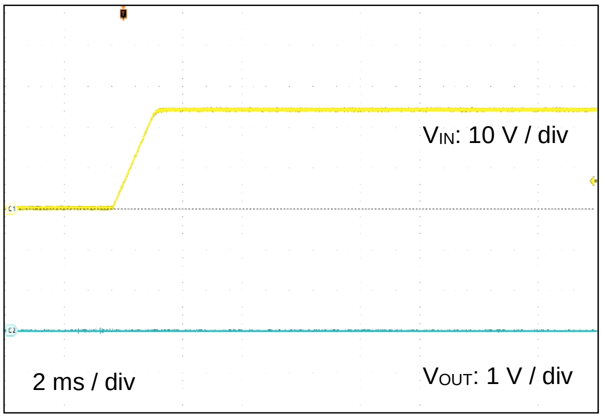
Example of VOUT output immediately after applying VIN



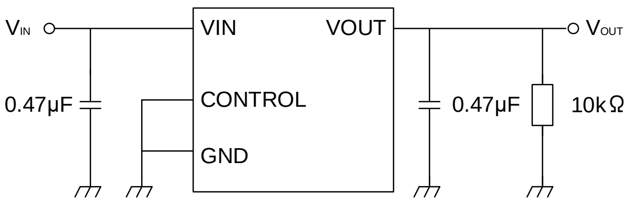
TCR1HF33B, V_{IN} = 0 V to 36 V, No Load



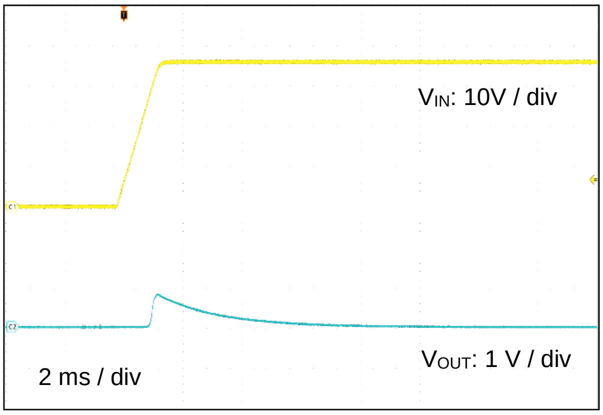
TCR1HF33B, V_{IN} = 0 V to 24 V, No Load



In addition, when V_{IN} is changing, a leak current occurs and V_{OUT} is output.
Therefore, if the output is loaded, the VOUT voltage will drop. (1 MΩ, etc.)



TCR1HF33B, V_{IN} = 0 V to 36 V, No Load



9.4. Attention in Use

- Input/Output capacitors
  Ceramic capacitors can be used with the IC, however some type capacitors may have very large temperature dependence. Please consider usage environment condition carefully to select the capacitors. Toshiba recommends under 10 ohm ESR capacitors.
  Please use over 0.47 μF capacitor as C_{OUT} for stable operation. If without any capacitors attached to C_{OUT}, there is a possibility to destroy or have a significant adverse effect on the IC.
  The input capacitor C_{IN} is not always required for stable operation of this device, however Toshiba recommends over 0.1 μF capacitor to improve the characteristics.

  There is a possibility to generate some voltage on V_{OUT} in case V_{IN} rises from 0 V even in the state CONTROL = L.
  In such case on the products without discharge function, the voltage is on V_{OUT} until the consumption current is generated to the outside load.

  Additionally, if the V_{IN} is rapidly fluctuating the V_{OUT} possibly to fluctuate transiently, regardless whether this device is stopped or operating.
  In such case please confirm that there are no problems with sufficient evaluation includes temperature dependence in actual applications,
  using bigger C_{IN} to suppress the changing value on V_{IN} rising, or using bigger C_{OUT} to suppress the V_{OUT} fluctuation.

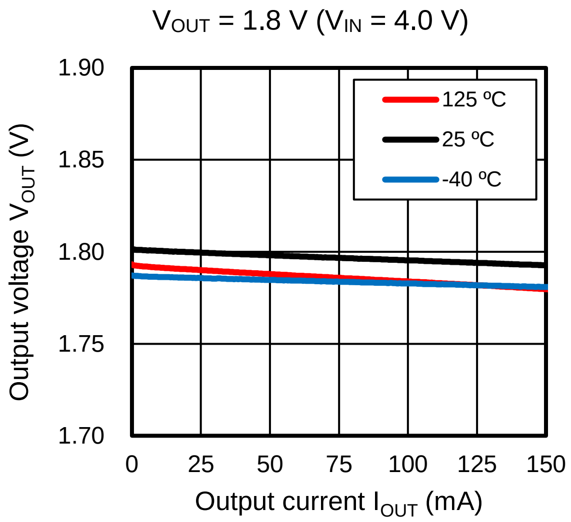
- Mounting
  The long distance between IC and output capacitor might affect phase assurance by impedance in wire and inductor. For stable power supply, output capacitor need to mount near IC as much as possible. Also VIN and GND pattern need to be large and make the wire impedance small as possible.

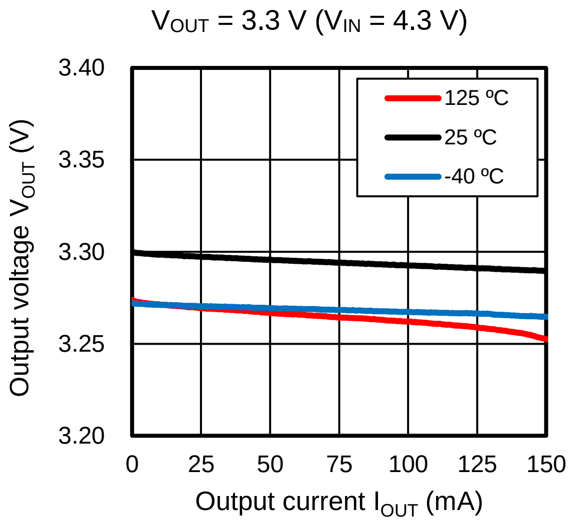
- Permissible Loss
  Please have enough design patterns for expected maximum permissible loss. And under consideration of surrounding temperature, input voltage, and output current etc., we recommend proper dissipation ratings for maximum permissible loss; in general maximum dissipation rating is 70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

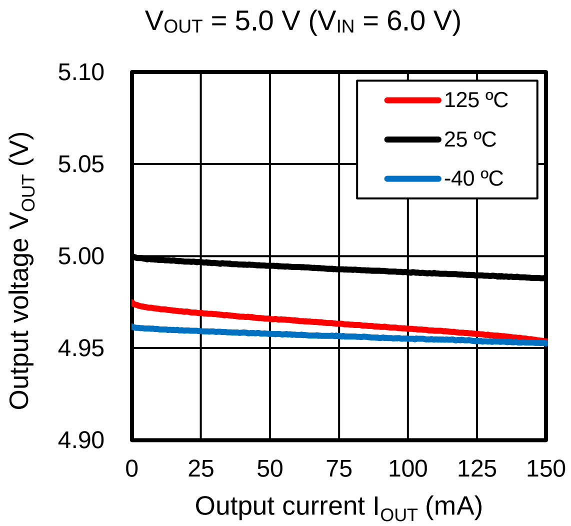
- Over current Protection and Thermal shut down function
  Over current protection and Thermal shut down function are designed in these products, but these are not designed to constantly ensure the suppression of the device within operation limits. Depending on the condition during actual usage, it could 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.

10. Representative Typical Characteristics (Note)

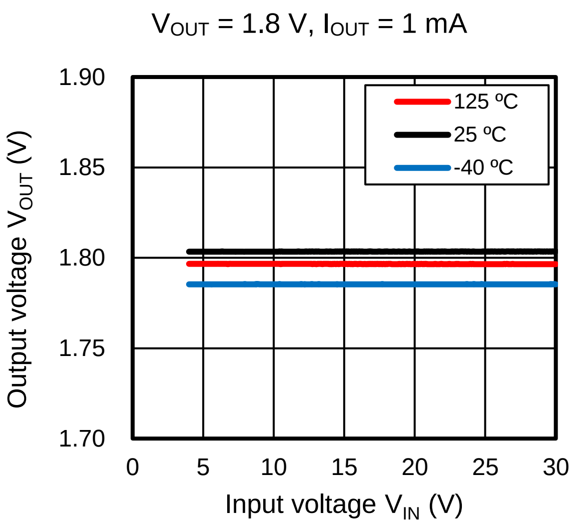
10.1. Output Voltage vs. Output Current

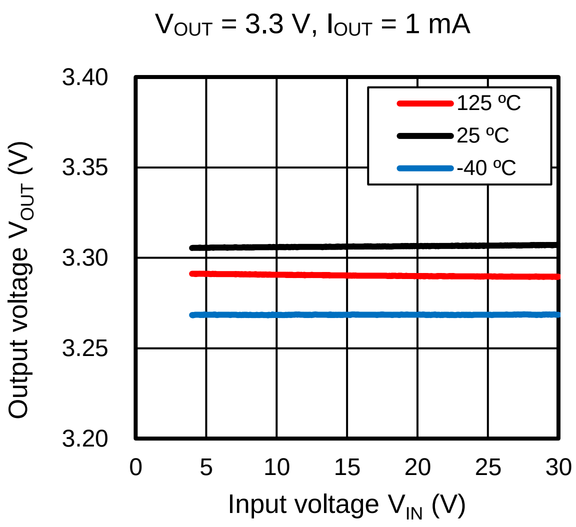


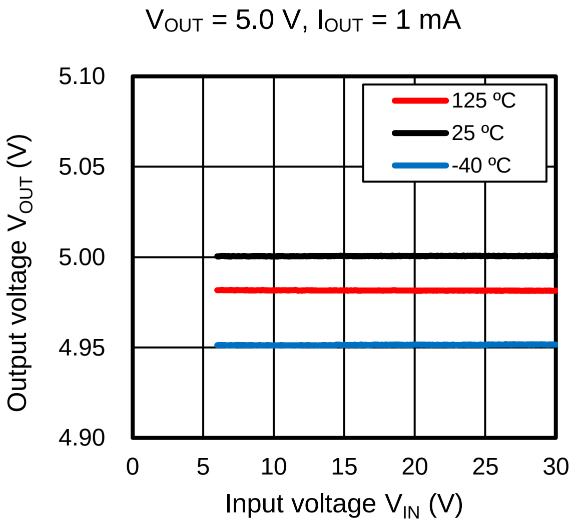




10.2. Output Voltage vs. Input Voltage

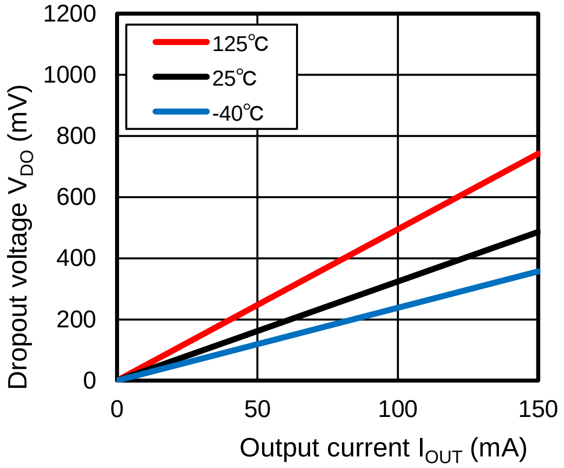




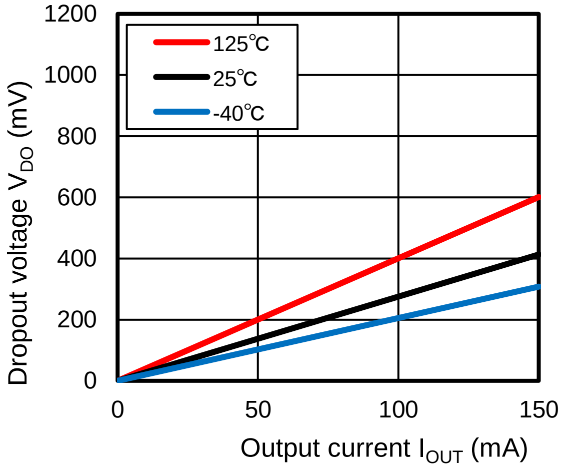


10.3. Dropout Voltage vs. Output Current

V_{OUT} = 3.3 V (V_{IN} = 4.3 V)

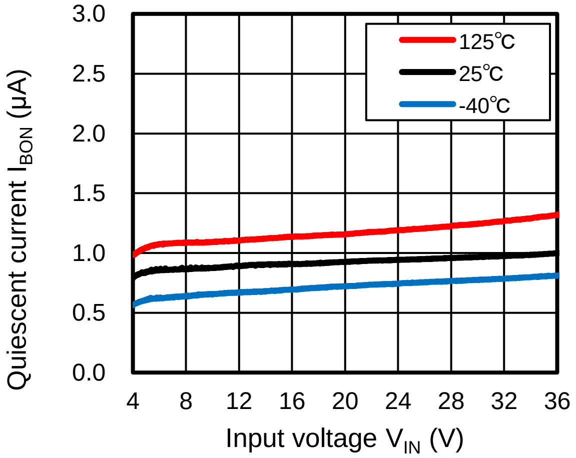


V_{OUT} = 5.0 V (V_{IN} = 6.0 V)

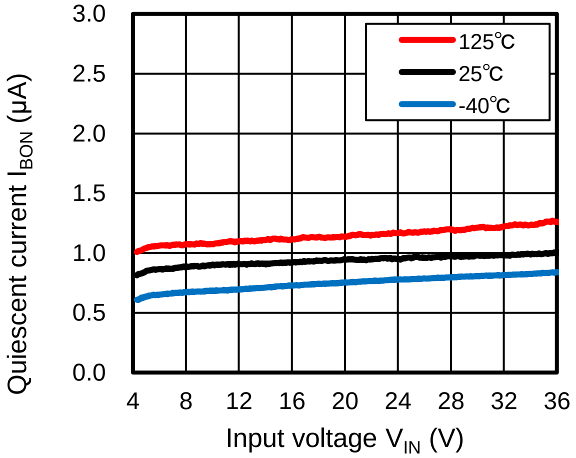


10.4. Quiescent Current vs. Input Voltage (I_{OUT} = 0 mA)

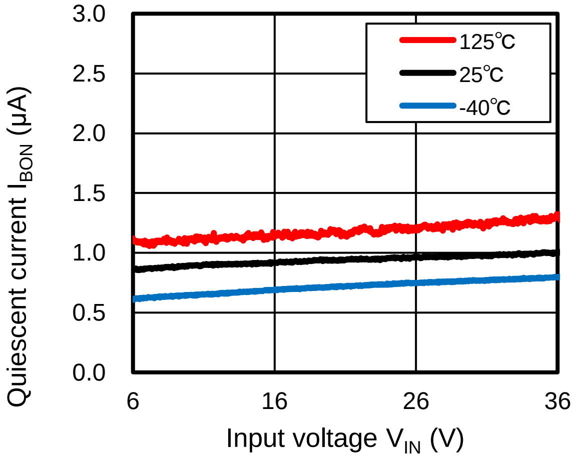
V_{OUT} = 1.8 V



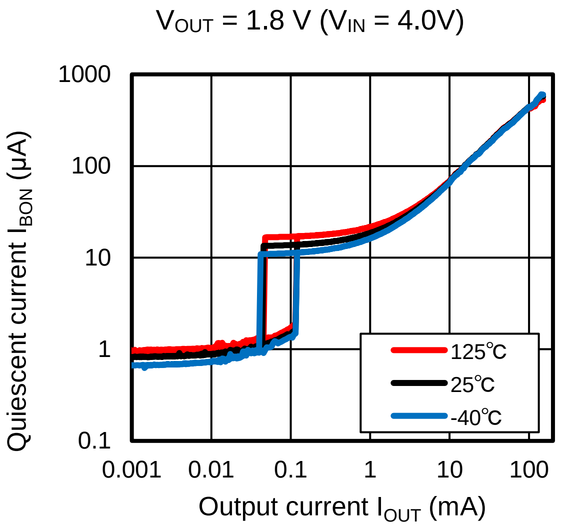
V_{OUT} = 3.3 V

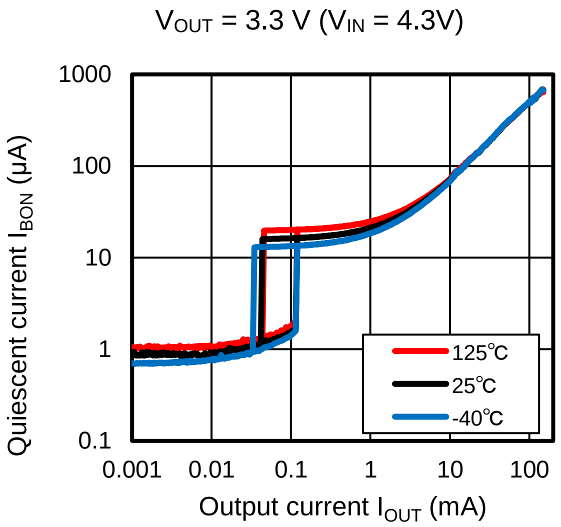


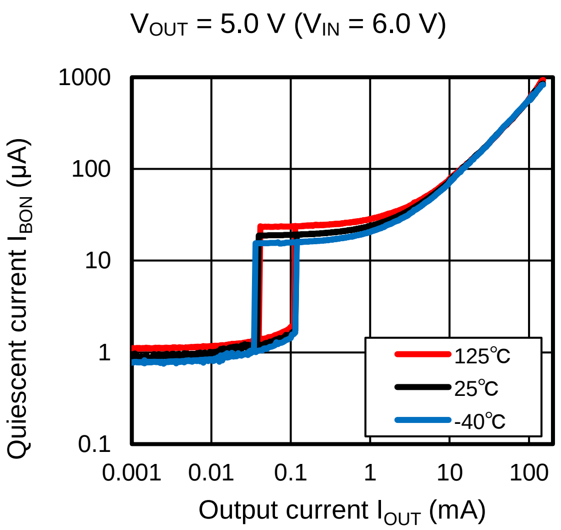
V_{OUT} = 5.0 V



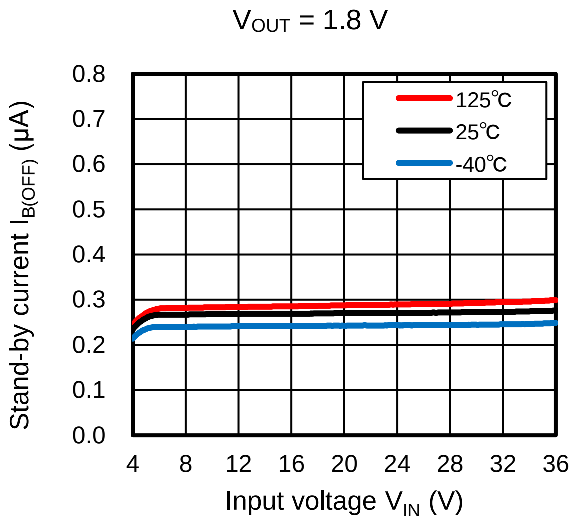
10.5. Quiescent Current vs. Output Current

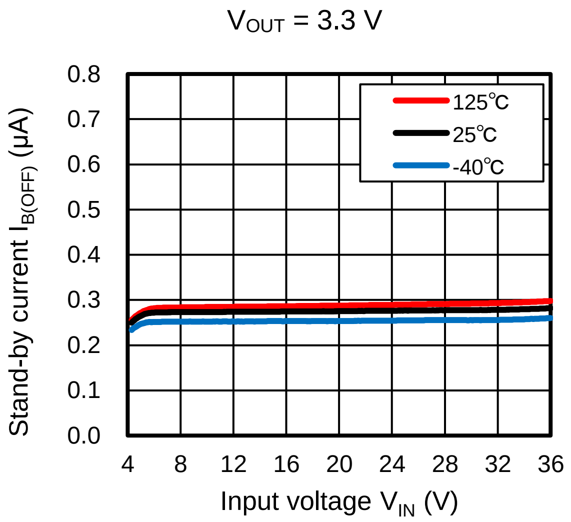


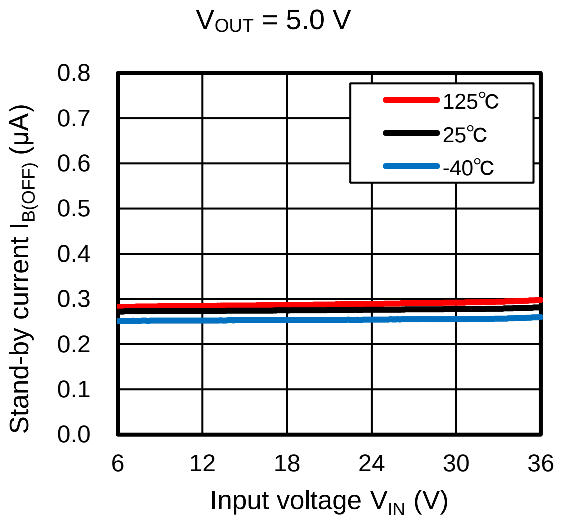




10.6. Standby Current vs. Input voltage

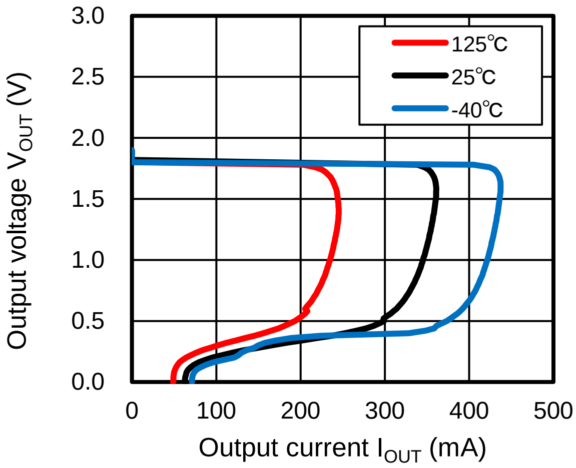




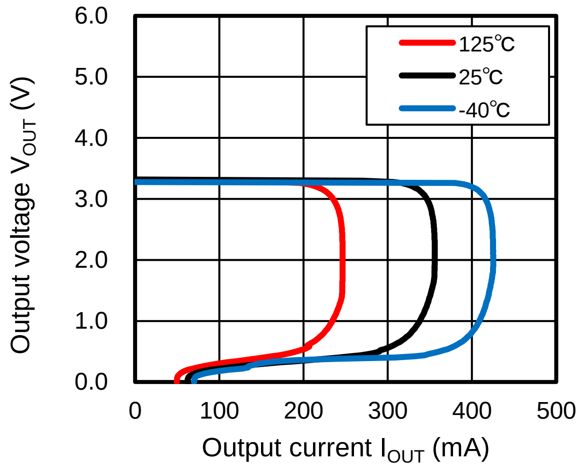


10.7. Output Current Limit

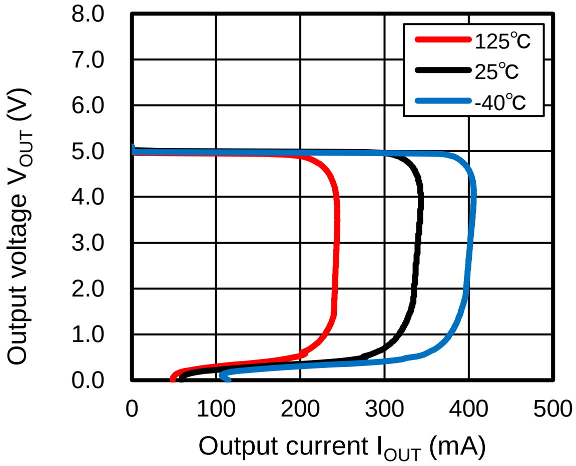
V_{OUT} = 1.8 V (V_{IN} = 4.0 V)



V_{OUT} = 3.3 V (V_{IN} = 4.3 V)

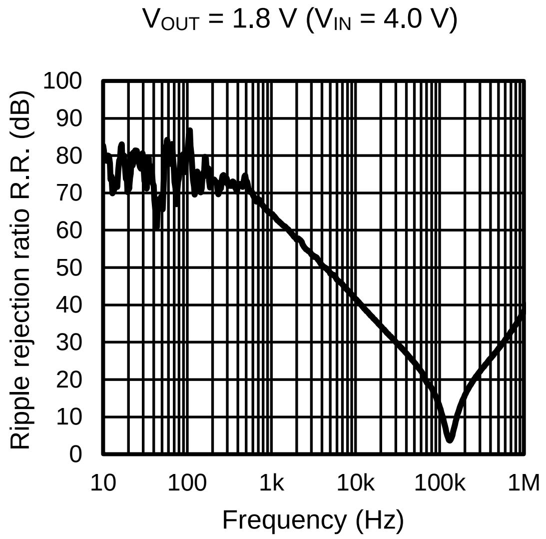


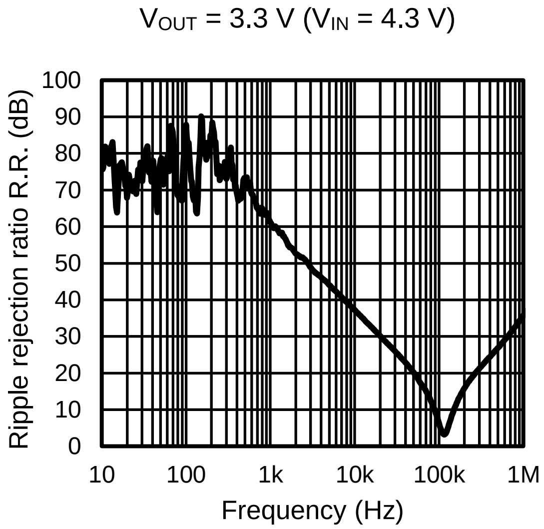
V_{OUT} = 5.0 V (V_{IN} = 6.0 V)

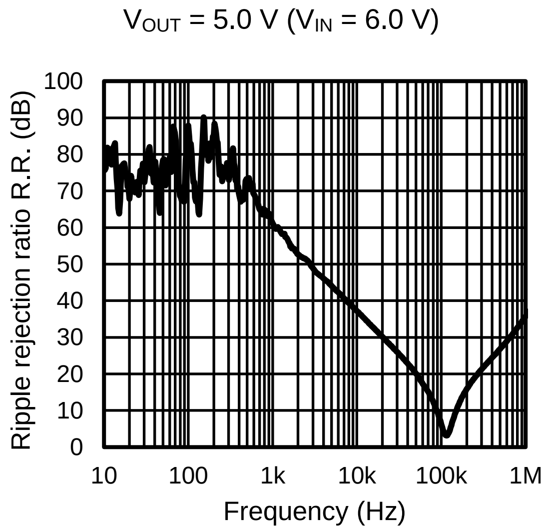


10.8. Ripple rejection Ratio vs. Frequency

(C_{IN} = none, C_{OUT} = 0.47 μF, V_{IN} Ripple = 100 mV p-p, I_{OUT} = 10 mA, Ta = 25 °C)

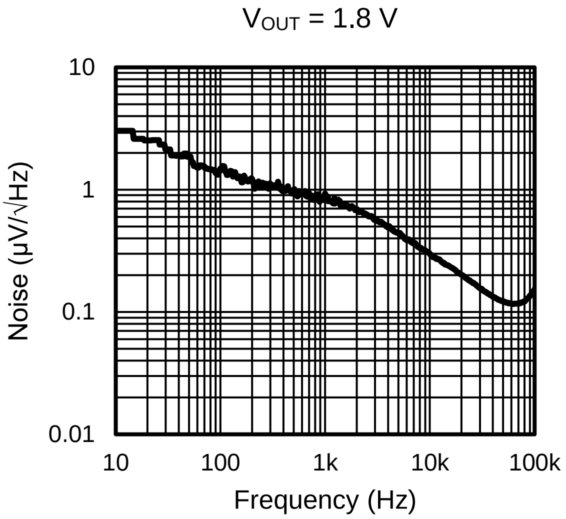


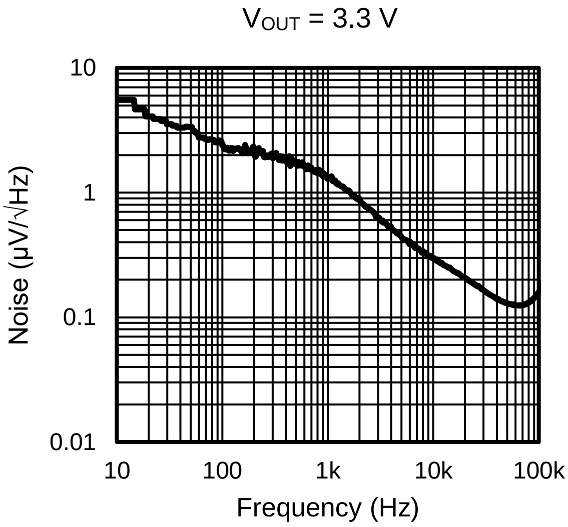


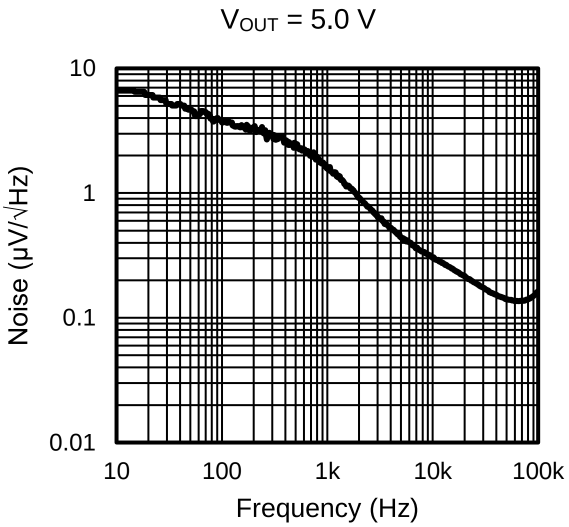


10.9. Output noise Voltage

(C_{IN} = 0.47 μF, C_{OUT} = 0.47 μF, V_{IN} = 24 V, I_{OUT} = 10 mA, Ta = 25 °C)



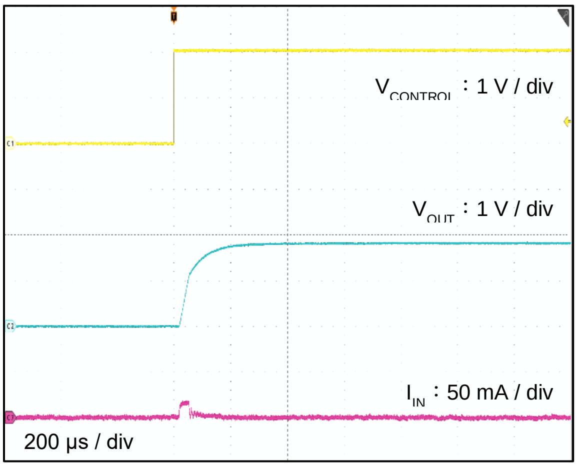




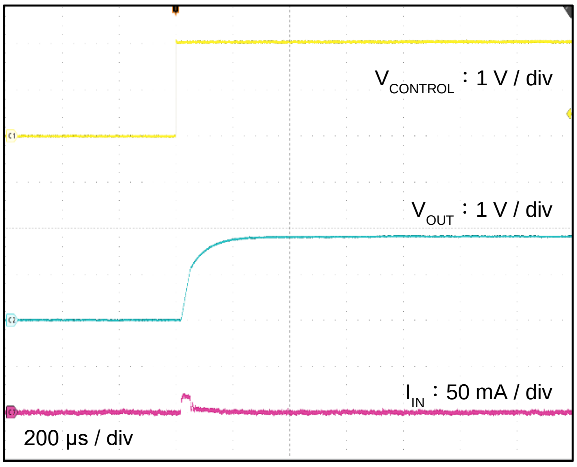
10.10. t_{ON} Response

(C_{IN} = 0.47 μF, C_{OUT} = 0.47 μF, I_{OUT} = No load, Ta = 25 °C)

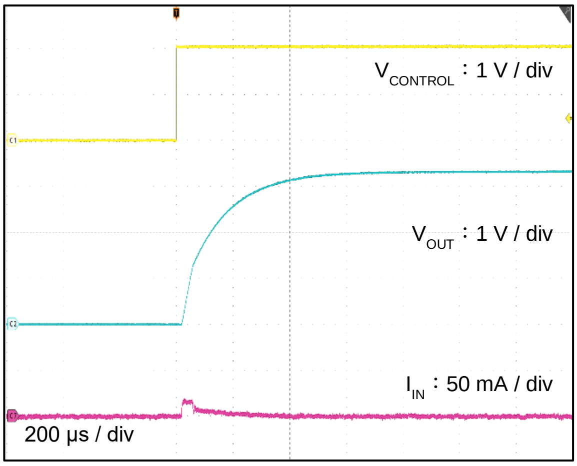
V_{OUT} = 1.8 V (V_{IN} = 4.0 V)



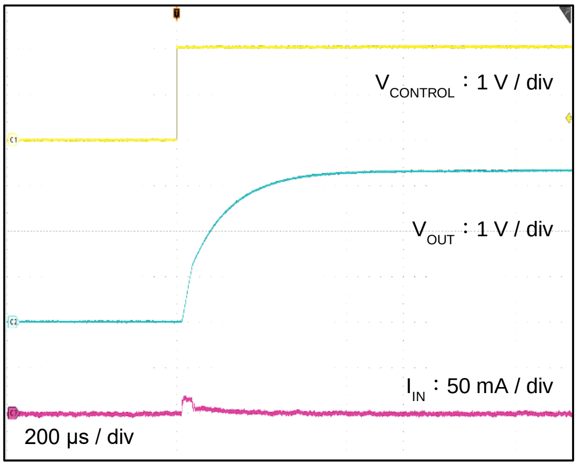
V_{OUT} = 1.8 V (V_{IN} = 24.0 V)



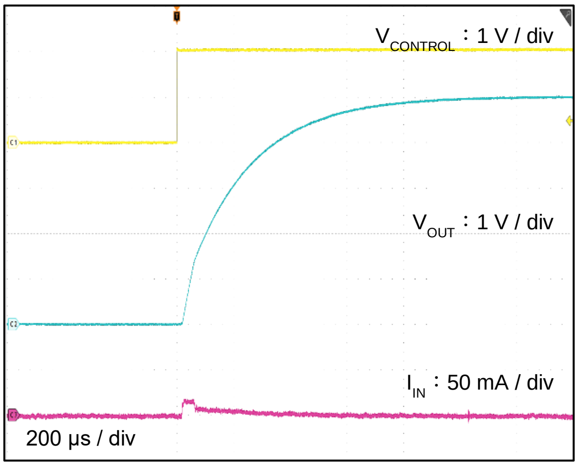
V_{OUT} = 3.3 V (V_{IN} = 4.3 V)



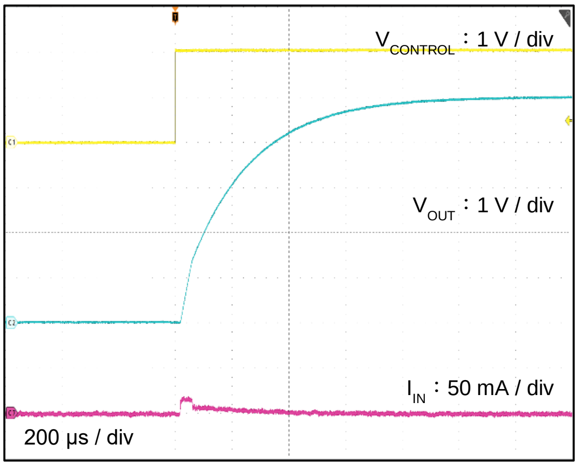
V_{OUT} = 3.3 V (V_{IN} = 24.0 V)



V_{OUT} = 5.0 V (V_{IN} = 6.0 V)



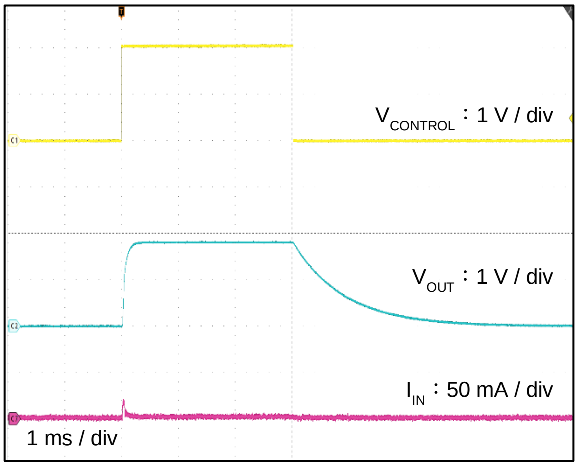
V_{OUT} = 5.0 V (V_{IN} = 24.0 V)



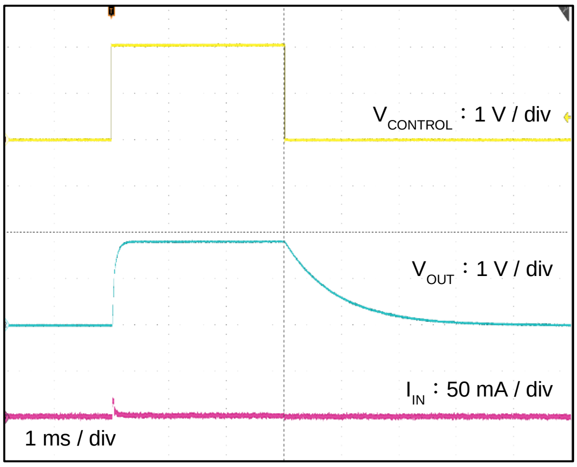
10.11. t_{ON} / t_{OFF} Response

(C_{IN} = 0.47 μF, C_{OUT} = 0.47 μF, I_{OUT} = 1 mA, Ta = 25 °C)

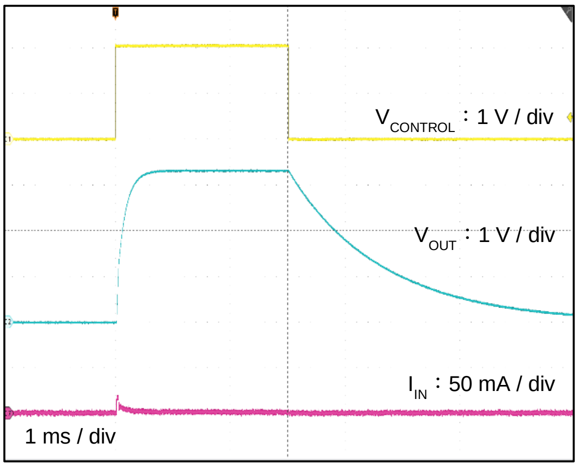
V_{OUT} = 1.8 V (V_{IN} = 4.0 V)



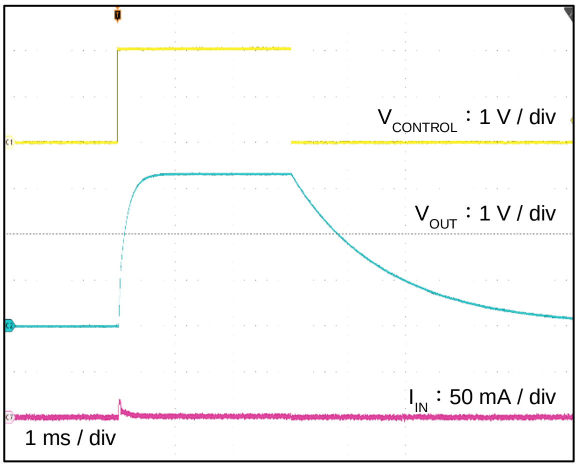
V_{OUT} = 1.8 V (V_{IN} = 24.0 V)



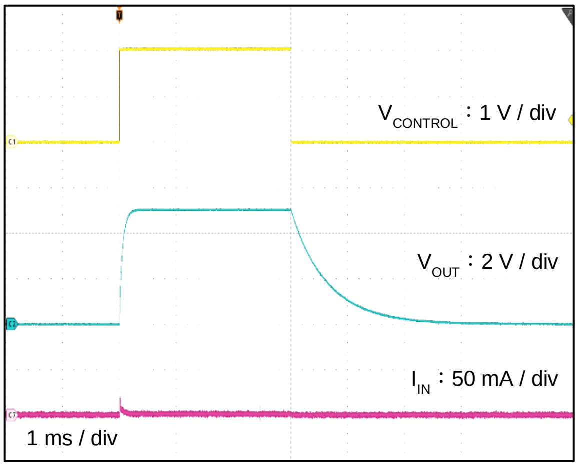
V_{OUT} = 3.3 V (V_{IN} = 4.3 V)



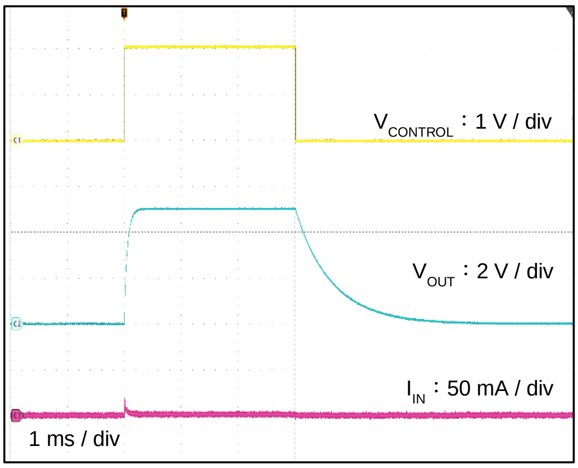
V_{OUT} = 3.3 V (V_{IN} = 24.0 V)



V_{OUT} = 5.0 V (V_{IN} = 6.0 V)



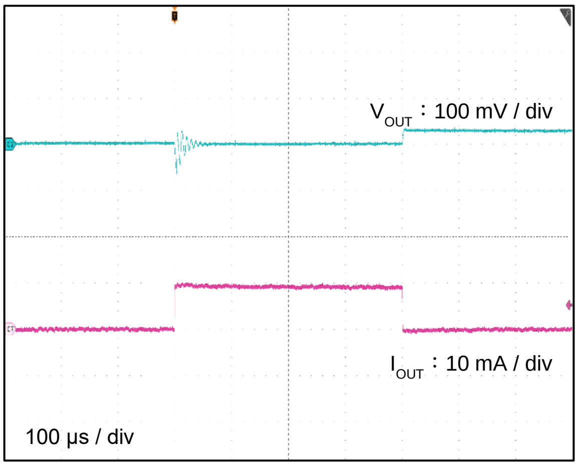
V_{OUT} = 5.0 V (V_{IN} = 24.0 V)



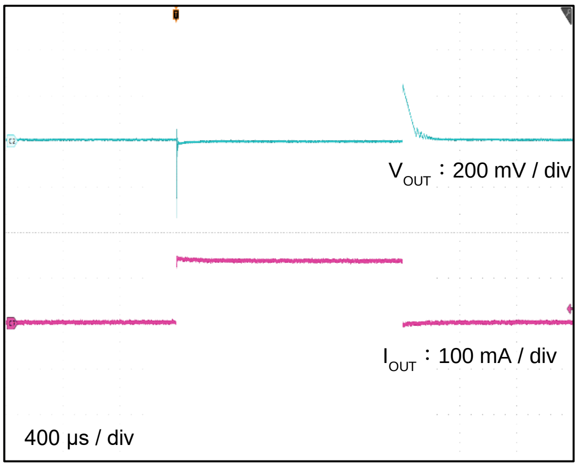
10.12. Load Transient Response

(C_{IN} = 0.47 μF, C_{OUT} = 0.47 μF, Ta = 25 °C)

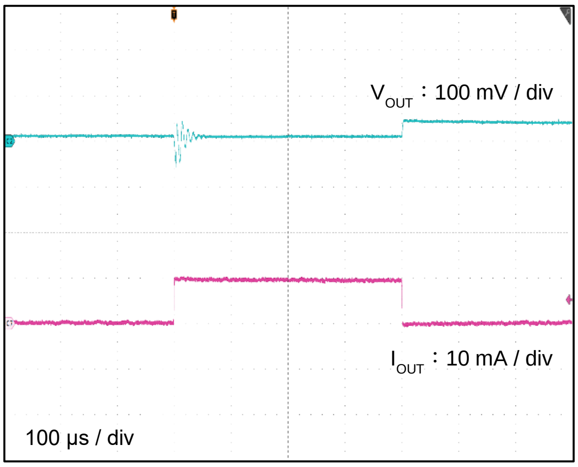
V_{OUT} = 1.8 V
(V_{IN} = 4.0 V, I_{OUT} = 0 mA ↔ 10 mA at 1 μs)



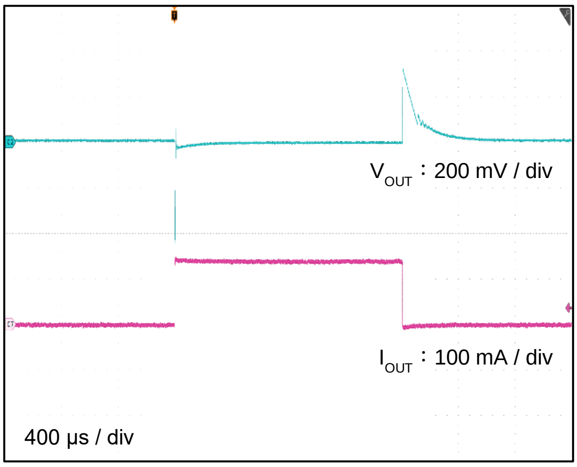
V_{OUT} = 1.8 V
(V_{IN} = 4.0 V, I_{OUT} = 1 mA ↔ 150 mA at 1 μs)



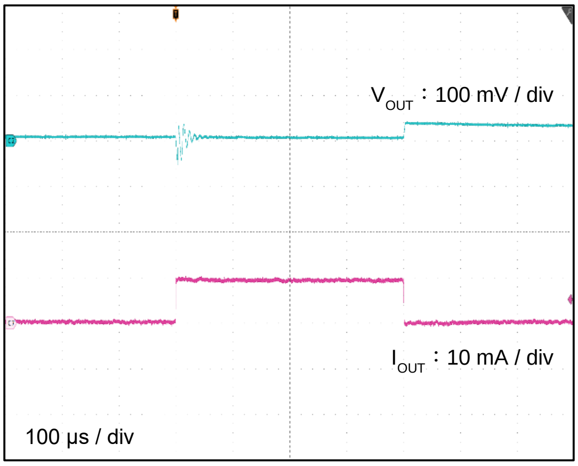
V_{OUT} = 3.3 V
(V_{IN} = 4.3 V, I_{OUT} = 0 mA ↔ 10 mA at 1 μs)



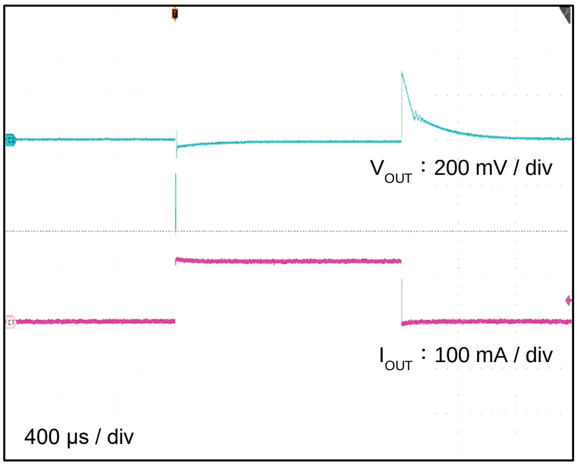
V_{OUT} = 3.3 V
(V_{IN} = 4.3 V, I_{OUT} = 1 mA ↔ 150 mA at 1 μs)



V_{OUT} = 5.0 V
(V_{IN} = 6.0 V, I_{OUT} = 0 mA ↔ 10 mA at 1 μs)



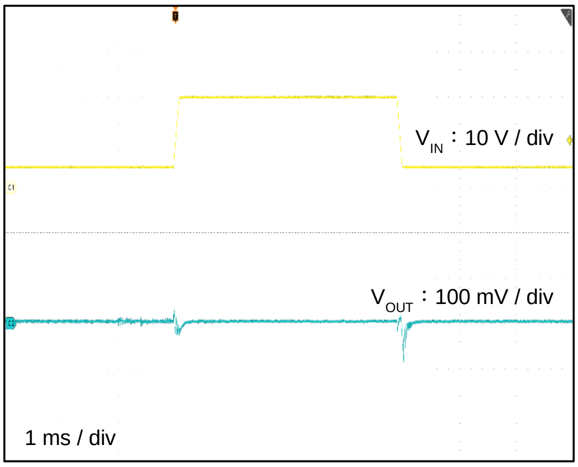
V_{OUT} = 5.0 V
(V_{IN} = 6.0 V, I_{OUT} = 1 mA ↔ 150 mA at 1 μs)



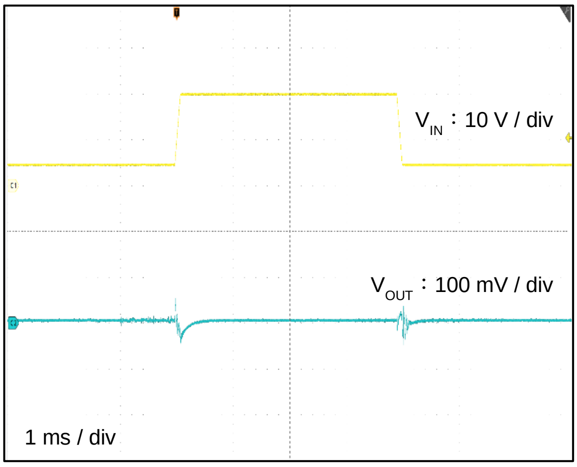
10.13. Line Transient Response

(C_{IN} = 0.47 µF, C_{OUT} = 0.47 µF, Ta = 25 °C)

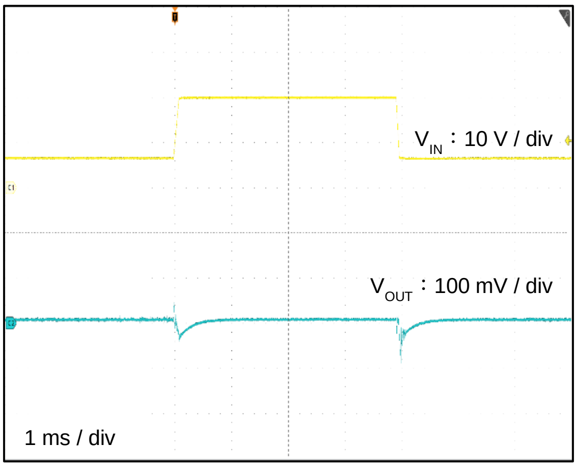
V_{OUT} = 1.8 V
(V_{IN} = 4 V ↔ 20 V), I_{OUT} = 1 mA



V_{OUT} = 3.3 V
(V_{IN} = 4.3 V ↔ 20 V), I_{OUT} = 1 mA



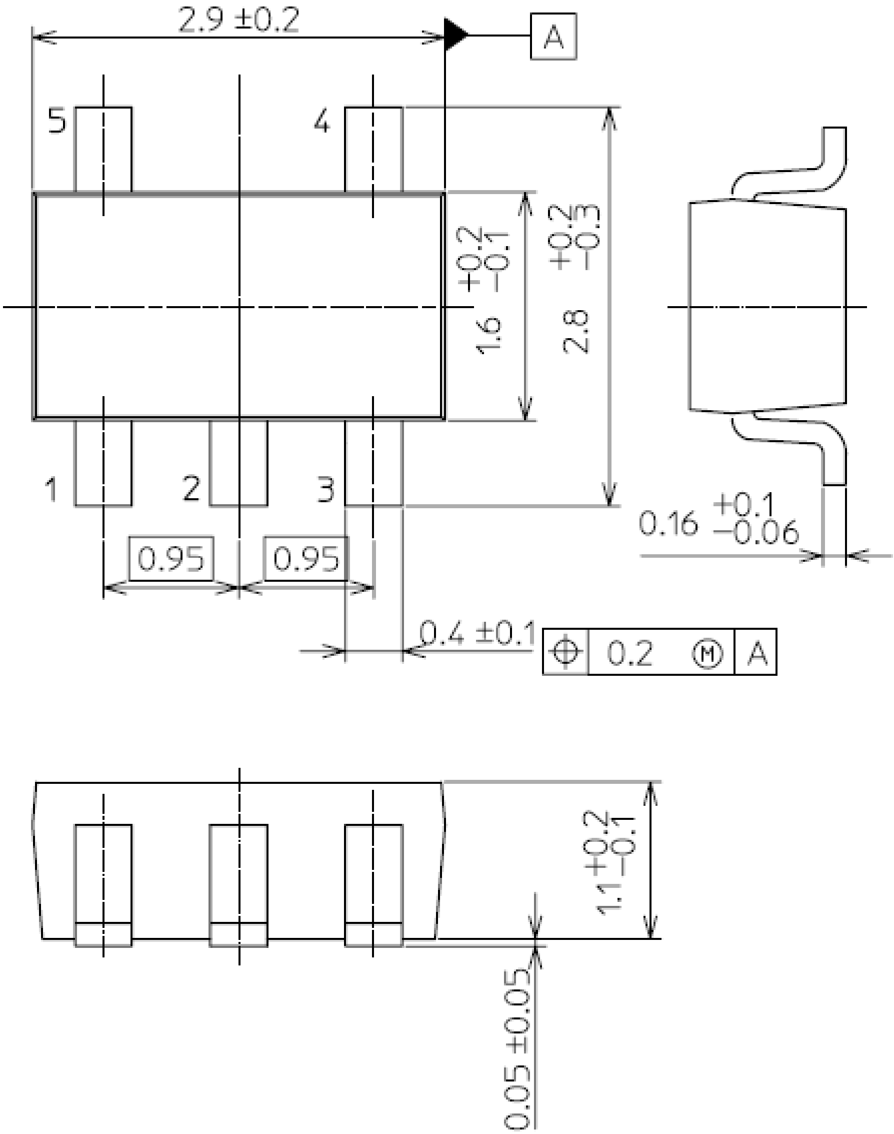
V_{OUT} = 5.0 V
(V_{IN} = 6 V ↔ 20 V), I_{OUT} = 1 mA



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

11. Package Information

SMV (SOT-25) (SC-74A) **Unit: mm**



Weight: 16 mg (Typ.)

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