

## 200 mA 36 V Input Ultra Low Supply Current VR

No. EA-332-230703

### OUTLINE

The R1524x is an ultra-low supply current voltage regulator featuring 200 mA output current and 36 V input voltage. This device consists of an Output Short-circuit Protection Circuit, an Over-current Protection Circuit, and a Thermal Shutdown Circuit in addition to the basic regulator circuits. The operating temperature range is from  $-40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$ , and the maximum input voltage is 36 V. All these features allow the R1524x to become an ideal power source of electric home appliances.

The output voltages are internally fixed (refer to *SELECTION GUIDE*). The output voltage accuracy is  $\pm 0.6\%$ . The packages for this device range from high-density mounting to ultra high wattage. The R1524x is offered in five packages; a 5-pin SOT-23-5, a 5-pin SOT-89-5, a 6-pin HSOP-6J, a 6-pin DFN(PL)1820-6, and an 8-pin HSOP-8E package.

### FEATURES

- Input Voltage Range (Maximum Rating) ..... 3.5 V to 36 V (50 V)
- Operating Temperature Range .....  $-40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$
- Supply Current ..... Typ. 2.2  $\mu\text{A}$
- Standby Current ..... Typ. 0.1  $\mu\text{A}$
- Dropout Voltage ..... Typ. 0.6 V ( $I_{\text{OUT}} = 200 \text{ mA}$ ,  $V_{\text{OUT}} = 5.0 \text{ V}$ )
- Output Voltage Range ..... 1.8 V / 2.5 V / 2.8 V / 3.0 V / 3.3 V / 3.4 V / 5.0 V /  
5.5 V / 6.0 V / 6.4 V / 7.0 V / 8.0 V / 8.5 V / 9.0 V /  
10.0 V / 10.5 V / 11.0 V / 12.0 V  
\*Contact our sales representatives for other voltages.
- Output Voltage Accuracy .....  $\pm 0.6\%$  ( $T_a = 25^{\circ}\text{C}$ )
- Output Voltage Temperature-Drift Coefficient ..... Typ.  $\pm 60 \text{ ppm}/^{\circ}\text{C}$
- Line Regulation ..... Typ. 0.01%/V ( $V_{\text{SET}} + 1 \text{ V} \leq V_{\text{IN}} \leq 36 \text{ V}$ )
- Built-in Output Short-circuit Protection Circuit ..... Typ. 80 mA
- Built-in Over-current Protection Circuit ..... Typ. 350 mA
- Built-in Thermal Shutdown Circuit ..... Thermal Shutdown Temperature: Typ.  $160^{\circ}\text{C}$
- Ceramic capacitors are recommended  
to be used with this device .....  $C_{\text{OUT}} = 0.1 \mu\text{F}$  or more
- Packages ..... SOT-23-5, SOT-89-5, HSOP-6J,  
DFN(PL)1820-6, HSOP-8E

### APPLICATIONS

- Power source for home appliances such as refrigerators, rice cookers, and electric hot-water pot.
- Power source for notebook PCs, digital TVs, cordless phones, and private LAN system.
- Power source for office equipment machines such as copiers, printers, facsimiles, scanners, and projectors.

### SELECTION GUIDE

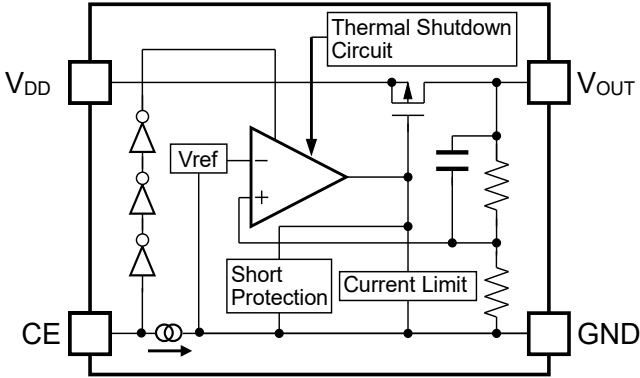
The set output voltage and the package type are user-selectable.

#### Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1524NxxxB-TR-FE	SOT-23-5	3,000 pcs	Yes	Yes
R1524HxxxB-T1-FE	SOT-89-5	1,000 pcs	Yes	Yes
R1524SxxxB-E2-FE	HSOP-6J	1,000 pcs	Yes	Yes
R1524KxxxB-TR	DFN(PL)1820-6	5,000 pcs	Yes	Yes
R1524SxxxH-E2-FE	HSOP-8E	1,000 pcs	Yes	Yes

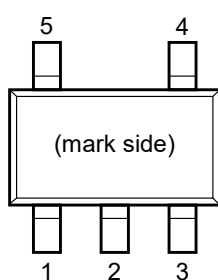
xxx: Specify the set output voltage ( $V_{SET}$ )  
1.8 V (018) / 2.5 V (025) / 2.8 V (028) / 3.0 V (030) / 3.3 V (033) / 3.4 V (034) / 5.0 V (050) /  
5.5 V (055) / 6.0 V (060) / 6.4 V (064) / 7.0 V (070) / 8.0 V (080) / 8.5 V (085) / 9.0 V (090) /  
10.0 V (100) / 10.5 V (105) / 11.0 V (110) / 12.0 V (120)  
\*Contact our sales representatives for other voltages.

### BLOCK DIAGRAM

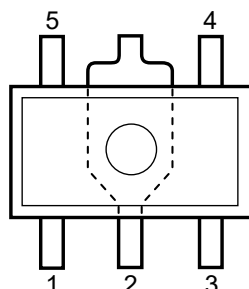


R1524x Block Diagram

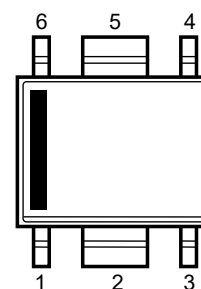
## PIN DESCRIPTIONS



SOT-23-5 Pin Configuration

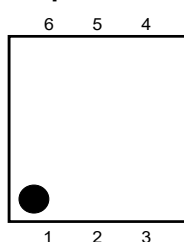


SOT-89-5 Pin Configuration



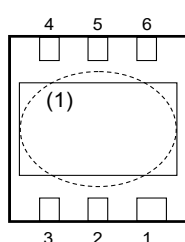
HSOP-6J Pin Configuration

Top View

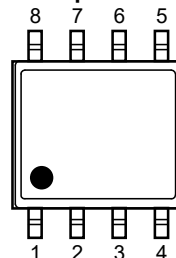


DFN(PL)1820-6 Pin Configuration

Bottom View

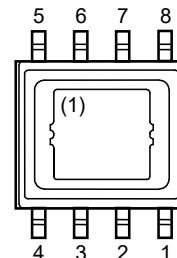


Top View



HSOP-8E Pin Configuration

Bottom View



## SOT-23-5 Pin Descriptions

Pin No.	Symbol	Description
1	GND <sup>(2)</sup>	Ground Pin
2	GND <sup>(2)</sup>	Ground Pin
3	CE	Chip Enable Pin (Active-high)
4	V <sub>OUT</sub>	Output Pin
5	V <sub>DD</sub>	Input Pin

## SOT-89-5 Pin Descriptions

Pin No.	Symbol	Description
1	V <sub>OUT</sub>	Output Pin
2	GND <sup>(3)</sup>	Ground Pin
3	CE	Chip Enable Pin (Active-high)
4	GND <sup>(3)</sup>	Ground Pin
5	V <sub>DD</sub>	Input Pin

(1) The tab on the bottom of the package enhances thermal performance and is electrically connected to GND (substrate level). It is recommended that the tab be connected to the ground plane on the board, or otherwise be left open.

(2) The GND pin must be wired together when it is mounted on board.

(3) The GND pin must be wired together when it is mounted on board.

## HSOP-6J Pin Descriptions

Pin No.	Symbol	Description
1	V <sub>OUT</sub>	Output Pin
2	GND <sup>(1)</sup>	Ground Pin
3	CE	Chip Enable Pin (Active-high)
4	GND <sup>(1)</sup>	Ground Pin
5	GND <sup>(1)</sup>	Ground Pin
6	V <sub>DD</sub>	Input Pin

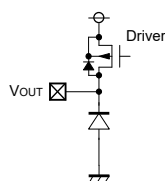
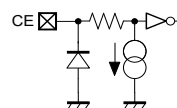
## DFN(PL)1820-6 Pin Descriptions

Pin No.	Symbol	Description
1	CE	Chip Enable Pin (Active-high)
2	NC	No Connection
3	GND	Ground Pin
4	V <sub>DD</sub>	Input Pin
5	NC	No Connection
6	V <sub>OUT</sub>	Output Pin

## HSOP-8E Pin Descriptions

Pin No.	Symbol	Description
1	V <sub>OUT</sub>	Output Pin
2	NC	No Connection
3	NC	No Connection
4	CE	Chip Enable Pin (Active-high)
5	GND	Ground Pin
6	NC	No Connection
7	NC	No Connection
8	V <sub>DD</sub>	Input Pin

## PIN EQUIVALENT CIRCUIT DIAGRAMS

V<sub>OUT</sub> Pin

CE Pin

<sup>(1)</sup> The GND pin must be wired together when it is mounted on board.

## ABSOLUTE MAXIMUM RATINGS

### Absolute Maximum Ratings

Symbol	Item	Rating	Unit	
V <sub>IN</sub>	Input Voltage	-0.3 to 50	V	
V <sub>IN</sub>	Peak Input Voltage <sup>(1)</sup>	60	V	
V <sub>CE</sub>	Input Voltage (CE Pin)	-0.3 to 50	V	
V <sub>OUT</sub>	Output Voltage	-0.3 to V <sub>IN</sub> + 0.3 ≤ 50	V	
I <sub>OUT</sub>	Output Current	300	mA	
P <sub>D</sub>	Power Dissipation <sup>(2)</sup> (JEDEC STD.51-7 Test Land Pattern)	SOT-23-5	660	mW
		SOT-89-5	2600	
		HSOP-6J	2700	
		DFN(PL)1820-6	2200	
		HSOP-8E	2900	
T <sub>j</sub>	Junction Temperature Range	-40 to 125	°C	
T <sub>stg</sub>	Storage Temperature Range	-55 to 125	°C	

### ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings are not assured.

## RECOMMENDED OPERATING CONDITIONS

### Recommended Operating Conditions

Symbol	Item	Rating	Unit
V <sub>IN</sub>	Input Voltage	3.5 to 36	V
T <sub>a</sub>	Operating Temperature Range	-40 to 105	°C

### RECOMMENDED OPERATING CONDITIONS

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

<sup>(1)</sup> Duration time: 200 ms

<sup>(2)</sup> Refer to *POWER DISSIPATION* for detailed information.

## ELECTRICAL CHARACTERISTICS

$C_{IN} = C_{OUT} = 0.1 \mu\text{F}$ , unless otherwise noted.

The specifications surrounded by   are guaranteed by design engineering at  $-40^\circ\text{C} \leq T_a \leq 105^\circ\text{C}$ .

### R1524x Electrical Characteristics

( $T_a = 25^\circ\text{C}$ )

Symbol	Item	Conditions		Min.	Typ.	Max.	Unit
$I_{SS}$	Supply Current	$V_{IN} = 14 \text{ V}$ $I_{OUT} = 0 \text{ mA}$	$V_{SET} \leq 5.0 \text{ V}$		2.2	<span style="border: 1px solid black; padding: 0 2px;">6.5</span>	$\mu\text{A}$
			$5.0 \text{ V} < V_{SET}$		2.5	<span style="border: 1px solid black; padding: 0 2px;">6.8</span>	
$I_{standby}$	Standby Current	$V_{IN} = 36 \text{ V}, V_{CE} = 0 \text{ V}$			0.1	1.0	$\mu\text{A}$
$V_{OUT}$	Output Voltage	$V_{SET} + 1 \text{ V}^{(1)} \leq V_{IN} \leq 36 \text{ V}, I_{OUT} = 1 \text{ mA}$	$T_a = 25^\circ\text{C}$	$\times 0.994$		$\times 1.006$	V
			$-40^\circ\text{C} \leq T_a \leq 105^\circ\text{C}$	<span style="border: 1px solid black; padding: 0 2px;"><math>\times 0.984</math></span>		<span style="border: 1px solid black; padding: 0 2px;"><math>\times 1.016</math></span>	
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	$V_{IN} = V_{SET} + 3.0 \text{ V}$ $1 \text{ mA} \leq I_{OUT} \leq 200 \text{ mA}$		Refer to the <i>Product-specific Electrical Characteristics</i>			
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	$V_{SET} + 1 \text{ V}^{(1)} \leq V_{IN} \leq 36 \text{ V}, I_{OUT} = 1 \text{ mA}$	$V_{SET} < 3.3 \text{ V}$	<span style="border: 1px solid black; padding: 0 2px;">-20</span>	5	<span style="border: 1px solid black; padding: 0 2px;">20</span>	mV
			$3.3 \text{ V} \leq V_{SET}$	<span style="border: 1px solid black; padding: 0 2px;">-0.02</span>	0.01	<span style="border: 1px solid black; padding: 0 2px;">0.02</span>	%/V
$V_{DIF}$	Dropout Voltage	$I_{OUT} = 200 \text{ mA}$		Refer to the <i>Product-specific Electrical Characteristics</i>			
$I_{LIM}$	Output Current Limit	$V_{IN} = V_{SET} + 3.0 \text{ V}$		<span style="border: 1px solid black; padding: 0 2px;">220</span>	350		mA
$I_{SC}$	Short Current Limit	$V_{IN} = 3.5 \text{ V}, V_{OUT} = 0 \text{ V}$		<span style="border: 1px solid black; padding: 0 2px;">60</span>	80		mA
$V_{CEH}$	CE Pin Input Voltage, high	$V_{IN} = V_{SET} + 1 \text{ V}^{(1)}$		<span style="border: 1px solid black; padding: 0 2px;">2.0</span>		36	V
$V_{CEL}$	CE Pin Input Voltage, low	$V_{IN} = 36 \text{ V}$		0		<span style="border: 1px solid black; padding: 0 2px;">1.0</span>	V
$I_{PD}$	CE Pull-down Current	$V_{IN} = 36 \text{ V}, V_{CE} = 2 \text{ V}$			0.2	<span style="border: 1px solid black; padding: 0 2px;">0.6</span>	$\mu\text{A}$
$T_{TSD}$	Thermal Shutdown Detection Temperature	Junction Temperature			160		$^\circ\text{C}$
$T_{TSR}$	Thermal Shutdown Released Temperature	Junction Temperature			135		$^\circ\text{C}$

All test items listed under Electrical Characteristics are done under the pulse load condition ( $T_J \approx T_a = 25^\circ\text{C}$ ).

<sup>(1)</sup>  $V_{SET} \leq 2.5 \text{ V}, V_{IN} = 3.5 \text{ V}$

The specifications surrounded by  are guaranteed by design engineering at  $-40^{\circ}\text{C} \leq T_a \leq 105^{\circ}\text{C}$ .

## R1524x Product-specific Electrical Characteristics

(Ta = 25°C)

Product Name	V <sub>OUT</sub> (V) (Ta = 25°C)			V <sub>OUT</sub> (V) (-40°C ≤ Ta ≤ 105°C)			ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub> (mV)			V <sub>DIF</sub> (V)	
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	TYP.	MAX.
R1524x018x	1.7892	1.80	1.8108	<input type="checkbox"/> 1.7712	1.80	<input type="checkbox"/> 1.8288	<input type="checkbox"/> -10	10	<input type="checkbox"/> 40	1.6	<input type="checkbox"/> 2.5
R1524x025x	2.4850	2.50	2.5150	<input type="checkbox"/> 2.4600	2.50	<input type="checkbox"/> 2.5400				1.2	<input type="checkbox"/> 2.2
R1524x028x	2.7832	2.80	2.8168	<input type="checkbox"/> 2.7552	2.80	<input type="checkbox"/> 2.8448					
R1524x030x	2.9820	3.00	3.0180	<input type="checkbox"/> 2.9520	3.00	<input type="checkbox"/> 3.0480				0.8	<input type="checkbox"/> 2.0
R1524x033x	3.2802	3.30	3.3198	<input type="checkbox"/> 3.2472	3.30	<input type="checkbox"/> 3.3528					
R1524x034x	3.3796	3.40	3.4204	<input type="checkbox"/> 3.3456	3.40	<input type="checkbox"/> 3.4544					
R1524x050x	4.9700	5.00	5.0300	<input type="checkbox"/> 4.9200	5.00	<input type="checkbox"/> 5.0800				<input type="checkbox"/> -18	18
R1524x055x	5.4670	5.50	5.5330	<input type="checkbox"/> 5.4120	5.50	<input type="checkbox"/> 5.5880					
R1524x060x	5.9640	6.00	6.0360	<input type="checkbox"/> 5.9040	6.00	<input type="checkbox"/> 6.0960					
R1524x064x	6.3616	6.40	6.4384	<input type="checkbox"/> 6.2976	6.40	<input type="checkbox"/> 6.5024					
R1524x070x	6.9580	7.00	7.0420	<input type="checkbox"/> 6.8880	7.00	<input type="checkbox"/> 7.1120	0.5				
R1524x080x	7.9520	8.00	8.0480	<input type="checkbox"/> 7.8720	8.00	<input type="checkbox"/> 8.1280					
R1524x085x	8.4490	8.50	8.5510	<input type="checkbox"/> 8.3640	8.50	<input type="checkbox"/> 8.6360					
R1524x090x	8.9460	9.00	9.0540	<input type="checkbox"/> 8.8560	9.00	<input type="checkbox"/> 9.1440	<input type="checkbox"/> -18	18	<input type="checkbox"/> 72	0.5	<input type="checkbox"/> 1.2
R1524x100x	9.9400	10.0	10.0600	<input type="checkbox"/> 9.8400	10.0	<input type="checkbox"/> 10.1600					
R1524x105x	10.4370	10.5	10.5630	<input type="checkbox"/> 10.3320	10.5	<input type="checkbox"/> 10.6680					
R1524x110x	10.9340	11.0	11.0660	<input type="checkbox"/> 10.8240	11.0	<input type="checkbox"/> 11.1760					
R1524x120x	11.9280	12.0	12.0720	<input type="checkbox"/> 11.8080	12.0	<input type="checkbox"/> 12.1920					

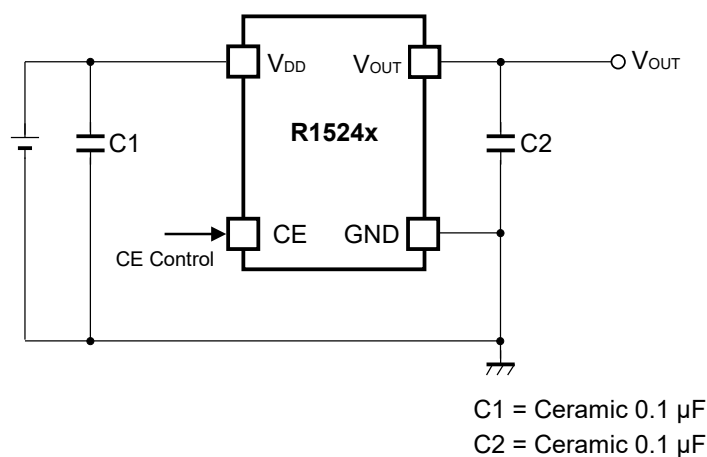
## THEORY OF OPERATION

### Thermal Shutdown

R1524x has a built-in thermal shutdown circuit, which stops the regulator operation if the junction temperature of this device increases to 160°C (Typ.) or higher. If the temperature drops to 135°C (Typ.) or lower, the regulator restarts the operation. Unless eliminating the overheating problem, the regulator turns on and off repeatedly and as a result, a pulse shaped output voltage is generated.

## APPLICATION INFORMATION

### TYPICAL APPLICATIONS



**R1524x Typical Applications**



## TECHNICAL NOTES

### Phase Compensation

In the R1524x, phase compensation is provided to secure stable operation even when the load current is varied. For this purpose, make sure to use 0.1  $\mu$ F or more of a capacitor (C2).

In case of using a tantalum type capacitor and the ESR (Equivalent Series Resistance) value of the capacitor is large, the output might be unstable. Evaluate the circuit including consideration of frequency characteristics. Connect 0.1  $\mu$ F or more of a capacitor (C1) between  $V_{DD}$  and GND, and as close as possible to the pins.

### PCB Layout

For SOT-23-5 package type, wire the following GND pins together: No. 1 and No. 2

For SOT-89-5 package type, wire the following GND pins together: No. 2 and No. 4.

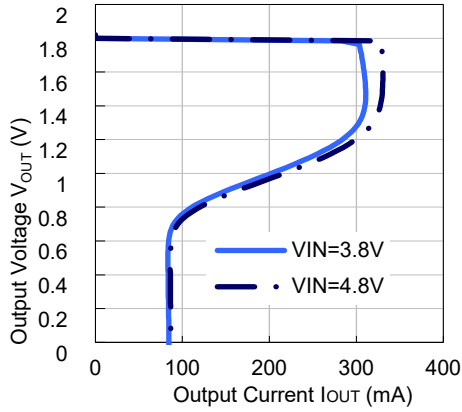
For HSOP-6J package type, wire the following GND pins together: No. 2, No. 4, and No. 5.

## TYPICAL CHARACTERISTICS

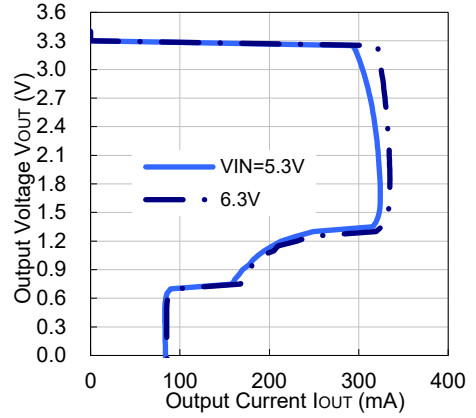
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

### 1) Output Voltage vs. Output Current (Ta = 25°C)

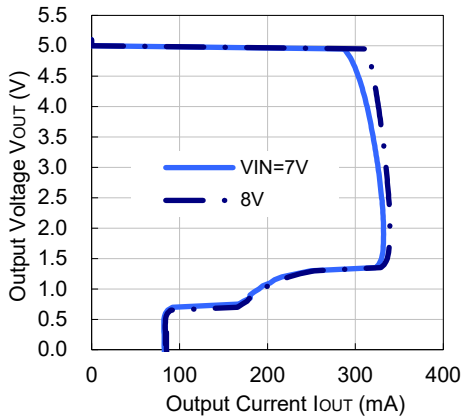
R1524x018B



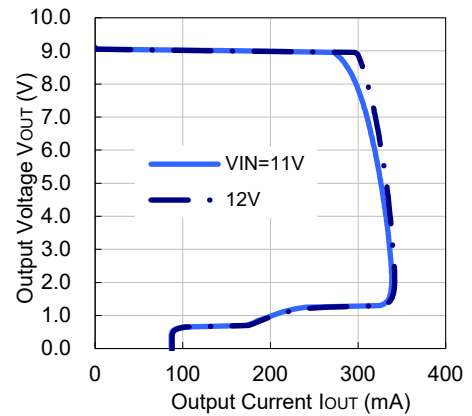
R1524x033B



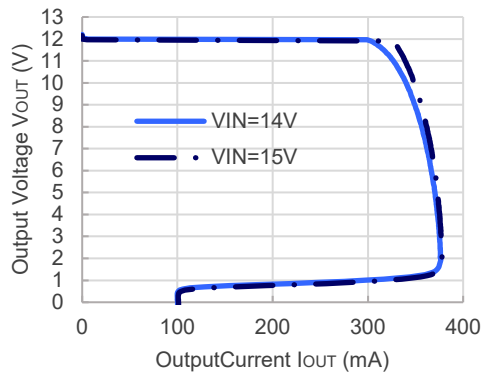
R1524x050B



R1524x090B

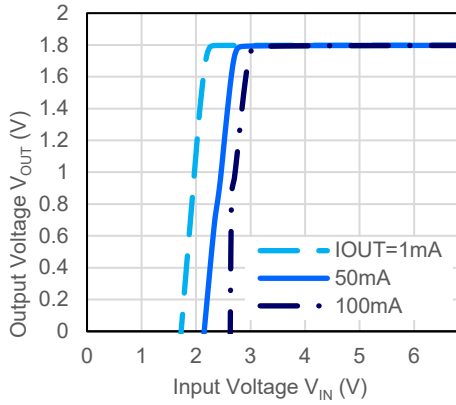


R1524x120B

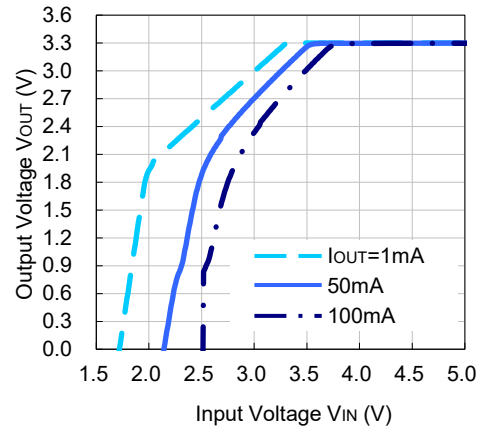


2) Output Voltage vs. Input Voltage (Ta = 25°C)

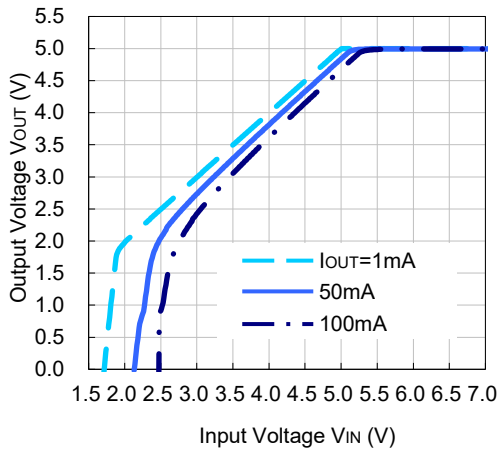
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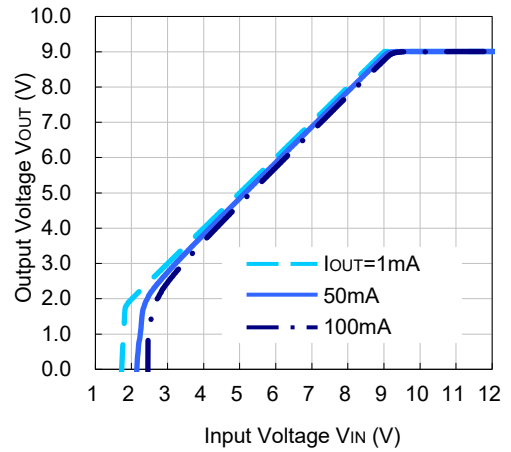
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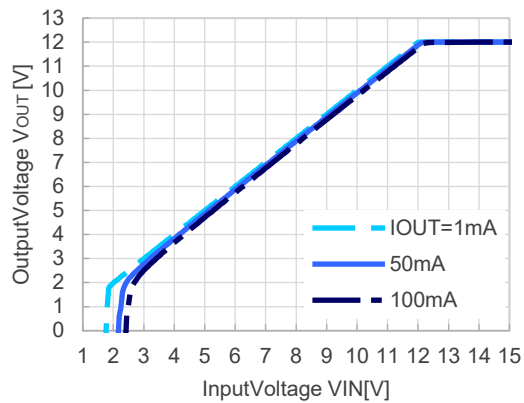
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R1524x090B

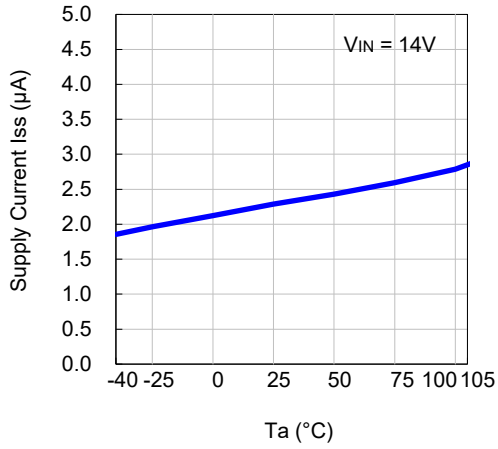


R1524x120B

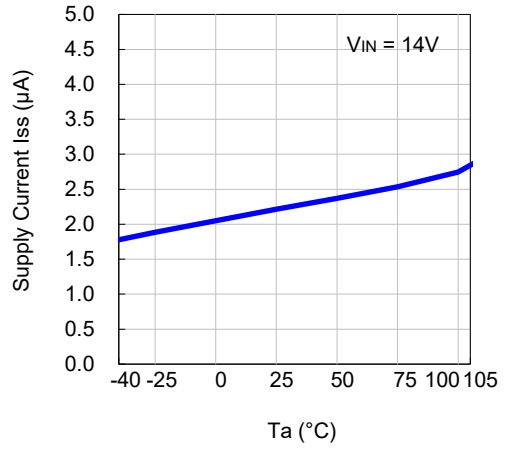


3) Supply Current vs. Temperature

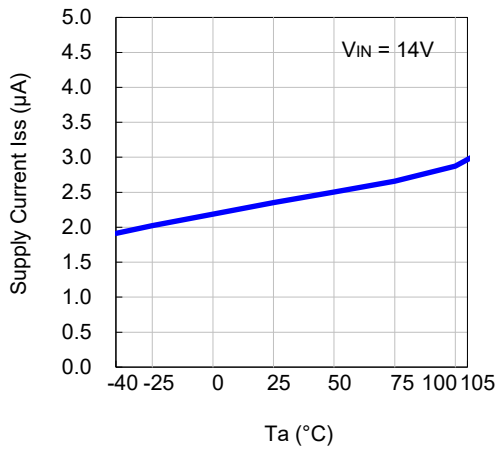
R1524x018B



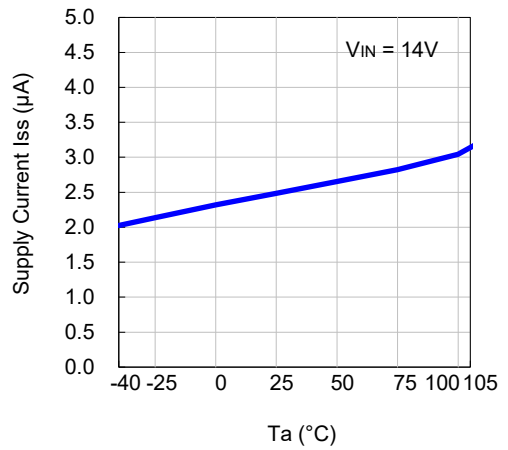
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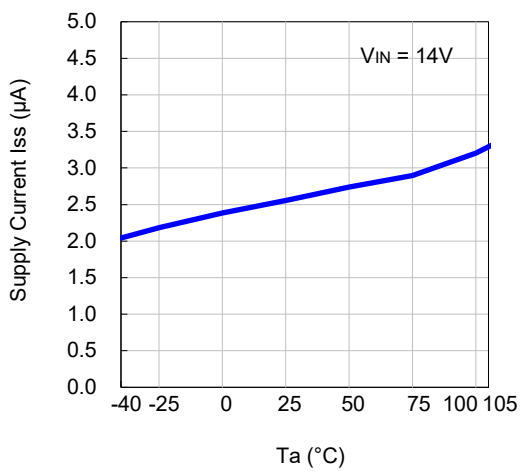
R1524x050B



R1524x090B

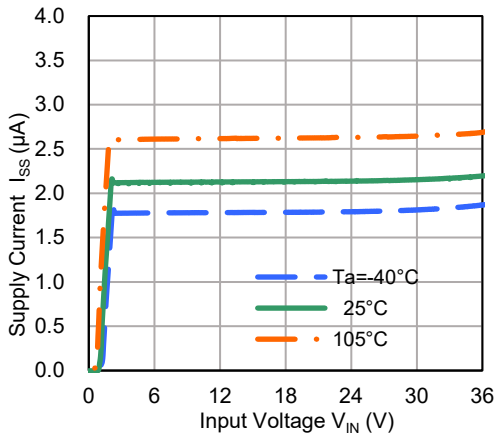


R1524x120B

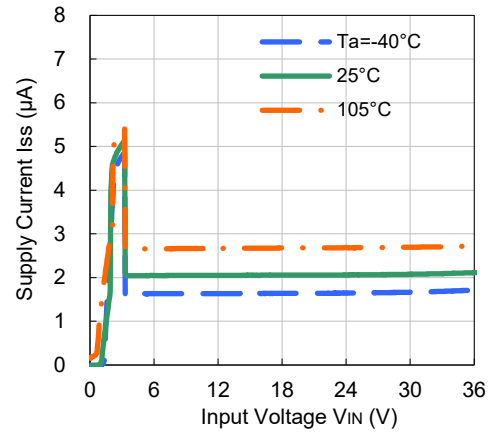


4) Supply Current vs. Input Voltage

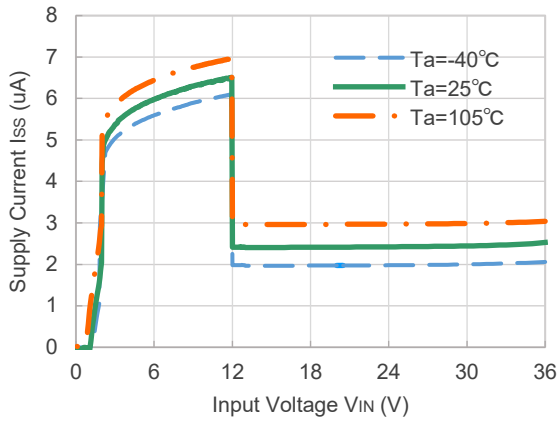
R1524x018B



R1524x033B

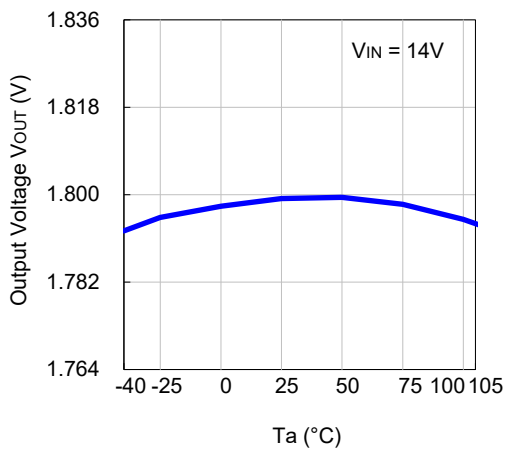


R1524x120B

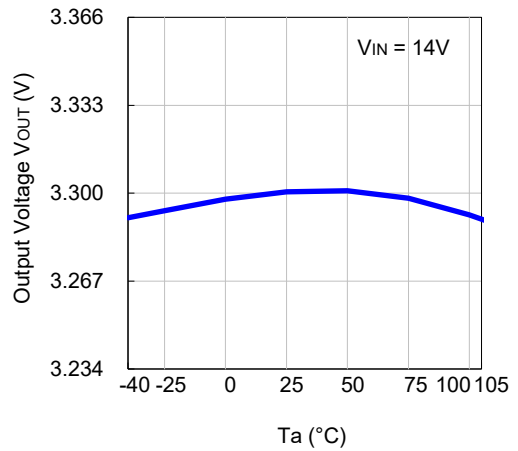


5) Output Voltage vs. Temperature ( $I_{OUT} = 1\text{ mA}$ )

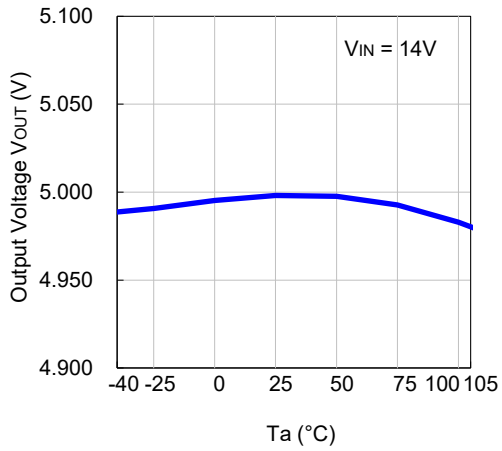
R1524x018B



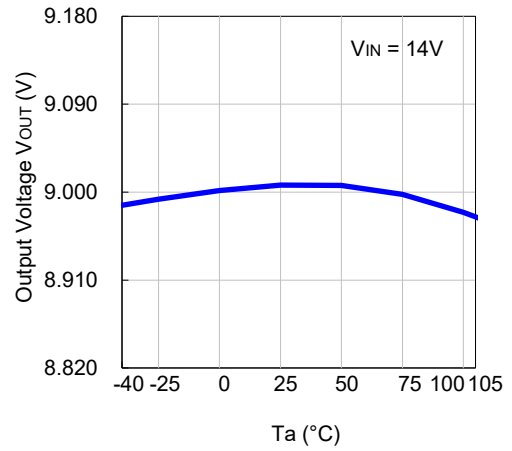
R1524x033B



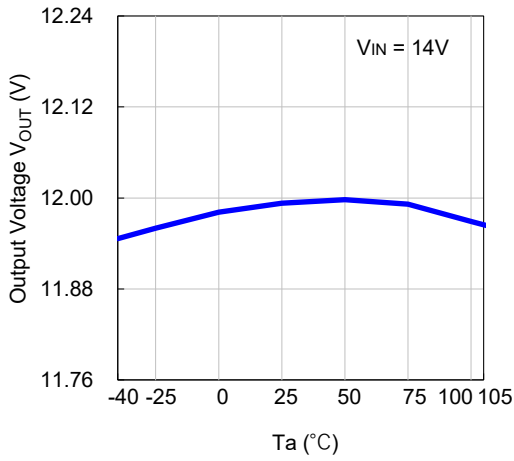
**R1524x050B**



**R1524x090B**

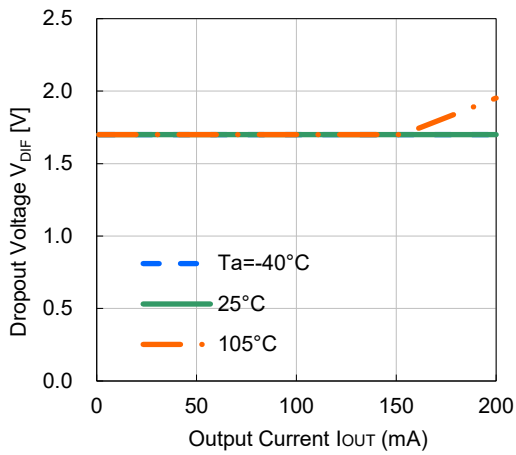


**R1524x120B**

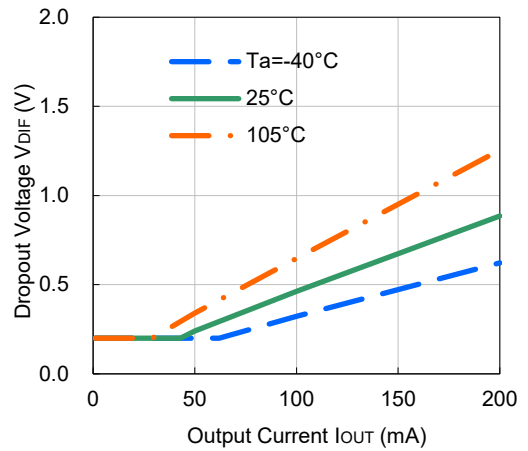


**6) Dropout Voltage vs. Output Current**

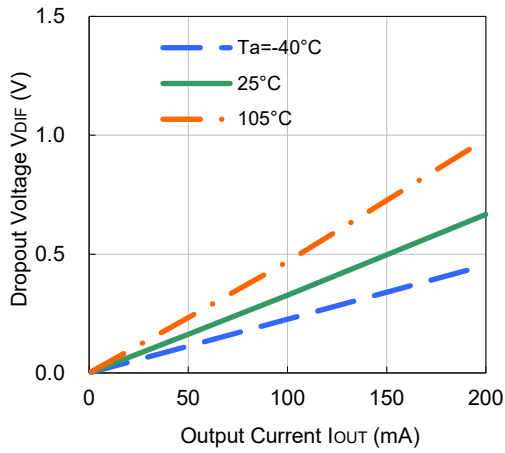
**R1524x018B**



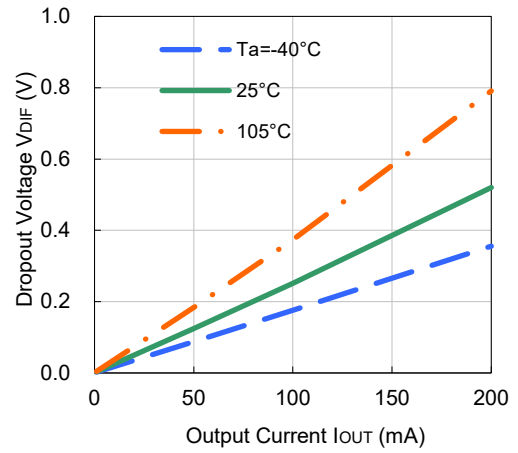
**R1524x033B**



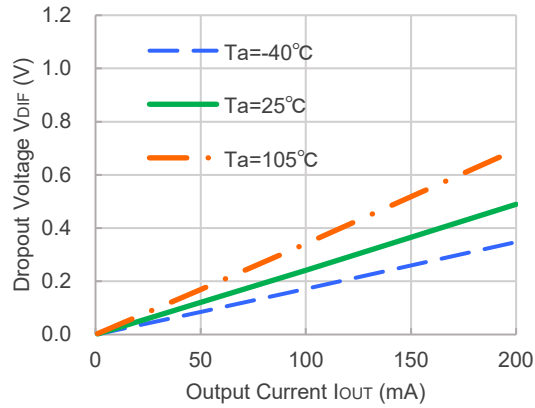
R1524x050B



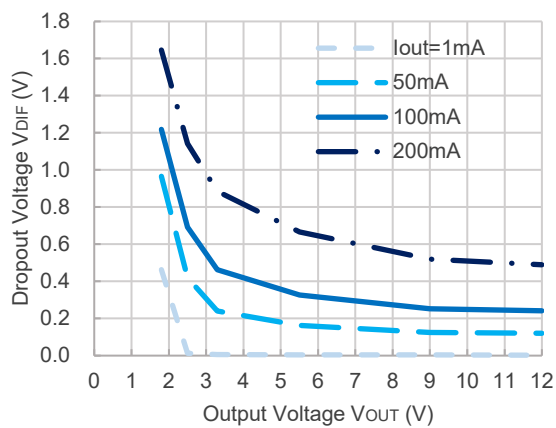
R1524x090B



R1524x120B

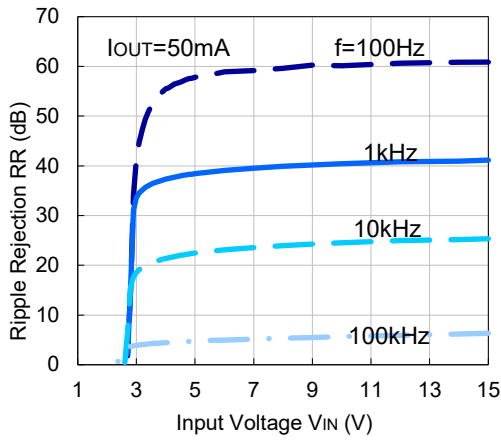


7) Dropout Voltage vs. Output Voltage ( $T_a = 25^\circ\text{C}$ )

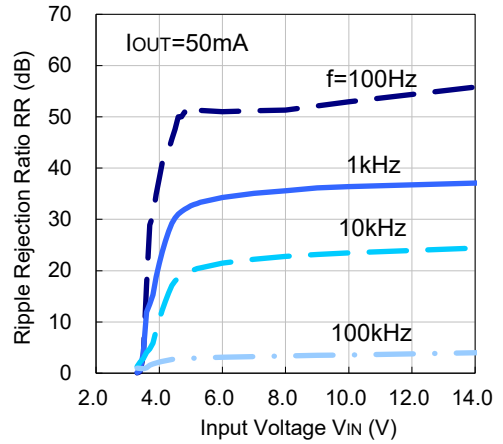


8) Ripple Rejection vs. Input Voltage (Ta = 25°C, Ripple = 0.2 Vpp)

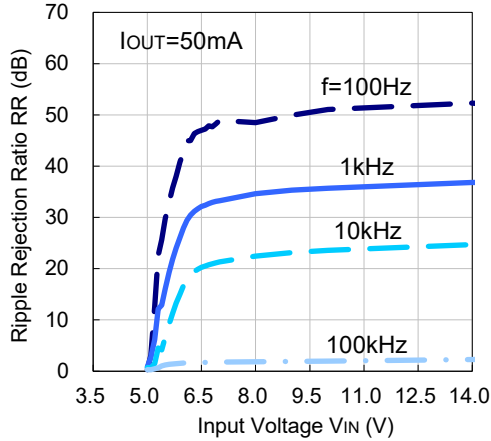
R1524x018B



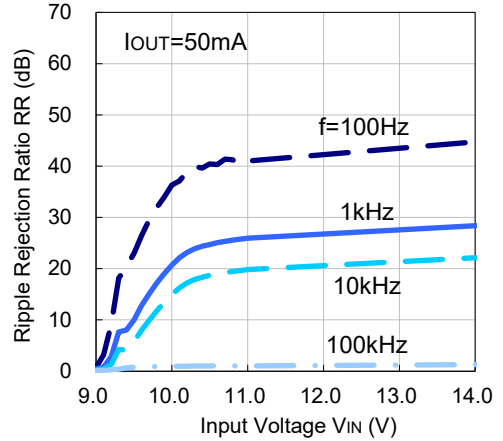
R1524x033B



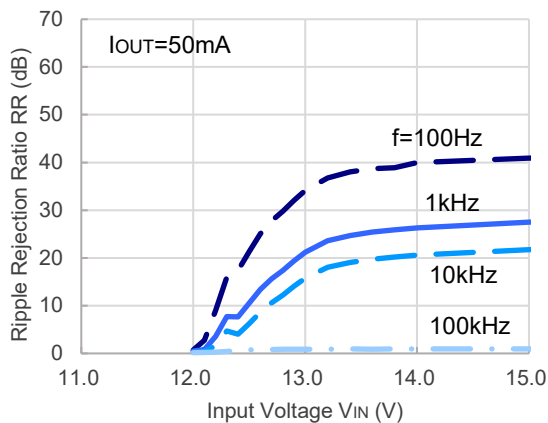
R1524x050B



R1524x090B



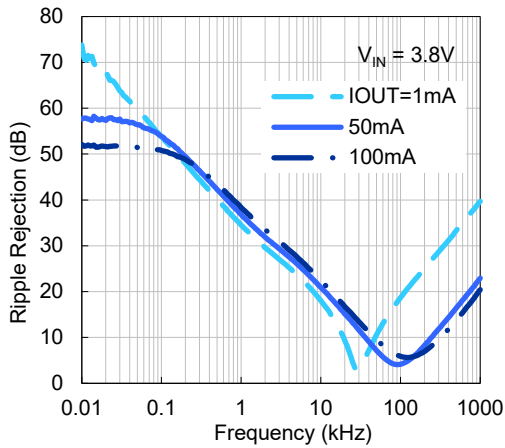
R1524x120B



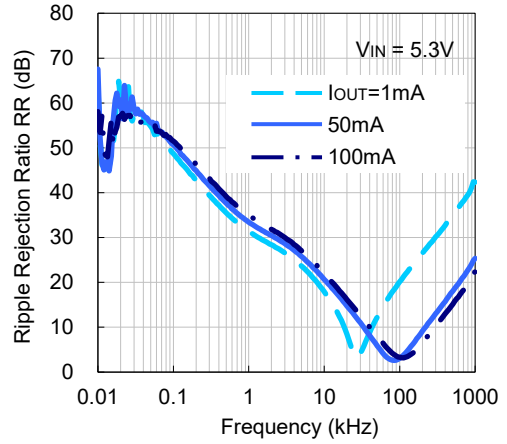


9) Ripple Rejection vs. Frequency (Ta = 25°C, Ripple = 0.2 Vpp)

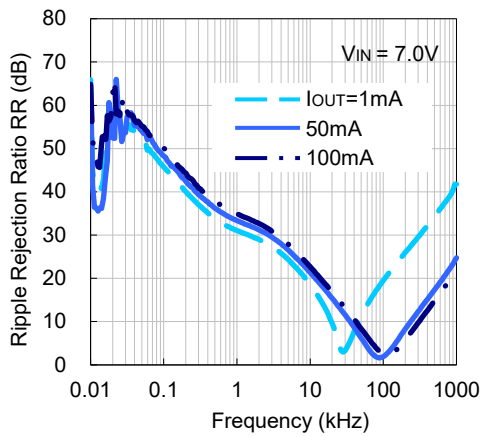
R1524x018B



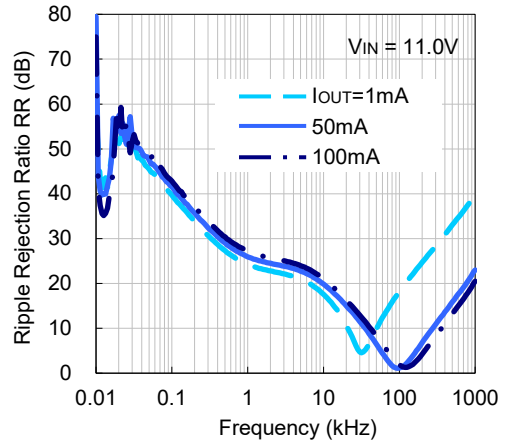
R1524x033B



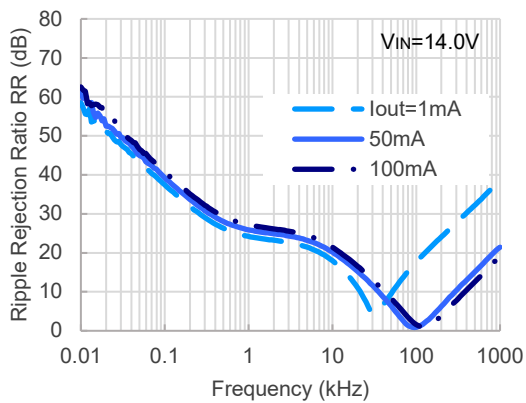
R1524x050B



R1524x090B

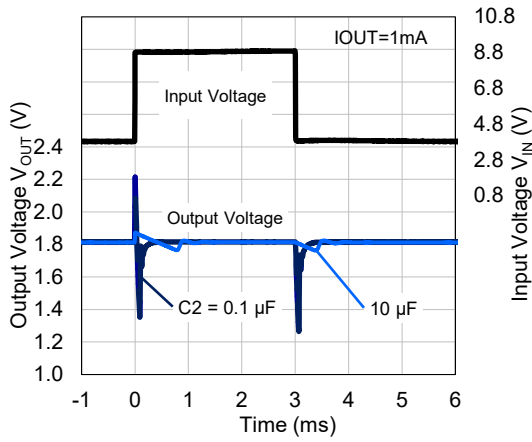


R1524x120B

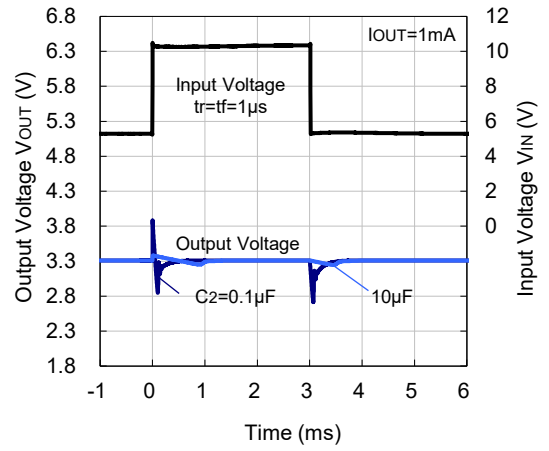


10) Input Transient Response (Ta = 25°C)

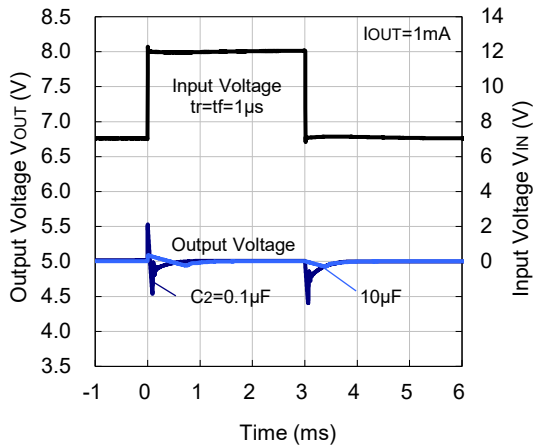
R1524x018B



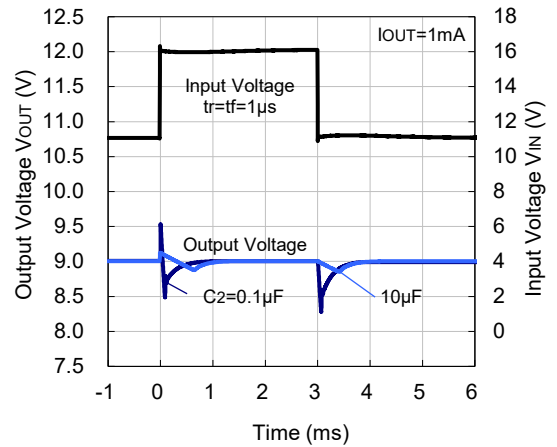
R1524x033B



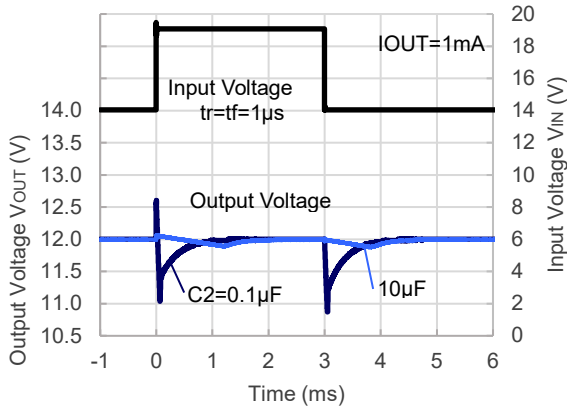
R1524x050B



R1524x090B

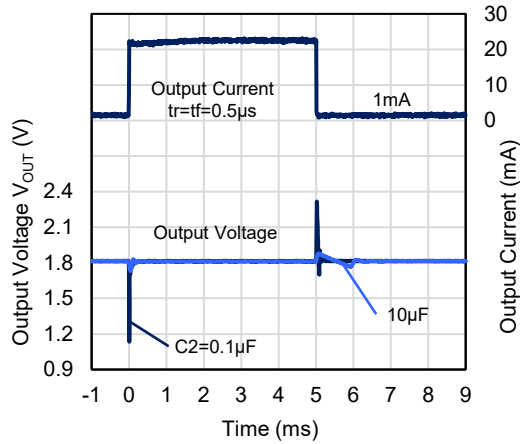


R1524x120B

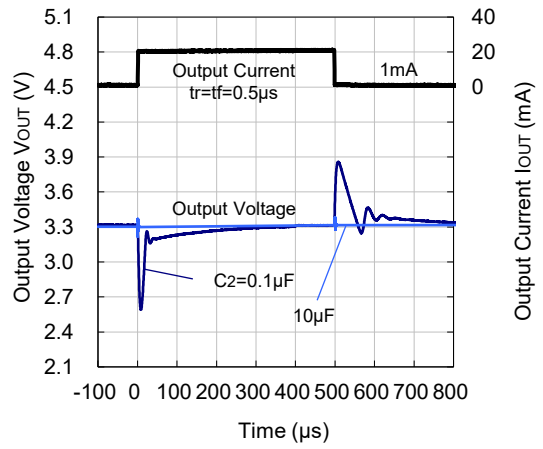


11) Load Transient Response (Ta = 25°C)

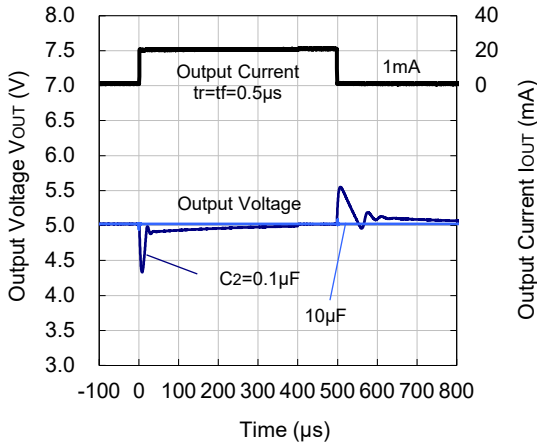
R1524x018B



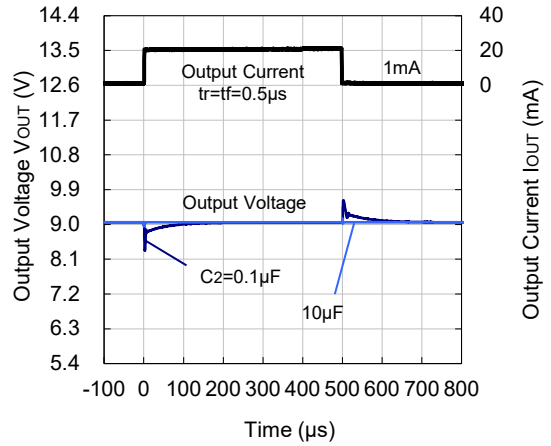
R1524x033B



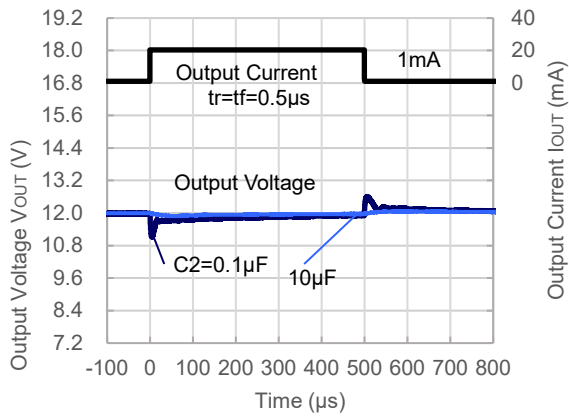
R1524x050B



R1524x090B

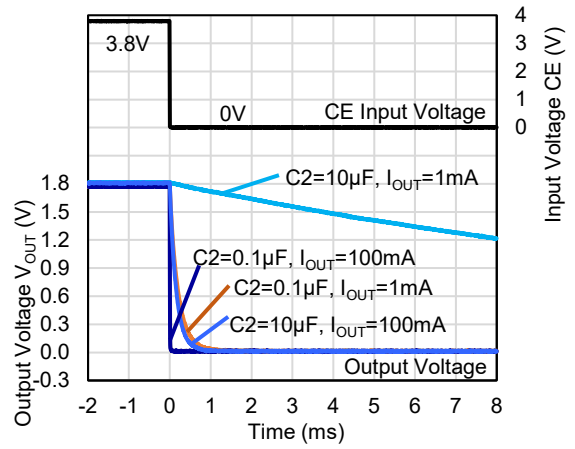
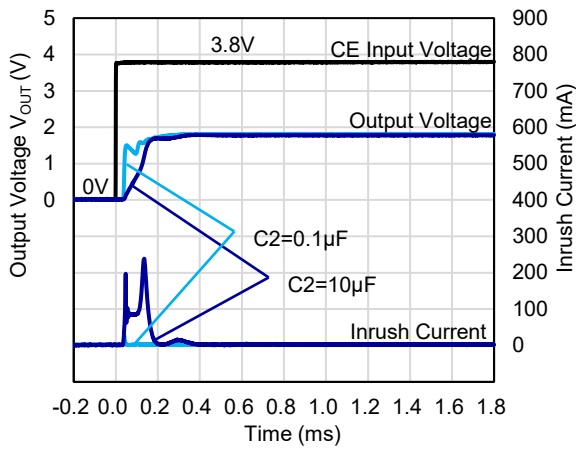


R1524x120B

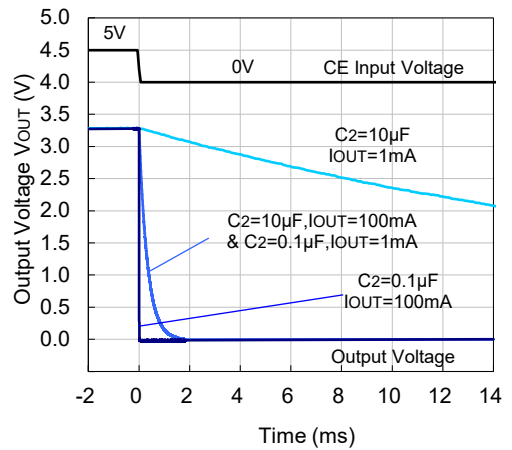
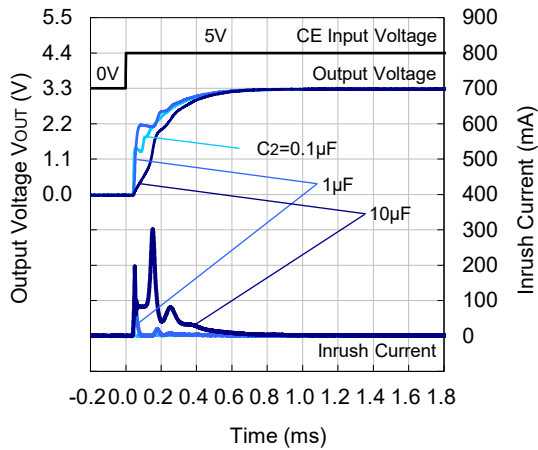


12) CE Transient Response ( $T_a = 25^\circ\text{C}$ )

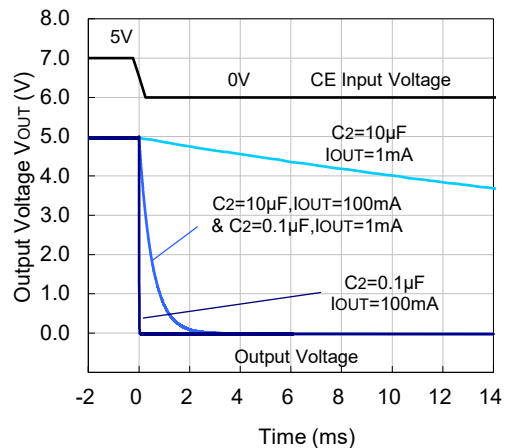
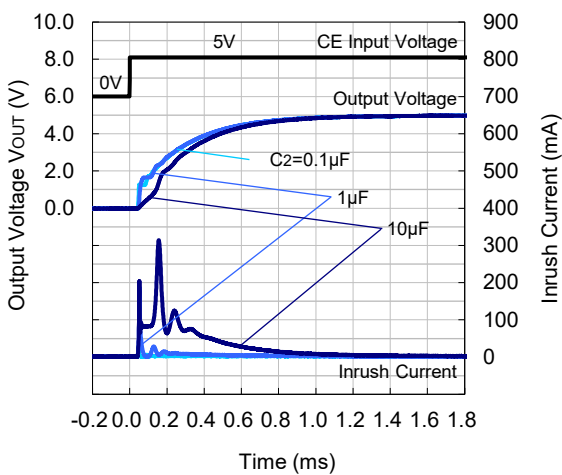
R1524x018B



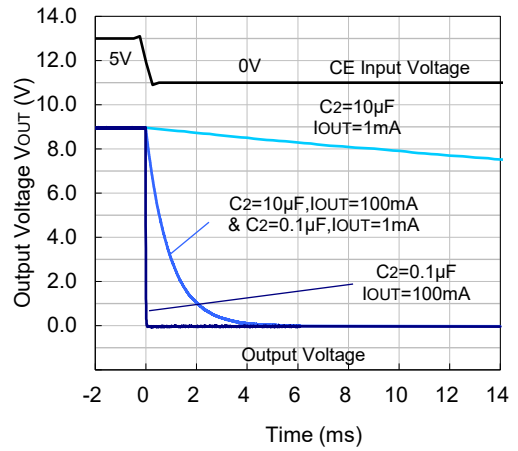
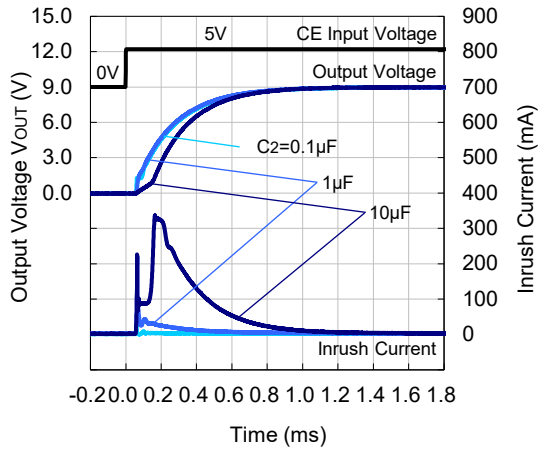
R1524x033B



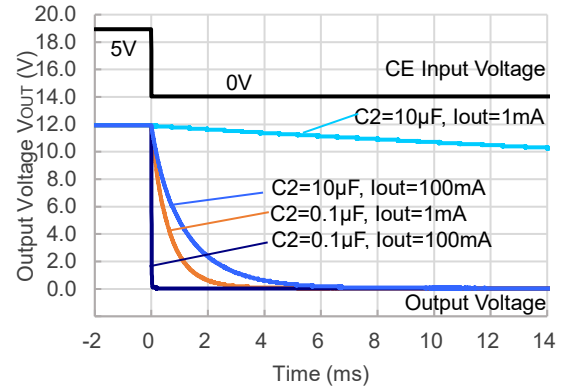
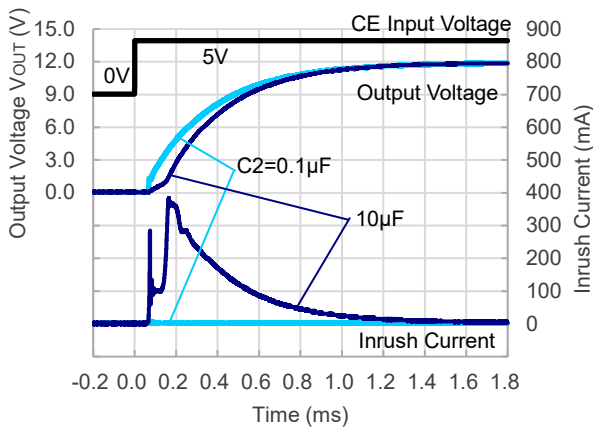
R1524x050B



**R1524x090B**

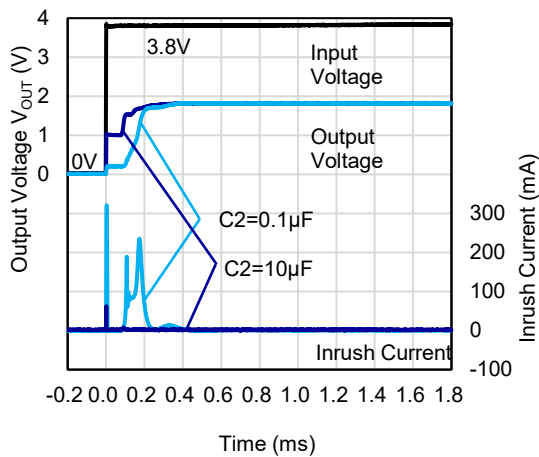


**R1524x120B**

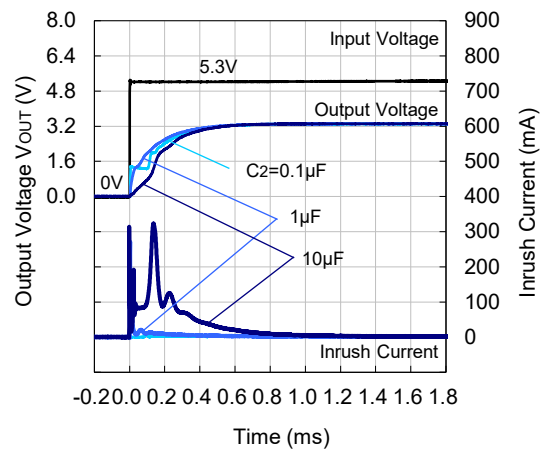


**13) Power-on Transient Response (Ta = 25°C, VCE = 5 V)**

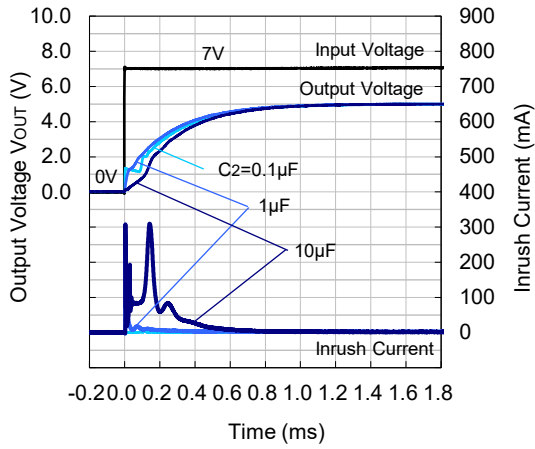
**R1524x018B**



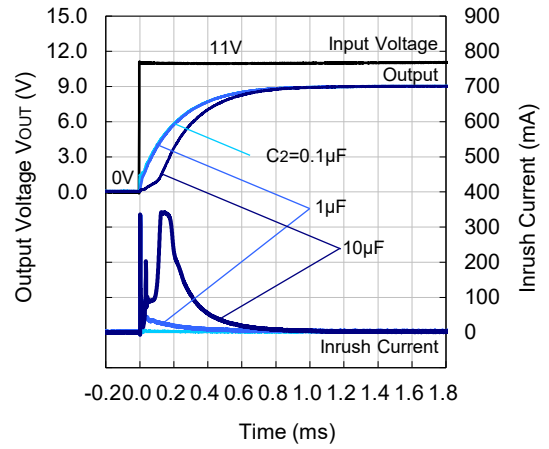
**R1524x033B**



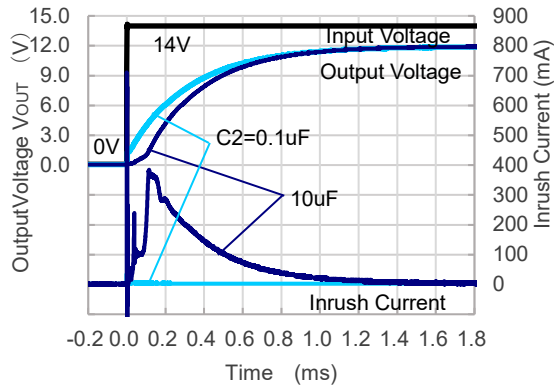
R1524x050B



R1524x090B

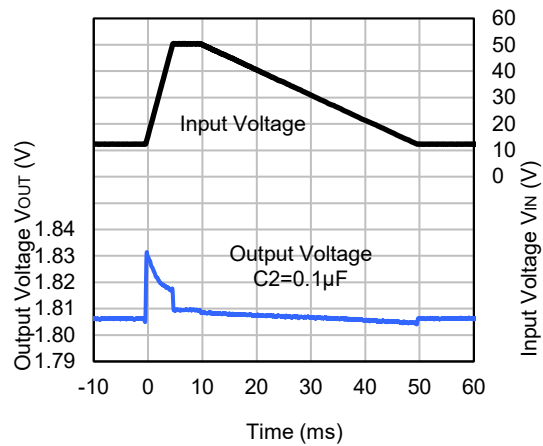


R1524x120B

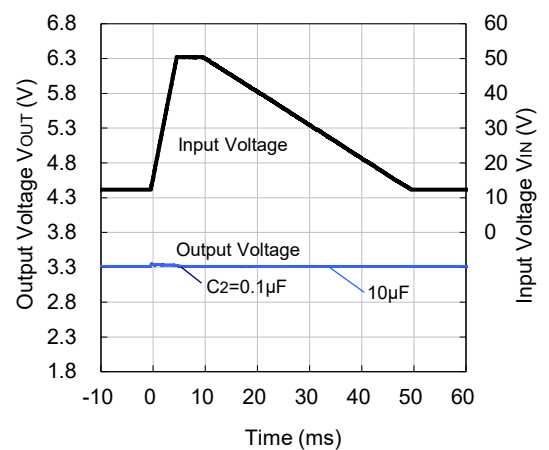


14) Load Dump (Ta = 25°C)

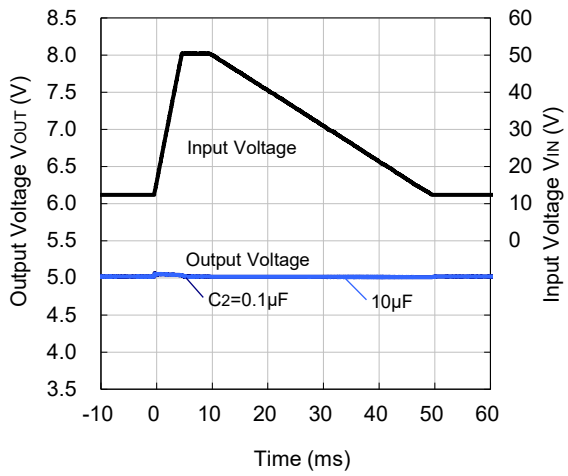
R1524x018B



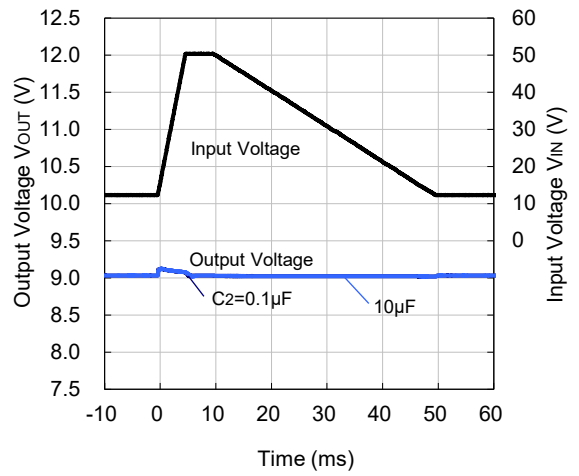
R1524x033B



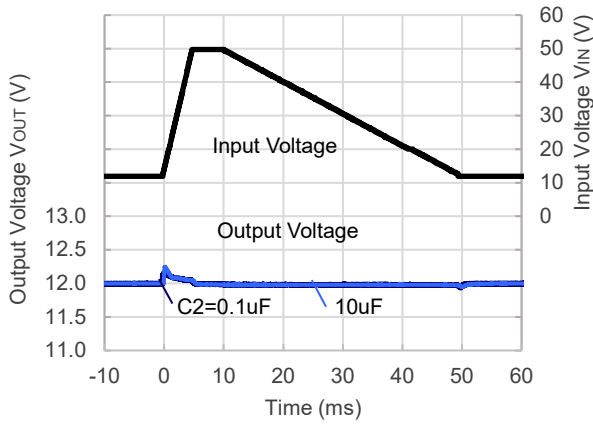
R1524x050B



R1524x090B

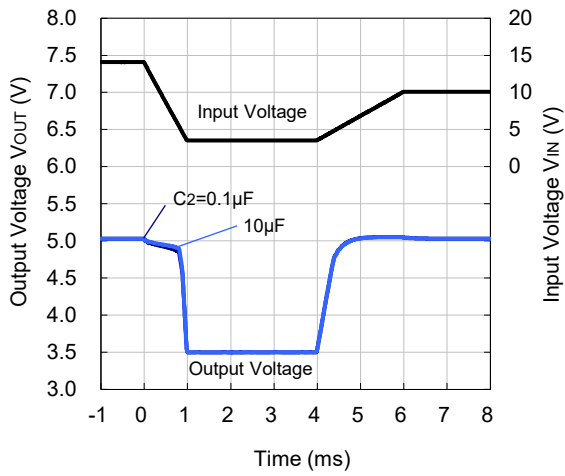


R1524x120B

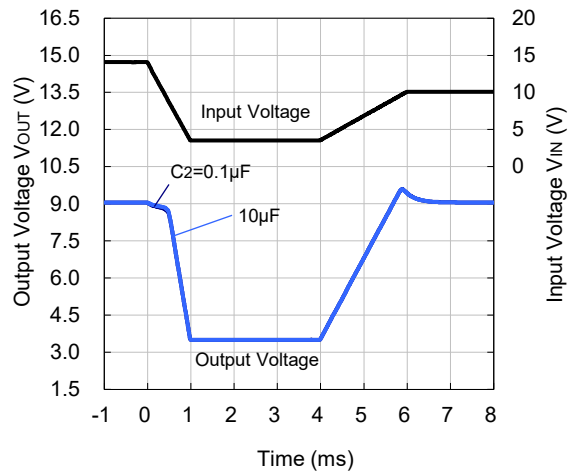


15) Cranking (Ta = 25°C)

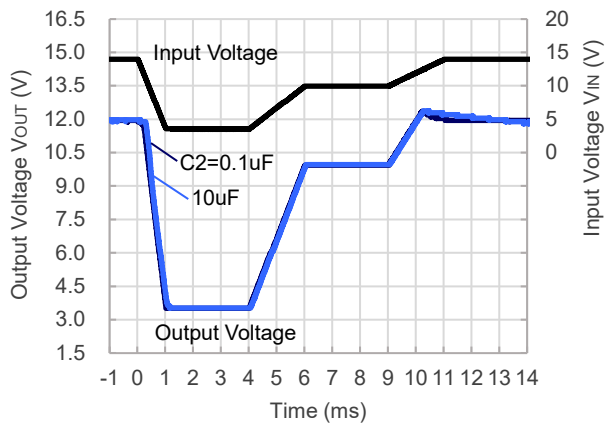
R1524x050B



R1524x090B



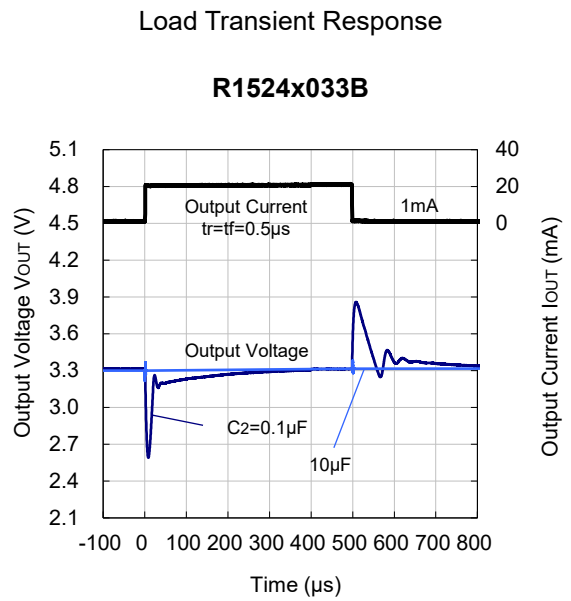
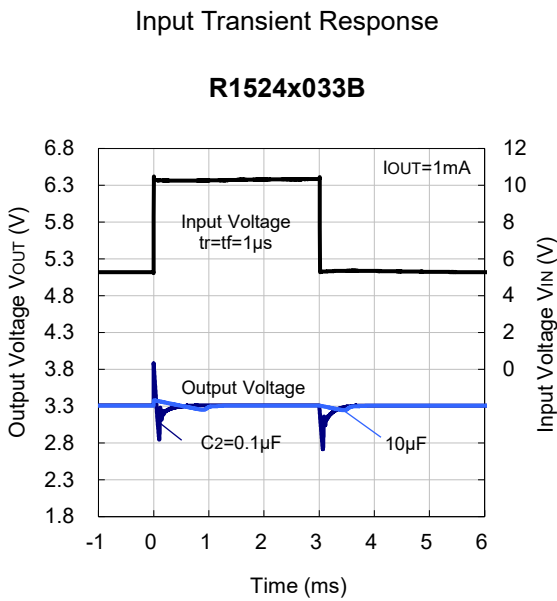
R1524x120B





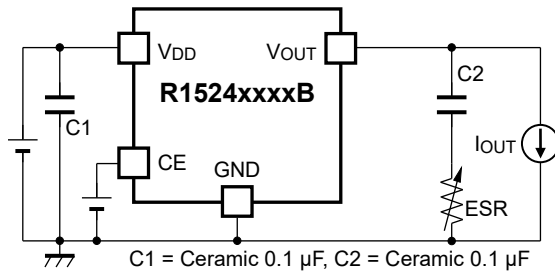
**Input Transient/Load Transient vs. Output Capacity (C2)**

R1524 performs a stable operation by using 0.1  $\mu\text{F}$  of ceramic capacitor as the output capacitor. However, the variation of output voltage may not meet the demand of the system when input voltage and load current vary. In such cases, the variation of output voltage can be minimized significantly by using 10  $\mu\text{F}$  or higher ceramic capacitor. When using an electrolytic capacitor for the output line, place the electrolytic capacitor outer side of the ceramic capacitor arranged close to the IC.

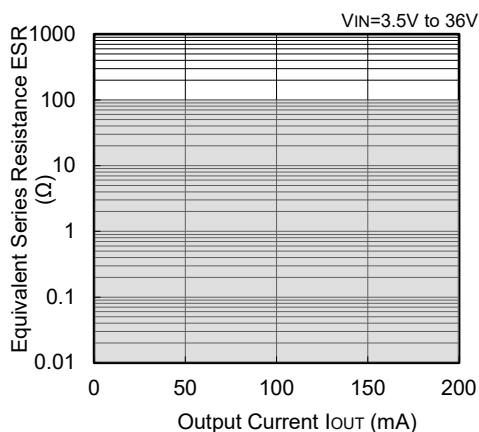


**ESR vs. Output Current**

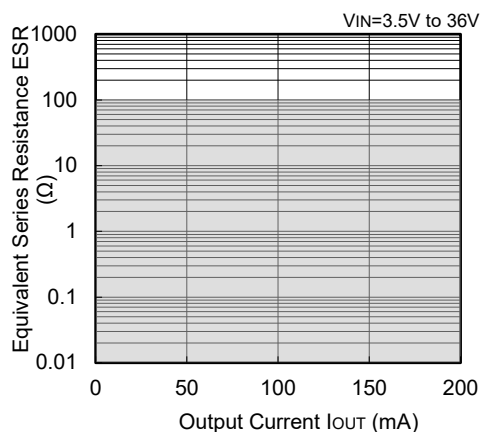
It is recommended that a ceramic type capacitor be used for this device. However, other types of capacitors having lower ESR can also be used. The relation between the output current ( $I_{OUT}$ ) and the ESR of output capacitor is shown below.



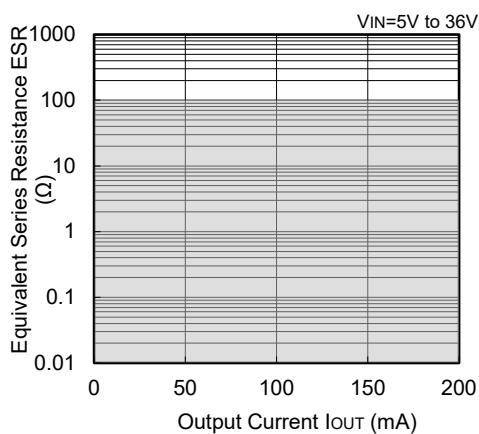
**R1524x018B**



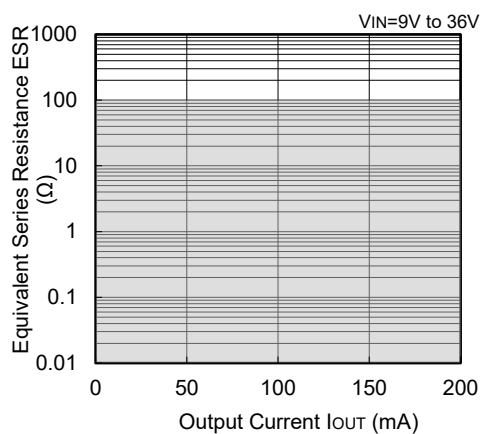
**R1524x033B**



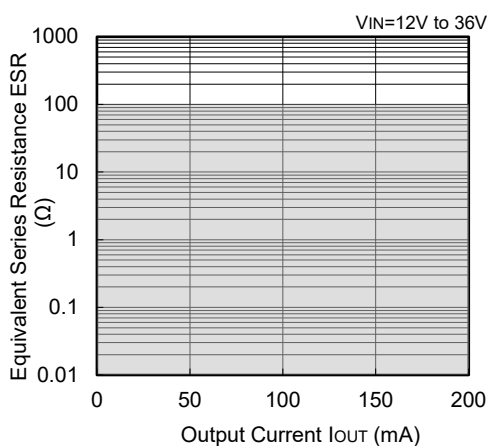
**R1524x050B**



**R1524x090B**



**R1524x120B**



**Measurement Conditions**

Frequency Band: 10 Hz to 2 MHz

Measurement Temperature: -40°C to 105°C

Hatched area: Noise level is 40 μV (average) or below

Ceramic Capacitors:

C<sub>IN</sub> = 0.1 μF, Murata, GRM188R71H104JA93D

C<sub>OUT</sub> = 0.1 μF, TDK, CGA3E2X7R1E104K

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

**Measurement Conditions**

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	φ 0.3 mm × 7 pcs

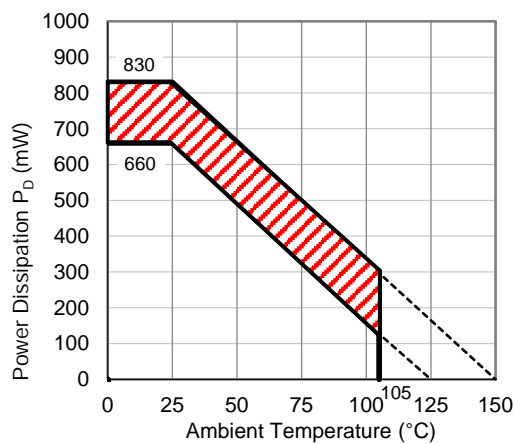
**Measurement Result**

(Ta = 25°C, Tjmax = 125°C)

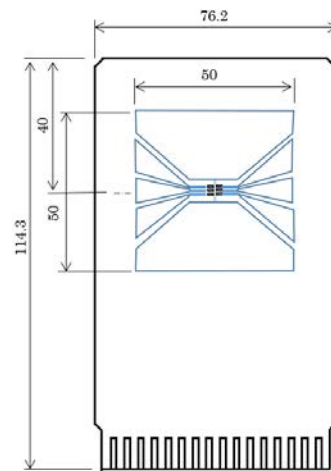
Item	Measurement Result
Power Dissipation	660 mW
Thermal Resistance (θja)	θja = 150°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 51°C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter



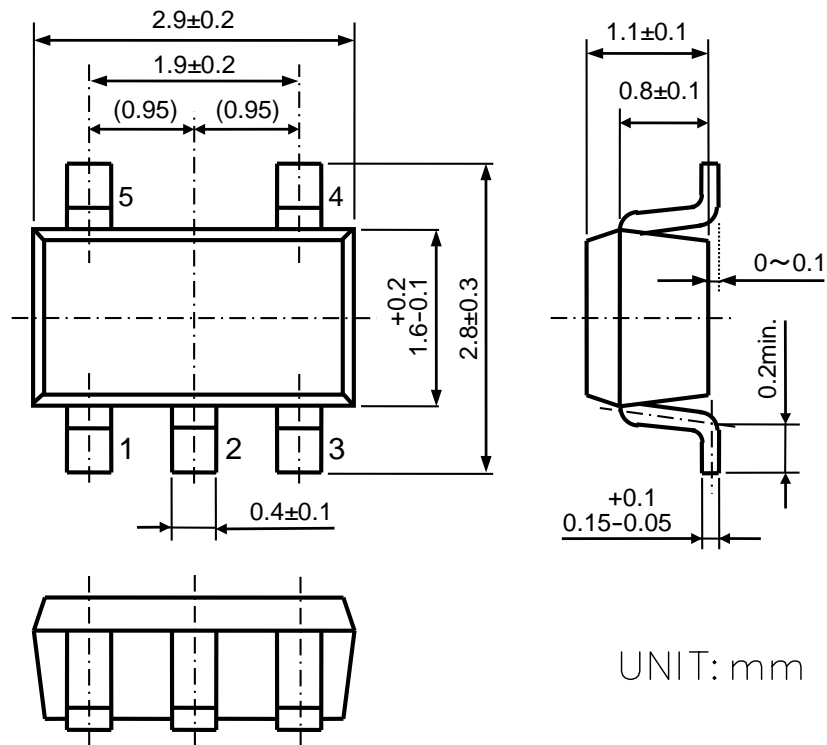
**Power Dissipation vs. Ambient Temperature**



**Measurement Board Pattern**

The above graph shows the power dissipation of the package at Tjmax = 125°C and Tjmax = 150°C. Operating the device in the hatched range might have a negative influence on its lifetime. The total hours of use and the total years of use must be limited as follows:

Total Hours of Use	Total Years of Use (4 hours/day)
13,000 hours	9 years



SOT-23-5 Package Dimensions

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

**Measurement Conditions**

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	φ 0.3 mm × 13 pcs

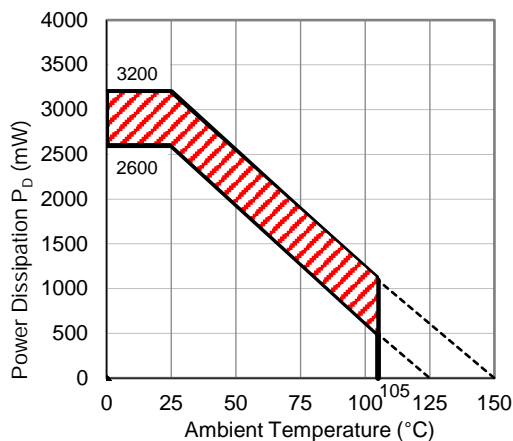
**Measurement Result**

(Ta = 25°C, Tjmax = 125°C)

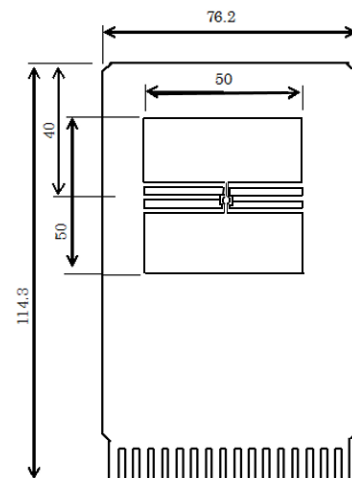
Item	Measurement Result
Power Dissipation	2600 mW
Thermal Resistance (θja)	θja = 38°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 13°C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter



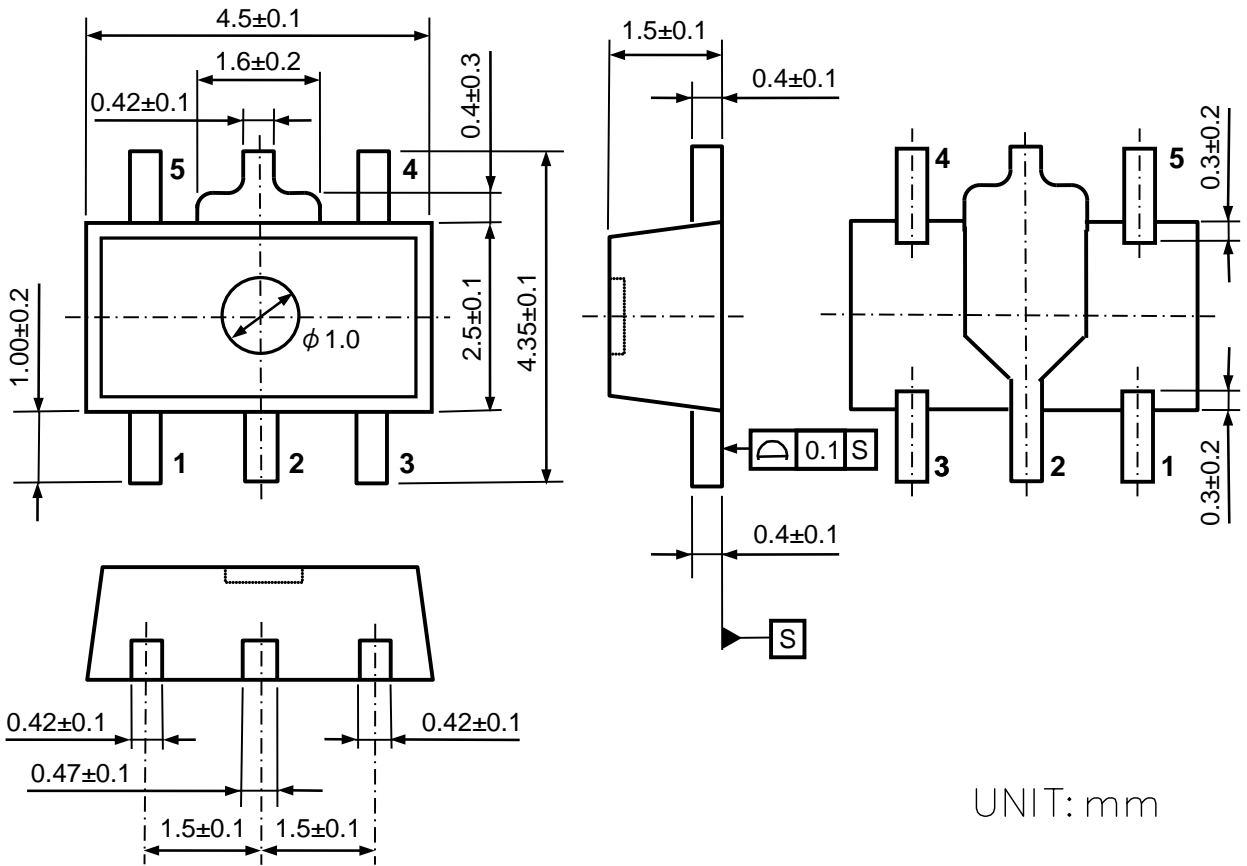
**Power Dissipation vs. Ambient Temperature**



**Measurement Board Pattern**

The above graph shows the power dissipation of the package at Tjmax = 125°C and Tjmax = 150°C. Operating the device in the hatched range might have a negative influence on its lifetime. The total hours of use and the total years of use must be limited as follows:

Total Hours of Use	Total Years of Use (4 hours/day)
13,000 hours	9 years



SOT-89-5 Package Dimensions

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

**Measurement Conditions**

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	φ 0.3 mm × 28 pcs

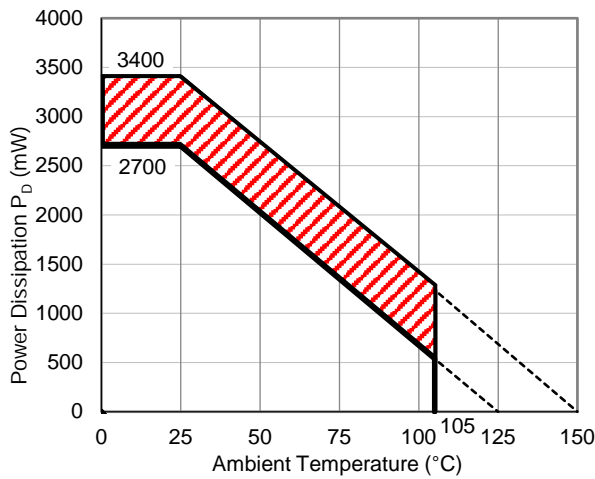
**Measurement Result**

(Ta = 25°C, Tjmax = 125°C)

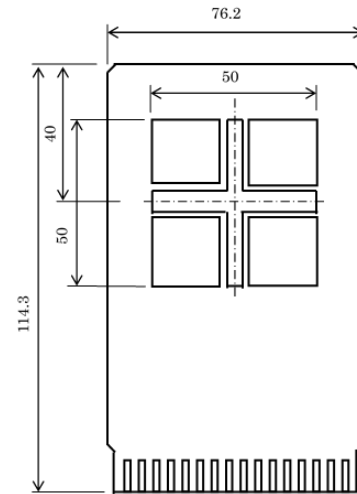
Item	Measurement Result
Power Dissipation	2700 mW
Thermal Resistance (θja)	θja = 37°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 7°C/W

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter



**Power Dissipation vs. Ambient Temperature**



**Measurement Board Pattern**

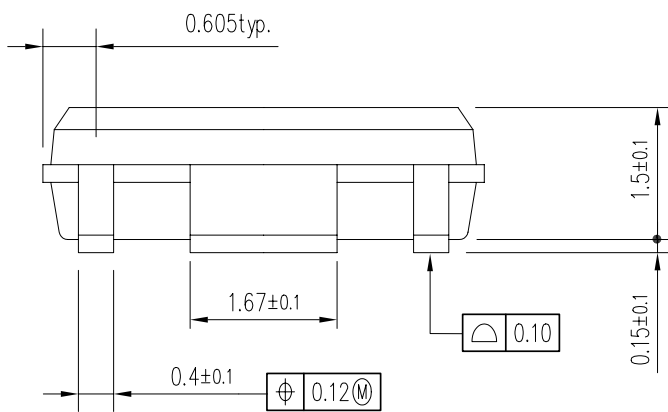
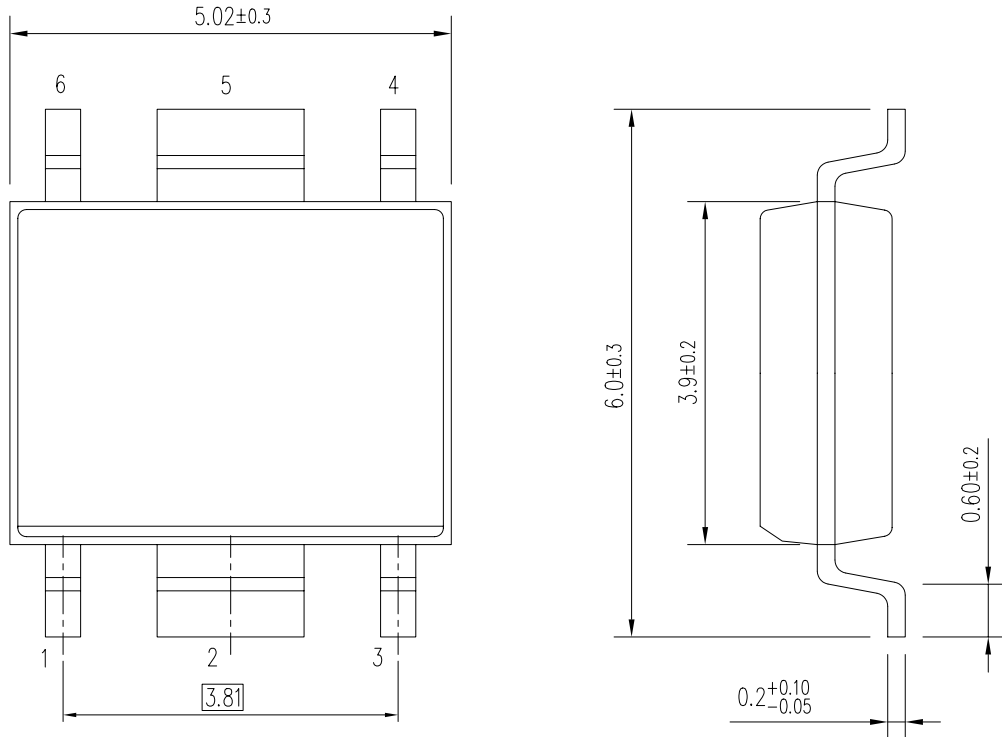
The above graph shows the power dissipation of the package at Tjmax = 125°C and Tjmax = 150°C. Operating the device in the hatched range might have a negative influence on its lifetime. The total hours of use and the total years of use must be limited as follows:

Total Hours of Use	Total Years of Use (4 hours/day)
13,000 hours	9 years

**PACKAGE DIMENSIONS**

**HSOP-6J**

DM-HSOP-6J-JE-A



UNIT: mm

**HSOP-6J Package Dimensions**



# POWER DISSIPATION

# DFN(PL)1820-6

PD-DFN(PL)1820-6-(105125150)-JE-C

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51.

### Measurement Conditions

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	φ 0.2 mm × 36 pcs

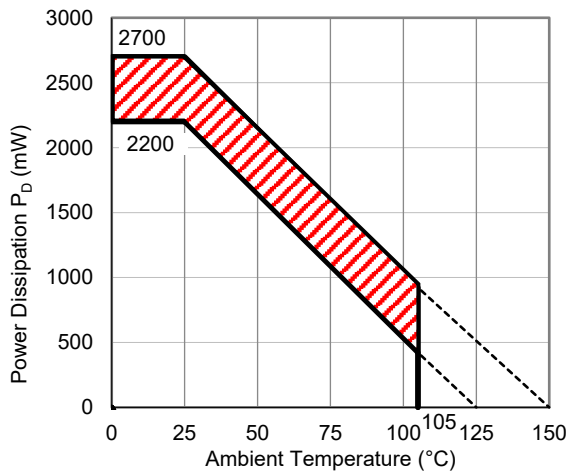
### Measurement Result

(Ta = 25°C, Tjmax = 125°C)

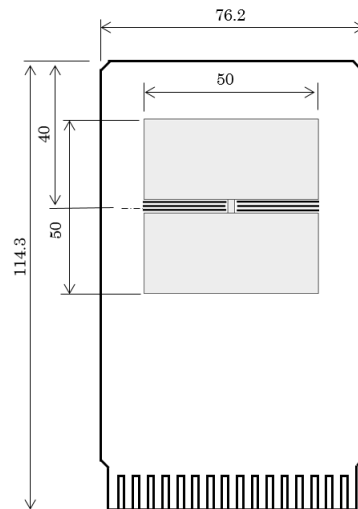
Item	Measurement Result
Power Dissipation	2200 mW
Thermal Resistance (θja)	θja = 45°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 18°C/W

θja: Junction-to-ambient thermal resistance.

ψjt: Junction-to-top of package thermal characterization parameter.



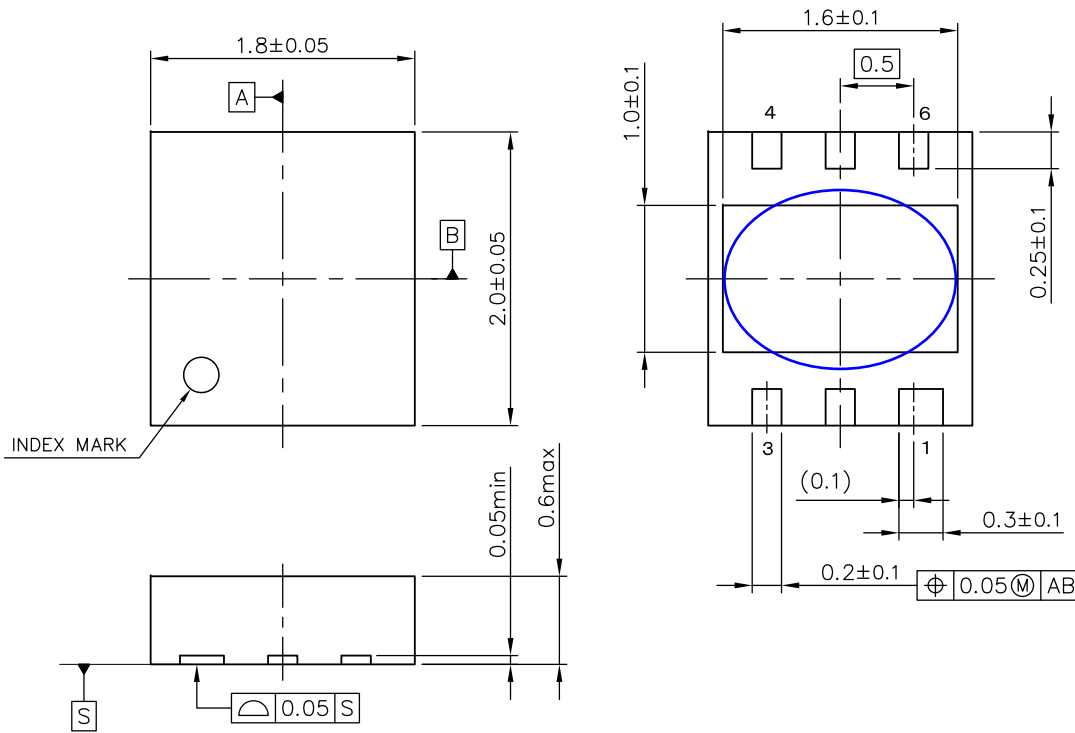
**Power Dissipation vs. Ambient Temperature**



**Measurement Board Pattern**

The above graph shows the power dissipation of the package at Tjmax = 125°C and Tjmax = 150°C. Operating the device in the hatched range might have a negative influence on its lifetime. The total hours of use and the total years of use must be limited as follows:

Total Hours of Use	Total Years of Use (4 hours/day)
13,000 hours	9 years



UNIT: mm

**DFN(PL)1820-6 Package Dimensions**

\* The tab on the bottom of the package is substrate level (GND/V<sub>DD</sub>). It is recommended that the tab be connected to the ground plane/the VDD pin on the board, or otherwise be left floating.

# POWER DISSIPATION

# HSOP-8E

PD-HSOP-8E-(105125150)-JE-B

The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following measurement conditions are based on JEDEC STD. 51-7.

### Measurement Conditions

Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx. 100% of 50 mm Square Outer Layer (Fourth Layer): Approx. 100% of 50 mm Square
Through-holes	φ 0.3 mm × 21 pcs

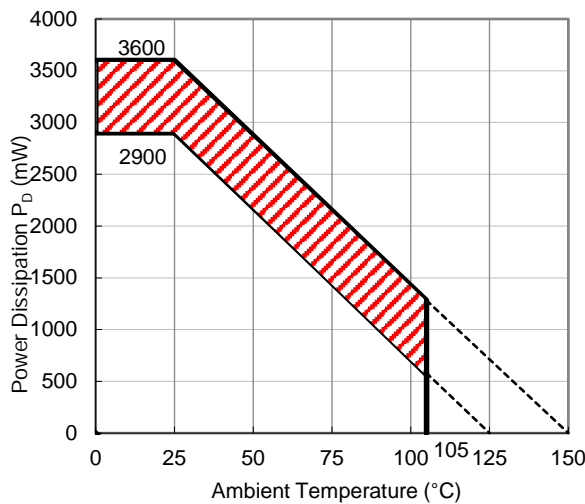
### Measurement Result

(Ta = 25°C, Tjmax = 125°C)

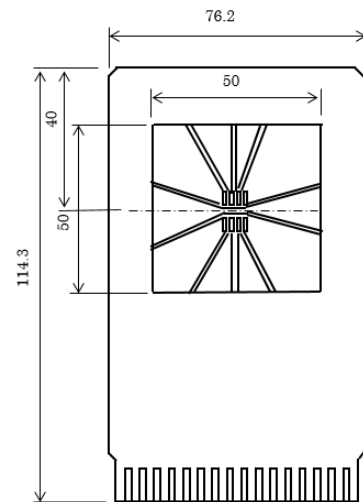
Item	Measurement Result
Power Dissipation	2900 mW
Thermal Resistance (θja)	θja = 34.5°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 10 °C/W

θja: Junction-to-ambient thermal resistance.

ψjt: Junction-to-top of package thermal characterization parameter.



**Power Dissipation vs. Ambient Temperature**



**Measurement Board Pattern**

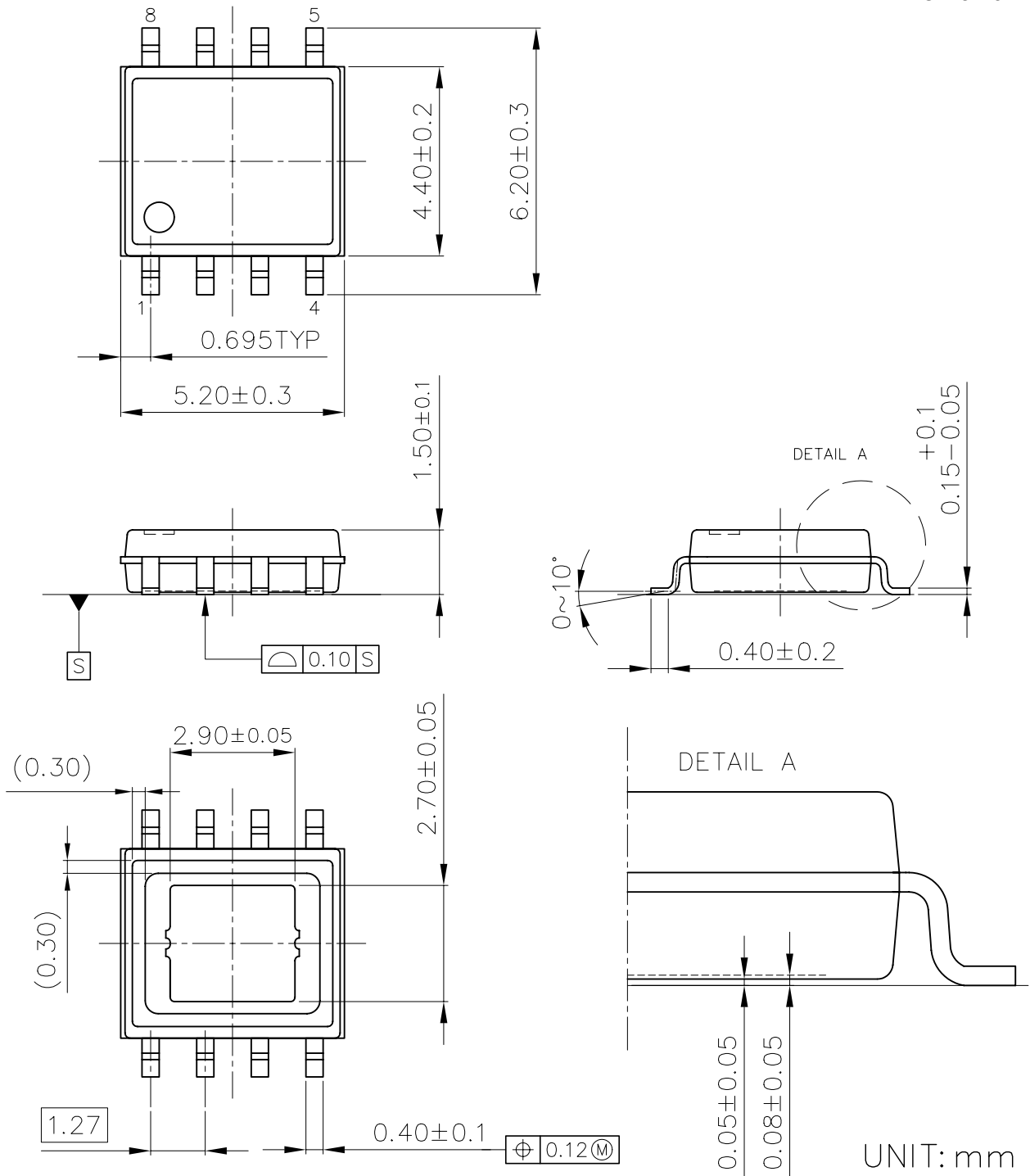
The above graph shows the power dissipation of the package at Tjmax = 125°C and Tjmax = 150°C. Operating the device in the hatched range might have a negative influence on its lifetime. The total hours of use and the total years of use must be limited as follows:

Total Hours of Use	Total Years of Use (4 hours/day)
13,000 hours	9 years

# PACKAGE DIMENSIONS

# HSOP-8E

DM-HSOP-8E-JE-B



UNIT: mm

HSOP-8E Package Dimensions

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When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.

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With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
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