

300 mA 10 V Input LDO Regulator for Automotive Applications

No. EC-205-190107

OUTLINE

The RP170x is an LDO regulator featuring 300 mA output current. Having the 10 V maximum input voltage, the RP170x can be used in 2 cell lithium-ion battery powered portable appliances and besides a portable equipment. The supply current is Typ. 23 μ A though an excellent response characteristics. The output voltage range from 1.2 V is possible. The output voltage accuracy and temperature-drift coefficient of output voltage of the RP170x is excellent. RP170x has a fold-back protection circuit and a thermal shutdown circuit. Moreover, a standby mode with ultra low supply current can be realized with the chip enable function. SOT-23-5 and SOT-89-5 with high power dissipation packages are available.

FEATURES

- Input Voltage Range (Maximum Rating).....2.6 V to 10.0 V (12 V)
- Operating Temperature-40°C to 105°C (RP170xx1x-xx-AE)
-40°C to 125°C (RP170xx1x-xx-KE)
- Supply CurrentTyp. 23 μ A
- Standby Current.....Typ. 0.1 μ A
- Dropout VoltageTyp. 0.20 V ($I_{OUT} = 100$ mA, $V_{OUT} = 3.0$ V)
.....Typ. 0.77 V ($I_{OUT} = 300$ mA, $V_{OUT} = 2.8$ V)
- Ripple Rejection.....Typ. 70 dB ($f = 1$ kHz)
- Temperature-Drift Coefficient of Output Voltage ...Typ. ± 80 ppm/°C
- Line RegulationTyp. 0.02%/V
- Output Voltage Accuracy..... $\pm 1.0\%$
- PackagesSOT-23-5, SOT-89-5
- Output Voltage Range.....1.2 V/1.25 V/1.5 V/1.8 V/2.5 V/2.8 V/2.9 V/3.0 V/
3.3 V/5.0 V/5.5 V/6.0 V
*Contact Ricoh sales representatives for other voltages.
- Built-in Fold Back Protection CircuitTyp. 40 mA (Current at short mode)
- Built-in Thermal Shutdown Circuit.....Shutdown Temperature at 165°C
- Constant Slope Circuit (Soft-start Function)
- Ceramic capacitors are recommended to be used with this IC 1.0 μ F or more

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

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SELECTION GUIDE

The output voltage, auto discharge function⁽¹⁾, and package for the ICs can be selected at the user's request.

Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
RP170Nxx1*-TR-#E	SOT-23-5	3,000 pcs	Yes	Yes
RP170Hxx1*-T1-#E	SOT-89-5	1,000 pcs	Yes	Yes

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

1.2 V (12) / 1.25 V (12) / 1.5 V (15) / 1.8 V (18) / 2.5 V (25) / 2.8 V (28) / 2.9 V (29) / 3.0 V (30) /
3.3 V (33) / 5.0 V (50) / 5.5 V (55) / 6.0 V (60)

If the output voltage includes the 3rd digit, indicate the digit of 0.01 as follows.

1.25 V → RP170x121*5

* : The auto discharge functions at off state are as follows.

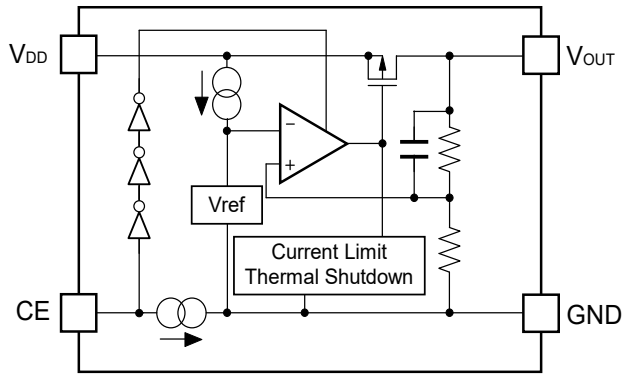
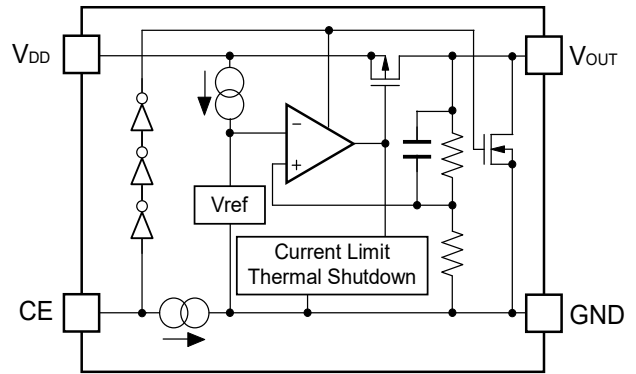
(B) without auto discharge function at off state

(D) with auto discharge function at off state

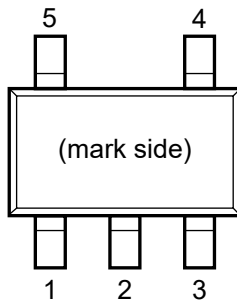
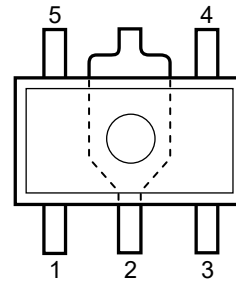
#: Quality Class

#	Operating Temperature Range	Test Temperature
A	-40°C to 105°C	25°C, High
K	-40°C to 125°C	Low, 25°C, High

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

BLOCK DIAGRAMS**RP170xxxxB Block Diagram****RP170xxxxD Block Diagram**

PIN DESCRIPTIONS

**SOT-23-5 Pin Configuration****SOT-89-5 Pin Configuration**

SOT-23-5 Pin Description

Pin No	Symbol	Pin Description
1	V_{DD}	Input Pin
2	GND	Ground Pin
3	CE	Chip Enable Pin (Active-high)
4	NC	No Connection
5	V_{OUT}	Output Pin

SOT-89-5 Pin Description

Pin No	Symbol	Pin Description
1	V_{OUT}	Output Pin
2	GND	Ground Pin
3	CE	Chip Enable Pin (Active-high)
4	NC	No Connection
5	V_{DD}	Input Pin

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings

Symbol	Item		Rating	Unit
V _{IN}	Input Voltage		12	V
V _{CE}	Input Voltage (CE Pin)		12	V
V _{OUT}	Output Voltage		-0.3 to V _{IN} + 0.3	V
I _{OUT}	Output Current		330	mA
P _D	Power Dissipation ⁽¹⁾	SOT-23-5 JEDEC STD. 51-7 Test Land Pattern	830	mW
		SOT-89-5 JEDEC STD. 51-7 Test Land Pattern	3200	
T _j	Junction Temperature		-40 to 150	°C
T _{stg}	Storage Temperature Range		-55 to 150	°C

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		2.6 to 10	V
T _a	Operating Temperature Range	RP170xx1x-xx-AE	-40 to 105	°C
		RP170xx1x-xx-KE	-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.

⁽¹⁾ Refer to *POWER DISSIPATION* for detailed information.

ELECTRICAL CHARACTERISTICS

$V_{IN} = V_{SET} + 1\text{ V}$, $I_{OUT} = 1\text{ mA}$, unless otherwise noted.

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

RP170xxxxB/D (-AE) Electrical Characteristics

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

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	
V_{OUT}	Output Voltage	$1.5\text{ V} < V_{SET}$	$T_a = 25^{\circ}\text{C}$	$V_{SET} \times 0.99$		$V_{SET} \times 1.01$	V
			$-40^{\circ}\text{C} \leq T_a \leq 105^{\circ}\text{C}$	$V_{SET} \times 0.965$		$V_{SET} \times 1.03$	
		$V_{SET} \leq 1.5\text{ V}$	$T_a = 25^{\circ}\text{C}$	-15		15	mV
			$-40^{\circ}\text{C} \leq T_a \leq 105^{\circ}\text{C}$	-53		45	
I_{OUT}	Output Current		300			mA	
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	$0.1\text{ mA} \leq I_{OUT} \leq 300\text{ mA}$		10	80	mV	
V_{DIF}	Dropout Voltage	$I_{OUT} = 300\text{ mA}$	Refer to the <i>Product-specific Electrical Characteristics</i>				
I_{SS}	Supply Current	$I_{OUT} = 0\text{ mA}$		23	45	μA	
$I_{standby}$	Standby Current	$V_{IN} = 10.0\text{ V}$ $V_{CE} = \text{GND}$		0.1	1.2	μA	
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	$V_{SET} + 0.5\text{ V} \leq V_{IN} \leq 10.0\text{ V}$ (Incase that $V_{SET} \leq 2.1\text{ V}$, $2.6\text{ V} \leq V_{IN} \leq 10.0\text{ V}$)		± 0.02	± 0.25	%/V	
I_{SC}	Short Current Limit	$V_{OUT} = 0\text{ V}$		40		mA	
I_{PD}	CE Pull-down Current			0.30		μA	
V_{CEH}	CE Input Voltage "H"		1.7			V	
V_{CEL}	CE Input Voltage "L"				0.8	V	
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature		165		$^{\circ}\text{C}$	
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		110		$^{\circ}\text{C}$	
R_{LOW}	Nch On Resistance for Auto Discharge (RP170xxx1D only)	$V_{CE} = 0\text{ V}$ $V_{IN} = 7.0\text{ V}$		250		Ω	

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

ELECTRICAL CHARACTERISTICS (continued)

Product-specific Electrical Characteristics

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

RP170xxxxB/D (-AE)

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

Product Name	V_{OUT} [V] ($T_a = 25^{\circ}\text{C}$)			V_{OUT} [V] ($T_a = -40$ to 105°C)			V_{DIF} [V]	
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	TYP.	MAX.
RP170x121x	1.185	1.200	1.215	1.147	1.200	1.245	1.400	1.925
RP170x121x5	1.235	1.250	1.265	1.197	1.25	1.295		1.655
RP170x151x	1.485	1.500	1.515	1.447	1.500	1.545	1.200	1.305
RP170x181x	1.782	1.800	1.818	1.737	1.800	1.854		1.185
RP170x251x	2.475	2.500	2.525	2.413	2.500	2.575		0.995
RP170x281x	2.772	2.800	2.828	2.702	2.800	2.884	0.770	0.995
RP170x291x	2.871	2.900	2.929	2.799	2.900	2.987		0.875
RP170x301x	2.970	3.000	3.030	2.895	3.000	3.090	0.600	0.875
RP170x331x	3.267	3.300	3.333	3.185	3.300	3.399		0.875
RP170x501x	4.950	5.000	5.050	4.825	5.000	5.150	0.500	0.875
RP170x551x	5.445	5.500	5.555	5.308	5.500	5.665		0.875
RP170x601x	5.940	6.000	6.060	5.790	6.000	6.180		0.875

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ELECTRICAL CHARACTERISTICS (continued) $V_{IN} = V_{SET} + 1\text{ V}$, $I_{OUT} = 1\text{ mA}$, unless otherwise noted.**RP170xxxxB/D (-KE) Electrical Characteristics**($-40^{\circ}\text{C} \leq T_a \leq 125^{\circ}\text{C}$)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit	
V_{OUT}	Output Voltage	$1.5\text{ V} < V_{SET}$	$T_a = 25^{\circ}\text{C}$	V_{SET} $\times 0.99$		V_{SET} $\times 1.01$	V
			$-40^{\circ}\text{C} \leq T_a \leq 125^{\circ}\text{C}$	V_{SET} $\times 0.960$		V_{SET} $\times 1.035$	
		$V_{SET} \leq 1.5\text{ V}$	$T_a = 25^{\circ}\text{C}$	-15		15	mV
			$-40^{\circ}\text{C} \leq T_a \leq 125^{\circ}\text{C}$	-60		50	
I_{OUT}	Output Current		300			mA	
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	$0.1\text{ mA} \leq I_{OUT} \leq 300\text{ mA}$		10	85	mV	
V_{DIF}	Dropout Voltage	$I_{OUT} = 300\text{ mA}$	Refer to the <i>Product-specific Electrical Characteristics</i>				
I_{SS}	Supply Current	$I_{OUT} = 0\text{ mA}$		23	47	μA	
$I_{standby}$	Standby Current	$V_{IN} = 10.0\text{ V}$ $V_{CE} = \text{GND}$		0.1	1.25	μA	
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	$V_{SET} + 0.5\text{ V} \leq V_{IN} \leq 10.0\text{ V}$ (In case that $V_{SET} \leq 2.1\text{ V}$, $2.6\text{ V} \leq V_{IN} \leq 10.0\text{ V}$)		± 0.02	± 0.25	%/V	
I_{SC}	Short Current Limit	$V_{OUT} = 0\text{ V}$		40		mA	
I_{PD}	CE Pull-down Current			0.30		μA	
V_{CEH}	CE Input Voltage "H"		1.7			V	
V_{CEL}	CE Input Voltage "L"				0.8	V	
T_{TSD}	Thermal Shutdown Temperature	Junction Temperature		165		$^{\circ}\text{C}$	
T_{TSR}	Thermal Shutdown Released Temperature	Junction Temperature		110		$^{\circ}\text{C}$	
R_{LOW}	Nch On Resistance for Auto Discharge (RP170xxx1D only)	$V_{CE} = 0\text{ V}$ $V_{IN} = 7.0\text{ V}$		250		Ω	

ELECTRICAL CHARACTERISTICS (continued)

Product-specific Electrical Characteristics

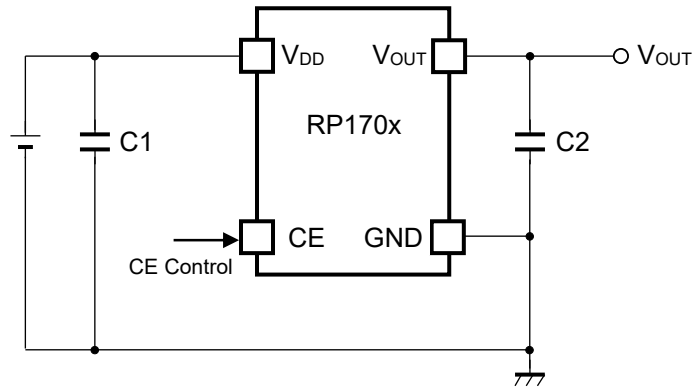
RP170xxxxB/D (-KE)

(-40°C ≤ Ta ≤ 125°C)

Product Name	V _{OUT} [V] (Ta = 25°C)			V _{OUT} [V] (Ta = -40 to 125°C)			V _{DIF} [V]	
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	TYP.	MAX.
RP170x121x	1.185	1.200	1.215	1.140	1.200	1.250	1.400	1.925
RP170x121x5	1.235	1.250	1.265	1.190	1.250	1.300		
RP170x151x	1.485	1.500	1.515	1.440	1.500	1.550	1.200	1.655
RP170x181x	1.782	1.800	1.818	1.728	1.800	1.863	0.980	1.305
RP170x251x	2.475	2.500	2.525	2.400	2.500	2.587	0.770	1.185
RP170x281x	2.772	2.800	2.828	2.688	2.800	2.898		
RP170x291x	2.871	2.900	2.929	2.784	2.900	3.001		
RP170x301x	2.970	3.000	3.030	2.880	3.000	3.105	0.600	0.995
RP170x331x	3.267	3.300	3.333	3.168	3.300	3.415		
RP170x501x	4.950	5.000	5.050	4.800	5.000	5.175	0.500	0.875
RP170x551x	5.445	5.500	5.555	5.280	5.500	5.692		
RP170x601x	5.940	6.000	6.060	5.760	6.000	6.210		

APPLICATION INFORMATION

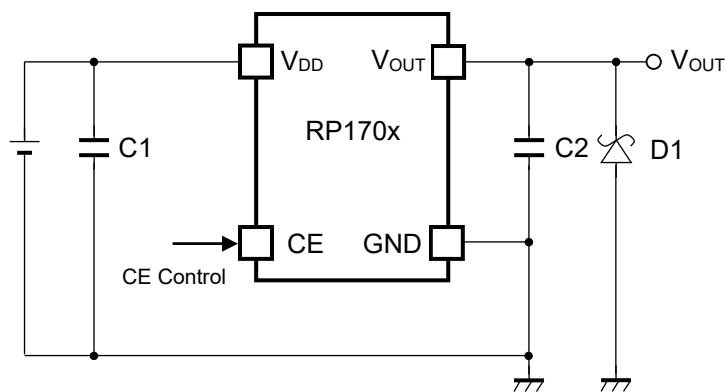
TYPICAL APPLICATION



External Components

Symbol	Descriptions
C1	1.0 μ F, Ceramic Capacitor, MURATA, GRM155B31A105KE15
C2	1.0 μ F, Ceramic Capacitor, MURATA, GRM155B31A105KE15

TYPICAL APPLICATION FOR IC CHIP BREAKDOWN PREVENTION



When a sudden surge of electrical current travels along the VOUT 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 VOUT pin and GND has the effect of preventing damage to them.

TECHNICAL NOTES

PHASE COMPENSATION

In these ICs, phase compensation is made for securing stable operation even if the load current is varied. For this purpose, use a capacitor C2 with 1.0 μF or more and good ESR (Equivalent Series Resistance).

(Note: If additional ceramic capacitors are connected with parallel to the output pin with an output capacitor for phase compensation, the operation might be unstable. Because of this, test these ICs with as same external components as ones to be used on the PCB).

PCB LAYOUT

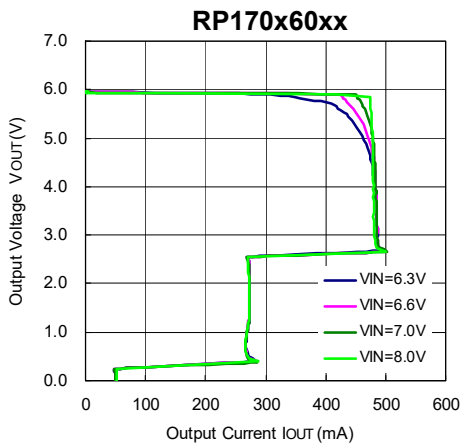
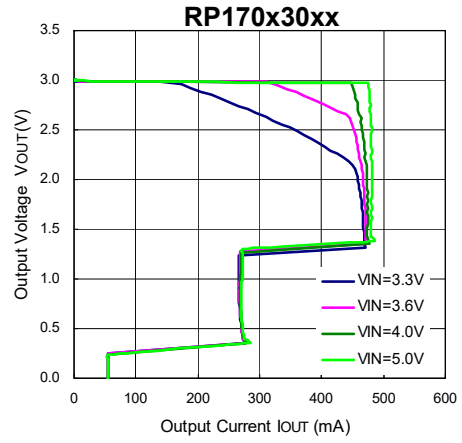
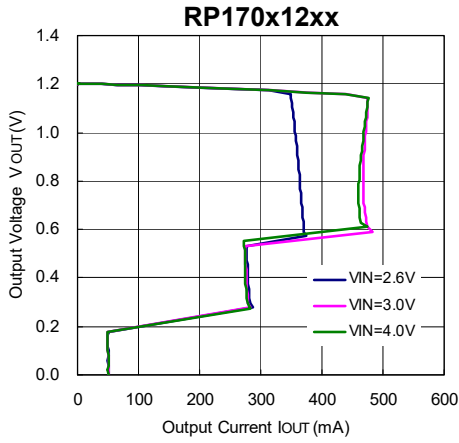
Make V_{DD} and GND lines sufficient. If their impedance is high, noise pickup or unstable operation may result. Connect a capacitor C1 with a capacitance value as much as 1.0 μF or more between V_{DD} and GND, and as close as possible to the pins.

Set external components, especially the output capacitor C2, as close as possible to the ICs, and make wiring as short as possible.

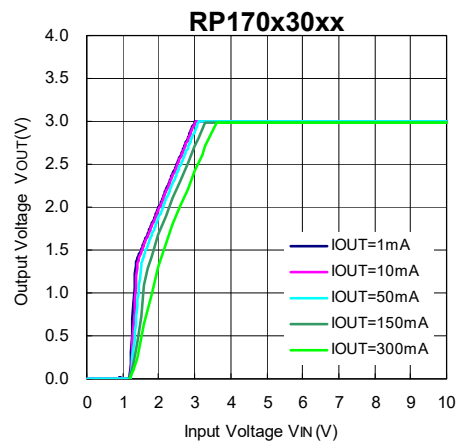
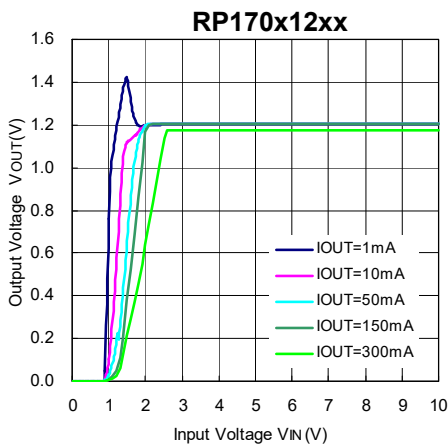
TYPICAL CHARACTERISTICS

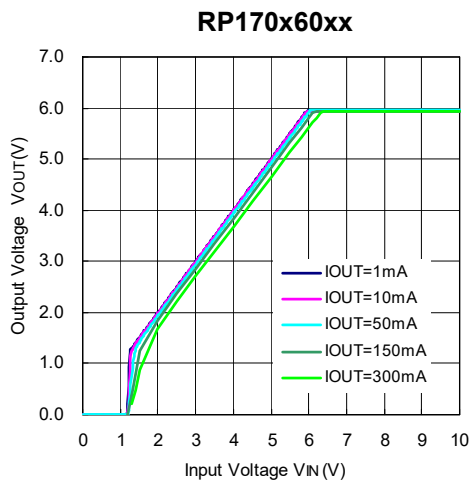
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

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

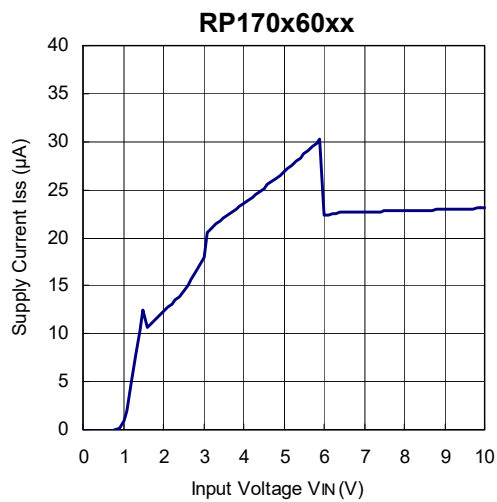
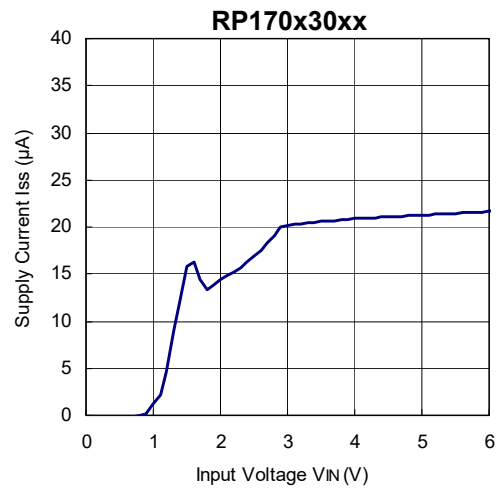
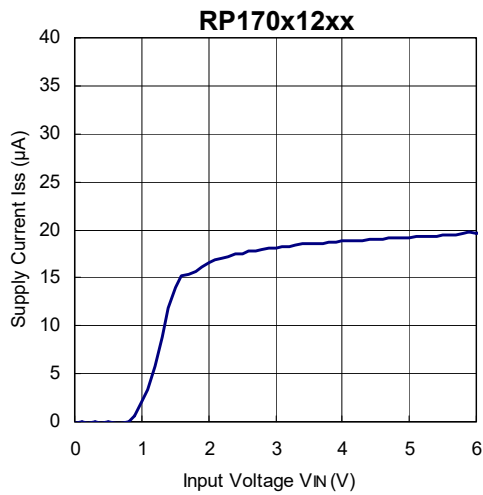


2) Output Voltage vs. Input Voltage (Ta = 25°C)





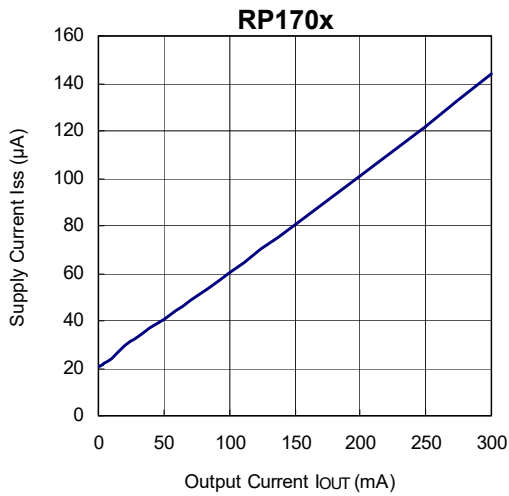
3) Supply Current vs. Input Voltage ($T_a = 25^\circ C$)



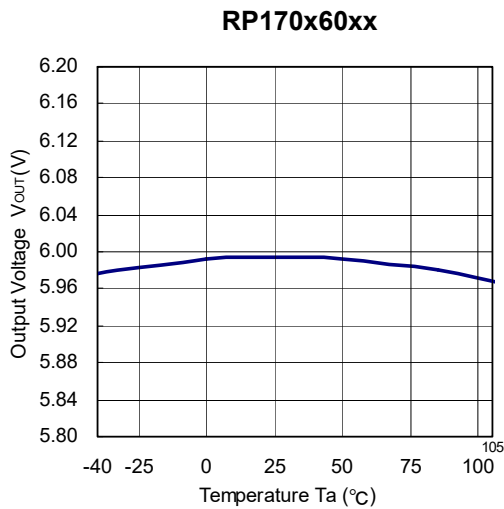
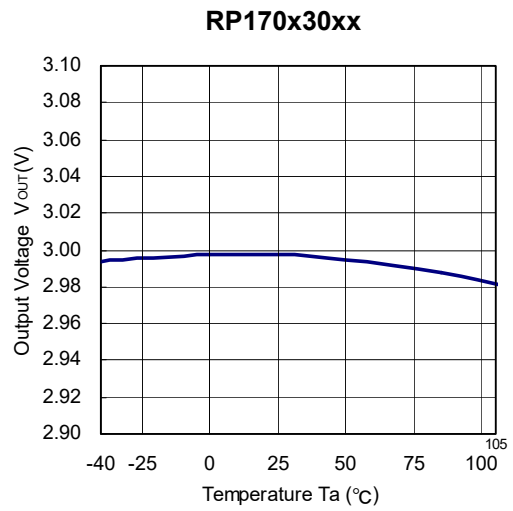
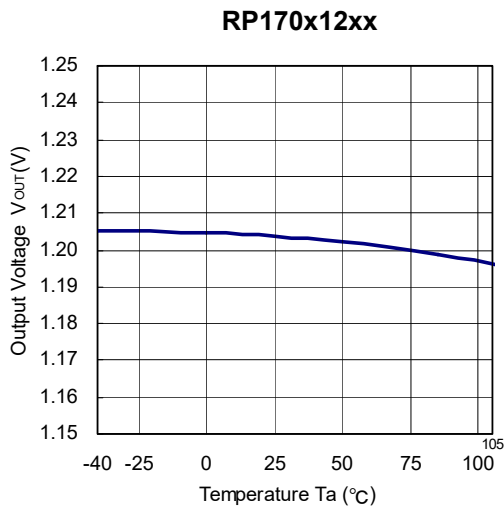
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4) Supply Current vs. Output Current (Ta = 25°C)

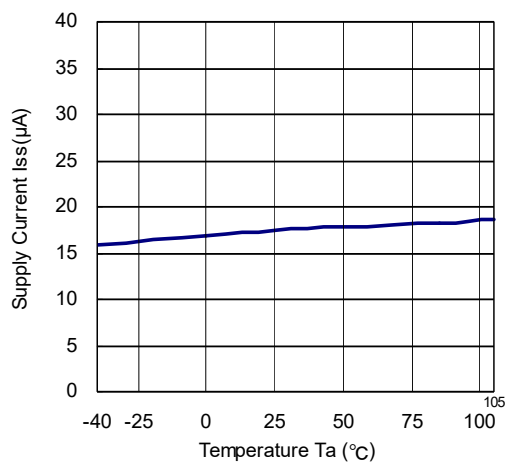


5) Output Voltage vs. Temperature

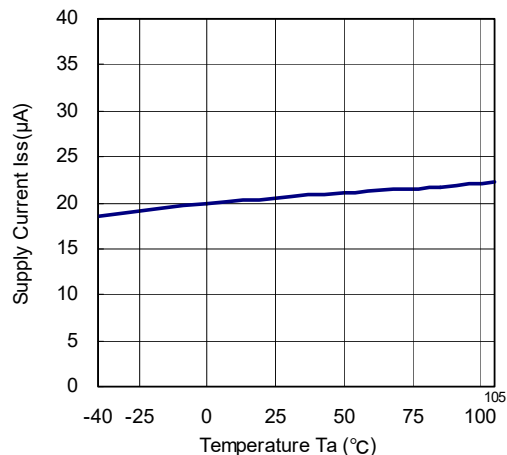


6) Supply Current vs. Temperature

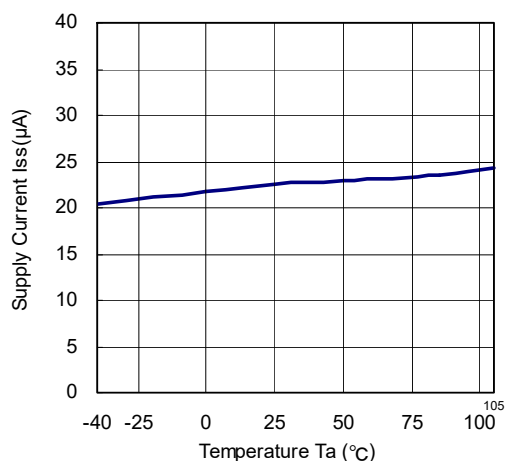
RP170x12xx



RP170x30xx

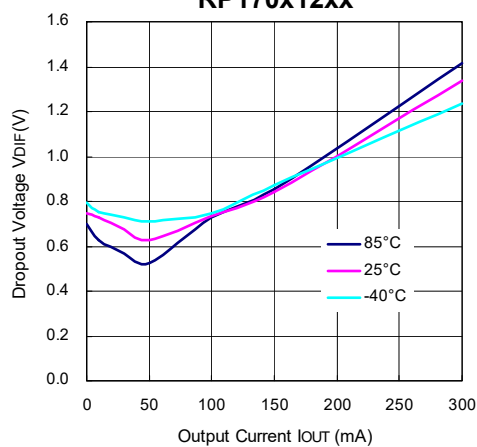


RP170x60xx

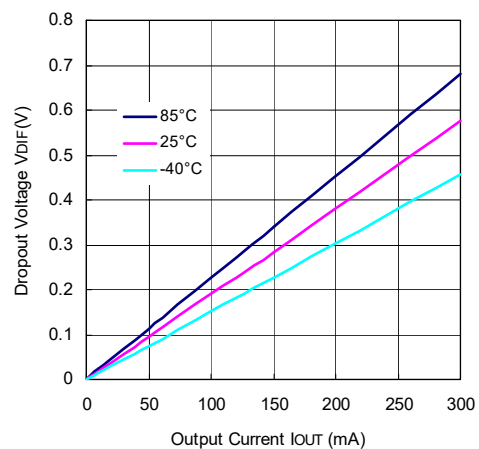


7) Dropout Voltage vs. Output Current

RP170x12xx

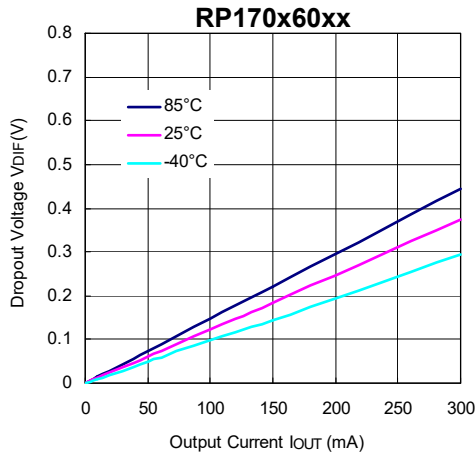
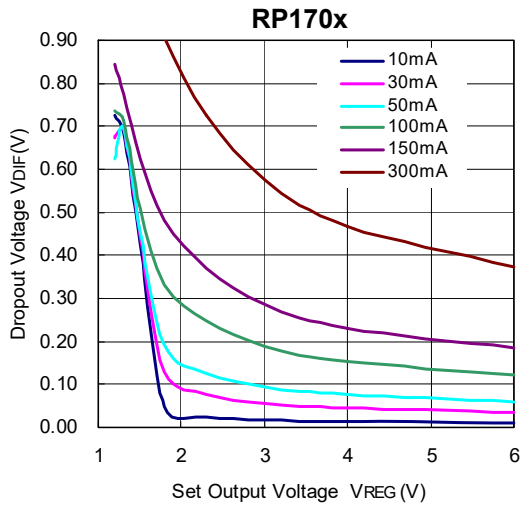
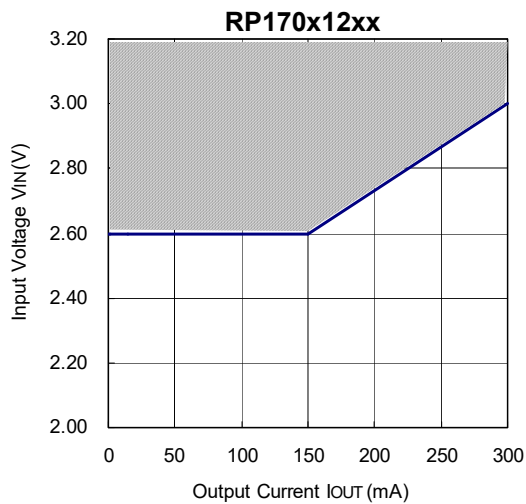


RP170x30xx



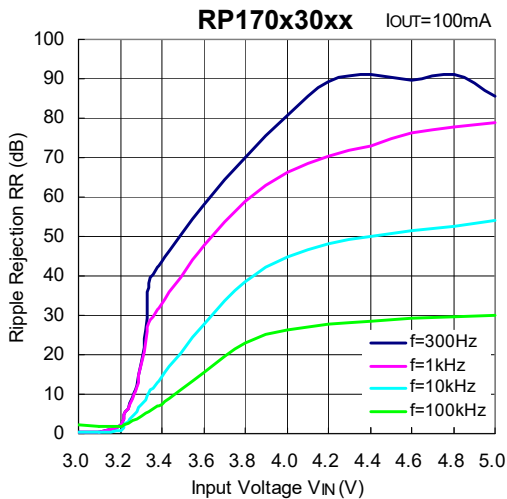
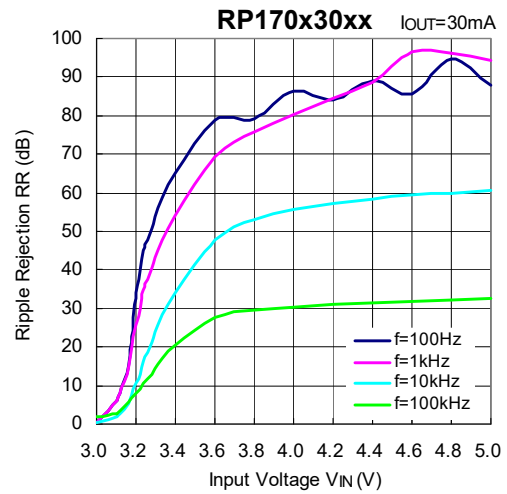
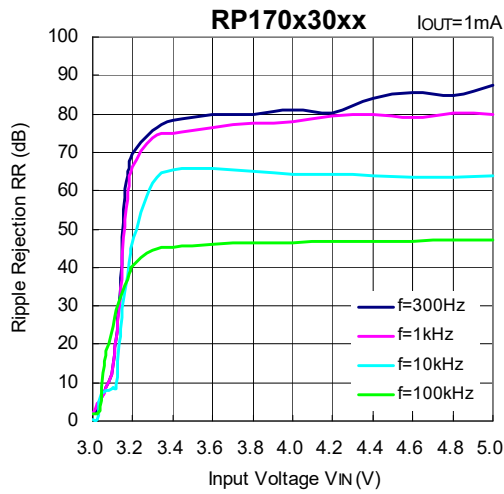
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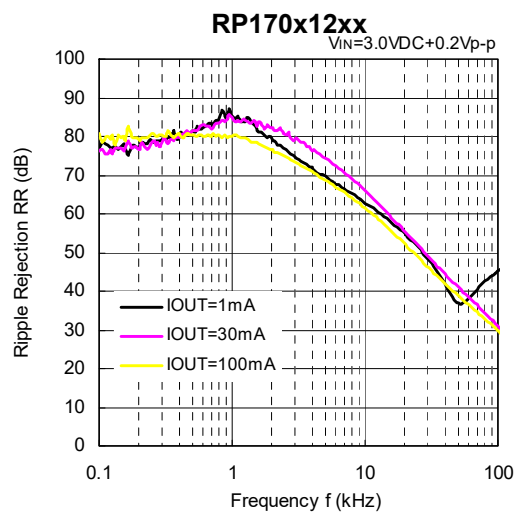
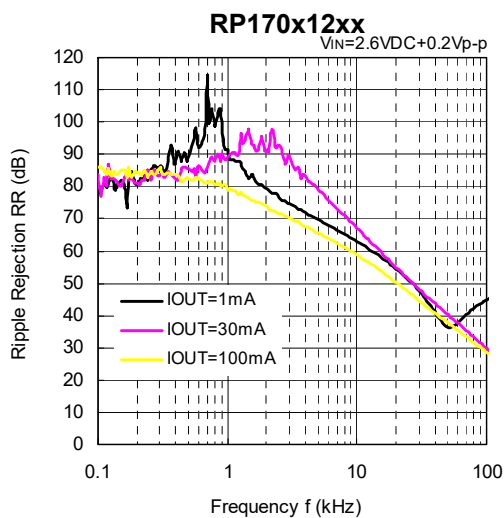
**8) Dropout Voltage vs. Set Output Voltage ($T_a = 25^\circ\text{C}$)****9) Minimum Operating Voltage**

Hatched area is available
for 1.2 V output

10) Ripple Rejection vs. Input Bias Voltage (C1 = none, C2 = Ceramic 1.0 μ F, Ripple = 0.2 Vp-p, Ta = 25°C)

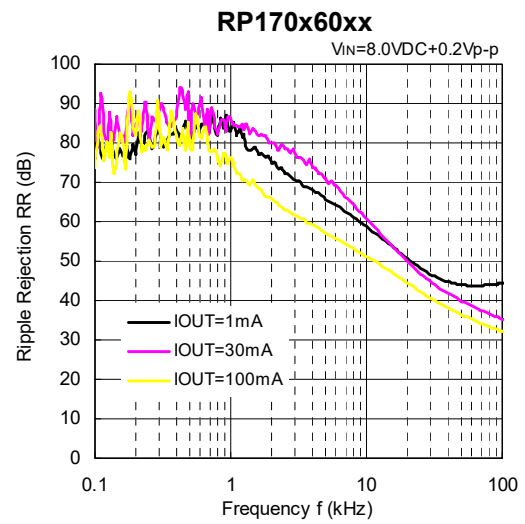
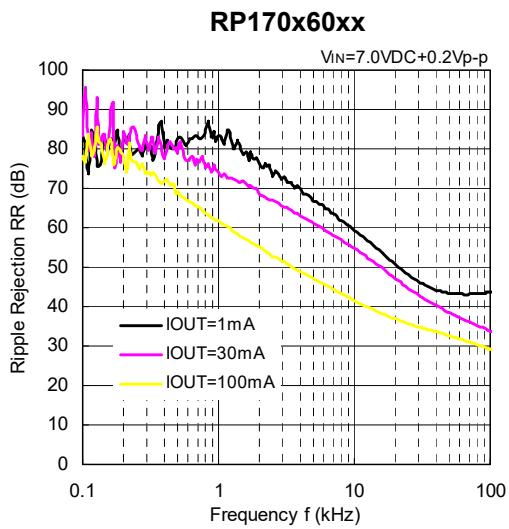
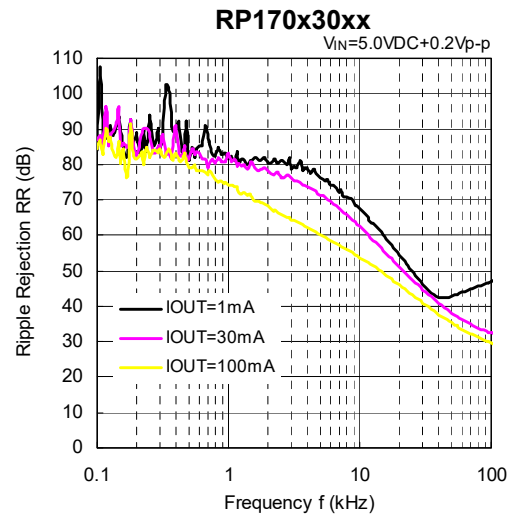
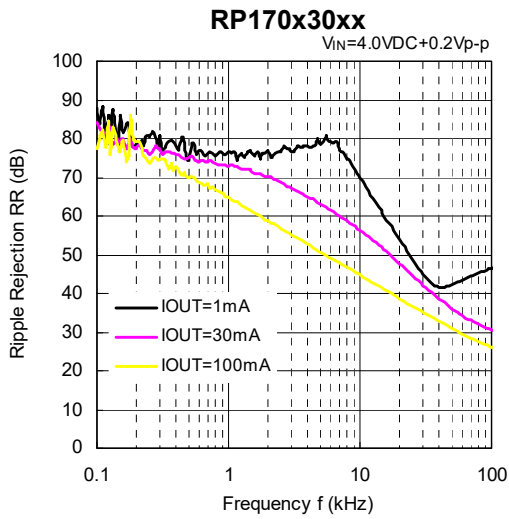


11) Ripple Rejection vs. Frequency (C1 = none, C2 = Ceramic 1.0 μ F, Ta = 25°C)

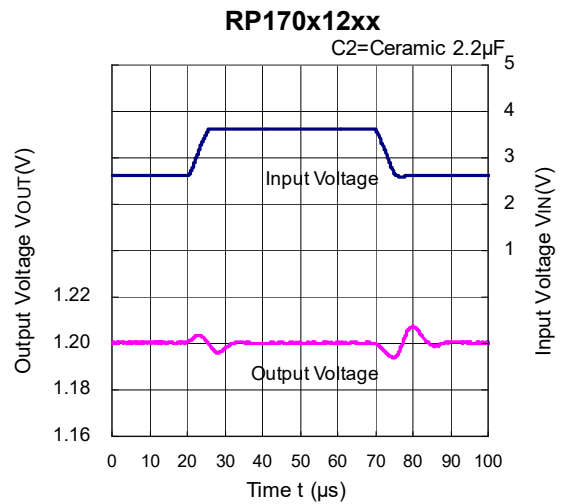
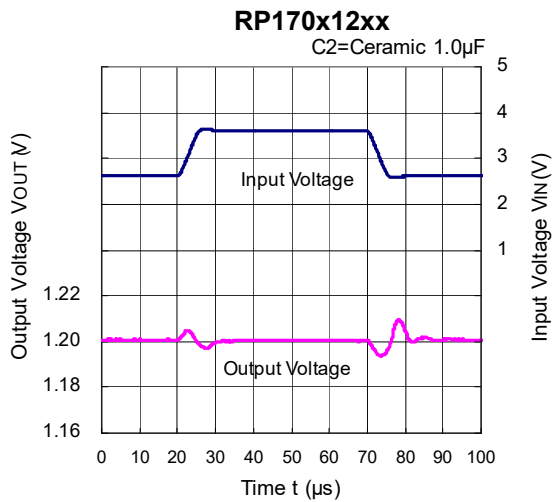


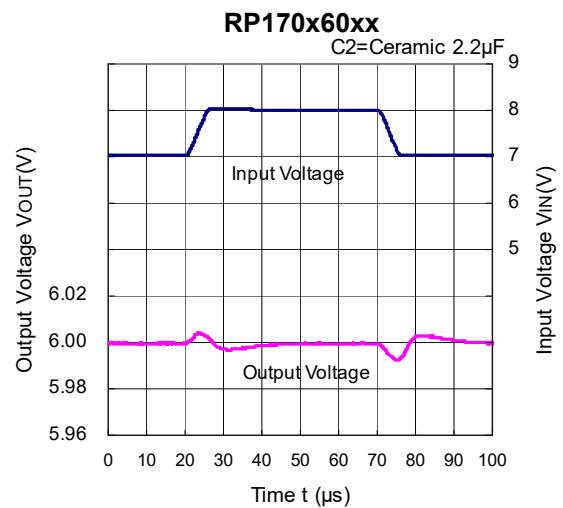
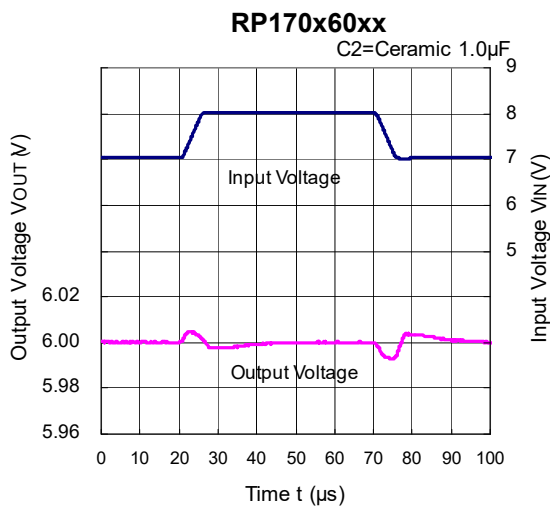
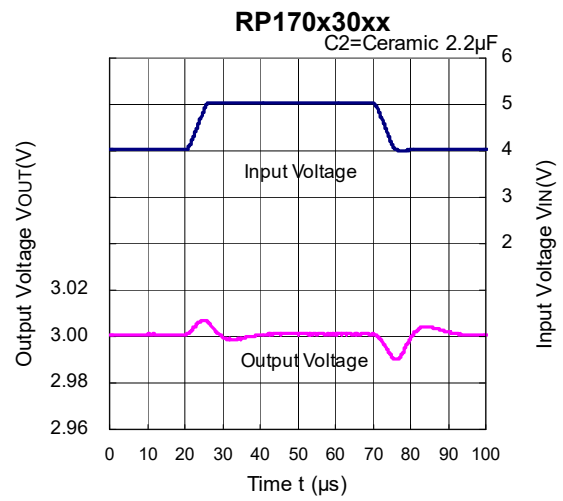
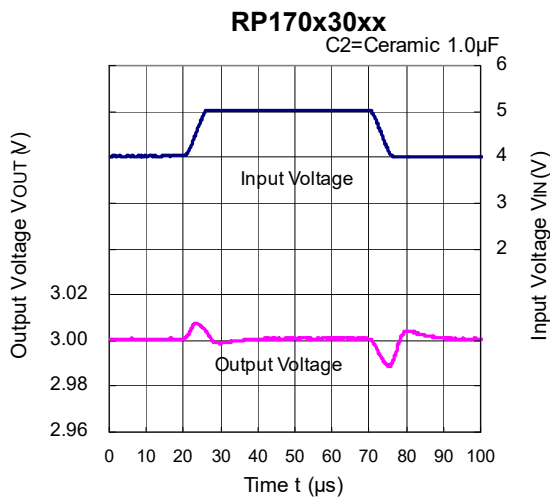
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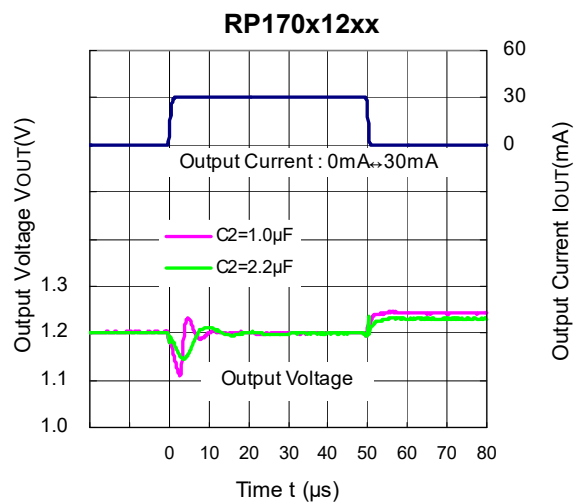
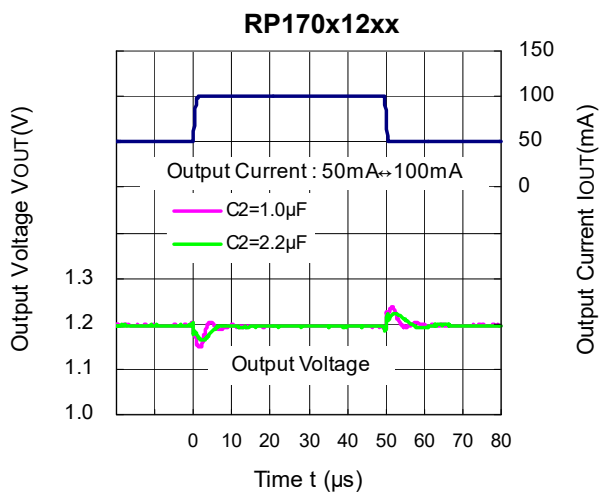


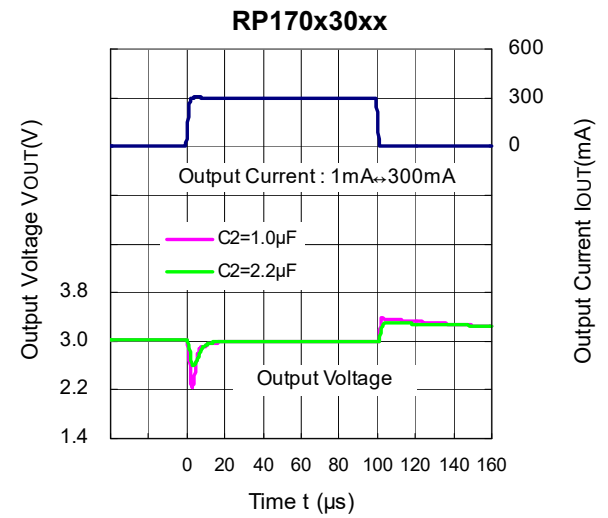
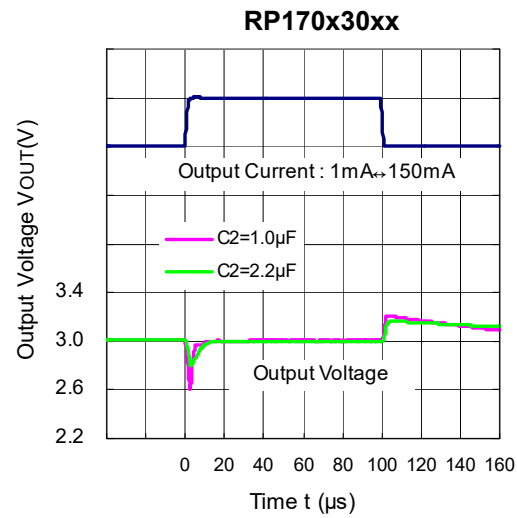
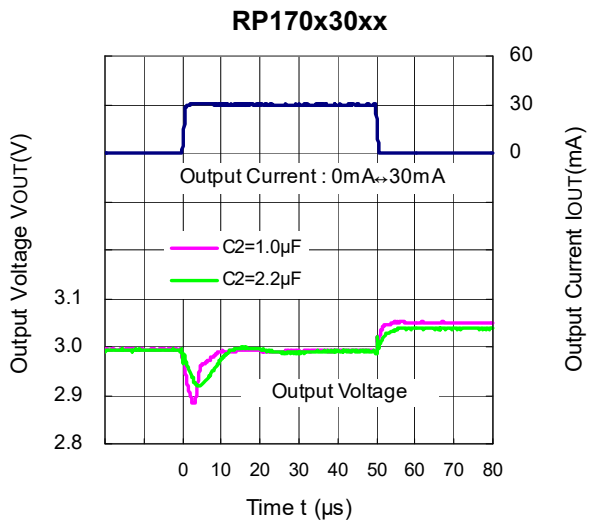
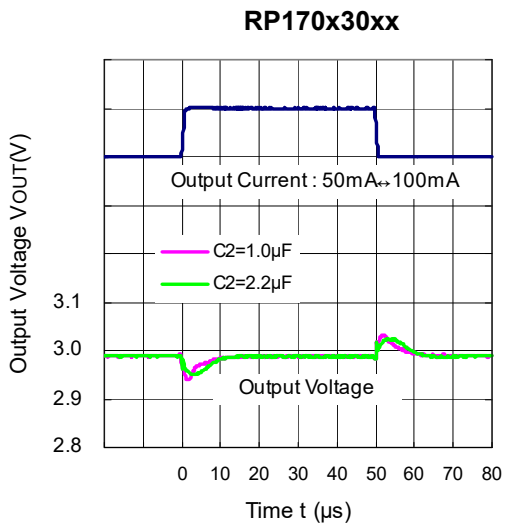
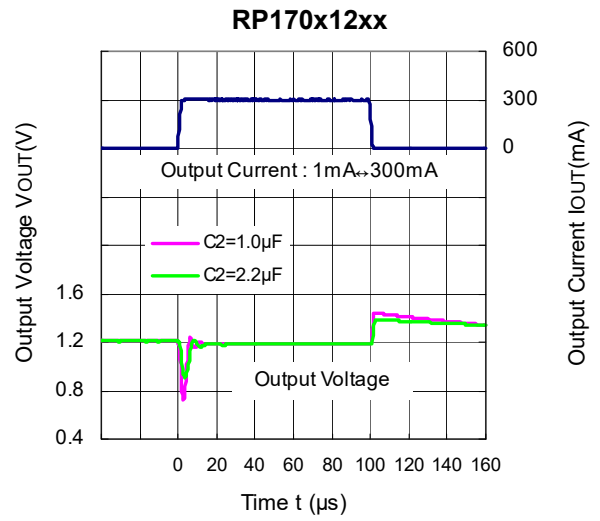
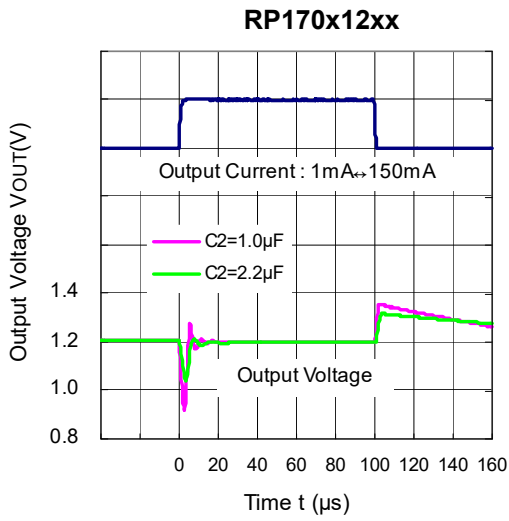
12) Input Transient Response (C1 = none, IOUT = 30 mA, tr = tf = 5 μs, Ta = 25°C)

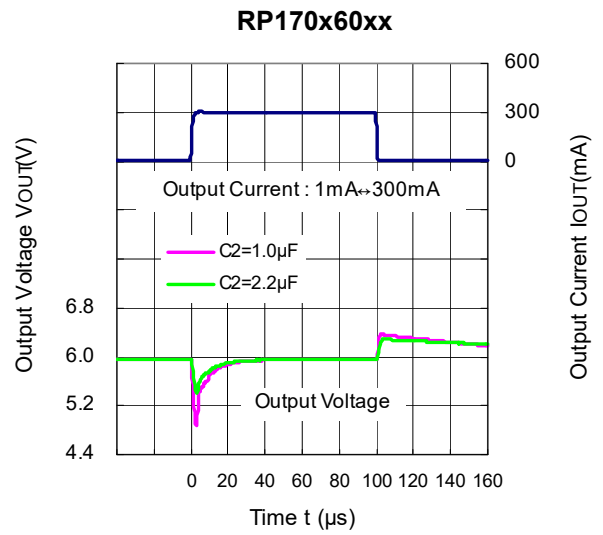
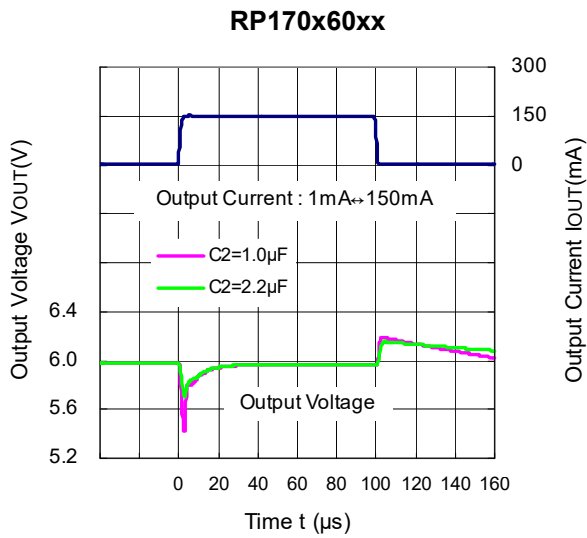
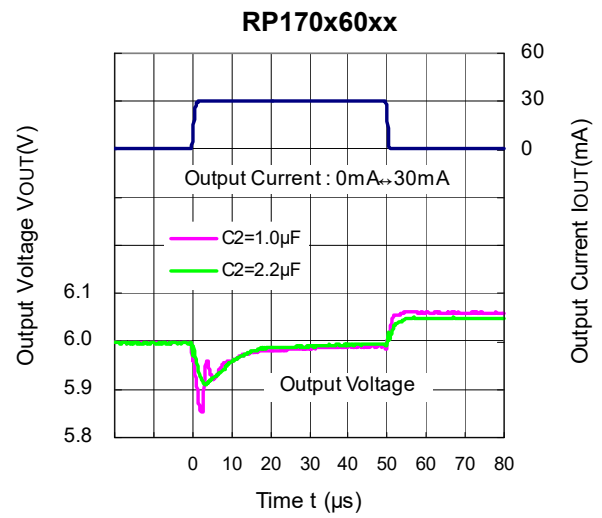
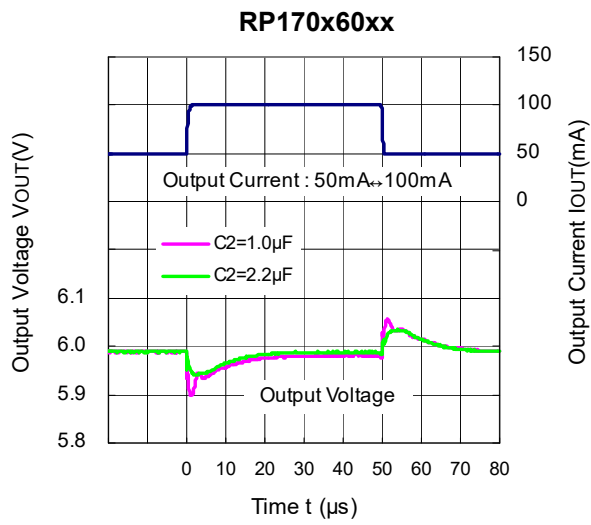




13) Load Transient Response (C1 = Ceramic 1.0 μ F, $t_r = t_f = 500$ ns, $T_a = 25^\circ C$)



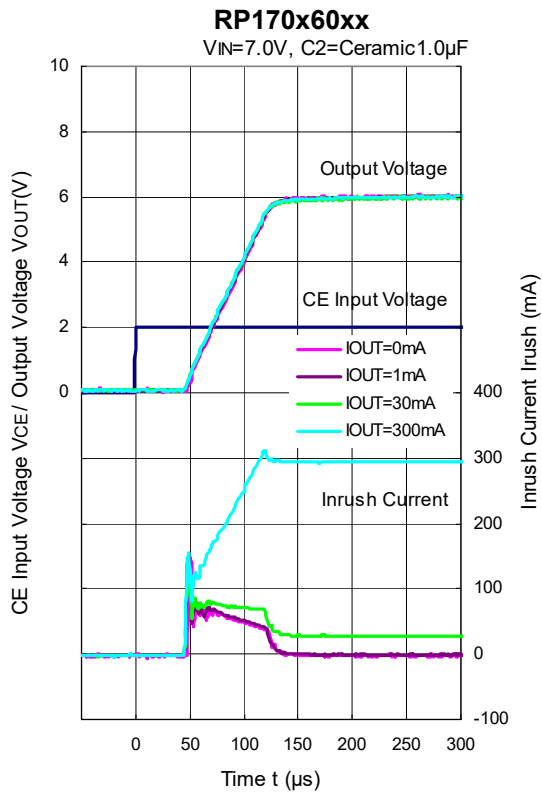
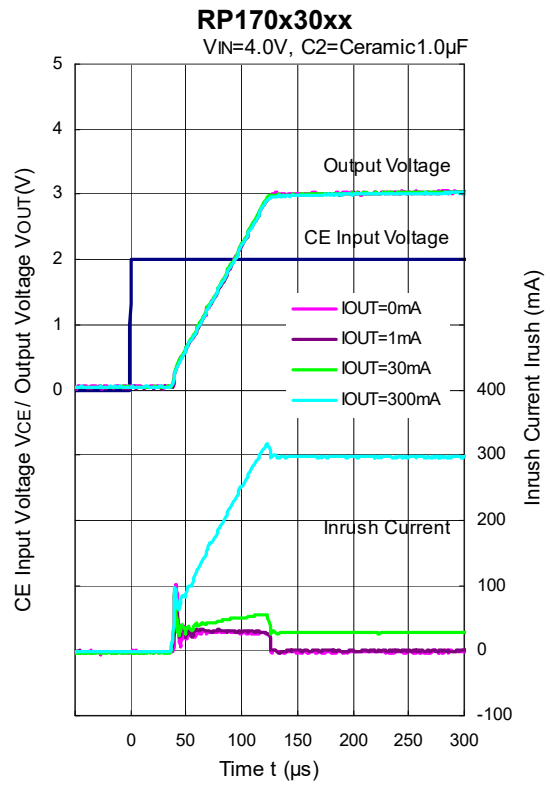
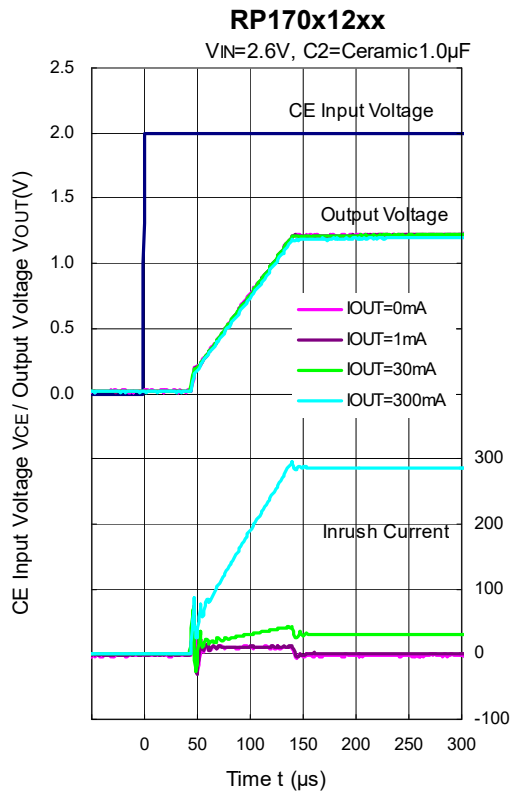


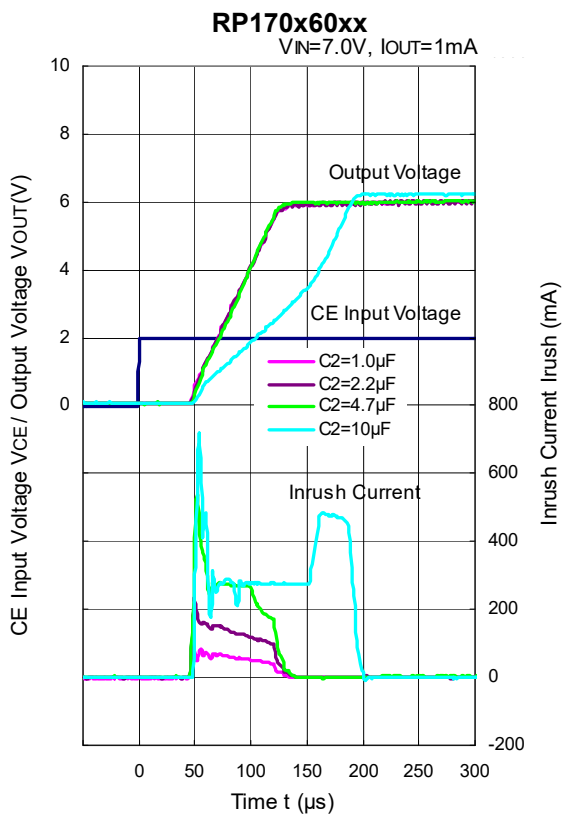
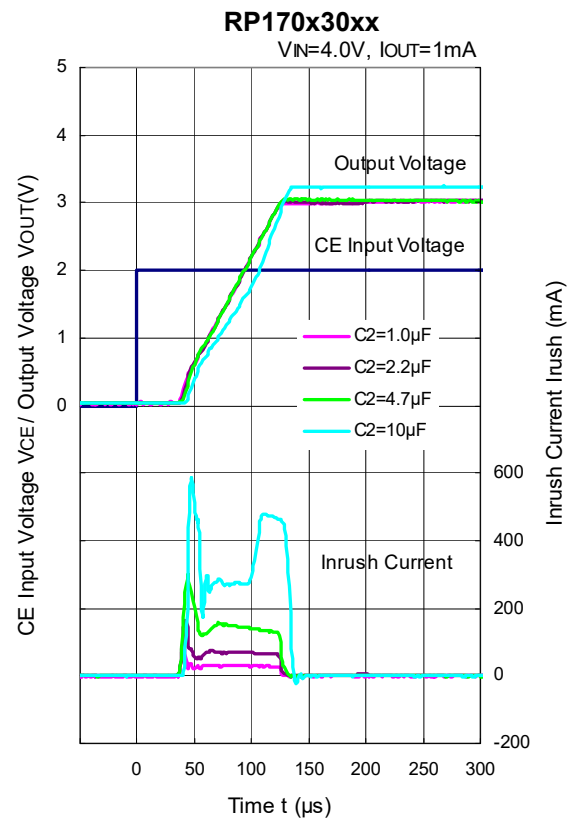
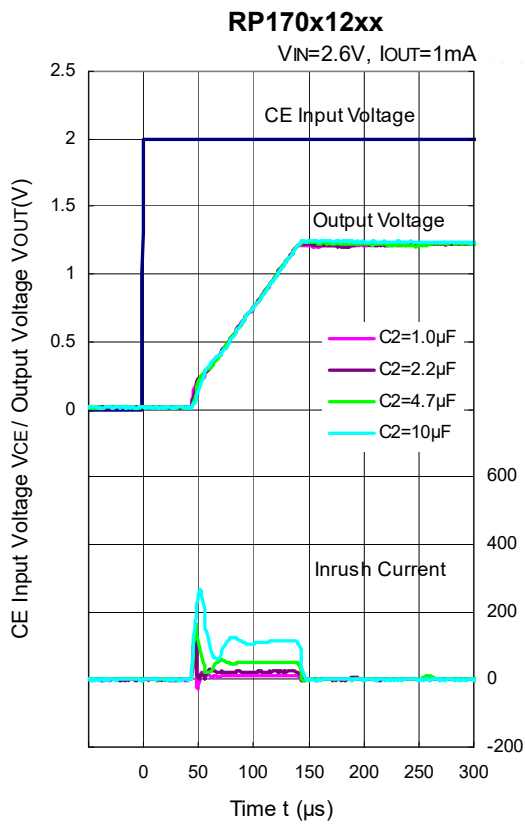


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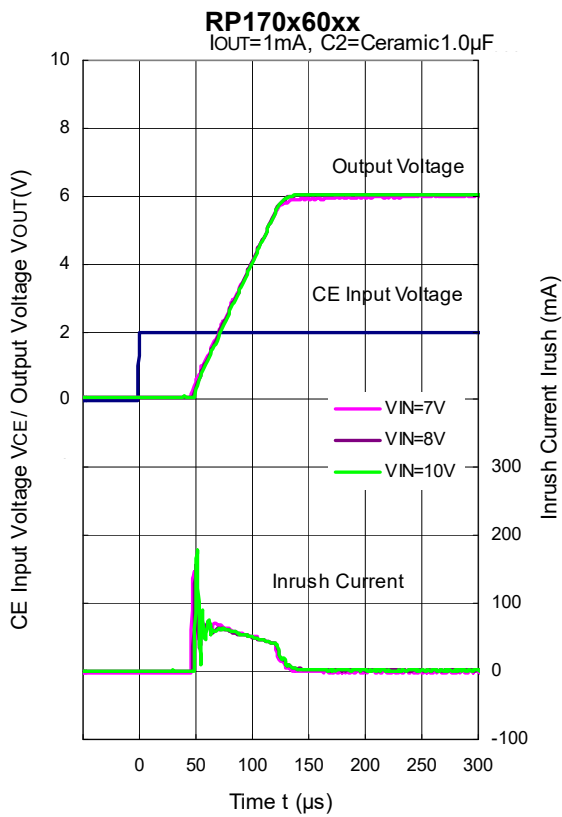
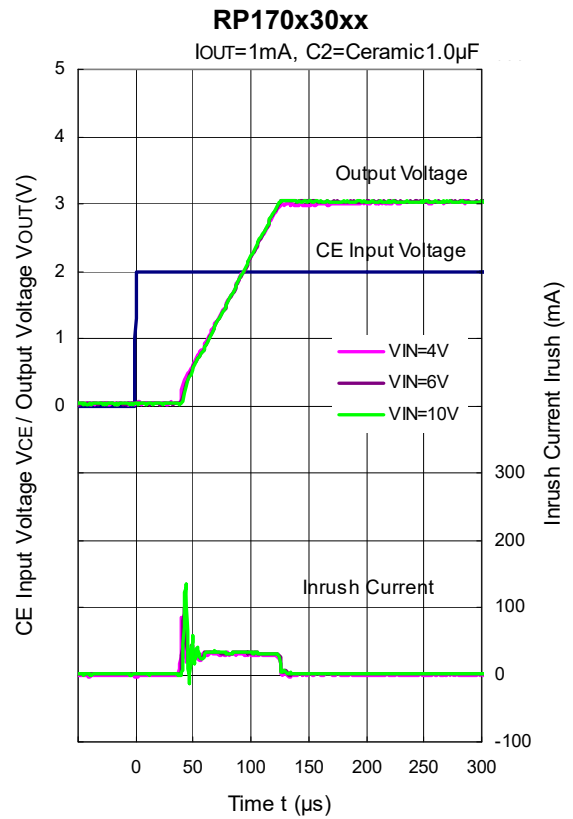
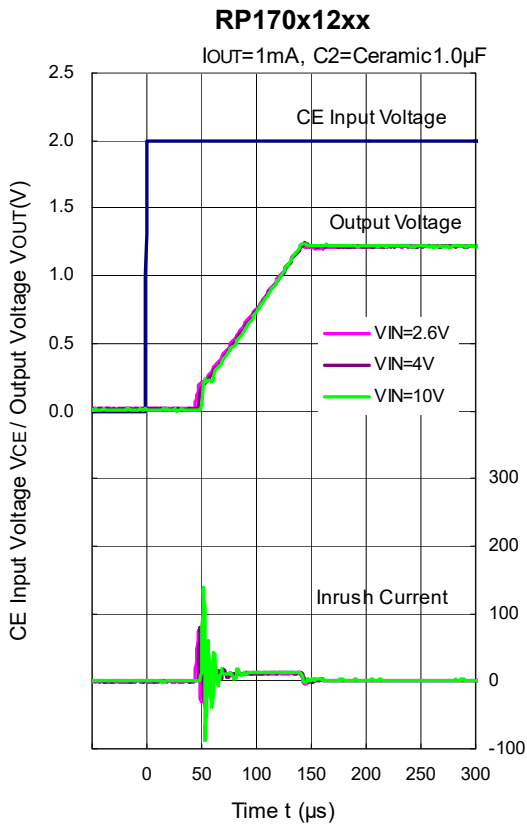
14) Turn On Speed with CE pin (C1 = Ceramic 1.0 μ F, Ta = 25°C)



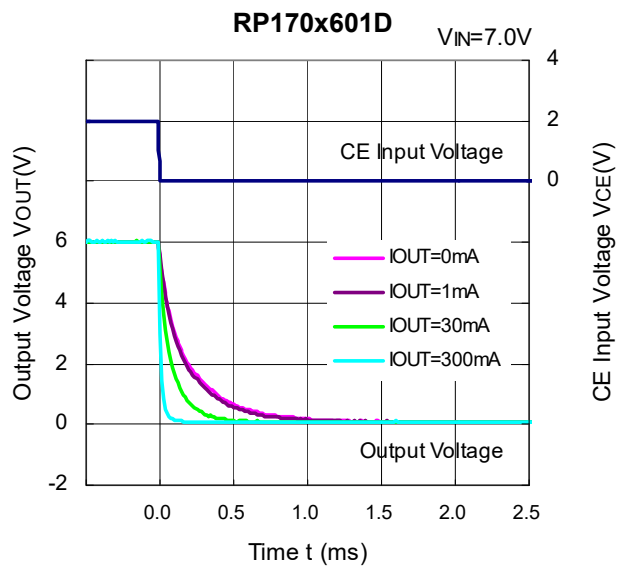
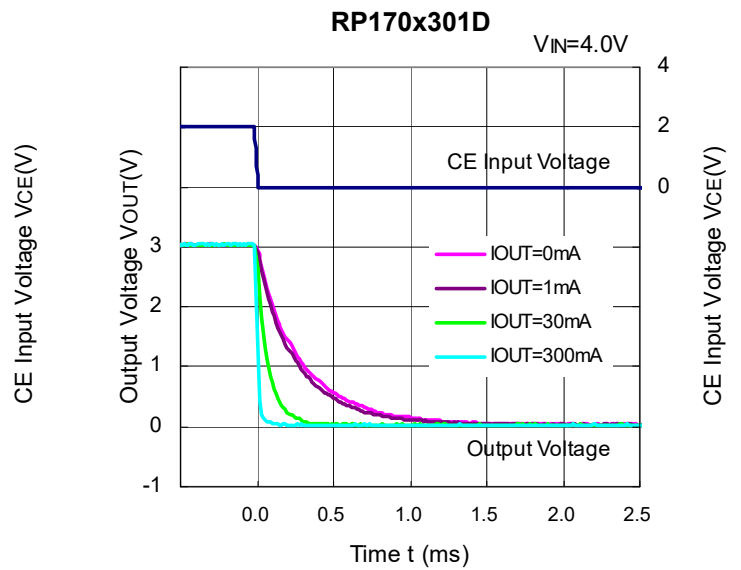
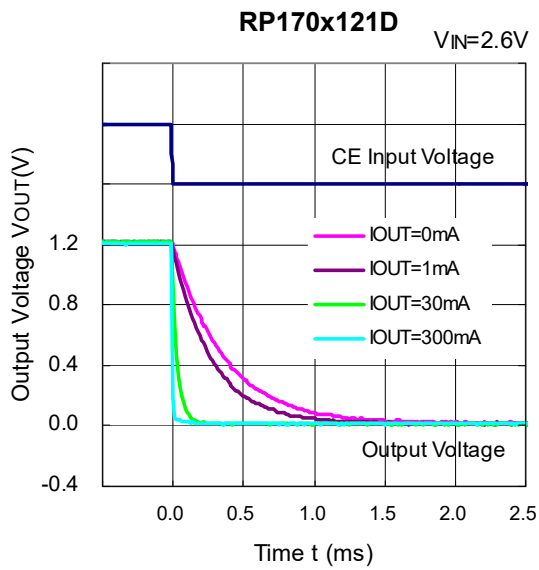


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15) Turn Off Speed with CE pin (RP170xxx1D) (C1 = Ceramic 1.0 μ F, Ta = 25°C)



ESR vs. Output Current

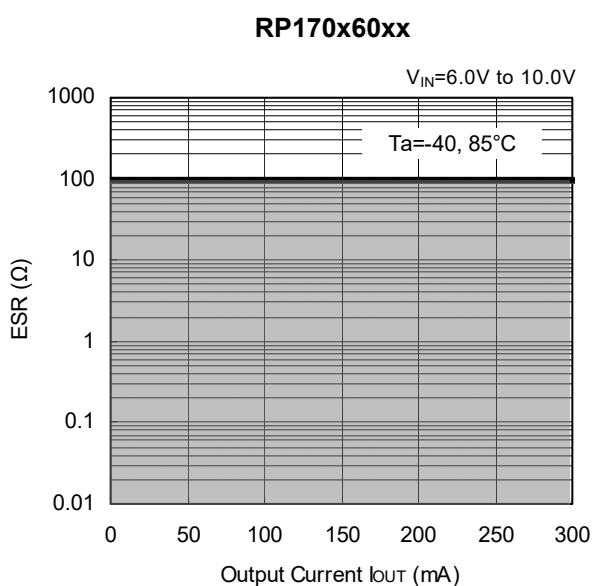
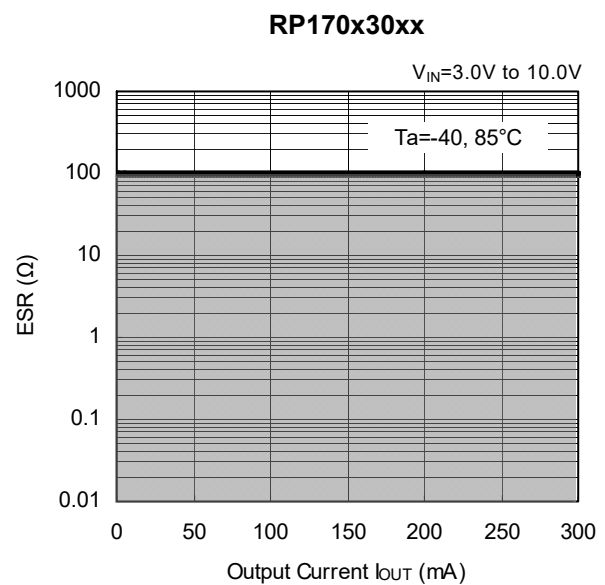
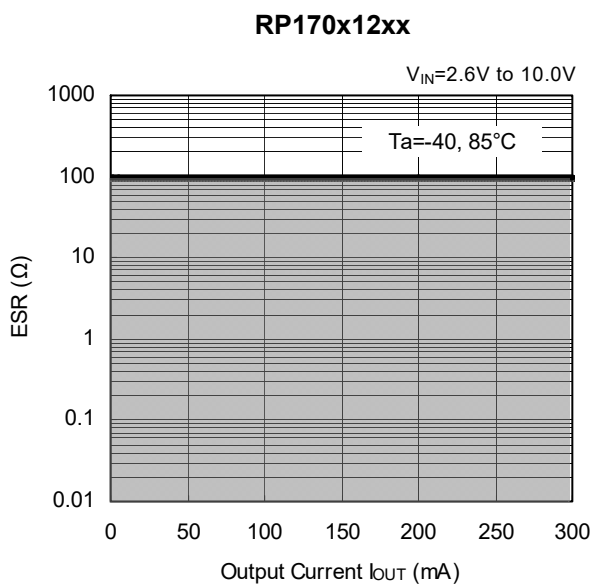
Ceramic type output capacitor is recommended for this IC; however, the other output capacitors with low ESR also can be used. The relations between I_{OUT} (Output Current) and ESR of an output capacitor are shown below. The conditions when the white noise level is under $40 \mu\text{V}$ (Avg.) are marked as the hatched area in the graph.

Measurement conditions

Frequency Band : 10 Hz to 2 MHz

Temperature : -40°C to 85°C

C1, C2 : Ceramic $1.0 \mu\text{F}$ (Murata GRM155B31A105KE)



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

Measurement Conditions

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

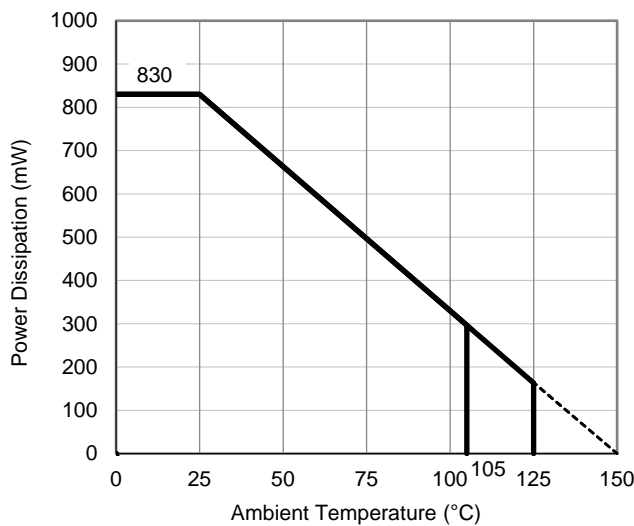
Measurement Result

(Ta = 25°C, Tjmax = 150°C)

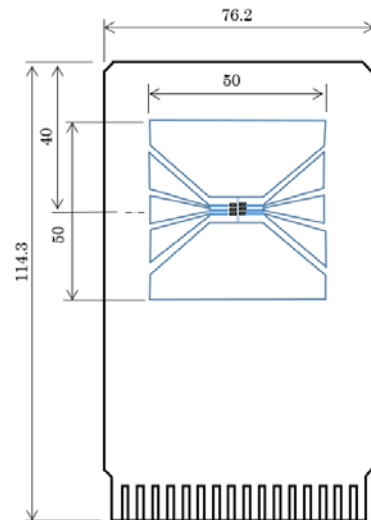
Item	Measurement Result
Power Dissipation	830 mW
Thermal Resistance (θ_{ja})	$\theta_{ja} = 150^\circ\text{C/W}$
Thermal Characterization Parameter (ψ_{jt})	$\psi_{jt} = 51^\circ\text{C/W}$

θ_{ja} : Junction-to-Ambient Thermal Resistance

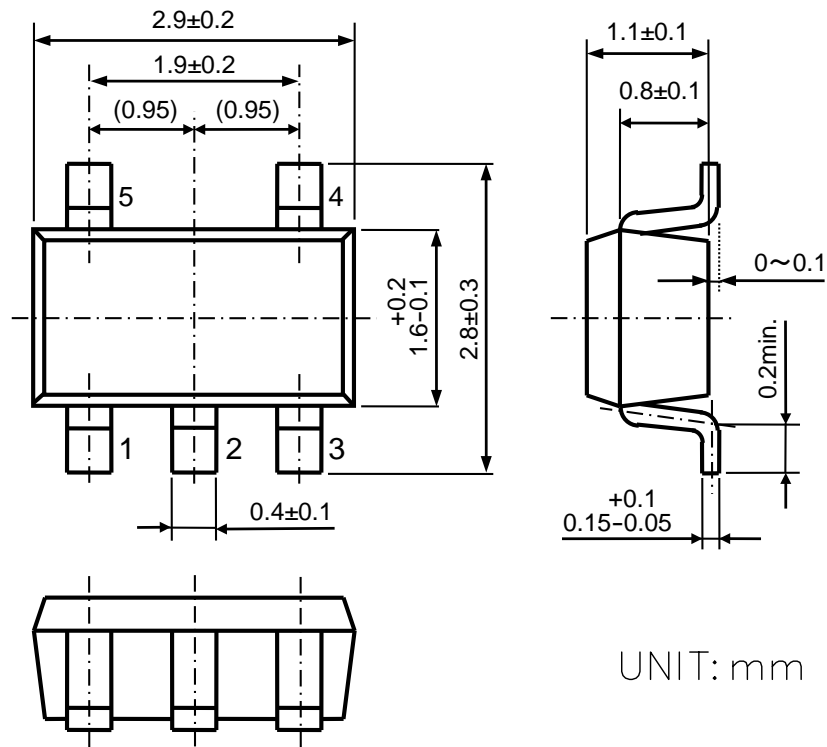
ψ_{jt} : Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern



SOT-23-5 Package Dimensions

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

Measurement Conditions

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

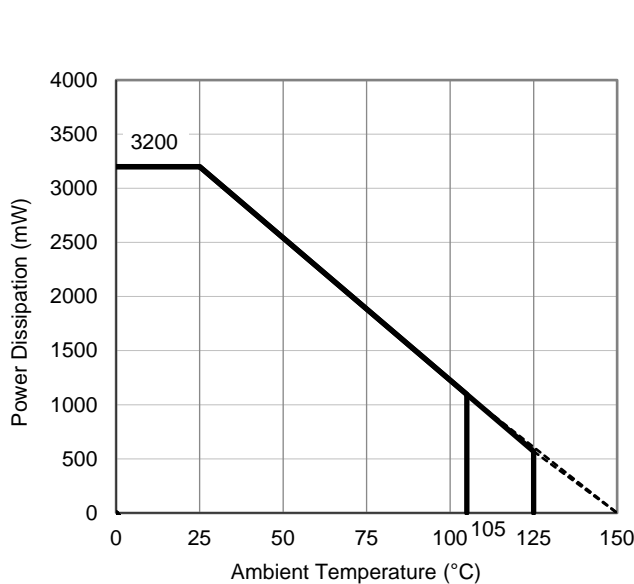
Measurement Result

(Ta = 25°C, Tjmax = 150°C)

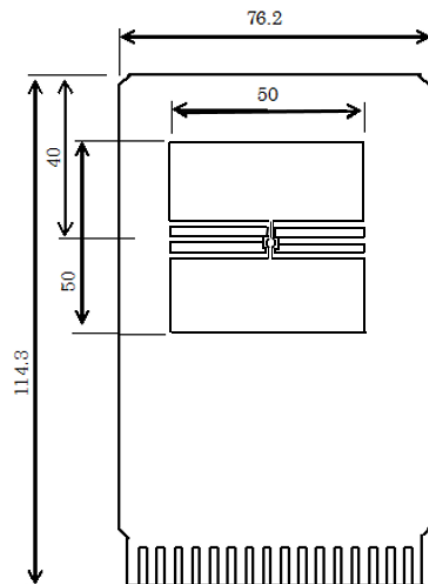
Item	Measurement Result
Power Dissipation	3200 mW
Thermal Resistance (θ_{ja})	$\theta_{ja} = 38^{\circ}\text{C/W}$
Thermal Characterization Parameter (ψ_{jt})	$\psi_{jt} = 13^{\circ}\text{C/W}$

θ_{ja} : Junction-to-Ambient Thermal Resistance

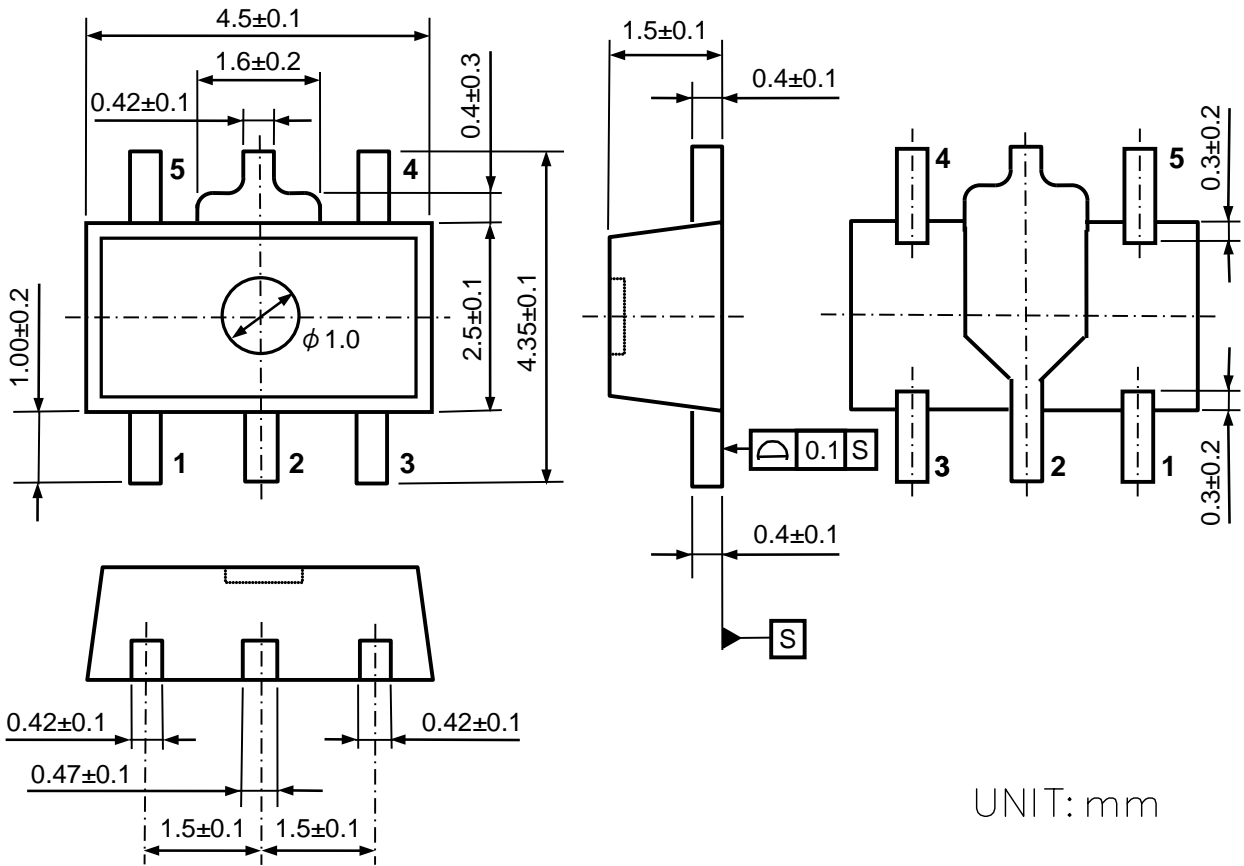
ψ_{jt} : Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern



UNIT: mm

SOT-89-5 Package Dimensions



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