
800mA LDO Regulator for Automotive Applications

NO.EC-084-131206

OUTLINE

The R1170x Series are positive voltage regulator ICs by CMOS process. The R1170x Series have features of high ripple rejection, low dropout voltage, high output voltage accuracy, and low consumption current. Each of these ICs consists of a voltage reference unit, an error amplifier, resistor net for setting output voltage, a current limit circuit at short mode, a chip enable circuit, and thermal-shunt circuit. Output Voltage of R1170 is fixed in the IC.

Low consumption current by the merit of CMOS process and built-in transistors with low ON-resistance make low dropout voltage and chip enable function prolong the battery life. These regulators are remarkable improvement on the current regulators in terms of ripple rejection, input transient response, and load transient response.

Maximum Output Current is large for its compact size.

Thus, the R1170x Series are suitable for various power sources for portable appliances.

This device is packaged in SOT-89-5 that achieves high-density mounting on boards.

FEATURES

- Input Voltage Range (Maximum Rating)..... Max. 6V (7.0V)
- Supply Current Typ. 80 μ A
- Standby Current Typ. 0.1 μ A
- Output Current Min. 800mA ($V_{IN}=V_{OUT}+1.0V$)
- Dropout Voltage Typ. 0.12V ($V_{OUT}=3.0V, I_{OUT}=300mA$)
- Output Voltage Accuracy..... $\pm 2.0\%$
- Temperature-Drift Coefficient of Output Voltage Typ. $\pm 100ppm/^{\circ}C$
- Line Regulation Typ. 0.05%/V
- Output Voltage 1.5V to 5.0V (0.1V steps)
- Ripple Rejection..... TYP. 50 dB
- Package SOT-89-5
- Built-in Current Limit Circuit
- Built-in Thermal Shutdown Circuit
- Ceramic capacitors are recommended to be used with this IC

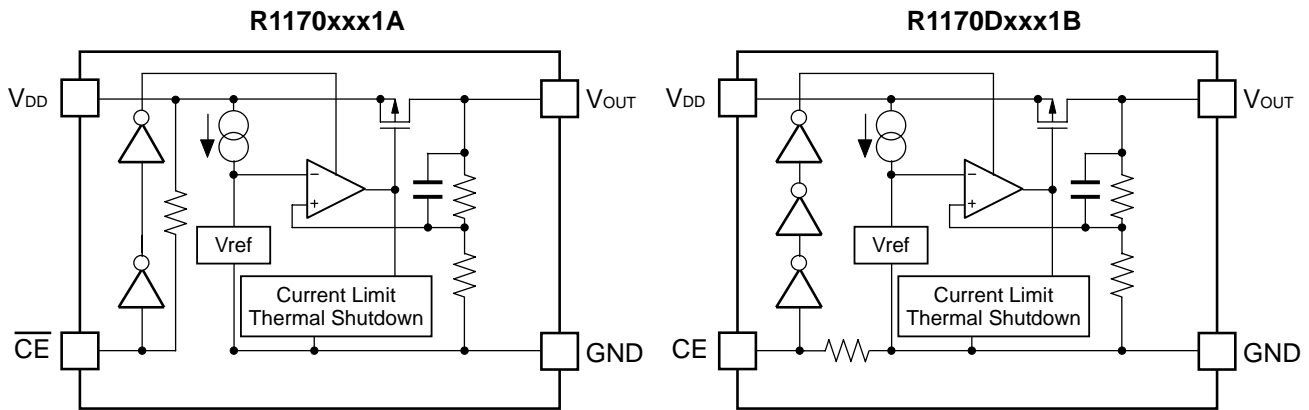
APPLICATIONS

- Power source for accessories such as car audios, car navigation systems, and ETC systems
- Power source for ECUs such as EV inverter and battery charge control unit

R1170H

NO.EC-084-131206

BLOCK DIAGRAMS



SELECTION GUIDE

The output voltage and the chip-enable polarity for the ICs can be selected at the user's request.

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1170Hxx1*-T1-#E	SOT-89-5	1,000 pcs	Yes	Yes

xx: The output voltage can be designated in the range from 1.5V (15) to 5.0V (50) in 0.1V steps.

* : CE pin polarity options are as follows.

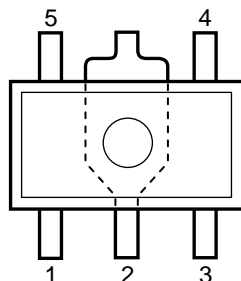
- (A) "L" active
- (B) "H" active

: Specify Automotive Class Code

	Operating Temperature Range	Guaranteed Specs Temperature Range	Screening
A	-40°C to 85°C	25°C	High Temperature
H	-40°C to 85°C	25°C	High and Low Temperature

PIN DESCRIPTION

• SOT-89-5



• SOT-89-5

Pin No	Symbol	Description
1	$\overline{\text{CE}}$ or CE	Chip Enable Pin
2	GND	Ground Pin
3	NC	No Connection
4	V _{DD}	Input Pin
5	V _{OUT}	Voltage Regulator Output Pin

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V _{IN}	Input Voltage	7.0	V
V _{CE}	Input Voltage (\overline{CE} or CE Input Pin)	-0.3 to V _{IN} +0.3	V
V _{OUT}	Output Voltage	-0.3 to V _{IN} +0.3	V
P _D	Power Dissipation (SOT-89-5)*	Standard Land Pattern	900
		High Wattage Land Pattern	1300
T _j	Junction Temperature	-40 to 125	°C
T _{stg}	Storage Temperature	-55 to 125	°C

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

ABSOLUTE MAXIMUM RATINGS	
<p>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.</p>	

RECOMMENDED OPERATING RATINGS

Symbol	Item	Rating	Unit
V _{IN}	Input Voltage	2.1 to 6.0	V
T _a	Operating Temperature Range	-40 to 85	°C

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

ELECTRICAL CHARACTERISTICS

R1170xxxxA

(Ta=25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
I _{SS}	Supply Current	V _{IN} -V _{OUT} =1.0V, V _{CE} =GND		80	160	μA
I _{standby}	Standby Current	V _{IN} =V _{CE} =6.0V		0.1	1.0	μA
V _{OUT}	Output voltage	V _{IN} -V _{OUT} =1.0V I _{OUT} =100mA	×0.98		×1.02	V
ΔV _{OUT} / ΔI _{OUT}	Load regulation	V _{IN} -V _{OUT} =1.0V 1mA ≤ I _{OUT} ≤ 300mA		30	100	mV
V _{DIF}	Dropout Voltage	I _{OUT} =300mA	Refer to the <i>Product-specific Electrical Characteristics</i>			
ΔV _{OUT} / ΔV _{IN}	Line regulation	I _{OUT} =100mA V _{OUT} +0.5V ≤ V _{IN} ≤ 6.0V		0.05	0.30	%/V
I _{LIM}	Output Current	V _{IN} -V _{OUT} =1.0V	800			mA
I _{SC}	Short Current Limit	V _{OUT} =0V		40		mA
R _{PU}	Pull-up resistance for \overline{CE} pin		1.25	2.50	5.00	MΩ
V _{CEH}	\overline{CE} Input Voltage "H"		1.50		V _{IN}	V
V _{CEL}	\overline{CE} Input Voltage "L"		0		0.25	V
T _{TSD}	Thermal Shutdown Detector Threshold Temperature	Junction Temperature		150		°C
T _{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		120		°C

R1170H

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R1170xxxxB

(Ta=25°C)

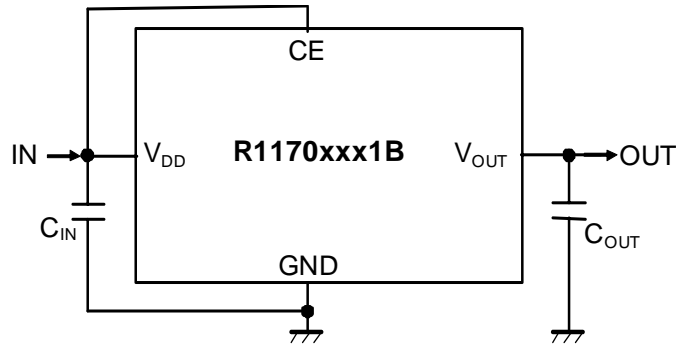
Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
I _{SS}	Supply Current	V _{IN} -V _{OUT} =1.0V, V _{CE} =V _{IN}		80	160	μA
I _{standby}	Standby Current	V _{IN} =6.0V, V _{CE} =GND		0.1	1.0	μA
V _{OUT}	Reference Voltage for Adjustable Voltage Regulator	V _{IN} -V _{OUT} =1.0V I _{OUT} =100mA	×0.98		×1.02	V
ΔV _{OUT} / ΔI _{OUT}	Load regulation	V _{IN} -V _{OUT} =1.0V 1mA ≤ I _{OUT} ≤ 300mA		30	100	mV
V _{DIF}	Dropout Voltage	I _{OUT} =300mA	Refer to the <i>Product-specific Electrical Characteristics</i>			
ΔV _{OUT} / ΔV _{IN}	Line regulation	I _{OUT} =100mA V _{OUT} +0.5V ≤ V _{IN} ≤ 6.0V		0.05	0.30	%/V
I _{LIM}	Output Current	V _{IN} -V _{OUT} =1.0V	800			mA
I _{SC}	Short Current Limit	V _{OUT} =0V		40		mA
R _{PD}	Pull-down resistance for CE pin		1.25	2.50	5.00	MΩ
V _{CEH}	CE Input Voltage "H"		1.5		V _{IN}	V
V _{CEL}	CE Input Voltage "L"		0		0.25	V
T _{TSD}	Thermal Shutdown Detector Threshold Temperature	Junction Temperature		150		°C
T _{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		120		°C

Product-specific Electrical Characteristics

(Ta=25°C)

Product Name	V _{OUT} [V]			V _{DIF} [V]	
	MIN.	TYP.	MAX.	TYP.	MAX.
R1170H151x	1.470	1.500	1.530	0.35	0.45
R1170H161x	1.568	1.600	1.632	0.30	0.35
R1170H171x	1.666	1.700	1.734	0.25	0.30
R1170H181x	1.764	1.800	1.836	0.20	0.25
R1170H191x	1.862	1.900	1.938		
R1170H201x	1.960	2.000	2.040		
R1170H211x	2.058	2.100	2.142	0.15	0.20
R1170H221x	2.156	2.200	2.244		
R1170H231x	2.254	2.300	2.346		
R1170H241x	2.352	2.400	2.448		
R1170H251x	2.450	2.500	2.550	0.12	0.18
R1170H261x	2.548	2.600	2.652		
R1170H271x	2.646	2.700	2.754		
R1170H281x	2.744	2.800	2.856		
R1170H291x	2.842	2.900	2.958		
R1170H301x	2.940	3.000	3.060		
R1170H311x	3.038	3.100	3.162		
R1170H321x	3.136	3.200	3.264		
R1170H331x	3.234	3.300	3.366		
R1170H341x	3.332	3.400	3.468		
R1170H351x	3.430	3.500	3.570		
R1170H361x	3.528	3.600	3.672		
R1170H371x	3.626	3.700	3.774		
R1170H381x	3.724	3.800	3.876		
R1170H391x	3.822	3.900	3.978		
R1170H401x	3.920	4.000	4.080		
R1170H411x	4.018	4.100	4.182		
R1170H421x	4.116	4.200	4.284		
R1170H431x	4.214	4.300	4.386		
R1170H441x	4.312	4.400	4.488		
R1170H451x	4.410	4.500	4.590		
R1170H461x	4.508	4.600	4.692		
R1170H471x	4.606	4.700	4.794		
R1170H481x	4.704	4.800	4.896		
R1170H491x	4.802	4.900	4.998		
R1170H501x	4.900	5.000	5.100		

TYPICAL APPLICATION



$C_{IN} = 10 \mu\text{F}$ (Ceramic), $C_{OUT} = 10 \mu\text{F}$ (Ceramic)

TECHNICAL NOTES

Phase Compensation

In these ICs, phase compensation is made with the output capacitor for securing stable operation even if the load current is varied. For this purpose, use as much as $10\mu\text{F}$ Capacitor as C_{OUT} .

If you use a tantalum type capacitor and ESR value of the capacitor is large, output might be unstable. Evaluate your circuit with considering frequency characteristics. Further, refer to the Typical Characteristics No. 12.

Response Time

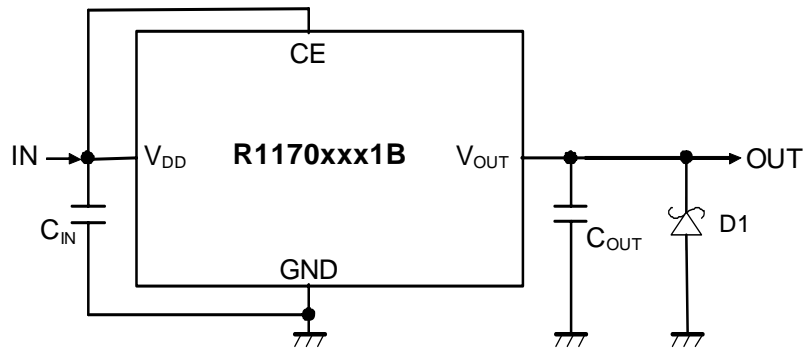
The response time by the chip enable function depends on the value of capacitor. When the capacitor value (C_{OUT}) is $40\mu\text{F}$ or more, the response time might change by the length of OFF time.

Mounting on PCB

Make V_{DD} and GND lines sufficient. If their impedance is high, a current flows, the noise picked up or unstable operation may result. Further use as much as $10\mu\text{F}$ capacitor between V_{DD} pin and GND pin as close as possible.

Set an Output capacitor between V_{OUT} pin and GND pin for phase compensation as close as possible.
(Refer to the example of typical application)

TYPICAL APPLICATION FOR IC CHIP BREAKDOWN PREVENTION



$C_{IN} = 10 \mu\text{F}$ (Ceramic), $C_{OUT} = 10 \mu\text{F}$ (Ceramic)

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 (C_{OUT}) 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.

PACKAGE INFORMATION

POWER DISSIPATION (SOT89-5)

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

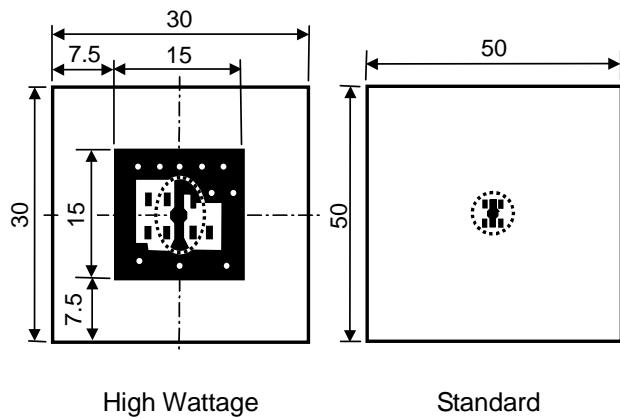
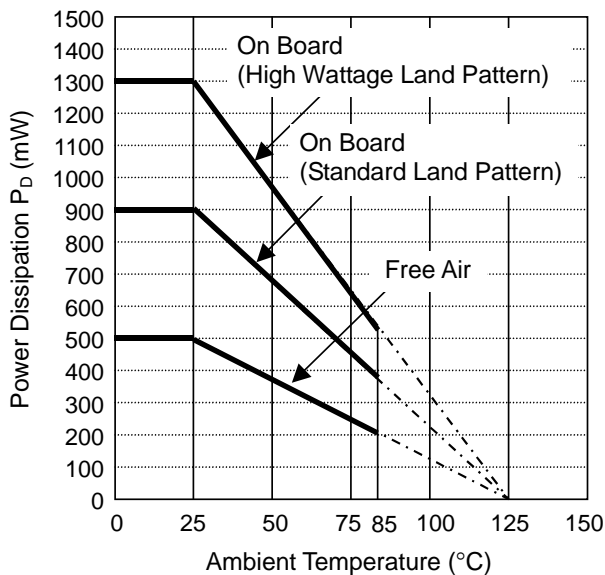
Measurement Conditions

	High Wattage Land Pattern	Standard Land Pattern
Environment	Mounting on Board (Wind velocity=0m/s)	Mounting on Board (Wind velocity=0m/s)
Board Material	Glass cloth epoxy plastic (Double sided)	Glass cloth epoxy plastic (Double sided)
Board Dimensions	30mm × 30mm × 1.6mm	50mm × 50mm × 1.6mm
Copper Ratio	Top side : Approx. 20% , Back side : Approx. 100%	Top side : Approx. 10% , Back side : Approx. 100%
Through-hole	φ0.85mm × 10pcs	-

Measurement Result

($T_a=25^\circ\text{C}$, $T_{jmax}=125^\circ\text{C}$)

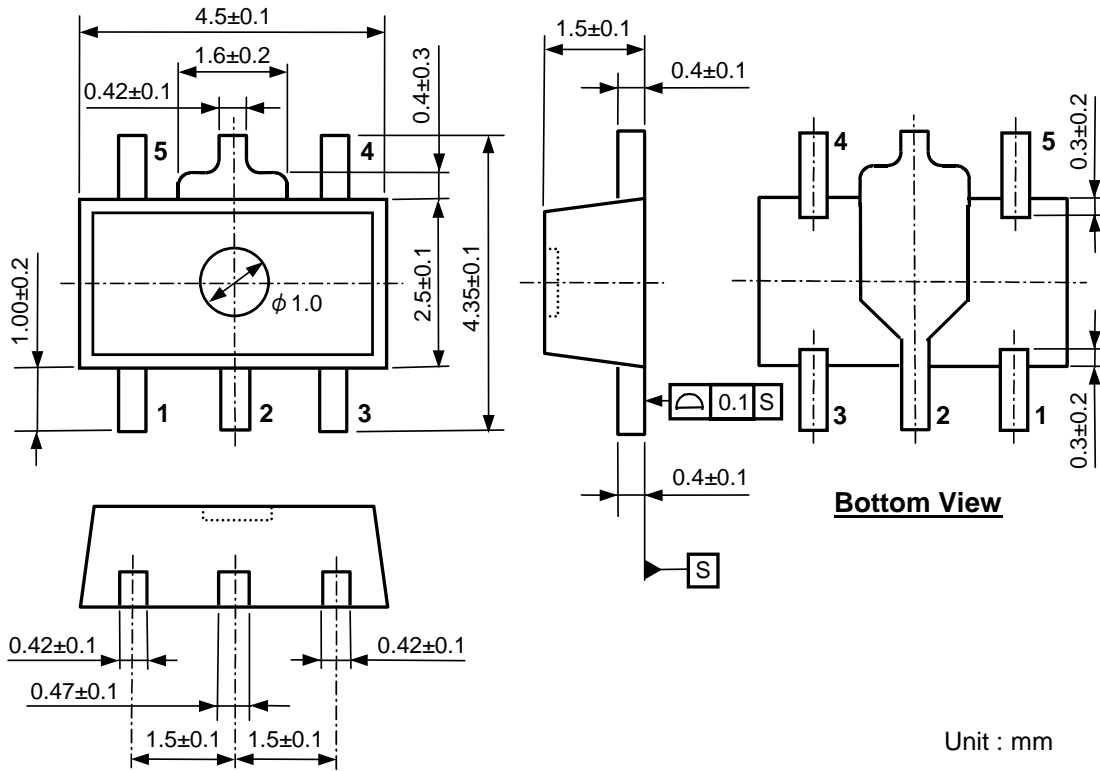
	High Wattage Land Pattern	Standard Land Pattern	Free Air
Power Dissipation	1300mW	900mW	500mW
Thermal Resistance	77°C/W	111°C/W	200°C/W



Measurement Board Pattern

○ IC Mount Area (Unit : mm)

PACKAGE DIMENSIONS (SOT89-5)

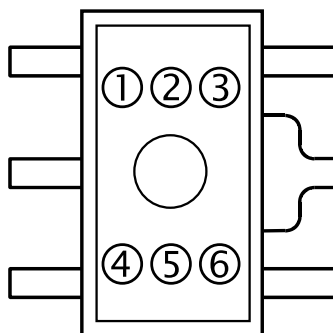


Package Dimensions (SOT89-5)

MARK SPECIFICATION (SOT89-5)

①②③④: Product Code ... Refer to MARK SPECIFICATION TABLE

⑤⑥: Lot Number ... Alphanumeric Serial Number



Mark Specification (SOT89-5)

R1170HNO.EC-084-131206

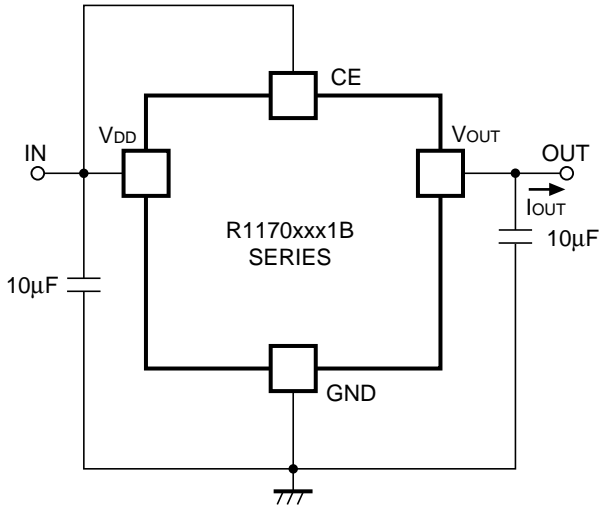
MARK SPECIFICATION TABLE (SOT89-5)**R1170HxxxA**

Product Name	① ② ③ ④	V _{SET}
R1170H151A	E 1 5 A	1.5V
R1170H161A	E 1 6 A	1.6V
R1170H171A	E 1 7 A	1.7V
R1170H181A	E 1 8 A	1.8V
R1170H191A	E 1 9 A	1.9V
R1170H201A	E 2 0 A	2.0V
R1170H211A	E 2 1 A	2.1V
R1170H221A	E 2 2 A	2.2V
R1170H231A	E 2 3 A	2.3V
R1170H241A	E 2 4 A	2.4V
R1170H251A	E 2 5 A	2.5V
R1170H261A	E 2 6 A	2.6V
R1170H271A	E 2 7 A	2.7V
R1170H281A	E 2 8 A	2.8V
R1170H291A	E 2 9 A	2.9V
R1170H301A	E 3 0 A	3.0V
R1170H311A	E 3 1 A	3.1V
R1170H321A	E 3 2 A	3.2V
R1170H331A	E 3 3 A	3.3V
R1170H341A	E 3 4 A	3.4V
R1170H351A	E 3 5 A	3.5V
R1170H361A	E 3 6 A	3.6V
R1170H371A	E 3 7 A	3.7V
R1170H381A	E 3 8 A	3.8V
R1170H391A	E 3 9 A	3.9V
R1170H401A	E 4 0 A	4.0V
R1170H411A	E 4 1 A	4.1V
R1170H421A	E 4 2 A	4.2V
R1170H431A	E 4 3 A	4.3V
R1170H441A	E 4 4 A	4.4V
R1170H451A	E 4 5 A	4.5V
R1170H461A	E 4 6 A	4.6V
R1170H471A	E 4 7 A	4.7V
R1170H481A	E 4 8 A	4.8V
R1170H491A	E 4 9 A	4.9V
R1170H501A	E 5 0 A	5.0V

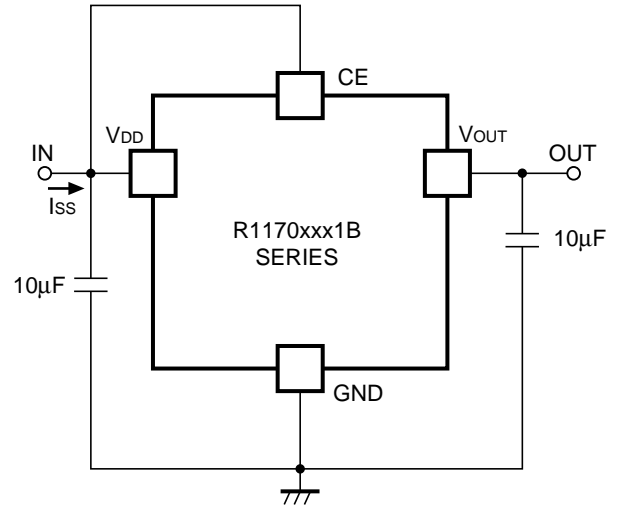
R1170HxxxB

Product Name	① ② ③ ④	V _{SET}
R1170H151B	E 1 5 B	1.5V
R1170H161B	E 1 6 B	1.6V
R1170H171B	E 1 7 B	1.7V
R1170H181B	E 1 8 B	1.8V
R1170H191B	E 1 9 B	1.9V
R1170H201B	E 2 0 B	2.0V
R1170H211B	E 2 1 B	2.1V
R1170H221B	E 2 2 B	2.2V
R1170H231B	E 2 3 B	2.3V
R1170H241B	E 2 4 B	2.4V
R1170H251B	E 2 5 B	2.5V
R1170H261B	E 2 6 B	2.6V
R1170H271B	E 2 7 B	2.7V
R1170H281B	E 2 8 B	2.8V
R1170H291B	E 2 9 B	2.9V
R1170H301B	E 3 0 B	3.0V
R1170H311B	E 3 1 B	3.1V
R1170H321B	E 3 2 B	3.2V
R1170H331B	E 3 3 B	3.3V
R1170H341B	E 3 4 B	3.4V
R1170H351B	E 3 5 B	3.5V
R1170H361B	E 3 6 B	3.6V
R1170H371B	E 3 7 B	3.7V
R1170H381B	E 3 8 B	3.8V
R1170H391B	E 3 9 B	3.9V
R1170H401B	E 4 0 B	4.0V
R1170H411B	E 4 1 B	4.1V
R1170H421B	E 4 2 B	4.2V
R1170H431B	E 4 3 B	4.3V
R1170H441B	E 4 4 B	4.4V
R1170H451B	E 4 5 B	4.5V
R1170H461B	E 4 6 B	4.6V
R1170H471B	E 4 7 B	4.7V
R1170H481B	E 4 8 B	4.8V
R1170H491B	E 4 9 B	4.9V
R1170H501B	E 5 0 B	5.0V

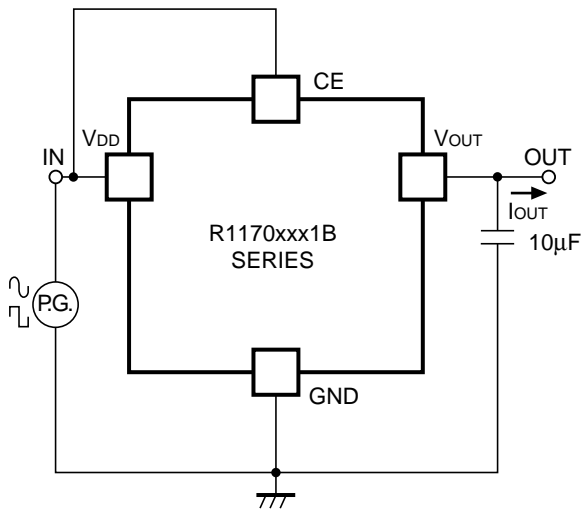
TEST CIRCUITS



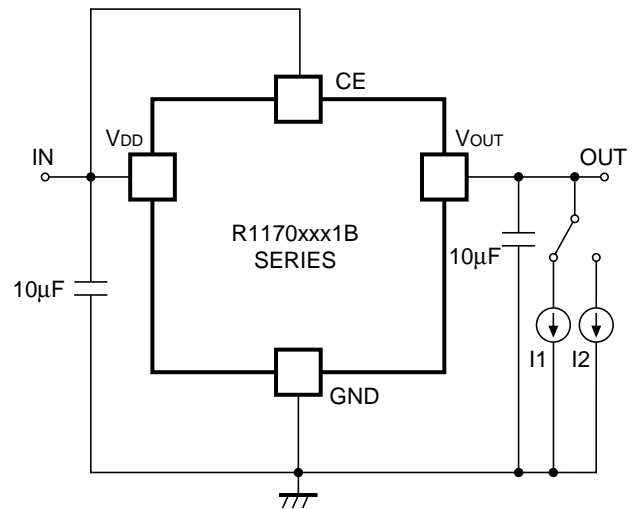
Standard Test Circuit



Supply Current Test Circuit



**Test Circuit for Ripple Rejection,
Input Transient Response**

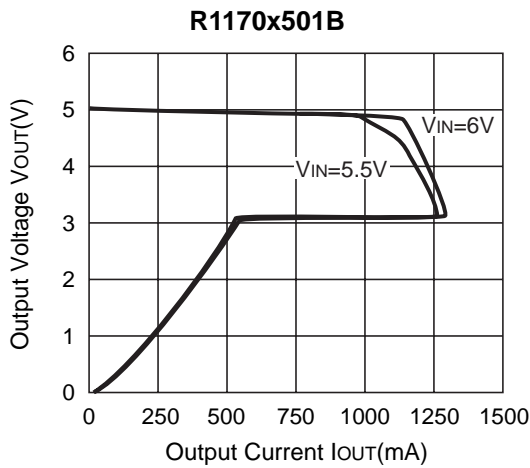
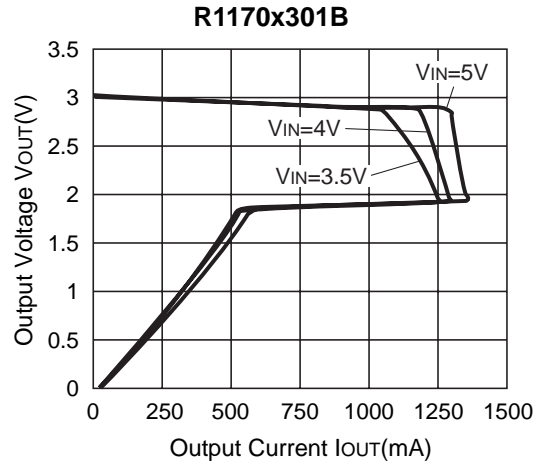
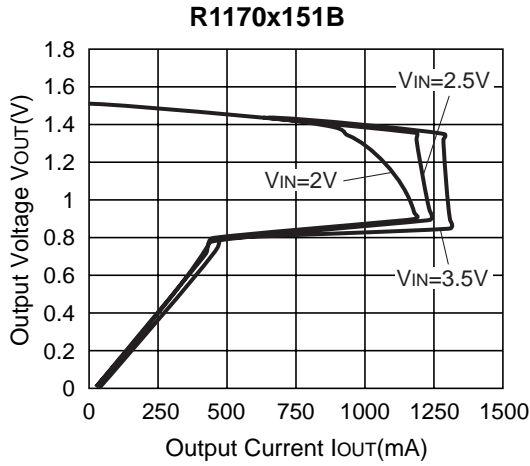


Test Circuit for Load Transient Response

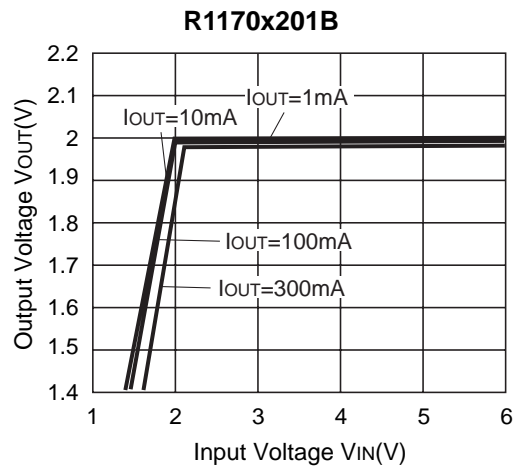
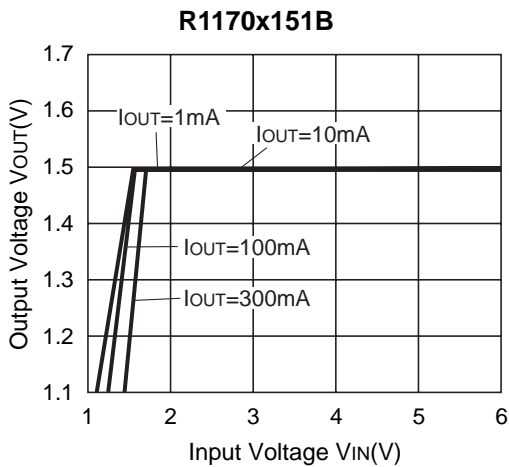
TYPICAL CHARACTERISTICS

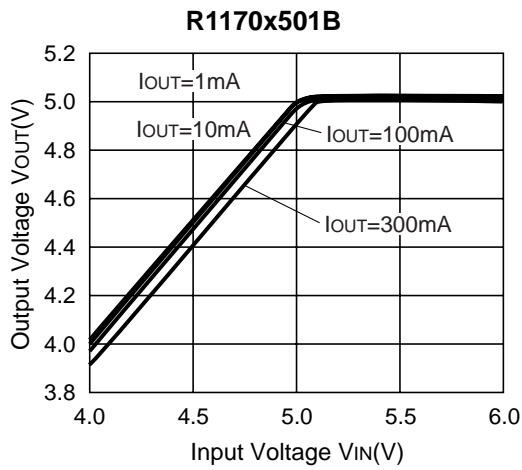
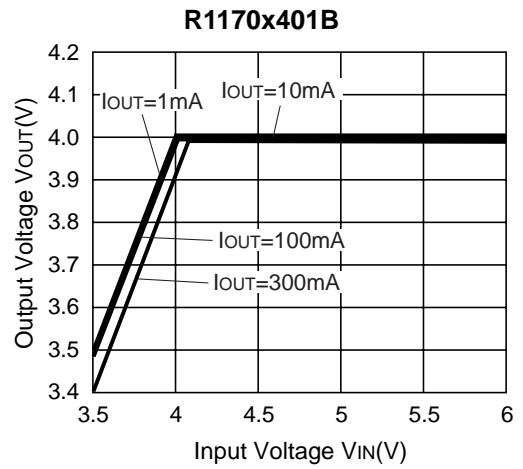
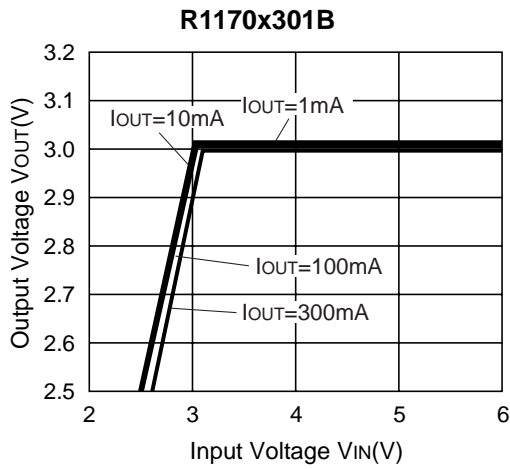
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

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

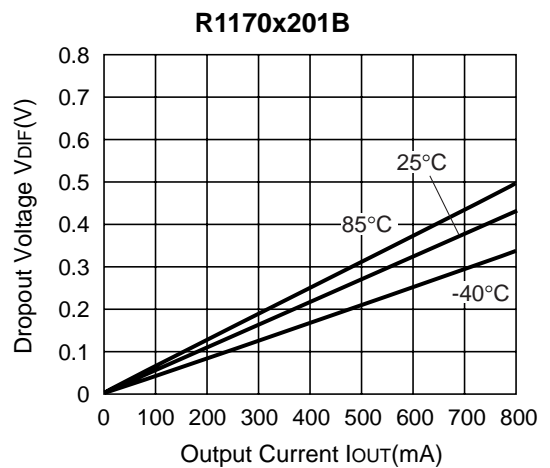
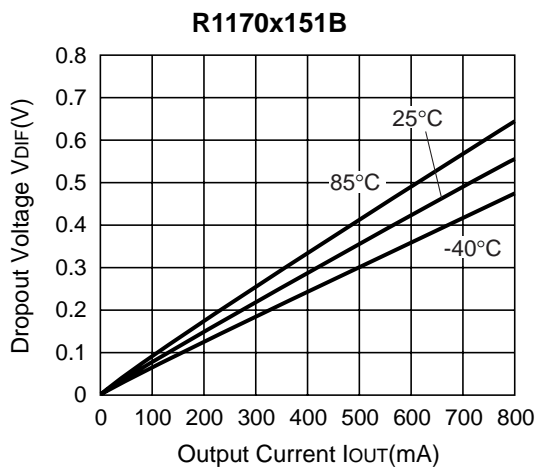


2) Output Voltage vs. Input Voltage ($T_a=25^\circ\text{C}$)



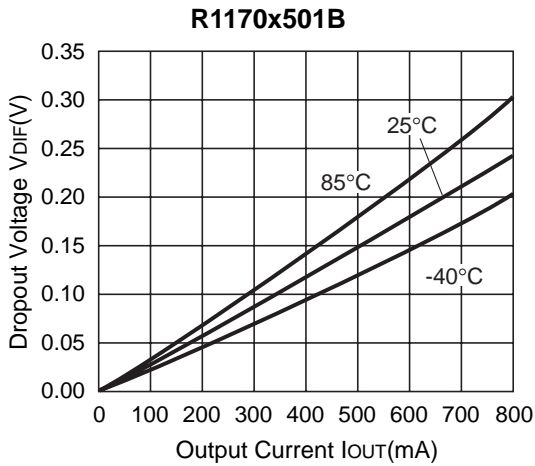
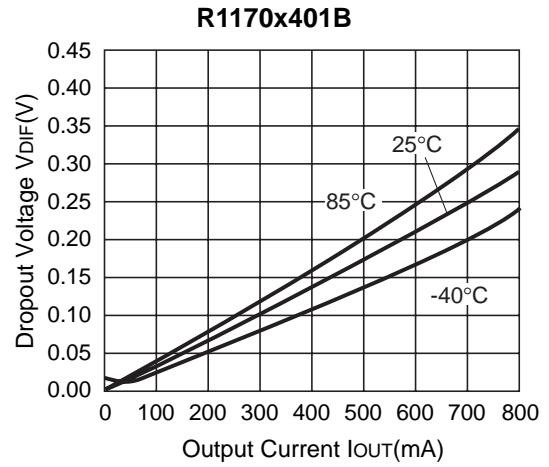
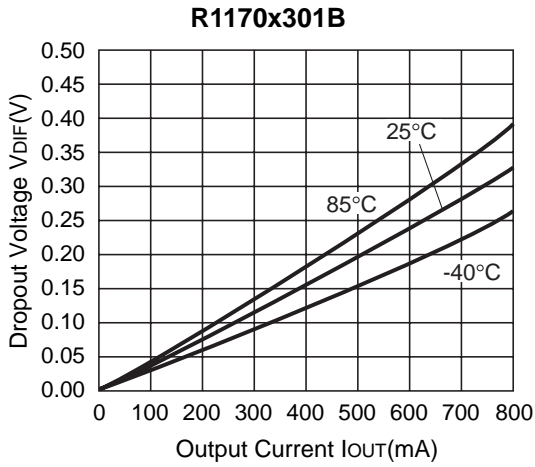


3) Dropout Voltage vs. Output Current

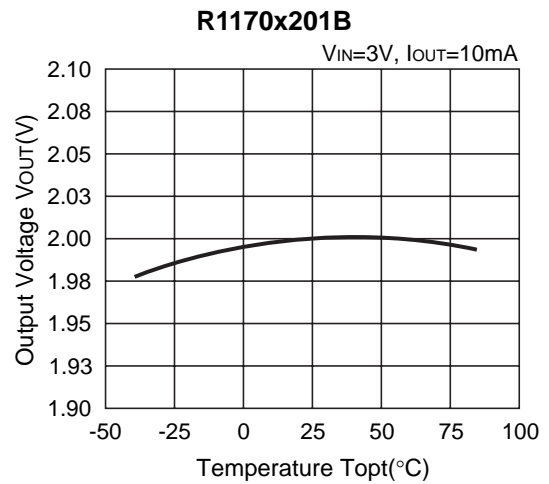
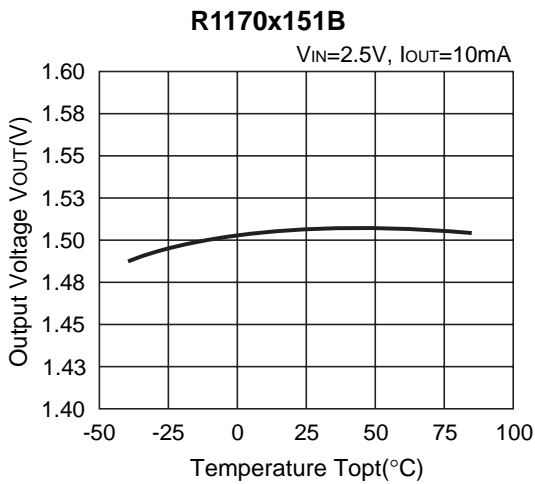


R1170H

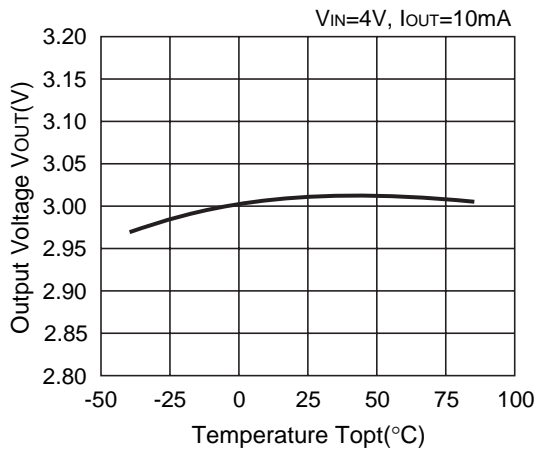
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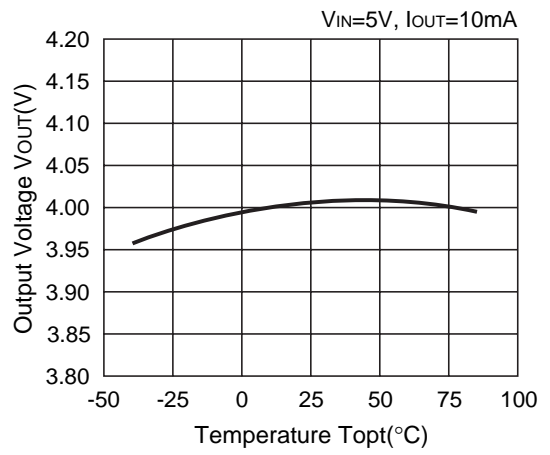
4) Output Voltage vs. Temperature



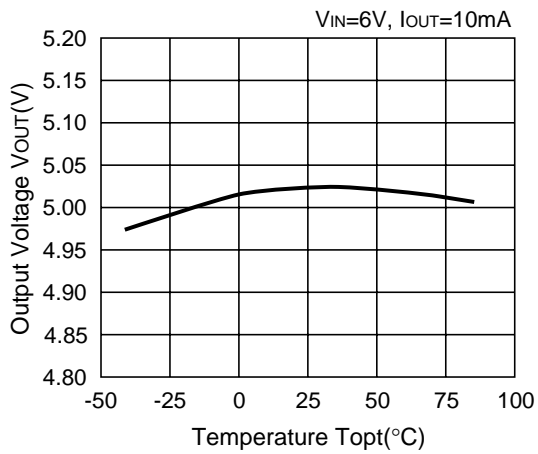
R1170x301B



R1170x401B

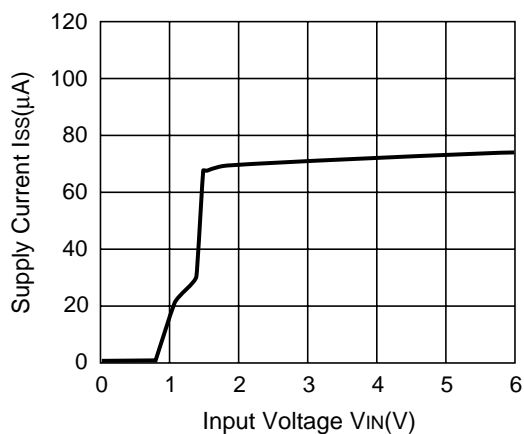


R1170x501B

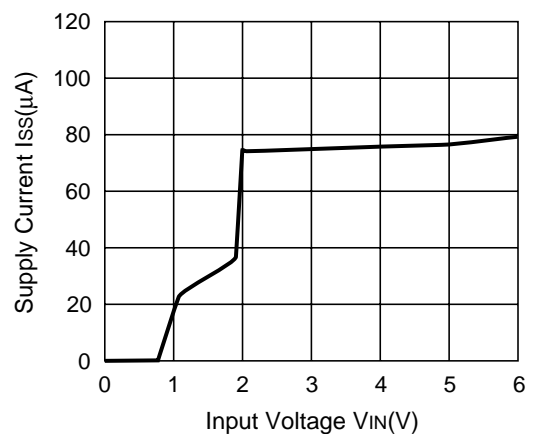


5) Supply Current vs. Input Voltage (Ta=25°C)

R1170x151B

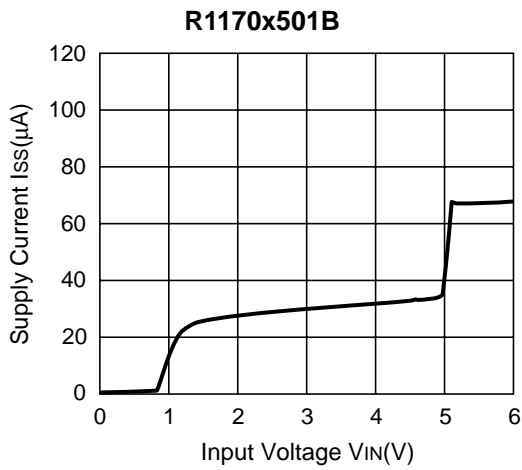
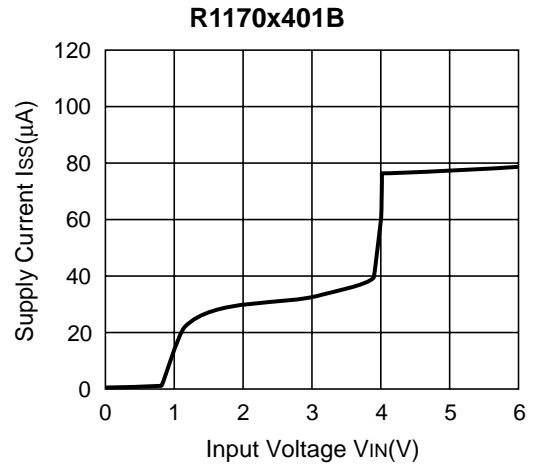
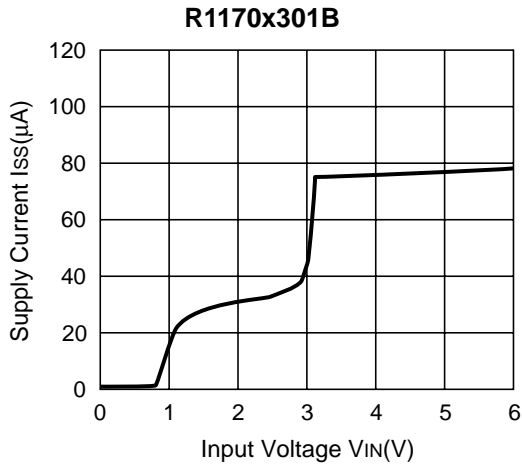


R1170x201B

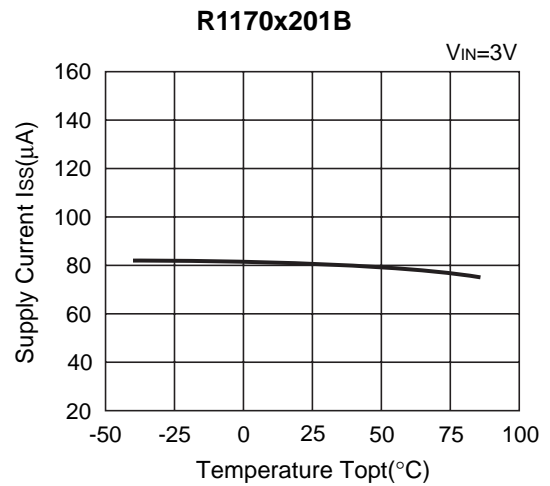
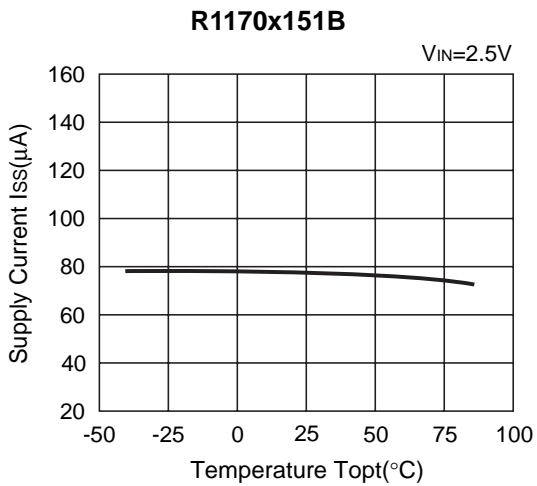


R1170H

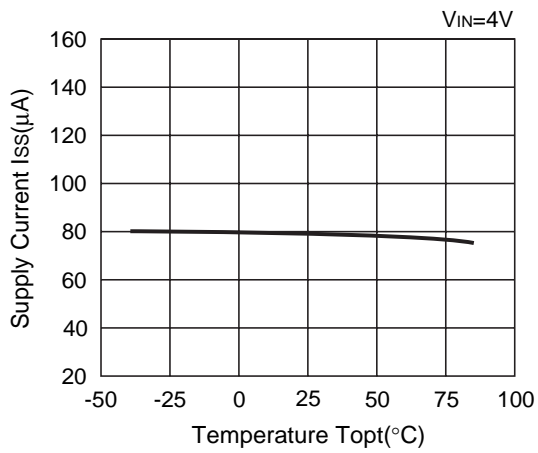
NO.EC-084-131206



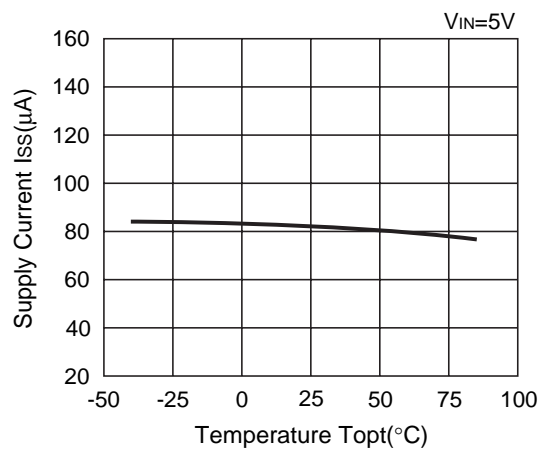
6) Supply Current vs. Temperature



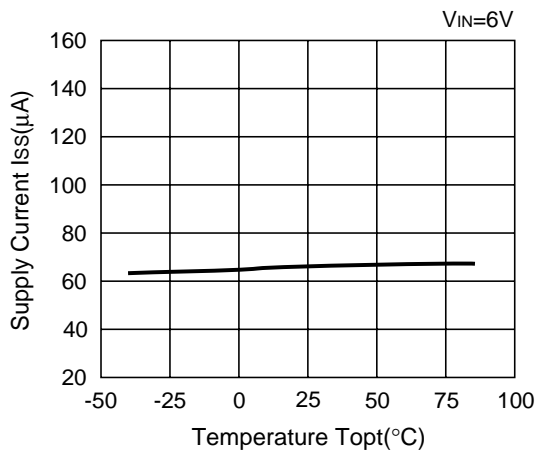
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R1170x401B

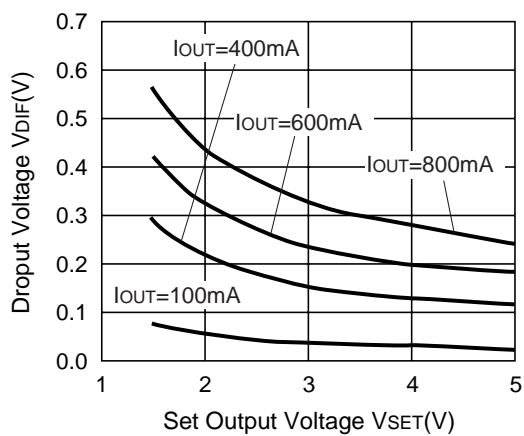


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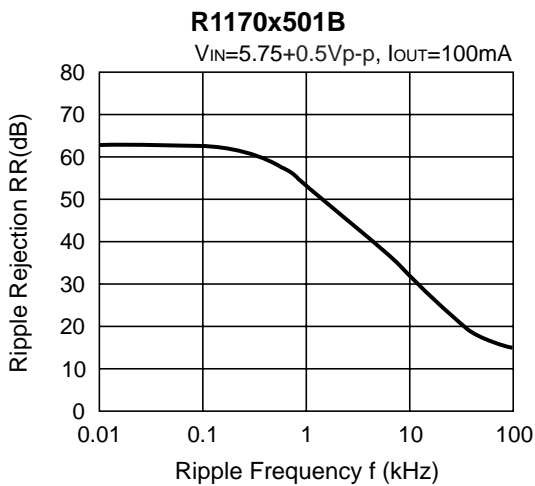
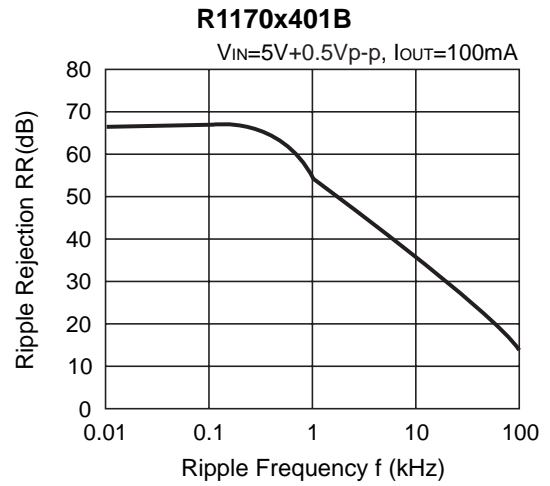
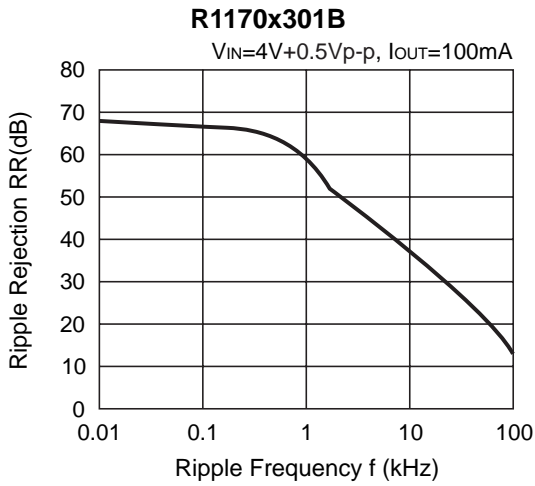
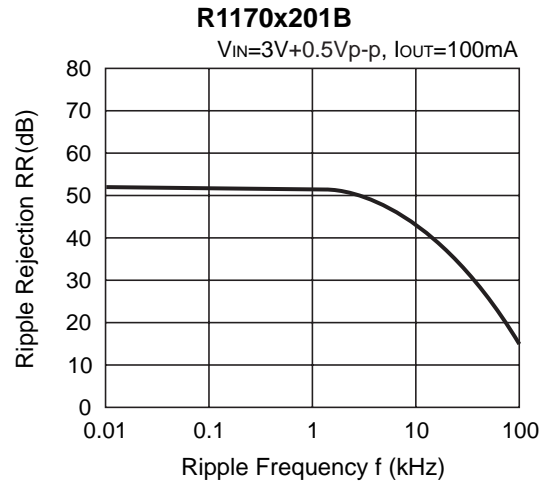
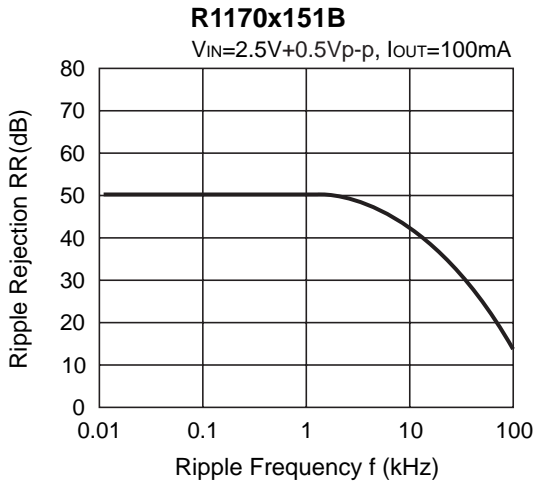


7) Dropout Voltage vs. Set Output Voltage ($T_a=25^{\circ}C$)

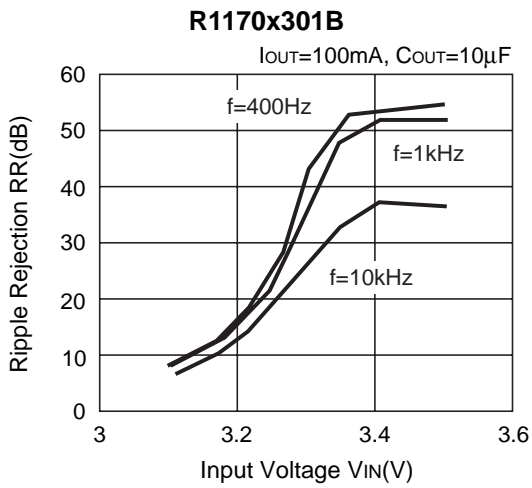
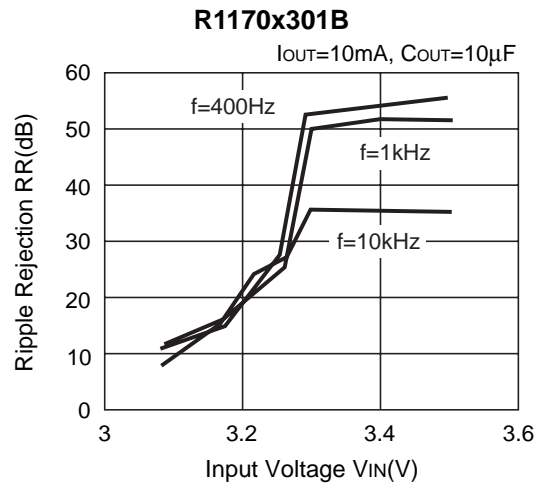
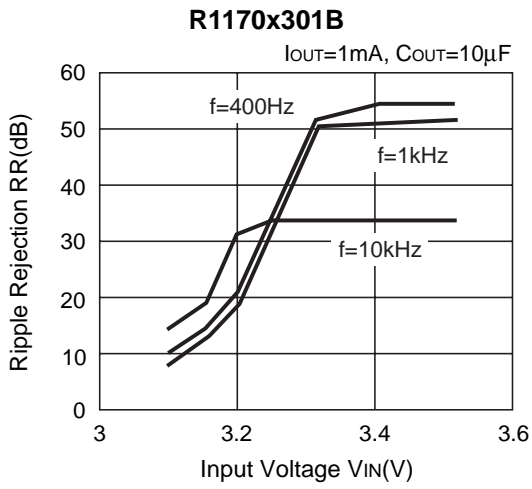
R1170x



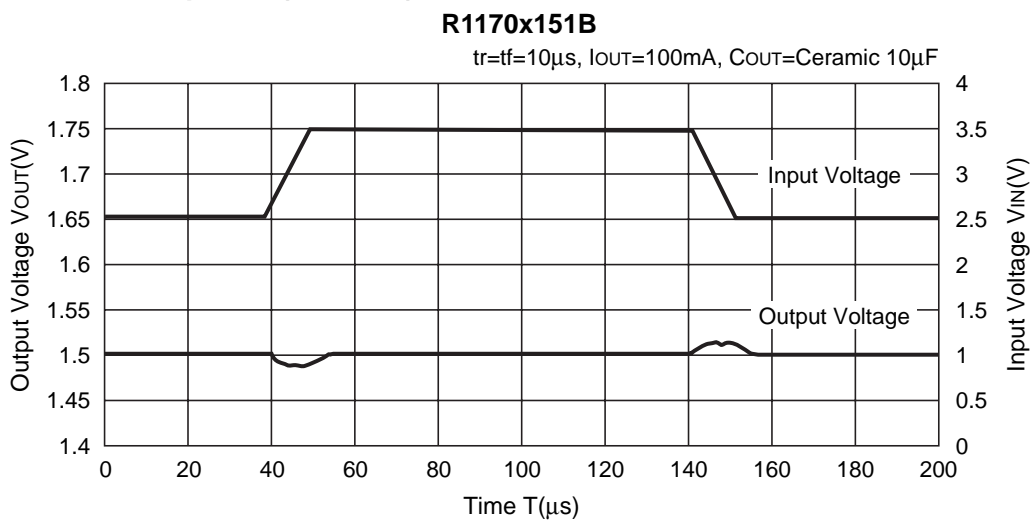
8) Ripple Rejection vs. Frequency

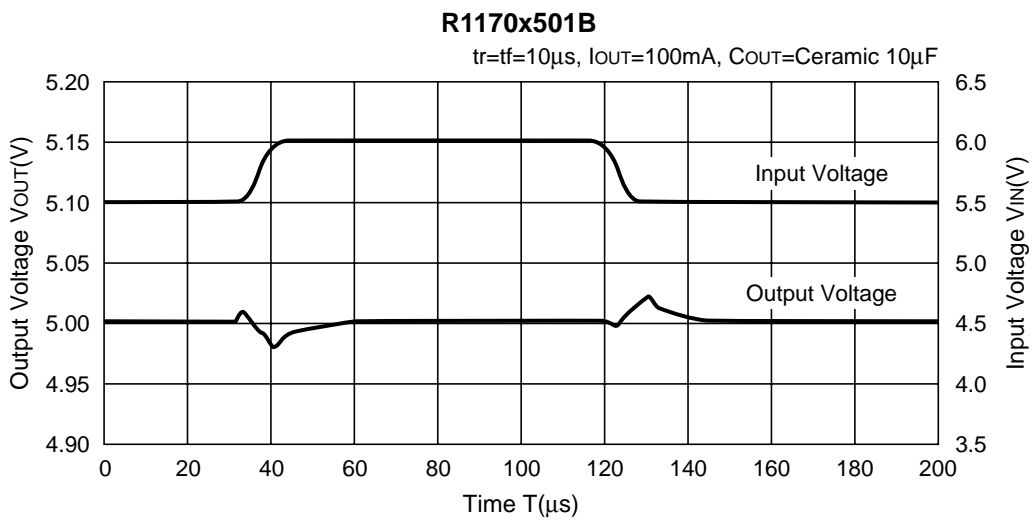
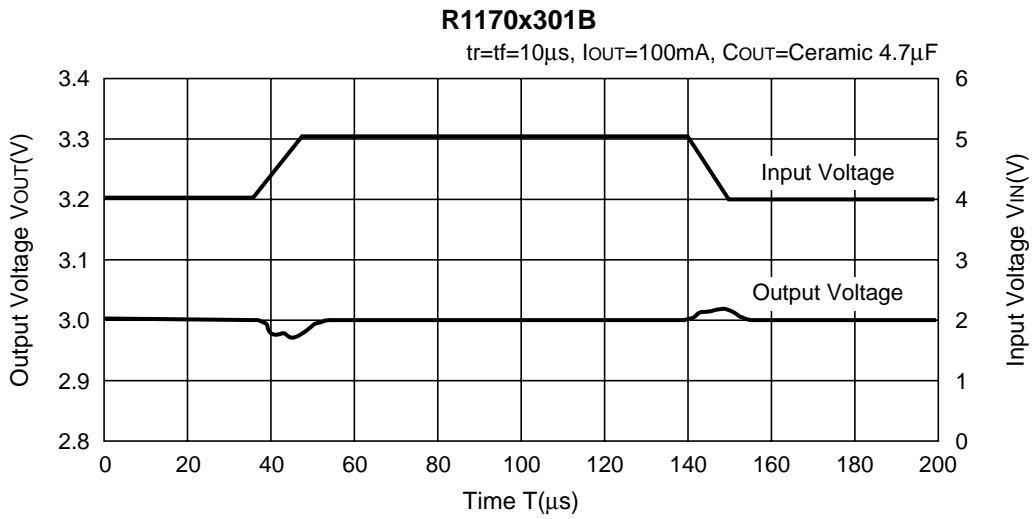
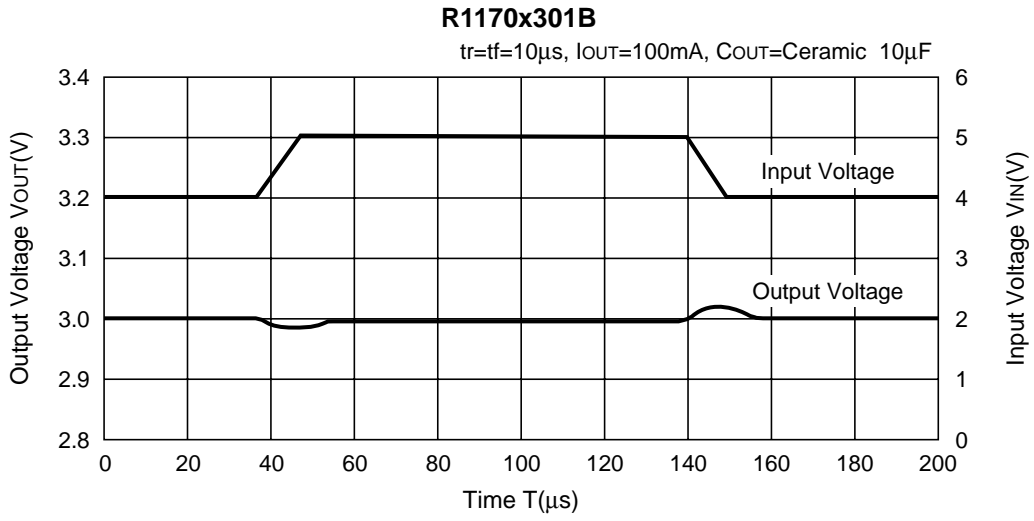


9) Ripple Rejection vs. Input Voltage



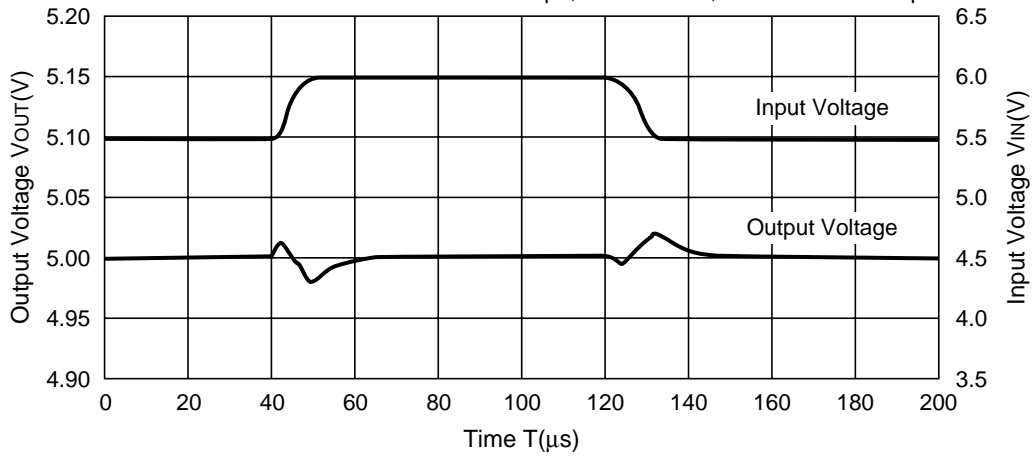
10) Input Transient Response (Ta=25°C)





R1170x501B

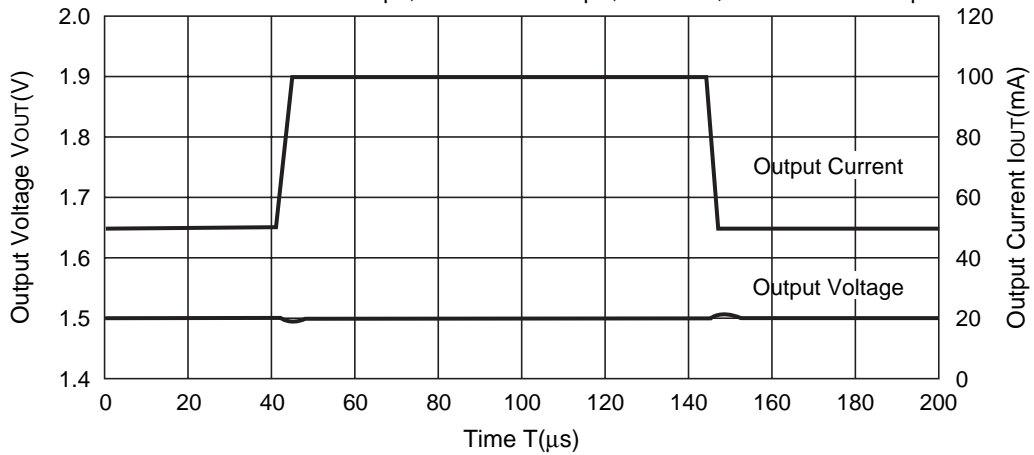
$t_r=t_f=10\mu s$, $I_{OUT}=100mA$, $C_{OUT}=\text{Ceramic } 4.7\mu F$



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

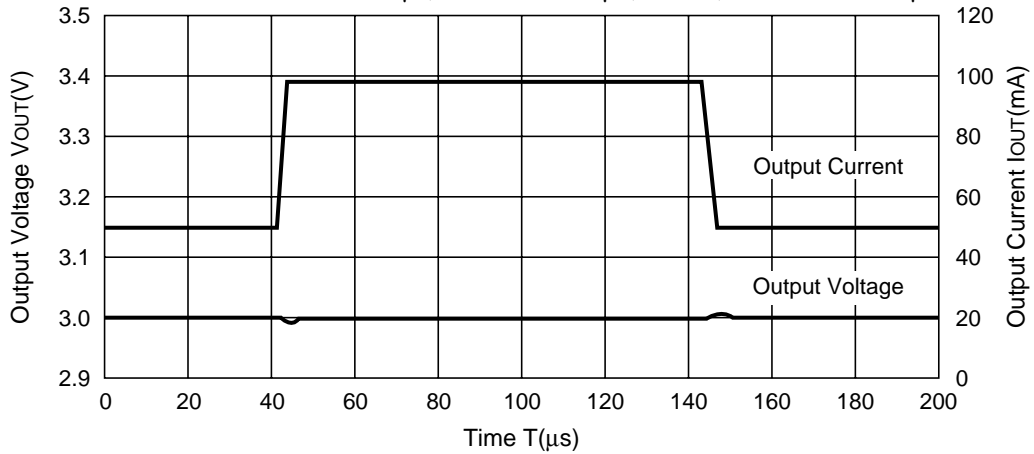
R1170x151B

$t_r=t_f=3\mu s$, $C_{IN}=\text{Ceramic } 10\mu F$, $V_{IN}=2.5V$, $C_{OUT}=\text{Ceramic } 10\mu F$



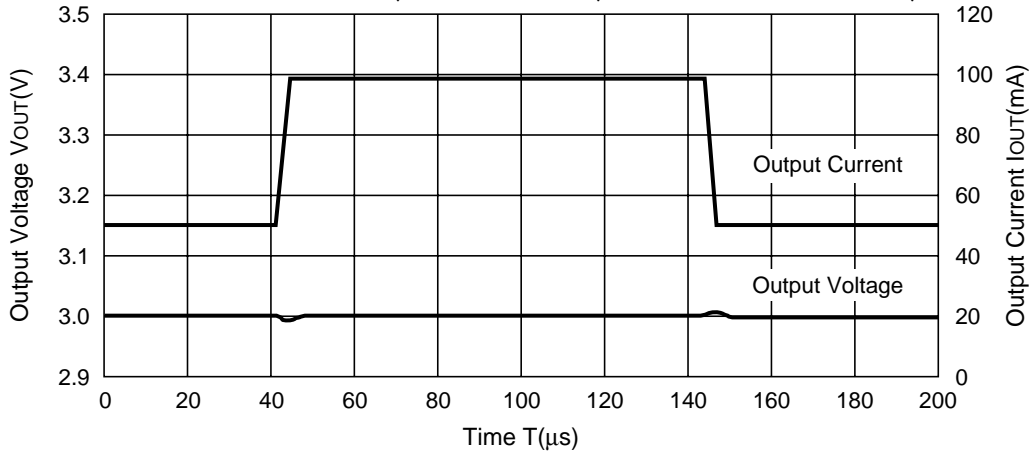
R1170x301B

$t_r=t_f=3\mu s$, $C_{IN}=\text{Ceramic } 10\mu F$, $V_{IN}=4V$, $C_{OUT}=\text{Ceramic } 10\mu F$



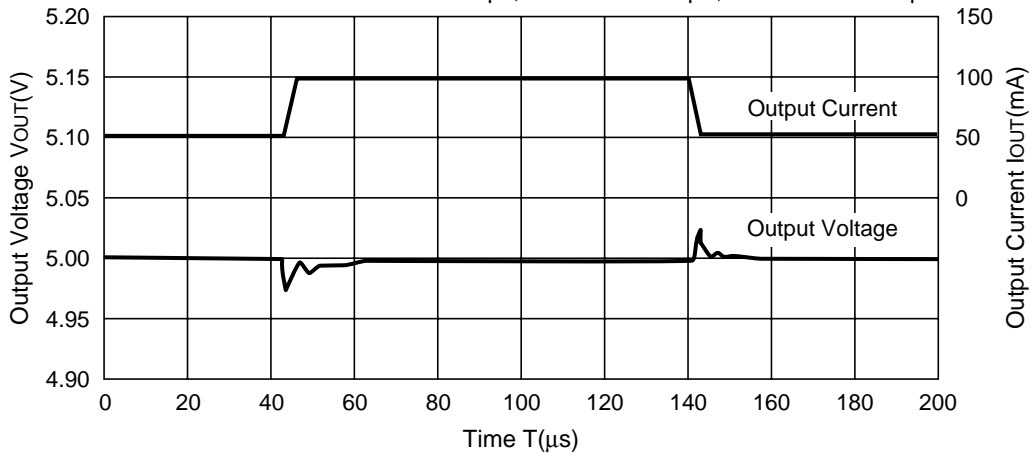
R1170x301B

$t_r=t_f=3\mu s$, C_{IN} =Ceramic $10\mu F$, V_{IN} =4V, C_{OUT} =Ceramic $4.7\mu F$



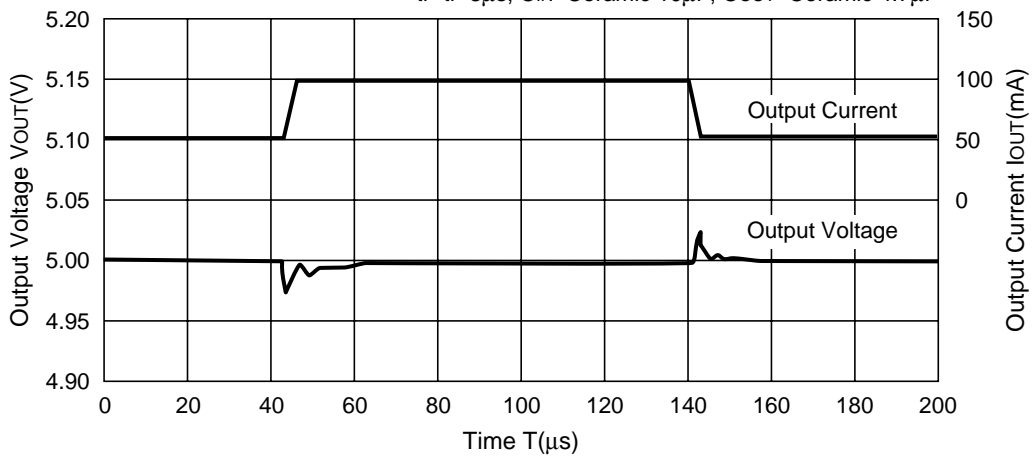
R1170x501B

$t_r=t_f=3\mu s$, C_{IN} =Ceramic $10\mu F$, C_{OUT} =Ceramic $10\mu F$

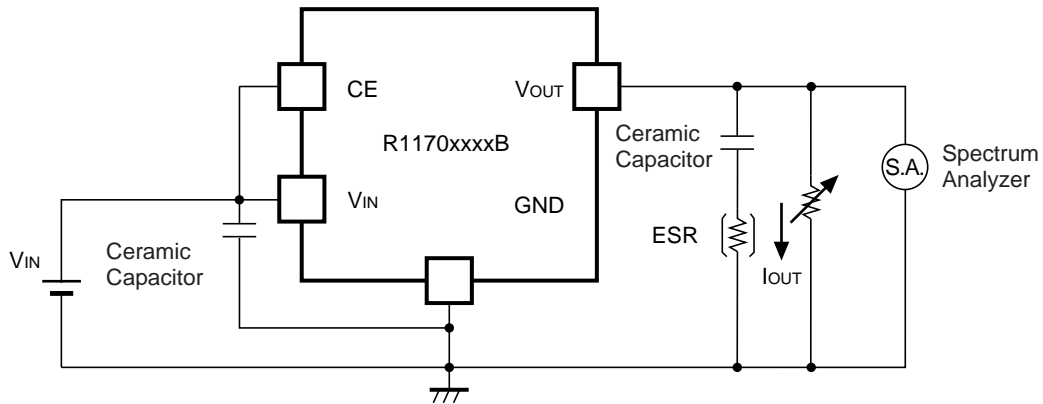


R1170x501B

$t_r=t_f=3\mu s$, C_{IN} =Ceramic $10\mu F$, C_{OUT} =Ceramic $4.7\mu F$

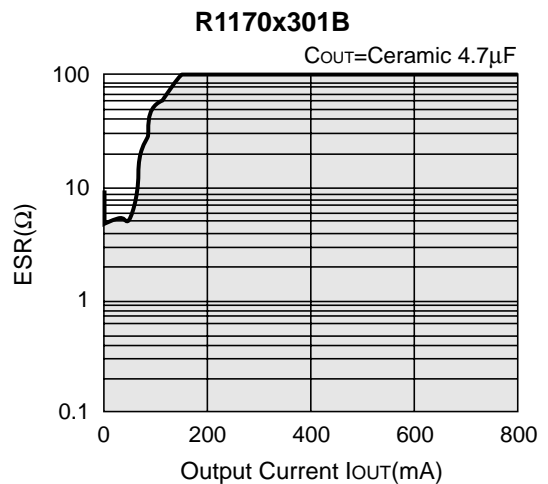
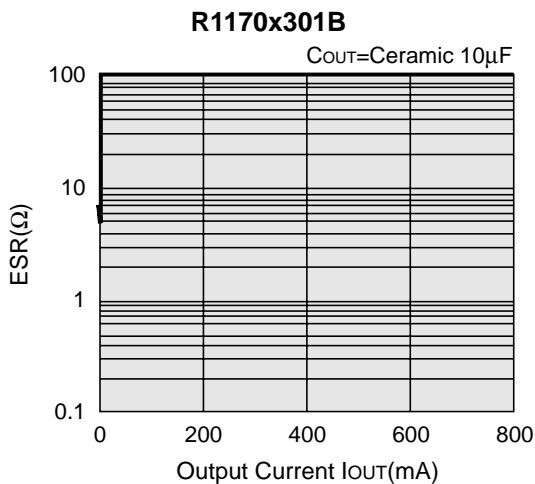
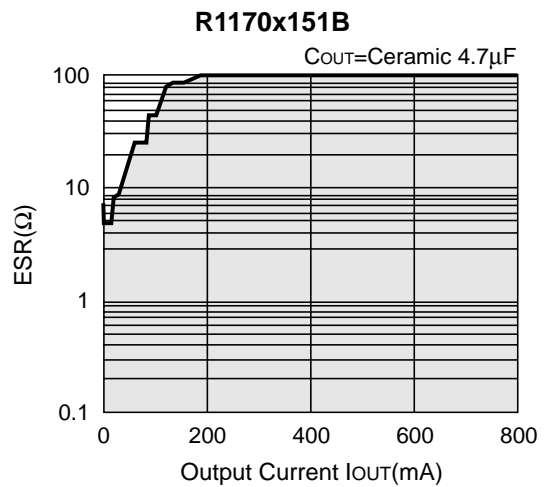
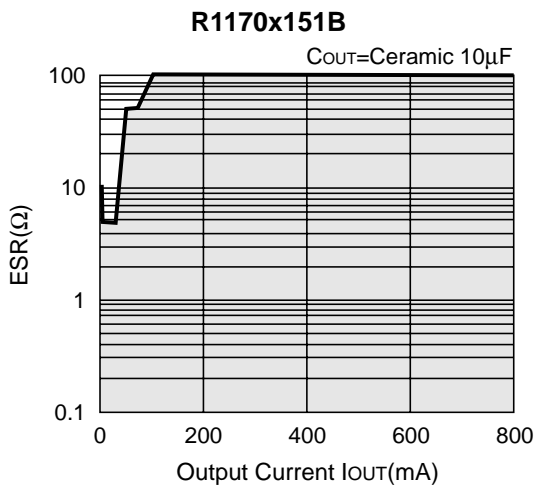


12) Stable Area ($T_a=25^{\circ}\text{C}$, $V_{IN} = \text{Set Output Voltage}+1\text{V}$, $C_{IN} = \text{Ceramic } 10\mu\text{F}$)

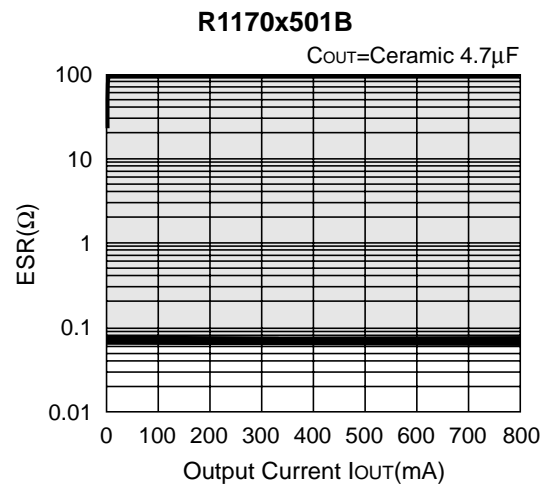
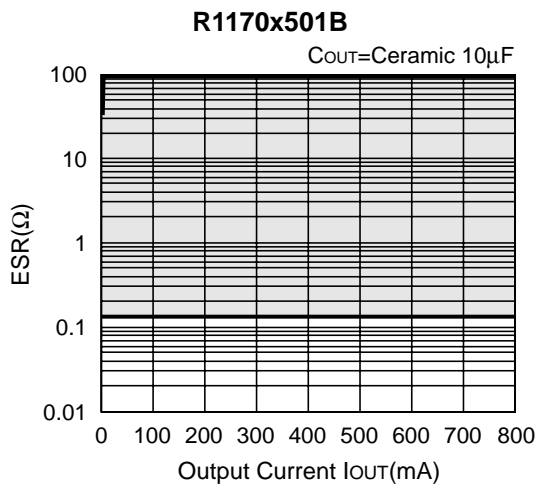


As an output capacitor for this IC, Ceramic capacitor is recommendable. However, other low ESR type capacitor can be used with this IC.

For your reference, noise level is tested with the circuit as shown above, and if the noise level is $40\mu\text{V}$ or less than $40\mu\text{V}$, the ESR values are plotted as stable area. Upper limit is described in the next four graphs, or ESR vs. Output Current. (Hatched area is the stable area.)



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**Note:**

When the large value of output capacitor (C_{OUT}) is used, the output rising time might be faster than the usual time depending on the status of the internal charge.



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