
36 V, High Accuracy, 300 mA Voltage Regulator for Automotive Applications

NO.EC-338-180510

OUTLINE

The R8156x is a CMOS-based voltage regulator (VR) that specifically designed for automotive applications featuring 300 mA output current and 36 V input voltage. Internally, the R8156x consists of a fold-back protection circuit, a short current protection circuit and a thermal shutdown circuit in addition to the basic regulator circuit.

The performance is specified for the -40°C to 125°C temperature range with $\pm 1.0\%$ output voltage accuracy. The operating temperature range is -40°C to 125°C and the maximum input voltage is 36 V. All these features make the R8156x ideal for power source for car accessories and electronic control units in automotive vehicles.

The R8156x is available in 1.2 V, 1.5 V, 1.8 V, 3.3 V, 3.4 V and 5.0 V fixed output voltage options. By using external divider resistors, the output voltage can be set over a 1.2 V to 18.0 V range. The R8156x is available in the ultra high wattage package, HSOP-8E.

FEATURES

- Input Voltage (Maximum Rating) 3.5 V to 36 V (50 V)
- Operating Temperature Range -40°C to 125°C
- Supply Current Typ. 75 μA
- Standby Current Typ. 0.1 μA
- Dropout Voltage Typ. 0.40 V ($I_{\text{OUT}} = 300 \text{ mA}$, $V_{\text{OUT}} = 5.0 \text{ V}$)
- Output Voltage Accuracy $\pm 1.0\%$
- Line Regulation Typ. 0.02%/V ($V_{\text{DD}} = V_{\text{OUT}} + 1 \text{ V}$ to 36 V)
- Package Type HSOP-8E
- Output Voltage 1.2 V / 1.5 V / 1.8 V / 3.3 V / 3.4 V / 5.0 V
- Short-current Protection Circuit Current Limit Typ. 50 mA
- Fold-back Protection Circuit Current Limit Typ. 450 mA
- Thermal Shutdown Circuit Shutdown at Typ. 160°C
- Ripple Rejection Typ. 70 dB ($f = 100 \text{ Hz}$)
- Ceramic Capacitor Compatible $C_{\text{IN}} = 1.0 \mu\text{F}$ or more, $C_{\text{OUT}} = 4.7 \mu\text{F}$ or more

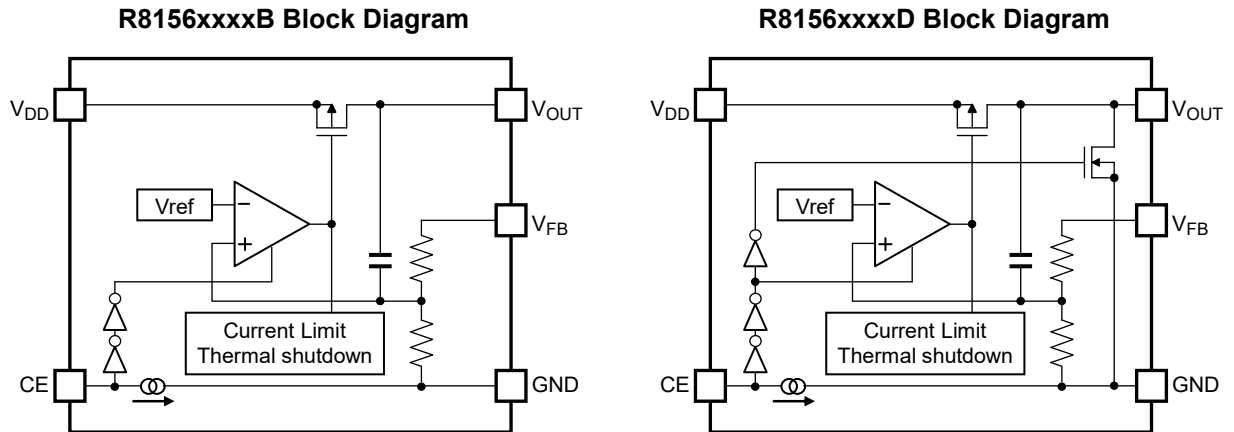
APPLICATIONS

- Power supply for electronic control units such as EV inverter and battery charge control unit.

R8156S

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BLOCK DIAGRAM



SELECTION GUIDE

The set output voltage and the auto-discharge option*1 are user-selectable options.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R8156Sxx1*-E2-FE	HSOP-8E	1,000 pcs	Yes	Yes

xx: Specify the set output voltage (V_{SET}) from below.

1.2 V (12) / 1.5 V (15) / 1.8 V (18) / 3.3 V (33) / 3.4 V (34) / 5.0 V (50)

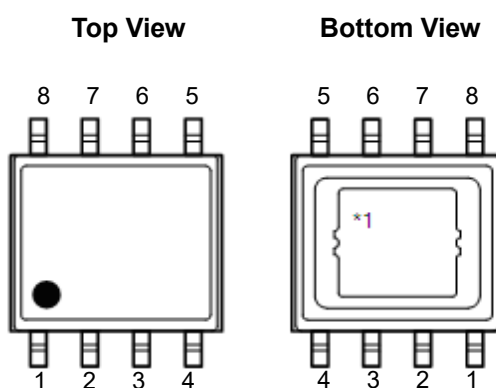
*: Specify the auto-discharge option.
 B: Auto-discharge option not included
 D: Auto-discharge option included

R8 Automotive Class Code

Operating Temperature Range	Guaranteed Specs Temperature Range	Screening
-40°C to 125°C	-40°C to 125°C	High and Low Temperature

*1 Auto-discharge function quickly lowers the output voltage to 0 V, when the chip enable signal is switched from the active mode to the standby mode, by releasing the electrical charge accumulated in the external capacitor.

PIN DESCRIPTION



HSOP-8E Pin Configuration

HSOP-8E Pin Description

Pin No.	Symbol	Description
1	V_{OUT}	Output Pin
2	V_{FB}	Feedback Pin
3	NC	No Connection
4	GND	Ground Pin
5	NC	No Connection
6	CE	Chip Enable Pin, Active-high
7	NC	No Connection
8	V_{DD}	Input Pin

*1 The tab on the reverse side of the IC is in GND level and it should be connected to GND pin (recommended) or should be left open.

ABSOLUTE MAXIMUM RATINGS**Absolute Maximum Ratings**

Symbol	Item		Rating	Unit
V _{IN}	Input Voltage		-0.3 to 50	V
V _{IN}	Peak Input Voltage* ¹		60	V
V _{CE}	CE Pin Input Voltage		-0.3 to 50	V
V _{FB}	V _{FB} Pin Input Voltage		-0.3 to V _{OUT} + 0.3 ≤ 50	V
V _{OUT}	Output Voltage		-0.3 ~ V _{IN} + 0.3 ≤ 50	V
P _D	Power Dissipation* ²	Ultra High Wattage Land Pattern	3600	mW
T _j	Junction Temperature		-40 to 150	°C
T _{stg}	Storage Temperature Range		-55 to 150	°C

*¹ Duration time = 200 ms

*² Refer to *PACKAGE INFORMATION* for detailed information.

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the life time 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	Item	Rating	Unit
V _{IN}	Input Voltage	3.5 to 36	V
T _a	Operating Temperature Range	-40 to 125	°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 when 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.

ELECTRICAL CHARACTERISTICS

$C_{IN} = 1.0 \mu\text{F}$, $C_{OUT} = 4.7 \mu\text{F}$, $V_{OUT} = V_{FB}$, V_{SET} = Set Output Voltage, unless otherwise noted.

R8156xxxxB/D Electrical Characteristics

($-40^{\circ}\text{C} \leq T_a \leq 125^{\circ}\text{C}$)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	
I_{SS}	Supply Current	$V_{IN} = 14 \text{ V}$, $I_{OUT} = 0 \text{ mA}$		75	110	μA	
$I_{standby}$	Standby Current	$V_{IN} = 36 \text{ V}$, $V_{CE} = 0 \text{ V}$		0.1	2.0	μA	
V_{OUT}	Output Voltage	$3.5 \text{ V} \leq V_{SET} + 1 \text{ V} \leq V_{IN} \leq 36 \text{ V}$, $I_{OUT} = 1 \text{ mA}$	$V_{SET} \leq 1.8 \text{ V}$	-18		18	mV
			$1.8 \text{ V} < V_{SET}$	$\times 0.99$		$\times 1.01$	V
		$3.5 \text{ V} \leq V_{SET} + 1 \text{ V} \leq V_{IN} \leq 14 \text{ V}$, $1 \text{ mA} \leq I_{OUT} \leq 50 \text{ mA}$	$V_{SET} \leq 1.8 \text{ V}$	-18		18	mV
			$1.8 \text{ V} < V_{SET}$	$\times 0.99$		$\times 1.01$	V
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	$3.5 \text{ V} \leq V_{SET} + 1 \text{ V} \leq V_{IN} \leq 36 \text{ V}$ $I_{OUT} = 1 \text{ mA}$	-0.02	0.01	0.02	%/V	
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	$3.5 \text{ V} \leq V_{IN} = V_{SET} + 1 \text{ V}$, $1 \text{ mA} \leq I_{OUT} \leq 300 \text{ mA}$	$V_{SET} \leq 1.8 \text{ V}$	-5		5	mV
			$V_{SET} = 3.3 \text{ V}$	-8		8	
			$V_{SET} = 5.0 \text{ V}$	-12		12	
V_{DIF}	Dropout Voltage	$I_{OUT} = 300 \text{ mA}$	$V_{SET} = 1.2 \text{ V}$			2.30	V
			$1.5 \text{ V} \leq V_{SET}$			2.00	
			$1.8 \text{ V} \leq V_{SET}$			1.70	
			$3.3 \text{ V} \leq V_{SET}$		0.39	0.74	
			$5.0 \text{ V} \leq V_{SET}$		0.32	0.60	
I_{LIM}	Output Current Limit	$V_{IN} = V_{SET} + 1.5 \text{ V}$	300	450		mA	
I_{SC}	Short Current Limit	$V_{OUT} = 0 \text{ V}$	40	50		mA	
R_{FB}	Feedback Resistance		1.0	2.4		M Ω	
V_{CEH}	CE Input Voltage "H"		2.2		36	V	
V_{CEL}	CE Input Voltage "L"		0		1.0	V	
I_{PD}	CE Pull-down Current	$V_{CE} = 5.0 \text{ V}$		0.2	0.6	μA	
		$V_{CE} = 36 \text{ V}$		0.5	1.3		
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature	150	160		$^{\circ}\text{C}$	
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature	125	135		$^{\circ}\text{C}$	
R_{LOW}	Low Output Nch Tr. ON Resistance (R8156xxxxD)	$V_{IN} = 14.0 \text{ V}$, $V_{CE} = 0 \text{ V}$	1.5	3.2	6.7	k Ω	

R8156S

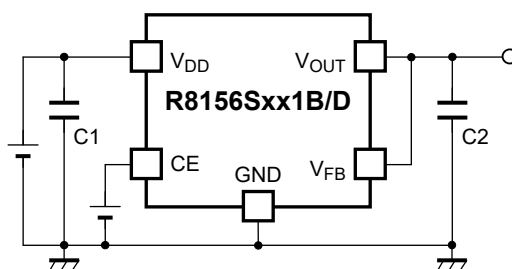
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Product-specific Electrical Characteristics

(-40°C ≤ Ta ≤ 125°C)

Product Name	V _{OUT} [V]			ΔV _{OUT} /ΔI _{OUT} [mV]		V _{DIF} [V]	
	MIN.	TYP.	MAX.	MIN.	MAX.	TYP.	MAX.
R8156x121x	1.182	1.200	1.218	-5	5		2.30
R8156x151x	1.482	1.500	1.518	-5	5		2.00
R8156x181x	1.782	1.800	1.818	-5	5		1.70
R8156x331x	3.267	3.300	3.333	-8	8	0.39	0.74
R8156x341x	3.366	3.400	3.434	-8	8	0.39	0.74
R8156x501x	4.950	5.000	5.050	-12	12	0.32	0.60

TYPICAL APPLICATION



R8156x Typical Application

External Components List

Symbol	Description
C1 (C _{IN})	1.0 μF, Ceramic Capacitor
C2 (C _{OUT})	4.7 μF, Ceramic Capacitor

TECHNICAL NOTES

Phase Compensation

Phase compensation is provided to secure stable operation even when the load current is varied. For this purpose, use a 4.7 μF or more output capacitor (C2) with good frequency characteristics and proper ESR (Equivalent Series Resistance). Connect a 1.0 μF or more input capacitor (C1) between the V_{DD} pin and the GND pin as close as possible to the pins.

In case of using a tantalum type capacitor with a large ESR, the output might become unstable. Evaluate your circuit including consideration of frequency characteristics.

Depending on the capacitor size, manufacturer, and part number, the bias characteristics and the temperature characteristics vary.

PCB Layout

Ensure the V_{DD} and GND lines are sufficiently robust. If their impedance is too high, noise pickup or unstable operation may result. The load regulation can be improved by short-circuiting V_{OUT} and V_{FB} close to the load device.

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Thermal Shutdown Function

Thermal shutdown function detects overheating of the regulator and stops the regulator operation to protect the device from damage. Thermal shutdown circuit stops the regulator operation if the junction temperature becomes higher than 160°C (Typ.) and restarts the regulator operation if the junction temperature drops below 135°C (Typ.). The regulator repeats turning on and off and creates pulse waveform until the cause of the overheating is removed.

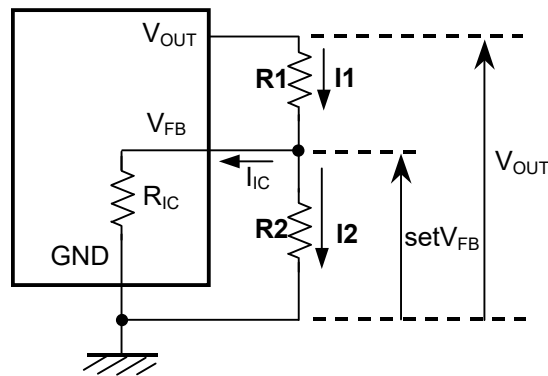
Adjustable Output Voltage Setting

Output voltage can be adjusted by using the external divider resistors (R1, R2). By using the following equation, the output voltage (V_{OUT}) can be determined. The voltage which is fixed inside the IC is described as V_{FB} .

$$V_{OUT} = V_{FB} \times ((R1 + R2) / R2)$$

Recommended Output Voltage Range: $1.2\text{ V} \leq V_{OUT} \leq 18\text{ V}$

$$V_{FB} = V_{SET}$$

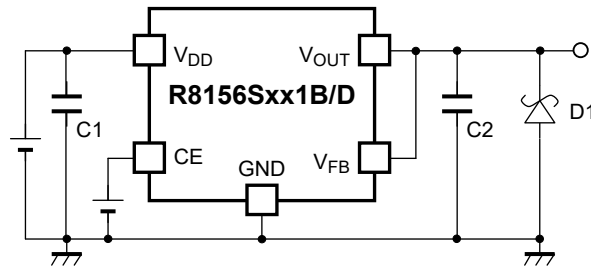


Adjustable Output Voltage Setting Using External Divider Resistors (R1, R2)

The minimum resistance value for a resistor (R_{IC}) is 1 M Ω ($T_a = 25^\circ\text{C}$, guaranteed by design). For better accuracy, setting $R1 \ll R_{IC}$ reduces errors. The resistance value for a resistor ($R2$) should be set to 33 k Ω or lower. If the resistance values set for $R1$ and $R2$ are larger, the impedance of the V_{FB} pin becomes larger.

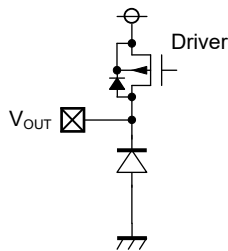
R_{IC} could be affected by temperature; therefore, evaluate the circuit taking the actual conditions of use into account when deciding the resistance values for $R1$ and $R2$.

TYPICAL APPLICATION FOR IC CHIP BREAKDOWN PREVENTION

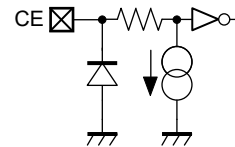


When a sudden surge of electrical current travels along the V_{OUT} pin and GND due to a short-circuit, electrical resonance of a circuit involving an output capacitor ($C2$) and a short circuit inductor generates a negative voltage and may damage the device or the load devices. Connecting a schottky diode ($D1$) between the V_{OUT} pin and GND has the effect of preventing damage to them.

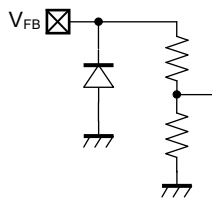
PIN EQUIVALENT CIRCUIT DIAGRAMS



V_{OUT} Pin Equivalent Circuit Diagrams



CE Pin Equivalent Circuit Diagrams



V_{FB} Pin Equivalent Circuit Diagrams

PACKAGE INFORMATION

POWER DISSIPATION (HSOP-8E)

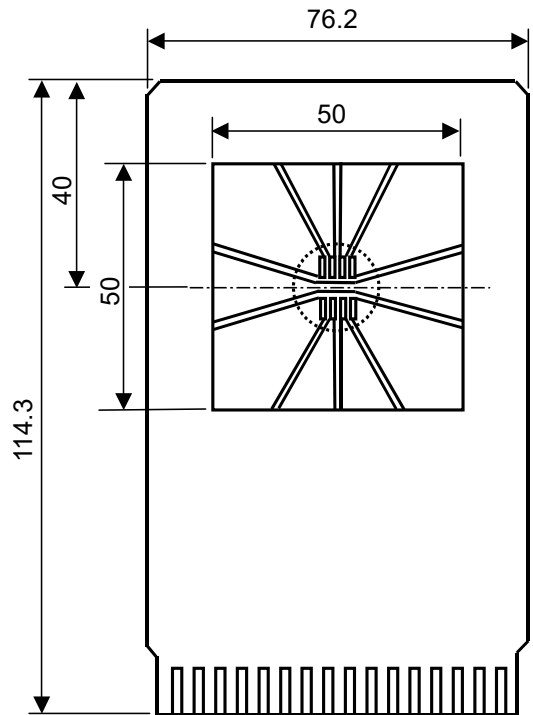
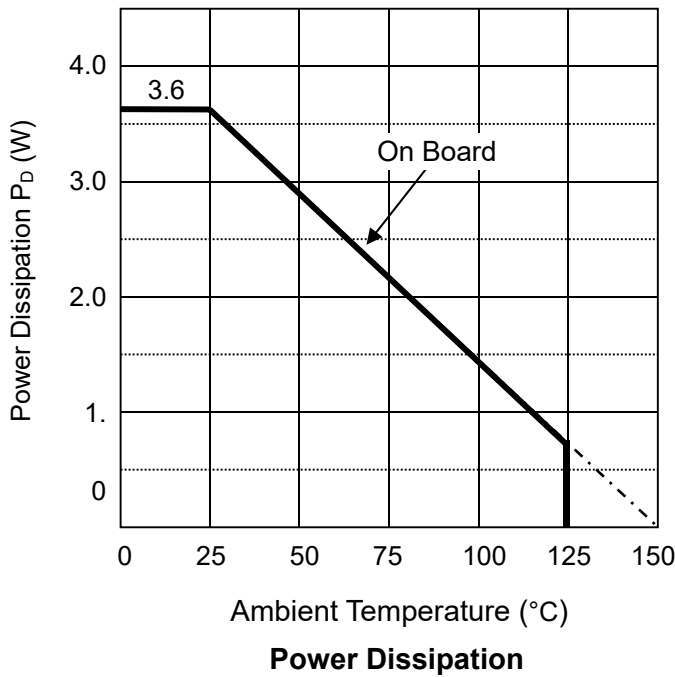
Power Dissipation (P_D) depends on conditions of mounting on board.
 This specification is based on the measurement at the condition below:

* Measurement conditions

	Ultra High Wattage land pattern
Environment	Mounting on board (Wind velocity 0 m/s)
Board Material	Glass cloth epoxy plastic (4 layers)
Board Dimensions	76.2 mm x 114.3 mm x 0.8 mm
Copper Ratio	Top side, Back side : 50 mm square : Approx. 95% 2nd, 3rd Layer : : 50 mm square : Approx. 100%
Through - hole	ϕ 0.4 mm x 21 pcs

* Measurement Results (Ta = 25°C, Tjmax = 150°C)

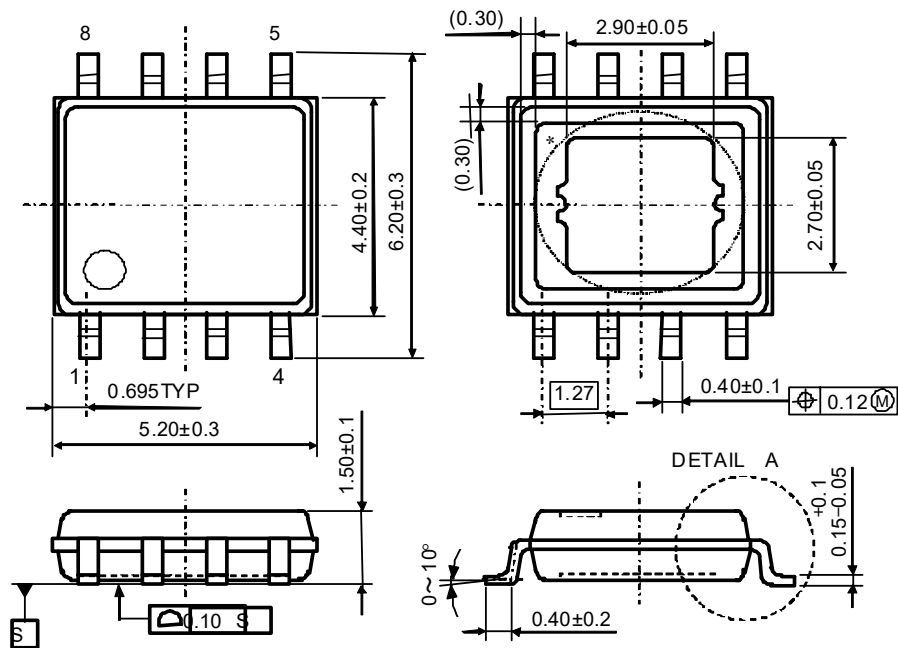
	Ultra High Wattage land pattern
Power Dissipation	3.6 W
Thermal Resistance	$\theta_{ja} = (150 - 25^\circ\text{C})/3.6 \text{ W} = 35^\circ\text{C/W}$
	$\theta_{jc} = 10^\circ\text{C /W}$



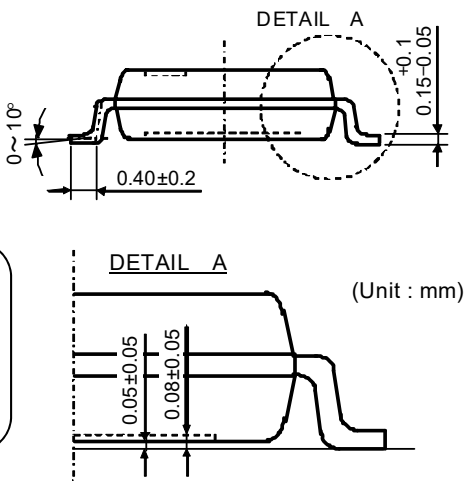
Measurent Board Pattern

○ IC Mount Area Unit : mm

PACKAGE DIMENSIONS (HSOP-8E)

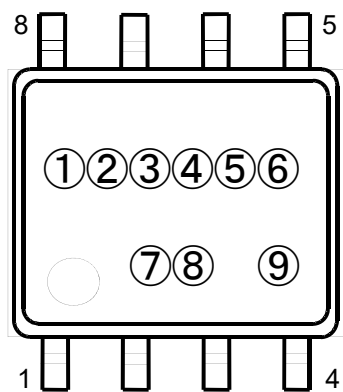


* The tab on the bottom of the package enhances thermal performance and is electrically connected to GND (substrate level). It is recommended that the tab be connected to the ground plane on the board, or otherwise be left floating.



MARK SPECIFICATION (HSOP-8E)

- ①②③④⑤⑥: Product Code ... **Refer to R8156S MARK SPECIFICATION TABLE**
- ⑦⑧: Lot Number ... Alphanumeric Serial Number
- ⑨: Lot Sub Number ... Alphanumeric Serial Number



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R8156S MARK SPECIFICATION TABLE (HSOP-8E)

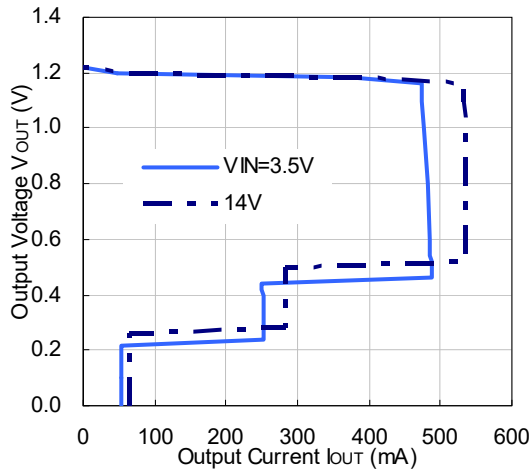
Product Name	①	②	③	④	⑤	⑥	V_{SET}
R8156S121B	R	S	1	0	8	A	1.2 V
R8156S151B	R	S	1	0	8	B	1.5 V
R8156S181B	R	S	1	0	8	C	1.8 V
R8156S331B	R	S	1	0	8	D	3.3 V
R8156S341B	R	S	1	0	8	E	3.4 V
R8156S501B	R	S	1	0	8	F	5.0 V
R8156S121D	R	S	1	0	8	G	1.2 V
R8156S151D	R	S	1	0	8	H	1.5 V
R8156S181D	R	S	1	0	8	J	1.8 V
R8156S331D	R	S	1	0	8	K	3.3 V
R8156S341D	R	S	1	0	8	L	3.4 V
R8156S501D	R	S	1	0	8	M	5.0 V

TYPICAL CHARACTERISTICS

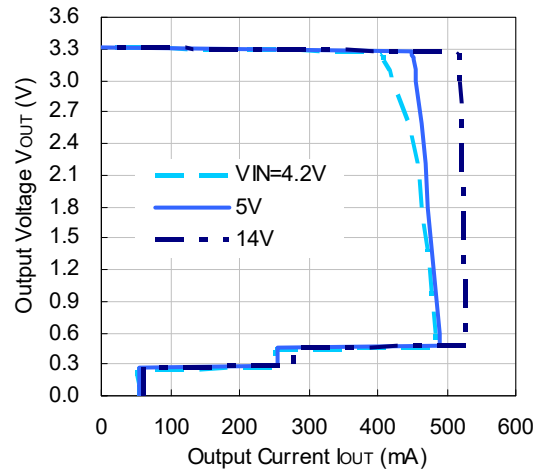
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

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

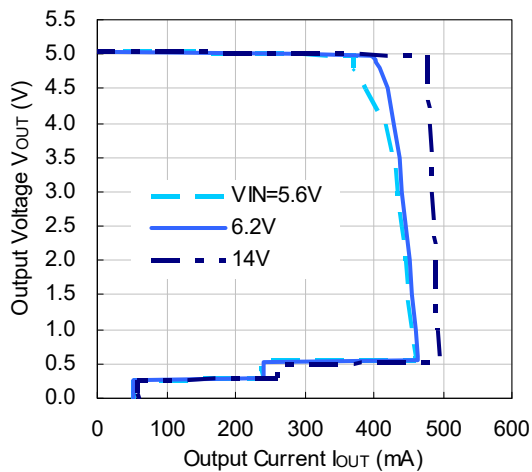
R8156S121B/D



R8156S331B/D

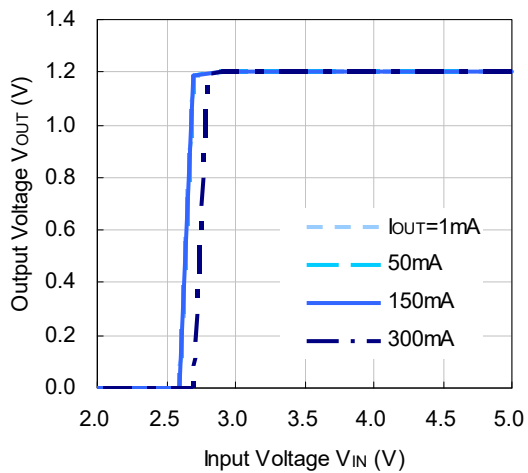


R8156S501B/D

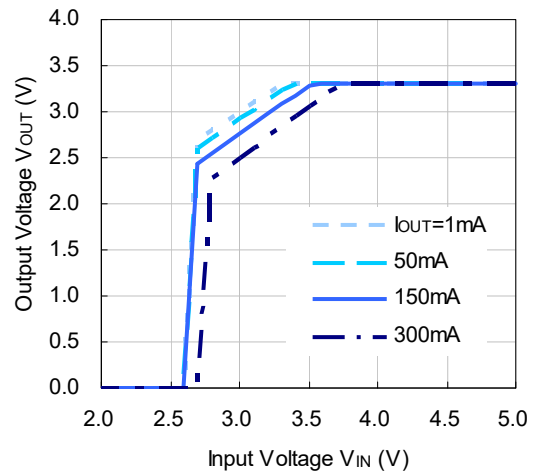


2) Output Voltage vs. Input Voltage (Ta = 25°C)

R8156S121B/D



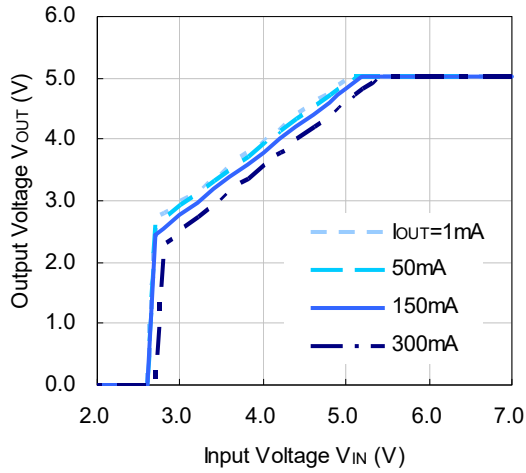
R8156S331B/D



R8156S

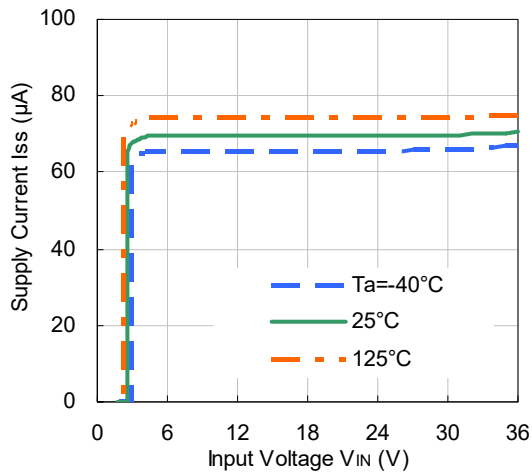
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R8156S501B/D

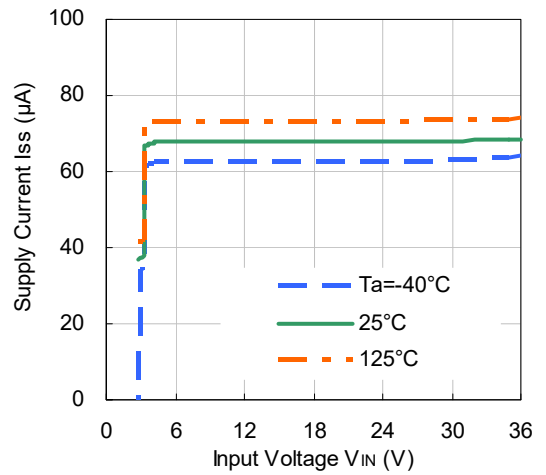


3) Supply Current vs. Input Voltage ($T_a = 25^\circ C$)

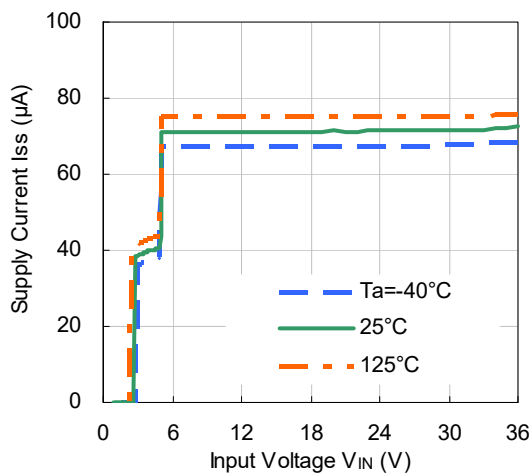
R8156S121B/D



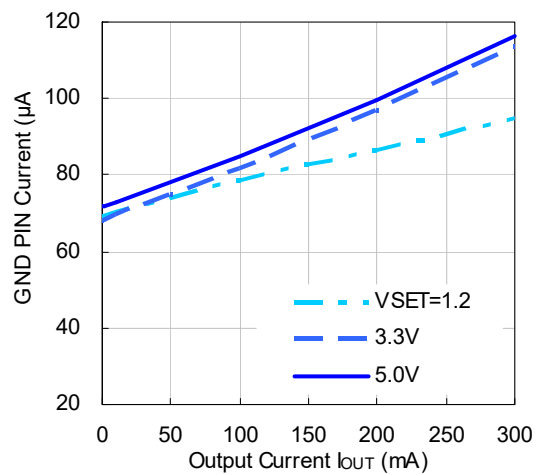
R8156S331B/D



R8156S501B/D

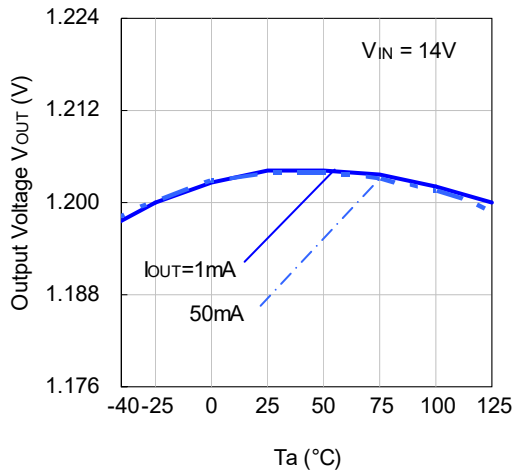


4) GND Pin Current vs. Output Current ($T_a = 25^\circ C$)

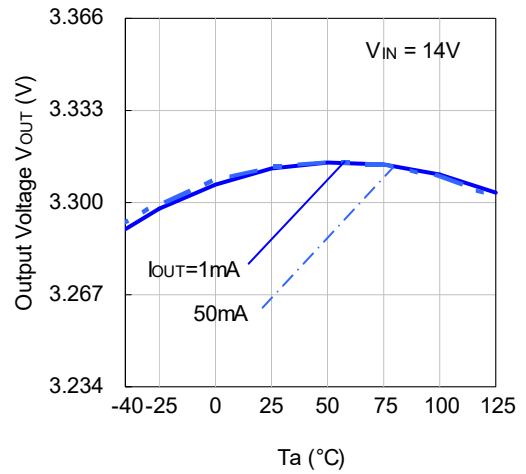


5) Output Voltage vs. Ambient Temperature

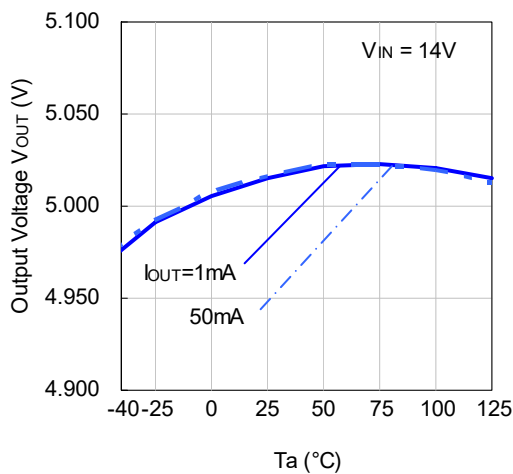
R8156S121B/D



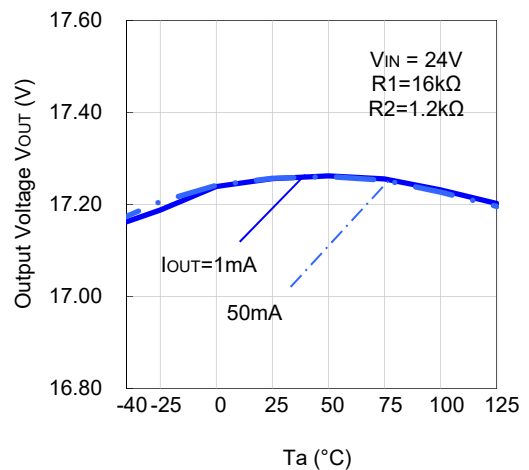
R8156S331B/D



R8156S501B/D

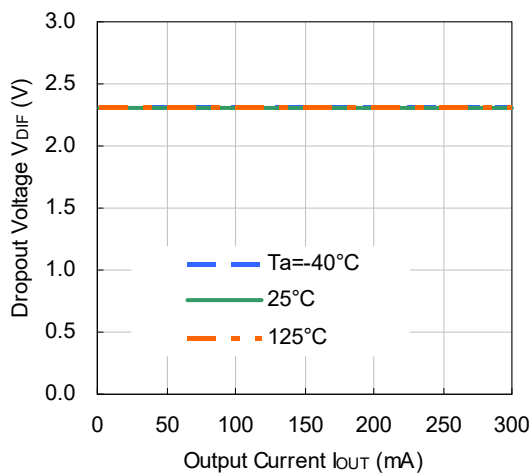


R8156S121B/D (Adjustable Output Voltage Setting)

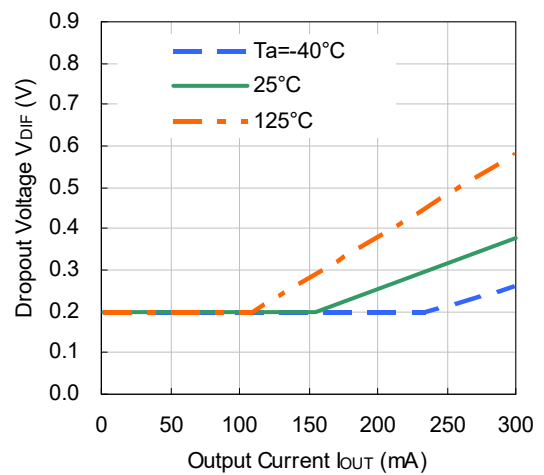


6) Dropout Voltage vs. Output Current

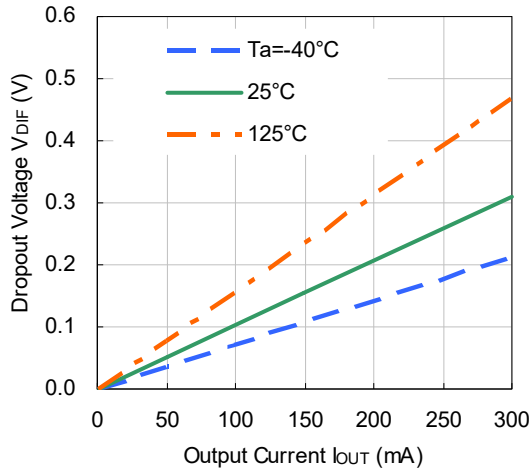
R8156S121B/D



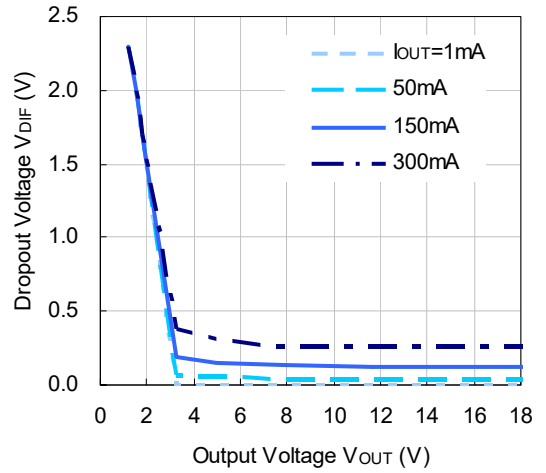
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R8156S501B/D

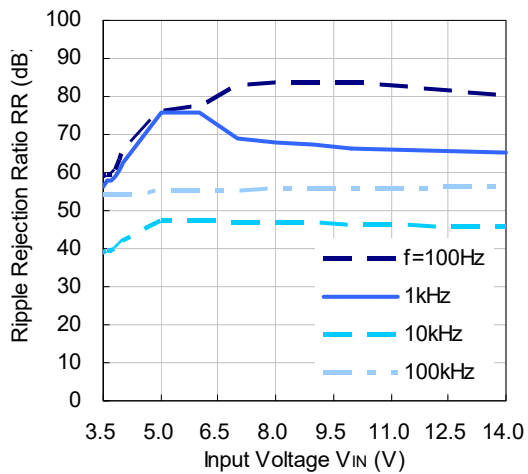


7) Dropout Voltage vs. Output Voltage ($T_a = 25^\circ\text{C}$)

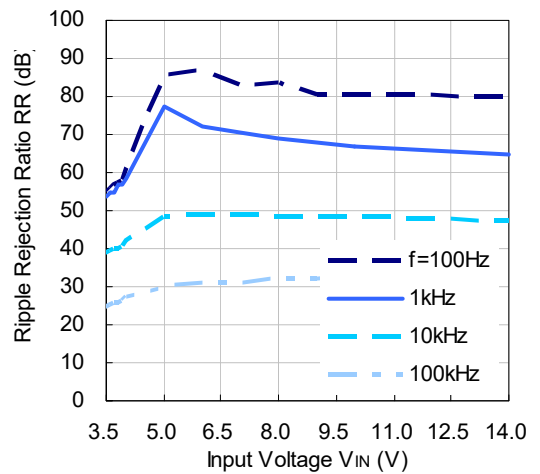


8) Ripple Rejection vs. Input Voltage ($T_a = 25^\circ\text{C}$, Ripple = 0.5 Vpp)

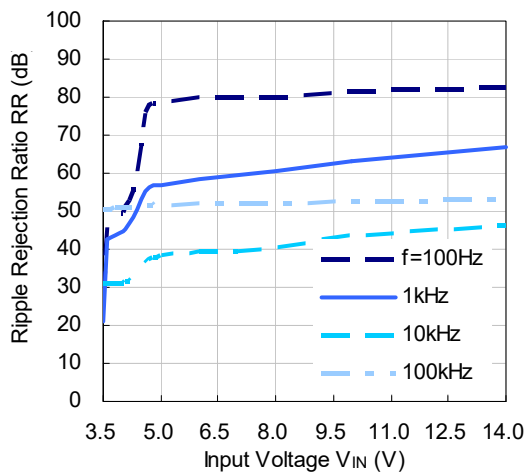
R8156S121B/D ($I_{OUT} = 1\text{ mA}$)



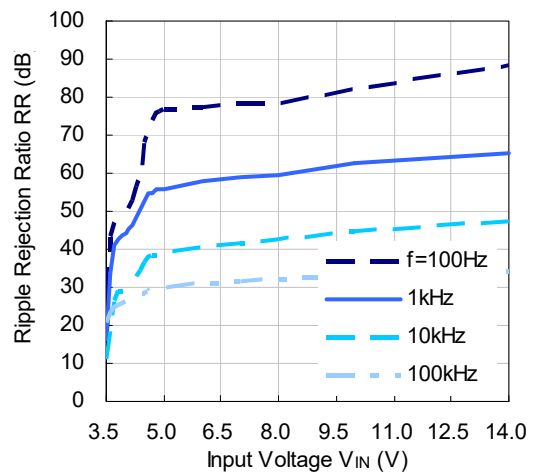
R8156S121B/D ($I_{OUT} = 50\text{ mA}$)



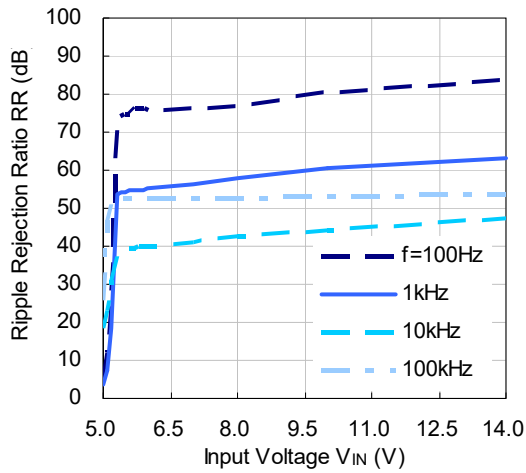
R8156S331B/D ($I_{OUT} = 1\text{ mA}$)



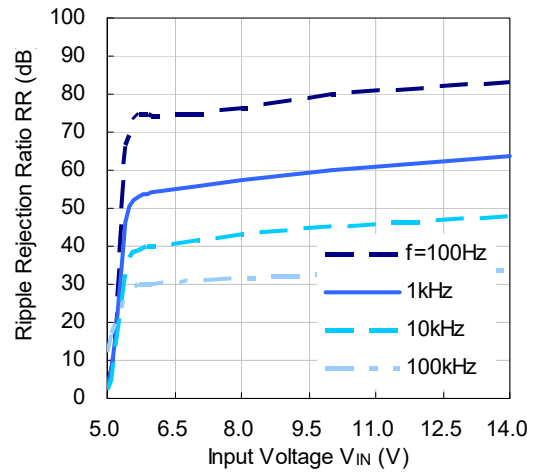
R8156S331B/D ($I_{OUT} = 50\text{ mA}$)



R8156S501B/D (I_{OUT} = 1 mA)

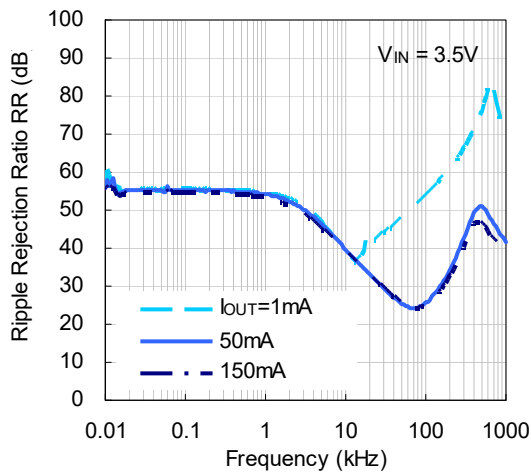


R8156S501B/D (I_{OUT} = 50 mA)

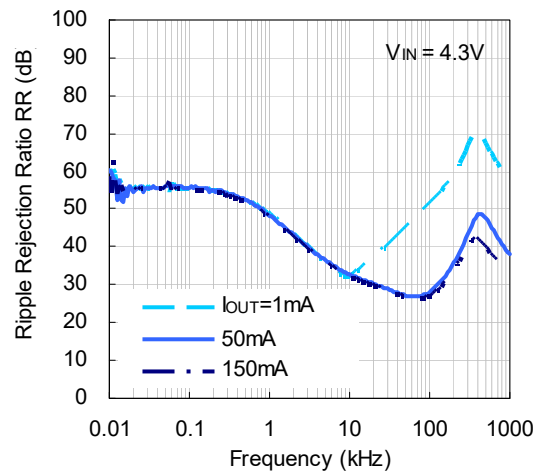


9) Ripple Rejection vs. Frequency (Ta = 25°C, Ripple = 0.5 Vpp)

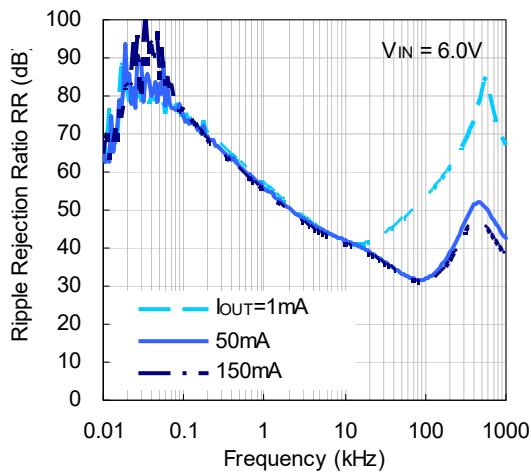
R8156S121B/D



R8156S331B/D



R8156S501B/D

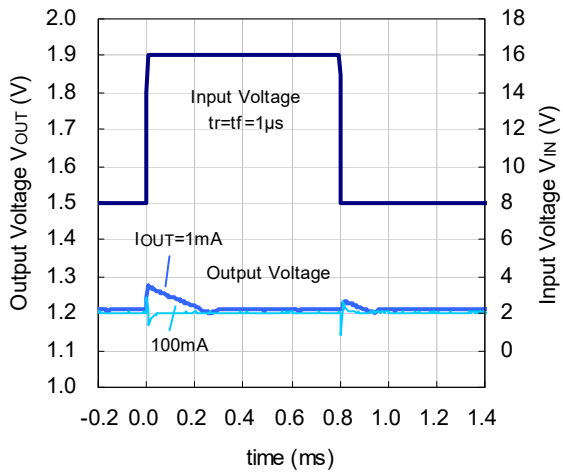


R8156S

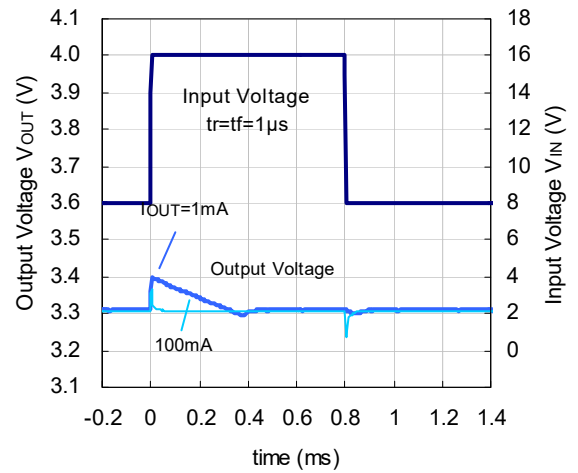
NO.EC-338-180510

10) Input Transient Response (Ta = 25°C, C2 = 4.7µF)

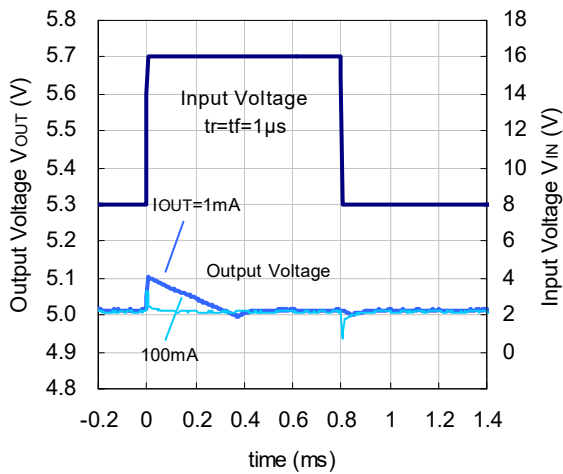
R8156S121B/D



R8156S331B/D

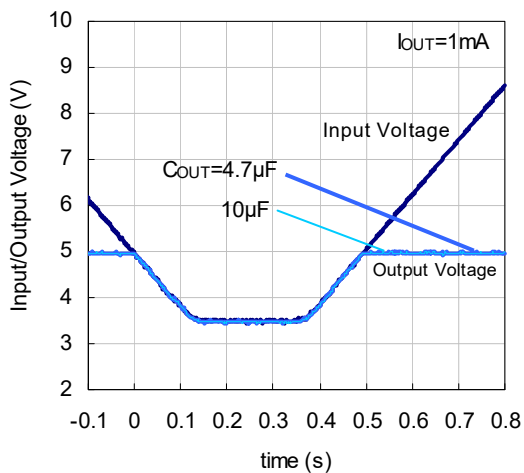


R8156S501B/D



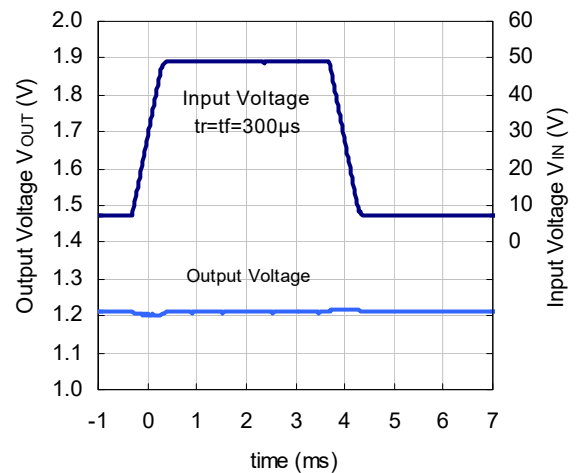
11) Cranking (Ta = -18°C)

R8156S501B/D

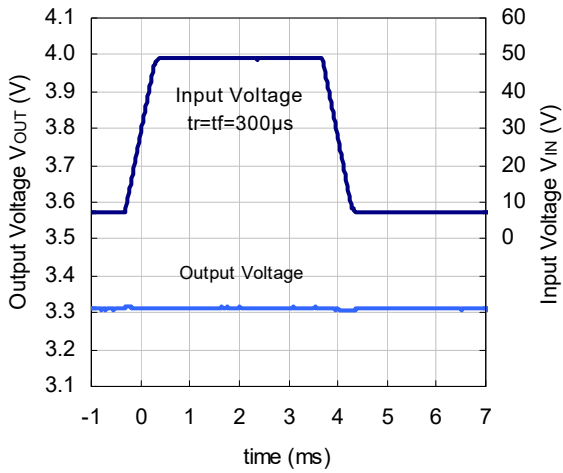


12) Load Dumping (Ta = 25°C, C2 = 4.7 µF)

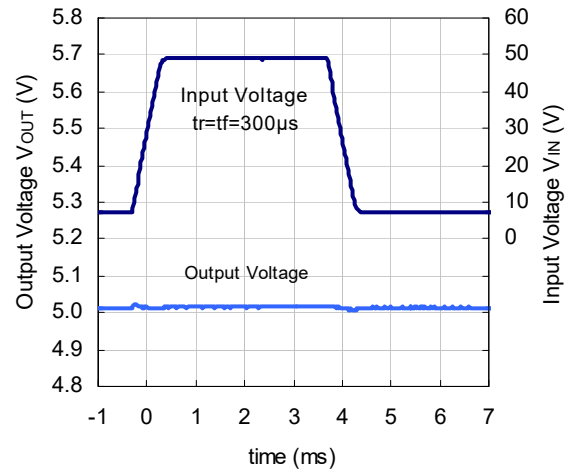
R8156S121B/D



R8156S331B/D

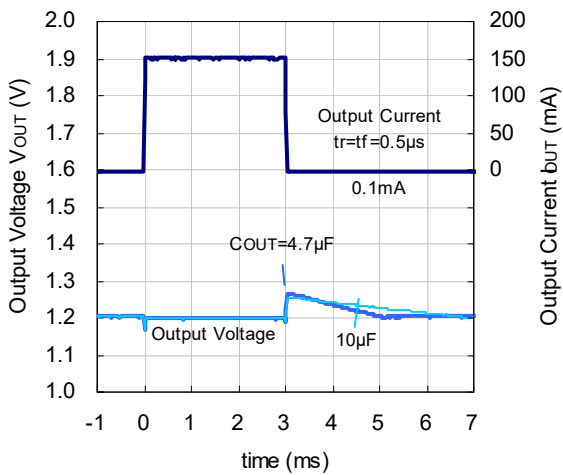


R8156S501B/D

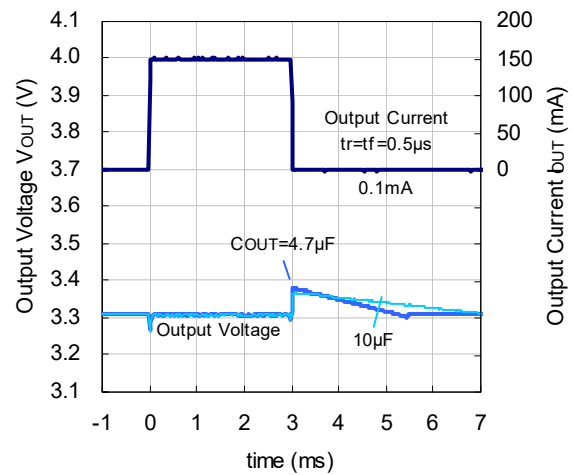


13) Load Transient Response ($T_a = 25^\circ C$)

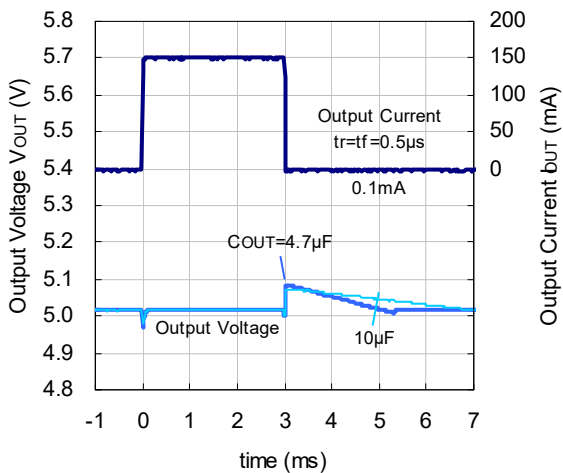
R8156S121B/D



R8156S331B/D



R8156S501B/D

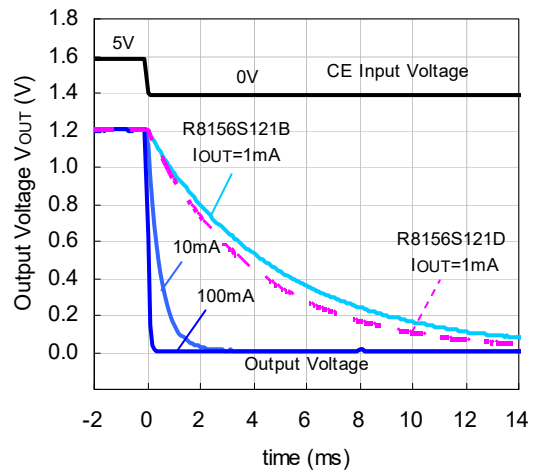
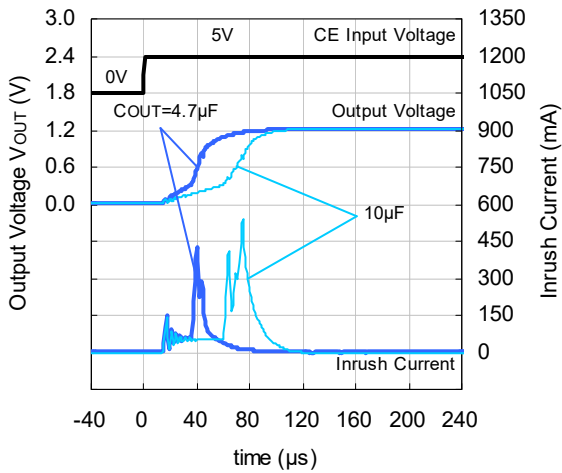


R8156S

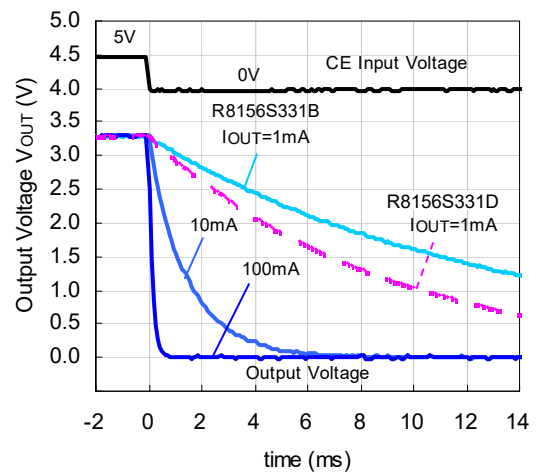
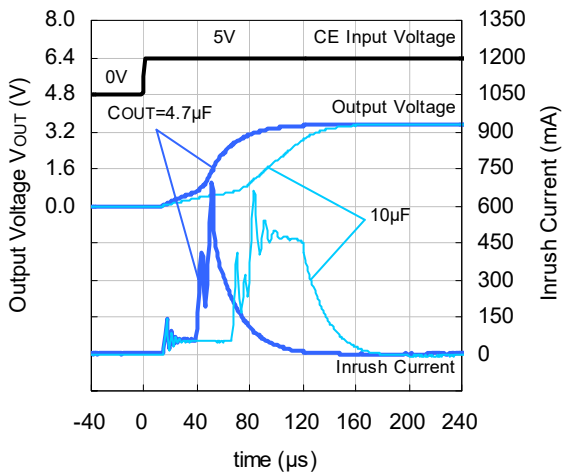
NO.EC-338-180510

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

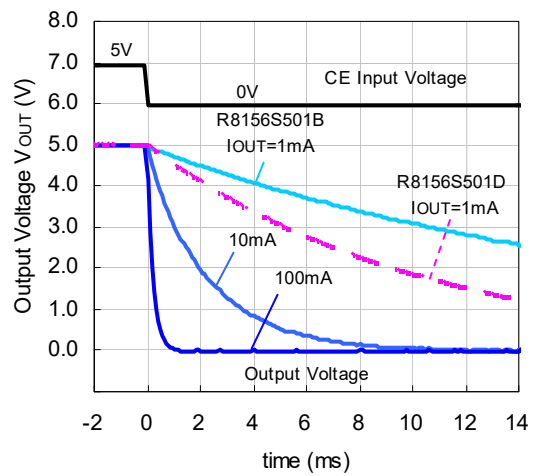
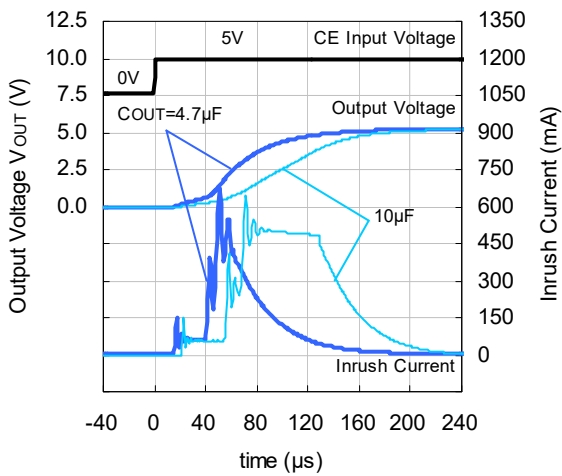
R8156S121B/D ($V_{IN} = 3.5\text{ V}$)



R8156S331B/D ($V_{IN} = 4.3\text{ V}$)

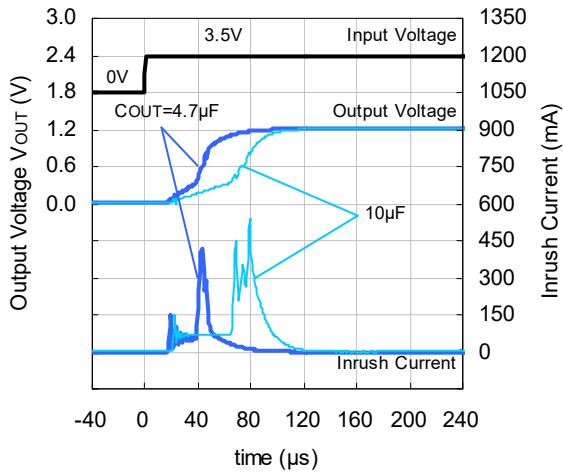


R8156S501B/D ($V_{IN} = 6.0\text{ V}$)

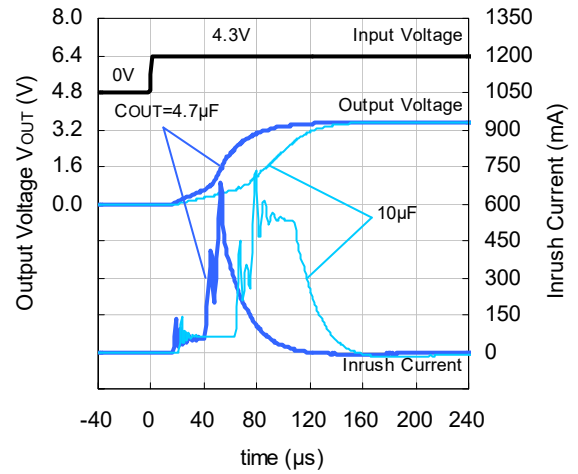


15) Power-on Transient Response ($T_a = 25^\circ\text{C}$, $V_{CE} = 5\text{ V}$)

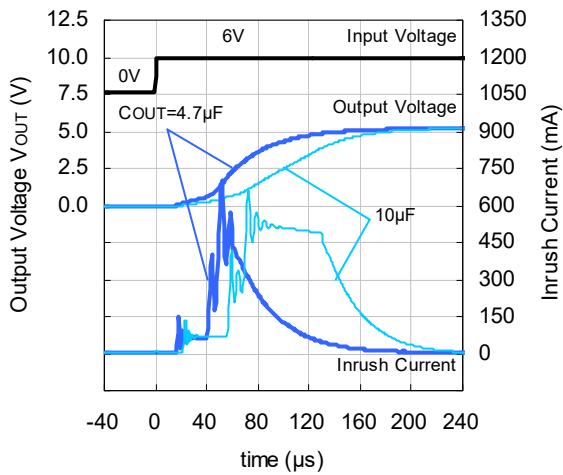
R8156S121B/D



R8156S331B/D

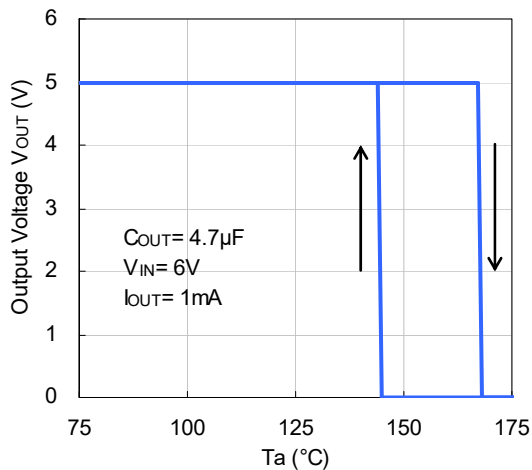


R8156S501B/D



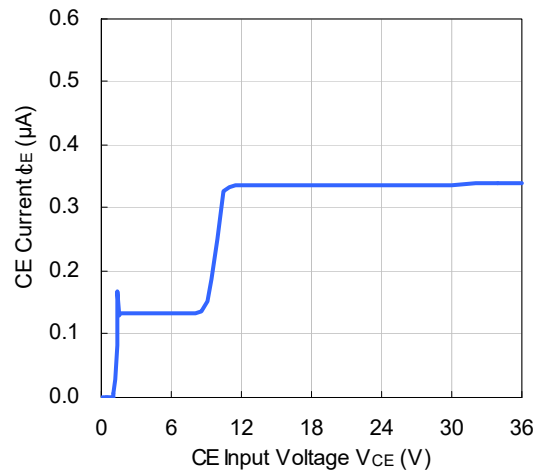
16) Thermal Shutdown

R8156S501B/D



17) CE Pin Current vs. CE Pin Voltage ($T_a = 25^\circ\text{C}$)

R8156Sxx1B/D

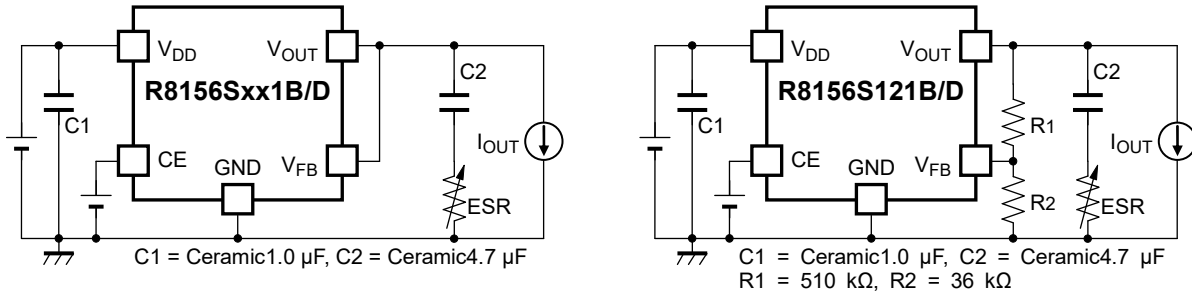


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Equivalent Series Resistance (ESR) vs. Output Current

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.



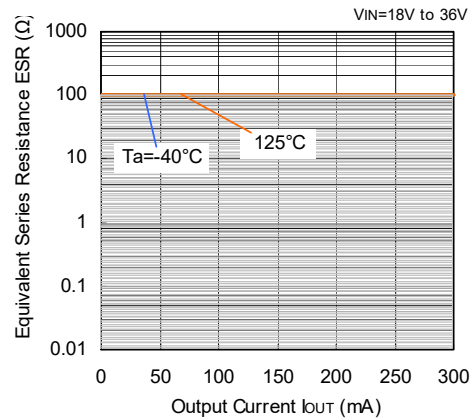
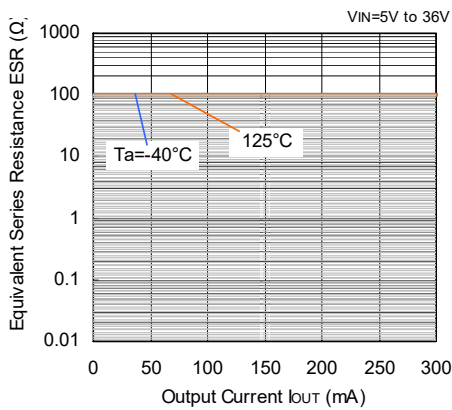
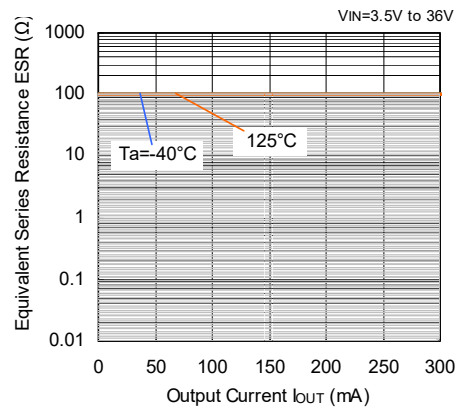
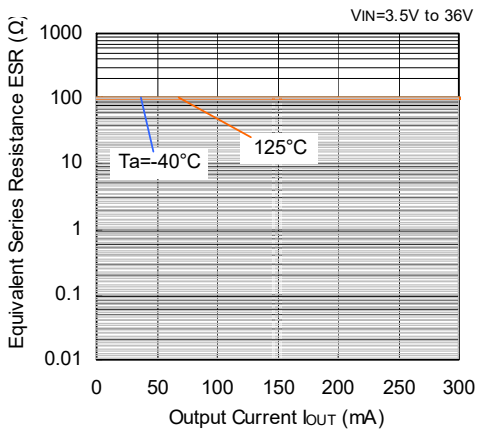
Measurement Conditions

Frequency Band: 10 Hz to 2 MHz

Ambient Temperature: -40°C to 125°C

Hatched Area: Noise level below 40 μ V (average)

Capacitor: C1 = 1.0 μ F Ceramic Capacitor, C2 = 4.7 μ F Ceramic Capacitor (C4532X7S1H685K)





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8. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
9. WLCSP products should be used in light shielded environments. The light exposure can influence functions and characteristics of the products under operation or storage.
10. There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or our distributor before attempting to use AOI.
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