R1526x Series

300 mA, 42 V Voltage Regulator with High Noise Immunity

No. EA-527-201014

OVERVIEW

The R1526x is a voltage regulator featuring 300mA output current and 42 V maximum input voltage. Since this device has excellent noise immunity to external electromagnetic interference, it is suitable for use in environments where electromagnetic waves may cause malfunctions.

KEY BENEFITS

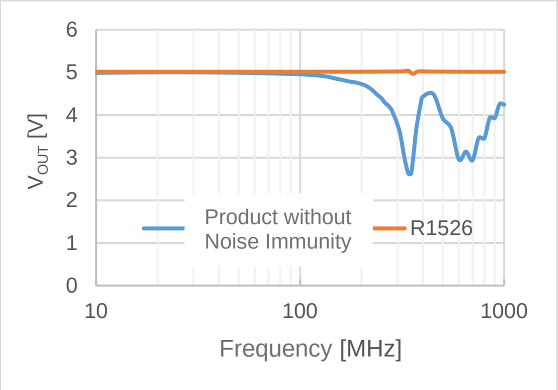
- Excellent noise immunity. Refer to *Noise Immunity Test* in Typical Characteristics.
- Pin configuration considering functional safety

KEY SPECIFICATIONS

- Input Voltage Range (Maximum Rating):
  3.5 V to 42 V (50 V)
- Operating temperature range: -40°C to 105°C
- Standby Current: Typ. 0.1 µA
- Dropout Voltage: Max. 0.5 V (I_{OUT} = 200 mA, V_{OUT} = 5.0 V)
- Output Voltage: 1.8 V to 9.0 V (in 0.1 V step)
- Output Voltage Accuracy: ±0.6 % (Ta = 25°C)
  ±1.6 % (-40°C ≤ Ta ≤ 105°C)
- Line Regulation: Typ. 0.01%/V (V_{SET} + 1 V ≤ V_{IN} ≤ 42 V)
- Short-circuit Protection: Limit at Typ. 100 mA
- Overcurrent Protection: Limit at Typ. 450 mA
- Thermal Shutdown: Detection Temperature. Typ. 160°C
- Output capacitor: C_{OUT} ≥ 10 µF
- Ripple Rejection: Typ. 50 dB (f = 100 Hz)

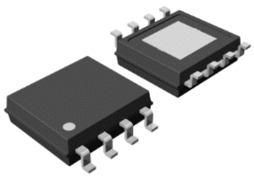
TYPICAL CHARACTERISTICS

Noise Immunity Test



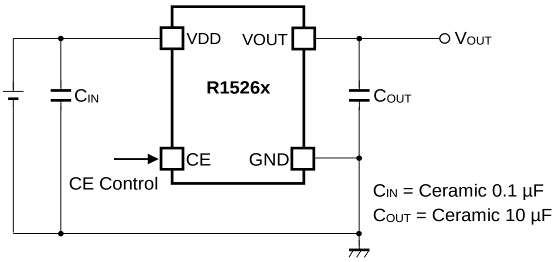
DPI method

PACKAGE



HSOP-8E
5.2 x 6.2 x 1.45 mm

TYPICAL APPLICATION



APPLICATIONS

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

SELECTION GUIDE

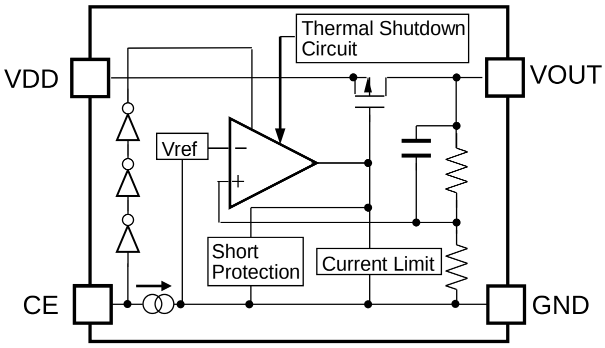
The set output voltage is user-selectable.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1526Sxx1B-E2-FE	HSOP-8E	1,000 pcs	Yes	Yes

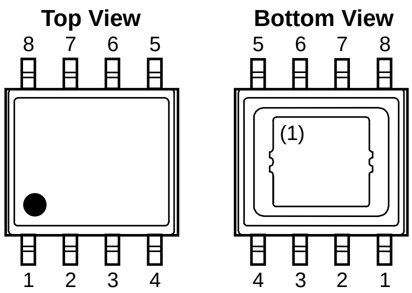
xx: Specify the set output voltage (V_{SET})
1.8 V (18) to 9.0 V (90) in 0.1 V step
Refer to *Product-specific Electrical Characteristics* for details.

BLOCK DIAGRAM



R1526x Block Diagram

PIN DESCRIPTIONS

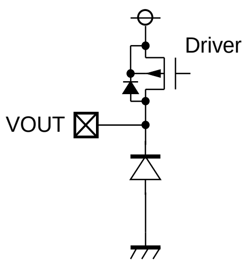


HSOP-8E Pin Configuration

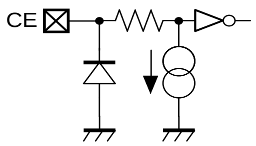
HSOP-8E Pin Descriptions

Pin No.	Pin Name	Description
1	VOUT	Output Pin
2	NC[2]	No Connection
3	NC[2]	No Connection
4	CE	Chip Enable Pin (Active-high)
5	GND[3]	Ground Pin
6	GND[3]	Ground Pin
7	NC[2]	No Connection
8	VDD	Input Pin

Pin Equivalent Circuit Diagrams



VOUT Pin Equivalent Circuit Diagram



CE Pin Equivalent Circuit Diagram

[1] The tab on the bottom of the package is substrate level (GND). The tab must be connected to the ground plane on the board.
[2] NC pin should be set to “Open”.
[3] GND pins should be connected together when mounted on a board.

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{IN}	VIN Pin Input Voltage	−0.3 to 50	V
V_{IN}	VIN Pin Peak Voltage(1)	60	V
V_{CE}	CE Pin Input Voltage	−0.3 to 50	V
V_{CE}	CE Pin Peak Voltage (1)	60	V
V_{OUT}	VOUT Pin Voltage	−0.3 to V_{IN} + 0.3 ≤ 50	V
I_{OUT}	Output Current	500	mA
P_D	Power Dissipation	Refer to Appendix *"Power Dissipation"*	
Tj	Junction Temperature Range	−40 to 125	°C
Tstg	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 is not assured.

RECOMMENDED OPERATING CONDITIONS

Recommended Operating Conditions

Symbol	Parameter	Rating	Unit
V_{IN}	Operating Input Voltage	3.5 to 42	V
Ta	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.

(1) Duration time: within 200 ms

ELECTRICAL CHARACTERISTICS

V_{IN} = 14 V, V_{CE} = V_{IN}, unless otherwise specified.
The specifications surrounded by $\boxed{}$ are guaranteed by design engineering at −40°C ≤ Ta ≤ 105°C.

R1526x-FE Electrical Characteristics **(Ta = 25°C)**

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
I_{SS}	Supply Current	V_{IN} = 14 V, I_{OUT} = 0 mA			32	$\boxed{55}$	μA
Istandby	Standby Current	V_{IN} = 42 V, V_{CE} = 0 V			0.1	$\boxed{2.0}$	μA
V_{OUT}	Output Voltage	8 V(1) ≤ V_{IN} ≤ 16 V, I_{OUT} = 1 mA	Ta = 25°C	×0.994		×1.006	V
			−40°C ≤ Ta ≤ 105°C	$\boxed{\times 0.984}$		$\boxed{\times 1.016}$	
$\Delta V_{OUT}/\Delta I_{OUT}$	Load Regulation (2)	V_{IN} = V_{SET} + 2.0 V, 1 mA ≤ I_{OUT} ≤ 100 mA	1.8 V ≤ V_{SET} ≤ 2.8 V	$\boxed{-5}$		$\boxed{45}$	mV
			2.8 V < V_{SET} ≤ 5.4 V	$\boxed{-5}$		$\boxed{40}$	
			5.4 V < V_{SET} ≤ 9.0 V	$\boxed{-5}$		$\boxed{72}$	
		V_{IN} = V_{SET} + 2.0 V, 1 mA ≤ I_{OUT} ≤ 300 mA	1.8 V ≤ V_{SET} ≤ 2.8 V	$\boxed{-5}$		$\boxed{68}$	
			2.8 V < V_{SET} ≤ 5.4 V	$\boxed{-5}$		$\boxed{60}$	
			5.4 V < V_{SET} ≤ 9.0 V	$\boxed{-5}$		$\boxed{108}$	
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation (3)	V_{SET} +1V(4)≤ V_{IN}≤42V, I_{OUT} = 1 mA	1.8 V ≤ V_{SET} ≤ 2.8 V	$\boxed{-30}$		$\boxed{30}$	mV
			2.8 V < V_{SET} ≤ 9.0 V	$\boxed{-0.02}$		$\boxed{0.02}$	%/V
V_{DIF}	Dropout Voltage (5)	I_{OUT} = 300 mA	1.8 V ≤ V_{SET} ≤ 2.4 V		1.73	$\boxed{1.76}$	V
			2.4 V < V_{SET} ≤ 2.8 V		0.75	$\boxed{1.35}$	
			2.8 V < V_{SET} ≤ 5.0 V		0.71	$\boxed{1.23}$	
			5.0 V < V_{SET} ≤ 8.0 V		0.40	$\boxed{0.74}$	
			8.0 V < V_{SET} ≤ 9.0 V		0.35	$\boxed{0.65}$	
I_{LIM}	Output Current Limit	V_{IN} = V_{SET} + 3.0 V		$\boxed{300}$	450		mA
I_{SC}	Short-circuit Current	V_{IN} = 3.5 V, V_{OUT} = 0 V			100		mA
V_{CEH}	CE Pin Input Voltage, High			$\boxed{2.0}$		42	V
V_{CEL}	CE Pin Input Voltage, Low	V_{IN} = 42 V				$\boxed{1.0}$	V
I_{PD}	CE Pull-down Current	V_{IN} = 42 V, V_{CE} = 2 V			0.2	$\boxed{0.6}$	μA

All parameters are tested under the pulse load condition (Tj ≈ Ta = 25°C).

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(1) When V_{SET} > 7 V, V_{IN} = V_{SET} + 1 V
(2) Output voltage change amount when 1 mA ≤ I_{OUT} ≤ 100 mA and 1 mA ≤ I_{OUT} ≤ 300 mA,
$\Delta V_{OUT}/\Delta I_{OUT}$ = V_{OUT} (@ I_{OUT} = 100 mA) - V_{OUT} (@ I_{OUT} = 1 mA) or
$\Delta V_{OUT}/\Delta I_{OUT}$ = V_{OUT} (@ I_{OUT} = 300 mA) - V_{OUT} (@ I_{OUT} = 1 mA)
(3) Output voltage change amount when V_{SET} +1V ≤ V_{IN} ≤ 42 V,
in case V_{SET} ≤ 2.8 V, $\Delta V_{OUT}/\Delta V_{IN}$ = V_{OUT} (@V_{IN} = 42 V) - V_{OUT} (@V_{IN} = V_{SET} + 1 V) or
in case V_{SET} > 2.8 V, $\Delta V_{OUT}/\Delta V_{IN}$ = (V_{OUT} (@V_{IN} = 42 V) - V_{OUT} (@V_{IN} = V_{SET} + 1 V)) / (42 – (V_{SET} + 1)) / V_{SET} x 100
(4) When V_{SET} ≤ 2.5 V, V_{IN} = 3.5 V.
(5) Dropout voltage is defined as the minimum value of the difference between the input and output voltages in order to supply a regulated output voltage with the specified load current.

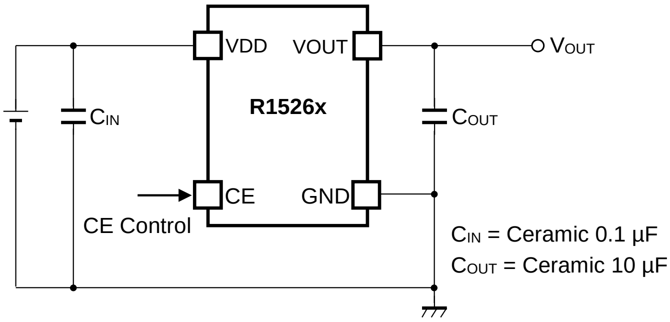
The specifications surrounded by ☐ are guaranteed by design engineering at -40°C ≤ Ta ≤ 105°C.

R1526x (-FE) Product-specific Electrical Characteristics (Ta = 25°C)

Product name	V_{OUT} (V) (Ta = 25°C)			V_{OUT} (V) (−40°C ≤ Ta ≤ 105°C)			V_{DIF} (V)	
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	TYP.	MAX.
R1526x018x	1.7892	1.80	1.8108	1.7712	1.80	1.8288	1.73	1.76
R1526x025x	2.4850	2.50	2.5150	2.4600	2.50	2.5400	0.75	1.35
R1526x028x	2.7832	2.80	2.8168	2.7552	2.80	2.8448		
R1526x030x	2.9820	3.00	3.0180	2.9520	3.00	3.0480	0.71	1.23
R1526x033x	3.2802	3.30	3.3198	3.2472	3.30	3.3528		
R1526x034x	3.3796	3.40	3.4204	3.3456	3.40	3.4544		
R1526x050x	4.9700	5.00	5.0300	4.9200	5.00	5.0800		
R1526x055x	5.4670	5.50	5.5330	5.4120	5.50	5.5880	0.40	0.74
R1526x060x	5.9640	6.00	6.0360	5.9040	6.00	6.0960		
R1526x064x	6.3616	6.40	6.4384	6.2976	6.40	6.5024		
R1526x075x	7.4550	7.50	7.5450	7.3800	7.50	7.6200		
R1526x080x	7.9520	8.00	8.0480	7.8720	8.00	8.1280		
R1526x085x	8.4490	8.50	8.5510	8.3640	8.50	8.6360	0.35	0.65
R1526x090x	8.9460	9.00	9.0540	8.8560	9.00	9.1440		

Product name	$\Delta V_{OUT}/\Delta I_{OUT}$ (mV) (1 mA ≤ I_{OUT} ≤ 100 mA)		$\Delta V_{OUT}/\Delta I_{OUT}$ (mV) (1 mA ≤ I_{OUT} ≤ 300 mA)		$\Delta V_{OUT}/\Delta V_{IN}$	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
R1526x018x	-5	45	-5	68	-30 (mV)	30 (mV)
R1526x025x						
R1526x028x						
R1526x030x	-5	40	-5	60	-0.02 (%/V)	0.02 (%/V)
R1526x033x						
R1526x034x						
R1526x050x						
R1526x055x	-5	72	-5	108		
R1526x060x						
R1526x064x						
R1526x075x						
R1526x080x						
R1526x085x						
R1526x090x						

TYPICAL APPLICATION CIRCUIT



R1526x Typical Application Circuit

Component examples

Symbol	Capacitance	Tolerance	Voltage resistance	Temperature characteristics
C_{IN}	0.1 µF	±10%	50 V	X7R
C_{OUT}	10 µF	±10%	50 V	X7S

THEORY OF OPERATION

Thermal Shutdown Function

When the junction temperature exceeds the thermal shutdown detection temperature (Typ.160°C), R1526x goes into standby state and suppresses its self-heating. When the junction temperature falls below the thermal shutdown release temperature (Typ.135°C), this device becomes active.

Chip Enable Function

By inputting "High" and "Low" to the CE pin, R1526x can be set to active or standby state. The CE pin is pulled down with a constant current of Typ. 0.2 µA inside the IC. If the chip enable function is not needed, connect the CE pin directly to the VDD pin. R1526x can apply a voltage to the CE pin even when no voltage is applied to VDD pin.

TECHNICAL NOTES

The performance of a power source circuit using this device is highly dependent on a peripheral circuit. A peripheral component or the device mounted on PCB should not exceed a rated voltage, a rated current or a rated power. When designing a peripheral circuit, please be fully aware of the following points.

Phase Compensation

R1526x uses the output capacitor capacitance and equivalent series resistance (ESR) for phase compensation, to secure stable operation even when the load current is varied. For this purpose, make sure to use an output capacitor (C_{OUT}) of 10 μF or more as close as possible to the VOUT pin. Since the output may oscillate depending on the ESR, select a low ESR capacitor with reference to *the series equivalent resistance vs. output current* characteristics in the datasheet. In addition, Make the power supply and GND lines sufficient.
Connect a capacitor (C_{IN}) of 0.1 μF or more between the VDD pin and GND, and keep the wiring as short as possible.

Behavior below the minimum operating voltage

When V_{SET} ≤ 2.8 V and the power supply voltage is below the recommended operating voltage, the output voltage may become unstable and exceed the set output voltage of LDO. To avoid this behavior at power-on, turn on the voltage of both VDD and CE pins at a slew rate of 35 V/ms or more when both pins are turned on at the same time. When turning on the VDD pin at a slew rate of 35 V/ms or less, change the CE pin from “Low” to “High” after the power supply voltage exceeds 3.5 V.
To avoid this behavior at power-off, turn off the voltage of both VDD and CE pins at a steeper slew rate than -35 V/ms when both pins are turned off at the same time.
When turning off the VDD pin at a slower slew rate than -35 V/ms, change the CE pin from “High” to “Low” before the power supply voltage falls below 3.5 V.

Thermal Shutdown Function

The thermal shutdown function prevents the IC from fuming and ignition but does not ensure the IC’s reliability or keep the IC below the absolute maximum ratings. The thermal shutdown function does not operate on the heat generated by other than the normal IC operation such as latch-up and overvoltage application.

The thermal shutdown function operates in a state over the absolute maximum ratings, therefore the thermal shutdown function should not be used for a system design.

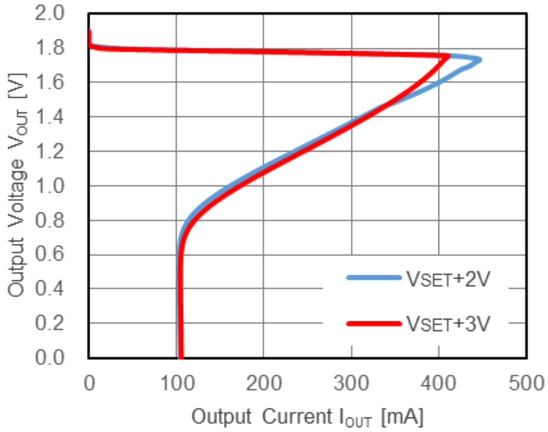
TYPICAL CHARACTERISTICS

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

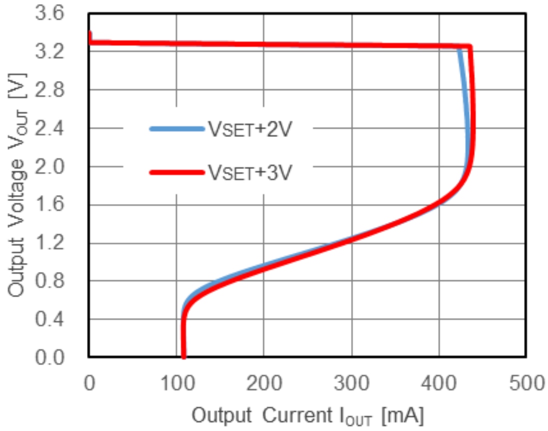
1) Output Voltage vs. Output Current

C_{IN} = none, C_{OUT} = 10µF, Ta = 25°C

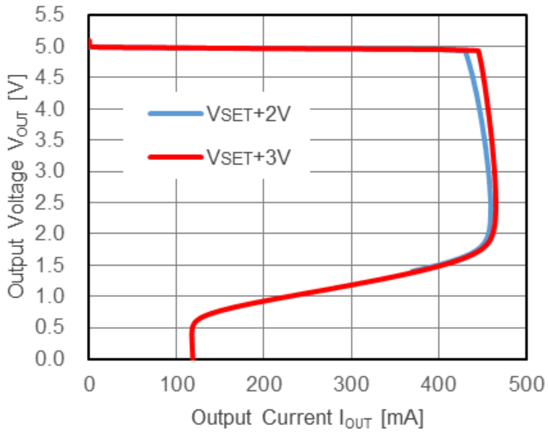
R1526x018



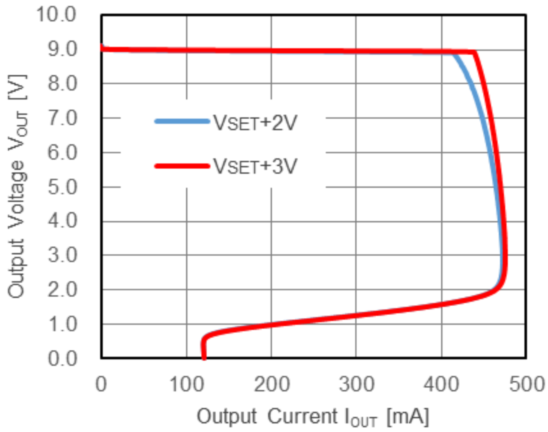
R1526x033



R1526x050



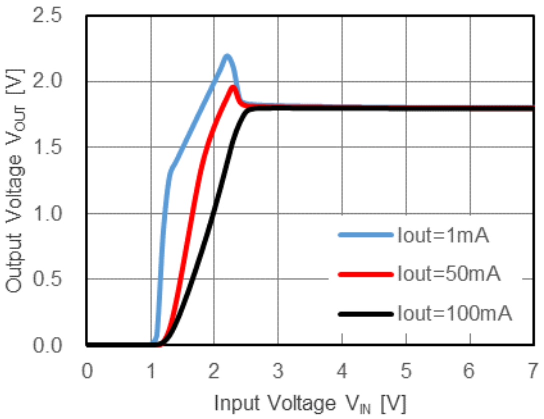
R1526x090



2) Output Voltage vs. Input Voltage

C_{IN} = none, C_{OUT} = 10µF, Ta = 25°C

R1526x018



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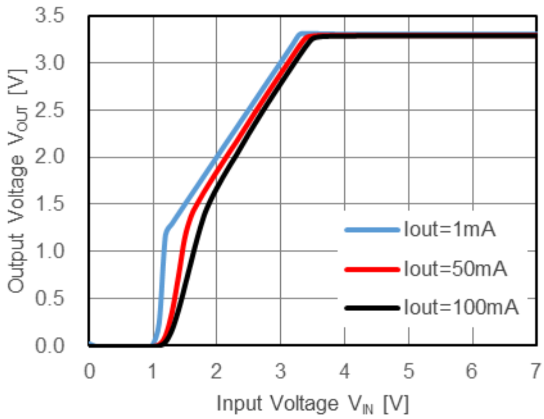

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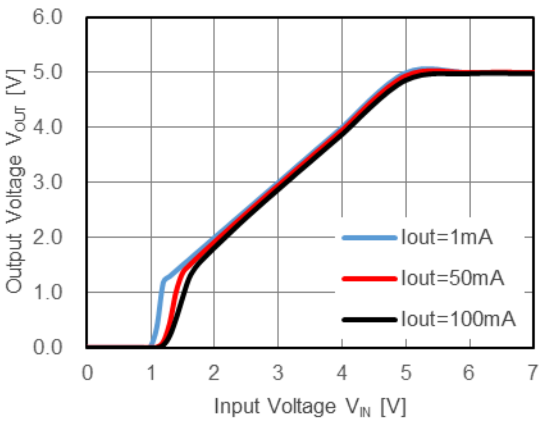

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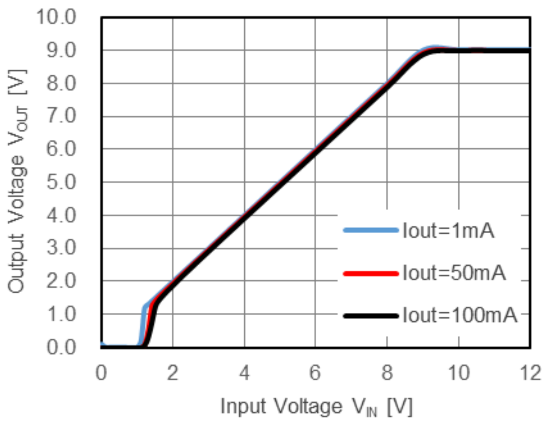
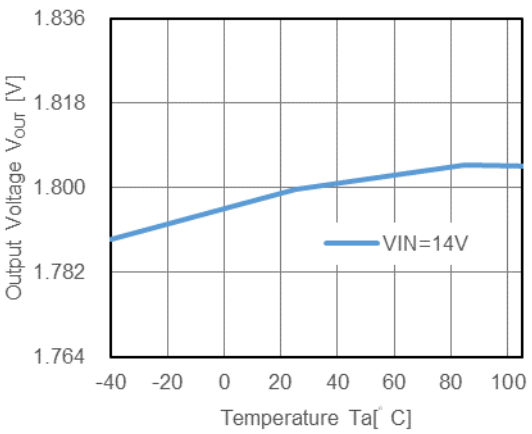


3) Output Voltage vs. Temperature

I_{OUT} = 1mA, C_{IN} = none, C_{OUT} = 10µF

R1526x018



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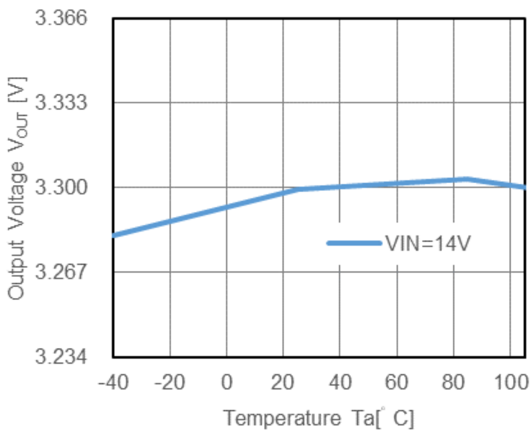

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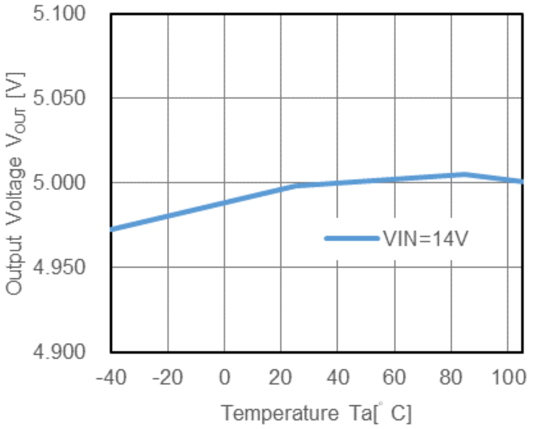

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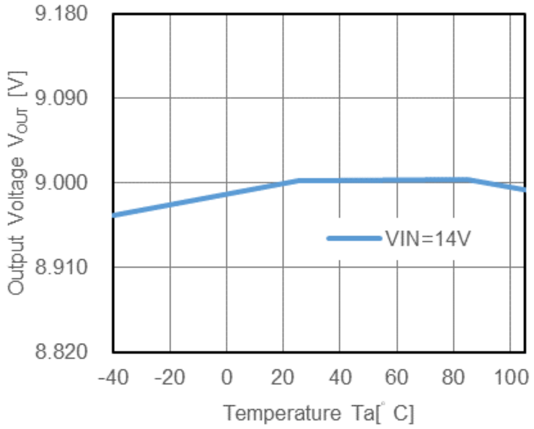
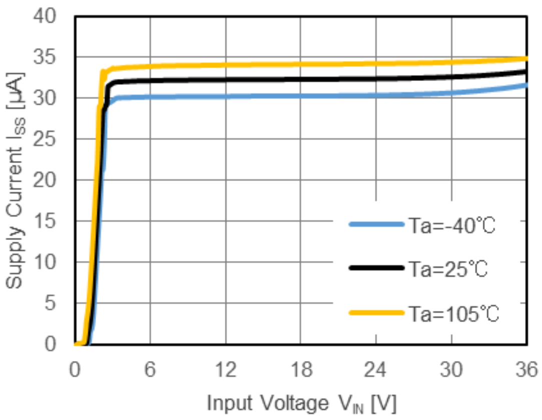


4) Supply Current vs. Input Voltage

C_{IN} = none, C_{OUT} = 10µF

R1526x018



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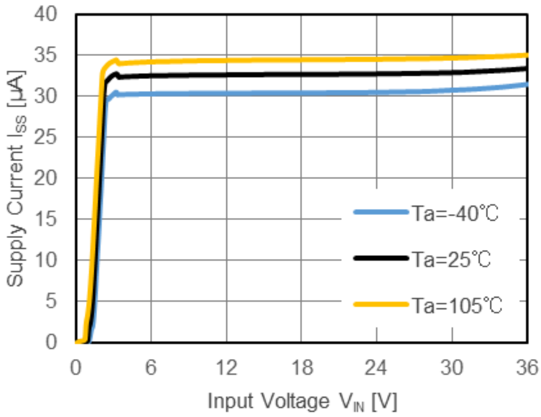
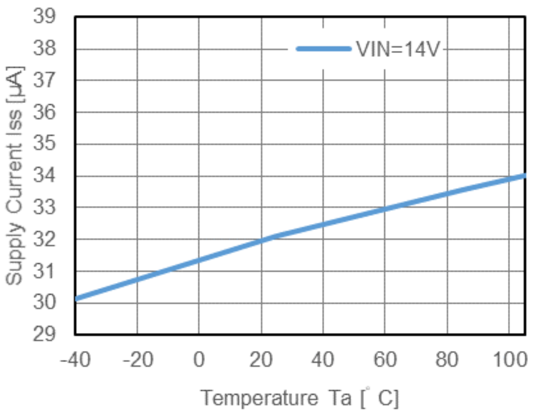


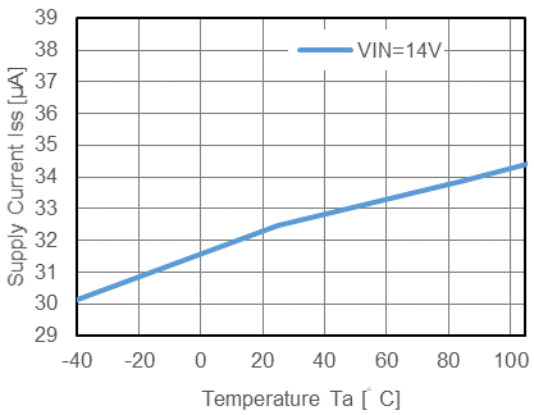
5) Supply Current vs. Temperature

C_{IN} = none, C_{OUT} = 10µF

R1526x018

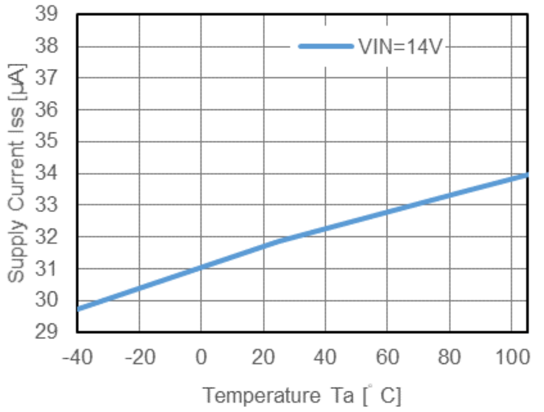


R1526x033



RICOH

R1526x050



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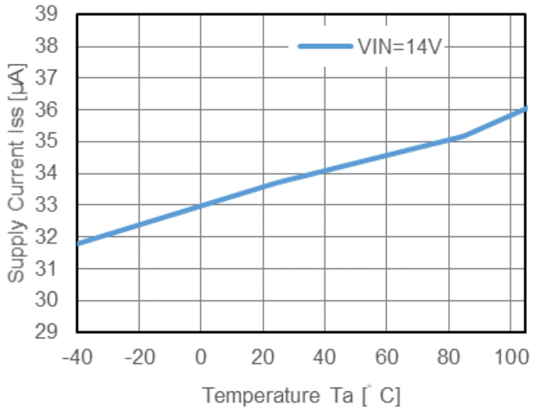
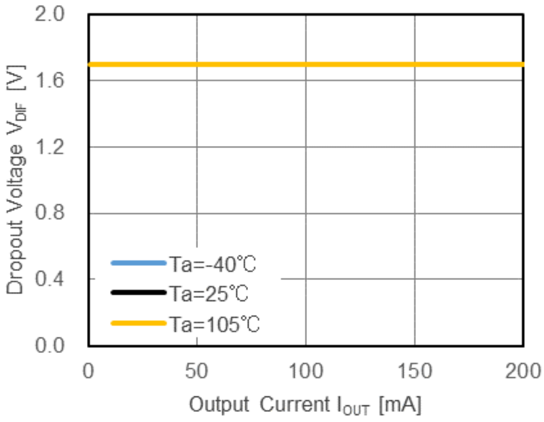


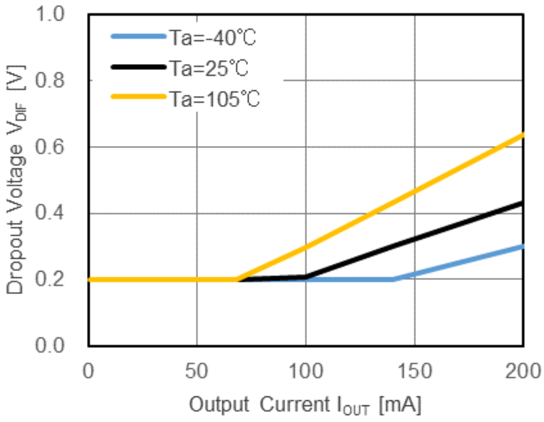
6) Dropout Voltage vs. Output Current

C_{IN} = none, C_{OUT} = 10μF

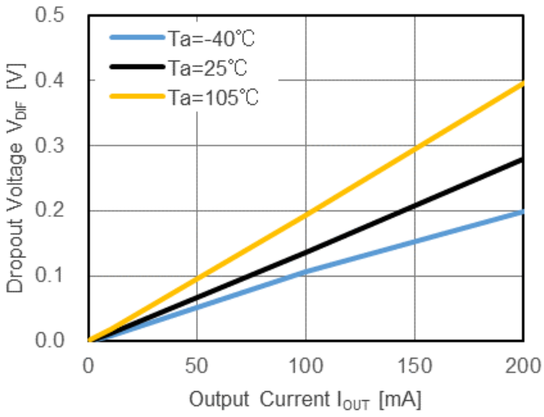
R1526x018



R1526x033



R1526x050



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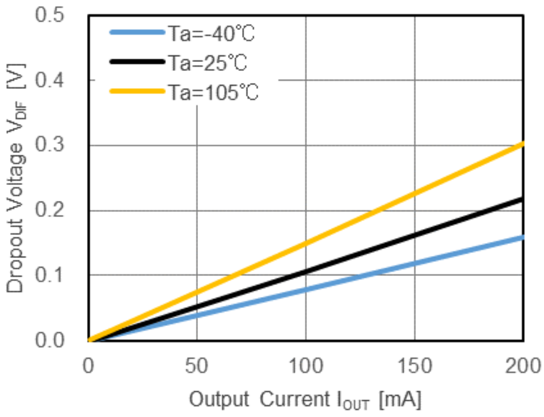
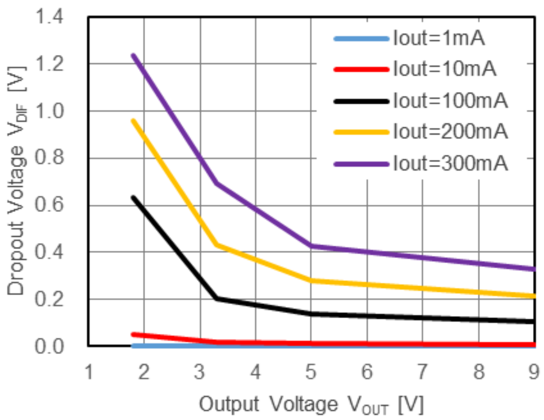


7) Dropout Voltage vs. Output Voltage

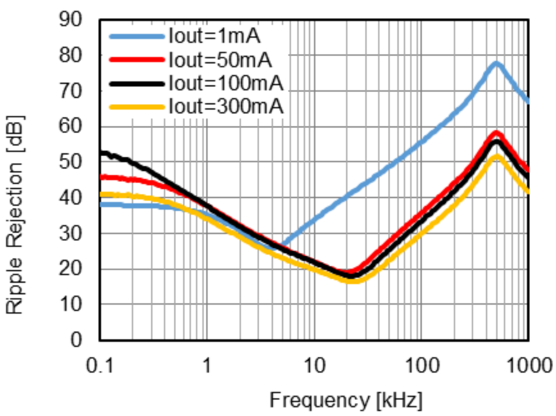
C_{IN} = none, C = 10μF, Ta = 25°C



8) Ripple Rejection vs. Frequency

V_{IN} = V_{SET}+2V, Ripple = 0.2Vpp, C_{IN} = none, C_{OUT} = 10μF, Ta = 25°C

R1526x018



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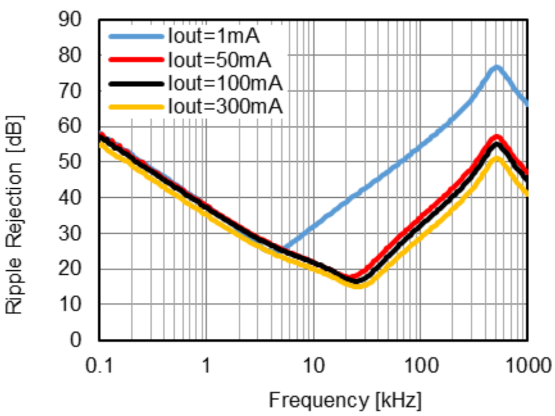

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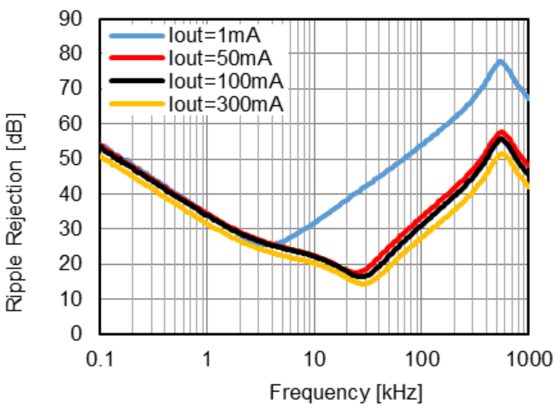

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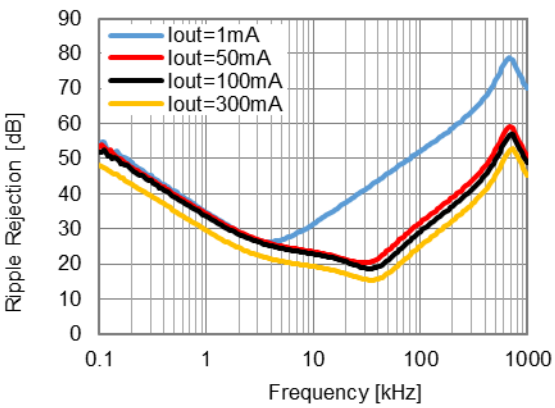
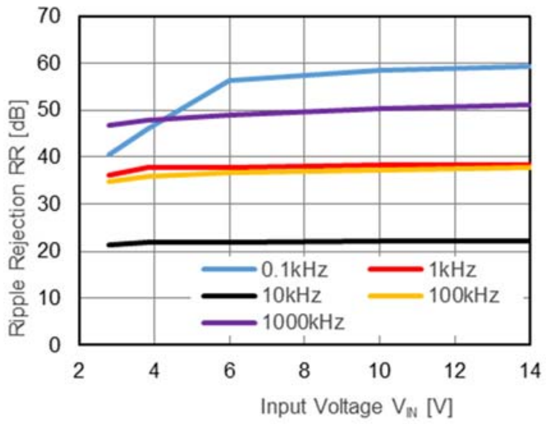


9) Ripple Rejection vs. Input Voltage

Ripple = 0.2Vpp, I_{OUT} = 50mA, C_{IN} = none, C_{OUT} = 10μF, Ta = 25°C

R1526x018



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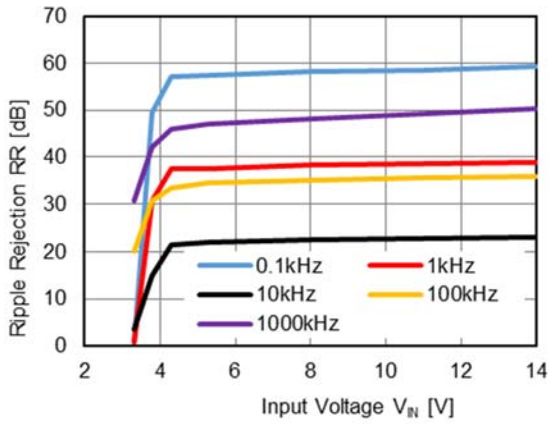

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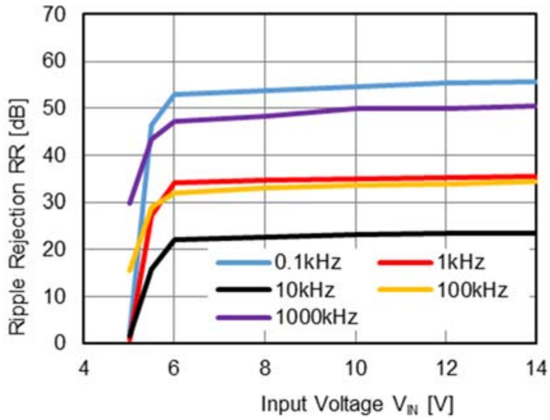

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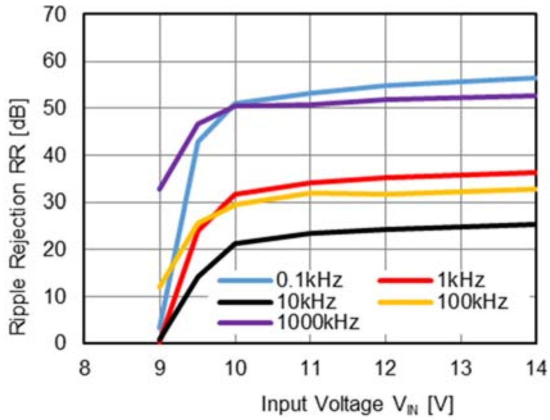
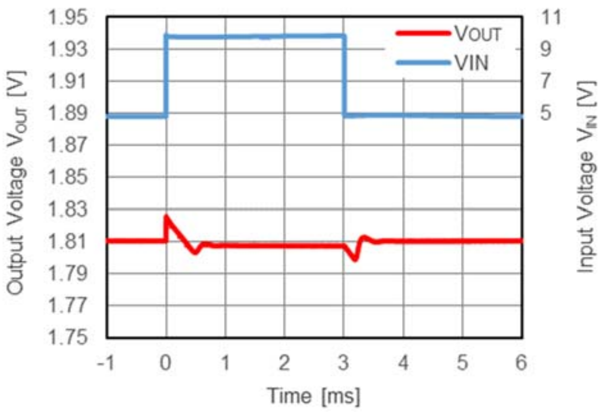


10) Input Transient Response

I_{OUT} = 1mA, C_{IN} = none, C_{OUT} = 10μF, Ta = 25°C, tr = tf = 1μs

R1526x018



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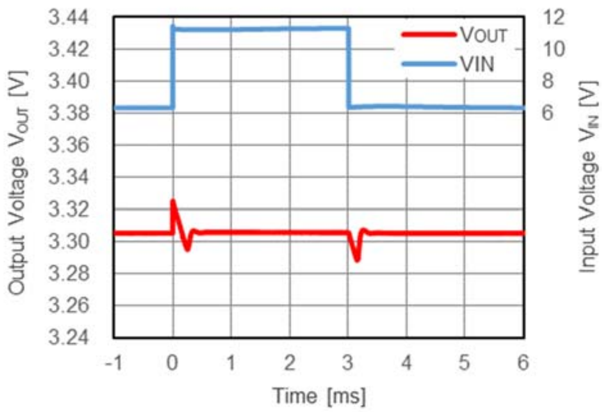

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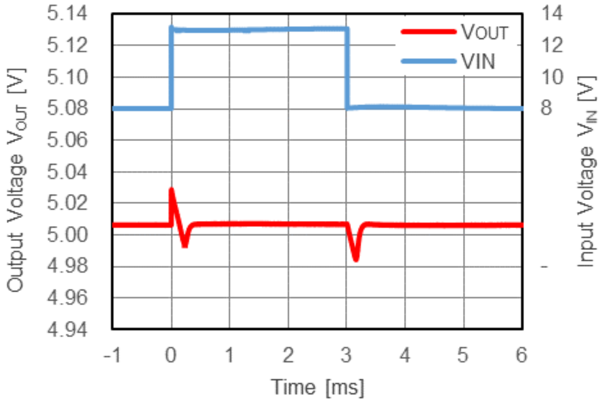

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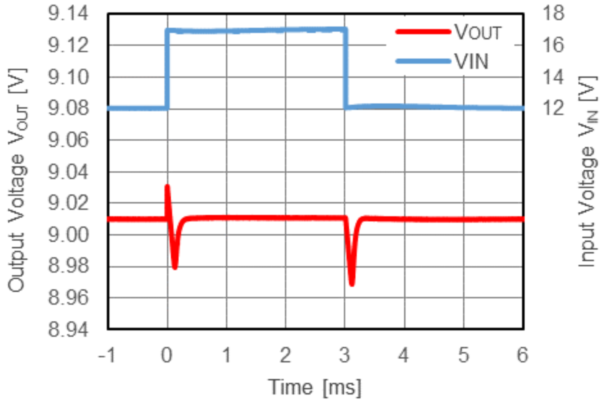
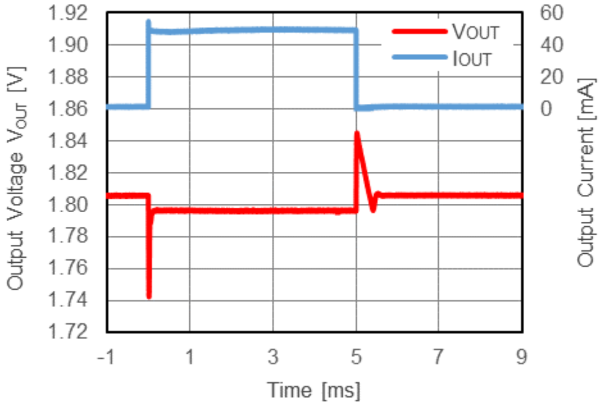


11) Load Transient Response

V_{IN} = 14V, C_{IN} = 0.1μF, C_{OUT} = 10μF, Ta = 25°C, tr = tf = 0.5μs

R1526x018



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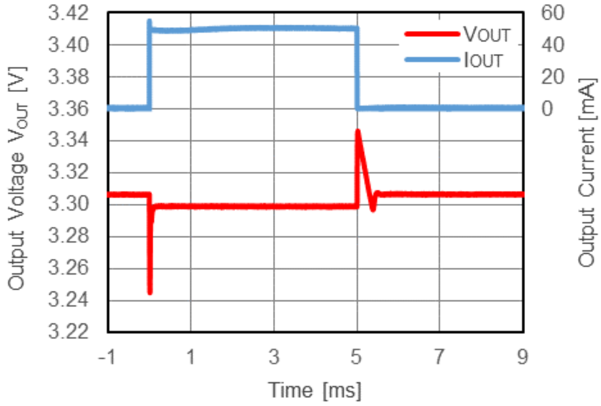

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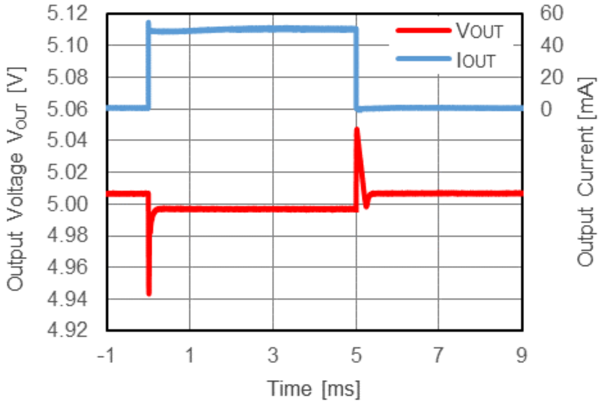

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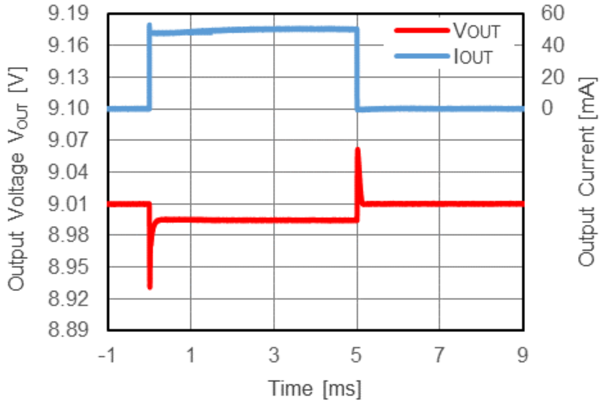
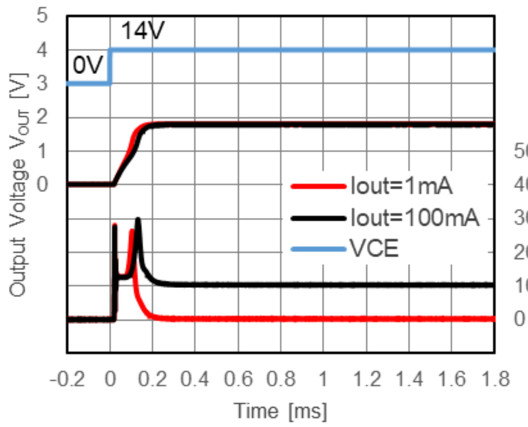
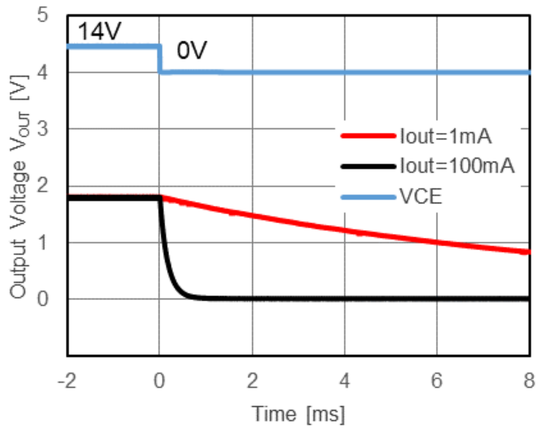


12) CE Transient Response

V_{IN} = 14V, V_{CE} = 0V → 14V, C_{IN} = 0.1μF, C_{OUT} = 10μF, Ta = 25°C, tr = tf = 1μs

R1526x018





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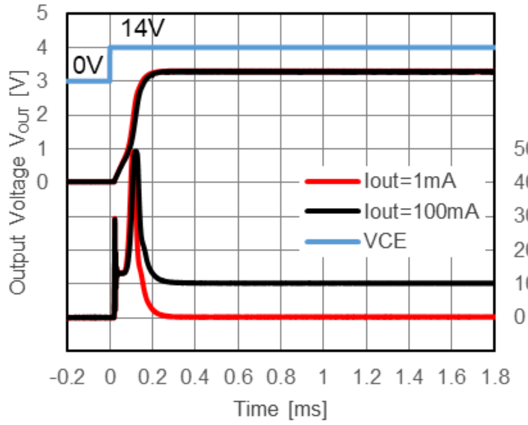

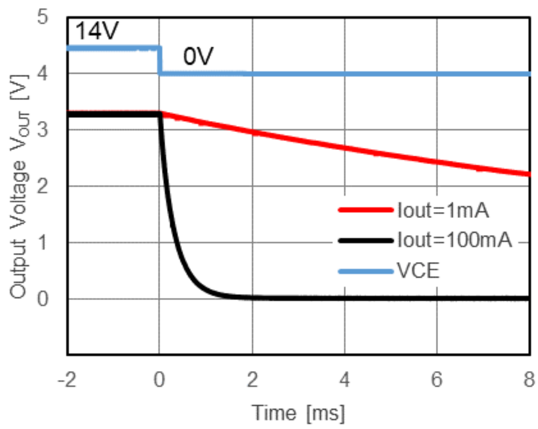

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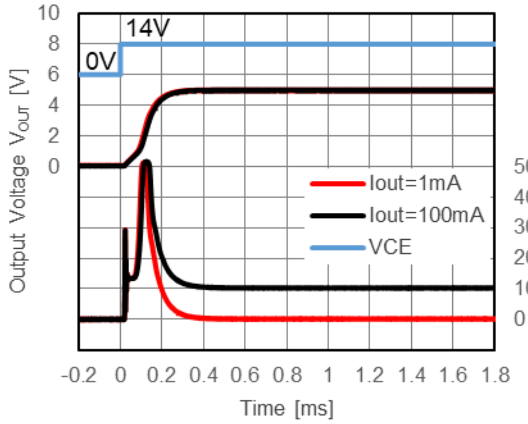

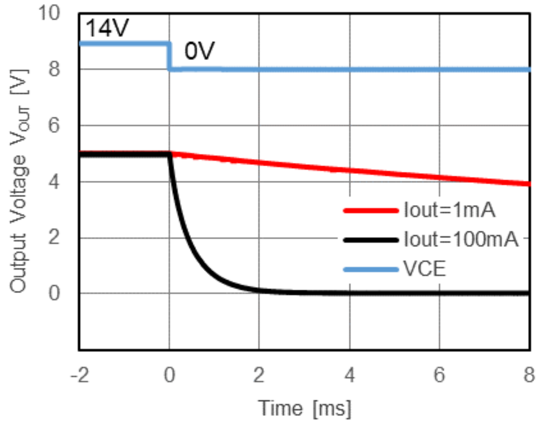

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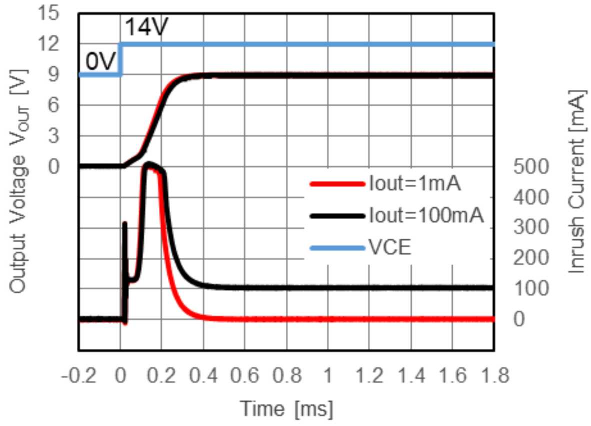
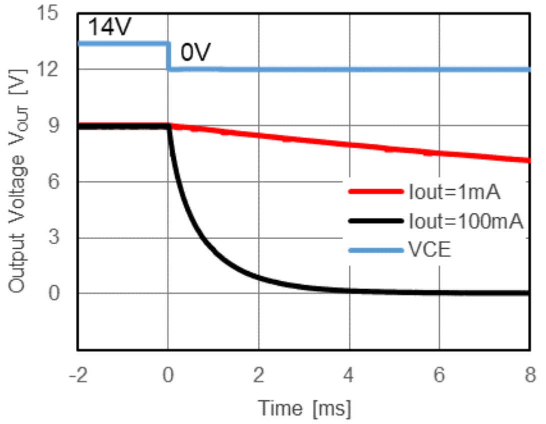
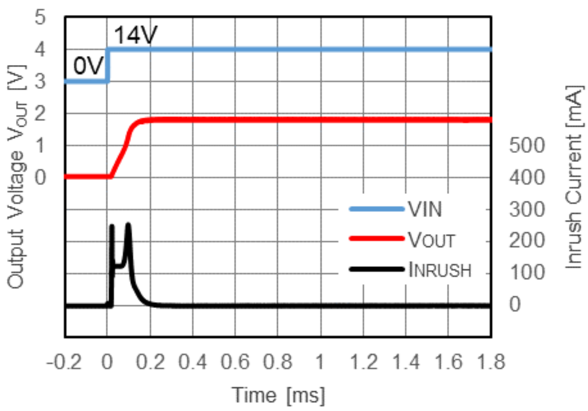




13) Power-on Transient Response

I_{OUT} = 1mA, C_{IN} = none, C_{OUT} = 10μF, Ta = 25°C, tr = 1μs

R1526x018



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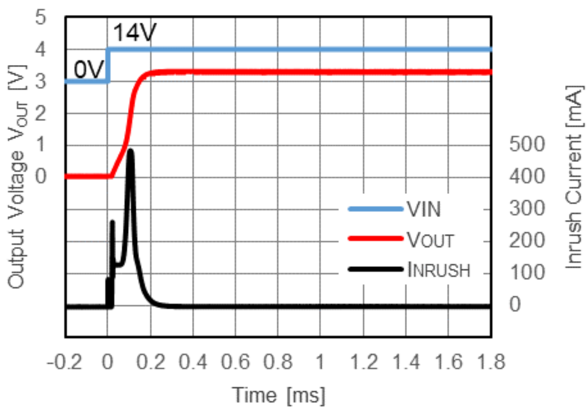

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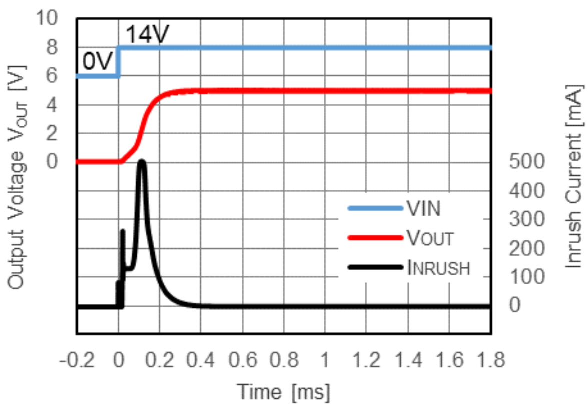

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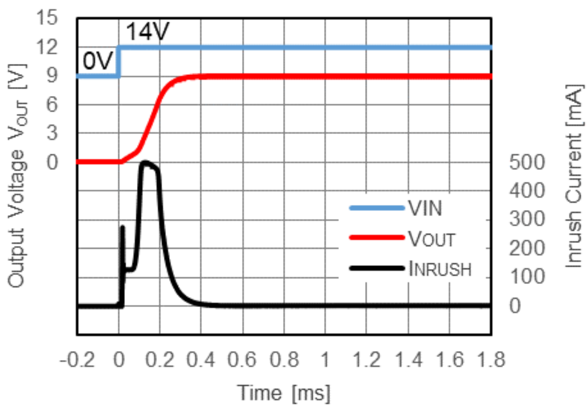
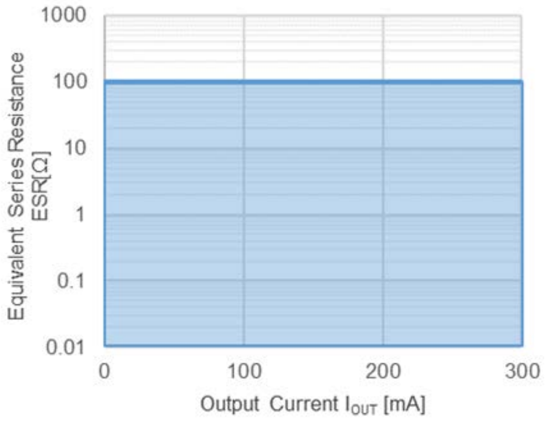


14) ESR (Equivalent Series Resistance)

C_{IN} = 0.1μF, C_{OUT} = 10μF, Ta = -40°C, 25°C, 105°C

R1526x018



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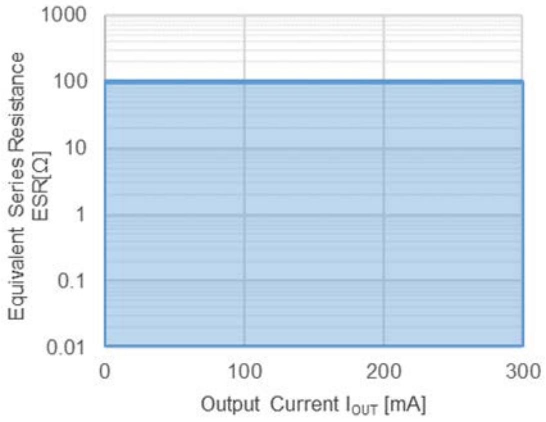

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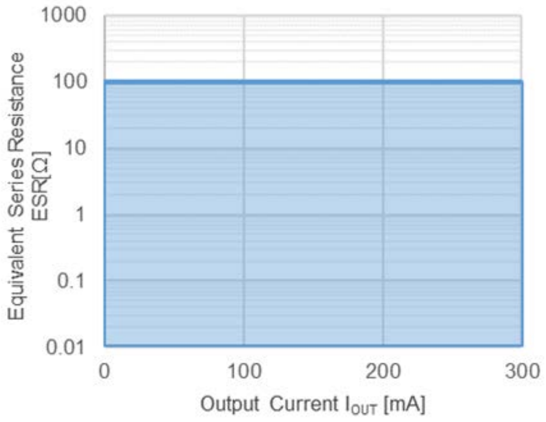

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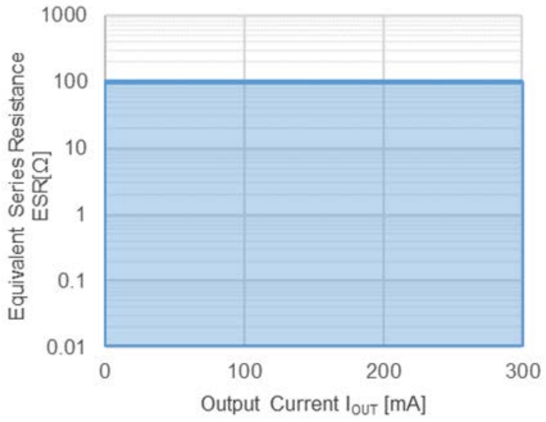
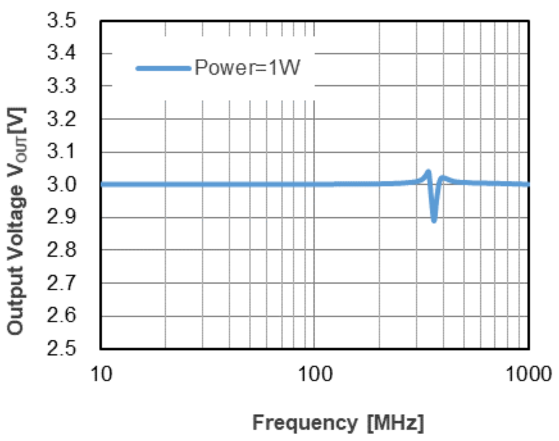


15) Noise Immunity

DPI method, V_{IN} = 14V, V_{CE} = 3V, V_{OUT} = 1W, C_{IN} = C_{CE} = 0.1μF, C_{OUT} = 10μF, Ta = 25°C

R1526x033



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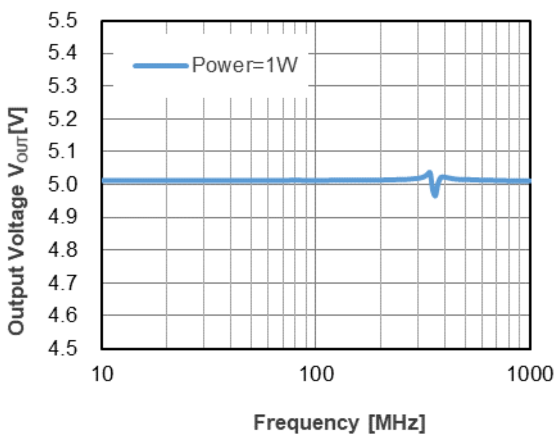
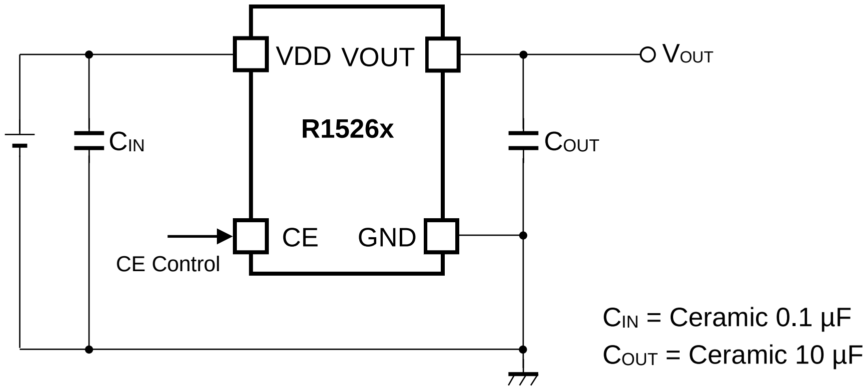


Test Circuit



Test Circuit for Typical Characteristics

Measurement Components

Symbol	Specification	Measurement Item	Manufacturer	Parts Number
C_{IN}	0.1µF	11,12,14,15	TDK	CGA4J2X7R1H104K
C_{OUT}	10µF	All Items	TDK	CGA4J1X7S1C106K

Measurement Components of Typical Characteristics

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PD-HSOP-8E-(105125)-JE-A

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

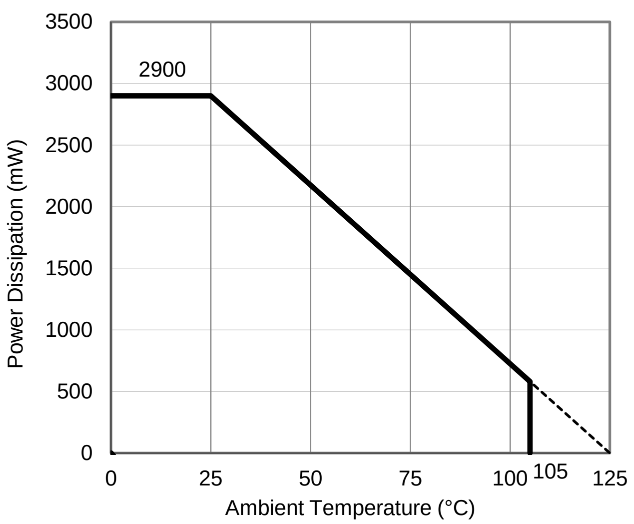
Item	Measurement Conditions
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Four-Layer Board)
Board Dimensions	76.2 mm × 114.3 mm × 0.8 mm
Copper Ratio	Outer Layer (First Layer): Less than 95% of 50 mm Square Inner Layers (Second and Third Layers): Approx.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

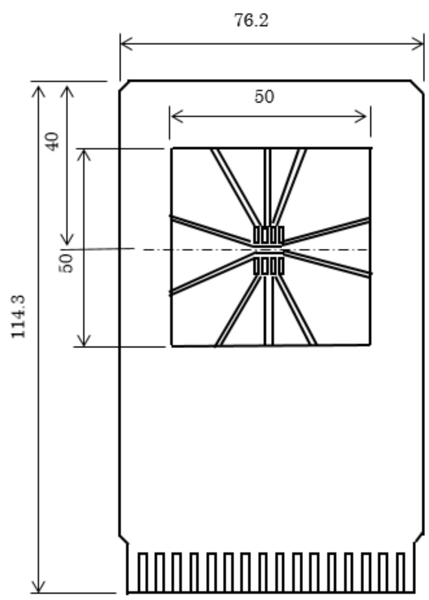
Item	Measurement Result
Power Dissipation	2900 mW
Thermal Resistance (θja)	θja = 34.5°C/W
Thermal Characterization Parameter (ψjt)	ψjt = 10°C/W

θja: Junction-to–ambient thermal resistance.

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



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

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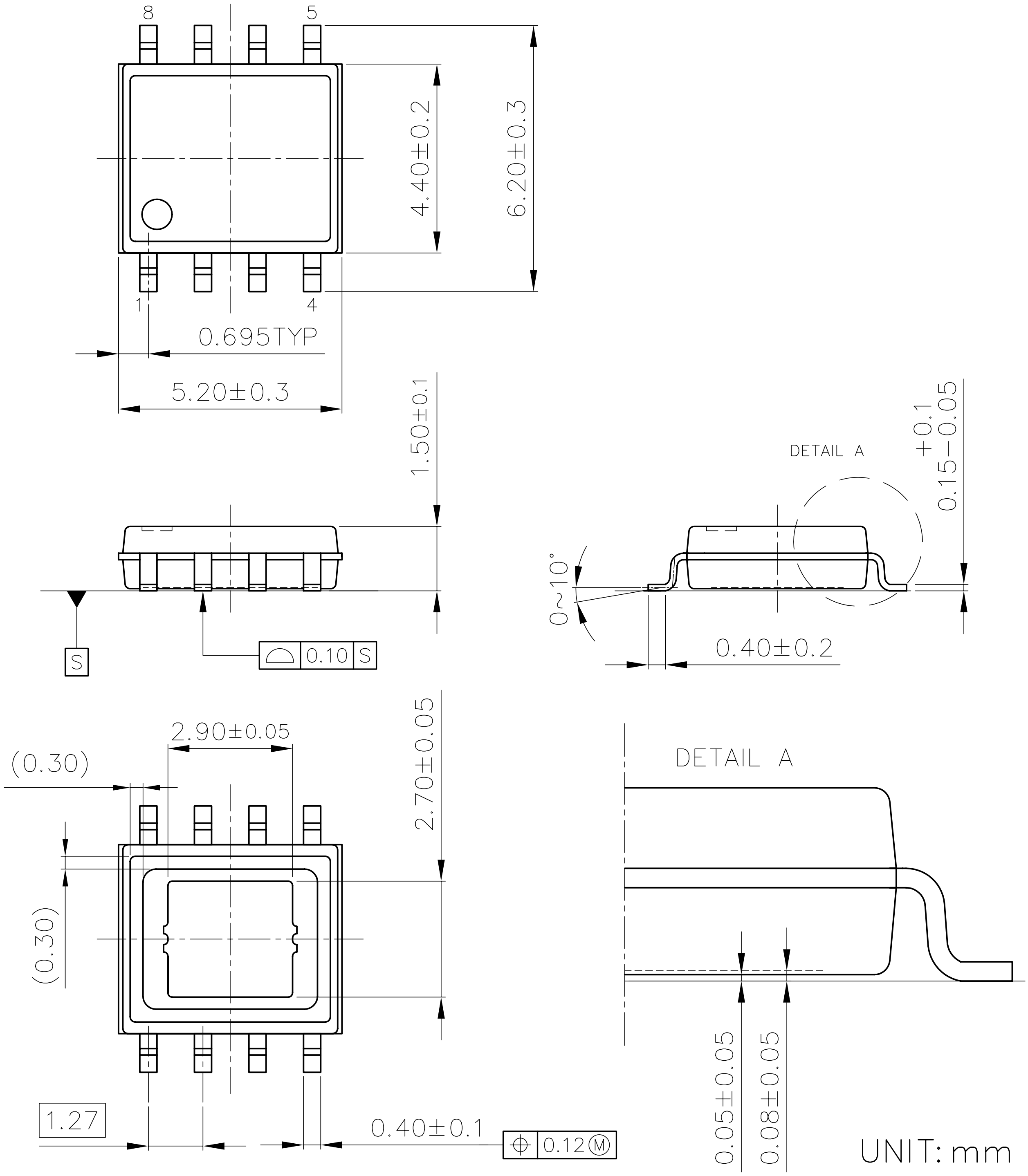
DM-HSOP-8E-JE-B



HSOP-8E Package Dimensions

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