

TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic

# TCR1HF Series

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

## 1. Description

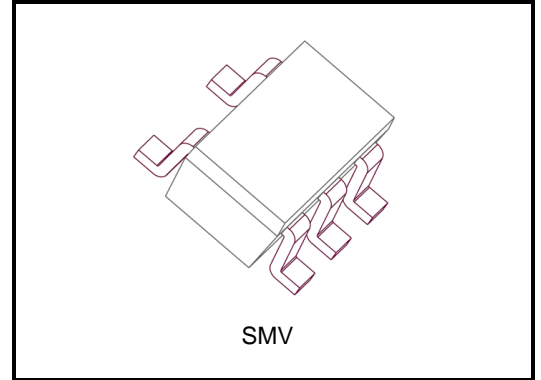
TCR1HF series are CMOS general-purpose single-output voltage regulators low quiescent current, high response load transient, an on/off control input.

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.)).

## 2. Applications

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



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

## 3. Features

- High input voltage 40 V (Absolute Maximum ratings), 4 V to 36 V (Operation input voltage)
- Low quiescent current  $I_{BON}$ : 1  $\mu$ A (Typ.) @  $I_{OUT} = 0$  mA
- High response load transient  
-60 mV / +50 mV @ 3.3 V output,  $I_{OUT} = 0$  mA  $\leftrightarrow$  10 mA
- Wide range output voltage line up ( $V_{OUT} = 1.8$  V to 5.0 V)
- High accuracy output voltage  $\pm 1$  % ( $T_a = 25$  °C)
- Overcurrent protection
- Thermal shutdown
- Inrush 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 <sub>IN</sub>	-0.3 to 40	V
Control voltage	V <sub>CT</sub>	-0.3 to 40	V
Output voltage	V <sub>OUT</sub>	-0.3 to 6	V
Output current	I <sub>OUT</sub>	150	mA
Power dissipation	P <sub>D</sub>	200 (Note1)	mW
		580 (Note2)	
Junction temperature	T <sub>j</sub>	150	°C
Storage temperature range	T <sub>stg</sub>	-55 to 150	°C

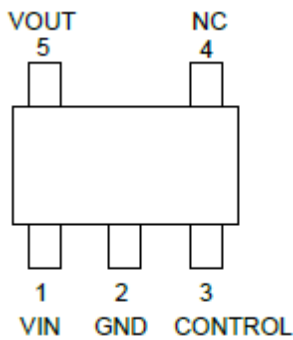
Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) 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)



### 6. Operating Ranges

Characteristics	Symbol	Rating (Note 3)		Unit
Input voltage	$V_{IN}$	$V_{OUT} \leq 3.3 \text{ V}$	4.0 to 36.0 (Note 4)	V
		$V_{OUT} > 3.3 \text{ V}$	$V_{OUT} + 1$ to 36.0 (Note 4)	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 5)	mA
Operation Temperature	$T_{opr}$	-40 to 125		°C
Output Capacitance	$C_{OUT}$	$\geq 0.47$		$\mu\text{F}$

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. Maximum output current of operating ranges table is defined as lifetime average junction temperature of 107°C where maximum output current = lifetime average current to avoid electro migration.

Note 4: Please refer to Dropout Voltage table (Page 5) and use it within Absolute Maximum Ratings Junction temperature and Operation Temperature Ranges.

Note 5: 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.

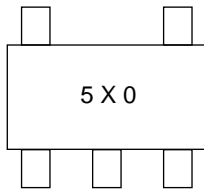
### 7. List of Products Number, Output voltage and Marking

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

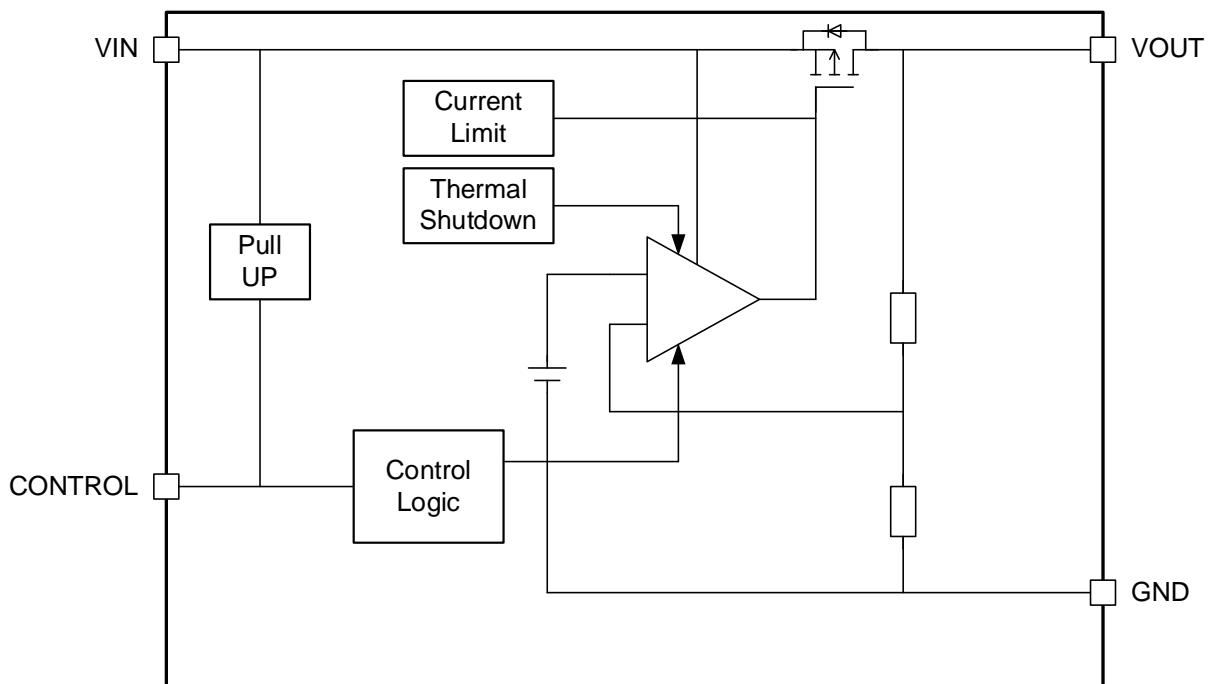
Please ask your local retailer about the devices with (\*) or other output voltages.

### Marking (Top view)

Example: TCR1HF50B (5.0 V output,)



### Block Diagram



### 8. Electrical Characteristics

(Unless otherwise specified,  $V_{IN} = 24\text{ V}$ ,  $I_{OUT} = 20\text{ mA}$ ,  $C_{IN} = C_{OUT} = 0.47\text{ }\mu\text{F}$ )

Characteristics	Symbol	Test Condition	$T_j = 25^\circ\text{C}$			$T_j = -40\text{ to }125^\circ\text{C}$ (Note 10)		Unit	
			Min	Typ.	Max	Min	Max		
Output voltage accuracy	$V_{OUT}$	$I_{OUT} = 10\text{ mA}$ (Note 6)	-1.0	—	+1.0	-3.5	2.0	%	
Input Voltage Range	$V_{IN}$	$I_{OUT} = 1\text{ mA}$ , $V_{OUT} \leq 3.3\text{ V}$	4	—	36	4	36	V	
		$I_{OUT} = 1\text{ mA}$ , $V_{OUT} > 3.3\text{ V}$	$V_{OUT} + 1$	—	36	$V_{OUT} + 1$	36	V	
Line regulation	Reg-line	$I_{OUT} = 1\text{ mA}$ (Note 7)	—	0	—	—	—	mV	
Load regulation	Reg-load	$0\text{ mA} \leq I_{OUT} \leq 40\text{ mA}$ (Note 8)	—	3.5	—	—	—	mV	
Quiescent current	$I_{BON}$	$I_{OUT} = 0\text{ mA}$	—	1	1.4	—	1.6	$\mu\text{A}$	
Stand-by current	$I_{B(OFF1)}$	$V_{CT} = 0\text{ V}$ , $V_{IN} = 4\text{ V}$	—	0.24	0.39	—	0.45	$\mu\text{A}$	
	$I_{B(OFF2)}$	$V_{CT} = 0\text{ V}$ , $V_{IN} = 24\text{ V}$	—	0.27	0.42	—	0.48	$\mu\text{A}$	
Control pull down current	$I_{CT}$	—	—	60	—	—	—	nA	
Drop-out voltage	$V_{DO}$	$I_{OUT} = 150\text{ mA}$	$V_{OUT} = 1.8\text{ V}$	—	760	—	—	1060	mV
			$V_{OUT} = 2.5\text{ V}$	—	670	—	—	920	mV
			$V_{OUT} = 2.8\text{ V}$	—	580	—	—	855	mV
			$V_{OUT} = 3.0\text{ V}$	—	535	—	—	820	mV
			$V_{OUT} = 3.1\text{ V}$	—	520	—	—	790	mV
			$V_{OUT} = 3.2\text{ V}$	—	520	—	—	780	mV
			$V_{OUT} = 3.3\text{ V}$	—	510	—	—	760	mV
			$V_{OUT} = 5.0\text{ V}$	—	415	—	—	660	mV
Output current limit	ICL	$V_{OUT} = V_{OUT(NOM)} * 90\%$ ,	300	—	—	200	—	mA	
Output noise voltage	$V_{NO}$	$I_{OUT} = 10\text{ mA}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ , $T_a = 25^\circ\text{C}$ (Note 8)	—	100	—	—	—	$\mu\text{V}_{rms}$	
Ripple rejection ratio	R.R.	$V_{IN} = 4\text{ V}$ , $I_{OUT} = 10\text{ mA}$ , $f = 1\text{ kHz}$ , $V_{IN\_Ripple} = 100\text{ mV p-p}$ , $T_a = 25^\circ\text{C}$ (Note 8)	—	60	—	—	—	dB	
Output voltage slew rate	$V_{OUTSR}$	—	—	10	—	—	—	mV / $\mu\text{s}$	
Load transient response	$\Delta V_{OUT}$	$I_{OUT} = 0\text{ mA} \rightarrow 10\text{ mA}$ , $1\text{ }\mu\text{s}$ $C_{OUT} = 1\text{ }\mu\text{F}$ (Note 9)	—	-60	—	—	—	mV	
		$I_{OUT} = 10\text{ mA} \rightarrow 0\text{ mA}$ , $1\text{ }\mu\text{s}$ $C_{OUT} = 1\text{ }\mu\text{F}$ (Note 9)	—	+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	—	—	—	$^\circ\text{C}$	
	$T_{SDL}$	$T_j$ falling	—	145	—	—	—	$^\circ\text{C}$	

Note 6: stable state with fixed  $I_{OUT}$  condition

Note 7:  $4\text{ V} \leq V_{IN} \leq 24\text{ V}$  ( $V_{OUT} \leq 3.3\text{ V}$ )

$V_{OUT} + 1\text{ V} \leq V_{IN} \leq 24\text{ V}$  ( $V_{OUT} > 3.3\text{ V}$ )

Note 8:  $V_{OUT} = 3.3\text{ V}$

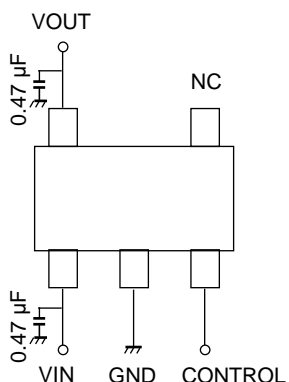
Note 9:  $V_{IN} = 4.0\text{ V}$  ( $V_{OUT} \leq 3.3\text{ V}$ )

$V_{IN} = V_{OUT} + 1\text{ V}$  ( $V_{OUT} > 3.3\text{ V}$ )

Note 10: 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 device. 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.

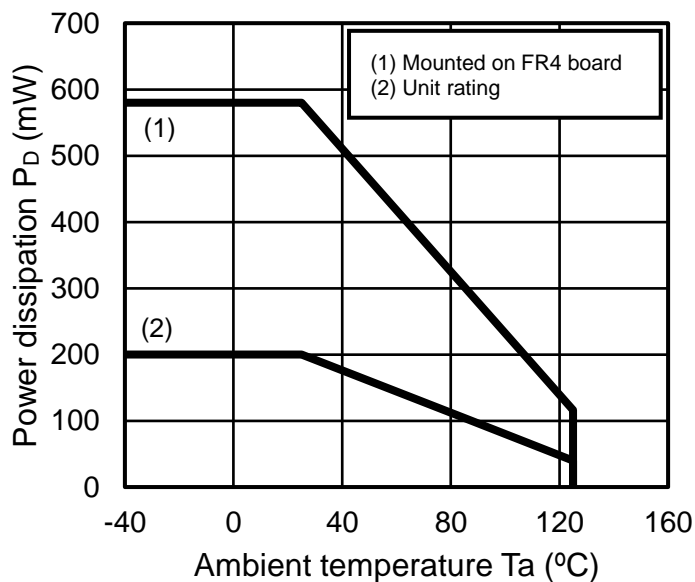
Power dissipation is measured on the board shown below.

##### Board conditions

\*Board material: FR4 board

Board dimension: 25.4 mm × 25.4 mm × 1.6 mm

Copper area: 645 mm<sup>2</sup>



### 9.3. About VOUT output immediately after VIN is applied

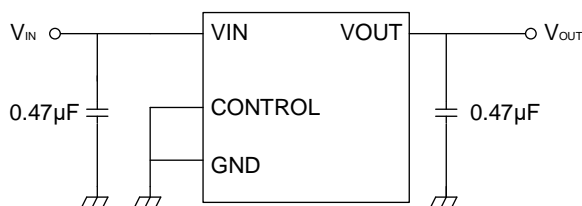
Depending on the VIN voltage and application speed, VOUT voltage may occur due to leakage current from VIN to VOUT even when CONTROL = L.

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

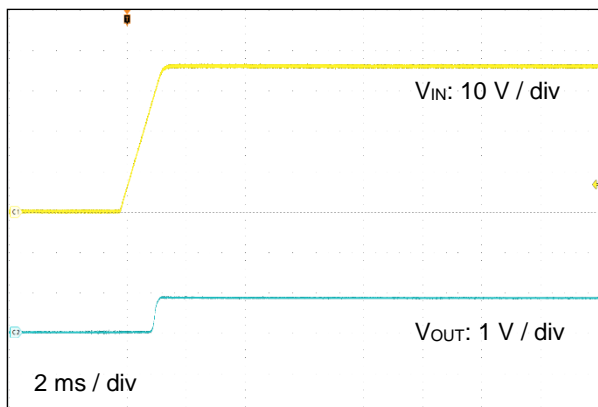
Is required. Make sure that there are no problems by performing thorough evaluations, including the temperature characteristics, in an actual application.

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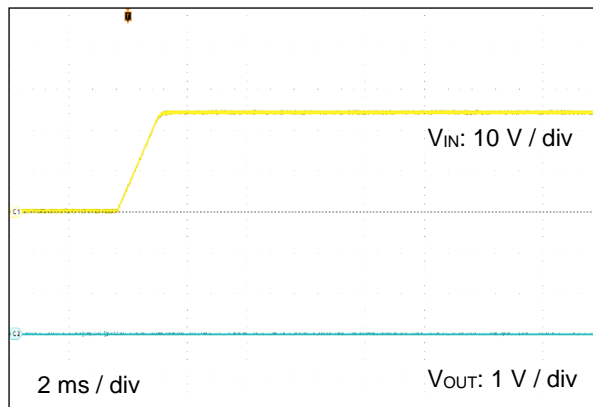
Example of VOUT output immediately after applying VIN



TCR1HF33B, VIN = 0 V to 36 V, No Load

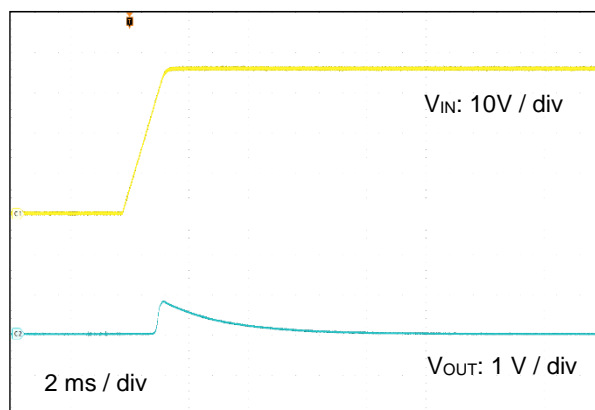
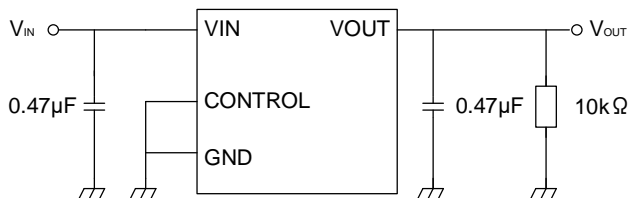


TCR1HF33B, VIN = 0 V to 24 V, No Load



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

TCR1HF33B, VIN = 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  $\mu\text{F}$  capacitor as  $C_{\text{OUT}}$  for stable operation. If without any capacitors attached to  $C_{\text{OUT}}$ , there is a possibility to destroy or have a significant adverse effect on the IC.

The input capacitor  $C_{\text{IN}}$  is not always required for stable operation of this device, however Toshiba recommends over 0.1  $\mu\text{F}$  capacitor to improve the characteristics.

There is a possibility to generate some voltage on  $V_{\text{OUT}}$  in case  $V_{\text{IN}}$  rises from 0 V even in the state  $\text{CONTROL} = \text{L}$ .

In such case on the products without discharge function, the voltage is on  $V_{\text{OUT}}$  until the consumption current is generated to the outside load.

Additionally, if the  $V_{\text{IN}}$  is rapidly fluctuating the  $V_{\text{OUT}}$  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  $C_{\text{IN}}$  to suppress the changing value on  $V_{\text{IN}}$  rising, or using bigger  $C_{\text{OUT}}$  to suppress the  $V_{\text{OUT}}$  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  $V_{\text{IN}}$  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 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 %.

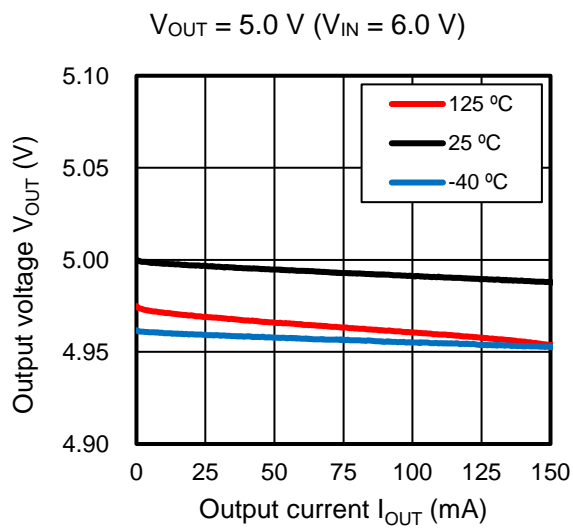
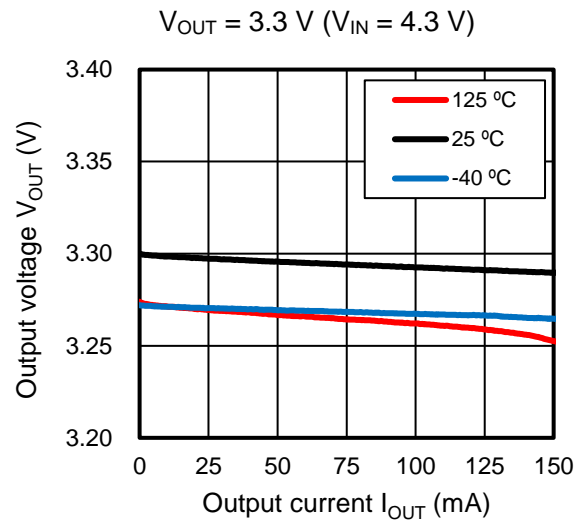
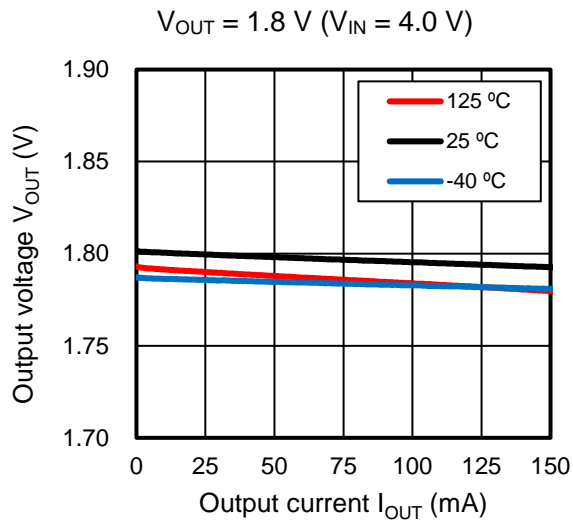
- Over current Protection and Thermal shut down function

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.

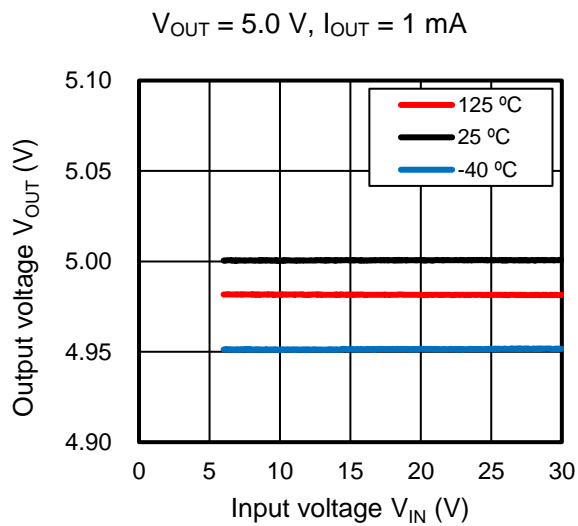
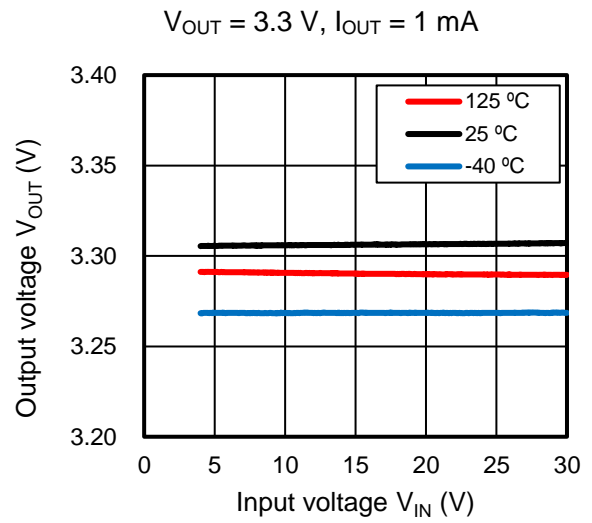
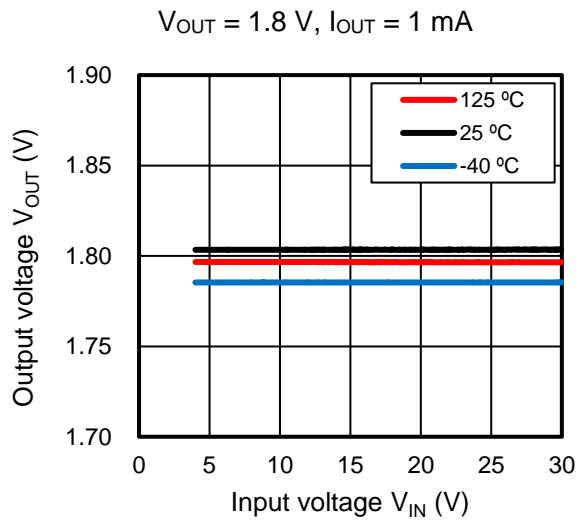
When using these products, please read through and understand the concept of dissipation for absolute maximum ratings from the above mention or our 'Semiconductor Reliability Handbook'. Then use these products under absolute maximum ratings in any condition. Furthermore, Toshiba recommend inserting failsafe system into the design.

## 10. Representative Typical Characteristics (Note)

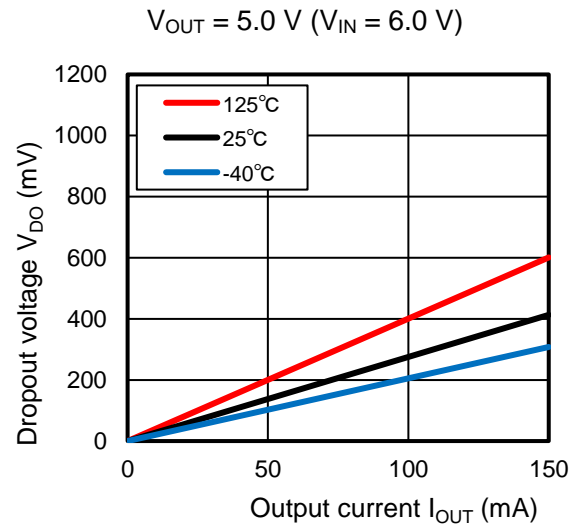
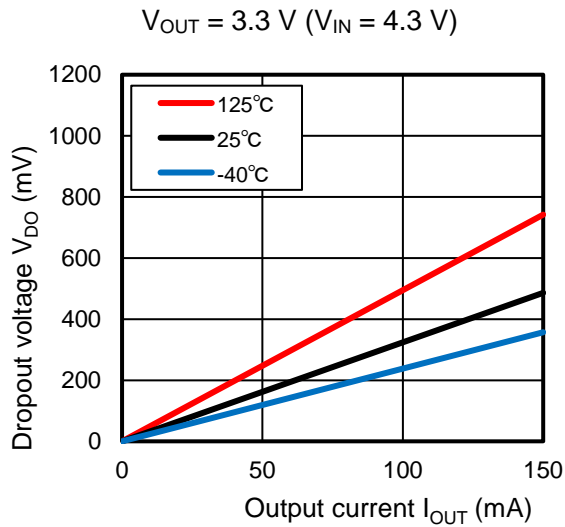
### 10.1. Output Voltage vs. Output Current



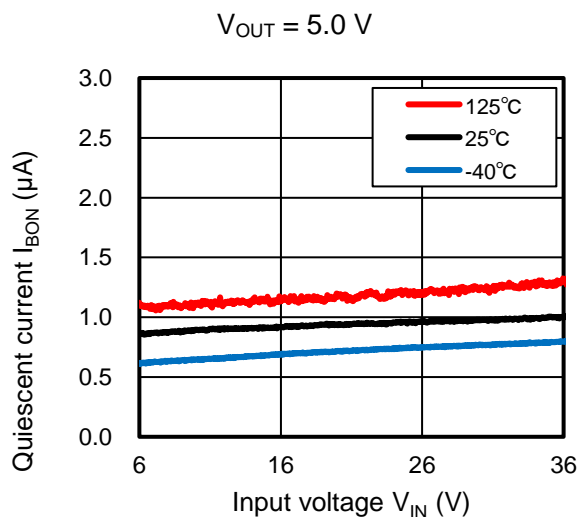
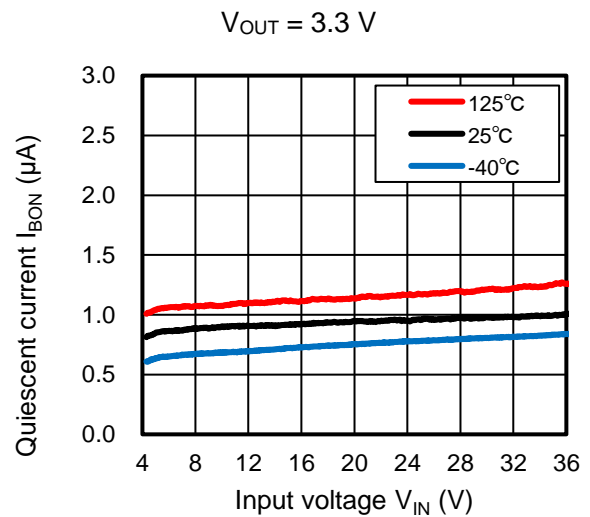
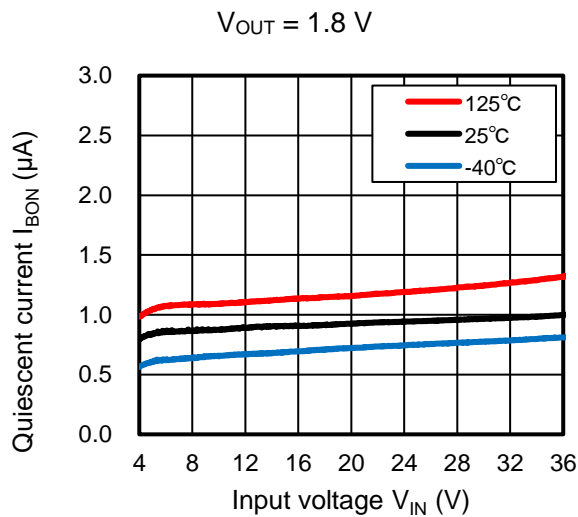
### 10.2. Output Voltage vs. Input Voltage



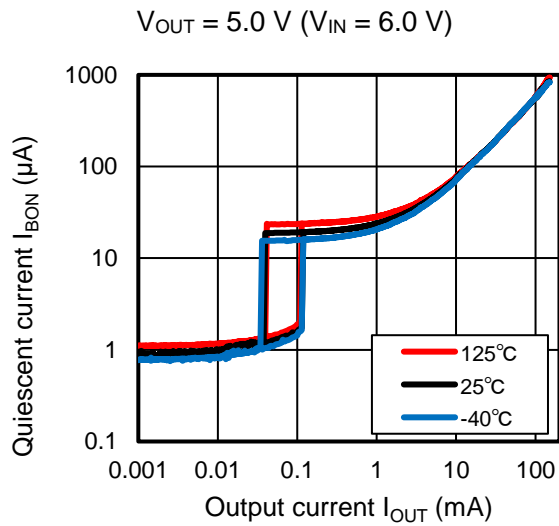
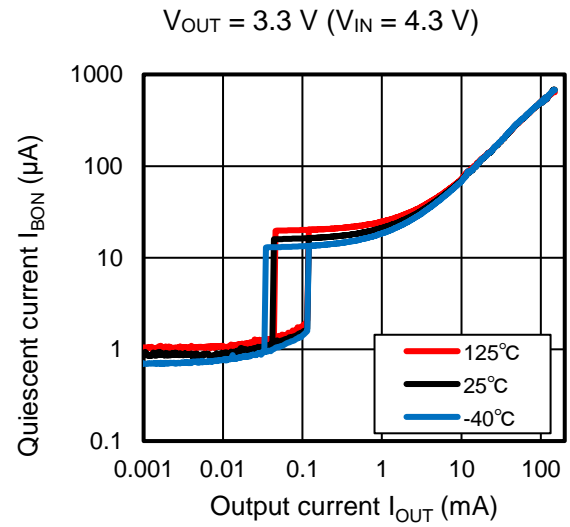
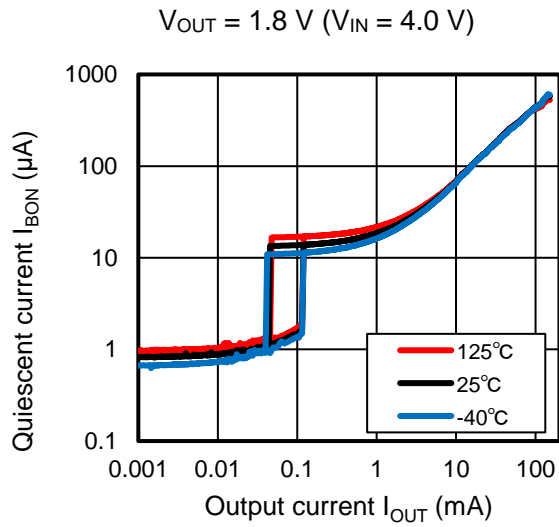
### 10.3. Dropout Voltage vs. Output Current



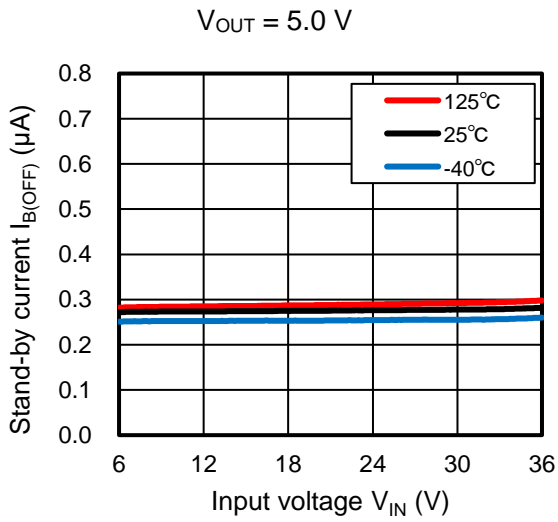
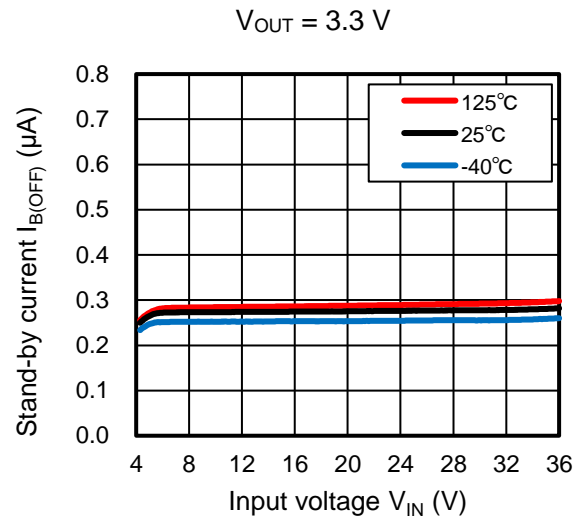
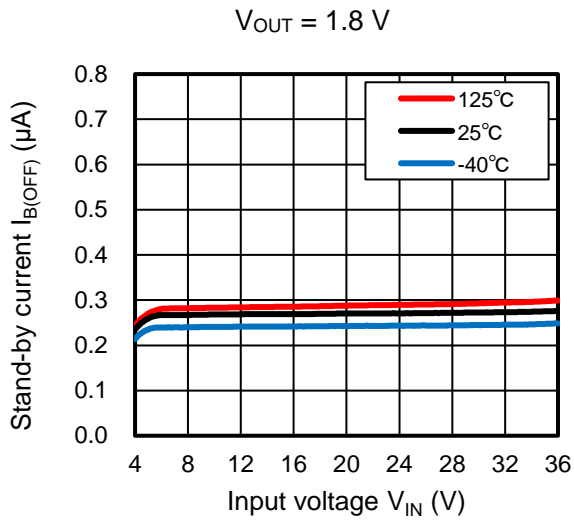
### 10.4. Quiescent Current vs. Input Voltage ( $I_{OUT} = 0\text{ mA}$ )



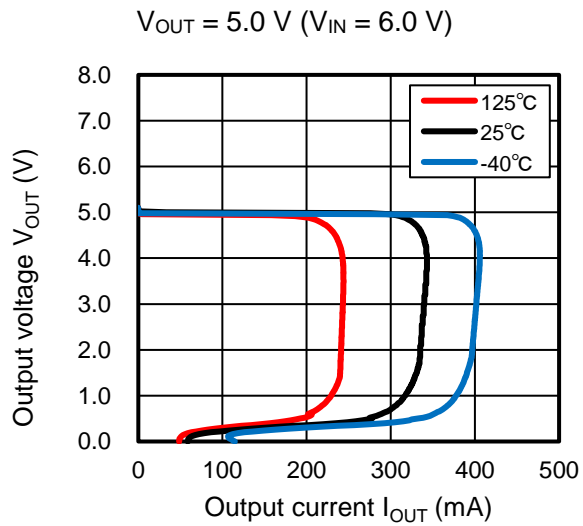
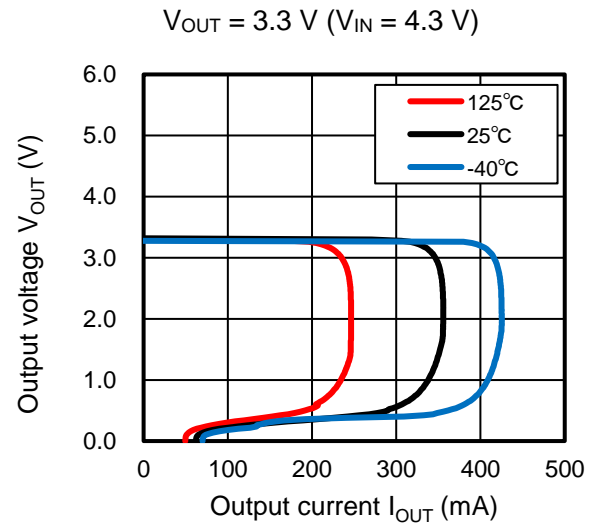
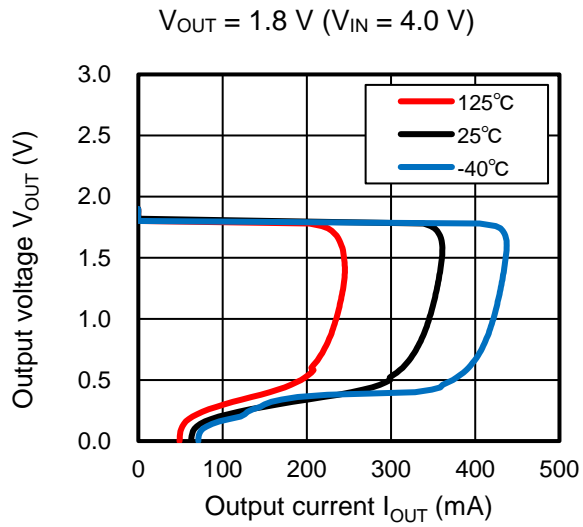
### 10.5. Quiescent Current vs. Output Current



### 10.6. Standby Current vs. Input voltage



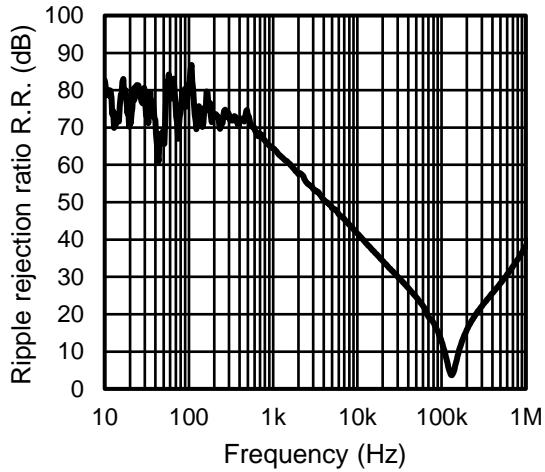
### 10.7. Output Current Limit



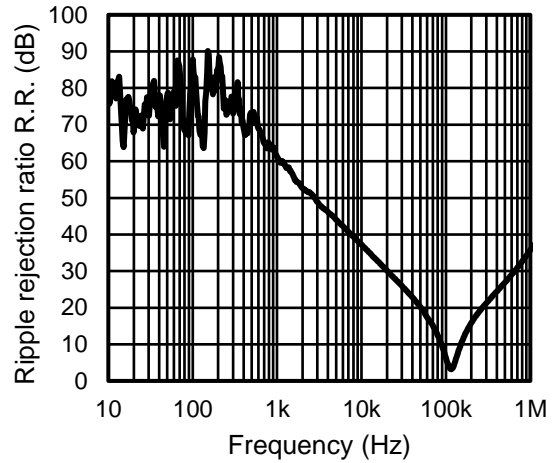
### 10.8. Ripple rejection Ratio vs. Frequency

( $C_{IN}$  = none,  $C_{OUT}$  = 0.47  $\mu$ F,  $V_{IN}$  Ripple = 100 mV p-p,  $I_{OUT}$  = 10 mA,  $T_a$  = 25  $^{\circ}$ C)

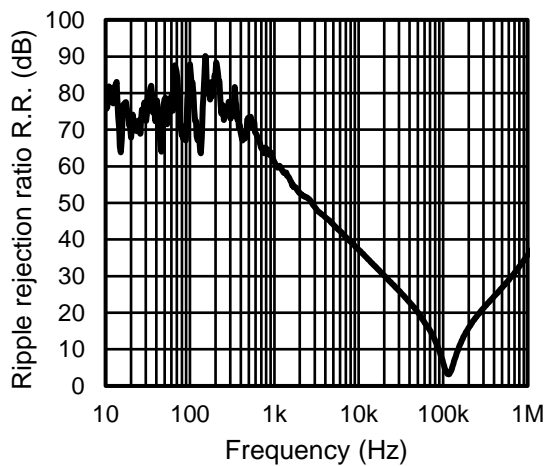
$V_{OUT} = 1.8$  V ( $V_{IN} = 4.0$  V)



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



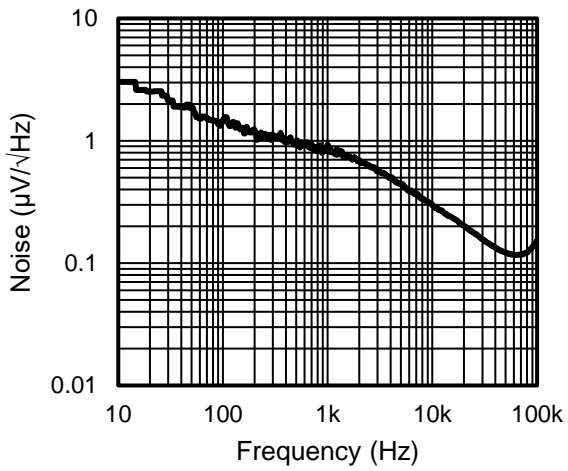
$V_{OUT} = 5.0$  V ( $V_{IN} = 6.0$  V)



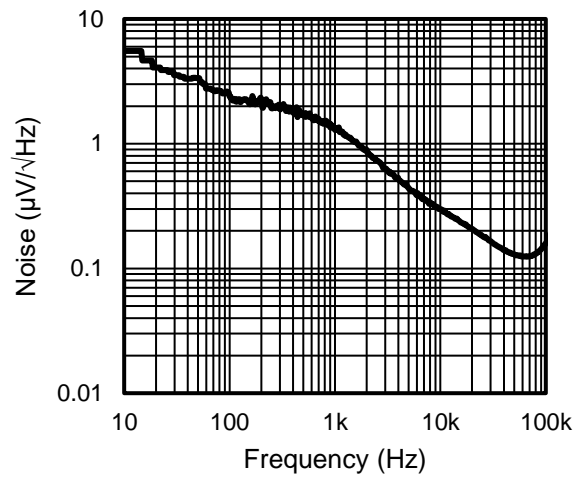
### 10.9. Output noise Voltage

( $C_{IN} = 0.47 \mu\text{F}$ ,  $C_{OUT} = 0.47 \mu\text{F}$ ,  $V_{IN} = 24 \text{ V}$ ,  $I_{OUT} = 10 \text{ mA}$ ,  $T_a = 25 \text{ }^\circ\text{C}$ )

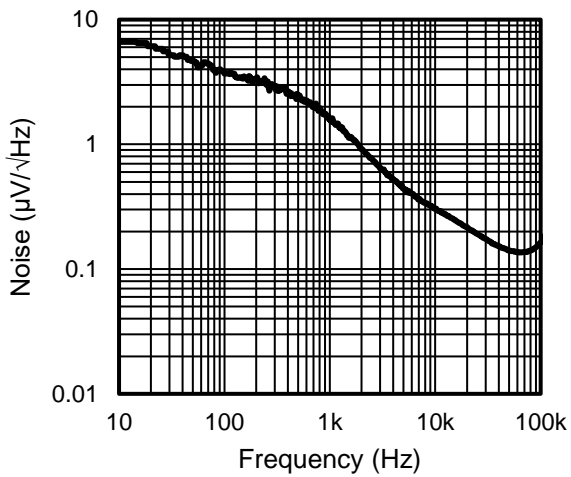
$V_{OUT} = 1.8 \text{ V}$



$V_{OUT} = 3.3 \text{ V}$



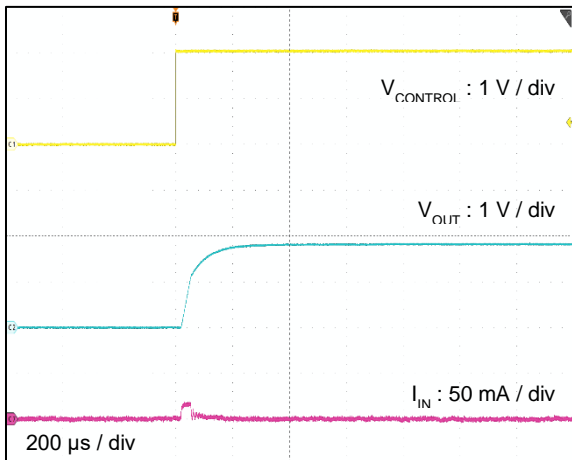
$V_{OUT} = 5.0 \text{ V}$



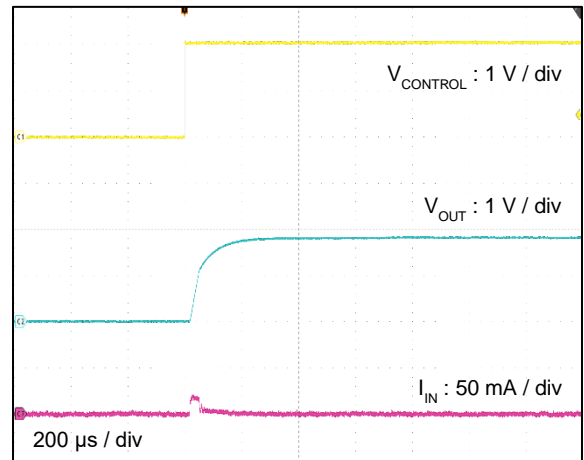
### 10.10. $t_{ON}$ Response

( $C_{IN} = 0.47 \mu\text{F}$ ,  $C_{OUT} = 0.47 \mu\text{F}$ ,  $I_{OUT} = \text{No load}$ ,  $T_a = 25 \text{ }^\circ\text{C}$ )

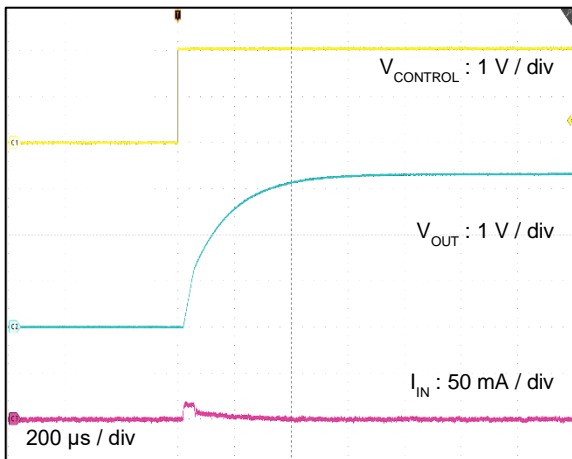
$V_{OUT} = 1.8 \text{ V}$  ( $V_{IN} = 4.0 \text{ V}$ )



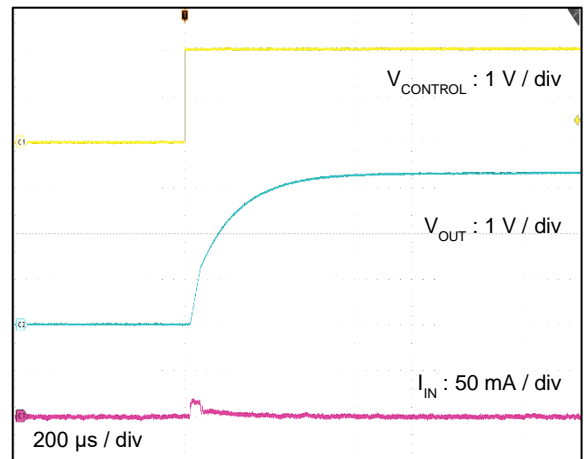
$V_{OUT} = 1.8 \text{ V}$  ( $V_{IN} = 24.0 \text{ V}$ )



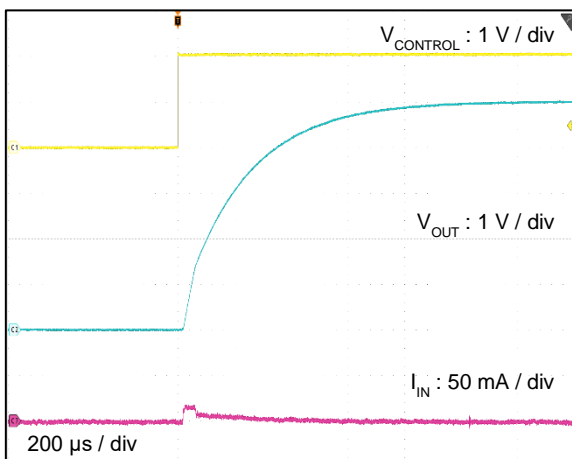
$V_{OUT} = 3.3 \text{ V}$  ( $V_{IN} = 4.3 \text{ V}$ )



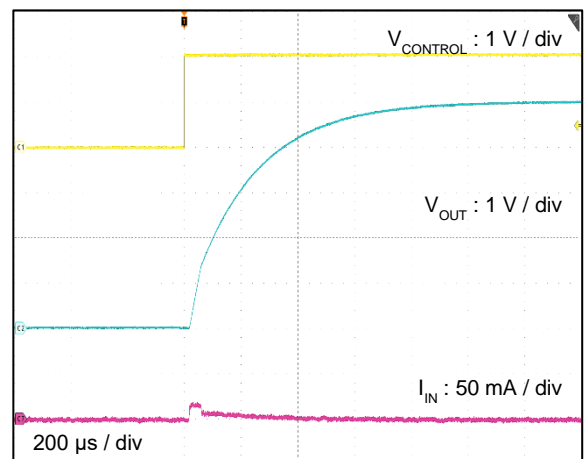
$V_{OUT} = 3.3 \text{ V}$  ( $V_{IN} = 24.0 \text{ V}$ )



$V_{OUT} = 5.0 \text{ V}$  ( $V_{IN} = 6.0 \text{ V}$ )



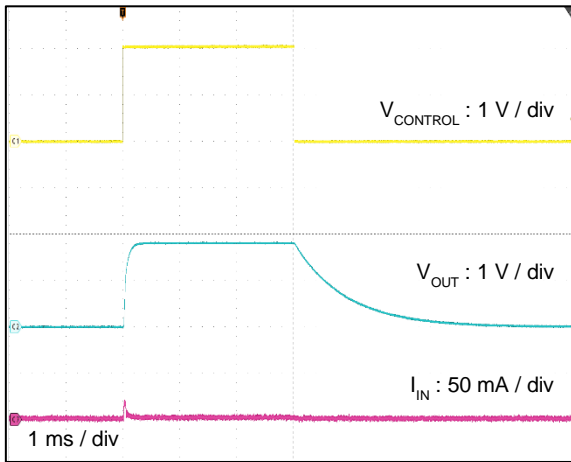
$V_{OUT} = 5.0 \text{ V}$  ( $V_{IN} = 24.0 \text{ V}$ )



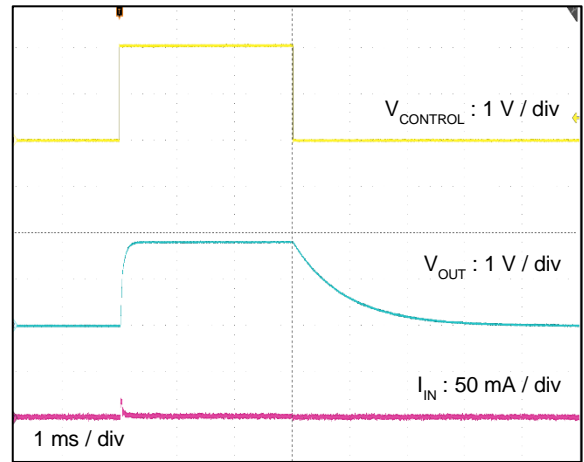
### 10.11. $t_{ON}$ / $t_{OFF}$ Response

( $C_{IN} = 0.47 \mu\text{F}$ ,  $C_{OUT} = 0.47 \mu\text{F}$ ,  $I_{OUT} = 1 \text{ mA}$ ,  $T_a = 25 \text{ }^\circ\text{C}$ )

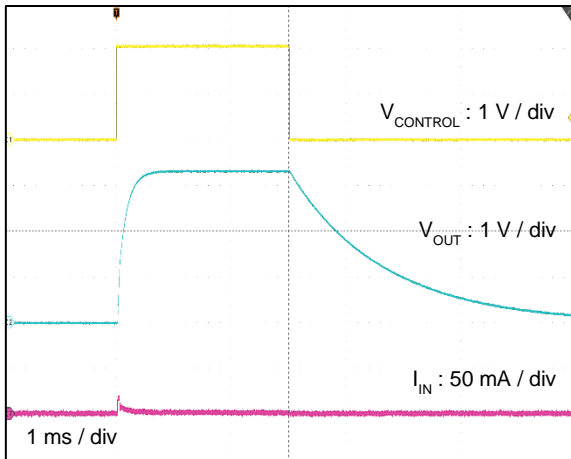
$V_{OUT} = 1.8 \text{ V}$  ( $V_{IN} = 4.0 \text{ V}$ )



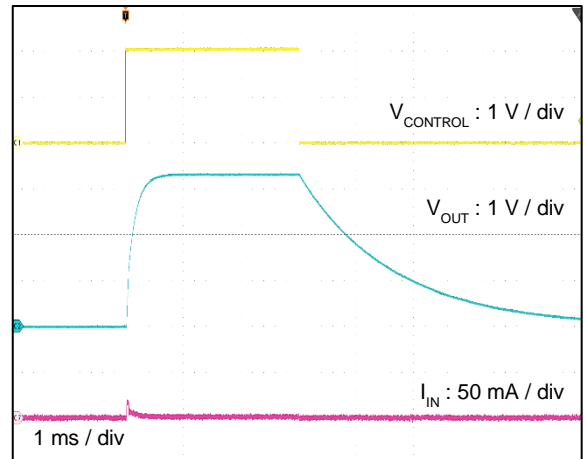
$V_{OUT} = 1.8 \text{ V}$  ( $V_{IN} = 24.0 \text{ V}$ )



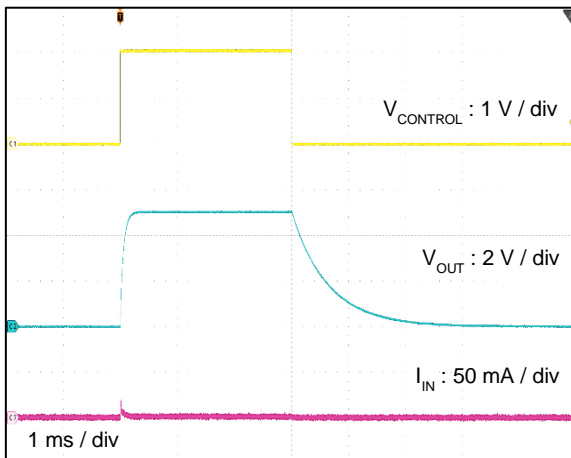
$V_{OUT} = 3.3 \text{ V}$  ( $V_{IN} = 4.3 \text{ V}$ )



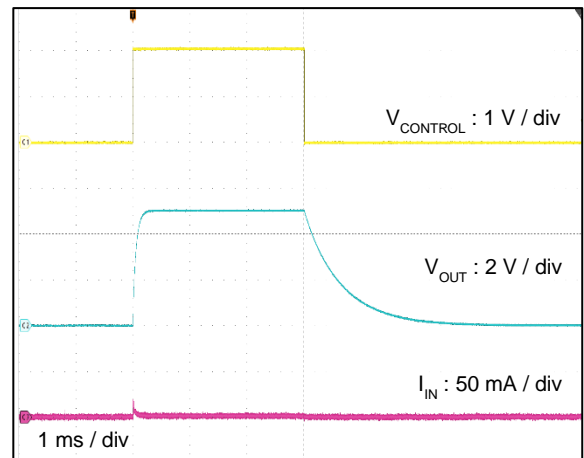
$V_{OUT} = 3.3 \text{ V}$  ( $V_{IN} = 24.0 \text{ V}$ )



$V_{OUT} = 5.0 \text{ V}$  ( $V_{IN} = 6.0 \text{ V}$ )



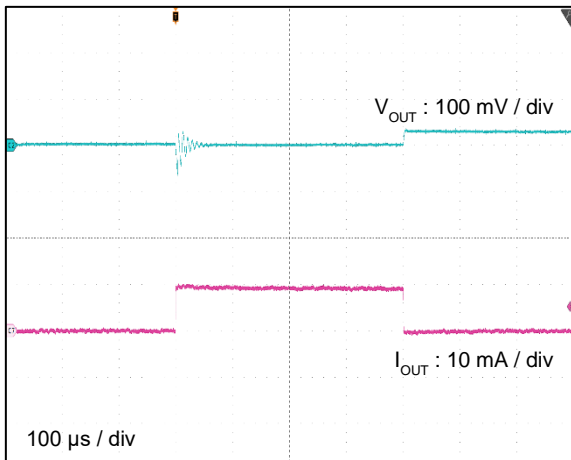
$V_{OUT} = 5.0 \text{ V}$  ( $V_{IN} = 24.0 \text{ V}$ )



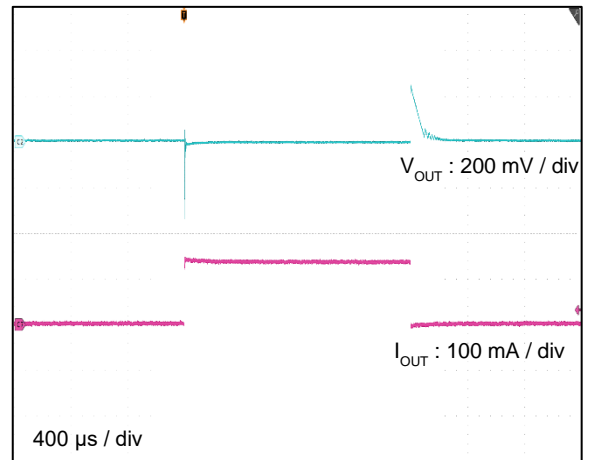
### 10.12. Load Transient Response

( $C_{IN} = 0.47 \mu\text{F}$ ,  $C_{OUT} = 0.47 \mu\text{F}$ ,  $T_a = 25 \text{ }^\circ\text{C}$ )

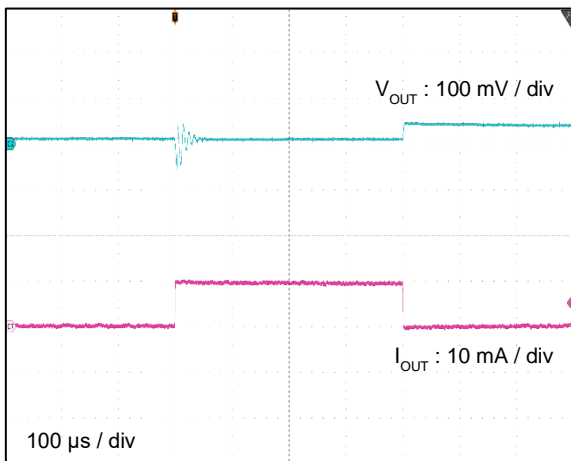
$V_{OUT} = 1.8 \text{ V}$   
 ( $V_{IN} = 4.0 \text{ V}$ ,  $I_{OUT} = 0 \text{ mA} \leftrightarrow 10 \text{ mA}$  at  $1 \mu\text{s}$ )



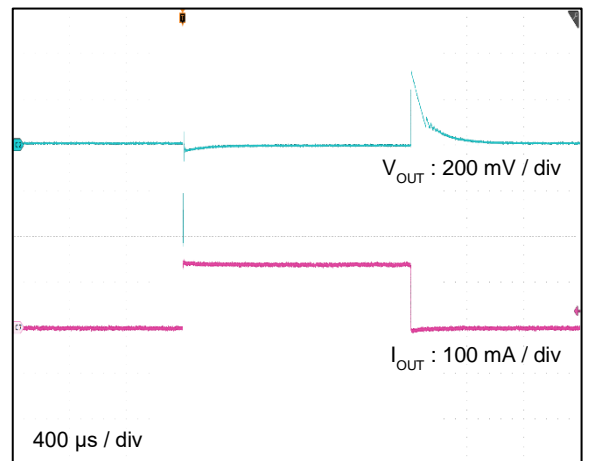
$V_{OUT} = 1.8 \text{ V}$   
 ( $V_{IN} = 4.0 \text{ V}$ ,  $I_{OUT} = 1 \text{ mA} \leftrightarrow 150 \text{ mA}$  at  $1 \mu\text{s}$ )



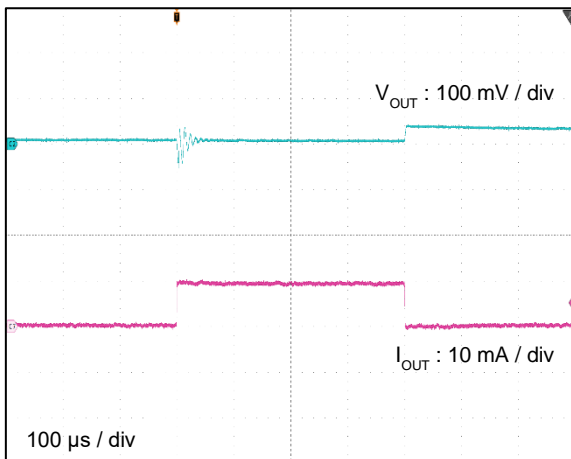
$V_{OUT} = 3.3 \text{ V}$   
 ( $V_{IN} = 4.3 \text{ V}$ ,  $I_{OUT} = 0 \text{ mA} \leftrightarrow 10 \text{ mA}$  at  $1 \mu\text{s}$ )



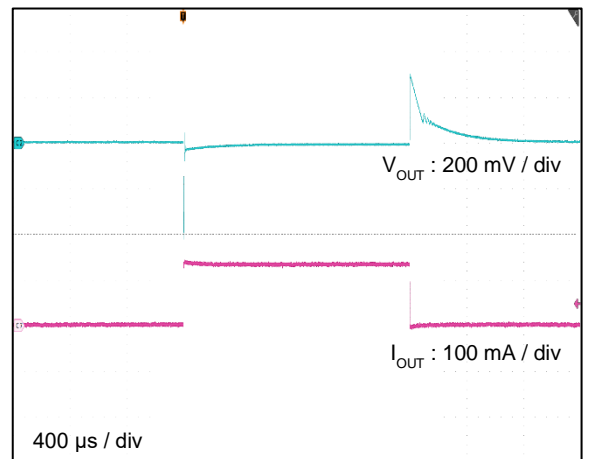
$V_{OUT} = 3.3 \text{ V}$   
 ( $V_{IN} = 4.3 \text{ V}$ ,  $I_{OUT} = 1 \text{ mA} \leftrightarrow 150 \text{ mA}$  at  $1 \mu\text{s}$ )



$V_{OUT} = 5.0 \text{ V}$   
 ( $V_{IN} = 6.0 \text{ V}$ ,  $I_{OUT} = 0 \text{ mA} \leftrightarrow 10 \text{ mA}$  at  $1 \mu\text{s}$ )



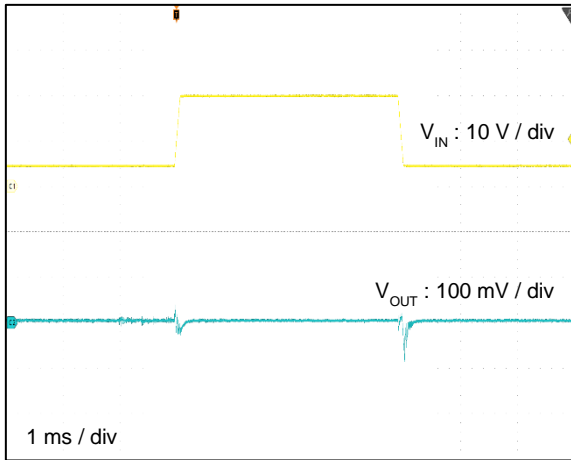
$V_{OUT} = 5.0 \text{ V}$   
 ( $V_{IN} = 6.0 \text{ V}$ ,  $I_{OUT} = 1 \text{ mA} \leftrightarrow 150 \text{ mA}$  at  $1 \mu\text{s}$ )



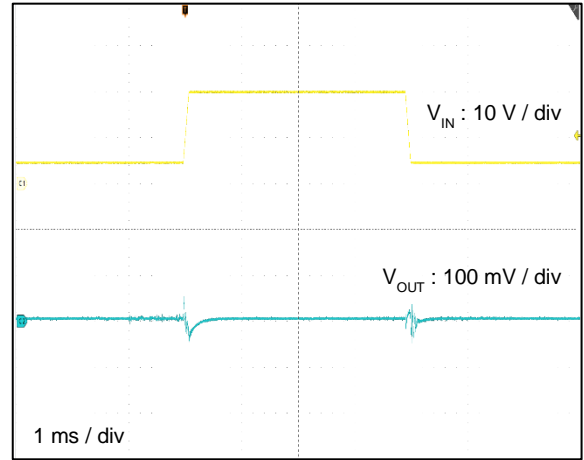
### 10.13. Line Transient Response

( $C_{IN} = 0.47 \mu\text{F}$ ,  $C_{OUT} = 0.47 \mu\text{F}$ ,  $T_a = 25 \text{ }^\circ\text{C}$ )

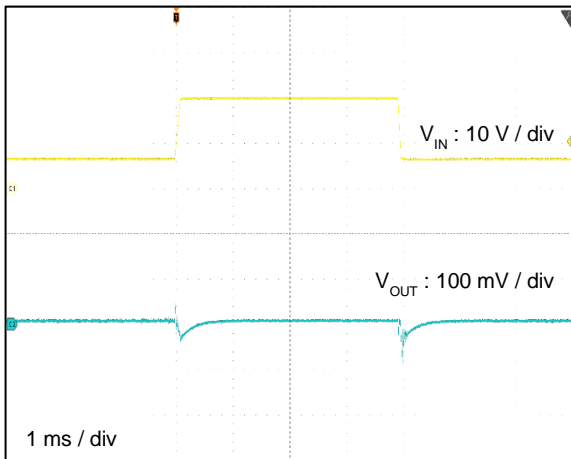
$V_{OUT} = 1.8 \text{ V}$   
 ( $V_{IN} = 4 \text{ V} \leftrightarrow 20 \text{ V}$ ),  $I_{OUT} = 1 \text{ mA}$



$V_{OUT} = 3.3 \text{ V}$   
 ( $V_{IN} = 4.3 \text{ V} \leftrightarrow 20 \text{ V}$ ),  $I_{OUT} = 1 \text{ mA}$



$V_{OUT} = 5.0 \text{ V}$   
 ( $V_{IN} = 6 \text{ V} \leftrightarrow 20 \text{ V}$ ),  $I_{OUT} = 1 \text{ mA}$

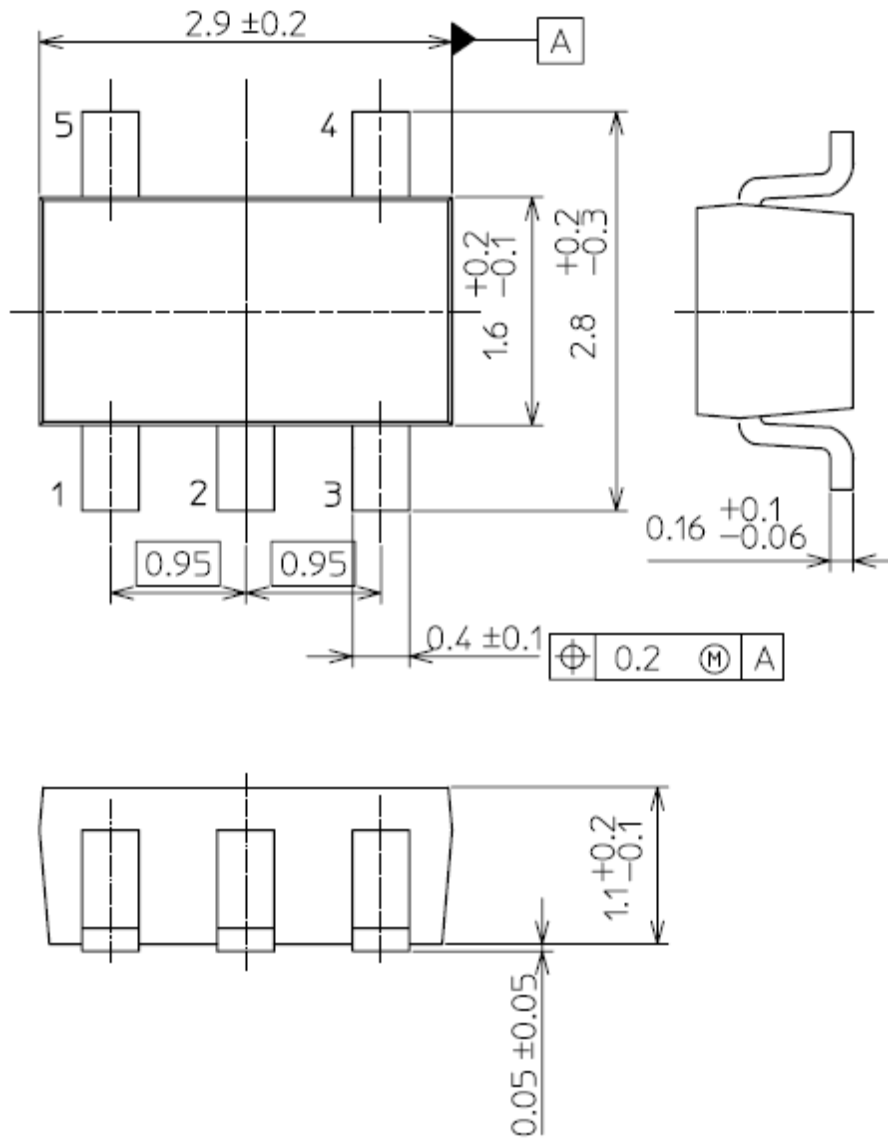


Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

## 11. Package Information

SMV (SOT-25) (SC-74A)

Unit: mm



Weight: 16 mg (Typ.)

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